

SECTION 03 10 00

CONCRETE FORMWORK

PART 1 - GENERAL

1.1 GENERAL

Work of this Section shall conform to requirements of Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification sections

1.2 SCOPE

Provide all labor, materials, equipment, services and transportation for formwork and related accessories required to complete all cast-in-place concrete work and the installation of embedded items as shown on Drawings, as specified herein, and as required by the job conditions.

1.3 RELATED WORK SPECIFIED IN OTHER SECTIONS

|                                                |                  |
|------------------------------------------------|------------------|
| Submittals                                     | Division 1       |
| Quality Control                                | Division 1       |
| Thermal and Moisture Protection                | Division 7       |
| Concrete Reinforcement and Embedded Assemblies | Section 03 20 00 |
| Cast-in-Place Concrete                         | Section 03 30 00 |

1.4 CODES AND STANDARDS

A. Building Code: Concrete work shall conform to the requirements of the Building Code identified on the Structural General Notes, and OSHA requirements, except where more stringent conditions or criteria occur in the standards referenced below and on the drawings.

B. Standards:

1. ACI 117 – Standard Specifications for Tolerances for Concrete Construction and Materials.
2. ACI 301 – Standard Specification for Structural Concrete.
3. ACI 318 – Building Code Requirements for Reinforced Concrete.
4. ACI 347 – Guide to Formwork for Concrete.
5. ACI 347.2R – Guide for Shoring/Reshoring of Concrete Multistory Buildings
6. American Society for Testing and Materials "ASTM Standards in Building Codes", various standards as referenced herein, latest edition.
7. PS 1 – United States Voluntary Product Standard for Construction and Industrial Plywood, latest edition.
8. SEI/ASCE 37 – Design Loads on Structures during Construction.

C. Definitions:

1. The term "Contract Documents" in this specification is defined as the design drawings and the specifications.
2. The term "SER" in this specification is defined as the Structural Engineer of Record for the structure in its final condition.
3. The term "Design Professionals" in this specification is defined as the Owner's Architect and SER.
4. The term "Contractor" in this specification is defined to include any of the following: General Contractor and their sub-contractors, Construction Manager, Concrete Contractor and their sub-contractors.
5. The term "Owner Testing Agency" in this specification is defined as an independent testing and inspection service engaged by the Owner for quality assurance observation and testing of concrete construction in accordance with applicable building code provisions and any additional activities listed in the Contract Documents.
6. The terms "for record" and "submit for record" in this specification are defined as Contractor submittals that do not require a response from the Design Professionals.
7. Working Days: Monday through Friday, excluding federal or state holidays.

## 1.5 QUALITY ASSURANCE

- A. Design Criteria: Formwork shall conform to American Concrete Institute's "Recommended Practice for Concrete Formwork" (ACI 347) and California Code of Regulations, Title 24, Part 2 (CBC) Chapter 19
  1. Formwork:
    - a) Shall prevent leakage or washing out of cement mortar.
    - b) Shall resist spread, shifting, and settling.
    - c) Shall reproduce accurately required lines, grades, and surfaces within tolerances specified.
  2. Safety: The Contractor shall be responsible for adequate strength and safety of all formwork including falsework and shoring.

## 1.6 CONTRACTOR QUALIFICATIONS

- A. The work of this section shall be performed by a company which specializes in the type of concrete formwork required for this Project, with a minimum of 10 years of documented successful experience and shall be performed by skilled workers thoroughly experienced in the necessary crafts.
- B. Contractor's Testing Agency Services: Required as specified in Division 1, and herein.
- C. Materials and installed work may require testing and retesting at anytime during progress of work, as directed by Design Professionals. Tests, including retesting of rejected materials for installed work will be done at Contractor's expense.

## 1.7 SUBMITTALS

- A. Where the SUBMITTALS section of this specification is in conflict with Division 1 Submittals, the more stringent requirements for the Contractor apply. Do not submit items not requested.

