

3	EARTHWORKS	3
3.1	GENERAL.....	3
3.1.1	Scope of Work	3
3.1.2	References	3
3.1.3	Definitions.....	4
3.1.4	Submittals.....	4
3.1.5	Quality Assurance.....	5
3.2	EARTHWORKS BY OTHERS.....	6
3.3	MATERIALS	6
3.3.1	General.....	6
3.3.2	Unsuitable Materials	7
3.3.3	Fill and Subgrade Materials	7
3.3.4	Rock Fill.....	8
3.3.5	Water.....	9
3.3.6	Performance Indicators.....	9
3.4	MAIN PLANT FOR EARTHWORKS	9
3.4.1	General.....	9
3.4.2	Compaction Trials.....	10
3.4.3	Rotary Cultivators	10
3.4.4	Water Sprinklers	10
3.4.5	Bulldozers.....	10
3.4.6	Motor Graders	11
3.4.7	Shovel Tractors	11
3.4.8	Compacting Equipment	11
3.5	EXCAVATION GENERAL	12
3.5.1	Removal of Unsuitable Soil and Soft Spots.....	12
3.5.2	Excavating High Level Areas	12
3.5.3	Rock Excavation.....	13
3.5.4	Manual Excavation	13
3.5.5	Excavation for Pits and Trenches	14
3.5.6	Double Handling	14
3.6	FILLING GENERAL.....	14
3.6.1	General.....	14
3.6.2	Filling Around Utilities	15
3.6.3	Fill Supplied by Qatar National Transport Organization (QNTO)	15
3.6.4	Contractors Imported Fill.....	15
3.6.5	Rock Fill.....	16
3.6.6	Compaction	17
3.6.7	Filling of Pits and Trenches.....	18
3.6.8	Work Over Sabkha	18
3.6.9	Trimming Side Slopes.....	19
3.7	STRUCTURE EXCAVATION AND FILLING	19
3.7.1	General.....	19
3.7.2	Excavation Supports.....	20

3.7.3	Dewatering	20
3.7.4	Excavation for Structures.....	20
3.7.5	Use of Materials.....	21
3.7.6	Cofferdams	21
3.7.7	Backfill Adjacent to Structures	22
3.8	FORMATION PREPARATION	22
3.8.1	Scope	22
3.8.2	Protection	23
3.8.3	Rectification.....	23
3.9	TOPSOIL	23
3.10	TESTING.....	23
3.10.1	General.....	23
3.10.2	Testing Degree of Compaction	24
3.10.3	California Bearing Ratio.....	24
3.10.4	Testing Levels and Evenness of the Formation	25
3.10.5	Testing Formation Works after Completion.....	25

3 EARTHWORKS

3.1 GENERAL

3.1.1 Scope of Work

- 1 This Part includes all the earthworks required to construct and maintain the roadway facilities as follows:
 - (a) Removing unsuitable materials.
 - (b) Excavating selected material from the roadway and borrow pits for use as specified.
 - (c) Placing and compacting of selected material.
 - (d) Structure excavation.
 - (e) Backfilling.
 - (f) Supplying and placing topsoil (sweet soil).
 - (g) Laying and compaction of fill for shallow embankments where additional slope protection measures are not required.
- 2 Related Parts are as follows:

This Section

Part 1,..... General
Part 2,..... Site Clearance
Part 4,..... Unbound Pavement Materials
Part 5, Asphalt Works
Part 6, Concrete Road Pavements
Part 19, Miscellaneous

Section 8, Drainage Works
Section 12, Earthworks Related to Buildings

3.1.2 References

- 1 The following standards are referred to in this Part:

ASTM D1556Standard Test Method for Density and Unit Weight of Soil in Place by Sand-Cone Method
ASTM D1557Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft lbf/ft³ (2,700 kN m/m³))
ASTM D4718Standard Practice for Correction of Unit Weight and Water Content for Soils Containing Oversize Particles
ASTM D1883Standard Test Method for CBR (California Bearing Ratio) of Laboratory Compacted Soils
ASTM D4318.....Standard Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils
ASTM D6913Standard Test Methods for Particle Size Distribution (Gradation) of soils using Sieve Analysis

- ASTM D4429.....Standard Test Method for (California Bearing Ratio) CBR of Soils in Place
- ASTM D4944.....Standard Test Method for Field Determination of Water (Moisture) Content of Soil by the Calcium Carbide Gas Pressure Tester
- ASTM D6938.....Standard Test Method for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth)
- ASTM D1140.....Standard Test Method for Amount of Material in Soils Finer than No. 200 (75- μ m) Sieve
- ASTM E1703.....Standard Test Method for Measuring Rut-Depth of Pavement Surfaces Using a Straightedge
- AASHTO T307Standard Method of Test for Determining the Resilient Modulus of Soils and Aggregate Materials
- BS 1377 - Part 3Methods of test for Soils for Civil Engineering Purposes: Chemical and electro-chemical tests

3.1.3 Definitions

- 1 Suitable material: material which is acceptable in accordance with Clause 3.3.3.
- 2 Imported material: suitable material obtained from outside of the Site.
- 3 Optimum moisture content (OMC): the moisture content of soil at which a specified compaction effort will produce the maximum dry density when determined in accordance with ASTM D1557.
- 4 Maximum dry density (MDD): The dry density of soil obtained using a specified compaction effort at the optimum moisture content when determined in accordance with the modified compaction test ASTM D1557. Unit weight and moisture content of materials containing more than 5% by mass of oversize fraction tested in accordance with ASTM D1557 should be corrected following ASTM D4718.
- 5 Subgrade: the compacted existing ground or fill for 500mm beneath formation.
- 6 Formation: the completed earthworks level shaped in accordance with the Drawings in readiness to receive the sub-base.

3.1.4 Submittals

- 1 The Contractor shall submit to the Engineer for approval his proposals for the compaction of each type of material to be used in embankments detailing the type of plant, number of passes and maximum loose depth of layer.
- 2 The contractor shall submit to the Engineer for approval method statements for the following:
 - (a) Materials production, handling, storage, identification, marking and traceability to source of production.
 - (b) Quality assurance and quality control plans for all construction activities.
 - (c) Quality control testing plan.
 - (d) Equipment and its suitability to fulfill all construction activities to the required quality.

