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ARAB ENGINEERING BUREAU

9 FORMWORK

9.1 GENERAL

9.1.1 Scope

- 1 This Part includes permanent forms, temporary formwork, and falsework for structural and architectural cast-in-place concrete including form liners, coatings, and accessories.
- 2 Related Sections and Parts are as follows:

This Section

Part 8,..... Transportation and Placing of Concrete

Part 10,..... Curing

Part 17,..... Structural Precast Concrete.

Section 11: Health and Safety

Part 1, Regulatory document

Part 2, Safety and accident prevention management/administration system (SAMAS)

9.1.2 References

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

ACI Committee 117 ...“Standard Tolerances for Concrete Construction and Materials” (ACI 117-90), American Concrete Institute, Detroit, 22 pp.

ACI Manual of Concrete Practice, Parts 2 and 5.

BS 8500Concrete

BS 5975Code of practice for temporary works procedures and the permissible stress design of falsework

EN 12812Falsework. Performance requirements and general design

CP3 chapter V-2:Code of basic data for the design of buildings. Loading - Wind loads;

.....EN 1991-1-4: Eurocode 1. Actions on structures - General actions - Wind actions

EN 1992-1-1Eurocode 2: Design of concrete structures. General rules and rules for buildings

EN 206Concrete. Specification, performance, production and conformity

EN 12390-3Testing hardened concrete — Part 3: Compressive strength of test specimens

Concrete Society Technical Report No. 13

9.1.3 Submittals

- 1 Shop drawings shall include plans and sections, giving the following minimum information for each level:

- (a) details of individual panels
- (b) position, size and spacing of adjustable steel shores
- (c) position, size and spacing of joists, soldiers, ties
- (d) details of formwork for columns, beams, parapets, slab and kickers

- (e) details of construction joints and movement joints
 - (f) details of retaining walls and deep beams showing the position and size of ties, joints, soldiers and sheeting, together with detailed information on erection and casting sequences and construction joints
 - (g) general assembly details
 - (h) full calculation sheets
 - (i) proposals at all penetrations through the concrete
 - (j) proposed sequence of shoring and reshoring beams and slabs for different spans and floor heights and number of floors shored, and the stripping time for supported and suspended structural elements, clearly identifying the supported element and suspended element.
- 2 Scales of shop drawings shall be as follows:
- (a) details: 1:1, 1:5, 1:10, 1:20
 - (b) construction: 1:50, 1:100
 - (c) layout and Site Plan: 1:100 or 1:200
- 3 The Contractor shall submit samples of all proposed formwork materials and samples of ties proposed for use in general situations above the water table and for fair faced concrete.
- 4 The Contractor shall allow 14 days for Engineer's review of submittals or samples.
- 5 Supply and delivery of built-in pipework should be clearly shown on the detailed construction program to be submitted by the Contractor.
- 6 Method Statements for erection and removal of formwork shall be submitted by the Contractor before the start of the works for the Engineer's review and approval. The Method Statement shall include the Risk Assessments related to the activity.
- 7 When the formwork is to be carried out by a sub-contractor, then the pre-qualification documents shall be submitted for the Engineer's review and approval.
- 9.1.4 Quality Assurance**
- 1 Formwork shall comply with the requirements of BS 5975 and EN 1992-1-1
 - 2 The erection of formwork and associated falsework shall be executed and supervised by fully qualified personnel having a minimum of five years experience.
 - 3 The Contractor shall obtain approval to load any particular section of the works from the Engineer.
 - 4 Formwork design shall be carried out in accordance with the Concrete Society Technical Report No. 13.
 - 5 The erected formwork shall be watertight from the ingress of external liquids and the egress of internal liquids. Adjustable steel supports and shores shall allow formboards and framework to be accurately adjusted to line and level. The Contractor shall ensure that adequate ground support for falsework is available, and if not shall take measures to make them suitable.
 - 6 Formwork shall be designed to be sufficiently rigid to maintain the correct position, shape and profile so that the final concrete structure is within the dimensional tolerances specified Subpart 9.7 of this Part.
 - 7 Formwork shall be designed to be demountable without causing shock, disturbance or damage to the concrete.

