PART III: STRUCTURAL DESIGN

1. SCOPE:

1.1. This part outlines the minimum requirements for the design procedures for structural systems, for new buildings, and repair and alteration projects for existing buildings on the UMB campus.

2. AMERICAN STEEL:

2.1. Only structural steel products manufactured in the United States shall be used or supplied for construction of University buildings. Steel products include all products rolled, formed, shaped, drawn, extruded, forged, cast, fabricated, or otherwise similarly processed from steel made in the United States. Request for deviation from the requirement to use only American steel must be submitted in writing to the UMB Design and Construction Department. Provide a market analysis that demonstrates that the cost of such steel products is unreasonable or inconsistent with the public interest and that the substitution is not in conflict with Federal Grant Regulations affecting the project.

3. CODES AND STANDARDS:

3.1. **Steel Structures:** The A/E shall employ either of the design codes listed below. The particular code used must be indicated on the construction drawings and listed in the specifications, and require a certification that the particular code has been used consistently for all structural steel design and construction.

a. Manual of Steel Construction, Load & Resistance Factor Design, Third Edition, 2001, American Institute of Steel Construction, Inc., herein referred to as "LRFD".

b. Manual of Steel Construction, Allowable Stress Design, Ninth Edition, 1989, American Institute of Steel Construction, Inc., herein referred to as "ASD".

3.2. **Concrete Structures:** The design of concrete structures shall be in compliance with the codes listed in Section 2 and the following codes:

a. Building code requirements for reinforced concrete, ACI 318-02, American Concrete Institute, or current edition at the date for approval of the Design Development phase.

b. Commentary on building code requirements for reinforced concrete, ACI 318-02, American Concrete Institute, or current edition at the date for approval of the design development phase.

4. STRUCTURAL DESIGN:

4.1. At commencement of design, the A/E team and UMB shall review the requirements of the program, foundation and site conditions, budget, materials market and schedule constraints, and develop recommendation(s) for the proposed structural system.

4.2. When multiple structural systems, can be designed for a project, the A/E shall submit documentation to UMB detailing the desirable and undesirable aspects of each proposed system, including estimated costs and schedule impact of each system, as part of the Schematic Design Phase.

4.3. All structural design shall be in accordance with the structural capacity requirements indicated herein as well as with any specific requirement of the project program. All structural loads used for design shall be shown in the construction documents, both on drawings and in the specifications. A graphic column schedule indicating the design loading for all columns shall be included in the structural drawings.

4.4. The A/E shall be responsible for the design of all connections, and shall review for approval the design and detailing of all connections submitted by each fabricator for compliance with the design. All connection design and details, and shop drawing submittals shall bear the hand-signed seal of the responsible registered professional structural engineer licensed in the State of Maryland.

4.5. Except with extraordinary justification, as approved by UMB, pre-stressed and post-tensioned concrete shall not be used in academic buildings. An exception which has precedent in campus building is the use of precast pre-stressed double-T structural members in long-span garages.

4.6. Construction documents shall clearly indicate all requirements for mixing, transport, placement, finishing, curing and testing of structural concrete. Requirements for cutting and patching of structural work during construction shall be defined, including unit costs as applicable. Non-structural fill concrete shall be addressed.

4.7. The material characteristics of concrete require an exceptional effort in coordination of all trades for placement of inserts, penetrations, clearances, etc. All details shall be titled to indicate both the subject of the drawing and its location(s) within the structure. Uncoordinated standard structural details without direct application to specific conditions in the project will not be permitted.

4.8. All structural construction documents, including shop drawings for connections and details, shall bear the hand-signed seal of the responsible structural engineer registered in the State of Maryland.

5. STRUCTURAL CAPACITY AND NOTATION:

5.1. Building Code Requirements: Building code requirements for floor and roof structural live loading shall be the minimum criteria for all building design. The minimum design loading shall be increased for institutional use as required herein or in the project program, or upon direction of the UMB. Specific consideration shall address the weight of special equipment and/or operations, as well as the control of vibration and/or deflection to meet operational requirements.

