THE DYNAMIC BUFFER ZONE

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ABSTRACT

Following a study of the 60 year old Canada Life Building in Toronto, Ontario, it was determined that the lack of insulation and relatively low humidity levels of interior air kept the stone cladding warm and dry. The growing need for modern environmental conditions inside the existing building led to increasing the humidification level. To preserve the exterior wall and cladding for another 60 years the dynamic buffer zone (DBZ) was designed, introducing an intentionally controlled environment space between the controlled interior environment and the variable environment outside. Further benefits of the DBZ were derived by integrating the DBZ with the building's HVAC systems.

INTRODUCTION

Restoration can be defined as "...preservation from loss or harm to the heritage of older buildings for the use and enjoyment of our own and future generation", (Weaver et al. 1993). It often requires to preserve the existing materials and structures and at the same time incorporate new construction and new environmental conditions inside the building. The restoration work must not only repair the existing visible problems but also anticipate the changes in the structure associated with the changed interior environment.

In 1930, Canada Life Assurance built its Toronto Head Office with uninsulated masonry/stone walls and bricked-in single glazed steel framed windows. The building

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envelope required little maintenance over these many years because of its ability to stay dry. The upgrading of the building through conditioning of the indoor air (heating, ventilating, humidifying, dehumidifying, and air-conditioning) places the building in a different service environment than what was originally intended for that particular building construction.

TRADITIONAL APPROACH TO BUILDING DESIGN

The traditional approach to wall design is to separate the interior and exterior environments with a static enclosure. It is the role of the mechanical systems to condition the indoor environment. Building heating and cooling loads are calculated and equipment is sized accordingly. Any shortcomings of the building envelope are accounted for by the building's HVAC systems. Static or passive wall design can provide good performance for occupancies in some climates for part of the year. As the environmental conditions change, however, passive walls may have performance problems made worst by workmanship.

Post-Insulating of Existing Buildings

The growing need for modern environment conditions inside existing buildings inevitably leads to increasing the humidification level and adding thermal insulation. Post-insulation of walls on the outside is generally preferred over interior insulation. However, heritage buildings would likely not be considered for an exterior insulation retrofit since the original facades would not be maintained. Interior insulation will place the wall in a colder environment than before the retrofit, thus drying time is lengthened. Moisture problems such as concealed condensation, corrosion of fasteners, and mould or mildew growth may occur within the concealed wall assembly. Furthermore, interior insulation does not allow for thermal coupling between the massive masonry wall and the interior space; advantage of thermal storage benefits cannot be taken since the interior space has been isolated from the massive masonry walls.

WATER VAPOUR AND AIR FLOW

When a mechanical upgrade is performed alone or in combination with additional insulation on the inside, the risk for moisture problems is high if there is not adequate consideration for the control of air leakage and vapour diffusion.

Vapour Diffusion

Control of vapour diffusion is generally simple to achieve and is primarily a function of the water vapour diffusion resistance of the materials and their position within the building envelope assembly in cold climates. All materials have a resistance to moisture diffusion, some more than others; the material with low permeability for vapour must be installed on the warm side of the assembly. The instruments, calculation methods, and psychometric charts are essential tools by which the vapour diffusion mechanism is evaluated (Hutcheon et al. 1989).

Air Leakage

While there is significant technology available related to vapour diffusion control there is minimal technology available related to air leakage control for the repair of existing building envelope. Air can penetrate through porous materials. Also, air leakage takes path through the openings which may develop after construction or after the conditions which the cladding was exposed have changed. Pressure differences inducing air leakage are caused by one or combination of the stack effect, wind action and imbalance of mechanical supply and exhaust air systems (Hutcheon et al. 1989, Quirouette 1990).

