



Technical Specification

Jakarta LRT Project – Corridor 1 (Phase 1):
Kelapa Gading-Velodrome Package P102
September 2016

PT Jakarta Propertindo

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Issue and revision record

Revision	Date	Originator	Checker	Approver	Description
A	1 Sep 2016	D Setianto	H Kusharwanto	S Bromley	Issue for Tender

Information class: Secure

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1 General

1.1 Application of the Technical Specification

1. The General Specification applies where work or items are not specifically refined to in this Technical Specification
2. The Technical Specification shall be read in conjunction with the other Contract Documents.
3. All clauses at section references in this Technical Specification shall refer to clauses and sections within this document unless specifically described otherwise.

2 Structural Excavation

2.1 Definition

Structural Excavation shall consist of excavation in earth, within the limits of the work as specified herein or as shown on the Drawings, that is made for structures. Any excavation which can be defined under any other Clause of this Specification shall not be considered to be Structure Excavation.

Structure Excavation shall be limited to excavation for the foundation of viaducts or concrete retaining walls, box culverts, wing walls and other structures, unless otherwise noted in these Specifications. It shall include backfilling with suitable material accepted by the Engineer; disposing of waste material, and all necessary materials and equipment for keeping the excavation free of surface run-off and ground water. Removal of free-surface water shall not be paid for under this Clause but will be considered to be covered by Section 1 of these Specifications.

2.2 Groundwater

- a. Whenever groundwater is encountered during structure excavation, the Contractor shall take such measures as are described in sub-clause 2.2.(c), to ensure that the excavation and footing are kept free of water.
- b. When the excavation is taking place in or directly adjacent to free-surface water, this will not be considered as groundwater and will be deemed to be covered by the Contractor's obligations under Section 1.23 of these Specifications and therefore not measured for additional payment under this Section. The decision as to whether water is free-surface water or groundwater will be at the absolute discretion of the Engineer. Where water can be kept out of the excavation by the use of a non-closed cofferdam, the water will generally not be considered to be groundwater.
- c. Suitable and practically watertight cofferdams shall be used wherever water bearing strata are encountered above the elevation of the bottom of the excavation. Upon request, the Contractor shall submit drawings showing his proposed method of cofferdam construction to the Engineer for his approval.

Cofferdams or cribs for foundation construction shall, in general, be carried out well below the bottoms of the footings and shall be well braced and as nearly water-tight as practicable. In general, the interior dimensions of cofferdams shall be such as to give sufficient clearance for the construction of forms and the inspection of their exteriors, and to permit pumping outside of the forms. Cofferdams or cribs which are tilted or moved laterally during the process of sinking shall be righted or enlarged so as to provide the necessary clearance.

When conditions are encountered which, as determined by the Engineer, render it impractical to dewater the foundation before placing the footing, the Engineer may require the construction of a concrete foundation seal of such dimensions as he may consider necessary, and such seal shall be placed as shown on the Drawings or as directed by the Engineer. The foundation shall then be dewatered and the footing placed. When weighted cribs are employed and the weight is utilized to overcome partially the hydrostatic pressure acting against the bottom of the foundation seal, special anchorages such as dowels or keys shall be provided to transfer the entire weight of the crib to the foundation seal. When a foundation seal is placed under water, the cofferdam shall be vented or ported at low water level as directed.

Cofferdams shall be constructed so as to protect green concrete against damage from sudden rising of the water and to prevent damage to the foundation by erosion. No timber or bracing shall be left in cofferdams or cribs, without the approval of the Engineer.

Any pumping that may be permitted from the interior of any foundation enclosure shall be done in such a manner as to preclude the possibility of any portion of the concrete materials being carried away. Any pumping required during the placing of concrete, or for a period of at least 24 hours thereafter, shall be done from a suitable pump located outside the concrete forms.

Pumping to dewater shall not commence until the seal has set sufficiently to withstand the hydrostatic pressure.

Unless otherwise provided, cofferdam or cribs, with all sheeting and bracing involved therewith, shall be removed by the Contractor after the completion of the substructure. Removal shall be effected in such a manner as not to disturb or damage any finished work.

d. Preservation of channel

Unless otherwise permitted, no excavation shall be made outside of caissons, cribs, cofferdams, or sheet piling, and the natural stream bed adjacent to the structure shall not be disturbed without the approval of the Engineer. If any excavation or dredging is made at the site of the structure before caissons, cribs, or cofferdams are sunk in place, the Contractor shall, after the foundation base is in place, backfill all such excavations to the original ground surface or streambed with material satisfactory to the Engineer. Material deposited within the stream area from foundation or other excavation or from the filling of cofferdams shall be removed and the stream area freed from obstruction.

2.3 Excavation

Prior to starting excavation operations in any area, the Contractor shall:

- Take steps on his own initiative to regulate the natural drainage of the water flowing on the surface of the ground, to prevent flooding of excavations.
- Ensure that all necessary Site Clearance and Demolition in that area has been performed in accordance with these Specifications.
- Notify the Engineer sufficiently in advance of the beginning of any excavation so that cross-sectional elevations and measurements can be taken of the undisturbed ground. The existing ground adjacent to the structures shall not be disturbed without the permission of the Engineer.

Trenches or foundation pits for structures or structure footings shall be of sufficient size to permit the placing of structures or structure footings of the full width and length shown. The sides of trenches or pits shall be adequately supported, as approved by the Engineer, at all times. The elevations of the bottoms of footings as shown on the Drawings shall be considered as approximate only and the Engineer may order, in writing, such changes in dimensions or elevations of footings as may be deemed necessary to secure a satisfactory foundation.

Boulders, logs, and any other unsuitable material encountered in excavation shall be removed from the site and shall not be used for backfilling purposes.

After each excavation is completed, the Contractor shall notify the Engineer to that effect, and no footing or bedding material shall be placed until the Engineer has approved the depth of excavation and the character of the foundation material.

All rock or other hard foundation material shall be cleaned of all loose material and cut to a firm surface, either level, stepped or serrated as directed by the Engineer. All seams or crevices shall be cleaned out and grouted. All loose and disintegrated rock and thin strata shall be removed.

When the footing is to rest on material other than rock, excavation to final grade shall not be made until just before the footing is to be placed. When the foundation material is soft or mucky or otherwise unsuitable, in the opinion of the Engineer, the Contractor shall remove the unsuitable material and replace it with granular backfill, as specified in Clause S4.08. This foundation fill shall be placed and properly compacted in 15 cm layers up to the foundation elevation at the density required by the Engineer.

If, in the opinion of the Engineer, the foundation material is unsuitable solely because of the Contractor's failure to fulfil his obligations, then the Contractor may either:

- Carry out at his own expense the removal and replacement described above; or
- Suspend works in that excavation until such time as the foundation material becomes suitable.

When foundation piles are used, the excavation of each pit shall be completed before the piles are driven and any placing of blinding stone shall be done after the piles are driven. However if for any reason it is impossible to drive the piles after excavation, piles shall be driven from the natural ground level, as directed by the Engineer. Surplus length of piles in this case will not be measured for payment.

After both the driving and the excavation are completed, all loose and displaced material shall be removed, leaving a smooth, solid bed to receive the footing.

All excavated material, so far as suitable, shall be utilized as backfill or embankment, or shall be removed from the site if surplus to requirements.

Where a box culvert is to be located in embankment the Engineer may instruct that the excavation shall be performed after the embankment has been constructed to the proposed sub-grade level and compacted sufficiently.

Necessary support shall be constructed so as to protect the current structure which will be above or side of the excavation. Excavation under railway shall include support with suitable foundation for the railway as shown in the drawings to secure the current railway transportation. All details of excavation under railway shall be approved by the Engineer before commencement of the work.

Structure excavation shall be made so that any adverse effect on the existing or adjacent roads or facilities shall be avoided or kept at minimum by use of sheet-piling and/or other suitable measures.

2.4 Blinding Stone

Blinding stone for use as a foundation for structures shall be provided as shown on the Drawings or instructed by the Engineer.

The main component of the blinding stone shall be approved cobble-stone or crushed rock, of the maximum size compatible with the thickness of blinding stone as shown on the Drawings. The minimum height of any stone as placed shall be 7 cm. Stone shall be closely packed by hand placing, to the dimensions shown on the Drawings, and then thoroughly rammed by mechanical rammer. Smaller stone pieces of minimum size 3 mm shall then be placed between the larger stones and the upper surface brought up to the finished level shown on the Drawings or instructed by the Engineer. The complete surface shall then be thoroughly compacted to the satisfaction of the Engineer using a mechanical rammer or vibrating roller.

The Contractor may propose an alternative to the above process, based on the use of graded, crushed stone of maximum size less than 5 cm. The Engineer's acceptance of this alternative and the maximum thickness to be laid in one layer will be dependant on the proposed compacting plant and its suitability for the restricted working area available.

2.5 Backfill and Embankment for Structure

2.5.1 Description

This work shall consist of the construction of embankment and backfill not specified elsewhere by furnishing, placing, compacting and shaping suitable material of acceptable quality obtained from approved sources in accordance with these Specifications, and to the lines, levels, grades, dimensions and cross-sections shown on the Drawings and as required by the Engineer.

2.5.2 Sources and Use of Material

Material for embankment shall consist of suitable material approved by the Engineer, excavated under any other clause of this Specification.

2.5.2.1 Removal and disposal of unsuitable material

When so directed in writing by the Engineer, the Contractor shall remove material unsuitable for use in the embankment and shall dispose of it as provided in section Waste

Where the excavation reveals a combination of suitable and unsuitable materials the Contractor shall unless otherwise agreed by the Engineer, carry out the excavation in such a manner that the suitable materials are excavated separately for use in the Works without contamination by the unsuitable materials.

When unsuitable material below sub-grade level in cut or below embankment foundation level is ordered to be removed, the soil left in place after the removal of the unsuitable material shall be compacted, to a depth of 20 cm, to a density of 90 percent of the maximum dry density determined according to AASHTO T 99.

When the material in cut is conglomerate or soft or weathered rock, such that in the opinion of the Engineer, it is not so firmly consolidated as to require drilling and blasting, the Contractor shall use an excavator with suitable steel tines, or other appropriate equipment for its removal.

2.5.2.2 Borrow Material

This work shall consist of the clearing and stripping of borrow pits, the excavating and hauling spreading and compacting of materials obtained from approved sources for constructing embankment, sub-grade and other parts of the work as required by the Contract or by the Engineer.

Borrow material shall be selected to meet the requirements and conditions of the particular fill or embankment for which it is to be used. Materials shall be free from detrimental quantities of organic material such as leaves, grass, roots and sewage.

Any material classified by the Unified Soil Classification System as OL, OH or Pt shall not be used.

Materials classified as GW, GP, GM, GC, SW, SP, SM and SC shall be accepted as suitable provided that the material is shown to be sound and has no peculiar characteristics. Materials classified as CH or MH can be used as embankment fill, unless otherwise indicated on the Contract Drawings or elsewhere, but not in the sub-grade unless it is possible to obtain the minimum design C.B.R. value required when compacted as specified in Clause S7.01.2.3.

Borrow material shall be obtained from approved private sources. Permission to open borrow pits, including advice as to suitability, shall first be obtained in writing from the Engineer. Nevertheless, the total amount of surplus material from excavation under Sections 2 and 3 of these Specifications, after deduction of the material declared unsuitable by the Engineer, shall be considered to be available for use in the embankment, and any borrow material resulting from the Contractor having used borrow pit in place of surplus material shall not be measured for payment under these Specifications.

The distance of borrow pits from the work site shall not be grounds for extra payment or revision of the Contract Price. In making his Bid the Contractor shall visit the site and form his estimate of the haulage costs on the basis of his own survey of the possible nature and locations of the borrow pits.

Where suitable material for embankments is available adjacent to the embankment the Engineer may order the excavation of drainage channels wider and deeper than normally required in which case such excavation will be measured and included in cross-sections as Common Excavation.

2.6 Formation of Embankment and Areas of Fill

2.6.1 Description

This work shall consist of the construction of embankment and backfill not specified elsewhere by furnishing, placing, compacting and shaping suitable material of acceptable quality obtained from approved sources in accordance with these Specifications, and to the lines, levels, grades, dimensions and cross-sections shown on the Drawings and as required by the Engineer.

2.6.2 Sources and Use of Material

Material for embankment shall consist of suitable material approved by the Engineer, excavated under any other clause of this Specification. Borrow material, however, shall only be used under the provisions of Clause 2.5 under this specification. Surplus or suitable material shall be disposed of as provided in Clause 2.5.

2.6.3 Construction

2.6.3.1 Compaction of Foundation of Embankment

When ordered by the Engineer, the Contractor shall excavate turf, decayed vegetable matter, or other unsuitable matter to such depth as the Engineer may require. This work shall be considered as Site Clearing or Common Excavation

Before beginning the construction of Embankment, the Contractor shall fill all holes, etc. within all the areas which have been cleared and grubbed, and such areas shall be suitably leveled at the level resulting after the removal of the topsoil. Fill material shall be approved by the Engineer.

Before the construction of the embankment is begun, the Engineer may order the compaction of the cleared surface or that resulting after removal of the topsoil, in which case the density after compaction shall conform to the requirements.

2.6.3.2 Placing and Compaction

Material for embankment, obtained and approved as provided above, shall be placed in horizontal layers of uniform thickness over a width determined by the Engineer and in conformity with the lines, grades, sections, and dimensions shown on the Drawings. The layer of loose material other than rock shall be not more than 20 cm thick, unless the compacting equipment used is capable of compacting a depth greater than 20 cm to a uniform density through the full depth which is acceptable to the Engineer, in which case the Contractor may place and compact the material other than rock, in layers of thickness approved by the Engineer. After adjustment of the moisture content to that required to obtain maximum density, the loose material shall be compacted to the required density.

Technical Specification

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3 Concrete Structures

3.1 Concrete

3.1.1 Scope

This work shall consist of the general items pertaining to the required class or classes of concrete, with or without reinforcement, constructed in accordance with these Specifications and the lines, levels, grades and dimensions shown on the Drawings, and as required by the Engineer.

Portland cement concrete shall consist of a mixture of cement, water and coarse and fine aggregates.

3.1.2 Concrete Classes and Their Use

The use of each class of concrete shall be as shown in Table 10-1 unless otherwise shown on the Drawings or directed by the Engineer:

Table 3.1: Strength Class, Use of Each Class of Concrete

Usage	Compressive Strength (Cylinder, MPa)	Compressive Strength (Cube, MPa)
• Pre-stressed concrete girders	50	60
• Pre-stressed concrete cantilever pier heads		
• Pre-stressed concrete spun piles		
• Reinforced concrete pier heads	40	50
• Reinforced concrete pier column		
• Reinforced concrete slab	30	35
• Reinforced concrete diaphragm		
• Reinforced concrete abutment		
• Reinforced concrete pile cap		
• Reinforced concrete bored piles		
• Approach slabs	20	25
• Precast concrete side ditch		
• Reinforced concrete Curb and parapet		
• Reinforced concrete plate for slab		
• Levelling concrete	10	12.5

3.1.2.1 Determining the Proportions and Batch Weight

No structural concrete shall be placed in the works until the relevant mix has been approved by the Engineer.

The proportions and batch weights for concrete will be determined as prescribed below. The determinations will be made after the materials furnished by the Contractor have been accepted.

a. Trial mixes

The Contractor shall, at least thirty five (35) days prior to the commencement of concreting, have laboratory trial mixes prepared which shall be witnessed by the Engineer.

The laboratory trial mixes shall be so designed by the Contractor that the resultant compressive or flexural strength result as applicable, (Preliminary Test Result), shall show an adequate working strength margin, in accordance with normal good practice so that the probability of site working strength test values falling below the minimum specified strength shown in Table 10-2 Standard Proportion of Concrete for Use in Structures is reduced to a value not exceeding 5%. The Engineer will determine the proportions on the basis of the trial mixes conducted with the materials to be used in the work.

The proportions for the trial mixes will be based on the values given in Table 3.2 Standard Proportion of Concrete for Use in Structures adjusted as described in this sub-clause. However the proportions given in the table are approximate values for the convenience of the Contractor's estimate only, excepting that it shall be understood that:

The water cement ratios given shall be absolute maximum values

The cement contents given shall be absolute minimum values

The minimum compressive strength values given shall be taken to mean the minimum site working strength

Table 3.2: Standard Proportion of Concrete for use in Structures (for Reference)

Concrete Class / Strength (fc' MPa) Cylinder Test	50	40	30	20	10
Max. Size of course aggregate	20	20	20	25	25
Slump (mm) ^{2/}	75±25	75±25	75±25	75±25	75±25
Water cement ratio W/C (%)	35	37.5	42.4	61.4	78.0
Water content W (kg/m ³)	170	170	172	181	157
Cement content C (kg/m ³)	450	455	405	295	178
Fine aggregates S (kg/m ³)	720	720	705	885	896
Coarse aggregate G (kg/m ³)	1100	1100	1147	1039	1187
Minimum compressive strength at 28 days by cube test (MPa) ^{3/5/}	60	50	40	25	12.5
Minimum compressive strength at 28 days by cylinder test (MPa) ^{4/5/}	50	40	30	20	10
Minimum flexural strength at 28 days (kg/cm ²) ^{6/}	-	-	-	-	-

Notes:

- 2/ Slump will be determined in accordance with AASHTO T 119 or JIS A 1101.
- 3/ Concrete compressive tests shall conform to the requirements of "SNI 03-6813-2002".
- 4/ Concrete compressive tests shall conform to the requirement of AASHTO T 22 and 23.
- 5/ In the event of any dispute regarding conformance with this Specification, the results obtained by the cylinder test will be taken as conclusive, unless the Engineer has previously agreed in writing to the use of cube tests for control purposes. (Kg/cm² can be read as (1/9.8)N/mm²).
- 6/ Flexural strength will be tested by the third point loading method in accordance with AASHTO T 97.

The weights of aggregate per cubic metre of concrete in Table 3.2 are based on the use of aggregates which have a bulk specific gravity of 2.65 when in a saturated surface-dry condition, the use of uniformly graded natural sand having a fineness modulus of 2.75, and the use of a uniformly graded coarse aggregate of the size indicated.

For aggregates having other specific gravities, the weights will be corrected by multiplying the weights shown in the table by the specific gravity and dividing by 2.65.

When angular, manufactured sand or sand having a fineness modulus greater than 2.75 is used, the amount of fine aggregate will be increased and the amount of coarse aggregate decreased. When using sand having a fineness modulus less than 2.75, the amount of fine aggregate will be decreased and the amount of coarse aggregate increased. For each change in fineness modulus of 0.10 as compared to 2.70, the percentage of sand will be changed by 1 percent in relation to the total weight of combined fine and coarse aggregates. The fineness modulus of fine aggregate will be determined by adding the cumulative percentage, by weight, of material retained on each of ASTM Standard sieves 4.75, 2.36, 1.18, 0.600, 0.300 and 0.150 mm, and dividing by 100.

The correction for fineness modulus will be made prior to making a correction in the weights of Table 10-2 for variations from 2.65 in specific gravity.

The Contractor may, subject to prior approval by the Engineer, use alternative sizes of coarse aggregate to those in Table 3.2.

If the use of an alternative size of coarse aggregate produces concrete which exceeds the permissible water content, thereby requiring additional cement above that specified, no compensation will be made to the Contractor for the additional cement. Designated sizes of coarse aggregate need not be separated into component sizes. However, two sizes are preferred when the maximum size exceeds 2.5 cm. If one or more of the component sizes used fails to meet the specified grading for its respective size, but a combination of the sizes can be used to meet the specified grading for the combined size, they may be used with the written permission of the Engineer.

b. Proportions and batch weight

The Engineer will designate the weight in kilograms of fine and coarse aggregate (in a saturated surface-dry condition) per cubic metre of concrete for the specified class of concrete and these proportions will not be changed except as provided in the paragraphs immediately following. In addition, the Engineer will also designate the batch weights of aggregate after he has made moisture determinations and corrected the saturated surface-dry weights for free moisture.

In batching aggregate for structures containing less than 25 cubic metres of concrete, the contractor may substitute approved volumetric measuring devices in lieu of weighing devices. In such event, weighing will not be required but the volumes of coarse aggregate and of fine aggregate measured into each batch shall be those designated by the Engineer.

c. Adjustment for variation in workability

If it is found impossible to obtain concrete of the desired place-ability and workability with the proportions originally designated by the Engineer, he will make such changes in aggregate

weights as are necessary, provided that in no case shall the cement content originally designated be changed.

d. Adjustment for variation in yield

If the cement content of the concrete, determined by means of the yield test, AASHTOT 121, varies more than plus or minus two (2) percent from the designated value in Table 3.2, the proportions will be adjusted by the Engineer to maintain a cement content within these limits. The water content shall in no case exceed the specified amount.

e. Adjustment for excess water content If, when using the designated cement content, it is

impossible to produce concrete having the required consistency without exceeding the maximum allowable water content specified in Table 3.2, the cement shall be increased by the Engineer so that the maximum water content will not be exceeded.

f. Adjustment for new materials

No change in the source or character of the materials shall be made without due notice to the Engineer and no new materials shall be used until the Engineer has accepted such materials and has designated new proportions based on tests or trial mixes as provided herein. Should the changes due to the new materials require an increase in the amount of cement, no additional payment shall be made to the Contractor for the cost of such additional cement.

3.1.2.2 Sampling of Concrete

In order to assess compliance of the concrete during construction, the Contractor shall prepare test specimens which will be cured and tested at 7 days or 28 days as determined by the Engineer, or at any other interval that may be deemed necessary to determine the strength of the concrete. (Site working strength).

Specimens shall be made in pairs and there shall not be less than eight pairs made for every 60 cubic metres of concrete or fraction thereof placed during one day's work or as deemed necessary by the Engineer. One specimen from each pair shall be tested at 7 days and one specimen at 28 days.

Irrespective of the quantity, every day's production of concrete shall be tested both for strength and for slump and every structure and every component of every structure shall likewise be so tested for strength and slump. The checking and testing of the concrete shall be the prerogative of the Engineer, and he may increase the specified strength and condition as required for the project.

The concrete test specimens will be tested by the Contractor at a conveniently located and properly equipped laboratory.

The Contractor shall take, on his own responsibility, every precaution to prevent injury to the test specimens during handling, transporting and storing.

3.1.2.3 Strength Requirements

- a. Specimen Preparation. The ultimate compressive strength of the concrete shall be determined on specimens obtained and prepared in accordance with "RSNI: PERENCANAAN STRUKTURBETON UNTUK JEMBATAN (2004) or SNI 03-6813-2002" or, if this is not possible with AASHTO T 141 (ASTM C 172) and AASHTO T 23 (ASTM C 31). Test cylinders made in the laboratory shall conform to ASTM C 192. The compression test performed on cylinders shall be according to specifications AASHTO T 22 (ASTM C 39).
- b. Compressive and Flexural Strength

The average site working strength value of any 4 consecutive results of the tests at the age of 28 days shall not be less than the minimum strength specified in Table 10-2 for the respective class of concrete. In the event of failure to comply with this requirement all of the concrete in all the batches represented by such specimens, including any batches within the sequence which were not sampled shall be deemed not to comply with the strength requirement of this clause. If at any time the average of any 4 consecutive results of tests at the age of 7 days falls below 70% of the prescribed minimum value at 28 days for compressive strength or below 80% of the prescribed minimum value at 28 days for flexural strength the cement content of the concrete will be increased by at least 20 kg per cubic metre of compacted concrete, without extra payment, until any necessary mix modifications have been agreed following examination of 28 day tests.
- c. Characteristic Strength

The characteristic strength of the various classes of concrete shall be determined as soon as the first 30 test results of each class become available.

The characteristic strength shall be calculated by the equation:

$$\bar{X}_o = X - KS$$

Where:

X_o : Characteristic strength

X : mean or average of the series of results

K : a factor depending upon the percentage of results allowed to fall below the characteristic strength

S : standard deviation given by equation:

$$S = \sqrt{\frac{(X - \bar{X})^2}{N - 1}}$$

Where:

X : the individual result

N : the total number of results

The values for the factor K are:

Table 3.3: The values for K factor

Percentage of results allowed to fall below the minimum	Value of K
0.1	3.09
0.6	2.50
1.0	2.33
2.5	1.96
5.0	1.64

If the characteristic strength so determined falls below the minimum site working strength the Contractor will increase the cement content in the same manner as described in Item (ii) above until such time as adjustments shall be made in the mix proportions or improvements made in the quality control measures to raise the average strength or reduce variation to the satisfaction of the Engineer.

d. Failure to comply with compressive strength requirements

In the event of compressive strength results not complying with the strength requirements of this clause or in the event of doubtful results, the Engineer will proceed to check the simple compression strength by means of crushing tests performed on test specimens taken with a rotary core borer at suitable points indicated by the Engineer on the structure already constructed.

Such tests shall be carried out by an agreed authority having suitable test facilities. If such tests show strength in compliance with the requirements herein specified, the concrete will be considered satisfactory. If such tests do not comply with the requirements, the Engineer may direct the Contractor to cut out and make good the defective work at the Contractor's expense.

e. Care of Specimens The cost of taking specimens and performing the tests including the cost of providing stout, substantial packing cases and the cost of shipping or transporting the test specimens from the site to the laboratory shall be included as part of the price bid for Portland cement concrete. The Contractor shall take, on his own responsibility, every precaution to prevent injury to the test specimens during handling and transporting.

f. Records

The records of all tests shall be kept by the Engineer but results shall be available at all times to the Contractor. The Contractor shall be responsible for making such adjustments as may be necessary to produce specification concrete and the test results shall include whether or not the concrete is satisfactory.

3.1.3 Materials

3.1.3.1 General

All materials to be furnished and used that are not covered in this section shall conform to the requirements stipulated in other applicable sections.

3.1.3.2 Cement

The Contractor shall use only one brand of any one type of cement having uniform quality for one project.

The cement used in the work shall be ordinary Portland Cement except when otherwise shown on the Drawings, or directed by the Engineer. Cement shall conform to the requirements of SNI 15-2049-1994 or JIS R 5210 "Portland Cement" or AASHTO M 85 (Type I).

3.1.3.3 Admixtures

Admixtures shall not be used without the written approval of the Engineer. The Contractor shall submit samples of any admixtures he requests to use to the Engineer at least 28 days prior to the date of commencement of construction of the particular structure or portion of structure on which he intends to use such admixtures.

3.1.3.4 Water

All water used in concrete shall be subject to the Engineer's approval. Water used in mixing, curing, or other designated applications shall be reasonably clean and free from oil, salt, acid, alkali, sugar, vegetable, or any other substance injurious to the finished product. If required by the Engineer, water shall be tested by comparison with distilled water.

Comparison shall be made by means of standard cement test for soundness, time of setting, mortar strength. Indication of unsoundness, change in time of setting of plus or minus 30 minutes or more, or decrease of mortar strength more than 10 percent compared with distilled water shall be sufficient cause for rejection of the water that is being tested.

Where the source of water is relatively shallow, the intake shall be so enclosed as to exclude silt, mud, grass, or other foreign materials.

3.1.3.5 Fine Aggregate

The fine aggregate for concrete shall consist of natural sand or, subject to approval of the Engineer, other inert materials with similar characteristics, having clean, hard and durable particles, and it shall be free from objectionable quantities of dust, silt, clay, organic matter, and other impurities.

The fine aggregate shall be uniformly graded and shall meet the following grading requirements:

Table 3.4: Grading of Fine Aggregate

Sieve Size (mm)	Cumulative Passing Percentage by Weight
9.5	100
4.75	95 – 100
2.36	80 – 100
1.18	50 – 85
0.600	25 – 60
0.300	10 – 30
0.150	2 – 10

Sieve analysis of fine aggregate shall be made in accordance with JIS A1102 (Method of Test for Sieve Analysis of Aggregate) or AASHTO T 27.

The gradation requirements given above are the extreme limits to be used in determining the suitability of material from all possible sources of supply. The gradation of materials from any one source shall not vary in composition beyond the range of values that govern the selection of a source of supply. For the purpose of determining the degree of uniformity, a fineness modulus determination shall be made upon representative samples, submitted by the Contractor, from such sources as he proposes to use. If fineness modulus of fine aggregate varies more than 0.2 from the value used in selecting concrete proportions, the fine aggregate shall be rejected unless suitable adjustment of the mix proportions are made with the approval of the Engineer.

The amount of deleterious substances in fine aggregate shall not exceed the limits specified in Table 3.5. Treatment of other deleterious substances which are not shown in the above table shall be determined by the direction of the Engineer.

Tests for material finer than 0.075 mm sieve shall be made in accordance with JIS A 1103 (Method of Test for Amount of Material Passing Standard Sieve 0.074 mm in Aggregates), or AASHTO T 11.

Table 3.5: Limits for deleterious substances in fine aggregate (percentage by weight)

Item	Maximum
Clay lumps	1.0
Material finer than 0.075mm sieve:	
Concrete subject to abrasion	3.0 ^{1/}
All other concrete	5.0 ^{1/}
Material coarser than 0.300mm Sieve floating on a liquid having a specific gravity of 1.95	0.5 ^{2/}

Note

1/ In the case of crushed aggregate, if the material finer than 0.075 mm sieve consists of the dust of fracture essentially free from clay or shale, these percentages may be increased to 5 and 7 percent respectively.

2/ This requirement does not apply to manufactured sand produced from blast furnace slag.

All fine aggregate shall be free from injurious amounts or organic impurities. Approximate determination of the presence of injurious organic impurities in natural sand shall be in accordance with JIS A 1105 (Method of Test for Organic Impurities in Sands). Aggregate subjected to the colorimetric test for organic impurities, and producing a colour darker than the standard shall be rejected.

However, any sand that fails to meet the above requirement may be used provided that the compressive strength of mortar specimens using such sand is more than 95% of that of mortar specimen using the same sand which is washed by 3% solution of sodium hydroxide and then by water, and approved by the Engineer. Testing age of mortar specimens shall be 7 and 28 days for normal Portland cement.

Compressive strength of mortar specimens shall be determined by AASHTO T 71, "Effect of Organic Impurities in Fine Aggregate on Strength of Mortar".

3.1.3.6 Coarse Aggregate

The coarse aggregate shall consist of one or more of the following: crushed stone, gravel, blast-furnace slag, or other approved inert materials of similar characteristics having clean, hard, durable pieces. It shall be free from objectionable quantities of flat or elongated particles, organic matter or other deleterious matter.

The coarse aggregate shall be uniformly graded and shall meet the grading requirement shown in Table 10-5 Table Grading of Coarse Aggregate.:

Table 3.6: Table Grading of Coarse Aggregate

Size of coarse aggregate (mm)	100	80	60	50	40	25	20	15	10	5	2.5
50-5			100	95-100		35-70		10-35		0-5	
40-5				100	95-100		35-70		10-30	0-5	
25-5					100	95-100		30-70		0-10	0-5
20-5						100	90-100		20-55	0-10	0-5
15-5							100	90-100	40-70	0-15	0-5
80-40	100	90-100	45-70		0-15		0-5				
60-40		100	90-100	35-70	0-15		0-5				
50-25			100	90-100	35-70	0-15		0-5			
40-20				100	90-100	20-55	0-15		0-5		

Sieve analysis of coarse aggregate shall be made in accordance with JIS A1102 (Method of Test for Sieve Analysis of Aggregate) or AASHTO T 27.

The amount of deleterious substance in coarse aggregate shall not exceed the limits prescribed in Table 3.7. Treatment of the other deleterious substances which are not shown in the table shall be determined by the direction of the Engineer.

Table 3.7: Limits for deleterious substances in coarse aggregate (percentage by weight)

Item	Maximum
Clay lumps	0.25
Soft particles	5.0
Material finer than 0.075mm sieve:	1.0 ^{1/}
Material floating on a liquid having a specific gravity of 1.95	1.0 ^{2/}

Note

1/ In the case of crushed aggregate, if the material finer than 0.075 mm sieve consists of the dust of fracture essentially free from clay or shale, this percentage may be increased to 1.5.

2/ This requirement does not apply to manufactured sand produced from blast furnace slag.

Test for material finer than 0.075 mm sieve shall be made in accordance with JIS A 1103 (Method of Test for Amount of Material Passing Standard Sieve 0.074 mm in Aggregates), or AASHTO T 11. Test for soft particles shall be made in accordance with JIS A 1126 (Method of Test for Soft Particles in Coarse Aggregate by Use of Scratch Tester), or AASHTO T 112.

3.1.3.7 Test of Aggregate

Before use, results of the foregoing tests of aggregate from each source shall be submitted to and approved by the Engineer. Tests for aggregate in use shall be made when required by the Engineer.

3.1.3.8 Expansion Joint Filler (Asphalted Joint Filler)

Expansion joint filler shall conform to the requirements of AASHTO M 33.

The filler for each joint shall be furnished in a single piece for the full depth and width required for the joint unless otherwise authorized by the Engineer. When the use of more than one piece is authorized for a joint, the abutting ends shall be fastened securely, and held accurately to shape, by stapling or other positive fastening satisfactory to the Engineer.

3.1.3.9 Storage of Materials

3.1.3.10 Storage of cement

Cement may be shipped from prestressed and approved bins at the mill. Cement shall be stored in a damp-proof warehouse with a floor raised at least 30 cm from the ground so as to permit easy access for inspection and for use in the delivered order.

Bagged cement shall not be piled more than 13 sacks high. Cement which has become damp, lumpy or otherwise not in proper condition shall not be used. Cement stored by the Contractor for a period longer than 60 (sixty) days shall require the Engineer's approval before being used on the work. Subject to the Engineer's approval of their use, cement of different brands, types, or from different mills shall be stored separately. The use of cement reclaimed from discarded or used bags will not be permitted.

3.1.3.11 Storage of aggregate

Fine and coarse aggregates shall be stored separately to prevent contamination by foreign material. Aggregate shall be stored in such a manner as to keep the moisture content as uniform as possible, and shall be handled in such a manner as to prevent segregation. Aggregate shall be stored so as to protect it from the direct rays of the sun. Aggregate from different sources of supply shall not be stored in the same place without permission from the Engineer.

3.1.3.12 Adhesive

3.1.3.12.1 Introduction

Epoxy resin adhesive shall be used for the jointing of precast concrete blocks.

3.1.3.12.2 Quality Standard

Table 3.8: Quality Standards

	Item	Unit	Quality Standard	Testing Condition	Curing Condition
Unhardened Adhesive	External Appearance		No foreign matters recognized as to be harmful shall be mixed in. No separation of materials shall be observed.		
	Specific Gravity		1.2 – 1.6	At room temperature	
	Viscosity	cp	1 x 104 ~ 1 x 105	At standard working temperature	
	Pot life	hour	2, more	At standard working temperature	
	Minimum thickness of	mm	0.3, or more	At standard working	

	Item	Unit	Quality Standard	Testing Condition	Curing Condition
Hardened	slack			temperature	
	Tensile strength	N/mm ²	12.5 or more	7 days (age) at room temperature	At room temperature
	Compressive strength	N/mm ²	50 or more	7 days (age) at room temperature	At room temperature
	Adhesive strength	N/mm ²	6.0 or more	7 days (age) at room temperature	At room temperature

Note

- 1/ "Room temperature" refers to the Class-2, Standard Temperature Condition specified in JIS Z 8703 (Standard Condition of Testing Location) i.e. 20 degrees Celsius ± 2 degrees Celsius
- 2/ "Standard Working Temperature" refers to 3 categories (summer type, spring-and-autumn type and winter type) according to working temperatures and are respectively 30 degrees Celsius ± 2 degrees Celsius, 20 degrees Celsius ± 2 degrees Celsius and 10 degrees Celsius ± 2 degrees Celsius.
- 3/ "Pot life" refers to 70% of the time from mixing to the start of gelation
- 4/ "Minimum slack thickness" refers to the minimum thickness of the adhesive layer formed by the application of the adhesive to a perpendicular surface to a thickness of approximately 1 mm, and measured after the adhesive has slackened downward.
- 5/ The adhesive strength shall be obtained from a shearing test

3.1.4 Equipment and Tools

Equipment and tools necessary for handling materials and performing the work, and satisfactory to the Engineer as to design, capacity, and mechanical condition, shall beat the site of the work before work is started.

If any equipment is not maintained in full working order or if the equipment as used by the Contractor proves inadequate to obtain the results prescribed, such equipment shall be improved or other satisfactory equipment substituted or added at the direction of the Engineer.

3.1.4.1 Batching Plant and Equipment

3.1.4.1.1 General

All material in the mix shall be proportioned wholly by weight. The batching plant shall include bins, weighing hoppers and scales for the fine aggregate and for each separated size of coarse aggregate. If cement is used in bulk, a bin, hopper and scales for the cement shall be included. The container shall be watertight.

Provision satisfactory to the Engineer shall be made for batching other components of the mix at the batching plant, which may be either stationary or mobile type. It shall be always properly levelled within the accuracy required for the proper operation of weighing mechanisms.

3.1.4.1.2 Bins and hoppers

Bins with adequate separate compartments for fine aggregate and for each required size of coarse aggregate shall be provided in the batching plant. Each compartment shall discharge efficiently and freely into the weighing hopper. Means of control shall be provided so that as the quantity desired in the weighing hopper is being approached, the material may be added slowly and shut off with precision. A port or other opening for removing any overload of the several materials from the hopper shall be provided. Weighing hopper shall be constructed so as to discharge completely.

3.1.4.1.3 Scales

The scales for weighing aggregates and cement shall be of either the beam type or the spring-less dial type. They shall be accurate within one-half of 1% under operating conditions throughout the range of use. Ten weights of 25 kilograms each shall be available for checking accuracy. All exposed fulcrums, clevises and similar working parts of scales shall be kept clean. When beam-type scales are used, provision shall be made for indicating to the operator that the required load in the weighing hopper is being approached. The device shall indicate at least the last 100 kilograms of load and up to 25 kilograms overload.

All weighing and indicating devices shall be in full view of the operator while charging the hopper and he shall have convenient access to all controls.

Cement may be measured by weight, or in standard sacks considered to weigh 50 kilograms net. When measured by weight a separate, satisfactory scale and hopper shall be provided together with a boot or other approved device to transfer the cement from the weighing hopper. Satisfactory methods of handling shall be employed.

Batching shall be so conducted as to result in the weights of material required, within tolerances of 1% for cement and 2% for aggregates.

3.1.4.2 Mixers

3.1.4.2.1 General

All concrete shall be mixed in batch mixers. Each mixer shall have attached to it in a prominent place a manufacturer's plate showing the capacity of the drum in terms of volume of mixed concrete and the speed of rotation of mixing drum.

3.1.4.2.2 Central plant mixers

These mixers shall be of approved drum or pan type capable of combining the aggregate, cement and water into the thoroughly mixed and uniform mass within the specified mixing period and of discharging the mixture without segregation. Central plant mixers shall be equipped with an acceptable timing device that will not permit the batch to be discharged until the specified mixing time has elapsed. The water

system for a central mixer shall be either a calibrated measuring tank or a metre and shall not necessarily be an integral part of the mixer.

The mixers shall be cleaned at suitable intervals. They shall be examined daily for changes in interior condition. The pick-up and throw-over blades in the drum shall be replaced when they have lost 10% of their depth.

3.1.4.3 Vibrators

Unless otherwise directed, the concrete shall be consolidated with approved mechanical vibrators operating within the concrete. In addition, external vibrators shall be used at locations directed by the Engineer. When required, vibrating shall be supplemented by hand spading with suitable tools to assure proper and adequate compaction.

The vibrators shall be of a type approved by the Engineer, with a minimum frequency of 3500 impulses per minute and shall be capable of visibly affecting a properly designed concrete with a 2 centimetre slump over a circular area of 45 centimetres radius. The number of vibrators used shall be sufficient to consolidate the concrete properly within 10 minutes after it is deposited in the forms and in addition spare vibrators shall be available.

3.1.4.4 Forms

Before constructing forms, the Contractor shall submit detailed drawings and, if required, design calculations of proposed forms for approval by the engineer. Such approval shall not relieve the Contractor of any of his responsibilities under the Contract for the successful completion of the structure.

Unless otherwise permitted by the Engineer, forms shall be prefabricated panel type, either metal or good quality plywood facing backed by timber. For major structural components the forms shall be supported by steel wailings or soldiers.

Forms shall conform to the shape, lines and dimensions of the members shown on the Drawings, and shall be so constructed as to prevent deformation due to load, drying and wetting, vibration, and other causes.

Forms shall be properly equipped with braces, ties and other devices, so as to maintain them in the positions and the shape as shown on the Drawings.

Forms shall be so constructed that they can be removed easily and safely joints in linings or panels shall be either horizontal or vertical as far as possible, and shall be sufficiently tight to prevent any leakage of mortar.

Curved forms shall be of the radius called for on the Drawings and acceptable flexible forms shall be installed with that radius.

After forms have been set in the correct location, they shall be inspected and approved by the Engineer before concrete is placed.

Care shall be exercised to keep forms free from dust, grease or other foreign matter. No material or treatment that will adhere to concrete or discolor concrete shall be used. All forms shall be treated with an approved oil prior to placing reinforcement and in addition, wood forms shall be flushed with water immediately before placing concrete.

For narrow walls, columns, etc., where the bottom of the form is inaccessible, lower form boards or parts thereof shall be left loose so that they may be removed for cleaning out extraneous material immediately before placing concrete.

Forms for exposed surfaces shall be constructed with triangular fillets not less than 2 cm x 2 cm attached so as to prevent mortar runs and to produce smooth straight chamfers at all sharp edges of the concrete.

Forms for the precast plates for use under deck slabs of bridges shall be manufactured from steel plates with minimum thickness 3 mm. The side plates will be welded in part with continuous welds, and, where removable type is required, shall be of steel which can be firmly bolted or clamped to the base plate before casting. Wood spacers or side plates shall not be permitted. The wood form shall not be used in any conditions.

3.1.4.5 Batching and Transporting Materials

For mixing at site of construction, aggregates shall be transported from the batching plant to the mixer in batch boxes, vehicle bodies, or other containers adequate in design and construction to carry properly the batch required. Partitions separating batches shall be adequate and effective to prevent spilling from one compartment to another while in transit or while being dumped.

Cement in original shipping containers may be transported on top of the aggregates. The number of sacks of cement required for each batch shall be placed on the aggregates for that batch. Sacked cement shall be emptied into the aggregates prior to dumping into mixer.

Batches shall be delivered to the mixer separately and intact. Each batch container shall be dumped cleanly into the mixer without loss of cement or mixing or spilling of material from one batch compartment into another.

3.1.4.6 Mixing Concrete

3.1.4.6.1 General

Concrete shall be mixed at a central mixing batching plant. Hand mixing may be used when approved by the Engineer. No concrete shall be mixed, placed, or finished when the natural light is insufficient, unless an adequate and approved artificial lighting system is operated.

3.1.4.6.2 Mixing at site of concrete construction

Concrete shall be mixed in a batching plant of the type and capacity approved by the Engineer.

Mixing time shall be determined by the Engineer in accordance with JIS A 1119 (Method of Test for Variation in Unit Weight of Air Free Mortar in Freshly Mixed Concrete). When results of the above tests are not available, the mixing time shall be longer than 1 ½ minutes after all the materials have been introduced into the mixer, but in no case shall the mixing time exceed three times the mixing time prescribed above. Charging of water into the mixer shall begin before the cement and aggregates enter the drum. During mixing, the drum shall be operated at speeds specified by manufacturers. Pick-up blades in the drum of the mixer which are worn down 2 cm or more at any part must be replaced.

The volume of a batch shall not exceed the manufacturer's rated capacity of the mixer without written permission of the Engineer. No mixer whose rated capacity is less than a one-bag batch shall be used.

Concrete shall be mixed only in such quantities as are required for immediate use, and concrete which is not of the required consistency at the time of placement shall not be used.

Re-tempering of concrete will not be permitted. Entire content of the mixer shall be removed from the drum before materials for the next batch are placed therein. Upon cessation of mixing for a considerable length of time, the mixer shall be cleaned thoroughly. Upon resumption of mixing, the first batch of concrete material placed in the mixer shall contain sufficient sand, cement, and water to coat the inside surface of the drum without diminishing the required mortar content of the mix.

3.1.4.6.3 Central plant mixing

When mixed at a central plant, the mixer and methods used shall be in accordance with the requirements of this specification

Mixed concrete shall be transported from the central mixing plant to the site of work in agitator or non-agitator trucks approved by the Engineer. Unless otherwise permitted in writing by the Engineer, agitator trucks shall be equipped with water-tight, revolving drum, and shall be capable of transporting and discharging concrete without segregation. The agitation speed of the drum shall be between 2 and 6 revolutions per minute. The volume of mixed concrete permitted in the drum shall not exceed the manufacturer's rating nor exceed 70% of the gross volume of the drum. Upon approval of the Engineer, truck mixers may be used in lieu of agitator trucks for transportation of central plant mixed concrete. Gross volume of agitator bodies, expressed in cubic metre, shall be as determined by the mixer manufacturer. The interval between introduction of water into mixer drum and final discharge time shall be as determined by the Engineer. During this interval the mixture shall be agitated continuously.

Bodies of non-agitator trucks shall be smooth and water-tight. Covers shall be provided when needed for protection against rainfall. The non-agitator trucks shall deliver concrete to the work site in a thoroughly mixed and uniform mass. Uniformity shall be deemed satisfactory if samples from the one-quarter and three-quarter points of the load do not differ more than 2.5 cm in slump. Placing of concrete shall be

completed within 30 minutes after introduction of mixing water into the cement and aggregates or if admixture is used at a time to be determined by the Engineer.

3.1.4.6.4 Hand mixing

Hand mixing will not be permitted, except in case of emergency, without written permission from the Engineer. When permitted, it shall be performed only on watertight mixing platforms made of metal, etc. Concrete shall be turned and returned on the platform at least six times and until all particles of the coarse aggregate are covered thoroughly with mortar and the mixture is uniform.

3.1.4.7 Re-tampering Concrete

Re-tampering concrete by adding water or by other means will not be permitted.

Concrete that is not within the specified slump limits at the time of placement shall not be used. Admixtures for increasing the workability or for accelerating the set will be permitted only with the written approval of the Engineer.

3.1.4.8 Consistency

Slump will be measured in accordance with AASHTO T 119 or JIS A 1101 and shall be in accordance with Table 3.2.

3.1.5 Construction

3.1.5.1 General

The Contractor shall maintain an adequate number of trained and experienced supervisors and foremen at the site to supervise and control the work. All construction, other than the concrete, shall conform to the requirements prescribed in other sections or clauses for the several items of work entering into the complete structure.

3.1.5.2 Foundation

Preparation of foundations shall conform to the details as shown on the Drawings in accordance with the requirements of specification on structure excavation. The elevations of the bottoms of footings as shown on the Drawings are approximate only and the Engineer may order further excavation as necessary to obtain satisfactory foundations.

Pile foundations shall be constructed in accordance with the provisions set out in the other relevant Clauses and as shown on the Drawings.

3.1.5.3 Falsework

Falsework shall be built on foundations of sufficient strength to carry the loads without appreciable settlement. Falsework that cannot be founded on solid footings must be supported by ample falsework piling provided at the Contractor's expense.

Before constructing falsework the Contractor shall submit detailed drawings and, if required, design calculations of proposed falsework for approval by the Engineer, but such approval shall not relieve the Contractor of any of his responsibilities under the Contract for the successful completion of the structure.

3.1.5.4 Formwork

Before concrete is placed the Engineer shall inspect all formwork and falsework and no concrete shall be placed until the Engineer has inspected and approved such formwork and falsework. Such approval shall not relieve the Contractor of any of his responsibilities under the Contract for the successful completion of the structure.

Internal formwork for hollow slab shall be made of plywood, thin metal plate or other materials. These materials shall have strength sufficient to resist the pressure of fresh concrete and the buoyancy.

Type and structure of joint and cover for the cylindrical form shall be tight to prevent any leakage of concrete, and shall be approved by the Engineer. Nominal diameter of cylindrical forms shall be the outer diameter, or the outer diameter of projecting portion in case of thin metal plate having projection. The height of the projection shall be less than 10 mm.

Internal forms shall be fixed in the correct position such that they will not displace or deform during placing concrete. U-shape bolts shall be used to fix the internal forms and the method of supporting and fixing the internal forms shall be approved by the Engineer. Care shall be taken to ensure that U-shape bolts and other items can resist the buoyancy of the formwork.

In falsework, bridge camber shall be considered in accordance with the Working Drawings prepared by the Contractor and approved by the Engineer.

3.1.5.5 Reinforcement

The Engineer shall inspect and approve all reinforcement in place in accordance with the requirements of Clause S10.02, before concrete is placed. An experienced steel fixer shall be present while all concrete is placed to ensure that no reinforcement becomes displaced during placing and if it does to reposition reinforcement before placing continues.

3.1.5.6 Placing Concrete

3.1.5.6.1 General

All concrete shall be placed within the time specified in Section 3.4.6 Concrete shall be placed in such a manner as to avoid segregation and the displacement of reinforcing bars and shall be spread in horizontal layers where practicable. Concrete shall be placed where necessary inside forms by hand shovels and in no instance shall vibrators be so manipulated to transport concrete inside formwork. Care shall be taken to prevent mortar from spattering forms and reinforcing steel and from drying ahead of the final covering with concrete. When spattering has occurred, the forms and steel shall be cleaned with wire brushes or scrapers before concrete is placed around steel or in forms which have been spattered.

Troughs, pipes, or short chutes used as aids in placing concrete shall be positioned in such a manner that segregation of the concrete will not occur. All chutes, troughs, and pipes shall be kept clean and free from coating of hardened concrete or mortar.

Concrete shall not be dropped freely over a vertical distance of more than 1.5 metres.

Concrete shall be placed continuously throughout each section of the structure or between indicated joints if shown on the Drawings or as directed by the Engineer.

If in an emergency it is necessary to stop placing concrete before a section is completed, bulkheads shall be placed as the Engineer may direct and the resulting joint shall be deemed a construction joint, and treated as specified herein below.

3.1.5.6.2 Concrete columns

Concrete in columns or bents shall be placed in one continuous operation unless shown on the Drawings or permitted by the Engineer.

3.1.5.6.3 Concrete slab and girder spans

Slabs and girders having spans of 10 metres or less shall be placed in one continuous operation unless otherwise stated on the Drawings. Concrete preferably shall be deposited by beginning at the centre of the span working from the centre toward the ends.

Concrete in slab spans shall be placed in one continuous operation and in one layer for each span, unless otherwise stated on the Drawings.

Concrete in girders spanning more than 10 metres may be placed in two operations, the first operation being the placing of concrete in the girder stems to the bottom of the slab haunches or the bottom of the slab whichever is applicable. A period of at least 24 hours shall elapse between the completion of placing concrete in the girder and the commencement of placing concrete in slab.

The construction procedure for the concrete deck slab on steel box girders shall be so arranged as to eliminate excessive stress in new or recently placed concrete.

Immediately before placing concrete, the top surface of the previously placed concrete shall be hammered with a sharp hand tool until the aggregate is exposed and cleaned. The Contractor shall check all falsework for shrinkage and settlement, and shall tighten all wedges to ensure minimum deflection of all formwork.

3.1.5.6.4 Walls, piers, etc.

Where walls, piers, columns, struts, posts and other such structural members allow horizontal construction joints, concrete shall not be placed on top of other concrete which has not been allowed to set for 12 hours or more.

Work shall not be discontinued within 45 centimetres of the top of any face, unless provision has been made for a coping less than 45 centimetres thick, in which case, if permitted by the Engineer, the construction joint may be made at the underside of the coping.

3.1.5.6.5 Culverts

The slabs of box culverts shall be placed for their full depth in one mass or layer and allowed to set not less than 12 hours before any additional work is done on them.

Before concrete is placed in sidewalls, bottom slabs shall be cleaned of all shavings, sticks, sawdust and other extraneous material.

The Contractor shall submit to the Engineer for approval his proposals for pouring culvert walls before commencing culvert construction. Concrete shall not be placed in layers more than one metre high relative to the concrete already placed. Deposition shall proceed in a systematic manner.

3.1.5.6.6 Depositing concrete underwater

Concrete shall not be deposited in water except with the approval of the Engineer and with his immediate supervision, and by the method described in this paragraph.

To prevent segregation, the concrete shall be carefully placed in a compact mass in its final position by means of a tremie tube or pipe, or a closed bottom-dump bucket, or by other means, and shall not be disturbed after being deposited. Special care must be exercised to maintain still water at the point of deposit. Concrete shall not be placed in running water. The method of depositing concrete shall be so regulated as to produce approximately horizontal surfaces.

Concrete seals shall be placed in one continuous operation. When a tremie tube or pipe is used, it shall consist of a tube or pipe not less than 25 centimetres in diameter constructed in sections having flanged couplings fitted with gaskets. The means of supporting the tremie shall be such as to permit free

movement of the discharge end over the entire top of the concrete and permit its being lowered rapidly when necessary to choke off or retard the flow. The tremie shall be filled by a method that will prevent washing of the concrete. The discharge end shall be completely submerged in concrete at all times and the tremie shall contain sufficient concrete to prevent any water entry.

When concrete is placed with a bottom-dump bucket, the bucket shall have a capacity of not less than 1.20 cubic metres and shall be equipped with loose-fitting top covers. The bottom door shall open freely downward and outward when tripped. The bucket shall be completely filled and be lowered gradually and carefully until it rests on the surface upon which the concrete is to be deposited. It shall then be raised very slowly during the discharge travel, the intent being to maintain, as nearly as possible, still water at the point of discharge and to avoid agitating the mixture.

Dewatering shall proceed only when the concrete seal is considered strong enough to withstand any pressures to be exerted upon it. This time will be decided by the Engineer. All laitance or other unsatisfactory material shall be removed from the exposed surface by scraping, jetting, chipping or other means which will not unduly injure the seal.

3.1.5.6.7 Construction joints

Construction joints shall be located where shown on the Drawings or permitted or instructed by the Engineer. Construction joints shall be perpendicular to the principal lines of stress and in general shall be located at points of minimum shear.

At horizontal construction joints, details shall be as approved by the Engineer. Before placing fresh concrete, the surfaces of construction joints shall be sandblasted or washed and scrubbed with a wire brush to expose clean aggregate, drenched with water until saturated, and kept saturated until the new concrete is placed. Immediately prior to placing new concrete the forms shall be drawn tight against the concrete already in place. Concrete in substructures shall be placed in such a manner that all horizontal construction joints will be truly horizontal.

Where vertical construction joints are necessary, reinforcing bars shall extend across the joint in such a manner as to make the structure monolithic. Special care shall be taken to avoid construction joints through paneled wing walls or other large surfaces which are to have an architectural finish.

Necessary dowel, load-transfer devices, and bonding devices shall be placed as shown on the Drawings or directed by the Engineer.

3.1.5.6.8 Expansion joints (asphaltic joint filler)

Expansion joints shall be asphaltic joint filler, 20 mm thick, and shall be located and formed as required on the Drawings or the direction of the Engineer. Asphaltic joint filler shall be paid for as provided in each structural concrete at Pay Item 10.01.

3.1.5.6.9 Water-stop

Cut-off plate for water stops used for the expansion joints shall be flexible PVC to JIS K 6773 and shall be placed in accordance with the Drawings.

The water stops shall be held firmly in place to prevent displacement during concreting. If after placing concrete water stops are materially out of position or shape, the surrounding concrete shall be removed, the water stop reset, and the concrete replaced, all at the Contractor's expense.

Water stop shall be furnished full length for each straight portion of the joint, without field splices. Water stop shall be cut and spliced at changes in direction as may be necessary to avoid buckling or distortion. All field splices shall be performed by heat sealing the adjacent surfaces in accordance with the manufacturer's recommendations to form continuous watertight joints.

Water stop shall be measured and paid for as provided at Pay Item 10.01 (14).

3.1.5.6.10 Open joints

Open joints shall be constructed where shown on the Drawings by insertion and subsequent removal of a wooden strip, metal plate, or other approved material. The insertion and removal of the template shall be accomplished without chipping or breaking the corners of the concrete. Reinforcement shall not extend across an open joint unless so specified on the Drawings.

3.1.5.6.11 Steel joints

The plates, or other structural shapes shall be accurately shaped at the shop to conform to the section of the concrete floor. The fabrication and painting shall conform to the requirements of the specifications covering those items. When called for on the Drawings or in the Specifications, the material shall be galvanized in lieu of painting. Care shall be taken to ensure that the surface in the finished plane is true and free of warping. Positive methods shall be employed in placing the joints to keep them in correct position during the placing of the concrete. The opening at expansion joints shall be that designated on the Drawings at normal temperature, and care shall be taken to avoid impairment of the clearance in any manner.

3.1.5.6.12 Anchor bolts

All necessary anchor bolts in piers or abutments shall be accurately set in holes formed while the concrete is being placed. Holes may be formed by inserting in the fresh concrete oiled wooden plugs, metal pipe sleeves, or other approved devices, and withdrawing them after the concrete has partially set. Holes so formed shall be at least 10 cm in diameter. Bolts shall be set accurately and fixed with grout completely filling the holes. The grout shall be non-shrink mortar of a type approved by the Engineer.

Anchor bolts used in connection with expansion shoes, rollers, and rockers shall be located with due regard to the temperature at the time of erection. Care shall be taken that full and free movement of the

superstructure at the moveable bearings is not restricted by improper setting or adjustment of bearings or anchor bolt and nuts.

3.1.5.6.13 Shoes and bearing plates

Bridge seat bearing areas shall preferably be finished high and ground to level required. Shoes and bearing plates shall be set as provided in Clause S10.11.

3.1.5.6.14 Drainage holes and weep holes

Drainage holes and weep holes shall be constructed in the manner and at the locations indicated on the Drawings or required by the Engineer. Ports or vents for equalizing hydrostatic pressure shall be placed below low water.

Forms for weep holes through concrete shall be PVC pipe. Exposed surfaces of weep drain pipe shall be flush with the concrete.

3.1.5.6.15 Pipe, conduits, and ducts

Pipes, conduits, and ducts that are to be encased in concrete shall be installed by the Contractor before the concrete is placed. Unless otherwise indicated, pipe embedded in concrete shall be standard, light-weight, non-corrosive pipes. Pipes shall be held or braced rigidly during concrete placement in order to prevent their displacement.

3.1.5.6.16 Piers and abutments

No superstructure load shall be placed upon finished bents, piers, or abutments until the Engineer so directs, but the minimum time allowed for the hardening of concrete in the substructure before any load of the superstructure is placed thereon shall be 7 days when normal Portland cement is used.

3.1.5.7 Curing Concrete

Immediately after forms have been removed and finishing completed, all concrete shall be cured by one of the following methods. The Engineer will specify the concrete surface which may be cured by either method.

3.1.5.7.1 Water method

The entire exposed surfaces other than slabs shall be protected from the sun and the whole structure shall be covered with wet burlap, cotton mats, or other suitable fabric for a period of at least seven days. These materials shall be kept thoroughly wet for the entire curing period. Curbs, walls, and other surfaces requiring a rubbed finish may have the covering temporarily removed for finishing, but the covering must be restored as soon as possible. All concrete slabs shall be covered as soon as possible with sand, earth or other suitable material and kept thoroughly wet for at least seven days. This covering material shall not

be cleared from the surface of the concrete slabs for a period of twenty one days. If wood forms are allowed to remain in place during the curing period, they shall be kept moist at all times to prevent them from shrinking.

3.1.5.7.2 Membrane forming curing compound

All surfaces shall be given the required surface finish prior to application of the curing compound. During the finishing period, the concrete shall be protected by the water method of curing.

Membrane curing compound shall be applied after the removal of forms, or after the disappearance of surface water. It shall be sprayed on the concrete surface in one or more coats at the rate instructed by the manufacturer.

Should the membrane seal be broken or damaged before the expiration of the curing period, the damaged area shall be immediately repaired by the application of additional membrane material.

The Contractor's proposals for the use of liquid membrane curing compound and the locations shall be subject to the approval of the Engineer.

3.1.5.8 Removal of Formwork and Falsework

3.1.5.8.1 Time of removal

Formwork and falsework shall not be removed without the approval of the Engineer. The Engineer's approval shall not relieve the Contractor of responsibility for the safety of the work. Blocks and bracing shall be removed at the same time as the forms and in no case shall any portion of the wood forms be left in the concrete.

Falsework removal for continuous or cantilevered structures shall be as directed by the Engineer or shall be such that the structure is gradually subjected to its working stress.

When the time for removal of forms and supports is determined based on concrete strength tests, such removal shall not begin until the concrete has attained the percentage of the specified design strength shown in the table below.

Table 3.9: Time for Removal of Forms

Structure Part	Standard Concrete	Early Strength Concrete	Percentage Design Strength
Under-side of girders, beams, frames or arches	14 days	7 days	80%
Floor slabs	14 days	7 days	70%
Walls	1 day	12 hours	20%
Columns	2 days	1 day	25%

Structure Part	Standard Concrete	Early Strength Concrete	Percentage Design Strength
Side of Beams and all other vertical surfaces	1 day	12 hours	20%

In continuous structures, falsework shall not be released in any span until the first and second adjoining spans on each side have reached the strength specified herein or in the special provisions. When cast-in-place post tensioned bridges are constructed, falsework shall remain in place until all post tensioning has been accomplished.

Falsework under all spans of continuous structures shall be completely released before concrete is placed in railings and bridge parapets.

Forms and falsework shall not be released from under concrete without first determining if the concrete has gained adequate strength without regard to the time element. In the absence of strength determinations, the forms and false-work are to remain in place until removal is permitted by the Engineer.

The forms for footings constructed within cofferdams or cribs may be left in place when, in the opinion of the Engineer, their removal would endanger the safety of the cofferdam or crib, and when the forms so left intact will not be exposed to view in the finished structure. All other forms shall be removed whether above or below the ground line or water level.

All formwork shall be removed from the cells of concrete box girders within which utilities are required, and all formwork except that necessary to support the deck slab shall be removed from the remaining cells of the box girder.

To facilitate finishing, forms used on ornamental work, railings, parapets, and exposed vertical surfaces shall be removed at least 12 but not more than 48 hours later depending upon weather conditions.

In order to determine the condition of concrete in columns, forms to columns shall always be removed before releasing supports from beneath beams and girders.

Falsework supporting the deck of rigid frame structures shall not be removed until fill has been placed behind the vertical legs.

3.1.5.8.2 Patching

Immediately following removal of the forms all projecting wires or metal devices that have been used for holding the forms in place shall be removed or cut back at least 2.5 cm beneath the surface of the concrete. Fins or runs of mortar and all irregularities caused by form joints shall be removed. Small holes, depressions, and voids that show on the concrete shall be filled with cement mortar mixed in the same proportions as that used in the body of the work, except without coarse aggregate.

The surface of this mortar shall be floated with a wooden float before initial set takes place. It shall be uniform in color with the surrounding concrete and neat and workmanlike in appearance.

3.1.5.8.3 Cause for rejection

Excessive honeycombing shall be sufficient cause for rejection of portions of the structure containing this honeycombing. The Contractor, on receipt of written orders from the Engineer, shall remove and rebuild such portions of the structure at his own expense.

3.1.5.9 Finishing Concrete

All concrete surfaces exposed in the completed work shall comply with the requirements in Item 3.1.5.9
(iii) Ordinary finish except where otherwise shown or specified.

3.1.5.9.1 Concrete decks

Immediately after placing concrete, concrete decks shall be struck off with templates to provide proper transverse sections and shall be hand finished smooth to the concrete levels. Finish shall be slightly but uniformly roughened by blooming. The finished surface shall not vary more than 10 millimetres from a 4 metre straightedge placed parallel to the centreline of the roadway and 10 millimetres from a transverse template cut to the true cross section of the roadway.

3.1.5.9.2 Curb and footpath surface

Exposed faces of curbs and footpath shall be finished true to lines and grades. The curb surface shall be wood floated to a smooth but non-slippery finish. Footpath surfaces shall be slightly but uniformly roughened by brooming across the direction of travel.

3.1.5.9.3 Ordinary finish

An ordinary finish is defined as the finish left on a surface after the removal of the forms when all holes left by form ties have been filled, and any minor surface defects have been repaired. The surface shall be true and even, free from depressions or projections and of reasonably uniform color.

The appearance of repaired surfaces of which is not satisfactory, shall be "rubbed" as specified in Item in this specification - Rubbed finish.

The concrete in bridge seats, caps, and tops of walls shall be struck off with a straightedge and floated to true grade. Unless shown on the Drawings the use of mortar topping for concrete surfaces will not be permitted.

3.1.5.9.4 Rubbed finish

After the removal of forms the rubbing of concrete shall be started as soon as its condition will permit. Immediately before starting this work the concrete shall be kept thoroughly saturated with water. Sufficient time shall have elapsed before the wetting down to allow the mortar used in patching to set thoroughly. Surfaces to be finished shall be rubbed with a medium coarse carborundum stone, using a small amount of mortar on its face. The mortar shall be composed of cement and fine sand mixed in the same proportions as those used in the concrete being finished. Rubbing shall be continued until all form marks, projections and irregularities have been removed, all voids filled, and a uniform surface has been obtained. The paste produced by this rubbing shall be left in place. After all concrete above the surface being treated has been cast, the final finish shall be obtained by rubbing with a fine carborundum stone and water. This rubbing shall be continued until the entire surface is of a smooth texture and uniform color.

After the final rubbing has been completed and the surface has dried, it shall be rubbed with burlap to remove loose particles and laitance. The final surface shall be free from all unsound patches, paste, powder and objectionable marks.

3.1.5.9.5 Backfill and road fills

All spaces which have been excavated and the volumes of which are not occupied by the concrete structure shall be backfilled and compacted with acceptable material in accordance with the provisions of Section 5 of these Specifications.

If there is likelihood of water accumulating behind any wall, the backfill shall not be placed until after the retaining, diaphragm, or spandrel walls are 28 days old. No fill shall be placed over arches and slabs until the concrete is 28 days old or until test specimens indicate the concrete has attained the required 28-day strength.

3.1.5.9.6 Loadings

Traffic or heavy construction equipment shall not be allowed on reinforced concrete structures until 28 days have elapsed from the last placing of concrete except as noted below. If it is proposed to use the structure at an earlier date, extra test specimens shall be cast. The structure may be used when tests of these specimens show that the concrete has attained its specified 28-day strength.

3.1.5.10 Adhesive

3.1.5.10.1 Construction Method

a. Smoothing Treatment of Jointing Surface

The block surface to which adhesive is to be applied shall be wire brushed until smooth, removing any sheath ends that may be projecting beyond the jointing surface.

b. Dust Removal and Degreasing

After treating the jointing surface to a smooth and flat surface, dust and dirt shall be removed using compressed air or other means. If any form of releasing agent or grease has been deposited, the surface shall be degreased using an organic solvent.

c. Drying of Bond Surface

After separating the form from the PC block, the surface shall be covered with a sheet cover, etc., as protection against rainwater, in order to maintain the bonded blocks in a dried condition. If bonding work must be performed when the PC blocks to be bonded are in a wet condition, forced drying by means of a torch lamp, gas burner, etc., must be performed.

3.1.5.10.2 Application of Adhesive

a. Mixing and Stirring

On completion of surface treatment, the base agent and hardener shall be mixed according to the specified mix proportion and thoroughly stirred.

b. Application Method

The adhesive is to be applied thoroughly to both bonding surfaces using a rubber, or metallic spatula. The optimum coat thickness for each concrete surface is about 1 mm and the adhesive should ooze out beyond the joints when the blocks are jointed and prestressing is introduced.

c. Jointing

The air temperature during block jointing should preferably be in the range from 5 - 35 degrees Celsius and work should proceed so that the first prestressing should be completed at least within the adhesive's pot life time. Since with the introduction of prestressing, the adhesive will ooze out beyond the joints, and at the same time, will be pushed inside the sheath, it is advisable to leave an uncoated area of 10 - 20 mm around the sheath.

Satisfactory results can be obtained also by covering the sheath holes by means of gum tape, etc.

d. Curing

For at least 24 hours after bonding, the jointed section should be protected against rainwater or excessive impact.

3.1.5.10.3 Cleaning Up

Upon completion of structure and before final acceptance, the Contractor shall remove all falsework, falsework piling, etc., down to 1.0 metre below the finished ground line. Excavated, or useless materials, rubbish, etc. shall be removed from the site and the site shall be left in a neat and presentable condition satisfactory to the Engineer.

3.1.5.10.4 Storage of precast concrete units

Precast concrete unit shall be stored or stacked on site after removal from forms so that no distortion or bending of the units shall occur. Where units are stacked on the ground, the surface of the ground must be level and be of such hard material that no softening of the soil, or settlement of the stack, will occur when the ground becomes wet. Two timber bearers (of minimum section 50 mm by 100 mm) will be placed on the ground, and be firmly seated and made level and parallel before any precast units are placed on them. Timber pallets may be used instead of the two bearers with the approval of the Engineer.

Care will be taken to avoid any damage to the precast concrete units during handling and storage. Any units which are damaged shall be rejected and removed from the site of works.

3.2 Reinforcing Steel

3.2.1 Description

This work shall consist of furnishing, fabricating, and placing reinforcing steel bars of the type and size provided in accordance with these Specifications and in reasonably close conformity with the Drawings or as directed by the Engineer.

3.2.2 Materials

Reinforcing steel shall conform to the requirements of the following specifications except that the weights of the standard bar sizes will be taken as per Tables 10-2-1 and 10-2-2, irrespective of the specification used in manufacture.

SNI 03-6816-2002 (A.C.I. 315)	: Tata Cara Pendetailan Penulangan Beton
AASHTO M31M / M31-07	: Deformed and Plain Billet-Steel Bar for Concrete Reinforcement.
SNI 07-6401-2000 (AASHTO M32M/ M32-07)	: Spesifikasi Kawat Baja dengan Proses Canay Dingin untuk Tulangan Beton
SNI 03-6812-2002 (AASHTO M55M/ M55-07)	: Spesifikasi Anyaman Kawat Baja Polos Yang Dilas untuk Tulangan Beton
AWS D 2.0	: Standard Specifications for Welded Highway and Railway Bridges
SNI 0136-80 (Grade BJTP 24) or JIS G 3112 (Grade SR 235) or AASHTO M 31M (Grade 400)	: Bar specified as being 9 mm diameter or smaller
SNI 03-6861.2 (Grade BJTD 30) or JIS G 3112 (Grade SD 345) or AASHTO M 31M (Grade 400)	: Bar specified as being 10 mm diameter or larger

Reinforcing bars shall be kept off the ground and stored within a building or provided with suitable cover.

Table 3.10: Reinforcement Steel Grade

Grade	Type	Yield Stress or 0.2 Percent Proof Stress (MPa)
BJTP 24	Plain Round	235
BJTD 30	Deformed	294
BJTD 40	Deformed	392

3.2.3 Storage and Handling

- (a) The Contractor shall deliver reinforcement to the site bundled, tagged, and marked with metal tags indicating bar size lengths and other information corresponding to the markings shown on the placement diagrams.
- (b) The Contractor shall handle and store all reinforcing steel in a manner as to prevent distortion, contamination, corrosion, or damage.
- (c) Reinforcing bars shall be kept off the ground and stored within a building or provided with suitable cover.

3.2.4 Construction

3.2.4.1 Fabrication

Reinforcing bars shall be accurately formed to the shapes and dimensions indicated in the design, and shall be fabricated in a manner that will not injure the material.

Unless otherwise permitted, all reinforcing bars requiring bending shall be bent cold. When reinforcing bars are bent by heating, the entire operation shall be approved by the Engineer. Should the Engineer approve the application of heat for field bending reinforcing bars, precautions shall be taken to assure that the physical properties of the steel will not be materially altered.

Reinforcing bars that cannot be straightened by means of fabrication shall not be used. Bars partially embedded in concrete shall not be bent except as shown on the Drawings or otherwise permitted.

Qualified men shall be employed for cutting and bending, and proper appliances shall be provided for such work.

If it is necessary for the Engineer to ascertain the quality of reinforcing bars, the Contractor shall test reinforcing bars, at his own expense, by means as directed by the Engineer.

3.2.4.2 Placing

Reinforcing bars before being positioned shall be cleaned and free from rust, dirt, mud and loose scale and from paint, oil, or any other foreign substance that destroys or reduces the bond.

Reinforcing bars shall be accurately placed in proper position so that they will be firmly held during placing concrete. Reinforcing bars for erecting shall be used when needed.

Bars shall be tied at all intersections by using annealed iron wire 0.9 mm or larger diameter or suitable clips.

Distances from the forms shall be maintained correctly by means of metal hangers, mortar blocks, metal supports, or other supports approved by the Engineer.

Reinforcing bars shall be inspected by the Engineer after placing. When a long time has elapsed after placing reinforcing bars, they shall be cleaned and inspected again by the Engineer before placing concrete.

3.2.4.3 Splicing

When it is necessary to splice reinforcing bar at points other than shown on the designs, positions and methods of splicing shall be determined based on strength calculations approved by the Engineer.

In lapped splices, the bars shall be lapped the required length and wired together at several points by using annealed iron wire larger than 0.9 mm.

Exposed reinforcing bars intended for bonding with future extensions shall be effectively protected from injury and corrosion.

Welding of reinforcing steel shall be done only if detailed on the Drawings or if authorized by the Engineer in writing.

Substitution of different size bars shall be permitted only upon the specific authorization of the Engineer. If steel is substituted, it shall be of a size equivalent to the design size or larger.

3.2.5 Method of Measurement

Reinforcing bars shall be accurately formed to the shapes and dimensions indicated in the design, and shall be fabricated in a manner that will not injure the material.

The quantity of reinforcing steel bar to be paid for shall be the weight (kg) of reinforcing bar erected as shown on the Drawings or ordered by the Engineer in writing. The weight calculated will be based upon the following tables:

Table 3.11: Unit Weights of Reinforcement Bars

Bar Size (diameter) mm	6	9	10	13	16	19	22	25	29	32	
Weight per linear metre in kg	Plain Round		Deformed								
	0.222	0.499	0.617	1.04	1.58	2.23	2.98	3.85	5.19	6.31	

The lengths to be taken in calculating the weight for the purpose of payment shall be shown on the Drawings or ordered in writing by the Engineer.

No measurement or payment will be made for splices added by the Contractor for his convenience or for splices which are not shown on the Drawings and are not approved by the Engineer.

Clips, ties or other material used for positioning and fastening the reinforcing bars in place shall not be measured for payment.

3.3 Prestressed Concrete

3.3.1 Description

3.3.1.1 General

This work shall consist of prestressed concrete structures and the prestressed concrete portions of composite structures, constructed in close conformity with the lines, grades, design, and dimensions shown on the Drawings, or established by the Engineer and in accordance with this and other specification items involved.

The work shall include the furnishing and installing of any appurtenant items necessary for the particular prestressing system to be used, including but not limited to ducts, anchorage assemblies and grout used for pressure grouting ducts.

It shall include the manufacture, transportation, and storage of beams, slabs, and other structural members of precast concrete prestressed by either pretensioning or post-tensioning methods. It shall also include the installation of all precast prestressed members.

For cast-in-place prestressed concrete, the term "member" as used in this section shall be considered to mean the concrete which is to be prestressed.

3.3.1.2 Definition

Post-tensioning is defined as any method of prestressing concrete in which the tensioned reinforcement is tensioned after the concrete is placed. Pretensioning is defined as any method of prestressing concrete

in which the tensioned reinforcement is tensioned before the concrete is placed. Prestressing reinforcement is defined as any reinforcement to which prestress is applied by post-tensioning or pretensioning.

3.3.2 Material

3.3.2.1 General

All materials to be furnished and used which are not covered in this Clause shall conform to the requirements stipulated in other applicable Clauses. Non prestressing reinforcement shall conform either to Clause 3.2 or, where prestressing quality is called for on the Drawings it shall conform to the requirements for prestressing steel.

3.3.2.2 Prestressing Steel

Prestressing steel shall be high tensile strength steel wire, high tensile strength steel strand or high tensile strength steel bar.

High tensile strength steel wire shall be stress relieved and shall conform to the requirements of JIS G 3536 or AASHTO M 204M "Uncoated Stress Relieved Wire for Prestressed Concrete".

High tensile steel strand shall be weld free and stress relieved after stranding and shall conform to the requirements of JIS G 3536 or AASHTO M 203M "Uncoated Seven Wire Stress Relieved Strand for Prestressed Concrete".

High tensile steel bar shall be stress relieved and shall conform to the requirements of JIS G 3109 or ASTM M 275M.

The testing of prestressing reinforcement shall be in accordance with the requirements of the AASHTO Specifications for the type of system intended to be used.

PC cable and bar shall be used as in the following table or as directed by the Engineer

Table 3.12: PC Cable Types

Notation	Nominal Diameter (mm)	Utilization (*)
PC Wire SWPR 1 (Type C)	7	PC Driven Pile
PC Wire SWPR 1 (Type B)	8	PC Sheet Pile
PC 7-Wire Strand SWPR 7A (Type D)	T 12.4	PC Box Girder PC I Girder
PC 7-Wire Strand SWPR 7B (Type A)	T 12.7	PC U Girder PC Hollow Slab
PC 19-Wire Strand SWPR 19	T 19.3	Diaphragm for PC Box Girder

Notation	Nominal Diameter (mm)	Utilization (*)
(Type E)		PC Hollow Column
PC Bar SBPR 80/95	23	
PC 7-Wire Strand SWPR 7B	T 12.7	
(Type F)		

(*) The exact use shall be in accordance with the Drawings

3.3.2.3 Anchorage

All post-tensioned prestressing steel shall be secured at the ends by means of approved permanent type anchoring devices.

All anchorage devices for post-tensioning shall be capable of holding the prestressing steel at a load producing a stress of not less than 95 percent of the guaranteed minimum tensile strength of the prestressing steel.

3.3.2.4 Ducts

All ducts shall be metallic and shall be mortar-tight. Ducts shall be strong enough to maintain their shape under working stresses, and where grouting is specified, air and grout holes shall be provided with pipes or other devices so that the injection of grout will completely fill all void spaces within the entire length of the duct.

3.3.2.5 Grouts

Grout shall consist of Portland cement, water, and an expansive admixture plus retarder as approved by the Engineer. Water shall be potable. No admixtures containing chlorides or nitrates shall be used.

The Contractor shall submit the proportion of mixing for approval of the Engineer.

Water shall be first added to the mixer followed by cement and admixture. The grout shall be mixed in mechanical mixing equipment of a type that will produce uniform and thoroughly mixed grout. Re-tampering of grout will not be permitted. Grout shall be continuously agitated until it is pumped.

3.3.2.6 Concrete

Concrete shall conform to the requirements of Class A or Class AA concrete of Clause 3.01 of this Specification and to the requirements specified below unless otherwise stated in the Drawings.

The Contractor shall develop his own mix designs which shall be submitted to the Engineer for approval.

The maximum size of aggregate for use in the manufacture of prestressed concrete shall be 20mm.

3.3.3 Construction

3.3.3.1 General

The Contractor shall provide a Technician skilled in the use of the system of prestressing to be used, who shall supervise the work and give the Engineer such assistance as the Engineer may consider necessary.

The Contractor shall provide all equipment necessary for the construction and the prestressing. Prestressing shall be done with approved jacking equipment. If hydraulic jacks are used they shall be equipped with accurately reading pressure gauges. The combination of jack and gauge shall be calibrated and a graph or table showing the calibration shall be furnished to the Engineer. Should other types of jacks be used, calibrated proving rings or other devices shall be furnished so that the jacking forces may be accurately known.

All of the applicable requirements of Clause 3.1.5 Construction shall be complied with, except as may be modified in this Clause. Prestressed concrete shall be formed, stressed, placed, cured, and protected at shops, manufacturing plants, and locations approved by the Engineer, where the fabrication of such members may be properly inspected and controlled.

3.3.3.2 Plan of Operation

The Contractor shall, if required, prepare, check and submit to the Engineer complete detailed Working Drawings or Schedules showing :

- (i) Contractor's alternative designs if the submission of alternatives is approved;
- (ii) Contractor's details of proposed manufacture and construction;
- (iii) Sequence of operations proposed; and
- (iv) Dimensions and complete descriptions of all devices, joints, bearings, and anchorages not specified or detailed in the Contract Documents.

Concrete shall not be cast prior to the Engineer's approval of the Contractor's Drawings, if any, of concrete mixtures, of formwork, of method of application of prestressing forces, of methods of placing, of curing, of protecting, of handling and of erecting members. Any alternative to the design in the Contract Documents, shall be subject to the Engineer's approval before manufacture or construction.

The Contractor shall inform the Engineer not less than 3 days in advance of the probable date of commencement of manufacture and the dates when tensioning of steel, casting of units and transfer of stress will be undertaken for the first time.

3.3.3.3 Placing Steel

All steel units shall be accurately placed in the position shown on the Drawings and rigidly held during placing and setting of the concrete. Distance from the forms shall be maintained by stays, blocks, ties, hangers, or other approved support. Blocks for holding units from contact with the forms shall be precast mortar blocks of approved shape and dimensions. Layers of units shall be separated by mortar blocks or other equally suitable devices. Wooden blocks shall not be used.

3.3.3.4 Pretensioning Method

The prestressing elements shall be accurately held in position and stressed by jacks. Stressing shall be applied to produce the stresses required in the wires or strands immediately after the anchorage as shown on the Drawings or as directed by the Engineer. Suitable allowances shall be made for friction in the jacks and for slip and yield in the grips or anchorages.

A record shall be kept of the jacking forces and the elongations produced thereby and the minimum age in hours of the concrete in the line at the time the tendons were released.

Several units may be cast in one continuous line and stressed at one time, in which case sufficient space shall be left between ends of units to permit access for cutting after the concrete has attained the required strength. No bond stress shall be transferred to the concrete, nor shall end anchors be released, until the concrete has attained a compressive strength not less than 85% of the specified 28-day strength as shown by standard specimens made and cured identically with the members. The elements shall be cut or released in such an order that eccentricity of prestress will be a minimum.

3.3.3.5 Curing

Steam curing process may be used as an alternative to water curing. The casting bed for any unit cured with steam shall be completely enclosed to prevent steam escaping and exclude outside atmosphere. Two to four hours after placing concrete and after the concrete has undergone initial set, the first application of steam shall be made. If retarding admixtures have been used, the delay before application of the steam shall be increased to four to six hours. Water curing methods shall be used from the time the concrete is placed until steam is first applied.

The steam shall be at 100% relative humidity to prevent loss of moisture and to provide moisture for proper hydration of the cement. Application of the steam shall not be directly on the concrete. During the application of the steam, the ambient air temperature shall increase at a rate not to exceed 22 degrees Celsius per hour until the maximum temperature is reached and shall be held until the concrete has reached the desired strength. In discontinuing the steam application, the ambient air temperature shall not decrease at a rate to exceed 22 degrees Celsius per hour until a temperature has been reached 10 degrees Celsius above the temperature of the air to which the concrete will be exposed. The maximum curing temperature shall be from 60 degrees Celsius to 67 degrees Celsius.

If the Contractor elects to cure by any other special method, the method and details shall be subject to the approval of the Engineer.

Except as specified or otherwise approved, curing shall comply with the requirements in Clause 3.1.

3.3.3.6 Post Tensioning

Tensioning of the prestressing reinforcement shall not be commenced until tests on concrete cylinders, manufactured of the same concrete of the particular member to be prestressed has attained compressive strength indicated in the Drawings or directed by the Engineer.

After all concrete has attained the required strength, the prestressing reinforcement shall be stressed by means of jacks to the desired tension and the stress transferred to the end anchorage.

Cast in place concrete shall not be post-tensioned until at least 10 days after the last concrete has been placed in the member to be post-tensioned and until the compressive strength of said placed concrete has reached the strength specified for the concrete at the time of stressing.

All side and inside forms for girders shall be removed before post-tensioning. The falsework under the bottom slab supporting the superstructure shall not be released until a minimum of 48 hours have elapsed after grouting of the post -tension tendons nor until all other conditions of the specifications have been met. The supporting falsework shall be constructed in such a manner that the superstructure will be free to lift off the falsework and shorten during post-tensioning.

The tensioning process shall be so conducted that the tension being applied and the elongation of the prestressing elements may be measured at all times.

A record shall be kept of gauge pressures and elongation at all times and submitted to the Engineer for his approval.

The load from the anchoring device shall be distributed to the concrete by means of approved devices that will effectively distribute the load to the concrete.

Where the end of a post-tensioned assembly will not be covered by concrete, the anchoring devices shall be recessed so that the ends of the prestressing steel and all parts of the anchoring devices will be at least 50 mm inside of the end surface of the members, unless a greater embedment is shown on the plans. Following post-tensioning, the recesses shall be filled with concrete, and finished as shown in the Drawings.

3.3.3.7 Bonding Steel

Post-tensioned steel shall be bonded to the concrete. All prestressing steel to be bonded to the concrete shall be free of dirt, loose rust, grease or other deleterious substances.

Prestressing steel shall be bonded to the concrete by filling the void space between the duct and the tendon with grout. All ducts shall be clean and free of deleterious materials that would impair bonding of the grout or interfere with grouting procedures.

All grout shall pass through a screen with 1.20 mm maximum clear openings prior to being introduced into the grout pump.

Grout injection pipes shall be fitted with positive mechanical shutoff valves. Vents and ejection pipes shall be fitted with valves, caps, or other devices capable of withstanding the pumping pressure. Valves and caps shall not be removed or opened until the grout has set.

3.3.3.8 Handling, Transport and Storage

Precast prestressed concrete shall not be moved from the casting position until the concrete has attained a compressive strength of 85% of the specified 28-day strength, nor transported until it has developed a strength of 90% of the specified 28-day strength.

Extreme care shall be exercised in handling and moving precast prestressed concrete members. Precast girders and slabs shall be transported in an upright position, shock shall be avoided and the points of support and directions of the reactions with respect to the member shall be approximately the same during transporting and storage as the member is in its final position. If the Contractor deems it expedient to transport or store precast prestressed units in other than this position, it shall be done at his own risk after notifying the Engineer of his intention to do so. Any unit considered by the Engineer to have become substandard shall be rejected and replaced at the Contractor's expense by an acceptable unit.

3.3.3.9 Marking of Precast Prestressed Members

Each precast prestressed member is to be uniquely and permanently marked so as to show its type, date of casting and reinforcement.

3.3.3.10 Testing of Precast Prestressed Members

When directed by the Engineer one or more beams shall be subjected to a loading test. The Contractor shall obtain the prior approval of the Engineer to the detailed arrangements for the testing. A beam which is to undergo testing shall be supported at its design points of bearing and the upward deflection due to the prestressing force measured relative to a line joining these points. Equal loads shall then be applied at the third points in ten equal increments, the total being sustained for 5 minutes. The beam shall then be unloaded.

The mid-span deflection relative to the reference line shall be measured for each increment of load. The load deflection curve plotted from these values must show no appreciable variation from a straight line. The Drawings shall show, or the Engineer shall direct, the loads to be applied and the corresponding deflections which must not be exceeded.

Any beam which fails to satisfy the Engineer under the prescribed test shall be rejected and all other beams cast in the same line as the rejected beam shall also be rejected unless tested at the Contractor's expense and found satisfactory.

The Contractor shall supply to the Engineer record sheets of the tests showing date of test, the loads, deflections, and load deflection curves, calculated values of "E" and the strength of the concrete at release as indicated by the relevant cube or cylinder test results.

The tests are to be carried out on units selected by and in the presence of the Engineer after he has agreed to the method of testing and form of records. The cost of such tests and records shall be included in the unit prices.

3.4 Precast Reinforced Concrete Beams

3.4.1 Description

This work shall consist of prestressed concrete structures and the prestressed concrete portions of composite structures, constructed in close conformity with the lines, grades, design, and dimensions shown on the Drawings, or established by the Engineer and in accordance with this and other specification items involved.

This work shall consist of precast reinforced concrete beams, furnished and placed in accordance with these Specifications and in conformity with the requirements on the Drawings or elsewhere in the Contract Documents.

The work shall include the manufacture, transportation, storage and installation of precast beams.

3.4.2 Materials

3.4.2.1 General

All materials to be furnished and used which are not covered in this clause shall conform to the requirements stipulated in other applicable clauses.

3.4.2.2 Concrete

Concrete shall conform to the requirements of Class B-1 concrete of Clause 3.1 of these Specifications unless otherwise stated in the Drawings.

3.4.2.3 Reinforcement

Reinforcement shall be in accordance with the provisions set out in Clause 3.2 of these Specifications.

3.4.2.4 Formwork

Forms for precast beams shall conform to the general requirements for concrete formwork as described in Clause 3.1 of these Specifications.

3.4.3 Construction

3.4.3.1 General

Construction shall comply with the applicable requirements of Clause 3.1.4 of these Specifications.

3.4.3.2 Plan of Operation

The Contractor shall, if required, prepare, check and submit to the Engineer complete detailed Working Drawings or Schedules showing:

- (i) Contractor's alternative designs if the submission of alternatives is approved;
- (ii) Contractor's details of proposed manufacture and construction; and
- (iii) Sequence of operations proposed.

Concrete shall not be cast prior to the Engineer's approval of the Contractor's Drawings, if any, of concrete mixtures, of formwork, of methods of placing, of curing, of protecting, of handling and of erecting members. Any alternative to the design in the Contract Documents shall be subject to the Engineer's approval before manufacture or construction.

3.4.3.3 Placing Reinforcement

All steel reinforcement shall be accurately placed in the position shown on the Drawings and rigidly held during placing and setting of the concrete. Distance from the forms shall be maintained by stays, blocks, ties, hangers, or other approved support. Blocks for holding units from contact with the forms shall be precast mortar blocks of approved shape and dimensions.

3.4.3.4 Casting

The beams shall be cast in a horizontal position. Special care shall be taken to place the concrete so as to produce a beam free from any air pockets, honeycomb or other defect. Concrete shall be placed continuously and shall be compacted by vibrating or by other means satisfactory to the Engineer.

3.4.3.5 Handling, Transport and Storage

Precast reinforced concrete beams shall not be moved from the casting position until the concrete has attained a compressive strength of 85% of the specified 28-day strength, nor transported until it has developed a strength of 90% of the specified 28-day strength.

Extreme care shall be exercised in handling and moving precast concrete beams. Precast beams shall be transported in an upright position, shock shall be avoided and the points of support and directions of the reactions with respect to the member shall be approximately the same during transporting and storage as when the member is in its final position. If the Contractor deems it expedient to transport or store precast beam unit in other than this position, it shall be done at his own risk after notifying the Engineer of his intention to do so. Any unit considered by the Engineer to have become sub-standard shall be rejected and replaced at the Contractor's expense by an acceptable unit.

3.4.3.6 Marking of Precast Beams

Each precast beam unit is to be uniquely and permanently marked including its date of casting.

3.4.4 Method of Measurement

The quantity of reinforced concrete beams to be measured for payment shall be the actual number of precast concrete beams installed in place, completed and accepted. Each beam shall include the concrete, reinforcement steel, and other such material contained within or attached to the beam unit.

3.4.5 Basis of Payment

The work measured as provided above shall be paid for at the Contract unit price for each type of precast reinforced concrete beam listed below.

The price and payment shall be full compensation for furnishing and placing all materials including concrete and reinforcement, for casting and for hauling, storage and erection of the beams including all labour, tools, equipment and incidentals necessary to complete the work as shown on the drawings and prescribed in this clause.

3.5 Pretensioned Concrete Piles

3.5.1 Description

This work shall consist of pretensioned spun concrete piles and pretensioned precast concrete piles furnished and driven in accordance with these Specifications and in reasonably close conformity with the requirements on the Drawings or elsewhere in the Contract Documents.

3.5.2 Materials

3.5.2.1 General

Pretensioned concrete piles shall be constructed in accordance with the details shown on the Drawings and to the requirements of AASHTO M 204M. Pretensioned spun concrete piles shall also comply with the requirement of JIS A 5335 Type A and Type B, pretensioned spun concrete piles.

The applicable provisions of Clause 3.3 shall be read into and become part of this Clause.

3.5.2.2 Concrete

Concrete shall be in accordance with the provisions of Clause 3.1 of these Specifications.

3.5.2.3 Reinforcement

Reinforcement shall comply with the provisions of Clause 3.2 of these Specifications and shall be positioned as shown on the Drawings.

3.5.2.4 Prestressing Steel

High tensile steel prestressing wire shall conform to the requirements of JIS G 3536 or AASHTO M 204M.

3.5.2.5 Certificate

Prior to furnishing pretensioned concrete piles the Contractor shall submit to the Engineer for approval a certificate by the manufacturer certifying that the piles comply with the specification requirements.

3.5.3 Construction

3.5.3.1 Preparation for Driving

3.5.3.1.1 Caps

The heads of all concrete piles, when the nature of the driving is such as to unduly injure them, shall be protected by caps of approved design having a suitable cushion next to the pile head and fitting into a casting which in turn supports a timber shock block. No pile head will be held so firmly that the slight rotation of the pile normally occurring while the pile is being driven will be prevented.

3.5.3.1.2 Joints

Joints of pretensioned concrete piles shall be carefully constructed in accordance with the Drawings or the instruction of the Engineer. Welding shall be made in accordance with the requirements specified in JIS A 7201 (Standard Practice for Execution of Spun Concrete Piles).

3.5.3.1.3 Pile shoes

Shoe bases shall consist of steel plate as shown on the Drawings.

3.5.3.2 Handling, Pitching and Driving

3.5.3.2.1 General

When raising or transporting piles the Contractor shall provide slings and other equipment necessary to prevent any appreciable bending of the pile.

The main setting out for the piles is to be completed prior to commencement of driving. Secondary or individual pile setting out is to be completed and agreed not less than 8 hours prior to commencing work on the piles concerned. All main setting out points, lines and stations are to be maintained safe and undisturbed until the work is complete.

Piles shall be pitched accurately in the positions and driven to the lines shown on the Drawings or fixed by the Engineer. Piles deflected from the vertical or proper line shall, where ordered by the Engineer, be withdrawn and re-pitched until the proper line is obtained.

No forcible method of correction of the position or line of any pile will be permitted. Any pile damaged by reason of improper driving or driven out of its proper location or driven below the elevation fixed by the Drawings or by the Engineer, shall be corrected at the Contractor's expense by one of the following methods approved by the Engineer for the pile in question :

The pile shall be withdrawn and replaced by a new and if necessary longer pile. Any holes from which piles are withdrawn shall be packed with approved non-plastic material before re-driving takes place; or

A second pile shall be driven adjacent to the defective pile.

All piles pushed up by the driving of adjacent piles or by any other cause shall be driven again.

3.5.3.2.2 Batter piles

Batter piles shall be driven accurately to the batter shown on the Drawings. The pile frame employed for the driving of the batter piles shall have leads capable of adjustment to the required angle. When piles have to be driven below the level of the bottom of the leads, extension leads shall be provided except where the use of a follower is specifically permitted by the Engineer.

3.5.3.2.3 Driving equipment

Before any piling work is commenced the Contractor shall submit to the Engineer full details of the pile driving equipment and the method of carrying out the work he intends to use. All piles shall be provided with caps for driving as specified in Clause S10.05.3.1(i) above. For special types of piling, driving head mandrels, or other devices in accordance with these requirements shall be provided so that piles may be driven without damage.

Piles shall be driven with steam, air or diesel hammers, a combination of hammers with water jets or gravity hammers. When diesel hammers are used, they shall be calibrated by a load test if necessary.

The plant and equipment furnished for steam and air hammers shall have sufficient capacity to maintain, under working conditions, the pressure in the manner specified by the manufacturer. The boiler or tank shall be equipped with an accurate pressure gauge, and another gauge shall be supplied at the hammer intake.

When gravity hammers are used for driving concrete piles, the drop of the hammer shall not exceed 2.5 metres and the hammer shall have a weight of not less than half the weight of the pile. The fall shall be regulated so as to prevent injury to the pile.

3.5.3.2.4 Driving

Piles shall be supported in line and position with leads while being driven. Pile drive leads shall be constructed so as to afford freedom of movement of the hammer, and they shall be held firmly in position to ensure rigid lateral support to the pile during driving. Except where piles are driven through water, the leads shall be of sufficient length to make the use of a follower unnecessary, and shall be so designed as to permit the proper placing of batter piles. If the condition at the site requires the necessity of a follower, the Contractor shall not use it without approval of the Engineer.

When water jets are considered by the Engineer to be necessary, the number of jets and the nozzle volume and pressure shall be sufficient to erode freely the material adjacent to the piling. The plant shall have at all times a pressure of at least seven (7) kilograms per square centimetre at two (2) centimetre jet nozzles. Before the required penetration is reached, the jets shall be shut off and the piles driven by hammer to final penetration.

A detailed accurate record of the driving of all piles shall be kept by the Engineer and the Contractor shall give every assistance to the Engineer to help him keep this record which will include the following : pile numbers, positions, types, sizes, actual lengths, dates driven, lengths in footings, penetration under final blows of the hammer, striking energy of the hammer, lengths extended, length cut off, and final pay lengths.

No piles shall be driven near freshly placed concrete.

3.5.3.2.5 Bearing values

Piles shall be driven to a bearing value of not less than that shown on the Drawings. The Engineer will specify the penetration and the Contractor shall drive the piles to the penetration specified, but if the Engineer is not satisfied that the desired bearing value has been attained the Contractor shall carry on driving until such desired bearing value is attained.

3.5.3.2.6 Cut off and extension

Piles shall be cut off at such elevation that they will extend into the cap or footing as shown on the Drawings. Care shall be taken that reinforcement or prestressing bars which extend beyond the cut-off point to bond the pile into the cap or footing are not damaged during cutting off of the pile.

The extended length of a pile shall be sufficient to reach the elevation of the bottom of the cap and shall be of the same section as the pile itself or as shown on the Drawings. After piles have been lengthened driving shall not be resumed until the approval of the Engineer has been given.

Unless otherwise specified, the length of pile cut off shall remain the property of the Contractor and shall be disposed of beyond Government property limits and outside the limit of view from the roadway to the satisfaction of the Engineer.

3.5.3.2.7 Connection with footing

All piles shall be connected to footings as shown on the Drawings or directed by the Engineer.

3.5.3.3 Test Piles

The Engineer may order the execution of test piles as he may consider necessary to ascertain the type of the foundation or the length of pile for the project. The Contractor shall furnish and execute test piling at the locations designated by the Engineer.

The lengths of the piles shown on the Drawings are based on information obtained from previous site investigations. However, piles of different lengths may be required and as ordered by the Engineer.

Before pile lengths are finally settled, the Contractor shall construct to the lengths shown on the Drawings such test piles as may be found necessary and these piles shall be driven in the positions specified by the Engineer who shall be notified in advance of the driving. The Contractor shall furnish the Engineer daily with a detailed record of the driving of test piles throughout the full depth of driving.

After attaining the approved set, driving shall be continued until the Engineer directs that it shall cease. Driving of test piles beyond the point at which the approved set is obtained will be called for to demonstrate that driving resistance continues to increase. The Contractor shall then furnish the remainder of the piles in the structure. In determining the lengths of piles the Contractor shall base his list on the lengths assumed to remain in the completed structure.

Test piles shall be used as foundation piles only on the written agreement of the Engineer.

The Contractor at his own expense may increase the lengths to provide for fresh heading and or such lengths as may be necessary to suit his method of operation.

3.5.3.4 Dynamic Testing of Piles

For the Dynamic loading test a proper weight of hammer shall be required to make sufficient energy to mobilize the soil element around the pile. As the method of testing, the minimal proper hammer weight shall be minimum 1 % of the expected ultimate bearing capacity. The standard test method shall be accordance with the requirement of ASTM D4945 "Standard Test Method for High-Strain Dynamic Testing of Piles

3.5.4 Method of Measurement

3.5.4.1 Piles Furnished

The unit of measurement for payment for furnishing pretensioned concrete piles shall be the linear metres, furnished as directed by the Engineer and the requirements of these Specifications and stockpiled in good condition at the site of the work by the Contractor, and accepted by the Engineer. The pay length of the furnished and accepted piles shall be measured from the tip to the cut-off, where the cut-off is defined as the top of the concrete of the pile after the excess length is removed, measured to the nearest centimetre to an annulus drawn around the highest point of unbroken concrete after cleaning the top of the pile. No allowance will be made for the length of piles furnished by the Contractor to replace piles previously accepted by the Engineer that are subsequently lost or those that are damaged prior to completion of the Contract while in stockpile, or during handling or driving, and are ordered by the Engineer to be removed from the site of the work or disposed of otherwise.

3.5.4.2 Piles Driven

The quantities of driven pretensioned concrete piles to be paid for shall be the number of linear metres of piles actually driven and accepted by the Engineer.

The quantities of driven pretensioned concrete piles to be paid for shall be the number of linear metres of piles actually driven and accepted. The pay lengths of the satisfactorily driven piles shall be measured as follows:

For pile caps/footings below ground level: from the tip of the pile to the underside of the pile cap or footing.

For pile caps/footings above ground level: from the tip of the pile to the surface level after clearing and grubbing.

3.5.4.3 Test Piles

The quantities of test piles as provided in Clause 3.5.3.3 to be paid for shall be the linear metres of test piles completed and accepted by the Engineer, whether they are executed inside or outside the foundation. The length to be paid for furnishing and driving shall be based on the length from the pile tip to the cut-off, where the cut-off is defined as the top of the concrete of the pile after the excess length is removed, measured to the nearest centimetre to an annulus drawn around the highest point of unbroken concrete after cleaning the top of the pile.

3.5.4.4 Dynamic Loading Test Piles

The quantities of dynamic loading test piles to be paid for will be the actual number of tested as instructed by the Engineer. The pile installation will be not excluded in this pay item.

3.5.5 Basis of Payment

The work measured as provided above shall be paid for at the Contract unit price per linear metre for the particular pay items given in the Bill of Quantities. The rate shall constitute full compensation for all materials including prestressing, reinforcement and shoes, equipment, hardware, furnishing, jointing, driving, jetting, welding, coupling, cutting-off, concrete filling for spun piles, reinforcement for connection with footing and all related tools, rigs, cranes, boilers, hammers, jets, labour and other incidental equipment and work.

Pile connection with footing, including reinforcement bars and including concrete filling for spun piles, will not be measured separately and is deemed to be included in the cost of pile driving.

Payment for test piles, completed and accepted, shall be made as the linear metre of test piles for furnishing and driving a test pile of the size specified. When test piles are incorporated in the foundation connection with footing is included and no additional payment shall be made for the pile so utilized other than as for test pile.

No payment shall be made for unauthorized, defective, unsound or unsatisfactorily driven piles or for any costs incurred by the Contractor for such piles.

The payment for dynamic loading test pile shall be full compensation for all labour, equipment, material, including required installing all facilities and carrying out the dynamic loading test method in a manner as approved by the Engineer. When test piles are incorporated in the foundation no additional payment shall be made for the pile so utilized other than as for test pile.

3.6 Steel Piling

3.6.1 Description

This work shall consist of steel piling for structure foundations furnished and driven in accordance with these Specifications and in reasonably close conformity with the Drawings at the penetration or depth ordered by the Engineer. When the Engineer judges that pile foundation is not necessary, based on the result of Test Drilling specified in Clause S10.08 or the result of Test Piling, Contractor shall change the footing design as directed by the Engineer.

3.6.2 Materials

Steel pile shall be shop-fabricated and shall have the type, weight, quality and dimensions specified in JIS A 5525 (Steel Pipe : SKK - 41), ASTM A 500 (Steel Pipe Grade B), or as shown on the Drawings.

Prior to furnishing steel piles the Contractor shall submit to the Engineer for approval a certificate by the manufacturer certifying that the piles comply with the specification requirements.

3.6.3 Construction

3.6.3.1 Preparation for Driving

(i) Caps

The heads of all steel piles, when the nature of the driving is such as to unduly injure them, shall be protected by caps of approved design having a suitable cushion next to the pile head and fitting into a casting which in turn supports a timber shock block. No pile head will be held so firmly that the slight rotation of the pile normally occurring while the pile is being driven will be prevented.

(ii) Joints of steel pile

Joints of steel pile shall be carefully constructed in accordance with the Drawings, or the instruction of the Engineer. When joints which are not specified on the Drawings are to be constructed, the Contractor shall obtain the approval of the Engineer and employ electric arc welding throughout the butt joint. Welding shall be made in accordance with requirements specified in JIS A 7201 (Standard Practice for Execution of Spun Concrete Piles).

(iii) Pile shoes

Shoe bases where used shall consist of steel plate as shown on the Drawings.

3.6.3.2 Handling, Pitching and Driving

(i) General

When raising or transporting steel pipe piles the Contractor shall provide slings and other equipment necessary to prevent any appreciable bending of the pile. No steel pile shall be lifted otherwise than by slinging from the lifting holes, the positions of which shall be as directed or approved by the Engineer.

The main setting out for the piles is to be completed prior to commencement of driving. Secondary or individual pile setting out is to be completed and agreed not less than 8 hours prior to commencing work on the piles concerned. All main setting out points, lines and stations are to be maintained safe and undisturbed until the work is complete.

Piles shall be pitched accurately in the positions and driven to the lines shown on the Drawings or fixed by the Engineer. Piles deflected from the vertical or proper line shall, where ordered by the Engineer, be withdrawn and re-pitched until the proper line is obtained.

No forcible method of correction of the position or line of any pile will be permitted. Any pile damaged by reason of improper driving or driven out of its proper location or driven below the elevation fixed by the Drawings or by the Engineer, shall be corrected at the Contractor's expense by one of the following methods approved by the Engineer for the pile in question :

The pile shall be withdrawn and re-driven or replaced by a new pile as decided by the Engineer. Any holes from which piles are withdrawn shall be packed with approved non-plastic material before re-driving takes place; or

A second pile shall be driven adjacent to the defective pile.

All piles pushed up by the driving of adjacent piles or by any other cause shall be driven again.

(ii) Battered piles

Battered piles shall be driven accurately to the batter shown on the Drawings. The pile frame employed for the driving of the batter piles shall have leads capable of adjustment to the required angle. When piles have to be driven below the level of the bottom of the leads, extension leads shall be provided except where the use of a follower is specifically permitted by the Engineer.

(iii) Driving equipment

Before any piling work is commenced the Contractor shall submit to the Engineer full details of the pile driving equipment and the method of carrying out the work he

intends to use. All piles shall be provided with caps for driving as specified in Item (a)

(i) above. For special types of piling, driving head mandrels, or other devices in accordance with these requirements shall be provided so that piles may be driven without damage.

Shoes shall be provided as shown on the Drawings. Piles shall be driven with steam, air or diesel hammers, a combination of hammers with water jets or gravity hammers. When diesel hammers are used, they shall be calibrated by a load test if necessary.

The plant and equipment furnished for steam and air hammers shall have sufficient capacity to maintain, under working conditions, the pressure in the manner specified by the manufacturer. The boiler or tank shall be equipped with an accurate pressure gauge, and another gauge shall be supplied at the hammer intake.

(iv) Driving

Piles shall be supported in line and position with leads while being driven. Pile drive leads shall be constructed so as to afford freedom of movement of the hammer, and they shall be held firmly in position to ensure rigid lateral support to the pile during driving. Except where piles are driven through water, the leads shall be of sufficient length to make the use of a follower unnecessary, and shall be so designed as to permit the proper placing of batter piles. If the condition at the site requires the necessity of a follower, the Contractor shall not use it without approval of the Engineer.

When water jets are considered by the Engineer to be necessary, the number of jets and the nozzle volume and pressure shall be sufficient to erode freely the material adjacent to the piling. The plant shall have at all times a pressure of at least 7 kilograms per square centimetre at two (2) centimetre jet nozzles. Before the required penetration is reached, the jets shall be shut off and the piles driven by hammer to final penetration.

A detailed accurate record of the driving of all piles shall be kept by the Engineer and

the Contractor shall give every assistance to the Engineer to help him keep this record which will include the following : pile numbers, positions, types, sizes, actual lengths, dates driven, lengths in footings, penetration under final blows of the hammer, striking energy of the hammer, lengths extended, lengths cut off, and final pay lengths.

No pile shall be driven near freshly placed concrete.

(v) Bearing values

Piles shall be driven to a bearing value of not less than that shown on the Drawings. The Engineer will specify the penetration and the Contractor shall drive the piles to the penetration specified, but if the Engineer is not satisfied that the desired bearing value has been attained the Contractor shall carry on driving until such desired bearing value is attained.

(vi) Cut off and extension

Steel pipe piles shall be cut off at such elevation that they will extend into the cap or footing as indicated on the Drawings.

The extended length of a pile shall be sufficient to reach the elevation of the bottom of the cap and shall be of the same section as the pile itself or as shown on the Drawings. After piles have been lengthened driving shall not be resumed until the approval of the Engineer has been given.

If so required and directed by the Engineer pile cut-off lengths, of 1.0 metre or more, shall be utilized as extension piles or otherwise. The preparation of such cut-off pile lengths shall be undertaken by the Contractor without additional payment or claim.

In compliance with this Clause all pile cut-off lengths shall be salvaged and safely stored and protected by the Contractor. On completion of the Works any unused pile cut-off lengths will become the property of the Contractor and shall be disposed of beyond Government property limits and outside the limit of view from the roadway to the satisfaction of the Engineer.

(vii) Connection with footing

All piles shall be connected to footings using reinforcing bars and steel plate, as shown on the Drawing or directed by the Engineer.

3.6.3.3 Test Piles

The Engineer may order the execution of test piles as he may consider necessary to ascertain the type of the foundation or the length of pile for the project. The Contractor shall furnish and execute test piling at the locations designated by the Engineer.

The lengths of the piles shown on the Drawings are based on information obtained from previous site investigations. However, piles of different lengths may be required and as ordered by the Engineer.

Before pile lengths are finally settled, the Contractor shall construct to the lengths shown on the Drawings such test piles as may be found necessary and these piles shall be driven in the positions specified by the Engineer who shall be notified in advance of the driving. The Contractor shall furnish the Engineer daily with a detailed record of the driving of test piles throughout the full depth of driving.

After attaining the approved set, driving shall be continued until the Engineer directs that it shall cease. Driving of test piles beyond the point at which the approved set is obtained will be called for to demonstrate that driving resistance continues to increase. The Contractor shall then furnish the remainder of the piles in the structure. In determining the lengths of piles the Contractor shall base his list on the lengths assumed to remain in the completed structure.

Test piles shall be used as foundation piles, only on the written agreement of the Engineer.

The Contractor at his own expense may increase the lengths to provide for fresh heading and or such lengths as may be necessary to suit his method of operation.

3.6.3.4 Method of Measurement

3.6.3.4.1 Piles Furnished

The unit of measurement for payment for furnishing steel piles shall be the weight (ton) including plates, jointing steel and cap reinforcement, furnished in compliance with the material requirements of these Specifications or as directed by the Engineer.

3.6.3.4.2 Piles Driven

The quantities of driven steel piles to be paid for shall be the number of linear metres of piles actually driven and accepted.

- (a) For pile caps/footings below ground level: from the tip of the pile to the underside of the pile cap or footing.
- (b) For pile caps/footings above ground level: from the tip of the pile to the ground surface level after clearing and grubbing.

3.7 Cast-in-place Concrete Piling

3.7.1 Description

This work shall consist of cast-in-place concrete piles with slurry bentonite or equivalent method constructed in accordance with these Specifications and with the requirements shown on the drawings or as directed by the Engineer based on the soil characteristic.

3.7.2 Design of piling and foundations

- a. The types and sizes of pile to be used shall be as shown on the drawings
- b. Lateral displacement of head of pile from its specified position shall not exceed 75 mm in any direction.
- c. Variations from the vertical or specified batter shall not exceed 20 mm per metre (i.e. 1 in 50)
- d. The bow of a cast-in-place concrete pile shall not exceed 0.01 of the length of a pile in any direction.
- e. The lateral bow of a steel pile shall not exceed 0.0007 of the gross length of the pile.
- f. The diameter of unlined bored hole shall be 0 to + 5 % of the nominal diameter at any position.

- g. Cement, aggregates and reinforcing steel shall be stored as required in section **Error!** **Reference source not found.** and section **Error!** **Reference source not found.** of this Specification.

3.7.3 Materials

Cast-in-place concrete piles shall be constructed in accordance with the details shown on the Drawings with concrete $f_c' = 30 \text{ MPa}$ as specified herein, mixed and placed in accordance with the provisions of Clause 3.1 of these Specifications.

Reinforcement shall comply with the provisions of Clause 3.2 of these Specifications.

3.7.4 Construction

3.7.4.1 Drilled holes

All holes for concrete piles cast in drilled holes shall be drilled to the tips of piles. The length of piles shall be instructed by the Engineer based on the result of soil investigation. The drilling machine shall be such that the hole can be maintained exactly vertical during drilling operations.

Completed piles and existing structures very close to the drilling area shall be protected from the influence of piling and the Contractor's proposals for this shall be submitted to, and approved by, the Engineer before the start of works.

Drilled holes shall be protected from collapse by a water surcharge, and by providing a steel casing at the top of the drilled hole. The steel casing shall be rigid and project at least 50 cm above ground level and shall penetrate at least five (5) metres below the top of the surface or as directed by the Engineer.

Drilled holes shall be protected from collapse by a water surcharge, by providing a steel casing (i.e. stand casing pipe). The stand casing pipe shall be rigid and project at least 50 cm above ground level.

Where indicated on the drawings piles shall be cast in a sacrificial liner to extend the pile above existing ground level or to form a smooth regular shape for columns.

The sacrificial liner shall be made of steel or plastic but must be adequate to retain the required shape.

The sacrificial liner shall be carefully removed without damage to the pile/column, once the required concrete strength has been achieved.

The water level of the inside of the drilled hole shall be always kept approximately 2m higher than the natural ground water level. Water supplied from a municipal water supply system or a river is allowed for this purpose.

All loose material existing at the bottom of the hole after drilling operations have been completed shall be removed by air lift or suction pump before placing concrete.

Reinforcement shall be positioned as shown on the Drawings. The connecting portions of main bars with hoops shall generally be welded by arc fillet welding.

During the placing of the reinforcement in the hole, the verticality and position of the reinforcement shall be carefully controlled to prevent collapse of the drilled hole or damage to the walls.

Concrete shall be placed in one continuous operation from tip to cut-off elevation by tremie tubes and shall be carried out in such a manner as to avoid segregation. The tip of the tremie shall generally be 2 m lower than the fresh concrete surface.

The Contractor shall initially cast an additional length of pile above the finished level of the top of the pile and subsequently remove any defective concrete to ensure satisfactory bonding of the pile head to the footing structure.

The Contractor shall furnish the Supervisor daily with a detailed record of the construction of piles.

The static level of slurry bentonite inside of the drilled hole shall be always kept approximately 2 m higher than the natural ground water level and shall be kept above water-table. This can be obtained by continuously filling the hole with slurry bentonite.

Drilling shall start with auger bit or bucket bit with suitable diameter to break the concrete pile cover. Drilling spoil dumped behind the rig and disposed away as soon as possible.

After drilling reached terminated depth (more than 2 metres deeper than the bearing layer), all loose material existing at the bottom of the hole after drilling operations have been completed shall be removed by the cleaning bucket before placing concrete. The Contractor shall confirm the bearing layer at each pile position based on the soil investigation data and drilled soil characteristic. The determination of the each pile length shall be directed by the Engineer.

3.7.4.2 Bentonite

The bentonite material shall be sourced from approved international brands or from equivalent material such as polymer, which shall be considered if there is influence of salt water from the seaside.

The bentonite shall be mixed in high turbulence mixers and pumped into storage silos or clean bentonite tank/pool built on site.

Slurry shall be pumped through 4" diameter steel pipes from and to the excavation. Used bentonite will be passed through de-sanding sieves and stored for re-used. Unsuitable bentonite slurry shall be stored separately and transported off site in slurry tankers and dumped in an approved area.