1. Submittal Schedule: See Section 03 30 00.
2. Formwork Shop Drawings:
  - a) Submit for Record: Formwork shop drawings sealed and signed by a registered design professional licensed to practice as a Professional Engineer in the state where the project is located. Shop drawings shall clearly indicate but not be limited to the following:
    - i. Size, type and quality of form materials including conditions at tops and ends of walls. (If wood is used, indicate species.)
    - ii. Form construction indicating structural stability and jointing including special form joints or reveals required by Contract Documents
    - iii. Location and pattern of form tie placement, and other items that affect the appearance of concrete that will remain exposed to view.
    - iv. Form finish clearly indicating proper locations and full coordination with concrete finishes required by Contract Documents.
    - v. Comprehensive (a single drawing per area/element) layout drawings showing openings in structural members, including floor slab, shearwalls, columns and beams. Drawings shall consolidate the work of all trades and shall be coordinated by the Contractor. Submit with or prior to reinforcement submittal for same element/area.
  - b) Submit for Review
    - i. Location of proposed construction joints in walls, floors, slabs, beams per specification Section 03 30 00.
3. Shoring/Reshoring Calculations: Submit for Record. Calculations sealed and signed by a registered design professional licensed to practice as a Professional Engineer in the state where the project is located. Calculations shall clearly address but not be limited to the following:
  - a) Shoring removal and reshoring installation procedure including timing and sequencing.
  - b) Concrete age and strength at the time of each shoring/reshoring operation.
  - c) Description of construction loads assumed including concrete, formwork, and construction live load in accordance with ACI 347.
  - d) A description of the distribution of construction loads between the shored/reshored levels.
  - e) The total construction load imposed on all levels supporting shoring/reshoring at each stage of the shoring/reshoring cycle.
  - f) A written statement by the Structural Professional Engineer that the total construction load imposed on any level supporting shoring/reshoring, at all stages of the shoring/reshoring cycle, accounting for concrete age and relative strength at time of loading, meets the requirement of Section 3.2.
4. Product Data - Submit copies of manufacturers' product data and installation instructions for proprietary materials used in exposed concrete work, including form liners, release agents, manufactured form systems, ties, and accessories.
5. Samples - At request of Architect, submit samples of form ties and spreaders

6. Compatibility Certification - Submit for record a written statement certifying that form release agent used is compatible with subsequent architectural finish materials applied to concrete surfaces. Submit along with manufacturer's data.
7. Asbestos and PCB Certification: Submit for record. After completion of installation, but prior to Substantial Completion, Contractor shall certify in writing that products and materials installed, and processes used, do not contain asbestos or polychlorinated biphenyls (PCB), using format in General Conditions.
8. Hazardous Materials Notification: Submit for record. In the event no product or material is available that does not contain hazardous materials as determined by the Owner, a "Material Safety Data Sheet" (MSDS) equivalent to OSHA Form 20 shall be submitted for that proposed product or material prior to installation.

- B. Submittal Process: See Section 03 30 00
- C. SER Submittal Review: See Section 03 30 00
- D. Substitution Request: See Section 03 30 00
- E. Request for Information (RFI): See Section 03 30 00

## 1.8 FORMWORK DESIGN

- A. Design of Formwork, Shoring/Reshoring, and its removal is the Contractor's responsibility.
- B. Design, erect, support, brace and maintain formwork so that it will safely support vertical and lateral loads per SEI/ASCE 37 that might be applied, until such loads can be supported by the concrete structure.
- C. Design Requirements:
  1. Forms shall be designed for fabrication and erection in accordance with Design Professionals' requirements and recommendations of ACI 301, 318 and 347.
  2. Design formwork in a manner such that the total construction load does not at any time exceed the total design load of new or existing construction and accounts for concrete age and relative strength at time of loading. See Section 3.2 for shoring/reshoring requirements.
  3. Design formwork for loads and lateral pressures outlined in Section 2.2, ACI 347, and wind and seismic loads as specified by SEI/ASCE 37-02 unless otherwise controlled by local building code.
  4. Design formwork to include loads imposed during construction, including weight of construction equipment, concrete mix, height of concrete drop, rate of filling of formwork, vibrator frequency, ambient temperature, foundation pressures, lateral stability, temporary imbalance or discontinuity of building components, and other factors pertinent to safety of structure during construction.

