

S.04: FORM WORK

- 4.1 These specifications shall be read in conjunction with the CPWD specifications 2019 and latest with up-to-date correction slips, MOST/MORTH (5th Revision) Specifications and other relevant specifications described in the S.01 of Section-VII-F of these specifications.

4.2 **Materials:**

Formwork shall be of timber, plywood (including marine plywood), steel or any other suitable material capable of resisting damage to the contact faces under normal conditions of fixing steel, erecting forms and placing concrete. The selection of materials suitable for form work shall be made by the Contractor based on the quality consistent with the specified finishes and safety. **For designated areas prominently in public view like piers, pier caps, portals, pier arms and any precast members forming a part of viaduct etc., only steel shuttering shall be used.** Steel material shall be in good condition. It should not be corroded. Condition of material shall be decided by the Engineer and if found not complying as per relevant standards or requirements, it shall be replaced. Number of uses (repetitions) for steel shuttering shall be between 50 and 100. However, the no of uses shall be decided by Engineer as per the condition of steel shuttering. Special finishes like grooves, logos, floral designs to be incorporated in the steel shutter itself during its fabrication. The material shall be approved by the Engineer before being erected at site. However, the entire responsibility of planning, designing, erection, dismantling, shifting and safety of false work lies with the contractor.

All formwork and formwork supports (centering, props, scaffolds etc.) shall only be in structural steel and preferably of pipes conforming to IS:806, IS:1161, IS:1239, IS:2750. Wooden ballies shall not be permitted as props/formwork supports. All props shall be properly braced using x & k bracings. **Ladders to be used at site should have treads and shall be fabricated from structural steel. Wooden / bamboo / aluminium / pipe ladders shall not be permitted. No additional payment to be made for all types of formwork and formwork supports including ladders to the contractor.**

Plywood:

Plywood used for formwork shall be **minimum 12 mm** thick. Shuttering quality plywood complying with IS: 4990 and of make approved by the Engineer. Suitable stiffeners and wallers shall be provided depending on the shuttering design.

Steel:

Steel formwork shall be made of minimum 4 mm thick black sheets stiffened with angle iron frame made out of M.S. angles 40mmx 40 mm x 6 mm supported at suitable spacing.

4.3 **Design & Drawings:**

All temporary works such as formwork, false work, staging, launching girder, cantilever form traveller scheme etc. shall be designed by the Contractor. The permissible stresses in materials of formwork, false work, staging, launching girder & cantilever form traveller shall be limited as same as that for permanent structure. **All calculations and drawings of the same including construction sequence shall be checked and verified by independent agency appointed by contractor.** Only after the checking of the same, the calculations and drawings (along with soft copy in CD ROM) shall be submitted to Engineer for approval well in advance of work. All temporary works shall also be inspected by the independent agency and independent report shall be

submitted to Engineer. All temporary works shall be robust, safe and constructed such a way that the concrete can be properly placed and thoroughly compacted to obtain the required shape, position and level subject to specified tolerances. It is the responsibility of the Contractor to obtain the results required by the Engineer, whether or not some of the work is sub-contracted. Approval of the temporary works by the Engineer shall not diminish the Contractor's responsibility for the satisfactory performance of the same, nor for the safety and co-ordination of all operations.

For pier formwork, it shall be ensured that total deflection (taking account of combined deflection of plate, stiffeners, wallers or any other supporting arrangement) shall not be more than 3 mm. All the formwork, launching truss and cantilever form traveller and other selected temporary works shall be tested for the load including factor of safety for which the truss/formwork is designed before use in works **at no extra cost**.

The design of false work should be such as to facilitate easy and safe access to all parts for proper inspection. Methodology for removal of form should be planned as a part of total form work design.

In case of pre-stressing concrete, careful consideration shall be given to re-distribution of loads due to pre-stressing.

