The Dynamic Buffer

A Mock Up in the East

By Vera Zec

In ABN 11, "Dynamic Buffer Zone" introduced the topic of the dynamic buffer zone system. This article provides the results of an actual side by side test during an historical building renovation.

The Traditional Approach

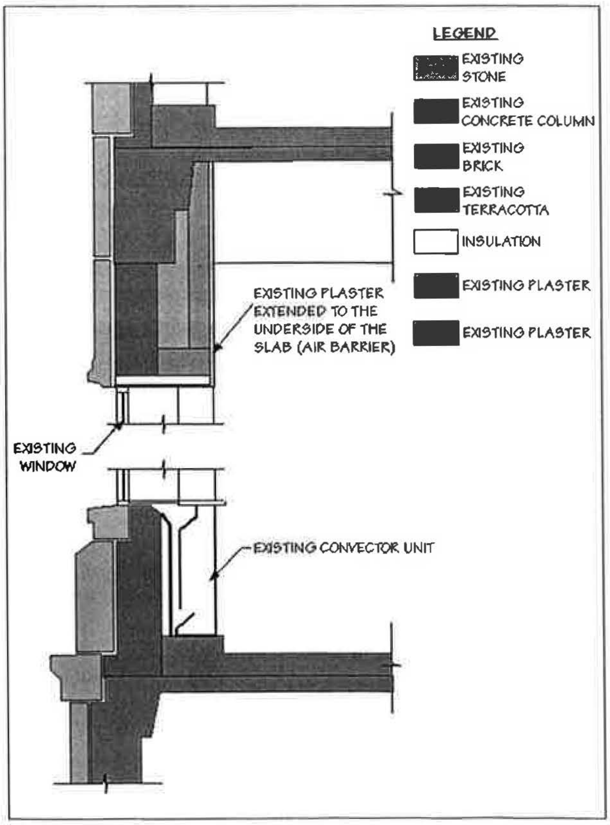
The renovation of traditional load bearing masonry wall buildings usually involves window and mechanical upgrades intended to pressurize and humidify the interior space.

This traditional approach inevitably generates environmental loads previously not experienced by the original enclosure.

As well, there is growing evidence to suggest that sustained air pressurization can be damaging to vintage building envelopes even when mechanical pressurization is kept low, and that the risk of poor performance and damage to the building envelope can be significant if the air leakage and vapour diffusion are not adequately controlled.

This article discusses a case study comparing the dynamic buffer zone system approach with the traditional renovation approach.

Figure 1: Section Detail



About the Building

Both the East and West Memorial Buildings (EMB & WMB), located on Parliament Hill in downtown Ottawa, were reviewed by the Federal Heritage Building Review Office and were approved for, and are now in, the process of upgrading and renovation.

Both buildings were erected as the Federal Government's principal memorials to those killed during the Second World War. With the renovation and upgrade, a part of the West Memorial Building will de designed to house the new archives, and the remainder of the WMB, and the entire EMB, will be upgraded into new office space.

Also included in the renovation is the introduction of a new mechanical system. The existing steam heating, installed in the masonry built exterior walls, will be replaced with the hot water system as high humidity levels are required in the archive areas and the office spaces will require humidity levels only high enough to maintain the occupants comfort.

Elimination of the steam heating from the walls will change the thermal gradient of the exterior walls dramatically. The current steam heating system produces temperature levels higher than 120°C. This heat is radiated through the walls and keeps the wall assembly dry under various environmental conditions of both the interior and the exterior. The new hot water system would decrease the temperature levels by one third, and, as well, would move the dew point inside the walls. Our calculations indicated that once the new mechanical system was implemented,

Zone Wall System

Memorial Building

and new environmental conditions produced, condensation would occur in the wall assembly.

The Building Envelope

The exterior walls of both buildings consist of uninsulated masonry with single glazed steel frame windows. The exterior finish is cut stone veneer on clay brick. A terracotta block with plaster finish comprises the interior side of the walls. The interior terracotta block is generally set clear of the brick back-up leaving a cavity, or void, for mechanical and electrical services. The building envelope is in, relatively, good condition given nearly half a century of useful service life. This good performance is often attributed to the factors that kept the wall assembly reasonably dry. The most recognized factor is the absence of insulation, which allows sufficient heat loss to maintain the temperature of wall components above the freezing or condensing temperature.

Requirements of the Environmental Separator

Air Barrier

Moisture in the walls often occurs due to two mechanisms: vapour diffusion and air leakage.