## 1.9 QUALITY ASSURANCE BY OWNER'S TESTING AGENCY

- A. General: The Owner's Testing Agency shall inspect concrete formwork as Work progresses. Failure to detect any defective work or material shall not in any way prevent later rejection when such a defect is discovered, nor shall it obligate Design Professionals for final acceptance.
- B. Testing Agency shall provide qualified personnel at site to inspect formwork using the latest Contract Documents and approved shop drawings as follows:

1. Prior to placement of reinforcement, inspect formwork for grade, quality of material, absence of foreign matter, and other imperfections that might affect suitability of concrete placement and tolerances stated herein.
  2. Inspect forms for location, configuration, compliance with specified tolerances, block outs, camber, shoring ties, seal of form joints and compliance with Contract Documents.
  3. Verify condition of bond surfaces, locations and sizes of all accessories, embedment items, and anchorage for prevention of displacement.
  4. Verify proper use/application of form release agents.
  5. Inspect concrete surfaces immediately after removal of formwork and prior to any patching or repair work.
- C. Submit inspection, observation, and/or test reports to the Design Professionals and provide an evaluation statement in each report stating whether or not concrete formwork conforms to the requirements of Specifications and Drawings. Specifically note deviations.
- D. Immediately report deficiencies to the Contractor. Contractor shall correct the deficiency at no cost to the Owner.
- 1.10 DELIVERY, HANDLING, STORAGE
- A. Comply with General Conditions and Division 1, including the following:
1. Store forms and form materials clear of ground and protect from damage.
  2. Deliver and store packaged materials in original containers with seals unbroken and labels intact until time of use.
- 1.11 JOB CONDITIONS
- A. Sequencing Schedule:
1. Ensure timely delivery of embedded items. Be responsible for cutting and patching necessitated by failure to place embedded items.
  2. Plan erection and removal to permit proper sequence of concrete placing without damage to concrete.
- 1.12 WARRANTY
- A. Comply with General Conditions, agreeing to repair or replace specified materials or Work that has failed within the warranty period. Failures include but are not limited to the following:
1. Discoloration of concrete scheduled to remain exposed to view.
  2. Damage of concrete finishes caused by forms.
  3. Damage of concrete caused by form stripping.
  4. Non-compliance with form finishes required for designated architectural finishes.
  5. Non-compatibility of form release agent with subsequent architectural finish materials applied to concrete surfaces.
  6. Excessive and/or noticeable bowing in placed concrete members caused by deflection of formwork during concrete placement.

## **PART 2 - PRODUCTS**

### **2.1 ACCEPTABLE MANUFACTURERS**

- A. Products of the manufacturers specified in this section establish the minimum functional, aesthetic and quality standards required for work of this section.
- B. Substitutions: Comply with General Conditions using form in Division 1.

### **2.2 FORMWORK REQUIREMENTS**

- A. General Requirements:
  - 1. Formwork shall meet construction safety regulations for locality in which this Project is located.
  - 2. Forms shall be removable without impact, shock or damage to concrete surfaces, the structure and adjacent materials.
  - 3. Forms shall be tight-fitting, designed and fabricated for required finishes and to withstand concrete weight and maintain tolerances as specified in ACI 117 for the following designations: (See architectural drawings for locations).
    - a) Class A – For surfaces prominently exposed to public view where appearance is of special importance.
    - b) Class B – Coarse-textured concrete-formed surfaces intended to receive plaster, stucco or wainscoting.
    - c) Class C – General Standard for permanently exposed surfaces where other finishes are not specified.
    - d) Class D - Minimum quality surface where roughness is not objectionable, usually applied where surfaces will be concealed.
  - 4. Furnish forms in largest practicable sizes to minimize number of joints and to conform to joint system shown on drawings, using form materials with sufficient thickness to withstand pressure of newly-placed concrete without bow or deflection.
  - 5. Butt Joints: Shall be solid and complete with backup material to prevent leakage of cement paste.
- B. Form Finishes for Exposed Surfaces:
  - 1. Type: Straight, smooth, free of cement paste leaks at butt-joints, surface imperfections and other irregularities detrimental to appearance of finished concrete, fully coordinated with requirements for required finish material.
  - 2. Form exposed areas of columns, beams, ledges, balcony fascias to achieve true alignment and level soffit of spandrel beams and concrete edges. All such areas must be sharp, straight and true to line and level. Spandrel beams and concrete canopies and ledges must have adequate shoring to prevent any visible amount of sag and sufficient bracing to prevent any lateral movement during construction.

