SECTION 031000

CONCRETE FORMING AND ACCESSORIES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. The drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This section covers design, construction, treatment of formwork to confine and shape concrete to the required dimensions, and formwork accessories.

B. Related Sections:

1. 013300 – Submittal Procedures
2. 014500 – Structural Testing, Inspection, and Quality Assurance
3. 032000 – Concrete Reinforcing
4. 033000 – Cast-in-Place Concrete
5. 033713 – Shotcrete
6. 033800 – Post-Tensioned Concrete

1.3 REFERENCE STANDARDS

A. The latest versions of the publications listed below form a part of this Specification; comply with provisions of these publications except as otherwise shown or specified.

1.	ACI 117	Standard Specification for Tolerances for Concrete
2.	ACI 301	Standard Specifications for Structural Concrete, including other standards referred to in ACI 301, such as ASTM, etc.

1.4 SUBMITTALS

A. Formwork Shop Drawings: Submit the following in accordance with Section 013300, "Submittal Procedures":

1. Formwork shop drawings sealed by an engineer licensed to perform the work in the jurisdiction where the project is located.
2. Calculations for formwork, reshoring, and backshoring sealed by an engineer licensed to perform the work in the jurisdiction where the project is located.
3. Exposed Concrete Surfaces: Show the general construction of forms including jointing, formed joints or reveals, form tie locations, and pattern of form placement, and other items that affect the exposed concrete visually.
4. Formwork Facing Materials: Data on form facing materials proposed for smooth-form finish.

B. Product Data: Include specifications and installation instructions for proprietary materials and items as required, including formwork release agents, form liners, manufactured form systems, form ties, and accessories.

C. Construction and Contraction Joints: Submit the location of construction and contraction joints proposed if different from those indicated in the Contract Documents.

D. Testing for Formwork Removal: Data on method for determining strength of concrete for removal of formwork when a method other than field-cured cylinders is proposed.

E. Formwork Removal Plans: Detail plans for formwork removal operations when removal of forms at concrete strengths lower than that specified is proposed.

F. Reshoring and Backshoring Plans: When reshoring or backshoring is required or permitted, submit procedures and plans of operations, before use, sealed by an engineer licensed to perform the work in the jurisdiction where the project is located.

G. Slab Survey Information: In accordance with Article 1.5.G of this Section. Survey results shall be submitted to the Architect/Engineer within 24 hours.

1.5 QUALITY ASSURANCE

A. Design and construction of concrete formwork is the responsibility of the Contractor. Design and construct formwork to furnish only those lines and shapes indicated on drawings, unless otherwise approved by Architect. Construct formwork for erection in satisfactory sequence and removal without damage to the resulting concrete surface.

B. Professional Engineer Qualifications: A professional engineer who is registered in the jurisdiction where the project is located and who is experienced in providing engineering services of the kind indicated.

C. Allowable Tolerances: Variations from plumb and designated building lines shall not exceed the tolerances specified in ACI 117.

D. Inspections: Refer to Section 014500, "Structural Testing, Inspection, and Quality Assurance," for inspection requirements performed by Owner’s Testing Agency.

E. Embedded Items: Where items, such as embedded plates, reglets, anchors, fastenings, conduit, piping and other items are supplied by other trades and specified elsewhere in the Contract Documents, coordinate and obtain approval of their placement in the forms prior to placing any concrete.

F. Forms for Reuse: Where applicable, construct and erect forms for reuse; withdraw all projecting nails and other objects from contact surfaces before reusing; clean and completely recondition all forms prior to reuse. Obtain approval for form reuse from Owner's Inspector; formwork with patches and repairs affecting the appearance of concrete surfaces will not be allowed.

G. Slab Survey: The Contractor shall provide a slab survey of points on the slabs as noted in Figure 1 and Table 1 of Appendix A of this Section. This survey shall meet a tolerance of 1/8 inch. Survey points shall be marked on the slab in such a way that they can be identified but are not visible in the finish surface.

1. Prepour Survey:
    a. This survey shall establish constructed elevations of the formwork.
    b. The survey points should be taken at nine locations per bay in accordance with Figure 1 of Appendix A.
    c. Survey results shall follow the format in Table 1 of Appendix A.