- (e) Personnel capability.
 - (f) Safety and environment preservation measures.
- 3 Before commencing any structural excavation work greater than 1.5 m in depth, the Contractor shall submit to the Engineer for his review details of proposals for supporting excavated faces.
- 4 The proposals shall be submitted in the form of calculations and drawings which clearly indicate the extent of excavation at all points along the structure relative to adjacent properties, roads and services.
- 5 In the case of supported excavations the proposals shall, for the actual soil properties, comprise detailed drawings of the support system stating method of installation and showing support member materials, sizes, spacing and engineering calculations to validate the design of the above, including the maximum theoretical deflections of the support members. The support system shall be designed in such a manner that no support members extend through surfaces exposed in the finished construction and no shoring or bracing is placed under permanent structures.
- 6 The engineering calculations shall be in English and shall show lateral earth pressures for the full excavation depths, faces at various stages of support during installation and removal and concrete placement, the anticipated equipment loads, anchorage loads of any description, the maximum design loads to be carried by various members of the support system and strut preload forces.
- 7 If the structure support system proposed includes tie-back anchors, the Contractor's submittal drawings shall show the profile of the soil in which each anchor is to be installed, the design load for the full depth of the excavation, the maximum design and proof loads, surcharge loads of any description; equipment loads, forces at various stages, support during installation and removal, and the criteria proposed for deformations under proof loads.
- 8 In addition to the approval submittal, shop drawings of the support system are to be submitted. Where a proposed system of tie-back anchors projects onto adjoining property beyond the vertical projection of the designated limits of the Contract, the permission of the owner shall be obtained in writing and documentation of such permission shall be included in the submittal.
- 9 Complete working drawings showing the type of dewatering and groundwater control system proposed shall be submitted for review. The submittal drawings shall show the arrangement, location and depths of the proposed dewatering system if required. A complete description of the equipment and materials to be used and the procedure to be followed shall be shown together with the standby equipment, standby power supply, and the proposed location or locations of points of discharge of water. Details of methods of cofferdam construction shall be included in the submittal.
- 10 The method and the type of equipment to be used for advancing dewatering wellpoints shall be submitted for review.

3.1.5 Quality Assurance

- 1 The designs of the structure excavation support systems and the dewatering system shall be prepared by and signed by a professional engineer specializing in this type of design work.

- 2 Blasting work shall be carried out by a specialist company with the appropriate license as detailed in clause 3.5.3.

3.2 EARTHWORKS BY OTHERS

- 1 Where earthworks have been carried out by others before commencement of the Works, the Contractor shall carry out all tests he considers necessary to satisfy him that the work already executed complies with this specification.
- 2 Should the Contractor consider the result of the tests unsatisfactory he shall immediately provide full details of all such tests carried out for the Engineer's review as to the remedial work to be undertaken.
- 3 The Contractor will be deemed to have satisfied himself as to the adequacy of any previous earthworks when he proceeds with his own work, and he shall be responsible for repairs to or replacement of any defective layer or surface where such failure was due to a fault in the previously executed work which would have been revealed by normal testing procedures.

3.3 MATERIALS

3.3.1 General

- 1 All excavated material shall be the property of the Owner and shall not be removed from the Site without the written consent from the Owner.
- 2 Suitable and approved excavated material from any part of the Site shall be hauled and used for filling in any other section of the Site. The Contractor shall store such material when necessary until the need arises for its use in filling as required by the phases of construction, or as directed by the Engineer.
- 3 Where the amount of suitable material exceeds the amount of fill required for the Works, the Contractor shall dispose of the surplus material at designated locations. The Contractor shall off-load, spread, level, water and carry out other related operations at the disposal site as directed by the Engineer. The Contractor shall ensure that the disposal site has been approved by the Municipality concerned.
- 4 Any excavation greater than the net volume required for the Works in length or width, shall be made up with suitable compacted fill material at no cost to the Owner and subject to inspection and approval of the Engineer.
- 5 Any additional excavation to remove unsuitable material at or below the bottom of foundation level or construction layers shall be replaced with mass concrete.
- 6 Before using material resulting from excavation for filling, the Contractor shall carry out field and laboratory testing to establish the suitability of said material for filling work. Whenever such excavated material indicates a change in characteristics the Contractor shall carry out additional testing.

- 7 Where the contract provides for the supply of fill material by others the Contractor shall remain responsible for checking each load received to ensure that it is in accordance with the specification requirements and for rejecting unsuitable material. The Contractor shall be responsible for maintaining all records of deliveries and documentation relating to the quality of such material.

3.3.2 Unsuitable Materials

- 1 Unstable materials shall mean materials other than suitable materials and include;
- (a) Material from marshes.
 - (b) Tree and plant stumps.
 - (c) Perishable material.
 - (d) Deposits of sabkha with more than 5% water-soluble salts.
 - (e) Material subject to spontaneous combustion.

3.3.3 Fill and Subgrade Materials

- 1 The subgrade material and the material used for filling and compacting below the formation level of the roadway, sidewalks, hard shoulder, drainage ditches and other areas on site shall consist of material approved for filling resulting from the excavation works.
- 2 In the event that such material is unsuitable or insufficient, the Contractor shall obtain and use filling material from borrow pits.
- 3 This material shall be clean and free from any unsuitable material and complies with the requirements listed in Table 3.1.
- 4 The maximum particle size of fill material shall be 75 mm unless the material is classified as rock as per this part of the specification and the placing and compaction are carried out according to the requirements for rock fill.
- 5 Unit weight and moisture content of materials containing more than 5% by mass of oversize fraction tested in accordance with ASTM D1557 should be corrected following ASTM D4718.
- 6 When nuclear gauge is used for field density and moisture content testing, 3 readings shall be made at each test location within a radius of 2 meters. The average of the 3 readings is considered to be the density for that test location. Individual density readings shall not be less than the target relative density by more than 0.5%.
- 7 Recycled aggregate produced from excavating natural ground and from demolition wastes can be used for filling purposes provided that the specifications stated in Section 6 - Part 9 are complied.