### **2.3 FORM MATERIALS**

- A. General: Plywood, fiberglass, metal, metal-framed plywood faced, or other acceptable panel-type materials.
  - 1. Provide materials with sufficient strength to prevent warping.

- B. Plywood: Of species and grade suitable for intended use, sound undamaged sheets with clean true edges.
  - 1. Panel Forms: Minimum 5/8-inch thick exterior grade plywood with sealed edges, United States Voluntary Product Standard for Construction and Industrial Plywood (PS 1) grade Plyform Class I and II B-B Exterior or APA HDO Exterior.
  - 2. Board Forms: Shiplap or tongue and groove lined with PS 1 grade Plyform Class I and II Exterior 1/2-inch or APA HDO Exterior 1/2-inch or 3/16-inch thick fiberboard, Class I or II as per strength requirements.
  - 3. Other Acceptable Sheet Materials: 14 gauge sheet steel or fibrous glass reinforced resin.
  
- C. Forms for Exposed Finish Concrete: Plywood, metal, metal-framed plywood faced, or other acceptable panel-type materials, to provide continuous, straight, smooth, exposed surfaces. Furnish in largest practicable sizes to minimize number of joints and to conform to joint system shown on Drawings.
  
- D. Lumber: Construction grade or better Douglas Fir without loose knots for other defects.
  - 1. Use only where entire width can be covered with one board 11-1/4" or less in width.
  
- E. Forms for Cylindrical Columns and Supports: Metal, glass-fiber reinforced plastic, or paper or fiber tubes that will produce smooth surfaces without joint indications.
  - 1. Provide units with sufficient wall thickness to resist wet concrete loads without deformation.
  - 2. Columns Forms: SONOTUBE or equal product substituted per Section 01 25 00, and as required for other configurations
  
- F. Pan-Type Forms: Glass-fiber-reinforced plastic or formed steel, stiffened to support weight of placed concrete without deformation.
  - 1. Pan Joist forms: Provide removable forms, Ceco Corporation or equal. Forms shall have adequate strength to maintain their shape during placing of concrete and shall permit easy removal without damage to concrete surfaces. Forms shall be true to shape, free from bulges, tears or other damage, and shall be free from oil, grease, paint, dirt or other deleterious coatings. Forms shall fit close, tight and straight. Forms shall be cleaned up before reuse.
  
- G. Chamfer for Form Corners:
  - 1. Types: Chamfer strips of wood, metal, PVC or rubber fabricated to produce smooth form lines and tight edge joints, 3/4" size, maximum possible lengths.
  - 2. Required for all exposed corners of beam, walls and column forms.
  
- H. Form Ties:
  - 1. Type: Factory-fabricated metal, adjustable length, designed to prevent form deflection and to prevent spalling concrete upon removal.
  - 2. Ties used for architecturally exposed concrete shall be galvanized.
  - 3. Ties shall not leave metal closer than 1-1/2" to exposed surface.