4.4 Formwork for Exposed Concrete Surfaces:

The facing formwork, unless indicated otherwise on drawings, or specifically approved by the Engineer in writing, shall generally be made with materials not less than the thickness mentioned below for different elements of the structure:

- i. Plain slab soffit and sides of beams, girders, joists and ribs and side of walls, fins, parapets, pardis, sun-breakers, etc. shall be made with:
 - a. Steel plates not less than 4mm thick of specified sizes stiffened with a suitable structural framework, fabricated true to plane.
 - b. Timber planks of 20mm actual thickness and of specified surface finish, width and reasonable length.
 - c. Plywood not less than 12mm thick (IS:4990 - Specification for Plywood for Concrete Shuttering Work) stiffened with a suitable timber frame work or 3mm thick plywood with a 20mm timber plank backing, of specified sizes stiffened with a suitable timber framework and bracing. At joints 6mm/10mm sponge to be provided.
- ii. Bottoms of beams, girders and ribs, sides of columns shall be made with:
 - a. Steel plates not less than 5mm thick of specified sizes stiffened with a suitable structural framework, fabricated true to plane .
 - b. Timber planks of 35mm actual thickness and of specified surface finish width and reasonable length.
 - c. Plywood plates not less than 12mm thick (IS 4990), of specified sizes stiffened with a suitable timber framework as approved by Engineer.
- iii. For Precast segments, precast girders, piers, pier heads, portals etc. suitable steel form work is to be used unless otherwise specified by Engineer.

- iv. For station areas suitable steel form work is to be used unless as specified by Engineer.

4.5 Formwork for Sloped Surfaces:

- i Forms for sloped surfaces shall be built so that the formwork can be placed board-by- board immediately ahead of concrete placement so as to enable ready access for placement, vibration inspection and finishing of the concrete.
- ii The formwork shall also be built so that the boards can be removed one by one from the bottom up as soon as the concrete has attained sufficient stiffness to prevent sagging. Surfaces of construction joints and finished surfaces with slopes steeper than 2 horizontal: 1 vertical shall be formed as required herein.

4.6 Formwork for Curved Surfaces:

- i The contractor shall interpolate intermediate sections as necessary and shall construct the forms so that the curvature will be continuous between sections. Where necessary to meet requirements for curvature, the form lumber shall be built up of laminated splices cut to make tight, smooth form surfaces.
- ii After the forms have been constructed, all surface imperfections shall be corrected and all surface irregularities at matching faces of form material shall be dressed to the specified curvature.

4.7 Formwork for Waffle Slab:

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4.8 Erection of Formwork:

The following shall apply to all kinds of formwork:

- i To avoid delay and unnecessary rejection, the Contractor shall obtain the approval of the Engineer for the design of forms and the type of material used before fabricating the forms. (Ref. ACI 347 Formwork for Concrete or equivalent 1.3 Code).
- ii All shuttering planks and plates shall be adequately backed to the satisfaction of the Engineer by sufficient number and size of wallers or framework to ensure rigidity during concreting. All shutters shall be adequately strutted, braced and propped to the satisfaction of the Engineer to prevent deflection under deadweight of concrete and superimposed live load of workmen, materials and plant, and to withstand pouring rate and vibration.
- iii Vertical props shall be supported on wedges or other measures shall be taken where the props can be gently lowered vertically during removal of the formwork. Props for an upper level shall be placed directly over those in the level immediately below, and the lowest props shall bear on a sufficiently strong area. Care shall be taken that all formwork is set plumb and true to line and level or camber or better where required and as specified by the Engineer.
- iv Provision shall be made for adjustment of supporting struts where necessary. When reinforcement (dowel bars) passes through the formwork care should be taken to ensure close fitting joints against the steel bars so as to avoid loss of fines during the compaction of concrete.

