H. Building Envelope

1. Introduction

The building envelope, sometimes referred to as the "building enclosure", is comprised of the various components, assemblies and systems that separate the interior environment of a building from the exterior environment. In establishing a boundary between the interior and exterior, the building envelope sets the conditions for the building mechanical and other environmental control systems to regulate the interior climate of the building.

Guiding Principles
The University of Chicago is a long term building owner and this is expected to have a significant impact on the Consultant's approach to not just the overall exterior form of the facility, but also system selection and detailing. Aesthetics are important, but of equal importance are maintenance, component replacement, and long term performance of the building envelope assemblies.

- For planning and evaluation purposes, the University assumes the life expectancy of all of their facilities to be 100 years except in special circumstances.
- Various portions of the building envelope will need to be replaced numerous times over the life of the facility, and it is the Consultant's responsibility in the design of the building to minimize the cost and inconvenience required for ongoing maintenance of the building envelope.
- Environmental impact is a concern of the University. Refer to sustainability requirements under "Related Sections".
- **Bird Safety:** Birds play a vital role in nature, the environment and add beauty to the campus. For these reasons, The University of Chicago places special importance on birds and their safety. Additionally, Chicago is located in a major flyway for migratory patterns in the spring and fall which increases the need for safety precautions. The Mississippi Flyway is part of a larger migration route that extends from northwest Canada, along the Great Lakes, and down the Mississippi River Valley. Each year, more than 250 species of migratory birds use this flyway to travel between their winter habitats in the southern U.S. and Central and South America, and their summer habitats in North America. Chicago's migratory season is from 17 March until 7 June and from 25 August until 25 October. With Lake Michigan to the east and farmland to the far west, Chicago's green spaces provide a variety of plant life and habitat for resting and refueling. Since the University is within this important flyway, standards need to increase the safety of birds.

  The FS2 document provides the opportunity for the University to become a leader in bird safe environments throughout the campus including buildings, landscaping and respect for bird habitats. Project management teams should use the Bird Safe Project Checklist in tandem with the LEED checklist to review design considerations during the Owners Project Requirement OPR and Basis of Design (BOD) development. **See Section IV.H.1. Bird Safe Project Checklist.** Consultants

should use the checklist on any project that would affect bird safety from window replacement, to landscaping, to new construction. Renovation projects that include existing conditions that could be improved for bird safety should also use the checklist.

- The Consultant shall work with the University in building envelope system selection, and prepare and submit explanatory information, including but not limited to:
  - Pros and Cons of the various proposed systems
  - Listing of multiple sources where the building components can be purchased
  - Outline of performance expectations showing major repair and replacement events anticipated over the 100 year life cycle of the building
  - Special consideration related to historical replacement events and costs. Refer to heritage resources requirements under "Related Sections".
- Materials and components of the building envelope systems shall be commonly available.
- It is expected that the project design follow all applicable FM Global Property Loss Prevention Data Sheets (Engineering Guidelines). The FS Project Manager will coordinate the review of system designs with FM Global.
- Materials, components and systems of the building envelope shall be subject to independent testing and evaluation.
- The University strongly believes that many envelope performance problems are the result of inadequate coordination or detailing of the transitions between various building envelope systems. The Consultant is responsible to ensure coordinated detailing at each connection and transition between these component parts and assemblies, starting in the Schematic Design phase.

Related Sections

Related sections of these standards include:

- Sustainability
  - In coordination with the University's commitment to objectives as outlined in the Sustainability section of these Standards, implement a Life Cycle Cost Analysis (LCCA) for the development and selection of the materials, components and assemblies that comprise the building envelope. System selection shall consider the following:
    - History of system performance in the Chicago marketplace
    - Life cycle expectations based on non-warranty related data
    - Initial installation and long term maintenance costs
- Vines (F. Site, Civil, and Grounds Requirements)
  - The image of the University is enhanced by its ivy covered quad buildings. Additionally, the University encourages the protection of and continued planting of vines on or next to building walls. The benefits of the correct species of vines are many fold
- Heritage Resources
  - Determine applicability and requirements regarding alterations to existing building envelopes as they relate to the Heritage Resources program.

2. Guidelines

a) Function

The various functions of the building envelope are grouped into categories as indicated below. The Consultant shall address each of these in the design process, and clearly communicate them in the project documentation. Utilize drawings, narrative, diagrams, modeling, mockups, tours and other means as required to successfully communicate to the University's staff and other project team members.

- **Support** – ability to resist and transfer structural loads (i.e. gravity, impact, wind, seismic, etc.)
- **Control** – method and capacity to regulate the flow of matter and energy
- **Finish** –desired aesthetics and surface characteristics

Support

The support elements of the building envelope are grouped into the building components indicated below. The project designer shall identify the support performance properties for each of these components during the design process, and clearly communicate them in the project documentation. Indicate the separate and combined loads for each component assembly, tolerances, and the anticipated movements under the design loading conditions and over time.

- Horizontal substructure (i.e. slabs-on-grade, earth-covered roofs, etc.)
- Vertical substructure (i.e. concrete foundation walls, masonry foundation walls, slurry walls, etc.
- Floor construction (i.e. cast-in-place concrete slab edge, precast concrete slab edge, etc.)
- Wall construction (i.e. load-bearing masonry, lightweight steel framing, curtainwall, etc.)
- Openings (i.e. doors, windows, building system penetrations, etc.)
- Traffic Bearing Horizontal Enclosures (i.e. plazas, vegetated roofs, etc.)
- Roofing (i.e. flat membrane, sloped shingles, sloped metal, etc.)

The following and other applicable building and component movements should be considered.

- Building deflection (wind (LL), occupant (LL), structure (DL), etc.)
- System deflection capacity/ resistance (L/600, L/360, L/240, etc.)
- Material expansion/ contraction (temperature, radiation, hygroscopic loading, etc.)
- Deformation (i.e. foundation settlement, concrete creep, etc.)
- Joint design (i.e. movement, capacity, layout, etc.)