Table 3.1
Fill and Subgrade Materials and Construction Specifications¹

Parameter	Standard	Specification Limits	Minimum Frequency
Percent passing the 75mm sieve	ASTM D6913	100%	<ul style="list-style-type: none"> - Each Source - Visible change in material - 1 per 1000 m³
Percent passing the 0.075mm sieve	ASTM D1140	30% max.	
Liquid limit	ASTM D4318 Method A	30% max.	
Plasticity Index	ASTM D4318	10 % max.	
California Bearing Ratio (CBR)	ASTM D1883 (Soaked)	15% min. at 95% MDD	
Swelling		2% max.	
Field Density	ASTM D6938 ASTM D1556	Min. 95% of MDD	<ul style="list-style-type: none"> - 1 per 200 m² per layer - 1 every 75m per lane per layer
In Place Moisture Content ²	ASTM D6938 ASTM D4944	± 2% of OMC	
In Place California Bearing Ratio (CBR)	ASTM D4429	15% min.	1 per 2000 m ²
Acid soluble Chloride Content	BS 1377 Part 3	2% max.	1 per 3000 m ³
Acid soluble sulphate content	BS 1377 Part 3	3% max.	
Organic Matter	BS 1377 Part 3	2% max.	

¹Loose materials for testing and acceptance shall be sampled from the un-compacted in-place layer.

²During compaction.

3.3.4 Rock Fill

- 1 Rock shall be defined as any naturally formed solid matter encountered in excavation having a crushing strength of not less than 7 N/mm² when dry and not less than 4 N/mm² after submergence in water for 24 hours.
- 2 This shall be determined on samples of 100 mm x 100 mm x 100 mm cubes obtained from the material (equivalent cores in lieu of cubes may be considered for testing at the discretion of the Engineer and the method of testing and acceptance criteria will be advised by the Engineer in such cases).
- 3 Individual masses of solid material found in excavation and weighing less than 500 kg shall not be considered as rock.
- 4 Any artificially formed solid matter such as block work or concrete shall not be considered as rock.

- 5 The Contractor shall supply any equipment and labor necessary to obtain suitable samples and carry out testing of rock or suspected rock. The Engineer shall determine the location and quantity of samples necessary to determine the extent of the rock. These samples shall be taken in the presence of the Engineer.
- 6 In the event that the tests prove that the material is rock, the Engineer shall determine the extent of such material and shall instruct the Contractor accordingly.

3.3.5 Water

- 1 Potable or brackish water shall be used for all earthwork operations except that only potable water shall be used for compaction of backfill material within one meter from all surfaces of the structure and for the backfill of all service trenches.
- 2 Brackish water shall have a maximum total dissolved solids (TDS) of 5000 ppm, a maximum chloride content of 1500 ppm and a maximum sulphate content (as SO₃) of 2000 ppm.

3.3.6 Performance Indicators

- 1 Upon the request of the Engineer, the following performance indicators shall be determined from loose in place materials for verification of the pavement structural design following the AASHTO Mechanistic-Empirical Pavement Design Guide:
 - (a) Resilient Modulus (M_R) in accordance with AASHTO T307 at optimum moisture content and maximum density as per ASTM D1557.
 - (b) Parameters and moduli required for determining the Permanent Deformation Potential in accordance with AASTHO Mechanistic Empirical Design Guide.
 - (c) Parameters and moduli required for measuring the Fatigue Cracking Potential for stabilized and surface layers in accordance with AASHTO Mechanistic Empirical Design Guide.
- 2 For performance testing, one sample shall be tested every 10,000 m³, and for constructions having less than 10,000 m³ volume, one sample shall be tested every 50% of the total volume.

3.4 MAIN PLANT FOR EARTHWORKS

3.4.1 General

- 1 The Contractor shall provide the Engineer with copies of catalogues, technical data and charts of the machinery to be used on site before the commencement of the work.
- 2 The Engineer will inspect the machinery and tools before the commencement of work. The machinery and tools used in carrying out earthworks and other related works for the road construction and in maintenance of the work shall be in good working condition, and the Contractor shall maintain them in such condition for the whole duration of the Work.
- 3 The Contractor shall use power screens equipped with clay reject screen with sufficient screen area and clay reject conveyor belt when processing subgrade materials. Static screens shall not be used to produce subgrade materials. Any deviations from this process must be approved by the Engineer.

- 4 The Contractor shall supply an adequate type and number of machines and tools for the proper and timely execution of the Works. The number of machines shall not be limited to the types of equipment or recommended minimum number stipulated in the Contract Documents, which shall be used for guidance purposes only.
- 5 The Contract is awarded on the understanding that the actual numbers of machines and other plant will not be reduced below the numbers shown in the Contract.
- 6 No plant shall be removed from the site without the specific written approval of the Engineer.

3.4.2 Compaction Trials

- 1 Before commencing construction of the permanent works, unless otherwise agreed with the Engineer, the Contractor shall carry out compaction trial, after submitting a method statement, for each type of fill material and construction situation of the earthworks to establish an approved rolling/compaction procedure which shall then be used as a minimum requirement for the permanent works unless otherwise directed or agreed by the Engineer.
- 2 The compaction trials shall involve all procedures specified for the permanent works including testing and any equipment, processes or procedures as proposed by the Contractor which are not included as a part of these specifications. Compaction trials for each main type of material shall be carried out on areas having dimensions of approximately 50 meters by 10 meters.
- 3 Construction of the permanent works shall not commence until a compaction procedure has been approved in writing by the Engineer.

3.4.3 Rotary Cultivators

- 1 Rotary Cultivators shall have axles rotated by a powerful motor and be equipped with metal teeth or plates. They shall be designed in such a way as to ensure proper pulverization and mixing of soil. They must be equipped with apparatus to lift and lower the axles so as to be always to the required depth.

3.4.4 Water Sprinklers

- 1 Water sprinklers shall be borne by trucks with pneumatic tires and shall be equipped with a pressure pump and water sprinkling distribution equipment. The pump shall be powered in such a manner that the pump pressure will remain uniform regardless of variations in truck speed. The distributors shall be so designed as to allow sprinkling and adding of water to the soil uniformly and in controlled quantities and shall be equipped with an approved gauge to control the quantity of water added during operation. Special spray bar attachments shall be provided and used in order to sprinkle water on sloped sections. The activation of the water system shall be controlled from the cab by the driver.