- v If the formwork is held together by bolts, these shall be so fixed that no iron will be exposed on surfaces against which concrete is to be laid. In any case wires shall not be used with exposed concrete formwork. The Engineer may at his discretion allow the Contractor to use tie-bolts running through the concrete and the contractor shall decide the location and size of such tie-bolts in consultation with the Engineer. Holes left in the concrete by these tie-bolts shall be filled as specified by the Engineer at no extra cost. These tie-bolts are not to be provided in structures with exposed surfaces.
- vi Provision shall be made in the shuttering for beams, columns, and walls for a port hole of convenient size so that all extraneous materials that may be collected could be removed just prior to concreting.
- vii Formwork shall be so arranged as to permit removal of forms without jarring the concrete. Wedges, clamps and bolts shall be used wherever practicable instead of nails. The formwork for beams and slabs shall be so erected so that forms on the sides of the beams and the soffit of slabs can be removed without disturbing the beam bottoms or props under beams.
- viii Surfaces of forms in contact with concrete shall be oiled with a mould oil of approved quality (form releasing agent). If required by the Engineer the contractor shall execute different parts of the work with different mould oils to enable the Engineer to select the most suitable. The use of oil which results in blemishes on the surface of the concrete **including Diesel oil, burnt oil or any other lubricating oil** shall not be allowed. Oil shall be applied before reinforcement has been placed and care shall be taken that no oil comes in contact with the reinforcement while it is being placed in position. The formwork shall be kept thoroughly wet during concreting and the whole time that is left in place. Nothing extra shall be paid to contractor for oiling.
- ix Immediately before concreting is commenced, the formwork shall be carefully examined to ensure the following:
 - a) Removal of all dirt, sawdust and any other refuse by brushing and washing **and compressed air / vacuum cleaning**.
 - b) The tightness of joints between panels of sheathing and between these and any hardened core.
 - c) The correct location of tie bars, bracing and spacers and especially connections of bracing.
 - d) Adequate cover blocks are in place.
 - e) Straightness and plumbness of form works.
 - f) Construction joint (wherever applicable) is properly prepared.
 - g) Side supports / restraints for the form work are enough and robust.
 - h) That all wedges are secured and firm in position.
 - i) That provision is made for traffic on formwork not to bear directly on reinforcing steel.
 - j) Pouring platform along with its approach from ground is robust and safe for workers movement
 - k) Arrangement for vibrators for compaction of concrete
 - l) Sequence of concrete pouring is well defined and is agreed upon by the Engineer and is explained to concrete pouring team m.
 - m) The Pouring area is well lit.
 - n) Curing arrangements are well planned and agreed upon by the Engineer.
 - o) The green concrete protection measures from sun & rain etc. are in place.

Note: Contractor shall make above arrangements at his own cost and no extra payment shall be made to contractor for the same.

- x The Contractor shall obtain the Engineer's approval for dimensional accuracies of the work and for the general arrangement of propping and bracing. (IS: 3696 -Safety Code of Scaffolds and Ladders, IS: 4014 Steel Tubular Scaffolding I & II). All scaffolding and staging shall be either of steel tubes or built up section of rolled steel with adequate bracing at several levels in each perpendicular direction connecting each prop. In addition to this diagonal bracing should be provided in elevation ideally at 45 degrees or between 30 and 60 degree. The Contractor shall be entirely responsible for the adequacy of propping, and for keeping the wedges and other locking arrangements undisturbed through the decentring period. (IS: 8989 Safety code for erection of concrete framed structures) and **cost of the propping and staging shall be inclusive of the quoted cost for the RCC works in BOQ.**
- xi Formwork shall be continuously watched during the process of concreting. If during concreting any weakness develops and formwork shows any signs of distress, the work shall be stopped and remedial action as directed by the engineer shall be taken.
- xii Staging for portal girder and cross girder (in station zone) shall be in the form of portal frame. It shall be ensured that minimum two lanes of traffic with a restricted height of 5.5m can ply underneath it with adequate protection to portal legs from moving traffic. All necessary permissions for the height restrictions on the existing highways, main road, etc., shall be taken by the contractor from the local authorities at his own peril.
- xiii For concourse floor (if any) over road, the contractor shall design and fabricate prefabricated type of staging and shuttering which can be erected in very short duration. Such erection will be only permitted in the night. In such case staging has to span the full width of the road in a portal shaped profile as shown in tender drawings. The portal frame shall have 5.5m (min) traffic clearance from the road for allowing safe movement of traffic below. In case no road runs beneath the concourse zone of station, the bidder may decide whether to use the above form of staging or any normal staging arrangement from the ground itself. All necessary permissions for the height restrictions on the existing highways, main road, etc., shall be taken by the contractor from the local authorities at his own peril.