Air leakage takes place only if there is an air pressure differential across the wall and if there are openings for air to flow through. Also, the combined action of the mechanical pressurization and the stack effect increase the interior air pressure at the upper levels of the building. This drives warm moisture through the inevitable local imperfections in the building envelope's air barrier. Therefore, the design of a continuous and durable air barrier must be carefully considered in order to reduce the possibility of air leakage into the wall enclosure.

Vapour Barrier

A vapour barrier is a high vapour resistance material that prevents the moisture diffusion. In northern climates the vapour barrier is generally positioned on the warm side of the wall assembly.

Humidity and Condensation

Humidity is the amount of water vapour present in the air. Condensation will always occur on a surface of the wall that is at, or below, the dew point of room air. Interior air is generally moister and warmer than the outside air in winter time. Once the warm, moist air reaches the surface of the wall assembly (which has a surface temperature below the dew point), condensation occurs. The condensation creates a potential ice build-up inside the walls during the cold season.

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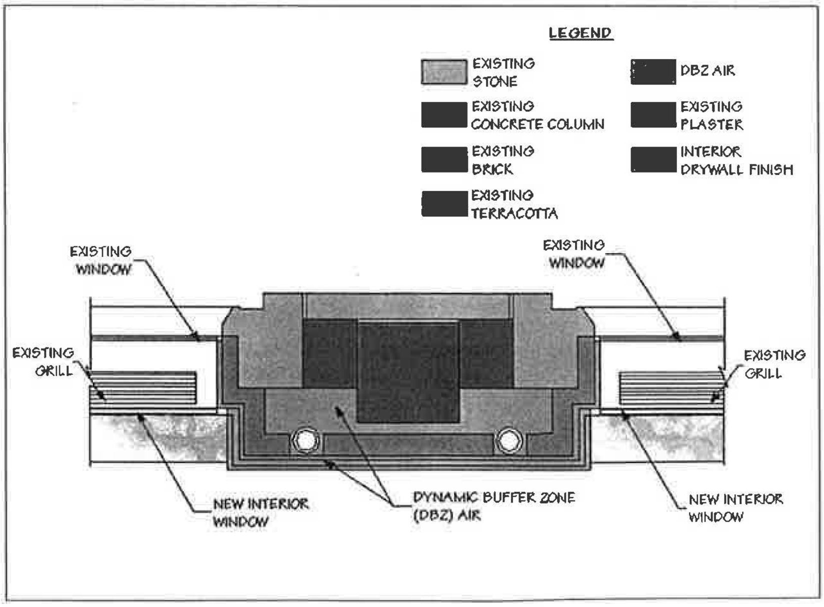

Figure 2:

Plan Detail

A mock-up was constructed in the East Memorial Building to investigate the effectiveness of introducing the Dynamic Buffer Zone system into the restoration process as compared to the traditional building restoration method.

The Dynamic Buffer Zone

In preserving the building envelope of vintage buildings, one of the key considerations is to not change the environmental conditions previously experienced by the building envelope. The new proven technology, known as the Dynamic Buffer Zone (DBZ), introduces a layer of warm, dry and pressurized air into the existing wall and provides a high degree of containment by controlling the air pressure differentials which cause moisture flow. As well, the layer of dry pressurized air offers energy management opportunities when it is extended to, and/or through the glazing, and combined with the building ventilation air. The introduction of the DBZ between the environmental separator and the interior finish is a potentially reliable way to compensate for minor defects which occur in the building envelope during, and after, construction.

The Mock-Up

A mock-up was constructed in the East Memorial Building to investigate the effectiveness of introducing the Dynamic Buffer Zone system into the restoration process as compared to the traditional building restoration method. Two chambers were built, the Dynamic Buffer Zone (DBZ) room, and the Window Replacement room (WRR).

Window Replacement Room

The Window Replacement Room (WRR) was designed in accordance with traditional rehabilitation methods, which included; upgrading of the mechanical system, air barrier design and the replacement of the existing windows. The steam heating system was replaced with a new hot water system. The exterior walls were not upgraded except for the existing plaster finish which was considered to be the most airtight element of the whole wall assembly and was used as an air barrier (Figure 1). Three single glazed steel framed windows were replaced with new windows designed to match the esthetics and the daylight openings of the original windows. The fourth original window in the room was cleaned and refurbished.