A mud testing laboratory shall be provided on site and shall contain the following apparatus and result of test shall be approved by the Engineer;

- 1 baroid filter press (free water test);
- 1 mud balance (density test);
- 1 marsh cone (viscosity test);
- 1 sand screen set (sand content test);
- Apparatus for measuring pH.

3.7.4.3 Soil Disposal

Soil waste from the drilled hole which is dumped beside the rig during drilling work. shall be transported away from the site immediately to prevent obstructing the drilling progress. The spoil shall be loaded into dump trucks with an excavator or loader and shall be carried to stockpile area inside the site and then transported out of project site to an approved waste disposal area.

3.7.4.4 Reinforcement bar

Reinforcement bar shall be positioned as shown on the Drawings. The connecting portions of main bars with hoops shall generally be welded by arc fillet welding. The length of piles shall be based on the bearing soil layer at the every piles position, therefore the reinforcement bar shall be arrange the adjustable bar such as over lapping at the site. The additional reinforcement bars such as lapping, cover and bearing bar are given in as directed by the Engineer.

Pipes installed for the ultrasonic measurement monitoring shall be set with the reinforcement bars before casting concrete work.

During the placing of the reinforcement in the hole, the verticality and position of the reinforcement shall be carefully controlled to prevent collapse of the drilled hole or damage to the walls.

3.7.4.5 Casting

The Concrete shall be placed in one continuous operation from tip until the top of concrete reaches about one metre above the design cut-off level for trimming later on and shall be carried out in such a manner as to avoid segregation. The tip of the tremie shall be 2 m lower than the fresh concrete surface.

The Contractor at his own expense shall initially cast an additional length of pile above the finished level of the top of the pile and subsequently remove any defective concrete to ensure satisfactory bonding of the pile head to the footing structure.

The concrete mix shall be retarded so as to give flexibility in arrival times for truck mixers. There shall be a radio or telephone link with the batching plant and arrangements shall be made for a back-up plant to be available in case of breakdown.

If an empty borehole is left above the concrete cut-off, it will be backfilled with suitable material, after the concrete has set.

To prevent collapse due to sudden loss of bentonite or approved similar material, a sufficient quantity of bentonite slurry will be kept at the bentonite plant. In addition the trench will be backfilled with spoil to stop the loss.

3.7.4.6 Testing and Reporting

The Contractor shall furnish the Engineer daily with a detailed working record and test pile of the construction of the piles. The record of pile work form shall be approved by the Engineer. The type and number of tests shall be approved by Engineer and in accordance to any requirements of relevant Authority.

3.7.5 Static loading Test Piles

The Engineer may instruct the load testing of cast-in-place concrete piles. Details of the loading test are given in as directed by the Engineer and in accordance with the requirements of maximum loading which is 150 % of service load.

3.7.6 Dynamic Loading Testing Pile

For the Dynamic loading test a proper weight of hammer shall required to make sufficient energy to mobilize the soil element around the pile. As the method of testing, the minimal proper hammer weight shall be minimum 1 % of the expected ultimate bearing capacity. The standard test method shall be accordance with the requirement of ASTM D4945 "Standard Test Method for High-Strain Dynamic Testing of Piles".

3.7.7 Non-destructive checking

3.7.7.1 Measurement Monitor of Drilling Hole-

The Contractor shall check all drilled holes by ultrasonic measurement before installation of the reinforcement bar, and the details of such method shall be approved by the Engineer. The monitor shall be check for the vertical drilling holes and the direct recording shall be in four directions (X-X' and Y-Y'). This work shall include in pay item 10.07 (1) and (2).

3.7.7.2 Pile Integrity Testing (PIT)-

The Contractor shall test all concrete piles by Pile Integrity Testing (PIT) after casting of concrete, which is a non-destructive integrity test method for foundation piles. It is a "Low Strain" Method (since it requires the impact of only a small hand-held hammer). The evaluation of PIT records is conducted either according to the pulse-echo (or Sonic Echo – a time domain analysis) or the transient response

(frequency domain analysis) procedure. The standard test method shall be accordance with the requirement of ASTM D5882-7 "Standard Test Method for Low -Strain Integrity Testing of Piles"

3.7.7.3 Ultrasonic Measurement monitor of concrete pile-

The Contractor may be requested to monitor concrete piles used installed pipe in the pile by ultrasonic measurement monitor after casting of concrete, and the result of such monitoring shall be approved by the Engineer and may instruct the location of the testing of cast-in-place concrete piles. The hole of pile for the ultrasonic equipment installation shall pour the suitable material after result of the ultrasonic test record. Specification of ultrasonic measurement monitor shall be approved the Engineer.

3.7.8 Method of Measurement

3.7.8.1 Cast-in-place Concrete Piles

The quantity of cast-in-place concrete piles to be paid for will be the actual number of linear metres of piles cast and left in place in the completed and accepted work.

Measurement will be made from the point of the tip of the pile to the bottom of the footing. Portions of piles cast deeper than required through over-drilling procedures will not be measured for payment.

3.7.8.2 Static Loading Test Piles

The quantities of static loading test piles to be paid for will be the actual number of piles installed and tested as instructed by the Engineer. Measurement of test piles will be independent of the length of test pile instructed by the Engineer.

3.7.8.3 Dynamic Loading Test Piles

The quantities of dynamic loading test piles to be paid for will be the actual number of tested as instructed by the Engineer. The pile installation will be excluded in this pay item.

3.7.8.4 Ultrasonic Measurement Monitor of Concrete Pile

The quantities of ultrasonic measurement monitor of concrete pile to be paid for will be the actual number of tested as instructed by the Engineer. The pile installation will be excluded in this pay item.

3.7.9 Basis of Payment

The work measured as provided above shall be paid for at the Contract price per unit of measurement for the pay items listed below.

The payment for cast-in-place pile shall be full compensation for construction of the piles including protection of existing piles and structures, ultrasonic measurement monitor for drilling holes, pile integrity testing, all materials for completion of the pile such as concrete, slurry bentonite, reinforcement bars with over lapping considered adjustment pile length as approved shop drawings and for all labour, tools, equipment, circulation with pumping facilities, slurry tankers, hauling, handling, jetting, jointing, cutting and all other incidental works connected therewith.

The payment for each test pile shall be full compensation for all labour, equipment, material, including temporary piles, required to install all facilities the test pile and carry out the loading test method in a manner as approved by the Engineer. When test piles are incorporated in the foundation no additional payment shall be made for the pile so utilized other than as for test pile.

3.8 Seismic Hazard Analysis

It is required for The Contractor to conduct a study and assessment on the seismic hazard (site specific seismic study) along proposed site location on dealing with seismological, geological and geotechnical aspects. This analysis will provides the selection of seismic hazard parameters, methods of analysis and the final evaluation of the seismic safety of the structure which the analysis will be based on the multidisciplinary engineering interpretation such as geology, geophysics, seismology, and geotechnical engineering.

3.8.1 Objective of Seismic Hazard Analysis

1. To obtain the level of ground motion and to develop design response spectra at bedrock for 1000 years return period of earthquake.
2. To design ground motion parameters at ground surface for providing basis for the seismic design. This ground motion parameters will be represented by peak ground acceleration, design spectra and time histories at surface for 1000 years return period of earthquake

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3.8.2 Report

The result of the report shall be submitted to Engineers for acceptance

3.9 Test Drilling

3.9.1 Description

This work shall consist of test drilling for the investigation of sites on which any structure foundation is to be provided.

3.9.2 Test Bores

3.9.2.1 General

When testing is required the Contractor shall take several test bores at each structure site to get the exact soil profile or as otherwise directed by the Engineer. Where rock is outcropping on the surface the Engineer may dispense with test bores.

3.9.2.2 Depth of Bores

The test bores shall be taken down to the bearing stratum and into it sufficiently to prove its continuity. Generally this will be five metres. When bearing stratum has not been reached within 50 metres of the surface, the test bore may be stopped after the approval of the Engineer.

3.9.2.3 Method of Boring

The Contractor may use rotary wash drilling. Basement rock shall be continuously core drilled.

3.9.2.4 Tests Required on All Holes

Standard penetration tests shall be taken at One (1) metre intervals or at each change of strata whichever is lesser. The static ground water level shall be recorded for each hole. In rock core drilling the full core shall be recovered and stored in core boxes for inspection by the Engineer.

3.9.2.5 Logging of the Bores

If so requested by the Engineer, the Contractor shall supply on the working day following completion of the bore the following information:

1. Structure name
2. Bore position and code number
3. Reduced level of top of the bore
4. Date and time of boring
5. Diameter of bore
6. Type of plant used
7. Depth to which bore was cased
8. Depth to base of each stratum from the surface
9. Description of strata
10. Depth and results of tests
11. Static water level
12. Remarks

All descriptions and classifications of soils shall be in accordance with "Procedures for Testing Soils, ASTM".

3.9.2.6 Further Tests that may be required

The Engineer may call for more elaborate testing than described above at any structure site if he finds that the information is not adequate.

When instructed by the Engineer, undisturbed core samples shall be taken in cohesive soil strata.

The sampling cylinder is to be sealed and used for transport of the core from site to testing laboratory. All laboratory testing will be the responsibility of the Contractor.

3.9.3 Method of Measurement

The test drilling will be measured for payment purposes as lengths of hole drilled no matter what materials are encountered.

3.9.4 Basis of Payment

Payment will be made on the quantities as measured above and at the rates shown in the Bill of Quantities. The payment shall include full compensation for all drilling, casing, if necessary, penetration test and split- barrel sampling, recording and presenting the results and storing the samples until their disposal is approved by the Engineer.

3.10 Bridge Expansion Joints

3.10.1 Description

This work shall consist of the supply and installation of expansion joints in bridges and piled slabs.

3.10.2 Submittals

A sample of any expansion joint material that the Contractor proposes to use in the work, together with a statement as to its source and test data giving its properties shall be submitted to the Engineer and approved by him before furnishing the joints.

Before furnishing the joints the Contractor shall submit to the Engineer for approval a certificate by the manufacturer certifying that the joints comply with the specification requirements. The Contractor shall prepare documents which shall include the following minimum requirements and shall be submitted to the Engineer for his approval.

- Details of all dimensions and/or shop drawings
- fabrication procedure
- Material specifications to be used
- Capability of the product
- Performance of the product and materials

- Durability, if any
- Details of protective coatings and protections of sliding surfaces against dust etc.
- Method of installation
- The name and address of the Manufacturer

Schedule of manufacture, testing and delivery, including name and address of testing laboratory

3.10.3 Expansion Joint Types

3.10.3.1 Surface Rubber joint with Load - supporting Type (Type A)

Surface Rubber joint with Load-supporting type (Type A) shall be for movable joints (30mm) for short span concrete bridges (PC-U, PC-I, Hollow slab, etc).

3.10.3.2 Adhesive Sealant Joint (Type B)

Adhesive Sealant type joints (Type B) shall be for fixed joints (20mm) for short span concrete bridges (PC-U, PC-I, Hollow slab, etc) and Piled slab.

3.10.3.3 Steel Finger Joint (Type C)

Steel Finger Joint (Type C) shall be for expansion joint of steel box girders. The expansion amount of each type shall be 60mm in Type C-1, 175mm in Type C-2 and 220mm in type C-3.

3.10.3.4 Rubberized Bitumen Binder Joint (Type D)

Rubberized Bitumen Binder Joint (Type D) shall be a combination of rubberized bitumen binder and a selected aggregate constructed in-situ by a hot process. Type D-1 shall be 40 cm wide and type D-2 shall be 30 cm wide.

3.10.3.5 Longitudinal Expansion Joint (Type E)

Longitudinal Expansion Joint shall be capability of adapting itself to deflection differences of vertical movements between the left-and right-side joints as well as displacement in the axial direction of widening bridge.

3.10.4 Materials

Materials for the various types of joints shall comply with the following requirements under each sub-heading. This specification shall be some reference of the material grade for the Engineer's approval, thus the contractor may be submit equivalent materials as same grade and quality of the expansion joint.

(i) Surface Rubber Joint with Load-supporting Type (Type A)

- The material of the rubber used shall be of the following specification:
- Tensile strength JIS K 6301 : $\geq 15 \text{ N/mm}^2$
- Elongation JIS K 6301 : $\geq 300\%$
- Hardness JIS K 6301 : $55 \pm 5 \text{ Hs}$
- Tearing strength JIS K 6301 : $\geq 3 \text{ N/m m}^2$
- Compressive permanent strain JIS K 6301 : $< 25\%$ (at 70°C , 22 hours)

The material of the support block used shall be of the following specification:

- Rolled Steel for General structure SS400 steel Plate (JIS G3101)

(ii) Adhesive Sealant Type Joints (Type B)

- Sealant material shall be a 2 part polysulphide material in accordance with JIS K 6301.
- Elongation : 500%
- Tensile strength : $\geq 8 \text{ kg/cm}^2$

(iii) Steel Finger Joint (Type C)

The steel Finger expansion joint shall be designed to accommodate the movements given on the Drawings and shall be in accordance with the Special Specification 3.5.

(iv) Rubberized Bitumen Binder Joint (Type D)

Material shall comply with the following specification requirements, or shall be in accordance with the specifications of the approved manufacturer.

Binder (Polymer modified bituminous materials)

- a. Softening point (by ring and ball method – ASTM E28) > 65 degrees C
- b. Flow resistance < 5% (BS 2499)
- c. Cone Penetration (at 25 degrees C, 150g, 5sec.-ASTM D217) : < 40 dmm

Extension Test Pass 3 cycles of : 5 degrees C (ASTM D1190/BS 2499)
extension to 50%, rate 3.2 mm/h

• Aggregate

Single size 20 mm conforming to BS63 (14 mm where the depth of joint is less than 75 mm).

- | | |
|--------------------------|-------------------|
| Aggregate Impact Value | : <15 |
| Aggregate Crush Value | : <20 |
| Aggregate Abrasion Value | : <8 |
| Polished Stone Value | : greater than 55 |
| Flakiness Index | : <25 |

Shape and Size Index per BS 594 : <60

(v) Longitudinal Expansion Joint (Type E)

- The material of the rubber used shall be of the following specification:

Tensile strength JIS K 6301 : ≥ 15 N/mm²

Elongation JIS K 6301 : $\geq 300\%$

Hardness JIS K 6301 : 55 ± 5 Hs

Tearing strength JIS K 6301 : ≥ 30 kN/mm²

Compressive permanent strain JIS K 6301 (at 70°C, 22 hours) : <25%

- The material of the support block used shall be of the following specification:

Rolled Steel for General structure : SS400 steel Plate (JIS G3101)

3.10.5 Construction

3.10.5.1 Storage and Preparation

Expansion joint material delivered to the bridge site shall be stored under cover on platforms above the surface of the ground.

It shall be protected at all times from damage, and when placed it shall be free from dirt, oil, grease or other foreign substance. Pre-moulded material shall be used in as large pieces as possible. The material shall be cut to a clean, true edge with a sharp tool. Rough or ragged edges will not be permitted. Joining of adjacent pieces shall be in accordance with the manufacturer's instructions.

3.10.5.2 Installation of Rubber Type Joints (General instructions)

(i) General

Expansion joints shall be shaped to the section, and of a type of material as shown on the Drawings or approved by the Engineer. The size of the gap shall be compatible with the mean bridge temperature at the time of installation. This temperature shall be determined in accordance with arrangements agreed with the Engineer.

The position of all bolts cast into concrete and all holes shall be accurately determined from templates. The mixing, application and curing of all proprietary materials shall comply with the manufacturer's requirements.

All joints shall be constructed according to physical details shown on the Drawings or as directed by the Engineer, and strictly in accordance with the manufacturer's recommendations.

(ii) Placing of concrete or epoxy mortar

Placing of concrete or epoxy mortar for joint type A shall be executed carefully work. The top layer shall be compacted with a vibrator to level with the surface pavement. Rough finishing shall be carried out with a wooden trowel and final finishing with a metallic trowel.

(iii) Prevention of damage

During the placing and hardening of concrete or mortar under expansion joint components, relative movement shall be prevented between them and the supports to which they are being fixed.

When one half of the joint is being set, the other half shall be completely free from longitudinal restraint. In particular where strong backs or templates are used to locate the two sides of a joint they shall not be fixed simultaneously to both sides. Screw threads shall be kept clean and free from rust.

Ramps shall be provided and maintained to protect all expansion joints from vehicular loading. Vehicles shall cross the joints only by means of the ramps until the Engineer permits their removal.

(iv) Time of installation

Setting of expansion joints shall be done after pavement works on the bridge are finished.

3.10.5.3 Installation of Rubberized Bitumen Binder Type Joints (General Instructions)

Installation shall be carried out complying with the following requirements, or strictly in accordance with the manufacturer's instructions.

(i) Time of Installation

Installation of expansion joints shall be carried out after pavement works on the structure are finished.

(ii) Marking out

The joint shall be marked out to the width shown in the Drawings or such other width as directed by the Engineer.

(iii) Excavation

The asphalt shall be cut full depth and broken out carefully by hand or plane to the structure slab ensuring that the slab concrete is not damaged.

(iv) Cleaning

The entire joint shall be thoroughly cleaned and dried using a hot compressed air lance immediately prior to filling. All loose debris shall be removed from the expansion gap.

(v) Caulking

The expansion gap shall be caulked with a tarred hemp in such a way as to allow 25 mm of binder in the expansion gap between the top of the arris and the finished level of the caulking yarn.

(vi) Tanking

The joint shall be coated with a layer of hot binder immediately after caulking and cleaning.

(vii) Plating

The joint gap shall be covered with an aluminium strip according to the width and the condition of the gap.

(viii) Material Preparation

Aggregate - The aggregate shall be dried, cleaned and heated in a drum mixer by means of hot compressed air. The aggregate shall be heated to a temperature of ± 150 degrees Celsius and all visible signs of dust shall be removed.

Binder - The binder shall be heated by means of a sealant pre-heater to a temperature of 170 - 190 degrees Celsius.

(ix) Material Installation

Layers of hot stone not less than 20 and not more than 40 mm thick shall be placed in the trench and immediately flooded with hot binder. Each layer shall be raked to ensure that the stone is fully coated and voids filled. This process shall stop approximately 25 mm from the top of the excavation for application of the final surface layer.

(x) Surface Layer

Hot pre-mixed prepared material shall be transferred to the joint and spread to a slight overfill.

(xi) Compaction

The material shall be compacted as soon as possible after filling using a vibrator plate or roller which shall be pre-wetted. At least 3 passes shall be carried out to bring the joint to the existing road surface.

(xii) Screeding/Finishing Work

The surface of the joint and the surrounding road shall be dried and cleaned with a hot compressed air lance prior to the final screeding. Immediately thereafter a single hot binder layer shall be applied to fill all surface voids.

3.10.6 Method of Measurement

The quantities to be paid for shall be the actual linear metres of expansion joints completed in place in accordance with the Drawings.

Sealant and back up form of foamed polystyrene or similar material used in adjacent curbs and parapet walls will not be measured separately for payment.

3.10.7 Basis of Payment

The quantities, measured as specified above, shall be paid for at the Contract price per unit of measurement, respectively, for each of the particular pay items given in Bill of Quantities, which price and payment shall constitute full compensation for all cutting and excavation of pavement, formation of construction joint with existing concrete and for all labour and equipment, furnishing of materials including epoxy concrete, epoxy mortar, fibre reinforced plastic, reinforcement, concrete, binder and aggregate, fabricating, transporting, painting, setting expansion joints, and for other incidentals. Payment for expansion joints will be deemed to include the cost of sealant used in adjacent works and parapets.

3.11 Bearings

3.11.1 Description

This work shall consist of furnishing and installing bearing shoes and bearing pads for bridge superstructure, piled slab and extended pile structure and rubber sheet for RC frame and approach slab

3.11.2 Materials

3.11.2.1 Bearing Shoes

Material for bearing shoes of general type shall conform to the following:

JIS G 3101 : Rolled Steel for General Structure SS 400

JIS G 5101 : Carbon Steel Castings - SC 450

The Contractor shall have the Engineer's approval prior to furnishing bearing shoes.

3.11.2.2 Bearing Pads

Elastomeric bearing pads shall conform to AASHTO M 251, or Bearing pads shall consist of alternative laminations of elastomer and metal bonded together, and shall conform to the following design requirements:

Durometer Hardness	: 53
Bearing stress	: 5.0-10.0 N/mm ²
Shearing Modulus	: 0.69 N/mm ²
Bulk Modulus	: 2000 N/mm ²

The elastomer portion of the elastomeric compound will be 100 percent virgin chloroprene meeting the requirements of Column B of Table 3.13, which shall be referred to unless in conflict with AASHTO M 251.

Laminates shall be rolled mild steel sheets embedded by a minimum of 3.2 mm of elastomer.

Prior to furnishing bearing pads the Contractor shall submit, together with samples, to the Engineer for approval a certificate by the manufacturer certifying that the bearing pads comply with the specification requirements.

Randomly selected samples of up to 5 units shall be taken out of every 100 units and tested to confirm compliance with the specification requirements.

Table 3.13: Elastomer Properties

ASTM Standard	Physical Properties	A	B
D2240	Hardness	50 ± 5	50 ± 5
D412	Tensile strength, min. psi	2500	2500
	Ultimate elongation, min. %	450	400
	Heat Resistance		
D573	Change in durometer hardness, max. points	± 10	± 15
70 hr. @ 158°F	Change in tensile strength, max. %	- 25	- 15

(69.9°C)	Change in ultimate elongation, max. %	- 25	- 40
D395 Method	Compression Set 22 hours @ 158°F (69.9°C), max. % 25(col.A)/100(col.B) pphm ozone in air by volume, 20% strain 100°F ± 2°F (37.7°C ± 1°C), 48 hours mounting procedure D518. Procedure A	25 No Cracks	35 No Cracks
D429,B	Adhesion Bond made during vulcanization, lba. per inch (kg/m)	40 714	40 714
D746	Low Temperature Test Procedure B Brittleness at -40°F (-40°C)	No Failure	No Failure

3.11.2.3 Bearing Shoes

The materials to be used in the manufacture for the bearing shall be new. All bonding of components for elastomeric rubber pad shall be assembled under heat and pressure during the vulcanizing process. The detailed material is given on the Drawings and shall be in accordance with the Special Specification 3.10.

3.11.2.4 Rubber Sheet

Material for rubber sheet shall be chloroprene or styrene-butadiene synthetic rubber and shall conform to the following:

ASTM D2240	Durometer Hardness	40 points ± 5
ASTM D412	Tensile Strength (min.)	1450 psi
	Ultimate Elongation (min.)	400%

Prior to furnishing rubber sheet the Contractor shall submit to the Engineer for approval a certificate by the manufacturer certifying that the rubber sheet complies with the specification requirements.

3.11.2.5 Anchor Bar

Anchor bar shall be made from steel JIS G3101 Grade SS400 or equivalent

3.11.3 Construction

3.11.3.1 Bearing Shoes

Bearing shoes shall be accurately set in the specified position. The shoes shall be set before construction of superstructure members unless otherwise approved by the Engineer. This detailed method is given in accordance with the Special Specification

3.11.3.2 Bearing Pads

The bearing pads shall be installed in the appropriate setting as directed by the Engineer or shown on the Drawings.

When they are set on thin beds of cement mortar, the mortar shall be cured and allowed to develop sufficient strength before the beams are erected.

The bearing pads shall be maintained in their correct position during the placing of the beams. After the beam has been completed, each bearing and the area around it shall be left clean.

3.11.3.3 Rubber Sheet

The rubber sheet shall be set at the hinge (concrete hinge) of continuous slab bridges at the end of RC frames and at the approach slabs as shown on the Drawings or directed by the Engineer.

3.11.4 Method of Measurement

3.11.4.1 Bearing Shoes

The quantities of bearing shoes shall be measured by the number of each type completed in place and accepted.

3.11.4.2 Bearing Pads

The quantities of bearing pads shall be measured by the number of each type completed in place in accordance with the Drawings.

3.11.4.3 Rubber Sheet

The quantities of rubber sheet shall be measured by the number of square metres completed in place and accepted.

3.11.4.4 Anchor Bar

The quantity of anchor bar measured for payment will be based on the weight of the anchor bar excluding the accessories, payment for which is included with the anchor bar.

3.11.5 Basis of Payment

The work measured as provided above will be paid for at the Contract unit price respectively. The payment shall consist of full compensation for furnishing, fabricating, transporting, painting, random sample testing and placing all materials including all labour, tools, equipment, and incidentals necessary

to complete the work prescribed. Details of necessary accessories are shown on the Drawings, and includes anchor bar and cap, and reinforcement, etc.

3.12 Seismic Isolator Bearing

This specification covers requirements for sliding pendulum seismic isolator bearing. There are two types of sliding pendulum:

- single sliding surface type
- two sliding surface type

Other requirements which are not cover in this specification shall refer to standard EN15129 – Anti-Seismic Devices.

Sliding pendulum works through combination movement between one or two primary spherical sliding surface and one secondary spherical sliding surface. Type and characteristic of the sliding pendulum shall be in accordance with this specification.

Design of movement of sliding pendulum relates to friction and effective radius which needs to be evaluated based on combination of sliding surfaces which:

- Primary spherical sliding surface has bigger sliding/ shear force which functions to dissipate energy and is the primary component in the design
- Secondary spherical sliding surface has lower sliding/ shear force which functions to accommodate rotational movement. This surface has minor function in the design.

Each of primary spherical sliding surfaces consists of main sliding material installed in a recess which moves on a spherical surface coated with chromium plating. The technical characteristics of primary spherical sliding surface are:

- Backing support plate from steel solid grade S355JR (specification EN 10025) or equivalent grade of steel plate
- Chromium surface covering the surface of backing support plate and which directly in contact with primary sliding surface which shall meet the following criteria:
 - Polished surface to the roughness: $R_a < 0.8\mu m$
 - Thickness of chromium plating: $100\mu m$
 - Deviation of theoretical surface of spherical against design: $0.0003 \times L$
 - The surface must be free from holes, pores and cracks
- Primary sliding material made from polymer material which shall be able to withstand working temperature between $-10^{\circ}C$ until $+80^{\circ}C$ installed in recess. The recess shall keep the primary sliding material in place under pressure. The primary sliding material shall meet following criteria:
 - Maximum compressive stress $> 180\text{MPa}$ measured at maximum temperature at service condition
 - Dynamic friction coefficient: 8% at design velocity, V_d , without the use of any lubrication
 - Variation of dynamic friction coefficient as the result from variation of sliding speed shall be less than 15% between design velocity (V_d), $2V_d$ and $0.5V_d$.

- Static friction coefficient shall not be higher than 10% against dynamic friction coefficient measure at design velocity (Vd)

Secondary sliding surface consists of secondary surface material installed in a recess which moves on a spherical surface coated with chromium plating. The surface of secondary sliding material shall be lubricated. The secondary sliding material, can be formed with dimples which function as lubricant' pockets. The technical characteristics of secondary spherical sliding surface are:

- Backing support plate from steel solid grade S355JR (specification EN 10025) or equivalent grade of steel plate
- Chromium surface covering the surface of backing support plate and which directly in contact with secondary sliding surface which shall meet the following criteria:
 - Polished surface to the roughness: Ra < 0.3µm
 - Thickness of chromium plating: 100µm
 - Deviation of theoretical surface of spherical against design: 0.0003 x L
 - The surface must be free from holes, pores and cracks
- Secondary sliding material made from polymer material which shall be able to withstand working temperature between -10°C until +48°C installed in recess. The recess shall keep the secondary sliding material in place under pressure. The secondary sliding material shall meet following criteria:
 - Maximum compressive measured at maximum temperature at service condition
 - Dynamic friction coefficient: <1% on average service temperature (23°C)

Other general characteristic of pendulum isolator:

- Effective radius shall be evaluated from combination of spherical sliding surfaces which has to be proved from calculation
- Sliding pendulum must be mechanically connected to structure to enable transfer of horizontal load during service condition or ultimate condition. The connection system must provide allowance for replacing sliding pendulum.
- Steel material use on sliding pendulum shall be S355JR (as per EN10025) or equivalent.
- Anti-corrosion protection shall in accordance to ISO 12944 category C5-M with dry film thickness \geq 320µm
- Bolt use shall meet grade 8.8 or 10.9. Bolt shall be protected against corrosion using hot-dip galvanize, dacromet or geomet coating. Black bolt without anti-corrosion protection shall not be used.

3.12.1 Tests

3.12.1.1 Prototype Test

2 (two) set of sliding pendulum from every type shall be tested in accordance with the requirements of type test in this specification. Report from this type test has to be submitted to the Engineer/ Bridge designer for approval of the isolator sliding pendulum design.

The requirement of type test shall be conducted as follows:

- Load bearing capacity: vertical load up to 2 x Nsd, applied in stages to maintain design pressure/ force as required.
- Frictional resistance force in service condition in accordance with requirements stated in EN 15129 (8.3.4.1.3)
- Sliding Isolation test shall follow test requirements in standard EN 15129, test D1, D2 and shall be conducted with movement equivalent to 25% and 50% of seismic movement, with test frequency in accordance with test D3. Sliding test shall be conducted at design velocity for maximum seismic condition which anticipated in the structural design.

3.12.1.2 Factory Production Control Tests

5% (five percent) from all sliding pendulum produced selected for factory production control tests. The number of bearing tested in prototype test (or called 'type test') as mentioned in clause 3.11.1.1 are included in this 5%. This test conducted by producer in laboratory appointed and approved by Engineer/ Bridge designer.

Report from this factory production control test shall be submitted to the Engineer for acceptance 30(thirty) days before delivery of product to project.

The requirement for factory production control test shall follow clause 3.11.1.1.

3.13 Sound Proof Barrier and Security Barrier

3.13.1 Description

This work shall consist of furnishing, manufacturing and installing steel post and sound proof barriers, security barriers and incidental structures, all as indicated on the Drawings and required by these Specifications and as directed by the Engineer.

3.13.2 Submittals

The Contractor shall prepare documents which shall include the following minimum requirements and shall be submitted to the Engineer for his approval.

- Details of all dimensions and/or shop drawings
- Fabrication procedure
- Material specifications to be used
- Capability of the product
- Performance of the product and materials
- Durability, if any
- Details of protective coatings.
- Method of transportation and installation
- The name and address of the Manufacturer

- Schedule of fabrication, testing and delivery, including name and address of testing laboratory

The Contractor shall submit Shop drawings to the Engineer for approval at least 4 weeks prior to commencing work.

The Contractor shall submit the results of inspection in accordance with the Specification.

3.13.3 Materials

All materials to be used in the manufacture for the soundproof and security barriers shall be new and assembling of soundproof panel shall be furnished as complete units by one manufacturing source.

Materials shall conform to the requirements of:

a. Table 3.14: Security Barriers (metal type)

Description	Material	Standard/ Grade
Front Plate	Aluminium Alloy : 1.0t	JIS H4000 / A5052
Back Plate	Hot-dip zinc-coated steel sheet :1.6t	JIS G3302 / SGH400-Z27
Side Plate	Hot-dip zinc-coated steel sheet :1.6t	JIS G3302 / SGH400-Z27
Sound Absorbing Material	Man-made fibre / Glass Wool	JIS A6301 / density 0.032
Protection for Sound Absorbing Material	Polyvinyl fluoride (PVF) film or polyethylene tetra fluoro ethylene (ETFE) film	Thickness 21mm
Blind Rivet	4f	JIS G4303 / SUS305
Sealing Material	Chloroprene rubber	2t x 30
Eye-Bolt	M12 x 50mm	JIS B1168 / SS400 or S20C
Hexagon Nut	M12	JIS B1181 / SS400

The surface of anchor bolts, nuts, post and base material for connection to concrete barriers shall be protected by galvanize in accordance with JIS H8641 HDZ35.

b. Table 3.15: Soundproof Barriers (Polycarbonate type)

Description	Material	Standard/ Grade
Sound Absorbing Material	Polycarbonate : 5t	JIS K6735G
Top and Bottom Frame	Aluminium	JIS H4100 / A6063S-T5
Vertical Frame	Aluminium	JIS H4100 / A6063S-T5
Supporting Material	Aluminium	JIS H4100 / A6063S-T5

3.13.4 Fabrication

Soundproof and security barriers Manufacturer shall be approved by the Engineer and shall have an experience in fabrication of soundproof and security barriers for the highway projects.

The Contractor shall submit a written description of fabricating capability including facilities, personnel and list of similar completed projects, including testing and quality control capability and specifically the type and extent of quality control procedure, which the manufacturer intends to employ on this Project.

3.13.5 Installation

Soundproof and security barriers and incidental parts shall be carefully handled and stored on blocking, racks or platforms so as not to be in contact with the ground and shall be protected from corrosion, dust, oil and other foreign matters.

Surfaces to be coated shall be carefully protected both in the shop and in the field. Threads shall be carefully protected from damage.

Soundproof and security barriers shall be carefully installed true to line and grade as shown on the Drawings, and no construction shall be commenced before the inspection and approval by the Engineer.

Soundproof barriers shall be fabricated and installed as indicated on the Drawings, and top of barriers shall be parallel to the grade of the road. Posts shall be set truly vertical unless otherwise instructed by the Engineer.

All exposed surfaces shall be thoroughly cleaned in an approved manner as a final operation under this project.

The Contractor shall furnish for the approval of the Engineer working drawings for the particular type of soundproof barriers to be installed.

3.13.6 Method of Measurement

The quantities of soundproof and security barriers to be paid for shall be the number of linear metres of soundproof and security barriers and accepted in accordance with the Drawings, these Specifications, and as directed by the Engineer.

Technical Specification

Jakarta LRT Project – Corridor 1 (Phase 1): Kelapa Gading-Velodrome



4 Structural Steel

4.1 General

4.1.1 Description

This work shall consist of the supply, fabrication, tests and inspections, trial assembly at fabrication shop, painting, delivery to the site and erection complete of all structural steel for bridges structure strictly in accordance with the Specifications and Drawings or as directed by the Engineer.

4.1.2 Standards and Specifications

When making reference to other specifications, standards, etc. in this Specification, the following abbreviations are used:

AASHTO	- American Association of State Highway and Transportation Officials
FHA	- Federal Highway Administration, Department of Transportation, USA
ASTM	- American Society for Testing and Materials
AWS	- American Welding Society
SSPC	- Steel Structures Painting Council (U.S.A)
JRA	- Japan Road Association, Highway Bridge PART I, II (2002 edition)
JIS	- Japanese Industrial Standard

If not otherwise indicated on the drawings or the Specifications, the fabrication and erection of the steel bridges shall conform to the requirements of JRA Standard Specifications for Highway Bridges.

In case of conflict between the above referenced specifications and this Specification, this Specification shall govern.

4.1.3 Testing and Inspection

4.1.3.1 Inspection Agency

The Contractor shall retain an independent Inspection Agency. The Inspection Agency shall be accepted by the Engineer and Inspection Agency shall be responsible for non destructive test of welds at the manufacturer's works and/or the site of fabrication.

The Inspection Agency shall be experienced and qualified.

All fees and expenses for the works of this Agency shall be paid by the Contractor and will be deemed to be included in the unit prices for this work.

The Inspection Agency shall admit the instructions from the Engineer and shall submit inspection reports to the Engineer. The Inspection Agency shall certify that all welds have been carried out in accordance with the Specification and the approved shop drawings.

The Inspection Agency's certificates shall not relieve the Contractor from his obligations under the Contract.

4.1.3.2 Inspection by the Contractor

Irrespective of the appointment of an Inspection Agency, the Contractor shall inspect by himself all materials, shop work and field work to determine that the requirements of the Drawings and Specifications are met and that the Works are carried out in a first-class and workmanlike manner.

The Contractor shall provide the necessary assistants, labour, materials, electricity, fuel, stores, apparatus and instruments and any other materials required to ensure that all testing and inspection by the Engineer or the Inspection Authority can be carried out efficiently.

4.1.4 Submittals

4.1.4.1 Overall Schedule

Before any technical submittals are made, the Contractor shall submit his proposed schedule for all Shop Drawing submissions, materials submissions, and fabrication processes. In this schedule, the Contractor shall allow the Engineer four (4) weeks from receipt of any submittal or re-submittal, for his review prior to commencing the work to which this submittal refers.

4.1.4.2 Necessity of Approvals

The Contractor shall not proceed with any purchase or fabrication of materials until the relevant Shop Drawings have been approved by the Engineer.

4.1.4.3 Shop Drawings

The Contractor shall submit shop drawings for the whole of the steelwork to the Engineer for his review. All Shop Drawings shall show full detailed dimensions, sizes and cambers for all component parts of the structure. The size and extent of all welds shall be clearly shown on the Shop Drawings such that the work can be fabricated from these drawings without reference to the Design Drawings. The required grade of steel for each individual fabrication shall be clearly indicated. All Shop Drawings shall also show method of construction, spacing of bolts, welding, sectional areas and other details necessary for the works. Bolted or welded construction may be employed subject to approval, soundness and neatness of design. Where welds are used, either at shop or on site, it shall wherever possible, be continuous around the joint to ensure that the joints are completely sealed against corrosion.

The details of connections on Shop Drawings shall be such as to minimize formation of pockets to hold condensation, water or dirt and a minimum gap between abutting angles and the like shall be provided wherever possible to eliminate any traps and facilitate maintenance painting.

The Contractor shall be responsible for correction of all errors of detailing, fabrications and correct fitting for all structural members.

In the preparation of Shop Drawings and in the fabrication works the Contractor shall give careful consideration to the following:

- The need for trial assemblage at the fabrication shop prior to shop painting and the delivery to site.
- The weight and size limitation of elements in transportation from the fabrication to the construction site
- The temperature variation between the fabrication yard and the site which shall be taken as 28 degrees Centigrade for the purposes of this Contract.
- The need for the measurements at site of the As-Built dimensions of sub-structures, e.g. pile caps and crossheads, for field correction or replacement if required.
- The prohibition of the use of site welding except for fixtures Concrete/Steel work – and avoidance of staining

4.1.4.4 Materials

The Contractor shall submit three (3) copies of the manufacture's certificates for bolts, nuts, washers, and filler for welding, mill test certificates and painting for structural steel for the Engineer's approval. These certificates shall include the names and locations of steel mills, analysis of chemical and physical properties, and shall be properly correlated to the various grades of structural steel to be used in the Works.

4.1.4.5 Welding Plan

The Contractor shall not proceed with any welding until the Engineer has approved the Welding Plan which shall include the following:

- All information on welding procedures, equipment, material, additives and preheating during the welding operations
- Details of non-destructive testing methods to be used for specific typical joints
- Details of correction and repair method
- Precautions with regard to welding shrinkage
- Possible treatment of completed welds by grinding with indication of grinding direction, etc.
- Procedures and programme of welding sequence (for each component and for welding components together)

The Contractor shall be responsible for confirming the suitability of the details contained in the Welding Plan, by tests as prescribed in the AWS "Standard Qualification Procedure", and follow without deviation such welding procedures and sequences.

4.1.4.6 Painting Plan

The Contractor in ample time before the commencement of the surface treatment, shall prepare and submit for approval a detailed programme relating to the execution of the painting works, in the workshop, at the site, etc., as well as the methods used, and a time schedule for the individual treatments. The programme shall be subject to approval by the Engineer prior to commencement of the work.

4.1.4.7 Fabrication Procedure

The Contractor shall not proceed with any welding until the Engineer has approved his fabrication procedure which shall include the followings;

- All information for fabricator
- Details of material procurement, marking, cutting, assembling, correction, repair and trial assembly at fabrication shop

4.1.4.8 Erection Plan

Prior to the start of fabrication the Contractor shall submit for the Engineer's approval a full description of his proposed erection method including;

- sequence of erection
- use of temporary or permanent stanchions, beams and bracing
- connection details
- erection camber diagrams to show the vertical position of the structure at each stage of the erection process
- design calculation to cover the various stages in the erection process, type of equipment to be used during erection, and safety measures.

The Engineer's approval of the above details shall not relieve the Contractor of his contractual obligations or of his responsibility for providing proper methods, equipment, workmanship and safety precautions.

4.1.4.9 Painting Certification

The Contractor shall submit to the Engineer, three (3) copies of certification stating that requirements pertaining to pre-paint cleaning and painting of steel have been performed in accordance with the Specifications.

4.1.4.10 Results of trial assembly inspection

The Contractor shall submit to the Engineer the report of the trial assembly inspection.

This report shall include measurement for all members, trial assembly and non destructive test that performed in accordance with the Specification.

4.1.4.11 Records

The Contractor shall maintain records of shop welding procedures, welders employed with date of qualification and identification symbol. Records shall also be maintained of all bolts tested and the corresponding torque values if torque control is used. These records shall freely available for the use of the Inspection Agency and shall be submitted to the Engineer on completion of all shop fabrication work.

4.1.4.12 Dry film thickness (Painting)

The Contractor shall inspect dry film thickness after painting and shall ensure that painting works have been carried out in accordance with the Specifications and the approved Shop Drawings. The inspection results shall be submitted to the Engineer for his approval.

4.1.4.13 As-built Drawings

Within four (4) weeks of completion of the related works, the Contractor shall submit 1 soft copy and 2 prints of the As-built Drawings. These drawings shall include details of actual camber achieved, details of temporary bracings left in the works, etc.

4.2 Material

4.2.1 Structural Steel

Structural steel shall be newly rolled and shall conform to the requirements of the following Specifications or their ASTM equivalents;

- JIS G 3101 Rolled Steel for General Structure : SS400
- JIS G 3106 Rolled Steel for Welded Structure : SM400, SM490, SM490Y, SM520 and SM570
- JIS G 3114 Hot-rolled Atmospheric Corrosion Resisting Steel for Welded Structure : SMA400W, SMA490W and SMA570W

All structural steel shall be delivered with certificates and shall be in accordance with the requirement of the current edition of JIS Standard G 3193. Structural steel shall be stored above the ground upon platforms, skids, or other supports. It shall be kept free from dirt, grease and other foreign matter, and shall be properly protected in order to minimize corrosion.

4.2.2 Bolts

4.2.2.1 High Strength Bolt (HTB)

HTB shall be high strength bolts, friction grip type, F10T and F8T, manufactured and delivered in accordance with JIS B 1186.

Washer and Nut for HTB shall be manufactured and delivered in accordance with JIS B 1186.

4.2.2.2 Other bolts

Other bolts, washers, nuts shall be manufactured in accordance with JIS B0205, JIS B1180, JIS B1181 and JIS B1256.

Spring washer shall be manufactured in accordance with JIS B1251.

4.2.2.3 Filler metal (for welding)

Filler material to be used for welding shall conform to JIS Z 3211, JIS Z3212, JIS Z3214 or shall conform to Structural Welding code AWS D1.1.

4.2.2.4 Headed studs

Headed studs shall conform to JIS B 1198, minimum yield point of 24 kgf/mm² and minimum tensile strength of 41 kgf/mm².

All headed studs shall be welded by studs welding machine and welding gun using ferrule.

4.2.2.5 Painting

Materials used in painting of steel structures shall be as shown on the drawings or specified elsewhere and shall conform to the requirements of the following Specifications.

- JIS K 5400 ; Testing Methods for Organic Coatings
- JIS K 5421 ; Boiled Oil and Boiled Linseed Oil
- JIS K 5516 ; Ready Mixed Paint
- JIS K 5492 ; Aluminium Paint
- JIS K 5621 ; Anticorrosive Paint for General Use
- JIS K 5622 ; Red-Lead Anticorrosive Paint
- JIS K 5623 ; Lead Suboxide Anticorrosive Paint (Class 1)
- JIS K 5624 ; Basic Lead Chromate Anticorrosive Paint (Class 1)
- JIS K 5625 ; Lead Cyanamide Anticorrosive Paint (Class 1)
- JIS K 5626 ; Zinc Dust Anticorrosive Paint
- JIS K 5627 ; Zinc Chromate Anticorrosive Paint
- JIS K 5628 ; Red-Lead Zinc Chromate Anticorrosive Paint
- JIS K 5633 ; Etching Primer (Class 2)
- JIS K 5664 ; Tar-Epoxy Resin Paint
- JIS K 5553 ; High Build Type Zinc Rich Paint
- JIS K 5554 ; Phenol Resin MIO Paint
- JIS K 5555 ; Epoxy Resin MIO Paint
- JIS K 5552 ; Zinc Rich Primer
- JIS K 5657 ; Polyurethane resin paint
- JIS K 5551 ; Epoxy Resin paint

Where paints are specified in the Specifications or drawings, paints may not comply with any of the above Specifications. Paint materials shall be supplied only by recognized manufacturers, and samples and technical data shall be submitted to the Engineer for his approval. In any paint system (viz. primer, undercoats, intermediate coat and finishing coats) each coat of paint shall be compatible with the other, and to ensure this, all paint shall be obtained from the same approved manufacturer with a guarantee of compatibility.

4.3 Workmanship

Except as otherwise denoted herein or on the drawings, all work shall be executed in accordance with the relevant sections of the Specification given in Clause 4.1.

The Contractor shall be responsible for any damage caused to other components of the structure including the substructures, by his operations for the duration of this Contract. In particular he shall take all necessary precautions to minimize concrete splash onto completed steel work or rust staining of concrete due to erected steel-work. He shall clean and/or repair all stains and other damage to completed work, before acceptance.

4.4 Fabrication

4.4.1 General

The Contractor shall fabricate structural steel in the fabrication shop. Bolted or welded connection shall be provided whether constructed on the shop or on the field as shown on the drawings or as directed by the Engineer. High strength bolts for all bolted connections shall be used unless otherwise shown on the drawings or directed by the Engineer.

All sharp edges and corners shall be ground to a minimum radius of 2mm and all sharp irregularities, burrs, slag and spatters on welds shall be removed.

The tolerance shall not exceed those shown on the drawings and each unit assembled shall be closely checked to ensure that all necessary clearances have been provided and that binding does not occur in any moving part.

In order to maintain accurate finished dimensions and shape, appropriate reverse strain or restraints shall be provided as required.

Any error or defect disclosed shall be immediately remedied by the Contractor.

Before disassembly for shipment, each piece of the structure shall be match-marked to facilitate erection in the field.

4.4.2 Fabricator

Structural steel fabricator shall be approved by the Engineer and shall have an experience in fabrication of structural steel for the projects of similar type. A fabricator's shop shall have a suitable space for trial assembly. The Contractor shall submit a written description of fabrication capability including facilities, personnel and list of similar completed projects, including testing and quality control capability and specifically the type and extent of quality control procedure, which the fabricator intends to employ on this Project.

4.4.3 Welding

4.4.3.1 General

All welding shall be planned and executed using the most suitable materials and working methods for the particular purpose. Site welding will only be permitted for fixtures and details of any fixture welding proposed by the Contractor must be clearly identified on the Shop Drawings and referred to in the accompanying submittal letter.

Welding requirements shall in all respects conform to the following sections of AWS D1.1-98: Section 2, Design of Welded Connections; Section 3, Workmanship; Section 4, Technique; Section 5, Qualification; Section 6, Inspection; and Section 9, Design of New Bridges.

All welding shall be executed by skilled, experienced welders holding valid welder examination qualifications based on the qualification tests specified in part C of Section 5 of AWS D1.1- 98 or similar internationally recognized qualification tests. A welder shall be qualified for each process used.

Prior to commencement of any welding, the joint shall be carefully freed from rust, scale, slag, and burrs. Where two welds for structural reasons have to cross each other the former has to be ground flush. Where a flush surface is required, the excess weld metal shall be ground.

During the assembly work, the components shall be held in position and supported in such a manner that no unfavourable inherent stresses or deformation shall develop. Drilling of holes for temporary assembly for welding proposes shall not be accepted.

Minimum preheating and interpass temperature shall comply with the welding procedure and shall be approved by the Engineer.

4.4.3.2 Welding Tolerances

The members to be connected by welding shall be so prepared that they fit exactly together, without being forced into position.

The tolerances concerning gap between parts to be welded, eccentricity and departure from theoretical alignment, dimensions of the cross section groove welded joints, etc. shall conform to Section 3.3, Assembly, of AWS D1.1-98, except that the gap between parts to be joined by fillet welds shall not exceed 1mm for fillet welds connecting flange to web in box girder and 5mm for all other fillet welds. Tolerances of weld profiles shall correspond to section 3.6 of AWS D1.1-98.

4.4.3.3 Trials of Welding Procedures

The Contractor shall perform test welds of the types of welding seams to be applied in the structure, according to a programme to be agreed upon with the Engineer. The quality of the test welds shall be approved by the Engineer prior to execution of the welding work in question. The test welding shall be made from working positions corresponding to the actual working positions during construction.

4.4.3.4 Inspection of Welding

The Contractor shall prepare and submit a detailed programme for welding control for the Engineer's approval, and the established programme shall not be changed without the Engineer's consent.

The Contractor shall assure the inspections to satisfy the requirements laid down in AWS D1.1 -98, Section 9.25, at his own cost. The Contractor's programme shall correspond to the following schedule;

Preparation for Welding

Visual inspection of edge preparation

Visual Inspection before and after welding

Visual inspection of surface conditions for cracks, gaps and other items that may cause any defect of welding. All welds shall be visually inspected in accordance with AWS D1.1, Section 9.25.1.

Non-destructive Testing of Welds

Welds that are subject to radiographic or magnetic particle testing in addition to visual inspection shall be unacceptable if the radiographic or magnetic particle testing show any of the types of discontinuities given in AWS D1.1, Section 9.25.2.

Welds that are subject to ultrasonic testing, in addition to visual inspection, are acceptable if they meet the requirements of table 9.25.3 in AWS D1.1-98. Welds that are subject to liquid penetration testing, in addition to visual inspection, shall be evaluated on the basis of the requirements for visual inspection.

Scope of Non-destructive Testing of Weld

Fillet welds shall be tested by the most suitable of either the magnetic particle test or liquid penetration test. Groove welds shall be tested by the most suitable of either the radiographic test or ultrasonic test.

Minimum Weld Test Requirements

Transverse butt welds in top and bottom flange plate shall be tested by radiographic test as follows:

1. Welds subject to tensile stress and reversal stress
 - a. Welding by automatic welding machine : 1 shot / each welding line
 - b. Welding by manual : 3 shots / each welding line
2. Welds subject to compressive stress
 - a. Welding by automatic welding machine : 1 shot / 5 welding line
 - b. Welding by manual : 1 shot / each welding line
3. Transverse butt weld in web plate
 - a. Welding by automatic welding machine : 1 shot / 2 welding line
 - b. Welding by manual : 1 shot / each welding line

Longitudinal fillet welds:

1. Top and bottom flange to web : 25%
2. Longitudinal rib to top and bottom flange : 10%
3. Horizontal stiffener to web : 10%

Diaphragm:

1. All butt welds : 25%
2. Fillet welds : 10%

Groove welds above the Bearing Shoe:

1. Groove welds above the bearing shoe shall be tested by ultrasonic test : 25%

Other welds not mentioned above : 20%

Note : The place of shot for the radiographic test above mentioned shall be proposed by the Contractor and approved by the Engineer.

The above figures are the minimum extent of testing and the Engineer may require additional tests.

The result of test shall satisfy the followings.

The welds subject to tensile stress shall be equal to or better than class-2 specified in JIS Z3104 or equivalent.

The welds subject to compressive stress shall be equal to or better than class-3 specified in JIS Z3104 or equivalent.

Stud Welding

After the studs welding, visual inspection shall be carried out. All studs which are found defect on the welding bead shall be carried out the bending test at his own expense.

Besides above, bending test shall be carried out randomly at least one percent of total quantities of studs at his own expense.

Bending test

Testing procedure is as follows:

- Step 1 : The stud shall be bended up to fifteen (15) degrees by the hammer. The quantities of tested studs shall be at least 1% of total.
- Step 2 : After bending, visual inspection of welding bead shall be carried out. Crack or defect is found on welding bead?
- Step 3 : If "Yes", = Additional bending test shall be done at least 2% of total. Crack or defect is found on welding bead?
 - If "No", = Acceptable
- Step 4 : If "Yes", = All studs shall be removed and replaced with new studs. After welding, bending test shall be done from Step 1

4.4.4 Templates and jigs

The Contractor shall supply all templates, jigs and other appliances necessary to ensure the accuracy of the work.

4.4.5 Straightening

Before any work is done on them, all plates shall be checked for flatness and all bars and sections checked for straightness and freedom from twist. Any corrective action shall be taken so that when assembled, adjacent surfaces shall be in close contact throughout. The methods adopted for the work above shall be such as not to damage, mark or impair the strength of the material.

4.4.6 Cutting

Marking shall be performed accurately and elaborately using full size rules and templates. Prior to marking, the dimensions and grade of materials shall be checked.

Cutting shall be done automatically. Hand cutting may be used exceptionally, in connection with the erection, if approved by the Engineer. In such cases the joint edges shall receive a finishing treatment, with planning and grinding tools.

Cutting by shearing machine may be used for plates not exceeding 10 mm in thickness provided that the plate edge be fully enclosed in a weld.

Oxygen cutting may be used provided a smooth and regular surface free from cracks and notches is secured and provided that the roughness of oxygen cut-surfaces shall be no greater than 50S in accordance with JIS B 0601 by the use of a mechanical guide.

The edges of all cut plates that will not be welded shall be ground to radius 2mm profile.

4.4.7 Drilling of Holes

Holes for bolts shall be drilled. Punching of holes shall not be permitted. If not otherwise indicated on the drawings, the diameter of bolt holes shall be 2.5 mm larger than the nominal diameter of bolts. The diameter of bolt holes of longitudinal ribs of box girder may be 4.5mm larger than nominal diameter of bolts.

4.4.8 Bending

Bending of plate may be machined by cold processes, provided that the bending inner radius is at least 15 times the thickness of the plate.

4.4.9 Sole plate for the bearing

The contact surface of Sole plates for bearing which are provided under bottom flange shall be ground by machining. Its gradient shall be calculated by the vertical alignment and super elevation. The top plate of the bearing shall be a level after completion of the bridge construction.

4.4.10 Trial Assembly

4.4.10.1 General

The Contractor shall carry out trial assembly for all structural steel bridges in his regular workshop. The trial assembly shall be inspected by the Engineer.

4.4.10.2 Trial Assembly by the Contractor

The Contractor shall submit his proposal for Trial Assembly for the approval of the Engineer.

Trial assembly shall be carried out to examine/control the fitness of prefabricated members by temporarily pre -assembling, to verify that the individual elements have the shape to fit exactly into adjoining elements, to ensure that assembled structures have been fabricated within tolerance and to inspect the camber geometry.

The Contractor shall perform measurement of structural members, and the trial assembly results shall be recorded and submitted to the Engineer.

The Contractor shall inform to the Engineer that the trial assembly has been completed and measured, and the structure shall not be dismantled until the trial assembly has been approved by the Engineer.

4.4.10.3 Trial Assembly Inspection by the Engineer

Prior to the trial assembly inspection by the Engineer, the Contractor shall submit the Report of Trial Assembly by the Contractor for the Engineer's review. This Report shall include results of measurement of structural member, trial assembly and non-destructive test.

The Contractor shall inform the Engineer of the scheduled date of the Engineer's Trial Assembly Inspection at least 28 days before the inspection.

In addition, the Contractor shall be responsible for the whole cost of trial assembly inspection by the Engineer and the Employer which cost shall include traveling cost, accommodation cost, inspection cost and others.

4.5 Tolerances

The Contractor shall, through appropriate planning and continuous measurements in the workshop and at the erection site, ensure that the tolerances given in the Specifications are strictly observed. The Engineer will require any specific working procedure changed in case such procedure appears not to afford sufficient security against exceeding the tolerances. Unless otherwise specified, fabricated structural steel shall apply to the tolerances shown in below Table below.

Table 4.1: Tolerances

No.	Inspection Item	Tolerance (mm)
1	Flange width b (m) Height of web plate (m) Web plate spacing (m)	± 2 ----- $b < 0.5$ ± 3 ----- $0.5 < b < 1.0$ ± 4 ----- $1.0 < b < 2.0$ $\pm (3 + b/2)$ ---- $2.0 < b$
2	Flatness of Plate : Web Plate : h (mm) Flange of Box : w (mm)	$h / 250$ $w / 150$
3	Squareness of Flange (mm)	$b / 200$
4	Length of Member L : Plate Girder (m) Expansion (m)	± 3 ----- $L < 10m$ ± 4 ----- $10m < L$ $0 \sim +30$
5	Straightness of compression member L (mm)	$L / 1000$
6	Total length of span length L (m)	$\pm (10 + L/10)$ $L : Span (m)$

No.	Inspection Item	Tolerance (mm)
7	Spacing centre to centre between main girder or main structure B (m)	± 4 ----- $B < 2m$ $\pm (3 + B/2)$ ---- $B > 2m$
8	Assembled height of main structure H(mm)	± 5 ----- $H < 5m$ $\pm (2.5 + H/2)$ ---- $H > 5m$
9	Straightness of main girder or main structure L (m)	$\pm 5 + L/5$ ----- $L < 100m$ 25 ----- $L > 100m$
10	Deflection of main girder or main structure L(m)	-5~+5 ----- $L < 20 m$ -5~+10 ---- $20 m < L < 40 m$ -5~+15 ---- $40 m < L < 80 m$ -5~+25 ---- $80 m < L < 200 m$
11	Tolerance of main girder or main structure at the end line of bridge (mm)	10
12	Vertically of main girder or main structure H(mm)	$3 + H/1000$ H (mm)
13	Gap of site connection (mm)	5

4.6 Camber

The Contractor is fully responsible for the calculation and provision of the necessary camber in the preassembled elements to obtain the correct levels in the completed bridge, duly considering the applied erection procedure and the sequence in the installation of the various dead load components.

The Contractor shall submit results of the camber calculation for the Engineer's review and its camber shall include Shop Drawings.

4.7 Erection

4.7.1 General

Before erection work is commenced, all members shall be checked for flatness and all bars and sections checked for straightness and free from twist. Any corrective action shall be taken so that when assembled, adjacent surfaces shall be in close contact throughout. The methods adopted for the work above shall be such as not to damage, mark or impair the strength of the material.

The Contractor shall be responsible for any damage caused to other components of the structure including the substructures, by his operations for the duration of the Contract. In particular he shall take all necessary precautions to minimize concrete splash onto completed steel work or rust staining of concrete due to erected steel -work, and clean and/or repair all stains and other damage to completed work prior to the Tests on Completion.

4.7.2 Bolted Connection

The surfaces of splice plates for high strength bolted joints shall be painted by inorganic zinc rich paint in accordance with the Specifications.

Prior to assemble in the field, the rust on joint surfaces, including those adjacent to bolt head, nut and washer, shall be removed by power tools and sand-paper. If the gap between splice plate and main structural steel of bolted connections is 2mm or less, the surface of main structural steel shall be tapered to eliminate the gap. The cap which is over 2mm shall install filler plate as required.

The minimum proof load of each high strength bolt shall be as follows:

Table 4.2: Bolt Size – Minimum Proof Load

Grade	Bolt size	Minimum Proof Load (kN)
F8T	M 20	133
F8T	M 22	165
F8T	M 24	192
F10T	M 20	165
F10T	M 22	205
F10T	M 24	238

High strength bolts shall not be reused for the permanent structure. All high strength bolts shall be tightened by torque wrenches or approved tightening method by the Engineer. Their setting bolts shall be such as to induce a bolt tension of 10% in excess of the above value.

These wrenches shall be calibrated at least once each working day and shall decide torque value (herein after "DTV") for tightening. High strength bolts shall be tightened by DTV.

After bolt tightening, the torque value of bolts, at least ten percents (10%) of installed bolts in the one splice plate, shall randomly be inspected torque value by the torque wrenches as below condition.

Step 1 : If the measured torque values of each bolts are within ten percent (10%) deviation of DTV, these bolts are deemed to be tightened suitable torque value. However, if the measured torque values are out of 10% deviation of DTV, "Step 2" shall be carried out.

Step 2 : The bolts which torque value is less than DTV shall be re-tightened up to DTV. The bolts which torque value is more than DTV shall be replaced. And "Step 3 shall be carried out.

Step 3 : At least, twenty percents (20%) of installed bolts in one splice plate shall randomly be inspected the torque value by the torque wrenches. If the measured torque values are within ten percent (10%) deviation of DTV, these bolts are deemed to be tightened suitable torque value. However, if the measured torque values are out of 10% deviation of DTV, "Step 4" shall be carried out.

Step 4 : The bolts which torque value is less than DTV shall be re-tightened up to DTV. The bolts which torque value is more than DTV shall be replaced. And "Step 5 shall be carried out.

Step 5 : All of the installed bolts in one splice plate shall be inspected torque value by the torque wrenches. If the measured torque values are within ten percent (10%) deviation of DTV, these bolts are deemed to be tightened suitable torque value. However, if the measured torque values are out of 10% deviation of DTV, "Step 6" shall be carried out.

Step 6 : The bolts which torque value is less than DTV shall be re-tightened up to DTV. The bolt which torque value is more than DTV shall be replaced.

4.7.3 Field Erection

The position of field splices as shown on the drawings is for information only and the Contractor is free to propose alternative procedures providing they comply with all the relevant requirements of the Specifications. The preparation of the calculations and detailed design to support the proposed alternative shall be at the Contractor's responsibility and cost.

The contractor shall provide the working drawings showing the details and installation method of templates and anchor bolts to be embedded in concrete for the Engineer's approval.

During erection, the members and sections shall be accurately assembled as shown on the approved Shop Drawings and any match-marks shall be followed. The material shall be carefully handled so that no sections will be bent, broken or otherwise damaged. Hammering which will damage or distort the members shall not be done. Bearing surfaces and surfaces to be in permanent contact shall be cleaned before the members are assembled.

The correction of minor misfits involving harmless amounts of reaming, cutting and chipping will be considered a legitimate part of the erection. However, any error in the shop fabrication or deformation resulting from handling and transportation which prevents the proper assembling and fitting up of parts by the moderate use of drift pins or by a moderate amount of reaming and slight chipping or cutting, shall be reported immediately to the Engineer and his approval of the method of correction obtained. The Contractor shall be responsible for correction for all misfits, errors and injuries and shall make the necessary corrections and replacements.

The straightening of plates, angles, other shapes and built-up members, when permitted by the Engineer, shall be done by methods that will not produce fracture or other damages. Distorted members shall be straightened by mechanical means or, if approved by the Engineer, by the careful planned and supervised application of a limited amount of localized heat, each application subject to the approval of the Engineer.

4.8 Transport Handling and Storage

Before dismantling the assembled structure at fabrication shop, all members and sections shall be appropriately marked with their identification numbers as detailed on the Shop Drawings. The Contractor shall submit all relevant drawings and lists showing all identification numbers and match marks of the finished structure steels to the Engineer for his review and approval.

The methods of transporting and handling shall be subject to the approval of the Engineer. Special care to protect against damage shall be taken in the packing, supporting, lifting handling and transporting of structural steel.

When the members are delivered to the Site, the Contractor shall check the material and immediately report to the Engineer any damages or defects therein. The Contractor shall also report in writing to the Engineer any such damage or defects, and give his proposals for the rectification or replacement or damaged sections.

Material to be stored at fabrication shop and at site shall be placed on skids above the ground and shall be kept clean and properly drained. Girders and beams shall be placed upright and shored.

Long members shall be supported on skids placed near enough together to prevent injury from deflection.

Any structural steel materials (whether painted or unpainted) shipped to the Site by ocean transportation, and positioned on board in such a way as to come into contact with salt water spray, shall be thoroughly washed with clean fresh water, using pressure hoses and stiff bristle brushes, prior to erection, whenever required.

4.9 Painting

4.9.1 Surface Treatment

4.9.1.1 General

This Sub -section covers the complete requirements for painting of steel works, including surface preparation, priming and final protective coatings. Surface treatment of structural steel work shall be considered in five classes as described Table 4.2 Classes Of Surface Treatment.

Table 4.3: Classes of surface treatment

System Ref. Number	Environment	Application
I	Severe atmospheric	External surface - General
II	Severe atmospheric	Internal surface - General
III	Severe atmospheric	External joint connection
IV	Severe atmospheric	Internal joint connection

System Ref. Number	Environment	Application
V	Encased in concrete	A part of system I and II

4.9.1.2 Surface Preparation

Before the application of any paint, the surfaces to be treated shall be thoroughly cleaned and freed from all scale, loose paint, rust, oil and others. Oil and grease shall be removed from the surface by washing with solvents or with a detergent solution before any blast cleaning operation. If any traces of oil or grease remain after blasting, they shall be removed by solvent cleaning and the area re-blasted.

All welding areas shall be given special attention for removal of weld flux slag, weld metal splatter, weld head oxides, weld flux fumes, silvers other foreign objects before blasting. If deemed necessary by the Engineer acid washing and subsequent washing with clean water shall be used.

Any rough welding seams have to be ground and must be inspected and approved by the Engineer before application of the coatings.

All structural steel which will be painted shall be cleaned by blast cleaning in accordance with SSPC-SP 10 Near-White Blast cleaning. Mill scale, rust and foreign matter shall be removed to the extent that the only traces remaining are light stains in the form of spots or stripes. Finally, the surface is cleaned with a vacuum cleaner or clean, dry compressed air.

The blast cleaning shall produce a surface roughness complying with the one specified by the paint manufacturer for the primer concerned. If cleaned surfaces rust or are contaminated with foreign material before painting is accomplished, they shall be re-cleaned by the Contractor at his expenses.

4.9.2 Painting Materials

All materials shall comply with the requirements of Sub-Section 4.2 hereof. The basic colour of the intermediate and final coats will be instructed by the Engineer.

4.9.3 Application of Paint

Unless otherwise specified, all painting and protective coating work shall be done in accordance with the Specifications. The execution of the painting works shall be carried out in the most perfect and workmanlike manner by experienced labor to the satisfaction of the Engineer. Furthermore, the application of the paints shall be carried out in accordance with the manufacturer's recommendations.

Planning and execution of the painting work shall be in conformity with the manufacturer's Specifications in respect to minimum and maximum intervals between the individual coats (layers).

Each coat shall be applied uniformly over the entire surface. Skips, runs, sags and drips shall be avoided. When these occur, they shall be brushed out immediately or shall be removed, and the surface shall be recoated. Each coat shall be allowed to dry for the time specified by the manufacturer or as directed by the Engineer before application of any succeeding coat.

The surface must be completely dry, and its temperature should be at least 5 degrees Celsius above the dew point. Paint should only be applied in suitable weather conditions and any fresh paint damaged by weather shall be repaired or replaced at the Contractor's expense. Measure shall be taken to prevent dust or other extraneous matter from adhering to wet paint.

Brushes, when used, shall have sufficient body and length of bristle to spread the paint in a uniform film. Paint shall be evenly spread and thoroughly brushed out. On all surfaces which are inaccessible for painting by regular means, the paint shall be applied by sheepskin daubers, bottle brushes, or by any other means approved by the Engineer. Rollers, when used, shall be of a type which do not leave a stippled texture in the paint film.

A water trap acceptable to the Engineer shall be furnished and installed on all equipment used in spray painting. Mechanical mixers shall be used to mix paint. Prior to applying, the paint shall be mixed for sufficient time to thoroughly mix the pigment and vehicle together and shall be kept thoroughly mixed during its application. The dry film thickness of the paint shall be measured in place with an appropriate instrument.

4.9.4 Dry Film Thickness

The specified film thicknesses for coating materials shall be strictly observed and shall be checked with appropriate film thickness gauges furnished by the Contractor. The Contractor shall calibrate the gauges for the thickness range to be checked. Calibration shall generally be carried out on a ground and polished steel plate of a quality corresponding to the structural steel to be coated.

The dry film thickness shown on Table shown in 4.9 is the minimum requirements, measure in accordance with the requirements of SSPC-PA 2, Measurement of Dry Paint Thickness with Magnetic Gauges.

4.9.5 Protection of Paintwork

The Contractor shall provide protective measures as necessary to prevent damage to the work and to other property or persons from all cleaning and painting operations. Paint or paint stains which result in an unsightly appearance on surfaces not designated to be painted shall be removed or obliterated by the Contractor at his cost. All painted surfaces that in the opinion of the Engineer are marred or damaged in any way, shall be repaired by the Contractor, at his cost, with materials and to a condition equal to that of the requirements specified in this Specification. The Contractor's proposal for re-treatment of areas damaged by flame cutting and welding operations should be clearly stated in the detailed painting plan. The painting shall be completed, and the surfaces shall be undamaged and clean.

The areas for high-strength bolts shall be protected by masking tape against undercoats application at the fabrication shop.

4.10 Method of Measurement

4.10.1 Structural Steel Furnished

The unit of measurement for payment for furnishing structural steel bridges shall be the mass of steel, furnished in compliance with the Specifications and stocked in good condition at the site of the work.

The mass of steel shall include permanent structural steel, and shall be calculated as net weight by approved Shop Drawings. But no reduction in mass shall only be applied for bolt holes. The mass of welds, headed studs, slab anchors for deck slab, temporary bolts and nuts, paint and any other temporary miscellaneous items for furnishing shall not be considered for calculation of the mass but shall be included the unit price.

The unit price shall include procurement materials, labours, fabrication, equipment and tools for fabrication, Inspection Agency, testing, inspections, shop painting, transportation to the site and stock at the site. The mass of permanent high strength bolts and its washers and nuts, permanent bolts and its nuts and washers shall include erection work.

The Contractor shall check and shall calculate the mass of the steel as shown on the approved drawings.

4.10.2 Structural Steel Erection

The unit of measurement for payment for erected structural steel bridges shall be the mass of steel, erected in compliance with the Specifications.

The mass of steel shall include permanent structural steel, permanent high strength bolts and its washers and nuts, permanent bolts and its nuts and washers. The mass shall be calculated as net weight by approved Shop Drawings. But no reduction in mass shall only be applied for bolt holes. The mass of welds, headed studs, slab anchors for deck slab, temporary bolts, field paint and any other temporary miscellaneous items shall not be considered for calculation of the mass but shall be included the unit price.

The unit price shall include labour, erection, equipment and tools for erection, testing, inspections and field painting.

The Contractor shall check and shall calculate the mass of the steel as shown on the approved drawings.

5 Mechanical Works

5.1 Fire Protection System

5.1.1 Standards and Reference

Table 5.1: Standards for Fire Protection

S/N	Requirements
1	SNI 03-1745-2000 Design and Installation of Standpipe for Fire Fighting in Building
2	SNI 03-1746-2000 Means of Egress
3	SNI 03-3985-2000 Fire Alarm Systems
4	SNI 03-3987-1995 Fire Extinguishers
5	SNI 03-3989-2000 Design and Installation of Automatic Sprinkler System
6	SNI 03-6570-2001 Fire Pump Installation
7	Indonesia Ministry Of Public Works (PerMen PU No 26/2008);
8	Local Regulations for Building: Perda DKI Jakarta No. 7 /2010 : Buildings in DKI Jakarta Perda DKI Jakarta No. 8/2008: Fire Safety Management in DKI Jakarta
9	Other National Standard For Building Services - Electrical And Mechanical (SNI)
10	Other International Standard Commonly Used In Indonesia NFPA 13 -2010 : Installation of Sprinkler System NFPA 14 – 2010: Standard of Installation of Standpipe and Hose System NFPA 20 – 2010: Centrifugal Fire Pumps NFPA 2001-2015: Standard on Clean Agent Fire Extinguishing Systems

5.1.2 Functional Requirements

5.1.2.1 General

Fire pumps and motors, sprinkler heads, valves and detectors shall be UL/FM/LPCB/NFPA listed and approved type.

Fire pumps shall be centrifugal constant speed, single stage, horizontal split case complete with electric motors, mating flanges, air releases, volute drain connection and base plates. The performance characteristics shall meet the requirement of related SNI.

Motor shall be totally enclosed fan cooled type (TEFC), squirrel cage with insulation class F, c/w sleeve bearings and service factor shall be 1.15. The torque/speed characteristic shall be selected to match the pump operation.

The pump set shall be tested in complete with the offered motor coupled to the pump, to meet the requirement as specified in SNI.

In general, pump design, construction and fittings shall meet the above requirement for maximum reliability.

All valves shall be located so as to be readily accessible from the floor.

All fire protection system piping shall be supported by independent pipe supports.

All new pipe work shall be thoroughly flushed after installation.

Contractor shall provide all penetrations for the pipe passage and make good after installation in compliance with local authority requirement. Contractor shall provide cables and terminations for fire alarm panel (FAP) and fire pump control panel.

Multi compartmented concrete fire tank shall be used for easy maintenance, and shall be completed with high and low alarm float switch, overflow, balancing valve, vent valve, drain and all necessary accessories to support the reliable water supply for fire-fighting purpose. Preventive measure in case of water storage leak or burst shall be provided, such as the bund walls with the pipe discharge to the nearest surface drain.

5.1.2.2 Automatic Sprinkler

The sprinkler system shall meet the below performance for Ordinary Hazard Classification:

Table 5.2: Automatic Sprinkler

Occupancy Group	Min. running pressure (bar)	Flow rate (l/min.)	Design density of discharge (mm/min.)	Assumed area of operation (m ²)
Ordinary Hazard	4.4	725	5	144
	4.0	1000		
	2.0	2050		

Sprinkler head (8.0 k factor) unless otherwise stated, shall be fusible link type of temperature rating 68 degree Celsius.

Water flow switches shall be incorporated with retards or time delay devices to avoid false alarms due to electrical surges.

A four way breeching inlet (siamese connection) shall be installed at an external wall not more than 18 m from the fire engine access-way. The breeching inlet shall be completed with brass caps with spring locks and stainless steel chains. The breeching inlet cabinet shall be stainless steel (grade 316) wall recessed type and clearly identified.

The sprinkler system shall be electrically earthed with a maximum impedance of 10 ohm.

A 25 mm diameter drain valve c/w pipe work shall be provided at the furthest point of each sprinkler zone and trap section of piping system and discharge to the nearest drain point such as toilets/floor drain. All drain valves shall be strapped and padlocked in "closed" position.

All monitored isolating valves shall be linked to the main alarm panel to give an audio and visual indication of when the valves are closed.

Air release valve c/w gate valve shall be provided at the highest point of each sprinkler installation.

Sprinkler pipes in un-sprinklered areas shall be fire rated.

Protective guard shall be fitted to each sprinkler head inside machine pit and other areas subject to mechanical damage.

The types and quality of the pipe work shall comply with the following schedule:

- a. sprinkler pipe work : black steel pipes, BS EN 10255, H series or equivalent
- b. air vent pipe work : copper, BS659 or equivalent
- c. drain pipe work : black steel pipes, BS EN 10255, H series

Install sprinkler piping with drains for complete system drainage

Hangers and supports shall comply with SNI or NFPA 13 for hanger materials and installation

5.1.2.3 Fire Hydrant System

The hydrant system shall be designed, installed and tested in accordance with SNI 03-1745-2000 and other related local regulations.

The types and quality of the pipe work shall comply with the following schedule:

- a. standpipe shall be of heavy duty galvanized wrought steel piping, BS EN 10255 or equivalent
- b. pipe fitting shall be wrought iron or galvanized, conforming to BS 143/ BS1256/ BS1740 or equivalent.

A four way breeching inlet (Siamese connection) shall be installed at an external wall not more than 18 m from the fire engine access way.

The breeching inlet shall be complete with brass caps with spring locks and stainless steel chains and shall be clearly identified.

The location of breeching inlets and hydrants shall be determined by architect with agreement from the local fire service.

The hydrant breeching inlet shall be properly earthed to a maximum impedance of 10 ohm.

The contractor shall allow expansion and contraction in the piping system to prevent excessive stress on the pipe work. The piping system shall also be securely and adequately supported and of sufficient strength to withstand the pressure and thrust forces to which they might be subjected.

A 25 mm drain valve shall be provided at each low point of the standpipe.

Automatic air release valves shall be provided at the highest point in each hydrant system to permit air in the pipe to discharge to atmosphere when water is pumped into the pipes.

The hose reel cabinet shall be 1.2 – 2.0 mm mild steel with top coat powder coating red signal, indoor A2 type in the public area.

Hydrant valves shall be a pressure regulating valve type.

5.1.2.4 Portable Fire Extinguishers

All portable fire extinguishers shall be installed in accordance with the standard issued by ministry of public works (PMPU), SNI 03-1746-2000 and other local code requirement

Generally, portable fire extinguishers should be installed in 30 m distance.

The locations of portable fire extinguishers to be finally determined by the architect.

Where extinguishers are exposed within public areas, they shall be housed within fire extinguisher cabinets with spring lock or lever type lock.

5.1.2.5 Fire suppression system

The design, installation and testing shall comply with the standard issued by local regulations and international standards. NFPA 2001

The sizing of pipe work and nozzles shall be determined according to engineered system.

Supervisory pressure switch shall be incorporated into the gas cylinders for gas leakage detection.

Gas leakage indication & alarm shall be recorded on clean agent local panel & fire control panel (FAP)

The manual/auto lock off device shall provide status indication for manual mode, auto mode & discharge mode on both clean agent local panel & FAP

The design, fabrication & installation of "do not enter" flashing signage & "evacuate" flashing signage shall comply with local requirement for "exit sign" 13 amp fuse spur units shall be provided for the flashing signage.

Dry contact in relay box with wiring & conduit from clean agent local fire panel to local ventilation and air conditioning control panel shall be provided for the purpose of tripping the ventilation fans & dampers in the plant rooms that have clean agent protection. Upon actuation of one zone of the clean agent detectors, the corresponding fs signal shall pass to the local MCP panel to close the dampers and shut down the vac system. Dry contact signals shall be provided.

The interfacing panels used shall be compatible & can be interfaced with both clean agent local panel & FAP.

All equipment for clean agent system installed outdoor shall be of weatherproof enclosure. The enclosure can be locked through from outside & shall be self-locked. The enclosure shall be easily opened at front without using of keys.

The clean agent system shall be reset at both FAP in the station control room & clean agent local panel.

The clean agent extinguishing control unit & auto/manual lock off units which are located at the entrance of the protected room shall have auto/manual control, a visible indication of gas released, auto/manual status and key switch for switching the system from auto mode to manual mode.

For room with a raised floor, the raised floor shall be protected by the clean agent.

5.2 Mechanical Ventilation and Air Conditioning

5.2.1 Standards and References

The applicable codes and standards for the design of the Mechanical Ventilation and Air Conditioning will include but not be limited to the following:

Table 5.3: Standards and References

S/N	Requirements
1	PerMen PU No. 26/2008 Technical Requirements of Fire Protection System in Building and Environment
2	Perda No. 8 th.2008 Fire Prevention and Safety Management System
3	SNI 03-6572-2001 : Design and Installation of Ventilation System and Air Conditioning in the Building
4	SNI 03-6571-2001 : Smoke Management System in the Building
5	Environmental protection law of building code
6	KepMen LH No. 48/1996 Noise Level
7	ASHRAE - American Society of Heating, Refrigerating and Air Conditioning Engineers - Standards and guidelines
8	SMACNA - Sheet Metal and Air Conditioning Contractors' National Association - Design guides and standards
9	BS 476 : Fire tests on building materials and structures

5.2.2 Functional Requirement

The contractor is to produce coordinated working drawings and or installation drawings which will indicate the precise positions of all services and plant.

Plant and final distribution shall be coordinated by the contractor based on the final working architectural layout and other services on site.

The physical size of all plant and equipment shall be suitable for the space allocated for the accommodation of such plant and equipment taking into account the requirement for access and maintenance. The exact equipment location and services routing shall be coordinated on site to suit the site conditions.

Hangers and steel supports shall be arranged in such a way as to maximize flexibility for future modification and addition of future connections/services.

All pipework and ductwork crossing building movement joints shall be fitted with expansion joints, flexible connectors, expansion loops, offsets or similar products.

Flexible connections shall be applied to all fan motor, pumps, attenuators, air terminals and indoor units. Length shall not exceed as per SMACNA, ASHRAE, CIBSE, BSRIA and HVAC standards.

All thermal and acoustic lining is not always indicated on the drawings. The general requirements can be summarized as follows:

- a. All air conditioning supply air ductwork, return air ductwork passing through non air-conditioned areas and pre-conditioned air ductwork shall be insulated.
- b. Ductwork associated with toilet exhaust and similar systems that draw make up air from air conditioned spaces shall be insulated where they pass through plant rooms, storage areas and other un-air conditioned or partially air conditioned spaces.

All plant shall c/w appropriate acoustic treatment. For local fans, the final selected product shall satisfy the local required NR or provide acoustic enclosures and attenuation where necessary.

Silencer and/or acoustic lining shall be considered wherever necessary to meet the design noise criteria.

For large plant items including those in the plantrooms, appropriate AVMS and acoustic enclosure will be required to satisfy the acoustic requirement.

All workmanship and material shall confirm to the relevant British Standards and local planning office, fire authority requirement, codes and the main contract prelims/sub-contract preliminary.

Contractor shall allow for appropriate noise attenuation to reduce/eliminate noise break out from fans, FCUS and any other motorised units. Contractor shall perform a specialist acoustic/sound testing onsite upon completion.

Weatherproof louvres to be at minimum of 50% equivalent area, with insect mesh, bird screen and burglar screen or subject to final product selections.

Parts of external weather louvers not used are to be blanked off behind using insulated blanking panels, c/w insulation with not less than 100mm. Vapour seal shall be provided with sheet metal plate behind or approved equivalent. Sealant and insulation shall be provided to provide sufficient weather proofing.

5.2.3 Mechanical Ventilation

Ventilation, cooling and heating shall be controlled via internal and external room averaging sensors interlinked with the BAS network. Room averaging RH sensors shall be placed in areas where RH control is required.

Internal climatic and conditioning sensors and external weather sensors location are subject to final coordination with architects and room layouts. Sensors and local control panels shall be installed at least 1500 millimetres above the AFFL. Final locations are to be agreed with the architects and MEP contractor on site.

Final setting of air terminals (supply & extract) shall be in accordance with the architect's coordinated reflected ceiling plans in coordination with other services including lighting.

All ductworks shall be in accordance with ASHRAE/ SMACNA/CIBSE standards. Access panels shall be provided in ductwork for maintenance access and cleaning purposes.

Provide general twin fan exhaust unit to maintain sufficient air change rate in WCs areas. Interlink to BAS for activation monitoring and control.

All supply and extract ductwork to be thermally insulated unless indicated otherwise.

Flexible connections shall be applied to all fan motor, pumps, attenuators, air terminals and indoor units. Length shall not exceed as per SMACNA, ASHRAE, CIBSE, BSRIA and HVAC standards.

All ductworks and plant equipment with open vertical discharges or inlets to be appropriately drained.

All dampers and ancillary items in ductwork shall be provided with access panels for maintenance and re-setting in accordance with SMACNA and CIBSE guidance.

Volume control damper shall be provided at each branch duct and other necessary location for air volume adjustment.

Motorised damper or other ductwork accessories shall be considered wherever necessary to ensure the complete functioning of the system.

All rectangular duct bends shall be radius or angled c/w turning vanes unless the associated pressure loss is higher.

Motorized damper shall be provided for each ventilation fan in parallel configuration to prevent air recirculation during the event of a fan not been in operation.

Allow for balancing dampers on all duct branches and spigot connections.

Fan system in duty / standby arrangement shall be c/w non return dampers to prevent recirculation of supply / extract air.

Propeller fan shall be supplied complete with auto-shutter.

Door grilles/ transfer air grilles shall be coordinated with architects wherever necessary.

Gasket access panels shall be provided in all sheet metal ducts and plenums to provide access and maintenance of the following equipment:

- a. Fire and smoke dampers
- b. Motorised dampers
- c. Non return dampers
- d. Duct bends with turning vanes
- e. Volume control dampers and regulators
- f. Other items of equipment which require access for inspection/maintenance.

All ductwork and plant equipment with open vertical discharges or inlets are to be appropriately drained.

All dampers and ancillary items in ductwork shall be provided with access panels for maintenance and re-setting in accordance with SMACNA and CIBSE guidance.

If the duct dimension is less than 600mm, the access panel shall be equal to the full size of the duct.

Ventilation, cooling and heating shall be controlled via internal and external room averaging sensors interlinked with the BAS network. Room averaging RH sensors shall be placed in areas where RH control is required.

Fan units in duty / standby arrangement shall be interlinked with mcc and BAS for load sharing and auto-change over in case of breakdown.

The air performance and sound level of ventilation fans shall be factory tested as per AMCA manual and standard 210 or approved equivalent standard.

Motors shall be totally enclosed fan cooled (TEFC), squirrel cage, with minimum enclosure protection of IP54. Winding insulation shall be of class F.

Depending on the site condition, suitable filter shall be provided for the intake line

5.2.4 Air conditioning

All pipeworks and ductworks shall be supported in accordance with ASTM/ British Standards/ DW144/ CIBSE/ HVCA standards.

Pipework insulation at the point where the pipework passes through fire barriers must have a period of fire resistance equal to the fire barrier.

All mission critical rooms shall be c/w with standby FCU or air conditioning systems, including signalling-telecommunication room, station control room and other operation related rooms.

Air cooled condenser units shall be located in ventilated plantroom with sufficient ventilation for heat rejection air flow rates. This shall be confirmed in the detailed design stage.

Refrigerant piping should be copper pipe properly insulated with foam rubber

Condensate pipe shall be heavy duty PVC, properly insulated with foam rubber and connected to the nearest floor trap.

Indoor unit shall be completed with generally washable air filter of minimum 85% arrestance and 25% of dust efficiency, tested in accordance with ASHRAE 52-76

Condensate drain from dx shall be insulated and drained to the nearest floor traps, via gravity or condensate lift pumps where required.

For FCUS or DX indoor units inside equipment rooms, in particular for electrical equipment, drain pan shall be provided to prevent any potential water leakage onto the electrical equipment.

All FCUS and DXS shall be c/w Local Control Panels Interlinked with local temperature/space averaging temperature sensors for air temperature control and monitoring. Control panels shall be interlinked with BAS for remote monitoring, metering, log recording and fault detection.

Rooms c/w DX air cooled condenser units shall c/w a refrigerant leakage detection system.

All duty / standby / backup systems including pumps, FCUs, DX, etc, shall be interlinked with the MCC and BAS for fault detection, load sharing and auto-change over.

5.2.5 Smoke and Fire Safety Related System

All penetrations through fire/smoke walls must be fire + smoke stopped and sealed between compartments to achieve nominated fire rating by approved means in accordance with BS 476 part 24 and in accordance with local code requirement.

Fire and smoke motorised control damper shall c/w remote interlink for all smoke control and fire dampers for remote status monitoring, reset, control configuration in the main fire panels and BAS.

Refer to the architectural coordinated reflected ceiling plan, gantry and riser for maintenance access.

Access doors must be provided in accordance with the recommendations of HVCA and British standards or equivalent. Notwithstanding this guidance, access doors shall be provided adjacent to all fire and smoke dampers. Access doors are general not indicated on drawings.

Ventilation duct designed for non-smoke exhaust operation shall be provided with fire damper at crossing of fire compartment and ventilation duct designed for smoke exhaust shall be fire rated for 1 hour with no fire dampers.

Smoke extraction system shall be provided in accordance with local standard on smoke and pressurisation system.

All smoke related system shall c/w dual electrical supply with at least one essential supply available during an emergency. Cables shall be fire rated hard wired connected.

Smoke systems and the associated ancillary items including smoke/fire dampers shall be controlled via the central fire control and damper panels for fireman operation in an event of emergency.

Smoke system shall be automatic based on the activation of the fire detection system.

Rooms which are equipped with a gaseous suppression system shall c/w gas removal extraction systems. This shall be in form of a dedicated system or utilised local mechanical ventilation extraction for gas removal.

Motorised dampers shall be provided with control system interlinked with BAS controls and fireman damper control, cable shall be fire rated for any emergency use and shall be c/w back up by ups in event of power failure.

Smoke extraction system shall be activated upon the detection of the fire detection system; system shall be in a fully fire rated construction for fan, motors, ducts and ancillary items.

All ventilation and air conditioning plant shall be interlinked with fire safety system and BAS.

5.3 Water Supply System

5.3.1 Standards and References

Water supply system shall be designed and installed in accordance with:

Table 5.4: Standards and References

S/N	Requirements
1	SNI 03-6481-2000 Plumbing System
2	SNI 7065-2005 Design of Plumbing System and other local authority requirements:
3	PERDA (Peraturan Daerah DKI) Nomor 7 Tahun 2010: Building Regulation in DKI Jakarta
4	PERGUB No. 122 /2005 Domestic Waste Treatment in DKI Jakarta
5	PERGUB No. 69 /2013 Waste water quality standard for various industries and activities
6	PERGUB No. 38 /2012 Green Building
7	INGUB No. 41 /2013 Water Trap Provision
8	International Plumbing Code 2012

The domestic water installation needs to comply with the latest local authority requirements.

Tank less booster pump set (duty and standby pumps) and pressure control vessel shall be installed to supply water from water tanks to various water points in the station.

All pipes material shall be of the following (minimum requirement), but not limited to:

- a. Transfer/distribution main gravity clean water inside building : PPR PN 10
- b. Distribution clean water outdoor/gardening: PPR PN 10
- c. Distribution hot water: copper pipe ASTM B.88

5.3.2 Domestic Water Heater

Electric instantaneous type water heaters shall be provided in area/room that requires hot water supply (nursing room, staff shower, etc.).

The capacity shall adequate during peak hour usage

Low flow cut out, high temperature cut out and other safety precaution shall be included in the heaters.

Water heater shall comply with SNI.

Enclose pipes passing through building elements, (walls, floors, partitions, etc.) concentrically within purpose made sleeves. Fit masking plates where visible pipes pass through building elements, including false ceilings of occupied rooms.

Where pipe insulation is carried through pipe sleeve, cut sleeves from material same as pipe one or two sizes larger than pipe and insulation to allow clearance. Do not use sleeves as pipe supports. Install sleeves flush with building finish. In areas where floors are washed down, install with a 100mm protrusion above floor finish.

Make final connections to equipment in accordance with manufacturer's instructions.

Arrange supports and accessories for equipment, appliances or ancillary fitments in pipe runs, so that no undue strain is imposed upon pipes. Ensure that materials used for supports are compatible with pipeline materials.

Arrange pipe work, valves, drains, air vents, de mountable joints, supports, etc., for convenient routine maintenance and renewals.

All pipes passing through retaining works or water-tight structures shall be made water tight with puddle flange at the point of penetration through structures. Pipe penetration through fire walls & floors shall be sealed with fire proofing materials.

All cold water pipes shown on plan shall be routed at the ceiling of the respective plan unless otherwise stated. All pipe work shall be concealed in pipe shaft/walls/partitions or run within false ceiling space unless otherwise stated.

All supply lines to WC, urinals, wash basins and sinks shall be provided with individual isolation valves.

Pipe connections and all accessories for setting into the tanks shall each comprise but shall not be limited to:

- Tank inlet(s) and outlet(s)
- Drain
- Overflow
- Level controllers
- Air vent
- Tank access and cover

All valves are to be located such that it can be readily accessed by maintenance personnel, access panel to architects approval shall be provided where necessary.

Ball valves are to be installed under all the wash basin and sink.

All hose bibs at public areas shall complete with lock and stainless steel box/cover.

Water points shall not be installed near to any power outlet.

Water storage tank shall be constructed of GRP with multiple compartments for maintenance purpose c/w access hatch, all necessary valves and fittings for reliable operation, safety and maintenance.

Preventive measure in case of water storage leak or burst shall be provided, such as the bund walls with the pipe discharge to the nearest surface drain.

Water tanks shall be mounted on concrete foundations, I-BEAM, steel base to manufacturer's recommended framework. Concrete plinths of minimum 100mm thickness shall be provided.

All support beams, support legs, platforms, hangers and anchor bolts required for proper installation of the tanks shall be submitted to engineer for approval.

All tap points without basins be provided with RC kerbs and wash area waterproofed with an approved water-proofing system.

All hangers supports, brackets anchors, bolts and nuts for pipes, trunking, conduit trays equipment etc. shall be hot dipped galvanised to BS EN ISO 1461 or equivalent.

Necessary earthing to all metallic equipment/pipework need to meet all requirements or the Indonesia standard.

5.3.3 Rain Water Harvesting System

Rain water storage tank shall be constructed of GRP with multiple compartments, installed on the reinforced concrete plinth and equipped with float-less level switches, access hatch and necessary valves and fittings for reliable operation, maintenance and safety.

Preventive measure in case of rain water storage leak or burst shall be provided, such as the bund walls with the discharge pipe to the nearest surface drain.

The first flush device shall be provided to flush off the first water of a storm before it enters the storage tank, to eliminate particulates, bird droppings and other materials laying on the roof to keep stored water clean.

5.4 Foul Water and Waste Water System

5.4.1 Standards and References

All internal drainage to be designed and installed in accordance with, but not limited to:

Table 5.5: Standards and References

S/N	Requirements
1	SNI 03-3989-2000
2	SNI 7065-2005
3	PerGUB No. 69 /2013 Waste water quality standard for various industries and activities

5.4.2 Platform and Floor Drainage

All internal drainage is to be designed and installed in accordance with local authority requirements.

Floor drains shall be provided in concourses, platforms, plant rooms, equipment rooms and other areas requiring drainage. Waste water shall then be drained by gravity via a system of floor drains and down pipes leading to waste water manholes in the lowest level of the station.

Platform and floors shall be laid to slopes to permit the drainage of floor washing water, and collected in channels formed and laid to falls within the slab and connected to suitable outlets.

Minimum pipe gradient for all soil waste and waste pipe installation shall be 1:60 to achieve self-cleansing velocities. Any flatter gradient than 1:60 must be proven by the contractor prior to receiving consent.

The outlets of any floor drain shall be of a type to prevent the egress of dirt or any foreign substances.

Pavement drainage shall be based on a 5 year return period storm.

5.4.2.1 Roof drainage

Roof drainage of the above ground structures and entrances shall be designed and constructed to dissipate water from the roof by the most effective and direct route as possible.

Rain water gutter and outlets shall be provided to all flat roofs to ensure the water rise during flash storm does not exceed 30 mm.

The gutter shall be adequate to collect the rain water from the roof without any spillage.

The capacity of roof drainage shall be of adequate size to cope with maximum intensity of rainfall over a prolonged period and shall be calculated in accordance with the rainfall data recorded.

Rainwater pipes shall be of sufficient bore diameter and with easy bends to ensure no water hammer will occur.

Rain water pipes shall be fitted with screw-on rodding eyes at the base of the stack.

5.4.2.2 Foul Water Drainage

Foul water drainage shall be provided to collect and dispose foul water generated within the Station from sanitary fixtures. Separate gravity drainage system with down pipes shall be provided to collect the foul water from all the toilets of the station into the foul water treatment facility and foul water terminal manhole before discharging to the surface drainage.

Foul water treatment facility shall comply with the requirement of the local code and regulation for discharging to the surface drainage.

5.4.2.3 Foul Water Treatment (bio-septic tank)

Scope of works for the Foul Water Treatment shall be included procurement, construction, testing and commissioning hence the output quality achieves applicable general regulation and regulation from Indonesian Supervision of Environment Ministry (KLH).

The Procurement and construction of Foul water treatment shall be in one package with minimum capacity 45 m³ / day.

Spare parts and maintenance guarantee shall be included in contract.

Bio septic tank shall be designed with base assumption:

- Capacity : 45 m³ / day
- Influent BOD : 300 mg / l
- Influent SS : 200 mg / l
- As per BPLHD standards, minimum produce processed water quality shall:
- Effluent BOD: 20 mg / l
- Effluent SS: 30 mg / l

Prior ordering any plant/equipment, contractor shall liaise with the manufacturer and confirm installation details, specifically operational tolerances and clearance requirements for maintenance procedures.

Allowance shall be made for the final coordination of all mechanical, electrical, public health, structural architectural elements.

Water proofing within kerb enclosure of tap point is to be provided for engineer's acceptance.

The grating cover for floor trap/floor waste shall be stainless steel material to SS304 of min 3mm thick.

All floor traps/floor waste serving condensate water shall be insulated with approved material.

All subsequent horizontal piping up to vertical stack shall be insulated.

Check valve of single flap type should be approved in addition to a gate valve on the discharge main.

Access covers to sumps, drains shall be provided with hinge unless otherwise stated.

Necessary earthing to all metallic equipment/pipeworks need to meet all requirements of the Indonesia standard.

The design and construction of the sanitary and drainage system shall comply with the SNI.

Access opening shall be provided for the foul water and waste water system which is enclosed in the duct.

Connection to the existing public sewer shall be approved by the PDPAL before work commences.

All soil and waste pipes shall be routed below the floor slab.

All vent pipes shown on plan shall be routed at the ceiling. All branch vents shall be minimum 50mm diameter. All termination of vent stack at roof to c/w vent cowl.

All pipes material shall be of the following (minimum requirement), but not limited to:

- Vent: PVC-D (5 kg/cm²)
- Rain water vertical installation inside shaft/outdoor: PVC-AW (10kg/cm²)
- Sewage/waste water/kitchen drain vertical installation/ inside shaft : PVC – AW (10kg/cm²)
- Sewage/waste water from STP: PVC-VP JIS K-6741
- Horizontal installation sewage, waste water and rain water, underground and outdoor: PVC-VP JIS K-6741

In case of pipe works shall cross the vehicle road, contractors shall ensure the vehicle loads will not damage the pipe works crossing below it.

Vitrified clay pipe is to be used for connection between proposed last inspection chamber and manhole to main public sewer.

All hangers support, bracket anchors, bolt and nuts for pipes, trunkings, conduit trays equipment etc. shall be hot dipped galvanised to BS EN ISO 1461.

Grease interceptor shall be of epoxy coated fabricated steel with separate trap. A perforated aluminium alloy strainer shall be provided of sufficient length to reach over the water level so that the congealed grease maybe removed by the lifting out the strainer.

All inspection chambers and sump covers located within carparks and roads shall be of approved heavy duty type capable of withstanding vehicular load.

Branch drain lines are of minimum dia. 100mm max 10m in length to the inspection chamber, main drain lines are of minimum dia. 150mm, max 50m in length between inspection chambers and all within acceptable gradients.

All bends, turns, elbows, or any other appropriate location shall be fixed with cleaning eye for the proper cleaning of pipe.

All traps to soil and waste fittings shall be two pieces tubular construction with minimum of 50mm deep water seal. The joint between the waste outlet and the trap shall be made with pipe seal and rubber sealing washer.

5.5 Escalator

The contract includes; design, supply, delivery, installation and commissioning of the escalator system in elevated stations.

The escalator system shall comply with applicable Indonesian standards or alternative international standards reviewed without objection by the employer's representative.

5.5.1 General requirement

The contractor shall submit proposals based on the below to the engineer or employer's representative for review before any of the work is put in hand.

Operation constant speed under light to heavy load conditions in both directions (upward or downward); operation for a period of not less than 20 hours per day, seven days per week with an alternating passenger load of 100% contract load for two hours and 50% contract load for 18 hours; transit speed of handrail same as treads. Initiate local audible alarm as well as the visual and audible alarm in station office via building automation system for any unplanned stoppage of escalator such as operation of safety devices etc.

Switching: key operated "on/off" and reversing direction, control and emergency "stop" buttons located at each end of unit. Submit the drawings showing the location and arrangement of the key operated switches and emergency stop button to the employer's representative for review.

Contract load: each exposed step to carry a uniformly distribution load of 120 kg.

Initiate local audible alarm as well as the visual and audible alarm in station office via building automation system for any unplanned stoppage of escalator such as operation of safety devices etc.

Escalator design shall be suitable for outdoor –covered operation. The body and truss material and protection coating shall be designed to minimize dust/dirt accumulation. Motor enclosure shall be suitable for outdoor-covered application.

Noise level at landings resulting from operation of escalator at rated speed and no load condition at 1m from the newels is not more than 60 dba.

Electrical components: controller, switches, conduit and conductors: all cables reviewed without objection by the employer's representative to be of flame retardant, low smoke halogen free sheath (LSHF), copper conductor. Provide weatherproof socket outlets and lightings inside upper and lower landing/drive and tension stations.

Illumination for steps and landings shall be provided.

Safety devices shall be provided to cut off the supply to the driving motor and to apply the brakes to bring the escalators to rest in the following items, but not limited to:

- Over speed device: driven from main drive shaft and cause the escalator to stop if the speed of the escalator increases to 20% above the normal running speed.
- On-reversal device: prevent reversal of the running escalator from the pre-set direction of motion.
- Broken step chain device: provide to stop the escalator in case either one or both of the step chains break at any point. Detect also any abnormal movement of the step chain tension device in either direction.
- Broken step safety device: provide two mechanically operated broken step safety devices, one at each landing, at a suitable location corresponding to the braking distance to detect a broken step
- Handrail finger guard safety switch: at each entry point of the handrails into the balustrade to protect against any object tending to be jammed into the handrail inlet.
- Comb plate safety switch: fitted with a safety switch to stop the escalator in the event of any object becoming jammed in the comb plate.
- Motor protection safety device: provide protective device for each phase of the motor winding to protect against excessive current due to either overloading or short circuiting. It shall disconnect the power supply to the motor and stop the escalator. Reset the device manually after the fault has been rectified.
- Phase protection device: prevent the motors running in the event of phase failure.
- Emergency brake switch: mechanically operated; detect the operation of the emergency brake and to isolate the power supply to the main motor if actuated.
- Earth leakage protection device: detect any earth leakage current and isolate the power supply to the main motor if actuated.

Contractor shall ensure that escalator pit shall be above the flood level

Prior to ordering any equipment, Contractor shall liaise with the manufacturer and confirm installation details, especially operational tolerances and clearance requirements for maintenance procedures.

5.6 Lift

5.6.1 Standard and Regulations

Table 5.6: Standards and Regulations

S/N	Requirements
1	SNI 03 – 6573 -2001 : Design Requirement of Vertical Transportation in Building

S/N	Requirements
2	PerDa DKI NO.7 /1991 Buildings in DKI, Transportation installation in Buildings
3	PerDa DKI No. 3/ 1992 Fire Lift Operation and Fire Rating.
4	PerMen PU No. 26/2008 Technical Requirements of Fire Protection System in Building and Environment
5	PerMenNaKer No. 03/ 1999 Requirement of Health and Safety of Lift for People Transportation

The contractor's responsibilities shall include but shall not be limited to; design, supply, deliver, install and commission machine-room-less type traction lifts in the all elevated stations and the depot.

Electric lift system shall be of gearless type for machine-room-less type traction machine with typical speed of 1m/s.

The design of the lift shall be suitable for use by the disable with minimum door opening 1000 mm (2 doors centre opening) and minimum cage area of 2.0 m2.

The escalator system shall comply with applicable Indonesian standards or alternative international standards reviewed without objection by the employer's representative.

All cables reviewed without objection by the employer's representative to be of fire rated for minimum 1 hour, low smoke halogen free sheath (LSHF), copper conductor. Provide weatherproof socket outlets and lightings inside upper and lower landing/drive and tension stations.

Lift cage, shaft and doors shall be 1 hour fire rated

Safety device in case of fire shall be provided:

- Automatic rescue device for power failure
- Car emergency lighting
- Overload detection system

Lift pit location shall be above the flood level

Dry sump pit of 400x 400 x400 mm c/w sensor shall be provided in the lift pit.

Lift design shall be suitable for outdoor-covered operation. Protection coating shall be designed to minimize dust/dirt accumulation. Motor enclosure shall be suitable for outdoor-covered application.

Prior to ordering any equipment, Contractor shall liaise with the manufacturer and confirm installation details, especially operational tolerances and clearance requirements for maintenance procedures.

6 Electrical Building Services

6.1 General

6.1.1 Standard and Codes

The LV electrical distribution system as well as the diesel generator shall take reference from below but not be limited to the following Standards.

Table 6.1: Standards and Regulations

S/N	Requirements
1	PM 29 Tahun 2011 Transportation Ministerial Regulation on Technical Requirement of Train Station Building
2	PM 24 Tahun 2015 Transportation Ministerial Regulation on Safety Standard of Railway System
3	SNI 0225 General Requirement of Electrical Installation
4	SNI 04-7018 Emergency and Standby Power System
5	SNI 04-7019 Stored Electrical Energy Emergency and Standby Power System
6	SNI 03-6575 Design Guideline on Building Artificial Lighting
7	SNI 03-6574 Design Guideline on Building Emergency Lighting , Signage and Emergency Warning System
8	SNI 03-3985 Standard Method on design, installation, and testing of building fire alarm and detection system
9	IEC 60364 Electrical Installation of Buildings
10	IEC 62305 Protection Against Lightning
11	IEC 60076 Power Transformers
12	IEC 60502 Power Cables With Extruded Insulation and Their Accessories for Rated Voltages from 1 kV ($U_m = 1,2 \text{ kV}$) up to 30 kV ($U_m = 36 \text{ kV}$)
13	IEC 62271 High-voltage switchgear and Controlgear
14	IEC 60947 Low-Voltage Switchgear and Controlgear
15	IEC 60439 Low-Voltage Switchgear and Controlgear Assemblies

6.2 Functional Requirement

6.2.1 LV Panels

6.2.1.1 LV Switchgear and MCC

The switchgear shall be type tested, withdrawable and arc flash proof panels, with minimum form of 3B type construction segregation and enclosure thickness of 2 mm.

The feeders shall be equipped with programmable relay module which provide protections of but not limited to over/under current, over/under voltage, earth fault, and phase sequence.

Motorized interlocking feeders which determine the supply power to the station building shall be controlled and monitored via BAS automation system.

The measurement device mounted in the door of the panel shall be well designed in accordance to the electrical parameter range, required in the particular feeder.

The measurement device shall be in digital type, and capable to transmit the parameter data to the automation system. i.e. BAS and/or SCADA.

The LV switchgear shall be designed for these minimum ratings, but not be limited to the following:

- a. Nominal voltage: 380V \pm 5%
- b. Number of phases: 3
- c. Ambient temperature 35°C
- d. Dielectric withstands test voltage:
 - Power circuit 2.5 kV for 1 minute
 - Control circuit 1 kV for 1 minute
- e. Rated frequency: 50 Hz
- f. Busbar material Copper
- g. IP rating:
 - h. Indoor IP 31
 - i. Outdoor IP 54

Selection of common motor starter feeder (exclude firefighting panel) would be as follows:

- a. Motor starter up to 3 kW DOL
- b. Motor starter above 3 kW up to 11 kW Star-Delta
- c. Motor starts above 11 kW Soft starters
- d. Motor starter for special adjustable speed Variable frequency Drive

The starter feeders shall be designed as modular type of starter, as per manufacturer standard. The motor contactors have to be equipped with proper numbers of NO and NC auxiliary contacts to provide proper control circuit to BAS and/or SCADA system.

Control switches, push buttons, indicating lamps, meters and relays shall be mounted on the front door. Current Transformers (CTs) and Voltage Transformers (VTs) shall be mounted on the fixed portion.

Rotary type operating handle of ACB and MCCB shall be provided in the panel door and should have clear position indication ON/OFF/TRIP. This handle has to be equipped with padlocking facility in order to implement the LOTO work procedure.

All wirings inside the switchgear shall be carried out with 600V/1000 Volt grade FRLS PVC insulated flexible stranded copper wires. Minimum size of conductor for control wiring shall be 2.5 mm² Copper.

An earth bus extending throughout the length of the Switch-board / PCC / MCC/ PMCC / DBs / APFCR Panel shall be provided.

The mushroom type of emergency push button shall be provided in the door of the feeder panel.

An earth bus extending throughout the length of the Switch-board / PCC / MCC/ PMCC / DBs /PFCR Panel shall be provided

6.2.1.2 Lighting panel / Distribution boards / Junction Box / LCS

Distribution boards shall be surface mounted consisting of a sheet steel case, and equipped with hot dip galvanized steel for its supporting mounting bracket.

The internal conductor shall be made from copper busbar, and this includes to the internal mcb connections as well.

The case shall be soundly constructed of sheet metal of not less than 1.5 mm thickness with a hinged door hung by means of internally fixed hinges to avoid the door sagging when opened.

A table stating the circuit served under each number and the MCB rating shall be fitted inside each case. The table shall be printed on durable material in such manner as to be permanently legible.

Proper size of terminal blocks shall be use to connect a wire to another.

The requirement of IP rating shall be in accordance to LV switchgear specification.

Control switches, push buttons, indicating lamps, and meters shall be mounted on the front door.

6.3 Transformer

6.3.1 20 kV/ 380 V distribution transformers

The 20 kV/ 380 V distribution transformers shall be oil immersed type on-load tap-changing, indoor or outdoor type (according to the installation location) with the following minimum ratings and requirements.

a.	High voltage winding	20 kV
b.	Low voltage winding	380 – 220 V
c.	Number of phase	3 phase – 4 wire method
d.	Rated frequency	50 Hz
e.	Cooling type	ONAN
f.	Of load tap changing equipment	± 8 tapping position, 1.25% each
g.	Connection designation	Dyn 11
h.	Lightning impulse withstand voltage:	
	High voltage winding	125 kVp
i.	Power frequency withstand voltage for 1 minute	
	High voltage winding	50 kV

Termination box shall be provided in the primary and secondary side of the transformer, suitable for busduct or multi cable termination method.

Neutral grounding method shall be according to the standard of national grid (SPLN) and SNI.

6.4 Cables

6.4.1 General

All cables shall be sized to carry the continuous current required by the specification and shall be based on the Contractor's calculations. The cables shall be able to withstand the short circuit currents inherent in the Contractor's design.

The ratings applied to any cable shall be determined by the most onerous installation condition in any cable route.

The cables required for firefighting and emergency system shall be fire resistant type, and comply with the Indonesian standard or appropriate international standard approved by the employer.

The cables required for common essential loads shall be flame retardant type, and comply with Indonesian standard or appropriate international standard approved by the employer.

6.4.2 Medium and Low Voltage Cables

Cables for medium voltage distribution

- Cables shall comply with IEC 60502, SPLN or equivalent equal.
- Cables for 20kV between equipment shall be provided with three cores and stranded copper conductor in trefoil formation sized to suit the power supply design and to satisfy short circuit current requirements.

Cables for low voltage distribution

- Cables shall comply with IEC 60502, SPLN or equivalent equal.
- Cables for LV distribution shall be provided with multicores and/or single core, heavy weather and rodent proof, and sized to suit the power supply design and to satisfy short circuit current requirements.
- The consideration of metal armor requirement shall take place whenever direct buried installation method is required.
- The insulation shall be extruded cross linked polyethylene with suitable outer sheath according to the application area.

6.4.3 Cable Support Equipment

All cable support equipment shall be protected from corrosion by means of hot dip galvanized protection method.

All cable support equipment shall be certified as per applicable local and international standard to carry the weight of power cables properly.

The maximum allowed span between steel support/bracket shall be in accordance to the manufacturer installation manual.

The maximum cables that can be fit into the cable support equipment shall refer to the applicable local and international standard.

The clearance between cable trays, from the cover of bottom trays to the base of top trays, shall be minimum 40 cm.

The 20% future spare capacity of electrical power supply shall be also considered to define the size and/or numbers of cable support equipment.

Every part of metallic cable support equipment shall be bonded in accordance to the applicable standard.

6.5 Uninterruptible Power Supply (UPS) System

The UPS unit shall be sized to power its full connected load for two hours. A UPS distribution board shall enable this period to be extended for selected loads.

The UPS shall include a rectifier/charger section, inverter section, a static by-pass switch, a manual by-pass switch, battery and all necessary control.

The UPS shall be provided in a single cabinet complete with control switches and meter. Its audible noise level shall not exceed 55 dBA at 1.5m in the front panel, over a load range 10% to 100% full load.

The battery shall consist of sealed lead-acid cells, thus obviating the specific need for flameproof equipment in the electrical supply room.

The UPS shall have a minimum degree of protection of IP31 in accordance with IEC 60529.

The UPS shall be designed for these minimum ratings, but not be limited to the following:

- Input voltage 380 V or 220 V, $\pm 10\%$
- Output kVA As per contractor design
- Output frequency 50 Hz $\pm 5\%$
- Output voltage 380/220 V $\pm 1\%$ TPN
- Output frequency 50 Hz $\pm 0.1\%$
- Distortion factor with linear load less than 5%
- Power factor 0.9 to 0.95
- THD Less than 1% with linear load and less than 5% with non-linear load

The UPS shall be of the solid state type with manual and solid state bypass switches and shall be complete with incoming T.P.&N. mains isolator, input and output ammeters, voltmeters and frequency meters, power on indication and fault indication.

The operation shall be fully automatic with all key elements being monitored and alarms generated. A control and monitoring panel shall be capable of displaying various system parameter, alarm indications and fault diagnostic information.

The UPS shall be fitted with a manually operated make before break mechanical by-pass system. The batteries shall be fitted with a circuit breaker.

6.6 Lighting System

The station lighting shall be controlled by the lighting control system (part of the BMS) with manual override facility provided in the station control room.

The type and quality of fittings and their luminous intensity shall relate to the space being illuminated and shall take into account the effect of the architectural color scheme, the lamp life; lamp correlated color temperature and maintainability of light fittings.

Light levels shall be uniformly distributed throughout the station and shall be designed such that glare, dark recesses and areas of poor lighting levels are avoided.

The lux level in all area shall comply with Indonesian standard or appropriate international standard approved by the owner. The emergency and escape route lighting system shall be designed in accordance with the requirements of the fire department and approved SNI standard.

Where necessary, accent lighting for functional highlighting or decorative purposes shall be used.

Escalators and stairways shall be well illuminated.

Concourse and ticket halls areas require a reduced level of lighting except at the ticket machines, automatic fare collection (AFC) gates and tops and bottoms of escalators and stairs.

The lighting intensity at platform level shall be compatible with that of the train car, reducing in intensity at platform ends, particularly the leading end, thus reducing glare to the driver on entering the station. Lighting shall provide a continuous run adjacent to the platform such that the threshold of the platform edge is well illuminated.

Lighting design and the selection of light sources shall consider efficacy, correlated color temperature, lamp life, maintenance and re-lamping of the installation.

1. Incandescent

Not used.

2. Tungsten Halogen

Only 12 Volt quartz tungsten halogen lamps of life span in excess of 5000 hours and correlated color temperature of 3000 Kelvins or higher shall be specified. Main voltage tungsten halogen lamps may only be used where 12 V lamps are considered unsuitable.

3. Linear Fluorescent

To reduce the complexity of operations, only 26-mm lamps with lamp life more than 10,000 hours correlated color temperature of 4000 Kelvins and a color rendering index of 80 or better shall be specified. 1200 mm shall be used as standard length of lamps throughout the project.

4. Compact Fluorescent

Only lamps with correlated color temperature of 4000 Kelvin and a color rendering index of 80 or better shall be specified. To ensure uniformity of lamp type to optimize operational effort, compact fluorescent lamps shall be used only when more than one hundred lamps of the same type are selected for a single station site.

5. Metal Halide

Metal halide lamps of correlated color temperature of 4000 Kelvin or higher and color rendering index of 80 or better for lamps below 400 Watts shall be used. A color rendering index of greater than 65 shall be specified for lamps 400 Watts or more.

6. High Pressure Mercury

High pressure mercury lamps of correlated color temperature of 4000 Kelvin and color rendering index of 42 or better shall be used. Lamps with integral control gears shall not be used.

7. High Pressure Sodium (SON)

Standard SON may only be used for exterior amenity lighting and parking facilities. Improved color SON with correlated color temperature of above 2000 Kelvin and color rendering index of 65 shall be specified. White SON shall not be used.

8. Low Pressure Sodium (SOX)

SOX shall not be used in the stations are associated facilities.

9. Neon and Cold Cathode

Neon and cold cathode lighting shall only be used for decorative purposes.

10. Fiber Optic and LED

Fiber optic and LED shall be used for special locations.

6.7 Building Automation System

The Building Automation System shall be reliable to control and be capable of monitoring loads in the station. The redundancy of the BAS system shall be considered in order to minimize the possibility of an automation system failure.

The BAS system topology shall be hierarchical in structure. Each level within the hierarchy shall be capable of functioning autonomously and shall be operated independently. The system shall be divided into the following 3 levels:

1. The management level

Industrial grade workstation with BAS software, for graphic-based operation, data storage and reporting shall be provided.