4. When removed, ties shall not leave holes larger than 1" diameter in concrete surface. Ties shall not leave fractures, spalls, depressions, or other surface disfigurations greater than 3/4-inch.
  5. Removable Ties: Use type with tapered cones, 1" outside diameter, for concrete walls which will remain exposed to view and scheduled for architectural finishes.
  6. Snap-Off Ties: Use for concrete walls below grade and walls which will not remain exposed to view and are not scheduled for architectural finishes.
  7. Wire Ties: Not acceptable.
- I. Nails, Spikes, Lag Bolts, Thru-Bolts, Anchorages:
1. Type: Of size, strength and quality to meet the required quality of formwork.
- J. Expansion Joint Filler:
1. Fiber Type: Premolded asphalt-impregnated fiber, ASTM D1751, 1/4-inch thick unless otherwise noted. Same as W. R. Meadows, Inc.'s "Sealtight Fiber Expansion Joint"; Grace Construction Materials "Serviced Fiber Expansion Joint Filler, Code 1390"; National Expansion Joint Co.'s "Fiber Joint Filler No. 12"; Burke Concrete Accessories, Inc.'s "Burke Fiber Expansion Joint"; or equal product substituted per Section 01 25 00.
  2. Cork Type: Preformed cork, ASTM D1752, Type II, 1/4-inch size unless otherwise noted. Same as W. R. Meadows, Inc.'s "Sealtight Cork Expansion Joint"; Sonneborn-Contech's "Sonoflex Cork"; Grace Construction Materials' "Serviced Standard Cork Expansion Joint Filler, Code 4323; or equal product substituted per Section 01 25 00.
- K. Form Sealer: Same as Nox-Crete's "Pre-Form HB", L&M Construction Chemical's "Form Life," or equal product substituted per Section 01 25 00.
- L. Form Release Agent:
1. Type: Commercial formulation form release agent of non-emulsifiable type which will not bond with, stain, or adversely affect concrete surfaces. Form release agent shall not impair subsequent treatment of concrete surfaces requiring bond or adhesion, or impede the wetting of surfaces to be cured with water or curing compounds. Form release agent shall be compatible with subsequent architectural finish materials applied to concrete surfaces. Apply in compliance with manufacturers' instructions.
  2. Form release agent shall meet, at a minimum, all federal requirements for volatile organic compounds (VOC's). Form release agent shall meet the requirements of CalGreen Section 5.504.4.3.
  3. For Steel Forms: Non-staining rust-preventative type.
- M. Reglets: Provide sheet metal reglets formed of same type and gauge as flashing metal, unless indicated otherwise on Drawings. Where resilient or elastomeric sheet flashing, or bituminous membranes are terminated in reglets, provide reglets of not less than 26 gauge galvanized sheet metal. Fill reglet or cover face opening to prevent intrusion of concrete or debris.
- N. Coordinate with materials as specified in Section 03 20 00: Concrete Reinforcement and Embedded Assemblies.



## 2.4 SOURCE QUALITY CONTROL

- A. Plywood shall bear American Plywood Association's "Guide to Plywood Grades" (APA) grade-trademark.

## PART 3 - EXECUTION

### 3.1 FORMWORK

#### A. General:

1. Inspect areas to receive formwork.
  - a) Immediately report to Owner's Testing Agency and Design Professionals in writing the conditions that will adversely affect the Work.
  - b) Verify that excavations are sufficient to permit placement, inspection and removal of forms.
  - c) Verify that excavations for earth forms have been neatly and accurately cut.
  - d) Verify that conditions are otherwise proper for formwork construction.
2. Do not start work until unsatisfactory conditions have been corrected.
3. Construct forms to sizes, shapes, lines, and dimensions shown on Contract Documents, and to obtain accurate alignment, location, grades, level and plumb work in finished structures.
4. Provide 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, and to maintain alignment.
5. Provide for openings, offsets, sinkages, keyways, recesses, moldings, rustications, reglets, drips, bevels, chamfers, blocking, screeds, bulkheads, anchorages and inserts and other features required in the Work.
6. Comply with shop drawings, ACI 301, 318, 347 and Contract Documents.
7. Maintain formwork and finished work construction tolerances complying with ACI 301, 117, and 347.
8. Provide shore and struts with positive means of adjustment capable of taking up formwork settlement during concrete placing operations, using wedges or jacks or a combination thereof.
9. Erect forms for easy removal without hammering or prying against concrete surfaces.
10. Provide crush plates or wrecking plates where stripping may damage cast concrete surfaces.
11. Provide top forms for inclined surfaces where slope is too steep to place concrete with bottom forms only.
12. Kerf wood inserts for forming keyways, reglets, recesses, and the like, to prevent swelling and for easy removal.
13. Chamfer exposed corners and edges as indicated, using wood, metal, PVC or rubber chamfer strips fabricated to produce smooth lines and tight edge joints.
14. Design, erect, support, brace and maintain formwork and shoring to support loads until such loads can be safely supported by the concrete structure.
15. Where specifically shown on the Contract Documents as monolithic, upturned beams, curbs and similar members in connection with slabs shall be formed so that they can be poured integrally with slabs.