3.4.5 Bulldozers

- 1 Bulldozers may be tracked or pneumatic-tire vehicles and shall be equipped with a blade for earth moving and levelling. Ripper attachments shall be provided when necessary. The blade level shall be hydraulically controlled to raise or lower it so that the work surface can be formed and adjusted as required.

3.4.6 Motor Graders

- 1 Motor graders shall be pneumatic-tire and shall be equipped such that it is possible to lift, lower and adjust the angle of the blade as required to control the grading operation and to perform grading without making undulations.

3.4.7 Shovel Tractors

- 1 Shovel tractors shall be tractors equipped with a shovel for earth hauling or moving and may be either on tracks or on pneumatic tires. The shovel shall be hydraulically controlled to raise and lower it as required.

3.4.8 Compacting Equipment

- 1 Rolling compacting equipment shall consist of pneumatic-tire and steel wheeled rollers as described below:
- (a) Pneumatic-tire rollers shall be equipped with tires of equal size and diameter which shall be uniformly inflated so that the air pressure of the tires shall not vary significantly, from one another. The wheels shall be spaced so that one pass will accomplish one complete coverage equal to the rolling width of the machine. There shall be a minimum of 6mm overlap between the tracks of the front and rear tracking wheels. Self-propelled, pneumatic-tire rollers shall have a minimum weight of 9 tons without ballast and a minimum weight of 18 tons with ballast.
 - (b) Steel wheeled rollers shall be of the following types:
 - (i) Three-wheeled rollers shall be self-propelled and equipped with a reversing clutch, a differential drive and with adjustable scrapers to keep the wheel surface clean.
 - (ii) Tandem rollers shall be self-propelled and equipped with reversing clutches and adjustable spring scrapers fitted to the driving and steering roller to scrape in both directions.
 - (iii) Vibratory steel tandem rollers shall have the requirements of the foregoing steel tandem rollers with a static weight of at least 5000 kg and a vibrating frequency between 1500 and 2000 cycles per minute.
 - (iv) Single drum vibratory steel rollers shall be double axle, self-propelled units with the rear axle equipped with pneumatic flotation wheels, they shall have vibrating frequency capabilities between 1500 and 2000 cycles per minute.
- 2 Portable vibratory compaction rollers shall be double axle tandem single-drum self-propelled equipped with a vibrating element delivering an impact of not less than 1590 kg at a frequency of about 5000 cycles per minute. The roller shall be easily maneuvered, of adequate width and suitable for rolling ditches with their side slopes having grades of up to 1:3.
- 3 Hand plate compactors shall be capable of delivering an impact of between 750 to 1500 kilograms.

3.5 EXCAVATION GENERAL

3.5.1 Removal of Unsuitable Soil and Soft Spots

- 1 If during the progress of the work the soil encountered has characteristics, as determined by tests conducted under the direction of the Engineer, that render it unsuitable for incorporation in the road embankment, the Contractor shall excavate and remove such unsuitable material to the extent directed by the Engineer.
- 2 Where contractor finds isolated soft spots during excavation, this material shall be removed to the extent directed by the Engineer.
- 3 No excavated suitable material shall be removed from the Site without the approval of the Engineer. Should the Contractor be permitted to remove suitable material to suit his operational procedure then he shall make good any consequent deficit of fill material arising therefrom.
- 4 Where the excavation reveals a combination of suitable and unsuitable material the excavation shall, unless otherwise agreed with the Engineer, be carried out in such a manner that the suitable materials are excavated separately for use in the Works without contamination by the unsuitable material.
- 5 The hauling of excavated material to areas of fill shall proceed only when sufficient spreading and compacting plant are operating at the place of deposition to ensure placing and compaction.
- 6 Unsuitable excavated material shall be removed and carted away to an approved dumping area after approval from the Engineer.
- 7 The Contractor shall replace this unsuitable material by other suitable surplus or imported material in layers not exceeding 150 mm compacted thickness to the density specified.
- 8 If the contractor considers in some situations it is impractical to replace unsuitable material with imported material he may elect to use granular material, which shall comply with the requirements of part 4 of this specification.
- 9 Granular material placed beneath water shall not require compaction, granular material placed above water shall be compacted and tested as per the requirements of part 4 of this specification.
- 10 If any solution cavities are found in lime stone material they shall be brought to the attention of the Engineer. The Engineer shall advise what treatment is to be carried out in such situations.

3.5.2 Excavating High Level Areas

- 1 The Contractor shall excavate high level areas in all materials including rock for the full width of the road construction down to the top of the required subgrade.
- 2 The Contractor shall then scarify a layer not less than 150 mm deep except that this requirement shall not apply where rock is present.

3 The soil shall be pulverized, watered as required, mixed, shaped and compacted to 95 % maximum dry density, as per ASTM D1557, to a depth of 150 mm.

4 In all excavations the groundwater level shall be maintained at least 300 mm below the formation level during the works.

3.5.3 Rock Excavation

1 Excavation in rock shall be as defined in clause 3.3.4 of the specification.

2 Excavation in rock may be carried out by a tracked bulldozer and ripper or by the use of blasting with explosives or any other method approved by the Engineer.

3 Blasting using explosives shall only be permitted if authorized by the civil defense, police and any other statutory authority. The Contractor's method statement shall be agreed before any blasting operation.

4 Blasting work shall be carried out in accordance with The Guide for Civil Users of Explosives in Qatar prepared by the former Ministry of Industry and Public Works.

5 For any blasting work involving the use of explosives the Contractor shall use a specialist company, licensed to carry out such work by the former Ministry of Industry and Public Works.

6 The specialist company shall possess the appropriate license for the required scope of work.

7 The purchase and delivery of each consignment of explosives for blasting work should be covered by a separate application for a possession license.

8 The transportation of explosives shall only be carried out after notification to the police and civil defense.

9 For each planned blasting operation the Contractor shall arrange for advance notification to be made to the police and civil defense authorities.

10 After it has been established that the excavated material is rock and after the area where such rock exists has been defined, the Contractor shall incorporate the rock in the embankment.