- 8 Soffit formwork, properly supported on shores only, shall be capable of being retained in position during the concrete maturing period.
- 9 The design shall allow free movement and accessibility under the formwork.
- 10 Shores for abnormal ceiling heights shall be specially designed.
- 11 The forms shall be designed to incorporate 20 mm chamfers on exposed corners of columns, walls and beams.
- 12 The design of formwork shall take into account the following:
- (a) height and rate of pour
 - (b) thickness of the member
 - (c) concrete slump and density
 - (d) placing temperature
 - (e) texture of finish
 - (f) construction joints
 - (g) wind load
 - (h) on soffit forms (in addition to concrete weight)
 - (i) an additional live load of 2.5 kPa, or
 - (ii) if a motorised cart is used, an additional live load of 3.75 kPa
 - (i) minimum design load for combined dead and live load
 - (i) 6.50 kPa
 - (ii) if a motorised cart is used, 7.75 kPa
 - (j) the worst combination of:
 - (i) self-weight
 - (ii) formwork forces
 - (iii) reinforcement weight
 - (iv) wet concrete weight
 - (v) construction loads
 - (vi) wind loads,
 - (vii) incidental dynamic effects caused by placing, vibrating and compacting concrete
 - (viii) the use of externally applied vibrators
 - (k) method of concrete discharge
 - (l) access for concrete placement and vibration.
- 13 Before beginning related formwork operations the Contractor shall erect a job mock-up, to a reasonable size including all items such as sheeting, stiffeners, soldiers, ties etc. (and including release agents, where used) for the following types of formwork, and shall obtain the approval the Engineer before proceeding:
- (a) columns
 - (b) slabs and beams
 - (c) staircases
 - (d) fair-faced concrete (show method used to conceal tie holes) cove ties not required.

- 14 Upon prior consultation, agreement of location and approval, the job mock-ups may remain as part of the finished work.

9.2 FORMWORK MATERIALS

9.2.1 General

- 1 Forms shall be of wood; metal or other material acceptable to the Engineer.
- 2 The design of formwork shall be the responsibility of the Contractor.
- 3 Formwork shall conform to the requirements of EN 1992-1-1
- 4 Form oil and form sealer shall be of quality as acceptable to the Engineer.

9.3 CLASS OF FINISH AND MATERIALS:

9.3.1 Unformed surfaces

- 1 Unformed surfaces shall be classified as either:
 - (a) U4, timber trowel finish
 - (b) U3, steel trowel finish
 - (c) U2, brush finished
 - (d) U1 other finish designated by the Engineer, such as:
 - (i) Screeeded Finish - Where the floor slab is to receive a screeded finish, the slab shall be laid to the slopes and levels shown on the drawings and the top surface shall be tamped whilst unset, to produce a suitable keyed surface for the receipt of the appropriate finishing materials.
 - (ii) Floated Finish - Where a floated finish is required to the floor slabs the top surface shall be leveled and floated whilst unset to an uniform finish to the slopes and levels shown on the drawings. The floating shall be done in such a manner as not to bring an excess of mortar to the surface.
 - (iii) Dustproof Finish - Where concrete surfaces are required to provide a dustproof finish these shall be treated with two coats of accepted material. Each coat shall be applied with a soft brush on a clean and dry surface in accordance with the manufacturer's printed instructions.
 - (iv) Non-slip Finish - Concrete surfaces described on the drawings as having a non-slip finish shall be treated with carborundum dust, evenly sprinkled on whilst the concrete is still green, at a rate of $1\frac{1}{2}$ kg/m² and lightly trowelled in before final finishing. Alternatively, the carborundum dust may be incorporated into the finish by means of a mechanical power float.
 - (v) Hardened Finish - Where a hardened finish is required to the floor slabs these shall be treated with three coats of accepted material. Each coat shall be applied with a soft brush on a clean and dry surface in accordance with the manufacturer's printed instructions.
 - (vi) Finishing Unformed Surfaces - Finishing unformed surfaces shall be tamped, floated, trowelled or brushed as defined below and shown on the drawings.
 1. Type T - Tamped surfaces shall be formed by levelling and tamping the concrete to produce a uniform plain or ridged surface, surplus concrete being struck off by a straight edge immediately after compaction. It is also the first stage of the following finish.

