Emerging Trends in Building Envelope Commissioning

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ABSTRACT

Building envelope commissioning is critical to ensure that the building envelope performs as intended and meets the established performance criteria by providing the desired thermal properties and resisting air and water migration. Due to the increased reliance by the mechanical systems on building envelope performance, failure of the building envelope can result in reduced occupant comfort, unrealized energy savings, and deterioration of some building envelope components. These building envelope failures can also result in costly repairs to re-establish the desired performance and may damage the reputation of the sustainable building industry. In Canada and the United States, building envelope commissioning is often misunderstood due to the lack of standard terminology and practice. This misunderstanding leads to confusion around the scope of services required to ensure that the building envelope performs as intended. Using examples from project experience and the commissioning framework provided by both NIBS (National Institute of Building Sciences) Guideline 3 and ASHRAE (American Society of Heating, Refrigerating and Air-Conditioning Engineers) Guideline 0, building envelope commissioning and building science consulting will be defined and their issues discussed. This discussion will include an overview of emergent and varying terminology in use in Canada and the United States, including LEED® Canada NC-1.0 Durability Credit MRc8.

INTRODUCTION

Commissioning, as defined by National Institute of Building Sciences (NIBS) Guideline 3 (GL-3) and American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE) Guideline 0 (GL-0), is the independent verification of the owner's project requirements (OPR) from project inception through occupancy and can continue for the life of the building. Applying this general commissioning definition to building envelope design and construction will ensure that the systems and materials that comprise the building envelope meet the OPR and result in successful, better built buildings.

The recommended level of commissioning can be informed by members of the design team and is based on the owner's tolerance to risk, the building type, complexity, and size, and the desired level of quality. The intent to commission the building envelope must be conveyed to the potential design team at the earliest opportunity and the framework for commissioning during design and construction should be agreed upon prior to project commencement to minimize cost and maximize benefits.

ASHRAE GL-0 provides extensive documentation that outlines the general process of commissioning, setting the framework by which to address all areas and components of a building. NIBS GL-3 builds on this framework and provides specific direction on commissioning the building envelope using verification, acceptance, and documentation during each project phase. NIBS also contains volumes of information pertaining to specific commissioning activities including: process flowcharts, roles and responsibilities, OPR development strategies, and testing procedures.

Attempts have also been made to apply building envelope commissioning principles to the green building industry in Canada by the introduction of a Durable Building credit (MRc8) in the LEED Canada-NC rating system. This

credit formalizes the material selection process utilizing the CSA-S478 Guideline on Durability in Buildings and requires the development of a Building Durability Plan along with an appropriate review process.

IMPORTANCE OF BUILDING ENVELOPE COMMISSIONING

The building envelope accounts for a substantial portion of the total construction budget and is often assembled over a long duration involving numerous trades. This critical assembly has no generally-accepted quality assurance mechanism outside the NIBS framework. Further, the air barrier is receiving attention as a newer technology in the United States, being adopted by State energy codes to improve building energy efficiency (MeLampy 2006). Due to the increased reliance by the mechanical systems on building envelope performance, failure of the building envelope can result in reduced occupant comfort, unrealized energy savings, and premature deterioration of some building envelope components.

Sustainable design projects often incorporate the use of innovative cladding technologies, complex cladding assemblies, and new cladding materials. Unfamiliarity with these materials by members of the project design and construction team or insufficient review of performance characteristics during design can contribute to building envelope failures. These failures can result in costly repairs to re-establish the desired performance characteristics and may damage the reputation of the sustainable building industry. A thorough understanding of envelope material and cladding system life cycle is required to maximize the benefits of sustainable and durable materials.

Analyses that evaluate comparatively the energy requirements, mechanical sizing, life cycle costing, and payback for various building envelope assemblies highlight the integral relationship between the envelope and mechanical systems by recognizing thresholds at which envelope improvements can result

in down-sized mechanical systems. Since energy savings are associated closely with improved building envelopes, commissioning the envelope is critical to ensure that the performance criteria are achieved and the anticipated energy savings are realized. Performing a cladding study in the schematic design phase leaves numerous stages at which design influences and coordination detailing can corrupt the intended service parameters of the envelope, which will be discussed later.

