

SECTION 03100

CONCRETE FORMWORK

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Design, construction, erection and removal of structural concrete formwork.

1.02 UNIT PRICES

- A. No separate payment will be made for concrete formwork under this Section. Include payment in unit price for structural concrete.

1.03 SUBMITTALS

- A. Conform to all provisions and sections of these specifications.
- B. Shop Drawings: Show location, member size and loading of shoring. When reshoring is permitted, submit plans showing locations and member size of reshoring.
- C. Product Data and Samples:
 - 1. Corrugated Fiberboard Carton Forms: Submit certification of compliance with design criteria, description of forms, and one-foot-long sample.
 - 2. Form-coating Materials: Submit trade or brand names of manufacturers and complete description of products.
 - 3. Form ties and related accessories, including taper tie plugs, if taper ties are used.
 - 4. Form gaskets.
- D. Detailed Layout for Slip-forming: Submit detailed layout of proposed slipforming, including description of equipment, rate of progress, and other data to show suitability of method. Show provisions for ensuring attainment of required concrete surface finish.

PART 2 PRODUCTS

2.01 MATERIAL

- A. Smooth Forms: New plywood, metal, plastic, tempered concrete-form hardboard, dressed lumber faced with plywood or fiberboard lining, or metal-framed plywood-faced panel material, to provide continuous, straight, smooth surfaces. Form material shall be free of raised grain, torn surfaces, worn edges, patches, dents or other defects. Furnish material in largest practical sizes to minimize number of joints and, when indicated on Drawings, conform to joint system indicated. Form material shall have sufficient strength and thickness to withstand pressure of newly placed concrete without bow or deflection.
- B. Rough Forms: Plywood, metal, dressed or undressed lumber free of knots, splits or other defects or other material acceptable to the Owner's Representative of sufficient strength and thickness to withstand pressure of newly placed concrete without bow or deflection.
- C. Plywood: Conform to PS 1, Class 1.
- D. Lumber: Conform to PS 20.
- E. Edge Forms and Intermediate Screed Strips: Type and strength compatible with the screed equipment and methods used.
- F. Plastic Forms: One-piece forms for domes, beams and pan joists. Single lengths for columns not exceeding height of 7'-6". For columns over 7'-6", use 7'-6" sections and filler sections as needed. To facilitate removal of pan joist forms, taper sides 1 inch per foot.
- G. Metal Pan Joist Forms: Removable type; fabricated of minimum 14-gage steel; one piece between end closures. Adjustable forms not allowed. Taper sides 1 inch per foot to facilitate removal.
- H. Earth Cuts for Forms:
 - 1. Use earth cuts for forming unexposed sides of grade beams cast monolithically with slabs on grade.
 - 2. Where sides of excavations are stable enough to prevent caving or sloughing, following surfaces may be cast against neat-cut excavations:
 - a. Sides of footings.
 - b. Inside face of perimeter grade beams not monolithic with slab on grade. When inside face is cast against earth, increase beam width indicated on Drawings by 1 inch.

- c. Both faces of interior grade beams not monolithic with slab on grade. When grade beam is cast against earth, increase beam width indicated on Drawings by 2 inches.
- I. Corrugated Fiberboard Carton Forms:
- 1. Corrugated fiberboard carton forms, when called for, are intended to form a void space beneath pile-supported and pier-supported slabs and other structural elements as shown.
 - 2. Provide products of a reputable manufacturer regularly engaged in commercial production of double-faced corrugated fiberboard carton forms, constructed of waterproof paper and laminated with waterproof adhesive.
 - 3. Fiberboard forms: Capable of supporting required dead load plus construction loads, and designed to lose their strength upon prolonged contact with moisture and soil bacteria.
 - 4. Seal cuts and ends of each form section by dipping in waterproof wax, unless liners and flutes are completely impregnated with waterproofing.
 - 5. Size forms as indicated on Drawings. Assemble as recommended by manufacturer, either with steel banding at 4'-0" maximum on centers, or, where liners and flutes are impregnated with waterproofing, with adequate stapling.
- J. Circular Forms:
- 1. Form round-section members with paper or fiber tubes, constructed of laminated plies using water-resistant adhesive with wax-impregnated exterior for weather and moisture protection. Provide units with sufficient wall thickness to resist loads imposed by wet concrete without deformation. Provide manufacturer's seamless units to minimize spiral gaps and seams.
 - 2. Fiberglass or steel forms may be used for round-section members.
- K. Shores: Wood or adjustable metal, with bearing plates; with double wedges at lower end.
- L. Form Ties:
- 1. Use commercially-manufactured ties, hangers and other accessories for embedding in concrete. Do not use wire not commercially fabricated for use as a form accessory.

