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## 7 **FORMWORK**

### 7.1 **SCOPE OF WORK**

The work under this Chapter shall comprise supply of all labour, plant and material and the performance of all work necessary for the design, fabrication, supply, erection, maintenance and removal of formwork and false work to form concrete structures as shown on the Construction Drawings or as otherwise directed by the Project Manager.

### 7.2 **DEFINITIONS**

- i) FORMS of FORMWORK shall mean the moulds into which concrete is placed.
- ii) FALSE WORK or SHORING shall mean the structural supports and bracings for forms used in any part of the Works.
- iii) CURVED FORMS shall mean any form not composed of plain surface and limits of curved forms shall not extend beyond the lines of tangency or intersections with flat surfaces.

### 7.3 **STANDARDS**


The formwork material, design, fabrication, erection, maintenance and removal of formwork shall conform to the latest revisions of the following Indian Standards or, where not covered by these standards, to the equivalent International Standards:


IS: 456                      Code of practice for plain and reinforced concrete.

### 7.4 **SUBMITTALS**

- i) At least 26 days in advance of any concrete work being carried out at the Site, the Contractor shall submit to the Project Manager details of the materials for formwork and surface finishes, and construction techniques which the Contractor proposes to use in order to achieve the required concrete surfaces and allowable tolerances.

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<div> <div>ii)</div> <div>At least 26 days prior to the construction of the steel formwork for the tunnel lining, the Contractor shall submit to the Project Manager the shop drawings, details, and structural computations, of the formwork construction.</div> </div> <div> <div>iii)</div> <div>At least 18 days prior to commencement of work on each particular structure, the Contractor shall submit to the Project Manager 4 copies of the detail shop drawings with all formwork details and 2 copies of the structural computations of the formwork construction.</div> </div> <div> <div>iv)</div> <div>Review by Project Manager of Contractor's drawing and calculations shall not relieve the Contractor of its sole responsibility for the adequacy of form and false work, or for the safety of persons or property, and for the successful completion of the work.</div> </div> <div> <div>7.5</div> <div><b><u>MATERIALS</u></b></div> </div> <div> <div>7.5.1</div> <div><b><u>FORMWORK</u></b></div> </div> <div> <div>i)</div> <div>Material used for form sheathing and lining shall be of wood, steel, plywood, or fibreglass. All materials used in formwork construction shall be of adequate strength and quality for their intended purpose.</div> </div> <div> <div>ii)</div> <div>Timber shall be sound, straight, free from warp, decay and loose knots and shall be dressed smooth. Except as expressly approved by the Project Manager, all timber brought to the Site for use as forms, shoring or bracing shall be new material.</div> </div> <div> <div>iii)</div> <div>Plywood for use as form shall be mill-oiled and edge-sealed. Plywood shall be non-warping, non-wrinkling and manufactured with special water-proof glues. Plywood sheets shall be of uniform width and length.</div> </div> <div> <div>iv)</div> <div>The surface of steel of steel lined forms shall be smooth. Forms with dents, buckled areas or other surface irregularities shall not be used.</div> </div> <div> <div>v)</div> <div>Forms for concrete surfaces exposed to flowing water (other than tunnel lining) shall be lined with sanded, uncoated, plywood veneer. Steel or impermeable plastic liners will not be permitted.</div> </div>		
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- vi) Rough sawn boards may be used only for the lowest grade of surface finish (F1).
- vii) Re-use of forms will be allowed only if they are thoroughly cleaned and repaired and capable of producing the finish required for the concrete. Timber or plywood forms repaired with metal patches shall not be used.
- viii) Damaged forms that have deteriorated through use shall not be used.
- ix) Where required, expanded metal fixed to the formwork shall be used in vertical construction joints.


#### 7.5.2 FORM TIES

- i) The type, number and positions of internal formwork supports and ties shall be to the approval of the Project Manager. Form inserts or other similar permanently embedded items shall be accurately located and securely fastened in place. The number and location of form ties and bolts shall be such as to ensure that forms fit tightly against the concrete previously placed and remain in tight contact during operations.
- ii) The whole or part of such formwork supports and ties shall be removed without damage to the concrete so as to leave no part embedded nearer the surface of the concrete than the designed cover of the reinforcement or 50 mm in the case of un-reinforced concrete. Only metal portions of formwork supports and ties shall be allowed to remain in place.
- iii) Through-bolts will not be permitted in water retaining walls or in underground linings.
- iv) Holes left after the removal of supports and ties shall be filled as described in the Chapter “Concrete – Repair of Defective Concrete”, and shall be finished off neatly to the standard of the concrete surface. Such filling shall be adequately cured.