11 When excavated material contains more than 25 % of rock larger than 150 mm in greatest diameter the rock shall be crushed, pulverized and further broken down. The resultant material from the excavation shall be placed on the embankment in accordance with clause 3.6.5.

3.5.4 Manual Excavation

1 The Contractor shall excavate manually in the vicinity of all services, structures, and any other areas, and if necessary uncover them, all as directed by the Engineer.

2 The Contractor shall take all precautions to prevent damages to services, properties and persons, and any damage resulting from the negligence of the Contractor, his agents, or his employees. Any such damage shall be repaired by the Contractor at his own expense.

3.5.5 Excavation for Pits and Trenches

- 1 All trenches and pits under roads shall, where possible, be excavated, backfilled and compacted before road construction commences.
- 2 The sides of the excavation shall be adequately supported at all times.
- 3 Trenches and pits shall be kept free of water.
- 4 In tidal and high water table areas the excavation shall be kept free from standing water at all times during construction.
- 5 Trenches for pipes or ducts shall be excavated to the levels and gradients indicated in the contract documents.

3.5.6 Double Handling

- 1 It shall be the Contractor's responsibility to assess at the start of the contract the quantity of suitable material available from an excavation for use as fill material and the requirement for imported fill material.
- 2 The Contractor shall plan earthworks operations to minimize the handling of fill material and disruption due to dust and noise from transportation operations.
- 3 The Contractor shall not be entitled to any additional payment for double handling of any excavated material from the site for imported fill.
- 4 If it is necessary to double handle the material the Contractor shall take all measures to avoid degradation or contamination of fill material.
- 5 The Engineer may instruct that the tests to assess the properties of the fill material are taken at any point during the transportation, placing and compaction process.

3.6 FILLING GENERAL

3.6.1 General

- 1 Filling low-level areas shall be to the level of subgrade as designated. After completion of clearing and grubbing, the Contractor shall carry out the necessary levelling in order to control the thickness of the layers of fill.
- 2 The existing natural ground shall then be scarified in place to a minimum depth of 150 mm for the full width of the embankment except where the material is classified as rock. The scarified material shall be watered as required, thoroughly mixed, shaped and compacted to a minimum of 95 % maximum dry density.
- 3 Where an existing embankment is being widened, the existing embankment slope shall be trimmed and compacted into benches of minimum width 1m and depth 500mm before placing and compacting each layer of new embankment material unless otherwise directed by the Engineer to suit particular circumstances.
- 4 The Contractor shall not proceed with filling and compacting any subsequent layer before testing and securing the approval of the Engineer for the previous layer.
- 5 All fill material for a depth of 500 mm below the formation level must meet the requirements provided in clause 3.3.3.

3.6.2 Filling Around Utilities

- 1 Filling around culverts, storm water and sewerage pipes, utility and structures, and between building plot and footpath areas shall be done in accordance with the specific requirements of the relevant utility authority and the following additional requirements.
- 2 Filling for these areas shall be from surplus excavated material obtained on site and approved by the Engineer. In the case of insufficiency of such material then approved material shall be obtained from borrow pits and filled to the designated levels. The maximum size of particle allowed in the backfill within one meter of culverts, storm water and sewage pipes, utilities and structures shall be 25 mm.
- 3 The Contractor shall take every precaution to protect bridge columns and lighting equipment when filling between median barriers and any damage to these items arising from the filling works shall be repaired by the Contractor.
- 4 The Contractor shall agree the type of plant or equipment to be used with the Engineer before undertaking this work.

3.6.3 Fill Supplied by Qatar National Transport Organization (QNTO)

- 1 If instructed under the projects specification, fill will be imported from other sources using the Qatar National Transport Organization (QNTO).
- 2 It shall be the responsibility of the Contractor to monitor and control both the quality and the quantity of this imported fill.
- 3 The Contractor shall ensure that all delivery notes for such material are verified and authenticated and then collated for submission to the Engineer.

3.6.4 Contractors Imported Fill

- 1 The project specifications shall designate areas for the Contractor to obtain borrow material for use in the construction of the Works. It is the Contractor's responsibility to satisfy himself that there is sufficient borrow material of suitable types.
- 2 The Contractor may elect to use alternative sources of borrow material.
- 3 It shall be the Contractor's responsibility to obtain all permits or permission and make any payments that may be required in acquiring the rights to borrow material whether the Contractor uses the designated areas or elects to use alternative areas. The Contractor shall ensure that the source of all borrowed material has been approved by the Municipality concerned.
- 4 The Contractor shall obtain and supply to the Engineer representative samples from the borrow pits he intends to use. The Engineer will be afforded the opportunity to be present during the sampling operations.
- 5 The Contractor will carry out the necessary laboratory and, if required, field testing to establish the suitability of the material for filling work and will advise the Engineer of the results. The Engineer will advise the Contractor whether such material is acceptable and whether the borrow pit is an approved source of borrow material.

- 6 The Contractor will test samples of the approved borrow pits material actually being imported onto the site, and should such material fail to meet the requirements of these Specifications, approval to the use of the borrow pits will be withdrawn and the Contractor shall immediately cease importation from the borrow pits until such time as the Engineer may approve alternative sources of material from within the same borrow pits based on sampling and testing as specified above.
- 7 The Engineer will decide whether the material already imported from the concerned borrow pits can remain as placed on the site, or whether the Contractor shall remove and replace the said material at his own expense.
- 8 Overburden and any unsuitable top layers at the borrow pit shall be stripped and stockpiled to the satisfaction of the Engineer. Upon completion of excavation the Contractor shall replace the overburden and unsuitable material, smooth the surface and leave the area clean and tidy to the satisfaction of the Engineer.
- 9 The Contractor's haul and traffic arrangements will be subject to the Engineer's approval before the work may be commenced.

