

Basis of Design

This section applies to the design and installation of cast-in-place concrete, shotcrete, precast concrete, and post-tensioned concrete.

Design Criteria

- Use most recent version of the International Building Code (IBC) with local municipality amendments. Referenced standards include American Concrete Institute (ACI) standards.
- Concrete mix designs shall be approved by the local municipality in addition to complying with all the requirements of this section.
- Concrete strength shall be not less than 3,000 psi at 28 days.
- Shotcrete shall meet the requirements found in the most current applicable Seattle Department of Planning And Development (DPD) Director's Rule. This requirement applies to all UW properties. (This Director's rule contains beneficial information that the UW wishes to apply to all sites.)
- Structural precast members shall be designed by the engineer of record. Precast stairs may be fabricator designed.
- Key construction joints for shear transfer and extend reinforcing through joint.
- Provide keyways at all construction joints and provide continuous waterstops at all joints exposed to weather or below grade. Take special care in design and specifying waterstops for conditions below the water table.
- Dowels shall be provided at each construction joint to lap with all reinforcing in the adjoining member. This includes: each curtain of wall reinforcing, top and bottom slab and beam reinforcing, and all column reinforcing.
- Slab temperature steel shall be provided each way throughout all slabs. Provide each way top and bottom for slabs greater than or equal to 8" thick.
- Provide corner bars to match all horizontal wall and longitudinal footing reinforcing.
- Where main slab bars are parallel to a support, specify a minimum of #4 @ 12" oc top bars extending a minimum of 2'-0" beyond the face of support into the slab. Specify a 90° standard hook into support where the slab is on one side only.
- In structural steel construction with steel deck and concrete fill, specify a minimum of #4 @ 12" oc top over steel members that are parallel to the steel deck. Extend bars a minimum of 2'-0" beyond the edge of the member flange. This will mainly occur over steel girders.
- Beams and girders shall be uniform in size and spacing.
- Provide the maximum reuse of forms for all cast-in-place concrete work. This requires repetition of design features throughout the project.
- Column cross section shall be constant for two stories, minimum. Change column cross section with an inside face setback. Circular free standing columns shall be of a constant diameter at each story. Reinforce with spiral hoops. Isolated column ties are unacceptable for circular columns.
- Dimensions of columns and beam sides shall be in multiples of 2 inches.

- Slope the top of all exposed concrete surfaces and provide cast-in drips at cantilevered leading edges.
- Special design attention shall be given to the long term effects of member shortening and creep cambering of pre or post-tensioned members.
- Provide chart on the structural drawings that clearly indicates each type of concrete used on the project. Include the following minimum information: strength, minimum cement content, maximum Water/Cement (W/C) ratio, air-entraining requirements and where each type of concrete is to be used.
- Specify low water/cement ratio for concrete to reduce potential shrinkage cracks.
- Provide chart on the structural drawings that clearly lists the minimum required lap lengths for each bar size and for each concrete strength.
- Chloride containing admixtures are not allowed.
- Admixtures either accelerating or retarding set times without water reduction are discouraged.
- Water reducing admixtures can be used to increase slump and workability without increasing mix water.
- The use of superplasticizers shall be considered to temporarily increase mix fluidity whenever strength dictated low water/cement ratios interfere with successful placement and consolidation. Applications include pumped concrete placement and in thin section construction where shrinkage must be minimized.
- Specify air entrainment admixtures for all slabs exposed to weather. Do not use with high-early strength type III cement.
- Consider specifying fly ash as a Portland cement replacement of up to 30% of the weight of the concrete.
- Sealers: The purpose of sealers is to protect exterior concrete from damage by water and to protect the window glazing from chemical leeching of the concrete.
- Use silica fume in concrete for all ramps greater than or equal to 5% grade.
- Epoxy and powder driven type fasteners are not allowed for tension applications.
- See Mechanical – Piping, Valves and Accessories for pipe sleeves and Link Seals or approved substitution.

Design Evaluation

The following information is required to evaluate the design:

- Schematic Design Phase: Provide schematic plan indicating typical concrete framing. Outline specifications.
- Design Development Phase: Provide framing plans, schedules, and typical concrete details. Draft specifications.
- Construction Document Phase: Complete design and specifications.