5.2. University Specific Live Load Requirements: Desired flexibility for re-use and consideration of long-term durability requires the following design and construction structural capacity for specific building functional types:

a. Live Loads: Generally, minimum floor live loads for all occupancies including administration, except parking and residential projects built by others, shall be 80 psf (pounds/square foot) with maximum deflection of L/360. In this, particular attention shall be given special equipment needs and Code requirements for corridors, stairs and assembly rooms which may require 100 psf. Live loading for wet laboratory floor plates shall be a uniform minimum 100 psf, with maximum deflection of L/750, including corridors, toilet rooms, building support, and office/ conference/teaching

areas, in order to provide flexibility across the entire floor plate for future renovations and/or changes in equipment. Concentrated laboratory support and equipment areas shall be designed as specifically required for initial occupancy with 100 psf as the minimum capacity.

b. **Building Systems Rooms:** Include equipment penthouses, mechanical equipment and switchgear rooms, elevator machine rooms, emergency power equipment, and similar facilities, shall have a minimum live load capacity of 150 psf with maximum allowable deflection of L/750.

c. **Pads:** Housekeeping pads, nominally four (4) inches high, shall be separated from the structural system and not contribute to the design capacity of the floor.

d. **Roof Areas:** Roof areas designated for equipment shall have a minimum live load of 150 psf, plus 30 psi snow load, or as required by Code.

e. **Parking Decks:** Parking Decks shall have a minimum live load of 50 psi with maximum deflection of L/360. Areas of decks over occupied space shall have an additional capacity of 50 psf to accommodate suspended ceilings, lighting, ductwork, sprinklers, etc. Roof areas used for parking should have an additional 30 psf for snow loading.

5.3. The designed structural capacity of all floor levels and structural systems, including equipment support, shall be noted on the drawings. Include a “Column Schedule”, showing column loading arrayed according to floor and foundation elevations shall be included.

5.4. Load bearing masonry walls and piers shall specifically note the minimum bearing capacity, as well as noting any lateral loading, in psf required of construction.

5.5. Concrete is the preferred roof deck material. All roof decks shall be designed and built with a positive slope to drain locations in excess of one quarter (1/4) inch per foot. Unless the roof level is intended for future build-out as an occupied floor, the slope shall be provided by the structure. As an exception, positive slope may be provided by tapered foam glass insulation at crickets and around equipment pads. Poured gypsum roof decking shall not be used.

5.6. At the Design Development Phase, an experienced professional structural engineer shall inform the University concerning the following:

a. Flexibility in future remodeling and/or limitations on adaptive re-use.

b. Possible fatigue and maintenance inherent in long-term, post twenty (20) and forty (40) year utilization.

c. Durability and other considerations relevant to institutional use.

6. FOUNDATIONS:

6.1. At commencement of design, the principal structural engineer shall review the requirements of the building program, configuration and dimensions of the site, and geotechnical investigation of subsurface conditions. The University has employed both spread footings and deep foundations to meet the needs of the program relative to such requirements as flexibility for future reconfiguration of use and for vibration control, and characteristics of the site such as ground water and proximity of adjacent structures. If one system is not clearly indicated and multiple

foundation systems are applicable, the alternative systems shall be presented in an engineering study with the submittal of the Schematic Design Phase documentation. Such study of foundation alternatives shall include the desirable and undesirable aspects of each proposed system relative to program and site requirements, budget estimates, anticipated market forces at the scheduled period of construction and the impact on the project schedule.

6.2. The A/E contract for services shall determine if design and documentation of a separate phase of construction for foundations is required. In this event, foundation documents shall not be issued for construction prior to completion of 50% Construction Document Phase for the superstructure and, at least firm determination of the requirements of utility services, superstructure, foundation waterproofing, and exterior façade profile. Any early foundation package that is issued for the project shall include architectural sections showing all components that are installed below grade. Exceptions; shall be approved in writing by the University.

6.3. Cast-in-place foundation concrete, unless required by the design engineer to be a higher psi, shall not be less then 3,500 psi Foundation concrete normally includes spread footings & grade beams.

6.4. Cast-in-place concrete for caissons, augured cast piles and pile caps and walls shall not be less then 4,000 psi unless otherwise required by the design engineer to be of a higher psi.

6.5. Specify that spread footings, pile caps, etc. may be earth formed only if the sides are stable, true and solid and free of old foundation or construction rubble and debris. Otherwise they must be installed using formwork in compliance with the latest A.C.I. standards. In any case the material under the footing and sloped from it must be solid undisturbed earth, rock, etc.

