APT – NTC Conference 2017

Friday October 13, 2017

Track 3: Delivery – Intervening into Historic Places/ Volet 3: Réalisation – Intervenir dans les lieux historiques

Session CS3.1: Heritage Windows

In this session, the focus is on the conservation of windows comprising assessment, testing, repair and improving performance. Types of windows covered will include bronze, steel, wood, and leaded glass; in varying configurations such as double hung sash and lay lights; different building structures including skyscrapers; and challenging cold climates environments amongst others. Projects highlighted from Oregon, Washington D.C, Ontario and Quebec.

Learning Objectives:

1. Upon completion, participant will be able to identify the appropriate ASTM standard for testing historic windows in situ.
2. Upon completion, participants will have an understanding of the means and methods for designing and fabricating stained and leaded glass lay lights and domes;
3. Design conservation solutions in order to improve the performance of historic wooden double-hung sash windows in skyscrapers and to preserve them; and
4. Learn how hygrothermal field monitoring can be used to evaluate and quantify the performance of heritage windows in cold weather climates.

Bronze, Steel, and Wood: An Air Infiltration Tale of Three Windows

Maya Foty, AIA, LEED AP – Principal, Architectural Resources Group

This presentation chronicles the procedures and results of in-situ ASTM testing methods by an accredited lab to determine the air infiltration/exfiltration levels and water penetration performance of historic windows before and after rehabilitation to identify areas of window leakage deficiency and to help guide appropriate rehabilitation methodologies.

Architectural Resources Group was recently involved in two separate projects that included the rehabilitation of three separate window types: wood, steel and bronze. Both buildings—the Oregon State Capitol in Salem and the Jefferson Sub-station in Portland, Oregon—are listed on the National Register of Historic Places. Both projects comprised substantial renovations that required extensive replacement of the mechanical and electrical systems and were required to meet strict energy standards as dictated by the State of Oregon and LEED. It was the intent of the design team to retain and rehabilitate the windows in both cases, but window performance criteria needed to be met in order to conform to the energy model designed by the mechanical engineer. The project team contracted with QED Lab to perform the following tests: ASTM E1105 Standard Test Method for Field Determination of Water Penetration of Installed Exterior

Windows, Skylights, Doors, and Curtain Walls, by Uniform or Cyclic Static Air Pressure Difference, and ASTM E783 Standard Test Method for Field Measurement of Air Leakage Through Installed Exterior Windows and Doors.

This presentation will discuss the following:

- Testing methodology before window rehabilitation and subsequent testing results;
- Testing methodology after window rehabilitation and subsequent testing results;
- How the testing before rehabilitation helped guide the team in defining the rehabilitation scope and specifications; and
- A general overview of the window rehabilitation methods used on the wood, steel, and bronze windows.

Defying Gravity - Conserving Historic Stained Glass Lay Lights and Domes; Maximizing Structural Integrity While Maintaining Original Design Aesthetic

Arthur Femenella, Sr. – President, Femenella & Associates, Inc.

Many of our significant historical structures are glazed with stained, leaded or decorative glass lay lights and domes. They are often found in courthouses and important government buildings. The subject matter and the way the subject is depicted within the leaded panels speak volumes about the public mores and prevalent culture of the day. It is imperative that we preserve these great works of art for cultural, artistic and historical reasons. There can also be health and safety issues; thousands of people walk and work beneath these glass ceilings every day.

Glass is very strong in compression but relatively weak in tension. Lead cames, the primary structural element of leaded glass panels, are highly malleable but not highly ductile. Lead has a low modulus of elasticity (E= 2.0). When leaded glass panels are placed into near or complete horizontal installations, the forces of gravity apply tensional strain to the glass and the lead. The lead experiences plastic deformation; the window deflects, typically downward. As the lead came matrix deflects, the glass is placed in tension. Once the glass exceeds its tensile limits, it breaks; as glass breaks, it weakens the panel, resulting in more deflection and more glass breakage. The cycle continues.

This paper will discuss the myriad forces that act to deteriorate leaded glass lay lights and domes. It will address the best practices to document the failure(s); this information is critical to designing the most appropriate conservation approach to follow. The paper will discuss best practice in terms of materials and technology to employ to rectify the immediate problems, proactively modify the design where necessary to forestall failure in the future all while maintaining the original design aesthetic and intent.