Construction Submittals

- Shop drawings for reinforcing steel and post-tensioning
- Concrete mix designs
- Grout mix design for bonded post-tensioning
- Formwork shop drawings
- Stamped engineering calculations and shop drawings for fabricator designed non-structural (or stair) precast.
- Product data: For each type material indicated.
- Submit a jointing plan to the Architect for approval.

Quality Assurance

- Provide inspection of all concrete, reinforcing steel and PT placement, PT stressing, and curing procedures by an independent testing lab.

Related Sections

- Facilities Services Design Guide - General Requirements - Structural
- Facilities Services Design Guide - Shoring
- Facilities Services Design Guide - Foundations
- Facilities Services Design Guide - Slab on Grade
- Facilities Services Design Guide - Sub-Grade Walls
- Facilities Services Design Guide - Structured Floors
- Facilities Services Design Guide - Roofs
- Facilities Services Design Guide - Thermal and Moisture Protection
- Facilities Services Design Guide - Finishes
- Facilities Services Design Guide - Piping, Valves and Accessories
- Facilities Services Design Guide - Hangers and Supports - Mechanical

Products, Materials and Equipment

- Cement: ASTM Designation C-150.
- Aggregates: Clean and natural crushed Steilacoom gravels complying with ASTM Designation C-33. Maximum size: not to exceed 1/5 of the minimum concrete section or $\frac{3}{4}$ of the clear distance between reinforcing bars.
- Reinforcing: Deformed bars shall be ASTM 615 or A 706 as required. Welded wire fabric shall be ASTM 185 furnished in flat sheets only.
- Water: Potable quality, free from oils, acids and injurious amounts of organics or salts.

- Air Entrainment Admixture: Vinsol-resin type.
- Waterstops: Flexible or self-expanding type.
- Extruded polystyrene that will remain in place permanently as a filler under concrete shall be specified as 40 psi minimum.
- Concrete mix batch weights and bulk specific gravity determinations shall be required for all selected aggregates based on saturated surface dry (SSD) conditions. This mix information must be sufficient to verify through absolute volume calculations the concrete's yield, cement factor, water/cement ratio and mortar to voids ratio as a primary basis for mix acceptance.
- Mix ingredients and proportions shall be such as to work readily into corners and around reinforcing without segregation and undue shrinkage while achieving the specified strength. Final mix shall be based on either laboratory test batches or field experience with standardized mixes.

Installation, Fabrication and Construction

- Forms may be of wood, steel or fiberglass. Exposed surfaces shall be equal in appearance to that of plywood. Forms shall be mortar-tight and sufficiently strong and rigid to resist deformation.
- Form ties shall be steel rods of adequate strength, providing a minimum 1-inch break back from the surface.
- Form all vertical footing surfaces. Remove all water from form work - by pump from an outside sump, if necessary. Forms shall be true, rigid, tight and clean.
- Job site application of a superplasticizer shall be monitored by the testing lab.
- Ready-mix concrete shall be utilized whenever locally available. Fully executed and signed trip tickets shall accompany each load and shall be recorded by the inspector at the job site at the time of entry. Re-tempering of concrete or adding water without authorization is unacceptable.
- All reinforcement and embedded items shall be securely fastened, inspected, and approved by the inspector before pouring operations may be started.
- Discharge of concrete shall be within 1 ½ hours, or before the drum has revolved 300 revolutions, whichever comes first, after the introduction of the mixing water to the cement and aggregates or the introduction of the cement to the aggregates. (This is an excerpt from the American Society for Testing and Materials (ASTM) C 94)
- Vibrate concrete in its final location to a uniform and homogeneous mass. Vibration by means of approved portable vibrators shall be done only to the degree necessary to produce a dense well-compacted concrete free from honeycomb and voids. The contractor must have available at all times at least one spare vibrator equal in performance to that in service.
- Existing concrete surfaces to receive new concrete shall be cleaned, roughened and coated with bonding agent prior to new concrete placement.
- Maintain the temperature of the concrete at 50° F or above for the entire curing period.
- Cure all concrete for a minimum period of 7 days after placing the concrete.