2. Post-Poured Shored Survey:
    a. This survey shall establish constructed elevations of the concrete before removal of shoring.
    b. The special inspector shall test the floor in accordance with Specification Section 033000, "Cast-in-Place Concrete".
    c. Survey results shall follow the format in Table 1 of Appendix A.

3. Post-Poured Unshored Survey:
   a. This survey shall establish slab elevations of the concrete after removal of shoring. For all levels, the survey shall be conducted within 72 hours after removal of shoring and then again 28 days after removal of shoring. Additional surveys may be required.
   b. Survey results shall follow the format in Table 1 of Appendix A.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Form-Facing Materials: Materials for form faces in contact with concrete shall meet the following requirements unless otherwise specified in the Contract Documents.

1. Rough Form Finish: No form-facing material is specified.
2. Smooth Form Finish: Use plywood, tempered concrete form-grade hardboard, metal, plastic, paper, or other acceptable materials capable of producing the desired finish. Form-facing materials shall produce a smooth, uniform texture on the concrete. Do not use form-facing materials with raised grain, torn surfaces, worn edges, patches, dents, or other defects that will impair the texture of concrete surfaces. Set the facing materials in an orderly and symmetrical arrangement, and keep the number of seams to a practical minimum.

B. Formwork Accessories: Use commercially manufactured formwork accessories that are partially or wholly embedded in concrete, including ties and hangers. Do not use non-fabricated wire form ties. Where noted in the Contract Documents, use form ties with integral water barrier plates in walls.

C. Formwork Release Agents: Use commercially manufactured formwork release agents that will prevent formwork absorption of moisture, prevent bond with concrete, and not stain the concrete surfaces.

D. Expansion Joint Filler: Premolded expansion joint filler shall conform to ASTM D994, ASTM D1751, or ASTM D1752.

E. Other Embedded Items: Use waterstops, sleeves, inserts, anchors, reglets, dovetail anchor slots, and other embedded items of the material and design indicated in the Contract Documents.

2.2 PERFORMANCE AND DESIGN REQUIREMENTS

A. Design and engineering of formwork shall be the responsibility of the Contractor.

B. Design formwork, shores, reshores, and backshores to carry all loads transmitted to them and to comply with the requirements of the applicable building code. Design formwork to withstand the pressure resulting from placement and vibration of concrete and to maintain specified tolerances.

C. Do not use earth cuts as forms for vertical or sloping surfaces unless required or permitted by Contract Documents.

D. Maximum deflection of facing materials reflected on concrete surfaces exposed to public view shall be L/240 of the span between structural members of the formwork.

E. Formed Construction: Locate and form construction joints that least impair the strength of the structure. Unless otherwise specified or permitted, locate and detail formed construction joints to the following requirements:

1. Locate construction joints within the middle third of the spans of slabs, beams, and girders. When a beam intersects a girder at this point, offset the joint in the girder a distance equal to or greater than twice the width of the beam.
2. Locate joints in walls and columns at the underside of floors, slabs, beams, or girders and at the tops of footings or floor slabs.
3. Make joints perpendicular to the main reinforcement.
4. Provide keyways as indicated in the Contract Documents.

2.3 FABRICATION AND MANUFACTURE

A. Formwork shall be tight to prevent loss of mortar from concrete.

B. Place 3/4-inch minimum chamfer strips in the corners of formwork to produce beveled edges on permanently exposed surfaces unless otherwise specified. Do not bevel re-entrant corners or edges of formed joints of concrete unless specified in the Contract Documents.

C. Provide temporary openings at the base of column and wall formwork and at other points where necessary to facilitate cleaning and inspection. Arrange such openings in sides of forms where concrete surfaces will be concealed by other materials or construction. Clean and inspect immediately before concrete is placed.

D. Fabricate form ties so ends or end fasteners can be removed with minimum spalling at the faces of concrete.

E. Locate waterstops in joints where indicated in the Contract Documents. Use pieces of pre-molded waterstop with a maximum practical length to hold the number of end joints to a minimum. Make joints in waterstops in accordance with the manufacturer's recommendations.