7. FLOOR SLABS:

7.1. **Flatness/Levelness:** All concrete slabs on grade or elevated on metal deck or as reinforced cast-in-place concrete shall meet the A.C.I. minimum standards for Flatness/Levelness as follows:

a. **Slabs on Grade:** Composite flatness shall be no less then thirty five (35) with the composite levelness of not less then twenty five (25).

b. **Elevated or Suspended Slabs:** Composite flatness shall be no less then thirty (30) with the composite levelness of not less then twenty (20) class two (2) or three (3).

c. **Slabs in Garages, Mechanical/Electrical or Non-Public Areas:** Slabs in these areas shall not be less then twenty five (25) for composite flatness and twenty (20) for composite levelness.

d. These minimum standards shall be met unless required by UMB to be higher.

7.2. **On Grade:** All building floor slabs on compacted fill and gravel shall be a minimum of five (5) inches thick over an eight (8) mil vapor barrier. All wire reinforcement or rebar shall be supported using manufactured metal chairs designed for such

purpose. The use of brick, rubble, or other materials shall not be permitted. The use of fiberglass or nylon reinforcement mat shall not be permitted.

7.3. Heavy weight interior cast-in-place concrete slabs on grade shall not be less then 3,500 psi with a low W/C ratio not exceeding 0.56, unless otherwise required to be at a higher psi for mechanical/electrical equipment, abrasive conditions, or heavy loads. If it is a loading dock area use a min of 4,000 psi air entrained min. 4% to 6%. Do not design any piping or conduit within slabs on grade. All such items shall be designed below the drainage fill.

7.4. **Above Grade:** All building floor slabs above grade shall be at a minimum of four (4) inches thick. All wire reinforcement or rebar shall be supported using manufactured metal chairs designed for such purpose. The use of brick, rubble, or other materials shall not be permitted. The use of fiberglass or nylon reinforcement mat shall not be permitted.

7.5. Lightweight cast-in-place concrete placed over a metal form or composite metal form deck shall not be less then 4,000 psi with a low w/c ratio of .56%. All lightweight concrete shall be 110-pcf +/- 3 pcf.

7.6. Slope all floors to drains where provided.

7.7. Levelness and flatness tolerance for floor slabs shall be clearly specified.

7.8. Control joints shall be provided for a maximum of nine hundred (900) square feet of floor area.

7.9. **Exterior Slabs:** All exterior slabs or hard surfaces abutting the building shall slope away from the building at a slope of one quarter (1/4) inch to twelve (12) inches.

a. Exterior concrete slabs for sidewalks, driveways, curbs, etc. shall be a min. of 3,500 psi air entrained cast-in-place concrete with a min. 4% to 6% air. Within Baltimore City the city does not normally allow reinforcing within general sidewalk or curb areas. There are of course some exceptions especially within concrete driveway aprons, heavy equipment support areas of over a deep fill area adjoining structures. All concrete must be placed over a compacted sub-grade and on a rolled and tamped four (4) inch min drainage fill.

8. PARKING STRUCTURES AND OTHER WET AREA LOCATIONS:

8.1. Parking structures require specialized experience in design and of new garages and in the investigation of existing structures not addressed fully in these Design Standards. The structural engineer engaged for the design and/or analysis of garage structures shall have demonstrable long-time experience in garage design.

8.2. The design and construction of garages requires specialized methods and experience. Except as otherwise justified by an A/E and/or builder experienced in multi-level parking structures, and approved by UMB, the University minimum requirements for service requires that all structural design include the following:

a. Live loading shall be as defined in these Deign Standards.

b. All structures shall be concrete with a minimum strength of 5,000 psi, of low water/cement ratio. Microsilica aggregate shall be used at all floor structures, deletion of this additive in certain circumstances where all reinforcing is epoxy coated, shall only be allowed with the approval of UMB.

c. DCI additives shall be provided for façade panels to decrease the graying of the concrete.

d. Fiber reinforcing shall be utilized in topping slabs and slabs on grade.

e. Reinforcing shall be epoxy coated, and shall be placed with a covering of twice the ACI recommendation for conventional structures.

f. Shear connectors, plates and fasteners shall be stainless steel. In certain circumstances, such as in stair towers not exposed to exterior elements, hot-dipped galvanized connectors and plates may be used, as approved by UMB, or in accordance with requirements of the project program. Steel angles for expansion joints shall not be used.

g. Traffic deck coatings shall be installed on supported floors and curbs in accordance with requirements of the project program, or as directed by the University. Garage slabs on grade shall be sealed in accordance with the project program.

h. Whenever placing concrete over precast joints whether within stairs or over any precast double tee, inverted tee or at a wall or spandrel do not place a tar paper strip or any other material that would inhibit bonding between the precast and the cast-in-place concrete. Install closed cell backer rods within the open joints with an adhesive polyurethane. Over all joints install a crack control joint per A.C.I. recommendations and install a self leveling polyurethane sealant over.