2. Fabricate ties so ends or end fasteners can be removed without causing spalling of concrete faces. Depth from formed concrete face to the embedded portion: At least 1 inch, or twice the minimum dimension of tie, whichever is greater.
 3. Provide waterstop feature for form ties used on liquid-containing structures and on concrete walls which will have earth backfill on one side.
 4. Removable ties: Taper ties may be used when approved by the Owner's Representative. In the hole left by the removal of the taper tie, insert a preformed neoprene or polyurethane plug sized to seat at the center of the wall.
- M. Form Coating: Commercial formulation of form oil or form-release agent having proven satisfactory performance. Coating shall not bond with, stain or otherwise adversely affect concrete surfaces, or impair their subsequent treatment, including application of bonding agents, curing compounds, paint, protective liners and membrane waterproofing.
- N. Coating for Plastic Forms: Alkali-resistant gel-coat.
- O. Chamfer Strips: Unless otherwise indicated on Drawings, provide 3/4 inch chamfer strips in corners of forms to produce beveled edges where required by Part 3, Execution.
- P. Form Gaskets: Polyethylene rod, closed cell, 1-inch diameter.

2.02 DESIGN OF FORMWORK

- A. Conform to ACI 117, ACI 347 and building codes, unless more restrictive requirements are specified or shown on Drawings. Contractor shall design and engineer concrete formwork, including shoring and bracing. Design formwork for applicable gravity loads, lateral pressure, wind loads and allowable stresses. Camber formwork to compensate for anticipated deflection during placement of concrete when required to maintain specified tolerances. Design formwork to be readily removed without impact, shock or damage to concrete surfaces and adjacent materials.
- B. Slip Forming: Permitted on written approval of the Owner's Representative. Contractor shall demonstrate suitability of method proposed.

PART 3 EXECUTION

3.01 INSTALLATION

A. Formwork Construction

1. Construct and maintain formwork so that it will maintain correct sizes of members, shape, alignment, elevation and position during concrete placement and until concrete has gained sufficient strength. Provide for required openings, offsets, sinkages, keyways, recesses, moldings, anchorages and inserts.
2. Construct forms for easy removal without damage to concrete surfaces.
3. Make formwork sufficiently tight to prevent leakage of cement paste during concrete placement. Solidly butt joints and provide backup material at joints as required to prevent leakage and fins. Provide gaskets for wall forms to prevent concrete paste leakage at their base.
4. Place chamfer strips in forms to bevel edges and corners permanently exposed to view, except top edges of walls, and slabs which are indicated on Drawings to be tooled. Do not bevel edges of formed joints and interior corners unless indicated on Drawings. Form beveled edges for vertical and horizontal corners of equipment bases. Unless otherwise indicated on Drawings, make bevels 3/4 inch wide.
5. Provide temporary openings at bases of column and wall forms and other points as required for observation and cleaning immediately before concrete is placed.
6. Where runways are required for moving equipment, support runways directly on the formwork or structural members. Do not allow runways or supports to rest on reinforcing steel.
7. Use smooth forms on formed concrete surfaces required to have smooth form finish or rubbed finish as specified in Section 03345 - Concrete Finishing.
8. Rough forms may be used on formed concrete surfaces indicated to have rough form finish as specified in Section 03345 - Concrete Finishing.

B. Forms for Surfaces Requiring Smooth Form Finish:

1. Drill forms to suit ties used and to prevent leakage of concrete mortar around tie holes. Uniformly space form ties and align in horizontal and vertical rows. Install taper ties, if used, with the large end on the wet face of the wall.
2. Provide sharp, clean corners at intersecting planes, without visible edges or offsets. Back up joints with extra studs or girts to maintain true, square intersections.