PART 3 - EXECUTION

3.1 CONSTRUCTION AND ERECTION OF FORMWORK

A. At construction joints, lap contact surface of the form sheathing for flush surfaces exposed to view over the hardened concrete in the previous placement by 1 inch minimum. Ensure formwork is held firmly against hardened concrete to prevent offsets or loss of mortar at construction joints and to maintain a true surface.

B. Construct formwork so concrete surfaces conform to the tolerance limits of ACI 117.

C. Provide positive means of adjustment (wedges or jacks) for shores and struts. Make adjustments in the formwork prior to concrete placement. Fasten form wedges in place after final adjustment of forms. Brace formwork securely against lateral deflection and lateral instability.

D. Camber formwork to compensate for anticipated formwork deflections. Set formwork and intermediate screed strips for slabs accurately to produce designated elevations and contours of the finished surface. Ensure that edge forms and screed strips are sufficiently strong to support vibration screeds or roller pipe screeds when the finish specified requires the use of such equipment.

E. When formwork is cambered, set screeds to a like camber to maintain required concrete thickness.

F. Anchor formwork to shores, supporting surfaces, or members to prevent upward or lateral movements of the formwork system during concrete placement.

G. Construct formwork for wall openings to facilitate removal and to counteract swelling of wood formwork.

H. Place sleeves, inserts, anchors, and embedded items required for adjoining work or form support of adjoining work before concrete placement.

I. Position and support expansion joint materials, waterstops, and other embedded items to prevent displacement. Fill voids in sleeves, inserts, and anchor slots temporarily with readily removable material to prevent entry of concrete into voids.

J. Clean surfaces of formwork and embedded materials of mortar, grout, and foreign materials before concrete is placed.

K. Cover surfaces of formwork with an acceptable material that will prevent bond with the concrete. A field-applied formwork release agent or a factory-applied liner may be used. If a formwork release agent is used, apply following these guidelines:

1. Apply to the surfaces of the formwork in accordance with the manufacturer's recommendations before placing reinforcing steel.
2. Do not allow formwork release agent to puddle in the forms.
3. Do not allow formwork release agent to make contact with reinforcing steel or hardened concrete against which fresh concrete is to be placed.

3.2 REMOVAL OF FORMWORK

A. When finishing is required, remove forms as soon as removal operations will not damage concrete.

B. Remove top forms on sloping surfaces of concrete as soon as removal will not allow concrete to sag. Perform needed repairs or required treatments at once, and follow immediately with specified curing.

C. Loosen wood formwork for wall openings when this can be accomplished without causing damage to the concrete.

D. Leave formwork and shoring in place to support the weight of concrete in beams, slabs, and in-place structural members until concrete has reached the specified compressive strength. If a lower compressive strength is proposed for removal of formwork and shoring, submit detailed plans for review and acceptance. When shores and other vertical supports are arranged to allow the form-facing material to be removed without loosening or disturbing the shores and supports, the facing material may be removed at an earlier age.

E. Construct formwork to permit easy removal.

3.3 RESHORING AND BACKSHORING

A. During reshoring and backshoring, do not allow concrete in beam, slab, column, or any structural member to be loaded with combined dead and construction loads in excess of the design loads indicated in the Contract Documents at the specified concrete compressive strength.

B. Place reshores and backshores in sequence with stripping operations.

C. Tighten reshores and backshores to carry the required loads without overstressing the concrete members. Leave them in place until required tests indicate the concrete compressive strength has attained the minimum value specified.

D. For floors supporting shores under newly placed concrete, either leave the original supporting shores in place or install reshores and backshores. The shoring system and the supporting slabs shall have capacities sufficient to resist the anticipated loads. Locate reshores and backshores directly under a shore position.

E. Extend reshoring or backshoring over a sufficient number of stories to distribute the weight of newly placed concrete, forms, and construction live loads such that the design loads of the floors supporting the shores, reshores, or backshores are not exceeded.

3.4 STRENGTH OF CONCRETE REQUIRED FOR REMOVAL OF FORMWORK

A. Vertical formwork not supporting the weight of concrete may be removed 24 hours after concrete placement, provided the concrete is hard enough to not be damaged and curing and protection operations are continued.