In addition to mechanical system and building envelope integration, the general quality of the building envelope benefits from the commissioning process. Transitions between building envelope components or assemblies generally total less than 1% of the building envelope area but can account for 90% of failures and leakage (NIBS Annex U 2006).

CASE STUDIES

The following examples highlight the importance of building envelope commissioning to ensure the successful construction of the envelope while recognizing the role of durability in material selection.

The first case study involves a sporting facility in the Greater Toronto Area constructed circa 2000 and containing a high humidity indoor pool environment that was experiencing a number of performance-related issues. Condensation on the interior and exterior and uncontrolled water infiltration during significant rain events resulted in damage to the interior finishes, hazardous winter conditions on the exterior due to icicle formation, and deterioration of exterior cladding elements.

A significant course of repair, which resulted in a large amount of waste being sent to landfill, included improving the building envelope and thermal barrier continuity to realize significant service improvements. Post-remediation

diagnostics concluded that there was 1) a significant reduction in air migration across the building envelope, 2) a reduction in thermal bridging across the building envelope, and 3) a reduction in condensation potential both on the interior and exterior. As a result of our involvement with this project, a commissioning-type function in the form of peer review of key architectural details was performed for a newly designed sporting facility by the same architect. This review highlighted key detailing and material selection improvements that could be incorporated into the façade with little aesthetic or cost impacts while achieving a significantly better performing envelope.

The second case study involves a recently constructed hospital in Ontario that was experiencing uncontrolled condensation, water infiltration, and air infiltration and exfiltration at the windows. Extensive evaluation of the as-built conditions revealed several deficiencies with the air barrier / vapour retarder system and the transitions between adjacent building envelope systems, despite periodic review by a contractor-retained and -directed building envelope consultant. The review process failed to identify and resolve key details, which resulted in gross failure of the façade in some areas.

The client's inability to tolerate water penetration due to the risk of mould growth and subsequent risk to patients contributed to our recommendation to remediate the window frames and sub-frames and improve the moisture management strategy at the window head. Extensive disruption to the occupied hospital and the high cost of the remedial repairs highlights the value of commissioning the building envelope. As importantly, this example illustrates some potential risks of using a non third-party commissioning agent.

Lastly, there is a well-documented case of a LEED Platinum building that experienced uncontrolled water infiltration and required extensive retrofit immediately upon occupancy (Lemieux and Totten 2004). A thorough review of the envelope materials and transition details identified several areas of concern

that could have been addressed by an envelope commissioning agent during design and construction, including the selection of the main cladding material. This case study provides a detailed overview of the envelope commissioning agent's role, which may or may not preclude the involvement of an envelope consultant, while recognizing that the commissioning agent's scope is highly dependant on the building type and complexity.

LEED and other sustainable building projects receive significant promotion and press attention upon their completion. Pairing these front-page stories with evidence suggesting failure of cladding systems, envelope components, or HVAC/envelope integration can be detrimental to the reputation of sustainable buildings.

These examples form a growing body of evidence that supports fundamental building envelope commissioning as a requirement on all projects. OPR verification at project inception coupled with the mechanism of building envelope and mechanical system commissioning may have avoided significant repair costs, dissatisfaction of the building owner and occupants, damage to the reputation of sustainable design, and potential liability issues resulting from defects and resultant performance issues.

NIBS states that the commissioning role could be performed by a number of parties – owner, program manager, construction manager, third party commissioning authority hired by the owner, LEED-required commissioning authority, general contractor, or other (NIBS Guideline 3 2006). The primary purpose of this role is to provide an independent review to verify the required building envelope performance.

COMMISSIONING SCENARIOS

Based on our experience as both building science consulting engineer and peer reviewer highlights key differences between these functions and the importance of confirming the level of expected commissioning at the earliest possible stage.

The first example of building envelope commissioning, acting as owner-retained building envelope consultants, includes our involvement with a large institutional project in the Niagara region. Working with the architect, contractors, and manufacturers, we performed multi-stage design drawing reviews, shop drawing reviews, building envelope laboratory mock-up testing, site review services, in-situ performance verification, and warranty follow-up to ensure OPR compliance throughout design, manufacture, and site assembly. We worked with the construction manager and sub-contractors on the owners behalf to resolve numerous issues that would have resulted in significant breaches in the building envelope. Follow-up field and infrared thermographic surveys confirmed OPR compliance, specifically in these problem areas.