4.9 Concrete Finishes:

This section deals with the surface of concrete on which forms had been fixed while concreting.

i. Formed Surface:

Allowable deviation from plumb or level and from the alignment profile, grades and dimensions shown on the drawings is defined as "tolerance" and is to be distinguished from irregularities in finishes as described herein. Tolerances in concrete construction are specified elsewhere.

The classes of finish and requirements for finishing of concrete surface shall be as shown on the drawings or as hereinafter specified. In the event of finishing not being definitely specified herein or in the drawings, finishes to be adopted shall be as directed by the Engineer.

Completed concrete surface shall be tested, where necessary to determine whether surface irregularities are within the limits specified hereinafter.

Surface irregularities are classified as "Abrupt" or "Gradual". Offsets caused by displaced or misplaced form sheathing, or form sections or by loose knots or otherwise defective timber form will be considered as abrupt irregularities, and shall be tested by direct measurements.

All other irregularities shall be considered as gradual irregularities and will be tested by use of template, consisting of a straight edge or the equivalent thereof for curved surfaces. The length of the template shall be 150 cm for testing of formed surfaces and 300 cm for testing of unformed surfaces.

The classes of finish for formed concrete surfaces are designated by one of the symbols F1, F2, F3 and F4. Unless otherwise specified or indicated on drawings, these classes of finish shall apply as follows:

Finish F1: This finish applies to surfaces where roughness is not objectionable, or surface that will otherwise be permanently concealed. Surface treatment shall be the repair of defective concrete, correction of surface depressions deeper than 25 mm and filling of tie rod holes. Form sheathing will not leak mortar when concrete is vibrated. Forms may be manufactured with a minimum of refinement.

Finish F2: This finish is required on surfaces permanent/ but not prominently exposed to public view for which other finishes are not specified except F1. Forms shall be manufactured in a workmanlike manner to the required offsets or bulges. Surface irregularities shall not exceed 5mm for abrupt and 8mm for gradual irregularities measured with a 1.5 m template.

Finish F3: This finish is required for coarse textured concrete surfaces intended to receive plaster, stucco or wainscoting. Surface irregularities shall not exceed 5mm for both abrupt and gradual irregularities.

Finish F4: This finish is designated for surfaces prominently exposed to public view where appearance is also of special importance. This shall include piers of viaducts, beams, parapets, railings and decorative features on the structure and on the viaduct and stations. To meet with requirements for F4 finish, forms shall be manufactured in a skilful, workmanlike manner, accurately to dimensions. There should be no visible offsets, bulges or misalignment of concrete. At construction joints, the forms shall be rightly set and securely anchored close to the joint. Abrupt and gradual irregularities shall not exceed 3mm. Irregularities exceeding this limit shall be reduced by grinding to a level of 1:20 ratio of height to length. Jute bag subbing or sand blasting shall not be used.

ii. **Unformed Surfaces:**

The classes of finish for unformed surfaces are designated by symbols U1, U2, U3 and U4. Unless otherwise specified or indicated on drawings, these classes of finish shall apply as follows:

Finish U1: This finish applies to unformed surfaces that will be concealed permanently or otherwise where a screeded surface finish meets the functional - requirements. Finish U1 is also used as the stage of finishes for U2 and U3. Finishing operations shall consist of sufficient levelling and screeding to produce an even uniform surface. Surface irregularities shall not exceed 10mm.

Finish U2: This is floated finish and used on all outdoor, unformed surfaces. Finish U2 is also used as the second stage of finish for U3. Floating to be performed manually or mechanically on stiffened screed surface shall be minimum to produce textured surface so as to perform effective trowelling. If finish U3 is to be applied, floating shall be continued till a small amount of mortar without excess water is brought to the surfaces so as to be effective trowelling. Surface irregularities shall be removed as directed by the Engineer.