2. Type F - Floated surfaces shall be uniform surface which has been worked no more than is necessary to remove screed marks by hand with a wood float or by power float of a type acceptable to the Engineer. The surface shall not be floated until the concrete has hardened sufficiently.
 3. Type ST - Steel trowelled shall be a hard, smooth finish, free from trowel marks and formed with a steel trowel under firm pressure. Trowelling shall not commence until the moisture film has disappeared and the concrete has hardened sufficiently to prevent excess laitance from being worked to the surface. If laitance is brought to the surface it shall be removed.
 4. Type BR - Brushed shall be formed before the concrete has hardened by drawing a wire broom over the concrete surface at right angles to the traffic flow to give an average texture depth of 1mm.
 5. For ground slab concrete shall be treated with sodium silicate or a similar dust preventive coating. This must be applied in accordance with the manufacturer's instructions.
- 2 The type of finish will be specified on the drawings or as directed by the Engineer. Before beginning any concrete pour with unformed surfaces, the Contractor shall obtain confirmation of the type of finish required from the Engineer.
- 3 Initial finishing of unformed surfaces shall commence immediately after the placing and compaction have taken place.
- 4 Suitable access boards or platforms shall be provided to allow access to all parts of unformed surfaces to be finished.
- 5 Where a protective treatment or topping layer is to be applied to the concrete the manufacturers and suppliers recommendations shall be followed concerning the required finish.
- 6 Brush to finish shall be obtained by carrying out a steel trial finish and then using a suitable stiff nylon brush dragged lightly across the surface.
- 7 The addition of small quantities of water to the finishing trowel will be permitted to aid finishing.
- ### 9.3.2 Surface Finish Classifications
- 1 Finishes to formed surfaces of concrete shall be classified as F1, F2 and F3, or such other special finish as may be designated.
- 2 Where the class of finish is not designated:
- (a) all internal concrete shall be finished to Class F3
 - (b) external concrete below ground shall be finished to Class F1
 - (c) where surfaces are to be tanked by covering with paint or sheeting, the formwork shall be capable of achieving a finish suitable for the proposed tanking as directed by the Engineer.
- ### 9.3.3 Formwork Materials
- 1 Formwork for Class F3 finish shall be lined with as large panels as possible of non-staining material with a smooth unblemished surface such as sanded plywood or hard compressed fibre board, arranged in a uniform approved pattern and fixed to back formwork by oval nails.
- (a) the same type of lining shall be used throughout any one structure
 - (b) unfaced wrought boarding or standard steel panels shall not be permitted.

2 Formwork for Class F2 finish shall be faced with wrought tongued and grooved boards or plywood arranged in a uniform approved pattern free from defects likely to detract from the appearance of the surface.

3 Formwork for Class F1 finish shall be constructed of timber, or of any suitable materials which will prevent loss of grout when the concrete is vibrated.

9.3.4 Exposed Concrete Surface Finishes

1 Exposed concrete surfaces shall have a Class F3 finish.

2 Care shall be taken to ensure that the finish to the exposed concrete on the external and internal surfaces are of the highest quality to produce a smooth concrete surface of uniform texture and appearance without visible imprint of grains, steppings or ridges.

3 The resulting concreting shall be free from honeycombing, stains, fins, lipping, nail and screw marks, raised grain marks or any other imperfections and shall be of a uniform surface texture and colour. Only very minor surface blemishes caused by entrapped air or water will be accepted provided that they do not exceed 0.5% by area of each square metre considered separately and in addition they shall not be concentrated in a manner such that they are noticeable.

4 Formwork to the wetted surfaces of water retaining structures shall be Class F3

5 All exposed concrete corners and edges shall have 20 mm by 20 mm chamfers.

6 Grooves in exposed concrete shall be formed by attaching tapered planed timber battens accurately aligned to the face of formwork.