Three projects will be reviewed: the circa 1860 monumental lay lights of the U.S. Capitol, Washington, DC; the 27 lay lights, each panel measuring 8' x 9', of the DAR National Headquarters in Washington, DC; and the 50' diameter dome of the Allen County Courthouse in Ft. Wayne Indiana.

The Challenge of Conserving Double-Hung Sash Windows in Historic Skyscrapers: the Example of the Price Building in Quebec City

Francois-Xavier Caron, OAQ – Conservation Architect, DFS inc.

A challenge of historic skyscraper conservation rarely discussed is the preservation of traditional windows, like the wooden double-hung sash. From the late 19th century to WWII, this long established window type had been widely used in high-rise buildings where it was exposed to specific conditions unusual in lower buildings. Indeed, a phenomenon like the stack effect is more pronounced in tall buildings and with winds stronger higher above ground, these windows have been exposed to greater air pressure and more intense weathering, especially in the cold climate of Quebec. This put sash windows to the test and often jeopardized their conservation during building envelope restoration for they perform poorly in high-rises. While these windows are an important character-defining element of early skyscrapers, they are now scarce in cities like Montreal and Quebec. Their conservation involves many obstacles as owners have increased expectations regarding thermal performance. In this conference I will share some of the lessons I learned while working on the preservation of wooden double-hung sash windows at the Price Building, an 18 story skyscraper designed by Ross and Macdonald and built in 1929 in today's Historic District of Old Quebec City.

The Price Building is a typical wall-braced cage high-rise, with its perimeter steel columns embedded in thick masonry walls made of bricks and limestone that play against the lateral loads of the wind. Its 390 windows are wooden double-hung sash protected by a storm window of the same type. Their conservation was imposed by the City. During the condition assessment of the windows, numerous problems were noted at different levels in the building, suggesting that height was playing an active role: air infiltrations were more severe at lower levels while evidence of condensation and frosting on glass plates were more predominant on higher floors, as was snow and rain infiltrations. The severity of the decay of wood, paint, sealant, weather stripping, and pulley and chain system would follow similar patterns while problems related to previous renovation works would be found throughout the building. The control of air infiltration and exfiltration and humidity transfer was our priority resulting in the upgrade of compression and brush seals, the addition of trickle vents and the tight adjustments of the sashes into their rebate. These were followed by the restoration or replacement of all damaged material including wood, glass plate, and window hardware. Despite all of these measures, as a result of the recurring problems at the higher levels, further modifications had to be made to the windows during the post-construction phase. The outcome of this project confirms that conservation of this window type in skyscrapers must be based on sustainability at large and authenticity, rather than on thermal performance only.

Upgrading the Performance of Heritage Windows to Suit Modern Design Conditions - 100 Wellington Street, Ottawa

Scott Tomlinson, P.Eng., Professional Engineer – Principal, Sr. Building Science Engineer, Morrison Hershfield

100 Wellington Street was constructed in Ottawa circa 1931 and served as the United States Embassy until 1997, when ownership was transferred to the Canadian Government. The Canadian Government was looking to repurpose this heritage designated building to public Gallery Space, capitalizing on its prominent location across from Parliament Hill.

With the proposed change to Gallery Space, the interior operating conditions were changed to add winter time humidification, with museum quality limits on temperature and relative humidity. The heritage designated windows, which consist of single glazed non-thermally broken bronze frames, needed to be upgraded to tolerate the proposed interior operating conditions during winter design conditions in a cold weather climate. The challenge was to upgrade the air-tightness and thermal properties of the windows without negatively impacting on the heritage character of the building.

This paper will discuss how hygrothermal field monitoring and analysis was used to evaluate and quantify the performance of the original heritage windows and building envelope to the proposed interior operating conditions. It will describe the window rehabilitation approach that was developed. The paper will also demonstrate the validity of the design concept through the construction and monitoring of a full scale in-situ mock-up. Finally this paper presents the hygrothermal monitoring results of the window mock-up and discusses the key findings and lessons learned related to the strategies and concepts utilized for dealing with heritage window upgrades in a cold weather climate