Centralized operator's workstation shall facilitate but shall not be limited to:

- General view of activities
- Password protected access/ viewing of information
- Password protected control
- Password protected acknowledgements to identify the authority
- Data on alarms
- Annunciations
- Customized reports
- Generated data security towards modification
- Software addressable flexibility
- Modularity & future extension

2. The communication level

An Information bus/communication network shall facilitate transfer of data between the workstation or the field controllers through a network system.

3. The processing level

Typical BAS shall be designed on a LAN system, where in all intelligent controllers are connected to either master controller or to workstation to provide easy access to data through Dynamic Data Access System.

The System shall keep a close watch on room conditions and alert the operator to a rising temperature, before the room occupant becomes aware of the problem.

1. Run time Maintenance

The manufacturers of major equipment specify preventive maintenance to be done each time the equipment has run a certain number of hours. The BAS shall monitor the running-time of the system/equipment and alert the operator, and then preventive maintenance can be scheduled accordingly.

2. Performance Monitoring

Equipment performance shall be monitored to ensure that the building is being run as efficiently as possible. Historical data for major equipment item in the system shall be collected and to present this information presented graphically.

3. User Friendliness

The BAS system shall allow the technician to plug into the system in any location where equipment is controlled, using a hand-held device and permit to access all the information in the network including historical data. It shall also allow the technician to change operating parameters for testing.

4. Availability

The BAS system shall have unavailability not less than 99.99%. The Contractor shall demonstrate that BAS meet the availability criteria, or that the system availability is as high as reasonably practicable, and that no further cost-effective means of improving reliability can be identified.

6.8 Fire Detection and Alarms

1. Each station shall be protected by means of automatic and addressable fire alarm system which shall form part of integrated fire detection and protection system having particular emphasis on passenger and operation safety.
2. Fire detection and alarms system shall be carried out in accordance with the Indonesian standards or appropriate international standard approved by owner.
3. The fire detection and alarm system shall include but shall not be limited to:
 - a. Main station fire alarm panel
 - b. Fire detectors
 - c. Manual call point
 - d. Alarm bell
 - e. Alarm lights
 - f. Telephone
 - g. Receiving and sending signal to other fire system and equipment including fire pumps, gas flooding system and fire shutters etc.
 - h. Emergency signage including exit and directional signs
4. The response to alarms from various combinations of the detectors, flow switches or manual call points shall, via the dedicated microprocessor, initiate performance of such other functions as may be required. Such functions shall include but shall not be limited to:
 - Alert station staff.
 - Alert line controller.
 - Initiate operation of fire suppression equipment.
 - Initiate operation of automatic public address system message
 - which will be provided by the Interfacing Contractor(s).
 - Initiate operation of Passenger Information Display System
 - which will be provided by the Interfacing Contractor(s)
 - Release smoke stop doors held open.
 - Allow any emergency exit fastenings to open on transmission of the evacuation signal.
 - Initiate illumination of the station no entry signs, on transmission of the evacuation signal (via the BAS).
 - Initiate closure of fire shutters
 - Initiate operation of fire dampers
 - Initiate ECS equipment shut down
 - Initiate Elevator and Escalator fire mode operation

6.9 Substation Earthing, Bonding and Lightning Protection System

1. The earth mats for the substation and including other structures shall be provided in accordance to IEEE 80 standard.
2. External conductive metal part such as water pipes, ducting and exposed metallic part of the station structures shall be bonded to equipotential zone of the electrical system.
3. External and/or internal lightning protection system shall be carried out in accordance to the risk assessment and design requirement of IEC 62305 and the updated SNI standard.

4. The lightning protection shall convey the lightning discharges to earth without electrification of the structure.
5. Concrete structures shall employ roof tapes (air tapes) while steel structures may use the structural steelwork frame as a collector and as a down conductor system. Vertical finials over 400mm will not be required.
6. The earthing inspection pits shall be made from concrete and equipped with concrete covers.
7. Where aluminum tapes are employed great care shall be exercised in protecting the system components from electrolytic corrosion due to dissimilar metals being in contact with each other. Special bi-metallic connectors shall be employed at junctions of copper and aluminum conductors.
8. Copper air and down conductor tapes shall be PVC sheathed.

6.10 Platform Touch Voltage Protection

6.10.1 General

1. The Contractor shall design and detail an effective platform insulation system to prevent passengers on the platform from possible electric shocks caused by touch voltage when boarding/alighting or touching the train or when touching the Platform Screen Doors (PSDs).
2. A “protection zone” by the platform edge areas adjacent to the tracks shall be electrically isolated (for example, from the station structure/electrical earth, or from traction earth, etc.). All appurtenances and the finishes to all structures (including floors, walls and columns) that fall within the protection zone shall be electrically isolated from earth, or provided with a suitable insulated coating, to avoid harmful touch potentials.
3. The extent of the protection zone shall be :
 - Vertically, between the top of platform structural slab level and a minimum 2.5 meters above platform finished floor level.
 - Transversely, from the platform edge to a minimum distance of 1.8 meters into the platform from any part of the inner face of the platform screen doors (PSDs) assembly, and from any metallic clad platform edge column,
 - Longitudinally, for the full length of the PSD assembly to encompass anywhere that is within 1.8 meters of the PSD assembly. In situation where the end return door, in the swing open position is within the PSD protection zone, the protection zone shall be extended a further 1.8m beyond the end return door.
4. The finishes to the platform between the platform edge and the remote side of the protection zone shall be fully electrically insulated from the structural slab below, and from all adjacent finishes and/or structures at the boundaries of the protection zone.
5. All cladding, including vitreous enamel, on walls or columns shall use electrically insulated fixings. Skirtings around walls or columns that fall within the protection zone shall also be isolated.
6. Insulated breaks in the finishes shall be provided at the boundaries of the protection zone to ensure that the isolated areas are not earthed to the non-isolated areas.
7. Metallic handrails that run along the platform edge in the buffer areas and which fall within the protection zone shall have an insulated finish.

6.10.2 Minimum insulation level

- a. A minimum platform floor to earth resistance of 10,000 and 35,000 ohm over a 300 x 300 mm area at 250V DC under damp and dry conditions respectively.
- b. A metallic finishes (e.g. handrails, metallic cladding, etc.) to earth resistance of 50,000 ohm at 500V DC under damp condition.
- c. A minimum resistance of 0.25M-ohm between PSD and Earth.

6.11 Emergency Generator**6.11.1 General**

The emergency generators shall be designed for these minimum requirements, but not be limited to the following:

1. Emergency generators shall be enclosed type diesel generators.
2. Emergency generators shall be of 380-220V AC rating and for using to 3 phases 4 wires system.
3. The Contractor shall determine the actual capacity of the emergency generators to cater for the starting and running of the equipment according to the operational scenarios as specified.
4. The emergency generators equipment shall be completed with fuel storage facilities and shall be capable of providing the specified performance continuously for a minimum of 8 hours, without the requirement for inspection and attention.
5. The emergency generators equipment shall be capable of withstanding a sudden short circuit at the emergency generator terminals, whilst operating at rated load and maximum working temperature without any damage.
6. The emergency generators equipment shall also capable of withstanding maximum over-speed without any damage.
7. The emergency generators and excitors shall be of the totally enclosed, brushless type, and shall comply with the requirements of applicable SNI or IEC 60034.
8. The line and neutral phase ends shall be brought out to separate terminal boxes.
9. The emergency generators and excitors winding insulation shall conform as a minimum to temperature "Class F" in accordance with IEC 60034.
10. All necessary metering instruments, current and voltage transformers for protection, control and metering shall be provided.
11. The emergency generators shall be complete with noise control facilities complying with applicable SNI and with the environmental requirements for noise pollution.

6.11.2 Protection and Monitoring

1. Protection shall be provided to trip the emergency generators in the event of rectifier failure.
2. The automatic voltage regulator shall be easily adjustable, for setting the reference voltage, gain and damping. The devices enabling adjustment shall not be mounted directly on the emergency generator, but in separate control cubicle.
3. The automatic voltage regulators shall be responsive to the three phase terminal voltage. Circuits shall be provided to detect malfunction of the automatic voltage regulator and trip the emergency generator.

4. The necessary voltage transformer, arranged in single phase units, shall be provided and shall be used exclusively for the regulator.
5. Anti-condensation heaters shall be provided in the emergency generator and exciter units.
6. Emergency power supply shall be controlled and monitored both remotely and locally. The Contractor shall provide local control panel with changeover switch, permitting local control or remote control. The control panel shall include all necessary control and monitoring devices, all protection system, all metering devices, and interface with BAS and/or SCADA to enable remote control and monitoring.
7. An auxiliary power supply shall be provided by means of appropriately sized battery to enable starting of the generator.
8. After starting, the auxiliary power supply shall then be connected to the output of the emergency generator.

6.12 Performance Requirement

1. Complete system studies shall be carried out, include but not limited to :
 - Load flow analysis with complete energize and de-energize configurations in accordance to the high, medium, low voltage distribution system and genset operation mode.
 - Short circuit, cable and busbar sizing, and voltage drop calculation.
 - Motor starting and transient study
 - AC and DC harmonic study
 - Protection relay setting coordination study
 - Earthing and lightning protection system study
2. Design life of the power equipment shall be for 30 years.
3. The permissible operating low voltage distribution shall be in the zone between minimum -5% of operation voltage and maximum +5% of operation voltage in accordance with SPLN.
4. Fast (less than 20 seconds) response of backup genset operation mode.
5. The variation of equipment sizing, rating, type, brand and the spare parts shall be maintained in accordance to interchangeable requirement

7 Trackwork

7.1 Standards

Table 7.1: Standards for Trackwork

Pos	Requirements
1	EN 13674 Rail Applications - Track - Rail Part 1
2	BS EN 15227 category C-IV
3	EN 13230-1, 2
4	EN 13481-2
5	ASME RT-1

Table 7.2: Functional Requirements

Pos	Requirements
	Track requirements are as follows:
1	<ul style="list-style-type: none"> • Gauge: 1435mm • Rail profile: 54E1 • Rail inclination: 1:40 • Track: slab track, top-down system • Design axle load: 12 tonnes • Design speed: 80 km/h • Minimum radius of curve at main line: 60m • Minimum radius of curve at depot: 40m
2	The concrete track bed shall consist of a pre-stressed mono-block or bi-block sleepers embedded into the reinforced concrete slab. This entire system shall be a so called top-down system: rails and sleepers to be adjusted and aligned before the slab concrete is casted. Alternatively a plinth system can be proposed.
3	<p>Rail</p> <p>3.1 All rail shall be new, standard 54E1 section control cooled carbon steel rail, manufactured and tested in accordance with the current EN 13674 Rail Applications - Track - Rail Part 1.</p> <p>3.2 Standard rail shall be of Grade 900A in accordance with UIC 860-0 with a minimum hardness of 300HB. Wear resisting rail shall be of at least Grade 1080 in accordance with UIC 860-0 with a minimum hardness of 320 HB. All rail shall be ultrasonically tested for internal imperfections.</p> <p>3.3 Millscale shall be removed according to the quoted standards (including, but not limited to UIC 860-0). Rail grinding such that the rail is in compliance to the EN 13674 standard shall be the Contractor's responsibility. Additionally, all rails on main line shall be ground to conform to 54E1 profile.</p> <p>3.4 All track is to be laid as continuous welded rail (CWR). In order to minimise the number of welds the rail shall be supplied in nominal 24 metre lengths and shall be furnished with blank ends.</p> <p>3.5 Rails shall be joined by means of flash butt welding into strings not exceeding 500 metres in length.</p> <p>3.6 All CWR track shall be laid to zero thermal stress. The maximum ambient temperature range in the Jakarta area varies between 15 and 40 degrees Centigrad. Based on this ambient temperature range, the rail temperature is anticipated to vary between 15 and 60°C and the nominal zero thermal stress range for the tracks shall be 35°C plus or minus 5 degrees.</p> <p>The maximum CWR forces shall be calculated using the following formula:</p> $N_t = E A \alpha T \times 1/9810, \text{ where:}$ <p>3.7</p> <p>E = Young's modulus in N/mm²; 2.1 x 10⁵.</p> <p>A = Area of the rail cross-section in mm²; 6977 for</p>

Pos	Requirements
	<p>54E1 rail.</p> <p>α = Coefficient of linear thermal expansion of steel in $^{\circ}\text{C-1}$; 1.18×10^{-5}.</p> <p>T = Maximum temperature differential in $^{\circ}\text{C}$.</p> <p>Nt = Maximum CWR forces in tonnes.</p>
	<p>Gap between CWR strings for anchoring to zero thermal stress shall be determined by using the following formula:</p> $G = (T_a - T_o) L \alpha + Q, \text{ where:}$ <p>G = Rail gap in metres.</p> <p>T_a = Actual rail temperature in $^{\circ}\text{C}$.</p> <p>T_o = Optimum anchoring temperature in $^{\circ}\text{C}$ (zero thermal stress).</p> <p>L = Length of unanchored rail in metres.</p> <p>α = Coefficient of thermal expansion $^{\circ}\text{C-1}$; 1.18×10^{-5}.</p> <p>Q = Rail gap prescribed for alumino-thermic welds.</p>
3.8	<p>Rail to be used in curves of 200 metre radius or less shall be pre-curved using industry accepted hydraulic press method or the standard roller bending method, and shall not be flash butt welded. Pre-curved rails shall be joined by means of alumino-thermic welding.</p>
4	<h4>Fastening System</h4> <p>Rail fastening system for slab track fit for 54E1 rail shall provide fixing, guidance, inclination, resilience and electrical isolation.</p> <p>Fastening system shall have a successful proven service of at least 5 years, with 25MGT/year, design axle load of 12 tonnes and design speed of 80km/h.</p> <p>Fastening system shall consist of spring steel clips, resilient rail pad, lateral adjustability, vertical adjustability by shimming plates and a minimum of two anchor bolts.</p> <p>To provide and to ensure a rail inclination of 1:40 (also when vehicle stands or passes the track);</p> <p>Fastening to be capable to adjust the rail lateral and vertical position by means of exchanging components;</p> <p>Contractor to define the stiffness of fastening system after considering passenger's comfort, vehicle characteristics, alignment, civil structures, noise and vibration, etc.</p> <p>Contractor shall determine longitudinal creep resistance of the track at each part of the project according to the local conditions (including the slope within the depot)</p> <p>Electrical insulation to be provided at least by two layers: rail – fastening and fastening – sleepers/(concrete)</p> <p>Rail insulation shall be provided in the fasteners by insulation which has hard surfaces and is orientated such that the surfaces are horizontal and be readily cleaned by use of high pressure jets.</p> <p>Rail shall be insulated from fastening system and slab:</p> <ul style="list-style-type: none"> • Track (2 rails) new, as constructed: $0.01\Omega/\text{stkm}$ ($100\Omega - \text{stkm}$); • Track (2 rails) during open operation $0.05\Omega/\text{stkm}$ ($20\Omega - \text{stkm}$); <p>A spacing of minimum 50mm shall be reserved between rail bottom and slab surface.</p> <p>In the vicinity of Insulated Rail Joints the same fastening shall be used.</p> <p>Fastening system shall be tested according to EN 13146.</p> <p>Fastening system shall allow an individual to install or to exchange the assembly with manual tools.</p> <p>Fastening system shall have stops or distinguishable marks indicating the correct location where the clips are to</p>

Pos	Requirements
	be positioned after installation.
4	<p>Sleeper</p> <p>4.1 Sleepers in the concrete slab track shall be pre-stressed mono-block or bi-block type. Alternatively a plinth system can be proposed for approval.</p> <p>4.2 Sleepers (or other prefabricated elements) to be provided with cast-in inserts for fastening system (and conductor rail bracket insert).</p> <p>4.3 To provide and to ensure a gauge precision of 1435mm, +0/-3mm;</p> <p>4.4 Sleepers shall be designed, produced and tested according to EN 13230-1, EN 13230-2 and 13481-2 (5.10)</p> <p>4.5 The compression strength of a cylinder specimen of 28 days concrete age shall reach at least 49 N/mm² (500 kgf/cm²).</p> <p>In the sleeper shall be the following be casted:</p> <ul style="list-style-type: none"> • Manufacturer; • Year of production; • Mold serial number; • Other related marks.
5	<p>Concrete trackbed</p> <p>5.1 The concrete track bed shall consist of a pre-stressed mono-block or bi-block sleepers embedded into a reinforced concrete slab. Alternatively a plinth system can be proposed.</p> <p>5.2 Slab track to a top-down construction: rails and sleepers to adjusted and aligned before the slab concrete is cast. Applied slab track construction to be a proven system on other international MRT and/or LRT systems.</p> <p>5.3 Relative displacement, both longitudinal and lateral, and separation between slab and viaduct shall be prevented.</p> <p>The diameter, material type and length of the connection (re)bar in the viaduct connecting the in-situ concrete track slab and viaduct deck shall be designed such that all transverse and longitudinal loads are transferred to the viaduct structure by the shear dowels alone, i.e. the grout bed shall be assumed to offer no lateral or longitudinal resistance.</p> <p>The track and all its components shall have no water accumulation within 50mm vertically of the rail foot and shall be readily self-draining. Drainage of the slab shall be consistent with the drainage of the viaduct. The concrete trackbed shall be designed to be discontinuous along its length to accommodate transverse drainage, and cable transitions from one side of the guideway/track to the other. The width of these trenches will normally be between 100mm and 200mm.</p> <p>5.6 Actual length of slab units will be dependent on the design length of viaduct segments.</p> <p>5.7 The finished surface of the concrete trackbed shall be designed to be parallel to the cross level of the rails.</p> <p>5.8 Trackbed shall have a casted concrete derailment wall at both sides of the slab. The wall locally gapped at conductor rail support.</p> <p>5.9 The concrete material to cast the in-situ concrete track slabs shall have a concrete compressive strength at 28 days of ≥ 350kg/cm².</p> <p>5.10 The slab shall contain a stray current collecting system</p>
6	<p>Additional trackforms</p> <p>6.1 Certain areas within the depot with specific functions shall have special trackforms.</p> <p>6.2 Embedded track</p> <p>To be applied at:</p> <p>6.2.1</p> <ul style="list-style-type: none"> • the automated and manual washing plants; • all single tracks in the workshop (with exception of the tracks in recess area); • there where tracks are intersecting the road.

Pos	Requirements
6.2.3	Trough providing sufficient space for resilience and insulation requirements;
6.2.4	To fix 54E1 rail and provide bracing, guide, resilience and electrical insulation;
6.2.5	To provide and to ensure a gauge precision of 1435mm, +0/-3mm (also when vehicle stands or passes the track);
6.2.6	To provide and to ensure a rail inclination of 1:40 (also when vehicle stands or passes the track);
6.2.7	To withstand an axle load of at least 12 tonnes;
6.2.8	Resilience of the embedded track shall have at least the same values as the mainline trackform.
6.2.9	Electrical insulation of the embedded track shall have at least the same values as the mainline trackform;
6.2.10	Successful proven service of at least 5 years;
6.2.11	Embedded track to be provide with water drainage in the trough.
6.3	Track on stilts
6.3.1	To be applied at the recess area.
6.3.2	Stilts consist of galvanised HEB 200 profiles, length approximately 700mm.
6.3.3	To fix 54E1 rail and provide bracing, guide, resilience and electrical insulation;
6.3.4	To provide and to ensure a gauge precision of 1435mm, +0/-3mm (also when vehicle stands or passes the track);
6.3.5	To provide and to ensure a rail inclination of 1:40 (also when vehicle stands or passes the track);
6.3.6	To withstand an axle load of at least 12 tonnes;
6.3.7	Resilience of the embedded track shall have at least the same values as the mainline trackform.
6.3.8	Electrical insulation of the embedded track shall have at least the same values as the mainline trackform;
6.3.9	Successful proven service of at least 5 years.
7	Alumino-thermic welding material
7.1	The 500 metre long rail segments are to be alumina-thermic welded on site. Also the pre-curved rails shall be joined by means of alumino-thermic welding.
7.2	The resistance across the alumina-thermic weld shall not exceed $200\mu\Omega$ upon installation.
7.3	Alumino-thermic welding to be suitable for welding between rails of grade which include 900 (or R260), 900HH, 1100 (or R320Cr);
7.4	Alumino-thermic welding to meet requirement of slowly-bending testing ASTM E290;
7.5	Alumino-thermic welding to achieve strength of 1150kN;
7.6	Alumino-thermic welding to be used between various long rails;
7.7	Alumino-thermic welding to be used between long rails and turnouts;
7.8	Grinding of all welds to be to allowable flatness
7.9	Pass magnetic particle inclusion testing and ultrasonic testing
7.10	Pass X-ray examination
7.11	Pass macro-etching examination
8	Insulated Rail Joint (IRJ)
8.1	Prefabricated IRJs shall be installed at track and turnouts where necessary for track circuit integrity.
8.2	The entire assembly of a prefabricated IRJs shall have a minimum length of 9 metres (each rail consisting of a minimum of 4.5 metres).
8.3	The IRJ includes two fish plates, six bolts, insulation material, washers and grafting material and shall be of a polyurethane construction, bonded type and shall be resistant to parting from the rail ends subject to water ingress, varying temperature and rail movement;
8.4	IRJ to fit rail type 54E1 grade 900;

Pos	Requirements
8.5	IRJs shall be designed to withstand a permanent voltage of 120V DC across the joint;
8.6	All Insulated Rail Joints and its components shall be manufactured from new materials and comply with the current valid UIC, EN, AREMA standards and other relevant national standards.
8.7	Insulation joints shall be tested fully according to regulations in AREMA chapter 4 - part 2 - 2.11;
8.8	In case conditions do not allow the use of prefabricated IRJs, in-situ IRJs may be used. Spacing between an in-situ IRJ and adjacent weld shall not be less than 1.5 metres.
9	Rail Expansion Joint
9.1	The Contractor shall determine whether rail expansion need to be applied. If rail expansion joints are to be applied they shall fulfil the following requirements.
9.2	The rails shall comprise two half set of switches, which in turn shall consist of one stock rail made from the standard rail section 54E1 and one flexing point tongue rail, fully made from the asymmetrical tongue rail profile 54E1-A1, according to EN 13674-2, with a homogeneously forged long transition area to rail profile 54E1.
9.3	The set of base plates shall contain all standard and special base plates, the rail fastening components and the fastening components for the fixation of the base plates to the sleepers, which are necessary to support the rails on all sleeper positions within the rail expansion joint. The base plate bodies shall be made of rolled sheet steel, forged steel or cast iron. The base plates of the rail expansion joint shall be elastically supported.
9.4	The set of sleepers for the rail expansion joint shall comprise all pre-stressed concrete sleepers required to support the rails with the base plates of the rail expansion joint.
9.5	All rail expansion joints and its components shall be manufactured from new materials and comply with the current valid European and other relevant national standards (EN 13674-1, EN 13674-2 and AREMA).
9.6	The forged transition shall individually be tested with ultrasonic testing devices to detect potential internal flaws and with dye-penetration testing methods to detect potential surface errors. The entire length of the tongue rail shall be free of all welding.
9.7	Rails at the rail expansion joint shall be bonded so that each joint feature has a resistance not exceeding no more resistive than 200 $\mu\Omega$.
10	Turnout
10.1	Turnout geometry shall be 1:6 R100 straight, 1:6 R=100 equal split, 1:6 R50 straight, 1:3.372 R40 curved
10.2	All running rails, closure rails, stock rails and wing rails shall be of profile 60E1 according EN13674-1 or profile 54E1 according UIC860
10.3	The asymmetric switch rails shall be of profile UIC 54E1-A1
10.4	The guard rails shall be of profile 33C1 according to pr EN 13674-3
10.5	All rails inside the turnout shall be of steel grade 1100 (acc UIC 860) or R320Cr (acc EN 13674-1) or better.
10.6	The running surface of switch points shall be heat treated to provide a minimum hardness of 320HB for a targeted minimum penetration of 13mm.
10.7	The turnout has to be equipped with a heat treated semi welded steel frog
10.8	The running rails shall have an inclination of 1:40
10.9	Rail clips shall be from the same manufacturer as the main line fastening system.
10.10	Turnouts at Kelapa Gading delta junction to be provided with an additional set of special baseplates to allow a single through track to be installed.
10.11	Turnout shall be designed for the wheel tread and flange contour details of vehicles to be used revenue service for Jakarta LRT and track maintenance equipment.
10.12	All special trackwork shall be designed with due consideration to noise and vibration sensitivities, and shall be supplied and installed as complete units, having similar resilience characteristics as the adjacent plain line
10.13	Connection of special trackwork to running rail shall be achieved by alumina-thermic welds
10.14	IRJs at turnouts shall be bonded so that each joint feature has a resistance not exceeding no more resistive than 200 $\mu\Omega$.

Pos	Requirements
10.15	Special trackwork components shall be new and be manufactured, fabricated, inspected and tested in accordance with current applicable EN 13232, German Federal Railway standards, VIC standards, or AREMA standards.
10.16	Turnouts shall be located on straight track, un-canted, laid flat on a constant grade and on a continuous structure clear of any structural expansion joints. The maximum gradient permitted (on the through track) will be 3% in mainline, 0% in depot ..
10.17	The point motors to be provided by the signalling contractor. The Trackwork Contractor shall agree the details of the interfaces with the Signalling Contractor during interface coordination of the works and include these interfaces in his designs. Design shall incorporate the attachment of throw and detector rods for the interface with the switch machines, where required.
11	Safety equipment
11.1	Sliding buffer stop
11.2	Buffer stop to absorb the kinetic energy of a fully loaded train (AW3) in case of an overrun;
11.3	Buffer stop shall be designed with consideration of speed, load condition, coupler type and coupler height and the crashworthiness (standard BS EN 15227 category C-IV or ASME RT-1);
11.4	Buffer stop to fit rail profile 54E1;
11.5	Friction elements to be clamped directly to the rail headrail without drilling holes into the web of the rails;
11.6	Buffer stop to stop the train within an available track length of 10m;
11.7	Sliding buffer stop to be installed at track ends at mainline.
11.8	Fixed buffer stop
11.9	Buffer stop to absorb the kinetic energy of an empty train (AW0) in case of an overrun;
11.10	Buffer stop shall be designed with consideration of speed, load condition, coupler type and coupler height and the crashworthiness (standard BS EN 15227 category C-IV or ASME RT-1);
11.12	To fit rail profile 54E1;
11.13	Fixed buffer stop to be installed at track ends of the stabling yard.
11.14	Wheel stops
11.15	Wheel stops are to stop an empty train (AW0) at a speed of 5km/h;
11.16	Wheel stops to fit rail profile 54E1;
11.17	Wheel stops to be designed for the wheel diameter applied to the Jakarta LRT rolling stock;
11.18	Wheel stop not to interfere with any component from the bogie which is located in front of the wheel;
11.19	Wheel stops to be installed at track ends of maintenance workshop.
11.20	When the track ends where wheel stops are installed consist of embedded rails, the rail head and rail web need to be left without the so called pouring compound in order to provide room for the wheel stops
11.21	Guard Rail
11.22	Guard rails to prevent trains from derailing (maintaining the wheels on the rail) in curves with a radius smaller 200 metres at the mainline;
11.23	Guard rail profile to be 33C1;
11.24	Guard rail to be designed for a hunting force of 60kN;
11.25	Guard rail to be designed and constructed with the concept of minimized damage and wear-off of all components during the operation
11.26	Steel grade of the guard rail to be the same as the steel grade of the running rail;
11.27	Guard rail to be pre-bended;
11.28	Guard rail to have a design life time corresponding to the running rails in the specific curve;
11.29	Guard rail to be installed between sleeper on the concrete surface of the trackbed;

Pos	Requirements
11.30	Design of guard rail inlets to be proposed by supplier;
11.31	Guard rail shall be insulated from earth and bonded back to the running rails using 1 x single core 150mm ² (minimum cross sectional area) insulated copper cable.
12	Level Crossing
12.1	Level crossing panel to be manufactured from rubber;
12.2	Level crossing panel to fit rail profile 54E1;
12.3	Design not to interfere with continuous railway track system;
12.4	Level crossing panel to fit track gauge of 1435mm, +0/-3mm;
12.5	Level crossing panel to accommodate applied wheel profile
12.6	Level crossing panel to provide a plane and slip free surface without any obstacles for the passing train/pedestrian;
12.7	Maintenance of track elements (rail, sleeper, fastener, ballast) still to be achievable;
13	Installation Tolerances
13.1	Gauge: +0mm / -3mm
13.2	Gauge variation: 1:1500
13.3	Rail inclination: 1:40 (\pm 10%)
13.4	Cross Level: \pm 2mm
13.5	Deviation from horizontal alignment: \pm 5mm
13.6	Horizontal alignment of rail: \pm 2mm
13.7	Deviation from vertical alignment: \pm 5mm
13.8	Vertical alignment of rail: \pm 2mm

8 High Voltage (HV) Power Supply

8.1 Receiver Substations (RSS)

8.1.1 Standards

Table 8.1: Standards for Receiver Substations

Pos	Requirements	Reference
1	IEEE Std 80-2000	IEEE Guide for safety in AC substation grounding
2	EIC 62305	Protection against lightning
3	Pergub DKI No.195 tahun 2010	Petunjuk pelaksanaan penempatan jaringan utilitas
4	SNI 04-6267.446-2003	Istilah Teknik Ketenagalistrikan – Bagian 446: Relai listrik
5	SNI 04-6267.601 - 2002	Kamus Istilah Ketenagalistrikan – Bab 601 : Pembangkitan , transmisi dan distribusi listrik – Umum
6	SNI 04-6267.602-2002	Kamus Istilah Ketenagalistrikan – Bab 602 : Pembangkitan , transmisi dan distribusi listrik – Pembangkitan
7	SNI 04-6267.603-2002	Istilah Teknik Ketenagalistrikan – Bab 603: Pembangkitan, penyuluran dan pendistribusian tenaga listrik – Perencanaan dan manajemen sistem tenaga listrik
8	SNI 04-6267.448-2001	Istilah Teknik Ketenagalistrikan – Bab 448 : Pengamanan sistem tenaga
9	SNI 04-6267.605-2000	Istilah teknik ketenagalistrikan – Bab 605: Pembangkit, transmisi dan distribusi listrik - Gardu induk
10	SNI IEC 60050-195:2014	Kosakata elektroteknik internasional - Bagian 195: Pembumian dan proteksi terhadap kejut listrik
11	SNI 04-1705-1989	Keandalan sistem distribusi
12	SNI IEC 60273:2011	Karakteristik insulator tonggak pasangan dalam dan pasangan luar untuk sistem voltase nominal lebih dari 1000V
13	SNI 7610:2011	Pembentukan gas pada cairan insulasi akibat stres dan ionisasi elektrik
14	SNI IEC 60137 : 2009	Busing Penginsulasi untuk tegangan bolak-balik di atas 1000 V
15	SNI 04-7068-2005	Insulasi cair - Penentuan tegangan tembus pada frekuensi daya – Metode Uji

Pos	Requirements	Reference
16	SNI 04-3591.1-2000	Spesifikasi minyak isolasi mineral baru untuk kabel dengan selubung minyak IEC 60465 (1988)
17	SNI 04-3591-1994	Spesifikasi minyak isolasi mineral baru untuk transformator dan perangkat hubung bagi
18	SNI IEC 60909-3:2011	Arus hubung pendek dalam sistem ab fase-tiga – Bagian 3: Arus selama dua hubung pendek saluran-ke bumi simultan yang terpisah dan arus hubung pendek parsial yang mengalir melalui bumi IEC 60909 (2003-09)
19	SNI IEC 60060-2:2011	Teknik pengujian tegangan tinggi Bagian 2: Sistem pengukuran IEC 60060-2 (1994-11)
20	SNI IEC 60694 :2009	Standar spesifikasi bersama untuk perlengkapan hubung bagi dan kendali tegangan tinggi IEC 60694
21	SNI IEC 60859 :2009	Hubungan kabel untuk PHB berselungkup logam berinsulasi gas untuk tegangan pengenal 72,5 kV dan diatasnya Kabel insulasi diekstrusi dan berisi fluida - Terminasi kabel tipe kering dan berisi fluida IEC 60859

8.1.2 Functional Requirements

Table 8.2: Functional Requirements for Receiver Substations

Pos	Requirements														
1	Switchgear														
1.1	GIS 150 kV														
1.1.1	The 150 kV switchgear shall comprise SF6 circuit breakers. All parts of the switchgear energized at 150 kV shall be enclosed in gas tight SF6 filled compartments.														
1.1.2	The 150 kV switchgear shall be of a free standing, modular type suitable for indoor installation.														
1.1.3	<p>The 150kV switchgear shall include the following minimum ratings and not exceed 2.5 p.u. over voltage for any switching or breaking duty:</p> <table border="1"> <tbody> <tr> <td>Nominal voltage:</td> <td>150 kV</td> </tr> <tr> <td>Number of phases:</td> <td>3</td> </tr> <tr> <td>Impulse withstand voltage:</td> <td>750 kV</td> </tr> <tr> <td>Power frequency withstands voltage for one minute:</td> <td>325 kV</td> </tr> <tr> <td>Rated frequency:</td> <td>50 Hz</td> </tr> <tr> <td>Rated normal current:</td> <td>1250 A</td> </tr> <tr> <td>Rated short circuit breaking current:</td> <td>40 kA</td> </tr> </tbody> </table> <p>The value of 40 kA is in accordance with the value of the rated short circuit breaking current of existing circuit breaker. The Contractor shall confirm the actual short circuit breaking current at receiving point for short circuit current study.</p>	Nominal voltage:	150 kV	Number of phases:	3	Impulse withstand voltage:	750 kV	Power frequency withstands voltage for one minute:	325 kV	Rated frequency:	50 Hz	Rated normal current:	1250 A	Rated short circuit breaking current:	40 kA
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Impulse withstand voltage:	750 kV														
Power frequency withstands voltage for one minute:	325 kV														
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Rated normal current:	1250 A														
Rated short circuit breaking current:	40 kA														

Pos	Requirements																
	Rated short time withstands current: 40 kA, 1 sec																
<p>The 150 kV switchgear shall include, but shall not be limited to, the following:</p> <ul style="list-style-type: none"> • Motor-operated disconnecting switches. • Motor-operated bus disconnecting switches. • Motor-operated earthing switches. • Current transformers of suitable ratings and temperature class for protection and measuring equipment • Voltage transformers of suitable ratings and temperature class for protection and measuring equipment. 																	
<p>Protection and measuring requirements for the 150 kV switchgear shall include, but shall not be limited to:</p> <ul style="list-style-type: none"> • Over-current and earth fault relay, ammeter, voltmeter and provisions for protection and metering interfaces with the PLN shall be provided for 150kV incoming bays. • Over-current relay with extreme inverse time/current characteristic and instantaneous over-current elements and transformer differential relay shall be provided for transformer feeder bays. • 150 kV bus zones protection relays shall be provided for bus section bay. • Kilowatt hour meter and maximum demand indicator shall be provided for each incoming line. 																	
1.1.4	All gas tight compartments shall be equipped with gas density monitoring device, and accessories shall be provided for filling, topping up or removal of SF6 gas.																
1.1.5	Two stage pressure monitoring shall be used for the circuit breaker and switch compartments, as follows: <ul style="list-style-type: none"> • The first stage shall give an alarm monitoring, without any control blocking. • The second stage shall give an alarm monitoring and shall block any control of the apparatus located within the relevant compartment. 																
1.1.6	Each the 20kV switchgear with circuit breaker shall be designed with adequate current ratings and short circuit braking duty according to its intended function																
<p>The 20 kV switchgear shall be metal-enclosed and conform to the requirements and suitable for indoor installation</p> <table border="1"> <tr> <td>Breaking medium</td> <td>Vacuum</td> </tr> <tr> <td>Insulating medium</td> <td>Solid, gas and/or air insulation</td> </tr> <tr> <td>Pole</td> <td>3</td> </tr> <tr> <td>Rated voltage (Ur)</td> <td>24kV</td> </tr> <tr> <td>Rated frequency</td> <td>50 Hz</td> </tr> <tr> <td>Rated lightning impulse withstand voltage (Up) applicable generally to the switchgear</td> <td>125kV (peak)</td> </tr> <tr> <td>Rated lightning impulse withstand voltage (Up) applicable to points of isolation</td> <td>145kV (peak)</td> </tr> <tr> <td>Rated normal current (Ir) for bus bars not less than</td> <td>2000A</td> </tr> </table>		Breaking medium	Vacuum	Insulating medium	Solid, gas and/or air insulation	Pole	3	Rated voltage (Ur)	24kV	Rated frequency	50 Hz	Rated lightning impulse withstand voltage (Up) applicable generally to the switchgear	125kV (peak)	Rated lightning impulse withstand voltage (Up) applicable to points of isolation	145kV (peak)	Rated normal current (Ir) for bus bars not less than	2000A
Breaking medium	Vacuum																
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Rated normal current (Ir) for bus bars not less than	2000A																
1.2	20 kV Switchgear																
1.2.1	20 kV switchgear shall include, but shall not be limited to the following: <ul style="list-style-type: none"> • 20 kV incoming circuit breaker units from 150/20 kV transformers. • 20 kV incomings and outgoings in the intermediate switchgear room of depot • 20 kV incomings and outgoings in the switchgear room of each station building. 																
1.2.3	Each the 20kV switchgear with circuit breaker shall be designed with adequate current ratings and short circuit braking duty according to its intended function																
1.2.4																	

Pos	Requirements
	Rated normal current for bus couplers (where used) not less than 2000A
	Rated normal current for feeders (between TSS, for traction TRUs and auxiliary transformers) Contractor to specify
	Short time withstand (carrying) current (Ik) no less than 25kA for 3 seconds

The 20 kV switchgear shall include, but not limited to the following equipment:

- Withdrawable design of circuit breakers
- Earthing switches
- Current transformers of suitable ratings and temperature class for protection and measuring.
- Voltage transformers of suitable ratings and temperature class for protection and measuring.

Protection and measuring facilities shall include, but not limited to the following:

- Ammeters, voltmeters and interface to protection system on 150 kV switchgear for main 150/20 kV transformer secondary circuit shall be provided.
- Ammeters and zone protection relays and over-current back up protection for distribution feeder shall be provided.
- 20 kV bus zone protection relays shall be provided, and include but not limited to an integrated directional and non-directional protection system.
- Voltmeter, ammeter, kilowatt meter, over-current and earth fault protection and under-voltage protection for bus sections shall be provided

2 Transformer

2.1 150/20 kV receiver transformers

The 150/20kV receiver transformers shall be oil immersed type on-load tap-changing, out-door type with the following minimum ratings and requirements.

High voltage winding	150 kV
Low voltage winding	20 kV
Number of phase	3 phase
Rated frequency	50 Hz
Cooling type	ONAN/ONAF
On load tap changing equipment	+ 8 tapping position, 1.25% each
Lightning impulse withstand voltage:	
• High voltage winding	650 kVp
• Low voltage winding	125 kVp
Power frequency withstand voltage for 1 minute	
• High voltage winding	275 kVp
• Low voltage winding	50 kVp
Audible sound level:	
• In AN condition not exceed 55dB at 0.3 meters	
• In AF condition not exceed 55dB at 2 meters	

Pos	Requirements																						
2.1.2	Oil duct flange for high voltage termination and air-filled cable box for low voltage termination shall be provided.																						
2.1.3	Neutral grounding method shall be according to the standard of national grid (SPLN) and SNI.																						
2.3	20 kV/380-220V operation transformers The 20/0.380kV operation transformers for supplying power to control equipment shall be oil immersed type, off-load tap-changing, indoor or outdoor type (according to the installation location) with the following minimum ratings and requirements: <table border="1"> <tr> <td>High voltage winding</td><td>20 kV</td></tr> <tr> <td>Low voltage winding</td><td>380 – 220 V</td></tr> <tr> <td>Number of phase</td><td>3 phase – 4 wire method</td></tr> <tr> <td>Rated frequency</td><td>50 Hz</td></tr> <tr> <td>Cooling type</td><td>ONAN</td></tr> <tr> <td>Off load tap changing equipment</td><td>+ 5 tapping position, 2.5% each</td></tr> <tr> <td>Connection designation</td><td>Dyn 11</td></tr> <tr> <td>Lightning impulse withstand voltage:</td><td></td></tr> <tr> <td>• High voltage winding</td><td>125 kVp</td></tr> <tr> <td>Power frequency withstand voltage for 1 minute</td><td></td></tr> <tr> <td>• High voltage winding</td><td>50 kVp</td></tr> </table>	High voltage winding	20 kV	Low voltage winding	380 – 220 V	Number of phase	3 phase – 4 wire method	Rated frequency	50 Hz	Cooling type	ONAN	Off load tap changing equipment	+ 5 tapping position, 2.5% each	Connection designation	Dyn 11	Lightning impulse withstand voltage:		• High voltage winding	125 kVp	Power frequency withstand voltage for 1 minute		• High voltage winding	50 kVp
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• High voltage winding	125 kVp																						
Power frequency withstand voltage for 1 minute																							
• High voltage winding	50 kVp																						
2	Control Source For Substation																						
2.1	Battery Units 2.1.1 For the receiving substation, and traction substations, the Contractor shall provide 110V battery system for safety tripping, service current functions and power to the SCADA remote terminal units. 2.1.2 The battery system shall be rated to supply the standing loads for a minimum of 10 hours in the event of a charger supply failure, and at the end of that period shall be capable of operating each item of equipment for two cycles, i.e. one cycle is open and close. 2.1.3 During such duty output voltage shall be within the tolerances defined for operation in the relevant equipment specifications. 2.1.4 The 110 V batteries shall be of the sealed, maintenance free type and shall not emit hazardous gases																						
2.2	Battery Chargers 2.2.1 Battery chargers shall be provided with self-regulation and shall be capable of restoring a minimum of 80% of battery capacity within 10 hours of full discharge. 2.2.2 Sufficient indications shall be provided on the battery charger to provide status information of the battery charger system, as a minimum this shall include battery voltage, trickle charge and booster charge currents, battery charge functioning and battery charge failure In addition status information shall be provided to the SCADA system. 2.2.3 Battery chargers shall incorporate measuring instruments such as ammeters and voltmeters as a minimum. 2.2.4 In receiving substations and traction substations, AC auxiliary power for the battery charger shall be fed from the secondary circuit of operation transformer.																						
3	Cables																						
3.1	General 3.1.1 All cables shall be sized to carry the continuous current required by the specification and shall be based on the																						

Pos	Requirements
	Contractor's calculations. The cables shall be able to withstand the short circuit currents inherent in the Contractor's design.
3.1.2	The ratings applied to any cable shall be determined by the most onerous installation condition in any cable route.
3.1.3	All cables and cable support facilities to be installed in the substations shall be low smoke non-halogen compound (LSZH) type and fire retardant.
3.2	High and Medium Voltage Cables
3.2.1	The ratings of cables used on the 150 kV and 20 kV power supply system shall be determined by the calculation in accordance with IEC 60287 or equivalent for a maximum operating conductor temperature of 90° C. All high and medium voltage cables shall be equipped with suitable screen and armour equipment in order to provide a proper mechanical protection feature
3.2.2	Cables For 150 kV Feeders <ul style="list-style-type: none"> • Cables shall comply with IEC 60840, SPLN or equal equivalent. • Cables for 150kV distribution shall have cross-linked polyethylene (XLPE) insulation, single cores and stranded copper or aluminum conductor in trefoil formation sized to suit the power supply system design and to satisfy short circuit current requirements
3.2.3	Cables for 20 kV distribution <ul style="list-style-type: none"> • Cables shall comply with IEC 60502, SPLN or equivalent equal. • Cables for 20kV between equipment shall be provided with three cores and stranded copper conductor in trefoil formation sized to suit the power supply design and to satisfy short circuit current requirements
3.2.4	Cables for low voltage distribution <ul style="list-style-type: none"> • Refer to the specification of building service equipment
4	Substation Earthing, Bonding and Lightning Protection System
4.1	The earth mats for the substation and including other structures shall be provided in accordance to IEEE 80 standard.
4.2	External conductive metal part such as water pipes, ducting and exposed metallic part of the station structures shall be bonded to equipotential zone of the electrical system.
4.3	External and/or internal lightning protection system shall be carried out in accordance to the risk assessment and design requirement of IEC 62305 and the updated SNI standard.
4.4	The lightning protection shall convey the lightning discharges to earth without electrification of the structure.
4.5	Concrete structures shall employ roof tapes (air tapes) while steel structures may use the structural steelwork frame as a collector and as a down conductor system. Vertical finials over 400mm will not be required.
4.6	The earthing inspection pits shall be made from concrete and equipped with concrete covers.
4.7	Where aluminum tapes are employed great care shall be exercised in protecting the system components from electrolytic corrosion due to dissimilar metals being in contact with each other. Special bi-metallic connectors shall be employed at junctions of copper and aluminum conductors.
4.8	Copper air and down conductor tapes shall be PVC sheathed.

8.1.3 Performance Requirements

Table 8.3: Performance Requirements for Receiver Substations

Pos	Requirements
1	Complete system studies shall be carried out, include but not limited to : <ul style="list-style-type: none"> • Load flow analysis with complete energize and de-energize configurations in accordance to the high

Pos	Requirements
	and medium voltage ring distribution system. <ul style="list-style-type: none">• Short circuit, cable and busbar sizing, and voltage drop calculation.• AC and DC harmonic study• Protection relay setting coordination study• Earthing and lightning protection system study
2	Design life of the power equipment shall be for 40 years.
3	The permissible operating voltage of 150kV shall be in the zone between minimum -10% of operation voltage and maximum +5% of operation voltage in accordance with SPLN.
4	The secondary voltage of each 150/20kV transformer shall be controlled within $\pm 2\%$ by using 150/20kV transformers with the on load tap changer.
5	The 20kV system shall be designed to ensure that voltage regulation under normal feeding is maintained within 5% of normal voltage.

9 Traction Power Supply

9.1 Standards

Table 9.1: Standards for Traction Power, Conductor Rail, Stray Current, Earthing and Bonding

Pos	Requirements
	IEC /TS 60479-1
	IEC 60176
	IEC 60146
	IEC 60551
1	IEC 61936-1: 2010 – Power Installations exceeding 1 kV A.C. – Common Rules.
2	IEC 62561 - Lightning protection system components
3	EN 50164 - Lightning protection system components
4	EN 50121-1– Railway Applications – Electromagnetic Compatibility. General.
5	EN 50121-2– Railway Applications – Electromagnetic Compatibility. Emissions of the Whole Railway System to the Outside World.
6	EN 50121-5– Railway Applications – Electromagnetic Compatibility. Emission and Immunity of Fixed Power Supply Installations and Apparatus.
7	EN 50122-1– Railway Applications – Fixed Installations - Electrical Safety, Earthing and the Return Circuit - Part 1: Protective Provisions against Electric Shock
8	EN 50122-2– Railway Applications – Fixed Installations – Electrical Safety, Earthing and the Return Circuit – Part 2: Provisions Against the Effects of Stray Currents Caused by DC Traction Systems.
9	EN 50122-3– Railway Applications – Fixed Installations – Electrical Safety, Earthing and the Return Circuit – Part 3: Mutual Interaction of AC and DC Traction Systems.
10	EN 50123-1– Railway Applications – Fixed Installations – D.C. Switchgear. General.
11	EN 50123-2– Railway Applications – Fixed Installations – D.C. Switchgear. D.C. Circuit Breakers.
12	EN 50123-3– Railway Applications – Fixed Installations – D.C. Switchgear. Indoor D.C. Disconnectors, Switch-Disconnectors and Earthing Switches.
13	EN 50123-4– Railway Applications – Fixed Installations – D.C. Switchgear. Outdoor D.C. Disconnectors, Switch-Disconnectors and Earthing Switches.
14	EN 50123-5– Railway Applications – Fixed Installations – D.C. Switchgear. Surge Arrestors and Low-Voltage Limiters for Specific use in D.C. Systems.
15	EN 50123-6– Railway Applications – Fixed Installations – D.C. Switchgear. D.C. Switchgear Assemblies.
16	EN 50123-7-1– Railway Applications – Fixed Installations – D.C. Switchgear. Measurement, Control and Protection Devices for Specific use in D.C. Traction Systems. Application Guide.
17	EN 50123-7-2– Railway Applications – Fixed Installations – D.C. Switchgear. Measurement, Control and Protection Devices for Specific use in D.C. Traction Systems. Isolating Current Transducers and other Current Measuring Devices.
18	EN 50123-7-3– Railway Applications – Fixed Installations – D.C. Switchgear. Measurement, Control and Protection Devices for Specific use in D.C. Traction Systems. Isolating Voltage Transducers and other Voltage Measuring Devices.
19	EN 50124-1+A2– Railway Applications – Insulation Coordination – Basic Requirements. Clearances and Creepage Distances for all Electrical and Electronic Equipment.
20	EN 50125-2– Railway Applications – Environmental Conditions for Equipment. Fixed Electrical Installations.
21	EN 50162 – Railway Applications – Protection Against Corrosion by Stray Current from D.C. Systems.
22	EN 50163+A1– Railway Applications – Supply Voltages of Traction Systems.
23	EN 50328 – Railway Applications – Fixed Installations – Electronic Power Converters for Substations.
24	EN 50329+A1– Railway Applications – Fixed Installations – Traction Transformers.

Pos	Requirements
25	EN 60044: Series – Instrument Transformers.
26	EN 60076: Series – Power Transformers.
27	EN 60270: 2001 – High Voltage Test Techniques – Partial Discharge Measurements.
28	EN ISO 15607– Specification and Qualification of Welding Procedures for Metallic Materials – General Rules.
29	EN ISO 15609-1 Specification and Qualification of Welding Procedures for Metallic Materials – Welding Procedure Specification – Arc Welding.
30	EN ISO 15609-2– Specification and Qualification of Welding Procedures for Metallic Materials – Welding Procedure Specification – Gas Welding.
31	EN ISO 15609-5– Specification and Qualification of Welding Procedures for Metallic Materials – Welding Procedure Specification – Resistance Welding.
32	EN 60445 – Basic and Safety Principles for Man-Machine Interface, Marking and Identification. Identification of Equipment Terminals, Conductor Terminations and Conductors.
33	EN 60529– Specification for Degrees of Protection Provided by Enclosures
34	EN 61000: Series – Electromagnetic Compatibility (EMC).
35	EN 61140: 2002+A1:2006, IEC 61140:2001– Protection Against Electric Shock – Common Aspects for Installation and Equipment.
36	EN 61537:2007 – Cable Management – Cable Tray Systems and Cable Ladder Systems.
37	EN 61547: 2009 – Equipment for General Lighting Purposes – EMC Immunity Requirements.
38	EN 62305-1– Protection Against Lightning – General Principles.
39	EN 62305-2– Protection Against Lightning – Risk Management.
40	EN 62305-3– Protection Against Lightning – Physical Damage to Structures and Life Hazard.
41	EN 62305-4– Protection Against Lightning – Electrical and Electronic Systems Within Structures.
42	BS 5467+A3– Electric Cables – Thermosetting Insulated, Armoured Cables for Voltage of 600/1000V and 1900/3300V
43	BS 6004 – Electric Cables – PVC Insulated, Non-Armoured Cables for Voltages up to and including 450/750V for Electric Power, Lighting and Internal Wiring
44	BS 6231: 2006 – Electric Cables – Single Core PVC Insulated Flexible Cables of Rated Voltage 600/1000 V for Switchgear and Control gear Wiring.
45	BS 6346: 1997 – Electric Cables – PVC Insulated, Armoured Cables for Voltage of 600/1000V and 1900/3300V
46	BS 6622: 2007 – Electric Cables – Armoured Cables with Thermosetting Insulation for Rated Voltages from 3.8/6.6 kV to 19/33 kV. Requirements and Test Methods.
47	BS 7211: 1998 – Electric Cables – Thermosetting Insulated, Non Armoured Cables for Voltages up to and Including 450/750 V, for Electric Power, Lighting and Internal Wiring, and Having Low Emission of Smoke and Corrosive Gases when Affected by Fire.
48	BS 7430: 1998 – Code of Practice for Earthing.
49	BS 7671: BS 7671:2008+A1:2011 – Requirements for Electrical Installations. IEE Wiring Regulations. Seventeenth Edition.
50	BS 7844-1: 1996 – Three-Phase Dry-Type Distribution Transformers 50 Hz, from 100 to 2500 kVA with Highest Voltage for Equipment not Exceeding 36 kV. General Requirements and Requirements for Transformers with Highest Voltage for Equipment not Exceeding 24 kV

9.2 Traction Power Substations (TSS)

9.2.1 Functional Requirements

Table 9.2: Functional Requirements for Traction Substations

Pos	Requirements
1	<p>General</p> <p>Supply shall be conveyed from the positive pole of the rectifiers of each TSS via cabling and switchgear to the conductor rail system.</p> <p>Return current from LRVs shall be conveyed via the running rails, negative return traction cables and negative busbar to the negative pole of the rectifier in the TSS.</p> <p>A suitably rated isolator shall be provided in the connection between the negative busbar and each rectifier.</p> <p>The following shall be designed and provided by the Main Contractor:</p> <ul style="list-style-type: none"> • Structural and civil engineering features (including TSS rooms and furniture) • Lighting, HVAC and domestic small power (e.g. sockets for small appliances) • Fire engineering measures • Viaduct structure, including earthing features • Station structures and facilities equipment (e.g. ventilation, escalators etc.) • Trackwork and associated bonding (not including conductor rail) • Cable basements and underfloor trenches, ducts and conduits • Cable risers and structural openings to allow for the Contractor's cable installation. <p>These provisions shall cater for the implementation of additional plant in future (in alignment with the Stage 2 system design described in 2.1 below). For example, TSS rooms shall be provided with space, cable trenches, access and lifting facilities for the future installation of additional proposed TRUs and their cables.</p> <p>The Contractor shall coordinate with the Main Contractor, providing all equipment layout, mass, installation requirements, clearance requirements and thermal performance data to the Main Contractor during the detailed design stage in order that appropriate arrangements are made.</p> <p>The Contractor shall be responsible for coordinating all interfaces within the Contract in addition to interfaces with work packages awarded to other Contractors/Detailed Design Consultants which impinge upon his scope of work.</p> <p>The Employers Engineer shall oversee the coordination between the PT:PLN, Main Contractor and other Contractors. However, the Contractor shall allow for any modifications to his works that may be needed to cater for the requirements of other Contractors.</p>
2	<p>System Design</p> <p>The Contractor's design shall include multi-train dynamic traction power simulation of the proposed rolling stock, service level and any changes to the alignment as agreed with the Employer. The system design shall cater for two stages of implementation as follows:</p> <ul style="list-style-type: none"> • Stage 1: Line 1 + depot only, with service level and rolling stock as specified by the Employer. The resulting allocation of traction equipment shall be implemented (built) by the Contractor. • Stage 2: Line 1 + Line 7 + depot, with service level and rolling stock as specified by the Employer. The resulting allocation of traction equipment over and above Stage 1 shall be implemented by others at a later date. <p>Equipment shall be sized, allocated and located (in plant rooms) with both Stages 1 and 2 in mind, to allow for easy implementation of Stage 2 with minimal rework.</p> <p>The Contractor shall provide detailed design of all components, including interfaces with other systems.</p>

Pos	Requirements
2.4	<p>Preliminary interfaces are described elsewhere in this document.</p> <p>In normal operating conditions all transformer-rectifiers shall supply the line.</p> <p>The equipment shall be designed to accept load variations under normal and emergency operating conditions, including a single outage condition, in which any one major piece of traction plant is out of service. The major pieces of plant shall include:</p>
2.5	<ul style="list-style-type: none"> • One traction transformer-rectifier • One DC busbar (or busbar section) • One DC track feeder cable (or set of cables). <p>Equipment shall be provided to ensure continuity of supply under the outages listed above; this shall include provision of bypass switches between electrical sections. This arrangement will also allow reduced services to be run over certain sections without degrading the service on the rest of the route.</p>
2.6	<p>The Contractor may remove the bypass switches from their design subject to suitable demonstration of compliant train voltages and equipment ratings through the dynamic simulation.</p> <p>Reduction of LRV service levels in the event of a failure is an option that can be considered in conjunction with the Employer.</p>
2.7	All power cables shall be rated to exceed the required RMS current demand, under normal conditions and single outage conditions.
2.8	A reference design for TSS systems is represented in Drawings in Volume 3.
2.9	The Contractor shall complete an insulation coordination study to cover all equipment under the Contractor's scope. Equipment shall be capable of withstanding without damage the effects of LRV regenerative braking, transients caused by the switching of AC and DC switching devices, and lightning.
2.10	<p>In the case of a fault or incident on a section, it shall be possible, after locating and isolating the section affected, to remotely re-energise the part of the section that remains serviceable. In the event of a failure of the centralised control system, it shall be possible to do this locally at the TSS.</p> <p>To mitigate electrical hazards during operation and maintenance activities, the traction supply system will have a complete interlocking scheme for :</p>
2.11	<ul style="list-style-type: none"> • each TSS • depot traction distribution equipment • gates and associated machinery at the depot
3	<h3>Control And Monitoring</h3> <p>The power supply system as a whole shall be managed by a centralised SCADA system in the Operation Control Centre (OCC). To facilitate this certain devices throughout the system shall be operable by remote control. In the event of a failure of the centralised management system these devices shall also be capable of being operated locally, either from the equipment panel or from a local mimic.</p> <p>The status of the Traction System including switch positions, voltages on the network, power measurements, alarms and statuses shall be reported to the Operation Control Centre OCC, so as to afford the OCC operator an overview of the power supply system as a whole and so be able to react quickly in case of an incident. These principal switching devices shall each be provided with volt-free contacts for both the open and the closed position, from which the status of the device may be inferred by the SCADA system.</p> <p>Alarms shall be arranged to facilitate detailed analysis of incidents. They shall be transmitted as discrete alarms in the case of incidents having serious consequences for the system as a whole, and shall be grouped if the consequences are not immediately dangerous. In the latter case, the identification of the fault should be done locally at equipment level.</p> <p>Full requirements for the SCADA system are detailed elsewhere in Appendix J and in drawings in Volume 3.</p>
4	<h3>Earthing, Bonding and Stray Current Control</h3>

Pos	Requirements
4.1	<p>System protective earthing shall be provided for electrical safety on the entire system, including earthing of non-current carrying metallic components, cable supports, transformer neutrals, lightning arrestors, etc.</p> <p>Earthing and bonding design shall conform to EN 50122-1.</p>
4.2	Jakarta LRT shall be designed; constructed, operated and maintained in such a manner that it does not cause corrosion or interference to either Jakarta LRT infrastructure or third party infrastructure.
4.3	The mainline and stabling areas in the depot of Jakarta LRT shall utilise a third rail 750V DC traction system that is floated (i.e. the negative traction return circuit is not connected to earth), with the running rails forming the negative return.
4.4	The traction return shall be separated from the station and trackside earthing systems to prevent stray currents from entering surrounding infrastructure.
4.5	All TSS negative busbars shall be directly connected to the running rails for traction current return.
4.6	Within the Depot TSS the traction negative busbar into two sections with a fully rated isolator. One section (feeding the Depot Station and the depot stabling area) shall be directly bonded to the running rails for traction current return; the other section shall be bonded to the depot main earth for the safety of staff.
4.7	<p>IRJs shall be installed at the following locations:</p> <ul style="list-style-type: none"> • Double IRJs between Earthed and Floating parts of the Depot; • Temporary IRJs at intervals to aid in the testing and commissioning of the railway. These shall be removed by the Contractor after use and the rail welded. • Single IRJs at TSS conductor rail gaps, around which continuity bonding shall be provided. These bonds shall be rated to cater for the loads projected in the Contractor's dynamic modelling. These bonds shall use bolted connections to allow for temporary disconnection and reinstatement to permit testing of the running rail resistance to earth.
4.8	Permanent DC (positive and negative) current and voltage measuring facilities shall be provided at each TSS busbar to allow for SCADA monitoring of voltage and current, hence allowing potential earth faults and stray currents to be identified. The monitoring equipment shall be capable of collecting, storing, trending and analysing data against the requirements.
4.9	Traction and non-traction loads such as station services and signalling equipment shall be supplied from a combined 20kV AC switchboard. LV supplies will be derived from dual 20kV/380V transformers.
4.10	The DC traction return system shall be electrically isolated from the earth system. Their interfaces shall be coordinated for safety.
4.11	<p>The following items shall be double insulated:</p> <ul style="list-style-type: none"> • Track feeder cables (from TSS to conductor rail); • Negative return cables (from running rails to TSS); • Traction bonding cables (of any type).
4.12	Within the depot, all metallic objects and equipment requiring an earth shall be bonded to the depot earth system.
4.13	<p>Emergency conductor rail shorting bars are to be provided at the following locations:</p> <ul style="list-style-type: none"> • two per station platform • one per LRV driving cab • a stock of bars (quantity to be determined by the Contractor) to be used by track and depot maintenance staff to be located at the depot.
4.14	For Jakarta LRT a design primarily based on prevention of stray current through thorough insulation of both running and conductor rails has been specified – throughout all areas of the LRT system. In addition to the insulation, a stray current collector system shall be provided. The stray current collector system shall comprise stray current collection mats, stray current collector cables, connections between the mats and cables, test points within the substations, insulation between the stray current collection

Pos	Requirements
	system and everything else.
4.15	The stray current collection mat in all track formations shall be formed of steel rebar and shall be positioned as close to the rail / under the sleeper as possible allowing for structural integrity of the track formation. The stray current collection mat shall be formed as a separate entity, electrically isolated from the structural reinforcement and the running rails. The mats shall be formed on a per track basis.
4.16	The collector mat shall be installed below all running rail including turnouts, pocket tracks, and crossing points.
4.17	The stray current collector mat shall have section breaks installed every 300m and these shall comprise of electrically insulated locations within the track formation where collection mats meet.
4.18	For electrical continuity; at each section break the collection mat shall be connected to a busbar within a stray current collection chamber by a stray current mat bond cable
4.19	The stray current collector cable shall run the length of each track on the mainline (i.e. one cable on the 'up' track and one cable on the 'down' track. Within the depot, a length of stray current collection cable will run adjacent to each track.
4.20	Each stray current collector cable will start and finish at a TSS, where it shall be terminated to an individual insulated enclosed terminal that facilitates the connection of test equipment by maintenance staff. The stray current collector terminals shall be in an insulated enclosure and segregated from all other equipment.
	The stray current collector cable shall be terminated at every busbar within a stray current collection chamber at section break in the stray current collector mat, thus linking all sections together between substations.
5	Rectifier Transformer
5.1	Rectifier transformers shall be provided at mainline TSSs and Depot, generally in line with the DC. sectioning diagram 362748-MMI-MVI1-XX-DR-324-3240 and as required by the Contractors traction power simulations and detailed design.
5.2	The rectifier transformer shall conform to the relevant clauses of BS EN 60076 series and BS EN 50329. The transformer and its secondary connections shall be designed and rated specifically for integration with the design of the rectifier.
5.3	The rectifier transformer shall be of a type suitable for use indoors in a building forming part of a major structure. The exact type of transformer and its type of cooling shall be determined by the Contractor.
6	Rectifier
6.1	Rectifiers shall be provided at mainline TSSs and Depot, generally in line with the DC. sectioning diagram 362748-MMI-MVI1-XX-DR-324-3240 and as required by the Contractors traction power simulations and detailed design.
6.2	Rectifiers shall be minimum 12 pulse output, configured in a series bridge arrangement and designed to match the rectifier transformer, to comply with EN50327, EN50328, EN 50329 and BS EN 60146.
6.3	Each rectifier shall be housed in a sheet steel enclosure suitable for indoor installation and shall use natural convection cooling. They shall be equipped with two-stage temperature sensors providing an alarm output to SCADA and a trip output to primary switchgear.
6.4	Each rectifier unit shall have surge suppression at both the AC and DC sides.
6.5	Rectifier designs shall incorporate fuses for isolation of failed diodes and shall provide a means of monitoring the fuses for local indication and remote indication by SCADA. The upstream MV Circuit Breaker (CB) shall trip if two or more fuses located at the same leg are blown.
6.6	The rectifier shall include an Open Circuit Arm Detector (OCAD)
	Overvoltage protection:
6.7	<ul style="list-style-type: none"> • Internal overvoltage: rectifiers must be equipped with internal circuit to eliminate voltage peaks caused by reverse recovery current, during turn-off • External overvoltage: The rectifier must be equipped on the DC side, with an RC filter capable of absorbing significant surges.

Pos	Requirements
7	DC Switchgear
7.1	DC CBs shall be electrically operated, metal-enclosed, mechanically or magnetically latched, single pole, high speed, draw-out, truck-mounted air CBs, with a trip-free mechanism as per BS EN 50123-1.
7.2	The DC busbars shall be fabricated of electrical conductivity, high-quality copper, and shall be capable of carrying the specified rectifier overloads without exceeding the allowable temperature rise.
7.3	Each DC CB shall have an arc chute consisting of arc chambers provided to house the main contacts and to confine and direct arcs until extinguished. The switchgear assembly shall be built to allow for the venting of ionised gases from the CB arc chutes without posing any hazard to personnel. Adequate provisions shall be made for release of gases from the units by means of suitable stacks or louvred vent openings.
7.4	Switchgear shall be suitably rated for use as a point of isolation and shall be provided with facility for padlocks to be applied at all relevant points.
7.5	The outgoing terminal of all track feeder CBs shall be provided with surge arresters.
7.6	The positive and negative DC switchgear enclosures and rectifier enclosures shall be insulated from ground by an insulated floor topping extending one metre around it allowing for CB withdrawal. Wherever the enclosure is less than one metre from any vertical building surface, such as a wall or column, the Contractor shall furnish non-hygroscopic sheet insulation to cover the vertical surfaces to protect against any accidental contact between the enclosure and the grounded surface.
7.7	Each enclosure will be connected to the substation earth system at one point via a frame leakage relay. Operation of the frame leakage relay will trip and lockout all DC feeder CBs on the switchboard and the rectifier MV CBs upstream.
7.8	The operation of the MV traction CB shall bring about an intertrip of the main DC High Speed Circuit Breaker (HSCB) immediately downstream of the rectifier.
7.9	Similarly the operation of the main DC HSCB shall bring about an intertrip of the MV traction CB.
7.10	These intertrips shall use dedicated hard-wired circuits.
7.11	At all mainline TSSs a negative busbar shall be provided to allow for:
7.12	<ul style="list-style-type: none"> • Bolted cable connections to the running rails • Rectifier negative isolator(s) for cabled connections to the rectifier negative pole • Connection via VLD to the TSS earth system
7.13	At the Depot TSS a negative busbar shall be provided to allow for:
7.14	<ul style="list-style-type: none"> • A fully rated negative isolator to create TWO sections of the negative busbar – where one section is to be used in a floated configuration for the Depot station area and the depot stabling tracks and the other section is to be solidly earthed for the depot heavy maintenance areas.
7.15	<ul style="list-style-type: none"> • Two sets of bolted cable connections to the running rails (one set floated, one set earthed) • Rectifier negative isolator(s) for cabled connections to the rectifier negative pole • Connection via VLD to the TSS earth system (one section only) • Connection via cable to the Depot Main Earth (one section only)
7.16	VLDs provided at the TSS negative busbar shall be provided as Type 2 (VLD-O) as per EN 50122-1. The Contractor shall devise a system for automatic resetting of the VLD, together with an appropriate SCADA alarm strategy.
7.17	Each rectifier DC CB shall be key-interlocked with a rectifier negative isolator, so that the rectifier DC CB cannot be closed unless the negative isolator is closed. The key interlock shall also prevent opening of the negative isolator unless the main DC CB is open.
7.18	To improve detection and clearance of faults, the DC switchboards will have an intertripping system (ITS) operating between adjacent TSSs. All auxiliary contacts, components and wiring necessary for intertripping and/or interfacing with external devices, CBs and similar identified at the detailed design stage, shall be provided. The intertripping system shall provide: <ul style="list-style-type: none"> • Dedicated trip send and receive for each outgoing DC circuit breaker to provide selective

Pos	Requirements
	<p>clearance of conductor rail faults</p> <ul style="list-style-type: none"> • Dedicated trip send and receive for each main DC circuit breaker • Intertrip bypass facilities (corresponding to conductor rail bypass switches) • Facility for the lockout of circuit breakers based on specific trips with remote or local reset • Emergency DC mass trip (based on SCADA signal or local push-button), to switch out all conductor rail sections and Transformer Rectifier Units (TRUs) at a given location (note this will require tripping of some DC CBs at adjacent sites) • Emergency mainline mass-trip (all DC circuit breakers) at the Electrical Control Desk in the Operational Control Centre. • Local trip (covering specific sections) for depot and workshops, with multiple plungers located at key locations in the Depot as required
8	<p>Depot</p> <p>Traction power for tracks inside the heavy maintenance workshop area shall be provided via stinger installations. Stinger cables attached to contact trolleys shall provide power from overhead conductor rails. Four stinger connections shall be provided as a minimum for each line in the main workshop. The stinger distribution board shall be provided with remotely operated load break isolating switches and fuses interlocked with the plug and vehicle receptacle such that the plug cannot be inserted / removed with power on the plug. A safety proving circuit shall be provided in each plug such that power cannot be turned on without the plug being inserted into a vehicle or test socket.</p> <p>Conductor rail shall be provided up to the entry point to each workshop line. In the workshop area itself, conductor rail shall not be provided.</p> <p>Note: means of isolating LRV shoe gear shall be provided for safe working in the workshop while an LRV is powered by a stinger.</p> <p>At the Depot TSS (serving both the Depot station and the main Depot) a negative busbar with two sections shall be provided:</p> <ul style="list-style-type: none"> • One section with a VLD connection to the Depot earth system, to which the return rail cable connections from the floating return sections shall be made. • One section with a connection to the Depot earth system, to which the return rail cable connections from the earthed return sections, shall be made. • A fully rated isolator shall be provided between the two negative busbar sections. This shall be key-interlocked with the Depot TSS DC bus coupler CB so that the bus coupler CB cannot be closed until the negative isolator is closed, and the isolator cannot be opened while the CB is closed.
8.1	
8.2	

9.2.2 Performance Requirements

Table 9.3: Performance Requirements for Traction Substations

Pos	Requirements
1	<p>General</p> <p>Design life of the following traction power equipment shall be 40 years:</p> <ul style="list-style-type: none"> • Transformers • Rectifiers • MV AC and DC traction cables • MV AC switchgear • DC switchgear (including trackside isolators and bypass switches)
1.1	

- LV and control distribution equipment, wiring and terminations
- Conductor rail and accessories

Design life of the following equipment shall be 20 years:

- Electronic protection relays
- SCADA interface equipment
- Battery chargers (not including batteries)
- PLCs, where used

Each TSS on the mainline and depot shall include, but not be limited to, the following major items:

- 3150kVA rectifier Transformers.
- 3000kW rectifiers.
- 750V DC positive switchboard.
- Traction negative busbar including connections to return rail, rectifier isolators and VLD.
- TSS 50V or 110V battery and charger system.
- Intertripping system.
- Marshalling Cabinet and SCADA RTU panel.

Quantities and ratings of power equipment shall be, in general, as per the details above and as per the drawings in Volume 3, however, these shall be confirmed in the Contractor's traction power simulations and detailed design once technical details of the chosen LRV are known.

1.5 Traction substations (TSSs) will transform and rectify 20kV AC to 750V DC, powering the LRV through the conductor rail system.

As per EN 50163 + A1 the following voltage levels shall apply to the DC components and systems:

- The Nominal Voltage (Un) shall be 750V.
- The Highest Permanent Voltage (Umax1) (under LRV regenerative braking) shall be 900V. The rolling stock shall be specified so that the conductor rail voltage does not exceed 900V.
- The Highest Non-permanent Voltage (Umax2) shall be 1000V.
- The lowest permanent voltage (Umin1) shall be 500V
- The lowest non-permanent voltage (Umin2) shall also be 500V.

PT Perusahaan Listrik Negara (PLN) delivers and terminates 150kV AC to Receiver Substations (RSS) where it will be transformed to 20kV AC for distribution by Jakarta LRT. The supply voltage from PLN substations to Jakarta LRT is nominally 20kV AC. - the voltage at the receiving end (LRT substation) will be in the range 19.5kV to 20.5kV AC.

2 System Design

The system design shall be such that under an outage at any one TSS the remaining Transformer-Rectifier Units (TRUs) at no more than 150% of its rated continuous output for not more than 2 hours.

If the outage cannot be resolved and / or the system reconfigured within two hours (to reduce the load on the affected TRUs), measures (such as reducing the number of LRV's running) must be taken to reduce the load on the affected TRUs such that the loading is reduced to below 100%. Note running the TRU's overloaded for more than 2 hours is detrimental to their lifespan and may cause safety issues.

2.2 TSS shall be equipped with Gaseous fire suppression systems as per CER's Type 1 and Type 2 detailed elsewhere in this appendix.

3 Earthing, Bonding and Stray Current Control

3.1 Expected three phase fault levels shall be advised by PLN for each feeding point. However, the high voltage equipment shall be rated for a minimum of 17.5kA fault level for 3 seconds.

For all areas the running rail fastenings (base plates, clips, bolts etc.) shall be in or on insulated pads and fittings. The running rail insulation features shall be designed to achieve a rail-to-earth resistivity of 100Ω.km per track, in dry conditions, after all construction works are complete including surface

finishing.

- 3.2 The return rail system shall be designed to achieve a minimum resistance to earth within each electrical section after 3 years operation of greater than $20\ \Omega\cdot\text{km}$ based on the Contractor's recommended maintenance strategy.
- 3.3 All Insulated Rail Joints (IRJs) shall be prefabricated as opposed to retro-fitted. IRJs shall be designed to withstand a permanent voltage of 120V DC across the joint. The joints shall be of a polyurethane construction, bonded type and shall be resistant to parting from the rail ends subject to water ingress, varying temperature and rail movement.
- 3.4 The longitudinal single rail resistance for each continuous rail section shall not exceed $50\text{m}\Omega/\text{km}$; this value shall be validated with all bonds assumed to be connected and in service.
- 3.5 Continuously welded rail shall be adopted throughout. Fishplated rail joints shall not be used. At rail welds the resistance across the weld shall not exceed $200\mu\Omega$ upon installation.
- 3.6 Rails shall be bonded across any discontinuities such as expansion joints, switches and crossings so that each feature has a resistance not exceeding $200\mu\Omega$. Continuity bonds shall be rated to cater for the loads projected in the Contractor's dynamic modelling.
- These bonds shall be permanent connections with no access for disconnection.
- Regular bonds shall be provided:
- Between the two rails of each track at a maximum spacing of 200m
 - Between the two tracks of each route at a maximum spacing of 400m
 - Using 1 x 150mm^2 double insulated copper cable.
 - These bonds shall use permanent connections with no facility for disconnection.
- 3.8 Any guard or check rails shall be insulated from earth and bonded back to the running rails using 1 x single core 150mm^2 (minimum cross sectional area) insulated copper cable.
- 3.9 Each TSS plant room will be provided with two separate earth terminals by the Main Contractor. Each terminal shall have a measured earth value of 2Ω or less. Each terminal shall be supplied from a separate earth mat. Combined, the two earth mats shall have an earth value of 1Ω .
- 3.10 No earthed electrical equipment or cabling associated with that equipment shall be installed closer than 75mm to either the running rail or conductor rails.
- All electrical equipment, metal or metallic objects (including building structures and cladding) shall be placed, where possible, further than 2.75m from the nearest rail (running or conductor).
- Generally a hierarchy of measures is applied to the bonding of lineside metallic equipment:
- 3.11 Eliminate by clearance – as far as is practicable, the equipment should be located at 2.75m or more from the traction return system so that no bond is required
- 3.12 Insulate – use insulated (e.g. GRP or polymer-coated) equipment so that contact with metallic parts cannot be made inadvertently
- Bond – make a connection between the equipment and traction return. Depending on the location and nature of the equipment, a Voltage Limiting Device (VLD) may be required in this connection.
- 3.13 Items such as trackside cabinets that contain 750V DC traction equipment only shall be directly bonded to the running rail.
- The following items shall be bonded to the running rails by a Voltage Limiting Device (VLD):
- 3.14 Metal or metallic objects such as fences, station furniture, sign posts and equipment such as cabinets, items containing or supporting electrical (generally LV or traction plus LV) equipment within 2.75m of the nearest rail (running or conductor) OR within 2.75m of an item that is directly bonded to the running rails equipment. Exceptions in line with Clause 6.3.1.2 of BS EN 50122-1 are permitted.
- 3.15 Buildings with metal cladding within 2.75m of the nearest (running or conductor) rail are prohibited.
- The platform surface impedance shall be such as to limit the body current (as a result of touching the train body) to levels specified in BS EN 50122-1 with the effect of body current limited to "perception" as defined in IEC /TS 60479-1.

4 Rectifier Transformer and Rectifier

- The rectifier transformer will be installed indoors with suitable ventilation and a shallow bund (if required) to retain fluid leaked from the transformer.
- The transformers shall have nine full capacity taps at each primary winding with four at steps 1.25% above and four at steps 1.25% below rated voltage;
- Transformer noise level shall meet the requirements of IEC 60176, 60146 and 60551 under any loading condition;
- The transformer shall have one delta and one star (wye) secondary winding, where the two output windings shall be shifted thirty degrees with respect to each other to facilitate 12 pulse rectification;
- 4.1 The design of the transformer shall take into account the special requirements of rectifier application, including the effects of harmonic currents and voltages;
- Bolted disconnect bars shall be fitted to the 20kV side of the transformer in an air insulated terminal box.
- The anode connections may be by cable, but all anode connections shall be arranged to minimise electromagnetic interference. These connections shall be as short as possible.

The rectifier transformer shall be based on the following parameters:

4.2	Type	Solid or liquid (K only) insulated, cooling to be determined to suit site environmental conditions – maybe Forced (F) or Natural (N)
	Overload capacity	Class VI to BS EN50329 and to suit the chosen traction rectifier 100% continuous 150% for 120 minutes 300% for 1 minute
	Phase	Two x three phase, three wire
	Frequency	50Hz
	Primary side nominal voltage	20kV ± 5% (maximum voltage 21kV)
	Secondary voltage	To suit the chosen traction rectifier
	No-load losses	< 1%
	Displacement power factor (including distortion factor)	≥ 0.95
	Accessories:	Functions to include (if liquid cooled): Oil temperature Oil level gauge with two stage (alarm and trip) contacts Buchholz gas and surge trips Oil temperature gauge with two stage (alarm and trip) contacts Overpressure trip device
	Transformer guard protection devices	

4.3 Rectifier

The rectifier shall be based on the following:

4.3.1	Type	Fully Enclosed Fuseless Series Connected Parallel Bridge (3000kW Duty Class VI)
	Surge Protection	5kV DC
	Input AC Voltage	To suit the chosen transformer and achieve the

	specified outputs
Input Frequency	50Hz
Norminal Output Voltage	750V DC
No Load Output Voltage	790V DC
Nominal voltage at 300% load	670V
Rated Insulation	1200V
Power Frequency / Impulse	3.6 / 8kV
Basic Direct Current	4000A
Basic Power	3000kW
Rating Class	EN 50328 Class VI (Table 4 Connection Diagram 12)
Overload capacity	Class VI duty cycle as defined in BS EN 60146-1-1, BS EN 50328, BS EN 50329 100% continuous 150% for 120 minutes 300% for 1 minute

4.3.2 If light load resistors are required to limit the light load voltage of the rectifier, the resistors shall be switched off when there is sufficient load on the rectifier to reduce the output voltage to below the nominal light load voltage. The switch control shall include an adjustable time delay of 0 – 60 seconds to switch the resistor off.

4.4 Transformer/Rectifier Unit

4.3.3 The short circuit current of the transformer-rectifier unit shall not exceed nine (9) times the rated load current.

4.3.4 The combined efficiency of the transformer and rectifier, including the power loss of any light load resistor, shall be not less than 98.2%;

4.3.5 The total transformer-rectifier unit noise at full load level shall not exceed 66dB when measured at 1 metre from the unit enclosure in any direction.

5 DC Switchgear

DC switchgear features (ratings to be confirmed by the Contractors detailed design)

Nominal system voltage Un	750V DC
Rated voltage UNe	900V DC
Bus bar Rated service current (INe)	8000A
Main DC feeder Rated service current (INe)	8000A
Outgoing feeder Rated service current (INe)	4000A
Rated short-circuit current (INss)	To be determined by the Contractor
CB total break time (tb) no more than	20ms

5.2 The outgoing terminals of all track feeder CBs shall be fitted with track alive relays that detect voltage on the conductor rail system in excess of 100V, and provide an indication to the OCC via the SCADA system.

9.3 Conductor (3rd) Rail

9.3.1 Functional Requirements

Table 9.4: Functional Requirements for 3rd Rail Conductor

Pos	Requirements
1	General 1.1 The design, procurement, installation and testing and commissioning of the conductor rail and its accessories are in the scope of the Contractor. 1.2 All DC cable connections to the conductor rail shall be made by the Contractor. 1.3 The position of the conductor rails shall ensure smooth, continuous contact with the LRV shoegear at the dimensions to be agreed with the LRV Supplier. 1.4 The conductor rails shall be installed between both tracks. At points and crossings, the conductor rail will be installed so that it is not possible for LRVs to become stranded. Where necessary, conductor rail may be located on the outside of the tracks. 1.5 The conductor rail and all connected parts shall be kept within a defined space constraint to prevent contact with passing trains. 1.6 The rails shall be mechanically sectioned to allow thermal expansion. Each mechanical section shall be positively anchored. The anchor is usually located at the mid point between expansion joints. The rails, insulators and supports shall be designed to withstand vehicle dynamic loads, wear, and electromagnetic loads and thermal loads imposed by normal electrical loads and full system short circuits.
2	Conductor Rail Sectioning and Gaps 2.1 The conductor rail system shall be divided into electrical sections in line with the DC sectioning diagram 362748-MMI-MVI1-XX-DR-324-3240 and as required by the Contractors traction power simulations and detailed design. 2.2 The conductor rail design shall be completed so that it is not possible to strand an LRV. 2.3 The conductor rail system in the mainline and depot shall have additional DC sub-sectioning and switches consistent with operational and safety requirements, and shall be designed to allow isolation of the conductor rail for the following functions: Normal depot cleaning, maintenance and overhaul operations; Safe stabling of a failed / crippled train in a bay platform or pocket track. At DC sub-sectioning locations, as a minimum, off-load, manually operated devices shall be provided. The location of each device shall be planned to facilitate easy access for operation, and so as not to create additional hazards for personnel. 2.4 Conductor rail switching devices shall be padlockable and suitably rated for use as a point of isolation. The location of each device shall be planned to facilitate easy access for operation, and so as not to create hazards for personnel. 2.5 Where DC feeder cables from a TSS are terminated onto conductor rail, each termination will be provided with an off-load, manually operated disconnector such as a "hook switch". The current rating of the disconnector shall be no lower than the current rating of the conductor rail. 2.6 Conductor rail gaps associated with TSSs shall be provided with an off-load, manually operated disconnector ("bypass switch") across the gap. The current rating of the disconnector shall be no lower than the current rating of the conductor rail. 2.7 Pocket tracks shall be provided with a three-position (or mechanically interlocked equivalent), off-load, manually operated disconnector ("transfer switch") to allow the pocket track conductor rail to be: <ul style="list-style-type: none">• supplied from the Eastbound conductor rail section OR• supplied from the Westbound conductor rail section OR• isolated.

Pos	Requirements
2.8	The current rating of the disconnector shall be specified by the Contractor based on the maximum LRV occupancy of the pocket track and the rolling stock specification.
3	Conductor Rail Supports
3.1	Conductor rails shall be supported at intervals which are sufficiently small to ensure that conductor rail deflection will not exceed the required dimensional tolerances.
3.2	In the event of an insulator/support failure, the conductor rail system shall continue to function correctly in respect of continuity of current collection and structural/electrical clearances. This shall include the effect of additional load on the rails caused by the remaining mass of the failed insulator/support and system short circuits.
3.3	Support brackets shall be used to interface the insulator with the civil / track structure and shall be designed to accommodate differing heights associated with slab / concrete sleeper trackforms.
3.4	The conductor rail shall be provided with a protective insulating cover that guards against inadvertent contact with the conductor rail, while allowing contact between the bottom of the rail and LRV shoegear.

9.3.2 Performance Requirements

Table 9.5: Performance Requirements for Conductor (3rd) Rail

Pos	Requirements
1	General
1.1	The proposed conductor rail type shall be a composite aluminium/steel type, specified as Brecknell Willis No. 4A, or similar other rail with the same or better electrical properties. The rail shall be configured for bottom contact with LRV shoegear. The maximum resistance of the composite rail, following installation and with all continuity cabling in place shall not exceed 14.5 $\mu\Omega$ per metre.
1.2	The conductor rail shall be supplied to site straight and in standard lengths of no less than 15m long. Rails shorter than 15m shall not be installed unless site constraints make this technically unavoidable. The minimum length of rail between successive joints shall be 4.5m unless otherwise specified. The conductor rails are jointed at their ends by means of bolted joints comprising of fishplates and Huckbolts. This provides a sound electrical and mechanical connection.
1.3	Authorised track crossings will be provided with a conductor rail gap of 2m away from each side of the crossing. The conductor rail shall not be within 2m of any authorised walking route or crossings.
1.4	Where the conductor rail cannot be located at a 2m clearance from a designated along-track walking route, the walking route shall be provided with a physical barrier to prevent inadvertent access to the conductor rail.
1.5	Components that wear or suffer regular arcing and require regular replacement, such as ramps and electrical sectioning locations, shall be designed for ready replacement, and shall be capable of being replaced in an overnight possession not exceeding 3 hours in duration.
2	Conductor Rail Sectioning and Gaps
2.1	Electrical sectioning of the conductor rail shall be achieved with ramped gaps providing a visible air break in the continuity of the rail. The air gap shall be longer than the length of one LRV contact shoe.
2.2	At depot locations where the floating return system meets the earthed return system, a gap in the conductor rail shall be provided. The gap shall have a length of approximately 5m. Two corresponding IRJs shall be provided in each running rail such that the floating (VLD-connected) negative sections in the depot and the earthed negative sections in the depot are separated.
3	Ramps
3.1	Entry and exit ramps shall be provided at turnouts, sectioning gaps, changes of the conductor rail location from one side of the track to the other and all other locations where a gap in the conductor rail is necessary.
3.2	High Speed Ramps in main lines (80km/h) shall have a slope of 1 in 50.
3.3	Low Speed Ramps (\leq 25km/h) shall have a slope of 1 in 30.

Pos	Requirements
3.4	At crossovers, use of side ramps is not preferred but is permitted if no other design solution is available
4	Conductor Rail Supports
4.1	The positive conductor rail shall be mounted on insulating supports. The insulation shall achieve a static electrical clearance of 75mm, and an insulator surface creepage distance not less than 120mm.
4.2	The insulators shall be designed to withstand a test voltage of at least 2.5kV DC for 1 minute, or a greater value as deemed necessary by the Contractor's insulation coordination study.

9.4 Electromagnetic Compatibility (EMC)

9.4.1 Standards

Table 9.6: Standards for EMC

Pos	Requirements
1	IEC 55103-1
2	IEC 55103-2
3	EN 50130-4
4	EN 50132-2-1
5	EN 55022
6	EN 55024
7	IEC 61000-3-2
8	IEC 61000-3-3
9	IEC 61000-6-1
10	IEC 61000-6-2
11	IEC 61000-6-3
12	IEC 61000-6-4
13	IEC 62236-4

9.4.2 Performance Requirements

Table 9.7: Performance Requirements for EMC

Pos	Requirements
1	Electromagnetic emissions produced by the Jakarta LRT railway system, as whole and with running trains, shall comply with the limits defined in IEC 62236-2.
2	Signalling and telecommunications equipment must comply (as a minimum), with the following EMC standards and regulations: <ul style="list-style-type: none"> • IEC 62236-4 (within the 3 m zone); • IEC 61000-6-2 (outside of the 3 m zone); • IEC 61000-6-4; • IEC 61000-3-2;

Pos	Requirements
3	<ul style="list-style-type: none"> • IEC 61000-3-3 (for equipment in the scope of). <p>outside of the railway environment (> 20 m with no connected cables running < 3 m away from the railway line, see IEC 62236-4) shall comply (as a minimum), with the following EMC standards and regulations:</p> <ul style="list-style-type: none"> • IEC 61000-6-3; • IEC 61000-6-1; • EN 50130-4 (immunity) for alarm systems; • IEC 55103-1 (emissions) and IEC 55103-2 (immunity) for public address systems; • EN 50132-2-1 (immunity) for CCTV system; • EN 55022 (emissions) and EN 55024 (immunity) for IT equipment; • IEC 61000-3-2; <p>IEC 61000-3-3 (for equipment in the scope of).</p>
4	Electromagnetic fields (EMF) produced by the signalling and telecommunications systems, including intentional emitters shall comply with the recommended exposure limits defined by the ICNIRP guidelines for time varying fields up to 300 GHz, regarding passengers, personnel (occupational) and other people in the vicinity of the Jakarta LRT Project.
5	Electromagnetic emissions produced by the rolling stock, as whole, shall comply with the limits defined in IEC 62236-3-1.
6	Electromagnetic emissions and immunity of apparatus within the rolling stock, shall comply with the limits defined in IEC 62236-3-2.
7	Technical coordination between the traction power supply system and rolling stock shall be carried out according to EN 50388.
8	UPS systems shall comply with IEC 62040-2.
9	Lifts, moving walks and escalators shall comply with EN 12015 (emissions) and EN 12016 (immunity).
10	Lighting equipment shall comply with IEC 61547 and EN 55015.
11	Self-commutated converters including direct DC.converters shall comply with IEC 60146-2.
12	High-voltage switchgear and control gear shall comply with IEC 62270-1.
13	Alarm systems (fire and security) shall comply with IEC 62599-2 (immunity).

9.5 Lightning Protection

9.5.1 Standards

Table 9.8: Standards for Lightning Protection

Pos	Requirements
1	IEC 62561 - Lightning Protection System Components
2	EN 50164 - Lightning Protection System Components
3	EN 62305-1 – Protection Against Lightning – General Principles.
4	EN 62305-2 – Protection Against Lightning – Risk Management.
5	EN 62305-3 – Protection Against Lightning – Physical Damage to Structures and Life Hazard.
6	EN 62305-4 – Protection Against Lightning – Electrical and Electronic Systems Within Structures.
7	BS EN 50122-1 +A2 - Railway applications. Fixed installations. Electrical safety, earthing and the return circuit. Protective provisions against electric shock
8	SNI 03-7015-2004 – Lightning Protection Systems for Buildings

Pos	Requirements
9	SNI 225 - General Requirements for Electrical Installation

Source: Mott MacDonald

9.5.2 Functional Requirements

Table 9.9: Functional Requirements for Lightning Protection

Pos	Requirements
1	General The Contractor shall carry out a Lightning Risk Assessment for all assets being constructed / supplied to form Jakarta LRT in accordance with EN 62305 Parts 1 and 2. The Lightning Risk Assessment shall be carried out in order to identify any structures, buildings, stations, equipment, or other items installed as part of the JAKARTA LRT works that may require lightning protection systems.
2	The Contractor shall provide copies of the Lightning Risk Assessment calculations, study and final report to the Employer.
3	The Contractor shall utilise the results of the Lightning Risk Assessment, to carry out the detailed design, obtain acceptance for the design (from the Employer), supply, install and test and commission the Lightning Protection Systems.
4	If the Lightning Protection System design affects a third party, the Contractor shall provide the Employer with all necessary information to enable the Employer to gain acceptance of the works from the third party.
5	Lightning Protection Systems shall include both internal and external requirements. <ul style="list-style-type: none"> • External Lightning protection systems shall consist of air termination networks, down conductors and earth termination networks (to prevent physical damage to structures and life hazard) in accordance with EN 62305-3; • Internal Lightning Protection systems shall consist of bonding and screening, ensuring proximities and cable routing are compliant and surge protection devices (to protect electrical and electronic systems within or on structures) in accordance with EN 62305-4.
5.1	Internal Lightning Protection Systems The Contractor shall detail required proximities / clearances of all electrical equipment and appropriate cable routing in accordance with EN 62305-4, and ensure these are adhered to during construction of the works.
5.1.1	The Contractor shall detail all required bonding and screen of cables and equipment accordance with EN 62305-4, and ensure these are adhered to during construction of the works.
5.1.2	Where necessary, as required by the Contractor's Lightning Risk Assessment and subsequent detailed design ; and any other Technical Requirements elsewhere in this document; the Contractor shall provide suitable type and suitably rated surge protection devices on:-
5.1.3	<ul style="list-style-type: none"> • incoming LV power supplies to buildings, stations and line side equipment housings • Incoming and outgoing HV power supplies • Incoming and outgoing DC traction power supplies • Incoming and outgoing ELV supplies, battery chargers, UPS's and similar systems. • Running and conductor rails • Any other power supplies or electrical systems that may require surge protection
5.1.4	The Contractor shall ensure that the third rail conductor system support structures and clamp mechanisms are selected with due cognisance of the risk of lightning strikes and that the materials of the components forming the conductor rail support system (base plates, brackets, clamps, supports, shroud etc.) provide inherent lightning protection . Where this is not feasible (either or wholly or partially), the support system shall be insulated from the ground by use of an insulated pad and insulated fixing bolt sleeves. The technical requirements of the insulation material(s) shall be determined by the Contractor (with consideration to voltage withstand and insulation levels

Pos	Requirements
	being required).
5.1.5	The Contractor shall ensure that a Type 2 (VLD-O) VLD in accordance with EN 50122-1 is provided in every substation connected between the traction negative and the station (or depot) earth. This shall provide a safe traction floating system and limit surges on the running rails caused by lightning strikes. Note special arrangements apply in the depot. Please refer elsewhere in this document for more details on the traction power systems and the TSS negative busbar arrangements.
5.2	External Lightning Protection Systems
5.2.1.	Any lightning protection systems provided shall be bonded to earth. The earth system shall be adequately sized and rated for the anticipated lightning strikes. The earth system for lightning shall be separate from other earthing systems.
5.2.2.	All extraneous conductive parts connected to the structure of the buildings, stations, equipment housings or item being protected shall be bonded to the associated lightning protection system.
5.2.3.	Where systems have components of, or are in contact with, dissimilar metals, the Contractor shall ensure appropriate precautions are taken to prevent electrolytic corrosion.
5.2.4.	Provide safety signage as required by IEC or EN standards for any lightning protection systems, ensuring every earth rod pit for the lightning system is clearly identified, and any bonds to earthing terminals have warning signs that the bond should not be disconnected.
5.2.5.	Air termination networks, where required by the Contractor's detailed design should be placed on the building roof. The Contractor's detailed design shall include lightning protection for any equipment placed on the building roof (such as air conditioning units, antenna).
5.2.6.	For sensitive equipment such as communication antenna, there should be an additional lightning rod specifically for that equipment.
5.2.7.	The external lightning protection system shall be equipotentially bonded to the nearest Main Earth Bar
5.2.8.	Air Termination Networks - A copper tape network with air termination rods or a metallic roofing structure shall be utilised to form the air-termination network to ensure a reliable low impedance connection is made between the perimeter down conductors and the roof steel work.
5.2.9.	Down Conductors - Down conductors shall be formed from dedicated copper strips mounted externally to the building being protected, alternatively the external steel structure / frame of the building may be utilised. In the event the external steel structure / frame is used the Contractor shall ensure that this provides an electrically continuous lowest resistance path for any lightning strikes. Welded continuity bonds on the steel structure / frame shall be provided if there are bolted connections or discontinuities in the frame. All down conductors shall have test points.
5.2.10.	If the external steel frame/structure of a building is utilised as down conductors, the Contractor shall ensure all other parts of the steel frame in that building are electrically continuous and interconnected with the natural down conductors – this is essential, particularly in multi-storey buildings.
5.2.11.	Earth Electrodes - The earth electrode shall be principally formed by either using the structural piles connected to the down conductors or by using a series of earth rods driven into the ground. The earth electrodes should be local to the down conductors and comply with EN 62305.

Source: Mott MacDonald

9.5.3 Performance Requirements

Table 9.10: Performance Requirements for Lightning Protection

Pos	Requirements
1	Any lightning protection system provided shall: <ul style="list-style-type: none"> • safely and reliably reduce the risk of damage to Jakarta LRT assets (whether these be structures, building, equipment cabinets or other items) or third party infrastructure identified as a result of the risk assessment

Pos	Requirements
	<ul style="list-style-type: none">• be capable of operating safely at all times, without damage by lightning.• be co-ordinated with the earthing and bonding provisions of adjacent equipment, structures, buildings, stations or other items that may contain or conduct electricity.
2	Any lightning protection systems provided shall comply with EN 62305.
3	Any lightning system provided shall consist of air termination networks, down conductors / tapes, joints, test points, earth rods etc. in accordance with IEC 62561 and EN 50164, as required by the design.
5	Earth termination networks for lightning protection system shall achieve an earth resistance ≤ 10 ohms.
6	Where possible, the earth rods forming the earth termination network for the lightning protection system shall be located as close as possible to the down conductors.

Source: Mott MacDonald

10 Signalling and Train Control

10.1 Signalling and Train Control

10.1.1 Standards

Table 10.1: Standards for Signalling and Train Control

Pos	Requirements
1	EN 62290-1:2014 Railway applications. Urban guided transport management and command/control systems. System principles and fundamental concepts
2	EN 62290-2:2014 Railway applications. Urban guided transport management and command/control systems. Functional requirements specification
3	EN 62267:2009 Railway applications. Automated urban guided transport (AUGT). Safety requirements EN 50159:2010
4	EN 50159-1 2010 EN 50159-2 2010 Railway applications. Communication, signalling and processing systems. Safety-related communication in transmission systems
5	EN 50126:1999 Railway applications - The specification and demonstration of reliability, availability, maintainability and safety (RAMS)
6	EN 50129:2003 Railway applications. Communication, signalling and processing systems. Safety related electronic systems for signalling
7	EN 50121 – 2015 Railway Applications : Electromagnetic compatibility (Parts 1 to 5)
8	EN 50122 – 2010/2011 Railway Applications :Fixed installations (Part 1-2011, Parts 2 and 3-2010)
9	EN 50125-2 – 2002 Railway applications - Environmental conditions for equipment - Part 2: Fixed electrical installations
10	EN 50125-3 – 2004 Railway applications - Environmental conditions for equipment - Part 3: Equipment for signalling and telecommunications
11	IEEE 1474.4-2011 IEEE Recommended Practice for Functional Testing of a Communications-Based Train Control (CBTC) System
12	IEC 61508:2010 Functional safety of electrical/electronic/programmable electronic safety-related systems - Part 1: General requirements
13	IEC 61511-1:2016 Functional safety - Safety instrumented systems for the process industry sector - Part 1: Framework, definitions, system, hardware and application programming requirements
14	BS 1376: 1974 Specifications for Colour Light Signals

Source: Insert source text here

10.1.2 Functional Requirements

Table 10.2: Functional Requirements for Signalling and Train Control

Pos	Requirements
1	Signalling, Control and related Traffic Management Systems and tools are part of the global OCC/TMS system, which also serve, in an integrated way, all the other relevant systems and sub-systems (energy, telecommunications, SCADA).
2	The TMS shall include all the necessary train management functions and tools, which allow the Automatic Route Setting (ARS) to send all route requests to the interlocking in advance, in normal operation, according to predefined schedule and LRVs position (Train Descriptor functions).

Pos	Requirements
3	The TMS shall be provided with all the tools to allow the advanced schedule preparation (times, train descriptions and all routes required by each LRV movements), either for normal schedule or special schedule, due to some extraordinary event.
4	All the above management functions shall be provided with the necessary simulation tools, which allow the advanced testing of schedule changes, in order to validate them, before putting them into service.
5	All relevant tools, such as Automatic Route Setting, Train Describer and Timetable Management shall be integrated in a way, that any change or update can be efficiently and quickly managed in real time, with a simple and intuitive interface to the OCC/TMS operators.
6	The train management tools shall give information to the passenger information system, in real time. Any change on the LRV programs, routes or schedules must reflect automatically and in real time to the passenger information systems.
7	The OCC shall be able to supervise, monitor and send automatic route requests to the interlocking and show the state of all relevant indications related to the railway status.
8	The OCC operators shall be able to send manual route requests, route cancelation requests and powered points switching movement requests to the interlocking.
9	The design of the OCC should be provided with display screens capable of showing all the relevant information for the efficient operation of the entire system, namely, but not limited to:
	<ul style="list-style-type: none"> • The complete and detailed track layout and the status of all signalling elements; • Position of all vehicles in real time and deviation of each one regarding the programmed schedule; • Alarms and warnings regarding all signalling and control systems, which require attention or action from the OCC.
10	An adequate system of radio communication between the OCC and LRVs shall be provided in order to allow communication of procedures in degraded mode operation.
11	A test terminal is to be provided at the OCC to enable the maintainer to fault find the system in the event of a system failure.
12	All operational systems are to be ergonomically designed so as not to place the LRV operators under undue stress.
13	The main objective of the Interlocking systems is to provide for the safe movement of vehicles and to prevent conflicting vehicle movements, and must cover the entire line including the Depot area.
14	Safe train detection (axle counters, in order to minimize the interface with track and traction power) and route setting logic shall cover the entire line and the Depot area (with the exception of the workshop area).
15	The position and number of track sections (axle counters) shall be minimized, in order to simplify the system and reduce the cost without compromising safety.
16	As axle counters don't provide any delayed pick up, on clearance, the route release logic must have the necessary protection against an early or unsafe route release.
17	The axle counter system shall require the installation of cables between stations (shall use connections through the fiber optics network to transmit evaluator information to and from one station to the adjacent) and should minimize the usage of local cables within the station area.
18	LED lineside signals, equipped with ATS, shall be installed on the line, based on the typical layout diagrams in Volume 3, and the following main principles:
	<ul style="list-style-type: none"> • LRV operation is unidirectional with an up and down direction. Block directions are fixed (right side track driving) and opposing LRV operation is not signalled into the sections between stations. • In normal operational conditions, the signalling system shall only allow one LRV to be present on each block (Absolute working); • Only one block section is permitted between the section entry signal and the home signal;

Pos	Requirements
19	<ul style="list-style-type: none"> As the block operation in non-permissive block type and in order to minimize the number of track sections, signal replacement by the first wheel of the LRV is not required; Route release by the LRV should be done as soon as safety conditions allow, in order to maximize operation flexibility; <p>The signalling principles to apply in Depot area shall be similar to the main line, with the exceptions to allow stabling of multiple trains on the same track section and all flexibility regarding joining and splitting of train compositions.</p>
20	ATS protection is not required on signals inside Depot area, taking into account the low operational speeds and the nonexistence of passenger movements.
21	Following the principles of LoS driving on the approach to the signals and the LRV brake characteristics, in principle no distant signals will be installed. The detailed project design should address the eventual need of any particular case, where the installation of a distant (or repeater) signal is advised, if any.
22	The vital interlocking functions (switches movement, locking and detection, route setting, cancel and release, train detection, ATS information, etc..) shall be implemented using SIL 4 equipment and circuits, logic and methods (according to the relevant applicable standard codes).
23	As stations will not be manned, no "local" control desks are foreseen to be required in stations. The OCC will be the only means of control to the interlocking systems and shall be provided with enough redundancy, in order to allow a continuous operation without disruption in the event of local or central equipment failure or network failure.
24	The interlocking equipment shall be housed in specific equipment rooms to be provided at all LRT stations and Depot control area. Each equipment room shall be provided with Telecoms, lighting, AC power. Station interlocking equipment can also be installed in outside locations, if the technical solution is approved and/or it is a more economical solution.
25	All switches shall be motorized, controlled and detected by the interlocking system.
26	Power motors installed in trailing switches (in direction of normal train movements) shall be of "trailing" type, allowing a LRV to pass over them, even when blades are not correctly positioned, without any damage to the LRV, switch blades or switch motor.
27	Point movement request in the interlocking must take in consideration the propagation and processing times, namely regarding the vacant track occupation and measures shall be taken to avoid the movement of points under the train, especially in cases where the point tips are positioned near the vacant track section frontier.
28	In the event of a switch failure, which will not allow the points to be moved from the interlocking, it shall be possible for the LRV driver to move them manually, locally on track, using a handle mechanism carried on board of the LRV.
29	When handle mechanism is authorized and in use, the electric power do the motor shall be disabled and all routes that use the switch shall be disabled in the interlocking.
30	Design and position of the switch motors and handle mechanism device shall take in consideration the necessary security measures to protect the driver from touch the 3 rd rail, when the manual operation is required.
31	A suitable and safe axle counter reset mechanism and operational procedure shall be implemented, in order to normalize the track sections, in the event of a miscount or axle counter equipment failure.
32	It shall be possible to initiate the axle counter reset function from the OCC.
33	Lineside signals aspects, visibility and technical characteristics shall be similar for main line and Depot, in order to simplify the operation rules and the maintenance activities.
34	Minimum visibility of lineside luminous signals shall be 400 m , allowing enough visibility distance for LoS sighting principles.
35	Signals on the line shall be mounted on post with adequate height to allow the best possible visibility at distance (typically around 2.5 meters above the running rail level).
36	Generically on main line, signals will be mounted right side of the track (regarding the direction of

Pos	Requirements
	movement). In special cases and in Depot, signals can be mounted left side of the track, if from that a better visibility is achieved or if no physical space exists on right side. During detail design and installation phases a complete site survey must be carried out in order to determine the best possible position for each signal and indicator.
37	Signal aspects and route indicators shall be LED technology and signal posts shall be folding type (without escalators) in order to simplify and minimize the maintenance activities.
38	In Depot, the signals can be mounted at rail level, in cases where they only need to be seen at short distances (parking sidings for example) and the clearance is limited. The position and mounting of low position signals must ensure that they are not easily missed by the driver and tripped, especially at night in low light conditions.
39	Main signals, route indicators and speed boards sharing the same position shall be installed using the same post, one above the other. The relative position between them must be consistent along the whole line.
40	Fixed maximum speed boards indicators using reflective material, as appropriate, to allow enhanced distant visibility reading during night-time operation.
41	Additional fixed signals and indicators (buffer stop, end of movement for routes not ending on a signal...) can be used during detail design phase by the contractor if it's required.
42	All luminous signals shall have an identification plate with the signal number. This allows the driver to identify the signal in a clear way, in cases where the signal cannot show a proceed aspect and operational procedures from OCC are in use.
43	Signals will display a colour light aspects, with two aspects: RED or GREEN .
44	Route indicators shall display a row of WHITE light indications.
45	On main line, a route indicator shall be associated to signals that can set more than one route, namely in order to inform the driver of the maximum allowable speed for the movement.
46	The route indicator shall only be alighted if signal shows a proceed aspect. In the event of route indicator proving failure, main signal must still able to show the proceed aspect.
47	In situation where the main aspect shows proceed but route indicator is dark, operational procedures must be taken in account regarding the maximum speed allowed (as no information is presented regarding the route that is set).
48	Each stabling track is designed to stable 2 trains, up to 120 m in length. The routes reading into the stabling tracks shall allow the route to be set and the signal to clear when a LRV is already stabled in final section of the stable track.
	In order to distinguish the situation where the first part of the stabling tracks is already occupied by another LRV, a different proceed aspect shall show depending on the last track section is occupied or clear, as follows:
49	<ul style="list-style-type: none"> • If last track section already occupied: Proceed aspect will be "Flashing Green"; • If last track section is clear: Proceed aspect will be "Green"; and • The remaining sections in route must be clear, in order to show any one of the 2 previous proceed aspects.
50	Route indicators on signals that set routes to the stabling yard, shall show the respective number of the route selected, instead of the direction type route indicator, used on main line and on rest of the Depot signals
51	A test track shall be provided with 2 signals equipped with ATS beacons, in order to allow the test of the ATS system and the correct actuation of the emergency brake on the train, when the trains leave the workshop, before they can go to service.
52	In the workshop area, no provision will be made for the track sections or exit signals, due to the position of the point working, inside the active work area of the workshop.
53	Points inside the workshop will all be electrically powered and will be operated from a local control panel in the workshop (in a suitable place to be defined in the detail design phase). The points in the workshop area

Pos	Requirements
	are not to be interlocked with routes and will not be provided with track detection. This will allow a more flexible movement of the vehicles inside the workshop, without the constraints imposed by the signalling system.
54	LRV's will be routed by the central control panel (OCC) to a signal at the workshop entrance area. The signal, which allows trains to go into the workshop, will be controlled by the local control panel in the workshop. That signal can only show a proceed aspect if requested by the local panel and a valid path is set by the point positions inside the workshop area.
55	In order to avoid simultaneous movements of trains, in opposite direction, over the berth track of the workshop area, a suitable request/acknowledge protocol must be established, during detail design, between the central operator and the local panel operation.
56	Local panel and points operation in workshop area can be installed using the same interlocking system as for the rest of the Depot (acting like a Local Shunt Area) or a separate logic with the adequate interfaces with interlocking system. Solution shall be developed during detail design phase, by the contractor.
57	To avoid the eventual unmanned movement of stabled LRVs, each one of the stable tracks shall be provided with a derailer, which only be set off the rail when a route in or out the respective stable is set. Derailer will return to on rail position, automatically after the relevant route is cleared and the respective track section is clear.
58	All signals on the main line shall be equipped with an ATS system, in such a way that, if an LRV passes the STOP signal, LRV will automatically be stopped by the ATS, using the emergency brake.
59	The signal aspect (Proceed or Stop), will be sent to the ATS, which will be collected from trackside loop or beacon and read by the LRV antenna. The information will be transmitted to the OBCS computer which will send a signal to the LRV brake system (depending on the technical solution supplied in detail design phase).
60	An ATS "reset" button/function shall be implemented on board the LRV, in order to release the brakes in the event of ATS activation.
61	The ATS balise information can be derived directly from lineside signal lamp circuits or provided by the interlocking system as alternative information.
62	The position of the balise in relation to the axle counter heads must be calculated to ensure that the LRV can read the ATS balise information before occupying the axle counter ahead. This calculation must take into account in determining the position of the antenna on the LRV (regarding the position of the first wheel) and all systems reaction times (ATS reading, axle counters occupation time, etc.).
63	The position of the trackside beacon shall also take into consideration the position of the platform stop position, in such a way that it ensures that the LRV will read the most recent information on departure.
64	Despite the coverage of the entire line with route locking, train detection and protecting signals, the LoS principle still applies on the approach to all signals, as in principle, no distant signals or overlaps will be provided.
65	For LoS operation and distance calculations, a driver's recognition/reaction time of 5 s shall be considered and added to the relevant breaking distances.
66	The application of the Line-of-Sight mode to all signals shall allow the driver to anticipate the signal aspect and stop the LRV, using service break, for any signal displaying a STOP aspect.
67	<p>Relevant considerations to the above principle may include:</p> <ul style="list-style-type: none"> • the available sighting distance; • the intended maximum speed of operation; • the braking performance of the LRV, taking into account the gradient and LRV brake equipment response time; • the effectiveness of the LRV headlamps, if it is intended to operate in darkness in unlit areas, or the effectiveness of any illumination of the track; • the expected driver reaction time; • the visibility of signals and points indicators;

Pos	Requirements
68	<ul style="list-style-type: none"> • the topology of the surrounding area including side roads/walkways; • Surrounding amenities; and • The configuration of the LRV. <p>A detailed calculation shall be done in the detail design phase, by the signalling contractor, defining the maximum LoS allowable approach speed for each of the signals. Target achievement should always be the maximum permitted track speed at each position.</p>

10.1.3 Performance Requirements

Table 10.3: Performance Requirements for Signalling and Train Control

Pos	Requirements
1	Design life of the TMS/OCC, Central Interlocking and all components shall be at least 15 years
2	The system design shall be such that spares in sufficient quantities are available for the complete lifecycle of the system.
3	Response times of the entire Signalling and Control Systems should be small enough to ensure that all information, actions, indications and interlocking reactions are updated fast enough, not only to ensure the safety conditions are fulfil, but also to ensure that operators perception in OCC/TMS is in real time.

11 Communication, Information and Control

11.1 TETRA Digital Voice and Data System

11.1.1 Standards

Table 11.1: Standards for TETRA Digital Voice and Data System

Pos	Requirements
1	ISO/IEC 80000 The International System of Units (SI) and its Application
2	IEC 60950-1 Safety of information technology equipment
3	ISO/IEC 11801 Telecommunications installations — Generic cabling for commercial premises
4	IEC 60529 Degrees of Protection - Enclosures for electronic equipment
5	IEC/CISPR 22:1993 Limits and methods of measurement of radio disturbance characteristics of information technology equipment.
6	IEC 61000-6-3 Electromagnetic Compatibility (EMC) – Various sections referenced within this specification
7	IEC 297(917) Dimensions of Mechanical Structures of the 19-inch (482.6-mm) Series—Part 3: Subracks and Associated Plug-in Units
8	BS 6701. 2010 Telecommunications equipment and telecommunications cabling speciation for installation, operation and maintenance
9	BS EN 50174-1,2,3 Information Technology cabling installation
10	BS7671 Requirements for Electrical Installation
11	BS 7718 Code of practice for installation of fibre optic cabling (now withdrawn but excellent reference)
12	BS EN 50159 Railway applications Communication, signalling and processing systems. Safety- related communications in transmission systems
13	EN50173-1 Generic cabling systems-General Requirements
14	BS EN 50346 Information Technology-Cabling Installation-Testing of installed cables
15	DIN 41494 Basic Specification for 19-inch Construction Rack Systems
16	IEEE-STD 299 Standard Method for Measuring the Effectiveness of Electromagnetic Shielding Enclosures.

Applicable TETRA Standards

1	Voice + Data (V + D)
2	300 392-1 General Design
3	300 392-2 Air Interface (AI)
4	300 392-3 Inter System Interface (ISI)
5	300 392-4 Gateways (PSTN and ISDN)
6	300 392-5 Peripheral Equipment Interface (PEI)
7	300 392-7 Security
8	300 392-9 Supplementary Services - General Design
9	300 392-10 Supplementary Services (SS) Stage 1
10	300 392-11 SS Stage 2
11	300 392-12 SS Stage 3
12	100 392-15 Frequency bands, duplex spacing & channel numbering.