B. Formwork Supporting Weight of Concrete

1. For conventionally reinforced slabs:
   a. After the concrete has been in place at least 3 days and has reached 75% of required design compressive strength, reshoring will be permitted, provided concrete does not remain unsupported more than 4 hours.
   b. Leave reshoring in place at least 7 days after concrete placement and until concrete design compressive strength is attained.

2. For post-tensioned slabs:
   a. After all prestressing has been applied to carry dead loads and construction loads, reshoring will be permitted.
   b. Leave reshoring in place at least 7 days after concrete placement and until concrete design compressive strength is attained.

C. When removal of formwork or reshoring is based on concrete reaching a specified compressive strength, concrete will be presumed to have reached this strength when test cylinders, field cured the same as the concrete they represent, have reached the compressive strength specified for removal of formwork and/or reshoring. Mold cylinders in accordance with ASTM C31, and cure them under the same conditions for moisture and temperature as used for the concrete they represent. Test cylinders in accordance with ASTM C39.

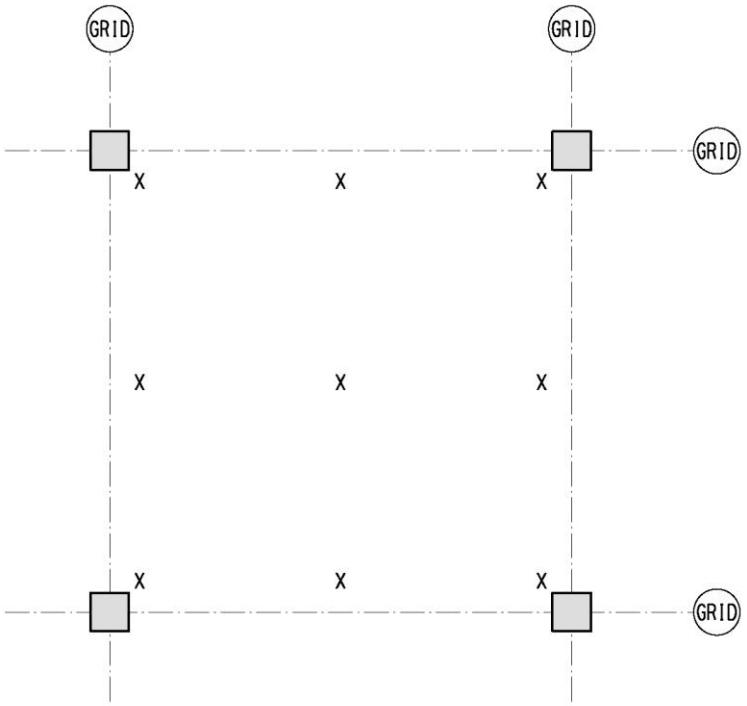
D. Alternatively, one of the following methods for evaluating concrete strength for formwork removal may be used, provided sufficient data is submitted, using project materials, to demonstrate correlation of measurements on the structure with the compressive strength of laboratory-cured molded cylinders or drilled cores. Submit correlation data on the proposed alternative method for determining strength to the Architect/Engineer.

1. Tests of cast-in-place cylinders in accordance with ASTM C873 (limited to slabs with concrete depths from 5 to 12 inches)
2. Penetration resistance in accordance with ASTM C803
3. Pullout strength in accordance with ASTM C900
4. Acceptable maturity-factor procedure in accordance with ASTM C1074
5. Break-off number of concrete in accordance with ASTM C1150

END OF SECTION

APPENDIX A

SLAB SURVEY FIGURE 1.



TYPICAL SLAB BAY

X - SURVEY POINT 1, 2, ..., ETC

SAMPLE SURVEY
FORMAT TABLE 1

ELEVATION	PRE POUR DATE	POST POUR-SHORED DATE	UNSHORED DATE	PRE POUR POST POUR-SHORED Δ	UNSHORED Δ
POINT 1					
POINT 2					
POINT 3					
POINT					

POST POUR-SHORED EL
-UNSHORED EL

PRE POUR EL
-POST POUR-SHORED EL