#### B. Walls and Other Formed Elements:

1. Erect outside forms for exposed exterior walls first and obtain the Architect's approval before reinforcement is placed. Obtain Architect's approval of the reinforcement before interior form is erected.
2. Carefully align inside and outside forms before tightening ties.
3. Plywood Forms: Insure vertical joints are plumb and horizontal joints are level; arrange joints and ties in geometrical pattern as approved by the Architect.
4. Form inside corners at exposed conditions with mitered boards or plywood so that no concrete is placed against form ends.
5. After erection, seal all cracks, holes, slits, gaps, and apertures in forms so that they will withstand the pressure and will remain completely watertight.
6. Provide a means to seal the bottom of forms at construction joints such as foam tape or other gasket devices.
7. Apply a coating of release agent prior to the erection of formwork. Follow approved manufacturer's recommendations.

**C. Formwork Loads on Grade**

1. Where loads from formwork bear on grade, provide suitable load-spreading devices for adequate support and to minimize settlement. In no event shall frozen ground or soft ground be utilized directly as the supporting medium.

**D. Earth Forms:**

1. Construct wood edge strips at top sides of excavations.
2. Provide forms for footings wherever concrete cannot be placed against solid earth excavation.
3. Remove loose dirt and debris prior to concrete pours.
4. Foundation concrete may be placed directly into neat excavations provided the foundation trench walls are stable as determined by the Geotechnical Engineer, subject to the approval of UCSDU.
  - a) The horizontal dimensions of unformed concrete footings shall be increased 1 inch at every surface at which concrete is placed directly against the soil where foundation details shown on plans do not show three-inch (3") clear minimum to the reinforcing steel.
  - b) The minimum formwork shown on the drawings is mandatory to ensure clean excavations immediately prior to and during the placing of concrete.

**E. Footings and Grade Beams:**

1. Provide forms for footings and grade beams if soil or other conditions are such that earth trench forms are unsuitable.

**F. Slab Forms:**

1. Establish levels and set screeds.
2. Depress slabs where required to receive special floor finishes.

**G. For slabs-on-grade, secure edge forms in such a manner as to not move under weight of construction loads, construction and finishing equipment, or workers**

**H. Concrete Accessories and Embedded Items:**

1. Obtain necessary information for coordination of formwork with items to be embedded in concrete and other relate work.

2. Install into forms concrete accessories, sleeves, inserts, anchor bolts, anchorage devices and other miscellaneous embedded items furnished by other trades or that are required for other work that is attached to or supported by cast-in-place concrete.
    - a) Use setting drawings, diagrams, instructions and directions provided by suppliers of items to be attached.
  3. Install reglets to receive top edge of foundation sheet waterproofing and to receive through-wall flashings in outer face of concrete frame at exterior walls, where flashing is shown at lintels, relieving angles, and other conditions.
  4. Install dovetail anchor slots in concrete structures as indicated on drawings or required by other trades.
  5. Forms for Slabs: Set edge forms, bulkheads, and intermediate screed strips for slabs to achieve required elevations and contours in finished surfaces.
  6. Coordinate with Section 03 20 00 Concrete Reinforcement and Embedded Assemblies.
  7. Install accessories and embedded items straight, level, plumb and secure in place to prevent displacement by concrete placement.
  8. Use templates to ensure accurate placement of anchor bolts, inserts, and other embedded items.
- I. Temporary Openings:
1. Locate temporary openings in forms at inconspicuous locations.
  2. For clean-outs and inspection before concrete placement, locate temporary openings where interior area of formwork would otherwise be inaccessible.
  3. For cleaning and inspections, locate openings at bottom of forms to allow flushing water to drain.
  4. Securely brace temporary openings and set tightly in forms to prevent loss of concrete.
  5. Close temporary openings with tight fitting panels, flush with inside face of forms, neatly fitted so that joints will not be noticeable on exposed concrete surfaces.
- J. Provisions for Other Trades: Coordinate and provide openings in concrete formwork to accommodate work of other trades.
1. Determine size and location of openings, recesses, chases, offsets, openings, depressions, and curbs from information provided by trades requiring such items.
  2. Accurately place and securely support items built into forms.
- K. Cleaning:
1. Normal Conditions
    - a) Thoroughly clean forms and adjacent surfaces to receive concrete.
    - b) Remove chips, wood, sawdust, dirt, standing water or other debris just before placing concrete.
    - c) Flush with water or use compressed air to remove remaining foreign matter.
    - d) Verify that water and debris can drain from forms through clean-out ports.
  2. During Cold Weather:
    - a) Remove ice and snow from within forms.

