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Structural

A. General Requirements

1. **Design Live Load.** Provide key plans of each building level that clearly indicates the design live load used for each different area including the roof. Indicate if live load reduction is utilized in the design. This information will assist the University during future tenant improvements etc.
2. **Structural Details.** The structural engineer is required to design all the structural details for the building. Fabricator/contractor designed details are not allowed. The use of "Similar" details is discouraged. If "Similar" details are used where appropriate, then specifically indicate on the detail just what is "similar" about it.
3. **Congested Spaces.** Provide "study" type building sections to illustrate how the installed work of all the disciplines fits into congested spaces. An example would be to show how the structure, fireproofing, ceiling, ductwork, cable trays, sprinkler piping etc. fits into a lab corridor space using the available floor-to-floor height. Show how the layering of the mechanical and electrical system are accessible for maintenance and repair etc.
4. **Penetrations.** Coordinate penetrations through structural members due to other trades.
5. **Building Envelope Maintenance Equipment.** Coordinate building envelope maintenance equipment: including swing stage anchors/loads and fall arrest anchors etc.
6. **Vibration and Acoustics.** Coordinate vibration and acoustic requirements due to mechanical or other equipment.
7. **Site Vault Lids.** Site vault lids shall be designed to support HS 20 wheel loads.

B. Seismic Improvements and Building Modifications

1. Seismic Studies

a. **Study Components.** Seismic study shall include copy of evaluation checklists, structural calculations, and prioritized list of deficiencies to be corrected.
b. **Submittal Timing.** Seismic studies shall be submitted to Engineering Services for review and discussion at a design team meeting prior to issuing final report.

2. Seismic Upgrades

a. **URM Buildings.** In Unreinforced Masonry (URM) Buildings, where the roof and floor structure is supported by a URM wall, provide secondary structure to support the vertical loads of the roof and floor members. This includes support of all the floor and roof structure including joists, beams, girders, rafters etc.
b. **Essential Facilities.** For hospital and other essential facilities utilize the following Enhanced Rehabilitation Objective: Immediate Occupancy Performance Level (1-B) at BSE-1 Earthquake Hazard Level, and Collapse Prevention Performance Level (5-E) at BSE-2 Earthquake Hazard Level.

c. **Existing Structural Defects.** All existing structural defects discovered during design, demolition, and construction shall be repaired. This includes patching of spalls at exposed rebar in slabs, beams, and columns.
d. **Campus Studies.** In addition to the drawings maintained in Campus Engineering Records, the University has completed structural analysis studies of some of the buildings on campus. Also, in October 1991, the Earthquake Readiness Advisory Committee (ERAC) at the University of Washington issued a report detailing its findings of its campus-wide seismic hazards survey. The purpose of the ERAC report was to establish a consistent set of rules to prioritize which existing buildings needed further seismic analysis. The ERAC report also prioritized existing buildings according to Damage Index numbers and Life Safety Index numbers and recommended a number of facilities that should have further detailed seismic analysis performed by a licensed structural engineer. A pdf copy of the ERAC report is available from Engineering Services.

3. Modifications to Existing Buildings

a. **Renovated Structures.** The resulting structure shall be at least as strong as or stronger than before the modifications. In no case shall the structure be weakened by the modifications. This applies to both gravity loads as well as lateral (seismic and wind) loads.
b. **Lateral Load Strength.** Re-establish lateral load strength of the building if wall penetrations are cut into shear walls.
c. **Diaphragm Effects.** Analyze lateral load diaphragm effects if floor or roof penetrations are significant.
d. **Existing Structural Defects.** All existing structural defects discovered during design, demolition, and construction shall be repaired. This includes patching of spalls at exposed rebar in slabs, beams, and columns.