Pos	Requirements
13	100 392-16
14	100 392-18
15	300 394
16	300 395
17	Direct Mode (DMO) 300 396-1
18	300 396-2
19	300 396-3
20	300 396-4
21	300 396-5
22	300 396-6
23	300 396-7
24	300 396-10
25	100 812
26	200 812
27	300 812
Technical Reports and ETSI Guides	
1	102 300-3
2	300-4
3	102 300-5
4	101 052
5	101 053-1
6	101 053-2
7	101 053-3
8	101 053-4
9	101 448
Other Specifications	
1	101 747
2	101 789-1
3	302 109
4	202 109
5	301 040
6	101 957
TETRA RELEASE 2 User Requirement Specification	
1	101-021-1
2	101-021-2
3	101-021-3
4	101-021-4
5	101-021-5

Pos	Requirements
6	101-021-6 SIM URS
7	101-021-7 Security URS
8	101-021-8 Air-Ground-Air Services

11.1.2 Functional Requirements

Table 11.2: Functional Requirements for TETRA Digital Voice and Data System

Pos	Requirements
1	The radio system shall comprise of a digital trunked radio network capable of simultaneous transmission/reception of both speech and data over the radio bearer, be capable of covering the required geographic area utilising IP connectivity into the Fixed Telecoms Network (FTN)
2	There is a requirement to ensure that the radio network shall meet the requirements of the rail infrastructure encompassing Voice and Data between trains and fixed stations. It shall have sufficient overall coverage to allow communications between, trains and fixed stations, track workers, station staff, operations and other defined personnel as required
3	An upgrade path to LTE should be available
4	The system shall be capable of integration into other radio Systems (including Analogue and other Networks)
5	The system shall be capable of inter-connection to Emergency Service, Police, Fire, Ambulance and or other security services
6	The system shall support the use of multi-vendor handsets and mobile equipment.
7	The system shall wherever practicable utilise Commercial off the Shelf Equipment (COTs)
8	The system shall utilise encryption and Authentication techniques to prevent unauthorised access
9	The system shall be capable of voice recording using such technology as RAID 5 to ensure that a minimum of thirty (30) days information can be retained before overwriting
10	The system shall be capable of supporting lawful interception facilities
11	The system shall be capable of interfacing with different technology gateways
12	The system shall be easy to maintain, troubleshoot and repair using "Hot Pluggable" modules
13	There shall be local support for the equipment within SE Asia (Indonesia) available within agreed SLA's
14	It is recommended that the UHF 1 band (410 to 430 MHz) is utilised for this network. It shall be the responsibility of the Contractor to work with the Ministry of Communications to secure appropriate frequency channels as determined at the detailed design stage.
15	A comprehensive subscriber management capability, providing system managers with the means to control the key aspects of subscribers' activity shall be supplied
16	A SDS Gateway that facilitates the use and sending of text messaging, shall be supplied It shall allow text messaging into / out of a dispatcher, which is particularly relevant in a control room environment. It shall allow storing and forwarding of SDS messages, for when a subscriber is not on the network, and also enables the network load to be reduced, as SDS messages received shall not then need to be re-transmitted over the air.
17	The system shall require Hot-pluggable replacement units to allow live replacements without impacting communications and thus reducing any possible downtime and therefore keeping the Mean Time To Repair (MTTR) to a target time of 30 minutes, excluding time to arrive at site.
18	Outdoor mounted equipment shall incorporate appropriate lightning protection, as specified in the appropriate international standards
19	The DVDMR shall encompass a full IP-based architecture and have N+1 redundancy for base station, switches and gateways.
20	Hand Portable Radios

Pos	Requirements
20.1	Shall comply to current TETRA standards
20.2	Shall support man down operation (verticality and movement detection)
20.3	Shall support GPS location services
20.4	Shall support emergency single press button with live microphone
20.5	Shall be supplied with individual and multiple charger options
20.6	Shall be supplied with leather carry case
20.7	Options to include ear piece and remote microphones, spare battery, or high capacity batteries.
20.8	Option to provide Intrinsically Safe ATEX 6 radios for use in hazardous atmospheres (Fires/fuel or explosive gases)
21	Train Borne Speech and Data Radio Equipment
21.1	Shall be of robust construction to meet the requirements of on board train requirements
22.2	Shall comply to current TETRA standards
23.3	Shall support GPS location services
22	Train borne Radio Equipment (Signalling System)
22.1	Shall be of robust construction to meet the requirements of on board train requirements
22.2	Shall comply to current TETRA standards
22.3	Shall support GPS location services
22.4	As part of the detailed design, in depth desktop radio coverage studies shall be carried out for proposed base station locations for the DVDMR System (See Appendix G) followed by in country surveys after construction, using calibrated radio survey equipment to verify the desktop study predictions, the suitability of proposed sites, frequency allocation requirements and validation of frequency plans & allocations. This survey shall be the benchmark for all future monitoring and testing of the system to ensure ongoing optimal performance during the operational life of the network.
22.5	Survey and analysis documentation shall include: calculations and formulae used and provenance of supporting data, proposed elevations and azimuths of antennae and tower mounted radio equipment, antenna radiation patterns, cable routes between equipment mounted on towers and buildings, lightning protection, cable routes within buildings, integration with Voice and Data Systems, SCADA Systems and the Vehicle Tracking System.
22.6	DVDMR Network management access shall be provided locally at each base station and in other designated locations such as the Communications Radio Room.
22.7	The DVDMR System shall route calls between fixed, mobile and hand portable transceivers via radio base stations by the shortest route and shall identify all transceivers in the service area of each radio base station. The DVDMR System shall distribute this information to all other base stations so that call routing can be accomplished in the most economical way.
22.8	The DVDMR system shall as far as possible be constructed using COTS equipment and all proprietary/bespoke equipment shall be kept to a minimum where possible to reduce costs and ensure long term supply of spares etc.
22.9	DVDMR System management access via a network management terminal shall be provided at designated locations, to be determined during the detailed design stage
22.10	Train to signaller calls shall be established by no more than two control operations, (such as lifting the train borne transceiver handset off hook and operating a push button), that initiates or accepts a call between the train and the signaller.
22.11	Signaller to train calls shall be established by no more than two control operations; such as a push button operation on the signaller's radio access terminal to select the train to be called (or is calling) and a further push button operation to initiate or accept the call.
22.12	The train borne radio transceivers shall also route train running data from the train to the signaller's radio access terminals for processing such that the identity and location of the train borne radio transceivers are displayed by the terminals.
22.13	Interfaces between the train borne DVDMR equipment and the railway signalling and asset protection systems

Pos	Requirements
	that are required for functional and/or operational reasons shall be developed during detailed design if required.
22.14	Train borne and signallers DVDMR System equipment functionality and configuration requirements shall be further identified and developed during detailed design in conformance with the railway's standard operating procedures.
23	Signalling Train Borne Equipment
23.1	During the detailed design stage the contractor shall define rail specific functionality for all on board DVDMR terminals.
23.2	The on board radio equipment shall contain interfaces to other on board systems to be defined during the detailed design stage.
	Train borne and signallers DVDMR System equipment functionality and configuration requirements shall be further identified and developed during detailed design in conformance with the railway's standard operating procedures.
24	Operations Control Centre (OCC) configuration
24.1	Site equipment of the TETRA system shall be installed at station locations as determined during the desk top study. The equipment shall include TETRA base stations, antenna/feeder and other accessories.
25	Propagation study
25.1	The desktop survey shall take into account such factors as potential interfering stations, frequency reuse patterns, maximum ERP, height of track above ground, urban clutter and vegetation etc.
25.2	The desktop survey shall be backed up by a physical survey during the Testing and Commissioning stage of the project, this will be utilised to optimise the network for coverage, hand-over QoS and other defined parameters to benchmark the network for future reference and continued maintenance utilising a continuously monitored regime using autonomous specialised network monitoring probes.

11.1.3 Performance Requirements

Table 11.3: Performance Requirements for TETRA Digital Voice and Data System

Pos	Requirements
1	Safety critical Data and voice
1	Minimum value of service and location measured over 100 metre blocks to give a probability of 95% at a level of - 95dBm for speeds lower than or equal to 80 Km/h
2	The TETRA Radio System infrastructure shall have a design life of 25 years
3	The Operational life of the TETRA Handsets and mobile radio sets shall be 10 years
4	Batteries shall be capable of supporting the handsets for a minimum of eight hours based on 10/10/80 usage patterns
5	The system shall be capable of making/receiving Railway Emergency Calls (REC)
6	The system shall be capable of making/receiving Passenger Emergency Calls (PEC)
7	The system shall be capable of generating group calls (Many to Many)
8	The system shall be capable of generating Broadcast calls (One to Many)
9	The system shall be capable of supporting Direct Mode Operation (DMO)
10	The system shall be capable of supporting up-to three antenna MIMO techniques to improve radio reception
11	A full desk top propagation study shall be carried out to determine the location of the Transmitter /Receiver base stations utilising a frequency of within the bands 410-430 MHz, 450-470 MHz, 385-390 MHz / 395-399,9 MHz. The output of this study will form the basis of the detailed design of the system.
12	The DVDMR System shall have IP-based architecture interconnected via a Communications backbone bearer with intelligence distributed throughout the system.

Pos	Requirements
13	The DVDMR system shall be capable of network connection via E1,T1, ISDN, IP or Fibre.
14	The DVDMR system shall be capable of operating via a star, ring or mixed system topology and shall employ an open system architecture, software interfaces/API
15	The DVDMR System reference data base shall be configured to provide 100% redundancy and the architecture wherever possible shall be configured so as to provide the highest achievable functional survivability in the event that elements of the DVDMR System become unavailable (reliability 99.99%).
16	A Packet Data Gateway that facilitates the use of IP based data transmission between subscriber and network, shall be supplied
17	The DVDMR shall be fully compliant to current TETRA standards
18	Hand Portable Radios
18.1	Shall have optional full keypad capability (Dependent upon operational requirements)
18.2	Shall be capable of a minimum output power of 1.8 Watts
19	Train Borne Speech and Data Radio Equipment
19.1	Shall be capable of a minimum output power of 25 Watts
19.2	Shall support a remote MMI unit and in the case of two radio units each MMI shall be capable of supporting the opposite end transceiver in the event of failure of that unit.
22	Train borne Radio Equipment (Signalling System)
22.1	Shall be capable of a minimum output power of 25 Watts
22.2	Shall support a DMU mounted in each driving position
22.3	Shall be capable of interfacing into on board train data/monitoring systems, tachometers and on board signalling computers and Wi-Fi systems
22.4	Power to the on board radio equipment shall be supplied via a separate, appropriately rated DC miniature circuit breakers
22.5	The DVDMR System shall be engineered to support achieving the overall signalling and train control system operational availability target to provide a fail-safe system with 99.99% availability; (Redundancy of Dx/RX=N+1) Refer to RAM's section xxx
22.6	The DVDMR System shall also provide a project-wide light traffic data communications bearer as defined by TETRA Standards; for SCADA, vehicle tracking and other monitoring systems as required.
22.7	The DVDMR System shall provide man-down alert for all hand portable transceivers and GPS backed tracking for all mobile and hand portable transceivers.
22.8	The DVDMR System shall provide suitable interfaces/gateways for associated telephone trunk circuits shall be provided for connection to the telephony system.
22.9	The base station air interface shall preferably be by antenna, although leaky feeder RF transmission techniques shall be considered to provide service where required within tunnels or other areas where it is not possible to erect suitable antenna systems.
22.10	The DVDMR System shall have IP-based architecture interconnected via a Communications backbone bearer with intelligence distributed throughout the system.
22.11	The DVDMR System shall also be capable of local site fall back, that is in fall back mode without connection to a switch or network, and the base station shall provide all the functionality of a small self-contained TETRA system. All subscriber information shall be stored at the Base Station enabling any subscriber to register on a base station in fall back mode.
22.12	The DVDMR System architecture shall be designed in such a way that all system elements (radio base stations, recording stations and gateways to external voice or data systems etc.) shall use similar network interfaces and shall all be addressed in the same way so as to allow flexibility for location of system elements and for system expansion. Additional system elements shall be treated as another client with their own IP addresses.
22.13	The DVDMR system shall require Hot-pluggable replacement units to allow live replacements without impacting communications and thus reducing any possible downtime and therefore keeping the Mean Time To Repair

Pos	Requirements
22.14	(MTTR) to a target time of 30 minutes, excluding time to arrive at site. The DVDMR shall need to be adaptable and requires flexible system architecture to allow scalability from small networks to large project wide systems. It shall encompass a full IP-based architecture and have N+1 redundancy for base station, switches and gateways.
22.15	DVDMR System voice traffic shall be recorded as required by the Employer.
22.16	It shall be possible for train crews to manually enter train description and location data into the train borne transceivers.
22.17	The DVDMR System design shall also include provision of train borne transceivers installed in portable transit cases including batteries, battery chargers and antennae, for use by on train personnel to assist in their duties/activities.
22.18	Train radio equipment shall normally be programmed to provide bi-directional connectivity between signaller's radio access terminals and train borne transceivers only.
22.19	The system shall have the capability to be enabled for wider but still controlled access, such as support to maintenance of permanent way or other operational activities.
23	Signalling Train Borne Equipment
23.1	External equipment (i.e. radio and GPS antennas etc.) shall not infringe the clearance requirements of the line.
23.2	Antenna locations shall be selected based on EMC studies and coverage considerations.
24	System Architecture The contractor shall provide a system architecture design shall be produced that provides coverage of all operational areas networked together in a redundant topology via the Fibre system as follows:
24.1	<ul style="list-style-type: none"> • OCC • Depot area. • Stations • Rail Alignment.
24.2	Wherever possible these sites shall be co-located with Signalling and Communications Equipment within the Common Equipment Rooms (CER) located at specified stations.
24.3	The preferred interface protocol shall be via IP over the Fibre system. Where coverage permits and predicted traffic density is low, dedicated TETRA timeslots may be used to interface adjacent base stations. This shall only be used to provide alternative traffic routes within the main architecture or for temporary deployments of mobile base station.
24.4	The backbone bearers for the DVDMR system shall be contained within the 96 core redundant optical fibre ring topology, but will use physically separated fibres for their respective circuits. Refer to fibre optical preliminary design for allocation table.
25	Operations Control Centre (OCC) configuration The system control node of the TETRA system shall be installed at the OCC technical room. The equipment shall include:
25.1	<ul style="list-style-type: none"> • TETRA core switch • management server • interface server • others as determined by detailed design or specified by the operator.
25.2	A backup centre for the TETRA system shall be included in the Emergency Control Centre (ECC), physically separated from the main data room.
25.3	The DVDMR shall share the equipment room and power supply with the signalling system.
26	Coverage Area For the DVDMR system, the coverage shall be project wide and include:
26.1	<ul style="list-style-type: none"> • full track alignment

Pos	Requirements
	<ul style="list-style-type: none"> • stations and their environs • OCC (Inside offices and external areas) • Depot (Inside offices and external areas) • any other areas defined by the Employer.
26.2	The radio network shall meet the requirements of the rail infrastructure encompassing voice and data between trains and fixed stations. It shall have sufficient overall coverage to allow communications between trains and fixed stations, track workers, station staff, operations and other defined personnel as required.
27	Safety critical data and voice
27.1	The project will require a minimum value of service and location probability of 95% coverage at a minimum level of -95dBm measured in 100m blocks for voice and safety critical data, for speeds ≤ 90km/h.
28	Propagation study
28.1	A Desktop propagation study and radio antenna location study shall be carried out to determine the total radio coverage of the TETRA network, the location of base stations, heights, types, gain and directions of antennas to achieve the required level of coverage, handover margins and sufficient coverage for operation in degraded mode.
29	Antenna Systems
29.1	The Antenna systems shall comprise of a combination of 12dB gain Yagi Antennas and 6dB gain Collinear antennas. Due regard shall be given to the placement of receiving antennas when deploying MIMO techniques.
29.2	The antennas shall be connected to the transmitter/Receivers via multi-port combining networks such as a Wilkinson combiner. Circulators and other equipment may be fitted during test and commissioning if any evidence of inter modulation issues arise.
29.3	As a minimum the antennas shall be connected to the network via LDF450 low loss co-axial cable and appropriate connectors. Short lengths of other coaxial cables may be used to link from the LDF 450 to the antenna connections when direct connection may not be possible.
29.4	Lightning finials shall be fitted at the appropriate height above all antenna arrays.
29.5	All coaxial cables shall be fitted with the appropriate earthing kits to further protect against lightning strikes
29.6	The Co-Axial cables shall be bonded to the building earthing systems where it enters the building via a suitable earth plate system
29.7	Suitable in line surge arrestors shall be deployed and earthed to the building protection earth to further protect the transmission and reception equipment from lightning strikes

11.2 SCADA

11.2.1 Standards

Table 11.4: Standards for SCADA

Pos	Requirements
1	BS 7430 Code of practice for protective earthing of electrical installations
2	BS 7671 Requirements for electrical installations. IET Wiring Regulations. 17th edition
3	BS EN 50121 Railway applications. Electromagnetic compatibility
4	BS EN 50122 Railway applications. Fixed installations. Electrical safety, earthing and the return circuit
5	BS EN 50125 Railway applications. Environmental conditions for equipment
6	BS EN 50126 Railway applications. The specification and demonstration of reliability, availability, maintainability and safety (RAMS)

Pos	Requirements
7	BS EN 50128 Railway applications. Communication, signalling and processing systems. Software for railway control and protection systems
8	BS EN 50129 Railway applications. Communication, signalling and processing systems.
9	BS EN 50174 Information Technology. Cabling installation
10	BS EN 50288-7 Multi-element metallic cables used in analogue and digital communication and control
11	BS EN 50310 Application of equipotential bonding and earthing in buildings with information technology equipment
12	BS EN 60073 Basic and safety principles for man-machine interface, marking and identification. Coding principles for indication devices and actuators
13	BS EN 60529 Degrees of protection provided by enclosures (IP code)
14	BS EN 60617 Graphical symbols for diagrams
15	BS EN 60870 Tele-control equipment and systems
16	BS EN 60950 Information Technology Equipment. Safety
17	BS EN 61000 Electromagnetic compatibility (EMC)
18	BS EN 61131 Programmable controllers
19	BS EN 61508 Functional Safety of Electrical/Electronic/programmable electronic safety-related systems
20	BS EN 62305 Protection against lightning
21	BS EN 62491 Industrial systems, Installations and equipment and industrial products – labelling of cables and cores
22	ISO 11801:2012 Information technology - Generic cabling for customer premises - Amendment 2
23	All Indonesia National and Municipal Codes, Acts and Regulations that are related to the SCADA system

11.2.2 Functional Requirements

Table 11.5: Functional Requirements for SCADA

Pos	Requirements
1	The SCADA system shall provide a centralised control function with appropriate SCADA facilities to provide the Operators with an efficient means of real-time monitoring and controlling the M&E plant and subsystems throughout the stations through the SCADA workstations.
2	The core of the SCADA system shall comprise a pair of redundant servers, configured in a hot-standby configuration to provide resilience and secondary recovery control positions. The detailed designs and configuration of the SCADA system shall be considered to maximise system reliability and availability which will minimise operational risk.
3	The SCADA system shall continuously monitor the status of M&E plant and subsystems. Equipment failures of M&E plant and subsystems shall generate alarms to the SCADA workstations which shall be automatically recorded and printed. The system shall provide comprehensive management information in the form of historical trends to enable the efficiency of station operation.
4	The SCADA workstations shall provide high quality data presentation using the latest Graphic User Interface (GUI) techniques showing the operational status of M&E plant and subsystems by means of dynamic plan layouts, single-line diagrams and icons.
5	The SCADA system shall interface with the M&E plant and subsystems at the following locations: <ul style="list-style-type: none"> • All stations

Pos	Requirements
6	<ul style="list-style-type: none"> • Depot • Traction power substations <p>The SCADA system shall be constructed in accordance with internationally recognised standards and designed for safe and efficient operation. All hardware and software of SCADA system shall be of a proven design and the major core components of the SCADA system shall have a service life of at least 15 years.</p>
7	<p>The SCADA system shall be certified to a high and continuous demand SIL2 standard in accordance with BS EN 61508.</p> <p>The SCADA system shall meet, but not limited to the following requirements:</p> <ul style="list-style-type: none"> • Commercial-off-the-shelf (COTS) and modular construction solution. • Open proprietary system.
8	<ul style="list-style-type: none"> • IP based and interfacing seamlessly with the M&E plant and subsystems. • Industrial grade with proven high quality and reliability, suitable for railway environment. • Supplied by proven system integrator with proven track record on rail systems. • Powered from UPS supplies to protect against failure of the incoming mains supplies.
9	<p>SCADA Servers / Workstations</p> <p>9.1 The OCC shall be installed with redundant SCADA servers; each console shall be installed with a SCADA workstation for the operation of the M&E plant and subsystems.</p> <p>9.2 The SCADA servers and workstations shall use the most recent proven computer technology consisting of hardware and software. All system hardware and software shall be of a type already widely used for rail application with full service and support facilities available.</p> <p>9.3 The SCADA servers shall be capable, in terms of processor and memory, to meet the performance requirements, including operator interface, database management, alarming and communication interfaces. The primary server shall handle communications with the RTUs, maintain the primary system database and interface with the SCADA workstations through the LAN in OCC or Fibre Optic Transmission System for those SCADA workstations that installed throughout the stations.</p> <p>9.4 The SCADA servers shall be configured in a hot-standby arrangement so that either server can immediately assume system mastership in the event of one server failure. Each server shall have two communication links to interconnect with two different network switches for receiving or transmitting I/O status from or to the fields RTUs, SCADA workstations or subsystems.</p> <p>9.5 The SCADA servers shall utilise the LAN connection to monitor and control of other subsystems including CCTV System, Public Address (PA) System, Help Points System, Passenger Information Display (PID) System, etc. through the IP protocol.</p> <p>9.6 A real-time database duplication mechanism shall be implemented. The database duplication shall be performed on a per transaction basis to ensure that the secondary server's database is consistent at all times with the primary server's database under normal conditions.</p> <p>9.7 The secondary server shall provide identical functions as primary server, including data storage and data printing. Furthermore, the secondary server can take over the primary server's function immediately without re-booting when a primary server failure occurs. The secondary server shall update the primary server's database and handover the supervisory and control function back to the primary server once it has recovered.</p> <p>9.8 It shall be possible to remove one server for maintenance without interrupting system operation and, upon its reinstatement, re-synchronize the database without interruption to system operations. The Operator shall designate either server as the primary or secondary server through the SCADA workstations.</p> <p>9.9 Each SCADA workstation at OCC shall accommodate with four monitors. One monitor shall be dedicated to display CCTV images (spot monitor), and three monitors shall be used to display GUI graphics for overview stations display, overview traction power substations display and alarm status display for control and monitoring.</p> <p>9.10 The design of the SCADA system shall be based on the concept that the operation from the OCC. However, the system design shall be such that control and backup of the system shall be possible from an alternate location.</p> <p>9.11 Each station shall be installed with a SCADA workstation that has the same basic system operations and</p>

Pos	Requirements
	functionality of the SCADA system. Each station SCADA workstation shall accommodate with three monitors. One monitor shall be dedicated to display CCTV images (spot monitor), and two monitor shall be used to display GUI graphics for overview station display and alarm status display of the particular station.
9.12	All SCADA servers and workstations shall be configured with password access levels so that access to the operating control level is available only to Operator with the appropriate access rights.
9.13	As a minimum, the SCADA workstations shall be comprised of colour monitors with a minimum size of 23.8", diagonal non-glare flat LED screens and have a minimum resolution of 1920 X 1080 pixels. The SCADA workstations shall display with colour GUI diagrams the current status of the M&E plant and subsystems.
9.14	Two black ink laser printers shall be provided. One printer shall be assigned for printing of recording alarms or event transactions, and the other printer shall be configured as standby. A colour laser printer that supports GUI graphics shall be provided and shall be assigned for printing of system reports and trending.
10	Remote Terminal Units
10.1	The SCADA system shall use the Remote Terminal Units (RTUs) to gather I/O status of M&E plant and subsystems from various stations. The RTU shall be of modular construction and proven reliability.
10.2	The RTUs shall be installed at stations, traction power substations and depot for control and monitoring of the various M&E plant and subsystems. Each location shall consist of redundant RTUs, install in different compartments within the local control panel.
10.3	The RTU for the traction power substations might need to be compatible with an IEC 61850 to provide parallel redundancy protocols for the Intelligent Electronic Device (IED) of switchgears.
10.4	The RTU shall use the most recent proven control technology consisting of hardware and software to implement complete functional systems. All system hardware and software shall be of a type already widely used for rail application with full service and support facilities available locally.
10.5	The RTUs shall be configured in a hot-standby arrangement so that either RTU can immediately assume system mastership in the event of equipment failure.
10.6	Each set of RTU shall be powered from dual power supply units to achieve system availability.
10.7	Each set of RTU shall comprise dual communication modules to interconnect with different network switches (diverse LAN route) for transmitting the received I/Os to the SCADA system.
10.8	The Fibre Optic Transmission System shall be used to link the RTUs at various locations back to the SCADA servers at depot. The RTUs for the substations shall be linked via a dedicated fibre optic cable to the nearby station for retransmission of I/Os back to the SCADA servers.
10.9	The RTU shall be intelligent, fully autonomous in operation and easily configurable to suit the status I/O requirements. Wherever possible, the status signal shall be derived from volt-free auxiliary contacts which are energised closed in the normal or healthy state to provide fail safe operation.
10.10	The RTU shall generate signals to implement the commands issued by the SCADA workstations for field devices or subsystems. These signals shall be a pulse whose length can be configured from the RTU to operate interposing control relays located remotely at M&E plant panels or electrical plant control panels at the substation.
10.11	Digital output modules shall incorporate relay contact channels or solid-state driver channels with a switching capability of at least 240VAC 5A, or 50 VDC 5A depending on the application. All digital modules shall provide LED status indication for each channel on the module front panel.
10.12	Analogue modules shall be electrically isolated. The signal standard shall be 4 to 20mA with high-resolution conversion to give an overall accuracy of +0.5% of full range. All field analogue cabling shall be twisted pair multi-core with individual and overall screens.
10.13	The Contractor shall interpret the control philosophy of M&E plant and develop the RTU programming for automatic control sequence of the M&E equipment.
10.14	The RTU programming shall be developed using ladder logic application programmes for automatic sequence control of the M&E plant. The programmes shall be written to take due regard of the safety-related nature of each M&E equipment, and shall incorporate all necessary and sufficient checks and interlocks to implement the procedures in a hazard-free manner.
10.15	The marshalling panels shall be installed for the field I/O cables termination to the RTUs. The RTUs shall be

Pos	Requirements
10.16	<p>connected to a single set of I/O modules to gather digital and analogue I/Os from various M&E plant.</p> <p>The panels of M&E plant shall include a local selector switch to override any interlocks imposed by the RTUs. The SCADA system shall advise the Operator locally of the interlock override. The Operators action related to the SCADA system shall be recorded.</p>
10.17	<p>The RTU shall operate satisfactorily in very high electrical interference environments. The RTU shall be protected against the effects of conducted electrical interference, including interference from lightning and ac mains power supplies</p>
10.18	<p>The RTU shall perform continuous self-diagnostics to monitor its own operational status. Any detected fault or abnormality, which could affect the RTU performance or operational capability, shall be reported to the SCADA servers.</p>
10.19	<p>The RTU shall be allowed local independent operation in case there is a communications failure back to the SCADA servers in the OCC.</p>
10.20	<p>The RTU shall have adequate spare capacity and processing power to permit future system expansion. Each group of RTU I/O module shall have 25% spare installed capacity and sufficient memory and processing power to accommodate a 25% expansion.</p>
10.21	<p>The SCADA system shall automatically monitor the status of all RTUs and report on their operational status. The status shall include details of RTU and its internal devices such as the operational state of the processors and power supplies. This system shall be in addition to any fault reports and status indications of the devices monitored and controlled by the RTU.</p>
11	<p>The functions of SCADA system shall include, but not limited to the following:</p> <ul style="list-style-type: none"> • Graphics – provide Operators with animated GUI graphics showing the current operation and control status of the M&E plant and subsystems. • Database manager – the database manager shall be capable of supporting records of the monitored and controlled points. The database manager shall allow the Operators to manage and print the records without affecting the normal operation of the SCADA system. • Logging and reporting – the logging and reporting features shall provide an alarm / event log and report log. The event log shall log all events alarms, system events and system error. Event logs shall be time stamped and shall include a description of the point. The report log shall log database reports on command from the Operators. • Alarm and event manager – alarms and events shall be displayed in order of assigned priority and sequence of events using a scrolled record. Alarms shall be conditioned, grouped and displayed with the most recent alarms at the top of alarm page. The most significant alarms that are required to be urgently responded to by the Operator shall be highlighted and flashing. Alarms shall be visually and/or audibly enunciated through the operator interface. • Historical trending – all measured variables shall be stored on database for at least 6 months. It shall be possible to select any variable for plotting against time on the screen to provide trending graphs, with start and duration times as Operator configurable parameters.
12	<p>The SCADA workstations shall function identically and independently, and shall allow the Operators to monitor and control the selected M&E plant or subsystems, provided they have the correct password security and access levels.</p>
13	<p>For maximum clarity, the information presented shall adopt colour GUI graphics, which shall be consistent for the animation symbols and display format presented on all SCADA workstations. The colour scheme philosophy shall utilise different colours for the symbols and displays to identify different levels of equipment status. This shall include equipment that is in an alarm state.</p>
14	<p>The graphic displays shall be categorised as either overview or details. Overview displays shall alert the Operators to the field M&E equipment or subsystems location, where an alarm or incident has occurred. From an overview display, the Operators shall be able to select another display for a specific interfaced subsystem or geographic section of the subsystem. Points to be controlled shall be selectable by cursor location through use of the Keyboard or mouse.</p>
15	<p>The GUI graphics symbols and colour codes representing the status shall be agreed by the Employer's Representative. The alarm and event lists reporting on the SCADA workstations shall be identical format as</p>

Pos	Requirements
16	<p>displayed on the SCADA workstations. The GUI graphics shall be able to display on the video wall.</p> <p>The guideline of GUI graphics shall be, but not limited to the following:</p> <ul style="list-style-type: none"> • Distinct colours and display attributes (e.g. flashing) shall be used to draw attention to alarm or abnormal conditions. • Consistent use of colours, geographic orientation, labels, display attributes and symbols. • Label and message contents shall use Indonesian or English language consistent with operations terminology.
17	<p>The GUI graphics shall use a toolbar for common operator commands. The Operators shall be able to request commonly used displays and activate system functions via drop-down menus. Functions available through the GUI graphics shall include, but not limited to the following:</p> <ul style="list-style-type: none"> • Operator command confirmation • Display and control of field equipment • Acknowledgment of alarms on a priority basis • Initiate printing of reports • Archive and retrieve event logs • View historical information on predefined trend and chart windows • Change password • Configure system parameters • Online editing • Online help facility • Communications – communication software shall be provided to handle communications with the RTUs, SCADA workstations and with devices connected to the SCADA servers.
18	<p>An alarm strategy shall be provided by the Contractor at detailed design stage to describe the presentation and prioritisation (including suppression) of alarm messages. This document shall be agreed with the Employer's Representative during the detailed design stage and prior to system configuration works.</p>
19	<p>All alarms shall have a priority classification, indicating the importance of the detected condition. Typically, these alarms shall be allocated one of three priorities, as detailed below:</p> <ul style="list-style-type: none"> • Urgent – assigned to important alarms, primarily associated with life safety issues in the stations. Alarms with this priority may require rapid Operator response and rapid resolution to maintain safe conditions for passengers. • Alert – alert alarms are of lower priority, involving unusual conditions, which the Operator should be aware of and should act upon as soon as is convenient. • Record – this classification covers routine events that are not treated as alarms on the SCADA workstations and do not require acknowledgement.
20	<p>The alarms shall be assigned one of four states according to their urgency status:</p> <ul style="list-style-type: none"> • Active – the condition generating the alarm is present and the alarm has not been acknowledged. • Acknowledged – the condition generating the alarm is still present but the Operators have acknowledged the alarm. • Reset – the condition generating the alarm no longer exists but the alarm has not yet been acknowledged. • Cleared – the condition generating the alarm no longer exists and the alarm has been acknowledged, in either order. A cleared alarm is automatically deleted from the alarm list. This state corresponds to the monitored signal being in an acceptable state with no outstanding operator actions required. Every alarm state with its date and time shall be archived in the historical list of alarms.
21	<p>The following facilities, at a minimum, shall be provided for the SCADA workstations, interpretation and recording of alarms:</p> <ul style="list-style-type: none"> • The GUI graphics shall have at least one line reserved for displaying the most recent, unacknowledged

Pos	Requirements
	<p>alarm. The alarm classification shall be indicated by the background colour of the banner.</p> <ul style="list-style-type: none"> • The alarm banner shall flash until acknowledged by the Operator. Once acknowledged, the previous unacknowledged alarm shall be displayed. • Upon initial receipt of an alarm with urgent classification, an audible chime shall sound until acknowledged by the Operator. This sound shall be distinctive and shall not be confused with audible alarms emanating from other equipment in the OCC. Other alarm classifications do not require an audible chime. • All alarms and events shall be displayed on separate monitor that allow the Operators to select current or historical alarms over a minimum period of 6 months. • When the Operators select the alarm pages for further detail, alarms of urgent (i.e. alarms of traction power substations) and alert categories shall be displayed in separate colours with the most recent alarm at the top. • Each alarm line shall contain the date and time at which the alarm condition was detected. • Unacknowledged alarms shall flash and change to steady upon acceptance. • Selected alarm pages shall be printed on the laser printer on operator demand.
22	The login authorisation level shall determine which functions the Operators are permitted to use. The SCADA system shall permit several Operators to be defined against the same login authorisation level.
23	The SCADA system shall be designed to support a minimum of 20 login authorisation levels. It shall support 6 default login authorisation levels to minimise configuration work. There shall be levels for all operators, which include station operator, station supervisor, station manager, engineer, maintainer and administrator.
	Each login authorisation level shall be able to have defined, at a minimum, the following:
24	<ul style="list-style-type: none"> • Authorisation to view GUI graphics status only. • Authorisation to operate the subsystems, i.e. CCTV / PA / PHP / PID systems. • Authorisation to control the M&E plant through BMS. • Authorisation to acknowledge alarms. • Authorisation to edit the parameters setting. • Authorisation to edit graphics and I/O setting. • Authorisation to print. • Authorisation to install software updates.
25	Within each authorisation level, there shall be the ability, on an individual data field basis, to hide the field from view entirely or restrict the field to being read only or read and write.
26	The SCADA workstations shall display the name of the operator who is currently logged in.
27	The Operators login or logout for the SCADA servers / workstations shall be recorded. Access to maintenance functions and features such as alarm time adjustments shall be particularly safeguarded and, when accessed, the date, time and identification of the Operator shall be recorded in addition to any changes made or maintenance functions undertaken.
28	User access rights shall be determined by use of a configuration table. Any changes to these rights shall be controlled and all changes recorded.

11.2.3 Performance Requirements

Table 11.6: Performance Requirements for SCADA

Pos	Requirements
1	The SCADA system shall incorporate redundancy and diversity techniques to minimise the effect of equipment failure. Access to equipment installed inside the station, in particular the substation, is normally restricted. It is therefore essential that the SCADA equipment installed within these areas shall survive failure of any single item

Pos	Requirements
2	<p>of equipment without significant loss of function.</p> <p>All monitoring and control signals of SCADA system shall be transmitted via the Fibre Optic Transmission system. The bandwidth required by the SCADA system shall depend on the functions of operation at that time. The bandwidth required for the SCADA system shall be a minimum of 1Mb/s.</p>
3	<p>Ideally, the SCADA system shall provide continue real-time monitoring and a fine closed loop control of the M&E plant and subsystems to enhance the efficiency of operation. The response time of command signal sending from the SCADA workstations to the field equipment at any locations shall be within 1 second, while the response time of alarm signal sending to the SCADA workstations from the field equipment at any locations shall be within 1 second.</p> <p>The response time of the SCADA system shall be as follows:</p> <ul style="list-style-type: none"> • SCADA GUI maximum scan time: < 500m seconds • SCADA servers duty changeover time: < 2 seconds • RTU program maximum scan time: < 500m seconds • RTU duty changeover time: < 2 seconds • Field alarm input to SCADA GUI: < 1 second • Command output from SCADA GUI to field: < 1 second • GUI navigation time: < 1.5 seconds
4	<p>The allocation of spare capacity for the SCADA system shall be as follows:</p> <ul style="list-style-type: none"> • SCADA I/O spare capacity – wired: >= 25% • SCADA I/O spare capacity – space: >= 25% • RTU memory spare capacity: >= 25%
5	<p>All SCADA cables shall be LSOH sheathed and those potentially exposed to mechanical damage shall also be armoured. Primary communication cables shall be run in enclosed cable routes.</p>
6	<p>The SCADA equipment shall be suitably protected against the effects of heat, vandalism and damage, and be located out of sight of the general public.</p>
7	<p>All SCADA equipment shall operate in the following worst case environment:</p> <ul style="list-style-type: none"> • Temperature: up to at least 55°C. • Relative humidity: up to 100% RH.
8	<p>The SCADA system shall be designed in such a way that no single point of failure shall cause in loss of a full SCADA system. All critical components shall be configured as follows:</p> <ul style="list-style-type: none"> • Each critical component shall consist of a pair of redundant hardware configured in a hot-standby configuration to provide resilience and secondary recovery control positions. These servers shall be located in separate buildings to offer the highest resilience. • Each critical component shall consist of a pair of network connections to separated network switches to provide comms link resilience. • Each critical component shall be powered from the UPS with at least two hours power backup.
9	

11.3 Fibre Optic Transmission System

11.3.1 Standards

Table 11.7: Standards for Fibre Optic System

Pos	Requirements
Fibre System Standards	
1	ISO/IEC 80000 The International System of Units (SI) and its Application
2	IEC 60950-1 Safety of information technology equipment
3	IEC 62305 Protection Against Lightning
4	IEC 11801 Telecommunications installations — Generic cabling for commercial premises
5	ISO 3864 International Standards for Safety symbols
6	IEC 60529 Degrees of Protection - Enclosures for electronic equipment
7	BS 6701. 2010 Telecommunications equipment and telecommunications cabling specification for installation, operation and maintenance
8	EN50173-1 Generic cabling systems
9	BS EN 50174-1,2,3 Information Technology cabling installation
10	BS7671 Requirements for Electrical Installation
11	BS 7718 Code of practice for installation of fibre optic cabling (now withdrawn but excellent reference)
12	BS EN 50346 Information Technology-Cabling Installation-Testing of installed cables
13	IEC/CISPR 22:1993 Limits and methods of measurement of radio disturbance characteristics of information technology equipment.
14	IEC 6100-4-2 Electrostatic Discharge (ESD) Standards for Commercial Electronic Products
15	IEC 6100-4-5 Surge Protection
16	IEC 61000-6-3 Electromagnetic Compatibility (EMC) – Various sections referenced within this specification
17	IEC 61850-3 Communication networks and systems in substations Part 3: General requirements
18	DIN 41494 Basic Specification for 19-inch Construction Rack Systems
19	IEEE 802 and all applicable sections Local and Metropolitan Area Networks
20	IEEE 1613 Environmental and Testing Requirements for Communications Networking Devices Installed in Electric Power Substations
21	IEEE-STD 299 Standard Method for Measuring the Effectiveness of Electromagnetic Shielding Enclosures.
22	RFC 3031 (published by IETF) MPLS Architecture
23	RFC 3032 (published by IETF) MPLS Label Stack Encoding
24	RFC 3815 (published by IETF) Definitions of Managed Objects for the Multiprotocol Label Switching (MPLS), Label Distribution Protocol (LDP)
25	RFC 4379 (published by Detecting Multi-Protocol Label

Pos	Requirements
	IETF)
26	ITU-T RecG.652 Series G: Transmission Systems and Media, Digital Systems and Networks Transmission media characteristics – Optical fibre cables. Characteristics of a single-mode optical fibre and cable
27	ITU-T RecG.652 Series G: Transmission Systems and Media, Digital Systems and Networks Transmission media characteristics – Optical fibre cables. Characteristics of a single-mode optical fibre and cable
28	ITU-T RecG.650 Series G: Transmission Systems and Media, Digital Systems and Networks Transmission media characteristics – Optical fibre cables. Definitions and test methods for linear, deterministic attributes of single-mode fibre and cable
29	IEC 60793 Parts 1 & 2 Optical Fibres General and Guidance, measurement methods and test procedures. Product specifications – General
30	IEC 60794 Parts 1 & 2 Optical Fibres Generic Specification General and Basic optical cable test procedures.
31	ISO/IEC 11801 - Edition 2.2 Information Technology – Generic cabling for customer premises
32	EIA/TIA 598 Fibre Optic Cable Colour Coding
33	TIA EIA 455-B Standard Test Procedure for Fibre Optic Fibres, Cables, Transducers, Sensors, Connecting and Terminating Devices
34	IEC 62149-1 Fibre optic active components and devices- Performance standards
35	ITU-T G.39 Optical System Design and Engineering Considerations
36	ITU-T G.652 Characteristics of A Single-Mode Optical Fibre and Cable
37	ITU-T G.653 Characteristics of a Dispersion-Shifted Single-Mode Optical Fibre and Cable
38	ITU-T G.654 Characteristics of a Cut-off Shifted Single-Mode Optical Fibre and Cable
39	ITU-T G.655 Characteristics of a Non-Zero Dispersion-Shifted Single Mode Optical Fibre and Cable
40	ITU-T G.661 Definition and Test Methods for The Relevant Generic Parameters of Optical Amplifier Devices and Subsystems
41	ITU-T G.662 Generic Characteristics of Optical Amplifier Devices and Subsystems
42	ITU-T G.663 Application Related Aspects of Optical Amplifier Devices and Subsystems
43	ITU-T G.664 Optical Safety Procedures and Requirements for Optical Transport Systems
44	ITU-T G.671 Transmission Characteristics of Optical Components and Subsystems
45	ITU-T G.691 Optical Interfaces for Single Channel STM-64 and Other SDH Systems With Optical Amplifiers
46	ITU-T G.692 Optical Interfaces for Multi-Channel Systems with Optical Amplifiers
47	ITU-T G.694.1 Spectral Grids for WDM Applications: DWDM Frequency Grid
48	ITU-T G.696.1 Longitudinally Compatible Intra-Domain DWDM Applications
49	ITU-T G.697 Optical Monitoring for DWDM Systems
50	ITU-T G.703 Physical/Electrical Characteristics of Hierarchical Digital Interfaces
51	ITU-T G.707 Synchronous Digital Hierarchical Bit Rates
52	ITU-T G.709/Y.1331 Interfaces for The Optical Transport Network (OTN)
53	ITU-T G.8201 Error Performance Parameters and Objectives for Multi-Operator International Paths within The Optical Transport Network (OTN)
54	ITU-T G.8251 The Control of Jitter and Wander within the Optical Transport Network (OTN)
55	ITU-T G.872 Architecture of Optical Transport Networks

Pos	Requirements
56	ITU-T G.873.1
57	ITU-T G.874
58	ITU-T G.911
59	ITU-T G.957
60	ITU-T G.959
61	ITU-T M.2120
62	ITU-T M.3010
63	ITU-T M.3400
Fibre Installation Standards	
1	BS 1371
2	BS 1377-9
3	BS 1387
4	BS 1710
5	BS 3900-G6
6	BS 4346
7	BS 4607-5
8	BS 6031
9	BS 6907
10	BS 60423
11	IEC 60304:1982
12	IEC 60364
13	EN50174-1
14	EN 50174-2
15	EN 50174-3
16	EN 50310
17	EN 50173-1
18	IEC 60529
19	IEC 60793-1-20
20	IEC 60793-2-50
21	IEC 60794-3-30
22	IEC 60794-3-10
23	IEC 61386
24	ISO 1461

Pos	Requirements
25	ISO 17025
26	ISO/IEC 8000
27	ISO/IEC 60950-1
28	IEC 62305
29	TIA/EIA 569
30	ISO 3864
31	BS6701:2010
32	BS7718
33	IFC April 30th 2007
	General requirements for the competence of testing and calibration
	The International System of Units (SI) and its Applications
	Safety of Information Technology Equipment
	Protection Against Lightning
	Commercial Buildings Telecommunications Pathways and Spaces
	International Standards for Safety Symbols
	Telecommunications Equipment and Telecommunications cabling Specification for installation, operation and maintenance
	Code of Practice for Installation of Fibre Optic Cabling (Now withdrawn but excellent reference)
	Environmental Health and Safety Guidelines for Telecommunications

11.3.2 Functional Requirements

Table 11.8: Functional Requirements for Fibre Optic Transmission System

Pos	Requirements
1	<p>The Fibre System shall comprise the following elements:</p> <ul style="list-style-type: none"> • a 10Gbps dual ring Core Routing Layer to provide interconnectivity between the various Jakarta LRT locations; • a 1Gbps Access Layer of Label Edge Routers (LER); • Switched Local Area Networks (LANs) of up to 1Gbps to provide network connectivity and Power over Ethernet (PoE) as required; • The Fibre System shall consist of a minimum 96-core Single Mode fibre optic cable and associated transmission equipment, and shall have a design life of twenty five (25) years.
2	The system shall be configured in a Dual Redundant Ring topology to ensure maximum resilience against fibre damage and equipment failure to provide a single fault tolerant network.
3	The Fibre System shall extend to all designated Project locations to facilitate interconnection of the telecommunication infrastructure services described above, for the aggregation of telecommunication services in that locality.
4	The system shall be designed to operate using Multiprotocol Label Switching (MPLS).
5	The design shall include a traffic study to determine the bandwidth requirements, traffic routing and final system configurations.
6	<p>As a minimum, the System design shall provide for the following services to be distributed and networked across the Project:</p> <ul style="list-style-type: none"> • Integrated Voice and Data Services • Rail Signalling System (Dedicated fibres two per redundant ring) • Digital Voice Mobile Radio (DVMR) Services • Security Services • CCTV Services • PA Systems • PIS Systems • Passenger Help points

Pos	Requirements
7	<ul style="list-style-type: none"> • Access Control Systems • Building management Systems • Automatic Fare collection Systems • Designated SCADA services • Supervision of Fire Detection Systems • Other Services as required. • All services shall utilise IP based protocols. <p>The System shall provide approximately 10Gbps connectivity, upgradeable to 40Gbps, over optical fibre cable conforming to ITU-T G.652.D and a minimum of 99.9% availability for all circuits. The System shall meet carrier grade requirements.</p>
8	The System shall provide inter-networking as required between different technologies used on the Project.
9	The System shall use resiliency protocols, such as Fast Re-route and Bi-directional Fault Detection, to determine failures and in turn switch to standby links.
10	The System shall support network quality of service, virtualization, traffic management and synchronous Ethernet with a management platform that automates and simplifies operations management.
11	The System shall support Class of Service/Quality of Service (CoS/QoS) and priority queuing features to ensure that latency sensitive and bandwidth intensive traffic is prioritised accordingly.
12	The System shall permit integration of multiple services, networks and protocols onto a common backbone platform.
13	Edge routers shall deliver high performance, high availability routing with advanced quality of service (QoS) and a comprehensive range of multi-service interfaces and protocols to support the service requirements
14	Edge routers shall provide redundant optical fibre connections to the switch routers and act as entry/exit points to the System. They may also act as network repeaters. They shall be equipped with interfaces to establish redundant connections to localised system equipment, server farms, and network management terminals as required.
15	Edge routers shall support 1Gbps, 10Gbps bandwidth capability with various chassis sizes and modules to meet the service requirements.
16	Interface types and bandwidth requirements at each location shall be confirmed during detailed design.
17	Equipment shall be chassis mounted, contain 25% spare port and space capacity for future expansion and incorporate redundancy in all critical components.
18	Edge routers shall be installed in equipment cabinets complete with cable termination frames, rack mounted UPS units and associated cross connect cables as required
19	Switch routers shall provide service aggregation and networking features through switch routing, quality of service and traffic management.
20	Switch routers shall act as entry/exit points to the System and also as network repeaters along the core route of the System. They shall be capable of supporting 10Gbps connectivity up to 60km from adjacent associated nodes
21	Switch routers shall support 1Gbps, 10Gbps bandwidth capability with various chassis sizes and support modules to meet the service requirements.
22	Switch routers shall be equipped with the necessary provisions (i.e. space for additional chassis cards) to increase the System bandwidth up to 40Gbps if required at a later date.
23	Switch routers shall be chassis mounted, contain 25% spare port and space capacity for future expansion and incorporate redundancy in all critical components.
24	Switch routers shall be of rugged industrial type design and shall be capable of operating in temperatures exceeding 60° C. Their performance shall not be affected by vibrations from passing trains on the rail alignment.
25	Switch routers shall be installed in Common Equipment Rooms (CERs) within cabinets complete with cable termination frames, rack mounted UPS units and associated cross connect cables as required.

Pos	Requirements
26	Access Switches shall provide the interface between field equipment, and Label Edge Routers (LER) shall form the basis of the interface between the Access and MPLS networks.
27	The design shall include provision of Global Positioning System (GPS) backed master clock servers located in the OCC.
28	The servers shall be operated in a main and standby configuration and shall provide both Network Time Protocol (NTP) and Simple Network Time Protocol (SNTP) synchronisation which shall be available locally and via the LAN.
29	The servers shall also have additional ports for local distribution using other time protocols as required. The design shall include provision of network management terminals and associated software for end-to-end service management of the System. The network management system shall simplify the administration and on-going management of the System and support the following features and functions: <ul style="list-style-type: none"> • Easy to use graphical user interface for configuration, performance monitoring and troubleshooting. • Alarm Management and real time surveillance to pinpoint root causes of problems • Physical, network and service topology views, complete with operations, administration and maintenance (OA&M) service diagnostic tools. • Object orientated programming with templates and workflow tools • Routing management: • Service Call Admission Control (CAC) • Switch Paths • Class of Service assignment (CoS) • IP-Virtual Private Networks (IP-VPN's) if required • Virtual Private LAN Services (VPLS) • Security Management to allow/prohibit user access and functions through password-based protection. This shall also permit logging of user activities.
30	Where maintained site power is available the System main nodes shall be provided with uninterruptible AC power supplies.
31	The design shall include all cable routes between Common Equipment Rooms (CER), OCC, DCR, Depot, Stations and shall include a traffic study to determine the bandwidth requirements, traffic routing and final system configurations.
32	The various telecommunications systems/services described above shall be routed on the Fibre System utilising dedicated fibre cores. The allocation of core traffic services to dedicated fibre cores shall be in a controlled manner so as to maximise the capabilities of the fibre infrastructure now, and for future developments, in accordance with the example table provided . There may be rational reasons for varying these requirements during the detailed design. Any variations shall be supported by valid justifications and submitted to the Employer for prior consideration and approval.
33	At each station two Layer 3 (L3) routers shall be provided, along with a number of Layer 2 (L2) Switches located in the Common Equipment Rooms (CERs) to support connectivity for all Telecommunications, Signalling, Electrification & Plant (E&P) and Station Operations functions. From each L2 switch, a connection shall be made to each of the L3 Routers, forming a meshed connection.
34	Security shall be a prime consideration throughout the design process. The following security mechanisms shall be provided and applied where required: <ul style="list-style-type: none"> • Firewalls at key locations; • User access control; • Device access control.
35	Included in the Fibre System shall be a Network Management platform. This shall enable monitoring and management of all of the Fibre System network components (Routers, Switches, Firewalls, etc.). The details and capabilities of the platform shall be confirmed as part of the detailed design process.

Pos	Requirements
36	Multiple WiFi Access Points (WAP) are to be provided longitudinally along the Jakarta LRT route (at approximately 200 metre intervals) to provide a back-up system to the TETRA Radio system in event of failure, consideration shall be given to connect these WAP locations to the nearest Common Equipment Room (CER) by alternative dedicated individual single-mode fibre optic cables (typically 4-core) rather than break-out the required fibres from the main 96-core fibre cable at each WAP location. Justification for the method adopted shall be provided to support the Reliability, Availability, Maintainability and Safety (RAMS) requirements.
37	The Fibre System design shall be coordinated with other disciplines responsible for the provision of track geometry, station layouts, cable management systems at stations, under track crossings, cable entry points into buildings, cable routes within buildings and other structures as required.
38	Metallic armouring of cables shall be earth free and gapped before entry into trackside termination cabinets or CERs and, if provided, at cable joints. Cable moisture barriers shall be isolated at trackside cabinets and CERs. These measures are intended to mitigate dangerous touch potentials in DC electrified areas that exceed the limits specified in EN 50122-1.
39	Cable routes shall be provided along both sides of the rail corridor and appropriate to the security requirements of Jakarta LRT. Under Track Crossings (UTX) shall be provided at the platform ends at each station to give access between each route and station cable management system.
40	A minimum of 25% spare capacity shall be provided for telecoms cables within cable routes. Unhindered and safe access to cable routes shall be afforded with regards to installation and in respect to platform construction.
41	Routers, Switches, Firewalls etc., shall be chassis mounted, contain 25% spare port and space capacity for future expansion and incorporate redundancy in all critical components.
42	Routers, Switches, Firewalls etc., shall be installed in equipment cabinets complete with cable termination frames, rack mounted standby battery units and associated cross connect cables as required.
43	Core Switch routers shall provide service aggregation and networking features through switch routing, quality of service and traffic management. They shall act as entry/exit points to the Fibre System and also as network repeaters along the core route of the system. They shall be capable of supporting 10Gbps connectivity up to 60km from adjacent associated nodes.
44	Access Switches shall provide the interface between field equipment, and LERs shall form the basis of the interface between the Access and MPLS networks.
45	The design shall include provision of Global Positioning System (GPS) backed master clock servers located in the OCC. The servers shall be operated in a main and standby configuration and shall provide both NTP and SNTP synchronisation which shall be available locally and via the LAN.
46	The servers shall also have additional ports for local distribution using other time protocols as required. The design shall include provision of network management terminals and associated software for end-to-end service management of the Fibre System. The network management system shall simplify the administration and on-going management of the System and support the following features and functions:
47	<ul style="list-style-type: none"> • Easy to use graphical user interface for configuration, performance monitoring and troubleshooting. • Alarm Management and real time surveillance to pinpoint root causes of problems • Physical, network and service topology views, complete with operations, administration and maintenance (OA&M) service diagnostic tools. • Object orientated programming with templates and workflow tools • Security Management to allow/prohibit user access and functions through password-based protection. This shall also permit logging of user activities. • Routing management: • Service Call Admission Control (CAC) • Switch Paths • Class of Service assignment (CoS) • IP-Virtual Private Networks (IP-VPN's) if required • Virtual Private LAN Services (VPLS)

Pos	Requirements
48	The Fibre System shall use resiliency protocols, such as Fast Re-route and Bi-directional Fault Detection, to determine failures and in turn switch to standby links.
49	Switch routers shall be of rugged industrial type design and shall be capable of operating in temperatures exceeding 60° C. Their performance shall not be affected by vibrations from passing trains on the rail alignment.
50	All services shall utilise IP based protocols and the use of alternative or bespoke interface protocols for connectivity to the Fibre System shall be avoided. Where this requirement cannot be met, comprehensive arguments for proposing alternative or bespoke interface protocols shall be supported by valid justifications and submitted to the Employer for prior consideration and approval.
	Generally, the telecommunications provided shall conform to the requirements of applicable ITU-T recommendations, as follows;
51	<ul style="list-style-type: none"> • Transmission Systems and Media, Digital Systems and Networks – "G" series documentation • Protection against interference – "K" series documentation • Global Information Infrastructure, Internet Protocol aspects and Next-Generation networks - 'Y' series documentation.
52	The design shall include a study to determine the bandwidth requirements for all interconnected systems and services, traffic routing and system configurations. The bandwidth study should assume that 100% of ports on all LERs are utilised and active.
53	To provide additional resilience to the Fibre System, consideration should be given to interconnecting network switches to form an arbitrary grid and the use of optical cross-connectors. The study shall be carried out in liaison with the Employer to determine the most advantageous configuration.
54	The Fibre System equipment shall be electrically safe for users and maintainers. Conformance with BS EN 60950 and BS 7671 is acceptable as evidence of this.
55	Where Routers are deployed, they shall deliver high performance, high availability routing with advanced quality of service (QoS) and a comprehensive range of multi-service interfaces and protocols to support the service requirements.
56	The construction and performance of the Fibre System is required to meet the minimum requirements defined in standards listed in this appendix.
57	The Fibre System equipment shall comply with all applicable legislative requirements and comply with the requirements for RAMS.
58	The System shall provide 10Gbps connectivity, upgradeable to 40Gbps, over optical fibre cable conforming to ITU-T G.652.D and a minimum of 99.9% availability for all essential circuits. The System shall meet carrier grade requirements. Determination of the transmission protocol shall be dependent upon the overall transmission strategy incorporating both rail signalling and general infrastructure requirements.
59	The System shall support network quality of service, virtualization, traffic management and synchronous Ethernet with a management platform that automates and simplifies operations management.
60	The System shall support Class of Service/Quality of Service (CoS/QoS) and priority queuing features to ensure that latency sensitive and bandwidth intensive traffic is prioritised accordingly.

11.3.3 Performance Requirements

Table 11.9: Performance Requirements for Fibre Optic Transmission System

Pos	Requirements
1	Fibre System equipment shall be suitable for use in environmental conditions complying with ETS 300 039-1-3 for operation in temperature controlled (class 3.1) locations. Temperature controlled environments include rooms within purpose built buildings (e.g. control centres), equipment rooms and trackside equipment housings containing 'active' equipment. Reference shall be made to the CER specification contained within section 3 of this

Pos	Requirements
	document for detailed environment requirement.
2	Fibre System equipment subracks shall comply with ETS 300 119-4. The equipment shall be installed in either miscellaneous equipment racks within equipment rooms, or within trackside equipment housings.
3	Liaison with the Employer is required to determine Network Availability Service-Level agreements to provide assurance that the Fibre System and MPLS/IP network configuration meets the Employer's availability targets.
4	Generally, compliance with the ITU-T 'Y' series standards for Next Generation Networks will meet this requirement.
5	A Network Management System shall provide the element management functions for, but not limited to, access, aggregation, edge network layers and a platform for value-added applications such as remote monitoring, alarm gathering, assurance and performance management.
6	The Fibre System and MPLS/IP network shall conform to the requirements of ITU-T 'Y' series standards for Architecture, Access, Applications, Network capabilities, Quality of Service and Interoperability for delivery of the systems identified in the System Overview above.
7	Resilience Resilience of the Fibre System is vital to the continued operation of LRT services, and the design shall make every effort to promote resilience by identifying and eliminating common mode failures in the Fibre System topology, which will occur when a single event causes interruption to multiple transmission rings. A major risk of a common-mode failure is presented by loss of service due to failure of cable infrastructure serving core nodes and access nodes. The following are design examples that shall be adopted to mitigate the effects of cable failure;
8	<ul style="list-style-type: none"> • Each fibre cable carrying core traffic into a network switch shall have its own building cable entry point. • Each building cable entry point at a network switch shall be at maximum separation within the confines imposed by the accommodation. • No optical fibre cable carrying core traffic shall be installed closer than 10 metres to any other optical fibre cable carrying core traffic at any point. • Where this is impracticable, at least one of the cables shall be separated to a minimum 3 metres apart in a suitable protective containment. • Where this is also impracticable then the Contractor shall provide alternative proposals supported by valid justifications and submitted to the Employer for prior consideration and approval.
9	Within accommodation (e.g. equipment rooms), routes for adjacent fibre cables shall be designed or selected to promote maximum separation.
10	The general performance criteria for the Fibre System shall meet an expected MTBF in excess of 80,000 hours for the whole system.
	Optical Loss Budget The optical loss budget over an optical link (fibre cable section between network switches) shall be kept to a minimum to reduce the requirement for optical signal regenerators. Because of the relatively short distances between stations and equipment rooms on the Jakarta LRT route, a jointless Fibre System shall be employed which will assist in achieving a low optical loss budget.
	Optical Cable Attenuation Optical cables employed in the Fibre System shall have a budgeted optical fibre loss aligned with the attenuation limits detailed in relevant ITU-T standards.
	Connector Loss Budgeted connector loss (for a pair of connectors) shall not exceed the limits detailed in relevant ITU-T standards.
	Splice Loss If it is unavoidable to incorporate a splice in a fibre cable section, then a budgeted splice loss shall not exceed the limits detailed in relevant ITU-T standards.
	System Interfaces

Pos	Requirements
15	The details of the interfaces shall be confirmed during the detailed design process.
16	<p>The Fibre System shall provide connectivity for alarm and monitoring data into the Network Management systems.</p> <p>The Fibre System shall provide the connectivity between the following components:</p> <ul style="list-style-type: none"> • The Fibre System shall provide connectivity for the CCTV system; • The Fibre System shall provide connectivity for the PAVA system; • The Fibre System shall provide connectivity for the IP Telephony system; • The Fibre System shall provide connectivity for the SCADA system; • The Fibre System shall provide connectivity for the PIS system; • The Fibre System shall provide connectivity for the TETRA system; • The Fibre System shall provide connectivity for the Master Clock system; • The Fibre System shall provide connectivity for each Automatic Fare Collection computer at each station; • The Fibre System shall provide connectivity for each gateline computer at each station; • The Fibre System shall provide connectivity for Access Management System.
17	<p>Maintenance Strategy and Spares</p> <p>The Jakarta LRT infrastructure is to deliver high reliability and availability in line with the overarching targets for the project. To provide assurance that these targets will be met at optimized whole-life cost, it is necessary to undertake analyses that seek to quantify the likely performance of the infrastructure in light of the maintenance that will be required. It is necessary to minimize the impact of maintenance and inspection activities on the operation of the railway.</p>
18	<p>Appropriate Operation and Maintenance documentation shall be provided by the Contractor for the Fibre System, MPLS/IP network and all systems identified in the System Overview above. This shall include, but not limited to, any specific requirements highlighted in manufacturer's recommended maintenance procedures.</p> <p>Inspection and maintenance activities that present a health and safety risk to staff and/or members of the public are required to be completed and clear of the station before start of daily train services. The Contractor therefore is required to ensure that all aspects of inspection and maintenance of the telecommunications design can be completed in time to allow for the maintainer to demonstrate to the Control Centre and station staff that the railway is safe to open at the start of service each day.</p>
19	<p>The Contractor shall prepare a high-level spares list and approximate quantities for the Fibre System, MPLS/IP network and all systems identified in the System Overview above. This information will be used to provide a broad estimate of spares holding requirements and cost.</p> <p>A detailed evaluation shall be undertaken in conjunction with the Employer and the main equipment suppliers for the Fibre System, MPLS/IP network and the systems identified in the System Overview above to identify the following;</p>
20	<ul style="list-style-type: none"> • Critical parts from RAM modelling (and other applicable means, such as prior experience/knowledge of a system) which are required to maintain LRT operational performance; • Long lead items, including the likely supply chain, cost and typical lead times; • Items classified as 'unique' or 'special' equipment for the Jakarta LRT, which require advanced procurement and manufacture, including the supply chain, cost and typical lead times. • Specialist maintenance tools and test equipment.
21	<p>Assessment shall be required for the proposed spares holding by the Contractor for Test & Commissioning, Test Running and Trail Operations, including the possible transfer of these assets to Jakarta LRTs nominated maintainer.</p>
22	<p>Asset Register</p>
23	<p>The Contractor is required to produce an asset register for all the equipment and materials used in the construction of the Fibre System and MPLS/IP network to enable the Employer to produce an Asset Management</p>

Pos	Requirements																																										
23.2	<p>Plan that will define how and when each asset shall be inspected, tested, maintained, repaired and, when necessary, replaced.</p> <p>The asset register shall contain, but not limited to, the following for all equipment associated with the provision of the Fibre System and MPLS network;</p> <ul style="list-style-type: none"> • Active equipment (e.g. requiring or supplying power) • Manufacturer • Equipment name • Equipment type/model • Version number • Serial number • Software version (where applicable) • Location (including Rack, Shelf, Slot positions where applicable) • Date of manufacture • Date of installation <p>Cable sheath marking (Fibre cables)</p> <ul style="list-style-type: none"> • The over sheath shall be marked in a contrasting colour on both sides with the legend; • SM Fibre Duct Cable (or SM Fibre LSZH Cable where applicable) • The number of fibres • The manufacturer's name • The month and year of manufacture • A unique number to identify the manufactured length • The complete legend shall be repeated at intervals of not greater than 1 metre. 																																										
24	<p>Service Allocation (Core Traffic) of Fibres;</p> <table border="1"> <thead> <tr> <th>Fibre No.</th><th>Tube No.</th><th>Service Allocation (Core Traffic)</th></tr> </thead> <tbody> <tr> <td>1 and 2</td><td>1</td><td>Signalling</td></tr> <tr> <td>3 and 4</td><td>1</td><td>Reserved in case of failure of fibres 1 and 2</td></tr> <tr> <td>5 and 6</td><td>1</td><td>TETRA</td></tr> <tr> <td>7 and 8</td><td>1</td><td>Reserved in case of failure of fibres 5 and 6</td></tr> <tr> <td>9 and 10</td><td>2</td><td>SCADA</td></tr> <tr> <td>11 and 12</td><td>2</td><td>Reserved in case of failure of fibres 9 and 10</td></tr> <tr> <td>13 and 14</td><td>2</td><td>CCTV</td></tr> <tr> <td>15 and 16</td><td>2</td><td>Reserved in case of failure of fibres 13 and 14</td></tr> <tr> <td>17 and 18</td><td>3</td><td>PA/VA</td></tr> <tr> <td>19 and 20</td><td>3</td><td>Reserved in case of failure of fibres 17 and 18</td></tr> <tr> <td>21 and 22</td><td>3</td><td>PHP</td></tr> <tr> <td>23 and 24</td><td>3</td><td>Reserved in case of failure of fibres 21 and 22</td></tr> <tr> <td>25 and 26</td><td>4</td><td>Master Clock</td></tr> </tbody> </table>	Fibre No.	Tube No.	Service Allocation (Core Traffic)	1 and 2	1	Signalling	3 and 4	1	Reserved in case of failure of fibres 1 and 2	5 and 6	1	TETRA	7 and 8	1	Reserved in case of failure of fibres 5 and 6	9 and 10	2	SCADA	11 and 12	2	Reserved in case of failure of fibres 9 and 10	13 and 14	2	CCTV	15 and 16	2	Reserved in case of failure of fibres 13 and 14	17 and 18	3	PA/VA	19 and 20	3	Reserved in case of failure of fibres 17 and 18	21 and 22	3	PHP	23 and 24	3	Reserved in case of failure of fibres 21 and 22	25 and 26	4	Master Clock
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25																																											

Technical Specification

Jakarta LRT Project – Corridor 1 (Phase 1): Kelapa Gading-Velodrome



Pos	Requirements		
27 and 28	4	Reserved in case of failure of fibres 25 and 26	
29 and 30	4	IP Telephony	
31 and 32	4	Reserved in case of failure of fibres 29 and 30	
33 and 34	5	Wired LAN	
35 and 36	5	Reserved in case of failure of fibres 33 and 34	
37 and 38	5	PIS	
39 and 40	5	Reserved in case of failure of fibres 37 and 38	
41 and 42	6	Access Control	
43 and 44	6	Reserved in case of failure of fibres 41 and 42	
45 and 46	6	Wireless LAN	
47 and 48	6	Reserved in case of failure of fibres 45 and 46	
49 and 50	7	Ticketing/Revenue Collection and Passenger Gateline Systems	
51 and 52	7	Reserved in case of failure of fibres 49 and 50	
53 and 54	7	Spare (or future development)	
55 and 56	7	Spare (or future development)	
57 and 58	8	Spare (or future development)	
59 and 60	8	Spare (or future development)	
61 and 62	8	Spare (or future development)	
63 and 64	8	Spare (or future development)	
65 and 66	9	Spare (or future development)	
67 and 68	9	Spare (or future development)	
69 and 70	9	Spare (or future development)	
71 and 72	9	Spare (or future development)	
73 and 74	10	Spare (or future development)	
75 and 76	10	Spare (or future development)	
77 and 78	10	Spare (or future development)	
79 and 80	10	Spare (or future development)	
81 and 82	11	Spare (or future development)	
83 and 84	11	Spare (or future development)	
85 and 86	11	Spare (or future development)	
87 and 88	11	Spare (or future development)	
89 and 90	12	Spare (or future development)	
91 and 92	12	Spare (or future development)	
93 and 94	12	Spare (or future development)	
95 and 96	12	Spare (or future development)	

Pos	Requirements
26	The Service Allocation (Core Traffic) of Fibres in the above table is only provided as guidance. There may be valid reasons for varying these requirements during the detailed design. Any variations shall be supported by valid justifications and submitted to the Employer for prior consideration and approval.

11.4 CCTV

11.4.1 Standards

Table 11.10: Standards for CCTV

Pos	Requirements
1	BS 6701
2	BS 7430
3	BS 7671
4	BS EN 50121
5	BS EN 50122
6	BS EN 50125
7	BS EN 50126
8	BS EN 50128
9	BS EN 50129
10	BS EN 50131
11	BS EN 50132
12	BS EN 50133
13	BS EN 50174
14	BS EN 50346
15	BS EN 60529
16	BS EN 60950
17	BS EN 61508
18	BS EN 61643
19	BS EN 61935
20	BS EN 62305
21	BS EN 62491
22	BS EN 62676
23	BS EN 61643
24	BS EN 61935

Pos	Requirements
	cabling in accordance with EN 50173
25	BS EN 62305 Protection against lightning
26	BS EN 62491 Industrial systems, installations and equipment and industrial products. Labelling of cables and cores
27	BS EN 62676 Video surveillance systems for use in security applications.
28	ISO 11801:2012 Information technology - Generic cabling for customer premises - Amendment 2
29	All Indonesia National and Municipal Codes, Acts and Regulations that are related to the SCADA system

11.4.2 Functional Requirements

Table 11.11: Functional Requirements for CCTV

Pos	Requirements
1	The CCTV system shall provide CCTV coverage of all public areas. The system shall be used for general surveillance of the station concourse, stairs, escalators, lifts, passageways and platform areas. This system shall enhance the safety and security of passengers and help in reducing crime and preventing terrorism and disorderly activity.
2	The CCTV system shall provide enhance the safety and security of public and Operators at the stations. The CCTV system shall comprise of colour video imaging, processing equipment, overview display and recording equipment which incorporates the video transmission system.
3	The CCTV system shall principally consist of fixed cameras with PTZ cameras for pro-active monitoring. The CCTV cameras shall provide a high level of sensitivity, excellent colour resolution and operate under all luminance levels. The cameras shall be carefully positioned to provide total video coverage of all public areas with a minimum of blind spots. Cameras with video area overlap shall be connected where possible by separate cable routes to provide resilience.
4	The Operators in the OCC shall have the ability to view footage from all cameras within the stations. The CCTV spot monitors shall be provided in the OCC providing split screen capability to allow more images to be viewed at the same time. Each camera video shall include an overlay providing details of the camera number, its location and the date/time.
5	All CCTV images shall be digitally recorded, including overlay information. When replaying images, the overlay information shall provide details of the camera and the time of the incident.
6	The images shall be recorded at full frame rate of 25fps during incidents and at lower frame rate nominally 4fps at all other times. The Network Video Recorder (NVR) shall support recording in colour and store for up to 31 days. All video images shall be digitally recorded onto hard-disk drives for instant access over the Fibre Optic Transmission System for playback and monitoring. This hard drive shall be secure and shall not allow access from any other source.
7	The recorder shall allow for video clips to be searched for using a variety of parameters such as the camera number and the date/time. When replaying images, the information displayed on the recorded image, such as time, date and camera detail, shall be identical to that pertaining at the instant of recording the original live image.
8	A Passenger Awareness Monitor (PAM) shall be installed in the concourse area to demonstrate to the passengers that the CCTV system is in operation in the station.
9	The CCTV system shall be interfaced with the SCADA system for selecting cameras to be displayed on the CCTV spot monitor and to provide health monitoring of the CCTV system. The CCTV system shall be capable of operating in standalone mode in the unlikely situation that the SCADA becomes non-operational.
10	The CCTV system shall be fully IP network based, utilise the Open Network Video Interface Forum (ONVIF)

Pos	Requirements
	standard for transmitting, storage, viewing and retrieving of CCTV video images. The CCTV video images shall be encrypted and provide high resolution smooth video. Those proprietary hybrid or non-standards based protocols shall be prohibited.
11	The operation of retrieving of CCTV video images shall be seamlessly integrated into the spot monitors located in the OCC. The NVR shall be used to record of CCTV video images. It shall be installed in every station and the OCC. The CCTV system shall utilise the Fibre Optic Transmission System to transmit the CCTV video images from various stations to the OCC.
12	The CCTV cameras shall be connected to the Power over Ethernet (PoE+) network switches to enable the simultaneous transmission of a high quality video channel and power supply over the CAT7 cable.
13	The spot monitors in the OCC shall be installed with Video Management Software (VMS) to provide the functional of retrieving the CCTV video images for the Operator to remotely view of live or recorded CCTV video images of the stations, substations and depot. The VMS shall be interfaced with the SCADA system to allow the selection of CCTV camera to be displayed on the spot monitor via SCADA workstations. A spot monitor shall be installed for each console in the OCC.
14	The Operator in the station and OCC shall be able to select the camera for live viewing or to select time and date of recorded CCTV video images from the SCADA workstations. Each station shall be provided with its own spot monitor for monitoring of the live footage of own station.
15	The CCTV system shall be installed at the following locations:
15.1	Passenger Stations
15.1.1	The HD dome IP cameras shall be installed in the stations to provide CCTV coverage for the station concourse, stairs, escalators, lifts, passageways and platform areas. It shall be linked to the OCC via Fibre Optic Transmission System to provide Operator at OCC with remote visual surveillance of all stations.
15.1.2	The cameras at stations shall be installed in the following areas to provide CCTV coverage: <ul style="list-style-type: none"> • Passenger main access route – general coverage of areas, including surveillance of vehicles and passengers at the taxi facility incorporating drop-off, pick-up, taxi ranking, passenger waiting and circulation areas. • Concourse unpaid area – general coverage of areas, including surveillance of passengers using the ticket vending machines, lifts, stairs and escalators. • UTS gate line – surveillance of passengers passing through the gates. • Concourse paid area – general coverage of areas, including surveillance of passengers using the PHPs, lift, stairs and escalators. • Platform area – general coverage of areas, including surveillance of passengers using the PHPs, lift, stairs and escalators.
15.1.3	The cameras shall be connected to the PoE+ network switches for power, video and control functions transmitted over the single CAT7 connection.
15.1.4	The NVR shall be provided in the CER of each station to record all CCTV video images of the particular station and nearby substation. All cameras shall be recorded constantly at a resolution of 1080p and 4fps. All recorded video shall be retained for 31 days after which it shall be automatically overwritten by the CCTV system.
15.1.5	The CCTV system shall interface with the Passenger Help Point (PHP) system, fire lift intercoms, escalator stop buttons, door alarms and fire alarm call points to provide camera switching related to event alarms. The video recording of these events shall be at a resolution of 1080p and 25fps.
15.1.6	The PAM monitor shall be installed at the gateline to display a video image of gate line.
15.2	Depot
15.2.1	The PTZ IP cameras shall be installed at the depot to provide CCTV coverage of main entrance and train parking areas. The cameras shall be linked via depot LAN to provide visual surveillance for the Operator at OCC. The cameras shall be connected to the PoE+ network switches for power, video and control functions transmitted over the single CAT7 connection.
15.2.3	The cameras at depot shall be installed in the following areas to provide CCTV coverage:

Pos	Requirements
	<p>Personnel main access route – general coverage of areas, including surveillance of entrances to the building.</p> <p>Trains main access route – general coverage of areas.</p>
15.2.4	All cameras shall be recorded constantly by the NVR at the depot with a resolution of 1080p and 4fps. All recorded video shall be retained for 31 days after which it will be automatically overwritten by the CCTV system.
15.3	<p>Traction Power Substation</p> <p>The PTZ IP CCTV cameras shall be installed at the substations to provide CCTV coverage of access points to the substation. The cameras shall be linked by a dedicated fibre optic cable to the nearby station for video recording and retransmitting of CCTV video images to the OCC for remote visual surveillance. The cameras shall be connected to the PoE+ network switches for power, video and control functions transmitted over the single CAT7 connection.</p> <p>The cameras at substations shall be installed in the following areas to provide CCTV coverage:</p>
15.3.1	Personnel main access route – general coverage of areas, including surveillance of main entrance into the substation.
15.3.2	All cameras shall be recorded constantly by the NVR at the nearby station with a resolution of 1080p and 4fps. All recorded video shall be retained for 31 days after which it will be automatically overwritten by the CCTV system.
15.3.3	All cameras shall be recorded constantly by the NVR at the nearby station with a resolution of 1080p and 4fps. All recorded video shall be retained for 31 days after which it will be automatically overwritten by the CCTV system.
15.3.4	The CCTV system shall interface with the SCADA system to provide camera switching related to access point alarm. The video recording of this event shall be at a resolution of 1080p and 25 frames per second.
15.3.5	The OCC Operators shall have the ability to select the camera for live viewing or to select time and date of recorded CCTV video images from the SCADA workstations.
16	Equipment
16.1	Fixed Cameras
16.1.1	The colour, HD and IP dome cameras shall be used to provide coverage at various locations. The CCTV cameras shall be fitted to ceiling, wall or posts.
16.1.2	The cameras shall provide a minimum resolution of 1920x1080 and be capable of streaming HD video data at the full frame rate within the constraints of the optical transmission system. It shall be configured to provide 25fps multicast stream for live viewing and event recording, and 4fps unicast stream for background recording.
16.1.3	The cameras shall support the video compression of H.264 and IP encoding for Local Area Network (LAN) and Wide Area Network (WAN) transmission.
16.1.4	Each camera shall equip a lens with the focal length ranging between 3mm and 9mm. The lens shall not impede the image quality of the camera and its overall performance. It shall have an appropriate focal length to optimise the coverage area as determined by the field of view requirements.
16.1.5	The cameras shall be directly powered from the PoE+ network switches over the CAT7 cables in compliance with IEEE 802.3at. The cameras shall be equipped with a RJ45 interface to allow connectivity to the CAT7 cable.
16.1.6	Each camera shall be set with a unique IP address so that the video signal can be available to the CCTV system at OCC.
16.1.7	The cameras shall be Open Network Video Interface Forum (ONVIF) specification compliant.
16.1.8	The camera shall support IP protocols as required by the VMS including those applicable for camera status and alarm management.
16.1.9	The cameras shall have an analogue composite Phase Alternate Line (PAL) output for local maintenance and setup purposes.
16.1.10	The cameras shall be capable of providing a good image under normal and emergency light levels in the station.
16.1.11	The cameras shall have minimum illumination of 0.01lux. The cameras shall incorporate a “wide dynamic range” feature to avoid detail of the image in dark areas being indistinguishable due to wash out from the lights.

Pos	Requirements
16.1.12	The cameras shall have an operating temperature range of -40°C to 50°C. The camera housing shall support ingress resistance of not less than IP65.
16.2	PTZ Cameras
16.2.1	The colour, HD and IP 360° dome cameras shall be used to provide coverage at various specified locations. It shall be fitted to ceiling, wall or posts.
16.2.2	The PTZ cameras shall be capable of achieving identification (120%R according to the Rotakin standard) at a distance of at least 30m when operating at maximum available focal length.
16.2.3	The PTZ station cameras shall be capable of providing an overall view of the whole platform when operating at minimum available focal length.
16.2.4	The PTZ cameras shall provide a view of the train to platform interface and as much of the platform as possible without distorting the image or perspective view and ideally shall be positioned such that they are located at the centre line of the platform.
16.2.5	The PTZ cameras shall provide a resolution of 1920x1080 and be capable of streaming HD video data at the full frame rate within the constraints of the optical transmission system. It shall be configured to provide 25fps multicast stream for live viewing and event recording, and 4fps unicast stream for background recording.
16.2.6	The PTZ cameras shall support the video compression of H.264 and IP encoding for Local Area Network (LAN) and Wide Area Network (WAN) transmission.
16.2.7	The cameras shall be directly powered from the PoE+ network switches over the CAT7 cables in compliance with IEEE 802.3at. It shall be equipped with a RJ45 interface to allow connectivity to the CAT7 cable.
16.2.8	Each camera shall be set with a unique IP address so that the video signal can be available to the CCTV system at OCC.
16.2.9	The cameras shall be Open Network Video Interface Forum (ONVIF) specification compliant.
16.2.10	The camera shall support IP protocols as required by the VMS including those applicable for camera status and alarm management.
16.2.11	The cameras shall be capable of providing a good image under normal and emergency light levels in the station.
16.2.12	The cameras shall have minimum illumination of 0.04lux. The cameras shall incorporate a "wide dynamic range" feature to avoid detail of the image in dark areas being indistinguishable due to wash out from the lights.
16.2.13	The cameras shall have an operating temperature range of -40°C to 55°C. The camera housing shall support ingress resistance of not less than IP65.
16.3	Video Storage Recorder
16.3.1	The video storage recorder shall be utilising NVRs. Each Passenger Station should be provided with the NVR to record CCTV footage from this particular station.
16.3.2	The NVRs located at the station shall also be used to record the CCTV video images from the nearby traction power substation which shall be transmitted via dedicated fibre network.
16.3.3	The NVRs shall be connected directly to the station LAN or depot LAN. The connectivity shall have sufficient bandwidth such that the on demand video is not disrupted by any simultaneous demand for camera recording.
16.3.4	The NVRs shall be configured as RAID5 to provide resilience and rebuild data in the event of drive failures. The storage array technologies utilise RAID and hot-swappable shall be considered for the design of CCTV storage.
16.3.5	The NVRs shall be capable of recording audio tracks simultaneously mapped with the video for the purposes of PHP or lift intercom recording.
16.3.6	The NVRs shall be capable of retaining all records for a minimum of 31 days, after this period the VMS shall automatically overwrite the old images unless it has been marked for retention. The video image of cameras shall include the camera number, location time and date.
16.3.7	The NVRs storage capability shall be sized by the specialist communication systems Contractor such that NVRs shall continuously record 4fps from their allocated cameras. In response to events signalled by the

Pos	Requirements
	SCADA, the VMS shall instruct the NVRs to record the 25fps for the event period. For PHP or lift intercom calls audio shall be associated with the event video recording.
16.3.8	The recorded images in NVRs shall be retrievable through a password or hardware lock system and have the copying facility to removable hard drive, e.g. USB support. The Operator can physically copy the recorded CCTV video images for remote archiving the images. The CCTV video images stored in the removable hard drive shall be easy to play, preferably with 'Windows Media Player' for familiarity.
16.4	Video Management System (VMS)
16.4.1	The VMS servers shall be installed with video management software to provide the basis of the video switching and routing distribution as a virtual matrix for the CCTV system.
16.4.2	Two VMS servers shall be provided and shall be installed in the separate CERs at OCC to provide resilience for the CCTV system. The VMS servers shall be configured as RAID 1 to provide 100% redundancy with duplicated data. It shall be configured as duplicated server with fully redundant.
16.4.3	The VMS servers shall be integrated with the SCADA workstations so that Operator can use the SCADA workstations to select and control the CCTV cameras, and to provide the viewing setting for the spot monitors and video wall.
16.4.4	The NVRs shall be managed by the VMS servers. The VMS servers shall command video streams of NVRs for viewing, real-time or time lapse recording. The time lapsed 4fps recording stream shall have the capability of changing by the event signalled from SCADA, the VMS shall instruct the NVRs to record the 25fps for the event period. The duration of initiate and stop recording of events shall be configurable by the VMS.
16.4.5	The VMS servers shall allow recordings to be marked for retention such that they have to be manually deleted.
16.4.6	The VMS servers shall support Network Time Protocol (NTP) from the Master Clock to provide time stamping for the CCTV video images.
16.4.7	The VMS servers shall provide a secure method of authenticating exported video files.
16.4.8	The VMS servers shall provide alarm management facility. All alarms rose from the cameras and NVRs shall be monitored by the VMS servers. Those camera video loss alarms or NVR hard drive failure including recording failure shall be displayed on the SCADA workstations.
16.4.9	The VMS servers shall support the metadata presentation of CCTV video images for displaying on the spot monitors. The display of CCTV video images shall be configured to include the camera number, location time and date.
16.4.10	The VMS servers shall provide the facility to allow Operators to configure split view on any spot monitors. Each monitor shall be displayed up to not less than 16 CCTV video images. The selection of these views shall be made available through the SCADA workstations. It shall also provide the facility to allow the Operators to configure camera sequences on any spot monitor.
16.5	Passenger Awareness Monitor
16.5.1	The PAM shall be located at the gate line to provide a view to the public that CCTV is in operation. It shall be sited facing to the entrance side of the gate line so that passengers can see their own image passing through the gate.
16.5.2	The PAM shall be connected to the PoE+ network switch via the CAT7 cable in order to retrieve those relevant CCTV video images to be displayed on the screen.
16.5.3	The PAM shall be utilising stainless steel housing with an impact resistant glass screen. The housing shall be compliant with the IP66 ingress requirement.
16.5.4	The PAM shall be at least 22", wide screen format monitor. The resolution of the monitor shall be a minimum of 1920 x 1080.

11.4.3 Performance Requirements

Table 11.12: Performance Requirements for CCTV

Pos	Requirements
1	<p>Response Time during operation:</p> <p>1.1 Video / control transmission to / from the CCTV camera shall be within 150m seconds.</p> <p>1.2 Fibre Optic Transmission System inclusive LAN shall be within 5m seconds.</p> <p>1.3 Therefore the overall response time for the CCTV system shall be within 155m seconds.</p>
2	The CCTV system shall provide a minimum of 95% coverage of all public areas, to a height of 2.6m from finished floor level.
3	<p>Field of View</p> <p>3.1 The field of view from each camera shall be determined based on the 'Rotakin' standard.</p> <p>The categories shall be measured by relating the views to the image height of a standard test target 1.7m high.</p> <p>3.2 When the image of the target fills the screen vertically, the image height shall be equivalent to 100% R, where 'R' is the abbreviation of 'Rotakin', a Police Scientific Development Branch's test target.</p> <p>The 'Rotakin' standard defines various purposes for CCTV cameras, which in turn determine the field of view of the cameras. The cameras to be installed shall comply with the following requirements:</p> <ul style="list-style-type: none"> 3.3 • Minimum 10% in all public areas. • Minimum 25% at specific high risk areas. • Minimum 50% at gate lines, Passengers Help Points (PHPs), lift intercoms <p>The cameras shall not face directly into bright sources of light and shall not be affected by reflections and shadows. The camera positions shall be designed to provide continuous area surveillance coverage with overlapping fields of view. A portion of the field of view of each camera shall, as far as practicable, be clearly visible within the field of view of at least one adjacent camera.</p> <p>3.4 The Contractor shall ensure that the installation of all cameras used in the system shall facilitate optimum coverage from the locations given, whilst at the same time being as unobtrusive as practical.</p>
4	<p>Spot Monitors</p> <p>4.1 The spot monitors shall be provided to display the live video coverage from the camera chosen by the Operator at OCC.</p> <p>4.2 The size of the spot monitors shall be a minimum of 23.8" and shall have a resolution of at least 1920 x 1080, in format of 16:9.</p> <p>4.3 The spot monitors shall utilise digital connection to avoid risk of reduced image quality while conversion to analogue signal.</p> <p>4.4 The spot monitors shall be operating but not be limited to quad view (2x2 live video footages from selected cameras). The Operators shall be able to increase the amount of displayed video footages to up not less than 16 (4x4).</p>

11.5 Voice over IP Telephony System

11.5.1 Standards

Table 11.13: Standards for Voice over IP Telephony System

Pos	Requirements
1	Electromagnetic Compatibility (EMC) – Various sections referenced within this specification
2	Local and Metropolitan Area Networks
3	Dynamic Host Configuration Protocol
4	Power Over Ethernet
5	Lightweight Directory Access Protocol
6	Simple Network Management Protocol
7	Simple Network Time Protocol
8	Audio Codec
9	Audio Codec
10	Session Initiation Protocol
11	ITU Telecommunication Standardization Sector (ITU-T) that defines the protocols to provide audio-visual communication sessions on packet network

11.5.2 Functional Requirements

Table 11.14: Functional Requirements for Voice over IP Telephony System

Pos	Requirements
1	The IP Telephony system shall use the network switches provided as part of the Local Area Network, along with specialised servers known as Call Managers, to provide telephony services. This minimises the amount of cabling required, reduces system complexity, and increases flexibility.
2	Call Managers shall be accessed via the Fibre System.
3	The call managers will be dimensioned so as to be able to handle the requirements for all the sites. The configuration shall allow a 25% growth of users.
4	The call managers shall be designed to guarantee 99.98% availability.
5	All meeting rooms will be equipped with a dedicated audio-conferencing device which will remain connected and fully operational permanently.
6	IP based help points will be located at each station; these will connect automatically to the OCC or alternatively can offer connection to the emergency services by use of a separate push button control on the front panel.
7	'Hard phone' handsets shall be designed for standard office environments.
8	The Fibre System shall be used as the carrier within the rail alignment, to deliver VoIP services and route On-Net calls.
9	Telephony gateways and related external communications lines shall be implemented, providing external connectivity.
10	Off-Net Dialling are External calls are those routed to the PSTN network through telephone gateways. A prefix number or E164 numbers will be used to route these calls.
11	Communications with the call manager and gateways shall be able to support SIP and H323 protocols.
12	The phone numbering strategy will be decided during the detailed design phase.

Pos	Requirements
13	Voice mail shall be provided as standard to each fixed phone account. Voice mails shall be forwarded as MP3 attachments automatically to the messaging system of the Employer, utilising a unified messaging system.
14	Faxes and Pay-Phones shall use fixed IP addresses (if required); all other wired or wireless Telephony devices shall comply to DHCP and retrieve dynamically their IP address and characteristics (DHCP options) from the network DHCP server.
15	The telephony system shall use Differentiated Services (DiffServ) and DSCP for Quality Of Service (QOS) in order to tag the voice traffic on the network. All the basic features listed below shall be made available to every user : <ul style="list-style-type: none">• Incoming and Outgoing Call• Transfer• Pickup and Pickup Group• Conference Ad hoc/Join Conference with at least 3 participants• Display name Internal/Display Caller ID• Corporate Directory Dial/Call History/Personal Directory/Date Display• Redial
16	<ul style="list-style-type: none">• Call Back• Monitor Line• Abbreviated Dial• Hold and Resume• Music On Hold (MoH)• Call Forward• Call Waiting• IP Phone customization• Call Park
17	Users shall be able to configure their IP Telephony service as their own by logging in to that phone and retrieve their individual device profile information, including line numbers, speed dials, services links, and other user-specific property, regardless of their physical location.
18	It shall be possible to recall the last login on the phone.
19	The list of calls shall be cleared when the user disconnects.
20	Directory integration: the list of users with their numbers shall be synchronised from the Employer Directory using the LDAP protocol. The distribution of incoming calls to multiple phones is based on hunt pilots, hunt lists, and groups of lines. The Call manager shall distribute calls to the handsets according to the pre-defined distribution algorithm that can be : <ul style="list-style-type: none">• Top-down• Circular• Longest idle time• Broadcast
21	A user shall be able to login and logout of a hunt group via a Soft key on the Phone. Basic features for IP Telephony shall include: <ul style="list-style-type: none">• Incoming and Outgoing Call• Call Transfer• Pickup and Pickup Group• Conference Ad hoc/Join Conference with at least 3 participants
22	
23	

Pos	Requirements
24	<ul style="list-style-type: none"> • Display name Internal/Display Caller ID • Corporate Directory Dial/Call History/Personal Directory/Date Display • Redial • Call Back • Monitor Line • Abbreviated Dial • Hold and Resume • Music on Hold (MoH) • Call Forward • Call Waiting • IP Phone customization • Call Park • Voice Mail <p>Assistant devices: They will allow the following options :</p> <ul style="list-style-type: none"> • Line monitoring with a Busy Lamp Field • Pickup Call • Speed dial (allowing the user to place a call by pressing a reduced number of keys)
25	<p>Attendant console: The following features shall be available for the attendant console:</p> <ul style="list-style-type: none"> • 50 Queues supported minimum • Queue wait time overflow • Queue limit overflow (no of calls) • Operator overflow (no operators) • Queue overflow destinations • Music in Queue • Busy Lamp Fields / Phone Status • Transfer Reversion (Call Recall)/ Hold Recall • Camp on • Call hold with notes/ Call Hold • Transfer/Conference
26	The call manager and telephone gateways shall be provided with uninterruptible AC power supplies.
27	This shall be provided by a combination of a battery/inverter type UPS providing sufficient autonomy in combination with the maintained site supplies.
28	In the event of power interruption during changeover of the generator in service the UPS shall maintain power to the equipment until generator power is restored. They shall operate from 230VAC +/- 10% 50Hz +/- 2.5%
29	The call managers and the telephone gateways shall be monitored by a communications Fault Monitoring system via SNMP V2.
30	The required information includes general equipment status such as equipment uptime and CPU utilisation. Critical Network interfaces shall also be able to report specific information such as status, byte counts, and error counts.
31	Call managers and Telephone gateways equipment shall support simple network time protocol (SNTP) for time synchronisation of event logging
32	The IP Telephony system shall provide full-service 'outbound' to enable calls from the Jakarta LRT rail network to external locations. The IP Telephony system shall also permit direct inbound dialling in to the Jakarta LRT rail network via appropriate firewalls/gateways and call manager servers.

Pos	Requirements
33	The IP Telephony system shall be capable of supporting a combination of 'hard phones', 'soft phones' and 'wireless phones'. Scope of Works
34	The types, locations and quantities where IP telephones are to be provided shall be determined during the detailed design phase by the Contractor in liaison with the Employer.
35	The IP Telephony system shall use the network switches provided as part of the LAN to provide the required telephony services internally to the Jakarta LRT rail network. This is aimed at minimising cabling requirements and complexity, and to provide flexible system architecture to allow adaptive scalability across the Jakarta LRT rail network.
36	IP Telephony firewalls/gateways shall provide the interface between the IP Telephony system and external connections to the Public Switched Telephone Network (PSTN). Through design analysis of 'traffic flow' requirements, the Contractor shall determine the number of external PSTN lines required to support rail operations.
37	In order to minimize the number of VoIP servers, the design shall consolidate the VoIP central infrastructure and deploy only two call manager servers. One shall be located in the OCC CER. A second call manager server shall be provided and configured in a standby arrangement to provide IP Telephony network resilience. This second call manager server shall be located at the DRC area.
38	One IP Telephony firewall/gateway shall be located in the OCC CER. A second IP Telephony firewall/gateway shall be provided and configured in a standby arrangement to provide IP Telephony to PSTN connectivity resilience. This second IP Telephony gateway shall be located at the DRC area.
39	Where IP Telephony services are stipulated in offices and control rooms, 'soft phone' options via a PC/Laptop interface shall be provided for staff use.
40	Fixed telephone handsets (hard phones) with hands-free 'audio-conferencing' capabilities shall be provided in all equipment rooms and all meeting rooms. IP Telephones ('hard phones') shall be connected to local switches utilising Cat 7A STP cable.
41	Internal direct dialling to any extension shall be available from any location and device, however local dialling to the PSTN or International call access will be blocked by default, and provided on a request basis controlled by the Employer.

11.5.3 Performance Requirements

Table 11.15: Performance Requirements for Voice over IP Telephony System

Pos	Requirements
1	The design shall include a study to confirm the IP Telephony services, traffic routing and system configurations. The study should assume that 100% of ports on all servers/switches are utilised and active.
2	In the event of a mains power failure the call manager and telephone gateways shall be provided with uninterruptible AC power supplies capable of sustaining full IP Telephony operation for 2 hours.
3	Equipment and cable redundancy shall be employed to the extent as described in section 1.2 above to ensure that the IP Telephony system is highly reliable meeting, as a minimum, a system availability of 99.99% per annum, with an assumed Mean Time to Repair (MTTR) of 30 minutes.
4	In establishing system availability the Contractor shall include in its calculations all relevant equipment, cables, interfaces, software and power supplies.
5	The minimum design life of the IP Telephony equipment supplied by the Contractor shall be 10 years.
6	The designer shall undertake a risk assessment to determine if a limited number of directly connected PSTN Plain Old Telephone Service (POTS) at the OCC, depot or stations should be provided (separate from VoIP provision) to provide a 'fallback' service in case of emergencies/fire etc., should a failure of the IP Telephony system prevent emergency calls being made.

11.5.4 Common Equipment Rooms

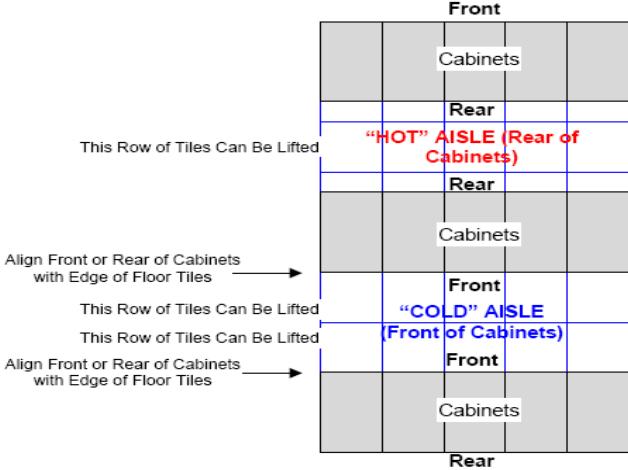
Table 11.16: Standards for Technical Rooms

Pos	Requirements
1	BS 476-22:1997
2	BS 5306-8-2000
3	BS 5588-5:2004
4	BS 6399-1:1996
5	BS 6399-2
6	BS 7671
7	EN 3-7:2004
8	EN 779:2002
9	EN 12101
10	EN 50131-1:2006
11	IEC 801-3
12	IEC 11801:2002
13	IEC 60529
14	IEC 60686
15	IEC 61340-5-1
16	IEC 61386
17	IEC 62305
18	IEEE 802.11
19	ISO 91.160.10
20	ISO 16814:2008
21	ISO-14520-8:2006
22	ISO 17497-2
23	ITU-G625D
24	TIA / EIA 942
25	TIA / EIA-568-B.1
26	TIA / EIA-568-B.2
27	TIA / EIA-568-B.3
28	TIA / EIA-569-A
29	TIA / EIA-606-A
30	TIA / EIA-607
31	TIA / EIA-758
32	TIA / EIA-942

11.5.5 Functional Requirements

Table 11.17: Functional Requirements for Technical Rooms

Pos	Requirements
1	Provision of Technical Rooms for hosting the servers etc to support the Jakarta LRT applications and data hosting
2	Type Two room shall be located at the OCC
3	Type One rooms shall be located one per station
4	Type Three rooms shall be located at the OCC and Stations to accommodate the Batteries and UPS systems, if required
	Room Sizes
5	The size of Type one rooms shall be as a minimum 3 Metres x 3 Metres
6	The size of Type Tw0 rooms shall be as a minimum 12.5 Metres x 13.2 Metres
7	The size of a Type Three room shall be as a minimum 3 Metres x 3 Metres
8	The minimum height of a computer room ceiling for small rooms is 2.6m and 3.0m for large rooms, from the bottom of the finished floor to any obstructions such as fire detection and suppression fittings, light fittings and cameras.
9	Due consideration shall be given to TIA/EIA-942 Telecommunications Infrastructure Standard for Data Centres.
10	Doors shall be of solid construction and shall be 2 hour fire rated. Single doors with 1000mm width for small computer room and double doors with a total of 1200mm width shall be installed for large rooms.
11	Self-closing mechanisms shall be installed on all doors. Door seals are to be installed around to the door, and drop down seals at the bottom of the door to prevent dust from entering and loss of air from the room.
12	Main door shall be a minimum 1000mm and secondary door shall be a minimum 775mm. Door height should be 2130mm (7ft) where possible.
13	Where possible the room should not have any doors which are external to the building to minimise dust entering the room. If direct access to the outdoors is required then there should be a double door system with a sealed area (airlock) in between.
14	The access doors to all rooms shall be secured with a high security locking and access systems, this shall be monitored and recorded via the OCC
15	All points of ingress to the technical rooms shall be monitored via CCTV
	Air Conditioning
16	Air-conditioning units shall be using an N+1 configuration. The N+1 configuration shall allow for any one unit to be on standby mode and automatically started for testing on a weekly basis.
17	In all CER's, they shall be designed to support the expected heat load of all the equipment within the room, including UPS and batteries, telecoms systems, radio, telemetry, and control systems and spare capacity of 25% heat load should be allowed for.
18	In large CER's, commercial grade floor-standing air conditioning units shall be installed, and wall mounted split systems will be sufficient for small CER's.
	The temperature and humidity for all Technical Room types shall be operated in the following ranges:
	Temperature: 20° C (+/- 5 degrees Celsius)
	Relative Humidity: 50 % (+/- 10 %)
19	Max Dew Point: 21°C
	Max Rate of Change: 5° C per hour
	Operating time: 24 hour/day, 365 day year
20	A positive pressure system shall be maintained within the rooms to reduce dust and particulate ingress
21	The cooling system and equipment floor plan shall be co-ordinated to allow airflow to travel in parallel with the

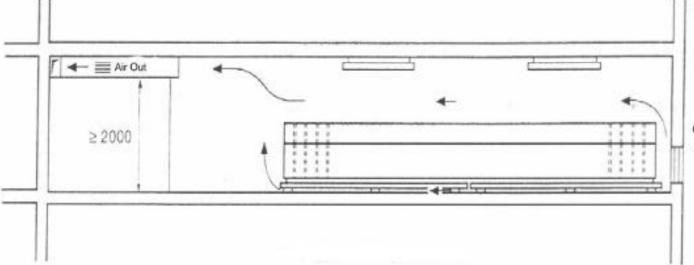
Pos	Requirements
	<p>rows of cabinets/racks as shown in the diagram below.</p> <p>Cooling system airflow and cabinets configuration diagram</p> 

22 Walls

- 22.1 All Technical Room walls in new facilities shall be constructed to afford two hours of fire protection.
- 22.2 Walls shall be constructed floor to ceiling (slab to slab) with no access through to common areas either in the ceiling or under the floor.
- 22.3 All penetrations shall be sealed. This serves as a fire suppressant and to contain the gas should the room use gas based fire suppression and to protect against dust and vermin entry into the room. Penetrations such as cable and conduit entry points in the floor are common places of dust, moisture and vermin ingress. All fire stopping shall be of approved materials and fully certified.
- 22.4 Walls constructed of Plasterboard, shall be of the fire rated type. Double sheeting is required both internally and externally of the room. The walls are to be sealed from slab to slab to prevent absorption of moisture.
- 22.5 The common equipment rooms shall not have any external windows.

23 Flooring

- 23.1 Rooms of types 1 and 2 shall have **anti-static floor**. In large rooms **false floors** shall be installed with a **600mm** clearance.
- 23.2 Floor loading capacity shall meet the required distributed and concentrated load of the installed equipment with associated cabling and media.
- 23.4 The floor installation and floor loading shall be in accordance with **TIA/EIA - 942** Telecommunications Infrastructure Standard for Data Centres.
- 23.5 The minimum recommended distributed floor loading for all Technical rooms is **7.2 kPa** and **12kPa** respectively.
- 23.6 The floor shall have a recommended **2.4 kPa** hanging capacity to support loads such as cable ladders that are suspended on the bottom of the floor (or ceiling of the floor below)
- 23.7 Where large and/or heavy equipment is to be installed, building structural limitations shall be considered.
- 23.8 Type 3 rooms shall have an acid resisting coating applied surfaced with quarry tiles or an Epoxy resin coating such as "Reprotec Acidcheck". This a high build chemical resistant epoxy resin coating which offers excellent

Pos	Requirements
	<p>durability and chemical resistance. It provides a superb glossy, hygienic and easily cleaned surface. These or similar materials are recommended, in case of a major accidental spillage for Type 3 rooms.</p>
24	<p>Fire Protection</p> <p>24.1 All CER's shall be fitted with early warning smoke detection systems and shall be connected to the building fire panels. All rooms shall have a fire suppression system installed.</p> <p>24.2 CER's Type 1 and Type 2 shall be equipped with Gaseous fire suppression systems.</p> <p>24.3 Photo-optical and ionisation smoke detectors shall be used to provide stage-1 detection for alerting the fire brigade or on site emergency services</p> <p>24.4 Warning via audible sirens and visual strobes shall be given throughout the detection process.</p> <p>24.5 All Type 1 and Type 2 rooms should be airtight, i.e. any ventilation must be facilitated using regulated ventilation systems.</p> <p>24.6 The use of automatic fire extinguishing systems demands airtight rooms.</p> <p>All Type 3 rooms should be properly ventilated as they will contain batteries that can give off Hydrogen gas. The way of air circulation should be as shown below. Refer to drawing no XXX for further reference. If the air in and air out are on the same side the room free volume must be greater than 2.5 times of the calculated air volume.</p> <p>Note: In EN 50272-2, a minimum distance between inlet and outlet of 2 m is required.</p>
24.7	
	<p>Battery rooms should be designed with adequate ventilation- exhaust systems which provides for continuous ventilation of the battery room to prohibit the build-up of potentially explosive hydrogen gas. During normal operation gas discharge by the batteries are relatively small.</p>
24.8	All Type three rooms shall be fitted with Hydrogen Gas Detection Systems and Sprinkler systems
24.9	All cable penetrations or other via's shall be fireproofed using approved products and the installation shall be certified and documented.
24.10	Monitoring and controls
24.11	Air temperature, air flow at a minimum shall be continually monitored 24x7 with alerts and data reports sent to the facilities manager and 24x7 monitoring team.
24.12	In large CER's, UPS and Air conditioning units shall be monitored with sensors installed.
24.13	In large CER's, fluid detection shall be installed to detect water leaks from any A/C units or leaks from above or adjacent rooms
	All CER's shall be equipped with a CCTV camera to monitor remotely at least the entry door.
25	<p>Lighting</p> <p>For all CER's, the minimum lighting level required is 500 lux and shall be in accordance with TIA/EIA-942 Telecommunications Infrastructure Standard for Data Centres.</p>

Pos	Requirements
25.2	All CER's shall be equipped with an exit and emergency lighting.
25.3	Some lighting fixtures in the computer room shall be connected to the UPS distribution board for orderly shutdown of equipment in the event of power loss; no dimmer switches are to be used
25.4	Emergency lighting and signs shall be installed as per LRT authority regulations to assist with emergency exit in the event of primary lighting loss.
26	Racking and Cable Management Racks fitted to all Common Equipment rooms shall be 42 U high, 750mm wide, 1000mm deep lockable racks with dual power rails/power strips. All racks and cabinets shall be painted light grey to conform to RAL 7035 or equivalent, with the following characteristics: <ul style="list-style-type: none"> • Dual multi-way 15A power rails with captive plugs each on a separate circuit or dedicated breakers. • 19" vertical rails set to allow for cable management and power rails/power cords at the front and back of the cabinet • 150mm cable trays • 6mm earth cables • Horizontal and vertical cable management • Lockable front and back doors and side panels • IP rated dust proofing capability for open space, high dust area. Standard racks with perforated doors should be used where dust exposure is minimal. • Heat extraction fan for IP rated racks • Load support greater than 500kg • Slim line KVM switch and LCD screen/keyboard and mouse combo for racks with multiple thin based servers (optional – to be specified in server racks). • Remote monitoring unit with temperature, humidity and camera (optional) for racks located at unmanned site or considered critical. Racks with locks are required to ensure separation of third party equipment from Employer owned equipment where the computer room is shared. Where specialised equipment is to be installed, vendor specific racks will be used. The use of rack blanking plates is strongly recommended in order to improve airflow within racks.
26.1	
26.2	All racks and cable trays shall be earthed (protective earth) along with a functional earth for telecommunications equipment.
26.3	Where a false floor is not used, overhead cable trays shall be used to carry power and communications cables between racks.
27	Power A minimum of two diverse incoming power supplies along with a UPS rated for eight hours autonomy shall be fitted. This may be reduced to one hour if a standby generator system is to be utilised. A UPS/Battery system shall be installed to give two hours standby power in the event of loss of mains power. If standby generators are not utilised then this time shall be increased to eight hours autonomy Surge Filters – Dedicated surge protectors shall be installed to protect the UPS and distribution board against over voltage and current surge. At least one surge filter should be installed in between the bypass switch and the UPS. Bypass Switch – Installation of bypass switch shall be fitted to allow UPS units to be fully isolated for maintenance while keeping the computer room powered in standby mode. The Remote Bypass Switch needs to have a padlock-able handle in all positions in order to comply with site lockout standard Cabinet MCB – Each cabinet MCB shall be cabled and connected to a single circuit breaker located in the DB, these breakers will be rated for the requirement of each cabinet. Each cabinet will contain mains outlets blocks for the use of test equipment and any associated interrogation computers
27.1	
27.2	
27.3	
27.4	
27.5	
27.6	

Pos	Requirements
27.7	The cabinet mains outlet block shall be fed from an internal MCB distribution within the cabinet
27.8	Cable trays – Cable trays shall be installed to ensure all power cable runs are installed within the tray system to allow separation from data cables and prevention of electromagnetic interferences.
27.9	Earthing- All racks, cable trays, should be earthed and bonded to the electrical system using a protective earth. A functional earth is required for telecommunication equipment such as wiring frames, telecoms cable screens.
27.10	Installation, labelling and records of the electrical system should be in accordance to BS 7671 standard and any local authority or Employer specific standards
27.11	Backbone cabling shall run in diverse pathways to provide redundancy to LAN and SAN switches For Type 1 and 2 common equipment room types, the cabling infrastructure shall be designed in accordance with a certified structured cabling system. Fully cabled Cat7 patch panels are to be installed in designated server racks and terminated at a centralised patching area using a wall-mounted or island-mounted 210 connecting block frame or patch panels in a 750mm wide rack. All patch panels should be fully cabled to:
27.12	<ul style="list-style-type: none"> • Remove the risk of disconnecting other active equipment sharing the same patch panel or rack • Remove the need to wait for additional cables to be installed by a cabling technician • Allow for servers and other equipment to connect to the network immediately.
27.13	Horizontal and vertical cable managements shall be used to maintain tidiness in patch cables installed, retain patch cables within the racks and eliminate patch cable overhang and connectors stress.
27.14	Installation of cables shall be installed to comply with IEC 11801:2000 as a minimum or in a workmanlike manner; parallel to walls, floors and ceilings and neatly loomed and continuously cable tied to the catenary cable or enclosed in conduit, tray or ducting.
27.15	Installation shall eliminate any possibility of strain on the cable itself or on cable terminations and are not to be directly embedded in plaster, concrete, mortar or other finishes
27.16	Care shall be taken in the grouping and installation of single core power cables to reduce inductive effects, including effects on surrounding metalwork. Where parallel 3 phase conductors are used, cables shall be grouped in trefoil formations.
27.17	Bending radii must comply with the maker's recommendation and in all cases not less than six times the overall cable diameter.
27.18	Install cables straight for at least 300mm immediately prior to entering equipment.
27.19	Where groups of sheathed cables are bunched together in the one enclosure, the maximum number of layers shall be two.
27.20	Cable marking to be permanent and indelible and indicate a cable number, a prefix relevant to the type of device at the destination of the cable and the equipment connection location the cable is connected to in the system.
	All data system cabling shall be identified using a cable marking system.
27.21	Each cable to be identified at each point of termination with the identification numbers clearly visible within fifty (50) mm of the termination.
	Cables in false ceilings
27.22	<ul style="list-style-type: none"> • Cables should be supported at intervals not exceeding 1200mm using catenary wires or approved hangers fixed to the ceiling structure. • Cables are to be neatly grouped together and at no point rest cables on the topside of the false ceiling, lighting fittings or other heat producing equipment. • Ceiling tile support systems are not to be utilized
	Cables in partitions or similar enclosures
27.23	Install cables in areas free from the protrusion of screws and similar fasteners. Allow cables to run slack.
27.24	Cabling installed vertically <ul style="list-style-type: none"> • Cables installed in vertical ducts shall be supported at intervals not exceeding 1200mm.

Pos	Requirements
	<ul style="list-style-type: none"> Acceptable methods of support include cable tray, cable ladder, unistrut channel or equivalent. Support cables installed in vertical wiring troughs at a maximum of 5-metre intervals using an efficient and approved method of clamping to the trough.
	Cables on Trays
27.25	<ul style="list-style-type: none"> Cables installed in trays shall be cable tied at fixed intervals not exceeding 1200mm by means of approved fastenings of non-corrosive materials. Maintain cable tray space capacity to be not less than 30% of maximum tray capacity.
	Conduits
27.26	<ul style="list-style-type: none"> Conduits concealed in wall chases, embedded in floor slabs or installed in inaccessible locations are to be complete with a draw cords to enable the pulling in of cables. Installation of conduits are to comply with IEC 61386 Corrugated flexible conduit may be used where sweep bends are required and for final connections onto equipment such as, cameras. Do not use flexible conduits underground.
	Catenary wire support shall comply with the following:
27.27	<ul style="list-style-type: none"> Secure catenary wires by anchoring to the floor slab of the floor above; Not more than 28 cables are to be bunched up and fixed to one catenary wire; The length of any span not to exceed 5 metres; The maximum sag of any span not to exceed 100mm; Minimum separation between catenary wires not less than 150mm; Minimum separation between catenary wires and high temperature pipes and steam pipes not less than 500mm; and Adhere to cable manufacturers recommended minimum bending radius and installation practices.
	Cable Labelling
27.28	<ul style="list-style-type: none"> All cables shall be labelled at both ends, and equipment cabinets to clearly indicate their function. Label all cables where cables enter or leave trays, racks, troughs or ducts according to the cable schedule or as directed with Mylar film labels under clear 'heat shrink' or other approved means. Provide nylon straps or ties to tie together single cables of the one circuit or system, to further assist maintenance identification
	The temperature and humidity for all Technical Room types shall be operated in the following ranges:
27.29	<ul style="list-style-type: none"> Temperature: 20° C (+/- 5 degrees Celsius) Relative Humidity: 50 % (+/- 10 %) Max Dew Point: 21°C Max Rate of Change: 5° C per hour Operating time: 24 hour/day, 365 day year
28	Electrical
28.1	The building shall be earthed to protect against lightning to IEC 62305
28.2	The Technical Room electrical systems shall be designed in accordance to BS 7671 wiring regulations.
	A minimum of one Emergency "Power Off" push button shall be installed in the small CER's and a minimum of two in the Large CER's. Emergency 'Power Off' push buttons shall be with hinged transparent flap to prevent accidental activation.
28.3	Activation of push button shall isolate the following: <ul style="list-style-type: none"> General power Uninterruptable power (including battery supply)

Pos	Requirements
28.4	<p>Lighting supplies shall not be isolated on activation of push button.</p> <p>An electrical system for a data centre room shall consist of the following:</p> <ul style="list-style-type: none"> • Main Switch Board (MSB) - Located in the switch room, it provides incoming power from the main site power to the Distribution Boards (DBs). • Typical power capacity requirements are based against floor area and are an indication only building at 700Wm² / Type 2 building at 800Wm² / Type 3 building at 1000Wm². • Distribution Board (DB) – Dedicated electrical boards connected to UPS to provide power to each rack. The board chosen should match the UPS being connected. A single phase UPS should be connected to a single phase DB and not be connected to a 3 phase DB. • DBs should be located against walls and away from air conditioning units, water pipes and other wet areas and comply with guidance on maximum height. • Surge Filters – Dedicated surge protectors shall be installed to protect the UPS and distribution board against over voltage and current surge. At least one surge filter should be installed in between the bypass switch and the UPS. • Bypass Switch – Installation of bypass switch is recommended to allow UPS units to be fully isolated for maintenance while keeping the Technical Room powered in standby mode. The Remote Bypass Switch needs to have a padlock-able handle in all positions in order to comply with site lockout standard. • Cabinet MCB – Each cabinet MCB shall be cabled and connected to a single circuit breaker located in the DB, these breakers will be rated for the requirement of each cabinet. • Each cabinet will contain mains power outlet blocks for the use of test equipment and any associated interrogation computers. • The cabinet mains outlet block will be fed from an internal MCB distribution within the cabinet. • Cable trays – Cable trays shall be installed to ensure all power cable runs are installed within the tray system to allow separation from data cables and prevention of electromagnetic interference. • Earthing- All racks, cable trays, should be earthed and bonded to the electrical system using a protective earth. A functional earth is required for telecommunication equipment such as wiring frames, telecoms cable screens. • Installation, labelling and records of the electrical system should be in accordance to BS 7671 standard and any local authority or Employer specific standards.
28.5	
29	<p>Uninterruptable Power Supply (UPS) system</p> <p>All CER's shall be equipped with Uninterruptable Power Supply (UPS) systems to provide continuous filtered power to all equipment when mains power fails providing 8 hour of autonomy for small computer rooms, and 8 hours for large computer rooms. (Unless emergency back-up generators are utilised then this time can be reduced to two hours)</p>
29.1	
29.2	The UPS installation shall be sized to support the room load plus a minimum of 25% additional load.
29.3	The UPS shall incorporate an Intelligent Battery Management system to continuously monitor the health via SNMP and a RJ45 / UTP connection.
29.4	The UPS system shall be comprised of user replaceable, hot swappable, battery modules.
30	<p>Cabling installations and cable Trays</p> <p>Installation of cables shall be installed in accordance with IEC 11801:2000 as a minimum or in a workmanlike manner; parallel to walls, floors and ceilings and neatly loomed and continuously cable tied to the catenary cable or enclosed in conduit, tray or ducting.</p>
30.1	
30.2	All power and data shall be installed on separate cable trays or on a single tray with a metal vertical separator between data and power circuits.