- b) Do not use de-icing salts.
- c) Do not use water to clean out completed forms, unless formwork and concrete construction will proceed within heated enclosure.
- d) Use compressed air or other means to remove foreign matter.

**L. Form Release Agents**

- 1. Before placing reinforcing steel and miscellaneous embedded items, coat contact surfaces of forms with an approved non-residual, low VOC form release agent in accordance with manufacturer's published instructions.
- 2. Do not allow release agent to accumulate in forms or come into contact with reinforcement or concrete against which fresh concrete will be placed.
  - a) Coat steel forms with nonstaining, rust-preventative material.
- 3. Remove form release agent and residue from reinforcement or surfaces not requiring form coating.

**M. Before Placing Concrete:**

- 1. Inspect and check completed formwork, shoring and bracing to ensure that work is in accordance with formwork requirements of this section and Contract Documents, and that supports, fastenings, wedges, ties, and parts are secure.
  - a) Make necessary corrections or adjustment to formwork to meet tolerance requirements.
- 2. Retighten forms and bracing before concrete placement to prevent mortar leaks and maintain proper alignment.
- 3. Notify Owner's Testing Agency sufficiently in advance of placement of concrete to allow inspection of completed and cleaned forms.

**N. During Concrete Placement:**

- 1. Maintain a check on formwork to ensure that forms, shoring, ties and other parts of formwork have not been disturbed by concrete placement methods or equipment.
- 2. Use positive means of adjustment as required for formwork settlement during concrete placing operations.

**O. Camber:**

- 1. Provide camber in formwork as required for anticipated deflections due to weight and pressures of fresh concrete and construction loads.
- 2. Camber bottom forms where indicated on the drawings. Whenever forms are cambered, screeded levels for establishing top of concrete must be cambered to the same amount and to the same profiles such that scheduled depth of member is not reduced by lifting of forms. Check camber and adjust forms before initial set as required to maintain camber.

**P. Expansion Joints:**

- 1. Provide in exterior concrete paving on grade at maximum 24-feet on center or as noted and at intersections with vertical surfaces, curbs, manholes or other penetrations through paving.
- 2. Use fiber type expansion joint fillers typically and depress 1/4-inch unless otherwise noted.

3. Use cork type expansion joint fillers at conditions with non-bituminous waterproofing, liquid waterproofing or sealant systems

**Q. Construction Joints:**

1. Provide where shown on the drawings as directed by the Architect and per CBC Section 1906.4.
2. Provide key indentations at all joints.
3. Provide pour strips on inside face of forms at horizontal joints, but remove strips and thoroughly clean out reglets before placing subsequent portions of wall.
4. Prevent formations of shoulders and ledges.
5. Provide means for drawing forms into firm contact with concrete before placing additional concrete over previous pours where shrinking and warping has separated concrete from forms.

**R. Surface Defects:**

1. Install forms that will not impair the texture of the concrete and are compatible with the specified finish type.

**3.2 SHORES AND RESHORES**

**A. Comply with ACI 347.2R for shoring and reshoring in multistory construction, and as specified herein.**

1. For non-post tensioned flat plate concrete structures of five supported levels or more, extend shoring/reshoring at least four levels below the floor or roof being placed (shore formwork, reshore three levels below)
2. For non-post tensioned flat plate concrete structures of less than five supported levels, extend shoring/reshoring to ground.
3. For all other concrete structures of four supported levels or more, extend shoring/reshoring at least three levels below the floor or roof being placed (shore formwork, reshore two levels below)
4. For all other concrete structures of less than four supported levels, extend shoring/reshoring to ground.
5. For shoring/reshoring placed on mud sills, adjustments shall be made by contractor to account for ground settlement.
6. Locate shores/reshores such that the factored (ultimate) construction load imposed onto any slab or beam at any time during the construction cycle does not exceed 90% of the factored (ultimate) design load for that slab or beam, scaled down to reflect effect on capacity of lower concrete strength at time of loading.
7. Construction load shall include the weight of wet concrete, total weight of formwork and shoring/reshoring, and a minimum construction live load of 50 psf (increase if construction operations will produce higher loading). Design load includes self weight of the slab, and superimposed dead and live loads as indicated on the drawings.
8. For comparison of construction loads to design loads, compare factored (ultimate) construction loads to factored (ultimate) design loads. Use the same load factors for the construction load that were used for the design of the slabs.
9. For flat plate or flat slab construction "backshores" or "preshores" as defined in ACI 347 shall be permitted only if appropriate calculations and construction sequences are provided demonstrating that the accumulation of shore loads will not overload any slab. In the absence of such calculations and construction sequences, shores must be removed and reshores installed in a sequence such

that each floor is permitted to deflect and carry its own weight prior to the installation of reshores.