Finish U3: This is a trowelled finish and shall be used for tops of parapets etc. prominently exposed to view. When the floated surface has hardened sufficiently, steel trowelling shall be started. Steel trowelling on hardened, floated surface shall be performed with firm pressure to

produce a dense uniform surface free from blemishes and trowel marks and having slightly glossy appearance. Surface irregularities shall not exceed 5mm.

Finish U4: This is a steel-trowelled finish, similar to finish U3, except that light surface pitting and light trowel marks such as obtained from the use of machine trowelling will be acceptable, provided that surface irregularities do not exceed the limits specified for finish U3.

Unformed surfaces which are nominally level shall be sloped for drainage as shown on drawings or as directed by Engineer unless the use of other slopes or level surface is indicated on drawings. Narrow surfaces such as tops of parapets, walls and kerbs shall be sloped approximately 1cm per 30cm of width. Broader surface such as roadways, platform and decks, shall be sloped approximately half centimetre per 30cm of width. Finishes of floor and roof slabs shall be sloped, if required, by the Engineer.

4.10 **Exposed Concrete Work:**

Exposed concrete surfaces shall be smooth and even originally as stripped without any finishing or rendering. Where directed by the Engineer, the surface shall be rubbed with Carborundum stone immediately on striking the forms. The Contractor shall exercise special care and supervision of formwork and concreting to ensure that the cast members are made true to their sizes, shapes and positions and to produce the surface patterns desired. No honeycombing shall be allowed. Honeycombed parts of the concrete including the surface defects in the concrete shall be removed by the Contractor without affecting the strength of adjoining concrete as directed by the Engineer and fresh concrete placed without extra cost, as instructed by the Engineer. Part of defective concrete thus removed shall be re-cast using fresh concrete of same grade or approved quality concrete repair material depending upon the size, location, thickness of the defective concrete and structural behaviour of the member having defective concrete as instructed by the Engineer without extra cost. For the purpose the Contractor shall prepare a comprehensive work procedure and get it approved from the Engineer. Nothing extra shall be paid for repair of the concrete. Contractor shall ensure that no air bubbles are formed on the exposed surface. Concrete pouring sequence, vibration methodology etc. shall be planned to avoid air bubbles. All materials, sizes and layouts of formwork including the locations for their joints shall have prior approval of the Engineer.

4.11 **Age of Concrete at Removal of Formwork:**

Age of Concrete at the time of removal of formworks shall be in accordance with CPWD specifications 2019 or IS: 456. The Engineer may vary the periods specified if he considers it necessary. Immediately after the forms are removed, they shall be cleaned with a jet of water and a soft brush.

4.12 **Stripping of Formwork:**

The work of form work removal should be planned and a definite scheme of operation worked out. Formwork shall be removed carefully without jarring the concrete and curing of the concrete shall be commenced immediately. Concrete surfaces to be exposed shall, where required by the Engineer, be rubbed down with Carborundum stone or bush-hammer to obtain a smooth and even finish. Where the concrete requires plastering or other finish later the concrete surface shall be immediately hacked lightly all over as directed by the Engineer. No extra charge will be allowed to the Contractor for such work on concrete surfaces after removal of forms.

4.13 **Reuse of Forms:**

The Contractor shall not be permitted reuse of plywood formwork brought new on the works more than 5 times for exposed concrete formwork and 8 times for ordinary formwork. 5 or 8 uses shall be permitted only if forms are properly cared for, stored and repaired after each use. The Engineer may

in his absolute discretion order rejection of any forms he considers unfit for use for a particular item irrespective of no of times the shuttering has been used and order removal from the site of any forms he considers unfit for use in the Works. Used forms brought on the site will be allowed proportionately fewer uses as decided by the Engineer. Use of different quality boards or the use of old and new boards in the same formwork shall not be allowed. If any other type of special or proprietary form work is used, the no. of times they can be used will be determined by the Engineer.