#### 7.5.3 TUNNEL FORMWORK

- i) Steel faced forms shall be used to achieve the F3/F3C finish required on the hydraulic tunnel-lining surfaces. The forms shall be fitted with ample

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windows at appropriate spacing and locations to allow the introduction of vibrators and to carry out inspections and any other work needed behind the form.

- ii) The formwork shall allow for continuous concrete pouring of the whole face. It shall be of rigid construction, non-deformable due to working loads imposed upon it. Once installed in the position the form shall maintain it without displacement during concrete placement.
- iii) The formwork shall be constructed in such a way that no abrupt irregularities arise at vertical construction joint. The joint in formwork shall overlap the vertical construction joint at least by 500 mm and one formwork element remains in contact with placed concrete while others are being stripped down and installed for following concreting stages.
- iv) Windows shall be provided in each side about the mid height at the tunnel and at 30 degrees from the crown on alternate sides of the centreline. The windows shall be at least 600 mm in the least dimension and shall be spaced at a distance not exceeding 2.5 m.

#### 7.6 **DESIGN**

- i) The Contractor shall be solely responsible for the adequate design, construction and maintenance of any and all formwork and false work required in the Works. Forms shall be designed to permit the concrete to be deposited as nearly as is practicable directly in its final position, and to allow inspection, checking the cleanup of the formwork and reinforcement to be completed without delay.
- ii) Formwork and false work shall be designed, fabricated, erected and removed in accordance with the applicable provisions of the recommended practice for concrete form of IS: 456.
- iii) All false work shall be designed to withstand safely all live and dead loads that might be applied to the false work during all stages of construction, service and removal.

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iv) For the purpose of formwork and false work design, the Contractor shall assume a value of  $25 \text{ kN/m}^3$  for the density of concrete. Further, construction loads shall also be applied and assumed to act simultaneously with the self weight of concrete. Such construction loads shall be of at least  $1.5 \text{ kN/m}^2$ .

v) The Contractor shall prepare detailed drawings of shoring and formwork. The calculations and drawings shall show the size and specification of the formwork, including the type and grade of all materials used in the construction, design loads on the formwork supports, horizontal forces imposed on the false work and used for design purpose, and details of splices and connections, including nail spikes and other fasteners. If mechanical equipment such as concrete buggies, screeding machines, etc., are to be used, this information shall be shown on these drawings.

#### **7.7 ERECTION OF FORMWORK**

i) Formwork and false work shall be constructed only after the formwork drawings have been accepted by Project Manager.


ii) The Contractor shall construct the false work and formwork in strict accordance with the approved formwork drawings, one set of which shall be kept at the Site at all times. No change will be allowed without prior written acceptance of such change by the Project Manager.

iii) Formwork shall be erected and maintained such as to confine the concrete without loss of mortar and to produce required finished surfaces. Forms shall be set and maintained within the specified tolerance limit such that the complete concrete surfaces are within these limits.

iv) Forms for concrete against which backfill is to be placed or which will not be exposed to view may be constructed of smooth tight boards not less than 25 mm nominal thickness.

v) Forms for concrete exposed to view shall be constructed of steel or plywood, which is smooth and free from defects, with matched and sanded joints to give a symmetrical pattern over the entire area. Chamfer strips, 25


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mm by 25 mm shall be used on all exposed corners, unless otherwise directed by the Project Manager.