Pos	Requirements
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The distance in the table below shall be maintained between power cables and twisted pairs :

	Quantity of circuits	Electrical Circuit Type	Separation Distance (mm)	Separation Distance (in)
30.3	1 -15	20A 110/240V 1-phase shielded or unshielded	Refer to 569B annex C	Refer to 569B annex C
	16 - 30	20A 110/240V 1-phase shielded	50 mm	2 in
	31 - 60	20A 110/240V 1-phase shielded	100 mm	4 in
	61-90	20A 110/240V 1-phase shielded	150 mm	6 in
	91+	20A 110/240V 1-phase shielded	300 mm	12 in
	1+	100A 415V 3-phase shielded feeder	300 mm	12 in

The picture below indicates the preferred type of cable trays

- 30.4 A ramp to allow access for large equipment shall be installed where the technical room has a false floor, based on a gradient of 1:8. The ramp shall be covered in black non slip vinyl. It shall also allow for the passage of Euro Pallets

11.6 Public Address (PA)

11.6.1 Standards

Table 11.18: Standards for PA

Pos	Requirements
1	BS 5839-8 Fire detection and fire alarm systems for buildings. Code of practice for the design, installation, commissioning and maintenance of voice alarm systems
2	BS 6259 Code of practice for the design, planning, installation, testing and maintenance of sound systems
3	BS 6701 Telecommunications equipment and telecommunications cabling
4	BS 7430 Code of practice for protective earthing of electrical installations
5	BS 7594 Code of practice for audio-frequency induction-loop systems (AFILS)
6	BS 7671 Requirements for electrical installations. IET Wiring Regulations. 17th edition
7	BS 8300 Design of buildings and their approaches to meet the needs of disabled people. Code of practice
8	BS EN 50121 Railway applications. Electromagnetic compatibility

Pos	Requirements
9	BS EN 50122 Railway applications. Fixed installations. Electrical safety, earthing and the return circuit
10	BS EN 50125 Railway applications. Environmental conditions for equipment
11	BS EN 50126 Railway applications. The specification and demonstration of reliability, availability, maintainability and safety (RAMS)
12	BS EN 50128 Railway applications. Communication, signalling and processing systems. Software for railway control and protection systems
13	BS EN 50129 Railway applications. Communication, signalling and processing systems.
14	BS EN 50132 Surveillance CCTV in security applications.
15	BS EN 50133 Alarm systems. Access control systems for use in security applications
16	BS EN 50174 Information Technology. Cabling installation.
17	BS EN 50346 Information technology. Cabling installation. Testing of installed cabling
18	BS EN 60118-4 Electroacoustics. Hearing aids. Induction-loop systems for hearing aid purposes. System performance requirements
19	BS EN 60529 Degree of Protection for Enclosures.
20	BS EN 60950 Information Technology Equipment. Safety
21	BS EN 61508 Functional Safety of Electrical/Electronic/programmable electronic safety-related systems
22	BS EN 61643 Components for low-voltage surge protective devices
23	BS EN 61935 Generic cabling systems. Specification for the testing of balanced communication cabling in accordance with EN 50173
24	BS EN 62305 Protection against lightning
25	BS EN 62491 Industrial systems, installations and equipment and industrial products. Labelling of cables and cores
26	BS EN 62676 Video surveillance systems for use in security applications.
27	ISO 11801:2012 Information technology - Generic cabling for customer premises - Amendment 2
28	All Indonesia National and Municipal Codes, Acts and Regulations that are related to the SCADA system

11.6.2 Functional Requirements

Table 11.19: Functional Requirements for PA

Pos	Requirements
1	The PA system shall be designed to provide voice announcements and shall also assist in the evacuation of the station in the event of emergency incidents. It shall be part of the voice evacuation alarm system. As a result, the system shall take into account the safety requirements for the stations and the speech intelligibility required for voice evacuation. The design of the PA system and all components shall be designed to optimise system resilience under fire conditions.
2	The PA loudspeakers shall be grouped into zones to allow separate messages to be broadcast to the station entrances and platforms etc.
3	Typically the PA system shall be designed to provide a minimum Sound Pressure Level (SPL) of 10dBA above normal ambient noise levels at all times with the range of 65dBA up to a maximum of 90dBA. The requirements for Intelligibility shall be measured by the Speech Transmission Index (STI). Typically this shall be at least 0.5 in the public areas and 0.45 in acoustically difficult areas such as platforms.
4	The PA system shall allow both pre-recorded and live voice announcements to be made to any zone. The

Pos	Requirements
	Operators in the OCC shall have the ability to make voice announcement to any or all zones in the station. Alternate loudspeakers shall be fed from different amplifier circuits to provide resilience.
5	The PA system shall interface with the Passenger Information Display (PID) system to allow a combination of visual and voice messages of station information to the passengers. An induction loop shall be installed to assist hearing impaired passengers through the use of an induction loop installed locally to each PID device
6	The PA system shall interface with SCADA system for selecting of zones and pre-recorded messages to be broadcast and to provide health monitoring of PA system. The PA system shall be capable of operating in standalone mode should the SCADA system not be operational.
7	The PA system shall be interfaced with the station Fire Alarm System for the broadcast of alarm evacuation announcements to the station. An emergency broadcast triggered from the Fire Alarm System shall be automatically broadcasted to all PA zones.
8	The PA system shall be based on digital audio system and fully redundant IP network. The PA design, components and installation for the stations shall be fully compliant with the BS 5839-8 and BS EN 54 standards.
9	The PA system shall consist of COTS type modular components that shall allow for the future expansion of additional loudspeakers, induction loops and audio inputs. All critical signal paths from the microphones through the audio amplifiers to the end of the loudspeaker lines shall be monitored by the SCADA system.
10	The PA system shall be interfaced with the SCADA system in order for the SCADA workstations to select the PA zones and control of the PA system for the broadcast of pre-recorded and live audio announcements using the microphone.
11	<p>The PA system shall include, but not limited to the following components:</p> <ul style="list-style-type: none"> • Audio routers inclusive of digital voice announcement storage, record and playback system. • Microphones with a 'Push to Talk' button. • Audio amplifiers. • Loudspeakers. • Ambient noise sensors • Audio Frequency Induction Loops (AFIL) • Station announcement points and radio microphones • Independent UPS • Fire integrity cabling
12	The PA system shall be installed at the following locations:
13	Passenger Stations
13.1	The loudspeakers shall be installed at the stations to provide audio coverage for the concourses and platforms. It shall be connected to the audio amplifiers via fire integrity cables.
13.2	The ambient noise sensors shall be installed on platforms and concourse to provide audio volume level adjustments for speaker zones according to the ambient noise being generated.
13.3	A microphone shall be installed for each station in the station control room to allow the Operator to broadcast live and pre-recorded audio announcements via the station SCADA workstation to any PA zones within the station.
13.4	A station announcement point shall be installed for each platform to allow the Operator to broadcast live audio announcements.
13.5	These microphones shall be interfaced with the audio router and SCADA workstation to allow selection of PA zone, grouped PA zones or all PA zones within the station.
13.6	An audio router shall be installed in the Common Equipment Room (CER) at each station. It shall be interfaced with audio amplifiers, microphone, station announcement point, ambient noise sensors, Fire Alarm System, Train Mass Detector, and SCADA system.
13.7	The audio frequency induction loops shall be installed at the journey planner boards in the ticket hall. The AFILs are used to convert the PA audio announcements into magnetic field, which is received by the hearing aid providing availability of audio announcements to people with hearing impairment.

Pos	Requirements
14	Depot
14.1	The loudspeakers shall be installed at the depot to provide audio coverage for the building and platforms for train stop. It shall be connected to the audio amplifiers via fire integrity cables.
14.2	The ambient noise sensors shall be installed on platforms and other depot premises to provide audio volume level adjustments for speaker zones according to the ambient noise being generated.
14.3	The Operator in the OCC shall be able to broadcast live and pre-recorded audio announcements via SCADA workstations to any PA zone for depot across the LAN network of Fibre Optic Transmission System.
14.4	The Operator in the OCC shall be able to remotely broadcast live and pre-recorded audio announcement via SCADA workstations to any PA zones for any stations across the Fibre Optic Transmission System.
15	The audio announcements shall be capable of being initiated either locally from the station or remotely from the OCC via the Fibre Optic Transmission System.
16	The audio routers and microphones shall be interfaced with the SCADA system in order to initial live and pre-recorded audio announcements to the stations. The PA system shall provide, but not limited to the following functions:
17	<ul style="list-style-type: none"> • Broadcast live audio announcements, • Broadcast pre-recorded audio announcements, and • Broadcast alarm evacuation audio announcements.
18	The PA system shall meet, but not limited to the following general requirements: <ul style="list-style-type: none"> • The acoustic quality of voice messages must be clear, intelligible and easy to understand. • The function of audio controllers shall be simple, intuitive and easy to operate. • Ability to play pre-recorded audio announcements. • System reliability shall be assured by good technical design, audio products that represent current technology in design and construction, and high industry installation and construction standards and practices.
19	Each station shall be provided with an audio router and microphone to enable station Operator to make audio announcement for the station. The station Operator shall select the PA zones allocated on the SCADA workstation to initiate either live or pre-recorded audio announcements. The audio router for the station shall be automatically switched to remote when local access is not required.
20	The PA system shall allow the Operator in the OCC to make live audio announcements and initiate pre-recorded messages stored in audio router for any stations and any PA zones via SCADA workstations. Each SCADA workstation in the OCC shall be fitted with a microphone. The event of audio announcements shall be time-stamped and recorded by the SCADA system.
21	Message prioritisation: Local access to the PA system at the stations shall take priority over remote access, except when a pre-recorded alarm evacuation message is broadcasting.
22	The PA components provided by the Contractor shall be delivered with the following elements of the system, and shall provide the following functional requirements:
23	Loudspeakers
23.1	The loudspeakers shall be placed throughout the public and non-public areas of the station such that all announcements shall be clearly audible taking into account ambient noise conditions.
23.2	The loudspeakers located at the public areas shall be integrated into the architectural finish for discretion without degrading audio output performance.
23.3	The loudspeakers shall operate directly from the audio amplifier outputs and provide variable tapping selection to accommodate sound level adjustment. Consideration shall be given to minimise the incidence of noise pollution to areas outside the station boundary.
23.4	The loudspeaker circuits shall be tested for earth leakage and short as well as open-circuit faults prior to commissioning.
24	Audio Frequency Induction Loops (AFIL)

Pos	Requirements
24.1	The AFIL shall be placed at the journey planners in the ticket hall for those with hearing impairments using hearing aid amplifiers allowing hearing the audio announcements when standing in front of the journey planners.
24.2	The AFIL shall be connected to the audio amplifier and monitored by the audio router. All faults shall be shown on the display of the audio router and SCADA system.
25	Ambient Noise Sensors (ANS)
25.1	The ANS shall raise and lower broadcast power levels in line with the surrounding ambient noise in the public areas, where the system shall set to very low amplitude when there is no ambient noise present. It shall be automatically adjusted the audio output level to compensate for the background ambient noise.
	An ANS shall be located at the following locations:
25.2	<ul style="list-style-type: none"> • Ticket hall / concourses; and • Platform areas.
25.3	As the applicable areas are likely to be highly reverberant, the ambient noise compensation level shall be 'frozen' during the duration of any announcements.
25.4	The ANS shall be monitored by the audio router. In the event of a microphone, electronics or cabling fault, the system shall default to a safe pre-set maximum volume. All faults shall be shown on the display of the audio router and SCADA system.
25.5	In case of fire alarm, the ANS shall not affect the sound level of the alarm evacuation announcements.
25.6	The ambient noise sensor shall be a dynamic type of the device, which provides real-time monitoring of the background noise and adjustments of the broadcasted announcements volume during the playback to compensate for changing background noise.
26	End-of-Lines (EOL)
26.1	The EOL resistor shall be installed at the last loudspeaker of each circuit. It shall also be installed along the line of the Loudspeaker circuits for ease of testing during the circuit failure when the line of loudspeakers covers various locations. The maximum amount of end-of-line modules shall not exceed 10 units per circuit.
26.2	The EOL shall be a close tolerance high stability power resistor for use with DC line monitoring. It shall be installed within the loudspeakers.
26.3	If the EOL is disconnected or an open-circuit in the loudspeaker circuit, an alarm declaring amplifier line open-circuit fault' shall be displayed on the audio router, with a reference to which audio amplifier is affected. The earth faults, short and open-circuit conditions of loudspeakers circuits shall be monitored. All faults and fault warnings shall be shown on the display of the audio router and SCADA system.
27	Microphones
27.1	The microphones shall be VoIP interface. It shall be interfaced with the audio routers through the station LAN to allow the Operator to make live announcement via the SCADA workstations for the selected PA zone.
27.2	The microphones shall be connected to the audio routers and the SCADA system via LAN connection.
27.3	The microphones shall be monitored by the audio router. All faults shall be shown on the display of the audio router and SCADA system.
28	Station Announcement Points & Radio Handset Microphones
28.1	A station announcement point shall be provided for each platform to allow the Operator to make live announcement at the platform for the platform PA zone. A fist microphone shall be provided in the station announcement point.
28.2	The station announcement points shall also be installed with the radio antennas to allow the Operator to make live announcement via radio handset microphones to the platform PA zone.
28.3	The station announcement points shall be monitored by the audio router. All faults shall be shown on the display of the audio router and SCADA system.
29	Audio Routers
29.1	Each station shall be installed with an individual audio router to interface with the audio amplifiers, Fire Alarm System, Train Mass Detectors, ambient noise sensors and station announcement points on the station.

Pos	Requirements
29.2	The depot shall be installed with an audio router to interface with the audio amplifiers, Fire Alarm System and ambient noise sensors.
29.3	The audio routers shall be IP interface. It shall provide audio monitoring and controlling inputs, programmable automatic and priority levels, and programmable surveillance tone generation. It shall act as a fully multi-channel routing system capable of routing any combination of audio inputs and outputs.
29.4	The audio routers shall be capable to store at least 8 x 60s pre-recorded messages.
29.5	The audio routers shall be interfaced with the SCADA system for PA zone selection and faults monitoring. It shall monitor the alarms of audio amplifiers, ambient noise sensors, station announcement points, loudspeakers' line earth leakage and open-circuit faults monitor via EOL.
29.6	The audio routers shall be interfaced with the Fire Alarm System to trigger of pre-recorded alarm evacuation announcements to all PA zones in the station.
29.7	The audio routers shall be interfaced with the train mass detectors to trigger pre-recorded audio announcement of "mind the gap" to the platform PA zones. It shall be also interfaced with the signalling system to initial an audio announcement of train service information in line with the PID display message.
	The examples of pre-recorded audio messages stored in the audio routers shall be as follows:
29.8	<ul style="list-style-type: none"> • Alarm evacuation message: "Ladies and gentlemen, your attention please, due to a reported emergency would all passengers please leave the station immediately." • Platform message: "Train is approaching to the station" or "Mind the gap between the train door and the station platform"
30	Audio Amplifiers
30.1	The audio amplifiers shall be used to amplify the PA audio signals. It shall be installed in the amplifier mainframes. The loudspeakers for each PA zone shall be connected using the A & B circuits. These circuits shall be isolated to ensure that failure of one circuit path shall not affect an entire PA zone.
30.2	The audio amplifiers shall be sized with consideration to the number and tapping power of the loudspeakers to be connected to the circuit. Each audio amplifier shall be provided with at least 25% spare capacity above the actual power demand required by the loudspeakers.
30.3	When a failure of audio amplifier is detected, the standby amplifier shall be automatically switched to the output line of the faulty amplifier.
30.4	The audio amplifiers shall be monitored by the audio router. All faults shall be shown on the display of the audio router and SCADA system.
31	Standby Battery Back-up
31.1	All PA equipment shall be powered from the UPS consisting of independent standby battery back-up. The independent UPS shall only serve the power supply for the PA system. It shall consist of a battery pack and charger.
31.2	The independent standby battery back-up shall have sufficient power capacity to maintain the PA system in operation for at least 24 hours, after which sufficient capacity shall remain to rebroadcast alarm evacuation announcements to all PA zones for at least 30 mins.
32	PA Zones
32.1	The PA system shall provide total audio coverage along the entire length of each station platform, throughout the public concourse area and all areas of the station accessible to passengers. It shall also provide the audio coverage for the back-of-house non-public area of the station.
	The audio amplifiers, loudspeakers and ambient noise sensors shall be divided into the following PA zones:
32.2	<ul style="list-style-type: none"> • Each platform. • Station concourses. • Back-of-house non-public areas.
33	Loudspeakers Equipment
33.1	The loudspeakers shall comply with BS EN 54-24 standards.

Pos	Requirements
33.2	The loudspeakers shall be protected from dust and water ingress, and shall be equipped with cable glands and an integral termination for the looping of the incoming and outgoing cables.
33.3	The loudspeakers shall be supplied with necessary fixtures and accessories to enable installation of any additional components as recommended by the manufacturer. The column loudspeakers shall allow for vertical and horizontal adjustment.
33.4	There is no requirement for loudspeakers to be painted a specific colour. The vendor logos or advertising are not permissible on the surface of this unit.
35	Audio Frequency Induction Loops (AFIL) Equipment
35.1	The AFIL shall comply with BS EN 60118-4.
35.2	The hearing aid 'T' sign shall be fitted next to the AFIL. The vendor logos or advertising are not permissible on the surface of this unit.
36	Ambient Noise Sensors (ANS) Equipment
36.1	The ANS shall be equipped with the microphone mounted on the front plate of the unit. The ANS shall provide readings of the noise levels, so the system can process ambient noise levels between 55dB and 95dB.
36.2	The ANS shall be housed in an IP65 compliant and vandal resistant enclosure.
37	End-of-Lines (EOL) Equipment
37.1	The EOL module shall be accomplished by installing a 10kΩ resistor at the end of the each speaker chain / line break. The EOL shall allow for the monitoring of each section by amplifier surveillance card.
38	Microphones Equipment
38.1	Each microphone shall be fitted with a flexible gooseneck paging microphone. It shall consist of a 'Push to Talk' button; the PA zone selection shall be via the SCADA workstations. The microphone installed within the station announcement point shall be fist type microphone.
39	Station Announcement Points & Radio Handset Microphones Equipment
39.1	The station announcement point shall be housed in an IP65 compliant, vandal resistant, lockable case.
39.2	The unit shall have visual indicators of 'Busy' and 'Speak Now' states.
39.3	The radio microphone receiver unit shall be installed to enable remote radio announcements from the handheld wireless-radio microphone.
40	Audio Routers Equipment
40.1	The audio router shall be compliant with BSEN54-16:2008 and BS EN 5839 Pt 8.
41	Audio Amplifiers Equipment
41.1	The audio amplifier units shall be housed in the amplifier frame, for modular installation and expansion capacities. The amplifier shall allow for power output adjustment via the provided software.
42	Standby Battery Back-up Equipment
42.1	The independent standby battery back-up shall comply with BS EN 54-16 and BS 5839-8.
42.2	The batteries shall be equipped with the health monitoring for a high battery resistance which shall indicate the approaching battery's end of life.
42.3	Batteries shall be charged directly from the audio amplifier units, and shall not require any additional chargers.
42.4	The batteries shall be sized to be installed at the base of the cabinets.

11.6.3 Performance Requirements

Table 11.20: Performance Requirements for PA

Pos	Requirements
1	<p>The loudspeakers shall be installed in accordance with the acoustic modelling for the stations. The Contractor shall responsible to validate the intelligibility requirements of acoustic modelling during the T&C.</p> <p>The audio levels of PA shall meet, but not limited to the following criteria:</p> <ul style="list-style-type: none"> • A minimum Sound Pressure Level (SPL) of 10dBA above the normal ambient noise level, within the SPL range from 65dB up to the maximum of 90dB;
2	<ul style="list-style-type: none"> • Even SPL between Loudspeakers for each PA zone; • Automatic volume control via ANS to monitor the background noise level; • Maintain intelligibility of announcements, i.e. a minimum Speech Transmission Index (STI) 0.5 in the public areas and 0.45 in acoustically difficult areas such as platforms; and • Control noise overspill without causing a nuisance to local residents.

11.7 Passenger Help Point (PHP)

11.7.1 Standards

Table 11.21: Standards for PHP

Pos	Requirements
1	BS 6259 Code of practice for the design, planning, installation, testing and maintenance of sound systems
2	BS 6701 Telecommunications equipment and telecommunications cabling
3	BS 7430 Code of practice for protective earthing of electrical installations
4	BS 7594 Code of practice for audio-frequency induction-loop systems
5	BS 7671 Requirements for electrical installations. IET Wiring Regulations. 17th edition
6	BS 8300 Design of buildings and their approaches to meet the needs of disabled people
7	BS EN 50121 Railway applications. Electromagnetic compatibility
8	BS EN 50122 Railway applications. Fixed installations. Electrical safety, earthing and the return circuit
9	BS EN 50125 Railway applications. Environmental conditions for equipment
10	BS EN 50126 Railway applications. The specification and demonstration of reliability, availability, maintainability and safety (RAMS)
11	BS EN 50128 Railway applications. Communication, signalling and processing systems. Software for railway control and protection systems
12	BS EN 50129 Railway applications. Communication, signalling and processing systems.
13	BS EN 50131 Alarm systems. Intrusion and hold-up systems. Intrusion detection.
14	BS EN 50132 Surveillance CCTV in security applications.
15	BS EN 50133 Alarm systems. Access control systems for use in security applications
16	BS EN 50174 Information Technology. Cabling installation.
17	BS EN 50310 Application of equipotential bonding and earthing in buildings with information

Pos	Requirements
	technology equipment
18	BS EN 50346 Information technology. Cabling installation. Testing of installed cabling
19	BS EN 60118 Electro acoustics - Hearing aids - Part 4: Induction loop systems for hearing aid purposes - Magnetic field strength
20	BS EN 60529 Degree of Protection for Enclosures.
21	BS EN 60950 Information Technology Equipment. Safety
22	BS EN 61508 Functional Safety of Electrical/Electronic/programmable electronic safety-related systems
23	BS EN 61643 Components for low-voltage surge protective devices
24	BS EN 61935 Generic cabling systems. Specification for the testing of balanced communication cabling in accordance with EN 50173
25	BS EN 62305 Protection against lightning
26	BS EN 62491 Industrial systems, installations and equipment and industrial products. Labelling of cables and cores
27	BS EN 62676 Video surveillance systems for use in security applications.
28	BS EN 61643 Components for low-voltage surge protective devices
29	BS EN 61935 Generic cabling systems. Specification for the testing of balanced communication cabling in accordance with EN 50173
30	BS EN 62305 Protection against lightning
31	BS EN 62491 Industrial systems, installations and equipment and industrial products. Labelling of cables and cores
32	BS EN 62676 Video surveillance systems for use in security applications.
33	ISO 11801:2012 Information technology - Generic cabling for customer premises - Amendment 2
34	All Indonesia National and Municipal Codes, Acts and Regulations that are related to the SCADA system

11.7.2 Functional Requirements

Table 11.22: Functional Requirements for PHP

Pos	Requirements
1	The PHP system shall be designed to provide reassurance to passengers by providing voice communications with the Operators in the OCC. During normal operation the voice intercom between the PHP and the OCC shall be by means of Voice over Internet Protocol (VoIP) using the Fire Optic Transmission System.
2	The PHP system shall be interfaced with the SCADA system for detecting PHP activity. The SCADA system shall instigate an audible and visible operator warning and the nearest CCTV camera shall automatically be selected to view the activated PHP and display the images on the CCTV spot monitor in the OCC. The CCTV System shall be automatically recording the video images from the PHP unit / lift intercom allocated CCTV camera (in full frame rate – 25fps and full resolution – 1920 x 1080) when the PHP is initiated. The PHP system shall be capable of operating in standalone mode in the unlikely situation that the SCADA becomes non-operational.
3	The PHP system shall consist of PHP units, lift intercoms, PHP servers and local IP microphone located in the OCC.
4	Each PHP unit / lift intercom shall be fitted with call button, speaker, and AFIL. The PHP units shall be located at the concourses and platforms, and shall not impede passengers flow. It shall be easily noticeable by the passengers in the station. The lift intercom units shall be located at each of the lifts at station and depot (if lift is

Pos	Requirements
	required).
5	The PHP system shall be capable to provide direct voice communication for the passengers and the Operators at the OCC for information or emergency call purposes.
6	The PHP system provided by the Contractor shall be delivered with the following elements of the system, and shall provide the following functional requirements:
7	PHP Servers
7.1	The PHP servers shall provide audio routing and handling of all calls throughout the stations. The PHP servers shall be IP based, and shall provide full-duplex voice transmission.
	The PHP servers shall log the following transmission information:
7.2	<ul style="list-style-type: none"> • Call times • Call duration • PHP / lift intercom identifier / location
7.3	The PHP servers shall provide health and operation status information to the SCADA.
7.4	The PHP servers shall store pre-recorded messages to be automatically broadcasted to the PHP units.
8	PHP Unit / Lift Intercom
8.1	The PHP / lift intercom units shall enable passengers to communicate directly to the OCC Operator, via hands free, voice medium. The PHP shall be utilised by the passengers while seeking assistance, requiring information or in the event of an emergency.
8.2	The PHP / lift intercom units shall utilise IP based communication and shall be connected to the station / depot LAN network.
8.3	The PHP units shall be positioned on the station platforms without obstructing other passengers flow, but also without introducing any additional hazards while operation.
8.4	The PHP units shall have a single button to initiate the communication with the Operator at OCC. After initiating the transmission, the voice shall be transmitted, and recorded in the CCTV NVR. The Allocated CCTV camera for triggered PHP shall start recording at the full frame rate of 25fps and resolution of 1920 x 1080. Video and audio footage shall be combined in the recorded CCTV video image along with the location of the PHP, date and time.
8.5	The voice transmission shall be full-duplex, 16 kHz bandwidth and voice over IP.
8.6	The internal ambient noise sensor shall automatically adjust the volume output of the speaker to suppress the background noise.
8.7	The PHP units shall include an Audio Frequency Induction Loop (AFIL) to assist passengers with hearing impairment.
	The PHP servers shall monitor the health status of the following associated equipment:
8.8	<ul style="list-style-type: none"> • Monitoring of connections of all the PHP cables. • Monitoring of PHP electronic circuitry. • Monitoring of the internal speaker and microphone. • Monitoring of the AFIL amplifier.
9	IP Microphone
9.1	The IP microphones shall be a part of the SCADA workstations and shall be utilised by the Operator to communicate with the passengers across the stations from the PHP / lift intercom units.
9.2	The microphone shall be IP based, and the transmitted voice shall be recorded.
10	PHP Calls
10.1	The call from any of the PHP units / lift intercoms shall be initiated by pressing the button on the PHP / lift intercom unit. The information about the call shall be displayed on the SCADA workstations, and Operator shall accept the broadcast.
10.2	In the case of multiple calls from various locations, they shall be stack sequentially on the waiting list.

Pos	Requirements
10.3	In case of waiting call, the Operator shall hear the "call waiting" tone.
10.4	The calls shall be answered on first come first served basis.
10.5	If the call is not answered within 2 minutes if all Operators are busy, the PHP user shall hear pre-recorded message "The Operator is busy, please try again in a few moments".
11	PHP Coverage
11.1	Two PHP units shall be located on each of the platforms and in the concourse area.
11.2	The PHP units shall be located in the visible and accessible location for the public. Location of the PHP units shall not introduce any obstructions to the flow of the passengers.
11.3	The PHP units shall be located in the safe place, without introducing any potential hazards to the users.
11.4	The lift intercoms shall be located within each of the lifts across all of the stations / depot. The lift intercoms shall meet the same functional as stated for PHP above.
12	The PHP system shall be installed at the following locations:
	Passenger Stations
12.1	The PHP units shall be installed on each platform and on the concourse level of all of the stations. Each lift shall be equipped with lift intercom unit, which is a part of the PHP system. Each PHP unit / lift intercom shall be provided with the connection to the LAN network and dedicated CCTV camera to monitor the events.
12.2	Depot
12.2.1	The depot shall accommodate main (at CER) and standby (at alternative location) PHP servers. The PHP servers shall be handling the call switching to OCC Operators.
12.2.2	Any lifts located at the depot premises shall be equipped with a lift intercom module, along with the dedicated CCTV camera to record the video footage when intercom is initiated.
13	PHP / Lift Intercom Units
13.1	The PHP / lift intercom units shall provide passengers with hands free, direct communication to the Operator at OCC. The PHP / lift intercom units shall be equipped with a single button to initiate connection with the Operator while seeking assistance, information or reporting the emergency.
13.2	The PHP units shall be visible and easy to distinguish in the station environment.
13.3	The lift intercom units shall be embedded into control panel within each of the lifts.
13.4	The PHP units shall be positioned to be accessible to both wheelchair and normal users, such that the centre line of the units shall be 1.2m from the finished floor level.
13.5	The PHP / lift intercom units shall be compliant with IP65 ingress requirements, vandal resistant and fire proof.
13.6	The PHP / lift intercom units shall be embedded with AFIL to assist passengers with hearing impairment.
13.7	The PHP / lift intercom units shall be provided with ambient noise sensor to adjust the volume of the speaker, to suppress the background noise around the PHP / lift intercom unit, for clear communications with the Operator at OCC.
13.8	Each of the PHP / lift intercom units shall have easy to see, magenta "hearing aid" sign to make passengers aware of the existence of AFIL unit located at PHP / lift intercom.
13.9	The PHP units shall be designed to meet the aesthetic of the station and shall be compliant with rugged requirements of the rail environment. All of the PHP units shall be wall or pole mounted.
14	PHP Servers equipment
14.1	Two PHP servers shall be provided for improved reliability and redundancy. Each server shall be located in a different location; main PHP server shall be located in the OCC CER, standby PHP server ideally in an alternative location.
14.2	The PHP servers shall be a modular unit, with provision for future upgrade / expansion by utilising various expansion cards.
14.3	The PHP servers shall be IP based and shall be connected to the depot LAN network.

Pos	Requirements
14.4	The PHP servers shall provide a data link to the CCTV system for audio transmission from any PHPs / lift intercoms. IP Microphone equipment
15	The IP microphones shall be a part of the SCADA workstations at the OCC. The IP microphones shall allow Operator to communicate with any of the PHP / lift intercom units through PHP GUI screen of SCADA workstations.

11.7.3 Performance Requirements

Table 11.23: Performance Requirements for PHP

Pos	Requirements
15	Response Time The response time for the PHP system to respond during the operation shall be as follows: <ul style="list-style-type: none"> • PHP unit response time shall be within 30ms. • Fibre Optic Transmission System inclusive LAN shall be within 5ms. • PHP server response time shall be within 10ms. 15.1 Therefore the overall latency for the system shall be less than 50ms. 15.3 The PHP system shall provide full-duplex transmission of 16kHz speech conversation bandwidth. 15.4 The PHP / lift intercom units shall be equipped with a speaker with the maximum output of 96dB to suppress the background noise if required by ANS. 15.5 The pre-recorded messages to be broadcasted to the PHP units shall be stored on the PHP servers and transmitted through the Fibre Optic Transmission System when required.
16	Acoustic Coverage The PHP units shall be embedded with ambient noise sensor, which shall monitor background noise around the PHP location. The PHP units shall be able to suppress the background noise with a power output up to 96dB, measured 0.3m from PHP centre, using 1kHz test signal). That shall allow for clear and easy to distinguish conversation with Operator at OCC.

11.8 Master Clock

11.8.1 Standards

Table 11.24: Standards for Master Clock

Pos	Requirements
1	EN 50121-4-2006
2	EN 61000-6-2:2005
3	EN61000-64:2007+A1:2011
	EC Declaration of Conformity

Pos	Requirements
4	EN 55022:2010 Information technology equipment. Radio disturbance characteristics. Limits and methods of measurement
5	EN55024:2010 Information technology equipment. Immunity characteristics. Limits and methods of measurement
6	EN 60950-1:2006 Information technology equipment. Safety. General requirements
7	ITU-T G.811 Timing characteristics of primary reference clocks

11.8.2 Functional Requirements

Table 11.25: Functional Requirements for Master Clock

Pos	Requirements
1	The Master Clock shall be used as the master time source for all subsystems that require synchronised time applications such as but not limited to: SCADA, Radio Base Stations, Station Time Clocks, PIS, PS systems
2	The master clock system shall be rack mounted
3	The master clock system shall be modular and upgradeable.
4	The master clock system shall be programmable via PC software and USB key, Setup, Status Alarms, etc., accessible via Internet browsers and or SNMP protocols
5	The master clock system shall support such synchronisation signals as GPS, Radio, NTP etc.
6	The master clock system shall be fitted with an OCXO to support time when no GPS lock
7	The time UTC or GPS shall be programmable
8	The master clock system shall be fitted with fully redundant clock modules with automatic changeover in the event of a failure and alarm indication via the SCADA network.
9	The master clock modules shall be supported via autonomous power supplies.
10	All modules shall be “hot pluggable”
11	The access to all modules shall be via the front panel
12	The accuracy with GPS Lock (24 Hours) shall be $< \pm 1 \times 10^{-9}$
13	The medium term accuracy with no GPS lock (two weeks) shall be 1×10^{-10}
14	The short term stability shall be: @ 1 second 1×10^{-11} @10 seconds 3×10^{-11} @ 100 seconds 3×10^{-11}
15	The master clock system Phase Noise shall be: @10 Hz -120 dBc/Hz @100 Hz -130 dBc/Hz @1 KHz -140 dBc/Hz @10 KHz -145dBc/Hz @100Khz -145 dBc/Hz
16	The master clock system shall have lightning protection devices fitted
17	The master clock system shall support active GPS antennas
18	The master clock time output accuracy to UTC (GPS Locked) shall be $\pm 25\text{Ns}$ max.
19	The master clock time to UTC output accuracy (Instantaneous phase locked) shall be $\pm 35\text{Ns}$ max.
20	The master clock system shall be capable of operation over a temperature range of 0° to 50°C at a Relative Humidity of 95% @ 40oC non condensing

Pos	Requirements
21	The master clock system shall conform to EN300-386 and EN 55022 EMC standards and EN60950 Electrical Safety Standards
22	The master clock system shall be RoHS compliant
23	The master clock system shall support PoE IEEE 802.af
24	The master clock system shall as a minimum support but not limited to 1 PPS TTL outputs and 10MHz outputs
25	The master clock system shall be capable of supporting and indicating fault diagnosis for all remote clocks slaved to the system.

11.9 Passenger Information Displays (PID)

11.9.1 Standards

Table 11.26: Standards for PID

Pos	Requirements
1	BS 6701 Telecommunications equipment and telecommunications cabling
2	BS 7430 Code of practice for protective earthing of electrical installations
3	BS 7671 Requirements for electrical installations. IET Wiring Regulations. 17th edition
4	BS EN 50121 Railway applications. Electromagnetic compatibility
5	BS EN 50122 Railway applications. Fixed installations. Electrical safety, earthing and the return circuit
6	BS EN 50125 Railway applications. Environmental conditions for equipment
7	BS EN 50126 Railway applications. The specification and demonstration of reliability, availability, maintainability and safety (RAMS)
8	BS EN 50128 Railway applications. Communication, signalling and processing systems. Software for railway control and protection systems
9	BS EN 50129 Railway applications. Communication, signalling and processing systems.
10	BS EN 50131 Alarm systems. Intrusion and hold-up systems. Intrusion detection.
11	BS EN 50132 Surveillance CCTV in security applications.
12	BS EN 50133 Alarm systems. Access control systems for use in security applications
13	BS EN 50174 Information Technology. Cabling installation.
14	BS EN 50310 Application of equipotential bonding and earthing in buildings with information technology equipment
15	BS EN 50346 Information technology. Cabling installation. Testing of installed cabling
16	BS EN 60529 Degree of Protection for Enclosures.
17	BS EN 60950 Information Technology Equipment. Safety
18	BS EN 61508 Functional Safety of Electrical/Electronic/programmable electronic safety-related systems
19	BS EN 61643 Components for low-voltage surge protective devices
20	BS EN 61935 Generic cabling systems. Specification for the testing of balanced communication cabling in accordance with EN 50173
21	BS EN 62305 Protection against lightning
22	BS EN 62491 Industrial systems, installations and equipment and industrial products. Labelling of cables and cores

Pos	Requirements
23	BS EN 62676 Video surveillance systems for use in security applications.
24	BS EN 61643 Components for low-voltage surge protective devices
25	BS EN 61935 Generic cabling systems. Specification for the testing of balanced communication cabling in accordance with EN 50173
26	BS EN 62305 Protection against lightning
27	BS EN 62491 Industrial systems, installations and equipment and industrial products. Labelling of cables and cores
28	BS EN 62676 Video surveillance systems for use in security applications.
29	ISO 11801:2012 Information technology - Generic cabling for customer premises - Amendment 2
30	All Indonesia National and Municipal Codes, Acts and Regulations that are related to the SCADA system

11.9.2 Functional Requirements

Table 11.27: Functional Requirements for PID

Pos	Requirements
1	The PID system shall be designed for the stations to provide the travel information and special messages to passengers on the concourse and platforms. It shall provide the departure and arrival information and other appropriate information relating to transport services to the passengers. The text messages shall be obtained from the train running schedules and from specific user messages selected by the Operators.
2	The PID system shall display in both the Indonesian and / or English languages. The location of PIDs shall consider the possible impact on the flow of passengers and the effect of screen reflections due to ambient light levels.
3	The PIDS shall be capable of providing self-reporting diagnostics in real-time and shall interface with the SCADA system for monitoring and archiving purposes.
4	The PID system shall interface with the PA system to allow for generation of audio announcements of train information.
5	The PID system shall be fully IP network based utilising LED dot matrix display panels to display text messages of real-time next train(s) arrival information, notice of incident or engineering works and clock information to passengers on the platforms.
6	The PIDs shall be installed in clear view from all positions on the platform where possible. It shall be visible along the entire length of the platform where practically possible and benefit for passengers standing at both ends of the platform.
7	The PID system shall be installed at the following locations:
7.1	Passenger Stations
7.1.1	The PIDs shall be installed at the platforms to provide text message train(s) arrival information to the passengers on the platforms
7.1.2	The information displayed on the PIDs shall be automatically controlled by the PID servers. The servers shall be interfaced with the Train Arrival Information System for the real-time train(s) arrival information. It shall also be interfaced with the Master Clock for the real-time clock information to be displayed on the PIDs.
7.2	Depot
7.2.1	All PIDs shall be managed and controlled by the PID servers. These servers shall be located in the separated CER rooms at depot to provide resilience and secondary recovery.
7.2.3	The PID servers shall be interfaced with the SCADA system for the Operators in the OCC to remotely monitor and control all PIDs via SCADA workstations. Only the SCADA workstations at OCC shall have the authority to edit / control the display modes for PIDs at the Platforms.
7.2.4	

Pos	Requirements
7.2.5	The PID system provided by the Contractor shall be delivered with the following elements of the system, and shall provide the following functional requirements:
7.3 SCADA Workstations	
7.3.1	The SCADA workstations shall be able to command the PIDs in either automatic mode based on the train(s) arrival information from the Train Arrival Information System or manually selecting from the pre-defined text messages by Operator in the OCC.
7.3.2	
7.3.3	The SCADA workstations shall have the function to group the PIDs and command them with a similar display message based on the time schedule setting.
7.3.4	The SCADA workstations shall have the facility to create the new text messages or revise the pre-defined text messages.
7.3.5	The SCADA workstations shall display the current text messages being displayed on the PIDs.
7.3.6	The SCADA workstations shall monitor the health status of the PID system utilising colour mimic diagrams and symbols to allow the Operators to easily identify the alarm status. The alarms from PID system shall be monitored by SCADA System as follows:
	<ul style="list-style-type: none"> • PID servers failure • Communication loss to Train Arrival Information System
7.3.6	<ul style="list-style-type: none"> • Communication loss or power failure to PIDs • PIDs failure inclusive LED fault • PIDs enclosure door opened • Tamper alarm of PIDs
7.3.7	When the tamper alarm is detected, the SCADA System shall control the nearest CCTV camera to automatically capture the incident and activate a full frame rate of video recordings.
7.3.8	The PIDs shall be time synchronised with the Master Clock to update internal clock and display on both sides of the PIDs.
7.3.9	The Train Arrival Information System shall provide the real-time train(s) arrival information to the PID servers; the train(s) arrival information shall then be transmitted to the respective PIDs at the platforms to display the real-time train(s) arrival information to the passengers.
	The PID system shall utilise prioritisation of text messages for the PIDs. The modes of display shall be configured as follows:
7.3.10	<ul style="list-style-type: none"> • Automatic Operation – train(s) arrival information on the displays shall be automatically generated by the PID servers according to the information from the Train Arrival Information System. This mode of operation shall have lower priority. • Manual Operation – during the incident situation, the Operators at OCC can manually overwrite the text messages of train(s) arrival information on PIDs through the SCADA workstation. This mode of operation shall have higher priority.
7.4 PIDs Viewing Coverage	
7.4.1	The text messages from PIDs shall be visible and readable along the whole platform length where possible. The position of the PIDs shall be considered of other assets that might be obstructing the passengers to view the text messages such as signage, lighting, CCTV cameras, etc.
7.4.2	If the length of platform is 100m, at least two PIDs shall be provided for the platform, so that the maximum reading distance of 25m is achievable to cover the whole length of platform.
7.5 Passenger Information Displays Equipment	
	The design and implementation of the PIDs at the platforms shall take into the following factors:
7.5.1	<ul style="list-style-type: none"> • Sight lines. • Structure of platform roof to support the PIDs • Cable routes along platform roof structure and the station CER.

Pos	Requirements
7.5.2	<ul style="list-style-type: none"> Interface to Fibre Optic Transmission System of the stations. <p>The PIDs shall be, but not limited to the following requirements:</p> <ul style="list-style-type: none"> Commercial-off-the-shelf (COTS) and modular construction solution. Industrial type with proven high quality and reliability, suitable to be used for railway environment. Proven equipment supplier with proven track record on rail systems. Interfacing seamlessly with the Train Arrival Information System and SCADA system. Design life of a minimum 15 years. Maintenance support for a minimum 10 years.
7.5.3	The PIDs shall be manufactured of LED technology, using advanced microprocessor control and IP addressable.
7.5.4	The PIDs shall consist of bright amber LED with automatic brightness control in accordance with the external ambient light.
7.5.5	The PIDs shall be visible over a range of ambient lighting conditions ranging from darkness to full sunlight. The LED shall be sun-readable for the prevalent light conditions.
7.5.6	The PIDs shall be double-sided; both sides shall be displayed with identical text messages. Each double-sided PID shall be configured with a single IP address.
7.5.7	The display of text messages for PIDs shall be assigned in accordance with the relevant commands controlled from the PID servers.
7.5.8	The PIDs shall consist of 4 lines of text messages, the upper 3 lines shall display of real-time train(s) arrival information and notice of incident or engineering works (if incident occurred). The lower line shall be used to display the clock information; the clock information shall be positioned in a portion of the display separated from the upper 3 lines portion.
7.5.9	<p>The 4 lines of text messages shall normally display the following messages:</p> <ul style="list-style-type: none"> Line 1: Train 1 final destination and countdown time. Line 2: Train 2/3 final destination and countdown time in barrel rolling format. Line 3: Service information, i.e. notice of incident or engineering works. Line 4: Clock information, i.e. HH:MM:SS.
7.5.10	The characters of upper 3 lines and lower line shall have a minimum height of 42mm and 34mm respectively. The reading distance for the upper 3 lines shall be readable by passenger with normal eyesight at a distance of within 25m. The upper 3 lines shall have a scrolling capability and display a line of text message of at least 255 characters. The scrolling format shall be used for service information.
7.5.11	The characters shall include all letters of the Indonesian and / or English alphabets, and a standard library of graphic symbols.
7.5.12	The PIDs shall operate in the minimum temperature range of -15c to +60c and a relative humidity of up to 90%.
7.6	PID Enclosure
7.6.1	The PIDs enclosure shall be installed at a minimum height of 2.5m above finished floor level.
7.6.2	The PIDs enclosures for the PIDs shall be fabricated to meet IP65 ingress protection and suitable for outdoor application. The material of enclosures shall be stainless steel.
7.6.3	The transparent screen in front of the PIDs shall be antiglare and anti-reflective.
7.6.4	The size of the PIDs enclosures shall be designed to fit within the limited space of the train platform, without exceeding the dynamic of the train envelope. The positioning and mountings of PIDs shall consider maintenance access and the ease for maintenance purposes.
7.6.5	The PIDs enclosures shall have good resistance to vandalism and wind damage and shall be supplied with tamper proof screws. It shall be fitted with a tamper sensor for vandalism detection.
7.6.6	The colour of enclosures shall be painted in black colour. The colour code shall be submitted to Engineer for approval prior to the commencement of painting.

Pos	Requirements
7.6.7	The PIDs enclosures shall be fitted with a thermostatically controlled tubular heater to prevent condensation. The thermostat shall have a temperature adjustable control and shall be mounted apart from the heater.
7.6.8	The waterproof cable glands shall be used for all external fittings to the enclosures.
7.7 PID Server	
7.7.1	The core of the PID system shall be a pair of dual-redundant servers configured in a main and standby configuration.
7.7.2	The configuration of interface of the PID servers shall be compatible with the Train Arrival Information System and SCADA system.
7.7.3	The PID servers shall be able to store a minimum of 32 static and 20 scrolling pre-defined text messages.

11.9.3 Performance Requirements

Table 11.28: Performance Requirements for PID

Pos	Requirements
	The response time for the PID system to respond during the operation shall be as follows:
1	<ul style="list-style-type: none"> • PID server response shall be within 300m seconds. • Fibre Optic Transmission System inclusive LAN shall be within 5m seconds. • PID controller response shall be within 250m seconds.
2	Therefore the overall response time for the PID system shall be within 560m seconds.

11.10 Access Management Systems (AMS)

11.10.1 Standards

Table 11.29: Standards for AMS

Pos	Requirements
1	BS EN 50133-1:1997 System requirements for access control systems
2	BS EN 50133-2:2000 Component requirements for access control systems
3	BS EN 50133-7:1999 Application guidelines for access control systems
4	IEE Wiring Regulations
5	LPS 1175 Requirements and testing procedures for the LPCB approval and listing of intruder resistant building components, strongpoints, security enclosures and free standing barriers, LPCB
6	NCP 109 NSI Code of Practice for Planning, Installation and Maintenance of Access Control Systems
7	PAS 24: 2007+A1: 2009 Enhanced security performance requirements for door assemblies
8	PAS 68: 2010 Impact test specifications for vehicle security barriers
9	SSAIB Code of Practice for Access Control Systems

Pos	Requirements
10	BSIA Guide to Integrated Security Management Systems (Form 203)
11	Disability Discrimination Act 1995 & Disability Discrimination Act 2005 as amended

11.10.2 Functional Requirements

Table 11.30: Functional Requirements for AMS

Pos	Requirements
1	The AMS shall provide control, monitoring and recording of personnel and authorised visitor movement through pedestrian and vehicular access and egress points, at un-manned buildings, control rooms and other areas at selected sites on the Jakarta LRT network.
2	The AMS shall be modular in construction and the design shall be such as to facilitate rapid first line maintenance.
3	The minimum permissible number of different modules shall be used throughout with all similar items of equipment and their components, together with spares, shall be made from identical materials and be fully interchangeable.
4	The intruder detection elements shall operate in conjunction with the access control system and shall use such systems as door sensors and Passive Infra-Red detectors to determine unauthorised detection/intrusion at out buildings etc.
5	The operators shall be able to control and monitor the access control system through the use of the SCADA workstations in the OCC. Full details of this interface shall be agreed with the SCADA system supplier to enable the systems to be fully integrated.
6	Access control shall be provided at each specified location to ensure secure access and egress, and shall be based on a contact-less, proximity detector type of card, working in conjunction with a card reader, which shall authorise or deny pedestrian or vehicular access by releasing the electrically operated doors, barriers, gates or turnstiles, as appropriate.
7	The access control function shall be able to detect any breaches of security or unauthorised intrusion, and any attempted forced entry via a secured door, barrier, gate, turnstile or beam detector shall raise an intruder alarm at the OCC.
8	The AMS shall include the capability to monitor the depot perimeter fence using a combination of infrared (IR) detection beams, microphonic cable and CCTV cameras to detect intruders.
9	IR fence posts shall be provided to detect intruders attempting to enter the depot/stabling area via track entry points and microphonic cables shall be installed to monitor fencing sections.
10	IR and microphonic cable detectors shall be interfaced to CCTV cameras to provide live images of potential intruders.
11	Any alarms produced by the depot perimeter fence monitors are to be presented on the main AMS monitoring facility in the OCC.
12	The AMS shall be designed to allow for ease of system expansion and the addition of any future access controllers.
13	The AMS servers shall be configured in a main and standby configuration to provide resilience and secondary recovery control positions. The servers shall provide all database and alarms handling for the AMS configuration and interface with SCADA system.
14	The AMS system shall be synchronised with the Master Clock System (MCS) directly over the LAN to obtain real-time clock signals.
15	Fully intelligent controllers shall integrate the functions of access control, input monitoring and local output control.

Pos	Requirements
16	The controller shall maintain, in internal non-volatile memory, the entire system application programme pertinent to its local region and shall process all local tasks, thus freeing the AMS servers from the burden of real-time decision making.
17	Local AMS Controllers
17.1	Each local AMS controller shall incorporate diagnostic indications to show mains on, controller power present and communications on-line. In addition, the controller shall provide indication when communications are received and transmitted.
17.2	In case of a communications failure to the AMS servers, the local AMS controllers shall operate in a 'non-degraded' in stand-alone mode, maintaining full local operation of all associated equipment in this stand-alone mode.
17.3	In the off-line mode, local programming of AMS functions shall be available, either via an integral keypad or via a plug in programming unit.
17.4	In the stand-alone mode the local controller shall buffer real-time events and reader transactions in an internal memory, for later up-loading when polled by the host AMS servers.
17.5	The local controller transaction buffer shall be expandable for multiple events as a contingency, in case of a prolonged communications failure with the main server.
17.6	All local AMS controller inputs shall operate satisfactorily in a high noise environment and equipment shall be protected to prevent mal-operation due to conducted and radiated electrical interference, including interference from lightning, signal line cabling and AC mains power supplies.
17.7	The Contractor shall ensure that where appropriate, the signal lines and input/output devices are provided with lightning protection to ensure no damage shall occur to equipment, other than that due to a direct hit by a lightning bolt.
17.8	The local AMS controllers shall be designed to allow for ease of system expansion and the addition of any future controllers within the buildings by the extension of the AMS LAN linking the local access controllers and the addition of extra controllers.
17.9	Local AMS controller equipment and enclosures shall be suitable for operating without forced-draught cooling or ventilation, in the stated environmental conditions.
17.10	All equipment enclosures carrying signals for the local AMS controllers shall be provided with tamper switches. Tamper switches shall be designed such that the defeat of the tamper switch is not possible prior to an alarm being registered by the access control system.
17.11	Card readers and door sensors shall be connected to the local AMS controller by means of signal cabling and containment where required.
17.12	The communications between the controllers and the AMS servers shall be by the LAN and Fibre System.
17.13	Under normal operating conditions, the local AMS controllers shall be connected to the main access control server. However, they shall continue to function normally in case of failure of the AMS equipment, or failure of other controllers on the network or any communication links.
17.14	The local AMS controller shall poll connected card readers and associated equipment, to determine the status of the card readers, doors and associated equipment.
17.15	The AMS servers shall monitor all local AMS controllers and report the status of all devices and sensors for display on the SCADA workstations.
17.16	The SCADA system shall take all associated actions such as providing an alarm banner to the operator and switching the CCTV cameras, where available, to show the area where the alarm has been detected.
17.17	The local AMS controllers required at each of the stations, substations etc., shall be located in the communications cabinet within appropriate buildings.
17.18	All local AMS controllers shall be constructed of epoxy coated steel or similar material and protected to IP54 and suitable for internal installation.
18	Card Readers
18.1	Proximity card readers shall provide access control for staff, visitors, contractors etc., through restricted areas.

Pos	Requirements
18.2	Where applicable, card readers shall be capable of accepting the input of Personal Identification Numbers (PIN), by a suitable tactile keypad.
18.3	Card readers and associated electro-magnetic locking devices shall each be hard wired back to a mains derived low voltage power supply, complete with standby battery capable of providing a minimum of 2 hours full operational back-up in the event of mains failure. In addition to this, the card readers shall be provided with full memory back-up for up to 12 hours after mains supply failure.
18.4	Card readers shall be connected to the appropriate controller and shall be uniquely identifiable by an appropriate tag or address.
18.5	Card readers shall be capable of accepting at least one input, which can be re-configured to provide a local duress alarm.
18.6	Construction: As the card readers shall be located on outside walls they shall be protected to IP65 and constructed of stainless steel.
19	Door Controllers
19.1	All access controlled doors shall be fitted with a suitable door closer to ensure long life and reliable door closing.
19.2	Doors shall generally be secured and released utilising fail safe low voltage electro-magnetic locking devices, to ensure reliable operation.
19.3	Appropriate emergency 'manual release facilities' shall be provided on all designated 'Emergency Exits'.
19.4	The AMS shall be capable of utilising both fail-safe and fail-secure locking devices.
19.5	The door locking devices shall be capable of a holding force of a minimum of 200 Kg.
19.6	All leaves of controlled and monitored doors shall be fitted with a status-monitoring device. Double pole recessed reed switches are preferred.
	The access controlled doors, which form part of a fire escape route, shall have a local method of disengaging the locks for emergency escape. The following safeguards shall be provided as a minimum;
19.7	<ul style="list-style-type: none"> • Where electro-magnetic locks are used, a green coloured break glass unit shall be installed, clearly marked 'Emergency Door Release' and connected directly in series with the door lock power supply; and • Where electro-mechanical locking devices are used, a suitable mechanical release shall be available on the secure side of the door, protected from normal use by a breakable cover.
19.8	In addition to any other tamper requirements specified or referred to in other sections of this specification; any tamper action to cabling installed outside of the AMS shall not permit release of the locking device. This shall include removal of local mains power supply, which shall have a battery back-up of 2 hours.
20	Access Control Cards
20.1	Each card shall carry unique site and user data, such that each card is capable of being individually identified.
20.2	The Contractor shall supply of 1000 proximity cards, in a format that permits the addition of a photograph, EPC Contractor's logo and other data. The supply shall include any photographic paper, laminations, etc., required to produce the 1000 passes.
2.3	The Contractor shall replace, at his own cost, all faulty cards supplied.
21	Intruder Detection
21.1	All normally un-manned outbuildings shall be fitted with an intruder detection system.
21.2	This system shall use a variety of means to detect an intruder, either by door sensors monitored as part of the access control system, or by movement detection using dual sensor PIR devices.
2.13	On detection of unauthorised entry the system shall raise an alarm on the SCADA workstations. In addition, the system shall activate the video recorder when entry is detected.
22	Pass Production
22.1	The pass production system shall allow the system administrator to design and produce quality passes for members of staff. These passes shall be enable proximity cards to be produced which shall include text, logos, various colours, graphics, photographs and digitised signatures.

Pos	Requirements
22.2	Pass production system and cardholder administration shall be configured by the system administration staff on a dedicated terminal which shall form a sub-system of the AMS system.
22.3	The administration and pass production system shall incorporate a suite of function keys which shall allow the system to be configured, changed and administered.
23	Card Administration
23.1	The administration and pass production system shall allow a minimum of 1000 access control cards to be issued and to send full details to the cardholder database.
23.2	The AMS administration terminal shall allow multiple cards to be issued with minimum repetitive data entry.
23.3	The system shall allow existing cardholder records to be amended without deleting and re-entering data.
23.4	A 4 digit PIN shall be assignable to each cardholder. The system shall permit user defined PIN's and shall not be restricted to having randomly calculated PIN's utilising a card number related algorithm or similar method.
23.5	Specific access levels shall be allocated to each card, which will define at which card readers the cards will be accepted.
23.6	It shall be possible to allocate time codes to each card, which will define the times at which a card will operate specific card readers.
23.7	The AMS shall have a minimum of 50 access levels and time codes to encompass site requirements.
23.8	The system shall allow individual cardholders to be monitored to create a unique alarm message, which is initiated when the cardholder's card is read.
23.9	In the event of a card being lost or stolen the system shall invalidate the card but continue to read it when presented and alert the operator.
24	Access Authorities
24.1	The system shall allow cardholders to be grouped together with other cardholders with the same access authority.
24.2	The system shall support a minimum of 255 card groups and each card group shall be able to include one, several or all cardholders.
	The system shall allow each card group to be granted access to specific card readers. At each card reader the system shall either;
24.3	<ul style="list-style-type: none"> • Permit access within a defined time zone; • Permit access; and • Refuse access.
25	Cardholder Database
25.1	The card database shall provide for up to 1000 cardholder records, and be fully relational in its file structure and manipulation. Records shall be indexed in the internal system directory, and be capable of being displayed by a search function for full or part matches in one or more record fields.
25.2	For each card entered, the system shall store a database record that shall include the information entered at the card administration stage.
25.3	It shall be possible to search the entire database and find any cardholder file or groups of cardholders matching defined search criteria. The search options shall cover any of the fields used in the database. Wildcard searches, as well as additive or subtractive searches, shall be supported.
26	Visitor Card Issue
26.1	To enable temporary cards to be issued to visitors, without having access to the card holder database, it shall be possible for the System Administrator to pre-validate cards for visitor use. Such cards shall be validated for a period of time not exceeding one day.
26.2	All Emergency exit doors at outbuildings and control buildings shall be protected by the intruder alarm system.
26.3	Staff access into lineside equipment rooms, into and within station buildings, into and within the OCC and depot, and other staff areas shall be controlled through an appropriate programmable key system (e.g. proximity card

Pos	Requirements
	and reader system) so as to enable the setting up of zoned entry levels. For areas requiring a higher or an extra level of access control, the system shall also be capable of supporting additional features such as an alpha-numeric keypad to enter a PIN or other code-word requirement.
26.4	In addition, an intercom system shall be provided adjacent to, or integrated with, the proximity card reader. Operation of the intercom shall connect the user to the OCC. The intercom facility shall enable personnel, not equipped with an appropriate proximity detector card, to request access to a restricted area and for the OCC operators to grant access, by remotely initiating the releasing of the electrical locking mechanism, should the request be acceptable.
26.5	The intercom unit shall be easy to operate, allowing hands free communication and shall be equipped with a flush mounted electronic call button, integral microphone and integral speaker.
26.6	All entrance/exit doors shall be held secure by magnetic shear catches. Egress from a room or building shall be achieved by depressing a door release button adjacent to the entrance doors.
26.7	In the event of fire alarm activation at a given location, hard-wired relays in the fire alarm panel shall release the door locking mechanism associated with that particular location.
26.8	Care shall be taken to zone 'fire alarm activation' to ensure that the system does not release secure areas such as CER's where this could lead to unauthorised entry.
26.9	The AMS administrator shall have the capability to enable immediate cancellation of any individual's access rights.
26.10	Management and control of the AMS shall be a simple and efficient administrative task, capable of being carried out at the OCC and other nominated locations to be agreed with the Employer.
26.11	Temporary cards for authorised visitors and contractors shall be 'time-limited', programmable by the AMS administrator.
	At the OCC the following facilities shall be provided:
26.12	<ul style="list-style-type: none"> • A specific AMS Control HMI; • Proximity card administration/issuing facilities; • Local maintenance terminal.
26.13	The AMS shall be synchronised with the Master Clock System (MCS) directly over the LAN to obtain real-time clock signals.
27	Depot Perimeter Security
27.1	The depot perimeter Intruder Detector System (IDS) shall interface directly with the CCTV system so, on the detection of an alarm, the camera covering the 'alarmed area' is automatically displayed on the appropriate CCTV monitor in the OCC.
27.2	Microphonic cable and analysers shall monitor noises generated in the cable's vicinity and generate an alarm when a noise associated with an intruder is detected. In locations where the cable is attached to a mesh fence, the system will associate the sound of mesh fence being cut or scaled as an intrusion.
27.3	Where microphonic cable is mounted in rattle brackets on the top of other types of fencing, the analyser shall detect the noise of the rattle bracket moving or being shaken if an intruder tries to climb the fence and triggers an alarm.
27.4	The microphonic cable analysers shall be capable of detecting a single noise or a string of multiple noises and their sensitivity shall have the capability to be adjusted to significantly reduce the likelihood of a false alarm.
27.5	At rail access/egress points to the depot, detection using infrared (IR) beams shall be provided. IR posts shall be installed either side of each track to detect an intruder passing across the security zone. Each zone shall incorporate a train module, which shall permit trains to pass through without generating an alarm but detects an intruder walking through the beams.
27.6	The perimeter fence detection devices (microphonic cable and infrared towers) shall interface with the LAN infrastructure so IP addresses shall be assigned to equipment in the AMS.

11.10.3 Performance Requirements

Table 11.31: Performance Requirements for AMS

Pos	Requirements			
	Event Source Type	Event Group	Event message	Priority
1	The AMS shall be programmed to know when a door should be closed and will therefore generate alarms when a door has been opened out of order and vice versa. It will also generate an alarm if a door does not close after a predetermined interval and if a request to enter or exit has been made but not taken			
2	The following is a list of alarms that shall appear on an HMI located at the OCC. These alarms are only a small section of the possible alarms that can be generated, but are those considered to require immediate attention.			
	Priority 5 has the highest rating and priority 1 has the lowest.			
	Door	Card Errors	Pass-back Attempted	4
	Door	Door Forced Open	Forced Door	5
	Door	Door Open Too Long	Door Open Too Long	3
	Door	Door Not Locked	Door Not Locked	2
3	Door	Door Status	Door Opened	1
	Door	Door Status	Door Re-secured	1
	The proximity card readers shall be manufactured and installed such that they significantly reduce, as far as practicable, acts of vandalism and prevent "false" operation of door release mechanisms if being tampered with.			
	All AMS equipment shall operate with a fast response time. Full operation of the AMS shall occur within 1 minute from a cold start.			
	Should the Master Clock fail the local GPS derived clock shall provide time synchronisation which shall be capable of maintaining real time as far as is reasonably practicable.			
	The AMS, including the central equipment, control facilities, power supplies, field equipment units, interfaces and cable routes shall be designed, as far as is possible, to minimise the effects of common mode failure on system operation.			
4	Equipment and cable redundancy shall be employed to the extent necessary to ensure that the AMS is highly reliable meeting, as a minimum, a system availability of 99.99% per annum, with an assumed Mean Time to Repair (MTTR) of 30 minutes. This shall include the depot perimeter fence detector systems.			
	In establishing system availability the Contractor shall include in its calculations all relevant equipment, cables, interfaces, software and power supplies.			
5	The minimum design life of the AMS equipment supplied by the Contractor shall be 10 years.			
9	Fail safe			
9.1	The AMS shall operate in a fail-safe mode such that the locking mechanism on Emergency Exits is released on activation of a Fire Alarm or by the use of a Break Glass Unit installed adjacent to the locked facility.			
10	System Capacity			
10.1	The installed AMS equipment shall be provided with an equipped spare capacity of 10%.			
10.2	The installed equipment capacity (required plus 10%) shall be capable of being expanded in the future to provide an additional 25% expansion in system capacity.			
11	System Capacity			
	The equipment shall be dust proof and the degree of internal protection shall be to BS EN 60529 Specification for Degrees of Protection Provided by Enclosures as follows:			
11.1	<ul style="list-style-type: none"> • IP 52 for equipment within equipment rooms and control rooms; • IP 55 for equipment which is located within covered areas and is not exposed to the external environment; • IP 65 for equipment, which is fully exposed to the elements. 			

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Pos	Requirements
11.2	The AMS and local access controllers (e.g. card readers/locking devices) shall be powered from local UPS standby power supplies. In case of mains failure an access controller shall continue to operate from battery back up standby power for a period of 2 hours full operation.
12	System Interface The AMS is required to interface with CCTV and Fire Alarm systems to maintain security and safety for staff and public.
12.1	The communications between the access controllers and the AMS servers shall be by the LAN and Fibre System.
13	Asset Register The Contractor is required to produce an asset register for all the equipment and materials used in the construction of the AMS to enable the Employer to produce an Asset Management Plan that will define how and when each asset shall be inspected, tested, maintained, repaired and, when necessary, replaced. The asset register shall contain, but not limited to, the following for all equipment associated with the provision of the AMS: <ul style="list-style-type: none">• Active equipment (e.g. requiring or supplying power)• Manufacturer• Equipment name• Equipment type/model• Version number• Serial number• Software version (where applicable)• Location (including Rack, Shelf, Slot positions where applicable)• Date of manufacture• Date of installation
13.2	

11.11 Local Area Network (LAN)

11.11.1 Standards

Table 11.32: Standards for LAN

Pos	Requirements
1	IEC 60950-1 Safety of information technology equipment
2	IEC 60529 Degrees of Protection - Enclosures for electronic equipment
3	IEC/CISPR 22:1993 Limits and methods of measurement of radio disturbance characteristics of information technology equipment.
4	IEC 61000-6-3 Electromagnetic Compatibility (EMC) – Various sections referenced within this specification
5	IEC 297(917) Dimensions of Mechanical Structures of the 19-inch (482.6-mm) Series - Part 3: Subracks and Associated Plug-in Units
6	DIN 41494 Basic Specification for 19-inch Construction Rack Systems
7	IEEE-STD 299 Standard Method for Measuring the Effectiveness of Electromagnetic Shielding Enclosures.
8	ISO 11801 Ed 2 Am2 Generic cabling for customer premises

Pos	Requirements
9	EIA/TIA568B-2-10 Commercial Building Telecommunications Cabling Standard
10	SNMP Simple Network Management Protocol
11	IGMP Internet Group Management Protocol
12	SNTP Simple Network Time Protocol

11.11.2 Functional Requirements

Table 11.33: Functional Requirements for LAN

Pos	Requirements
1	A data network based on a Wired (Ethernet) LAN system to the IEEE 802 family of standards, and interconnected via the Fibre System, shall be provided at each location across the entire Jakarta LRT rail network, to include Depot, OCC, Stations, and track side.
2	The data network shall comprise a 10Gbit/s Core Routing Layer to provide interconnectivity between all Jakarta LRT rail locations. A 1Gbit/s Access Layer of edge routers and switched LANs shall provide network connectivity at all stations, CERs, depot and the OCC.
3	The design shall enable highly available, secure and optimized connectivity for multiple remote-site LANs to provide the network foundation and services to enable the following: <ul style="list-style-type: none"> • IP connectivity across the whole of the Jakarta LRT rail network; • Primary and secondary links to provide redundant topology options for resiliency; • Wired LAN access at all remote sites. The LAN node shall provide an access layer bandwidth of 1Gbit/s to support connectivity for all subsystem applications including but not limited to the following: <ul style="list-style-type: none"> • Digital Voice and Data Mobile Radio • SCADA • CCTV • Public Address/Voice Alarm • Passenger Help Points
4	<ul style="list-style-type: none"> • Master Clock and Slave Clocks • IP Telephony • Wired LAN • Passenger Information Displays • Access Control/Intruder detection system • Wireless LAN connectivity • Ticketing and Revenue Collection systems, and • Passenger Gateline systems.
5	LAN access nodes shall be distributed around each station and its adjacent areas as required by the design. It shall be a Layer 2 device that functions as an access layer module to allow connectivity for devices such as, but not limited to, cameras, telephones, displays, and SCADA utilising Power over Ethernet (PoE) technology.
6	Category seven A cable (Cat 7A STP) shall be installed at all stations, the depot and OCC to support device connectivity to the LAN systems as required, and shall be determined during detailed design.
7	The data network shall be secure and for use by staff only in the case of the LAN. Access shall be provided for the general public at stations and other public areas to provide internet access to passengers.

Pos	Requirements
8	Public access to the internet via the LAN shall enable smart phone users to access such information as train times and onward journey information that may not be available on the passenger information displays, and shall enable users to access the internet generally whilst at the stations.
9	MPLS Layer 3 VPNs shall be used for the Jakarta LRT systems network and interfaces using a peer-to-peer VPN model that leverages the Border Gateway Protocol (BGP) to distribute VPN-related information.
10	The topology that should be considered for deployment is the hub-and-spoke topology, where remote stations (spokes) are connected to the central site (hub), i.e. the OCC. The design shall enable the following network capabilities:
	<ul style="list-style-type: none"> • IP any-to-any WAN connectivity for remote station and central site locations; • Deployment of dual fibre ring in the core network (Fibre System) for resiliency using dual routers in both remote (spoke) and central (hub) sites; • Dynamic BGP peering within the MPLS core network for site-to-site communications; • Support for Layer 2 and Layer 3 distribution switching designs; • Support for IP multicast VPN (mVPN) service; and • QoS for WAN traffic such as Voice over IP (VoIP) and business critical applications.
12	Virtual Private LAN Service (VPLN) shall be deployed to connect 'external' interfaces (e.g. those systems not within the Communication, Information and Control scope) such as Automatic Fare Collection etc.

11.11.3 Performance Requirements

Table 11.34: Performance Requirements for LAN

Pos	Requirements
1	The design shall include a study to confirm the bandwidth requirements for all interconnected systems and services, traffic routing and system configurations. The bandwidth study should assume that 100% of ports on all servers/switches are utilised and active.
2	The data network equipment shall be electrically safe for users and maintainers. Conformance with BS EN 60950 and BS 7671 is acceptable as evidence of this.
3	Generally, the operation of the data network shall be in accordance with suite of applicable IEEE standards for LAN applications.
4	Data network equipment shall be suitable for use in environmental conditions complying with ETS 300 039-1-3 for operation in temperature controlled (class 3.1) locations. Temperature controlled environments include rooms within purpose built buildings (e.g. control centres), equipment rooms and trackside equipment housings containing 'active' equipment.
5	Data network equipment subracks shall comply with ETS 300 119-4. The equipment shall be installed in either miscellaneous equipment racks within equipment rooms, or within trackside equipment housings. Some LAN servers may require to be installed in office environments (OCC or stations) to meet the Cat 7A cable maximum length requirements. Where this is the case, the Contractor shall identify smaller equipment cubicles suitable for office environments and submit details to the Employer for agreement for use.
6	Resilience of the data network is vital to the continued operation of Jakarta LRT services, and the design shall make every effort to promote resilience by identifying and eliminating common mode failures in the data network topology, which will occur when a single event causes interruption to the data network. The RAM targets for the Data network as a whole shall be as follows;
7	<ul style="list-style-type: none"> • Availability shall exceed 99.999% per annum • MTBSAF for Data network failures shall exceed 50 years

Pos	Requirements
8	<ul style="list-style-type: none"> • MART shall not exceed 30 minutes <p>System Interface</p> <ul style="list-style-type: none"> • The data network shall provide the element management functions for, but not limited to, Core Routing and access layers and a platform for value-added applications such as remote monitoring, alarm gathering, assurance and performance management. <p>The data network shall be provided to interconnect project wide core traffic services and circuits required to support the operation of the Jakarta LRT network, including but not limited to the following;</p> <ul style="list-style-type: none"> • Digital Voice and Data Mobile Radio • SCADA • CCTV • Public Address/Voice Announcement • Passenger Help Points <p>8.2</p> <ul style="list-style-type: none"> • Master Clock and Slave Clocks • IP Telephony • Wired LAN • Passenger Information Displays • Access Control/Intruder detection system • Wireless LAN connectivity • Ticketing and Revenue Collection systems, and • Passenger GateLine systems.
9	<p>Asset Register</p> <p>9.1</p> <p>The Contractor is required to produce an asset register for all the equipment and materials used in the construction of the data network to enable the Employer to produce an Asset Management Plan that will define how and when each asset shall be inspected, tested, maintained, repaired and, when necessary, replaced.</p> <p>The asset register shall contain, but not limited to, the following for all equipment associated with the provision of the data network;</p> <p>Active equipment (e.g. requiring or supplying power)</p> <ul style="list-style-type: none"> • Manufacturer • Equipment name • Equipment type/model <p>9.2</p> <ul style="list-style-type: none"> • Version number • Serial number • Software version (where applicable) • Location (including Rack, Shelf, Slot positions where applicable) • Date of manufacture • Date of installation

11.12 Wireless Area Network (WAN)

11.12.1 Standards

Table 11.35: Standards for WAN

Pos	Requirements	
1	802.11 ac	Wi-Fi Standard
2	IEC 60950-1	Safety of information technology equipment
3	ISO/IEC 11801	Telecommunications installations — Generic cabling for commercial premises
4	IEC 60529	Degrees of Protection - Enclosures for electronic equipment

11.12.2 Functional Requirements

Table 11.36: Functional Requirements for WAN

Pos	Requirements
1	The system shall operate using 802.11ac Wave 2 standards
2	The system shall be capable of supporting 802.11n standards if required
3	The system shall be capable of supporting 4 x MIMO operation
4	The system shall support 20, 40, and 80 MHz channels with optional support for contiguous 160 MHz channels or non-contiguous 80+80 MHz channels
5	The system shall support beamforming techniques
6	The system shall be capable of operating from Power over Ethernet PoE via suitable media convertors for external WAP's or if used internally directly from PoE via the LAN and PoE switches
7	The system shall connect to the Wide Area Network (WAN) via the fibre System via IP connectivity
8	The system shall support four spatial streams
9	The system shall be capable of operation in the 5GHz licence exempt bands
10	All external WAP's shall conform to IP67 rating or be placed within National Electronics Manufacturers Association (NEMA) enclosures or equivalent.
11	The cell edges shall overlap at -59 dBm to maintain the support of high modulation levels offered by the standard
12	The WAP's shall be capable of operating over a temperature range of 0o C to +60o C
13	The WAP's shall be capable of operating up to 95% RH non condensing
14	The WAP's shall be capable of resetting after power failure with no manual intervention
15	The Wi-Fi system shall have a supported design life of 15 years
16	The design shall include a study to confirm the bandwidth requirements for all interconnected systems and services, traffic routing and system configurations. The bandwidth study should assume that 100% of ports on all servers/switches are utilised and active.
17	The Wi-Fi network equipment shall be electrically safe for users and maintainers. Conformance with BS EN 60950 and BS 7671 is acceptable as evidence of this.
18	A full desktop propagation study shall be carried out prior to installation to determine positioning of the WAP's and to give an assurance that cell overlaps will comply with the requirements previously outlined. The output of this study will form the basis of the detailed design of the system.
19	After construction, a full physical survey of the Wi-Fi system shall be undertaken, using calibrated Wi-Fi survey

Pos	Requirements
20	equipment to verify the desktop study predictions, the suitability of proposed sites and to confirm overlap margins are within the defined parameters. This survey shall be the benchmark for all future monitoring and testing of the system to ensure ongoing optimal performance during the operational life of the network.
21	The Wi-Fi System shall be engineered to support achieving the overall signalling and train control system operational availability target to provide safe system with 99.99% availability. The Wi-Fi System shall also provide a project-wide data communications bearer for CCTV, SCADA, PA, PIS, vehicle tracking and other monitoring systems as required.

12 Automatic Fare Collection (AFC)

12.1 AFC

12.1.1 Standards

Table 12.1: Standards for AFC

Pos	Requirements
1	IEEE 802.11 Telecommunications and information exchange between systems – Local and metropolitan area networks – Specific requirements – Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications
2	IEEE 802.3 Carrier sense multiple access with collision detection (CSMA/CD) access method and physical layer specifications
3	ISO/IEC 14443 Identification cards - Contactless integrated circuit(s) cards - Proximity cards
4	ISO/IEC 14443-1 Identification cards - Contactless integrated circuit(s) cards - Proximity cards - Part 1: Physical characteristics
5	ISO/IEC 14443-2 Identification cards - Contactless integrated circuit(s) cards - Proximity cards - Part 2: Radio frequency power and signal interface
6	ISO/IEC 14443-3 Identification cards - Contactless integrated circuit(s) cards - Proximity cards - Part 3: Initialization and anti-collision
7	ISO/IEC 14443-4 Identification cards – Contactless integrated circuit(s) cards – Proximity cards Part 4: Transmission protocol
8	ISO 1745 Information processing - Basic mode control procedures for data communication systems
9	ISO 7810 Identification cards — Physical characteristics
10	ISO 7813-3 Data structure and data content of magnetic tracks
11	ISO 7816 Identification cards -- Integrated circuit cards
12	ISO/IEC 10373 Identification cards -- Test methods
13	ISO/IEC 15408 Information technology -- Security techniques – Evaluation criteria for IT security
14	ISO/IEC 18092 Information technology -- Telecommunications and information exchange between systems -- Near Field Communication -- Interface and Protocol
15	IEC 56 Electronic Guide of maintainability of equipment
16	IEC 721 Classification of environmental conditions
17	IEC 255-4 Electromagnetic Compatibility
18	EN 50081 Electromagnetic compatibility - Generic emission standards
19	EN 50082 Electromagnetic compatibility - Generic immunity standard
20	EN 50122-1 Railway applications, Fixed Installations. Part 1: Protective provisions relating to electrical safety and earthing
21	EN 50122-2 Railway applications, Fixed Installations. Part 2: Protective provisions against the effects of stray currents caused by D.C. traction systems
22	EN 50125 Railway applications - Environmental conditions for equipment
23	EN 50140 Radiated radio frequency electromagnetic field immunity tests
24	EN 55011 Industrial, scientific and medical equipment– Radio-frequency disturbance characteristics Limits and methods of measurement
25	EN 60947 Low voltage switchgear and control gear
26	EN 60950 Safety of Information Technology equipment
27	EN 61000-4 Quality System. Model for quality assurance, production, facilities and associated services
28	EN 50141 Electromagnetic compatibility. Basic immunity standard. Conducted disturbances induced by radio

Pos	Requirements
	frequency fields. Immunity tests

12.1.2 Functional Requirements

Table 12.2: Functional Requirements for AFC

Pos	Requirements
1	<p>General</p> <p>1.1 Design life of the Fare Collection equipment housing shall be 30 years.</p> <p>1.2 Design life of the Control System of Fare Collection shall be 15 years.</p> <p>1.3 The Automatic Fare Collection System shall be designed as a total "Close Type System", which means no single point of "Free Access", shall be allowed in the entire line.</p> <p>1.4 The AFC System shall be designed to cater for "inclusion" of other transport services. The fare shall be charged for "Full Fare" according to the fare structure, "Concession Fare" can be applied for the following passenger and tickets can only be purchased at Ticket Office with valid identification. Child with age under 5 can be travelled free with Adult with valid ticket.</p> <ul style="list-style-type: none"> • Senior Citizen (for age over 65) • Students for age under 12
2	<p>Ticket Media</p> <p>Contactless Smart Cards shall be the only fare media to be used in the system. The Cards can be initialised for the following tickets type (including full fare and concession). All cards except Single Journey Tickets will be able to re-use until the cards reach its design life cycle.</p> <ul style="list-style-type: none"> • Single Journey Tickets • Complimentary Tickets • Day Pass (based on time or number of journey) • Stored Value Ticket • Season Pass • Staff Travel Pass • Maintenance Pass <p>CSC shall be coloured to indicate their type. Space shall be reserved on the front side of CSCs for Employer's logo and advertising.</p> <p>The CSC shall be compliant with ISO14443 Type A (Part 2~4), ISO 14443 Type B (Part 2~4) or ISO 18092 Type F. Also in order to achieve its security level, the card shall have at least Evaluation Assurance Level (EAL) 4 or above except for the Single Journey Tickets.</p> <p>Each CSC shall be encoded at IM with a unique thirty two (32) bit identification number, initialisation date, type, encoding device reference number and other pertinent data that shall not change throughout the useful life of the CSC.</p> <p>In order to encourage non-frequent users who only buy Single Journey Tickets occasionally, the Single Journey Tickets shall allow to top-up any single journey fare once per time for up to 7 times within a month period. A discount fare would be considered to give for the 3rd time and onward top-up.</p>
3	<p>Ticket Gate</p> <p>3.1 Gate will be installed at each station concourse where distinguish the concourse into free area and paid area.</p> <p>3.2 Flap or Traceable type of Gate will be used. Turnstile type will not be acceptable.</p> <p>3.3 The reader/writer devices for the gate shall be interface identical with the ticket media, which shall comply with ISO14443 Type A (Part 2~4), ISO 14443 Type B (Part 2~4) or ISO 18092.</p> <p>3.4 The reader/writer devices for the gate shall have a minimum of 8 slots for SAM which shall be comply with ISO/IEC 7816.</p>

Pos	Requirements
3.5	<p>The following gate type will be installed at each station, the quantity will subject to station patronage, and its location will depend on the station layout.</p> <ul style="list-style-type: none"> • Entry Only Gate • Exit Only Gate • Bi-Directional Gate • Wide Gate for disable passenger <p>The minimum quantity of Gate is listed in below, as per gate array of station.</p> <ul style="list-style-type: none"> • Entry Only Gate *1 • Exit Only Gate *1 • Bi-Directional Gate *1 • Wide Gate for disable passenger *1 <p>The minimum through rate of Gate under normal open position shall be at least 45 passengers per minute. (this is consider to have 45 completed transaction)</p> <p>Based on the current patronage figure of 10,000 (peak hour in/out per station), the total number of gate estimated per station will be as follows:</p> <ul style="list-style-type: none"> • Entry Only Gate *4 • Exit Only Gate *4 • Bi-Directional Gate *1 • Wide Gate for disable passenger *1 <p>3.9 The aisle width for standard gate shall be 500mm, and 900mm for wide gate.</p> <p>3.10 The gate array will be next to the PAO (Passenger Agent Office) so that it can be monitored and controlled by the PAO. It should also be fitted with a remote release system which may be operated from the PAO.</p>
4	<h4>Ticket Vending Machine</h4> <p>4.1 Ticket Vending Machine (TVM) and Ticket Office shall be installed for each station for the entire line, where passenger can procure, revalue, revalidate, analyse and upgrade tickets. Tickets will only be available at stations. Ticket Vending Machine (TVM) will accept both Banknotes & Coins commonly used in Jakarta as listed for following value. When buying tickets, the TVM shall indicate the correct amount of payment, and once received correct transaction, it shall issue tickets and correct change (if necessary).</p> <ul style="list-style-type: none"> • IDR 100 • IDR 200 • IDR 500 • IDR 1000 • IDR 2000 • IDR 5000 • IDR 10000 <p>4.3 There will have 2 types of TVM at each station, one of them will have full function of TVM as well as issuing Single Journey Tickets, another one will only have the function of "top-up" and analyse the tickets.</p> <p>4.4 The preference of TVM array would be "Rear Maintenance Type", it provides higher security for the ticket storage as well as money collection, and therefore the TVM array shall be enclosure with physical partition.</p> <p>4.5 In the case of TVMs have to be installed as a "Free Standing" type due to station layout, a proper enclosure to ensure the security of TVM area shall be provided.</p> <p>4.6 A proper design of Fare Table signage at the top of TVM area shall be installed.</p> <p>4.7 The propose width of TVM would be roughly 1200mm.</p>
5	<h4>Ticket Office</h4> <p>5.1 Ticket Office shall equipped with Passenger Service Machine (PSM) which shall have the identical function of TVM, apart from it can accept the payment by Banknotes and Debit/Credit Card.</p> <p>5.2 The quantity of TVM and Ticket Office Window will determine by the station patronage, in order to encourage the usage of TVM, the assumption has made that 80% of passenger will be used TVM and the rest of 20% for Ticket</p>

Pos	Requirements
	<p>Office.</p> <p>The proposed quantities of TVM and Ticket Office Window (quantities of PSM) per station are:</p> <ul style="list-style-type: none"> • TVM with full function * 2 • TVM with only “top-up” and analyse tickets *5 • Ticket Window * 3
5.3	
6	Passenger Enquire Machine
6.1	There will have 1 Passenger Enquire Machine to be installed at both Paid area and Un-Paid area of the station to allow passenger to check their latest status of the tickets without assistance from station staff.
7	Cash Handling Room
7.1	A Cash Handling Room shall be provided at the back office area of the station where higher security level shall be applied. The cash handling room shall have space to store the trolley as well as empty/full cash vaults. Cash received from TVM will be stored in a secured cash vault, which will be collected by station staff to the
7.2	Station Cash Handling room when it is close to its limited capacity. The cash vault can only be unlock and open with security key and/or PIN under operation of authorised staff.
	Equipment needs to be installed at the Cash Handling Room would be cash/coin counting machine, coin/cash bagging equipment, etc. To maintain high security level, the entry of the room will need to equip with security key pad as well as monitor by CCTV
7.4	The Security from Banks will collect and distribute the cash daily from stations to the Bank.
8	Station Computer Room
8.1	Normal operations of the AFC equipment will be based on the AFC Station Computer System located in the station computer room and PAO. Provisions will be made for the status of items of station AFC components to be monitored and, where appropriate, controlled from the AFC Central Computer System (CCS). Throughout the operating day, data from the station equipment will be sent to the CCS in real time.
8.2	The Station Computer System (SCS) will be located in the Station Computer Room at every station. The SCS communicates with the Central Computer System (CCS) and transmits information to the CCS for monitoring, analysis and report generation. The Station Computer System receives all system operating parameters including date, time, fare tables, user ID and blacklists from the CCS and disseminates it to the AFC equipment. It also downloads application software upgrades and performs version checks.
8.3	Central Computer System (CCS)
8.4	Central Computer System will be equipped at OCC as well as the Revenue Collection Department.
8.5	The CCS shall provide function of Equipment control, status information, reporting and data analysis for automatic fare collection.
	The CCS shall have the identical function as Station Computer System, however it will act as monitoring purpose for normal operation, in case of the system operating parameters need to upgraded, it will download and disseminates from CCS.
8.6	
8.7	The database of CCS shall contain all data related to the fare collection system for minimum period of 7 years.
9	Level of Security
9.1	AFC system contains monetary items (such as tickets) as well as some personnel data (ID if needed), higher security level shall be applied through entire network for hardware and software. All TVM arrays, PAO, Ticket Window, and Cash Handling room shall be equipped with CCTV for close monitor.
	To maintain the security level of the AFC system, the level of access shall include the following level:
9.2	<ul style="list-style-type: none"> • System Administrator • Maintenance • Supervisor • Operator
10	Operating Rule
10.1	The validity of each ticket shall be parameterised so that it is possible to invalidate any ticket type. All tickets shall

Pos	Requirements
10.2	be initialised with the ticket type and a unique serial number. For integration between the LRT, BRT and others, SVT and SP types of tickets shall be available for multi-mode transfers (future).
10.3	Single Journey Tickets issued from TVMs and PSMs shall only valid for a single journey on the day of issue. On exit, the remaining value shall be encoded to zero and coding for number time of usage. In order to encourage non-frequent users who only buy Single Journey Tickets occasionally, the Single Journey Tickets shall allow to top-up any single journey fare once per time for up to 7 times within a month period.
10.5	Entry and exit gates have to be used in the correct sequence. Once the ticket has been presented and processed by an entry gate, the passenger shall not be allowed to use the ticket at an entry gate again until it has been processed by an exit gate. Conversely, once a ticket has been used in an exit gate, it must next be used at an entry gate before it is again be accepted by an exit gate.
10.6	A time in system check shall be incorporated whereby the time between entry and exit gate transactions is checked against a downloadable table of allowable station-to-station and/or zone journey times.
10.7	Should a passenger "over-stay" in the LRT system, the exit gate shall give a warning message and instruct the passenger to PAO. The PAO shall deduct the relevant surcharge and possibly a penalty amount from the card balance.
10.8	The AFC system shall have a minimum entry value that shall be equal to or greater than zero and shall be operator configurable from the CCS. An entry gate shall prevent a passenger from entering the paid area if the remaining balance on the passenger's CSC is less than the minimum entry value. An information display in the gate shall direct the passenger to go to the PAO.
10.9	All practicable fail-safe features shall be incorporated to protect against the creation of duplicate ticket IDs in the system, either through hardware or software failures.
10.10	The AFC System shall provide a range of ticket IDs to be blacklisted. These ticket IDs shall be entered at the CCS for downloading to the AFC System equipment. It shall not be possible for the same person to enter as well as download blacklisted IDs.
10.11	Blacklisted tickets shall be rejected at entry gates. The PSM shall discretely identify such tickets to the operator who shall take the necessary action according to operational procedures prevailing at that time. The PSM shall not be able to upgrade any blacklisted tickets so identified. The TVM shall not accept blacklisted tickets for add value functions.
10.12	It is possible for CSC to have a remaining value that is insufficient to cover the fare for the journey. Such tickets shall be rejected by the exit gates. Passengers shall pay the difference between the remaining value and the fare at the PSM. In addition to the difference, an under fare charge may apply which shall be parameterised and downloadable from the CCS. Each ticket type shall have its own under fare charge. It shall be possible to set the parameter value to zero (0).
10.13	The remaining value for CSC shall be allowed to assume negative values, but not exceeding the amount of deposit paid for the ticket. Hence, it shall be always possible to cover the cost of a journey, or an under fare situation from the deposit value.
10.14	The "credit" given to the passenger shall be recovered when the ticket is revalued at TVMs and PSMs. However, it shall not be possible to commence a new journey with a CSC that has a negative remaining value.
10.15	It shall be possible to disable the system from allowing the CSC remaining value to go negative where passengers shall have to revalue their cards before exiting the paid area.
10.16	Should there be any disruption to the train service; a degraded mode of AFC operation called "Service Disruption Mode" shall be provided. The enabling and disabling of this mode shall be done by downloading commands from the CCS to the gates of selected or all stations
10.17	During service disruption, the relevant fare shall be deducted by the exit gates for all ticket types. There shall be an option to reduce the fare through a parameter, which shall vary with each ticket type, to compensate the fact that passengers may have to take other modes of transport during the disruption of train service. It shall be possible to put the parameter to "zero" so that this reduction is not applicable. For tickets with the same station of exit as entry, no fare shall be deducted.
10.18	A minimum deposit will be charged when purchase the following 3 type of CSC, the deposit will be refunded

Pos	Requirements
	<p>when CSC is no longer being used and return to PAO. A handling fee will be deducted from the deposit.</p> <ul style="list-style-type: none"> • Day Pass (based on time or number of journey) • Stored Value Ticket • Season Pass
10.19	<p>The system shall provide means to refund and replace tickets that are rejected by the system and good tickets based on customer's request, at the PSM. The value of the replaced and refunded ticket shall be set to "zero" when replacement or refund is performed. The refund and replacement system shall be secured against any attempts of fraud. An accounting system for refund and replacement system, and card usage system shall be provided.</p>

12.1.3 Performance Requirements

Table 12.3: Performance Requirements for AFC

Pos	Requirements
1	<p>General</p> <p>The AFC system to be designed, procured supplied, installed, tested and commissioned by the Contractor, will allow for use of smart card tickets complying with ISO/IEC 14443 Type A (part 2~4) & Type B (part 2~4) or ISO/IEC 18092 Type F and will include configuration, expansion and integration features allowing also valid for multiple transportation schemes in Jakarta</p> <p>The hardware design shall include all necessary elements of the fare collection system comprising of vending, validation, cancellation, monitoring and security of revenue and tickets</p> <p>The equipment shall be of modular design so that the AFC System can be expanded with minimum interruption to the operation of the railway</p> <p>Hardware and Software of the AFC system shall utilise the latest technology available in the current market</p> <p>The fare structure shall be defined as operating parameters which allow the operator to adjust according to the passenger trend, such as peak period or off-peak period</p> <p>Fare structure shall be designed based on travelling distance and to have a "Station-to-Station" and/or "Zone graduated" fare structure.</p>
2	<p>Hardware Requirements</p> <p>The Contract shall responsible for design, supply, and manufacture for the following main hardware components of the AFC system.</p> <ul style="list-style-type: none"> • Entry Gates • Exit Gates • Bi-Directional Gates • Wide Aisle Gates • Ticket Vending Machines • Passenger Service Machines • Initialization Machine • Mobile Validator • Station Computer System • Central Computer System • Tickets (Contactless Smart Card) • Station LAN • Cabling • Spare Parts
2.1	

Pos	Requirements
3	<p>Ticket Media</p> <p>Each CSC shall have the unique card serial number printed or moulded into the card during manufacturing. The printing, moulding or other method shall be resistant to scratching. The design shall be subject to the approval of Employer.</p> <p>Each CSC shall have its own definable access key comprising a minimum of three (3) blocks (1 block = 16 bytes). A common area of a minimum of 4 blocks shall also be provided. A minimum of 52 blocks shall be available for operator data.</p> <p>There shall provide a minimum of 8 slots of Security Access Module (SAM) in the card read/write module in order to accommodate other cards issued by other service providers. The Contractor needs to ensure the design of the CSC shall be compatible and interoperable with other systems currently in used or will be used in Jakarta.</p> <p>The design life (data retention period) of the Ticket Media shall be at least 10 years in normal use with respect to the physical life due to wear and tear, except for the Single Journey Tickets and Complimentary Tickets, as both will be consider being "one time disposal", therefore different card material shall be used.</p> <p>CSC used shall be sufficiently durable to withstand a minimum of 50,000 transactions where one (1) transaction equates to one (1) transaction on PSM or gate.</p> <p>The CSC shall provide at least thirty percent (30%) spare capacity for memory (Flash and DRAM).</p>
4	<p>Ticket Gate</p> <p>Gates shall be identical for the ticket interface, displays and for passenger movement in both entry and exit directions. It shall process all tickets issued for the Jakarta LRT as well as issued from other transport providers.</p> <p>The Gate shall be connected via a station LAN to the SCS that will download fare tables, operating parameters and gate application software disseminated from the CCS. The Gate shall upload transaction, status and event information to the SCS for processing and upload to the CCS. In the event of a station LAN failure, the Gate shall be able to operate in a standalone mode.</p> <p>The gate shall be ergonomically designed and intuitive to use. Where possible, the passenger interface components such as the passenger display, transaction status indicators and smart media validator and acceptor shall be collectively located in a single passenger console.</p> <p>The AFC gate shall have the capability to count passengers entering and exiting the system in real time and continuous recording.</p> <p>The AFC gate design shall cater for the integrated ticketing system to be implemented in the near future which will allow common ticketing for the public transports in Jakarta, different bus operators, other transport providers or even car parks.</p> <p>The gates shall be operated by presenting a valid ticket. The ticket shall be read, encoded and verified by the CSC (validator/acceptor). All tickets shall be re-coded with the appropriate data.</p> <p>Should the ticket be invalid, an "INVALID TICKET" display shall be flashed to the passenger. At the same time, the barrier shall prevent the passenger from passing through the gate.</p> <p>The instruction display shall be clearly visible under all conditions including direct sunlight without requiring an external protruding shield. The display shall have a protective cover. It shall be switched off after the passenger has removed their ticket from the proximity of the CSC touch panel.</p> <p>At exit, the gates shall do the necessary validation on the ticket and deduct the correct amount before allowing the passenger to leave the paid area.</p> <p>If the value on a SJT at exit is insufficient for the journey just terminated, "INVALID TICKET" together with a "Seeking Assistance from Station Staff" sign shall be flashed to the passenger.</p> <p>The gate shall be able to detect tailgating by two or more passengers with one valid ticket.</p> <p>The AFC gate shall be standalone system where it shall be able operate normally if network connection to the SCS or CCS failed.</p> <p>The AFC gates shall have an LCD Maintenance Panel for maintenance purposes.</p> <p>All AFC gate sub modules shall have their own diagnostic tests controlled by the gate application. The Maintenance Panel shall be used to run the diagnostic tests.</p>

Pos	Requirements
4.15	An Indicator shall be provided with an audible signal to both passengers and station staff for the transaction. It shall give audible notifications to passengers on transaction status.
4.16	A concession indicator shall be provided which a high visibility lamp is located on the top of the gate cabinet and is used to alert station staff that a concession card has been used.
4.17	The gate shall have a number of passenger sensors within an aisle that are used to track passengers through the gate and to ensure safe operation of the barrier system.
4.18	The Passenger Information Display (PID) provides passengers with information on card validation and gate availability.
4.19	The barrier system controls the passage of passengers through the gate aisle. It shall consist of a pair of retractable barriers. The flaps shall be operable in normally closed or normally open mode.
4.20	The barrier shall prevent the passage of a person without a valid card without causing injury or undue inconvenience to other passengers.
4.21	A directional display shall be at the front of the cabinet at both ends of each gate, except for end gates. A single LED display shall show either "Enter" or "Do Not Enter". The display shall employ internationally accepted symbols, i.e., for "Enter" a green arrow pointing to the passageway to be used, and for "Do Not Enter" a red circle with a red horizontal bar.
	The Software for the AFC gate shall contain following modes:
4.22	<ul style="list-style-type: none"> • Maintenance Mode • In Service Mode • Out of Service Mode • Emergency Mode • Degraded Mode • Free Service Mode
5	Ticket Vending Machine
	The basic functions and characteristics of the TVM shall include but not limited to the following:
5.1	<ul style="list-style-type: none"> • Issue full fare SJTs and RJTs • Revalue full fare and concession SVTs and revalidate SPs • Provides customers access to view relevant data on ticket • Accept payment by Banknotes and Coins • Print receipt upon request by passenger. • 19" TFT LCD SVGA colour display with touch screen panel for passenger input and navigation for information. • Ability to purchase multiple ticket (i.e. SJT and RJT) within a single transaction • Passenger help and assistance information explaining fares, ticket purchase procedures, the TVM number, customer service number, etc., both displayed visually and annunciate • Speakers for audible feedback and announcement of purchasing instructions, ticket dispensing and currency insertion. • Give change in notes and coins • Switch out of service when detecting any relevant faults • Overhead display to indicate the operational mode to passengers at a distance. • Control and monitor sub-modules, i.e., coin acceptor, bank note acceptor and ticket issuer. • Upload audit, transaction and performance data, and maintenance status of TVM to SCS and CCS. • Print out audit report once received command from maintenance panel during maintenance mode. • Store coins and bank notes in vaults. • Have the flexibility in accepting new coins or notes (when introduced by Bank of Indonesia) in future. • Receive fare tables, other operating parameters and software updates from SCS and CCS. • Able to cater with any changes to the current fare structure. • TVM shall recognize command sent by SCS and CCS such as Set time, Clear Alarm, Set out of service

Pos	Requirements
	/ in service.
5.2	<ul style="list-style-type: none"> • Uninterruptible power supply suitable for completing transactions in the absence of utility power. • Diagnostic software resides in the TVM for maintenance, trouble shooting, and alarm generation. • Restrict interior access to authorized personnel with an associated PIN and/or access card. • Security system that issues alarms for TVM security events. <p>The language used shall be English and Bahasa Indonesia</p>
5.3	<p>The sequence of customer actions required to complete each transaction shall be designed to be as efficient and customer friendly as possible. The Contractor shall provide the Employer with scripts and screens that define all possible transaction sequences.</p> <p>Each TVM shall normally be ready to respond to a passenger selection when it is in the idle condition. If the TVM is not ready, all operating functions shall be disabled. A configurable touch screen display shall be provided for passengers to complete a transaction. The display screen shall direct the passenger through the steps of the transaction with the passenger's inputs being entered through the touch screen.</p> <p>When failures occur during a transaction, the TVM shall not complete the transaction and all deposited funds shall be returned to the passenger. If the TVM has limited functionality, all such situations shall be displayed on the TVM idle screen and overhead display. If a customer leaves a TVM during a transaction process, the TVM shall display a warning before initializing itself back to the start/idle screen after a configurable and downloadable time period.</p>
5.4	<p>Each TVM shall normally be ready to respond to a passenger selection when it is in the idle condition. If the TVM is not ready, all operating functions shall be disabled. A configurable touch screen display shall be provided for passengers to complete a transaction. The display screen shall direct the passenger through the steps of the transaction with the passenger's inputs being entered through the touch screen.</p> <p>When failures occur during a transaction, the TVM shall not complete the transaction and all deposited funds shall be returned to the passenger. If the TVM has limited functionality, all such situations shall be displayed on the TVM idle screen and overhead display. If a customer leaves a TVM during a transaction process, the TVM shall display a warning before initializing itself back to the start/idle screen after a configurable and downloadable time period.</p>
5.5	<p>Each TVM shall normally be ready to respond to a passenger selection when it is in the idle condition. If the TVM is not ready, all operating functions shall be disabled. A configurable touch screen display shall be provided for passengers to complete a transaction. The display screen shall direct the passenger through the steps of the transaction with the passenger's inputs being entered through the touch screen.</p> <p>When failures occur during a transaction, the TVM shall not complete the transaction and all deposited funds shall be returned to the passenger. If the TVM has limited functionality, all such situations shall be displayed on the TVM idle screen and overhead display. If a customer leaves a TVM during a transaction process, the TVM shall display a warning before initializing itself back to the start/idle screen after a configurable and downloadable time period.</p>
5.6	<p>The TVM shall generally consist of a Ticket/CSM Issuer, CSM Validator, two (2) or more CSM hoppers with dispensing mechanism, a coin validator with escrow unit, a coin and note change dispensing system, a coin vault, note vault, a note acceptor, ECU, maintenance panel, a LCD touch screen, overhead display and all other associated electronic modules.</p>
5.7	<p>The coin vault and note vault shall be self-locking when removed from their proper position.</p> <p>The following information, at a minimum, shall be Encoded & Verification on each CSM</p> <ul style="list-style-type: none"> • Date of issue • Time of issue • Issuing TVM ID (Equipment ID) • Sales location (Station ID)
5.8	<ul style="list-style-type: none"> • Ticket Journey • Ticket type (SJT, RJT or Concession) • Fare category • Purchase price • Ticket expiration date/time • Other data as per the approved ticket encoding design
5.9	<p>Each TVM shall have a capacity of at least three thousand (3000) pcs of CSMs.</p> <p>There shall have 5 different operating modes for TVM, as listed in follows:</p> <ul style="list-style-type: none"> • Normal Service Mode • Limited Service Mode • Maintenance Mode • Out of Service Mode • Offline Mode
5.10	<p>For each sales transaction the TVM shall capture, store, and send to the SCS and CCS all data relevant to the sale. This data shall be used for the generation of all sales reports and any additional processing required by the CCS. Sales transactions shall be transmitted to the CCS as part of the polled data</p> <p>The data captured for each sale shall include, at a minimum:</p> <ul style="list-style-type: none"> • Transaction sequence number • TVM ID • TVM location
5.11	
5.12	

Pos	Requirements
	<ul style="list-style-type: none"> • Date and time of purchase • Tickets purchased: <ul style="list-style-type: none"> ➢ Serial number ➢ Origin/destination ➢ Special event ID (if applicable) ➢ Type (SJT/RJT or Concession) ➢ Fare category ➢ Purchase Price ➢ Expiration date/time ➢ Quantity • Total purchase price • Payment method • Funds received (cash only) • Change issued (cash only)
6	Passenger Service Machines
6.1	The Passenger Service Machine (PSM) shall provide a point of sales for various types of ticket, which will be operated by station staff instead of being full automatic. The PSM must have self-explanatory and user friendly interfaces to ensure quick and efficient sale operations to cater for high passenger volumes.
6.2	The PSM shall record all transactions included sales activities, non-sales activities and must be able to produce sales report (revenue and non-revenue) and end of shift report. The PSM shall perform the following but not limited to: <ul style="list-style-type: none"> • Sell, issue, encode, analyse, revalue, revalidate, replace, refund, and upgrade CSC • Accept payments in various methods such as credit card, debit card and cash • Issue transaction receipts to passengers • Generate end of shift reports • Perform hardware and sub-modules diagnostics
6.3	<ul style="list-style-type: none"> • Send transaction data to the SCS • The PSM shall encode/issue the CSC for the following transaction but not limited to: <ul style="list-style-type: none"> • Single Journey Ticket sales • Stored Value Ticket (SVT) sales and revalue • Season Pass sales and revalidation • Day Pass sales and revalidation • Complimentary Ticket issuance
6.4	The PSM shall be able to analyse and upgrade tickets and apply penalty or administrative charges as applicable.
6.5	The PSM shall be able to perform ticket replacement and refund transactions. The replacement and refund transactions must be recorded in the revenue system as "replacement" and "refund" accordingly. This is to ensure the money returned back to customer is accounted properly.
6.6	The PSM shall not issue Maintenance Pass, Test Ticket and Staff Pass.
6.7	The system shall ask for an operator's username and password. Both of the fields are numeric, and the details shall be inserted by using keypad buttons on the system's user interfaces. The system shall not take more than 5 seconds to authenticate a log in. The PSM system shall consist of the following major components: <ul style="list-style-type: none"> • CSC issuer • Touch Screen • Workstation • Passenger Information Device • Receipt Printer • CSC Reader

Pos	Requirements
	<ul style="list-style-type: none"> • Revenue Drawer • Communication Interface • Power Supply, including small UPS <p>The PSM shall have capability to update the following without disrupt the PSM operation by download process but not limited to:</p>
6.9	<ul style="list-style-type: none"> • PSM Application • Fare Table • Configuration and Parameter files
6.10	<p>The PSM system shall store a record of sales totals for the current shift and print it at the end of shift when an operator logs out.</p>
7	<p>Mobile Validator</p> <p>The Mobile Validator contains a CSM reader, processor, data storage, display, network port, rechargeable battery pack and a pouch for keeping collected ticket</p> <p>The Mobile Validator shall meet, at a minimum, the following functional requirement:</p> <ul style="list-style-type: none"> • Validate CSM via a read and update of the appropriate fare products and value. • Validation shall take no more than 0.3 seconds for processing of fare payment transactions. • Provide real time, resettable passenger counting for capacity management. • Provide visual indication of validation status via the passenger display and coloured LEDs. • Validation shall be accompanied by distinct audible tones suitability loud for environment, to indicate the passenger both successful and unsuccessful validation of the fare media. • Allow configuration Mobile Validators from the CCS to restrict the use of tickets to only the routes for which they were issued and provide the parameters for capacity management. • Have the capability to retain and automatically activate all the LRT fare structures. • Record all validations in the existing transaction format. • Transmit all data transactions and event data to the CCS. <p>The ticket inspector shall use the Mobile Validator to check and update the ticket information including but not limited to:</p> <ul style="list-style-type: none"> • CSM serial number • Mobile Validator serial number • Staff id of ticket inspector • Entry / Exit station number • Issue date • Issue time • Transaction amount • Last station of entry • Remaining value • Concession type (Adult, Student etc) • Expiry date • Transaction date and time
7.3	<p>Electrical Connectors</p> <p>8.1 All electrical connectors shall be made of lightweight alloy body (die cast).</p> <p>8.2 All connections shall have a catch or fastener to prevent accidental disconnection.</p> <p>8.3 All connections, including those to coin vaults, shall withstand the vibration present within the AFC system equipment.</p>
9	<p>Power Failure</p> <p>The AFC equipment shall have station UPS backup, provided by others and shut down in a controlled manner. It must not lose data or passengers' money during the switch over from normal supply to UPS and vice versa. The</p>

Pos	Requirements
	Station UPS provided by others may not provide a smooth transition. All equipment holding data or money shall handle such conditions.
10	Electronic Control Units (ECU) for Gates and TVMs The control of ticket processing, passenger interface, data communications, operation and all other functions of the TVMs and gates shall be performed by an ECU. As far as practical ECUs shall be physically and functionally interchangeable between the Gates and TVMs. The ECU shall be micro-processor based with adequate capacity to provide the specified functions. Adequate power fail safe features shall be included to prevent any data corruption in the event of power interruption. The ECU shall ensure standalone operation of the equipment should any loss of communication with the controlling computer occur, except those requiring updated information from the controlling computer. The operation of the ECU shall be controlled by program code downloaded via data links from the Central Computer and alternatively by portable device to up load and down load data manually for each individual AFC equipment. There shall be a fail-safe means of detecting ECU failure with the ability to reset it when necessary. The ECU shall contain diagnostic provisions to assist the technician with "trouble-shooting" and fault identification. These provisions shall include controls and a display at the Maintenance Panel of important equipment functions. A test of all displays and indicators shall be included within each ECU. All major fault conditions (in addition to test of various elements, such as displays and keyboard functions) shall be identified to enable rapid "trouble-shooting".
11	Station Computer Room The Station Computer System receive all system operating parameters including date, time, fare tables, user ID and blacklists from the CCS and disseminate it to AFC Equipment. It also downloads application software upgrades and performs version checks. The Station Computer System shall receive all transactions, events and error message data from the AFC equipment and transfer to CCS. The SCS shall be able to control and command PSM, Gate and TVM. The SCS shall be able to command equipment including but not limited: <ul style="list-style-type: none">• Change gate, PSM and TVM modes into in service, out of service, incident and emergency mode• Set reversible gates into entry, exit or bi-directional mode.• Activate or change equipment configuration.• Open gates in array for emergency.• Lock or Open one or all entry gates in array.• Lock or Open one or all exit gates in array.• Set time of the Gate, PSM and TVM.• Cancel alarm The SCS shall also be able to request the following from Gate, PSM and TVM: <ul style="list-style-type: none">• Current status of the equipment.• Current mode of the equipment.• Current version of the application running at equipment.• Current version of parameter.• Alarm occur at equipment The normal communication mode of the Station Computer System is to transmit and receive data to and from the CCS via the wide area data communication links provided by Communication System. However, an alternate secure data exchange by floppy/compact disks, USB devices and laptop is possible. The Station Computer System shall be able to store data from equipment for a minimum period of thirty (30) days.
11	Central Computer System (CCS) The CCS shall provide the following features: <ul style="list-style-type: none">• Repository for all status, event, alarm, command, configuration and transaction data.• Real time device status, event and alarms.

Pos	Requirements
	<ul style="list-style-type: none"> • Real time command and control of devices. • Management of configuration and operating parameters (such as, fare tables, equipment configuration and User id) • Transaction consolidation and reporting. • Interface to upload data from text file, spreadsheet format and other most commonly used format provided by others into database
12 Initialization Machine (IM)	
12.1	The IM shall use the common Contactless Smart Media Electronic module (CSM-EM). The IM shall perform the following main tasks: <ul style="list-style-type: none"> • Initialize new CSM (personalized or non-personalized) • Issue SVT and SP with pre-encoded value or period for distribution to outside agents (if required) • Issue test tickets • Issue Staff Travel Pass or Maintenance Pass.
12.4	All tickets stock shall be inserted manually into the hoppers prior to being processed by the IM and output from the IM back into hoppers for distribution.
12.5	The rate of encoding of tickets from a hopper shall not be less than 10000 tickets per hour.
12.6	Location of the IM shall be the secure area. Under normal operating conditions the IM shall communicate with the CCS that shall generate audit and summary information and monitor the performance. Data shall be transferred from the IM to the CCS on regular basis so that status and audit information can be displayed and/or printed at the CCS.
12.7	In the event of failure of communication link between the IM and the CCS, the IM shall be able to operate and shall store all data for later transmission. Data storage shall be sufficient to allow standalone operation for thirty (30) days without any loss of data. An alternate means of data transfer shall also be provided.
13 Data Retention	
13.1	In the event of loss of communication between CCS, SCS and other AFC equipment, all AFC equipment shall be capable of operating in standalone mode with a minimum retention of all transaction data for a period of thirty (30 days).
13.2	Should there be a prolonged communication failure between the equipment and the SCS or CCS, it shall be possible to manually retrieve data from the individual equipment via a laptop computer or other portable device.
13.3	All AFC equipment shall be able to store all the blacklisted ticket serial numbers, ranges and bitmap files for detection of blacklisted tickets.
14 Level of Security	
14.1	When any door/cover permitting access to the areas of the equipment containing tickets or money is opened and closed, status signals shall be sent to the station computer.
14.2	Access to the interior of equipment cabinets shall be restricted. Locks and mounting attachments shall be such that an attempted forced entry by punching the exterior surface to remove the lock cylinder shall not result in door openings. Any attempted force entry, shall trigger an audible alarm and shall be recorded by SCS and CCS
15 Electronic Tagging	
15.1	All equipment used on the AFC system shall be configured with an electronic ID and has a serial number to enable equipment traceability and usage for reliability purposes.
15.2	All major modules shall be electronically "tagged" so that they can be uniquely identified when put into service in any equipment, and their run time logged.
15.3	Major modules, which consider critical, are to be installed with a radio frequency tag or a contact type tag which shall automatically transmit its ID once the modules are in place. Other modules shall be also installed with either radio frequency or contact type interface to provide identification.
16 Testing Facility	
16.1	The Test Facility shall be provided which shall be a reference system to the live AFC System where it shall be equipped with all the central and station level AFC equipment. It shall use the same equipment and software version as the live system.

Pos	Requirements
	<p>The Test Facility shall enable the Employer to carry out, but not limited to, the following:</p> <ul style="list-style-type: none"> • Conduct refresher operational and maintenance AFC training to staff or training to new staff. • Perform operational parameter testing prior to download to live system • Carry out ticket quality operational cycle test • Perform testing of new spares and components prior to trial at the live system
16.2	17 Station LAN
17.1	All AFC equipment, including Gate, TVM, PSM, etc shall be connected to the AFC system through the station LAN. The Station LAN is a 100 BASE-T Ethernet.
17.2	The station LAN will be connected via CTS provided by Communication system and its structure shall be based on IP based network.
18	Power Supply
	<p>The power supply module for all AFC equipment shall be required to conform to the following features:</p> <ul style="list-style-type: none"> • Switching mode type • Over voltage protection for all output • Over current protection for all output • Transient protection • Ripple and noise less than 1 % or 100 mV p-p • Efficiency more than 70% • MTBF = 100,000 hours
18.2	The power supply module shall have at least 40% spare power capacity.
19	Auxiliary Power Source
19.1	The auxiliary power source shall permit reading the register data after a long period (min 100 hours) when the power is restored. This battery or another energy source shall be sufficient to return a ticket in the transport upon failure of the equipment, and return coins to the passenger. Upon reinstatement of power, regardless of the duration of power interruption, the auxiliary power source shall be automatically recharged or restored.
20	Cabling Requirements
20.1	<p>The transmitted data between the Station Computer System and all other AFC equipment and among components within each equipment shall be adequately protected against corruption or loss due to electromagnetic interference of the type normally associated with a railway system.</p> <p>The Contractor shall take power supply from a distribution board fed by UPS. All cabling downstream of this DB is the responsibility of the AFC Contractor. The cable shall run in ducting, conduits and or underfloor trunking to be provided by the AFC Contractor complete with accessories. The cable shall run in the available ducting and or conduits provided by the Contractor. All cables shall be pest resistant and shall be adequately protected against electrical noise or electromagnetic interference. The cables employed shall be low smoke, fire retardant type and are to be approved by the Employer.</p>
21	Noise Level
21.1	Gates and TVMs shall have a noise level of less than sixty five (65) dBA at one and one-half metres from the equipment when any alarm or audible device is not in operation.
22	Identification Labels
22.1	An identification label shall be permanently attached to the outside of each gate, TVM and PSM. A metal label shall be mounted inside each cabinet indicating the manufacturer's name and model or part number, serial number, month and year of manufacture, and any change revisions incorporated.
23	Cabinet Construction
23.1	Cabinets with surfaces that are exposed to the public, including all gate console surfaces, PSM, TVM surfaces shall be clad with Stainless Steel.
23.2	Special attention shall be given to the forming of the individual parts with welds removed, and all sharp edges and corners eliminated by a radius or chamfer.
	The equipment shall be designed such that any spillage of liquid, intentional or non-intentional, shall be drained

Pos	Requirements
23.3	off without the liquid entering into the modules and components inside the gate, thus, minimizing chances of damage to the equipment and modules. All practicable fail-safe features shall be incorporated to protect against the creation of duplicate ticket IDs in the system, either through hardware or software failures
23.4	The exposed metal of the AFC equipment shall be bonded to an earthing conductor in accordance with the requirements of NFPA 70 or equivalent.