4.14 Formwork for Precast/ Prestressed Concrete:

The provisions in this section shall be considered supplementary to the general provisions stated above and additional Technical Specifications for pre cast segments. Precast concrete members and panels shall be made in accurately constructed moulds, on a properly prepared casting bed. All aspects of the making, curing and erection of precast units shall be subject to the approval of the Engineer. The contractor shall submit detailed drawings of formwork for the approval of the Engineer. Finishing with cement mortar shall not be allowed.

The formwork should be so designed that it does not restrain the shrinkage movements and possible shortening due to pre-stress of the concrete. The formwork shall be of sturdy construction with special considerations to shutter vibrators when used. All edges and joints of the formwork should be designed and sealed so that no cement grout can escape and there is no wedging or keying to the concrete. The effect of curing on the formwork should be given special consideration. Depending on care, curing erection and maintenance after stripping, the following number of/ uses can be made with different types of formwork.

Plywood with timber backed formwork - As per satisfaction of Engineer

Steel moulds

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No of uses of shuttering shall be as per approval of the Engineer. In cases where concrete moulds can be satisfactorily provided by the contractor, the Engineer's approval shall be obtained before use on the works.

4.15 Stripping:

As soon as the precast units have attained sufficient strength, the formwork shall be stripped. The precast unit shall be lifted uniformly out of the formwork without being subjected to tilting or restraint effects or any other stresses and as per the guidelines issued by Engineer or his authorised representative.

If proprietary system of form work is used, detailed information as given in Annexure 4.1 shall be furnished to Engineer for approval before use.

4.16 Measurements (Not applicable for Schedule B):

Unless stated otherwise, the rate for concrete in plain concrete, reinforced concrete or in pre-stressed concrete shall be deemed to include the cost of all formwork / shuttering, staging, launching etc.

ANNEXURE 4.1**Information to be Supplied by Manufacturers of Proprietary Systems of Formwork****1. General**

- 1.1 The information which the manufacturer is required to supply shall be in such detail as to obviate unsafe erection and use of equipment due to the intention of the manufacturer not having been made clear or due to wrong assumptions on the part of the user.
- 1.2 The user shall refer unusual problems of erection/assembly not in keeping with intended use of equipment, to the manufacturer of the equipment.

2. Information Required

- 2.1 The manufacturers of proprietary systems shall supply the following information;
 - a. Description of basic functions of equipment.
 - b. List of items of equipment available, giving range of sizes, spans and such like, with manufacturer's identification number or other references.
 - c. The basis on which safe working loads have been determined and whether the factor of safety given applies to collapse or yield.
 - d. Whether the supplier's data are based on calculations or tests. This shall be clearly stated as there may be wide variations between results obtained by either method.
 - e. Instructions for use and maintenance, including any points which require special attention during erection, especially where safety is concerned.
 - f. Detailed dimensional information, as follows :
 - i. Overall dimensions, depths and widths of members.
 - ii. Line drawings including perspectives and photographs showing normal uses.
 - iii. Self-weight.
 - iv. Full dimensions of connections and any special positioning and supporting arrangements.
 - v. Sizes of members, including tube diameters and thicknesses of material.
 - vi. Any permanent camber built into the equipment.
 - vii. Sizes of holes and dimensions giving their positions.
 - viii. Manner of fixing including arrangements for sealing joints.
 - ix. Method of de-stripping, storing & shifting.
 - g. Data relating to strength of equipment as follows:
 - i. Average failure loads as determined by tests.
 - ii. Recommended maximum working loads for various conditions of use.
 - iii. Working resistance moments derived from tests.
 - iv. Working shear capacities derived from tests.
 - v. Recommended factor of safety used in assessing recommended loads and deflections based on test results.
 - vi. Deflections under load together with recommended pre-camber and limiting deflections.
 - vii. If working loads depend on calculations, working stresses should be tested. If deflections depend on theoretical moments of inertia or equivalent moments of inertia rather than tests, this should be noted.
 - viii. Information on the design of sway bracing against wind and other horizontal loadings.

- ix. Allowable loading relating maximum extension of bases and/or heads.

Any restrictions regarding usage of any component or full assembly with regard to spans, heights and loading conditions.