3.6.5 Rock Fill

- 1 Material consisting predominantly of rock fragments of such a size that it cannot be placed in layers of the thickness allowed without crushing, or further breaking down, may be placed in the embankment in layers not exceeding twice the average size of the larger fragments.
- 2 No layer of rock fill shall exceed 800 mm loose thickness.
- 3 Rock fill shall be placed and spread so that the largest boulders and fragments are evenly distributed, with the voids in-between completely filled with smaller fragments, sand or gravel, watered in if necessary.
- 4 Each layer shall be bladed and leveled by a track laying tractor.
- 5 Quality control tests will not normally be performed on this material but each layer must be approved in writing by the Engineer before the next is placed.
- 6 Embankment layers which consist of material that contains rock but also has sufficient compatible finer material other than rock shall be placed and compacted as for soil embankments. Quality control tests will be made wherever the Engineer determines they are feasible.
- 7 Compaction shall be carried out by a vibratory roller with the following minimum mass:

<u>Mass per Meter Width of Vibration Roll (kg/m)</u>	<u>Depth of Fill Layer (mm)</u>	<u>Minimum number of Passes of the Roller on each Layer</u>
2300 - 2900	400	5
2900 - 3600	500	5
3600 - 4300	600	5
4300 - 5000	700	5
>5000	800	5

3.6.6 Compaction

- 1 The Contractor shall carry out the required compaction specified after grading and leveling the surface to be compacted. In areas to be filled, compaction shall include adding necessary soil, water and compacting the first layer in addition to subsequent layers up to the proposed levels.
- 2 In areas already excavated down to the required level, compaction shall include adding the necessary water, and compacting the surface, in accordance with the procedure outlined in paragraphs 3 to 12 below.
- 3 After carrying out the grading, leveling, scarifying and pulverizing of the soil layer the Contractor shall add the necessary amount of water to permeate the pulverized soil.
- 4 The soil shall then be thoroughly turned after each addition of water so as to achieve homogeneous moisture content in the whole thickness of the layer.
- 5 Before compacting, samples of the pulverized soil shall be tested using a 'Speedy Moisture Device' (ASTM D4944) or similar instrument to measure the moisture content. If the moisture content is not within $\pm 2\%$ of the optimum moisture content as determined by ASTM D1557, the area represented by this sample shall be scarified and aerated or water added until the moisture content is within $\pm 2\%$ of the optimum moisture content. The soil shall then be primarily leveled in order to commence earth compaction.
- 6 After primary levelling referred to above, compaction shall be commenced by means of the approved rolling pattern.
- 7 Filling shall be in layers not exceeding 150 mm compacted thickness.
- 8 All areas including embankment roadway, medians, shoulders, sidewalks and verges shall be compacted to 95 % of Maximum Dry Density as determined by ASTM D1557 unless otherwise specified or directed by the Engineer.
- 9 The rolling shall be carried out in the direction of the road axis until the soil reaches the required density. In crowned sections, rolling shall start from both edges of the road in the direction of the road axis. If the road is super elevated, rolling shall commence from the lower side and continue to the higher side. In order to compensate for the amount of water loss in evaporation during the course of compaction, additional quantities of water shall be added as required.
- 10 Each layer shall be levelled and rolled to achieve uniform compaction free from undulations, soft spots and depressions.
- 11 No layer shall be covered by the next layer until it has been tested, inspected and approved by the Engineer.
- 12 The Contractor shall be responsible for reinstatement to the satisfaction of the Engineer of any layer damaged or disturbed after compaction and approval, by any means or cause, before placing the next layer.

3.6.7 Filling of Pits and Trenches

- 1 The bottom of all excavations shall be formed to the lines and levels shown on the drawings.
- 2 Any pockets of soft soil or loose rock in the bottom of pits and trenches shall be removed and the resulting cavities and any large fissures filled with suitable material and compacted to a minimum relative compaction of 95 % based on ASTM D1557.
- 3 Prior to proceeding with filling, the base of the excavation shall be compacted to a minimum relative compaction of 95 % based on ASTM D1557.
- 4 The full width of the compaction plant shall fit inside the surface area of the backfilling with sufficient space to permit adequate compaction. Under no circumstance shall compaction be carried out with plant straddling backfilled and existing surfaces.
- 5 Trenches and pits shall be backfilled in layers not exceeding 150 mm compacted thickness unless otherwise directed by the engineer.

3.6.8 Work Over Sabkha

- 1 Where the road embankment passes over Sabkha areas with a high water table the contractor shall take special precautions during the construction.
- 2 These precautions shall include but shall not be limited to the construction of suitable temporary haul roads for all construction plant operating in the area.
- 3 Haul roads shall be constructed using rock fill and geotextiles as necessary to ensure a safe stable surface.
- 4 The use of geotextiles and geosynthetics shall be in accordance with Part 15 when used for the permanent embankment.
- 5 If directed by the Engineer the Contractor shall construct embankments over Sabkha areas with a surcharge of excess material that shall remain in place till all appreciable settlement has stopped. The Contractor shall provide a means of monitoring the settlement. The Engineer shall decide when appreciable settlement has stopped.
- 6 Unless a specific treatment in using geotextiles or geosynthetics is described elsewhere in the contract, work over Sabkha shall comprise of initially stabilizing the existing Sabkha area by laying and rolling rock fill layer type 1 according to Table 3.2. This operation should be continued by adding and rolling type 1 rock fill layer with steel vibratory roller till the layer is completely stabilized.
- 7 A layer of geotextile fabric should be laid over the compacted type 1 pervious backfill.
- 8 A layer of 50mm pervious backfill type 2 according to Table 3.2 should be laid over the stabilized layer to protect the geotextile fabric.
- 9 Layer of 200mm thick rock fill type 1 should be laid over type 2 pervious backfill to receive the required road layers after the above operation.

Table 3.2
Definition of Type 1 & 2 backfill materials

Size (mm)	Percentage Passing	
	Type 1	Type 2
152.0	Max.	-
125.0	85 - 100	-
100.0	75 - 90	-
50.0	45 - 65	-
37.5	35 - 55	-
19.0	20 - 35	100
12.5	10 - 25	95 – 100
9.5	5 - 20	70 – 100
4.75	-	0 – 55
2.36	-	0 – 10
0.075	-	0 – 3

3.6.9 Trimming Side Slopes

- 1 Embankment side slopes shall be trimmed to the profiles and dimensions shown on the contract drawings.
- 2 The earthworks shall be trimmed to within ± 20 mm of the designated profile.
- 3 The side slopes shall be thoroughly compacted after trimming to ensure a hard surface.
- 4 Side slopes shall be tested for compaction in accordance with this part of the specification and the minimum density requirement shall be 95% of the maximum dry density as per ASTM D1557.