The second example, as a member of a third-party peer review team in the development process for two health care facilities, highlights a fundamentally different and less thorough approach to building envelope commissioning. Working with architectural, structural, mechanical, electrical, and communications consultants, our primary role was to verify the OPR throughout design development. This independent review, or low-level commissioning service, assisted the design team in developing key details to ensure OPR compliance and a durable, functional, and constructable building envelope.

The third example, within the framework identified in the LEED Canada-NC Durable Building credit, identifies a scope somewhere between envelope consulting and peer review. Developing the Durable Building Plan assists in facilitating the discussion of cladding durability and material life cycle; however, based on our experience there is insufficient oversight of construction activities which increases the potential for defects to go unidentified. Depending on the

project's complexity, a high level of envelope quality assurance must be provided by a dedicated party. This dedicated party should be independent of the contractor (or have sole responsibility for envelope quality assurance) and may be independent from the envelope consultant. The envelope commissioning agent's role is then defined as oversight of envelope quality assurance procedures. Failure to establish clearly the role of the envelope commissioning agent may result in varying and high fee quotes for this scope and, ultimately, poor market uptake. Further, it is clear that the Durable Building credit does not supplant the role of the building envelope consultant nor the requirement for quality assurance procedures by the construction team.

While these examples represent a broad range of potential roles for the building envelope commissioning agent, our experience, and the body of evidence presented herein, confirms that building envelope commissioning is required throughout the design, construction, occupancy, and post-occupancy phases to ensure project success. The level of involvement of the envelope commissioning agent is dependent on a number of factors including: project complexity, cladding material selection, and an owner's risk tolerance.

Challenges to incorporating this role in every project include 1) owners who may not appreciate the importance of commissioning, 2) developers motivated by short-term cost horizons, 3) building codes that do not include a mechanism to ensure successful buildings, and 4) perceived familiarity with the use of innovative materials and assemblies. As a result, the end user and, ultimately, society pays for buildings that perform inadequately and fail prematurely.

SUMMARY

A more detailed review of commissioning mechanisms currently available to the design professionals by governing authorities is required to assess whether legislation or other such code mandates are required to ensure that best

practices are employed on every building. Incorporating a building envelope commissioning agent at project inception, clear articulation of the OPR, and integration of the design and construction team are paramount.

The LEED Canada-NC Durable Building credit encourages the green building sector to adopt the concept of envelope commissioning by utilizing an established standard to evaluate envelope durability; however, the scope fulfilled by this credit does not supplant the building envelope consultant or the requirement for rigorous quality assurance procedures by the construction team.

While nuances exist depending on the relationship between owner, designer, constructor, and user, as well as the complexity, size, and use of the project, the case studies presented suggest that incorporating a reputable building envelope consulting firm as the primary deliverer of building envelope commissioning services will result in higher levels of envelope and mechanical system integration and, ultimately, better built buildings.

References

ASHRAE 2005. *ASHRAE Guideline 0-2005, The Commissioning Process*. Atlanta: American Society of Heating, Refrigerating and Air Conditioning Engineers, Inc.

Barista, Dave 2007. Air Barriers The Latest Tool in Moisture Control. Building Design and Construction < http://www.bdcnetwork.com/article/CA6410054.html>.

CaGBC 2007. LEED® Green Building Rating System for New Construction and Major Renovations LEED® Canada-NC Version 1.0 Addendum. Ottawa: Canada Green Building Council.

Lemieux, Daniel J.;Totten, Paul E. 2004. The Importance of Building Envelope Commissioning for Sustainable Structures. Fairfax.

MeLampy, Michael F. 2006. Building Enclosures – Getting Them Built Correctly. National Conference on Building Commissioning Proceedings. San Francisco.

NIBS 2006. *NIBS Guideline 3-2006, Exterior Enclosure Technical Requirements For the Commissioning Process.* Washington: National Institute of Building Sciences.