8.3. Within garages the precast tee structures shall normally be designed for not less then a 50 psf live load plus dead loading and have a deflection not exceeding L/360.

a. When a precast/cast-in-place structure is installed over office areas, mechanical/electrical rooms, etc., the live loading shall not be less then 100 psf plus dead loading, including suspended ceilings, with a deflection not exceeding L/750.

b. If the structure over has a roof supporting mechanical/electrical equipment then comply with min.150 psf live loading within equipment areas plus the 30 psf snow plus dead loads. If the space below includes an office space, include loading for structural supported mechanical and ceiling.

8.4. The sill heights at all elevators within garages and wet area conditions must be at least one (1) inch higher then the elevator lobby floor areas. The floor area in front of the elevators must be sloped away from the elevator sills in compliance with ADA maximum permissible slopes for drainage. Provide a non slip surface to the floor. If within a garage or wet area use a non-slip traffic deck coating.

8.5. If the elevator lobby area is partly enclosed provide proper slope of water drainage out of the lobby area. Water ponding shall not be permitted within such areas. If the elevator lobby is located adjacent to an exterior open wall area when wind driven precipitation may enter in and around the elevator shaft, provide wind panels, a wing wall, etc. to protect both patrons and the elevator equipment. Water shall not be allowed to enter the elevator shaft or pit.

8.6. If the elevators are within a wet and/or corrosive environmental area specify #4 brushed stainless steel jambs, doors and interior front elevator panels. Sills shall be heavy duty non corrosive nickel/bronze alloy.

8.7. At garage or wet area stair entry/exit doors the floor elevation at and under any threshold must be at least one (1) inch higher then the adjoining floor outside of the stair door. The floor outside of the stair door must slope away from the door in compliance with ADA. There shall be no ponding water in or around the stair door and the floor surface must be made non-slip. Use traffic deck coating within corrosive garage areas.

8.8. ADA compliant aluminum thresholds shall be used at all stair doors. They shall be set in a full bed of polyurethane sealant. Install combination vinyl weather sweeps and rain-drips at door bottoms set in sealant. Install perimeter weather-stripping and rain-caps at frame heads set in sealant. If a garage interior stair door is anywhere near the exterior walls where wind-driven rain can penetrate a door, include wind panels for protection.

9. EXISTING STRUCTURES:

9.1. **Concrete Structures:** When existing concrete structures are selected for renovation, the existing structure shall be surveyed to identify it's current condition. The investigation shall visually examine all elements of the structure. If the initial examination indicates possible deterioration, further examination shall determine the capacity and/or safety of the system, including such areas as the subsurface examination of foundations, creep deflection, and connections which may require core drilling, petrographic analysis and/or load testing for capacity, soundings, and x-ray or magnetic examination for location of reinforcing steel and/or other devices. The structural engineer engaged for such examinations shall have demonstrable long-time experience in forensic analysis.

9.2. **Steel Structures:** When existing steel structures are selected for renovation or when replacement of infrastructure equipment is required, the structure shall be surveyed for current condition and compliance with the requirements of this part for new construction. The structural engineer, engaged for such examinations, shall be registered in the State of Maryland, and have demonstrable long-time experience in forensic analysis.

10. STRUCTURAL STEEL FRAMING:

10.1. All structural steel design shall be in accordance with the building codes listed herein as well as any specific requirements of the project program for equipment for the future. All loads (dead and live) used for design shall be indicated in the construction documents, both drawings and specifications. A graphic column schedule indicating the design loading for all columns shall be indicated in the structural drawings.

10.2. Floor loadings shall be as described in these Design Standards.

10.3. Flat roofs shall have a minimum slope of one quarter (1/4) inch in twelve (12) inches.

10.4. Special conditions of the program shall be considered, including vibration control, durability of the building or structure relative to special environmental exposure(s), and impact and fatigue loads that may exist in the structure.