3.7 STRUCTURE EXCAVATION AND FILLING

3.7.1 General

- 1 In addition to the work specified, the Contractor shall include all operations necessary to excavate and backfill as required for the construction of any structure's installations and utilities.
- 2 This work shall include necessary, pumping, dewatering, draining, sheeting, bracing, and the necessary supply and construction of cribs and cofferdams and their subsequent removal.
- 3 The Contractor shall take all necessary precautions, to the satisfaction of the Engineer, to prevent loss of natural cementation in the existing subsoil during, and as a consequence of, dewatering operations.
- 4 This work shall also include the furnishing and placing of approved foundation fill material or concrete to replace unsuitable material encountered below the foundation elevation of structures.

3.7.2 Excavation Supports

- 1 Battered excavation slopes greater than 1.5 m high shall not be used without the express written permission of the Engineer. Where such permission is not granted or where only a part of the overall depth of an excavation is permitted to be with battered slopes all faces of excavations greater than 1.5 m high shall be supported.
- 2 The Contractor shall submit his proposals for supporting excavated faces.
- 3 Before commencing any structural excavation work greater than 1.5 m in depth, the Contractor shall obtain the Engineer's approval of his proposals for supporting excavated faces.

3.7.3 Dewatering

- 1 At locations where the excavation extends below the groundwater table, a dewatering system shall be provided. This will effectively reduce the hydrostatic pressure and lower the groundwater levels below excavation levels, as required for the safe and proper excavation of the work. It will result in obtaining a stable, dry subgrade for the execution of subsequent operations.
- 2 The Contractor shall design dewatering methods and settling basins so that no critical amounts of soil, sand or silt are removed during either the initial operations or the construction operations. Complete working drawings showing the type of dewatering and groundwater control system proposed shall be submitted to the Engineer for his review.
- 3 The Contractor's submitted drawings shall show the arrangement, location and depths of the proposed dewatering system if required. A complete description of the equipment and materials to be used and the procedure to be followed shall be shown, together with the standby equipment, standby power supply, and the proposed location or locations of points of discharge of water.
- 4 Any required dewatering system design shall also include the measures taken to prevent damage due to settlement of pavement, utilities, sewers, buildings and other structures outside the excavation but within the area affected by the dewatering procedures.
- 5 Dewatering shall not be terminated without the approval of the Engineer and in the case of structures retained by ground anchors dewatering shall not be terminated until the ground anchors have been stressed to the full working load and approved by the Engineer.

3.7.4 Excavation for Structures

- 1 The Contractor shall notify the Engineer sufficiently in advance of the beginning of any excavation so that cross-sectional elevations and measurements may be taken of the undisturbed ground.
- 2 Trenches or foundation pits for structures or structure footings shall be excavated to the designated lines and grades or elevations. They shall be of sufficient size to permit the placing of structures or structure footings of the full width and length shown. The designated elevations of the bottoms of footings 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.

- 3 Boulders, logs, and any other unsuitable material encountered in excavations shall be removed from the site.
- 4 Unless otherwise designated structure excavation shall be carried out for a width of at least 500 mm beyond the horizontal outside limits of the foundation, footing, box culvert or structural member to which the excavation relates. Concrete blinding or sub-foundations are not to be considered as structure for the purpose of defining such excavation.
- 5 If during the progress of the work, loose or improperly compacted soil or such other material as the Engineer considers would be detrimental to load distribution of new foundations to the underlying soil is encountered below the structure foundation level such material shall be removed within the limits as directed by the Engineer.
- 6 The resulting void shall be backfilled with either blinding concrete or with suitable material compacted to a density not less than 95 % of the maximum dry density as per ASTM D1557. The Engineer shall specify the type of backfill to be employed at each location.
- 7 After each excavation is completed, the Contractor shall notify the Engineer to that effect, and no footing, bedding material or pipe culvert shall be placed until the Engineer has approved the depth of excavation and the character of the material on which the foundations will bear.
- 8 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 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.

3.7.5 Use of Materials

- 1 All excavated material, so far as it is suitable, shall be used as backfill or roadway fill.
- 2 All excavated material shall be approved by the Engineer before being used as fill. All surplus excavated material and excavated material rejected by the Engineer for use on the site shall be removed from the site and disposed of in locations approved by the Engineer.
- 3 Where the Engineer designates a disposal location this shall be within a 50 km radius of the site of the Works.

3.7.6 Cofferdams

- 1 Suitable and practically watertight cofferdams shall be used wherever water-bearing strata are encountered above the elevation of the bottom of the excavation.
- 2 Cofferdams or cribs for foundation construction shall, in general, be carried well below the bottoms of the footings and shall be well braced and as nearly watertight 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.

- 3 When conditions are encountered which, as determined by the Engineer, render it impracticable 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 of such thickness as to resist any possible uplift. The concrete for such a seal shall be placed as directed by the Engineer. The foundation shall then be dewatered and the footing placed.
- 4 If weighted cribs are employed and the weight is used to overcome partially the hydrostatic pressure acting against the bottom of the foundation seal, special anchorage's 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.
- 5 As an alternative to a cofferdam, the Contractor may propose a wellpoint dewatering system, for approval by the Engineer, to keep structural excavation works dry. Such proposal shall include, but not be limited to, sufficient calculations, sketches and drawings, to justify the wellpoint positions and lengths in addition to pumping capacity required. The use of a wellpoint dewatering system may not preclude the use of support or shoring within the excavation to provide adequate stability and safety to the satisfaction of the Engineer.

3.7.7 Backfill Adjacent to Structures

- 1 Excavated areas around structures shall be backfilled with suitable excavated materials or imported materials as approved by the Engineer. Backfill materials shall be placed in horizontal layers not over 150 mm in depth and compacted to a minimum of 95% of the maximum dry density obtained by ASTM D1557.
- 2 Material used for backfill adjacent to structures shall have a sulphate content of less than 2.5 g/L when tested in accordance with BS 1377.
- 3 Each layer shall be moistened or dried as required and thoroughly compacted as specified. The maximum size of particle allowed in the backfill within one meter of structures shall be 50 mm.
- 4 Backfill and embankment behind walls of any culvert shall not be placed until the top slab of the culvert has been placed and cured.
- 5 Backfill to culvert walls shall be carried out simultaneously behind opposite walls.