Consider and provide for access to components of the building envelope, including maintenance and repair access, as well as construction site logistics.

Control

The control components of the building envelope are grouped into the barrier layers as indicated below. The project designer shall identify each of the layers in the building envelope during the design process, and clearly communicate them by means of building sections and details in the project documentation. Clearly indicate when a layer is intended to serve more than one function.

- Water barrier
  - Indicate type (i.e. membrane, rain screen, etc.)
- Air barrier
  - Indicate type (i.e. membrane, etc.)
  - Indicate the location of planned openings in the building envelope, how these openings are intended to interact with the building ventilation systems, and what mechanisms will be provided to regulate air migration through the openings.
  - Recognizing that air flow rates and pathways can change with air pressure difference patterns across the building envelope, separately indicate the likely scenarios for air pressure differentials
- Thermal barrier
  - Indicate type (i.e. rigid, semi-rigid, blanket, spray-applied, etc.)
  - Perform a dewpoint analysis for each type of building envelope assembly for typical heating and cooling design conditions. Note the anticipated duration of condensation events and drying potential.
- Vapor barrier (layer for control of water vapor diffusion)
  - Indicate type (i.e. membrane, concrete, unit masonry, etc.)
  - By means of building envelope sections and details, demonstrate the location and continuity of the barrier.
  - Indicate the vapor permeability for materials and assemblies.
  - Identify the layer in each building envelope assembly that is intended to serve as the assembly's primary vapor barrier.
- Sunlight/radiant energy barrier
  - Indicate type, location, and performance parameters.
  - In concert with project Sustainability objectives, indicate areas of fenestration (vertical, sloped and horizontal) and other non-opaque elements in the building envelope.
  - Establish parameters for control of light transmission through these non-opaque elements for each exposure and condition in order to facilitate coordination with heating, cooling, daylighting, and other related building aesthetic and performance goals. Where applicable, indicate the following:
    - Visible light transmittance
    - Exterior reflectance
    - Shading coefficient
    - Solar heat gain coefficient
    - Light to solar gain ratio
  - In addition to fenestration, indicate other components of the design that are essential to the control of light transmission, such as light shelves, louvers, screens, etc.

    - Where appropriate to meet project performance and sustainability objectives, provide a dynamic daylighting model to assess the effect of natural lighting on thermal and lighting demands.
- Sound/ vibration barrier
    - Indicate type, location, and performance parameters.
    - Project Manager in consultation with the Consultant will determine whether to undertake an environmental noise and vibration survey for existing conditions at the project site.
    - The building envelope shall be designed to limit sound and vibration transmission as required to achieve the programmatic requirements for interior noise and vibration levels.
        - Indicate the appropriate outdoor/indoor transmission class (OITC) necessary for the building envelope to attenuate exterior airborne sound to acceptable interior levels.
- Fire/ smoke barrier
    - Indicate type, location, and performance parameters.
    - Indicate the design listings (i.e. UL Design, etc.) being used in the building envelope to achieve the required fire/ smoke resistance ratings.

Finish

The finish components of the building envelope are grouped as indicated below. The project designer shall identify each of the finish properties in the building envelope during the design process, and clearly communicate them in the project documentation.

- Surface hardness
- Slip resistance
- Corrosion resistance
- Resistance to abrasion, erosion and general wear
- Appearance
- Ease of maintenance

b) Performance Criteria

These standards are intended for buildings that enclose a controlled environment. The application of these standards to buildings and structures of a more open nature (i.e. parking facilities, etc.) is subject to determination on a case by case basis.

- Reduce uncontrolled air movement through the building envelope.
- Heating climate. Limit interior moisture-laden air exfiltration through the building envelope.
- Cooling climate. Limit exterior moisture-laden air infiltration through the building envelope.
- Avoid negative affects to indoor air quality (IAQ) and occupant comfort resulting from air leakage through the building envelope.
- The design of building enclosure components shall incorporate elements to meet the air/water infiltration requirements through details that utilize a redundant system

concept. Examples of this include, but are not limited to masonry cavity walls, rainscreen facades, and pressure-equalized curtainwalls.

Performance Criteria - Support

- Design each building enclosure system component to allow for their proper attachment to the structural frame of the building taking into account the fabrication and erection tolerances allowed for the elements of the frame and all predictable structural deflection.
- Maximum design criteria for predictable vertical structural deflections for the elements of the structural frame with superimposed load midspan vertical deflection limits between any two columns on the edge of any floor: L/600 (where "L" is the column spacing) or 3/8", whichever is smaller.
- Maximum design criteria for horizontal building movement (interstory drift) at any floor: H/400; where H is the floor-to-floor height at that floor.
- Maximum anticipated long-term differential settlements for adjacent perimeter column foundations: 1/2" inch.
- Anticipated column shortening: 1/8" per 10 feet of column height.
- Design all parts of the building enclosure component for pressures and loads satisfying governing code but not be less than values specified herein
- Gravity Loads:
    - Dead Loads: Actual weight of all components and elements of the building enclosure system, and any associated materials.
    - Live Loads:
        - Roof Coping/Gutter Load: 500 lbs. on three square feet, located anywhere.
        - Interior Window Sills: 250 lbs. on 72 square inches, located anywhere.
        - Horizontal Wall System Projections wider than 6": 20 psf maintenance load.
- Wind Loads: Horizontal design wind pressures.
    - The minimum design wind pressures shall meet or exceed the requirements of all applicable codes (i.e. Chicago Building Code, etc.).
    - In addition to applicable code requirements, design wind pressures shall be those derived from calculations or wind tunnel tests conducted by consulting wind engineers.
- Window Cleaning and Façade Maintenance Equipment Loads:
    - The Consultant, in consultation with the FS Project Manager and façade maintenance contractor, will determine the provisions necessary for proper maintenance and worker safety.
- Thermal Loads: Take into account self-straining forces and effects arising from expansion or contraction due to normally anticipated and design temperature ranges.
- Strength Requirements: Take into account analysis of loads and conditions of service for the installation.
- Thermal Break Criteria: All curtainwall and window unit components are to be thermally broken to meet requirements of the condensation resistance requirements of

this standard. Thermal breaks shall be designed per AAMA TIR A8, *Structural Performance: Poured and Debridged Framing Systems*.