The Dynamic Buffer Zone Room

The DBZ room was designed to minimize the influence of the mechanical pressurization and the stack effect on the walls and windows, and to ensure that the exterior walls maintained similar environmental conditions as was originally experienced.

The DBZ system was introduced through two cavities; the existing air cavity in the wall and between the existing plaster finish and the new interior drywall finish (Figure 2). By introducing dry, slightly heated air and pressurizing the cavities slightly higher than room pressure, full control over the air pressure differentials was achieved which eliminated the moisture flow from the interior into the wall.

The intention of the DBZ system is to combine and incorporate the walls and the windows into a dynamic building envelope. Hence, the existing steel framed windows were preserved in the DBZ room and, since they were not air tight, they were used for a fresh air supply for the mechanical system. New interior windows were also introduced. These new interior windows were fully integrated with the DBZ cavity. Three of the windows had pressurized air seals, and the fourth window was designed to allow air circulation between the window panes (Figure 3).

Both rooms were tested under similar environmental conditions. High humidity levels were introduced ranging between 20 to 40 per cent. The interior temperature was kept at 22°C and the exterior temperature ranged between -5°C to -25°C.

The Monitoring Data

Our investigation, research and monitoring confirmed the DBZ theory. The prime factors as to why the exterior walls had performed so well during their many years were, firstly, the absence of insulation and, secondly, due to the heat loss from the interior and the steam heating system.

The monitoring data showed that the wall assembly in the DBZ room was kept warm and dry and was not affected by the variable exterior and interior conditions.

The performance of the walls and the windows in the Window Replacement room, however, was not satisfactory. Even with the continuous and tight air barrier, high humidity levels were recorded in the wall cavities and the new windows suffered from condensation.

The DBZ system proved not only to protect the building envelope from different external influences, but also to recuperate quickly after a system shut down. The most important result was that no perimeter heating was required in the DBZ room. In terms of comfort, even with relative humidity levels of 35 per cent in the room, a sense of comfort was felt immediately upon entering.

Conclusion

The main purpose of the Dynamic Buffer Zone is to extend the service life of an existing building that is undergoing major interior retrofit and to provide comfortable interior environmental conditions. This approach was initially reserved for moisture sensitive buildings, yet, there are further benefits which can be drawn from this technology; for example, the control of air movement within interior enclosure cavities can recuperate energy losses from the building or dissipate solar gain before it becomes a problem that the mechanical system must address.

The conditioning of the wall or window cavities would reduce the need for processing the large volumes for air required to generate comfort. The system also allows an effective wall renovation without modifying the architecture of the original building facade.

This air management system also has benefits that go beyond operating cost. A technology that controls all aspects of energy and moisture transfer within the building envelope will ultimately result in capital cost savings and a level of occupant comfort otherwise unachievable through the conventional upgrades.

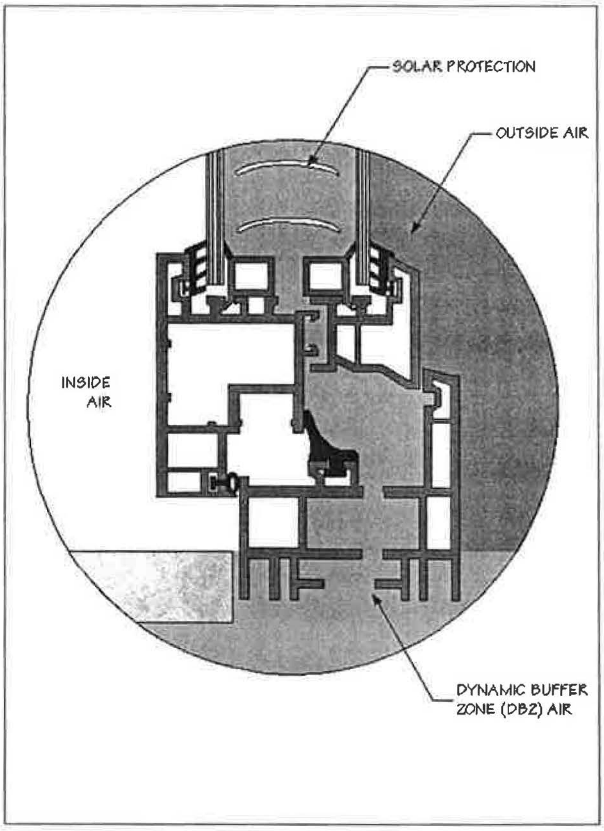

Figure 3:

Sill detail of the proposed dynamic window

Continued on page 17