9.3.5 Form Ties

1 Form ties shall conform to the following requirements:

- (a) factory-fabricated
- (b) adjustable in length
- (c) use removable or snap-off metal form ties
- (d) designed to prevent formwork deflection and to prevent spalling concrete surfaces on removal
- (e) no metal shall be left closer than the applicable level of cover to the surface of the concrete
- (f) holes larger than 10 mm diameter in the concrete surface, when using snap ties shall not be permitted
- (g) form ties shall have a factor of safety not less than 1.5.

9.3.6 Coating and Accessories

1 Form coatings shall be commercial formulation form-coating compounds that will not bond with, stain, nor adversely affect concrete surfaces requiring bond or adhesion, nor impede the wetting of surfaces to be cured, shall be used. The use of form coatings shall be strictly in accordance with the manufacturer instructions.

2 Formwork in contact with the concrete shall be treated with a suitable non-staining mould oil to prevent adherence of the concrete.

3 Forms for exposed surfaces shall be coated with oil before reinforcement is placed. Forms for unexposed surfaces may be thoroughly wetted with water in lieu of oiling, immediately before placing of concrete except during freezing weather.

- 4 Excessive oiling of the forms shall not be permitted in order to prevent discolouration of the cement plaster. Where concrete surface is to be painted, the form-oil must not affect the bond between concrete and paint.
- 5 Care shall be taken to prevent the oil from coming in contact with reinforcement or with concrete at construction joints. Any oil on reinforcing steel shall be removed.
- 6 Release agents shall not be used where concrete surfaces receive special finishes or applied coatings which may be affected by the agent, unless approved by the Engineer.
- 7 Fillet and chamfer strips shall be PVC or timber to the approval of the Engineer.
- 8 Tapes to be used to seal joints of formwork panels for smooth finish concrete shall be plastic faced adhesive tape to the approval of the Engineer.
- 9 Precast concrete moulds shall be rigid steel, wood or fibreglass moulds.
- 10 Flashing reglets shall be galvanised steel of the longest possible length.

9.4 FORMWORK EXECUTION

9.4.1 General

- 1 Where formwork to external faces will be permanently exposed, all horizontal and vertical formwork joints shall be so arranged that joint lines will form a uniform pattern on the face of the concrete.
- 2 Where the Contractor proposes to make up the formwork from standard sized manufactured formwork panels, the size of such panels shall be approved by the Engineer before they are used in the construction of the Works.
- 3 The finished appearance of the entire elevation of the structure and adjoining structures shall be considered when planning the pattern of joint lines caused by the formwork and by the construction joints to ensure continuity of horizontal and vertical lines.
- 4 Masonry nails or similar items shall not be used to fix formwork of the like to permanent concrete works.

9.4.2 Trial Panels

- 1 The trial panels shall comprise surfaces that have unformed surfaces and formed surfaces F1, F2 and F3.
- 2 The concrete cast from the job mock-up shall be used to assess the acceptability of the Contractor's workmanship for finishing.
- 3 If the finishing is deemed unacceptable by the Engineer, the Contractor shall prepare a further mock-up with a particular class of finish.
- 4 The job mock-ups shall be retained during the course of the works to allow comparative inspection, with production concreting and finishing and for the purpose of colour comparison to ensure colour consistency.

9.4.3 Formwork Face in Contact with Concrete

- 1 Faces of formwork in contact with concrete shall be free from adhering foreign matter, projecting nails and the like, splits or other defects, and all formwork shall be clean and free from standing water, dirt, shavings, chippings or other deleterious matter.
- 2 Joints between forms and tie holes shall be watertight to prevent the escape of mortar or the formation of fins or other blemishes on the face of the concrete.

- 3 The Contractor shall verify lines, levels and measurement before proceeding with formwork erection.
- 4 The formwork surface shall be made clean and free from any foreign and deleterious matter, prior to start the concrete pour.
- 5 In hot weather, the surface of the formwork shall be sprayed with water in order to lower the temperature, prior to start the pour.