13 Platform Screen Doors (PSDs)

13.1 Platform Screen Doors (PSD)

13.1.1 Standards

Table 13.1: Standards for PSD

Pos	Requirements
1	NFPA 130 - Standard for Fixed Guideway Transit and Passenger Rail Systems

13.1.2 Functional Requirements

Table 13.2: Functional Requirements for PSD

Pos	Requirements
1	The PSD system shall prevent unauthorised person access from the station platforms to the Main Line.
2	The PSD system shall include structural frame, motorised Automatic Sliding Door, Fixed Screen, Emergency Egress Door, Emergency End Return Door, sensors, control and monitoring system, power supply and other necessary facilities.
3	The PSD system for the Jakarta LRT shall comprise transparent half height barriers with structural frames extending for the full length of the station platform and from platform floor level up to a height of 1.5m from platform finished floor level. It shall be floor mounted and entirely self-supporting.
4	No part of any sliding or hinged door or its control system or any other component used in the PSD system shall be capable of causing injury to passengers or personnel as a result of door operation. Particular attention shall be paid to detecting trapped obstacles in the sliding doors.
5	As a minimum, the following warning signage shall be provided: <ul style="list-style-type: none">• "Do Not Lean Against the Door" on all Automatic Sliding Doors;• "Keep Fingers Away from Gap Between Sliding door and Fixed Screen" on all Automatic Sliding Doors; and• "Warning that door may be opened inwards during an emergency" on all Emergency Egress Doors and the Platform End Return Doors.
6	As a minimum, the following instructions for use signage shall be provided: <ul style="list-style-type: none">• "Push bar to open" on the panic bars on the trackside of the Emergency Egress Doors and Platform End Return Doors; and• "Pull Handles to Open" adjacent to the opening handles on the trackside of the Automatic Sliding Doors.
7	The PSD system provider shall provide cabling path requirement to civil/station contractor and incorporate station design.
8	The PSD system provider shall provide necessary equipment dimension to be housed in the PSD system equipment room and the desired room size.
9	The PSD system equipment to be housed inside the PSD system equipment room include but not limited to the CCU (Central Control Unit), PDU (Power Distribution Unit) and UPS.
10	The PSD system CCU, PDU, UPS subsystems must be housed in a room that has a controlled environment.
11	The PSD system room shall only allow authorised personnel to access.
12	The PSD system equipment room shall be air-conditioned with smoke/fire alarm detectors and necessary fire mitigation controls in line with the station fire safety requirement.
13	The equipment room shall provide sufficient switch-on lighting and low voltage power outlets for PSD system maintenance staff and operators.
14	The PSD system shall maintain all metallic parts exposed to passengers or station personnel at an equal electrical potential to the body of the LRV. To prevent possible electric shock due to a potential difference between the LRV body and the PSDs, all metallic parts of the PSDs shall be electrically bonded to the running

Pos	Requirements
	rails at a position at mid-point of the platform. The PSD system shall be insulated from system earth.
15	The platform screen is to be electrically bonded to the track rail at a single point.
16	The PSD system shall have earth points for maintainers to attach equipment to when performing maintenance tasks on the PSD system.
17	The PSD system shall have a single platform screen earth bonding point to which all the screens components are electrically bonded
18	All the platforms floor level shall not have gradient.
19	All the platforms shall be in straight line.
20	All the platforms shall not have expansion joints on the platform that lies underneath the PSD structure.
21	Power supplies required to control and operate the PSD system at each station will be provided through station primary power supplies and shall be terminated by means of switched fused isolators.
22	The PSD system provider shall coordinate its power supply requirements with the station primary power supplies provider.
23	The PSD system provider shall be responsible for the power distribution from the switched fused isolators to the PSD system.
24	Any UPS or battery backed supplies necessary to support the operation of PSDs shall be provided by the PSD system provider.
25	The PSD system shall be designed to prevent any corrosion resulting from any stray current.
26	The PSD system shall facilitate operation of LRVs in either direction at any platform.
27	Each doorset shall consist of bi-parting, power operated sliding door doors.
28	The Automatic Sliding Doors shall be synchronously controlled throughout the length of the platform.
29	The PSD system shall minimise the risk of entrapment between LRV and the PSD system SFAIRP (So Far As Is Reasonably Practicable).
30	The Automatic Sliding Doors opening and closing speeds must be adjustable (per individual door) with adjustment increments of 0.1 seconds.
31	The Automatic Sliding Doors shall provide a clear opening width of not less than 1,000mm wider than the clear opening width of the LRV doors.
32	Each door mechanism shall incorporate a mechanical latch, which shall automatically engage when the door is fully closed, preventing the doors from being opened by the passengers on the platform. The mechanical latch shall release automatically when the door opening mechanism is operated.
33	The Emergency Egress Doors and the Platform End Return Doors shall be a hinged door type that opens inwards towards the platform. The lock assembly shall be fitted with an approved emergency push bar on the track side (non-passenger side), to enable quick passenger access to platform in the event of emergency condition. It shall be possible for authorised persons on the platform side to manually unlock, by means of an authorised key, and open the hinged screens without activating the emergency push bar.
34	Once the emergency push bar of these hinged doors has been activated it shall remain in the activated position until reset by means of an authorised key.
35	The Emergency Egress Doors and the Platform End Return Doors shall equip with sensor to detect upon their opening status. The sensor shall be interlocked with the "PSD Safe for Entering Indicator" situated at the track entry point of each platform.
36	Each automatic sliding door shall have a different visual indication showing the following: <ul style="list-style-type: none"> • when the Automatic Sliding Doors are closed and standby for open; • when the Automatic Sliding Doors are opened; • when the Automatic Sliding Doors are closing; • when the Automatic Sliding Doors fail to close due to obstacles or malfunctions; • when the Automatic Sliding Doors are not going to open due to door isolation.

Pos	Requirements
37	Each Automatic Sliding Door shall have a different audible messages indicating the following: <ul style="list-style-type: none">• audible buzzer when the Automatic Sliding Doors are closing;• pre-recorded announcement when the Automatic Sliding Doors are not going to open due to door isolation.
38	Each Emergency Egress Door and Platform End Return Doors shall have a different visual indication showing the following: <ul style="list-style-type: none">• when these doors are opened;• when these doors are isolated.
39	The PSD system must provide a mechanism for authorised personnel to isolate a faulty Automatic Sliding Door.
40	The PSD system must provide a mechanism for authorised personnel to isolate a faulty Emergency Egress Door.
41	The PSD system must provide a mechanism for authorised personnel to isolate a faulty Platform End Return Doors.
42	A set of local controls and indications for the local operation of the PSD system, by operations staff shall be housed at suitable locations on the platform and with protection for operation by authorised staff only.
43	In the event of failure of the normal power supply to the PSD system, the PSD system shall continue to operate from an uninterruptible power supply for a period of not less than one (1) hour.
44	In the event of failure of the normal power supply to the PSD system, warning to the Operation Control Centre shall be provided immediately when the UPS starts to provide backup power. Total PSD power lost operation procedure shall be in standby. The operator shall develop the most suitable operation procedure.
45	In the event of failure of the normal power supply and/or the UPS supply to the PSD system, the mechanism to manually unlatch the Automatic Sliding Doors, either by an authorised person on the platform side or from the trackside, shall not be affected.
46	With the exception of the structural frame and glass panels, replacement or rectification of faults of all components, sub-assemblies, or major assemblies shall be accessible entirely from the platform side and shall be capable of maintenance or replacement within a maximum time period of 3 hours.
47	If glass panels cannot be replaced from the platform side, it shall be possible to install a temporary safety screen from the platform side and such temporary safety screens shall be provided at every station.
48	When a LRV is correctly positioned at a platform, the PSD system shall receive door open command from the LRV driver who operates the door opening remotely through wireless interface inside the driving cab.
49	The LRV driver shall have on-board side cameras with instant visual graphics of passenger exchange of all the doors that are opened.
50	The opening operation of the PSD system Automatic Sliding Doors shall be synchronised with the LRV external passenger doors.
51	The mechanism to check the status of the Automatic Sliding Doors, Emergency Egress Doors, and Platform End Return Doors shall be designed to be Safety Critical.
52	The closed and latched status of all Automatic Sliding Doors shall be continuously monitored by the PSD system.
53	Each platform has a stopping position align point/marker board for driver to align the most correct stopping position.
54	The align point/marker board shall be visible for driver when the LRV enters the platform area, and the line of sight between the driver and align point shall not be obstructed by any building structures or passengers.
55	A "PSD Safe for Entering Indicator" located at each entry point of the platform shall be provided and illuminate with certain colour, when all the sliding door doors and hinged screens of that corresponding platform have proved to be closed and latched.
56	A different colour apart from green and red or illuminating frequency shall be designed for this "PSD Safe for Entering Indicator" to warn the driver it is not safe to enter the platform due to one of the sliding doors or hinged screens are not closed and latched.
57	The position of the "PSD Safe for Entering Indicator" shall be located to ensure that it can be clearly observed by the train drivers from their normal seated position.

Pos	Requirements
58	If the "PSD Safe for Entering Indicator" does not have straight line of sight to the drivers such as curve before stations, a synchronised relay indicator shall be provided within 50 metres from the original indicator upstream.
59	A "PSD Safe for Departure Indicator" located at each exit point of the platform shall be provided and illuminate with certain colour, when all the sliding door doors and hinged screens of that corresponding platform have proved to be closed and latched.
60	A different colour apart from green and red or illuminating frequency shall be designed for this "PSD Safe for Departure Indicator" to warn the driver it is not safe to depart from the platform due to one of the sliding doors or hinged screens are not closed and latched.
61	The position of the "PSD Safe for Departure Indicator" shall be located to ensure that it can be clearly observed by the train drivers from their normal seated position.
62	The PSD system automatic sliding door opening and closing speed and delay times must be coordinated with the proposed rolling stock to achieve synchronised movement with the proposed rolling stock doors.
63	The PSD system must be able to accommodate single LRV formation (30m) up to three LRVs formation (90m).
64	The PSD system must allow egress from the proposed rolling stock, irrespective of the proposed rolling stock stopping position.
65	Each PSD system automatic sliding door must be located such that its opening centre line aligns with the opening centre line of the corresponding rolling stock external door.
66	The PSD system automatic sliding door opening width shall be as wide as the proposed rolling stock doors plus two times the desired stopping accuracy margin (0.5m).
67	The proposed rolling stock doors shall be sliding door instead of plug doors.
68	The PSD system must provide an access point to allow the authorised staff to manually operate the LRV emergency door release device from the platform.
69	The access point for operating the LRV emergency door release device shall only be accessible by authorised personnel with authorised key.
70	The proposed rolling stock shall have on-board side cameras with instant visual graphics of passenger exchange of all the doors that are opened. The instant visual images shall be displayed in the driving cab for driver to monitor the whole passenger exchange process.
71	The proposed rolling stock shall have remote PSD system automatic sliding door open and close switch inside the driving cab. The remote control shall only control the PSD system of the own platform.
72	The remote PSD system automatic sliding door opening switch shall have built in relay with LRV brake system and the PSD system automatic sliding doors would only respond to function when the LRV is immobilised (when brakes are applied).
73	The proposed rolling stock shall have stopping position checking mechanism and an indicator inside the driving cab providing information that the LRV is stopped within the correct range for PSD system automatic sliding door opening. If the LRV is stopped outside this range, the checking circuit shall not grant PSD system automatic sliding door opening command even when driver presses the door open button.

13.1.3 Performance Requirements

Table 13.3: Performance Requirements for PSD

Pos	Requirements
1	All materials and equipment for the PSD system shall be proven design and shall be provided by a manufacturer who has accomplished platform screen door system projects within the last 10 years.
2	The Design Life for the PSD system shall be 30 years with the need for refurbishment running not less than 15 years into this period.
3	The PSD system shall comply with the appropriate requirements of NFPA 130, and in particular the emergency egress from the LRV to the platform shall be possible regardless of the stopping position of the LRV.

Pos	Requirements
4	The materials used in the PSD system shall: <ul style="list-style-type: none">• not introduce a significant fire load into the station;• not be a cause of flame spread; and• be constructed of materials, which minimise smoke and heat emission and shall not generate toxic gases during fires.
5	All doors shall be constructed of toughened glass and be compliant with relevant Indonesian National Standard.
6	The PSD system shall be designed and constructed to ensure a high level of electromagnetic compatibility (EMC) in accordance with IEC 61000-2-7.
7	The design of the PSD system shall also ensure that no permanent deformation is caused from the effects of cyclic and repetitive loading associated with crowd load, impact, wind and/or train movements over the Design Life of the PSD installation.
8	The structural design of the PSDs shall take into account the following air pressure effects: <ul style="list-style-type: none">• when LRVs enter into and depart from or pass through any station, also taking into consideration the most onerous operation speed and the physical characteristics of the LRV and the Civil Infrastructure; and• wind loadings.
9	The design of the PSD system shall be such that the system as installed will resist all expected combinations of loading conditions, throughout the Design Life of the installation.
10	For those electrical equipment located with exposure to outside environment such as Door Operation Indicators (DOI), Door Control Unit (DCU), etc., They shall have minimum protection level of IP54 or above.
11	Local Control Panel (LCP) located at the platform area must have minimum protection level of IP67 or above and should be covered with canopy.

14 Depot Equipment

14.1 Depot Equipment

14.1.1 Functional Requirements

Table 14.1: Functional Requirements for Depot Equipment

Pos	Requirements
1	The auxiliary vehicles shall be capable of performing works for Jakarta LRT network include but not limited to – Viaduct maintenance, track maintenance, third rail maintenance, rescue operation, shunting LRVs within the depot.
2	The auxiliary vehicles shall be self-powered through petrol or diesel instead of LRV traction power.
3	The auxiliary vehicle for shunting inside the maintenance workshop shall generate the least exhaust as possible. If possible, an electrical shunter can be used.
4	The auxiliary vehicle shall have the same coupler device as used on LRV.
5	The lifting jacks shall have enough lifting and carrying capacity for lifting the selected LRV.
6	The lifting jacks shall be synchronised in both rising and lowering, and shall be controlled through a master controller.
7	For the Jakarta LRV with 30 metres, 8 lifting jacks shall work together as a group.
8	The lifting jacks shall have safety push to stop buttons on all the liftings devices, and shall be synchronised to stop all other lifting devices within the same group..
9	The repair workshop area has a dedicated electronic room area to repair components such as SIV, battery, air-conditioning HVAC units, traction system, coupler, etc. These rooms should be air-conditioning and provide a working environment with sufficient lighting and ventilation.
10	The dedicated bogie repairing workshop should have the necessary facility for bogie repairing such as bogie cleaning facility, hydraulic bogie press, bogie hoist, bogie loading testing benches, wheel boring stand.
11	The Automatic Train Wash Plant shall have a 20 metre non-third rail zone in the washing area.
12	The Automatic Train Wash Plant shall have working environment with anti-slippery floor surface and with safety railing for area on the 1st floor.
13	The local control panels of Automatic Train Wash Plant shall have good water proof and located away from the adjacent third rail.
14	The water tank, compressor and other subcomponents of the Automatic Train Wash Plant can be located on the ground floor separate from the wash plant which is on the 1st floor.
15	The Manual Train Wash Plant shall have anti-slippery platform for cleaning staff to stand on.
16	The Manual Train Wash Plant platform shall be high enough away from the third rail for safety purposes.
17	Third rail within the Manual Train wash Plant shall be covered and should have good water proof environment.
18	For safety purposes, the ground level third rail sections coming from outside of the workshop shall end before the stinger transition zone.
19	The stinger transition zone shall start within 20m after the end point of the third rail, allowing at least one LRV of 30m to have the leading end to arrive at the transition zone while the trailing end still has traction contact to the third rail.
20	Along the stinger conductor rail the necessary collecting trolleys, trailing cable and power plug shall be moveable and shall be moved together with the LRV within the recess area and stinger transition zone.
21	The desired rolling stock shall have compatible secured and locked socket to allow the stinger power plug to be plugged in while traveling within the recess area.
21	The desired rolling stock shall have the sockets on both sides.
22	When the stinger system is not in used, proper isolation status of power feed to the overhead conductor rail must be visually visible within the entire recess area, and the stinger cable and power plug shall be securely fasten and tighten to a safe manner.

Pos	Requirements
23	The Underfloor Wheel Lathe should allow maintenance staff to work with good ventilation environment.
24	The underfloor wheel lathe should have safety stairs or pathways for maintenance staff to get to underneath the LRV and operate the underfloor wheel lathe.
25	The Underfloor Wheel Lathe shall have swarf delivery mechanism and swarf crusher to transport the shaved swarf material to the collector bin outside the hut.
26	The painting booth shall have length to cater a 30 metre LRV to be painted at once.
27	The painting booth does not have third rail system therefore shunter is required to move the LRV in and out from the painting booth.
28	Paint booth will require equipment such as spraying facility, compressor and water treatment equipment, and the draining of paint booth should ensure environmental friendliness in the surrounding area.
29	The storage for the paint should be kept in area with good ventilation environment, any flammable material must be kept away from the infrastructure in a dedicated hut.
30	The paint booth chimney exhaust system shall generate clean emission which does not affect the overall environment of the depot area

14.1.2 Performance Requirements

Table 14.2: Performance Requirements for Depot Equipment

Pos	Requirements
1	The contractor shall take line alignment with gradient into considering when calculating the vehicle rescuing ability. And provide the most feasible rescue operation auxiliary vehicle.
2	The Automatic Train Wash Plant drive through speed for LRV shall be no less than 5km/h and still provide a front, side, top cleaning of the passing LRV.
3	The Automatic Train Wash Plant shall clean a 90 metre LRV under the retrieving headway time agreed by the operator.
4	The underfloor wheel lathe shall make sure each LRV wheelset can be re-profiled within 1 hour.

15 Rolling Stock

15.1 Application to this Contract

The rolling stock is to be designed, manufactured and delivered, tested and commissioned under separate procurement.

Spare part and tools for the rolling stock are to be separately procured. Integration of the system is included within this Contract, including Training is included within this Contract.

15.2 Training

15.2.1 Training Programme

1. A Training Programme shall be provided which includes the scope and training content for the operation, maintenance, re-railing and cleaning of the LRVs.
2. All training materials for the courses and forms of training shall be given in such a way that others can disseminate that training in due course.
3. The training documentation shall be provided in the Bahasa Indonesian and English language.

15.2.2 Driver Training

The Supplier shall train 6 Drivers and 2 Instructors, which shall be split into 2 or 3 groups of trainees, to a point where they can safely operate the LRV under all circumstances on Jakarta LRT network. This training shall include:

1. Appropriate technical overview;
2. Familiarisation with Driver Manuals;
3. LRV control and performance under normal operation;
4. LRV control and performance under abnormal operation;
5. Simple fault recognition and rectification;
6. Recovery procedures; and
7. Evacuation procedures.

15.2.3 Maintenance Staff Training

The Supplier shall train all the Operator's maintenance staff, which shall be split into a suitable number of groups of trainees, in order that they can maintain and repair the LRVs. This training shall include:

1. Detailed technical information on all LRV systems functionality
2. Fault diagnostic procedures
3. Familiarisation with Maintenance Schedules, Instructions and Procedures
4. Familiarisation of Spares Catalogues
5. Repair procedures
6. Recovery procedures, including re-railing and wheel-skate use
7. Use of Special Tools and test equipment
8. LRV Cleaning

15.2.4 Emergency Services Training

Suitable training for the relevant emergency services shall be provided, including Fire, Police and Ambulance services as required.

This training shall include:

1. Emergency isolation procedures
2. Lifting
3. Pushing/towing
4. Overview of emergency isolation devices and equipment
5. Emergency access

16 Architectural Outline

16.1 General

This outline specification for Architectural design works present the specific requirement for the material and components of design to be applied in the Jakarta LRT project.

The Contractor shall ensure that these requirements are strictly adhered to when carrying out the Works, unless otherwise instructed.

16.2 Quality

16.2.1 Interpretation

16.2.1.1 Definitions

For the purposes of this work section the following definitions apply:

- Quality package: a designated part of the works for which an individual quality system is required.
- Contractor: the supplier of a product to the Client within the defined quality package. Includes the contractors' subcontractors and suppliers.
- Product: that which is supplied by the contractor, which may be either tangible (e.g.: a built item); intangible (including services such as design and delivery of tangible product) or both.

16.2.1.2 Interfacing Details

Co-ordinate all interfacing details and submit these as part of the shop drawing package for each interfacing material.

16.2.1.3 Warranty

List of warranties to be submitted by the Contractor:

Table 16.1: List of Warranty

Warranty	Period	Warranty Provided by	Against
Architectural structural steel	15 years	Contractor, Contractor's designer and supplier	All defects in design, material and workmanship
Fire stopping	10 years	Contractor and supplier	All defects in materials and workmanship
Waterproofing	10 years	Contractor and supplier	All defects in materials and workmanship
Roof sheeting systems	15 years	Contractor, Contractor's designer and supplier	All defects in design, material and workmanship
Stainless steel gutters	5 years	Contractor, Contractor's designer and supplier	All defects in design, material and workmanship
Stainless steel components, railings, bars, rods, hollow	15 years	Contractor,	All defects in design,

Warranty	Period	Warranty Provided by	Against
sections, cables, etc.		Contractor's designer and supplier	material and workmanship
Sealants	15 years	Contractor, Contractor's designer and supplier	All defects in design, material and workmanship
Pre-finishes	15 years	Contractor, Contractor's designer and supplier	All defects in design, material and workmanship
Overall metal cladding systems	15 years	Contractor, Contractor's designer and supplier	All defects in design, material and workmanship
Overall stone cladding systems	15 years	Contractor, Contractor's designer and supplier	All defects in design, material and workmanship
Glazing	15 years	Contractor, Contractor's designer and supplier	All defects in design, material and workmanship
Overall louvre cladding system	15 years	Contractor, Contractor's designer and supplier	All defects in design, material and workmanship
Overall roof system including canopy	15 years	Contractor, Contractor's designer and supplier	All defects in design, material and workmanship
Skylight	15 years	Contractor, Contractor's designer and supplier	All defects in design, material and workmanship
Stainless steel linings	15 years	Contractor, Contractor's designer and supplier	All defects in design, material and workmanship
Cladding system pre-finishes	10 years	Contractor, Contractor's designer and supplier	All defects in design, material and workmanship
Aluminium panelling system	15 years	Contractor, Contractor's designer and supplier	All defects in design, material and workmanship
Vitreous Enamel Panelling	15 years	Contractor, Contractor's designer and supplier	All defects in design, material and workmanship
Aluminium louvres and grilles	10 years	Contractor, Contractor's designer and supplier	All defects in design, material and workmanship
Polyester powder coating system	10 years	Contractor and supplier	All defects in materials and workmanship
Fluorocarbon coating system	10 years	Contractor and supplier	All defects in materials and workmanship
Proprietary door sets	5 years	Contractor, Contractor's designer and supplier	All defects in design, material and workmanship
Ironmongery (workmanship/installation)	12 months	Contractor and supplier	All defects in materials and workmanship
Ironmongery (materials/mechanism)	5 years	Contractor and supplier	All defects in materials and workmanship
Ceiling systems	15 years	Contractor, Contractor's designer and supplier	All defects in design, material and workmanship
Ceiling component pre-finishes	10 years	Contractor, Contractor's designer and supplier	All defects in design, material and workmanship
Partitions and linings – proprietary wall access panels	5 years	Contractor, Contractor's designer and supplier	All defects in design, material and workmanship

Warranty	Period	Warranty Provided by	Against
Proprietary and fabricated metalwork items and components, generally	15 years	Contractor, Contractor's designer and supplier	All defects in design, material and workmanship
Fall arrest safety system	5 years	Contractor, Contractor's designer and supplier	All defects in design, material and workmanship
Fixed furniture items	10 years	Contractor, Contractor's designer and supplier	All defects in design, material and workmanship
Joinery, furniture item and component	10 years	Contractor, Contractor's designer and supplier	All defects in design, material and workmanship
Sanitary accessories	5 years	Contractor, Contractor's designer and supplier	All defects in design, material and workmanship
Floor and wall tiling	15 years	Contractor and supplier	All defects in materials and workmanship
Precast concrete tiling	15 years	Contractor and supplier	All defects in materials and workmanship
Access floor system	5 years	Contractor, Contractor's designer and supplier	All defects in design, material and workmanship
Proprietary paint systems and components	5 years	Contractor and supplier	All defects in materials and workmanship
Fire protective coatings	10 years	Contractor and supplier	All defects in materials and workmanship
Proprietary signage systems and components	7 years	Contractor, Contractor's designer and supplier	All defects in design, material and workmanship
Floor hardener	10 years	Contractor and supplier	All defects in materials and workmanship
Hardscape	10 years	Contractor, Contractor's designer and supplier	All defects in design, material and workmanship

16.2.1.4 Use

It is intended that this specification defines the standards and requirements for the project set out in the drawings and documents. Where changes/substitutes/deletions arise through the course of the work these should be recorded for future reference.

16.2.1.5 Referenced Documents

Use referenced documents which are editions, with amendments, current 3 months before the commencement date of construction, except where other editions or amendments are required by statutory authorities.

For the purposes of this specification, where standards provide information in imperial units it shall be converted to metric in accordance with SNI 19-3213, SNI 19-2746.

Where the standards referred to in this specification make recommendations or suggestions, these shall be taken as mandatory requirements.

In the event of conflict or contradiction between referenced standards, or within this specification, the strictest requirement shall be adopted.

16.2.1.6 Contractual relationships

Read all architectural drawings in conjunction with the structural and services design including combined services drawings (CSD) and structural electrical and mechanical (SEM) drawings and other installation drawings issued on the project.

Verify all dimensions on site prior to the start of the works.

Resolve any discrepancies on site prior to the start of the works.

16.2.1.7 General standards

Units of measurement:

- To SNI 19-3213, SNI 19-2746. Building Law of Indonesia No. 28/2002.
- All material for structure and interior finishes shall meet non-flammable or semi non-flammable (semi non-combustible) or fire retardant requirements in accordance to ISO 5660-1. In case of proposing other than non-flammable and/or fire retardant material, it needs to be tested by Cone Calorimeter (ISO 5660-1).
- Non-Combustible: To SNI 1740-2008.
- Peraturan Kayu Indonesia, PPKI-NI-5/1961.
- Persyaratan Umum Bahan Bangunan Indonesia (PUBI-1992) NI-3.
- Plumbing and drainage: To SNI 02-2406-1991, SNI 03-6481-2000.

16.2.1.8 Interpretation

The following definitions apply:

- Accepted: "Accepted", "reviewed", "directed", "rejected", "endorsed" and similar expressions mean "accepted (reviewed, directed, rejected, endorsed) in writing by the Client/consultant.
- Client/Consultant's Representative: Any person appointed by the Client/Consultant to assist him in his duties or to perform any other duties assigned to him by the Client/Consultant.
- Exterior: "Exterior" and "External" refer to spaces outside the perimeter wall of the building.
- Give notice: "Give notice", "submit", "advise", "inform" and similar expressions mean "give notice (submit, advise, inform) in writing to the Client/Consultant.
- Interior: "Interior" and "Internal" refer to building spaces within the perimeter wall of the building.
- Obtain: "Obtain", "seek" and similar expressions mean "obtain (seek) in-writing from the Client/Consultant.
- Proprietary: "Proprietary" means identifiable by naming manufacturer, supplier, installer, trade name, brand name, catalogue or reference number.

- Provide: "Provide" and similar expressions mean "supply and install".
- Samples: Includes samples, prototypes and sample panels.
- Substantial completion: "Substantial Completion" and "Practical Completion" are synonymous terms.
- Supply: "Supply", "furnish" and similar expressions mean "supply only".

16.2.1.9 Technical

Zinc-coated steel: Includes zinc-coated steel, zinc/iron alloy-coated steel, and aluminium/zinc-coated steel.

Pipe: Includes pipe and tube.

16.2.1.10 Abbreviations

AAMA: American Architectural Materials Association

ABS: Acrylonitrile-butadiene-styrene

ACI: American Concrete Institute

ANSI: American National Standard Specification

ASCE: American Society of Civil Engineer

ASTM: American Society for the Testing of Materials

AWS: American Welding Society

BMS: Building management system

CFCs: Chlorofluorocarbons

CSD: Combined services drawings

EPDM: Ethylene Propylene Diene Monomer

GRP: Glass-fibre Reinforced Polyester.

ISO: International Standards Organization

JIS: Japanese Industrial Standard

KAN: Komite Akreditasi Nasional

M&E: Mechanical and Electrical
PE: Professional Engineer registered in Indonesia.
PVF₂: Polyvinylidene fluoride
PTFE: Polytetrafluoroethylene
PVB: Polyvinyl Butral (plastic interlayer in laminated glass)
QP: Qualified person (architect) registered in Indonesia.
SEM: Structural Electrical and Mechanical
SNI: Standar Nasional Indonesia
SWC: System wide contractor
STC: Sound transmission co-efficient
UDL: Uniformly distributed load
UPVC: Unplasticised polyvinyl chloride.
UV: Ultra violet light.

U-value: Heat loss, watts/square metre/degree Kelvin W/m²K

16.2.1.11 Regulatory Authority's Approvals

Arrange all inspections and approvals required by regulatory authorities in sufficient time to ensure the regular progress of the works and eliminate unnecessary delays.

Provide documentary evidence of all required inspections and approvals prior to covering work.

16.2.1.12 Contract Documents

Architectural details shown on the drawings show design intent only, except where noted otherwise.

Follow figured dimensions where provided or calculable. Before commencing work, obtain measurements and other necessary information.

Levels: Spot levels take precedence over contour lines and ground profile lines.

16.2.2 Materials and components

Product data: For proprietary equipment, to provide the manufacturer's product data including:

- Outline specifications and drawings;
- Type test reports;
- Performance and rating tables; and
- Recommendations for installation and maintenance.
- Country of origin
- Health and safety data sheets

Proposed products schedules: to provide a schedule of proprietary and custom made products proposed for use.

Product certification: If products must comply with product certification schemes, submit evidence of compliance.

16.2.2.1 Sources policy Alternatives

If alternatives are proposed, submit proposed alternatives and include samples, available technical information, reasons for proposed substitutions. If necessary, provide an English translation. State if provision of proposed alternatives will necessitate alteration to other parts of the works.

16.2.2.2 Manufacturers' or suppliers' recommendations

General: Select, if no selection is given, and transport, deliver, store, handle, protect, finish, adjust, prepare for use, and provide manufactured items in accordance with the current written recommendations and instructions of the manufacturer or supplier.

Instructions: Submit the recommendations and instructions, and advise of conflicts with other requirements.

Project modifications: Advise of activities that supplement, or are contrary to, manufacturer's or suppliers' written recommendations and instructions.

Product certification: If products must comply with product certification schemes, provide them in accordance with the certification requirements.

Benchmark of product or sample and any respective mock-up is to be provided as per the Employer requirement and subject for approval.

16.2.2.3 Sealed containers

If materials or products are supplied by the manufacturer in closed or sealed containers or packages, bring the materials or products to point of use in the original containers or packages.

16.2.2.4 Consistency

For the whole quantity of each material or product use the same manufacturer or source and provide consistent type, size, quality and appearance.

16.2.2.5 Separation

Identify all locations where contact between adjacent materials will lead to a reduction in the anticipated life span of either.

Prevent direct contact between incompatible materials by either

- Inserting an acceptable separation layer
- Coating the contact face of the materials

16.2.3 Services Connections

16.2.3.1 Statutory authorities' requirements

If the authorities elect to perform or supply part of the works, make the necessary arrangements. Install equipment supplied, but not installed, by the authorities.

16.2.3.2 Connections

Connect to statutory authorities' services or service points. Excavate to locate and expose connection points. On completion reinstate the surfaces and facilities which have been disturbed.

16.2.4 System Integration

Interconnect system elements so that the installations perform their designated functions.

16.2.5 Services Coordination

Documentation: Prepare detailed drawings of the proposed positioning of plant and equipment:

- Ensure coordination with other building and service elements.
- Show adjusted positions on the shop and record drawings.
- Provide details of all loadings imposed on the structure.

16.2.6 Building Penetration

All details of building penetrations must be submitted to the Client/Consultant and the appropriate System Wide Contractor for acceptance prior to work starting on site.

16.2.6.1 Piping sleeves

General: Provide metal sleeves formed from pipe sections, for piping penetrations through building elements.

Sleeve diameter (for non-fire rated building elements): Sufficient to provide an annular space around the pipe or pipe insulation of at least 12 mm.

Minimum sleeve thickness:

- Metal: 1 mm.

Sleeve terminations:

- If cover plates are fitted: Flush with the finished building surface.
- In floors draining to floor wastes: 50 mm above finished floor.
- In fire-rated and acoustic-rated building elements: 50 mm beyond finished building surface.
- Elsewhere: 5 mm beyond finished building surface.

Finish: Prime paint ferrous surfaces.

16.2.6.2 Cable sleeves

Provide sleeves formed from accepted non-conductive materials, for penetrations through ground floor slabs, beams and external walls by cables not enclosed in conduit. Fire rated building elements. Cross Refer: Fire Stopping

16.2.6.3 Non-Fire Rated Building Elements

Seal penetrations around conduits and sleeves. Seal around cables within sleeves. If the building element is acoustic rated, maintain the rating.

16.2.6.4 Limitations

General: do not penetrate or fix to the following without approval:

- Structural building elements including external walls, fire walls, fire doors and access panels, other tested and rated assemblies or elements, floor slabs and beams.
- Membrane elements including damp-proof courses, waterproofing membranes and roof coverings.

Membranes: If agreement is given to penetrate membranes, provide a waterproof seal between the membrane and the penetrating component.

16.2.6.5 Accuracy

Documents: Incorporate all modifications made during the progress of the work and testing period. Show any provisions for the future.

Endorsement: Sign and date all record drawings. Keep one set of shop drawings on site at all times expressly for the purpose of marking changes made during the progress of the works.

16.3 Brick laying and blockwork

16.3.1 General

16.3.1.1 Cross References

The material and workmanship for brick layer and block shall in general follow the specifications indicated in the Employer's Requirement. Refer to the General Requirements work section.

16.3.1.2 Related work sections

Refer to the following work sections: Civil & Structural Specification; Adhesives, sealants, fasteners; Plastering

16.3.2 Standard

Materials, components and detailing to adhere to the following:

- Block work to SNI 03-2156-1991, SNI-033430-1994, ASTM C90, ASTM C-652.
- Peraturan Daerah DKI Jakarta Nomor 7 Tahun 1991 Tentang Bangunan Dalam Wilayah Daerah Khusus Ibukota Jakarta.

Where required in the contract, the contractor may be asked to take responsibility for the design elements within ACI 530.1-92/ASCE 6-92/TMS 602-92 for Masonry Structures.

Masonry units: To SNI-03-6821-2002, SNI-03-6882-2002, SNI-03-6891-2002, SNI-15-3758-2004, ASTM C90. Blocks shall be constructed as solid where fire rating of wall is required.

- SNI-15-2049-2004
- SNI-03-6821-2002
- ASTM C150.
- ASTM C144-11.
- ASTM D882
- ASTM STP 992-88.
- ASTM E814.
- ASTM C270.
- ASTM C90.
- ASTM C91.
-

16.3.2.1 Definitions

Bedding:

- Face shell: Covering the parts of a hollow unit which are connected by webs, but not the webs themselves with mortar.
- Full: Covering the entire plan area of a solid unit with mortar. Brickwork and block work types:
- Standard: Brickwork and block work which is not tested for specified strength values.
- Light Weight (Autoclaved aerated Concrete) Block work : Block work with a maximum density of 600 kg/m³ and able to achieve minimum two hour fire rating with a maximum thickness of 100mm.

Compressive strength:

- Brickwork or block work: The characteristic unconfined compressive strength determined in accordance with ASTM C90; ACI 530.1-92/ASCE 6-92/TMS 602- 92 for Masonry Structures.

Face units: Bricks or blocks used in face work, including purpose-made units such as squints, sills and thresholds.

Face work: Brickwork or block work in which the form, or form and colour, of the face units and joints is visible in the completed works.

Joint:

- Bed joint: Joint formed by the mortar on which the bricks and blocks are laid.
- Control joint: Joint constructed in brickwork or block work to control and absorb movements in it.
- Flush joint: Joint that is finished flush with the surface of the bricks or blocks.
- Perpend: Joint formed between adjacent bricks or blocks laid in the same course.
- Raked joint: Joint that is raked out to a specified depth behind the face of the bricks or blocks.
- Tooled joint: A joint, including flush joint and raked joint, in which the surface is trowelled or ironed to a smooth, dense finish.

Ties:

- Cavity tie: Tie connecting two leaves of masonry that are separated by a cavity of any width.
- Head and column tie: Tie connecting masonry to a structural support.
- Type A tie: Tie not required to have specific seismic design characteristics.
- Type B tie: Tie required to have specific seismic design characteristics.
- Veneer tie: Tie connecting a masonry veneer to a frame or wall designed to resist lateral forces.

The bench mark/mock-up Sample: The Employer approved sample held by the main contractor and available for viewing during the construction periods.

16.3.3 Materials and Components

16.3.3.1 Concrete Masonry Units

Reference to SNI-03-6821-2002, with nominal dimensions: H190mm x L390mm x W100/150/200mm, or as per manufacturer standard product. Application shall refer to indicated drawings. Unconfined compressive strength (MPa): 20 MN/m².

16.3.3.2 Clay Masonry Units

Reference to SNI-15-2049-2004, with nominal dimensions: H50mm x L200mm x W100mm, or as per manufacturer standard product. Application shall refer to indicated drawings. Unconfined compressive strength (MPa): 2.8 N/mm².

16.3.3.3 Steel Components

Durability shall be in accordance with classification to ACI 530.1–92/ASCE 6-92/TMS 602-92 for Masonry Structures.

16.3.3.4 Connectors and Accessories

Durability shall be in accordance classification to ASTM STP 992–88.

16.3.3.5 Mortar Materials

- Cement type to : ASTM C91.
- Portland Cement : To SNI 15-2049-2004, ASTM C150.
- White cement : Iron salts content ≤ 1%.
- Lime : To SNI 15-0301-1989.
- Sand : Fine aggregate with low clay content and free from efflorescing salts, selected for colour and grading.
- Sand for face work:
 - Colour: to approval
 - Grading: sharp to ASTM C144-11.
- Admixtures : Plasticisers to comply with ASTM C1384-12a.
- Water : potable

Mortar mix table

Mortar type to SNI 03-6820-2002;	Mortar proportions
ASTM C1329	(cement: lime: sand)
Concrete or calcium silicate masonry	1:0.5 + water thickener

Grouted and reinforced masonry	1:0:4 + water thickener
Underpinning, high strength masonry	1:0 - 0.25:3
Other masonry	1:1:6

16.3.3.6 Mortar Mix

Batching: Use purpose made gauge boxes and mix using a mechanical batch mixer to SNI-03-6882-2002.

16.3.3.7 Grout

Composition: Cement water to SNI-03-6891-2002, ASTM C270

Characteristic compressive strength (MPa): 17MPa (full cure)

16.3.4 Face work

16.3.4.1 Single Face Walls

Location: Perimeter of plant room adjacent to structural walls, or other location as shown on drawings.

16.3.4.2 Double Face Walls

General: Select face units for uniform width and double-face qualities in single leaf masonry with face work both sides. Before starting, obtain a ruling as to which is the preferred wall face, and favour that face should a compromise be unavoidable.

Location: Plant room, or as shown on drawings.

16.3.4.3 Perforations

Exposed: Provide solid face units where perforations would otherwise be visible.

16.3.4.4 Joints

Surface: Work with a jointing tool to a dense smooth surface, except where the surface is to be bagged.

Joint profile: to approval of engineer

Depth of raking: 5mm

16.3.4.5 Colour Mixing

General: Where the colour of the face units is visible, evenly distribute the colour range of units. Prevent colour concentrations and "banding".

16.3.5 Damp-Proof Courses

16.3.5.1 Material

Standard: To ASTM D41, Class B Bitumen sheet 3.3kg/m² ; To ASTM D882 low density polyethylene tensile strength 14.4Mpa.

16.3.5.2 Installation

General: Lay in long lengths; full lap width at angles and intersections and at least 150 mm at joints. Step as necessary, but not exceeding 2 courses per step. Sandwich damp-proof courses between mortar.

Junctions: Preserve continuity of damp-proofing at junctions of damp-proof courses and waterproof membranes.

16.3.6 Cavity Walls

16.3.6.1 Minimum cavity width

Masonry walls: 50 ± 10 mm.

Masonry veneer walls: 25 mm, between the masonry leaf and the load bearing frame and 40 mm between the masonry leaf and sheet bracing.

16.3.6.2 Openings

Closure: Do not close the cavity at the jambs of external openings.

16.3.6.3 Wall ties

Stainless Steel: Durability classification to ASTM STP 992–88.

Table 16.2: Wall Ties Category Table

Classification to	Service Condition
Medium duty	Normal cavity construction and at abutments
Heavy duty	Cavities > 60 mm wide

Embedment of wall ties: Cavities > 60 mm wide: 75 mm minimum.

Wall ties in reinforced masonry: location: In unreinforced courses.

Flexible wall ties; Type: Where ties or anchors extend across control joints, provide ties or anchors which do not impair the effectiveness of the joint.

16.3.7 Control Joints

16.3.7.1 Filler material

Type: Provide compatible sealant and bond breaking backing materials which are non-staining to masonry. Do not provide bituminous materials with absorbent masonry units.

Foamed materials: Closed-cell or impregnated, not water-absorbing.

Bond breaking materials: Non-adhesive to sealant, or faced with a non-adhering material.

Primer: Required.

16.3.7.2 Installation

Cleaning: Clean joints thoroughly before sealing.

Joint width:

- Vertical joints: 20mm
- Horizontal joints: 10mm
- Sealant depth: 0.67 - 1.0 times joint width.

Toothed joints: Not permitted.

Fire rated control joints - Refer to Fire stopping work section.

General: Where a control joint occurs in an element of construction required to have a fire resistance rating, construct the control joint using fire stopping materials so that the fire resistance rating of the element is not reduced. Fire stopping: shall be in accordance with ASTM E814.

16.3.8 Bed Joint Reinforcement

16.3.8.1 Reinforcement

Material: Stainless steel welded wire mesh.

Width: Equal to the width of the masonry leaf, less 15 mm cover from each exposed surface of the mortar joint.

General: Lap 450 mm at splices. Fold and bend at corners so that the longitudinal wires are continuous. Stop 200 mm short of control joints.

In brickwork: Extend 450 mm beyond each side of openings.

Location:

- In third bed joint above bottom of wall.
- In second bed joint below top of wall.
- In first 2 bed joints above and below openings.
- In first 2 bed joints above and below head and sill flashings to openings.

Maximum vertical intervals: 500 mm.

16.3.9 Reinforced Masonry

Designation: Masonry strengthened with embedded stainless steel reinforcement, other than bed joint reinforcement. Refer to Civil & Structural Workmanship specification.

[16.3.9.1 Cleaning core holes](#)

Block work: Provide purpose-made cleanout blocks or machine cut a cleaning hole at the base of each reinforced core. Locate on the side of the wall which is to be rendered or otherwise concealed. Cover the hole with formwork and grout the core.

[16.3.9.2 Bond beams](#)

Type: Provide bond beams made from purpose-made hollow concrete blocks with reinforcement grouted in place. Type of reinforcement shall be two 12 mm diameter galvanized rods.

16.3.10 Lintels

Pre-cast Lintels shall be used. Uses of pre-stressed lintels are not permitted.

16.3.11 Finishes

[16.3.11.1 Dry bagging](#)

Preparation: Cut joints flush before bagging.

Application: Apply laying mortar to the surface using a hessian bag or similar. Flush up irregularities, but leave the minimum amount of mortar on the surface.

16.3.11.2 Textured bagging

Preparation: Cut joints flush before bagging.

Application: Apply laying mortar to the surface using a sponge float. Flush up irregularities, but leave approximately 2 mm of mortar on the surface. When initial set is reached, create texture using a hand bristle brush.

Texture: to the approval of the Engineer.

16.4 Paving and Tiling

Refer to the following work sections:

- Adhesives, Sealants and Fastenings
- Brick Laying & Block
- Cementitious Toppings
- Waterproofing
- Gratings
- Civil and Structural Specification
- Metal Fixtures
- Steel, Metals and Pre-finishes

16.4.1 Standard

The following codes/standards are references to the minimum quality acceptable for materials,/products/workmanship:

- SNI-06-0691-1996.
- SNI 03-6880-2002
- SNI 03-6883-2002
- ACI 301-10;
- ASTM C1028.
- ASTM C1329
- ASTM C911
- ASTM C207
- ASTM C144
- ASTM A1064
- ASTM D 2487
- ASTM C936,
- ASTM C140

Location	Description in Standard
External paving	External colonnade, walkways and pedestrian crossings.
External ramps	External ramps
Stairs and Steps	External stairs nosing

16.4.2 Interpretation

16.4.2.1 Tiling Definition

- Substrate: The building element to which the tiles are to be bedded.
- Underlay: An intermediate layer (e.g. render, screed or sheeting) applied to the substrate to provide a suitable surface for tile bedding.
- Separation layer: A membrane laid on the substrate beneath the bedded finish to prevent the two elements from adhering to each other.
- Waterproof Membrane: A membrane laid on the substrate beneath the underlay to prevent dampness penetrating across from one side of the membrane to the other.
- Cross refer: Waterproofing
- Isolation Membrane: A membrane laid on the substrate beneath the underlay to isolate the floor finish from stray electrical currents.
- Approved sample: To be available for inspection and benchmark review.

16.4.2.2 Paving Definition

- Class A foundation: Most sand and rock sites.
- Class S foundation: Most silt and some clay sites.
- Class M foundation: Moderately reactive clay sites.
- Light traffic: Vehicles with a gross mass < 3 t.
- Medium traffic: Vehicles with a gross mass between 3 t and 10 t, with infrequent use by heavier vehicles.
- Density ratio: Percentage of the maximum density at optimum moisture content as determined.
- Dry Lay: The layout of paving as defined on the drawings prior to placing for the purposes of verifying the colour, tone and texture of individual units.

16.4.3 Materials and Components

16.4.3.1 Tiles and Accessories

Slip resistance of floor tiles: To ASTM C1028.

16.4.3.2 Fully vitrified homogeneous ceramic tiles/ nosing tiles

- Dust-pressed ceramic tiles with water absorption of equal or less than 3%.

- Bending strength of greater than 27 N/mm².
- Hardness greater than 6 Mohs and impact resistance of greater than 20.
- Special matching nosing tile where indicated on the architectural drawings.
- Colour and type of tile shall be selected and approved by the Client/Engineer.

A proposal must be submitted proposals for the protection of all exposed edges.

Provide tile accessories which match the composition, colour and finish of the surrounding tiles.

For coves, nosing and skirting provide matching stop ends and internal and external angle tiles moulded for that purpose.

16.4.3.3 Adhesives

Adhesive based material: PVA (polyvinyl acetate) and shall not be used for wet areas or external.

Provide adhesives which compatible with the materials and surfaces to be adhered.

Prohibited uses: Do not provide the following combinations:

- Cement-based adhesives on metal, painted or glazed surfaces, gypsum-based plaster.
- Organic solvent-based adhesives on painted surfaces.
- Organic PVC-based adhesives and organic natural rubber latex adhesives in damp or wet conditions.

16.4.4 Mortar

16.4.4.1 Materials

Cement type to ASTM C1329 / C1329M-12.

- White cement: Iron salts content ≤ 1%.
- Off-white cement: Iron salts content ≤ 2.5%.
- Lime: To ASTM C911 – 06; ASTM C207.
- Sand: Fine aggregate with a low clay content selected for grading.
- Water: To ASTM C144.

16.4.4.2 Bedding mortar

Proportioning: Select proportions from the range 1:3 - 1:4 cement: sand to obtain satisfactory adhesion.

Provide minimum water. Mixing: To ASTM C144.

16.4.5 Grout**16.4.5.1 Type**

Cement based proprietary grout: Mix with water. Fine sand may be added as filler in wider joints.

Portland cement based grout: Mix with fine sand. Provide minimum water consistent with workability.

- For joints < 3 mm: 1:2 cement : sand.
- For joints ≥ 3 mm: 1:3 cement : sand.

16.4.5.2 Pigments

Pigments for coloured grout: Provide colourfast fillers compatible with the grout material. For cement-based grouts, provide lime-proof natural or synthetic metallic oxides compatible with cement.

16.4.5.3 Epoxy Grouts

To be used in areas subject to chemical attack. Epoxy grout with two (2) part pack to be mixed each time colour to approval.

16.4.6 Substrates

Substrate shall be in accordance with: SNI 03-0106-1987

16.4.6.1 Drying and shrinkage

Before tiling, allow at least the adequate times to elapse (for initial drying out and shrinkage) for these substrates, as per the manufacturer/supplier recommendation (to comply with the local regulation and the respective industry standard):

- Concrete slabs.
- Concrete block work.
- Toppings on slabs and rendering on block work.

16.4.6.2 Isolation Membrane

Where required by the drawings, provide an isolation membrane to the requirements of the Client/Consultant. For waterproof Membrane shall refer to work section "Waterproofing".

16.4.7 Tiling in General**16.4.7.1 Sequence**

Fix wall tiles before floor tiles. Leave the base course of wall tiles. Fix floor tiles.

Scribe base course to floor profile leaving 6mm joint for sealant.

Cutting: Saw cut tiles neatly to fit around fixtures and fittings, and at margins where necessary. Drill holes without damaging tile faces. Saw cut recesses where necessary for fittings such as soap holders. Rub edges smooth without chipping.

Laying: Return tiles into sills, reveals and openings. Butt up to returns, frames, fittings, and other finishes. Strike and point up beds where exposed.

16.4.7.2 Variations

Mix tiles or tile batches before laying to distribute variations in hue, colour, or pattern uniformly.

16.4.7.3 Waterproof Membrane

Check that waterproof membranes are in place before commencing tiling where required e.g. showers/toilets on suspended slabs.

16.4.8 Setting Out

Joint widths: Set out tiles to give uniform joint widths within the following limits:

- Internal tiling: 1.5 - 3 mm.
- External tiling: 3 – 5 mm.
- Mosaic Nominal 2 mm or as dictated by pattern.

Quarry tiling: 6 - 12 mm.

Chemical resistant epoxy jointed floor tiling: 5 - 6 mm.

Joint alignment: Set out tiling with joints accurately aligned in both directions and wall tiling joints level and plumb, to a tolerance of ± 2 mm in 2 m from the design alignment.

Margins: Provide whole or purpose-made tiles at margins where practicable, otherwise set out to give equal margins of cut tiles. If margins width is less than half tile width are unavoidable, locate the cut tiles where they are least conspicuous.

Fixtures: If possible position tiles so that holes for fixtures and other penetrations occur at the intersection of horizontal and vertical joints or on the centre lines of tiles.

Continue tiling fully behind fixtures which are not built in to the tiling surface. Before tiling ensure that fixtures interrupting the tile surfaces are accurately positioned in their designed or optimum locations relative to the tile layout.

16.4.9 Falls and Levels

General: Grade floor tiling to even and correct falls to floor wastes gratings and elsewhere as required. Make level junctions with walls. Where falls are not required lay level.

Fall, as shown on drawings general: 1:100 minimum

Fall, in shower areas: as shown on drawings: 1:60 minimum.

Deviation: Maximum deviation of the finished floor level between points of contact under a 2 m straight edge laid in any direction on an area of uniform grade to be 1:300 or 3 mm, whichever is the lesser.

Sudden changes of level will not be accepted.

Maximum difference in level between two adjacent tiles: 0.5mm

Change of finish: Maintain finished floor level across changes of floor finish including carpet.

16.4.10 Bedding

16.4.10.1 Preparation of Tiles

Adhesive bedding: Fix tiles dry; do not soak.

Mortar bedding: Soak porous tiles in water for half an hour and then drain until the surface water has disappeared.

Use bedding methods and materials which are appropriate to the tile, the substrate, the conditions of service, and which leave the tile firmly and solidly bedded in the bedding material and adhered to the substrate. Form falls integral with the substrate.

16.4.10.2 Thin adhesive beds

General: Provide only if the substrate deviation is less than 3 mm when tested with a 2 m straight edge. Cover the entire tile back with adhesive when the tile is bedded. Thickness: 1.5 - 3 mm.

16.4.10.3 Thick adhesive beds

General: Provide on substrates with deviations up to 6 mm when tested with a 2 m straight edge with tiles having deep keys or frogs: and with tiles having uneven backs. Nominal thickness: 6 mm.

16.4.10.4 Mortar beds

For floor tiles: Either lightly dust the screeded bed surface with dry cement and trowel level until the cement is damp, or spread a thin slurry of neat cement, or cement-based thin bed adhesive, on to the tile back. Do not provide mortar after initial set has occurred.

Nominal thickness: 25 mm.

For wall tiles: Apply the bed to the substrate as a floated coat, bring up to a true surface with a wood float and allow to stiffen for up to 2 hours. Then either apply a back-up skim coat (1 - 2 mm thick) of 1:2 mortar to the bed, or butter the tile with 1:2 mortar or a cement based thin bed adhesive, before applying the tile to the bed.

Nominal thickness: 15 mm.

Thick reinforced beds: Place mortar bed in two layers, and incorporate the mesh reinforcement in the first layer.

16.4.10.5 Additives

Use in accordance with the manufacturer's instructions

16.4.10.6 Mechanical fixing

Provide a proprietary system of support and fixing appropriate to the type of tile and the substrate conditions.

16.4.11 Schedules

16.4.11.1 Wall Tiling Schedule

Location:

- Public Toilets, disabled toilets, Staff Changing Rooms.
- Crew Toilets, Refuse store, Cleaner's store, Bin point,
- or as per drawing indication.

16.4.11.2 Tile

Type Fully vitrified ceramic tiles

- Size (mm) 300 x 300mm x 9mm thick
- Colour As per approval
- Surface Semi-matt
- Tile Edge Square
- Tile or bond pattern as per drawings

Bedding

- Type Adhesive Mortar
- Thickness 6mm 15mm

Grout

- Type: Proprietary
- Colour: To approval

16.4.11.3 Floor Tiling Schedule

Location: public Toilets, Disabled toilets, Staff Changing Rooms, Staff Room, First Aid Room, Maintenance Office, General Purpose Office, CER, SER & SCS room, Bin Point, crew toilets, cleaner's store, refuse store, or as indicated on drawings.

16.4.11.4 External

Public circulation area: Concourse, Platform, Entrance, Staircase, as per drawings.

16.4.11.5 Tile

Type fully vitrified homogeneous ceramic tiles

- Size (mm) 300x300mm x 9 mm 600x600mm x 12mm
- Colour As per approval As per approval
- Surface Slip resistant to ASTM C1028 or R11
- Slip resistant to ASTM C1028 or R11
- Tile or bond pattern As per drawings As per drawings

16.4.11.6 Separation layer

Location Waterproofing liquid: Cross Refer Waterproofing, type Liquid applied

16.4.11.7 Bedding

Location

- Public Toilets, Disabled
- toilets, Staff Changing Rooms, Staff Room,
- First Aid Room, Maintenance Office, General Purpose Office. CER, SER & SCS
- room, Bin Point, crew toilets, cleaner's store,
- Refuse store, as per drawings.

External: public circulation area: Concourse, Platform, Entrance, Staircase, as per drawings.

Type: Mortar

Grout: property; colour to approval from Clients/ Engineer/ Consultant

16.4.12 Joints

16.4.12.1 Movement Joints

Location: To provide movement joints

- over structural (isolation, contraction, expansion) joints;
- at internal corners;
- at junctions between different substrates; and
- to divide large tiled areas into bays, maximum 5 m wide, maximum 15 m².

Depth of joint: Right through to the substrate.

Sealant width: 6 - 25 mm.

Depth of elastomeric sealant: One half the joint width, or 6 mm, whichever is the greater.

Cross refer: Adhesives, Sealants and Fastenings

Preformed strip: A proprietary expansion joint consisting of a neoprene filler sandwiched between plates with lugs or ribs for mechanical keying. Set flush with the finished surface.

Sealant: Two-pack self-levelling non staining, non-hardening mould resistant, one-part silicone or polyurethane sealant applied over a backing rod. Finish flush with the tile surface.

Backing rod: Compressible closed cell polyethylene foam with a bond-breaking surface.

16.4.12.2 Floor Movement Joint Materials

- Tensile strength: 586 kg/cm²
- Shore A hardness: 60 -70
- Movement Accommodation Factor: 5%
- Chemically resistant to, dilute acid, alkalis, detergents and common pollutants.

16.4.12.3 Divider Strips

Set divider strips accurately and firmly to the required locations and levels, with mortar as per manufacturer recommendation.

16.4.12.4 Grouted and Caulked Joints

Grouted Joints

- General: Commence grouting as soon as practicable after bedding has set.
- Clean out joints as necessary before grouting.
- Face grouting: Fill the joints solid and tool flush. Clean off surplus grout. Wash down when the grout has set. When grout is dry, polish the surface with a clean cloth.
- Edges of tiles: Grout exposed edge joints.
- Epoxy grouted joints: Ensure that tile edge surfaces are free of extraneous matter such as cement films or wax, before grouting.
- Grouting mosaics: If paper faced mosaics are to be bedded in cement mortar, pre-grout the sheeted mosaics from the back before fixing. After fixing, rub grout into the surface of the joints to fill any voids left from pre-grouting. Clean off surplus grout. When grout has set, wash down. If necessary use a proprietary cement remover.

Caulked Joints

- General: Provide caulked joints filled with sealant and finished flush with the tile surface as follows:
- Where tiling is cut around sanitary fixtures.
- Around fixtures interrupting the tile surface, for example pipes, brackets, bolts and nibs.
- At junctions with elements such as window and door frames and built-in cupboards.
- At internal corners.
- Width: 5 mm
- Depth: Equal to the tile thickness

16.4.12.5 Joint Accessories

Floor Finish Dividers

General: Finish tiled floors at junctions or as shown on drawings with differing floor finishes with a corrosion resistant metal dividing strip suitably fixed to the substrate, with top edge flush with the finished floor. Where changes of floor finish occur at doorways make the junction directly below the closed door.

- Type: Stainless steel
- Material: Grade 316
- Finish: Top edge polished
- Width: 5mm (at bridge); 3mm (other areas)
- Depth: To suit depth to substrate

16.4.12.6 General: Paving

- Fill for sub-grade: Sand, gravel or quarry rubble.
- Sub-base: Well-graded. Sand, gravel or crushed rock. Maximum particle size $\square \square$ 1/3 sub base layer thickness.
- Base course: Well-graded crushed rock or gravel, free from deleterious material.
- Maximum particle size 26.5 mm. Uniformly graded. Maximum clay content 6% by mass.
- Special toppings: Pebbles (sizes to be confirmed)

16.4.12.7 Concrete pavements and edging

Concrete Materials and construction: To ACI 301-10; SNI 03-6880-2002; SNI 03-6883 2002

16.4.12.8 Tiling

Cross refer: 'Tiling'

16.4.12.9 Granolithic Wash

Cross refer; 'Cementitious Toppings'

16.4.12.10 Concrete pavement reinforcement

Machine-welded mesh: To ASTM A1064.

Bar: To ASTM A615.

16.4.12.11 Granolithic Wash Paving (foot traffic only)

Cross refer: 'Cementitious Toppings'

16.4.12.12 Tactile Markings

Refer to "Tiling"

16.4.12.13 Jointing Strip

- Jointing strip material: Stainless Steel Austenitic
- Grade: 316
- Width 5mm
- Depth: 25mm or the depth of the paving material whichever is the greatest.

16.4.12.14 Geotextile fabric

Cross refer: Soft Landscaping or Civils & Structural Material Workmanship.

16.4.12.15 Concrete kerbs and channels (gutters)

Manually or machine placed: To ACI 301-10; SNI 03-2442-1991

16.4.12.16 Tree grates

- Sections: Proprietary grating comprising purpose-made removable equal segments.
- Material: Cast iron
- Size(s) (mm): Circular 1500/1800/2100/2400 diameter. Square 1500 x 1500.

- Finish: Black

16.4.12.17 External duct covers

Type: Proprietary system removable cover or grating in a fixed frame, with the necessary accessories, and suitable for the duct size and pavement loading.

16.4.12.18 Painting

Thermo plastic markings : Refer to Painting.

16.4.12.19 Special Topping

Pebbles to be semi-imbedded into top face of the concrete pavers – method and standards to be confirmed.

16.4.12.20 Sub-grade

- General: Remove topsoil containing grass roots. Fill and compact as necessary.
- Ensure strength and stiffness is similar throughout, including soft spots and service trenches. If necessary, loosen the subgrade to a depth of 200 mm and adjust the moisture content before compaction.
- Level tolerance: + 0, - 25 mm.
- Clay fill: Moisture condition near long term equilibrium moisture condition.
- Cohesive sub grade soils:
Minimum dry density ratio (standard compaction) to ASTM D 2487 : 100%.
- Cohesionless sub grade soils:
Minimum density index to ASTM D 2487 : 80%.

16.4.12.21 Sub-base

- Minimum dry density ratio: 98% to ASTM D 2487
- Thickness tolerance: + unspecified, - 5 mm.
- Level tolerance: ± 25 mm.

16.4.12.22 Base course

- Placing: Spread and compact the base course. Adjust the moisture content to facilitate compaction.
- Minimum dry density ratio: 98% to ASTM D 2487
- Thickness tolerance: + unspecified, -5 mm.
- Level tolerances: Generally - 0, + 25 mm, but at existing structures - 0, + 10 mm. Over 3m length of design profile, ± 10 mm.

16.4.12.23 Drainage

Finished surface cross falls: Between 1% and 10%.

Ponding: Grade pavements to even falls so as to drain away from buildings to drainage outlets without ponding.

Surface run-off: Provide channels and drains to discharge points.

Poorly drained sites: Select from the following:

- Stabilise sub-grade or pavement courses.
- Provide subsurface drains or pervious granular material, slotted or pervious pipes, or both, under or beside the pavement.

At walls: Set finished level of pavements below damp-proof course, weep holes and drainage openings.

16.4.12.24 Embedded Services

Place all embedded services at substrate level unless instructed otherwise by the Client/Consultant.

16.4.12.25 General tolerances

16.4.12.25

- Surfacing layer thickness: - 0.
- Surfacing layer level: ± 25 mm. Over 3 m length of design profile, ± 10 mm.
- Maximum deviations:
 - Across junctions between adjacent pavement surfaces : Cross refer: Granite Flooring.
 - Across junctions between adjacent pavement unit surfaces : Cross refer: Granite Flooring.

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16.4.12.26 Control joints

General: Provide movement joints over structural joints in the base (isolation, contraction, expansion) right through the paving and bed to the substrate. Fill joint with a compressible material. Joint filler: Cross refer: Adhesives, Sealants and Fasteners.

16.4.12.27 Pavement finish junctions

Location: Where changes of pavement finish occur at gateways, locate the junction directly beneath the closed gate. Dividing strip: Insert a dividing strip the full width of junctions between different pavement finishes, with the top edge flush with the finished pavement.

Fixing: Embed strip in solid finishes, or screw fix to the substrate.

Dividing strip material: stainless. steel G316 - 5mm thick.

16.4.13 Interlocking Paving

- Standard: To ASTM C936, ASTM C140
- Dimensional deviation category: Plan and Height 2-3mm .
- Minimum thickness:
 - Foot and bicycle traffic: 40 mm.
 - Light traffic: 50 mm.
 - Medium Traffic: 65 mm
- Unconfined compressive strength (concrete units) (minimum): 12 MPa.
- Breaking load (minimum):
- Foot and bicycle traffic: 2kN.
- Light traffic: 3kN.
- Medium traffic: 5kN.

16.4.13.1 Base course thickness

Foot and bicycle traffic: Not required.

16.4.13.2 Bedding sand course

Thickness: Roughly uniform, minimum 30 mm after compaction. Do not disturb the bedding course before the units are laid.

16.4.13.3 Mortar bedding course

Over concrete base slabs: Lay units on a mortar bedding course at least 12 mm thick. Mix: 1:3 cement: sand.

16.4.13.4 Geo-textile fabric

Fabric separation or drainage layer: Required.

16.4.13.5 Placing

After laying, compact the units using a vibrating plate compactor. Paving pattern: Refer to drawings.

16.4.13.6 Joints

- Thickness: 3 mm nominal, except where spacer nibs are provided.
- Dry joints: Fill the joints flush with clean, fine sand or screened bedding sand passing a 1.18 mm sieve, vibrated into the joints using a vibrating plate compactor.
- Mortar joints: Fill the joints flush with dry cement sand mortar, brush in, and dampen using a fine water spray. Clean pavement progressively to remove mortar smears and discolouration.
- Open joints: Close butted, or spaced as required.

16.4.14 Edging

16.4.14.1 Lateral restraint to interlocking paving

Perimeter: Provide concrete edge restraints to bedding and units, where not provided by other structures.

Type: Proprietary; In-situ

16.4.14.2 Restraint at base of slopes/ramps

Provide restraint to the lower edge of all slopes/ramps steeper than 1 in 10 to prevent the displacement of pavers and/or loss of substrate under the anticipated loads.

16.4.15 Surface Drainage

Cross refer: 'Gratings'.

16.4.16 Tactile Markings

Refer to Barrier Free accessibility guidelines for building and facilities. Tactile flooring has typically 300mm wide in sections.

The approved ceramic tile stud or strip, to comply with the related local regulation.

Appearance: minimum 30% luminance contrast to surrounding surface, as per related regulation: size 300 x 300 mm area in "guidance strip" and/or "stud" form. Layout: refer to drawings.

Top surface coarse intended to render them slip resistant when wet.

16.4.17 Floor Mats

Type: Recessed reversible very heavy duty suitable for external environment, as required per indicated drawing.

Slip resistance: Minimum coefficient of Friction 0:60 (wet) in accordance with ASTM E303.

Loading: Rolling Load Performance: Minimum 200kg / wheel

Construction: Closed with rubber wiper strips interwoven with nylon fibres and aluminium scraper strips locked together with high tensile steel wire or bars.

Nominal thickness 18 - 20mm, recessed flush with surrounding floor.

Frame: Nominal 25mm deep aluminium secured to substrate flush with surrounding floor. All fixings are to be hidden.

On completion of installation of frame, provide temporary filler in recess and cover with temporary protection.

16.5 Roofing and Cladding

16.5.1 Definitions

All references to roofing and roofing systems in the section include external metal soffits and fascia systems.

16.5.1.1 Lightning Protection

All elements of the roof shall comply with SNI 03-7014.1-2004. Lightning protection where required to be mounted externally, lightning conductors shall be located in recesses and/or extrusions made fit for the purpose.

16.5.1.2 Equipotential Bonding Requirements (EPB) and Touch Voltage Protection

Equipotential bonding requirements and touch voltage protection shall comply with the requirements of Persyaratan Umum Instalasi Listrik (PUIL); (SNI 0225:2011/Amd 1:2013; Amd2:2014; Amd3:2014 - Standar Nasional Indonesia), where metals are proposed within the station protection zone.

16.5.1.3 Interpretation

Fixing: the term 'fixings' shall be taken to mean:-

- Supporting fixings that transfer the self-weight of the cladding to the structure. Supports may also include a restraint function.
- Restraint fixings: Fixings that tie back the cladding to the structure and resist variable loads such as but not limited to wind loads, vibration, and live loads from cleaning equipment.
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16.5.2 Standards

The following codes/standards are references to the minimum quality acceptable for materials/products/workmanship:

- ASTM F594
- ASTM B221-14
- ASTM B345
- ASTM F593
- ASTM C954

- ASTM A653
- ASTM E2058
- ASTM A653
- ASTM E84 - 14
- ASTM 1354
- ASTM E136 - 12
- ASTM E814 - 13a
- ASTM E119 - 14
- AAMA-605-2-1992
- ASTM D897, ASTM D1002, ASTM D3330M, ASTM D3652M, ASTM D3654M, and ASTM D3715M.
- JIS A2017
- SNI 03-7014.1-2004 – Protection of structures against lightning.
- ASTM C1288 – Standard Specification for Discrete Non-Asbestos Fiber-Cement Interior Substrate Sheets.
- ASTM C1186 – Standard Specification for Flat Fiber-Cement Sheets.
- ASTM B221 – Standard Specification for Aluminum and Aluminum-Alloy Extruded Bars, Rods, Wire, Profiles, and Tubes.
- ASTM B209 – Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate.
- AAMA 2605 – Specification, Performance Requirements And Test Procedures For Superior Performing Organic Coatings On Aluminum Extrusions and Panels

16.5.3 Performance Criteria

16.5.3.1 Minimum Requirements

Provide a roofing system and associated work which

- remains intact and waterproof under the local or regional ambient climatic conditions;
- provides adequate means of dealing with vapour pressure, condensation, corrosion and thermal movement;
- supports the specified imposed loads and types of roof access without impairment of performance;
- Provides the minimum thermal resistance required by the drawings or current legislation in Indonesia, whichever is the higher; and
- Shall satisfies other specified performance requirements.

16.5.3.2 Ambient Climatic Conditions

Wind loading: refer to Civil and Structural Specification/ design criteria

Design rainfall intensity: To match 1 in 200 year anticipated rainfall intensity,

Cross reference to: Civil and Structural Specification/ design criteria.

16.5.3.3 Imposed Loading and Dynamic loading

Uniformly distributed (kPa): Cross refer: Civil and Structural Specification/ design criteria

Concentrated (per 2000 mm² of roof space) (kN): refer to: Civil and Structural Specification/ design criteria.

16.5.3.4 Thermal Insulation

Maximum thermal transmittance: 0.5W/m²oK

16.5.3.5 Drainage and Water Ponding

Minimum acceptable fall on flat roofing: 1 in 80.

Ensure that there is no ponding on completed roofs or gutters.

16.5.3.6 Drawings

Contract drawings show generic design principles and design intent only and illustrate geometry and appearances of visible structure and surfaces and shall be used as guidance by the contractor in producing his detailed design.

The contractor shall assume responsibility for developing this design including members, details and extrusions in accordance with the drawings to satisfy the performance requirement stated.

After acceptance of the concept the system shall be verified by submission and acceptance of drawings and computations with tests all as specified.

16.5.3.7 Design Life

The cladding system is required to achieve the performance standards, under environmental conditions it is like to experience for the minimum period as per the

Employer requirement: any routine maintenance required to achieve this shall be identified.

16.5.3.8 Weather Proofing

- The façade shall be resistant to water ingress when tested in accordance with the standards.
- The cladding system shall adopt pressure equalized and drained cavities.
- This philosophy shall apply to the cladding system itself as well as all interfaces with other elements, structure and surfaces.
- Sealants shall be used for weather seals only where a leak will not occur if the seal fails.

16.5.3.9 Air Infiltration

The façade shall not leak air excessively nor give rise to noise as a result of wind movements.

16.5.3.10 Thermal Performance and Conclusion

The façade system shall have an appropriate level of insulation to prevent excessive heat transfer to the interior.

Vapour barriers shall be located to prevent interstitial condensation.

Minimum thermal properties be: 0.95W/m²oC for solid area U-value

16.5.3.11 Lightning Protection

All elements of the façade shall comply with SNI 03-7014.1-2004 Lightning protection.

If required to be mounted externally, lightning conductors shall be located in recesses and/or extrusions made fit for the purpose.

16.5.3.12 Maintenance & Replacement

Any elements shall be anticipate requirement maintenance, repair or replacement shall be accessible from either inside or outside and avoid excessive disruption to the operator and public.

16.5.4 Movement

General: Provide for deflections, displacements and other movements within the cladding system, or between the cladding and the building (including fire stop and smoke flashing connections), including movements caused by ambient temperature changes, wind loads, design dead and live loads and shrinkage.

Accommodation: Provide a cladding system which accommodate these movements silently and without permanent deformation, reduction of performance, or other detrimental effects such as

- damage to or undue stress on structural elements, fixings, glass and spandrel panels;
- failure of joint seals; and
- loss of normal function in operable elements such as doors and windows.

Ambient temperature range (°C): 20 – 40°C

Surface (°C): 65°C

16.5.4.1 Building movements

- General: See the Civil and Structural Materials and Workmanship Specification
- Dead load: the vertical deflection of a structural member under dead load must not less than 3mm and with clearance between member and a non-structural member (such as glass or spandrel panel) immediately below; or under 3mm clearance between the member and operable elements such as windows and doors.

16.5.5 Loads

16.5.5.1 Equipment loads

General: If a cladding framing member is required to take loads from mechanically operated window cleaning equipment or a building maintenance unit (BMU) (e.g. via a guide rail), the member must carry the loads stated in the Civil and Structural Specification without exceeding the maximum allowable deflection/span ratios for frame members.

Equipment design loads (maximum):

- Type of BMU equipment: As proposed by the Contractor, with reference to manufacturer recommendation.
- Design for equipment design loads on framing members : Normal and Horizontally parallel to the wall plane: as per manufacturer's calculation recommendation.

16.5.5.2 Earthquake loads

Is not required however all cladding elements shall be designed against an in plane load of 5% of self-weight.

16.5.5.3 Attachment Loads

Include for gutters/covers & support systems and sustain the stress imposed thereon without exceeding the maximum deflection/span ratios for framing members.

16.5.5.4 Displacement limits

- where the deflection of a structural member may cause bending in a masonry, cement rendered or similar panel, restrict the deflection/span ratio of the member to a maximum of 1:360; and
- restrict the deflection of the cantilevered end of a cantilevered structural member of cantilever length L to maximum given in the Civil and Structural Materials and Workmanship Specification. Restrict the compression or extension of sealant joints affected by the cantilever deflection to a maximum of half of the sealant depth.

16.5.6 Materials and Components

16.5.6.1 Standing Seam Roofing System (Double lock system)

The topmost profiled sheeting of double standing seam roof system manufacture from aluminium alloy core AlMn1Mg1 as specified in JIS A2017, pre-weathered zinc surface. Minimum material thickness is 0.7mm.

Material properties as follows:

- Aluminium core: Sea-water resistant aluminium alloy AlMn1Mg1 JIS A2017
- Melting point: approx. 650°C
- Specific gravity (density): 2.7 kg/dm³

16.5.6.2 Finishes/Colours

Fluoride resin coated steel panel, which is pre-painted hot-dip 55% aluminium-zinc alloy steel sheet.

A Pre-weathered zinc surface finish shall be as per approved sample.

Sheets are to be laid to meet the requirements of the roof geometry. The aluminium roof elements will be supported by and joined longitudinally over concealed extruded aluminium clips.

Aluminium clips shall be capable of transmitting all reaction forces.

Fixing Bolts, Anchors, Brackets, Screws, Rivet and Nuts

Stainless steel shall be to ASTM F593-13a and ASTM F594-09e1 (grade 316).

Rivets, shear pins etc. provided from aluminium alloy of appropriate grade complying with ASTM B221-14.

16.5.6.3 Fasteners

All fixings and fastenings shall be appropriate to the work, shall transmit all imposed loads and stresses, and shall ensure the structural integrity of the roof.

All fixings and fastenings shall be non-corrosive.

Self-drilling screws: To ASTM C954-05; C954-11.

Finish: Pre-finish exposed fasteners with an oven baked polymer coating to match the roofing material, or provide matching purpose-made plastic caps.

16.5.6.4 Galvanized Steel Liner

Trapezoidal trough perforated steel liner, 0.7mm thick, 1000mm cover width x 35mm deep corrugation at 200mm c/c spanning at 1500mm c/c.

The substrate is hot dipped galvanised steel coil ZM 275 of JIS G3302: 1998 coating class-minimum spangle conforming to ASTM A653; A653M-13 or equivalent.

Powder coated finish. Colour to the approved sample.

16.5.6.5 Intermediate layer

Mineral wool insulation shall have 50mm thickness x minimum 80kg/m³ and fire classification to standard ASTM E2058-13a.

Single layer of asphalt roofing felt membrane c/w double sided aluminium insulation foil.

Two layers of 6mm thick cement board should be laid to overlap and to smooth curvature of the roof.

16.5.6.6 Compressed fibre cement (Cement Board)

- Standard: To ASTM C1185, C1186.
- Sheet: Density 1100-1200kg/m³
- Wall linings: W Type A category 4.
- Minimum thickness: 6mm
- Type: Autoclaved compressed panel
- Edges: Square
- Pre-finished to match face of board
- Fire Performance: Non-combustible to ASTM E136-12 and Class I surface spread of flame to ASTM E84-14.
- Movement from ambient to fully saturated: 0.1%
- Alkalinity: Less than pH value 10.
- Finish: Double faced
- Colour: To Approved RAL Colour
- Tolerance: Length: +0/-2mm
- Diagonal: +/- 2mm

16.5.7 Composite Aluminium alloy Honeycomb Panel Roofing System Sandwich Panel

Composite Aluminium alloy honeycomb panel comprising a 8.5mm aluminium honeycomb core sandwiched and bonded by a thermoplastic adhesion system between two skins of 1 mm (front side) and 0.5 mm (rear side) thick aluminium alloy.

- Aluminium Skin : 1.0 and 0.5 mm thick
- Mechanical Properties : Tensile strength Rm \geq 125 N/mm²
- 0.2% proof stress Rp0.2 \geq 80 N/mm²
- Elongation A50 \geq 5 %
- Modular of elasticity 70,000 N/mm²
- Sound Absorption Factor of 0.05(m^2), Airborne Sound Insulation of 21 Index Rw (dB),
- Rigidity at 21900 kNcm²/m, Panel weight at 5.3 kg/m²

16.5.7.1 Finish

PVDF (Polyvinylidene fluoride) / fluorocarbon coating applied by a reverse roller coating process. Total dry-film thickness of the coating shall be 25 microns minimum consisting of a chromate conversion coating, an inhibitive primer and a topcoat. The coated surface shall comply strictly with the 'Specification for coated coil for exterior building applications', which adhere to ASTM D3794-13, to achieve the Quality Label Category 1.

Application of the PVDF / fluorocarbon coating system by means of spray coating after forming and shaping of the roofing elements shall not be permitted.

16.5.7.2 Colour

For both sides to be as per approved RAL colour.

16.5.7.3 Aluminium Extrusions

Extrusions shall be of an aluminium alloy conforming to; ASTM B221-14, ASTM B209M-14 and PVDF factory spray painted finished.

16.5.7.4 Fixings

- a. Fasteners, including concealed screws, nuts, bolts and other items required by connecting aluminium to aluminium or aluminium to steel shall be of nonmagnetic stainless steel.
- b. Blind rivets used for fastening panel to aluminium sub-frame shall be of aluminium alloy with stainless steel mandrel.
- c. All fixing anchors, brackets and similar attachments used in the erection shall be of aluminium or non-magnetic stainless steel.

16.5.7.5 Dissimilar Materials

Where two surfaces of dissimilar materials come into contact, such surfaces shall be insulated with a layer of PVC or Polyethylene tape.

16.5.8 Thermal movement

Provide for thermal movement to suit the climatic conditions in Indonesia in the roof installation and the structure, including movement in joints and fastenings.

16.5.9 Safety Mesh

Standard General: To ASTM 847-14a.

16.5.10 Sheet Metal Roofing and Cladding

The material shall comply to ASTM 1592.

Provide a roofing system and purpose-made accessories.

Design and installation: To ASTM 1592.

Pre-painted and organic film/metal laminate products: To ASTM A755, A755M-11.

Provide ventilation to the underside of sheet metal roofing where recommended by manufacturer.

- Location: Main roof, Link Bridge & Lift Lobby, as per drawing.
- Product type: Aluminium-zinc alloy – metal roofing system
- Product finish: Pre-weathered zinc coating.
- Material: Aluminium-zinc alloy pre-formed sheet
- Thickness (mm): 0.7
- Grade: AlMn1Mg1 As per JIS A2017
- Substrate: Trapezoidal trough perforated steel liner, 0.7mm thick
- Insulation: 50mm, 80kg/m³ mineral wool
- Vapour barrier: Double sided alum. Foil
- Base (mm): 2 layers of 6mm cement board
- Location: Sloping entrance roofs, covered link ways, as per drawings.
- Product type: Composite honeycombed aluminium
- Product finish: PVDF; fluorocarbon coating.
- Material: Aluminium pre-formed board
- Thickness (mm): 10 (total)

16.5.10.1 Ridges and eaves

Treat ends of sheets as follows:

- Project sheets 50 mm into gutters.
- Close off ribs at bottom of sheets using mechanical means or with purpose-made fillers or end caps.
- Turn pans of sheets up at tops and down into gutters by mechanical means.
- Provide pre-cut notched eaves flashing and bird-proofing where necessary.
- Close off ridges with purpose-made ridge fillers of closed cell polyethylene.
-

16.5.10.2 Ridge and barge capping

Finish off along ridge and verge lines with purpose-made ridge capping or barge rolls.

16.5.10.3 End laps

General: Where end laps are unavoidable, and the sheet profile is not suitable for interlocking or contact end laps, construct a stepped type lap.

Length of lap (mm): 200mm

16.5.10.4 Pan type sheets

Removal: Capable of being de-indexed and removed without damage.

16.5.10.5 Curved corrugated sheet

General: Form by rolling from material recommended for curving or bull nosing.

Minimise crimping or creasing across the face of the sheet. Trim off crimped or creased edges and ends.

16.5.11 Tensile Roofing

(This section will be added in subsequent revision issuance)

16.5.12 Metal Separation

Prevent direct contact between incompatible metals, and between green hardwood or chemically treated timber and aluminium or coated steel, by either

- applying an anti-corrosion, low moisture transmission coating to contact surfaces; or
- inserting a separation layer.

16.5.13 Roof Plumbing

Cross refer: Civil and Structural Materials and Workmanship Specification.

Standard: To SNI 03-7065-2005, SNI 03-6481-2000

General: Provide the flashings, cappings, gutters, rainwater heads, outlets, overflows and downpipes necessary to complete the roof system.

The manufacturer's name, diameter of pipe, class designation, relevant standard, length of pipe and year of manufacture shall be legibly and durably marked on each pipe and fitting.

16.5.13.1 Materials

Metal rainwater goods: To SNI 03-7065-2005, SNI 03-6481-2000

16.5.13.2 Jointing sheet metal rainwater goods

Butt joints: Make joints over a backing strip of the same material.

Soldered joints: Do not solder aluminium or aluminium/zinc-coated steel.

Sealing: Seal fasteners and mechanically fastened joints. Fill the holes of blind rivets with silicone sealant.

16.5.14 Flashings and Capping

Flashing material: To ASTM B209M-14; ASTM B221-14.

Type: Folded profiles of the same material and finish as the related roof sheeting & cappings.

Installation: Flash roof junctions, upstands, abutments and projections through the roof.

Preform to required shapes where possible. Notch, scribe, flute or dress down as necessary to follow the profile of adjacent surfaces. Mitre angles and lap joints 150 mm in running lengths. Provide matching expansion joints at 6 m maximum intervals.

Upstands: Flash projections above or through the roof with two part flashings, consisting of a base flashing and a cover flashing, with at least 100 mm vertical overlap. Provide for independent movement between the roof and the projection.

Wall abutments: Provide over flashings where roofs abut walls, stepped to the roof slope in masonry and planked cladding, otherwise raking.

- In masonry: Build into the full width of the outer leaf. Turn up within cavity, sloping inward across the cavity and fixed to or built in to the inner leaf at least 75 mm above.
- In concrete: Turn 25 mm into joints or grooves, wedge at 200 mm centres with compatible material and point up.

Fixing to masonry or concrete: Step in courses to the roof slope. Interleave with damp-proof course, if any.

Fixing to pipes: Solder, or seal with neutral cured silicone rubber and either

- secure with a clamping ring; or
- provide a proprietary flexible clamping shoe with attached metal surround flashing.
-

Flashing and Capping schedule

Material and finish	Thickness and grade	Profile and size	Jointing method
Aluminium alloy; PVF2;	0.9mm to ASTM	To match roof profiles	To suppliers Recommendation
Fluorocarbon	B209M-14;		
	B221-14		

Galvanized steel, as applicable

16.5.15 Gutters and Down Pipes

- General: Prefabricate gutters to the required shape where possible. Form stop ends, downpipe nozzles, bends and returns. Dress downpipe nozzles into outlets. Provide overflows to prevent back-flooding.
- Matching gutter and fascia: Provide a proprietary metal eaves gutter and accessories formed and pre-coated to match the fascia system.
- Gutter and sump support: Provide framing and lining to support valley gutters, box gutters and sumps. Line the whole area under the gutters and sumps.
- Valley gutters: Profile to suit the valley supports. Turn back both edges 180□□x 6 mm radius. Nail or screw to the valley supports at the top end to prevent the gutter creeping downwards.
- Gratings and guards: Provide removable gratings over rainwater heads and sumps and leaf guards to gutters and gutter units.
- Expansion joints: Provide expansion joints in guttering longer than 30 m.
- Leaf guards to gutters: galvanized steel Mesh in frames
- Leaf guards to gutter outlets: galvanized steel Mesh in frames
- Ball guards to gutter outlets: Removable to match outlet material
- Colour: as per approved RAL colour.

16.5.15.1 Down pipes

General: Prefabricate downpipes (galvanized steel; for exposed, external area) to the required section and shape where possible. Connect heads to gutter outlets and, if applicable, connect feet to rainwater drains.

- Access cover: Provide a removable watertight access cover at the foot of each downpipe stack.
- Downpipe support: Provide supports and fixings for downpipes.
- Spreaders: Provide spreaders to match the downpipe materials, where required.
- Include all required supports and fixings.
- Colour: as per approved RAL colour.

16.5.15.2 Internal Down Pipes

Material: UPVC (for enclosed area; BOH). Size (mm): Varies; as per drawing.

Access: Provide access openings as follows:

- At each junction and bend.
- At the foot of each stack.
- At every second floor level.

Type of access opening: Watertight

Sound insulation: Mineral fibre pipe insulation 50 mm thick, spirally bound on with 1.5 mm wire at 150 mm pitch.

Building in: Where pipes are built into masonry or concrete, spiral wrap the pipe (and insulation, if any) with building paper.

16.5.16 Roof Fall Arrest System

The Contractor shall provide the system in accordance with the relevant standards and for the following activities and any other associated activity not listed:

- Confirm the suitability of the system types provided.
- Determine the configuration and composition of the fall-arrest system and the size and fixing methods of anchor points.
- Determine the size and frequency of the primary and secondary support framing for the fall-arrest systems.
- Determine the locations, types and arrangements of all necessary fixings, stanchions, plates, cleats and the like to be attached to the structure for the fall arrest system.

The fall arrest system must follow the standards that are relevant at the time of construction in addition to: ANSI Z359.1; ASTM F887.

16.5.17 General Cladding

16.5.17.1 Waterproof membrane

Application shall refer to indicated drawing as required.

16.5.17.2 Insulation

Insulation: Rockwool or other approved equivalent slab 80kg/m³ density.

16.5.17.3 Fibre cement

Standard: To ASTM C1186; ASTM C1288 -

Type A Category 3 (modulus of rupture 7 MPa). Edges: Square.

16.5.17.4 Aluminium

Aluminium extrusions/frames/brackets etc to AA6063-T5, 6063-T6 (ASTM B345) minimum wall thickness 2mm for any element.

16.5.17.5 Finish

Pre-coated PVF2 (Fluorocarbon). – AAMA – 605.2, as applicable for aluminium alloy panel.

16.5.18 Metal Panel Cladding

On completion, metal cladding shall be free from distortion including, but not limited to, twist, oil canning and welding deformations, within the tolerances defined by the formula $(A-B) \times 100 \leq 0.5\%$, where:

A = the greatest dimension of divergence from the design plane or curve measured at right angles from that plane or curve.

B = the shortest dimension separating points of nil and greatest divergences, measured along the plane or curve.

16.5.18.1 Type

General: Cladding system comprising

- metal panels, installed as part of an open joint cladding system with waterproofing on RC walls behind.

- a metal substructure of stringers, carrier rails and furring, protected against corrosion to the manufacturer calculation recommendation, which the panels are fixed with proprietary concealed fixings matching trim where required to form parapet cappings, reveals and sills to openings;
- accessories and fixings necessary to complete the installation; and
- provision for thermal movement.

16.5.18.2 Metal panels

Provide all necessary stiffeners/ backing to comply with the requirements of this specification.

16.5.18.3 External Cladding Panels

- Facing material: 3mm thick aluminium alloy/ steel panel sheet, where applicable.
- Type Folded tray on 4 sides.
- Backing layer machined to minimise external fold radius.
- Thickness 3mm
- Pre-finish PVF2 or galvanized steel finish; where applicable
- Colour As per approved RAL colour ranges
- Fixing type Concealed patent type, with self-draining
- Joint type 15mm open (Horizontally; Vertically)
- Gutter cover Aluminium/steel cover in lengths to match cladding module
- Penetrations Columns/ access hatches/ beams
- Pre-forming To fit profiles of structural members
- Backing Calcium silicate board (12 mm; as per manufacturer recommendation, where applicable)

16.5.19 Internal Cladding Materials

16.5.19.1 Compressed fibre cement (Cement Board)

- Standard: To comply with respective local regulation and the employer's requirement.
- Sheet: Density 1100-1200kg/m³
- Wall linings: W Type A category 4.
- Minimum thickness :9mm
- Location: Varies
- Type Autoclaved compressed panel
- Edges: Square; Pre-finished to match face of board
- Fire Performance: ASTM E119
- Movement from ambient to fully saturated: 0.1%
- Alkalinity: Less than pH value 10.
- Finish: Double faced pre-coated, U.V, graffiti and abrasion resistant
- Colour: To approved RAL Colour
- Tolerance: +/- 2mm(length; diagonal)

16.5.19.2 Calcium Silicate Board

Type Compressed calcium silicate matrix reinforced with selected fibres and fillers, cured in a high pressure steam autoclave. Shall not contain asbestos or other inorganic fibres

- Density (normal dry density): 1500 kg/m³
- Minimum thickness 12mm
- Moisture movement □0.1%
- Fire Resistance: ASTM E119
- Alkalinity: □□pH value 10.

16.5.19.3 Stainless Steel (skirting and cover panels)

- Standard To comply with respective local regulation and the employer's requirement.
- Sheet: Minimum 3 mm thick
- Backing material 6mm thick Calcium Silicate

16.5.19.4 Composite Panels

Face material: Corrosion resistant Aluminium alloy; galvanized steel, as applicable.

Thickness: 1.0mm

Core: Honeycombed core; non-combustible

Backing material: Corrosion resistant Aluminium alloy; galvanized steel, as applicable

Thickness: 0.5mm

Panel thickness: Minimum 4mm

Finish: Pre-finished fluorocarbon paint; galvanized steel with approved RAL colour, as applicable.

Tolerance: +/-2mm (Width and length)

Thickness: +/- 0.2mm

Diagonal: +/- 4 mm

16.5.20 Internal Cladding Components

16.5.20.1 Support Framework

Material: Proprietary galvanized mild steel channel support system complete with all fixings and brackets.

Proprietary Grade 316 stainless steel support system complete with all fixings and brackets, proprietary cold-formed galvanised steel framing.

16.5.20.2 Fasteners

Cross refer: Adhesives, Sealants and Fastenings

All fixings and fastenings shall be non-corrosive

No visible fixings will be acceptable

All fixings and fastenings shall be appropriate to the work, shall transmit all imposed loads and stresses, and shall ensure the structural integrity of the cladding.

All fixings and fastenings shall be effectively insulated from electrochemical reaction with incompatible materials.

Steel nails: Hot dip galvanized.

16.5.20.3 Adhesives

Cross refer: Adhesives, Sealants and Fastenings.

Contact adhesives for plasterboard

16.5.20.4 Double Sided Tape

Very high bond pressure sensitive tapes: To ASTM D897, ASTM D1002, ASTM D3330M, ASTM D3652M, ASTM D3654M, and ASTM D3715M.

16.5.21 Internal Cladding Systems**16.5.21.1 Cladding Type AP1 / AP2**

Location: To the external Lift shaft and other entrance areas, internal wall at concourse/platform area, as shown in the drawings.

Description: 3mm Aluminium panel with Calcium Silicate backing fixed on to proprietary extruded Aluminium sub-frame.

■ Material	Aluminium alloy; steel panel, as applicable
■ Grade	3mm thickness
■ Finish	PVF2; galvanized steel, as applicable
■ Colour	RAL to be confirmed
■ Backing	Calcium silicate board (12 mm thickness)
■ Background	Sub-frame substrate shall be adequately water proofed
■ Fixing	To Engineers / Specialists supplier detail
■ Cladding fixing	Secret fixed to proprietary frame
■ Loading	1.5kPa Point Loads
■ Removable/ De-mountable	For normal access
■ Accessories	Fascias, trims and all necessary fixings
■ Panel Size;	to centre line of joint
■ Typical / Varies; as per drawing	
■ Edge	'V' cut and folded all sides over backing

Tolerance

Width & Length +2mm/-1mm

Thickness 1.0mm

Joints Typically recessed nominal 15mm wide. To seal with the approved/ colour sealant.

Ensure no fixings are visible in joints.

Framing

Material Hot dip galvanised mild steel, adjustable cleats/brackets

Sizes Varies to specialist detail.

16.5.21.2 Cladding Type AP3

Location: To the internal wall of the Passenger Service Centre and the Station Master Room as shown on drawings.

Description: Low weight High rigidity Aluminium sandwich panel with honeycombed Aluminium alloy foil core.

■ Finish Material	Aluminium
■ Grade	Thickness 1.0mm
■ Finish	PVF2
■ Colour	RAL to be confirmed
■ Core	Honeycombed Aluminium alloy foil
■ Cell size	6.3mm
■ Bare compressive	
■ Strength	2.7N/mm ²
■ Reverse cover material	Aluminium

16.5.21.3 Technical properties

■ Tensile Strength of Cover sheet	Minimum 125N/mm ²
■ Modulus of Elasticity	70.0N/mm ²
■ Linear Thermal Expansion	2.4mm/m at 100°C

16.5.21.4 Installation

■ Fixing	Concealed clip fixing to specialists / supplier detail
■ Joints	Nominal 6mm wide joints
■ Sub-frame	Hot dipped Galvanised Mild Steel sub-frame to Engineer's detail, complete with cleats, brackets etc.
■ Access panels	Provide concealed hinges for panels shown as access panels.
■ Accessories	Fascias, trims and all necessary fixings
■ Panel Size	to centre line of joint.
■ Vertical distance -	controlled at 450mm; as per drawing
■ Horizontal distance –	varies
■ Edge	'V' cut and folded all sides over honeycomb core

16.5.21.5 Framing

■ Material	Hot dip galvanised mild steel, adjustable cleats/brackets
■ Sizes	Varies to specialist detail.

16.6 Carpentry, Joinery, Furniture and Fittings

16.6.1 References

The material and workmanship for carpenter, joiner, furniture and fitting shall in general follow the specifications indicated in the Employer's Requirement.

16.6.1.1 Related work sections

Refer to the following work sections: Adhesives, Sealants and Fasteners, Steels, Metals and Pre-finishes

16.6.2 Interpretation

16.6.2.1 Approved Sample

Approved sample is a sample held by the Contractor and available for viewing during the construction periods.

16.6.3 Equipotential Bonding Requirements (EPB)

Comply with the requirements of Persyaratan Umum Instalasi Listrik (PUIL); (SNI 0225:2011/Amd 1:2013; Amd2:2014; Amd3:2014 - Standar Nasional Indonesia)

Cross Refer: Section on 'Design' of the General Requirements.

16.6.4 Design

16.6.4.1 Drawings

The contract drawings show generic design principles and design intent only.

16.6.4.2 Detailed Design

Where required develop and complete the design intent to a working detail and ensure they meet the intent and comply with the required standards and codes of practice and performance requirements stated here in.

16.6.5 Performance Criteria

16.6.5.1 Requirement

Where furniture and fittings are shown in design intent and detail design have to be developed by the Contractor, complete their design, fabrication and installation, including fixings, as required to ensure that they are entirely sufficient for the purpose, having due regard for all service conditions that they may reasonably be anticipated. The completed items shall satisfy the requirements below, without excessive movement due to thermal effects, wind pressure, effects of dead loads, without buckling of components and without excessive stress to any members or assemblies.

16.6.5.2 Safety

Complete the design of, and install complying to the requirements of the Section on 'General Requirements' and the regulations of the related statutory authority.

16.6.6 Standards

16.6.6.1 General

The following codes/standards are references to the minimum quality acceptable for materials/products/workmanship:

Carry out all tests in accordance with Section on 'Tests' of the General Requirements.

16.6.6.2 Fire hazard limits

The material for interior finishes shall meet non-flammable or semi non-flammable (semi non-combustible) or fire retardant requirements in accordance to ISO 5660-1. In case of proposing other than non-flammable and/or fire retardant material, it needs to be tested by Cone Calorimeter (ISO 5660-1).

Non-combustible to ASTM E136-12; SNI 1740-2008.

An index of performance (I) not exceeding 12 and a sub-index (i) not exceeding 6 when tested to ASTM E2058-13a

16.6.6.3 Weighted sound reduction index (R_w)

Movable office and workstation screens: Type test screens required to have a particular weighted sound reduction index (R_w) rating, to JIS A 1419-1:2000

- SNI 03-2445-1991 – Wood for housing and buildings, Sizes
- SNI 03-3233-1998 – Method for wood preservation for housing and building
- Peraturan Konstruksi Kayu Indonesia NI-5, PKKI 1961

- ASTM A554,
- JIS G3446
- ANSI Z124
- ASTM-D-570
- ASTM D256
- ASTM E84.
- ANSI MH28

16.6.7 Materials and Components

16.6.7.1 Fire hazard

General: Do not provide materials which, when subject to fire conditions, will emit excessive smoke or dangerous fumes. Do not use materials which contain known carcinogenics.

16.6.7.2 Toxins

Toxic materials: Use materials which are certified free of asbestos and lead, or any other known toxin, and free of, nor requiring the use of, toxic solvents.

16.6.8 Metals in General

Cross reference to: "Metals and Pre-finishes".

Confirm that materials used in conjunction are compatible with one another, the substrates on which they are used, and all adjacent materials in the completed building.

16.6.8.1 Corrosion

Cross refer: Section on 'Materials and Components' of General Requirements.

16.6.8.2 Steel tube

Surface: For painted work: To ASTM A554, JIS G3446; (Semi-bright).

For electroplated work: To ASTM A554, JIS G3446 (Bright).

16.6.8.3 Steel sheet

Surface finish: For electroplating: P (plating quality).

For painting: B (bright) or M (matt).

16.6.8.4 Stainless steel

Grade:

- 316 (for external use)
- 304 (internal use only).

Surface finish: continuous hairline achieved using a 180 – 240 grit size.

16.6.8.5 Decorative overlays

Refer to respective detail drawing as indicated.

16.6.8.6 High-pressure decorative laminate sheets

Standard: To ANSI/NEMA-LD-3.05; 3.10.

Thickness (minimum):

- For horizontal surfaces fixed to a continuous background: 1.2 mm.
- For vertical surfaces fixed to a continuous background: 0.8 mm.
- For post formed laminate fixed to a continuous background: 0.8 mm.
- For vertical surfaces fixed intermittently (e.g. to studs): 3.0 mm.
- For edge strips: 0.4 mm.

16.6.8.7 Solid Compact laminate

For use in toilet areas only:

- 13mm solid compact laminates with high density water resistant phenolic core.
- Type: To ANSI Z124.3 & 6,
- Tensile strength: not less than 6000 psi,
- Tensile modulus of 1.5×10^3 psi.
- Elongation: not more than 0.4% (ASTM-D-638).
- Hardness: 94 according to the Rockwell 'M' scale.
- Water absorption shall be less than 0.04 (ASTM-D-570). There shall be no visible
- Boiling water resistance: no change (ANSI/NEMA-LD-3.05).
- Colour stability: no change (ANSI/NEMA-LD-3.10).
- Impact resistance: 0.24 ft/lbs minimum (ASTM D256, Method A).
- Flame spread: 25 maximum (ASTM D570).
- Smoke Developed: 30 Maximum (ASTM D570).

16.6.8.8 Non-combustible board

Type: asbestos free calcium silicate matrix reinforced with selected fibres and fillers with a smooth sanded surface.

Moisture movement: 0.1% maximum from ambient to saturated.

Alkalinity: less than pH value 10.

Fire resistance: must have a limited combustibility Class '1' as defined in the American

Building Regulations and Class 'A' surface spread of flame to ASTM E84.

16.6.8.9 Adhesives

Cross refer Adhesives, Sealants and Fasteners.

16.6.9 Fittings – Containers, Bins, Cabinets

16.6.9.1 Letter Box

Proprietary stainless steel letter box, with lockable hinge door and accessories.

Location: Passenger Service Centre (PSC) glazed wall as shown on drawings.

Size: the letter slot to allow for standard mail.

Letter box shall be fixed to the internal side of the glazing by double sided heavy-duty adhesive tape. A slot conforming to that of the letter box shall be pre-cut on the adjacent glazing as shown on drawings.

16.6.10 7.3.2 Shelves

16.6.10.1 Light Duty shelving

Requirement: Provide full-height rows of 300mm deep proprietary light-duty, wall mounted shelves to the full length of the wall as shown on drawings.

Materials: Pre-finished steel hollow section framework with slotted faces for the adjustable positioning of the pre-finished, folded, steel sheet shelves.

Shelves capable of carrying a minimum uniformly distributed load of 100 kg/m of span, without deflection exceeding 5 mm and to comply with the requirements of the

'PERFORMANCE CRITERIA' as necessary.

Location : Cleaner's Store, as shown on drawing.

Installation : In accordance with the manufacturer's recommendations.

Accessories: necessary for the satisfactory erection and service use of the shelving.

16.6.10.2 Heavy Duty Adjustable shelving

Standard: in accordance with ANSI MH28.1-1982

Location: Maintenance Store, Station Store, Permanent Way Store, as shown on drawing.

Requirement: Provide full-height rows of 600mm deep proprietary heavy-duty shelving, wall-mounted to the full length of the wall as shown on drawings.

Materials: Pre-finished steel hollow section framework with slotted faces for the adjustable positioning of the pre-finished, folded, steel sheet shelves. shelf height adjustable in increments not exceeding 50 mm; shelves capable of carrying a minimum uniformly distributed load of 200 kg/m of span, without deflection exceeding 5 mm and to comply with the requirements of the

'PERFORMANCE CRITERIA' as necessary.

Accessories: necessary for the satisfactory erection and service use of the shelving.

16.6.11 Whiteboards

Location: Passenger Service Centre; Station Master's Room; refer to respective drawing as indicated.

16.6.11.1 Whiteboard panels

General: White seamless vitreous enamel surface on sheet steel base, resistant to chipping and fracture when the base is slightly flexed, fixed with a suitable contact adhesive to a backing of calcium silicate at least 9 mm thick.

Size (mm): 1650 X 850; 2000 X 1000

Surface: Suitable for use with fast-evaporation, dry-erase pens.

Edges: Trim the edges of the panels with clear anodised aluminium sections mitred at corners.

Pen rails: Proprietary aluminium section fixed to the full width of the bottom edge of the board.

16.6.11.2 Installation

Attach the panels to building substrates with wallboard adhesive to ASTM C557.

16.6.12 Furniture Work Stations

Location: Passenger Service Centre, Station Master's Room, Ticket Sales Office.

16.6.12.1 General

A system comprising an assembly of work tops, mobile pedestal or credenza storage units, drawer units, individual bookshelves, floor ducted cable enclosures, cable trays under-the-work-top and accessories necessary for satisfactory assembly and installation.

Work surfaces

- Core material: 19mm thick calcium silicate board
- Finish: Minimum 5mm thick proprietary solid surfacing material
- Finished in bull nose along the free side.
- Height (mm): 710mm from the finished floor level.

16.6.12.2 Keyboard supports

Fit the keyboard support section of computer equipment with a mechanism capable of being operated by a seated person to raise and lower the keyboard above or below the level of the work surface.

Installation: install each workstation system in its required location using concealed fixings; and steel supports that are integral with the glazing sub-structure.

16.6.12.3 Serviced equipment

General: if equipment requiring connection to power, telex, computer, telephone or other service is to be installed as part of the workstation system, make the necessary service connections.

16.6.13 Fixed Furniture

16.6.13.1 Long Seat with no back rest

Location: as shown on drawings.

Description: proprietary stainless steel bench unit with legs and no back rest, fixed onto custom made S/S structural frame and integrated with granite clad, as shown on drawings.

Arrangement: proprietary seat system with S/S support structure fixed onto

Galvanised Steel structure with necessary corrosion preventive isolators and concealed within granite cladding as shown on drawings.

16.6.13.2 Passenger Call Point (PCP) Assembly

Location: to the platform area as shown on the drawings.

Requirement: provide the PCP assembly as shown on drawings, consisting of aluminium cover fixed to a galvanised steel substructure, installed securely to the structural floor slab. Fix the cladding to the steel framework using concealed fixings satisfying the requirements of the 'PERFORMANCE CRITERIA' as necessary.

Proposal: submit proposals for the design of the framework and include a certificate stating that the proposed framework is suitable for the intended use and that the framing and fixings are capable of withstanding the applicable service loads. Do not commence installation of the assembly prior to receiving the approval.

Finish description: aluminium sheet of sufficient thickness pressed into shape as shown on drawings to form a cover on one side and openable panel on the other and fixed onto a vertical extruded aluminium post with necessary concealed supports, hinges, conduits, bearings etc to perform as required by the drawing. Part finished in

PVF2 and part in anodised metallic finish, compliant to the requirements of the 'Metal Finishes' Subsection. To provide for the fixing of necessary signage.

16.6.13.3 Telephone Blade Assembly

Location: as shown on the drawings.

Requirement: provide the TELEPHONE BLADE assembly as shown on drawings, consisting of metal cladding fixed to a galvanised steel substructure, installed securely to the structural floor slab. Fix the cladding to the steel framework using concealed fixings satisfying the requirements of the 'PERFORMANCE CRITERIA' as necessary.

Proposal: submit proposals for the design of the framework and include a certificate stating that the proposed framework is suitable for the intended use and that the framing and fixings are capable of withstanding the applicable service loads. Do not commence installation of the assembly prior to receiving the approval.

Finish description: aluminium sheet of sufficient thickness pressed into shape as shown on drawings to form a cover and by a concealed system fixed onto a GS structure with necessary supports, hinges, conduits, bearings etc to perform as required by the drawing. Provide an access panel at the lower end

as shown on drawings. Part finished in PVF2 and part in anodised metallic finish, compliant to the requirements of the 'Metal Finishes' Subsection. To provide for the fixing of necessary signage including the base tempered glass piece on top of the structure as shown on drawings.

16.6.13.4 Signage Blade Assembly

Location: Platform, Concourse and other area, as shown on drawings.

Refer to Signage Design and to provide for the assembly as required.

16.6.14 Loose Furniture

16.6.14.1 Bench Seat

Location: to the staff changing room areas, as shown on drawings.

Requirement: to provide a proprietary bench seat with clothe hooks as shown on drawings.

Description: Bench slats to be fabricated from high-density, phenolic-core board with melamine finish on both sides and edges. Structure to be fabricated from powder coated aluminium hollow sections.

Nominal dimensions (mm) : H x W x D : 430 (seat) x 1800 x 430

Accessories: to provide with coat hooks of powder coated aluminium (quantity per bench, evenly spaced, as shown on drawings).

16.6.14.2 Lockers

Location: to the staff changing room areas, as shown on drawings.

Requirement: to provide a proprietary locker system.

Description: fabricated from high-density, phenolic-core board with melamine finish on both sides and edges. Structure to be fabricated from anodised aluminium hollow sections, with panel dimensions as follows:

- Side and back panels: 6mm.
- Top and bottom panels: 13mm
- Doors and shelves: 13mm

Arrangement:

- Units of 2-tier – total quantity of lockers per room, as shown on drawings.
- Hardware: provide the following standard hardware / accessories: stainless steel hinges allowing 180degree swing.
- Cylinder cam lock. Numbering plate. Hanging rail.Triple swivel hook.

- Nominal dimensions: Each unit to be of the following dimensions (mm): H x W x D:1850 x 300 x 500.

Installation: in accordance with the manufacturer's recommendations.

16.6.15 Built-in Cabinets and Fitments

16.6.15.1 Cabinets

Location: to the Staff Room area, as shown on drawings.

Requirement: to provide a built-in cabinet fabricated of calcium silicate with laminate finish on both sides and edges. The panel dimensions as follows: side and back panels: 6mm top and bottom panels: 13mm doors and shelves: 13mm

Size: to the full width of the room, above and below the counter top, as shown on the drawings.

Accessories: all necessary hinges, catches, pull handles, drawer runners, shelf pins and the like and with all associated bearers and fixings.

16.6.15.2 Mop / Broom Holder

Location: to the Cleaner's Store areas, as shown on drawings.

Requirement: to provide Stainless Steel Grade 304, mop and broom holder, surface mounted and secured to walls by an oval head plated steel sheet with metal screws complete with concealed backing. Holders shall be spring loaded, rubber cam with plated steel retainer. There shall be one holder per cleaner's store.

16.6.15.3 Umbrella Hooks

Location: to the PSC area, as shown on drawings.

Requirement: to provide 3 proprietary Stainless Steel Grade 304 umbrella hooks where shown on drawings.

Accessories: necessary screws, flanges, cover plates etc appropriate to the wall substrate and as required by the recommendations of the manufacturer.

16.6.15.4 Key Rack

Location: to the PSC area, as shown on drawings.

Requirement: to provide a proprietary key rack (for 20 keys) where shown on drawings.

16.6.15.5 Paper Towel Dispenser-cum-Waste Receptacles

Location: to the public and staff toilet areas, as shown on drawings.

Requirement: to provide proprietary wall-recessed Paper towel dispenser-cum-waste receptacles of size (mm) 325 x 670 x 110, all dimensions +/- 10%, fabricated of Grade 304 S/S in satin finish. The unit shall comprise a cabinet and a waste container. The minimum capacity of the waste container shall be 7.6L complete with hooks for the liners. The doors shall be double pan construction fabricated of 22 gauge 304 S/S with a 6mm thick 'no-flex' structural fibre board core. Mount doors to cabinet body by stainless steel piano hinge. Recessed cabinet shall be fabricated with face trim of one piece construction with no mitres or welding and returning 6mm to wall. All doors shall be provided with a tumbler lock keyed alike.

16.6.15.6 Hand Dryers

Location: to the public and staff toilet areas, as shown on drawings.

Requirement: to provide proprietary wall mounted medium duty hand dryer, of size:

340mm wide x 300mm high, x 120mm deep, all dimensions +/- 10%, fabricated in vandal resistant non-plastic finish of colour: white. All fixings shall be fully concealed and non-corrosive. The unit shall be capable of being operated with one hand.

Air temperature Range: 50 – 55⁰C.

Volume of Air: minimum 153cfm

Operating noise: less than 80Db.

To start within 0.5 – 0.8 seconds after hand is positioned within 200mm of hot air outlet. To turn off automatically after 60 seconds maximum.

Equipotential Bonding: to comply with the requirements in the General Requirement as required.

16.6.15.7 Napkin Disposal Bin

Location: to all female WC cubicles, as shown on drawings.

Requirement: to provide proprietary wall-recessed Sanitary napkin disposal of size (mm) 285 x 400 x 110), all dimensions +/- 10%, fabricated of Grade 304 S/S in satin finish on all exposed surfaces. The doors shall be of minimum 18 gauge, secured with concealed full-length stainless steel hinges and fitted

with tumbler lock. The door shall be equipped with international graphic symbol identifying napkin disposal.

16.6.15.8 Toilet Roll Dispenser

Location: to all WC cubicles, as shown on drawings.

Requirement: to provide Partition/Wall mounted 'Jumbo' Toilet roll dispenser fabricated in Stainless Steel Grade 304 with a supply status viewing window, of size: 285mm dia. x 110mm depth, all dimensions +/- 10%.

Capacity: rolls of 400.0m with spindle of 45mm.

Fixings: Fully concealed non-corrosive.

16.6.15.9 Liquid Soap Dispenser

Location: adjacent to wash basins, as shown on drawings.

Requirement: to provide a wall mounted Liquid Soap Dispenser with vandal resistant refill window, fabricated of Stainless Steel Grade 304 and with satin finish.

Capacity: 1.3 litres, minimum.

Fixings: Fully concealed non-corrosive fixings.

Ironmongery: Full length heavy duty recessed hinge and tumbler locks on door giving access to soap container.

Corrosion resistant valve to dispense liquid soaps lotions and detergents.

Remarks: Enclosed soap container to allow for easy refilling. To be operated with one hand without grasping, pinching or twisting of the wrist. The activation of valve shall require no more than a force of 22.0N.

16.6.15.10 Soap Holder

Location: to all shower cubicles, as shown on drawings.

Requirement: to provide one-piece soap holder mounted on Partition/Wall, fabricated of Stainless Steel Grade 304 in satin finish, with no more projection than 100mm. The Dish shall have necessary drain holes as well as ridges to support the bar of soap.

16.6.15.11 Baby Changing Station

Location: to the disabled toilet area, as shown on the drawings.

Requirement: to provide one wall mounted baby changing station of a horizontal design type. Station shall be of high impact polyethylene reinforced with stainless steel on stainless steel hinges and 10 gauge stainless steel mounting supports and shall have at least the following features:

Type: Fold down complete with pneumatic shock absorber.

Size: H x W x D (mm): 510 x 900 x 100 – height and width dimensions +/- 10%.

Maximum projection 510mm when open; maximum projection 100mm when closed.

Fixings: Fully concealed non-corrosive.

Remarks:

- To be fitted with baby holding straps.
- To be devoid of sharp corners.
- To be shaped to conform with child's body.
- To be capable of being opened and closed with one hand.

16.6.15.12 Towel Rails

Location: to the shower areas, as shown on drawings.

Requirement: to provide Partition/Wall mounted proprietary single towel round rails, fabricated of 19mm Dia Stainless Steel Grade 304 pipe polished, with concealed fixing.

Size: 550mm long; to project a maximum of 100mm from the mount surface.

Accessories: Solid Virgin Brass chrome plated flanges, mounting plates, screws etc.

16.6.15.13 Grab Bars

Location: to the Disabled Toilet area, as shown on drawings.

Requirement: to provide Wall mounted proprietary round grab bars, fabricated of 40mm diameter Stainless Steel Grade 304 pipe polished, to the number, location and lengths as shown on drawings.

Accessories: Solid Virgin Brass chrome plated flanges, mounting plates, screws etc.

16.6.15.14 Coat Hook-cum-Door Stopper

Location: to all shower and WC cubicles, as shown on drawings.

Requirement: to provide Wall/Partition mounted proprietary coat hook-cum-door stopper, fabricated of Stainless Steel Grade 304 in satin finish. The doorstopper shall have a maximum projection of 75mm and shall have a bumper made of durable rubber.

16.6.16 Counter Top and Vanities

16.6.16.1 Support Framing

Type fully concealed.

- Material Stainless steel (wet areas only).
- Galvanised steel (dry areas).

16.6.16.2 Top Material

- Stone: Natural Stone, as indicated on drawing. To have essentially the same colour, grain, pattern, appearance, and physical properties.
- Finish: Polished, with stone sealer as required for any open side.
- Thickness: Not less than 20mm unless otherwise indicated, gauged.
- Solid Surface/Laminate: Thickness minimum 12mm.
- Colour: As per approved sample.
- Upstand: To provide upstand at all junctions with walls. Height minimum 10mm.
- Fascia: To provide fascia at all exposed edges.
- Cut-outs: To suit basins and taps.
- Remarks: To provide raised lipping along all edges to prevent spillages falling to the floor.