- Joint Design:
  - Provide movement joints to accommodate the full range of manufacturing tolerance, thermal movement, floor, beam deflection and column settlement and to accommodate the worst possible combination of effects so as to prevent internal stress, oil canning, failure, deterioration or failure of weather seals.
  - Adequate accommodations such as sleeving should be made during detailing to allow for alignment from piece to piece with internal sleeves.
- Stiffness Requirements:
  - Aluminum and Steel: The maximum allowable deflections of the members under the action of gravity load or design wind pressures combined with appropriate gravity loads and thermal effects shall be as follows:
    - Design per AAMA TIR-A11, *Maximum Allowable Deflection of Framing Systems for Building Cladding Components at Design Wind Loads*.
    - Maximum allowable deflection: 0.125" in the plane of the wall; except 0.250" at corner mullions.
    - Compliance with these provisions shall be verifiable by the test methods of ASTM E330.
  - Glass:
    - Glass center deflection, relative to glass edges, at 50 percent of the appropriate design wind load, shall not exceed one (1) inch.
    - Glass deflection at 1.5 times the appropriate design wind load shall be limited to prevent glass disengagement from the frame.
- Connections/Attachments Requirements:
  - General: Design and detail connections and attachments to provide all resistance to forces and effects considered in their design. Prevent friction between connected materials from inducing unanticipated restraint by the use of appropriate friction-inhibiting detailing.
  - Gravity Load Connections: Design gravity load connections to not rely on friction between connected materials induced by bolt tension to transfer gravity loads at vertical slots.
  - Wind or Thermal Connections: Provide wind or thermal connections with slotted or oversized holes or other approved means of non-restraint Snow Loads: Provide snow clips on the entire perimeter of the building where copings, sills, ledges, mullions or any projection is greater than 4", unless otherwise recommended by consulting wind engineer.
  - Fasteners:
    - As a minimum, conform to the requirements of industry standards.
    - Design fasteners to prevent loosening under all service conditions. "Lockable" fasteners must have a demonstrable and successful history of use.
  - Provisions for Thermal Movements: Design and fabricate each component of the building enclosure system to allow for noiseless thermal expansion and contraction for unrestrained members, and to provide appropriate anchoring for restrained members, without causing undue stresses or other detrimental effects

caused by changes in system component material temperatures and ambient air temperatures.
    - Ambient air temperature range: 130 °F (-30 °F low, 70 °F nominal and 110 °F high).
    - Material temperatures: Evaluate and provide for anticipated material surface temperatures, due to solar heat gain, and night sky heat loss, analyzed with the assumption of an interior temperature range of 45 °F to 100 °F.
- Material Degradation:
    - All dissimilar metals shall be effectively separated with bituminous/epoxy coatings or other suitable separation material as required to prevent galvanic action.
    - All materials which may cause staining, discoloring, degradation or other detrimental effects when in contact, shall be effectively isolated from each other.
- Animate Nuisance Control: Design each component of the building enclosure system to inhibit the unintended entry to the building interior through cavities and components of the system itself, insects and/or small animals, which would constitute a nuisance by their presence.

Performance Criteria – Control

The Consultant shall review these performance criteria with project sustainability objectives established elsewhere in these Standards. In cases of conflict, the FS Project Manager shall determine the criteria to be used on the project in consultation with appropriate professional.

- Water Barrier: Design each component of the building enclosure system to prevent water penetration
    - Water penetration shall be as defined as the appearance of water other than condensation, on any interior surface of the building enclosure systems.
- Air Barrier:
    - The **air infiltration resistance** of the building envelope is intended to comply with the minimum material, assembly and whole building standards indicated below, and with applicable code and regulatory requirements, whichever is more stringent.
        - Materials: **0.004 cfm/sf @ 0.3 in w.g.** (ASTM E2178)
        - Assemblies: **0.04 cfm/sf @ 0.3 in w.g.** (ASTM E2357 or E1677)
        - Whole Building: **0.25 cfm/sf @ 0.3 in w.g.** (ASTM E779)
- Thermal Barrier:
    - The building envelope shall be designed to limit thermal transmission as required to achieve the project objectives for energy conservation and sustainability. Reference the Sustainability section of these Standards for further requirements.
    - Condensation Resistance: Design, fabricate, assemble and erect the enclosure systems for the project to provide the following condensation resistance:
        - General Condition: No uncontrolled or visible condensation shall form on any interior surface when the exterior temperature is **-10 degree F** with a 15 mph wind and the interior conditions are **72 degree F** at a relative humidity of **30%**.

        - Provide a continuous vapor barrier within the enclosure. The vapor barrier shall prevent water vapor from condensing within the wall assembly.
        - In addition to normal primary weather/water control, provide secondary flashing systems to drain condensation and other sources of water to the exterior.
        - Provide thermally broken window/curtainwall frame extrusions and detailing, to meet the specified condensation criteria.
- Vapor Barrier:
    - The building envelope shall be designed to limit vapor transmission as required to avoid undesirable moisture accumulation within the building envelope assembly, and to achieve the project objectives for energy conservation and sustainability. Reference the Sustainability section of these Standards for further requirements.
    - Permeability Resistance: Design, fabricate, assemble and erect the enclosure systems for the project to provide the following vapor resistance:
        - Materials: 0.01 perms (US) (ASTM E96)
    - Moisture migration and accumulation within the building envelope resulting in undesirable or deleterious conditions will be unacceptable.
    - Review building envelope materials for vapor permeability. Avoid conditions where moisture can be trapped between vapor barriers with no potential for drying.
    - Below grade vapor barrier must be capable of withstanding hydrostatic pressure.
    - Note: Bentonite has very poor water vapor permeability ratings. It should **not** be relied upon to provide the vapor barrier in a building enclosure.
- Sunlight/ Radiant Barrier:
    - The building envelope shall be designed to limit sunlight and other radiant energy transmission as required to achieve the project objectives for energy conservation and sustainability. Reference the Sustainability section of these Standards for further requirements.
    - Where appropriate to meet project performance and sustainability objectives, select glass and glazing materials and coatings that contribute to natural daylighting and exterior views while limiting undesirable radiant heat transmission.
- Sound/ Vibration Barrier:
    - The building envelope shall be designed to limit sound and vibration transmission as required to achieve the programmatic requirements for interior noise and vibration levels.
        - Indicate the appropriate outdoor/indoor transmission class (OITC) necessary for the building envelope to attenuate exterior airborne sound to acceptable interior levels.
    - Windows in the exterior wall of auditoriums, lecture rooms, conference rooms, classrooms and other similar spaces shall have a minimum rating of STC 35, unless otherwise recommended by the acoustical consultant.
- Fire/ Smoke Barrier:

- Use of combustible materials in exterior envelope components is allowed only for non-load-supporting elements and is subject to the limitations of the building code for isolation, maximum flame spread, and the like.
- Provide a complete fire containment system along the floor level perimeter including all exterior wall/floor or wall/roof junctures equal in rating to that required for the floor or roof assembly. The perimeter fire containment system shall prevent fire from spreading from floor to floor. Indicate the requirements of the UL listing for each condition. Adjacent work and conditions shall be coordinated with the appropriate containment assembly.
- The building enclosure and systems shall receive the local code authority's approval.

c) Material and Assembly Requirements

General Exterior Wall Requirements

- Exterior wall system shall have two continuous and separate lines of protection against water and air infiltration. Provide for pressure equalization and a weep system to drain the cavity created by the two separate lines of protection at each component part of the exterior wall.
- Design through wall flashings such that no modifications to the through wall system are required as other interconnected building systems are replaced.
- Provide a weep system at each line of flashing (including at the base of the wall) as required to insure positive drainage of the exterior wall.
- All anchors, supports and fasteners used for the attachment and support of exterior wall components shall be of corrosion resistant material.

Cast-in-Place Concrete Requirements

- Slabs-on-grade as components of the building envelope shall include a vapor barrier (retarder) between the bottom of the slab-on-grade and compacted aggregate subgrade, unless otherwise recommended by the consulting soils engineer.
  - Vapor barrier shall be a minimum 15 mils in thickness and meet or exceed ASTM E1745, Class A
  - Seal around pipes and other penetrations
- Reference the Accessibility section of these Standards for further requirements regarding floor surface flatness.

Precast Concrete Requirements

Design precast concrete systems in coordination with project LCCA activities where the University can expect a minimum of **50** or more years of overall system performance.

- All precast concrete panel joints shall be provided with two lines of seal (two-stage sealant joint) as conceptually presented within the PCI Architectural Precast Handbook.
- The exterior seal will be intermittently weeped/ vented/ baffled with water and moisture directed toward the exterior.

- The interior seal shall be as continuous as is practicable. This seal may be installed from the exterior or interior of the structure within a concept coordinated with guttering requirements, curtain wall and flashing systems.
- Single wythe precast concrete panels shall incorporate gutters within the air cavity on the back side of the panel that are weeped to the exterior through 3/8" inside diameter flexible tubing in a manner which will not stain the exterior face of the panel. Gutters shall be provided at a minimum of every two (2) stories of continuous precast panel.
- Insulating composite precast panels shall be designed to accept water drainage between the face mix and the integral insulation (i.e. drainage flutes within insulation).

Masonry Requirements

Design masonry assemblies and systems in coordination with project LCCA activities where the University can expect a minimum of **40** or more years of overall system performance. It is understood that this will likely require the design and installation of systems that are of higher quality and have longer-term performance than industry standards.

- Design, detailing and construction shall be consistent with best industry practices, and at a minimum with the following:
  - Brick Industry Association (BIA), *Technical Notes on Brick Construction*
  - National Concrete Masonry Association (NCMA), *TEK Manual for Concrete Masonry Design and Construction*
- Deflection for masonry supporting systems between support connections to the building structure shall be limited to length/600 or ½ inch maximum in any direction, whichever is less.

Glass and Glazing Requirements

Design glass and glazing components of building envelope assemblies in coordination with project LCCA activities where the University can expect **20** or more years of overall system performance. It is understood that this will likely require the design and installation of systems that are of higher quality and have longer-term performance than industry standards.

- Design, detailing and construction shall be consistent with best industry practices, and at a minimum with the following:
  - Glass Association of North America (GANA), *Glazing Manual*
  - Insulating Glass Manufacturers Alliance (IGMA), *North American Glazing Guidelines for Sealed Insulating Glass Units for Commercial & Residential Use*
- Tempered Glass
  - Monolithic, fully tempered glass should be specified only where required to satisfy code, strength, and application requirements.
  - When monolithic, fully tempered glass is specified, the architect of record shall provide structural and thermal stress calculations when required by code or upon request from the University project manager (Facilities Services Operations/Capital Project Delivery/Campus Planning + Sustainability).
  - All tempered glass to comply with ASTM C1048.
  - When specified, heat strengthened or laminated safety glass shall be used, even when a choice between them or tempered glass is allowed by code.
  - When monolithic, fully tempered glass is required and specified, an alternate price shall be requested for all tempered glass in the project to undergo heat