C. Foundations, Shoring, Slab on Grade, Sub-Grade Walls, Tunnels

1. Foundations

a. **Montlake Landfill.** Structures located on the Montlake Landfill that are supported on piling need to have the piling extend down to the underlying firm clay layer in order to avoid additional loading on the refuse and peat.
b. **Drilled Piers.** Concrete placed into drilled piers shall be conveyed in a manner to prevent separation or loss of materials. In no case shall the concrete be allowed to freefall more than 5 feet. Tremie concrete where required.
c. **Temporary Foundations.** Temporary foundations, such as for tower cranes, that are outside the footprint of the building need to be removed.
d. **Utility Tunnels and Clearance.** Locate piling, drilled piers etc. no closer than 3 feet clear from the outside face of existing utility tunnels or vaults.

e. **Utility Tunnels and Loading.** New construction shall not impose any added load or surcharge to the existing utility tunnel or vault walls or lid/top.
f. **Water Table.** If the foundation extends below the water table, demonstrate how the design team will address the issues involved with designing and constructing a structure below the water table. This effort should include, but not be limited to the following:
    i. Temporary dewatering the site for construction.
    ii. Permanent sub-grade wall and/or under slab drainage systems if needed.
    iii. Penetrations through the waterproof membrane for utilities, drainage systems etc.
    iv. Excavation type, laid back or shored, shoring location relative to subgrade walls.
    v. Show how rebar and formwork etc. is to be supported without penetrating the subgrade wall waterproof membrane.
    vi. If Demonstrate the phasing required to account for hydrostatic uplift issues. For example: how much of the building needs to be constructed prior to turning off the dewatering pumps?

2. Shoring

a. **Water Table.** At shoring for structures located below the water table, locate the shoring walls a sufficient distance outside the face of the permanent basement walls to allow for proper installation and inspection of positive-side waterproofing.
b. **Underpinning.** Soldier piles used as underpinning shall be jacked to a load as specified by the engineer of record to preload the piles to prevent settlement of the existing building.
c. **Voids Behind Lagging.** All voids behind lagging shall be filled prior to excavating subsequent lifts. Use material and method that will not interfere with the free drainage system.
d. **Top of Shoring.** Remove top of shoring system a minimum of 3 feet below finished grade. Also remove additional depth as required by the local municipality or adjacent property owner.
e. **Temporary Tiebacks.** De-stress all temporary tiebacks.

3. Slab On Grade

a. **Joints.** Provide joints in all concrete slabs on grade.
b. **Joint Spacing.** Provide control or construction joints on all column lines and at 20’-0” maximum spacing each way in between. Structural engineer to determine closer spacing requirements.
c. **Plans.** Show the location of control and construction joints on the plans.
d. Reinforcement. Reinforce with conventional reinforcing steel each way. Welded wire fabric is not allowed.
e. **Flatness.** Design and specify floors that are engineered and constructed to achieve the following minimum degree of flatness when measured in accordance with ASTM E 1155: Overall FF = 35, Localized FF = 25. Garage floors may be Overall FF = 25, Localized FF = 20.
f. **Levelness.** Design and specify floors that are engineered and constructed to achieve the following minimum degree of levelness when measured in accordance with ASTM E 1155: Overall FL = 25, Localized FL = 17. Garage floors may be Overall FL = 17, Localized FL = 13.
g. **Capillary Breaks.** Provide below slab capillary break at all slabs on grade. Provide additional details and groundwater collection and drainage systems as required for slabs on grade located below the ground water table.

4. Sub-Grade Walls

a. **Material.** Use only concrete construction. Masonry is not allowable.
b. **Wall Length.** Place below-grade building walls in lengths limited to 40 feet.
c. **Retaining Wall Joint Spacing.** Space vertical expansion joints in site concrete retaining walls no more than 20 feet on center. Show specific location of joints on the drawings.
d. **Weep Holes.** Provide 2-inch round weep holes at 10'-0" on center maximum spacing in site concrete retaining walls.
e. **Joint Details.** Include all types of joint details on the drawings.
f. **Waterstops.** Provide waterstops at all construction joints below grade.

5. Tunnels

a. **Wheel Loads.** Design bar grating and hatch at top of utility vault manholes to support HS 20 wheel loads.
b. **Future Loads.** Size all components for piping support racks for the maximum possible loads and forces taking into account future piping.

