

Commissioning the Windows: Design Phase Strategies for High Performance Buildings

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Synopsis

Building envelope plays a crucial role in the total performance of any building and it must be addressed as part of any commissioning effort. A failed building envelope will not only create persistent operational problems from leaks and drafts, other building systems cannot perform as intended. This paper will discuss common envelope issues that arise during commissioning, focusing on proper window design integration as a critical component to ensuring proper HVAC performance, lighting, and occupant comfort.

About the Author

Paul Tseng has been a practitioner in the art and science of high performance buildings for his entire career. His passion is in helping owners and the project teams delivering high performance buildings through the use of integrated multi-disciplinary design and quality assurance process of commissioning. He advocates thermal envelope commissioning as an integral part of commissioning on green buildings. As a facility manager, he witnessed first hand the impact of costly envelope failures on building operations and strains such failures placed on building maintenance staff. He also experienced the satisfaction in achieving superior occupant comfort and ultra-high energy efficiency in buildings that works as intended by the owner. He currently serves on the Guideline Committee of National Institute of Building Sciences (NIBS Guideline 3-2005) on Exterior Enclosure Technical Requirements for the Commissioning Process. He also is an instructor on Commissioning Process for Building Assemblies and Systems at University of Wisconsin-Madison. He co-authored a technical article – “*The role of commissioning in LEED certification*”, a guidance paper on commissioning for green building projects for owners and commissioning practitioners.

Thermal Envelope – A Neglected Subject in Commissioning

Building envelope commissioning continues to be largely a neglected area in most commissioning efforts. The overwhelming majority of commissioning projects currently performed does not include it in the project scope. High performance buildings need high performing building envelope systems that include the window systems. In most LEED projects and among the majority of commissioning practitioners, building envelope performance receives minimal scrutiny. Anecdotal evidences are emerging of completed LEED and green building projects experiencing significant envelope failures with high degree of occupant discomfort and poor performance. This paper addresses issues of concern for building envelope integrity and with specific focus on window systems. Recommendations on design phase strategies for commissioning the building envelope on LEED projects are also included. Suggestions to the owners on scoping the commissioning requirements will be presented.

Issues in Building Envelope Integrity

Radiative Heat Transfer and Thermal Bridging

Heat is transferred by radiation in a glazing system. Radiative heat transfer through the window system in a building envelope is a complex design issue involving the balance between interior heating and cooling loads and daylighting strategies. Significant amounts of energy can be transferred through radiation, making window and other glazing system design very important to the energy balance of a building. The framing of a window system can further compound the energy balance by failing to provide a true thermal break in its construction. The undesirable effect of condensation from thermal bridging in the window frames will be a persistent maintenance problem. Commissioning-focused reviews during the design phase should address the energy balance through radiative heat transfer and ensure that the entire window system, especially the framing details, delivers a true thermal break element in its design.

Water Intrusion

Rainwater intrusion and moisture migration within and through the building envelope must be controlled to prevent moist air from contacting and condensing on cold surfaces or on elements within the envelope. The glazing system in a building envelope must have an integral rainwater management design. While glass in a glazing system or window has high resistance to water vapor transport, its framing design and construction technique can be prone to water intrusion problems. Performance of a window system is not only function of its glazing properties it is also dependent on the connection to the adjacent envelope elements. Installation procedures for the window systems can contribute to the seriousness of this problem when improperly done. The most common contributor to water intrusion from the window system is the improper application of caulking on the window framing elements that undermines the rainwater channel design by the window manufacturer. Commissioning during construction – by verification of

the proper installation of window and appropriate application of caulking around it -- can contribute to the long term performance of the window system.

Thermal and Visual Comfort

A pattern commonly observed by many design teams is that misunderstandings often occur between the designed window systems and the thermal and visual comfort in the final product. To a surprising degree, many architects and design engineers lack fundamental understanding on the interplay between the glazing system and the desired level of thermal and visual comfort their design intended to produce in their buildings. The decision to select a particular window or glazing system is often made on the basis of aesthetics and first costs and rarely reflects the desired comfort criteria or long term performance of the window elements. The resulting draft from poor thermal performance and visual discomfort from inappropriate attention paid to light transmittance of glazing system are common problems in supposedly 'green' buildings. As commissioning practitioners, we need to make the effort to include criteria in the peer reviews and inform the design team of its importance and potential pitfalls.

Window Design Phase Strategies

Window systems are major player in the energy balance of buildings. Their design is a critical part of the building process. The selection of the glazing properties, materials, and systems can have major impact on the energy use and occupant comfort in the building.

- **Air Tightness:** Air infiltration and exfiltration through window systems is unwanted movement of air within the building envelope. Three principle causes of this problem are: poor product design, poor quality control, and lack of design details for use during construction. Thermal performance of window systems can be addressed by maintaining air tightness and thermal insulation integrity at the connection of the glazing system to the opaque portions of the envelope. Test procedures such as ASTM and AAMA are helpful, but not a guarantor of performance for windows. Window details, especially at intersections and connections to the rest of the building envelope, in the design documents are crucial information for the contractors during construction. Commissioning-focused review needs to cover a scrutiny for air tightness design of window systems.
- **Daylighting Strategies and Visible Transmittance.** Daylighting can improve the environment within the building, reduce lighting energy use and improve visual comfort, if properly design. Improper daylighting design, however, can create harsh glare and severe visual discomfort requiring costly window treatment to be installed. In many office buildings a design including floor-to-ceiling windows is intended to provide ample daylight. Yet, the final design often has the windows heavily tinted which defeat the intent of daylighting strategy. The other extreme is making the window entirely clear without any shading properties in the mistaken attempt to maximize daylight available, but causing glare instead.