soaking in accordance with EN-14179, Glass in Building – Heat Soaked Thermally Toughened Soda Lime Silicate Safety Glass.
    - Use post-tempering heat soaking requirements for specialized applications such as those near high traffic areas, over entrances, next to busy sidewalks, etc. In large applications that may have glass spiders or fins, laminated glass (SGP) is recommended.
    - When heat soak testing in accordance with EN-14179 is provided, factory logs documenting heat soak testing of all monolithic, fully tempered glass for the project shall be submitted for approval by the architect of record and the University project manager.
        - For lites larger than 9sf, unless a substantial frit pattern is present to mask abnormalities, specify to minimize the impact of distortion:
        - Produce all heat treated glass for a given project on the same equipment using the same processing parameters, and if possible, from the same batch
        - Consider a thicker outer lite to mitigate distortion
        - Orient heat treated glass so that the roller wave is parallel to the window sill/header
    - Consultants shall coordinate with the University project manager to develop and enforce a project-based QA/QC program for all monolithic, heat treated glass, including tempered glass, that may include but is not limited to manufacturing and testing standards and documentation, roller wave and ripple tolerances and other distortions, transport and delivery requirements, and installation, verification and acceptance requirements.
- Quality assurance/quality control (QA/QC) - each project phase includes initiatives intended to increase compliance with project requirements and objectives by integrating quality assurance measures into the Project Development & Delivery Process. The Consultant shall develop and implement a complete quality assurance/quality control (QA/QC) program for the project based on the requirements in these Standards. Consistent with this effort, the Consultant will also be responsible that the design and documentation for the project establish coordinated QA/QC requirements for the Contractor.
- **NOT ACCEPTABLE:** Argon filled insulating glass units are **not** acceptable.
- Safety glazing shall comply with CPSC 16 CFR 1201 Categories I and II.

Glass and Aluminum Curtainwall Requirements

Design glass and aluminum curtainwall systems in coordination with project LCCA activities where the University can expect **50** or more years of overall system performance. It is understood that this will likely require the design and installation of systems that are of higher quality and have longer-term performance than industry standards.

- Design, detailing and construction shall be consistent with best industry practices, and at a minimum with the following:
    - Aluminum Association (AA)
        - *Specifications for Aluminum Structures*
        - *Specifications for Aluminum Sheet Metal Work in Building Construction*
    - American Architectural Manufacturers Association (AAMA)

        - CW-DG-1, *Aluminum Curtain Wall Design Guide Manual*
        - MCWM-1, *Metal Curtain Wall Manual*
        - SRM-1, *Aluminum Storefront and Entrance Manual*
    - National Association of Architectural Metal Manufacturers (NAAMM)
        - *Metal Finishes Manual*
- All components shall be selected and engineered to withstand applied wind pressures in accordance with sound and accepted engineering practice.
- Metal-to-metal joinery without the inclusion of a solid or closed cell elastomer, shall not be considered a watertight (face) seal.
- Minimal dependence shall be placed on sealants and caulking materials. Weeps and gutters shall be provided to drain to the outside any condensation and water, which may enter the pressure equalization chambers.
- System shall employ concealed weeps or drainage holes, baffled to prevent percolation.
- Where possible and practical, sealants employed as air seals shall be located so as to be accessible and maintainable, through the employment of sill covers, removable trim, etc.

Windows

Select unit window systems in coordination with project LCCA activities where the University can expect **100** or more years of overall system performance. It is understood that this will likely require the selection, design and installation of systems that are of higher quality and have longer-term performance than industry standards.

- Design, detailing and construction shall be consistent with best industry practices, and at a minimum with the following:
    - Provide windows capable of complying with performance requirements indicated, based on testing manufacturer's windows that are representative of those specified, and that are of minimum test size required by AAMA/WDMA 101/I.S.2/NAFS.
    - Acceptable frame materials include aluminum, steel, wood, aluminum clad wood. Application will vary by context & scope and is subject to approval by the University.
    - Minimum Standards include but not limited to:
        - National Woodwork Manufacturer's Association:
            - "Industry Standard for Wood Windows" 1-S-2-73, Class A
        - Architectural Aluminum Manufacturer's Association:
            - "Specifications for Aluminum Windows" Standard SW-1-68T, 60/25 H/H
        - National Association of Architectural Metal Manufacturers (NAAMM)
            - *Metal Finishes Manual*
- All components shall be selected and engineered to withstand applied wind pressures in accordance with sound and accepted engineering practice.
- Metal-to-metal joinery without the inclusion of a solid or closed cell elastomer, shall not be considered a watertight (face) seal.
- Minimal dependence shall be placed on sealants and caulking materials. Weeps and gutters shall be provided to drain to the outside any condensation and water, which may enter the pressure equalization chambers.

- System shall employ concealed weeps or drainage holes, baffled to prevent percolation.
- Where possible and practical, sealants employed as air seals shall be located so as to be accessible and maintainable, through the employment of sill covers, removable trim, etc.
- Replacement versus renovation - wood windows: existing wood window frames and sash should be examined for possible renovation. Although advances in replacement window unit design have improved (energy efficiency), maintaining historic character with reasonable energy efficiency can be achieved using traditional wood window + storm window configurations.

Doors and Frames

Select doors and frames in coordination with project LCCA activities where the University can expect **50** or more years of overall system performance. It is understood that this will likely require the design and installation of doors and frames that are of higher quality and have longer-term performance than industry standards.

- Design, detailing and construction shall be consistent with best industry practices, and at a minimum with the following:
    - American National Standards Institute (ANSI):
        - ANSI/DHI 115.IG – Installation Guide for Doors & Hardware
        - A250.4 – Test Procedure and Acceptance Criteria for Physical Endurance for Steel Doors and Hardware Reinforcings
        - A250.6 – Hardware on Standard Steel Doors-Reinforcement and Application
        - A250.8 – Recommended Specifications for Standard Steel Doors and Frames
    - ASTM International (ASTM):
        - A366-97 – Standard Specification for Commercial Steel (CS) Sheet, Carbon (0.15 Maximum Percent) Cold-Rolled (Discontinued 2000)
        - A525 – Steel Sheet, Zinc-Coated (galvanized) by the Hot-Dip Process, Commercial Quality
        - A666 – Standard Specification for Annealed or Cold-Worked Austenitic Stainless Steel Sheet, Strip, Plate, and Flat Bar
        - A924 – Standard Specification for General Requirements for Steel Sheet, Metallic-Coated by the Hot-Dip Process
        - E2074-00: Standard Test Method for Fire Tests of Door Assemblies, Including Positive Pressure Testing of Side-Hinged and Pivoted Swinging Door
    - National Association of Architectural Metal Manufacturers/Hollow Metal Manufacturers Association (NAAMM/HMMA)
        - 861 – Guide Specifications for Hollow Metal Doors and Frames
    - National Fire Protection Association (NFPA):
    - Steel Door Institute (SDI):
        - SDI-109 – Hardware for Standard Steel Doors and Frames
    - Underwriters Laboratories (UL):