D. Structured Floors and Roofs

1. Typical Building Floors

a. **Penthouse Floors.** Design penthouse floors to support a live load of 75 PSF or the actual equipment weights, whichever is greater.
b. **Vehicle Loading.** Design areas where trucks, man lifts or other vehicles have access for a minimum of HS20 loading. Design for fire truck loading in all fire lanes and appropriate areas.
c. **Equipment Access.** Design platforms for equipment to provide adequate access for maintenance personnel. This may include the design of catwalks and ladders at or above the main platform level. Design team to coordinate with mechanical design consultant and UW facilities shops on where platforms are needed.
d. **Flatness.** Design and specify floors that are engineered and constructed to achieve the following minimum degree of flatness when measured in accordance with ASTM E 1155: Overall FF = 35, Localized FF = 25.
e. **Levelness.** Design and specify floors that are engineered and constructed to achieve the following minimum degree of levelness when measured in accordance with ASTM E 1155: Overall FL = 25, Localized FL = 17. Note that the use of FL on structured floors is limited to when the slab is still supported in its original as-cast position (still shored) and when the slab has no camber.
f. **Sleeves and Curbs.** Provide sleeve and/or curb at all floor slab penetrations.
g. **Future Loads.** If a floor is designed for a future load, indicate clearly on the plan (or a key plan) the location, footprint, operating weight and move-in pathway as applicable. This may typically apply to future medical or lab equipment.

h. **Shrinkage.** Limit the shrinkage to 0.00030 inches per inch (including all admixtures) in the concrete in garage floor framing. The contractor shall submit shrinkage test results of mix, conducted per ASTM C-157, a minimum of 4 weeks prior to use.
i. **Garages.** Garage floors may be Overall FF = 25, Localized FF = 20.
j. **Pedestrian Bridges**. Design pedestrian bridges to support a minimum live load of 100 PSF. Also coordinate with Project Manager for any equipment loads that may be used on the bridge.
k. **Electrical Rooms.** Design slabs over electrical rooms with micro silica concrete mix or limit shrinkage to 0.00030 inches per inch and add polypropylene fibers. Treat all cracks with Methylmethacrylate.
l. **Post-Tensioned Slabs.** In post-tensioned slabs, provide for a method of permanently identifying each tendon's location on the soffit of the structure for future remodels. Identification shall be a maximum of 10 feet oc. Possible method is by use of ¾" chamfer strips on soffit of forms. Discuss with Project Manager and Engineering Services.
m. **Floating Slabs.** Avoid using "Floating Slabs" i.e., slabs that are acoustically isolated from the structural slab with insulation between the two slabs. These slabs are usually constructed before the building is "closed in" or protected from rain. Consequentially they are exposed to rain which saturates the insulation, making the acoustical performance ineffective and providing a breeding place for mold and mildew. Consult with Engineering Services if floating slabs are considered.

2. Laboratory Building Floors

a. **Live Loads.** Design all floors in new laboratory buildings to support a live load of 100 PSF. In addition, use 30 PSF for equipment load plus 20 PSF uniformly distributed partition load. Do not reduce the live load in the design of the floor slabs, floor beams and floor girders. Consider the equipment load as a live load.
b. **Columns and Footings.** Design the columns and footings to carry the 100 PSF floor live load reduced in accordance with the current building code. Do not reduce the equipment or partition loads.
c. **Shrinkage.** Limit the shrinkage to 0.00030 inches per inch (including all admixtures) in the concrete in the floor framing. The contractor shall submit shrinkage test results of mix, conducted per ASTM C-157, a minimum of 4 weeks prior to use.

3. Vibration

a. **Framing Scheme.** Some buildings on campus contain research instrumentation that is extremely sensitive to vibration. The structural engineer shall select a framing scheme as well as the size and spacing of columns to keep the floor vibrations within the criteria established for the project.
b. **Maximum Vibration.** Basic design is 2000 micro-inches/sec. maximum for lab areas. Refer to building program for more restrictive vibration criteria. Areas of some buildings may require 1000 micro-inches/sec. maximum. Use a walking speed of 100 steps per minute minimum.