- vi) Any forms, which in the opinion of the Engineer are unsafe or inadequate in any respect, may, at any time, be rejected and the Contractor shall promptly remove the rejected forms from the works and replace them.
- vii) An adequate number of temporary clean-out holes or short weep-holes (pipes) shall be provided in the forms to secure the drainage of rainwater.
- viii) When a second lift is placed on hardened concrete, the number, location and tightening of ties at the top of the old lift and bottom of the new shall be such as to prevent any damage to concrete. The form of a new lift shall overlap the hardened concrete by at least 100 mm, to prevent abrupt irregularities.
- ix) Forms for sloping concrete surfaces shall permit their placing board-by-board or panel-by-panel immediately ahead of concrete placement so as to enable access for placement, vibration, and inspection of the concrete.
- x) All form surfaces shall be thoroughly cleaned before erection and shall be lubricated with a non-staining mineral oil. Excess oil shall be wiped off from the forms prior to placement of concrete. Oil shall not be allowed to come into contact with reinforcement steel or other embedded items.
- xi) Immediately before the concrete is placed, all forms shall be inspected to ensure that they are properly placed, sufficiently rigid, clean, tight, properly surface treated and free from excess of oil or other foreign materials. No concrete shall be placed until the formwork has been inspected and accepted by Project Manager.
- xii) The formwork for the gate groove areas shall be accurately drilled to permit the placement of first stage anchor couplings and anchor-plates that are to be embedded in the primary concrete. Both, the anchor couplings and the anchor plates shall be fixed by fasteners, attachments and/or wires through the formwork, so that they stay in their position while concreting. The Contractor shall take care that the first stage anchors couplings and anchor-

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plates remain flush with the primary concrete face and that the couplings do not get plugged.

#### **7.8 FINISHED TOLERANCES**


Forms shall be so constructed that the finished concrete surfaces shall be of uniform texture in accordance with the types of finish specified in the Chapter "Concrete".

#### **7.9 REMOVAL OF FORMWORK**

- i) Removal of forms shall be performed with care so as to avoid injury to the concrete and as soon as permissible in order to avoid delay in curing and repair of surface imperfections. Forms shall not be removed without the consent of the Project Manager.
- ii) Forms shall not be removed until the concrete has attained sufficient strength to prevent damage to concrete. Damaged concrete shall be repaired or treated by the Contractor as soon as possible, but not before the Project Manager has inspected such damage and agreed to the remedial works.
- iii) The elapsed time between the completion of concrete placing and the removal of forms shall generally be in accordance with IS: 456. Forms should not be removed until the concrete has attained a sufficient strength (estimated at this time as at 70% strength but not less than 7 days for vertical supports, and 35% strength but not less than 48 hours for side supports over 1.5 m), but not less than the following:
  - a) Undersides of beams, deck type slabs, undersides of openings      7 days
  - b) Lifts 1.5 m and under      24 hours
  - c) Lifts over 1.5 m      48 hours
  - d) Tunnel linings      16 hours
  - e) Mass concrete      24 hours
- iv) The minimum periods indicated above are only indicative. The governing rule to be observed is the 28-day compressive strength, which shall be

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## 7.10 MEASUREMENT AND PAYMENT

### 7.10.1 GENERAL


- i) Measurement for formwork will be of the formed area for the class of finish shown on the Construction Drawings.
- ii) Payment will be made at the Unit Prices per square meter entered in the Bill of Quantities for various classes of flat and curved formwork, which shall include the entire cost of design, maintenance, oiling, erection, all necessary ties and fixings, supply and erection of all material, labour, access scaffoldings, forming of chamfers up to 1000 mm<sup>2</sup> either internal or external and edges up to 100 mm width.
- iii) Openings in the forms for block outs, niches, etc., for the areas which are smaller than 0.5 m<sup>2</sup> will not be deducted from the area measured for payment.
- iv) Measurement and payment for the D-shaped tunnel formwork is included in the concrete rates in the chapter "Concrete"
- v) Measurement for formwork used to form contraction and expansion joints will be made of the flat area in square meters of joints shown on the Construction Drawings.

### 7.10.2 EXCLUSIONS

No extra measurement or payment will be made for the following:

- a) Any kind of construction joints and key boxes,
- b) Formwork used for concrete linings in Tunnels, surge shaft, draft tube gate shafts, bus ducts and ventilation ducts,
- c) Formwork used for manufacturing of precast concrete units,
- d) Unformed surfaces,
- e) Any forms rejected by the Project Manager and the replacement thereof,

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<div> <div>f)</div> <div>Any damage caused by Contractor's negligence during forms removal.</div> </div> <div>End of Chapter</div>		
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