9.4.4 Sloping Surfaces

- 1 Formwork shall be provided for the top surfaces of sloping work where the slope exceeds 15 ° from the horizontal (except where any such top surface is specified as a spaded finish).
- 2 The formwork shall be anchored to enable the concrete to be properly compacted and to prevent flotation.
- 3 Care shall be taken to prevent air being trapped under the sloping formwork.

9.4.5 Temporary Openings

- 1 The Contractor shall provide temporary openings for inspection of the inside of the formwork and for the removal of water used for washing down. The openings shall be formed as to be easily closed before placing concrete.
- 2 Temporary opening shall be avoided in the case of fair faced concrete.

9.4.6 Form Windows

- 1 The Contractor shall provide windows in forms wherever directed by the Engineer or necessary for access for concrete placement and vibration.
- 2 The windows shall be of a size adequate for tremies and vibrators spaced at maximum 1.8 m centres horizontally.
- 3 Any windows shall be tightly closed and sealed before proceeding to place concrete at a higher level.

9.4.7 Co-ordination

- 1 The Contractor shall ensure that the work of other trades in forming and setting openings, slots recesses, chases, sleeves, bolts, anchors and other inserts is fully co-ordinated.

9.4.8 Conduits

- 1 Conduits or pipes shall be located so as not to reduce the strength of the construction.
- 2 In no case shall pipes other than conduits be placed in a slab 125 mm or less in thickness.
- 3 Conduits embedded in a concrete slab shall not have an outside diameter greater than one-third the thickness of the slab nor be placed below the bottom reinforcing steel or over the top reinforcing steel.
- 4 Conduits may be embedded in walls provided they are not larger in outside diameter than one-third the thickness of the wall, are not spaced closer than three diameters on centre, and do not impair the strength of the structure.
- 5 Embedded pipes and conduits shall be supported independently from reinforcing steel in a manner to prevent metallic contact and thereby prevent electrolytic deterioration.
- 6 Pipes and conduits where embedded shall be placed as nearly as possible to the centre line of the concrete section.

- 7 Conduits, piping, and other wall penetrations or reinforcements shall be subject to the Engineer's review and approval.
- 8 Conduits shall be fixed properly to avoid any displacement during concreting and prevent coming in contact with the forms.

9.4.9 Ties and Bolts

- 1 The position of ties passing through concrete shall be subject to the approval of the Engineer.
- 2 Ties, bolts or other devices shall not be built into the concrete for the purpose of supporting formwork without the prior approval of the Engineer. The whole or part of any such supports shall be capable of removal so that no part remaining embedded in the concrete shall be nearer to the surface than the cover required for reinforcement.

9.4.10 Chamfers

- 1 Chamfer moulding strips shall be positioned on the exposed corners of columns and beams.

9.4.11 Cambers

- 1 If required, cambers shall be as shown on the Drawings.
- 2 The depth of beams at all points in the span, where cambers are used, shall be as shown on the Drawings.
- 3 Allowance shall be made for compression and settlement of the formwork on line and level.

9.4.12 Exterior Angles

- 1 All exterior angles to concrete exposed to view in the completed structure shall be cast to the true angles evenly throughout the length.
- 2 Care shall be taken to ensure that no waviness occurs along the angle and that no spalling occurs to the concrete on removal of the formwork.

9.4.13 Surface Retarders

- 1 Surface retarders shall not be used on any formwork surface in contact with concrete unless expressly authorised by the Engineer.

9.4.14 Detection of Movement During Concrete Placement

- 1 Devices of telltale type shall be installed on supported forms and elsewhere as required to detect formwork movements and deflection during concrete placement.
- 2 Where required slab and beam cambers shall be checked and correctly maintained as concrete loads are applied on forms.
- 3 Workmen shall be assigned to check forms during concrete placement and to promptly seal all mortar leaks.
- 4 The forms shall be checked during concreting in order to identify any displacement and provide corrective actions immediately.

9.4.15 Building in Pipes

- 1 Pipes and pipe specials through concrete walls and floors shall as far as possible be positioned and built in during construction. They shall be located exactly in the positions shown on the Drawings and shall be true to line and level.
- 2 The Contractor shall take particular care to ensure that fully compacted concrete is in contact with the pipe at all points.