10.5. Connections: Loads used in the design of major structural components, including connections, shall be shown on the construction drawings. The A/E shall be responsible for the design of all connections, and also shall review and approve the design and detailing of all connections submitted by the fabricator. All connection design and details shall bear the seal of the responsible registered professional structural engineer licensed in the State of Maryland.

10.6. Steel Framing for Mechanical and Electrical Systems: The structural steel design shall include all structural steel components, details, elevations, and sections required to support horizontal and vertical pipe and conduit systems in the project. Coordinate requirements with the Architect and MEP Engineer.

10.7. Steel Framing for Mechanical and Electrical Equipment: The structural steel design shall include all structural steel components, details, elevations, and sections required to support mechanical and electrical equipment and related piping and conduits elevated above the finished grade and/or finished roof level in the project. Where equipment also requires elevated maintenance platforms see requirements in Sections 3 MD Parts 2 & 3 and Section 3 ED and coordinate with Architect and MEP Engineer.

11. COLD FORMED METAL FRAMING:

11.1. When exterior load bearing steel and stud brick and/or stone veneer walls are considered in lieu of masonry back up initiate a discussion with UMB and their review staff to discuss options and rationale. The following standards shall apply:

a. Comply with AISI specifications when calculating characteristics of cold formed metal framing. Use AISI's “Load and Resistance Factor Design Specification for Cold-Formed Steel Structural Members". Comply also to the Center for Cold-Formed Steel Structures (CCFSS) technical bulletin, Vol 2 No. I February 1993, and "AISI Specification Provisions for Screw Connections".

b. Welded connections are not desired because of the resulting damage caused to the galvanized surfaces. If welded connections are permitted they must all be cleaned and coated with a Galv-a-weld protective coating material.

c. Design the framing systems to withstand design loads without deflections greater then L/750 of the unsupported wall height for all masonry veneer walls and L/360 for exterior walls receiving an exterior "EFIS"-type insulation and high performance coating system.

d. Design framing system to provide for movement of framing members without damage or over stressing of sheathing, connections or veneer.

12. METAL FABRICATION:

12.1. All steel, including fasteners, plates, etc., related to this Section which are exposed to exterior weather conditions, located in wet areas or mechanical and electrical equipment rooms, or within exterior wall construction used to support masonry and/or insulated panel skin, etc. are to be fabricated and finished with hot-dipped galvanized coatings.

12.2. Examples shall include, but not be limited to the following:

a. Ladders, including ships ladders, railings, etc.

b. Catwalks including stairs up to them, gratings, plates, rails, etc.

c. Roof top or penthouse and mechanical equipment grillage steel.

d. Loose steel lintels.

e. Shelf and relieving angles.

f. Overhead door steel channel and angle support frames.

g. Loading dock edge angles.

h. Exterior corner guard.

i. Pipe and wheel guards.

j. Pipe bollards.

12.3. Rooftop or penthouse and mechanical equipment grillage steel.

13. MISCELLANEOUS METALS:

13.1. Metal Studs:

a. Specify all metal stud types, size, minimum three and five eighths (3 5/8) inch or six (6) inch, and spaced at sixteen (16) inches on center in compliance with the latest edition of the National Gypsum Company Construction Guide Manual.

13.2. Service and Receiving Areas:

a. Bollards, and steel angles or channels shall be designed for all service and receiving areas to protect the building from damage. All exterior miscellaneous steel shall be hot dip galvanized.

14. DESIGN COORDINATION:

14.1. Coordinate the placement and detailing of all structural members with the requirements for all other disciplines, including elevators, plumbing, hvac, electrical, and architectural systems.

14.2. The A/E shall make site visits sufficient to ensure that no detail of existing conditions is omitted from either the design or the contract documents.

15. CONSTRUCTION DOCUMENTS:

15.1. As indicated below the construction documents shall also include the following:

a. The construction documents shall clearly indicate all special erection procedures necessary; including required temporary bracing.

b. Special conditions and/or requirements shall be designed and clearly indicated on the construction drawings; a general cover-all statement in the Specification shall not be considered sufficient to define the work.

c. For exterior brick and stone facades, in particular, the location and dimensioning of supporting angles is of particular importance. Notes and detailed dimensions shall be included in large scale three (3) inches = one (1) foot – zero (0) inches plans, sections and details. Details that show only

the exterior profile shall not be considered sufficient information by the A/E to adequately describe the design intent to the fabricator and installer.

END OF SECTION 3 AD - PART III