10. Reshores shall not be removed until the concrete has attained its specified 28 day strength.
11. Two levels of shoring or one level of shores over one level of reshores shall be maintained below any newly cast level until it has attained design strength and is at least 28-days old.

**B. General**

1. Adequately brace and maintain shoring to safely support vertical, lateral, and asymmetrical loads until completed structure has attained design strength.
2. Distribute shoring loads over area where shoring is erected and protect against undermining or settlement.
3. Provide means for making vertical adjustments to compensate for settlement either before or during placing of concrete.
4. Construct shores for soffits of beams to permit removal of forms without removing shores.
5. Reshoring will be permitted. Shores and reshores shall be designed by a Civil Engineer registered in the State of California and installed under his/her direction. This Civil Engineer shall be employed by the Contractor.

**3.3 REMOVING FORMS**

- A. Secure the Architect's approval for time and sequence of form removal.
- B. Formwork not supporting weight of concrete, such as sides of beams, walls, columns, and similar parts of the work, may be removed after cumulatively curing at not less than 50°F (10°C) for 12 hours after placing concrete, provided concrete is sufficiently hard to avoid damage by form-removal operations, and provided curing and protection operations are maintained after removal of formwork.
- C. Formwork supporting weight of concrete, such as beam soffits, joists, slabs, and other structural elements, may not be removed until concrete has attained at least 75% of design compressive strength as proven by cylinder test . If stripping occurs before [3] days, 100% strength must be achieved.
  1. Results of the cylinder break shall be presented to the Architect to demonstrate compliance with above specified strength requirements prior to form removal.
  2. Provide reshores as required per ACI 347.
  3. Determine potential compressive strength of in-place concrete by testing field-cured specimens representative of concrete location or members
- D. Remove formwork progressively using methods to prevent shock loads or unbalanced loads from being imposed on structure. Forms shall be removed without damage to the concrete. Comply with ACI 347.
- E. Loosen forms carefully. Do not wedge pry bars, hammers, or tools against concrete surfaces.
- F. Reshore structural members where required due to design requirements, construction requirements, or construction conditions.
  1. Reshore on same day shoring and forms are removed.

- G. Whenever formwork is removed during the curing period, the exposed concrete shall be cured per requirements of Section 03 30 00.
- H. All wood formwork, including that used in void spaces, pockets and other similar places shall be removed.
- I. Form tie holes shall be filled as per approved samples submitted to the Architect and Engineer.
- J. The Contractor shall assume responsibility for all damage due to removal of the forms.

### **3.4 RE-USING FORMS**

- A. Before forms can be re-used, surfaces that will be in contact with freshly poured concrete must be thoroughly cleaned, damaged areas repaired, projecting nails withdrawn, and forms must be straight and free from dirt or hardened concrete.
  - 1. Split, frayed, delaminated or otherwise damaged form-facing material will not be acceptable.
  - 2. Apply new form release agent on re-used forms.
- B. When forms are extended for successive concrete placement, thoroughly clean surfaces, remove fins and laitance, and tighten forms to close joints. Align and secure joints to avoid offsets. Reuse of formwork with repairs or patches which would result in adverse effects to architectural concrete finish will not be permitted.
- C. Forms for exposed concrete may be reused only if the surfaces have not absorbed moisture and have not splintered, warped, discolored, stained, rusted or peeled, subject to acceptance by the Design Professionals. The Design Professionals reserve the right to require the Contractor to remove and reconstruct such formwork as will produce subsequent areas that are acceptable. Do not use "patched" forms for exposed concrete surfaces, unless approved by the Design Professionals.
- D. Clean and repair any damage caused by placing, removal, or storage.
- E. Store formwork in manner to prevent damage or distortion.
- F. Reseal as required to achieve concrete of specified quality.

END OF SECTION