- All components shall be selected and engineered to withstand applied wind pressures in accordance with sound and accepted engineering practice.
- Metal-to-metal joinery without the inclusion of a solid or closed cell elastomer, or fully welded connection shall not be considered a watertight (face) seal.
- Minimal dependence shall be placed on sealants and caulking materials.
- Where possible and practical, sealants employed as air seals shall be located so as to be accessible and maintainable, through the employment of sill covers, removable trim, etc.

Waterproofing Requirements

Design waterproofing systems for below grade applications in coordination with project LCCA activities where the University can expect **40** or more years of system performance. It is understood that this will likely require the design and installation of systems that are of higher quality and have longer-term performance than industry standards.

- Incorporate life cycle cost control, practicality of installation, and ease of maintenance in the design.
- Utilize materials and systems that are time-proven.
- Take into consideration the sensitivity of the space, occupants and contents when selecting the appropriate system (i.e. library and museum archives will likely require systems with absolute system integrity and maximum watertight security).
- Investigate, select and design waterproofing components and systems that are compatible and work together with other elements of the building envelope to achieve performance requirements.
- Below grade horizontal waterproofing shall maintain an unobstructed minimum positive slope to drain of ¼ inch per foot, with a clear, concise drainage plan. All plaza drains shall be bi-level type.
- The Consultant is expected to:
    - Specify time-tested materials and assemblies.
        - When materials and assemblies without a proven record of successful performance in the local climate and environment are being proposed in order to meet other project objectives, the Consultant shall make recommendations for supplemental research and pre-testing, as required to satisfy the performance concerns of the University. This shall be completed prior to the end of the DD phase in order to identify and account for any impact to the project schedule and budget.
    - Specify appropriate QA/QC requirements necessary to assure satisfactory completed work and reduced risk associated with removal of overburden materials normally associated with below grade waterproofing installations. These include, but are not limited to:
        - Testing of horizontal areas prior to installing topping materials by both of the following means:
            - Electric Field Vector Mapping (EFVM) in conjunction with the installation of a compatible conductive screen grounding layer below the waterproofing membrane.

- Flood testing with standing water over the entire area for a period of 48 hours. (Note: Take the care necessary to avoid overburdening of the roof structure resulting from the accumulation of water not anticipated as a design condition.)
- After passing the tests, immediately cover and protect the waterproofing membrane from any possible damage. At no point is the finished waterproofing system to be left exposed and vulnerable to damage.

        - Extensive on-site observation, verification and measurement of the installed work by the University's waterproofing/roofing consultant or independent Testing Agency.
    - At the times indicated in the project schedule, submit waterproofing drawings and specifications as part of the building envelope documents for review by the University's waterproofing/roofing consultant.

Roofing Requirements

Design roofing systems in coordination with project LCCA activities where the University can expect many years of overall system performance. It is understood that this will likely require the design and installation of systems that are of higher quality and have longer-term performance than industry standards.

- Incorporate life cycle cost control, practicality of installation, and ease of maintenance in the design.
- Utilize materials and systems that are time-proven.
- Refer to FM Global Data Sheets and approved materials listings for roofing systems and related design criteria including those for green roof systems as applicable. It is expected that every consultant follow FM Global requirements.
- Take into consideration the sensitivity of the space, occupants and contents when selecting the appropriate system (i.e. library and museum archives will likely require systems with absolute system integrity and maximum watertight security).
- The Consultant is expected to:
    - Use time-tested materials and assemblies.
        - When materials and assemblies without a proven record of successful performance in the local climate and environment are being proposed in order to meet other project objectives, the Consultant shall make recommendations for supplemental research and pre-testing, as required to satisfy the performance concerns of the University. This shall be completed prior to the end of the DD phase in order to identify and account for any impact to the project schedule and budget.
    - Investigate, select and design roofing components and systems that are compatible and work together with other elements of the building envelope to achieve performance requirements.
    - At the times indicated in the project schedule, submit roofing drawings and specifications as part of the building envelope documents for review by the University's roofing consultant.
    - Provide for roof access to all roof areas. This is important for observation and maintenance of the roof over its useful life.

- Construction.
  - Contractor shall have a minimum of 10 years of successful experience in the Chicago area installing the types of roofing indicated in the design drawings, including the roofing interfaces with adjacent and transitional elements in the building envelope.
  - Contractor shall employ experienced and properly skilled workers to install the roofing and underlayment work.
  - Frequent on-site observation and testing is recommended for roofing installations.
    - Objectives:
      - Monitor workmanship, weather conditions, and other elements that can affect the completion of a successful installation
      - Improve discovery and facilitate immediate correction of problems
      - Reduce risk from a problematic installation
    - The determination of whether a project merits full-time observation, or a reduced level, will be made by the Project Manger based upon the Consultant's recommendation, the LCCA, budget and other factors.
  - Contractor shall prevent damage to new and existing materials, including but not limited to damage by personnel, ladders and other materials and equipment. Potentially damaging materials such as metal scraps, acid flux, and other debris shall not be allowed to come into contact with the roof surface.
- Low-slope roofs:
  - Unobstructed positive slope to drain from ¼ inch per foot to 2 inch per foot.
  - Design to meet FM 1-90 standards as a minimum. Higher wind standards may be required and it is the Consultant's responsibility to determine when those higher standards should be incorporated into the project.
- Gravel Surfaced Built-up Roofing:
  - Design gravel surfaced built-up roofing systems where the University can expect **30** or more years of overall system performance.
- Roofing system shall conform to the recommendations of the NRCA Roofing and Waterproofing Manual and the recommendations of the University's roofing consultant.
- PVC Roofing:
  - Design PVC roofing systems where the University can expect **20** or more years of overall system performance.
  - Manufacturer shall have a demonstrated history of more than 20 years of successful roofing installations in projects with comparable climate and exposure.
  - Material and system testing shall demonstrate good resistance to industrial pollutants, bacterial growth, and extreme weather conditions.
  - PVC is incompatible with bitumen and polystyrene, and therefore care must be taken to avoid direct contact with these materials.
  - It is intended that PVC sheet roofing contain types, grades and quantities of plasticizers sufficient for long-term performance of the roofing membrane, without excessive degradation resulting from migration, exposure or aging.
- Vegetated "Green" Roofing:

- Design vegetated roofing systems where the University can expect **50** or more years of overall system performance.
- Vegetated roofing is generally classified into two types:
  - Extensive (lower weight, tolerant plants only, and no regular traffic)
  - Intensive (heavier weight, wider variety of plants, and support recreational traffic)
- Decisions to implement vegetated roofing in pursuit of project objectives must be weighed heavily, taking into consideration the life cycle cost of the system, ease of maintenance and difficulties with assessing and repairing potential leaks.
- In the event that the FS Project Manager approves the use of vegetated roofing on the project, the Consultant will consider use of systems available from Sika Sarnafil as the preferred manufacturer, subject to the following criteria:
  - Manufacturer has a demonstrated history of more than 20 years of successful vegetated roof installations.
  - Systems and materials provide long-term protection from puncture, constant dampness, ponding water, root growth, heavy overburden, algae, and insects.
  - Systems and materials are compatible with the installation of a conductive screen grounding layer below the waterproofing membrane for use in electronic leak detection.
  - Single-source, 20-year warranty for extensive vegetated roof assemblies that includes overburden material, waterproofing and vegetated cover.
- The Consultant is expected to specify appropriate QA/QC requirements necessary to assure satisfactory completed work and reduced risk associated with removal of overburden materials normally associated with vegetated roofing installations. Refer to the requirements for flood testing and EFVM in the "Waterproofing Requirements" section.

- **NOT ACCEPTABLE:** Tray type systems are **not** acceptable due to roof maintenance concerns.
- Clay Tile Roofing:
  - Design clay tile roofing systems where the University can expect **75** or more years of overall system performance.
  - The University purchases clay tile and specialty fittings directly from the material supplier: Ludowici Roof Tile.
  - The Consultant shall provide a dimensioned roof plan, drawn to scale, for use by the supplier in performing material take-offs.
  - Lead time for specialty units and fittings can be as long as four months.
  - It is the joint responsibility of the Consultant and material supplier to make site inspections, so as to determine the quantities and locations of specialty fittings and avoid delays in shipping resulting from known lead time issues.
- Sheet Metal Roofing:
  - Design sheet metal roofing systems where the University can expect **40** or more years of overall system performance.
  - Material shall comply with National Coil Coater's Association Technical Bulletins for factory color-coated steel.

  - Sheet metal items shall be in accordance with recommendations of *The Architectural Sheet Metal Manual*, published by the Sheet Metal and Air-Conditioning Contractors National Association, Inc. (SMACNA), unless noted otherwise.
  - Welding shall be in accordance with standard practices outlined in the American Welding Society (AWS), Code for *Welding in Building Construction*. All welds shall be completed by an AWS certified welder.
  - Copper roofing shall conform to the *Standard Specifications for Sheet Copper Work* published by the Copper Development Association, unless noted otherwise.
  - Skilled workers performing field soldering shall demonstrate their ability by preparing, field soldering and cutting open a minimum 12" long test seam in the presence of the independent Building Enclosure Consultant or Testing Agent.
- **NOT ACCEPTABLE:** Lightweight insulating concrete deck is **not** acceptable for low –slope roofing installations.
- **NOT ACCEPTABLE:** Cementitious wood-fiber deck panels (commonly known by the brand name "Tectum") are **not** acceptable for low –slope roofing installations.
- **NOT ACCEPTABLE:** Precast lightweight concrete deck panels are **not** acceptable for low –slope roofing installations. **NOT ACCEPTABLE:** Expanded polystyrene (EPS) and extruded polystyrene (EPS) insulation is **not** acceptable for roofing installations utilizing heat of sufficient temperature to pose the risk of melting the insulation (i.e. hot asphalt, induction welded membranes, etc.).

Exterior Paints and Coatings

Protection of new and existing exposed exterior building components is paramount to the life of a building. The University expects its selected design team to select the most appropriate paint and/or coating system that meets FS2 standards. New fixtures, products, and/or systems should be prefinished/painted in shop prior to installation on site. Exterior systems and components that require proper protection include (but are not limited to):

- Steel frames, heavy metal & medium metal
- Exterior metal panels
- Wood framed windows
- Aluminum curtain wall & storefront
- Steel framed windows
- Wood door frames & doors
- Aluminum door frames & doors
- Steel door frames & doors
- Roof systems:
  - Metal, or painted metal, flat seam, non-structural.

Selection and submittals:

- Submittals, including samples, product data, & warranties, for all paints and coatings and associated colors shall be provided to the University for approval prior to issuing of bid documents. Application, surface preparation, maintenance requirements, and warranty information must be provided. This includes pre-finished components and systems.