- The Contractor may leave the formwork in place for the curing period and provide moisture-retaining covers over any exposed concrete. Moisture-retaining covers: Waterproof paper, polyethylene film or polyethylene-coated burlap meeting the requirements of ASTM C 171.
- If the formwork is removed before the 7-day curing period has elapsed, the concrete must be thoroughly wetted and a moisture-retaining cover provided. Place the cover in the widest practical width with sides and ends lapped at least 3 inches and sealed by waterproof tape or adhesive
- If the temperature is expected to exceed 75° F for the two days following placement of the concrete, loosen the forms as soon as it can be done without damage to the concrete. Apply water continuously using soil-soaker hoses and allow to run down the inside of the forms.
- Cure building concrete slabs using liquid membrane-forming curing compound complying with ASTM C 309, Type 1-D, Class B, with fugitive dye. The curing compound shall be water-based acrylic. Solvent-based curing compounds shall not be used. The curing compound shall be applied to the surface of the concrete as soon as the bleed water evaporates from the surface of the concrete, and finishing procedures are complete. The total amount of material applied on the surface shall be at the rate recommended by the manufacturer. Two applications at right angles to each other shall be provided.
- Cure shotcrete walls using liquid membrane-forming curing compound as specified for building concrete slabs.
- Do not use curing compounds on surfaces that are to receive additional concrete, paint or tile, unless it has been demonstrated that the membrane-curing compound can serve as a base for the later application. Verify that the curing compound is compatible with finish materials. If the curing compound hinders positive bond, remove it (by sandblasting, etc.) after a 7-day curing period, or cure the concrete using water curing or by sealing with moisture retaining cover.
- Curing compounds are not allowed on slabs in laboratories and mechanical rooms and slabs over electrical rooms. Provide water curing only.
- Forms shall be removed at such time and manner to guarantee the safety of the structure. Primary supports for elevated slabs shall not be removed before 28 days in the case of regular concrete usage. Other mix ingredients may affect this time and any primary shoring removal shall be verified by break strength tests of at least two job cured cylinders. Equivalent strength of fly ash concrete may require up to 58 days to cure properly.
- Where post-tensioned construction is allowed per Section 3H, the structural engineer shall determine the minimum length of time needed for the post-tensioned slabs to cure, after the post-tensioning forces are applied, prior to casting any adjacent pour strips. The absolute minimum length of time shall be 28 days. The structural engineer shall determine what length of time over and above 28 days is needed in order to minimize cracking and assure proper performance of the post-tensioning system. It is crucial that the contractor or CMGC schedule this time into the construction schedule.
- Finishing shall follow immediately upon form removal and patching. Finish all exposed concrete walls as follows and note on drawings:
 - 1) Class A: Provide a dry surface honed to a uniformed and even color and texture. Follow by a wet bagged (burlap) rub with 1 part Portland cement and 1 ½ parts fine sand. When dry, remove excess grout with a second sacking.
 - 2) Class B: Remove irregularities by chipping and grinding. After wetting, sack as describe for Class A finish above.

- Specify that the design and camber of the formwork to maintain levelness (or camber if a cambered system) after the weight of the wet concrete is introduced is the contractor's responsibility. Contractor shall adjust formwork as required prior to subsequent pours if necessary to meet floor tolerances specified.
- A Special Formwork Survey shall be performed by the contractor for all areas of structured floors where the center to center of supports is greater than or equal to 35 feet. At a minimum, survey at the mid-span of each member. Conduct and document the survey at the following stages of construction at a minimum:
 - 1) Immediately prior to pouring concrete, survey bottom of soffit form.
 - 2) One day after concrete pour, survey top of concrete and bottom of soffit form.
 - 3) One day after removal of all shores and reshores, survey top of concrete.

These survey values will enable the contractor and structural engineer to determine what movement is due to the formwork system settling (crushing) and what movement is due to structural deflection after the temporary vertical supports are removed. Contractor is to review each survey immediately to verify the assumptions made for their formwork design and make adjustments if necessary. Require, prior to subsequent pour, that the contractor submit in writing that they have reviewed the survey and describe what modifications, if any, they are incorporating to improve the results for subsequent pours.

- Submit results of Special Formwork Survey within 3 days of shore and reshore removal. Submit results in the form of a plan with the elevations clearly noted for each survey point. Submit copies to owner, architect and structural engineer.

END OF DESIGN GUIDE SECTION