16.7 Steel, Metal and Pre-Finishes

16.7.1 Equipotential Bonding Requirements (EPB) and Touch Voltage Protection

Comply with the requirements of Persyaratan Umum Instalasi Listrik (PUIL); (SNI 0225:2011/Amd 1:2013; Amd2:2014; Amd3:2014 - Standar Nasional Indonesia), where metals are proposed within the station protection zone.

16.7.2 8.1.3 Standards

16.7.2.1 General

Ferrous Metals to comply with minimum hour of requirement on intermittent salt spray test to ASTM B117-02. Pass criteria, no visible changes.

Submission of calculations and drawings from an Indonesia licensed Professional

Engineer concurrently with the shop drawings and showing, but not limited to, the compliance with all relevant Indonesia legislation and regulations.

The following codes/standards are references to the minimum quality acceptable for materials/products/workmanship:

- SNI 07-2052-2002.
- SNI 3567:2006/Amd1:2011.
- SNI 03-1729-2002.
- SNI 03-6405-2000.
- ASTM A240/A240M.
- ASTM A276.
- ASTM A554.
- ASTM A568.
- ASTM A595.
- ASTM A164.
- ASTM A1085.
- AAMA 2604.
- AAMA 2605-05.
- AAMA 605-2.
- ASTM A240/A240M.
- ASTM A29
- ASTM D16.
- ASTM F2329
- ASTM A123 – Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
- ASTM A653/A 653M – Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process
- ASTM F2329 – Standard Specification for Zinc Coating, Hot-Dip, Requirements for Application to Carbon and Alloy Steel Bolts, Screws, Washers, Nuts, and Special Threaded Fasteners
- ASTM B183 – Standard Practice for Preparation of Low-Carbon Steel for Electroplating
- ASTM B242 – Standard Guide for Preparation of High-Carbon Steel for Electroplating
- ASTM B252 – Standard Guide for Preparation of Zinc Alloy Die Castings for Electroplating and Conversion Coatings
- ASTM B253 – Standard Guide for Preparation of Aluminium Alloys for Electroplating

- ASTM B254 – Standard Practice for Preparation of and Electroplating on Stainless Steel
- ASTM A36 – Standard Specification for Carbon Structural Steel, Hot Rolled Steel

16.7.3 Materials and Components - Metals

Following are the materials/components which to adhere to the minimum acceptable standard as per the Employer requirement.

16.7.3.1 Steel

- Hollow section: To ASTM A1085
- Bars sections: To SNI 07-2052-2002
- Sheet: To ASTM A568

16.7.3.2 Steel for pre-finishes

- Electric resistance welded pipe: To ASTM A595
- Cold rolled bar: ASTM A29
- Cold rolled sheet: To SNI 3567:2006/Amd1:2011

16.7.3.3 Coated steel

- Metallic coated sheet: To ASTM A924
- Thickness: Metal thicknesses specified are base metal thicknesses.
- Ferrous hollow sections by electro-galvanizing: To ASTM B633
- Ferrous hollow sections by a continuous or specialised process: ASTM A385
- Steel wire: To ASTM A1072; ASTM A855

16.7.3.4 Stainless steel

- Plate, sheet and strip: To ASTM A240/A240M.
- Bars: To ASTM A276.
- Welded pipe (round/square): To ASTM A554.
- Type: Austenitic Grade: 316.

16.7.3.5 Cast stainless steel

Method: Investment or lost wax casting. Grade: 316.

16.7.3.6 Aluminium and aluminium alloys

- Drawn rod, bar and strip: ASTM B221
- Extrusions: ASTM B221
- Drawn pipe: ASTM B210
- Plate and sheets: ASTM B209

16.7.4 Metal Finishing

Before applying decorative or protective pre-finishes to metal components, complete welding, cutting, drilling and other fabrication, and prepare the surface using the method as per approval.

Priming steel surfaces: Where site painting is specified to otherwise uncoated mild steel or similar surfaces; primer shall be applied after fabrication and before delivery to the works; and after installation, repair damaged priming to match the standard of undamaged areas and complete the coverage to unprimed surfaces.

16.7.4.1 Welding

- Steel: To AWS D01.1.
- Aluminium: To AWS D01.2
- Stainless steel: AWS D01.6.
- Site welding: Will not be accepted unless identified beforehand and with prior approval.

16.7.4.2 Brazing

General: Ensure brazed joints have sufficient lap to provide a mechanically sound joint.

For butt joints do not rely on the filler metal fillet only.

Filler metal: ASTM F106; AWS C3.3.

16.7.4.3 Finishing

Visible joints: Finish visible joints made by welding, brazing or soldering using methods appropriate to the class of work (including grinding or buffing) before further treatment such as painting, galvanizing or electroplating. Ensure self-finished metals are without surface colour or textural variations after jointing.

Do not finish welds on site without prior approval and beforehand identification.

16.7.4.4 Damage

If pre-finishes are damaged, including damage caused by unauthorised site cutting or drilling, remove and replace the damaged item.

16.7.4.5 Cutting

Do not cut or grind metals in the vicinity of stainless steel.

16.7.4.6 Metal Separation

Prevent direct contact between incompatible metals, and between green hardwood or chemically treated timber and aluminium or coated steel, by either applying an anti-corrosion, low moisture transmission coating to contact surfaces; or inserting a separation layer.

16.7.5 8.3.2 Self Finishing

The system of stainless steel item at exposed situation to be applied with no. 4 continuous hairline polished using 180-240 grit size.

16.7.6 8.3.3 Electroplating

16.7.6.1 Electroplated coatings

- Zinc on iron or steel: To ASTM A-164.
- Chromium on metals: To ASTM B456.
- Nickel on metals: To ASTM B456.

16.7.7 8.3.4 Galvanizing

16.7.7.1 Galvanizing

- Zinc Chromate Primer to ASTM D6386.
- Zinc-rich coating, commercial Blast cleaning and Zinc-rich coating system, to ASTM D4146.
- Fabricated ferrous articles, to ASTM A123.
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16.7.7.2 Repair of galvanizing

General: For galvanized surfaces which have been subsequently welded: Power clean the affected area, to ASTM A780. Degrease and remove all surface contaminants. Apply 2 coats zinc rich primer, 50% solids by volume to a minimum dry film thickness of 100 microns.

Stipple edges of painted area to achieve the optimum appearance of the repair.

16.7.7.3 Factory applied coatings

All paint on steelwork or aluminium shall be factory applied prior to the delivery of fabricated work to the site unless agreed with the Client/Consultant. Do not transport or handle assemblies until the paint is dry. Protect the paint work during transport and handling.

16.7.7.4 Components in contact with concrete

Passivate galvanized surfaces to be cast into or in contact with concrete by dipping in 0.2% sodium dichromate solution.

16.7.7.5 Coating quality

General: Continuous, adherent, smooth or evenly textured and uniform, free from defects detrimental to the end use of the finished article, such as lumps, blisters, gritty areas, uncoated spots, acids and black spots, dross and flux.

16.7.8 Hot-dip galvanized coatings

16.7.8.1 Care

Mechanical properties: Avoid mechanical damage. Ensure that mechanical properties of the base metal do not change.

Dimensional change: Avoid.

Embrittlement: Take due care in processing steel that is susceptible to embrittlement.

16.7.8.2 Drilling

Provide holes required for filling venting or draining etc. to ASTM A123.

Drilling and oxy-cutting by the galvanizer is not acceptable.

16.7.8.3 Surface preparation

Surface contaminants and coatings generally: chemical clean, then acid pickle.

Surface contaminants and coatings which cannot be removed using chemical cleaning: abrasive blast clean.

Standard for surface preparation to: ASTM B183; ASTM B242; ASTM B252; ASTM B253 and ASTM B254.

Chemical cleaning: cleaning designation

Acid pickling:

- Acid: Hydrochloric.
- Inhibitor

Abrasive blast cleaning:

- Grade: SA 2½
- Abrasive

16.7.8.4 Surface finish

Coating quality: Continuous, adherent, smooth or evenly textured and uniform, free from defects detrimental to the end use of the finished article, such as lumps, blisters, gritty areas, uncoated spots, acids and black spots, dross and flux.

- Silicon killed steels: Dull grey is acceptable.
- Friction-type bolted connections: Treat contact surfaces to achieve the required slip factor.
 - Method: Wire brushing or light grit blasting.
 - Finish for contact surfaces: galvanizing
 - Slip factor: to ASTM A36
- Surplus zinc on fastener threads: To remove.

16.7.8.5 Coating reinstatement

Method: Wire brush or mechanically buff the surface. Apply 2 coats zinc-rich primer to 100µm dry film thickness. Stipple edges of the primed area.

- Surface preparation
- Primer zinc rich containing minimum 50% solids by volume.

Extent: Significant areas of uncoated surface, and areas damaged by handling at the galvanizing plant.

Size of area to be repaired: Relevant to the size of the article and the conditions of service. All repairs which is visible on the completed work to be masked off and to end on straight lines.

Structural sections

- Cold worked items: Except for hollow sections, anneal to 650°C before galvanizing.
- Coating mass: Other than nut and bolt thread surfaces: minimum average: 600 g/m².
- Hollow sections: Provide seal plates with breather holes.

16.7.8.6 Components in contact with concrete

General: Chromate passivate.

Chromate passivation process: Dip in 0.15 - 0.2% sodium dichromate solution, as per manufacturer recommendation.

16.7.9 Anodising

16.7.9.1 Anodising

Standard: To ASTM B580, ASTM B681

Thickness grade:

- Indoor applications: At least 10 micron.
- Outdoor applications: At least 25 micron.

16.7.10 Powder Coating

16.7.10.1 Thermoset powder coating

Standards: To AAMA 2604 for aluminium alloy galvanised steel, to ASTM D3451.

Internal and External use

Finish: 30% gloss.

16.7.10.2 Preparation

General:

- Use chemical pre-treatments recommended by the coating manufacturer.
- If recommended by the coating manufacturer, provide conversion coatings.

Unprotected steel: Remove rust to the recommendations to grade. Clean by immerse in trichloroethylene or an alkaline solution, and apply a coat of iron phosphate.

Galvanized steel: Clean by immersing in a suitable alkaline or acidic solution, apply a zinc phosphate chemical conversion coating, rinse and degrease.

Aluminium: Pre-treat including application of a conversion coating.

16.7.11 Pre-painting

16.7.11.1 Pre-painted metal products

Standard: To ASTM D16.

Product type: Not lower than the type appropriate to the field of application.

Product finish: Matt

16.7.11.2 High performance organic coatings

Type: Factory applied spray coatings on aluminium products, including polyvinylidenefluoride (PVF2) / fluorocarbon coatings.

Standards: To AAMA 605-2-1992.

16.7.11.3 High performance organic coatings

Applied by specialist applicator who will provide a programme of records and samples of entire coating production.

- Minimum number of coats: 3
- Coating material: PVF2 / fluorocarbon
- Coating thickness: ≥40 microns
- Colour: To approval

16.7.11.4 Equipment paint system

General: Brush, roller or spray application, as recommended by the paint manufacturer, using paint as follows:

- Prime coat to metal surfaces generally, ASTM D16.
- Head and chromate free primer for iron & steel substrates.
- Prime coat to zinc-coated steel: Undercoat.
- Full gloss enamel finish coats, oil and petrol resistant: two coats.
- Aluminium paint

Do not spray paint in underground locations.

16.7.11.5 Two-pack liquid coating

Primer: Two pack epoxy primer, to ASTM D16.

Topcoat:

- Internal use: Proprietary polyurethane or epoxy acrylic system.
- External use: Proprietary polyurethane system.

Application: Spray.

Finish: Full gloss.

16.7.11.6 Epoxy Polysiloxane

Two coat primer free system.

Application: Spray

Finish: Gloss

16.7.11.7 Air-drying enamel

Internal use:

- Primer: Two-pack epoxy primer, to ASTM D16.
- Topcoats: 2 coats

Application: Spray or brush.

Finish: Full gloss.

16.7.11.8 Stove enamel

Internal use: Primer & Top coat: to ASTM D16.

Application: Spray or dip.

16.8 Plastering

16.8.1 Definitions

The terms “plaster” and “plastering” include the terms “render” and “rendering”, except where the context otherwise requires.

16.8.2 Standard

16.8.2.1 General

The following codes/standards are references to the minimum quality acceptable for materials/products/workmanship:

- ASTM C 109
- ASTM C 531
- ASTM C 185
- ASTM C1329
- ASTM C911
- ASTM C207
- ASTM C144
- SNI 15-2049-2004
- SNI 15-0301-1989

Submit calculations and drawings from an Indonesia licensed Professional Engineer concurrently with the shop drawings and showing, but not limited to, the following:

To comply with all relevant Indonesia legislation and regulations respectively,

16.8.3 Materials and Components

16.8.3.1 Plaster materials

- Cement type: To SNI 15-2049-2004; ASTM C1329
- Off-white cement: Iron salts content $\leq 2.5\%$.
- Lime: To SNI 15-0301-1989; ASTM C911; ASTM C207
- Sand: To ASTM C144

Pigments: Manufactured either synthetically or from naturally occurring mineral ores, resistant to lime bloom and efflorescence.

Pigment proportions: $\leq 5\%$ by weight of cement; follow manufacturer recommendation.

Gypsum plaster:

Admixtures: Use proprietary products. Submit all proposed admixtures for the approval prior to the start of work on site.

Bonding Agents: Use proprietary products. Submit all proposed bonding agents for the approval prior to the start of work on site.

16.8.3.2 Expanded Metal lath

Galvanized sheet steel expanded to a mesh by slitting and stretching: Coating class Z275 (minimum).

Stainless steel expanded to a mesh by slitting and stretching.

Self-furring type: Metal lath with staggered indentations which hold the body of the sheet 10 mm clear of the substrate.

Ribbed type: Metal lath with integral ribs designed to increase the strength of the lath and the allowable span between supports.

Edge rim, Stop ends, Stainless steel G304 internal G316 external.

16.8.3.3 Lime putty mixes

Make a coarse mix of lime putty and sand 24 hours before use. Prevent from drying out.

16.8.3.4 Gauged mixes

If required to improve workability, gauge mixes specified to contain only cement and sand by the addition of lime up to 25% of the cement content (i.e. not as a substitute for the cement).

16.8.3.5 Autoclaved aerated concrete walls

Provide a proprietary render or premixed plaster recommended by the wall system manufacturer.

16.8.4 Materials Application

16.8.4.1 Correction of substrate

Before plastering make good any defects in the substrate. Hack off excessive projections. Fill voids and hollows with a mix not stronger than the substrate nor weaker than the first coat.

16.8.4.2 Untrue substrate

One coat work: If the substrate is not sufficiently true to comply with the thickness limits for one coat, or has excessively uneven suction resulting from variations in the composition of the substrate, carry out the work in two coats.

Where the substrate is out of tolerance and it is impossible to correct the deviation through changes to the substrate, provide a method statement to show how plaster thickness will be amended and/or reinforced to deal with the deviation. Do not start work until the method statement has been accepted by the Client/Consultant.

16.8.4.3 Embedded items

Ensure that all embedded items are sheathed to permit movement. If un-galvanized steel items are to be embedded in gypsum plaster, provide rust protection treatment not inferior to prime painting with zinc rich primer.

16.8.4.4 Chases

If chases or recesses are more than 50 mm wide, cover with metal lath extending at least 75 mm beyond each side of the recess.

16.8.4.5 Suction

Control suction by dampening if necessary. Avoid over-wetting.

16.8.4.6 Dense concrete

If not sufficiently rough to provide a mechanical key, roughen by scabbling or the like to remove 5 mm of the surface and expose the aggregate; then dash coat. If scabbling and dash coating does not provide a good key for external render, cover with expanded metal lath.

16.8.4.7 Brickwork

If not rough-jointed, rake out joints 5 mm deep. If raking out is impracticable, hack at close intervals to roughen the surface, or cover with expanded metal lath.

16.8.4.8 Concrete blockwork

Apply a dash coat or a proprietary bonding agent.

16.8.4.9 Metal backgrounds

Fix metal lath to provide a key.

16.8.4.10 Previously painted surfaces

Remove paint, hack at close intervals, or cover with expanded metal lath.

16.8.4.11 Dash coat

Application: Mix to the consistency of a thick slurry and forcibly dash on to the background to give a roughcast coating 3 – 5 mm thick.

Curing: Allow the dash coat to harden in damp conditions and protect it from drying out before applying the next coat.

16.8.4.12 Fixing metal lath

Generally: Provide the necessary accessories. Run the long way of the mesh across supports. In vertical applications slope the strands inwards and downwards away from the background face. Lap ends at least 20 mm and sides at least 10 mm. Tie laps with 1.25 mm galvanized wire every 150 mm. Do not finish edges of sheets at corners but bend around.

Fixing: Fix lath to the background at edges and at supports with fixings approved by the lath manufacturer, spaced at 150 mm maximum centres. Place fixings in the mesh corners so that the heads cover 2 strands.

Fixing to masonry: Use non-corrosive masonry anchors, or masonry or concrete nails. Not to use explosive powered fastenings.

Fixing to metal studs or furring: Use non-corrosive self-tapping screws, or galvanized wire.

16.8.5 Plastering

16.8.5.1 General

All plastering works shall be carried out and tiling works to maintain the minimum requirement as per this specification.

Materials shall be mixed in sufficient quantities of immediate use and shall not be used after one hour has elapsed from the addition of water. Gauges are not to be mixed with each other or old batches re-tempered.

No plastering or tiling works shall be carried out in unsuitable weather conditions unless adequate protection is arranged beforehand to the acceptance of the Authority.

All surfaces to be plastered or screed, including previous coats, are to be brushed down to remove all dust and loose material and are to be well wetted.

All undercoats and screeds to receive tiling, paving etc., are to be well scratched with a wire comb or trowel to form a key.

Render coats shall be applied with sufficient pressure to thoroughly fill all voids, chippings, chasings, rakings in one operation. Heavily cross scratch render coats before initial set to provide mechanical key.

Metal lath shall be deemed provided where necessary for all plastering work exceeding 20mm thick, and at the junction of concrete walls/columns and brick wall/ block wall.

16.8.5.2 Two or Three Coat Set Plaster

- Undercoats: 1:1:6 cement: lime putty: sand.
- Setting coat: 1:1 lime putty: gypsum plaster.

16.8.5.3 Cement Plaster

Proportions (cement: lime: sand)

- Clay brick, concrete: 4:1:16.
- Concrete block: 1:0:6.
- Calcium silicate brick : 3:2:16

16.8.5.4 Waterproof Render

General: Provide cement based render with proprietary waterproofing admixture.

Protection: Avoid puncturing or plugging waterproof render. Where it is necessary to drill through waterproof render for installation of services or fixings, restore the barrier by sealing around the penetrations.

16.8.5.5 Vermiculite Plaster

Gypsum plaster and expanded vermiculite aggregate. Apply using power spray equipment.

16.8.5.6 Self-coloured Render

Colour the finishing coat to match the approved sample panel. Provide white cement, white sand, and pigments. Mix the pigments with the white cement before adding sand and water. Steel trowel finish.

16.8.5.7 Skim Coat Plastering

Skim coat plastering shall be applied to all concrete surfaces. It shall be applied by means of bristle brushes to provide a bonding coat within pits, air holes or blemishes in the parent concrete.

Before the mix has dried, a dry grout of cement and clean masonry sand shall be applied by means of damp pads. The grout shall then be wall scrubbed into dry pits and air holes to provide a dense mortar. When dried, there shall not be any visible film of grout on the surface.

A thorough wash using stiff bristle brushes shall follow in order that no extraneous materials remain on the surface of the concrete after the application of skim coat plaster.

Skim coat surface finish quality (including “skim coat” surface quality before and after applying primer and paint or anti-dust paint) should comply with the following:

The overall surface should be even, gaps between services, penetrations and wall/ceiling should not be seen.

There should not be no spalling, leaks or stains; no visible cracks or pin-holes; no rough, dusty or patchy surface. Paintwork on this surface shall have good opacity.

16.8.5.8 Thickness limits

One coat work: 12 – 15 mm.

Multi-coat work:

- First coat: 9 – 15 mm.
- Floating coat (if any): 6 – 9 mm.
- Finishing coat (except setting coats): 6 – 9 mm.
- Setting coat: 2 – 3 mm.

16.8.5.9 Tolerances

Finish plane surfaces within a tolerance of 3 mm in 1.8 m, determined by a 1.8 m straight edge placed anywhere in any direction. Finish curved surfaces within equivalent tolerances.

16.8.5.10 Proportioning

Apply successive coats no stronger (i.e. no richer in cement) than the substrate or undercoat to which they are applied.

16.8.5.11 Hidden surfaces

Insides of cupboards, if any, are included in the plaster finish required to any area.

16.8.5.12 Incidental work

Return plastering into reveals, beads, sills, recesses and niches. Plaster faces, ends, and soffits of projections in the substrate, such as string courses, sills, pilasters and corbels.

Run throating on soffits of external projections neatly finished. Trim around openings.

16.8.5.13 Joining up

If joining up is unavoidable in a large area of work, make joints invisible in the finished work.

16.8.5.14 Cement based undercoats

Before applying the next coat, allow the undercoat to dry out, dust down, and, if necessary, dampen to give correct suction.

16.8.5.15 Keying

General: Press plaster through the apertures of metal lath, and wings of casing beads.

Keying undercoats: In multi coat work, scratch comb each undercoat in two directions when it has stiffened.

16.8.5.16 Surface finishes

Wood float: Provide an even texture by wood floating the finishing coat.

Fine sand textured finish: Provide an even surface by wood float and finish with a plastic foam float to a fine sand textured finish.

Steel trowel: Provide a smooth dense surface free from texture and free from shrinkage cracks, but not glass-like.

16.8.5.17 Cement render

Proportions (cement: lime: sand): minimum thickness 20mm

- Clay brick, concrete: 4:1:16.
- Concrete block: 1:0:6.

16.8.5.18 Waterproof render

General: Provide cement based render with the approved proprietary waterproofing admixture.

16.8.6 Joints**16.8.6.1 Movement joints**

General: Provide movement joints in the finish which coincide with movement joints in the substrate. Ensure that the substrate joint is filled with the specified jointing material, and is not bridged during plastering.

Plastering on metal lath: Provide movement joints to divide the plastering area into rectangular panels not exceeding 16m².

Location: As identified on drawings or to approval.

Depth: Extend the joint right through the plaster to the substrate.

Width: 3 mm, or the same width as the substrate joint, whichever is greater.

Joint finish: Open

Joint filling (joints more than 3 mm wide): Fill with a resilient sealant.

16.8.6.2 V-joints

Provide V-joints, cut right through the plaster to the substrate, at the following locations:

Junctions between different substrate materials.

Abutments with other finishes.

Abutments with metal door frames.

Between adjacent plaster panels as indicated on drawings typically to public areas in modular grid/pattern.

16.8.7 Trim

16.8.7.1 Terminations

- Re-entrant corners: Finish square.
- Salient angles: Finish up to a 1.6 mm radius corner bead.
- Edge trim: Provide the necessary corner beads, casing beads and stop beads.
- Material: Purpose-made stainless steel sections.
- Fixing: Nail to structure at 300 mm centres. Wire to metal lath.

16.8.7.2 Finish without cornice

General: Produce a square re-entrant corner between ceiling and wall finishes.

16.9 Glazing

16.9.1 Related Work Sections

Refer to the following work sections:

- Civil and Structural Materials and Workmanship Specification/Design Criteria
- Glazing Design Criteria
- Adhesives, Sealants and Fasteners.
- Metals and Pre-finishes.
- Curtain Walls.
- Metal fixtures / Assemblies

16.9.2 Drawings

The outline design drawings show generic design principles and design intent only.

The Contractor shall construct the system in accordance with the relevant standards and be responsible for the following design activities and any other associated design activity not listed:

- Confirm the suitability of the system types specified;
- Confirm the thickness of the glass panels for the nominated sizes;
- Determine the configuration and composition of the Glazing system and the size and fixing methods of glass panels;
- Determine the size and frequency of the primary and secondary support framing for the fall-arrest systems;
- Determine the locations, types and arrangements of all necessary fittings, gaskets, beadings, spacers, articulated point fixings, cleats and the like to be attached to the structure for the Glazing system.
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16.9.2.1 Glass type and thickness

Verify and confirm that all glass thickness specified are sufficient to meet the anticipated loadings on the glazing.

Take into account the variations in height, shape and all other factors which are applicable to the works.

16.9.2.2 Installation

Ensure that the entire installation accommodates all building tolerances and anticipated movement.

16.9.2.3 Touch Voltage Protection

Comply with the requirements of Persyaratan Umum Instalasi Listrik (PUIL); (SNI 0225:2011/Amd 1:2013; Amd2:2014; Amd3:2014 - Standar Nasional Indonesia) where glass/metal fixings are proposed within the station protection zone.

16.9.2.4 Building structure

Expected amounts of differential movements: Cross refer: Civil and Structural Materials and Workmanship Specification.

16.9.2.5 Environment

Design wind pressure (Pa): Cross refer: Civil and Structural Specification.

Thermal resistance (R): Refer to curtain walling section.

Fire resistance level (FRL): Nil, unless indicated as per drawings.

16.9.2.6 Failure

Ensure that laminated glass is capable of remaining in position for a minimum of 72 hours after the breakage of one layer of glass.

16.9.2.7 Standards

The following codes/standards are references to the minimum quality acceptable for materials/products/workmanship:

Provide glass and glazing in accordance with the following standards:

- ASTM C 1048: Standard Specification for Heat-Strengthened and Fully Tempered Flat Glass
- ASTM C1036: Standard Specification for flat glass.
- ASTM C1172: Standard Specification for Laminated Flat Glass.
- ASTM C162: Terminology for Glass and Glass Products.
- ASTM E283.
- ASTM C1087.
- ASTM D-3330.
- ASTM D-897.
- ASTM D-1002.
- SNI15 – 2690 – 2006
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16.9.2.8 Structural glazing

Comply with the recommendations of AAMA CW-13.

16.9.2.9 10.1.4 Interpretation

For the purpose of this document the following terms shall be interpreted as the description.

- Terminology for work on glass:
- The terms 'tempered' and 'toughened' mean the same and are interchangeable.

16.9.2.10 Twin ground plate

Plate glass ground simultaneously on both faces so that uniform glass thickness and parallel faces are maintained within close limits.

16.9.2.11 Structural glazing

A glazing method in which the glass is adhered to the framing system with a structural sealant. Structural sealant: Structural adhesive sealants or tapes.

16.9.2.12 Laminated

For the purpose of the test, Item laminated glass includes glass plies laminated to accepted safety film.

16.9.2.13 Fritted glass

Glass produced by applying a coloured ceramic layer, or frit, to the glass surface and then baking it on during the manufacture of tempered or heat strengthened glass. The coating may be patterned and screen printed on to the glass.

16.9.2.14 Opacified glass

Laminated glass made opaque by introducing an opaque PVB interlayer.

16.9.2.15 Laminated Glass

Test laminated glazing to demonstrate that it will remain in position for a minimum of 72 hours after the breakage of one ply of glass.

- Location of test: On site.
- Size of test: Full size panel as used on site.
- Method of glazing: As recommended by glazing supplier.
- Orientation of panel: As per approved indicated drawing.
- Ply to be broken: As per approval.
- Loading: external glazing: Dead load.
- Live load: As climatic conditions at the time of the test.
- Loading: internal glazing: Dead load.

The laminated glass will be considered to have failed this test if broken glass does not remain fixed in position for a minimum of 72 hours.

The breakage of further plies of glass during the test shall not constitute a failure provided it/they remain in position for the period of the test.

16.9.2.16 Structural glazing

Shop glazed units: Submit details of a test de-glazing procedure, or a panel bond strength test procedure.

- Rate of tests
- one unit in the first 10;
- one unit in the next 40;
- one unit in the next 75; and
- one unit in each 100 thereafter.

16.9.2.17 Sealant

Type test to ASTM C1087, to demonstrate compatibility with the other materials and accessories of the structural glazing system which it may contact.

16.9.3 Materials and Components

16.9.3.1 Glass and glazing materials

Glass and glazing materials generally: Free from defects which detract from appearance or interfere with performance under normal conditions of use.

16.9.3.2 Glass tolerances

Size, squareness and flatness

Plate and sheet (i.e. not patterned):

- Roller wave: Maximum 0.15 mm.

16.9.3.3 Float glass quality

Glazing Select Quality q₃ to ASTM C1036.

16.9.3.4 Safety glasses

Type: Grade A when used in curtain walls.

Heat soaking: Required for all tempered glass.

16.9.3.5 Ceramic coated glass (fritted glass)

Heat strengthened or toughened glass with a coloured ceramic coating fused to and made an integral part of the surface: To ASTM C1048, Condition B.

16.9.3.6 Opacified glass

Type of opacifier: coloured PVB film – colour as per approved sample. Permanently bond to the inner face of the plies in the laminated glass.

Unacceptable blemishes in heat-treated flat glass (including tinted and coated glass)

Standard: To ASTM C1048.

16.9.3.7 Toughened glass

Roller wave to be horizontal.

16.9.3.8 Laminated glass

Standard: To ASTM 1048.

16.9.3.9 Solar control glass

Glass with a hard pyrolytic coating in either position 3 or 4 with U-Value not more than 4.0W/m²K and a Light Transmission value of not less than 49%.

16.9.3.10 Glass Assignment

The nominated glass type and thickness for the following Glazing systems. The nominal/ detail thickness to be as per approved sample, manufacturer recommendation and as per indicated drawing.

Table 16.3: Glass Assignment type

Id	Description
1.	Tempered and laminated glass
2.	Tempered, laminated and heat soaked glass (Solar control glass for Skylights)
3.	Tempered, laminated and fritted (ceramic coated) glass
4.	Tempered, laminated, fritted and heat soaked glass
5.	Tempered, laminated and opacified glass

Table 16.4: Glass Assignment

Area	Location	Nominal Height(mm) as per drawing	Type	Color	Nominal Thickness (mm)
Entrance; Paid/ Unpaid area; Lift Lobby	Balustrade	1200	4	Clear	12
	External Face	As per drawing	1	Clear	12
	Roof eaves	As per drawing	1	Clear	12
Link Bridge	Retail	2700	1	Clear	12
	External face	2700	5	Opaque Color	15
Concourse; Free Area	Unpaid area; Retail	As per Drawing	1	Clear	12
	External face	As per Drawing	5	Opaque Color	15
PSC	Internal face	As per Drawing	3	Frit	15
	Internal partition	As per Drawing	3	Frit	15

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Area	Location	Nominal Height(mm) as per drawing	Type	Color	Nominal Thickness (mm)
Glazed Lift	Shaft wall	As per Drawing	1 & 3	Clear & Frit	20
Stair void	Wall cladding	As per Drawing	4	Frit	12
	Soffit cover	As per Drawing	4	Frit	12
Platform end roof	Canopy edge	As per Drawing	1	Clear	12
Concourse; Platform; Depot	End Gate	1200	4	Clear	12
	End Balustrade	1200	4	Clear	12
	Void balustrade	1200	4	Clear	12
	Skylight	As per Drawing	2	Clear Solar control Glass	24

Refer to drawings for glass applied area specific cut outs/ interfaces thickness/ dimensions.

16.9.3.11 Glazing Materials

Glazing materials (including, but not limited to, putty, glazing compounds, sealants, gaskets, glazing tapes, spacing strips, spacing tapes, spacers, setting blocks and compression wedges): Appropriate for the conditions of application and the required performance.

16.9.3.12 Setting Blocks

Use setting blocks comparable with the accepted sealant.

Neoprene blocks, 90 Shore A durometer hardness.

Minimum Length: 100mm.

Maximum imposed load: Cross Refer: Civil Design Criteria.

Use Silicone setting blocks of 90 Shore A durometer hardness where structural silicone occurs at sills.

Secure setting blocks against migration.

16.9.3.13 PVB film

Type: Proprietary film (interlayer).

Thickness: 1.52mm or as agreed with the client/Consultant; to conform with the performance of laminated glass.

Colour: to approval.

16.9.3.14 Jointing materials

Provide jointing and pointing materials which are compatible with each other and with the contact surfaces, and non-staining to finished surfaces. Do not provide bituminous materials on absorbent surfaces.

16.9.3.15 Glazing tapes

Standards: To AAMA 804.3, 806.3, 807.3, as applicable.

Expanded cellular glazing tape: To AAMA 800.

16.9.3.16 Elastomeric sealants

Sealing compound (polyurethane, polysulphide, acrylic):

- Single component: Type II, Class A.
- Multi component: To ASTM C920.

Sealing compound (silicone):

- Single component: Class A.
- Multi component: To ASTM C920.

Sealing compound (butyl): To ASTM C1311.

Glazing compounds: To AAMA 802.3 (Types I or II), or 805.2, as applicable.

Narrow joint seam sealer: To AAMA 803.3.

Exterior perimeter sealing compound: To AAMA 800.

Non-drying sealant: To AAMA 800.

16.9.3.17 Very high bond pressure sensitive tapes

Cross Refer: Civil Design Criteria.

- Minimum Peel strength: To ASTM D-3330.
- Minimum Normal Tensile (T-block): To ASTM D-897.
- Minimum Dynamic Shear: To ASTM D-1002.

Demonstrate U.V. resistance for external applications.

16.9.3.18 Extruded gaskets and seals

Type: Non cellular (solid) elastopressive seals.

Location / function: as indicated in the drawings, as per approval.

Material: Rubber products (neoprene, ethylene propylene diene monomer (EPDM) or silicone rubber):

16.9.3.19 Priming

Apply the sealant manufacturer's recommended primer to the surfaces in contact with sealant materials.

16.9.3.20 Backing Materials

Apply the sealant manufacturer's recommended backing materials,

Width: 25% wider than the joint width.

16.9.3.21 Movement joints

Depth of elastomeric sealant: One half the joint width, or 6 mm, whichever is the greater.

Foamed materials (in compressible fillers and backing rods): Closed-cell or impregnated types which do not absorb water.

Bond breaking: Provide backing rods, and other back-up materials for sealants, which do not adhere to the sealant.

16.9.3.22 Structural Glazing Materials – Structural Sealant

Type: A proprietary silicone sealant from an established manufacturer, recommended for use as a structural glazing sealant.

16.9.3.23 Very high bond pressure sensitive tapes

Cross refer: Section 3.2 above.

Use proprietary tapes from an established manufacturer.

Submit certification confirming their use as a structural glazing adhesive.

16.9.3.24 Mirrors – Reflective Surface

Type: Silver layer deposited on the glass or glazing plasticizer glazing plastic.

Protective coatings: Electrolytic copper coating at least 5 µm thick, and 2 coats of mirror backing and edge sealing paint having a total dry film thickness of at least 50 µm.

Location: Public Toilets/ Staff Toilets/ Locker room/ Crew Toilet, as per drawings.

Thickness minimum 6mm thick polished edges, 1mm rounded.

16.9.3.25 Product Identification

Permanently mark each piece of glass in a discrete but visible location with the following information: type of glass, manufacturer, properties, standards.

16.9.3.26 Safety glazing materials

Identify each piece or panel to meet the minimum requirement as specified,

16.9.3.27 Noise reducing glazed assemblies

Label each panel with a legible non-permanent mark, self-destroying when removed, stating and certifying the R_w rating, and identifying the testing authority. Remove when directed.

16.9.3.28 Curtain wall glazing

Permanently mark tempered or reflective coated glass, identifying strength grade, manufacturer and orientation.

16.10 Painting**16.10.1.1 References**

The material and workmanship for painting shall in general follow the specifications indicated in the Employer's Requirement.

Refer to the General Requirements work section.

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16.10.1.2 Standards

The following codes/standards are references to the minimum quality acceptable for materials/products/workmanship:

- SNI 03-2410-1991 – Code of practice Wall painting with emulsion paint,
- SNI 2407:2008 – Code of conducts for wood painting for houses and buildings.
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16.10.1.3 Interpretation

Steelwork: refers to all fabricated work, including castings, of a structural or general nature, in grades of steel other than stainless steel.

Aluminium: refers to all fabricated work, including castings, of a structural or general nature, in aluminium.

Paint System: refers to a series of compatible paint coats applied to a substrate and which, together, constitute a protective system for that substrate.

Approved Sample: A sample held by the Client/Consultant and available for viewing during the construction periods.

16.10.1.4 Coated Type Schedule

Table 16.5: Coated Schedule

Coated Type Schedule			
Substrate	Paint system	System Code	Color
Cement Mortar Plastering	External Paint	WF1	As per approval
Cement Mortar Plastering	Textured Paint	WF4	As per approval
Concrete	Anti-Dust Sealer	WF3	As per approval
Cement Mortar Skim Coat	Anti-Dust Sealer	WF5	As per approval
Cement Mortar Plastering	Anti-Dust Sealer	WF2	As per approval

16.10.2 Materials and Components

16.10.2.1 Materials

Do not use products which give off toxic emissions in the event of a fire.

Do not use materials which contain known carcinogenic.

Confirm that materials used in conjunction are compatible with one another, the substrates on which they are used, and all adjacent materials.

16.10.2.2 Paints

Provide the authority accepted paint systems.

16.10.2.3 Combinations

General: Do not combine paints from different manufacturers in a paint system.

16.10.2.4 Delivery

Deliver paints to the site in the manufacturer's labelled and unopened containers.

16.10.2.5 Storage

Store all paint in a secure ventilated area away from other building products.

Do not store paint in paint in underground locationsunderground locations.

Ban all smoking and naked flames in the vicinity of stored paint.

16.10.2.6 Tinting

General: Provide only products which are colour tinted by the manufacturer or supplier.

16.10.2.7 Colour Selection

Use standard colours from: RAL colour range standard.

16.10.2.8 Components

The following items and type of painting are subject to minimum standard as per the respective OCS requirement:

- Gloss enamel
- Undercoat paint for gloss enamel
- Lead and chromate free primers for Iron and Steel substrates
- Mineral Solvents
- Extenders for paints
- Solvent based paint removers

16.10.2.9 Toxic ingredients

- Do not use paints containing pigments incorporating barium or cadmium.
- Do not use paints containing toxic solvents.
- Do not use lead based paints.
- Do not use paints containing mercury.

16.10.2.10 Paint Systems

Final coat: If a paint is referred to only by its final coat (for example by the generic name) provide in addition to the final coat, the manufacturer's recommended stains, primers, sealers and undercoats, suitable for the substrate and compatible with the finish coat and each other.

No system description given: If a surface is to be painted but no system is nominated select the system from the minimum for compliance to the Employer requirement.

16.10.2.11 Number of coats

Unless specified as one coat or two coat systems, each paint system consists of at least 3 coats. Provide additional coats if necessary to

- prepare porous or reactive substrates with prime or seal coats consistent with the manufacturer's recommendations;
- achieve the total film thickness or texture; or
- achieve a satisfactory opacity.

16.10.2.12 Tinting

Ensure each coat of an opaque coating system has a noticeably different tint from the preceding coat, except for top coats in systems with more than one top coat.

16.10.2.13 Paint systems schedules

General: These schedules specify, for each of the wall finishes listed in the Schedule of Finishes, and for each substrate to which those systems are applied in the project,

- The order and paint type for each coat; and
- The minimum dry film thickness for each coat, where applicable.

WF 1

- | | |
|----------------|--|
| ■ Location | External Walls; as per drawing |
| ■ Substrate | Plastering |
| ■ Primer | Water based Epoxy primer; 40 microns dry film thickness;
application with Brush / Roller. |
| ■ Finish Paint | Water based Acrylic weatherproof paint; 250 microns dry film thickness;
application with Brush / Spray. |

WF 2

- | | |
|----------------|---|
| ■ Location | Internal Walls and Columns; as per drawing |
| ■ Substrate | Plastering |
| ■ Primer | Water based Acrylic Sealer for porous surfaces; 40 microns dry film
thickness; application with Brush/ roller / spray; |
| ■ Finish Paint | Water based Anti-Dust, UV Stable Polyurethane paint; 40 microns dry film |

thickness; application with brush/roller.

WF 3

- Location External and Internal Concrete surfaces; as per drawing
- Substrate Pre-cast or Cast-in-Situ Concrete
- Finish coat Solvent based Non Silicon weatherproof Transparent paint; 40 microns Dry Film Thickness; Application with pneumatic Spray.

WF 4

- Location External Fire Stair; as per drawing.
- Substrate Cast-in-Situ Concrete or plastering
- Sealer Deep penetrating Alkali resistant Solvent based sealer; 20 microns dry film thickness; application with brush/ roller/ spray.
- Texture coating Medium profile granular water based Resinous acrylic texture coating; 650 microns dry film thickness; application with spray – hopper gun.
- Finish coat High build, pigmented, water based Resinous acrylic coating; 90 microns Dry film thickness; Application with spray.
-

WF 5

- Location Cable basement and other Sub-soil areas; as per drawing
- Substrate Skim coat on concrete walls
- Primer Water based Epoxy primer; 40 microns dry film thickness; application with brush / roller.
- Finish Paint Water based UV Stable Polyurethane paint; 2 coats of 40 microns Dry Film Thickness; Application with Brush/Roller.

16.10.2.14 PVF2 / PVDF / Fluorocarbon coating

Refer to Steel, Metals & Pre-finishes work section, as applicable.

16.10.2.15 Access panels

Match the paint system used on the walls/ceiling in which the panel occurs.

16.11 Insulation and Barriers**16.11.1 Standards**

The following codes/standards are references to the minimum quality acceptable for materials/products/workmanship:

- SNI 03-0186-1987 – Penyekat panas terbuat dari glass wool

- SNI 1740:2008 – Cara uji bakar bahan bangunan untuk pencegahan bahaya kebakaran pada bangunan rumah dan gedung
- ASTM D2582 – Standard Test Method for Puncture-Propagation Tear Resistance of Plastic Film and Thin Sheeting
- ASTM D882 – Standard Test Method for Tensile Properties of Thin Plastic Sheeting
- ASTM C423 – Standard Test Method for Sound Absorption and Sound Absorption Coefficients by the Reverberation Room Method
- ASTM E795 – Standard Practices for Mounting Test Specimens During Sound Absorption Tests

16.11.1.1 Interpretation

Membrane material: Flexible material normally used for waterproofing, vapour proofing or thermal reflectance.

Mineral wool (including glasswool and rockwool): Entangled mat of fibrous non-crystalline material derived from inorganic oxides or minerals, rock, slag or glass, processed at high temperatures from a molten state.

16.11.2 Materials and Components

16.11.2.1 Bulk Insulation

Mineral wool battens and blankets: To SNI 03-0186-1987.

Mineral wool in loose fill: To SNI 03-0186-1987.

16.11.2.2 Membrane Material

Material: Aluminium composite film

- Type: double sided light weight reflective metallised aluminium
- Thickness: 5 mil (150 microns) thickness
- Puncture propagation and tear resistance: To ASTM D-2582
- Tensile strength: To ASTM D-882
- Elongation percentage: To ASTM D-882
- Acoustic tissue: To: ASTM C423 and E795

Material: glass fibre

- Type: non-woven sound absorbent
- Thickness: 0.2 mm thick
- Weight 61g/m²
- Colour: black
- Tensile strength not less than 130N/50 mm 2%
- Elongation: less than 2% at maximum tensile strength.
- Fire Rating: Class 0

16.11.2.3 Fasteners and Supports

Galvanized steel - Painted black when fully installed.

Mesh support to acoustic insulation

Wire netting:

- Size: 51 mm mesh x 1 mm diameter.
- Welded safety mesh
- Expanded metal mesh tray
- Size: 22 x 57 x 2.0 mm thickness. Minimum 80% open area.
- Material: Aluminium
- Finish: Powder coated
- Colour: Black

16.12 Adhesives, Sealants and Fasteners

16.12.1 General

16.12.1.1 Cross References

Refer to the General Requirements work section.

Table 16.6: Sealant Property

Sealant Property Standard		
Item	Property to be tested	Applicable standard
Wet sealant Weather seal	'Hand Pull'	ASTM C794
Wet sealant Air Seal	'Hand Pull'	ASTM C794
Dry Seal (gaskets)	Air/water penetration	In-situ as required

16.12.1.2 Standards

The following codes/standards are references to the minimum quality acceptable for materials/products/workmanship:

- ASTM A123 / A123M – Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
- ASTM A574M – Standard Specification for Alloy Steel Socket-Head Cap Screws (Metric)
- ASTM F1941/F1941M – Standard Specification for Electrodeposited Coatings on Threaded Fasteners (Unified Inch Screw Threads)
- ASTM F2329 – Standard Specification for Zinc Coating, Hot-Dip, Requirements for Application to Carbon and Alloy Steel Bolts, Screws, Washers, Nuts, and Special Threaded Fasteners
- ASTM A307 – Standard Specification for Carbon Steel Bolts, Studs, and Threaded Rod.
- ASTM F436 – Standard Specification for Hardened Steel Washers

- ASTM C1513 – Standard Specification for Steel Tapping Screws for Cold-Formed Steel Framing Connections
- SNI 0661:2008 — Hexagon head bolts for general usages
- SNI 05-2247-1991 – Cross recessed raised countersunk head tapping screws
- SNI 05-2245-1991 - Cross recessed pan head tapping screws
- SNI 05-2246-1991 – Cross recessed countersunk head tapping screws.
- SNI 05-2213-1991 – Slotted countersunk flat head tapping screws
- SNI 05-2212-1991 – Slotted pan head tapping screws
- SNI 05-2214-1991 – Slotted raised countersunk (oval) head tapping screws
- SNI 05-0323-1999 Nails
- SNI 05-0541-1992 Hexagon nuts and bolts for general and bridge construction
- SNI 05-3067-1992 Hexagon head bolts with metric fine pitch thread -Product grade A and B
- SNI 05-3064-1992 – Hexagon head bolts - Product grade C
- SNI 05-3068-1992 – Hexagon nuts, style 1 - Product grade A and B
- SNI 05-3069-1992 – Hexagon nuts style 2 - Product grade A and B
- SNI 05-3070-1992 – Hexagon nuts - Product grade C
- SNI 05-3066-1992 – Hexagon head screws with metric fine pitch thread - Product grade A and B
-

16.12.2 Materials and Components

16.12.2.1 Adhesives - performance

Provide adhesives capable of: transmitting imposed loads, sufficient to ensure the rigidity of the assembly, and which will not cause discolouration of finished surfaces or have any detrimental effect on materials with which it comes into contact.

- Performing as specified when in contact with run-off from other materials.
- Performing as specified for the lifetime specified in individual work sections.
- Performing as specified in the ambient climatic conditions of Jakarta.

16.12.2.2 Structural sealant

Type: A proprietary silicone sealant from an established manufacturer, recommended for use as a structural glazing sealant.

Cross Refer: Glazing.

16.12.2.3 Adhesive types

Mastic adhesive: Do not use silicone sealants as adhesives.

16.12.2.4 Very high bond pressure sensitive tapes

Cross Refer: Civil Design Criteria

- Minimum Peel strength: To ASTM D-3330
- Minimum Normal Tensile (T-block): To ASTM D-897
- Minimum Dynamic Shear: To ASTM D-1002

Demonstrate U.V. resistance for external applications.

16.12.2.5 Sealants

Provide sealants which will:

- Fully adhere to the materials either side of the joint.
- Not react chemically with the materials which they come into contact with.
- Not discolour adjacent finished surfaces.
- Not sag or shrink in use.
- Remain elastic and weatherproof.
- Accommodate the range of movement anticipated for their location but in no case less than 25%.
- Have no adverse effects after 5 weeks exposure to 15-25 E-Vitons of UC Energy at 70°C.
- Have no adhesion or coefficient failures, nor significant changes after 8000 hours, when subjected to accelerated aging tests (ASTM E-42 Method E).

Sealant colour:

- To match adjacent surfaces; as specified on the drawings.

16.12.2.6 Elastomeric sealants

Sealing compound (polyurethane, polysulphide, acrylic):

Single / Multi component: To ASTM C920.

16.12.2.7 Sealing compound (silicone):

Single / Multi component: To ASTM C920.

16.12.2.8 Polysulphide sealants

One / Two - part: To ASTM C920.

16.12.2.9 Multi component epoxidized polyurethane sealant.

- Adhesion in peel: 6.3kg.
- Hardness: 25 (shore A) after 7 days at 24°C. Average 35 after 5 years.
- Pot life: Maximum 7 hours.
- Tack free time: Less than 72 hours.

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16.12.2.10 Backing Rods

Provide backing rods to sealants as required by the manufacturer's printed instructions.

Material: polyethylene foam.

Size: to suit the joint width but in no case smaller than the joint width + 25%.

16.12.2.11 Bond Breaker

Use bond breaker tape where backing rods are not provided to prevent adhesion to the rear face of a joint.

Material: As recommended by the sealant manufacturer.

16.12.2.12 13.2.3 Fasteners

Masonry anchors: Purpose-made proprietary expansion or chemical types.

Plain washers: To ASTM F436

- General: Provide washers to the heads and nuts of bolts and coach screws.

Plugs: Purpose-made plastic.

Steel nails: To, SNI 05-0323-1999.

Length: At least $2\frac{1}{2}$ x the thickness of the member being secured, and at least 4 x the thickness if the member is plywood or building board < 10 mm thick.

Unified hexagon bolts, screws and nuts: To SNI 05-0541-1992.

Isolate dissimilar materials to prevent galvanic corrosion.

Fastenings to Aluminium (including Aluminium alloys): Aluminium alloys or non-magnetic stainless steel.

Fastenings to Stainless Steel: Appropriate stainless steel materials only. Passivate the threads of threaded fastenings.

Fastenings to Galvanised/Painted Steel: Identify on shop drawings.

16.12.2.13 Performance

Provide fasteners capable of transmitting the loads imposed, and sufficient to ensure the rigidity of the assembly.

Provide fasteners equal or greater than the material strength and corrosion resistance of the lowest of the materials being joined.

Use tamper proof fixings where they will be accessible to the general public.

All fasteners and associated brackets shall be corrosion resistant. The use of untreated mild steel, or cadmium plated steel will not be acceptable.

16.12.2.14 Bolts

- Coach bolts: To ASTM A307
- Hexagon bolts Grades A and B: To, SNI 05-3067-1992.
- Hexagon bolts Grade C: To SNI 05-3064-1992.

16.12.2.15 Nuts

Hexagon chamfered thin nuts Grades A and B:

- Hexagon nuts Style 1 Grades A and B: To, SNI 05-3068-1992.
- Hexagon nuts Style 2 Grades A and B: To, SNI 05-3069-1992.
- Hexagon nuts Grade C: To, SNI 05-3070-1992.

16.12.2.16 Screws

- Coach screws: To ANSI B 18.2.3.8M
- Hexagon screws Grades A and B: To, SNI 05-3066-1992
- Hexagon screws: Grade C
- Hexagon socket screws: To ASTM F3042
- Machine screws: To ASTM C1513
- Self-drilling screws: To ASTM C1513
- Corrosion resistance: ASTM C1513

16.12.2.17 Head tapping screws:

- Crossed recessed countersunk (flat - common head style): To, SNI 05-2246-1991
- Crossed recessed pan: To, SNI 05-2245-1991
- Crossed recessed raised countersunk (oval): To, SNI 05-2247-1991
- Hexagon: To, SNI 05-3066-1992
- Slotted countersunk (flat - common head style): To SNI 05-2213-1991
- Slotted pan: To, SNI 05-2212-1991
- Slotted raised countersunk (oval - common head style): To, SNI 05-2214-1991
- Grub screws: To the approved material.

16.12.2.18 Finishes

Electroplating:

- Metric thread: To ASTM F1941.
- Imperial thread: To ASTM F1941.

Galvanizing:

- Threaded fasteners: To ASTM F2329
- Other fasteners: To ASTM A123.

Mild steel fasteners: To galvanize where

- exposed to weather;
- embedded in masonry.

16.13 Waterproofing

16.13.1.1 Standards

The following codes/standards are references to the minimum quality acceptable for materials/products/workmanship:

- ASTM D41 – Standard Specification for Asphalt Primer Used in Roofing, Damp proofing, and Waterproofing
- ASTM D412 – Standard Test Methods for Vulcanized Rubber and Thermoplastic Elastomers—Tension
- ASTM D2240 – Standard Test Method for Rubber Property—Durometer Hardness
- ASTM D624 – Standard Test Method for Tear Strength of Conventional Vulcanized Rubber and Thermoplastic Elastomers
- ASTM C836 – Standard Specification for High Solids Content, Cold Liquid-Applied Elastomeric Waterproofing Membrane for Use with Separate Wearing Course
- ASTM D471 – Standard Test Method for Rubber Property—Effect of Liquids
- ASTM E96 – Standard Test Methods for Water Vapor Transmission of Materials
- ASTM D751 – Standard Test Methods for Coated Fabrics
- ASTM D146 – Standard Test Methods for Sampling and Testing Bitumen- Saturated Felts and Woven Fabrics for Roofing and Waterproofing

16.13.2 Materials and Components

16.13.2.1 Membranes

Ensure that waterproofing materials used in conjunction are compatible with one

anotheroneanother, the substrates on which they are used and all adjacent materials in the

completed building

16.13.2.2 Asphalt tanking membranes

Waterproof 5 mm thick, of bituminoid asphalt materials, reinforced with fabric, with at least one layer in each sheet of an impermeable, non-corroding material.

16.13.2.3 Single layer membranes

Fix and lap sheets with appropriate proprietary adhesive or by heat welding using a gas torch ("torch on"), self-finished or finished with a proprietary surfacing.

16.13.2.4 Seamless membranes

Membranes applied in liquid or gel form and air cured to form a seamless film.

16.13.2.5 Cementitious Waterproofing System

Trowel brush or spray applied to clean solid substrate, thoroughly sealed beforehand.

16.13.2.6 Tanking

Refer to Civil & Structural M&W Specification

16.13.2.7 Wet Area Waterproofing System**Table 16.7: Properties**

Properties	Type/ Standard
Type	Fast drying, tar free, one part seamless membrane to ASTM 836-1989
Tensile Strength	ASTM D412: 3.0 Mpa
Elongation at break	ASTM D412: 1440%
Hardness Shore A	ASTM D2240: 30
Tear Resistance	ASTM D624 Die C: 7.4 kN/m
Adhesion strength	ASTM C836-89: 1.7 kg.cm
Tensile strength @ 100% elongation	ASTM D412: 0.62 Mpa

16.13.2.8 Membrane Roofing - Platform RC Roof Beam

Waterproofing to the top side of the station's perimeter RC roof beams shall consist of

a fully bonded type flexible SBS (styrene-butadiene-styrene) modified bitumen,
minimum 2.50mm thick preformed membrane reinforced with 180 gm/m² of non woven
polyester fabric.

The waterproofing membrane shall be laid by the manufacturer's approved applicators
strictly in accordance with the recommendations of the manufacturer and with
accepted good practice in the trade. Proper accessories such as anchor strips, pipe
collars, outside and inside corners, steel laminated plates etc. should be used for the
correct and secure application of the waterproofing system.

Surfaces to be waterproofed shall be first prepared to manufacturer's instructions.

A

bituminous primer coat shall be applied at the receiving surfaces prior to the laying of
the waterproofing membrane. The primer shall be capable of penetrating and sealing
porous surfaces.

Properties of the primer coat shall comply with the requirements of ASTM D-41.

- a. a. Water content: Nil
- b. b. Distillation, volume % of primer
 - Up to 225 deg C : Not less than 35%
 - Up to 360 deg C : Not more than 65%
- c. c. The residue obtained from distillation up to 360 deg C conforms to the following requirements:
 - (i) Penetration at 25 deg C. 100gms 5 sec.: 20 to 50 Dmm
 - (ii) Matter soluble in trichloroethylene: Not less than 99%

Installation procedures for the waterproofing shall be in strict accordance with the
manufacturer's instructions.

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After installation, a protective screed 50mm thick
minimum shall be installed to ensure that the membrane is not damaged.
The
complete installation shall be to the approved status.

16.13.2.9 Roof outlets for membrane roof

General: Proprietary rain water outlet cast into the roof concrete, set flush with
membrane, with a removable stainless steel grating and provision for sealing the
membrane into the base of the outlet.

16.13.2.10

16.13.2.11 16.13.2.10 Movement joints

Contractor to provide a movement joint detail to adhere to local regulation and to
obtain the approved status.

16.14 Fire Stopping

16.14.1.1 Standards

Service penetration fire-stopping systems: To provide the required period of fire resistance.

Control joint fire-stopping systems: To provide the required period of fire resistance.

Materials to Fire rating minimum 2 hrs unless otherwise stated.

The following codes/standards are references to the minimum quality acceptable for

materials/products/workmanship:

- SNI 1740:2008 – Cara uji bakar bahan bangunan untuk pencegahan bahaya kebakaran pada bangunan rumah dan gedung
- ASTM E119 – Standard Test Methods for Fire Tests of Building Construction and Materials.
- ASTM E814 – Standard Test Method for Fire Tests of Penetration Firestop Systems.

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- - ASTM E136 – 12 – Standard Test Method for Behavior of Materials in a Vertical Tube Furnace at 750°C (combustibility)
- - ASTM E84 – 14 – Standard Test Method for Surface Burning Characteristics of Building Materials
- - ISO 5660-1:2002 – Reaction-to-fire tests -- Heat release, smoke production and mass loss rate

16.14.2 Materials and Components

Shelf life: Ensure materials used have not exceeded their shelf life.

Toxic materials: Free of asbestos and lead, or any other known toxin, and free of, nor requiring the use of toxic solvent.

Do not use products which give off toxic or carcinogenic emissions in the event of a fire.

Corrosivity: Non-corrosive.

Do not use intumescent materials or rely on intumescent coatings internally.

16.14.2.1 Fire-stop mortars

Type: Re-enterable cement-based compound, mixed with water. Non-shrinking, moisture resistant.
Insoluble in water after setting.

Setting and Curing time: As per the supplier recommendation.

16.14.2.2 Formulated compound of incombustible fibres

Material: Formulated compound mixed with mineral fibres, non-shrinking, ~~moisture~~
~~resistant~~moisture resistant.

-Insoluble in water after setting.

16.14.2.3

16.14.2.4 16.14.2.3 Fibre stuffing

Material:

- - Mineral fibre stuffing insulation, dry and free of other contaminants.
- - Ceramic fibre stuffing insulation, dry and free of other contaminants.
- -
- Standard: to approval

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Sealant: to approval

Submit the manufacturer's certification that alkaline water contamination will not cause corrosion of metal penetrating items.

16.14.2.5

16.14.2.6 16.14.2.4 Fire-stop composite sheets

Perforated galvanized steel sheet faced 2 sides fibre cement board nominally 9.5m thick with accessories/framing systems.

16.14.2.7

16.14.2.8 16.14.2.5 Fire-stop sealants

Material: Elastomeric sealant. Soft, permanently flexible, non-sag, non-shrinking, moisture resistant.

Capable of providing a smoke-tight, gas-tight and waterproof seal when properly installed. Insoluble in water after setting.

16.14.2.9

16.14.2.10 16.14.2.6 Fire-stop collars

Material: Mechanical device with incombustible intumescent fillers covered with sheet steel jacket. Airtight and watertight.

16.14.2.11 16.14.2.7 Fire-stop pillows

Material: Formed self-contained compressible flexible mineral fibre in cloth bags, rated to permit frequent changes in service.

16.14.2.12 16.14.2.8 Accessories

Primer: As recommended by manufacturer for substrates on site.

Permanent retaining material: Non-combustible.

Installation accessories: Provide clips, collars, fasteners, temporary stops and dams, and other devices required to position, support and contain fire-stopping and accessories.

16.14.2.13 16.14.2.9 Systems

Table 16.8: Insert Table Title here

Fire Stopping Systems		
Location	Substrate; Penetrants	FRL Resistance to the incipient spread of fire
Fire walls; Stair Wall	Concrete/ blockwork/ brickwork	
Room to room walls/ partitions – head/ slab junction	Cables/metal pipes/ducts and conduit	
Floors	Metal pipes/ ducts and conduit	To follow the respective drawing indication in accordance to the employer's requirement
Ceiling to roof soffit	Cables/metal pipes/ducts and conduit	
Curtain wall, between slab and inner face of curtain wall	Refer to curtain wall drawing; as applicable	

16.15 Concrete Finishes

16.15.1 General

This section specifies requirements for architectural finishes for in situ and pre-cast concrete within the station development boundary as shown on the architectural drawings.

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16.15.1.1 Cross References

Refer to the General requirements work section.

16.15.1.2

16.15.1.3 16.15.1.2 Related work sections

This section shall be read as an addendum to and in conjunction with: Civil and

Structural M & W Specification.

16.15.1.4 16.15.1.3 Standard

The following codes/standards are references to the minimum quality acceptable for

materials/products/workmanship:

- ASTM C779 – Standard Test Method for Abrasion Resistance of Horizontal Concrete Surfaces
- ACI 301 – Specifications for Structural Concrete
- ACI 116R – Cement and Concrete Terminology (Reapproved 2005)
- ACI 121R – Guide for Concrete Construction Quality Systems in Conformance

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16.15.1.5 16.15.1.4 Quality of Concrete Finishes

The quality of concrete finish shall be identified by the following, whereby applicable to the

most surfaces exposed to view, with additional finish requirements as further described

herein.

16.15.1.6 16.15.1.5 Surface Finish

This finish shall be obtained by the use of high quality concrete and properly designed

formwork or rigid moulds of timber, plywood, plastic, concrete or steel.

The concrete

shall be thoroughly compacted and all surfaces should be true, with clean arises.

Small

blemishes caused by entrapped air or water may be expected, but the surface shall be

free from voids, honeycombing or other blemishes, with no staining or discoloration

from the release agent.

For any required exposed concrete surface without additional finishes (at area that is

exposed to public), the concrete surface is then improved by carefully removing all fins

and other projections, thoroughly washing down, and then filling the most noticeable

surface blemishes with a cement and fine aggregate paste to match the colour of the

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original concrete.

The release agent shall be carefully chosen to ensure that the

concrete surface will not be stained or discoloured.

After the concrete has been

properly cured, the face shall be rubbed down, where necessary, to produce a smooth

and even surface.

16.15.2 Materials and Components

16.15.2.1 Materials

Ensure materials are free of, or do not require the use of toxic solvents.

Do not use

materials, which contain known carcinogens.

16.15.2.2 Concrete

Refer to Civil and Structural M & W Specification.

16.15.2.3 Pre Cast Concrete

Refer to Civil and Structural M & W Specification.

16.15.2.4 Fluro-Silicate Sealers

Type: penetrating, non-staining, transparent sealant

16.15.2.5 Surface hardeners

Type: non-metallic

Abrasion resistance. To ASTM C779.

Hardness: 9 mohs minimum

Adhesion: 4.5. kg/sq.cm. minimum

Chemical resistance of at least 4 to 6 times greater than untreated surface.

16.15.2.6 Colour Consistency

- a. a) The consistency of the concrete colour (light grey) is deemed to be of great importance on the project. The Contractor shall select all suppliers and materials and all methods to ensure the specified finish and consistency, including but not limited to the following:
 - (i) Main plant to have consistent supply to achieve specified finish, to approval.
 - (ii) Back-up plant selected to achieve similar approved supply
 - (iii) Cement, fines and other aggregates to achieve light grey concrete colour.
- b) The Contractor shall maintain the approved colour range that will be acceptable, based on the on-site mock up or other benchmarks, or samples which will then become the colour standard for the project.

b.

16.15.2.616.15.2.7 Tolerances

Determine tolerance classes using a straight edge placed anywhere on the surface in any direction. Curved profiles shall be determined using curved edges on the surface in the direction of the curve. Abrupt changes in the line of the finished concrete will not be acceptable.

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Table 16.9: Tolerances

Tolerances	Maximum deviation (mm)
Gradual irregularities, expressed as maximum permissible deviation from a 3m straight edge	+/- 5mm
Overall height and width under 3m	+/- 5mm
Height and width over 3m	+/- 5mm for each additional 3m
Out of square (different in length of two diagonals)	5mm per 3m
Position of cast in items, inserts, bolts, pipe sleeves, electrical conduits, etc.	+/- 5mm

16.15.2.716.15.2.8 Surface Modifiers

Apply to clean surfaces. Do not apply to non-slip topping.

16.15.2.8 16.15.2.9 Unformed Surfaces - Screeding

Strike off, consolidate and level slab surfaces to finished levels, to tolerance class A.

16.15.2.9 16.15.2.10 Finishing methods

Machine floated finish: After screeding consolidate the surface using a machine float.

Hand float in locations inaccessible to the machine float. Cut and fill to tolerance class

B and re-float immediately to a uniform, smooth, granular texture.

Steel trowelled finish: After machine floating, use power trowels to produce a smooth

surface relatively free from defects. Then, when the surface has hardened sufficiently,

use steel hand trowels to produce the final consolidated finish free of trowel marks and

uniform in texture and appearance, to tolerance class A. Where floor coverings are to

be installed, remove defects that would show through them.

Wood float finish: Produce the final finish using a wood float.

16.15.2.10 16.15.2.11 Formed Surfaces

To be used in conjunction with 'Surface Finishes for Formwork or Moulds' in the

Material and Workmanship for Civil & Structural Works with the following additional

classifications:

- a. a) Produce a smooth even finish with purpose made, rigidly constructed steel moulds arranged in an approved regular pattern as a feature of the surface to coincide with the shape and dimension as indicated in the architectural drawings.
- b. b) Do not replace parts of formwork panels where this may cause a change in colour in the concrete.
- c. c) The surface shall be free from discolouration caused by contamination from dirt, release agent, demoulding oil, grout leakage or other sources. Surfaces visible to the public shall not be marked with paint/ permanent markers for identification of component pieces.

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- d. d) The use of spacers shall first be as per approval. Cover spacers shall not be visible. No rust marks are allowed.
- e. e) Generally, surfaces shall be free from voids, honeycombing, segregation and other defects. Voids shall be kept to an absolute minimum whilst ensuring compliance with other requirements of the Specification. The following shall be observed:
 - Blowholes greater than 2mm in diameter shall be repaired up to a maximum of 5mm diameter.
 - Minor chipped-offs to square edges, chamfers, corners, recesses shall be repaired up to a maximum of 5mm in any direction.
 - The concrete shall have a consistent, uniform, matt, light grey coloured face. Colour to be agreed with the Client/Consultant.
 - The concrete shall be free of surface blemishes visible to the eye at 8 metres.
 - No repairs are permitted to formwork without approval. Damaged panels shall be replaced with material of the same performance and shall be grout washed to blend in with existing panels.
 - No water or grout loss will be permitted. Marks no larger than 50mm in any dimension will be acceptable.
- f. f) Formwork tie holes shall be in an approved regular pattern, filled with exact matching prepared cement/fine aggregate paste to an approved sample as specified.
- g. g) Where rebates or features are shown these shall also be the panel joints. No other joints are permissible. The design of panel joints, rebates, striking pieces and other elements are the responsibility of the Contractor, and shall be subject to the prior approval.
- h. h) The manual trowel work to any unformed face of the mould shall first be agreed prior to proceeding.

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16.15.2.1116.15.2.12 Smooth rubbed finish

For this type of finish, to remove the forms while the concrete is green, patch

immediately, and complete the rubbing not later than the following day.

Wet the

surface and rub using a carborundum or similar abrasive brick until a uniform colour

and texture are produced. Do not provide cement grout other than the paste drawn

from the green concrete by the rubbing process.

16.15.2.12 16.15.2.13 Schedule

Table 16.10: Integral Finishes Schedule

Item	Pre-cast concrete arches & roof beams; All pre-cast parapet	All in situ parapets; All in situ stairs support beams, downstand & soffits; Pre-cast beams; Station columns & cross head beams
Location	Concourse; Platform	Entrances/ link bridge; Ground/ concourse / platform
Surface modifier	Options for clear or opaque sealant	Options for clear or opaque sealant
Formwork	Rigid steel moulds	Contractor to propose and submit for approval
Admixture	Medium Grey	Medium Grey

16.16 Doors and Hatches

16.16.1.1 Related work sections

Refer to the following work sections:

Steel, Metal and Pre-finishes

Painting

Doors and Window Hardware

Civil & Structural Design Criteria

Louvers

Paving and Tiling

Roof & Cladding

16.16.1.2 Interpretation

Door set: An assembly comprising a door or doors and supporting frame, guides, and

tracks, including the hardware, signage and accessories necessary for satisfactory

operation.

Public Face: The face of the door set where one side is visible to the public in normal operation.

16.16.1.3 Standards

- —ASTM A653 – Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process
- —ASTM C864 – Standard Specification for Dense Elastomeric Compression Seal Gaskets, Setting Blocks, and Spacers
- — ASTM B221 – Standard Specification for Aluminum and Aluminum-Alloy Extruded Bars, Rods, Wire, Profiles, and Tubes

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16.16.1.4 Touch Voltage Protection

Comply with the requirements of Persyaratan Umum Instalasi Listrik (PUIL); (SNI 0225:2011/Amd 1:2013; Amd2:2014; Amd3:2014 - Standar Nasional Indonesia), where doors are proposed within the station protection zone.

16.16.1.5 Electrical Locking System

Ensure that any electrical locking system meets the requirements of the security and escape strategy as agreed with the system operator and relevant building control authority.

16.16.2 Materials and Components

The contractor shall conform to the following:

- — Toxic materials: Use materials which are certified free of asbestos and lead, or any other known toxin, and free of, nor requiring the use of, toxic solvents.
- — Do not use products which give off toxic emissions in the event of fire.
- — Do not use materials which contain known carcinogens.
- — Confirm that materials used in conjunction are compatible with one another, the substrates on which they are used, and all adjacent materials in the completed building.

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16.16.2.1 Flashing and Weathering

General: Provide flashings and weathering which are corrosion resistant, compatible

with the other materials in the installation, and coated with a non-staining compound
where necessary.

16.16.2.2 Jointing Materials

Provide recommended jointing and pointing materials which are compatible with each other and with the contact surfaces and non-staining to finished surfaces.

Do not

provide bituminous materials on absorbent surfaces.

16.16.2.3 Extruded gaskets and seals

Type: Non cellular (solid) elastopressive seals.

Material: Rubber products (Ethylene propylene diene monomer (EPDM): To ASTM C864.

16.16.2.4 Nylon brush seals

Dense nylon bristles locked into galvanized steel strips and fixed in a groove in the edge of the door or in purpose-made anodised aluminium holders fixed to the door with very high bond pressure sensitive double sided tape.

16.16.2.5 Steel Doors & Frames

Steel Frame are used in combination with steel doors, louvered doors and over clad doors.

Reference on the related schedule to be as per drawing indication of door schedule/detail.

16.16.2.6 Description

Door leaf: 47mm thick door-leaves formed from minimum 1.5mm thick zinc-coated

(bonderised) steel to ASTM A653 skins reinforced with internal C-profiled through going stiffeners welded to the outer skins, insulated with sound attenuating proprietary core infill, complete with preparations for locks, reinforcement plates for overhead door closer, fixed, recessed hinge pockets and a base to accommodate uneven floor finishes.

Frame: made of minimum 1.5mm thick zinc-coated (bonderised) steel to ASTM A653 welded, recessed head-jamb, complete with mortar boxes.

An uninterrupted air seal by means of a continuous rubberized seal seated within a recess formed in a proprietary four-sided frame shall be provided. The frame shall come prepared for hinges, door closer and strikes. A stainless steel striker plate shall be provided.

16.16.2.7 Finish

Zinc coated bonderised steel Pre-finish: Zinc-iron.

Stainless Steel Pre-finish: Continuous hairline finish polished using grit size 180-240 unless otherwise specified.

Shop priming: Shop prime the sections for the painting system.

Finishing coats: Shop apply all paint coats except the final coat. Apply the final coat on site on completion of the works.

Hardware: Hardware preparations as required by the specifications in the door schedule shall be provided.

Double-Leaf doors: Equal or Unequal door leaves as required by the door schedule shall be provided with appropriate proprietary seal arrangements.

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16.16.2.8 Fire Rating

Minimum 2 hours fire rating for respective door type as shown on drawing/schedule.

16.16.2.9 Assembly methods

Shop assemble fire rated and heavy duty frames by continuous welding.

Grind the

welds smooth and cold galvanize the welded joints before shop priming.

16.16.2.10 Hardware and accessories

General: Provide for fixing hardware including hinges and closers and accessories as

signage plates, using back plates and lugs sufficient to carry the weight of the door and

the forces acting on it.

Screw fix the hinges into tapped holes in the back plates.

Spreader: Removable spreader bar for frames to be built into masonry construction.

Hardware accessories: Mortar guards and reinforcing plates for the hardware.

Silencers/Buffers: Minimum two resilient grommet type silencers/buffers per leaf.

Cavity flashing: For external frames in cavity masonry.

Glazing beads (for glazed transom lights): Fabricate from material of the same type as

the frame. Mitre corners. Screw to frames with matching countersunk head screws at

300 mm maximum centres.

16.16.2.11 Scheduling of steel door set types

Steel door set types to include reference to : Door steel thickness, Frame steel

thickness, Steel type, Steel pre-finish, Paint type, Profile Type, Width between flanges

(mm), Width of Architrave faces(mm), Depth of Door seat rebate (mm), Glazing beads.

16.16.2.12 Aluminium Louvered Doors & Frames

Aluminium Louvered doors are used in combination with the Louver Panel System.

Reference on the related schedule to be as per drawing indication of door
schedule/detail.

Door Leaf: With maximum 130mm deep door leaves assembled from extruded
aluminium sections and louvers, including necessary accessories such as buffers, pile
strips, strike plates, fixing ties or brackets and cavity flashing, with suitable provision for
fixing specified hardware; prefinished with protective coatings, built in or fixed to
prepared openings.

Louvers: The louver blades shall be proprietary sinuous curved type, manufactured
from extruded Aluminium AA 6063T5 or equivalent with a nominal thickness 1.2mm
and be storm resistant single bank fixed blade type with concealed unitised sub-frame.

The blades shall be installed at an angle of 35 degrees and shall have a vertical height
of not less than 71mm. Louvres shall be delivered as finished units.

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Frame: shall be made of fully manufactured from extruded Aluminium AA6063T5 or
equivalent with a minimum thickness of 2.0mm and shall have a unitised inner
structural frame. Split mullion with a pressure equalisation chamber shall be used.

Wet

seals shall not be used. The mullions shall incorporate two drainage channels in the
extrusion.

Press formed coil or sheet will not be accepted.

16.16.2.13 Finish

General: Louvre system shall be coated in PVF2/ Fluorocarbon to a minimum thickness of 40 microns. Colour sample should be submitted to the Client/Consultant for approval.
“Public Face” finish to match adjacent cladding system finish with matching joints/alignment etc.

Bird Guard: shall be provided to all ventilation louvers where indicated on the drawings. The size of the mesh shall be 30mm by 10mm austenitic stainless steel and shall be factory fitted to the internal unitised frame.

The bird guard shall be clamped to the internal frame using extruded Aluminium section of minimum dimension 25mm by 25mm.

Flat bar shall not be permitted.

16.16.2.14 Hardware and accessories

General: Provide for fixing hardware including hinges and closers and accessories as signage plates, using back plates and lugs sufficient to carry the weight of the door and the forces acting on it. Screw fix the hinges into tapped holes in the back plates.

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Hardware: All fixing hardware to be used in the assembly of the louver shall be manufactured from austenitic Stainless steel or Aluminium. All fasteners shall be concealed. Provide for all necessary accessories such as buffers, strike plates,

spreaders, mortar guards, ties, brackets with suitable reinforcement for fixing
hardware.

Special hardware and pivot hinges all to be concealed from public face.

Include allowance for any increases to the spindle and cylinder.

16.16.2.15 Frameless Glass Doors

Frameless Glass Doors are used in combination with a fully glazed wall.

Reference on

the related schedule to be as per drawing indication of door schedule/detail.

16.16.2.16 Description

A proprietary glazed door system, installed by the manufacturer, or a subcontractor
approved by him, consisting of toughened and / or tempered and laminated, glass door
panels hung with purpose-made metal patch fittings and including the manufacturer's standard or optional proprietary push bars or plates, floor springs and a means of locking.

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Door Leaf: The door leaf shall be of sufficient thickness as appropriate to the clear
opening size and specification of the glass type as described in the Door and Glazing schedules.

The glass used for the door leaf shall be similar in appearance to that of its
adjacent glazing, including frit pattern, colour and opacity.

16.16.2.17 Glass

Thickness (mm): All thickness specifications shall be as per recommendation of

glazing specialist and shall comply with the relevant codes of practice.

All exposed

edges of the glass shall be polished, chamfered and comply to other requirements of

the section 'Glazing' of this document.

16.16.2.18 Patch fittings and locks

Proprietary patch fittings shall be approved prior to preparation of glass.

Finish: 304 / 316 Grade Stainless steel of linear Hairline 180-240 Grit.

16.16.2.19 Hanging

Double Action Floor springs with a hydraulic hold-open function recessed flush in floor.

Offset pivot fixing floor hinges shall be provided where required by the door schedule.

The top cover plate shall match the patch fittings in finish and colour.

16.16.2.20 Hardware and accessories

Refer to Door & Window Hardware Section.

16.16.2.21 Over-clad Doors and Frames

Over-clad doors and frames are used in combination with the cladding systems.

Reference on the related schedule to be as per drawing indication of door
schedule/detail.

16.16.2.22 Description

Door leaf: 47mm thick door-leaves formed from minimum 1.5mm thick zinc-coated
(bonderised) steel skins to AS 1397, reinforced with internal C-profiled through-going
stiffeners welded to the outer skins and engineered to support a weight of 100Kg/m² of

external cladding, insulated with sound attenuating proprietary core infill, complete with preparations for locks, reinforcement plates for overhead door closer, fixed, recessed hinge pockets and a base to accommodate uneven floor finishes.

Frame: made of minimum 1.5mm thick zinc-coated (bonderised) to ASTM A653 or 304 / 316 grade Stainless Steel, welded, recessed head-jamb, complete with mortar boxes.

An uninterrupted air seal by means of a continuous rubberized seal seated within a recess formed in a proprietary four-sided frame shall be provided. The frame shall come prepared for hinges, door closer and strikes. A stainless steel striker plate shall be provided.

16.16.2.23 Fire Rating

Minimum 2 hours fire rating for respective door type as shown on drawing/schedule.

16.16.2.24 Cladding

Door with aluminium cladding and louver cladding system to be as per drawing indication of door related schedule/detail.

16.16.2.25 Hardware and accessories

General: Provide for fixing hardware including hinges and closers and accessories as signage plates, using back-plates and lugs sufficient to carry the weight of the door and the forces acting on it. Screw fix the hinges into tapped holes in the back plates.

Hardware: All fixing hardware to be used in the assembly of the louver shall be

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manufactured from austenitic Stainless steel or Aluminium.

All fasteners shall be

concealed. Provide for all necessary accessories such as buffers, strike plates, spreaders, mortar guards, ties, brackets with suitable reinforcement for fixing hardware. Special hardware and pivot hinges all to be concealed from public face.

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Include allowance for any increases to the spindle and cylinder.

16.16.2.26 Gates

Security gates are used in combination with Fences, Balustrades and Parapet walls.

Reference on the related schedule to be as per drawing indication of door schedule/ detail.

16.16.2.27 Stainless steel gates

Grade 316 Stainless steel gates and frames in external locations, made of Square

Hollow Sections and Flats complete with preparations for locks, reinforcement plates for other hardware, signage etc.

The Hollow sections shall be reinforced with

concealed steel sections at appropriate junctions and supports.

Hardware and accessories: Provide for all necessary accessories, such as buffers,

strike plates, spreaders, ties, concealed reinforcements for fittings and hardware.

The

door leaves shall be butt hinged to the anchored S/S fence posts.

Provide an integrated push plate with facility for signage 'Push to Open' shall be

provided on the egress side.

16.16.2.28 Galvanized mild steel gates

Galvanised Mild Steel gates and supports at the Maintenance Vehicle Area, made of
Square Hollow Sections and Flats complete with preparations for locks, reinforcement
plates for other hardware, signage etc., hinged on one side onto anchored GMS posts
and with a hinged joint in the middle moving on Heavy Duty Castor Wheels.

The

Hollow sections shall be reinforced with concealed steel sections at appropriate
junctions and supports. A track plate made of 12mm thick GMS flat shall be fixed flush
to the ground finish to cover the path of the Castor wheels.

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Finish: Glossy Enamel paint system

16.16.2.29 Glazed emergency gate system

A custom made glazed emergency gate system, installed by the contractor or a
specialist sub-contractor approved by him, consisting of toughened glass gate panels
hung from purpose-made Grade 316 SS Rectangular Hollow Section Top rail.

The gate

shall include provisions for proprietary floor springs, Electrical Door Release system
and a means of locking as suggested in the drawings.

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Door Leaf: shall be of sufficient thickness as appropriate to the clear opening size and
specification of the glass type as described in the Door and Glazing schedules.

The

glass used for the door leaf shall be similar in appearance to that of its adjacent glazing, including frit pattern, colour and opacity.

Hardware and accessories: Provide for all necessary accessories, such as buffers, strike plates, spreaders, ties, brackets with suitable reinforcement for fittings and hardware.

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Concealed pivot hinges within top frame and recessed flush into floor finish.

16.16.2.30 Touch Voltage Protection

Provide and Install to the required Standards.

16.16.2.31 Finish

Hairline finish for Grade 316 / 304 Stainless steel.

16.16.2.32 Access Hatches - Back of House Hatches

Proprietary hinged access hatch door in floor plant rooms at ground floor providing access to the cable chamber.

Doors are made up of a grating for air passage.

Material: Galvanised Mild Steel of minimum 4.76mm thickness.

Cover: GMS grating with overlapping flange, fully welded at corners and reinforced to carry the applied loading on the adjacent floor. Extruded EPDM rubber gasket shall be permanently adhered to cover.

Frame: GMS frame with anchor flange around the perimeter.

Complete with fixing lugs

each side sufficient to resist the forces acting on the hatches. Cast into concrete.

Integral barriers to prevent accidental falls into hatch opening.

Hinges: Continuous heavy-duty type 316 grade Stainless steel.

Latch: Grade 316 Stainless steel slam lock with fixed interior handle and removable exterior turn / lift handle. The release should be protected by a flush, gasketed, removable screw plug.

Lift Assistance: Torsion bars that pivot on cam-hinges. Provide automatic hold-open arm with grip handle release.

Finish: Glossy Enamel paint on Alkyd based red oxide primer.

Hardware: All other hardware other than that specified as stainless steel to be zinc plated or chromate sealed.

16.16.2.33 Front of House Hatches (Hinged)

Proprietary hinged access hatch door in floor of public areas, designed with a pan to cover to accept the corresponding floor tiles/finishes to match the surroundings.

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Material: Cover and frame to be of aluminium.

Cover: Aluminium plate reinforced to carry the applied loading on the adjacent floor.

The cover should be designed with a pan to accept the corresponding floor tiles/finishes.

Frame: Extruded aluminium frame built with anchor flange around the perimeter.

Complete with fixing lugs each side sufficient to resist the forces acting on the hatches.

Cast into concrete.

Hinges: Continuous heavy-duty type 316 Grade Stainless steel hinge.

Latch: Grade 316 Stainless steel slam lock with fixed interior handle and removable exterior turn / lift handle. The release should be protected by a flush, gasketed, removable screw plug.

Lift Assistance: Counterbalancing gas struts to enable covers to be opened by one man. Automatic hold-open arm with grip handle release.

Hardware: Grade 316 Stainless steel hinges. All other hardware shall be zinc plated or chromate sealed.

16.16.2.34 Front of House Hatch (Unhinged)

Custom made unhinged maintenance hatch panel in floor of public areas to cover cable pull boxes.

Material: Cover and frame to be of Aluminium.

Cover: Aluminium plate reinforced to carry the applied loading on the adjacent floor.

The cover should be designed with a pan to accept the corresponding floor tiles/finishes.

The cover shall be provided with lift-hook eyes at diametrically opposite corners.

Extruded EPDM rubber gasket shall be permanently adhered to the cover.

Frame: Extruded aluminium frame built with anchor flange around the perimeter.

Complete with fixing lugs each side sufficient to resist the forces acting on the hatches.

Cast into concrete.

Hardware: The lift-hook eyes shall be of 316 Grade Stainless steel.

16.16.2.35 Roof Hatches (Hinged)

Proprietary hinged roof scuttle in non-public areas to provide access to the main roof, designed to integrate retractable aluminium fire ladders.

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Material: Cover and frame to be of Aluminium.

Cover: Break formed, hollow-metal design with a minimum 25mm thick concealed fibreglass insulation, beaded and with overlapping flange, fully welded at corners and internally reinforced for minimum 195Kg/m² live load. Extruded EPDM gasket shall be permanently adhered to the cover.

Curb: 305mm high integral cap flashing shall be provided with minimum 25mm thick fibreboard insulation, fully welded at corners and mounting flanges fully secured to the concrete curb provided for the purpose.

Hinges: Provide Grade 316 Stainless steel heavy-duty hinges and pins.

Latch: Provide slam latch with interior and exterior turn handles and padlock hasps.

Lift Assistance: Counterbalancing gas struts to enable covers to be opened by one man. Automatic hold-open arm with grip handle release.

Finish: Mill finished Aluminium.

Hardware: Grade 316 Stainless steel hinges. All other hardware shall be zinc plated or chromate sealed.

16.16.2.36 17.2.7 Access Panels Aluminium Access Panel

Proprietary system comprising an aluminium panel faced door to suit the adjacent aluminium cladding. The panels shall be side hung to a steel door frame, inclusive of

the necessary hardware and accessories including hinges and lock and lugs or other suitable means for installation.

Flush faces and edges pressed from hot dipped metal sheet to ASTM A653, welded at joints. Apply zinc-rich primer to welds.

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Refer: Roofing and Cladding chapter.

Finish: Factory-applied finish consisting of one coat zinc phosphate etch and one coat zinc chromate primer for the frame. Aluminium panels shall be pre-finished and matched to the adjacent panels.

Locks: Provide Master key operated cylindrical lock.

16.16.2.37 Aluminium Louver Access Panel

Custom made system comprising a proprietary aluminium louver panel, to suit the adjacent louver cladding system.

The panels shall be side hung to an extruded aluminium door frame, inclusive of the necessary hardware and accessories including hinges and lock and lugs or other suitable means for installation.

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Refer: Louvers chapter.

Finish: The Louvers shall be pre-finished to match the adjacent louvers.

Locks: Provide Master key operated cylindrical lock.

16.16.2.38 Cladded Access Door

Proprietary recessed access panel door designed for installation in walls finished with

respective cladding. The door shall accept material to match the respective finish of the adjacent wall cladding. The door when closed would lay flush with the wall surface, with the door-to-frame clearance a maximum of 1.5mm. The panels shall be side hung to an extruded aluminium door frame, inclusive of the necessary hardware and accessories including hinges and lock and lugs or other suitable means for installation.

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Refer: Roofing and Cladding chapter.

Finish: Factory-applied finish consisting of one coat zinc phosphate etch and one coat zinc chromate primer for the frame, to match the approved colour of adjacent panel.

16.16.2.39 Cladded Access Panel

Proprietary system comprising an aluminium cladding panel fixed with concealed ball catches, to an aluminium frame, inclusive of the necessary hardware and accessories including lugs or other suitable means for installation.

Flush faces and edges pressed from hot dipped metal sheet to ASTM A653, welded at joints. Apply zinc-rich primer to welds.

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Refer: Roofing and cladding chapter.

Finish: Factory-applied finish consisting of one coat zinc phosphate etch and one coat zinc chromate primer for the frame.

The panel shall be proprietary cladding panel to match the adjacent wall cladding. Provide Touch latch indicator spot.

Locks: Concealed spring loaded touch latch.

16.16.2.40 Stainless Steel Access Panel

Proprietary access panel designed for installation in walls finished with ceramic/tiling.

The door when closed would lay flush with the wall surface and the frame and door edges shall be fully concealed.

The door-to-frame clearance shall be in the range of

2mm to 3mm and shall match the grout line of the adjacent wall tiles.

The doors and

panels shall be constructed from 316 Grade Stainless steel.

The panels shall be side

hung to the door frame, inclusive of the necessary hardware and accessories including

hinges and lock and lugs or other suitable means for installation.

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Refer: Paving and Tiling chapter.

Locks: Provide Master key operated cylindrical lock.

Finish: Hair line finish to Grit size 180-240.

16.16.2.41 Access Panel with Tiling finish

Proprietary recessed access panel designed for installation in walls finished with ceramic tile. The panel shall accept ceramic tiles thickness and to match the finish of the adjacent wall cladding.

The panel when closed would lay flush with the wall surface

and the frame and panel edges shall be fully concealed.

The panel-to-frame clearance

shall be in the range of 2mm to 3mm and shall match the grout line of the adjacent wall tiles.

The panel and the frame shall be constructed from 316 Grade Stainless steel.

The panels shall be screwed to the frame and shall include the necessary hardware and accessories including lugs or other suitable means for installation.

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Refer: Section Paving and Tiling.

Locks: Provide Master key operated cylindrical lock.

Finish: Factory-applied finish consisting of one coat zinc phosphate etch and one coat zinc chromate primer for the frame.

16.16.2.42 Water Tank Access Panel

Location: Potable Water Tank and Fire/ Sprinkler Water Tank.

Custom built access panel designed for installation, with 6mm thick SS angle shall form the frame.

The frame edges and the panel when closed would lay flush with the wall surface or to have the vertical upturn for top accessed tank.

The panel-to-frame

clearance shall be in the range of 2mm to 3mm.

The panel and the frame shall be

constructed from 316 Grade Stainless steel. The panels shall be fixed to the frame by SS butt hinges and other necessary hardware and shall include accessories such as lugs or other suitable means for installation.

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Locks: Refer Schedule of Doors and Ironmongery.

Finish: Hairline finish for Grade 316 Stainless steel.

16.16.2.43 Other Accessories - Scupper Drain Covers with Infill

Scupper Drain covers shall be of 200 x 600mm (nominal dimension; or as shown on drawing) with 50 x 30 x 5mm thick stainless steel angle frame set in floor screed, 25 x 25 x 5mm thick stainless angle cover. Infills to match the finish and colour of the adjacent flooring shall be spanned across 220 x 30 x 5mm thick stainless steel flat bar in the centre.

16.17 Roller Shutters and Grilles

16.17.1 Related work sections

Refer to the following work sections:

— Steel, Metals and Pre-finishes

— Painting

— Door and Window Hardware

16.17.1.1 Interpretation

Cycle: One complete operation from the closed position to fully open and back to closed.

Shutters: All references to shutters and grilles shall be taken to include motors and all accessories required for their operation.

16.17.1.2 Standard

— ASTM E119 – Standard Test Methods for Fire Tests of Building Construction and Materials

— SNI 0225:2011

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16.17.1.3 Equipotential Bonding Requirements (EPB) and Touch Voltage Protection

Comply with the requirements of Persyaratan Umum Instalasi Listrik (PUIL); (SNI 0225:2011/Amd 1:2013; Amd2:2014; Amd3:2014), where metals are proposed within the station protection zone.

16.17.2 Materials and Components

16.17.2.1 Roller Shutters

Type: Proprietary system comprising a flexible curtain sliding between vertical guides,
raised or lowered by rolling or unrolling around a horizontal drum (barrel) mounted
above the opening, inclusive of the manufacturer's standard operating gear, hardware,
and accessories necessary for satisfactory performance.

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Reference: Door Schedule as shown on the drawing.

16.17.2.2 Roller Grille Shutter

Location: to the concourse paid area, as shown on drawings.

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Requirement: Provide a roller shutter in which the curtain consists of a grille of horizontal members spaced apart and connected by vertical links, to form a security gate to close off the Station after-hours.

16.17.2.3 Operation

To be motorised and electrically operated, with a pull chain for manual over-ride.

The

control gear for the shutter to be suitably located as shown in drawings.

The motor

- should be supplied with brake release level, limit switch, built-in thermal protector, one unit 3-way push button switches with door key.
 - Opening and closing speed of shutters should comply with the recommended safety speed.

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Chain manual: By pulling on an endless chain passing over a sprocket on the drum, with reduction gears where necessary.

Install so that the force required to operate the door manually does not exceed 220 N.

16.17.2.4 Roller Grille Shutter Component Schedule

Table 16.11: Roller Grille

Property	Component
Horizontal grille members Material	Stainless Steel Grade 316
Size (mm)	12mm diameter, 2mm thick
Finish	Continuous Hairline Polish using 180-240 grit
Links: Material	Stainless Steel Grade 316
Finish	Continuous Hairline Polish using 180-240 grit
Spacing and pattern	Nominally, 250mm
End pieces	Stainless Steel
Bottom curtain rail Form	Fabricated angle
Material	Stainless Steel Grade 316
Finish	Continuous Hairline Polish using 180-240 grit
Vertical guides Material	Stainless Steel Grade 316 (with Nylon bushes for noise attenuation)
Size (mm)	nominal 110mm
Finish	Continuous Hairline Polish using 180-240 grit
Drum Material	Steel
Drum Springs	Helical torsion springs housed and arranged to counterbalance the curtain weight without exceeding the safe working stress of the spring material.
Drum deflection	1/360th of the span (maximum)
Operation method	Motorized
Motor capacity	220V, 60Hz 3 phase or 900V, 50Hz, 3 phase

Property	Component
Hardware Item	Anti-picked shackle catch device with spring action
Material	Stainless Steel
Finish	To approval
Accessories	Pull chain for manual over ride

16.17.2.5 Fire Resistant Roller Shutters

Standard: To ASTM E119.

Location: to the concourse unpaid area and the retail units, or as shown on drawings.

Requirement: Provide a roller shutter in which the curtain consists of inter-linked

horizontal slats, to form a fire barrier and with a fully enclosed shutter box, between areas as shown on drawings.

Table 16.12: Fire Shutter Component Schedule

Property	Component
Fire resistant level	2 hours
Material	Roll form first grade high tensile Grade 316 Stainless steel
Shutter Curtains	Slats with interlocking grooves and auto cut-off edge end lock.
Curtain Finish	Continuous Hairline Polish using 180-240 grit
Bottom Bar	Fabricated of SS angles of minimum size 38x38x3mm to form an inverted T-section bolted, riveted or welded together to shape.
Side Guide rails	Fabricated from SS angles of minimum 2mm thickness with a groove depth of minimum 75mm.
Drum	Heavy duty steel pipe with both ends fitted with ball bearing supports and solid steel shaft mounted to the heavy duty steel end plate at both ends.
Shutter Enclosure Box	Fabricated from hollow steel section with mild steel covers and painted to comply with the corrosion resistant requirement of the Authority's Materials & Workmanship specifications.
Vertical guides	Stainless Steel
Material	Grade 316 (with Nylon bushes for noise attenuation)
Drum Material	Steel
Drum Springs	Helical torsion springs housed and arranged to counterbalance the curtain weight without exceeding the safe working stress of the spring material.
Drum deflection	1/360th of the span (maximum)

16.17.2.6 Operation

To be motorised and electrically operated, with a pull chain for manual over-ride.

The

control gear for the shutter to be suitably located as shown in drawings.

-The motor

should be supplied with brake release level, limit switch, built-in thermal protector, one

unit 3-way push button switches with door key. Opening and closing speed of shutters

should comply with the recommended safety speed.

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Chain manual: By pulling on an endless chain passing over a sprocket on the drum,

with reduction gears where necessary. Install so that the force required to operate the

door manually does not exceed 220 N and such that the safety closing speed is

achieved.

16.17.2.7 Control System Sequence for Fire Mode

The fire shutters shall, upon receipt of fire alarm signal, the attached electrical brake

releaser shall release the brakes and lowers the shutter.

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Fire shutters shall be equipped with solenoid type 24V DC electrical brake releaser to

activate the Fire Shutters to shut down the opening by means of Gravity Drop Force.

16.17.2.8 Wind loading

Install so that the shutter, in its closed position, withstands pressure on the surface of
_ at least 550 Pa without impairment of its ability to function under ambient temperature.

16.17.2.9 Wind locks

Wind lock end clips and guides to retain the curtain in wide openings or under extreme
_ wind conditions.

16.17.2.10 Operation

Method of raising and lowering the curtain:

- Motorised: If a wicket is fitted to the shutter, provide a limit switch device to prevent motor operation until the wicket and frame are clear of the curtain.

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16.17.2.11 Stainless Steel Grilles and Gates

Location: At the Ground floor around the Emergency Stairs as a fence.

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Cross refer:

- Section on 'Steel, Metals and Pre-finishes'.
- Section on 'Doors and Hatches'.

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Requirement: Provide custom made Stainless Steel grilles and gates as shown on the
_ drawing.

_ The vertical support hollow sections shall be well fixed to an anchored base in
_ the ground and shall be reinforced at appropriate junctions to provide adequate
_ stability and shall be self-propelled. Gates which are integrated into the grilles are dealt
_ separately as stainless steel type in the section on 'Doors and Hatches'.

16.18 Door and Window Hardware

16.18.1 General

16.18.1.1 Related Work Sections

Refer to the following work sections:

- Doors and Hatches
- Roller Shutters and Grilles
- Roofing and Cladding

16.18.1.2 Definitions

Door set: An assembly comprising a door or doors and supporting frame, including the guides, and tracks, including the hardware and accessories necessary for satisfactory operation.

Hardware: all fittings and fixtures to the door or hatch which includes any items traditionally specified as ironmongery or door furniture.

16.18.1.3 Standard

The following codes/standards are references to the minimum quality acceptable for materials/products/workmanship:

- ASTM E119 - 14
- ASTM E814 - 13a
- ASTM E136 - 12
- ASTM E84 - 14
- ASTM 1354
- ANSI A156.5
- ASTM A653

16.18.2 Materials and Components

16.18.2.1 Metal Finishes

All materials: High corrosion resistance

Generic items: The following minima apply to the relevant finishes on hardware items described in generic terms (i.e. not as proprietary items):

- Coating class for steel sheet: At least Z275.
- Anodising class for internal applications: At least AA15.
- Brass, copper alloy or bronze surface : Coated with transparent lacquer, or equivalent coating.

- Stainless steel: Austenitic stainless steel as applicable, grade 316, and subject to the approved sample. No rust staining, discolouration or evidence of contamination by other metals, or corrosion by oxides, will be acceptable.

16.18.2.2 Components Generally

Hardware specified generically: Provide hardware of sufficient strength and quality to perform its function, appropriate to the intended conditions of use, suitable for use with associated hardware, and fabricated with fixed parts firmly joined.

Deliver door hardware items, ready for installation, in individual complete sets for each door, each set

- in a separate dust and moisture proof package;
- clearly labelled to show its intended location; and
- including the necessary templates, fixings and fixing instructions.

Ensure working parts are accurately fitted to smooth close bearings, without binding or sticking, free from rattle or excessive play, lubricated where appropriate.

16.18.2.3 19.2.3 Hinges

Fire Doors: To ASTM E119.

Wide throw: Where necessary provide wide throw hinges to achieve the required door swings in the presence of obstacles such as nibs, deep reveals and architraves.

Hinge pins: exterior or security doors opening out: Provide fixed pin hinges or security hinges.

Key Material

- Pin tumbler locks: Nickel alloy, not brass.
- Lever locks: Malleable cast iron or mild steel.

Identification: supply each key with a purpose-made plastic or stamped metal label legibly marked to identify the key, attached to the key by a metal ring. Key rack to be provided per site for contractors keys.

Group and Master Keying:

Keying control security system: Where cylinder or pin-tumbler locks accept a group key (e.g. master key, maison key) provide to those locks a proprietary keying control security system.

Existing system: Obtain the details of existing group or master key systems to which a new system is required to be an extension.

Future extensions: Provide master and grandmaster group keying systems which are an extension of the existing system.

Stamping: Stamp keys and lock cylinders to show the key codes and/or door number as scheduled.

Contractor's Keys: Master key systems: Do not use any key under a master key system.

Key code Schedule Legend

Table 16.13: Key code schedule legend

Code	Description and function
KD	Keyed to differ: Each lock has a unique key which will operate that lock only.
KA	Keyed alike: All locks in the group will pass the same key, but that key will not operate any locks outside the group.
MK	Master keyed: The master key will operate all the locks in the MK group, in addition to their KD or KA keys.
GMK	Grandmaster keyed: The grandmaster key will operate all the locks in the group, in addition to their KD, KA or MK keys.
GGMK	Great Grandmaster keyed: The great grandmaster key will operate all the locks, in addition to their KD, KA, MK or GMK keys.

Key Code Schedule: To be completed by the key supplier and submitted for the approval

Door No.	KD	KA group	MK group	GMK group	GGMK group	Maison keyed, to doors numbered

Key code schedule entries: In the KD and KA, MK, GMK and GGMK group columns

- any entry, including *, means that the lock is a member of that key code type;
- the entry * means the lock is a member of the key code type, but that code stamping is not required; and
- any other entry is the code required to be stamped on key and cylinder.

Maison keyed: In the Maison keyed: column, the entries are the door numbers of the doors whose keys will operate the lock of the door in the Door no.: column. Code stamping not required.

Table 16.14: Number of keys table

Code	Key type	Minimum number of keys
GGMK	Great grandmaster keys	>>to be confirmed

Code	Key type	Minimum number of keys
GMK	Grandmaster keys	>>to be confirmed
MK#	Master keys	>>to be confirmed
KD	Locks keyed to differ	>>to be confirmed
KA#	Locks keyed alike:	
-	2 locks in code group	>>to be confirmed
-	3-10 locks in code group	>>to be confirmed
-	11-40 locks in code group	>>to be confirmed
-	41 and over locks in code group	>>to be confirmed

16.18.2.4 Locks and Latches

Door locks and latches: To meet the operational and security requirements of the project. The use of locks and latches are scheduled in accordance with the requirements of the system operator.

Name	Sash lock lockset
Description	Lock case with latch activated by lever handle, deadbolt activated by cylinder - including strike plate and face plate.
Quality	It shall pass the fire test. Certificates of compliance shall be submitted. Loss of tension of springs for latches, push bars or handles are considered a defect.
Materials	Cases - are to be closed on all sides to protect internal parts and manufactured from galvanised heavy gauge steel. Follower - 8mm square, made of hardened or stainless steel. Latch bolt, latch cam, anti-thrust bolt, pre-formed strike-plate and face-plate - from stainless steel. Nylon, brass or any parts with a melting point below 850 degrees centigrade are not permitted.
Critical Dimensions	Compatible with Europrofile cylinder Compatible with 8mm square spindle 60 – 70mm backset Minimum 20mm throw for dead bolt.
Performance	Heavy duty. Reversible latch bolts and strike plate without removing the lock case cover. Cases are threaded for securing through bolt. Single sided lever handle fixing if necessary. Stainless steel countersunk fixing screws are used throughout. Spring action for handle included in lock case.
Fire Requirements	All proposed locksets must be suitable for fire doors up to 2 hours fire rating. The Supplier must ensure that their locksets have the necessary test reports certifying their suitability on fire doors supplied by the Contractor.

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Variations	V1 – Lockset is suitable for fire doors up to 4 hours fire rating. V2 – Modular – compatible with other lockcases 9.2, 9.3, 9.4, 9.5 Combinations - V1&V2
Examples where it may be used	Electrically Locked Plant Room doors.

Name	Night latch lockset (Automatic locking)
Description	Lock case with latch activated by cylinder - including strike-plate and face-plate.
Quality	It shall pass the fire test. Certificates of compliance shall be submitted. Loss of tension of springs for latches, push bars or handles are considered a defect.
Materials	Cases - are to be closed on all sides to protect internal parts and manufactured from galvanised heavy gauge steel. Follower - 8mm square, made of hardened or stainless steel. Latch bolt, latch cam, anti-thrust bolt, pre-formed strike-plate and face-plate – made from stainless steel. Nylon, brass or any parts with a melting point below 850 degrees centigrade are not permitted.
Critical Dimensions	Compatible with 17mm diameter Europrofile cylinder 60 – 70mm backset
Performance	Heavy duty. Anti thrust bolt function for security. Its position and the hole on the strike plate shall be relatively apart so that should the door sag, the anti-thrust bolt will not engage the strike plate thereby rendering its function ineffective. Reversible latchbolts and strike plate without removing the lockcase cover. Cases are threaded for securing through bolt. Stainless steel countersunk fixing screws are used throughout. Suitable for use with pull handle or ring pull on outside, and lever handle on inside. Spring action for handle included in lockcase.
Fire Requirements	All proposed locksets must be suitable for fire doors up to 2 hours fire rating. The Supplier must ensure that their locksets have the necessary test reports certifying their suitability on fire doors supplied by the Contractor.
Variations	V1 – Lockset is suitable for fire doors up to 4 hours fire rating. V2 – Modular – compatible with other lockcases 9.1, 9.3, 9.4, 9.5 V3 – Narrow lockcase with 20 to 30 mm backset. Combinations - V1&V2.
Examples where it may be used	Self-locking key operated doors

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Name	Deadbolt lockset
Description	Lock case with deadbolt activated by cylinder - including strike-plate and face-plate.
Quality	It shall pass the fire test . Certificates of compliance shall be submitted. Loss of tension of springs for latches, push bars or handles are considered a defect.
Materials	Cases - are to be closed on all sides to protect internal parts and manufactured from galvanised heavy gauge steel. Follower - 8mm square, made of hardened or stainless steel. Pre-formed strike-plate and face-plate – made from stainless steel. Nylon, brass or any parts with a melting point below 850 degrees centigrade are not permitted.
Critical Dimensions	Compatible with 17mm diameter Europrofile cylinder 60 – 70mm backset Minimum 20mm throw for dead bolt.
Performance	Heavy duty. Cases are threaded for securing through bolt. Stainless steel countersunk fixing screws are used throughout. Suitable for use with pull handle or ring pull.
Fire Requirements	All proposed locksets must be suitable for fire doors up to 2 hours fire rating. The Supplier must ensure that their locksets have the necessary test reports certifying their suitability on fire doors supplied by the Contractor.
Variations	V1 – Lockset is suitable for fire doors up to 4 hours fire rating. V2 – Modular – compatible with other lockcases 9.1, 9.2, 9.4, 9.5 V3 – Narrow lockcase with 20 to 30mm backset V4 – Key can't be released unless deadbolt is projected V5 – Thumbturn can only retract and not project deadbolt. Combinations - V1/V2, V1/V3, V3/V4, V3/V5, V4/V2, V5/V2.
Examples where it may be used	Toilet doors.

Name	Latch Lockset
Description	Lock case with latch activated by lever handle - including strike-plate and face-plate.
Quality	It shall pass the fire test . Certificates of compliance shall be submitted. Loss of tension of springs for latches, push bars or handles are considered a defect.
Materials	Cases - are to be closed on all sides to protect internal parts and manufactured from galvanised heavy gauge steel. Follower - 8mm square, made of hardened or stainless steel. Latch bolt, latch cam, pre-formed strike-plate and face-plate – made from stainless steel. Nylon, brass or any parts with a melting point below 850 degrees

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Name	Latch Lockset
	centigrade are not permitted.
Critical Dimensions	Modular – compatible with other lockcases 9.1, 9.2, 9.3, 9.5 60 – 70mm backset.
Performance	Reversible latch bolts and strike plate without removing the lock case cover. Heavy duty. Stainless steel countersunk fixing screws are used throughout. Spring action for handle included in lock case.
Fire Requirements	All proposed locksets must be suitable for fire doors up to 2 hours fire rating. The Supplier must ensure that their locksets have the necessary test reports certifying their suitability on fire doors supplied by the Contractor.
Variations	V1 – Lockset is suitable for fire doors up to 4 hours fire rating. V2 – Anti thrust bolt function for security. Its position and the hole on the strike plate shall be relatively apart so that should the door sag, the anti-thrust bolt will not engage the strike plate thereby rendering its function ineffective. V3 – Strength required to turn spindle suited to flush cup ring pull. V4 – Modular – compatible with other lock cases 9.1, 9.2, 9.3, 9.5 Combinations - V1&V4, V2&V4, V3&V4.
Examples where it may be used	Non lockable doors

Name	Night latch lockset (Classroom function)
Description	Lock case with latch activated by lever handles, cylinder locks/releases external handle, including strike-plate and face-plate.
Quality	It shall pass the fire test Certificates of compliance shall be submitted. Loss of tension of springs for latches, push bars or handles are considered a defect.
Materials	Cases - are to be closed on all sides to protect internal parts and manufactured from galvanised heavy gauge steel. Follower - 8mm square, made of hardened or stainless steel. Latch bolt, latch cam, anti-thrust bolt, pre-formed strike-plate and face-plate – made from stainless steel. Nylon, brass or any parts with a melting point below 850 degrees centigrade are not permitted.
Critical Dimensions	Compatible with 17mm diameter Europrofile cylinder 60 – 70mm backset
Performance	Heavy duty. Anti thrust bolt function for security. Its position and the hole on the strike plate shall be relatively apart so that should the door sag, the anti-thrust bolt will not engage the strike plate thereby rendering its function ineffective. Reversible latchbolts and strike plate without removing the lockcase

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Name	Night latch lockset (Classroom function)
	cover. Cases are threaded for securing through bolt. Stainless steel countersunk fixing screws are used throughout. Suitable for use with lever handle on both side. Locking mode can be changed through use of the cylinder. In unlocked mode the door acts as a latch, in locked mode the external lever handle is rendered inoperative. Spring action for handle included in lock case.
Fire Requirements	All proposed locksets must be suitable for fire doors up to 2 hours fire rating. The Supplier must ensure that their locksets have the necessary test reports certifying their suitability on fire doors supplied by the Contractor.
Variations	V1 – Lockset is suitable for fire doors up to 4 hours fire rating. V2 – Modular – compatible with other lockcases 9.1, 9.2, 9.3, 9.4 Combinations - V1&V2
Examples where it may be used	Self locking key operated doors

Name	Sliding Door Hook bolt Lockset
Description	Lock case with hook bolt activated by cylinder - including strike-plate and face-plate.
Quality	It shall pass the fire test Certificates of compliance shall be submitted.
Materials	Cases - are to be closed on all sides to protect internal parts and manufactured from galvanised heavy gauge steel. Pre-formed strike-plate and face-plate – made from stainless steel. Nylon, brass or any parts with a melting point below 850 degrees centigrade are not permitted.
Critical Dimensions	Compatible with 17mm diameter Europrofile cylinder
Performance	Heavy duty. Cases are threaded for securing through bolt. Stainless steel countersunk fixing screws are used throughout. Suitable for use with pull handle.
Fire Requirements	All proposed locksets must be suitable for fire doors up to 2 hours fire rating. The Supplier must ensure that their locksets have the necessary test reports certifying their suitability on fire doors supplied by the Contractor.
Variations	V1 – Lockset is suitable for fire doors up to 4 hours fire rating.
Examples where it may be used	Sliding Doors

Name	Patch lock Lockset
Description	Lock case with deadbolt activated by cylinder for mounting on underside

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Name	Patch lock Lockset
	of glass doors – includes socket for floor
Quality	It shall pass the fire test. Certificates of compliance shall be submitted.
Materials	Cases - are to be closed on all sides to protect internal parts and manufactured from stainless steel. Nylon, brass or any parts with a melting point below 850 degrees centigrade are not permitted.
Critical Dimensions	Compatible with 17mm diameter Europrofile cylinder Minimum 20mm throw for dead bolt.
Performance	Heavy duty. Suitable for mounting on varieties of glass thickness Cases are threaded for securing through bolt. Stainless steel countersunk fixing screws are used throughout.
Examples where it may be used	Shop Glass Entrance doors

Name	Roller Latch Lockset
Description	Recessed Roller latch enabling opening by pulling and pushing door. Includes plate for mounting on door frame.
Minimum Standard	To comply with respective local regulation and the employer's requirement.
Quality	As per approved sample.
Materials	Stainless Steel
Critical Dimensions	As per approved sample
Performance	Must be capable of adjustment to alter the force required to open and close the door.

Name	Power Grid Meter Cabinet Lockset
Minimum Standard	To comply with respective local regulation and the employer's requirement.

Name	Single Cylinder
Description	17mm diameter Europrofile Single key access Cylinder with three keys.
Quality	Cylinders shall be designed for tensile loading of 12800 Newtons against wrenching and pulling of the plug within the cylinder. Cylinders shall be provided with 6 or more pins. For added security the cylinder shall possess multi-part construction of the pin mechanism coupled with rotation factor and off centre pin to key alignment features. The cylinders shall have detainer pins to protect against picking. Cylinders shall have minimum grades for durability (50,000 cycles) and 4 for Security.

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Name	Single Cylinder
Materials	Nylon, brass or any parts with a melting point below 850 degrees centigrade are not permitted.
Critical Dimensions	Exact projection from the door to be subject to the Authorities agreement.
Performance	Each Cylinder has a different key with one masterkey per station.
Fire Requirements	All proposed cylinders must be suitable for fire doors up to 4 hours fire rating. The Supplier must ensure that their cylinders have the necessary test reports certifying their suitability on fire doors supplied by the Contractor.
Variations	V1 - Offset cylinder length to suit offset clad door arrangement with additional thickness to that listed in item 5 on one side of 20mm to 60mm.
Examples where it may be used	Locked access hatches

Name	Single Cylinder with Thumb Turn
Description	17mm diameter Europrofile Cylinder with key access from one side and thumb turn the other. Includes three keys
Quality	Cylinders shall be designed for tensile loading of 12800 Newtons against wrenching and pulling of the plug within the cylinder. Cylinders shall be provided with 6 or more pins. For added security the cylinder shall possess multi-part construction of the pin mechanism coupled with rotation factor and off centre pin to key alignment features. The cylinders shall have detainer pins to protect against picking. Cylinders shall have minimum grades under for durability (50,000 cycles) and 4 for Security.
Materials	Nylon, brass or any parts with a melting point below 850 degrees centigrade are not permitted.
Critical Dimensions	The cylinder shall suit door thickness from 40mm up to a maximum door thickness of 60mm. Exact projection either side of the door to be subject to the Authorities agreement.
Performance	Each Cylinder has a different key with one master key per station.
Fire Requirements	All proposed cylinders must be suitable for fire doors up to 4 hours fire rating. The Supplier must ensure that their cylinders have the necessary test reports certifying their suitability on fire doors supplied by the Contractor.
Variations	V1 - Offset cylinder length to suit offset clad door arrangement with additional thickness to that listed in item 5 on one side of 20mm to 60mm. V2 – Thumturn can only retract and not project deadbolt Combination – V1/V2
Examples where it may be used	Normal Doors

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Name	Double Cylinder
Description	17mm diameter Europrofile Cylinder with key access from both sides. Includes three keys.
Quality	Cylinders shall be designed for tensile loading of 12800 Newtons against wrenching and pulling of the plug within the cylinder. Cylinders shall be provided with 6 or more pins. For added security the cylinder shall possess multi-part construction of the pin mechanism coupled with rotation factor and off centre pin to key alignment features. The cylinders shall have detainer pins to protect against picking. Cylinders shall have minimum grades; 5 for durability (50,000 cycles) and 4 for Security.
Materials	Nylon, brass or any parts with a melting point below 850 degrees centigrade are not permitted.
Critical Dimensions	The cylinder shall suit door thickness from 40mm up to a maximum door thickness of 60mm. Exact projection either side of the door to be subject to the Authorities agreement.
Performance	Each Cylinder has a different key with one masterkey per station. The cylinders shall be capable of being unlocked from either side if another key is already inserted
Fire Requirements	All proposed cylinders must be suitable for fire doors up to 4 hours fire rating. The Supplier must ensure that their cylinders have the necessary test reports certifying their suitability on fire doors supplied by the Contractor.
Variations	V1 - Offset cylinder length to suit offset clad door arrangement with additional thickness to that listed in item 5 on one side of 20mm to 60mm.
Examples where it may be used	Toilet Doors

Name	Lever Handles
Description	2 Cylindrical unsprung lever handles with return and spindle.
Minimum Standard	Unless stated otherwise, handles shall comply with the requirements of the local regulation of the Code on Barrier Free Access in Buildings for disable persons.
Quality	The handle shall be heavy duty and scratch proof.
Materials	Stainless steel handle in satin finish High tensile Steel Spindle with Zinc and passivate finish
Critical Dimensions	Handle: Minimum 65mm from face plate to centre line of handle. Minimum 110mm from centre line of spindle to centre line of return. (130mm length with 20mm diameter) 20mm Minimum diameter.