Products:

- Paints and coatings shall be professional grade as opposed to contractor grade.
- Approved Manufacturers (Paint & Coatings):
  - Pratt & Lambert
  - Sherwin-Williams
  - Pittsburgh
  - Benjamin Moore
  - Glidden Professional
  - Devoe High Performance Coating
  - PPG Industries
- Quality Assurance
  - Single-source responsibility: Materials selected for each coating system and type of surface shall be the product of a single manufacturer

Preparation of Surfaces:

- Site Conditions:
  - Apply paints and finish products within the temperature range, humidity, and environmental conditions acceptable to the manufacturer of the product, as listed on the product label or product data sheet. Contractor and/or installer is to record temperature and humidity levels on days of coating application.
- Protection:
  - Prior to all surface preparation and painting operations, completely mask, remove, or otherwise adequately protect all surfaces and/or items in contact with painted surfaces but not scheduled to receive paint.
- Cleaning:
  - Before applying paint or other surface treatment, thoroughly clean all surfaces involved according to paint or finish coat manufacturer's recommendations.
  - Schedule all cleaning and painting so that dust and contaminants from cleaning process will not fall on wet, newly painted surfaces or other finished surfaces.
  - Clean metal using chemical or mechanical methods recommended by the finish coat manufacturer for the metal substrate indicated. Thoroughly clean all surfaces until they are completely free from dirt, oil, and grease.
- Existing painted surfaces preparation:
  - Remove dust, dirt, residues, grease, oil, flaking or peeling paint, and correct all defects. .
  - Patch cracks and holes, sand smooth, and spot prime prior to finishing.
  - Feather edges at surface repairs.
- Priming:
  - Spot prime all exposed nails and other metals that are to be painted with emulsion paints using a primer recommended by the manufacture of the coating systems.
  - Prime surfaces as recommended by manufacturer of finish.
- Material Separation:
  - Separate dissimilar metals and other materials to prevent degradation, staining, etc.

Installers:

- The University requires that the installing Contractor have completed paint or coating applications similar in material, design, and extent as the Project calls for and that have resulted in a successful in-service performance.
- Touch-up or repainting of surfaces shall cover the entire item, frame, or wall area. "Spot" touch-up work will not be permitted.

d) Renovation/ Alterations

Although these Standards are generally written in the context of new construction, they are expected to be implemented in renovation and alteration work to the extent practicable, taking into account existing conditions, historical stewardship and other project specific conditions. As part of the design process, the Consultant will make recommendations regarding further investigations, reasonable adjustments to the standards and alternate courses of action necessary to achieve project objectives, for consideration by the FS Project Manager.

The following general guidelines shall be incorporated in renovation and alteration work involving the building envelope:

- Embrace the historic fabric and form of current building envelope components and assemblies, with minimal compromise to overall aesthetics.
- Identify the underlying functional characteristics of the existing building envelope in terms of Support, Control and Finish. Design alterations that are compatible with the existing construction, and with project performance objectives.
- Obtain a history of known non-performing characteristics of the existing building envelope.
- Develop a site logistics plan that minimizes disruption of occupancy, acknowledges the quality of life for students and staff, control interruptions of services including pedestrian and vehicular traffic, while maintaining a safe and productive workplace for the contractors, users and public for the duration of the project.
- Provide for full-time or discretionary periodic observation of the work by an independent Building Envelope Consultant and/or Testing Agency.
- Verify the availability of service providers that have been pre-qualified by the University for the type of work included in the project scope. Early in the project make recommendations regarding revisions to the service provider lists, as appropriate for the work.

e) Design Documentation

Coordinate and show each type of penetration through the building enclosure for such items including but not limited to lightning protection, electrical receptacles & boxes, exterior lighting, building signage, wall hydrants, exhaust ducts, etc. Indicate the methods for maintaining the integrity of each control barrier.

f) Performance Verification & Measurement

Early in the project schedule, the Consultant, Project Manager and other project team members will compare the risks and costs associated with potential remediation relative to the costs budgeted for design, construction and quality assurance activities. Based on this, the project team will determine the appropriate degree and extent of performance verification and measurement (V&M) activities to be included in the project. The extent of these activities will be re-evaluated periodically based on the complexity and proven-record for the component systems envisioned in the building envelope design.

- Materials, components and systems are unique or have unproven records of performance shall be identified early in the project schedule so that suitable verification, testing, measurement and assessment can be made prior to the end of the Design Development (DD) phase. Changes to the design may be required for unproven systems.
- Where appropriate, more robust quality control measures may be implemented on the project to better ensure adherence to the desired performance requirements. These may include additional material testing, mockup testing, field testing, thermal imaging, monitoring and measurement of the work on site.

g) Mockup Testing

Where mockup testing is included in the project V&M program, the project delivery method shall provide for the following:

- Provide all labor, materials, equipment and services required to install and test a full size mock-up of the wall system at the facilities of a recognized testing agency.
- Mock-up(s) shall include the furnishing and installing of all building envelope system components (i.e. masonry, precast concrete panels, aluminum and glass window system, insulation, flashing, glazing, gypsum board, and sealants) as specified for the portion of the building envelope being tested.
- Design Review of Mock-up: Upon completion of the erection of the mock-up, and prior to the commencement of any pre-testing, it shall be reviewed by representatives of the University and Consultant. This review shall be for general compliance with the visual design concepts of the building enclosure systems.
- Prior to the commencing of testing, the Testing Agency shall submit for review a detailed statement of the procedures and sequence of testing, the testing methods to be employed, the test loads, pressures, temperatures, etc. for each test, and the design performance requirements and evaluating methods for each test.

h) Field Observation

Where field observation is included in the project V&M program, the project delivery method shall provide for the following:

- Retain an independent Building Envelope Consultant and/or Testing Agency to perform the field observations. To the extent practicable, they should be retained directly by the University.
- Testing Agency shall perform field observations and prepare reports.

Determine the degree and extent of field observation appropriate to meet the project accessibility objectives. This can vary from periodic observations to full-time, on-site monitoring of the work.

i) Field Testing

Where field testing is included in the project V&M program, the project delivery method shall provide for the following:

- Retain an independent Testing Agency to perform the field testing. To the extent practicable, the Testing Agency should be retained directly by the University.

3. References

The Consultant shall become familiar with applicable federal, state and local regulations, and with current construction industry standards as applicable to the project design. Include those that are applicable in the design documentation for the project, and were appropriate indicate more stringent requirements as required to meet project goals. Unless otherwise required, the current editions and revisions of standards are applicable.