Daylighting design is a powerful passive design strategy to harvest daylight and enhance visual comfort. To achieve an optimal balance, a careful analysis of appropriate visible transmittance desired through the windows and the proper incorporate passive daylight design is needed. The opportunity to address this feature is during the design phase. Commissioning-focused peer review can augment the efforts of the design team and help to achieve the outcome desired in the final product.

- **Water Intrusion Control and Management:** Windows and glazing systems need water intrusion management features in order to perform. Rainwater penetration through windows has been a persistent problem for building owners. Uncontrolled water intrusion destroys interior finishes, deteriorates structural framing and promotes indoor air quality problems. It is of paramount importance that the window systems control and weep to the outside water that will eventually intrude into the building envelope. The intersections of windows with other building envelope elements are inviting opportunities for water intrusion and thermal bridging. The submittals and shop drawings from window and curtainwall system manufacturers do not address such details necessary for installers to follow through with the design intent. Window design details in design documents must clearly delineate rainwater management and channeling requirements. A sound window system should have these attributes of waterproofing – (1) design for drainage, (2) incorporates internal drain paths, (3) integral weep systems, (4) provisions for sub sills and flashing, and (5) resilient gaskets and sealants.

Recommendations to Owners

- **Recommendation #1: Insist on a Multi-Disciplinary Team Approach for Building Envelope during Design.** Too many design teams carry out their design on LEED projects in the same old manner with the same failed habits of passing an architectural design, already cast in stone with regard to building envelope elements, to the other design disciplines to complete “filling-in the blanks” for their respective specialties. Often, this approach means the mechanical design engineer had to beg for mechanical room space, which the architect had neatly allocated for other “critical” program spaces, or simply put them on the roof. The electrical designer “wires up” the lighting layout shown on the reflected ceiling plan already “completed” by the architect and the plumbing engineer takes care of connecting the roof drains “predetermined” by the roof layout. The resultant oversizing of the mechanical system, the overly conservative upsizing of the electrical distribution, and the ample pipe sizes provided for the plumbing system give the owner a building design that is neither integrated nor optimized. Of course, all the design team members complain loudly about the trouble and time it takes to do a green building or crow about how energy efficient the whole building design is.

The project owner--who holds the purse-strings and who will suffer the outcome of any design--needs to insist on genuine teamwork and collaboration within the design team. A

commissioning authority, accountable to the owner, can serve a constructive role during the design phase. Both for LEED and any green building project, monitoring the adherence to the Owner's Project Requirements and the review of the Basis of Design by the design team can be a vehicle for promoting inter-disciplinary coordination and integration of design elements as part of the design phase commissioning process. With the owner's firm backing, the commissioning authority --one that is experienced in the nuances of building envelope design-- can and should ask the right set of questions as part of the commissioning-focused reviews for the owner to facilitate the team communication between the design team members. An optimized daylighting design, a cost-efficient HVAC and lighting systems and a maintainable building can be the fruit of this collective effort. An owner needs to insist on this outcome.

- **Recommendation #2: Define acceptance criteria for the Building Envelope.** In many LEED and green building projects, there is an observed pattern of "over-invest" in the showy building envelope elements, especially the window elements, and "under-invest" in the durable building systems that pay dividends for the life of the building such as a coherent daylight harvesting envelope design. To achieve an optimized daylight harvesting design, especially using passive design approach, without the undesirable glare problem can only be done with careful orientation and modeling of any proposed window and glazing system.

The acceptance criteria should include (1) daylight harvesting design with passive glare control, (2) waterproofing measures for window systems, (3) thermal efficiency of window products, and (4) durability of cladding materials. The criteria should be part of a commissioning process and incorporate into the scope for commissioning providers.

Summary of Design Phase Commissioning for Windows

Windows are the eyes of a building. It allows an observer to see the rest of the building design. Windows shape the perception of a building and define a building's unique personality. The performance of a window system cannot be separated from the overall performance of a building; this is especially true regarding its mechanical and lighting systems.

The reticence by many commissioning practitioners in addressing the need for commissioning the window design may due to the concern of liability exposure of building failures. Such fear is not grounded, since the lack of properly commissioning the window design during the critical decision phase of the design actually promotes building failures and complicates the rest of the commissioning effort.

The commissioning professionals also need to develop expertise in thermal envelope as part of their practice. Many commissioning practitioners have indicated that they will do it only if they are being paid to do it and learn on the job. Since commissioning is only valuable if added value can be discerned, such a passive attitude is not helpful to the success for the project. Commissioning providers should invest in self-study and training

in the art and nuances of thermal envelope commissioning, so that collectively as an industry we can offer more value to the owners and the project teams.

Owners are encouraged to include envelope and window commissioning as part of their project requirements, especially for green buildings. Owners also need to insist that those who provide such services are competent and conversant with the rigors of commissioning windows and other building envelope features. The modest additional fee will be more than offset by a building envelope that performs from day one, with resultant occupant satisfaction and long term robust performance in their green buildings.

References

Carmody, John: *Window Systems for High Performance Buildings*, Norton, 2005