4. Roofs

a. **Slope.** Slope the structural roof system to accomplish the roof slopes shown on the drawings. This applies to plaza decks and walkways also.
b. **Snow Load.** Design for a minimum Snow Load of 25 PSF.
c. Flatness. Design and specify roofs that are engineered and constructed to achieve the following minimum degree of flatness when measured in accordance with ASTM E 1155: Overall FF = 25, Localized FF = 20.
d. **Levelness.** Design and specify roofs that are engineered and constructed to achieve the following minimum degree of levelness when measured in accordance with ASTM E 1155: Overall FL = 17, Localized FL = 13. Note that the use of FL on roofs is limited to when the slab is still supported in its original as-cast position (still shored) and when the slab has no camber or slope.
e. **Camber.** Camber structural system as needed to assure positive flow of rainwater. Check for progressive deflection due to ponding.
f. **Dead Load for Re-Roofing.** Design with additional dead load to allow for reroofing once.
g. **Roofs as Future Floors.** If the roof is to be designed as a future floor, detail tops of columns and walls above the roof level for ease of future vertical extensions and to minimize the disturbance to the existing roofing. Clearly indicate on the drawings the extent of future addition that is designed for.
h. **Rooftop Platforms.** Design rooftop elevated platforms for equipment to provide adequate access for maintenance personnel. This may include the design of catwalks and ladders at or above the main platform level. Design team to coordinate with mechanical design consultant and UW facilities shops on where platforms are needed.
i. **Bracing of Rooftop Equipment.** Design for bracing of fume hood exhausts and other items that project above the roof including towers, antennas etc. Arrange guy wires and supports in a manner to minimize aesthetic disturbance.
j. **Window Washing Equipment and Fall Arrest Anchors.** Design for all window washing equipment and fall arrest anchor support.

E. Structural Materials

1. Concrete

a. **Strength.** Concrete strength shall be not less than 3,000 psi at 28 days.
b. **Dowels.** 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.
c. **Slab Temperature Steel.** 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.
d. **Concrete Fill Over Steel Deck.** 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.

e. **Concrete Chart.** 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.
f. **Water/Cement Ratio.** Specify low water/cement ratio for concrete to reduce potential shrinkage cracks.
g. **Ramps.** Use silica fume in concrete for all ramps greater than or equal to 5% grade.
h. **Epoxy and Powder-Driven Fasteners.** Epoxy and powder driven type fasteners are not allowed for tension applications.
i. **Curing.** Curing compounds are not allowed on slabs in laboratories and mechanical rooms and slabs over electrical rooms. Provide water curing only.

2. Reinforced Masonry

a. **Below-Grade.** Do not use masonry below grade.
b. **Control Joints.** Provide control joints in CMU walls and expansion joints in multi-wythe brick walls at a spacing not to exceed 1 ½ x the wall height or 25'-0" whichever is less. Provide vertical and horizontal reinforcing in CMU walls. Wall reinforcing shall not be less than #5 at 48" oc vertical and 2 #4 in horizontal bond beam at 4'-0" oc.
c. **Exterior Wall Metal Accessories.** At exterior walls, all metal accessories shall be stainless steel.

3. Steel

a. **Connection Design**. All connections are to be designed by the engineer of record. Fabricator designed connections are allowed.
b. **Open Web Steel Joists.** Use of open web steel joists is acceptable only for roofs in areas that are not supporting rooftop or suspended units greater than 400 pounds operating weight. Do not utilize open web steel joists to support fall arrest anchors, or loads from fall arrest anchors. Do not utilize open web steel joists for floor construction.
c. **Steel Decking.** Steel decking may be used for garage construction as a form only. Provide reinforcing bars (not WWF) in slab to support 100% of the design loads.
d. **Structural Steel Fabricator.** Structural steel fabricator shall be an AISC-Certified Plant Category Standard (Std). As an alternate to this requirement, the contractor shall pay for full-time inspection during the fabrication of the project steel. This inspection will be conducted at the fabrication plant by the owner's inspection agency.
e. **Button Punching of Side Lap Connections.** Button punching of side lap connections of steel roof deck (where no concrete topping) is not allowed. Provide welded, screwed, or other means to connect side laps.

4. Timber

a. **OSB.** OSB (oriented strand board) is not allowed for floors and roof.
b. **Gluing.** Glue all floor sheathing with minimum 3/16" diameter continuous bead of construction adhesive. Use two continuous beads at abutting panels.