- 3 Where it is not practicable to cast pipes and specials in the concrete, boxholes shall be formed in the shuttering.
- 4 The box shall have six or eight sides, depending on the pipe diameter, and shall be no larger in size than will give adequate clearance for the subsequent positioning and grouting in of the pipe. The sides of the boxhole shall be provided with a tapered central annular recess to provide a positive key. The boxhole shall be provided with a grout hole and, at the top of the central annular recess, a vent hole. The boxhole shall be stripped with the main shuttering and the concrete surface thoroughly cleaned and roughened.
- 5 When the pipe is later fixed, the remaining hole shall be reshuttered and filled with non-shrink epoxy grout or non-shrink concrete. In the case of water retaining structures, the Contractor shall ensure that the measures adopted shall provide a finished joint which is resistant against and free from leakage.

9.4.16 Working Platform

- 1 Safe working platform shall be provided according to Section 11 (Health and Safety).

9.4.17 Safe Access

- 1 Safe access shall be provided for the workers, inspectors, and other users according to Section 11 (Health and Safety).

9.4.18 Kickers

- 1 Kickers shall be provided for walls and columns
- 2 The kickers shall be water tight in order to prevent any grout loss.

9.4.19 Cover Spacers

- 1 Cover spacers shall be used in order to maintain the required cover between the formwork and reinforcement.

9.4.20 Water Bars

- 1 In the case of watertight constructions water bars or equivalent, as approved by the Engineer, shall be used at joints.

9.5 REMOVAL OF FORMWORK

9.5.1 General

- 1 The Engineer shall be notified in writing before the removal of any formwork.
- 2 The Contractor, under no circumstances, shall strike the formwork until the concrete has attained adequate strength to resist damage, in particular to arises and features.
- 3 Concrete shall be thoroughly wetted as soon as the forms are first loosened and shall be kept wet during the removal operations and until the curing media is applied.
- 4 A potable water supply with hoses having fine fog spray attachments shall be ready at each removal location before operations are commenced.
- 5 The forms after removal shall be cleaned and prepared for subsequent use.

9.5.2 Stripping of Formwork

- 1 The period of time elapsing between the placing of the concrete and the striking of the formwork shall be approved by the Engineer after consideration of the loads likely to be imposed on the concrete and shall in any case be not less than the periods shown in Table 9.1

- 2 Stripping of the formwork within the time limits listed above does not relieve the Contractor from successfully crushing test cubes and achieving the specified compressive strength results.
- 3 Notwithstanding the foregoing the Contractor shall be held responsible for any damage arising from removal of formwork before the structure is capable of carrying its own weight and any incidental loading.
- 4 Where finished surfaces have re-entrant angles, the formwork shall be removed as early as possible, within the time limits set above, to avoid shrinkage cracks.
- 5 The formwork shall be carefully stripped to avoid sudden shocks from the removal of wedges, or vibration which might cause damage to the concrete.
- 6 Reshoring to beams and slabs shall be placed immediately after stripping formwork.

Table 9.1
Stripping Times of Formworks

Type Of Formwork	Minimum Period Before Stripping (Times Are From Concrete Placement)
Beam sides, walls and column	1 d
Soffits of slabs (props left under)	4 d
Soffits of beams, joists and girders (props left under)	10 d
Props to slabs	11 d
Props to beams	15 d

9.5.3 Holes to be Filled

- 1 Holes formed in concrete surfaces by formwork supports or the like shall be filled neatly with non-shrink grout.
- 2 The Contractor shall clean and scarify any hole that is to be filled with non-shrink grout.

9.5.4 Repair to Damaged Concrete Surfaces

- 1 Where the concrete surface has been damaged, the Contractor shall break out any loose, broken or cracked concrete or aggregate.
- 2 The concrete surrounding the hole shall be then be thoroughly soaked after which the surface shall be dried so as to leave a small amount of free water on the surface. The surface shall then be dusted with ordinary Portland cement by means of a small dry brush until the whole surface that will come into contact with the dry-pack mortar has been covered and darkened by absorption of the free water by the cement. Any dry cement in the hole shall be removed
- 3 Dry-pack material shall then be placed and packed in layers having a compacted thickness in accordance with the manufacturer's instructions. Compaction shall be carried out by the use of a hardwood stick and a hammer and shall extend over the full area of the layer, particular care being taken to compact the dry-pack against the side of the hole. After compaction the surface of each layer shall be scratched before further loose material is added
- 4 The hole shall not be over-filled and the surface shall be finished by layering a hardwood block against the dry-pack fill and striking the block several times. Steel finishing tools shall not be used and water shall not be added to facilitate finishing.