3. Form molding shapes, recesses and projections with smooth-finish materials and install in forms with sealed joints to prevent displacement.
 4. Form exposed corners of beams and columns to produce square, smooth, solid, unbroken lines.
 5. Provide exterior exposed edges with 3/4-inch chamfer or 3/4-inch radius.
 6. Arrange facing material in orderly and symmetrical fashion. Keep number of joints to practical minimum. Support facing material adequately to prevent deflection in excess of allowable tolerances.
 7. For flush surfaces exposed to view in completed structure, overlap previously-placed hardened concrete with form sheathing by approximately 1 inch. Hold forms against hardened concrete to maintain true surfaces, preventing offsets or loss of mortar.
- C. Forms for Surfaces Requiring Rubbed Finish: Provide forms as specified in paragraph 3.01B, Smooth Form Finish. Use smooth plywood or fiberboard linings or forms, in as large sheets as practicable, and with smooth, even edges and close joints.
- D. Edge Forms and Screed Strips for Slabs: Set edge forms or bulkheads and intermediate screed strips for slabs to obtain required elevations and contours in finished slab surface. Provide and secure supports for types of screeds required.
- E. Circular Forms: Set forms in one piece for full height of member.
- F. Surfaces to Receive Membrane Waterproofing: Coordinate surface finish, anchors, reglets and similar requirements with membrane waterproofing applicator.
- G. Fireproofing Steel Member: Construct forms to provide not less than the concrete thickness necessary, measured from face of steel member, to provide the required fire rating. Forms for concealed surfaces may be unlined.
- H. Tolerances:
1. Unless noted otherwise on Drawings, construct formwork so concrete surfaces will conform to tolerance limits listed in Tables 03100A and 03100B at end of this Section.
 2. Establish sufficient control points and benchmarks as references for tolerance checks. Maintain these references in undisturbed condition until final completion and acceptance of the work.
- I. Adjustment of Formwork:

1. Use wedges or jacks to provide positive adjustment of shores and struts. After final inspection and before concrete placement, fasten in position wedges used for final adjustment of forms.
2. Brace forms securely against lateral deflections. Prepare to compensate for settling during concrete placement.
3. For wall openings, construct wood forms that facilitate necessary loosening to counteract swelling of forms.

J. Corrugated Fiberboard Carton Forms:

1. Place on smooth firm bed of suitable material to prevent vertical displacement; set tight to prevent horizontal displacement. Exercise care to avoid buckling of forms. Install in accordance with manufacturer's directions and recommendations.
2. Fit carton forms tightly around piles and piers; completely fill the space between subgrade and concrete placement with carton forms to form a void space.
3. Protect carton forms from moisture and maintain in a dry condition until concrete is placed on them. If they become wet before placement of concrete, allow them to dry and carefully inspect for strength before concrete is placed.
4. Before concrete placement, replace damaged or deteriorated forms which are incapable of supporting concrete dead load plus construction live loads.

3.02 PREPARATION OF FORM SURFACES

- A. Clean surfaces of forms and embedded materials before placing concrete. Remove accumulated mortar, grout, rust and other foreign matter.
- B. Coat forms for exposed or painted concrete surfaces with form oil or form-release agent before placing reinforcement. Cover form surfaces with coating material in accordance with manufacturer's printed instructions. Do not allow excess coating material to accumulate in forms or to contact hardened concrete against which fresh concrete will be placed. Remove coating material from reinforcement before placing concrete.
- C. Forms for unexposed surfaces, other than retained-in-place metal forms, may be wet with water immediately before concrete placement in lieu of coating. When possibility of freezing temperatures exists, however, the use of coating is mandatory.

3.03 REMOVAL OF FORMS

A. Time Limits:

1. When repair of surface defects or finishing is required before concrete is aged, forms on vertical surfaces may be removed as soon as concrete has hardened sufficiently to resist damage from removal operations.
2. Remove top forms on sloping surfaces of concrete as soon as concrete has attained sufficient stiffness to prevent sagging. Loosen wood forms for wall openings as soon as this can be accomplished without damage to concrete. Leave formwork for water-retaining structures in place for at least 4 days. Formwork for non-water-retaining columns, walls, sides of beams and other formwork components not supporting weight of concrete may be removed after 12 hours, provided concrete has hardened sufficiently to resist damage from removal operations, and provided removal of forms will not disturb members supporting weight of concrete.
3. Forms and shoring supporting weight of concrete or construction loads: Leave in place until concrete has reached minimum strength specified for removal of forms and shoring. Do not remove such forms in less than 4 days.

B. Circular Paper or Spiral Tube Forms: Follow manufacturer's directions for form removal. Take necessary precautions to prevent damage to concrete surface. When removal is done before completion of curing time, replace form, tie in place and seal to retard escape of moisture.**C. Removal Strength:**

1. Control Tests: Suitable strength-control tests will be required as evidence that concrete has attained specified strength for removal of formwork or shoring supporting weight of concrete in beams, slabs and other structural members. Furnish test cylinders and data to verify strength for early form removal.
 - a. Field-cured Test Cylinders: When field-cured test cylinders reach specified removal strength, formwork or shoring may be removed from respective concrete placements.
 - b. Laboratory-cured Test Cylinders: When concrete has been cured as specified for structural concrete for same time period required by laboratory-cured cylinders to reach specified strength, formwork or shoring may be removed from respective concrete placements. Determine length of time that concrete has been cured by totaling the days or fractions of days, not necessarily consecutive, during which air temperature surrounding concrete is above 50 degrees F and concrete

has been damp or thoroughly sealed against evaporation and loss of moisture.