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Name	Lever Handles
	Spindle: Length suited to door thickness up to 60mm 8mm square thickness
Performance	Snap on assembly with Allan keys or stainless steel screw from one side only.
Fire Requirements	Suitable for door with fire rating of up to 4 hours.
Variations	V1 – Only one Handle with spindle V2 – Spindle length customised for door thickness more than 60mm Combination - V1/V2
Examples where it may be used	Normal Doors

Name	Standard Pull handle
Description	1 Cylindrical pull handle of minimum 150mm long
Minimum Standard	Unless stated otherwise, handles shall comply with the requirements of the local regulation of the Code on Barrier Free Access in Buildings for disable persons.
Quality	The handle shall be heavy duty and scratch proof.
Materials	Stainless steel handle in satin finish
Critical Dimensions	Handle: Minimum 65mm from face plate to centre line of handle. Minimum 130mm from centre line of two ends. (150mm length with 20mm diamater) 20mm Minimum diameter.
Performance	No visible fixings on face of door, no escutcheons
Fire Requirements	Suitable for door with fire rating of up to 4 hours.
Variations	V1 – 300mm long overall V2 – 600mm long overall V3 – Offset from lock case by a distance dependent on backsets.
Examples where it may be used	Toilet Doors

Name	Plates
Description	Pair of Standard stainless steel cover plates fixed by counter-sunk screws
Minimum Standard	To comply with respective local regulation and the employer's requirement.
Quality	Cut outs for lever handle, pull handle and cylinders to be exact and predrilled in factory. Counter-sunk screws to be in stainless steel with philips head and fixed in four corners and visible from inside room only. No on-site cutting of holes is permitted.

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Name	Plates
	Outside plate to be fixed from behind, welding not to leave any visible distortions from the front.
Materials	Stainless Steel, finish to be fine continuous hairline brush with 180 to 240 grit.
Critical Dimensions	Each plate to be 200mm x 200mm x 2.0mm thickness with rounded corners
Fire Requirements	Suitable for door with fire rating of up to 4 hours.
Variations	V1 – Only one plate -without visible screws V2 – Only one plate - dimensions to be 100mm width x 200mm height x 2.0mm thickness (for pull handle with no keyhole) V3 – Only one plate - dimensions to be 200mm width x 400mm height x 2.0mm thickness (as push plate)
Examples where it may be used	Normal Doors

Name	Flush Cup Ring Pull Handle
Description	Flush Cup Ring pull handle with spindle.
Quality	As per approved sample.
Materials	Stainless steel handle in satin finish Mild Steel Spindle with Zinc and passivate finish
Critical Dimensions	Handle: Maximum protrusion of 15mm from door Diameter of fixing between 70 and 100mm Length suited to door thickness up to 60mm 8mm square thickness
Fire Requirements	Suitable for door with fire rating of up to 2 hours.
Variations	V1 – Spindle length customised for door thickness more than 60mm V2 – No spindle
Examples where it may be used	Cladding hatches

Name	Panic Push Bar
Description	Bar extending across width of door for release of latch when pressed inwards in panic situations.
Quality	All Panic Hardware shall have a proven efficiency rating after 100,000 test cycles. Test reports to be submitted. Panic bar shall spring back once released and allow re-latching of the door.
Materials	All external elements shall be stainless steel Internal construction of corrosive resistant steel to give long, trouble free operation. Nylon, brass or any parts with a melting point below 850 degrees

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Name	Panic Push Bar
	centigrade are not permitted.
Critical Dimensions	<p>The length of the bar shall be customised for leaf widths between 900mm and 1200 mm in width.</p> <p>Protrusion of the push bar from the door shall not exceed 90mm.</p> <p>Push bar shall have minimum diameter of 25mm.</p>
Performance	<p>All Panic Hardware shall provide easy operation and long life under heavy traffic conditions.</p> <p>All panic hardware shall be weather proof and rust resistant.</p> <p>The force required to operate the push bar shall not exceed 67 Newtons.</p> <p>Internationally recognised photoluminescence signage shall be used.</p> <p>For unlockable doors; panic bar can be used in conjunction with Latch lockset, lever handle (Single – V1) and cover plate (Single - V1)</p> <p>For lockable doors; panic bar can be used in conjunction with Nightlatch lockset, Single cylinder, pull handle and cover plate (Single V1)</p>
Fire Requirements	<p>All Panic Hardware must be suitable for fire doors up to 2 hours fire rating.</p> <p>The Supplier must ensure that the Panic Hardware has the necessary assessment or test reports certifying their suitability on fire doors supplied by the Contractor.</p>
Variations	<p>V1 – Push bar is suitable for fire doors up to 4 hours fire rating.</p> <p>V2 – Push bar for use on double door which includes automatic top/bottom bolts for release of each door leaf</p>
Examples where it may be used	Public Escape routes

Name	Handicapped Indicator Bolt and lever handle
Description	Handicapped indicator bolt and lever handle including strike plate to receive bolt
Minimum Standard	Unless stated otherwise, handles shall comply with the requirements of the current edition of the Code on Barrier Free Access in Buildings for disable persons.
Quality	The handle shall be heavy duty and scratch proof.
Materials	<p>Stainless steel handle in satin finish</p> <p>Stainless steel indicator bolt</p>
Critical Dimensions	<p>Lever handle:</p> <p>Minimum 65mm from face plate to centre line of handle.</p> <p>Minimum 110mm from centre line of spindle to centre line of return. (130mm length with 20mm diameter)</p> <p>20mm Minimum diameter.</p> <p>Indicator Bolt:</p> <p>Suited to door widths upto 50mm thick</p>
Performance	<p>Bolt can be activated by pushing lever upwards to vertical position and released by returning lever to horizontal position</p> <p>An indicator shall be provided on the outside to reflect occupancy.</p>

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Name	Handicapped Indicator Bolt and lever handle
	A strike plate shall be provided on the door frame to receive the bolt. Bolt to be capable of release from outside in the event of an emergency.
Examples where it may be used	Handicapped toilet

Name	Additional Key
Description	Additional key above the three supplied as standard with each cylinder (Items 9.10, 9.11 or 9.12)
Minimum Standard	ANSI A156.5
Quality	Identical to the original keys for that cylinder

Name	Escutcheon
Description	1 Stainless Steel Escutcheon or Rose
Minimum Standard	To comply with respective local regulation and the employer's requirement.
Quality	Cut outs for lever handle, pull handle and cylinders to be exact and predrilled in factory. To be firmly fixed to the door and allow unobstructed movement of any lever handle.
Materials	Stainless Steel, finish to be fine continuous hairline brush with 180 to 240 grit.
Critical Dimensions	50mm Diameter
Fire Requirements	Suitable for door with fire rating of up to 4 hours.
Examples where it may be used	Alternative to plates

16.18.2.5 Door Controllers

Door controllers specified generically: Provide door controllers, including door closers, floor or head spring pivots and automatic door operators, which are suitable for the door type, size, and weight, the door swings required and the operating conditions, including wind pressure.

Name	Door Closer (DC)
Description	Surface mounted door closers
Quality	A proven efficiency rating after 500,000 cycles
Materials	Arms shall be solid forged metal. Hydraulic fluid shall be able to withstand extreme temperatures and be non-combustible.

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Name	Door Closer (DC)
Critical Dimensions	As per respective condition of installation
Performance	<p>Able to operate door leaves of up to 80kg in weight and between 750 and 1100mm in width.</p> <p>Maximum opening of 180</p> <p>Be designed and installed to prevent damage to adjacent walls.</p> <p>Have an adjustable latching force, including at least 30Nm, to ensure that the door is properly closed and latched.</p> <p>A back-check feature to prevent the door handle from hitting the adjacent wall operational from 85 to 180.</p> <p>Be totally reversible without adjustment.</p> <p>Include Power adjustment.</p> <p>A Delayed closing: Operational from 85 to 180.</p> <p>Speed adjustable so that closing time between 90 and 12 can take more than 3 seconds.</p> <p>Include a pressure relief valve to prevent oil leakage and damage to the back check valve.</p>
Fire Requirements	Suitable for fire doors with up to 2 hours fire rating
Variations	<p>V1 - Able to operate door leaves of up to 100kg in weight and 1250mm in width. . .</p> <p>V2 - Able to operate door leaves of up to 120kg in weight and 1400mm in width.</p> <p>V3 - Able to operate door leaves of up to 160kg in weight and 1550mm in width</p> <p>V4 - Able to operate door leaves less than 750mm in width.</p> <p>V5 - Modified for push side fixing for opening into public areas: parallel arm for rack and pinion, slide arm fixing to door for cam action, or other alternative.</p> <p>V6 - Able to close and latch door leaves under pressure of up to 400 Pascal's acting against the motion of the closer and suitable for doors up to 4 hours fire rating.</p> <p>V7 - Door fitted with closer can be pushed or pulled open with a maximum force of 22N during the full arc of opening the door (For doors used by public).</p> <p>V8 - Suitable for doors up to 4 hours fire rating.</p> <p>Combinations: V1/V5, V2/V5, V4/V5, V6/V5, V7/V5, V1/V6, V2/V6, V3/V6, V1/V8, V2/V8, V3/V8, V4/V8, V5/V8</p>
Examples where it may be used	All Fire rated doors (Not on inactive leaf of equipment access doors)

Name	Floor Spring (FS)
Description	floor flush mounted closers
Quality	A proven efficiency rating after 500,000 cycles. Test report to be submitted.
Materials	Hydraulic fluid shall be able to withstand extreme temperatures and be non-combustible.

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Name	Floor Spring (FS)
Critical Dimensions	As per respective location of installation
Performance	<p>Be available in with varying closing forces up to 25NM</p> <p>Be suitable for doors up to 120kg : and suitable for glass doors.</p> <p>Be available with interchangeable spindle from 5mm to 50mm.</p> <p>Be provided with pressure relief valve to prevent overloading and oil leaking .</p> <p>Be of a depth of not more than 60mm. The Supplier shall work with the Contractor to ensure that the floor spring is flush with the surrounding floor finish.</p> <p>Maximum opening of 180</p> <p>Be designed and installed to prevent damage to adjacent walls.</p> <p>Have an adjustable latching force to ensure that the door is properly closed and latched.</p> <p>A back-check feature to prevent the door handle from hitting the adjacent wall operational from 85 to 180.</p> <p>A Delayed closing: Operational from 85 to 180.</p> <p>Speed adjustable so that closing time between 90 and 12 can take more than 3 seconds.</p>
Fire Requirements	Suitable for fire doors with up to 2 hours fire rating
Variations	<p>V1 – Provided with a hold open of 90 degrees and a delayed closing of up to 45 seconds.</p> <p>V2 – Suitable for doors up to 4 hours fire rating.</p> <p>V3 – Suitable for doors up to 250kg in weight,</p> <p>V4 – Able to close and latch door leaves under pressure of up to 400 Pascal's acting against the motion of the closer and suitable for doors up to 4 hours fire rating.</p> <p>V5 – Able to close and latch door leaves under pressure of up to 1200 Pascal's acting against the motion of the closer and suitable for doors up to 4 hours fire rating.</p> <p>Combinations: V2/V3, V3/V4</p>
Examples where it may be used	Clad doors, Glass doors

Name	Recessed Door Selector (DS)
Description	Door selector recessed into frame header
Quality	<p>Be of stainless steel finish</p> <p>Have a proven efficiency rating after 50,000 cycles.</p> <p>Use arms that are shock absorbing.</p>
Materials	As per approved sample
Critical Dimensions	As per respective door requirement
Performance	Able to operate door leaves of up to 80kg in weight and between 750 and 1100mm in Width.
Fire Requirements	Suitable for fire doors with up to 2 hours fire rating
Variations	V1 - Able to operate door leafs of up to 120kg in weight and

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Name	Recessed Door Selector (DS)
Description	1400mm in width.
Variations	V2 – Suitable for doors up to 4 hours fire rating. Combinations : V1/V2,
Examples where it may be used	All Fire rated public escape doors.

Name	Electrically Operated Hold-open
Description	Electrical Flush mounted floor spring.
Quality	A proven efficiency rating after 50,000 cycles. Test report to be submitted.
Materials	As per approved sample
Critical Dimensions	As per respective door requirement
Performance	Adjustable Electrical hold open angle from 85 to180 Able to operate door leafs of up to 100kg in weight and between 950 and 1250mm in Width. . Maximum opening of 180 Be designed and installed to prevent damage to adjacent walls. Have an adjustable latching force to ensure that the door is properly closed and latched. A back-check feature to prevent the door handle from hitting the adjacent wall operational from 85 to 180. Include Power adjustment for leaf widths between 750mm and 1250mm. A Delayed closing: Operational from 85 to 180. Automatic release on receipt of a signal from a central fire alarm so that the door properly closes Automatic release if physically pushed, if test button is pressed or if power fails.
Fire Requirements	Suitable for fire doors with up to 2 hours fire rating.
Variations	V1 - A Surface mounted hydraulic door closers.
Examples where it may be used	Smoke stop lobby doors in public access routes.

Name	Automatic Electrical Door Operators
Description	Complete automatic door operators for opening and closing doors, including door hanging (hinges, pivots or sliding gear) and electrical connection to distribution board. Operation mode: Electric locking: Access key switch: Power failure: Manually adjustable function: Automatic activation options:

Name	Automatic Electrical Door Operators
Minimum Standard	To comply with respective local regulation and the employer's requirement.
Quality	<p>A proven efficiency rating after 200,000 cycles. Test report to be submitted.</p> <p>Installation: Provide necessary recesses and cores, grout in components where required, and make good. Provide cover plates for access to units in door heads, frames or transoms.</p> <p>Automatic adjustable function: If the door opening angle or width is manually set below the maximum possible, under conditions of continuous traffic the doors must automatically creep to full opening, returning to reduced opening on the next cycle.</p>
Materials	As per approved sample
Critical Dimensions	As per respective door requirement
Performance	<p>Automatic opening to 90 with adjustable delayed closing.</p> <p>Opening via sensors placed on either side of the door or from receipt of a central signal.</p> <p>Fail safe in the open position.</p> <p>Able to operate door leafs of up to 80kg in weight and between 750 and 1100mm in Width. .</p> <p>Be designed and installed to prevent damage to adjacent walls.</p> <p>Include Power adjustment for leaf widths between 750mm and 1100mm.</p> <p>A Delayed adjustable closing time.</p> <p>Automatic opening on receipt of a signal from a central fire alarm so that the door opens fully.</p> <p>Automatic opening if physically pushed, if test button is pressed or if power fails.</p>
Fire Requirements	Suitable for fire doors with up to 2 hours fire rating.
Variations	V1 - Includes full installation (closing devise and double swing door).
Examples where it may be used	Air-con separation doors, entrance doors.

Name	Outward Facing Door Selector (DS)
Description	Door selector device fixed to front face of frame and includes connectors to the door. May drop down under gravity or spring outwards upon opening of door.
Minimum Standard	To comply with respective local regulation and the employer's requirement.
Quality	<p>Have a proven efficiency rating after 50,000 cycles. Test report to be submitted.</p> <p>Use arms that are shock absorbing.</p>
Materials	As per approved sample
Critical Dimensions	As per respective door requirement
Performance	Able to operate door leafs of up to 80kg in weight and between 750 and 1100mm in Width.

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Name	Outward Facing Door Selector (DS)
Fire Requirements	Suitable for fire doors with up to 2 hours fire rating
Variations	V1 - Able to operate door leaves of up to 120kg in weight and 1400mm in width. V2 – Suitable for doors up to 4 hours fire rating. Combinations : V1/V2,
Examples where it may be used	All Fire rated public escape doors.

Name	Standard Arm Door Selector (DS)
Description	Standard arm with roller fixed below frame header.
Quality	Be of stainless steel finish Have a proven efficiency rating after 50,000 Test report to be submitted. Be approved under the appropriate Badan Standarisasi Nasional (BSN) Label Scheme. Use arms that are shock absorbing.
Materials	As per approved sample
Critical Dimensions	As per respective door requirement
Performance	Able to operate door leafs of up to 80kg in weight and between 750 and 1100mm in Width.
Fire Requirements	Suitable for fire doors with up to 2 hours fire rating
Variations	V1 - Able to operate door leafs of up to 120kg in weight and 1400mm in width. V2 – Suitable for doors up to 4 hours fire rating. Combinations : V1/V2
Examples where it may be used	All Fire rated public escape doors.

Name	Integrated Door Selector (DS)
Description	Integrated selector for use with slide arm closer if proposed.
Quality	Be of stainless steel finish. Have a proven efficiency rating after 500,000 cycles
Materials	As per approved sample
Critical Dimensions	As per respective door requirement
Performance	Able to operate door leaves of up to 80kg in weight and between 750 and 1100mm in Width.
Fire Requirements	Suitable for fire doors with up to 2 hours fire rating
Variations	V1 - Able to operate door leaves of up to 140kg in weight and 1400mm in width. . V2 – Suitable for doors up to 4 hours fire rating. Combinations : V1/V2

Examples where it may be used All Fire rated public escape doors.

16.18.2.6 Door Bolts

Bolting Hardware: To cover all variants of performance requirements and door details respectively.

Name	Surface Mounted Bolt
Description	Bolt including bolt receiver for securing door/hatch to frame
Quality	Have a proven efficiency rating after 10,000 cycles
Materials	Stainless steel
Critical Dimensions	Bolt shall have a throw of 20mm and minimum diameter of 8mm.
Performance	Exact type of receiver shall be co-ordinated with the Contractor to suit the frame. Capable of operating with a side load of 250 N, and also after a side load of 1000 N has been applied Resistance to end load of 3000N and side load of 4500N
Examples where it may be used	Hatches to outside of room.

Name	Flush Bolt
Description	Concealed bolt recessed at door edge.
Quality	All fixings shall be concealed. Have a proven efficiency rating after 10,000 cycles
Materials	Stainless steel
Critical Dimensions	Bolt length of 300mm. Bolt shall have a throw of 20mm and minimum diameter of 8mm.
Performance	Bolt shall be flush and lever action with dovetail returns to resist forcing and/or frame damage. Capable of operating with a side load of 250 N, and also after a side load of 1000 N has been applied Resistance to end load of 3000N and side load of 4500N
Fire Requirements	Suitable for doors up to 4 hours fire rating.
Variations	V1 – Increased bolt length to 600mm for doors between 2200mm and 2550mm in height. V2 – Increased bolt length to 1000mm for doors above 2550mm in height.
Examples where it may be used	All inactive leaves.

Name	Easy Clean Socket
Description	Socket for receive bolt.
Minimum Standard	To comply with respective local regulation and the employer's requirement.

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Name	Easy Clean Socket
Quality	To approved sample as required.
Materials	Stainless Steel.
Critical Dimensions	Able to take Bolt with throw of 20mm and diameter of 12mm.
Performance	Curved to allow easy cleaning.
Examples where it may be used	For receiving flush bolt.

Name	Dust Proof Strike
Description	Socket for receiving bolt with spring loaded cover.
Minimum Standard	To comply with respective local regulation and the employer's requirement.
Quality	To approved sample as required
Materials	Stainless steel.
Critical Dimensions	Able to take Bolt with throw of 20mm and diameter of 12mm.
Examples where it may be used	For receiving flush bolt.

Name	Automatic Flush Bolt
Description	Concealed bolt recessed at door edge, releases upon active leaf opening
Quality	All fixings shall be concealed. Have a proven efficiency rating after 10,000 cycles
Materials	Stainless steel
Critical Dimensions	Bolt shall have a throw of 20mm and minimum diameter of 8mm
Performance	Capable of operating with a side load of 250 N, and also after a side load of 1000 N has been applied Resistance to end load of 3000N and side load of 4500N
Fire Requirements	Suitable for doors up to 4 hours fire rating
Examples where it may be used	For double doors on public escape routes

16.18.2.7 Accessories

Name	Door/Wall Stops
Description	Rubber stops mounted to wall or door to prevent door hitting obstruction
Minimum Standard	To comply with respective local regulation and the employer's requirement.
Quality	As per approved sample.
Materials	Stainless steel and Rubber

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Performance	They shall have a rubber buffer at its tip which cannot be easily removed. Door stop shall have concealed fixing. Capable of being mounted on either wall or door.
Guidance on use	Where the door or its ironmongery would hit an obstruction if opened beyond 170 degrees. Alternative use of floor stop.

Name	Floor Stops
Description	Rubber stops mounted to floor to prevent door hitting obstruction
Minimum Standard	To comply with respective local regulation and the employer's requirement.
Quality	As per approved sample.
Materials	Stainless steel and Rubber
Critical Dimensions	They shall be approximately 40mm long and diameter no less than 40mm
Performance	They shall have a rubber buffer around the top which cannot be easily removed. Floor stops shall be provided with expandable bolts 70mm long x 8mm in diameter. Floor stop mounting shall be concealed under the floor stop.
Guidance on use	Where the door or its ironmongery would hit an obstruction if opened beyond 170 degrees. Alternative use of wall/door stop.

Name	Padlock
Description	Padlock
Quality	The core pins shall be made of resistant hardened bronze and it shall have detainer pins to protect against picking.
Materials	Solid stainless steel body and shall be weatherproof and rust resistant.
Critical Dimensions	Shackle clearance shall be no less than 60mm height and 35mm wide.
Performance	Padlock shall be suited under the same master key system with a minimum of 6 tumbler pins. All padlocks to be delivered directly to the Authority.

Name	Hasp and Staple
Description	Stainless steel loop and retainer for fixing padlock across doors.
Quality	As per approved sample.
Materials	Stainless Steel
Critical Dimensions	Able to take standard padlock
Performance	Fixed to door with countersunk stainless steel screws. Hasp to return over screws to render them in accessible in the closed position.

Name	Kick Plates
Description	Stainless steel Kick plate fixed by counter-sunk stainless steel screws
Minimum Standard	To comply with respective local regulation and the employer's requirement.
Quality	No on-site cutting of holes is permitted. Counter-sunk screws to be located as required to hold kick plate tight against door
Materials	Stainless Steel, finish to be fine continuous hairline brush with 180 to 240 grit.
Critical Dimensions	Each plate to be 200 high and 2.0mm thickness with rounded corners. Length to be 20mm less than the visible width of the door in the closed position Length to suit leaf width which varies between 900 and 1200mm.
Fire Requirements	Suitable for door with fire rating of up to 4 hours.
Guidance on use	On push side of well used active leaves only (corridors and staff rooms).

16.19 Louvers

16.19.1 Related Work Sections

Refer to the following work sections: Civil & Structural Specification

Steel, Metals and Pre-finishes

Roofing and Cladding

Doors and Hatches

16.19.1.1 Standards

The following codes/standards are references to the minimum quality acceptable for materials/products/workmanship:

- ASTM E84 - 14
- ASTM 1354
- ASTM E136 - 12
- ASTM E814 - 13a
- ASTM E119 - 14
- AAMA-605-2

16.19.1.2 Drawings

Contract drawings show generic design principles and design intent only and illustrate geometry and appearances of visible structure and surfaces and shall be used as guidance by the contractor in producing his detailed design.

The contractor shall assume responsibility for developing this design including members, details and extrusions in accordance with the drawings to satisfy the performance requirement stated.

After acceptance of the concept, the system shall be verified, by submission and acceptance of drawings and computations with all specified tests.

Design Life

The louver system is required to achieve the under noted performance standards under the environmental conditions it is like to experience for a minimum period as per the Employer requirement. Any routine maintenance required to achieve this shall be identified.

Weather Proofing

The façade shall be resistant to water regress when tested in accordance with this specification. The louvre system shall have drained joints. This philosophy shall apply to the louvers as well as all interfaces with other elements, structure and surfaces. Sealants shall be used for weather seals only where such seals are not the sole method of preventing water proofing.

Air Infiltration

The façade shall not leak air excessively nor give rise to noise as a result of wind movements within sealed cavities.

Lightning Protection

All elements of the façade including louvers, solar shades and fins shall comply with the Lightning protection requirement. If required to be mounted externally, lightning conductors shall be located in recesses and/or extrusions made fit for the purpose.

Maintenance & Replacement

Any elements reasonably anticipated to require maintenance, repair or replacement shall be accessible from either inside or outside to avoid excessive disruption to the operator and public.

16.19.1.3 Movement

General: Provide for deflections, displacements and other movements within the louvers, or between the louvers and the building (including fire stop and smoke flashing connections), including movements caused by ambient temperature changes, wind loads, design dead and live loads and shrinkage.

Accommodation: Provide louvers which accommodate these movements silently and without permanent deformation, reduction of performance, or other detrimental effects such as:

- damage to or undue stress on structural elements, fixings, adjacent panels;
- failure of joint seals; and
- loss of normal function in operable elements such as doors and windows.
- Ambient temperature range ($^{\circ}\text{C}$): 20-40 $^{\circ}\text{C}$
- Surface ($^{\circ}\text{C}$): 65 $^{\circ}\text{C}$

Building Movements: General: Refer to the Civil and Structural Specification.

Louver Panel Movements: Dead load: The vertical deflection of a structural member under dead load must not

- reduce below 3mm the clearance between the member and a non structural member immediately below; or
- reduce below 3 mm the clearance between the member and operable elements such as windows and doors.

Earthquake loads

Is not required however all cladding elements shall be designed against an in plane load of 5% of self-weight.

Displacement Limits

Restrict the member displacements and maximum deflection/span ratios of structural members subject to the above loads to the performance, except that:

- where the deflection of a structural member may cause bending in a masonry, cement rendered or similar panel, restrict the deflection/span ratio of the member to a maximum of 1:360; and
- restrict the deflection of the cantilevered end of a cantilevered structural member of cantilever length L to the maximum given in the Civil and Structural Specification. Restrict the compression or extension of sealant joints affected by the cantilever deflection to a maximum of half of the sealant depth.

16.19.1.4 Interpretation

Definition

Louvers included in this section are individual or panellised elements acting as screen to services, plant rooms, sunscreen and the like or expressed as a finish.

Type 1 – Aerodynamic single bank louver

Location: Plant room and service areas, or as shown on drawings.

Requirement:

- a. Provide Storm resistant single bank Aluminium fixed blade type with concealed unitised sub-frame as shown on drawings. Extruded aluminium construction; frame with channel profile, corner joints mitred and mechanically fastened, with intermediate mullions matching frame.
- b. All exposed edges and ends of metal must be dressed smooth and free from sharp edges.

Blades

- a. The front louvre blade shall be weather resistant and with 'aerodynamic' profile manufactured from extruded Aluminium with a nominal thickness 1.2mm. This one piece extrusion front blade will be installed at an angle of 45 degrees and will have a vertical height of not less than 71mm.
- b. Horizontal front blades shall be aligned using butt joint of adjacent panels, considering expansion allowance so that blades appear to be continuous without any face frame.

Louvers Frame

- a. The louver frame should be fully manufactured from extruded Aluminium with a minimum thickness of 2.0mm. Louvers that have a surface area greater than 3 square metres shall have a unitised frame consisting of an outer weather frame and an inner structural frame.
- b. The inner frame shall be of a unitised construction with the second pass blades factory fitted to the inner frame. Split mullion with a pressure equalisation chamber shall be used. Wet seals shall not be used.
- c. The mullions shall incorporate two drainage channels in the extrusion. Press formed coil or sheet will not be accepted.
- d. All fixing hardware to be used in the assembly of the louver shall be manufactured from austenitic Stainless steel or Aluminium. All fasteners shall be concealed.
- e. Louvers that have a surface area less than 3 square metres shall be delivered as finished units.

Performance

Design wind load: Cross refer: Civil and Structural Specification.

The louver system shall be designed to withstand the design wind load of 2.0Kpa.

Cumulative deflection of the blade and mullion under full wind load shall not exceed mullion span / 180. The full design wind load shall be applied to the surface of the louver, no allowance for pressure drop across the louver shall be permitted.

Water penetration resistance: To match design wind load.

Louver manufacturer to confirm the performance of the performance louver when tested to the minimum requirements as per the outline Specification "Laboratory testing and rating of weather louver when subjected to simulated rain". The louver shall achieve a minimum 79% water effectiveness at ventilation rates up to 1.0m/s with wind directed at the louvers face at a velocity of 13m/s and a rain fall rate of 75mm/hr.

The louver shall provide the following minimum performance characteristics;

	m^3/s							
Ventilation Rate	0.0	0.5	1.0	1.5	2.0	2.5	3.0	3.5
Rating Achieved	C	C	D	D	D	D	D	D

Airflow Requirements: The pressure drop across the louver shall be less than 15Pa at airflow of $2\text{m}^3/\text{s}$.

Type 2 – Aerodynamic double bank louver

Location: to all plant room and service areas, or as shown on drawings.

Requirement:

- a. Storm resistant series; double bank Aluminium fixed blade type with concealed unitised sub-frame. Extruded aluminium construction; frame with channel profile, corner joints mitred and mechanically fastened, with intermediate mullions matching frame.
- b. All exposed edges and ends of metal must be dressed smooth and free from sharp edges.

Blades

- a. The front louver blade shall be weather resistant and with 'aerodynamic' profile manufactured from extruded Aluminium with a nominal thickness 1.2mm. This one piece extrusion front blade will be installed at an angle of 45 degrees and will have a vertical height of not less than 71mm.
- b. The second pass blade shall be the weather resistant. This separate piece extrusion blade shall incorporate three concealed drainage channels to trap and drain rain water to jamb and mullion downspout to prevent flooding of the second pass blade. Blade spacing to be at a pitch of 75mm and fixed at angle of 45 degrees. All second pass blades shall be factory fitted to the inner frame.
- c. Horizontal front blades shall be aligned using butt joint of adjacent panels, considering expansion allowance so that blades appear to be continuous without any face frame.

Louver Frame

- a. The louver frame should be fully manufactured from extruded Aluminium with a minimum thickness of 2.0mm. Louvers that have a surface area greater than 3 square metres shall have a unitised frame consisting of an outer weather frame and an inner structural frame.

- b. The inner frame shall be of a unitised construction with the second pass blades factory fitted to the inner frame. Site installation of the second pass blades will not be permitted. Split mullion with a pressure equalisation chamber shall be used. Wet seals shall not be used.
- c. The mullions shall incorporate two drainage channels in the extrusion. Press formed coil or sheet will not be accepted.
- d. All fixing hardware to be used in the assembly of the louver shall be manufactured from austenitic Stainless steel or Aluminium. All fasteners shall be concealed.
- e. Louver that have a surface area less than 3 square metres shall be delivered as finished units.

Performance

Design Wind Load: Cross refer: Civil and Structural Specification.

The louver system shall be designed to withstand the design wind load of 2.0Kpa.

Cumulative deflection of the blade and mullion under full wind load shall not exceed mullion span / 180. The full design wind load shall be applied to the surface of the louver, no allowance for pressure drop across the louver shall be permitted.

Wind Driven Rain: to match design wind load: Louvre manufacturer to confirm the performance of the performance louver when tested to the minimum requirements as per the outline specification "Laboratory testing and rating of weather louvers when subjected to simulated rain".

The louver shall achieve a minimum 98.8% water effectiveness at ventilation rates up to 2.0m³/s with wind directed at the louver face at a velocity of 13m/s and a rain fallrate of 75mm/hr.

The louver shall provide the following minimum performance characteristics:

Ventilation Rate	m ³ /s							
	0.0	0.5	1.0	1.5	2.0	2.5	3.0	3.5
Rating Achieved	A	A	A	A	B	C	D	D

Airflow Requirements: The pressure drop across the louver shall be less than 45Pa at airflow of 2m³/s. The coefficient of discharge shall be calculated based on the "Laboratory testing and rating of weather louvers when subjected to simulated rain".

Type 3 – Aerofoil solar fin horizontal bank louver

Location: to the entrance areas, link bridge areas and concourse paid areas as shown on drawings.

Requirement:

To provide an external fixed solar shading horizontal system with proprietary aluminium aerofoil extrusions fixed on sub frame fabricated of galvanised steel, to reduce solar glare and wind driven rain, as shown on drawings.

Performance

Design Wind Load: Cross refer: Civil and Structural Specification.

The louver system shall be designed to withstand the design wind load of 2.0Kpa. The full design wind load shall be applied to the surface of the louver, no allowance for pressure drop across the louver shall be permitted.

Installation angle: the aerofoils shall be fixed in parallel at an angle as shown on drawings.

Type 4 – Aerofoil solar fin vertical bank

Location: to the entrance areas and link bridge areas as shown on drawings.

Requirement: to provide an external fixed solar shading vertical system with proprietary aluminium aerofoil extrusions fixed on sub frame fabricated of galvanised steel, to reduce solar glare and wind driven rain, as shown on drawings.

Performance

Design Wind Load: Cross refer: Civil and Structural Specification.

The louvre system shall be designed to withstand the design wind load of 2.0Kpa. The full design wind load shall be applied to the surface of the louver, no allowance for pressure drop across the louver shall be permitted.

Installation angle: the aerofoils shall be fixed in parallel at an angle as shown on drawings.

Aerofoil Specification

Extrusion: aerofoil and the end plate: to be extruded of aluminium alloy 6063 T5 or equivalent.

Thickness: 3mm

Nominal reference; as per manufacturer recommendation.	Type 3	Type 4
Width of an aerofoil extrusion module	250	425

Height of an aerofoil extrusion module	51	66
Optimal pitch (mm)	200	350
Weight of a module (Kg/m)	4.95	8.5

16.19.2 Materials and Finishes

16.19.2.1 General

Cross refer: Steel, Metals and Pre-finishes

Adhesives, Sealants and Fasteners

Louvers Blades

Material: Provide louver blades that are of extruded aluminium with a nominal thickness of 1.2mm. Provide clips or other fixing components that are concealed and resistant to vandalism. Components are to be corrosion resistant, compatible with the other materials in the installation, and coated with a non-staining compound where necessary.

Solar Fins Material: Provide solar fins of required dimensions that are of extruded aluminium with a nominal thickness of 3mm. Components are to be corrosion resistant, compatible with the other materials in the installation, and coated with a non-staining compound where necessary.

Flashings Materials: Provide flashings and weathering which are corrosion resistant, compatible with the other materials in the installation, and coated with a non-staining compound where necessary.

Fasteners: All fastenings shall be appropriate to the work, shall transmit all imposed loads and stresses, and shall ensure the structural integrity of the louver assemblies.

Stainless steel grade: 316

No visible fixings will be acceptable.

16.19.2.2 Aluminium Louvers, Frames and Solar Fins

Organic 3 coat PVF2 / Fluorocarbon paint system

- Coating thickness not less than 40 microns.

- Application spray applied to AAMA-605-2.

RAL colour to approval.

16.19.2.3 Louver Assemblies

Mount louver blades in a metal surround frame or sub frame. Ensure entire assembly is able to withstand the design wind pressure for that location without failure or permanent distortion of members, and without blade flutter.

Expansion joints

Provide for expansion and contraction in continuous sections (e.g. continuous louvers, interlocking mullions) at spacing not exceeding those recommended by the manufacturer, or 6 m, whichever is the lesser.

Louver blades

Provide metal louver blades mounted in a metal surround frame or sub-frame.

Louvre arrangement:

- Horizontal: Louvers span between frame stiles or mullions.
- Continuous horizontal: Louvers run continuously past, and are supported by, concealed mullions.
- Vertical: Louvers span between frame heads and sills.

Metal Louvers

Provide metal louver blades mounted in a metal surround frame or sub-frame.

Louvre arrangement.

Horizontal: Louvers span between frame stiles or mullions.

Continuous horizontal: Louvers run continuously past, and are supported by, concealed mullions.

Vertical: Louvers span between frame heads and sills.

Frames

Include the necessary sills, jambs, mullions, transoms, internal and external corners, beads, brackets, anchors, straps and accessories.

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Louver assemblies schedule				
Louver designation	LP1	LP2	LP3	LP4
Louvre type	Aerodynamic Single Bank	Aerodynamic Double Bank	Aerofoil Solar Fin Horizontal bank	Aerofoil Solar Fin Vertical bank
Pitch (mm)	71		200 nominal	350 nominal
Accessories	Bird / Insect screen, Backlining	Insect screen	–	–
Method of operation	Fixed			
Minimum free area (mm ²)	> 50%			
Pressure drop	< 15Pa (1m ³ /s)	< 45 Pa (2m ³ /s)	NA	NA
Finish (color to approval)	PVF ₂ / Fluorocarbon			

Louver materials schedule						
Louver designation	Type 1 & Type 2					
	Component	Material	Finish	Type	Size (mm)	Thickness (mm)
Stiles and mullions	Aluminium	PVF2	Drained	As drawings	2.0mm	
Accessories	Cills	PVF2	Drained	As drawings	1.25mm	
Frame	Aluminium	PVF2	Drained	As drawings	2.0mm	
Blade	Aluminium	PVF2	Drained	As drawings	1.25mm nominal	

16.19.2.4 Bird / Insect Screen / Blank-off Panel

- Insect Screening and Bird Guard. Insect screen / Bird Guard shall be provided to all ventilation louvers where indicated on the drawings.
- The size of the mesh shall be 71x55 per 10cm, weight shall be 100gsm and yarn thickness shall be 0.275mm. Bird guard shall be 30mm by 10mm austenitic stainless steel.
- Insect screen / Bird Guard shall be factory fitted to the internal unitised frame. The insect mesh/bird guard shall be clamped to the internal frame using extruded Aluminium section of minimum dimension 25mm by 2mm thick. Flat bar shall not be permitted.
- Where blank off panels is needed (ventilation is not required but maintaining the continuity of front blades), a minimum 2.0mm thick aluminium sheet shall be used. Colour sample should be submitted for approval prior the fabrication process.

- Removable by one operative. Aluminium frame and mesh secured to interior of louvers. Colour to match louver.

16.20 Partitions

16.20.1 Related Work Sections

Refer to the following work sections: Steel, Metal and Pre-finishes.

Adhesives Sealants and Fastenings

Roof and Cladding

16.20.1.1 Definitions

Non-demountable partitions: Wet construction methods may be used for assembly and jointing. Non-demountable partitions, removable panels: A non-demountable system in which certain designated panels are demountable and re-useable without damage except for accidental damage to surface finish. Frameless partitions: The panels (including glazed panels) are joined at their edges by an edge jointing system (e.g. splines, tongues and grooves, adhesive jointing), are fixed to the building structure at head and foot, and themselves provide the necessary resistance to external forces. Partly framed partitions: Structural frames occur only at designated locations, e.g. at doorways, or as glazing mullions; otherwise frameless. Fully framed partitions: Each partition panel, or the partition lining is supported by a separate structural frame.

16.20.1.2 Standards

- ASTM A123 – Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
- ASTM A653 – Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process
- ASTM E119 – Standard Test Methods for Fire Tests of Building Construction and Materials
- SNI 4-6252.12-2001 – Papan tercetak - Bagian 12: Spesifikasi panel laminasi masal (papan tercetak berlapis-banyak semi manufaktur)
- ASTM B221 – Standard Specification for Aluminum and Aluminum-Alloy Extruded Bars, Rods, Wire, Profiles, and Tubes
- ASTM B308 – Standard Specification for Aluminum-Alloy 6061-T6 Standard structural Profiles
- ASTM B429 – Standard Specification for Aluminum-Alloy Extruded Structural Pipe and Tube
- ASTM B 209 – Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate
- ISO 5660-1 – Reaction-to-fire tests -- Heat release, smoke production and mass loss rate.

16.20.1.3 Performance

Strength and stability

Provide partitions which, under normal conditions of use (including the slamming of doors), remain stable and do not show signs of deflection, permanent deformation, or rattling.

Imposed loads

Criteria: Provide a partition system

- which will support imposed dead loads, crowd loads, including designated eccentric loads; and
- in which deflection induced in the partition will not exceed:
- The lesser of H/300 or 15 mm for partitions subjected to crowd loads and lined with a flexible cladding.
- The lesser of H/360 or 12 mm for partitions subjected to crowd loads and lined with a brittle material.
- H/500 for eccentric loads.
- Imposed loads (crowd load): 3.0 kN/m run @1.1m above FFL (for public area and escape route).

16.20.2 Materials and Components

16.20.2.1 General

Coated steel

Coating class: Z200.

Proprietary galvanised mild steel support system.

Mild steel panel facings and trim: A factory-applied high performance pigmented powder or fluorocarbon coating of minimum thickness 60 µm.

Cross refer: Sheet, Metals and Pre-finishes.

Aluminium

Framing members: Alloy 5005.

Cross refer: Metals and Pre-finishes.

Metal fittings and hardware

Stainless steel surfaces: Satin self-finish. - Grade 304

Recoating

Provide pre-finishes which do not require site recoating either before or after installation.

Fire hazard

General: Do not provide materials which, when subject to fire conditions, will emit excessive smoke or dangerous fumes.

Fire hazard limits schedule

	Index to ASTM E84	Applies to (location)
Spread of flame	Class A	All materials

All material for structure and interior finishes shall meet non-flammable or semi non-flammable (semi non-combustible) or fire retardant requirements in accordance to ISO 5660-1. In case of proposing other than non-flammable and/or fire retardant material, it needs to be tested by Cone Calorimeter (ISO 5660-1).

16.20.2.2 Partition Panels

Phenolic

13mm solid compact laminates with high density water resistant phenolic core.

16.21 Suspended Ceilings

16.21.1 General

16.21.1.1 Cross References

Refer to the General requirements work section.

Related work sections

Refer to the following work sections: Sheet, Metal and Pre-finishes

Adhesives Fixings and Fastenings

Roofing and Cladding

Insulation and Barriers

Painting

16.21.1.2 Standards

General

The following codes/standards are references to the minimum quality acceptable for materials/products/workmanship:

- ASTM C636 – Standard Practice for Installation of Metal Ceiling Suspension Systems for Acoustical Tile and Lay-In Panels
- ASTM E136 – Standard Test Method for Behavior of Materials in a Vertical Tube Furnace at 750°C
- ASTM E119 – Standard Test Methods for Fire Tests of Building Construction and Materials
- ASTM E84 – Standard Test Method for Surface Burning Characteristics of Building Materials
- AAMA 2605:2013 – Specification, Performance Requirements And Test Procedures For Superior Performing Organic Coatings On Aluminum Extrusions And Panels
- ASTM A 123 – Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
- ASTM A 653 – Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process
- JIS H4000 : 1988 – Aluminium and aluminium alloy sheets and plates, strips and coiled sheets
- ASTM B 209 – Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate.
- ASTM B221 – Standard Specification for Aluminum and Aluminum-Alloy Extruded Bars, Rods, Wire, Profiles, and Tubes
- ISO 5660-1 – Reaction-to-fire tests -- Heat release, smoke production and mass loss rate.

16.21.1.3 Interpretation

Definitions

Demountable ceiling: The ceiling material is capable of being removed from below by hand or by hand tools without damage to the system, and subsequently reassembled without the need for finishing.

Fully demountable ceiling: Any part or all of the ceiling is demountable.

Semi demountable ceiling: Only designated parts of the ceiling are demountable.

Suspension system: An assembly of ceiling components for suspending ceiling systems.

Supporting structure: the part or parts of the building to which the suspended ceiling system is attached.

Suspended ceiling system: A ceiling or external soffit and its suspension system, suspended from a supporting structure.

Fixings: supporting fixings that transfer the self-weight of the cladding to the structure supports may also include a restraint function.

Test types

Site test: A test made on site of the installed suspended ceiling system.

Laboratory test: A test made in a laboratory on a test specimen certified to be a full scale model of the system.

Type test: A test previously conducted by or for the manufacturer on the type of system specified.

16.21.1.4 Performance Criteria

Strength

General:

- Design live load (kPa): Cross refer : Civil & Structural Materials & Workmanship Specification.

External ceilings:

- Upward wind load (kPa): Cross refer: Civil and Structural Materials and Workmanship Specification.
- Downward wind load (kPa): Cross refer: Civil and Structural Materials and Workmanship Specification.
- Terrain category: Cross refer: Civil and Structural Materials and Workmanship Specification

Bulkheads:

- Vertical face load (kPa): Cross refer: Civil and Structural Materials and Workmanship Specification.
- Horizontal face load (kPa or kN/m): Cross refer: Civil and Structural Materials and Workmanship Specification.

Imposed dead loads (other than the dead load of the ceiling system)

- Include provision for light fittings, PA speakers, cameras & other MEP components.

Fire performance: non-combustible to ASME E-136.

Do not use materials which, when subject to fire conditions, emit excessive smoke or dangerous fumes.

Fire Safety in Rapid Transit Systems

All material for structure and interior finishes shall meet non-flammable or semi non-flammable (semi non-combustible) or fire retardant requirements in accordance to ISO 5660-1. In case of proposing other than non-flammable and/or fire retardant material, it needs to be tested by Cone Calorimeter (ISO 5660-1).

Acoustic properties

Sound absorption coefficient:	Hz	250	500	1000	2000	4000	8000
		0.65	0.80	0.85	0.85	0.85	0.8

Thermal properties

Thermal resistance (R): As shown on the drawings or required by current legislation in Indonesia, whichever is the higher.

Accessibility

Access hatches: As shown on the drawings.

Protection

Surfaces: Protect all finished surfaces to prevent damage or defacement.

16.21.2 Materials and Components

16.21.2.1 Supports and Trims

Coated steel

General: To ASTM A 123 Coating class: Z200 or AZ150 as applicable.

Proprietary galvanised mild steel support system complete with all fixings and brackets

Aluminium

General: To ASTM B221.

- Finish: Architectural quality: Cross Refer Metals and prefinishes.
- Aluminium sheet
- Pre-formed Aluminium sheet To JIS H4000 or ASTM B209, 303.

Aluminium Sections/Extrusions

To A6063-T5, T6 alloy. Minimum wall thickness 2mm.

16.21.2.2 Fasteners**General**

Cross refer: Adhesives, Sealants and Fasteners

All fixings and fastenings shall be non-corrosive

All fixings and fastenings shall be appropriate to the work, shall transmit all imposed loads and stresses, and shall ensure the structural integrity of the ceiling.

16.21.2.3 22.2.3 Panels**Pre-formed and profiled Aluminium**

Pressed from aluminium sheet, curved to desired profile and fixed to framing, as per indicated on the drawings.

Aluminium tiles

Pressed from aluminium sheet, perforated as per indicated on the drawings and suitably backed to give the required acoustic and other performances.

Aluminium strips

Preformed from 5005 aluminium alloy coil strip.

Expanded Aluminium Mesh Tray (Acoustic)

Support Frame Galvanized steel frame – colour to match mesh finish

Material Expanded aluminium mesh Size: 22 x 57 x 2.0 mm thickness. Minimum 80% open area.

Insulation Cross refer to Insulation & Barriers

Tolerance:
- Length +0/-2mm
- Diagonal +/-2mm

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Composite Honeycomb Aluminium Panels

Standard	General: To AA3005, H44
Minimum thickness	10mm minimum
Fire behaviour	Surface spread of flame to ASTM E84 Class A
Composite core	aluminium honeycomb
Edges:	Square Pre-finished to match face of board Edge folding to manufacturer's recommendation
Perforations:	Nil
Adhesive:	2 Part high temperature cured PU system
Finish:	PVF2 / Fluorocarbon
Colour:	To approval

Calcium silicate board

General:	Board shall consist of asbestos free calcium silicate matrix reinforced with selected fibres and fillers with a smooth sanded surface
Minimum thickness:	10mm minimum
Fire behaviour:	To ASTM E119 and ASTM E136 and surface spread of flame, ASTM E84 Class A
Edges:	Square Pre-finished to match face of board
Perforations:	Nil
Moisture:	Movement from ambient to saturated should not be more than 0.04%.
Alkalinity:	pH value 10
Finish:	PVF2 /Fluorocarbon
Colour:	To approval

Insulation

Cross refer: Insulation and barriers

16.21.2.4 Schedules

Ceiling code	Integrated ceiling systems
Location	Platform; Concourse paid area; Concourse free area; Entrances & lift lobbies (applicable area of CS1, CS2, CS3, CS4 as per indicated drawing)
Demountability	Not applicable
Supporting system	CS1 – Suspended and restrained from Steel roof by S/S Rods and proprietary fixings to Engineer's approval. CS2 – CS 4 – Integrated ceiling support fixed to cast-in inserts, to Engineer's approval
Basic support grid (mm)	Various – refer to indicated drawings
Material	Galvanised mild steel minimum 2mm thick
Exposed member finish	Fluorocarbon finish
Colour	RAL To be confirmed
Ceiling lining/ panels/tiles: -Material	Aluminium
Form	Factory formed to curved profile as indicated in the drawings
Panel size	Various – refer to drawings
Panel Thickness (nominal)	3mm
Pattern	N/A
Colour	RAL To be confirmed
Perforation	None
Type	N/A
Edge trim	Extruded aluminium fascia panel – refer to drawings
Insulation	Acoustic inner lining to specialist's requirement

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Ceiling code	Aluminium expanded mesh tray with acoustic lining (CS 5)
Location	Concourse paid area, Concourse free area (as per indicated drawing).
Demountability	Proprietary fixing system, removable with minimum tools
Supporting system: - Type	Integrated ceiling support fixed to cast-in inserts
Basic grid (mm)	Various – refer to drawings
System	Custom made Galvanized steel frame supporting two layers of expanded Aluminium mesh with acoustic interlayer.
Size	22 x 57 x 2.0 mm thickness. Minimum 80% open area.
Exposed member finish	Fluorocarbon finish
Colour	RAL to be confirmed
Acoustic lining material	Approved 50mm insulation with bonded acoustic paper sandwiched between mesh, matching with the required acoustic properties.
Ceiling lining/ panels/ tiles: - Material	Aluminium
Form	Factory fabricated
Panel size	Various – refer to drawings
Panel Thickness (nominal)	55mm with insulation.
Pattern	Orthogonal
Colour	RAL to be confirmed
Perforation	N/A
Sample at tender stage	Yes

Ceiling code	Perforated Aluminium ceiling panels (CS 6)
Basic grid (mm)	1200x300mm, 600x600mm other sizes varies– refer to drawings
Material	Galvanised Mild Steel proprietary clip in rail, wind and security plate fixing. Contractor to vary dimension and propose alternative if necessary.

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Ceiling code	Perforated Aluminium ceiling panels (CS 6)
Exposed member finish	Fluorocarbon finish
Colour	RAL to be confirmed
Ceiling lining/ panels/ tiles: -Material	Aluminium
Form	Factory fabricated tray returned on 4 sides
Panel size	1200x300mm, 600x600mm other sizes varies– refer to drawings
Panel Thickness (mm)	1.5mm
Pattern	Orthogonal
Colour	RAL to be confirmed
Perforation	30-35% to approval
Type	Mirror finished panels
Panel size	sizes varies – refer to drawings
Insulation	50mm with bonded black acoustic paper. Face of insulation to be separated from perforation using hidden spacers with minimum of 15mm gap

Ceiling code	Aluminium ceiling panels (CS 7)
Location	Concourse paid area, Concourse free area, Link bridges, Changing rooms, and public toilets. (as per indicated drawing)
Demountability	Proprietary clip fixing, easily removable.
Supporting system: - Type	Integrated ceiling support fixed to cast-in inserts
Basic grid (mm)	1200x300mm, 600x600mm other sizes varies – refer to drawings
Material	Galvanised Mild Steel proprietary clip in rail, wind and security plate fixing. Contractor to vary dimension and propose alternative if necessary.

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Ceiling code	Aluminium ceiling panels (CS 7)
Exposed member finish	Fluorocarbon finish
Colour	RAL to be confirmed
Ceiling lining/ panels/ tiles: - Material	Aluminium
Form	Factory fabricated tray returned on 4 sides
Panel size	1200 x 300mm, 600x 600mm other sizes varies– refer to drawings
Panel Thickness (mm)	1.5mm
Pattern	Orthogonal
Colour	RAL to be confirmed
Perforation	30-35% to approval
Type	Mirror finished panels
Panel size	sizes varies – refer to drawings
Insulation	50mm with bonded black acoustic paper. Face of insulation to be separated from perforation using hidden spacers with minimum of 15mm gap.

Ceiling code	Calcium silicate recessed perimeter ceiling panels (CS 8)
Location	Concourse paid area, Concourse free area, Staff rooms, offices and toilets (as per indicated drawing)
Demountability	Not necessary to be easily removable.
Supporting system: - Type	Custom made GMS wall support brackets.
Basic grid (mm)	Sizes varies depending on setting out of Aluminium ceiling panels -refer to drawings.
Material	Galvanised Mild Steel sections. Contractor to vary dimension and propose alternative if necessary.
Exposed member finish	Fluorocarbon finish

Colour	RAL to be confirmed.
Ceiling lining/ panels/ tiles: - Material	Calcium silicate panels with joints skimmed and sand to smooth finish.
Form	On site; as per indicated drawings.
Panel size	Sizes varies depending on setting out of Aluminium ceiling panels - refer to drawings.
Panel Thickness (mm)	10mm
Colour	RAL to be confirmed.

Ceiling code	Composite Aluminium ceiling panels with honeycomb core (CS 9)
Location	Concourse paid area, Concourse free area (as per indicated drawing).
Demountability	Proprietary aluminium clip fixing, easily removable for access.
Supporting system: - Type	Galvanised Mild Steel proprietary clip in rail, wind and security plate fixing. Contractor to vary dimension and propose alternative if necessary.
Basic grid (mm)	Sizes varies -refer to drawings
Material	Galvanised Mild Steel sections. Contractor to vary dimension and propose alternative if necessary.
Exposed member finish	Fluorocarbon finish
Colour	RAL to be confirmed.
Ceiling lining /panels / tiles: -Material	Composite Aluminium ceiling panel.
Form	Factory fabricated tray returned on 4 sides.
Panel size	Sizes varies -refer to drawings.
Panel Thickness (mm)	6mm
Pattern	Orthogonal

Ceiling code	Mirror finished Aluminium ceiling panels (CS10)
Location	PSC, SMR and Ticket Sales Office (as per indicated drawing).
Demountability	Proprietary aluminium clip fixing; easily demountable

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Ceiling code	Mirror finished Aluminium ceiling panels (CS10)
Supporting system: - Type	Integrated ceiling support fixed to cast-in inserts; suspension system by means of adjustment springs, suspension rods etc.
Basic grid (mm)	Controlled in length at 600mm; width varies
Material	Galvanised Mild Steel proprietary clip in rail, wind and security plate fixing. Contractor to vary dimension and propose alternative if necessary.
Exposed member finish	Fluorocarbon finish
Colour	RAL to be confirmed
Ceiling lining/ panels/ tiles: - Material	Mirror finished Aluminium panels; made of aluminium alloy anodized in chrome.
Form	Factory fabricated tray returned on 4 sides.
Panel size	Controlled in length at 600mm; width varies – refer to drawings
Panel Thickness (mm)	1.5mm.
Pattern	Orthogonal
Colour	to be confirmed.
Perforation	30-35% to approval.
Type	Mirror finished panels.
Panel size	sizes varies – refer to drawings.
Insulation	Sound absorptive acoustic pad material to meet recommended acoustic requirements.

16.22 Cementitious Toppings

16.22.1 General

16.22.1.1 Cross References

Refer to the General requirements work section.

Related work sections

Refer to the following work sections: Paving and Tiling

16.22.1.2 Interpretation

Cementitious Toppings

A cementitious material applied to a base slab for the purposes of achieving a flat floor finish. Refers to a stand-alone finish or base to take on an applied finish e.g. tiling.

Bonded Topping: Toppings that are fully bonded to their substrate.

16.22.1.3 Standard

- ASTM A1064 – Standard Specification for Carbon-Steel Wire and Welded Wire Reinforcement, Plain and Deformed, for Concrete.
- ASTM C779 – Standard Test Method for Abrasion Resistance of Horizontal Concrete Surfaces
- ASTM C494 – Standard Specification for Chemical Admixtures for Concrete
- ASTM C1384 – Standard Specification for Admixtures for Masonry Mortars
- ASTM C150 – Standard Specification for Portland Cement
- SNI 15-2049-2004 – Portland cement
- ASTM C144 - 11 – Standard Specification for Aggregate for Masonry Mortar

16.22.1.4 Tolerances

Tolerance classes

Determine tolerance classes using a straight edge placed anywhere on the surface in any direction. Maximum deviation is 3mm, on measurement of 3m straight edge.

Deviation shall not occur suddenly with the rate of departure not greater than 1.5mm for each 500mm in distance from any point of contact along the straight edge.

16.22.1.5 Surface Modifiers

Surface hardeners

Suitable for cementitious toppings or as laid surfaces. Apply to clean surfaces. Do not apply to non-slip topping.

Floor hardener

Type: Non-metallic

Composition: natural aggregates blended with cement and resin mortars with

Abrasion resistance: to ASTM C779.

Hardness: 9 mohs minimum

Adhesion: minimum 4.5. kg/sq.m.,

Chemical resistance: required for battery acids.

16.22.2 Materials and Components

16.22.2.1 General

Toppings shall comply with BRE Information Paper IP 11/84, Table 2, Category A.

Cement: To Section on Specification for Civil and Structural Works

Sand/aggregates: To ASTM C144

Plasticiser: To ASTM C1384: may only be used as per approved material.

Waterproofing agent: proprietary waterproofing agent as per approved material.

Bonding compound: proprietary bonding compound as per approved material.

Reinforcement:

Type: 50 x 50 x 2.5mm thick galvanised wire mesh as recommended by ASTM A1064

16.22.2.2 Cement/Sand Toppings

Mix

Ratio: 3:1 – cement : sand.

Water cement ratio: 0.5 maximum.

16.22.2.3 Granolithic Toppings

Mix

Ratio: 1:1:1.5 cement : fine aggregate : 5 mm coarse aggregate.

Water : cement ratio: 0.5 maximum.

Slump: 50 mm maximum.

Placing

Monolithic placing: Compact and float.

16.22.2.4 Waterproof Cement Toppings

Mix

Ratio: 1 : 2.5 – cement : graded coarse aggregate screenings, maximum size 5 mm.

Slump: Zero.

Waterproofing agent

Proprietary integral admixture, as per approved material.

16.22.2.5 23.2.5 "No Fines" Toppings

Mix

Ratio: 1:6 cement : coarse aggregate, maximum size 10 mm. Mixing water per bag of cement, 20 L maximum.

Slump: Zero.

Finish

Trowel to an even natural texture. Rule to the designated pattern.

16.22.2.6 23.2.6 Composite Stone Toppings

Execution

By a specialist subcontractor.

Mix

Grading: Cement and selected aggregate graded from fine to coarse, maximum size

6 mm.

Proportions (cement : fine aggregate : coarse aggregate): 1:2:3 by weight.

Water cement ratio: 0.5 maximum

Colour and texture

Expose the aggregate by washing off the surface cement film with water. Do not use acid.

16.22.2.7 23.2.7 Margins to Toppings

Integral margins

Integrally form margins in the topping material.

Coved skirtings

General: Form coves in the topping material, and finish the top to a neatly struck line.

Mitre internal and external angles.

Radius (mm): 25mm nominal

Height (mm): 175mm nominal

16.22.2.8 23.2.8 Nosing

General

Reinforced nosings

General: Provide the topping carborundum inserts minimum 2 full width of treads

Location: First storey plant room areas.

Preformed nosings

General: Proprietary nosing section to finish flush with the adjoining surface.

Location: First storey plant room areas.

Material: Stair width - 50mm Top face textured minimum 50mm wide.

Anti-slip strips

General: Form grooves and fill with anti-slip compound consisting of 1:1 cement :

silicon carbide grains.

Location: Stair and landing nosings.

Grooves:

- - Size: 15 mm wide, 12 mm deep
- - Spacing (mm): 50 mm curves
- - Number: minimum 2

16.22.2.9 Control Joints

Additional joints

Provide control joints as necessary to divide the topping into approximately square bays of not more than 15m².

Where additives are used, provide control joints as recommended by the additive manufacturer.

Edges of joints

Square.

Control joint filler

Preformed strip: Proprietary strip consisting of a neoprene filler sandwiched between plates with lugs or ribs for mechanical keying.

Sealant: Cross refer Adhesives Sealants and Fasteners.

Dividing strip: Corrosion resistant minimum 5mm wide x 25mm deep.

Material: Aluminium

16.22.2.10 Joint Accessories

Floor finish dividers

General: At junctions between differing floor finishes provide a corrosion resistant metal dividing strip suitably fixed to the substrate, with top edge flush with the finished floor. Where changes of floor finish occur at doorways make the junction directly below the closed door.

Type: Flat bar with logs/ribs

Material: Stainless steel G304 internal

5mm wide x 25mm G316 external

16.23 Access Floors

16.23.1 General

16.23.1.1 Cross References

Related work sections

Refer to the following work sections: Adhesives, sealants and fasteners

16.23.1.2 Standards

The following codes/standards are references to the minimum quality acceptable for materials/products/workmanship:

- JIS A 1450:2009 Test methods for raised access floor

- ASTM E119 - 14 Standard Test Methods for Fire Tests of Building Construction and Materials

16.23.1.3 Performance

Use

Area function:

- Passenger Service Centre (PSC)
- Station Master's Room (SMR)
- Other area as indicated.

Intended use of system: A readily accessible underfloor space suitable for running electrical, mechanical, computer or communication services and the like.

Stability

General: Provide a completed floor system which is rigid, free from vibration, creep, squeaking, and the like, which has a smooth and uniform finished surface, and which will maintain these conditions when sufficient panels have been removed for normal access.

Access for maintenance: All panels to be capable of removal using special panel lifting tools provided for the purpose.

Dimensional tolerances of installations

Horizontal dimensions (mm):

- Maximum deviation from true floor grid: 3mm
- Maximum deviation of a grid line from straight: 3mm
- 1:1000 up to a maximum of 3mm within the tolerances defined by the formula $(A \div B) \times 100 \leq 0.5\%$, where:

A = the greatest dimension of divergence from the design grid line measured at right angles from that line

B = The shortest dimension separating points of nil and greatest divergences, measured along the plane or curve.

Dimensional tolerances of tiles Squareness: +/- 0.51mm for 600 x 600mm tiles

Fire rating

Tiles and pedestals: Non-combustible.

Floor finish: To comply with the employer requirements.

Structural loading

Superimposed loads: Provide an access floor system which is capable of carrying a uniform live load minimum of 1.5kN/m² with a deflection ≤0.25mm. Pedestals shall not deform under a 2270kg load.

16.23.2 Materials and Components

[16.23.2.1 Pedestals](#)

Description

Material: Metal: Galvanized; corrosion resistant

Finish: As per approved sample

Head to panel connection: Lugs

Floor fixing: Adhesive, as per approval.

Adjustable floors

General: Incorporate in each unit a means of height adjustment within the limits specified, without requiring rotation of the head, and a means of locking the adjustment to prevent accidental displacement.

Height: to provide floor finish minimum 300 mm above the concrete sub-floor or as show on drawings.

Height adjustment limits (mm):

Maximum extension: as per approved product recommendation

Minimum extension: as per approved product recommendation

Fire rating

Non-combustible, made using materials with melting point ≥ 350°C.

Location

Under every corner of every panel, as per manufacturer recommendation.

16.23.2.2 Stringers

Description

- | | |
|---------------------------------|---------------------------------------|
| ■ Material: Metal: | Corrosion resistant |
| ■ Finish: | As per approved product. |
| ■ Form: | As per approved product. |
| ■ Spanning: | In both directions between pedestals. |
| ■ Connection to pedestal heads: | Mechanically interlocked |

Fire rating: non-combustible, made using materials with melting point $\geq 350^{\circ}\text{C}$.

16.23.2.3 Panels

Description

Form: Pressed steel top and bottom pans

Material: Zinc-coated minimum 0.6mm steel.

Core: Foamed lightweight concrete

Edge strips: As per approved sample.

Finish: Factory applied HP laminated minimum 2mm thick, as per approved sample.

Dimensions

Coordinating size: 600 x 600 mm.

Minimum size of cut tiles (mm): Show all cut tiles less than $\frac{1}{2}$ tile width on shop drawings and obtain approval for the layout

Overall thickness (mm): As per approved material.

Maximum weight: 18 kg.

Cut outs

General: Provide cut outs for cable access and air grilles as necessary.

Edge cut outs: Provide stringer or pedestal, or both, support.

Omitted panels: Permanently omitted panels are not permitted.

Labelling

Non-standard panels: Identify for relocation purposes.

16.23.2.4 Accessories

Services

Coordinate detailing of outlets using standard access boxes and installation with the following:

Electrical outlets: as per approved product.

Data outlets: as per approved product.

Telephone outlets: as per approved product.

Combined services boxes: as per approved product.

Cable access grommets: as per approved product.

Lifting devices

Number required: 4

Marking: If panels must not be lifted from the side, mark lifting devices "Lift panel vertically at centre".

16.23.2.5 Finishes

General

Steel elements: Galvanized.

Coating class for sheet: At least Z350.

Panels

Integral floor finishes: Required.

Material: Carpet tile or high pressure laminate minimum 2mm thick, as per approved product and drawing indication (non-combustible material).

Adhesive: to approval

Surface treatment: Preserve conductive properties of floor surface.

Underside facing: Non-combustible.

Underfloor

Corrosion-resistant finish to metal under structure.

Sealing

Perimeter gap sealing method to approval

Vermin sealing of underfloor space: Required.

Subfloor surface treatment

Seal concrete/screed surface: Cross Refer Cementitious Toppings.

16.24 Gratings

16.24.1 General

16.24.1.1 Cross References

General

Conform to the General Requirements work section.

Related work sections

Conform to associated work sections as follows:

- Adhesives Sealants and Fasteners
- Waterproofing
- Roofing and Cladding
- Plumbing and Sanitary Fixtures
- Paving and Tiling
- Civil & Structural specification

16.24.1.2 Equipotential Bonding Requirements (EPB) and Touch Voltage Protection

Comply with the requirements of Persyaratan Umum Instalasi Listrik (PUIL); (SNI 0225:2011/Amd 1:2013; Amd2:2014; Amd3:2014) where grating proposed within the station protection zone.

16.24.1.3 Standards

General

To the requirements of the District Public Works Service (Dinas PU) of DKI Jakarta.

The following codes/standards are references to the minimum quality acceptable for materials/products/workmanship:

- ASTM B179
- ASTM C857 - 14
- ASTM C478
- ASTM A123
- ASTM A653
- ASTM A792
- ASTM A924
- SNI 03-7065-2005
- SNI 03-6481-2000

External Drainage:

- Load Class A15: to 15 kN
- Load Class B125: to 125 kN
- Load Class C250: to 250 kN
- Load Class D400: to 400 kN
- Load Class E600: to 600 kN

16.24.1.4 Design

Drawings: contract drawings show generic design principles and design intent only.

16.24.2 Materials and Components

16.24.2.1 General

Toxic materials: Use materials which are certified free of asbestos and lead, or any other known toxin, and free of, nor requiring the use of, toxic solvents.

Do not use products which give off toxic emissions in the event of a fire.

Do not use materials which contain known carcinogens.

Confirm that materials used in conjunction are compatible with one another, the substrates on which they are used, and all adjacent materials in the completed building.

The manufacturer's name, class designation, relevant standard, and year of manufacture shall be legibly and durably marked on each item.

Accessories

Provide the accessories necessary for the correct installation of all items.

16.24.2.2 Drainage Channels

Refer to civils and structural materials classification & cast/in-situ.

Material: Concrete

Cover: Galvanised Steel

16.24.2.3 Drainage Channel Gratings

In panels as set out in regular modular grid except as indicated on drawings.

Type 1

Location	Entrance - top & bottom landings of escalators, as per drawing indication.
Type	Removable Fixed with concealed or flush recessed fixings
Openings	Slotted
Material	Stainless steel, grade 316.
Load class	Stainless steel flat bar in panels with locating lugs
Heel guard protection	Regular pattern with flush fixings
Locking system	Security bolts Flush in regular pattern

Type 2

Location	Covered link ways, as per drawing indication
Type	Fixed with concealed or flush recessed fixings
Openings	Slotted; Perforated
Material	Galvanised steel
Load class	Galvanised mild steel flat bar in panels with locating lugs
Heel guard protection	Perforated in regular pattern with flush fixings
Locking system	Security bolts; Flush in regular pattern
External Cladding	Refer to Removable Grating to rainwater drainage.

16.24.2.4 Floor Gullies

General

Provide gullies with rounded bodies and without sharp corners which might trap dirt.

- Loading: 2.5 kN/m²
- Type: Square
- Material: Stainless steel, grade 316.
- Gratings: Flat
- Material: Stainless steel, grade 316.
- Fixings: No visible fixings or flush recessed.
- Finish: Perforated

16.24.2.5 Rainwater Outlets

- Type: Roof gutter; Downspout
- Material Galvanized steel; To approved RAL colour
- Gratings Domed; as per indicated drawing
- Fixing Bolted; Twist action release
- Finish Slotted
- Outlet Vertical; Slanted; 45O; 90O

16.25 Plumbing and Sanitary Fixtures

16.25.1 General

16.25.1.1 Cross References

Refer to the General requirements work section.

Related work sections

Refer to the following work sections: Adhesives, Sealants and Fasteners

Civil & Structure specifications

Paving and Tiling

Partitions

16.25.1.2 Standards

Toilet fittings and accessories:

The following codes/standards are references to the minimum quality acceptable for materials/products/workmanship. Nominal dimension to be as per approved product, to comply with the related local regulation.

- To the Guidebook for Better Public Toilet Design and Maintenance
- To the requirements of the respective Department of the Environment.
- SNI 03-6481-2000 – Plumbing Systems
- Toilets for use by disabled persons: To the respective Code on Barrier Free Access for Disable persons
- SNI 03-0680-1998
- SNI 03-2988-1998
- SNI 03-2399-2002

16.25.1.3 Equipotential Bonding Requirements (EPB)

Cross Refer: Section on 'Design' of the General Requirements.

16.25.1.4 Design

Drawings

Contract drawings show generic design principles and design intent only

16.25.2 Materials and Components

16.25.2.1 General

All sanitary ware and accessories shall be the approved product by the Ministry of Public Work (KepMen PU) for use in Indonesia.

16.25.2.2 Sanitary Fixtures

General

Provide the accessories necessary for correct installation.

Tolerances on all dimensions quoted are –5%/+10% unless otherwise noted. The finalized alignment and provision to be as per the approved indicated drawing.

Fixings

- In accordance with the Section on 'Adhesives, Sealants and Fasteners'.
- As required by manufacturer.

W.C.: Public toilets

Type: wall mounted for P-trap and floor mounted for S-trap, siphonic flush.

Nominal size, Length: 605mm, Width: 355mm, Height to rim, 370mm. In disabled toilets height to seat to be 450mm minimum, 480mm maximum.

Finishes: Vitreous China, Colour: White

Outlet: To suit stack position to SNI 03-2399-2002; SNI 03-2988-1998; SNI 03-0680-1998 as indicated on the drawings.

Accessories: Seat and cover to SNI 03-2399-2002; SNI 03-2988-1998; SNI 03-0680-1998; colour: white.

Flush Valve, with Push button switch

W.C.: Staff toilets

Type: Close coupled

Nominal size: Length: 605mm, Width: 355mm, Height to rim, 370mm.

Finishes: Vitreous China, Colour: White

Outlet: To suit stack position to SNI 03-2399-2002; SNI 03-2988-1998; SNI 03-0680-1998 as indicated on the drawings.

Accessories: Seat and cover to SNI 03-2399-2002; SNI 03-2988-1998; SNI 03-0680-1998; colour: white.

Flush Valve, with Push button switch

W.C.: Asian Style (squat)

Type:

- complete with footrests minimum 255mm long, x 120mm wide.
- to finish flush with adjacent floor finish.

Nominal size: Length: 670mm, Width: 305mm, Depth: 300mm.

Finishes: Vitreous China, Colour: White.

Outlet: To suit stack position to SNI 03-2399-2002; SNI 03-2988-1998; SNI 03-0680-1998 as indicated on drawings.

Accessories: Flush Valve, with Push button switch

Urinal

Type: Wall hung with fully concealed fixings.

Nominal size: Overall height: 800 mm, Overall width: 460mm.

Height to rim 530mm (at least 1 urinal to comply with Barrier free code height of 400mm)

Finishes: Vitreous China, Colour: White.

Fixings: fully concealed, corrosion resistant.

Accessories: Flush Valve, with Push button switch

Wash Basin

Type: To be integrated with the counter top.

Nominal size: Width: 500mm, Breadth: 360mm, Depth: 200mm.

Basin capacity: 8.0 litres.

Finishes: Solid surfacing, Colour White.

Fixings: Fully concealed, non-corrosive.

Remarks:

- Provide plug.
- Provide chromium plated cast bronze or brass outlet.
- Provide opening to take single tap.

Cleaner's Sink

Type: heavy duty gauge stainless steel.

Fixings: wall mounted cantilever brackets.

Taps: chrome bib taps.

Remarks:

- outlet shall be fitted with a diameter 50 mm CI S-trap.
- provide plug

Kitchen Sink

SS sink and drainer at Staffroom: Read with Furniture and Fittings.

W.C. Flush Valve with Push Button Switch

Type: flush valve with push button switch.

Finishes: Grade 304 grade hairline finish stainless steel polished using 180 - 240 grit.

Fixings: Fully concealed, non-corrosive fixings.

Remarks:

- Must deliver maximum 6.0 litre flush.
- Must be supplied complete with vacuum breaker.
- To be fully compatible with flush valve and obtained from the same manufacturer.

Urinal Flush

Type: Infrared detection type sensor to identify a person standing within 600mm of the urinal and send a message to flush if the detection lasts more than 5 seconds.

Finishes: Grade 304 grade hairline finish stainless steel polished using 180 - 240 grit.

Fixings: Fully concealed, non-corrosive, and compatible with all adjoining metals.

Remarks:

- - No user over-ride button to be provided.
- - Must deliver maximum 2.5 litre flush.

Self-Closing Delay Action Tap

Location: All wash basins except those fitted in cubicles for the disabled and First Aid room.

Finishes: Bronze or brass casting chromium plated.

Fixings: Fully concealed, non-corrosive.

Through opening in wash basin.

Remarks:

- To be capable of being pressure operated by one hand using a force no greater than 22N.
- To close after supplying water for not more than 3 seconds.
- Push button to be centred on spout.

Long Shank Basin Pillar Tap

Location: All wash basins in cubicles for the disabled and the First Aid room and Staff room kitchen sink.

Finishes: Bronze or brass casting chromium plated.

Fixings: Fully concealed, non-corrosive. Through opening in wash basin.

Remarks: To be capable of being operated by one hand using a force no greater than 22N.

Wall Mounted Bib Tap

Location: All squat WC cubicles.

Finishes: Chromium plated.

Fixings: Fully concealed, non-corrosive.

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Remarks: To be fitted with a bidet spray and hose to allow for personal hygiene.

Bidet Spray And Hose

Location: All squat WC cubicles.

Finishes: Rubber hose, bronze or brass cast wall outlet and bracket with chromium plated finish, chromium plated metal spray and nozzle.

Fixings:

- Vandal proof connection between hose and bib tap.
- All fixings to be fully concealed and non-corrosive.
- To be supplied complete with polished stainless steel wall clip to retain shower spray head.

Hose length: nominal 1200mm.

Remarks

- Spray to be adjustable by use of lever handle at outlet.
- Hose to be clear of ground when shower head is held by bracket.
- Hose to be capable of withstanding water pressure of 17.5 bar.

Shower Head

Type: Heavy duty fixed angle shower head.

Location: Staff shower areas.

Finishes: Cast bronze or brass with chromium plating and matching perforated metal shower outlet.

Fixings: Fully concealed non corrosive.

Flange with matching finish to be provided to cover wall penetration.

Automatic Hand Drier

Type: Wall mounted.

Nominal Size: 340mm wide x 300mm high, x 120mm deep, all dimensions +/- 10%.

Finishes: Vandal resistant non-plastic finish, Colour: white.

Fixings: To be fully concealed, non-corrosive.

Air temperature Range: 50 – 55°C.

Operating noise: less than 80 Db.

Remarks:

- - To be capable of being operated with one hand.
- - To start within 0.5 – 0.8 seconds after hand is positioned within 200mm of hot air outlet.
- - To turn off automatically after 60 seconds maximum.

Soap Dispenser

Type: Recessed and wall mounted with vandal resistant refill window.

Location: as indicated in drawings.

Capacity: 1.3 litres, minimum.

Finishes: 304 stainless steel with hairline finish polished using 180-240 grit.

Fixings: Fully concealed non-corrosive fixings.

Ironmongery:

- Full length heavy duty recessed hinge and tumbler locks on door giving access to soap container.
- Corrosion resistant valve to dispense liquid soaps lotions and detergents.

Remarks

- - Enclosed soap container to allow for easy refilling.
- To be operated with one hand without grasping pinching or twisting of the wrist.
- Valve activation to require no more than a force of 22.0 N.

Toilet Roll Dispenser

Type: 'Jumbo' toilet roll holder with a supply status viewing window.

Location: All WC cubicles.

Nominal Size: 285mm dia. x 110mm depth +/- 10%.

Capacity: rolls of 400.0m with spindle of 45mm.

Finishes: 304 stainless steel with hairline finish polished using 180-240 grit.

Fixings: Fully concealed non-corrosive.

Baby Changing Shelf

Type: Fold down complete with pneumatic shock absorber.

Location: In disabled toilet

Nominal Size: 900mm wide, 100mm deep, projecting 510mm when open.

Finishes: High impact plastic.

Fixings: Fully concealed non-corrosive.

Remarks:

- To be fitted with baby holding straps.
- To be devoid of sharp corners.
- To be shaped to conform with child's body.
- To be capable of being opened and closed with one hand.

16.26 Metal Fixtures

16.26.1 General

16.26.1.1 Cross References

Refer to the Civil and Structural Specification and General requirement work section.

Related work sections

Refer to the following work sections: Steel, Metals and Pre-finishes

Painting

Roofing and Cladding

Glazing

16.26.1.2 Equipotential Bonding Requirements (EPB) and Touch Voltage Protection

Comply with the requirements of Persyaratan Umum Instalasi Listrik (PUIL); (SNI 0225:2011/Amd 1:2013; Amd2:2014; Amd3:2014), where metals are proposed within the station protection zone.

16.26.1.3 Interpretation

Fixing: the term 'fastener' shall be taken to mean:

- Supporting fixings that transfer the self-weight of the fixture to the structure. Supports may also include a restraint function.
- Restraint fixings: Fixings that tie back the fixture to the structure and resist variable loads such as crowd loads.

16.26.1.4 Standards

The following codes/standards are references to the minimum quality acceptable for materials/products/workmanship:

- ASTM B308;
- ASTM B429
- ASTM E330
- AWS D1.2
- AWS QC7-93
- ANSI ASC A14.

16.26.1.5 Design

Drawings

Contract drawings show generic design principles and illustrate geometry and appearance of visible elements/surfaces only and shall be used to as guidance by the contractor to develop his detailed design.

16.26.1.6 27.1.6 Movement

General: Provide for deflections, displacements and other movements within the building, including movements caused by ambient temperature changes, crowd loads, design dead and live loads and shrinkage.

Ensure that there will be no failure of seals or fasteners, or other damage as a result of the loads identified.

Accommodate movements silently and without permanent deformation, reduction of performance, or other detrimental effects such as:

- damage to or undue stress on fixtures
- failure of joints

Ambient temperature range (°C): 20 – 40° C.

Building movements

General: Refer to the Civil and Structural Specification.

Deflection Limits

Restrict the maximum deflection/span ratios of members subject to the identified loads to the performance requirements of ASTM E330, except that the deflection/span ratio of the member will be restricted to a maximum of 1:360; and restrict the deflection of the cantilevered end of a cantilevered structural member of cantilever length L to the maximum given in the Civil and Structural Specification.

Loads

For details of crowd loads see the Civil and Structural Specification.

16.26.2 Materials and Components

16.26.2.1 Metals

Performance: Provide metals suited to their required function, finish and method of fabrication, in sections of strength and stiffness adequate for their purpose.

Performance: Provide metals so that they transmit the loads imposed and ensure the rigidity of the assembly without causing deflection or distortion of finished surfaces.

Incompatible metals: Separate using concealed layers of suitable materials in appropriate thicknesses.

Cross refer: Steel, Metals and Pre-finishes.

Fasteners

Performance: Provide fasteners so that they do not cause galvanic corrosion.

Materials: Provide fasteners in materials of mechanical strength and corrosion resistance at least equal to that of the lowest resistant metal joined.

To copper and copper alloys: Provide copper or copper-alloy fixing devices only.

To aluminium and aluminium alloys: Provide aluminium alloy or non-magnetic stainless steel fixing devices only.

To stainless steel: Provide appropriate stainless steel materials only.

Aluminium structures

Standard: To ASTM B308; ASTM B429

Fabrication

Workshop: Fabricate and pre-assemble items in the workshop wherever practicable.

Edges and surfaces: Keep clean, neat and free from burrs and indentations. Remove sharp edges without excessive radiusing.

Tube bends: Form bends in tube without visibly deforming the cross section.

Colour finished work: Match colours of sheets, extrusions and heads of fasteners.

Thermal movement: Accommodate thermal movement in joints and fastenings.

Fabrication tolerances structural work generally: ~ 2 mm.

Joints

General: Fit joints to an accuracy appropriate to the class of work. Finish visible joints made by welding, brazing or soldering using grinding, buffing or other methods appropriate to the class of work, before further treatment.

Self-finished metals: Free of surface colour variations, after jointing.

Joints: Fit accurately to a fine hairline.

16.26.2.2 Welding and Brazing

Quality: Provide finished welds which are free of surface and internal cracks, slag inclusion, and porosity.

Site welds: Do not weld on site.

Butt weld quality level: Not inferior to the appropriate level recommended in AWS D1.2.

Finishing

Visible joints: Finish visible joints made by welding, brazing or soldering using methods appropriate to the class of work (including grinding or buffing) before further treatment such as painting, galvanizing or electroplating. Ensure self-finished metals are without surface colour or textural variations after jointing.

Where indicated a drawings welds to be concealed or ground back clean and smooth. All elements with visible welded joints shall be sized appropriately to prevent "ghosting" on non-welded side.

Brazing

General: Ensure brazed joints have sufficient lap to provide a mechanically sound joint.

Do not used butt joints relying on the filler metal fillet only.

16.26.2.3 Stainless Steel

Type: Cross refer: Steel, Metals and Pre-finishes

Fixings: Cross refer; Adhesives Sealants and Fasteners.

Surface finish

Type: Continuous hairline achieved using a 180-240 grit size or non-directional finish.

Welding stainless steel

Certification of welders: To AWS QC7-93

Riveting

Riveting may be used only to join stainless steel sheet or strip less than 1 mm thick.

Drill (not punch) the rivet hole, and drive the rivet cold. On completion, clean and passivate the riveted assembly.

Soldering

Do not solder stainless steel.

Jointing

Joints to be aligned as drawings spigots/sleeves to handrails to recessed nominal 5mm where necessary.

16.26.2.4 Finishes Schedules

Metal fixtures self-finishes schedule

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Jakarta LRT Project – Corridor 1 (Phase 1): Kelapa Gading-Velodrome



Item	Surface	Finish
Public Area handrail & connecting spigot to post; Public Area balustrade with infill glazed panels or s/s rods; All railing on pre-cast/ cast in-situ RC parapets; External public area entrances ramps, queue rails, railings; External fire escape balustrade, railings, gates and grilles; Public/non- public (main corridor) gates; Public area barrier Paid/Unpaid at AFC line; Patch fittings for glass cladding/pivoting clamps	S/S 316; some section in conjunction with glazing	Hairline

Metal fixtures galvanizing schedule

Item to be galvanized	Coating class
Plant room area stair handrail/ posts/ balustrade sections	275g/m2 chromate passivated

Metal fixtures coating schedule

Item to be coated	Colour	Type of coating
All architectural louvers	To approval	PVF2; Fluorocarbon, or Galvanized coating, as per indicated drawing.

16.26.2.5 Platforms and Walkways

Standard

Materials, design and construction: Comply with the recommendations of ANSI ASC A14.

Design loads (kPa)

Cross Refer Civil and Structural Specification: 1.5kPa minimum.

Material Pre-finish: Galvanised steel.

Flooring type: removable square grid pattern in individual framed sections.

Kick plate (Toe board) required height (mm): 200mm

16.26.2.6 Handrails and Balustrades

Standard

Materials to comply with the recommendations of ANSI ASC A14.

Design: as shown on drawings.

Joints

Produce smooth unbroken surfaces at joints. On welded joints scribe the joints between posts and rails. Make end-to-end joints over an internal sleeve and express joint.

Bends:

- Make changes of direction in rails by evenly curved pipe bends.
- Where handrails are bent to a large radius to follow a curve on plan, ensure that the radius continues in a smooth unbroken line across all joints in the handrail. 'Segmented' curves will not be accepted unless they are identified as such on the design drawings.

Free ends: Seal the free ends of pipes with fabricated or purpose-made end caps & finish to match.

Ensure no extraneous materials are trapped within the pipes prior to sealing.

Fixing to structure

Provide fabricated predrilled or purpose-made brackets or post bases, and attach the pipework to the building structure with fixings, including bolts into masonry anchors, and coach screws or bolts into timber, of metal compatible with the pipework.

Galvanizing

Cross Refer: Steel, Metal and Pre-finishes.

16.26.2.7 Service Gates

Design: as shown on drawings.

Fabrication

General: Fabricate all service gates in controlled workshop conditions.

Method: Welding.

Ironmongery

Provide for fixing ironmongery including hinges and, using back plates and lugs sufficient to carry the weight of the gates and the forces acting on it. Screw fix the hinges into tapped holes in the back plates.

Hinges: provide steel rising butt hinges to match the material of the gate, complete with matching screw fixings. Recess hinge into support post. Provide patch fittings to glass.

AMS Locking

Provide all required reinforcement within the gate to cope with the AMS locks, as per approved product. To coordinate with the approved product to ensure that all necessary provisions have been made.

16.26.2.8 Metal Stairs

Standard: to comply with the recommendations of ANSI ASC A14.

Service access stairs

Location: refer to drawings.

Access stairs to machine rooms, including handrails/ brackets etc. to use hot dip galvanized mild steel.

16.26.2.9 Fixed Ladders

Location: To cable basements, sump pits, Lift Machine Rooms etc., as per indicated drawings.

Description: Galvanised Mild Steel ladder permanently fixed to the structure, incorporating steps, rungs or cleats, with a pitch of 90° from the horizontal.

Standard

To comply with the recommendations of ANSI ASC A14

Ladder type: vertical

Metal: Mild steel hot dip galvanised

Landing surface: Open grid galvanised mild steel in panels framed all round

Ladder cage: as required, per indicated drawing.

Grab Bars

Horizontal or vertical grab bars with the same lateral spacing as that of the vertical legs of the rung shall be provided. Grab bars shall extend at least 1000mm above the access/egress level or landing platform served by the ladder.

Fixing

Fix ladder stiles securely to the building structure at tops and bottoms of flights, and at intermediate points.

Design Supervision

The design of fixed ladder system shall be under the general supervision of a qualified professional engineer.

16.26.2.10 Retractable Ladders

Location: as required, per indicated drawing.

Description: Aluminium retractable ladder in 3 sections with the first section firmly anchored and fixed to the vertical surface. The ladder shall be complete with mountings and a ladder safety system, whose function is to arrest the fall of a user, including the carrier and its associated attachment elements, safety sleeve, body support and connectors. The carrier shall be permanently attached to the climbing face of the ladder.

Retractable Section

The ladder shall be designed such that the transition from one section to the other shall be smooth so as to afford minimum interference with the gripping surface. Such sections shall be designed so as to ensure full structural continuity of the side rails.

The retractable sections of the ladder shall be provided with a cranking system, that can be operated from within the Ladder storage room. Such system shall be designed to be operated by one person with ease and shall function to extent and retract the movable sections of the ladder. The forward end of the ladder shall be designed to rest firmly on the ladder access platform fixed permanently to the roof.

The minimum size of the Aluminium extrusions and their treatment shall be to AA SAS- 30-1986: ASTM B308; ASTM B429;

Safety

All components of the ladder shall be designed to conform with the safety requirements. The maximum length of the connection between the centreline of the carrier and the point of attachment to the body belt shall not exceed 210mm.

16.26.2.11 Corner Protection

Provide metal corner protection.

- fitting close to adjoining surface finishes;
- solidly grouted up at the back to eliminate voids; and
- securely fixed by a method which does not cause distortion in the metal surface and consists of either concealed built in lugs, or flush countersunk head fixings into masonry anchors.

Location: All exposed external corners in plant areas.

Material: Galvanised mild steel, painted.

Dimensions (mm): as per manufacturer recommendation and product approval.

Height: minimum 1.1m from FFL

Angle leg length: min 50x50

16.26.2.12 Perforated Platform Screens

Location: To the external side of the via-duct at the Platform level as shown on drawings.

Description: Perforated and stove enamelled 0.7mm thick Aluminium alloy sheet panels fixed onto intermediate vertical Galvanised Mild Steel frames as shown on drawings, to provide visual privacy.

Edges: The edges of the sheets shall be mechanically bend to L-shape.

Perforations: The perforations shall be 1.0mm in diameter in a 2mm triangular pattern and a minimum 23% open area. The non-perforated border shall be 10mm.

Design

The drawings show the design intent only. The Contractor shall work out the details to match this intent with sufficient and appropriate structural systems.

Wind Load: The design Wind Load and other parameters shall be based on the requirements of the Civil Design Criteria.

16.27 Fencing and Bollard

16.27.1 General

16.27.1.1 Cross References

Conform to the General Requirements work section.

Related work sections

Conform to associated work sections as follows: Steel, Metals and Pre-finishes

Paving and Tiling

16.27.1.2 28.1.2 Standards

The following codes/standards are references to the minimum quality acceptable for materials/products/workmanship:

- ASTM A500
- ASTM A1085
- ASTM A817
- ASTM F626
- ASTM A615
- ASTM C150
- ASTM C33
- ACI 318; 315

16.27.1.3 Design

Drawings

Contract drawings show generic design principles and design intent only.

16.27.2 Materials and Components

16.27.2.1 Steel

Steel tubes

Posts, rails, stays: To ASTM A500, ASTM A1085

Wire

Chain wire, cable wire, tie wire and barbed wire: To, ASTM A817, ASTM F626.

Finish: Match chain wire.

Fasteners

Cross refer: 'Adhesives, sealants and fasteners'

Use fasteners capable of transmitting all applied and dead loads.

Use tamper proof fasteners requiring specialised tools for their removal.

16.27.2.2 Fence Types

Galvanized Tube Railings

Dimensions

Type: Sidewalk, as required

Height: 1200mm nominal, as per indicated drawing

Length: 3000mm nominal individual section

Galvanised mild steel tube with radius corner: 50mm diameter

Pre-welded 12mm steel flats at equal centre in vertical pattern to 2 horizontal bars.

Footing: concealed, 500 x 450 x 300mm concrete

Finish: Epoxy paint at ground level extending below finished footing level.

Finish coat: epoxy polysiloxane

Colour to approval.

Type: Railing

Height: 1200mm nominal, as per indicated drawing

Length: 1200/4275 nominal panels.

Galvanized mild steel tube radius corners: 50mm diameter with 25mm diameter horizontal railings.

Finish: Galvanized.

Welded Mesh Fencing

Fence as required per indicated drawings.

Height (mm): nominal 1500 mm

Maximum post spacing: 2440 mm.

Component sizes

End corner and intermediate posts:

- 42.4 mm diameter, 2.6 mm wall thickness.

Panel wire:

- Horizontal: 4.95 mm diameter at 50 mm centres.
- Vertical: 4.95 mm diameter at 50 mm centres.

Footing type: Concrete, as per endorsed loading calculation.

16.27.2.3 Bollard

Galvanized Steel Tube

Dimensions

Height: 1100mm nominal, as per indicated drawing.

Radius: 100mm nominal individual section, as per drawings.

Colour: To approved finish and standard road signage guideline.

Galvanised steel tube with radiused corners, filled with concrete, and set into the ground at a depth of min. 500mm with concrete footing (ASTM A615; ACI 318; min. grade 40; ACI 315; ASTM C33; ASTM C150). To withstand the minimum force impact of equivalent to 50 tons.

16.28 Soft Landscaping

16.28.1 General

16.28.1.1 Definitions

Specimen Tree

"Specimen" shall mean that the plant is of optimum quality. The plant shall have a matured, natural growth form, healthy, vigorous in growth. It shall be free from any form of pest attack or scars/wounds that may arise from transportation from nursery to site and during planting operation.

Sapling

"Sapling" shall mean that the plant is grown from seed/cutting/marcots. It shall have a full crown, with its branches, root system intact when planted as shown in the construction drawings.

Mature

"Mature" shall mean the optimum size/growth of the plant of the particular species.

Bushy

"Bushy" shall mean that the plant shall have a well branched crown filled with leaves.

Rooted Cuttings

"Rooted cuttings" shall mean that each stalk of stem cutting shall have its own supportive root system.

Instant Tree

"Instant Tree" shall mean a mature tree of between 100mm to 150mm diameter caliper (unless otherwise noted), measured 1.0m from ground level. The instant tree shall have a well-balanced pollarded crown containing at least 4 main branches 500mm to 1,000mm long. The tree should have a clear stem of at least 1.8m from ground level, with an overall height of 3-4m after pruning.

Cleaning Out Works

"Cleaning out works" shall mean removal of dead, dying and diseased branches.

Standard Specimen

"Standard Specimen" shall mean that the plants specified is to have similar appearance, i.e. bulge on the trunk of palms will occur at the same height, caliper of trunk, shape of crown.

Collar

"Collar" refers to the base of the trunk/stem at soil level.

Graduated Pattern

"Graduated Pattern" shall mean that the branching or shoots of the plant occurs at staggered heights.

Standard Trees

"Standard Trees" are medium size nursery grown trees pruned during growth to produce a tight well rounded head, and a straight stem cleared of leaves or twigs.

Trees shall be 31mm to 38mm caliper when measured 1.0m from ground level and shall have a clear straight stem of minimum 1.5m. The head shall be well balanced and rounded and contain at least four main branches with a well-developed secondary branch system and a defined central leader that has not been pruned.

Heavy Standard Trees

“Heavy Standard Trees” are large size nursery grown trees pruned during growth to produce a tight well rounded head and a straight stem cleared of leaves or twigs.

Trees shall be 38mm to 50mm caliper when measured 1.0m (3 ft) from ground level and shall have a clear straight stem of minimum 1.8 metres. The head shall be well balanced and rounded and contain at least four main branches with a well-developed secondary branch system and a central leader.

Extra Heavy Standard Trees

“Extra Heavy Standard Trees” are large size nursery grown trees pruned during growth to produce a tight well rounded head and a straight stem cleared of leaves or twigs.

Trees shall be 45mm to 60mm caliper when measured 1.0m above ground level and shall have a clear straight stem of minimum 2m. The head shall be well balanced and rounded and contain at least four main branches, and a well-developed secondary branch system. Trees shall have a defined central leader.

16.28.1.2 Scope of Work

General

Provide landscape plantings in the areas shown on the Drawings with plants in a healthy, vigorous growing condition and as requested by authority during inspection for the handing over and clearance. All work indicated on the Drawings by notes shall be provided whether or not specifically mentioned in this Standard or the Specifications.

Any items not specifically shown in the Drawings or specified, but normally required to conform with such intent, are considered part of the work. The Client/Consultant reserves the right to make field adjustments and reasonable substitutions to insure implementation of the landscape concept in relation to field conditions.

The work of this Section includes but is not limited to the following:

- a. Plant Acquisition and Supply
- b. Erosion Control
- c. Clearing and grubbing
- d. Imported screened soil and backfill
- e. Pre-planting weed control
- f. Soil Preparation and fine grading/mounding
- g. Planting Operations
- h. Landscape Maintenance Supervision.
- i. Warranty

- j. Preparation & Maintenance of Project Nursery
- k. Landscape Drainage System
- l. Pre-inspection by related authority prior to planting
- m. Demarcation of maintenance boundary on site by providing boundary stones or the equivalent
- n. Reinstatement works to playground.

Purpose

The purpose of these specifications is to insure the acquisition and installation of healthy plant materials of the highest quality in the quantity desired specifically for this project.

Existing Plant Preservation Work

Erect Protective Fencing and provide regular maintenance to preserve existing trees as per the requirement on the project site as indicated on the drawings.

Plant Acquisition Work

Locate, purchase and transport plant materials specified herein to the project site.

Substitution

- a. If any plant specified is not obtainable, submit a written substitution request to the Client/Consultant one (1) month upon award of contract. This request may present either a different size of the same species or a similar alternate species with the proposed adjustments to the contract price for each.
- b. Substitutions of plant materials will not be permitted unless agreed and authorized in writing by the Client/Consultant.

Selection, Tagging and Ordering Plant Material

- a. Six months prior to installation of plant material, Contractor to submit a request for inspection and documentation to the Client/Consultant, on plant material that has been ordered and delivered to the nursery.
- b. Plants shall be subject to inspection and rejection by the Client/Consultant at place of growth and after delivery for conformance with specifications. All plants not conforming to specification will be rejected.
- c. The Client/Consultant reserves the right to request inspection of plants identified as specimen, field grown, field stock, and all palms at place of growth.

Screened Soil

- a. After the contract is awarded, furnish the source of screened soil to the Client/Consultant.
- b. Take representative soil samples from the proposed source area. Submit samples to a recognized laboratory for analysis for required fertilizers, pH and salinity of soil. Test report to be submitted.

- c. Submit test results and schedule of fertilizers to the Client/Consultant for review before soiling works begin on site. A change of the specified fertilizers may be issued based on the soil analysis results.

16.28.1.3 Standards

General

The following codes and standards are a guide to the minimum quality acceptable for materials, products and workmanship:

ASTM - American Society for Testing and Materials

- Recommendations for General Landscape Operations (excluding hard surfaces).
- Peat

Other Codes: any other relevant applicable relevant Code/Standard which may be enforced at the time of construction.

16.28.2 Materials and Components

16.28.2.1 Growing Media

Screened Soil

Natural, fertile, friable soil free from stones, noxious seeds, weeds, roots, and subsoil in any quantity.

Provide soil analysis test results and soil sample for approval by the Client/Consultant. Soil analysis test results are to determine the values of PH, texture as well as contents of nitrogen, phosphorus, potassium, magnesium and percentage of organic matter.

In-Ground Planting Backfill Mix: the backfill mix for in-ground plantings of trees, palms and shrubs shall consist of the following:

- 2 parts of screened soil
- 1 part of cocopeat or peat moss
- 1 part of coarse river sand (no salty material)
- 1 kg/cu.m. Slow release NPK 15-15-15 Fertilizer (coarse granule)

Any other additives to balance PH and organic matter content as determined by the soil test. Mix thoroughly before placing in the planting pit.

Backfill Light Weight Mix for Planters

- 20% of screened soil
- 30% expanded clay
- 20% of cocopeat or peat moss

- 30% part of river sand (no salty material)
- 10 lbs/cu yd. Slow release NPK 15-15-15 Fertilizer (coarse granule).

Planting mix for Axonopus compressus (Cow grass)

The backfill mix for areas planted with Axonopus compressus shall consist of the following:

- 2 parts of screened soil
- 1 part of cocopeat or peat moss
- 2 part of river sand (no salty material)
- 10 lbs/cu yd. Slow release NPK 15-15-15 Fertilizer (coarse granule)

Note: Planting Mixture Quality for the above:

- a. Do not reuse excavated salty clay site material in backfill mix. Deposit all excavated material at location as indicated by the Contractor for removal.
- b. It shall be free from heavy clay or coarse sand, stones, lumps, site debris, other vegetation, roots, sticks and other foreign materials or chemicals and toxic matter liable to be harmful to plant growth.
- c. All shall be of the same composition and structure throughout.
- d. All shall not be delivered, handled, or placed in a muddy condition.

Top soil for Planting

Top soil shall be fertile natural red/brown top soil transported to the site, free from stones, clay, wood and sod, and obtained from naturally well drained area. Top soil shall neither be excessively acidic or alkaline and shall be free from any toxic matter liable to be harmful to plant growth. All top soil to be mixed off-site thoroughly before transporting to site to prevent undesirable odours. Planting mixtures specified in Item 2.1. Top soil shall generally be reasonably loose in a form containing not more than 10 - 15% of moisture content. Top soil delivered in a wet and soggy condition shall be rejected by the Client/Consultant.

Fertilizer

- N-P-K as recommended by soil analysis, uniform in composition, free-flowing and suitable for application with approved equipment, delivered to the site in unopened containers, each fully labelled, conforming to the applicable fertilizer laws, and bearing the name or mark of the manufacturer.
- Plant Tablet: Agriform 21 grams tablet or equivalent - 4 nos. to be applied to every tree/palm planting hole.
- Manure: Well-rooted poultry manure or as approved.

Mulch

- Peatmoss or approved equivalent.
- Provide 25mm layer over all planting areas except turf and areas without under planting.

Pre-planting Herbicide

- 'Round up' or equivalent.

Pre-emergent Weed Control

- Rontar-G, Treflan, Eptam, Vegitex or equivalent.

16.28.2.2 Plant Material

Quantities

Provide sufficient quantities of plant materials needed to complete the work as shown on the planting plans. Quantities indicated on the planting plans are approximate only and are provided for the convenience of the Contractor. If plants that are undersized in spread are installed, the Contractor shall fill in additional plants at his own cost to cover gaps in the plant bed that would otherwise not be there if plants conforming to specifications had been installed.

Nomenclature

Names of plants shall conform with names generally accepted in the local nursery trade and as interpreted by the Client/Consultant. In all cases of dispute, the decision of the Client/Consultant shall be final.

Condition

- a. All trees, palms, shrubs, groundcovers & climbers (herein referred to as "plant") shall have a normal habit of growth and shall be sound, healthy, vigorous and free from insect infestations. They shall be of varieties, sizes and quantities shown in contract drawings.
- b. All plants shall be of cultivated stock. The Contractor shall furnish all plants shown on the contract drawings. No substitutions or omissions thereof shall be permitted unless accepted by the Client/Consultant.
- c. All plants shall be typical of their respective species or variety and shall have normal growth and be legibly tagged with proper botanical names.
- d. The minimum acceptable size of all trees and shrubs measured after pruning, with branches in normal positions, shall conform to the measurements specified on the plant list.
- e. Calliper measurement shall be taken at a point on the trunk 1.0 meter above natural ground line for trees with 100mm in calliper and above.
- f. Plants that meet the measurements specified, but do not possess a normal configuration or balance of height and spread will be rejected.
- g. Trees and shrubs larger in size than specified may be used, but the use of larger plant materials will make no change in the Contract price. Height shall not be substituted for balance or good form.
- h. Trees and shrubs shall have been grown in containers, and shall have sufficient roots to hold the root ball together after removal from containers without being root bound.
- i. Specimen, field grown and field stock palms and trees shall have a root ball of sufficient size to support the plant's recovery from transplanting. Palms and trees delivered with small or inadequate root balls will be rejected. In all cases, the decision of the Client/Consultant shall be final.

- j. All large and 'specimen' trees and palms shall be transplanted from growing site by mechanical crane and planted at site by mechanical crane. Manual labour is not acceptable.
- k. Any tree or shrub with a weak thin trunk not capable of supporting itself when planted in the open will be rejected.
- l. Trees will be straight and of uniform shape without damaged, crooked, or multiple leaders, unless specified. The height of the plant (measured from the crown of the roots to the average height of the top branches) shall be not be less than the minimum size designated on the contract drawings (also see appendix). The trunk of each tree shall be a single trunk growing from the single unmutilated crown of root. Trees with abrasions of the bark, sunscalds, disfiguring knots, or fresh cuts of limbs over 12mm which have not been pruned and painted or completely calloused, will be rejected. No tree showing vigorous bark growth on all edges post pruning shall be accepted.
- m. Rooted cuttings shall be healthy, vegetative material with well-established roots at one or more nodes.
- n. Turf plugs shall be 100mm in diameter, neatly trimmed, with minimum 75% of the root system intact.
- o. Shrubs used in the works shall meet the requirements for spread or height specified on the contract drawings. Measurement for the height of shrubs shall be taken from the ground level to the average height of the tallest branches of the shrubs and not to the longest branch or stem. Single stemmed or thin plants shall not be accepted. The side branches shall be generous, well twigged and all shrubs, as a whole, shall be well branched to the ground.
- p. All plants must come with pots or plastic bags in which they were originally grown and established in the nursery. The only exception being instant plants and large shrubs that have to be specially transplanted.
- q. All plants are to be removed from their original growing receptacles prior to installation. They should be arranged in a manner (triangular setting out to be approved by Client/Consultant), such that the leaves complement each other and are within touching distance of the other and not overlapping one another unless specified to the contrary.
- r. All planting works shall have the appearance of established growth. Plants shall be arranged with their foliage showing off their best face so that the intended design effect shall be fully realised.
- s. All green buffer and peripheral verges free from any encroachment above and below the planting level.
- t. To provide lawn edger or approved equivalent for all planting beds to prevent soil washing onto the foot path and drain.
- u. Tree planting verges should be generally flat (gradient not steeper than 1:40. Slope if any, should not be steeper than 1:2.5.

16.28.2.3 Water

Water for the works shall be provided by the Contractor. The Contractor shall also be responsible for providing hoses from these watering supply points.

16.28.2.4 Miscellaneous Materials

The Contractor shall allow for the following list of materials.

- a. Wood Tree Stakes: 50mm x 50mm x 2.5M rough construction grade hardwood with no paint or stain. Bamboo may be substituted. Only clean, new timber shall be used.
- b. Hose and Wire Ties: (12mm) diameter rubber hose with no. 12 galvanized iron wire and turnbuckles.
- c. Guy Wire: No 12 galvanized iron for large potted trees. No 9 galvanized iron for field grown trees. Wires to be encased in rubber hose for safety.
- d. Rebar: No 4, 600mm minimum length for large potted trees. No 7, 1M minimum length for larger field grown trees.
- e. Marker: Plastic surveyor tape. Bright colour, minimum 500mm long. Use same colour throughout project.
- f. Tree Paint: Cabot tree seal or equal.
- g. Grey/White Coloured River Washed Stones : 3" - 1" diameter range.

Water Absorbent Crystal: Water Absorbent Crystal (to match control samples in Client/Consultant's office) - to be used to Manufacturer's Specifications.

- Palms: 150gm to be sprinkled at the base of each planting pit.
- Trees: 60gm to be sprinkled at the base of each planting pit. Palms: 150gm to be sprinkled at the base of each planting pit.

Shrubs & Groundcovers Beds: 400gm to be mixed thoroughly with one (1) cubic meter of in-ground planting backfill mix for shrubs and groundcover beds.

Lawn Edging Material

Lawn edging or header with anchors or equivalent as relevant or specified. Sample shall be submitted for approval.

Drainage Materials

Perforated Drain Pipe: 100mm (4") diameter PVC pipe with saw cuts at 50mm centres 10mm holes may alternatively be drilled or equivalent. Cover to be provided over all inlets.

Drainage Gravel: Upgraded aggregate or crusher run, 15 - 30mm size or other aggregate as indicated on drawings.

Filter Fabric: Plastic filter mesh, Landscape drainage filter fabric.

Cell Drainage system, on horizontal surface extend up along planter vertical sides to 50mm above top of finished soil.

Drainage Mat to be supplied wrapped in geo-textile fabric.

50mm thick layer coarse washed river sand.

16.29 Granite Flooring

16.29.1 Related Work Sections

Refer to the following work sections:

- Cementitious toppings
- Adhesives, Sealants and Fastenings
- Internal Cladding
- Tiling

16.29.1.1 Interpretation

Inclusion: An irregular and sudden change in the colour, texture, or geological constituent of the granite.

Substrate: The actual surface to which the granite flooring is to be bedded or attached.

Dry Lay: The layout of granite flooring as defined on the drawings prior to placing for the purposes of verifying the colour, tone and texture of individual granite units.

Granite Finishes: to the definitions of the American National Building Granite Quarries Association Inc.

Viz:

- Polished : Mirror glass with sharp reflections
- Honed : Dull sheen, without reflections,
- Flamed : Produced by the application of high temperature flame to the surface. Large surfaces may not have shadow lines caused by the overlapping of the torch.
- Fine Rubbed : Smooth and free from scratches – no sheen.
- Shot ground : Plane surface with pronounced circular markings or trails having no regular pattern.
- Sand blasted, coarse stippled : Coarse plane surface produced by blasting with an abrasive, coarseness varies with type of preparatory finish and grain structure of the granite
- Sand blasted, fine stippled : Plane surface, slightly pebbled with occasional slight trails or scratches.
- 8-cut : Fine bush hammered
- 6-cut : Medium bush hammered
- 4-cut : Coarse bush hammered.

In addition the following finish applies. Samples are to be held by the client/ consultant for comparison:

- Saw cut: The finish obtained from the saw used to cut the granite.
- "Brushed" to sample - uneven but smooth surface (finished with metal brush).

16.29.1.2 30.1.3 Standards

The following codes/standards are references to the minimum quality acceptable for materials/products/workmanship:

- ASTM A1064
- ASTM C150.
- ASTM C33
- ASTM C1028.
- ASTM E303.

16.29.1.3 Design

Building structure

Expected amounts of differential movements:

Cross refer: Civil and Structural Materials and Workmanship Specification.

Touch Voltage Protection

Comply with the requirements of Persyaratan Umum Instalasi Listrik (PUIL); (SNI 0225:2011/Amd 1:2013; Amd2:2014; Amd3:2014 - Standar Nasional Indonesia), where metals are proposed within the station protection zone.

16.29.2 Materials and Components

16.29.2.1 Granite

Provide granite which is:

- of the appropriate quality grade for the purpose;
- of uniform quality within that grade;
- selected for the optimum matching of visual properties such as colour, tone and pattern; and
- sound and free from defects liable to affect its strength, appearance, durability or proper functioning under the intended conditions of use.
- obtained from quarry stone extracted in blocks sufficiently large to suit the project requirements, and containing no more than a small degree of micro cracking.

Granite selection

Grading: Select stone of the appropriate quality grade for particular purposes.

Matching: Within each grade, select stone for the optimum matching of visual properties such as colour, tone and pattern.

Source of stone supply

Nominated source: Source not defined. Refer to Control samples retained by the client/ consultant.

Water

Free from matter harmful to granite or to items built into it or in contact with it.

Cement

Type to ASTM C150.

Aggregates

Standard: To ASTM C33

Sand: Fine aggregate.

Reinforcement

Standard: To ASTM A1064

Protective coating: Galvanized.

Sealer

Standard:

A colourless penetrating sealer intended for brush or roller application and which will prevent the absorption of moisture from the substrate or its transmission through the tile. Silane based invisible below surface 100% vapour permeable UV resistant leaving complete natural appearance.

Stainless Steel

Trims/joints/tactile inserts

Grade 316 Austenitic Stainless Steel

Grout Type

Cement based proprietary grout: Mix with water. Fine sand may be added as a filler in wider joints.

Portland cement based grout: Mix with fine sand. Provide minimum water consistent with workability.

- For joints < 3 mm: 1:2 cement: sand.
- For joints = / > 3 mm: 1:3 cement: sand.

Pigments

Pigments for coloured grout: Provide colourfast fillers compatible with the grout material. For cement-based grouts, provide lime-proof natural or synthetic metallic oxides compatible with cement.

16.29.2.2 Tolerances

Maximum deviation from required dimensions.

Granite slabs

Face dimensions: $\pm 1.0\text{mm}$

Squareness (difference between diagonals): 1.5 times the tolerance on a long edge.

Thickness: $\pm 1.0\text{mm}$

Flatness:

- Polished or honed faces: $\pm 0.5\text{ mm per meter}$.
- Sawn or sandblasted faces: $\pm 1.5\text{ mm per meter}$.
- Flame exfoliated faces: $\pm 3\text{ mm per meter}$.
- Fine tooled or hammered faces: $\pm 2\text{ mm per meter}$.

Edge straightness: $\pm 0.5\text{ mm per meter}$.

Bow or twist: Maximum deviation of stone face from plane: 1.5 mm in 1200 mm.

Falls and level

Deviation of the finished floor from its true form: maximum 1:300.

Deviation between laid slabs and/or adjacent floor finishes: maximum 0.5mm

16.29.2.3 Slip Resistance

Station area	Description in Standard
External paving	External colonnade, walkways and pedestrian crossings.
External ramps	External ramps
Station entrances and lifts serving grade	External foyers, public area
Internal ramps	Internal ramps
Lift lobbies except those serving grade	Lift lobbies above external entry level
Toilets	Toilet facilities in offices, hotels, shopping centres
Subways and passages	Undercover concourse areas of sports stadium
Concourse	Undercover concourse areas of sports stadium
Platform	Undercover concourse areas of sports stadium
Stair tread	External stair nosings
Test all slip resistance on wet granite	

Slip resistance to refer to ASTM C1028.

16.29.2.4 Movement Joints

Locations

Form movement joints through the full depth of the granite and under bed directly over movement joints in the substrate.

Joint schedule

Location	Type	Exposed surface finish
Concourse; Platform; Link Bridge; as per drawings	Stainless Steel Strip	180 - 240 grit

Movement joint filler

Select from the following:

- A proprietary preformed strip consisting of a neoprene elastomeric core sandwiched between metal or ebonite plates, with lugs or nibs for mechanical keying to the substrate.
- A proprietary sliding joint cover system.

16.29.2.5 30.2.5 Joint Accessories

Divider strips

General: Finish tiled floors as indicated on drawings.

Type: 3mm x 25mm flat bar

Material: Stainless steel Grade 316

Butt jointed in lengths or at corners

Division Requirement

Divide granite paving into panels with divider strips as on drawings.

Form junctions with differing floor finishes with stainless steel dividing strip.

Setting divider strips

Set divider strips accurately and firmly to the required locations and levels, with epoxy mortar. Fix divider strips to the substrate, with top edge flush with the finished floor. Where changes of floor finish occur at doorways make the junction directly below the closed door.

16.29.2.6 Tactile Markings

Refer to ADA (Americans with Disabilities Act) for accessibility guidelines for building and facilities.

Tactile inserts into Granite Flooring in Sections typically 300mm wide.

Type

Stainless steel stud or strip. Grade 316 austenitic.

Appearance

Minimum 30% luminance contrast to surrounding surface.

Size 300 x 300 mm area in "guidance strip" and/or "stud" form.

Layout: refer to drawings.

Finish

Top surface coarse intended to render them slip resistant when wet.

Sides of studs/strip mirror polished No. 8

Fixing

Studs strips to be fixed into granite flooring to fit snug and even without rocking.

16.29.2.7 Access Hatches

Refer to Doors & Hatches.

Stainless steel with tray for inlay of flush granite finish to match surrounding tile pattern.

16.29.2.8 Floor Mats

Type: Recessed reversible very heavy duty suitable for external environment.

Slip resistance: Minimum coefficient of Friction 0:60 (wet) in accordance with ASTM E303.

Loading: Rolling Load Performance: Minimum 200kg / wheel

Construction: Closed with rubber wiper strips interwoven with nylon fibres and aluminium scraper strips locked together with high tensile steel wire or bars.

Nominal thickness 18 - 20mm, recessed flush with surrounding floor.

Frame: Nominal 25mm deep aluminium secured to substrate flush with surrounding floor. All fixings to be hidden.

On completion of installation of frame, provide temporary filler in recess and cover with temporary protection.

Technical Specification

Jakarta LRT Project – Corridor 1 (Phase 1): Kelapa Gading-Velodrome



Appendices

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