3.8 FORMATION PREPARATION

3.8.1 Scope

- 1 This work shall consist of the preparation of the graded formation upon which sub-base, base course or pavement materials are to be placed, all in accordance with these Specifications.
- 2 All subgrade shall be compacted to the previous requirements of these Specifications.
- 3 Preparation and surface treatment of the formation shall be carried out after all duct and pipe installations in the subgrade have been completed.

- 4 Any non-compliant subgrade material shall be excavated, replaced, and compacted to the required density.

3.8.2 Protection

- 1 Once prepared, the formation shall be maintained in the finished condition until the first succeeding course of sub-base, base, or asphalt pavement material has been placed.
- 2 The Contractor shall take all precautions necessary to protect the formation from damage: hauling over finished subgrade shall be limited to that which is essential for construction purposes.
- 3 Any equipment used for hauling over the prepared subgrade which in the opinion of the Engineer is causing undue damage to the prepared subgrade or to the underlying materials shall be removed from the Works at the request of the Engineer.
- 4 All cuts, ruts and breaks in the surface of the subgrade shall be repaired by the Contractor before placing any subsequent layer. The Contractor shall protect the prepared subgrade from both his own and public traffic.
- 5 The Contractor shall maintain the subgrade by blading and rolling as frequently as may be necessary to preserve the subgrade in a completely satisfactory condition.

3.8.3 Rectification

- 1 Any surface area of the formation which is too high shall be graded off, scarified and re-compacted to the full depth of the affected layer.
- 2 Any surface area of the formation which is too low shall be scarified and corrected by the addition of subgrade material of the same classification and moisture content.
- 3 The Contractor shall carry out additional testing as required by the Engineer to ensure that the standard of compaction is satisfactory through the full depth of a layer or previously placed layers.

3.9 TOPSOIL

- 1 Topsoil (sweet soil) shall be fertile, free draining, non-toxic soil capable of sustaining healthy plant growth.
- 2 The material proposed for use as topsoil shall be approved by the Agricultural Department of the Ministry of Municipality (MM).
- 3 Topsoil shall be loosely placed at the designated thickness.

3.10 TESTING

3.10.1 General

- 1 For verification of material, moisture content, compaction, thickness and other properties of the materials or workmanship the Engineer shall at all times have access to all portions of the works and sites. All sampling and testing of material and work shall be carried out under the direction of the Engineer.

- 2 The minimum frequency of testing shall follow the frequencies mentioned in Table 3.1 unless more frequent tests are shown elsewhere in the contract documents or directed by the Engineer. Other testing shall be carried out as directed by the Engineer.

3.10.2 Testing Degree of Compaction

- 1 Testing shall be done in accordance with ASTM methods of testing, or other approved equivalent test or designated procedure.
- 2 The density-in-place of earthworks layers shall be tested by the sand replacement method (ASTM D 1556) or nuclear method (ASTM D6938).
- 3 Nuclear density gauge testing should only be carried out by personnel who have approved user certification issued by the Ministry of Municipality and Environment.
- 4 Each in-situ density nuclear gauge shall be calibrated and a calibration form issued. The Contractor shall maintain on site and with the instrument a copy of the Ministry of Municipality and Environment safety and training manual for the use of nuclear density gauges.
- 5 When nuclear gauge is used for field density and moisture content testing, the density and moisture content for each material shall be verified by measurements in accordance with ASTM D1556 and ASTM D2216, respectively. The mean value of the replicate readings shall be used as the calibration point value for each material.
- 6 When determining the laboratory maximum dry density the method described in ASTM D1557 shall be applied.
- 7 No person or company will be permitted to determine in situ density by means of a nuclear type density measuring device without complying with the requirements of the Ministry of Municipality and Environment. Refer to clause 1.5 of part 1 of this Section.
- 8 The density of any layer requiring compaction shall be determined in accordance with the specifications mentioned in Table 3.1.
- 9 If a layer does not conform to the required density, additional tests may be taken to determine the limits of the failing area, after which the Contractor shall rework the area until the specified density is obtained. The Contractor shall allow enough time in his daily work program to permit the performance and checking of the above tests, before he proceeds into any subsequent operations.

3.10.3 California Bearing Ratio

- 1 The soaked value of the California Bearing Ratio shall be determined on specimens compacted at the optimum moisture content and 95 % of the maximum dry density as per ASTM D1557 after soaking for 4 days in accordance with ASTM D1883. CBR value shall comply with the minimum requirement as per Qatar Highway Design Manual (QHDM).
- 2 The test surcharge to be used for the equivalent pavement thickness shall be designated by the Engineer.

3.10.4 Testing Levels and Evenness of the Formation

- 1 The Engineer shall test the levels and evenness of the finished formation surface to ascertain compliance.
- 2 The Contractor shall make available to the Engineer a three-meter straight-edge and a crown template of sturdy and approved design and the necessary labor to assist in the checking operations.
- 3 When tested in accordance with ASTM E1703 by a three-meter straight-edge placed at right angles to, or parallel to, the road centerline or when tested by a crown template placed centrally at right angles to the road centerline, the maximum gap between the road formation surface and the testing edge shall not be greater than 20 mm. Measurements shall be carried out at maximum spacing of 50m of road length for each lane.
- 4 The subgrade shall be prepared to the levels shown on the contract drawings to a tolerance of between + 15 mm and – 20 mm when checked by a level instrument.
- 5 Variation in the falls to cross-sections of the road shall not exceed 0.4 %.
- 6 These tests shall be made at any point requested by the Engineer. In the event of any failure, the Contractor shall correct the unevenness of the surface and resubmit the area for approval by the Engineer.

3.10.5 Testing Formation Works after Completion

- 1 All completed works shall be inspected at any time as directed by the Engineer in order to verify the compliance of the executed work to the requirements of the contract as per requirement of Part 5 in Section 3.

END OF PART