2. Compressive Strengths: The minimum concrete compressive strength for removal of formwork supporting weight of concrete is 75 percent of specified minimum 28-day strength for class of concrete involved.

3.04 RESHORING

- A. When reshoring is permitted, plan operations in advance and obtain the Owner's Representative's approval of such operations. While reshoring is under way, keep live load off new construction. Do not permit concrete in any beam, slab, column or other structural member to be subjected to combined dead and construction loads in excess of loads permitted for developed concrete strength at time of reshoring.
- B. Place reshores as soon as practicable after form-stripping operations are complete but in no case later than end of day on which stripping occurs. Tighten reshores to carry required loads without over stressing construction. Leave reshores in place until tests representative of concrete being supported have reached specified strength at time of removal of formwork supporting weight of concrete.
- C. Floors supporting shores under newly-placed concrete: Leave original supporting shores in place, or re-shore. Locate reshores directly under shore position above. Extend reshoring over a sufficient number of stories to distribute weight of newly-placed concrete, forms and construction live loads in such manner that design superimposed loads of floors supporting shores are not exceeded.

3.05 FORM REUSE

- A. Do not reuse forms that are worn or damaged beyond repair. Thoroughly clean and recoat forms before reuse. For wood and plywood forms to be used for exposed smooth finish, sand or otherwise dress concrete contact surface to original condition or provide form liner facing material. For metal forms, straighten, remove dents and clean to return forms to original condition.

TABLE 03100A

TOLERANCES FOR FORMED SURFACES CONCRETE IN BUILDINGS**

VARIATION FROM	VARIATION IN	FOR ANY 10-FOOT LENGTH	FOR ANY 20-FOOT LENGTH OR ANY BAY	MAXIMUM FOR ENTIRE DIMENSION
PLUMB OR SPECIFIED BATTER	Lines And Surfaces of Columns, Piers, Walls And Arrises	1/4"	---	1"
	Exposed Corner Columns, Control Joint Grooves, And Other Conspicuous Lines	---	1/4"	1/2"
LEVEL OR SPECIFIED GRADE	Slab Soffits, Ceilings, Beam Soffits, And Arrises (Measured Before Removal of Shores)	1/4"	3/8"	3/4"
	Exposed Lintels, Sills, Parapets, Horizontal Grooves And Other Conspicuous Lines	---	1/4"	1/2"
DRAWING DIMENSIONS	Position of Linear Building Lines, Columns, Walls, And Partitions	---	1/2"	1"
	Size And Location of Sleeves, Floor Openings And Wall Openings	---	---	±1/4"
	Cross Section of Columns, Beams, Slabs, And Walls	---	---	+1/2", -1/4"
	Footings* in Plan	---	---	+2", -1/2"
	Footing Misplacement or Eccentricity in Direction of Error (The Lesser Of)	---	---	2% OF WIDTH OR 2"
	Footing Thickness Decrease	---	---	5%
	Footing Thickness Increase	---	---	NO LIMIT
	Step Rise in Flight of Stairs	---	---	±1/8"
	Step Tread in Flight of Stairs	---	---	±1/4"
	Consecutive Step Rise	---	---	±1/16"
Consecutive Step Tread	---	---	±1/8"	

* Footing tolerances apply to concrete dimensions only, not to positioning of vertical reinforcing steel, dowels, or embedded items.

** Includes water and wastewater process structures.

TABLE 03100B
TOLERANCES FOR FORMED SURFACES
CONCRETE IN BRIDGES, WHARVES AND MARINE STRUCTURES

VARIATION FROM	VARIATION IN	MAXIMUM
PLUMB OR SPECIFIED BATTER	Surfaces of columns, piers and walls	1/2" in 10'
LEVEL OR SPECIFIED GRADE	Top surfaces of slabs	See Section 03345
	Top surfaces of curbs and railings	3/16" in 10'
DRAWING DIMENSIONS	Cross section of columns, caps, walls, beams and similar members	+1/2", -1/4"
	Thickness of deck slabs	+1/4", - 1/8"
	Size and location of slab and wall openings	± 1/2"
	Footings in plans	+2", -1/2"
	Footing misplacement or eccentricity in direction of error (the lesser of)	2% of Width or 2"
	Footing thickness decrease	5%
	Footing thickness increase	No Limit
	Step rise in flight of stairs	±1/8"
	Step tread in flight of stairs	±1/4"
	Consecutive step rise	±1/16"
	Consecutive step tread	±1/8"

END OF SECTION