- 5 The surface of the concrete shall be rubbed down smooth with carborundum and water in an approved manner within three days of removing the formwork. Holes left after removal of such supports shall be neatly filled with non-shrink grout of a suitable consistency and matching colour.

9.6 DELIVERY AND STORAGE

9.6.1 Delivery

- 1 The delivery of formwork materials shall be done in such a manner that damage can be prevented.

9.6.2 Storage

- 1 Formwork should be stored, after cleaning and preparing for reuse if used before, in such a manner that access to all different materials is available.
- 2 Materials which can be affected by weathering shall be stored in appropriate buildings or under cover.

9.7 TOLERANCES

- 1 The concrete work shall be constructed to an accuracy which shall permit the proper assembly of components and installations and shall be compatible with the finish. The accuracy of the work shall be within the tolerances shown on the Drawings or specified elsewhere and, in the absence of any other requirements, shall comply with the following:

All laying out dimensions	± 5 mm
Sections of concrete members	± 5 mm
Surface of foundations against ground	± 10 mm
Top surfaces of foundations, bases and piers	± 20 mm
Surface level of floor slabs (5m straight edge)	± 5 mm
Surface level of floor slabs to datum	± 10 mm
Plumb of columns and walls in storey height	± 5 mm
Plumb of columns and walls in full building height (for each storey) above the top of foundation:	
$20m \geq$ building height	± 20 mm
$150m \geq$ building height ≥ 20 m	$\pm(1/1000)$ of height
building height ≥ 150 m	± 150 mm
Inside faces of elevator shafts in storey height	± 5 mm
Inside faces of elevator shafts in full building height (for each storey) above the top of foundation:	
$20m \geq$ building height	± 10 mm
$150m \geq$ building height ≥ 20 m	$\pm(0.5/1000)$ of height
building height ≥ 150 m	± 75 mm

9.8 EARLY LOADING

- 1 The Contractor should note that the loading from the falsework and wet concrete, during the construction of a floor, will not exceed the permissible loading on the floor immediately below. Consequently two of the floors immediately below the one being constructed will need to be used, to share the loading.
- 2 While propping through two floors, the Contractor shall ensure, that the props beneath the floor last constructed are released over its full extent as soon as the concrete has achieved sufficient strength to support itself plus any superimposed loading, but not sooner than the periods given in Table 9.1. The props shall then be re-tightened so that these may be used to share the construction loading from the floor above.
- 3 Not notwithstanding the requirements of this Section for the removal times for formwork, the following provisions shall apply to early loading of concrete.
- 4 Concrete shall at no time be subject to loading including its own weight which will induce a compressive stress in excess of 0.33 of the actual compressive strength of the concrete at the time of loading or 0.33 of the specified 28 d characteristic strength whichever is the lower. For the purpose of this clause the assessment of the strength of the concrete and the stress produced by the loads shall be subject to the agreement of the Engineer.
- 5 If, due to his method of construction, the Contractor wishes to place an imposed load on the structure, he shall arrange for additional cubes to be cast at the point of the structure to be loaded and these cubes will be crushed to monitor the compressive strength in accordance with EN 12390-3 Compressive strength of test specimens. The Contractor shall submit calculations showing the stresses induced by any proposed temporary loads to be placed on the structure.
- 6 No superstructure load shall be placed upon finished piers or abutments until the Engineer has given his approval in writing and in no case shall any load be placed until the curing period is complete.
- 7 Deck slabs of bridges shall only be opened to traffic or construction equipment and plant when authorised by the Engineer and in no case until the curing period is complete.

END OF PART