It is not uncommon for engineers to design and operate mechanical ventilation systems to provide an excess of air supply over exhaust in order to pressurize the building (pressurization results in reduced infiltration and entry of air pollutants and thus improves comfort). Very substantial pressure differences due to mechanical ventilation system were reported (Wilson et al. 1966). In combination with stack effect in high buildings, the pressure difference is reduced at the bottom and increased at the top approximately by the amount of pressurization. Infiltration is thus reduced at lower levels and exfiltration increased at upper ones. In general, moisture problems due to exfiltration will increase with increasing building height, decreasing average outdoor temperature and increasing indoor humidity.

The air leakage can result in moisture deposit in the order of two of three times higher than that due to vapour diffusion (Wilson et al. 1966, Hutcheon et al. 1989). Furthermore, moisture deposition due to air leakage may be concentrated in the vicinity of the cracks through which air flow occurs.

Air Barrier Location

Air leakage control is a complex objective; air barrier must be continuous, nearly impermeable to air, and structurally able to withstand peak air pressure loads. While the environmental loads are defined by Part 4 "Structural Design" of the National Building Code of Canada, the air barrier is now defined under Part 5 "Environmental Separation" and Part 11 "Energy Efficiency" (new Part for 1995).

To minimize thermal stresses of air barrier and consequent deterioration it should be located on the warm side of the assembly. The Canada Life building envelope, consisting of stone/brick cladding with mortar joints was preserved in good condition due to low interior humidities. This condition was caused by a negative pressure difference across the exterior walls since the neutral plane of the building was probably near the 10th floor due to the configuration of openings in the exterior walls. The remaining floors would have been exposed to a relatively small positive pressure. Also, the exterior wall was kept warm by heat radiated from existing hot water risers located within the cladding cavity. The cladding itself remained relatively airtight. However, if the mechanical system pressurizes the building and humidity is increased, air interchange between the building interior and post-renovation cold surfaces will produce some moisture accumulation in the brick/stone walls which may result in staining, stone displacement and stone anchor corrosion. This amount of condensation may not be necessarily enough to produce a large quantities of water, however, this water is absorbed by the backup mortar, which when frozen causes displacement and cracking of the cladding elements. Once the mortar is cracked, air exfiltration increases and contributes to the moisture accumulation.

DYNAMIC BUFFER ZONE

To reproduce the environmental conditions, which are believed to have protected the Canada Life cladding in past, it was determined to incorporate a dynamic buffer zone (DBZ) in the upgraded exterior walls. The DBZ involves introducing an intentionally controlled environment space between the precisely conditioned indoor environment and the variable outdoor environment (Garden 1988). The space is maintained at a slightly higher air pressure thus the transport of moisture into the wall assembly by air leakage is hindered as well as the associated moisture problems.

Dry and tempered air is delivered to the DBZ cavity by the existing induction unit risers. At the same time, the DBZ cavity is an "intermediate duct" supplying outdoor air to the floors and thereby incorporated in the HVAC system (Fig. 1). The integration of the DBZ and the building's HVAC systems results in highly effective cladding protection, since the potential for problems due to minor workmanship imperfections is eliminated. Furthermore, smoke control within the perimeter of the building became a by-product of the DBZ due to constant pressurization.

Energy Benefits

Since the conditions within the DBZ are controlled, an energy management approach may be incorporated whereby energy losses are minimized or at least recovered. The DBZ may remove heat in the summer and may raise the temperature of the interstitial space in the winter. The DBZ space may also be heated by conducted heat transfer across the wall assembly. This altering of interstitial space temperature minimizes heat losses during the heating season, and heat gain during the cooling seasons. Consequently, human thermal comfort is also improved.

An additional benefits may be recognized or quantified when the facility is in operation for some time. Since the DBZ is a new system, close monitoring will be required.

New Buildings

New buildings have the additional advantage of having the DBZ incorporated in the design stages for improved performance. The DBZ may be incorporated into the buildings which are maintained at high relative humidity, such as hospitals and indoor swimming pools, since there is a greater risk for moisture damage to the exterior walls. the pressurization of the perimeter also allows airborne contaminants to be contained in a space and

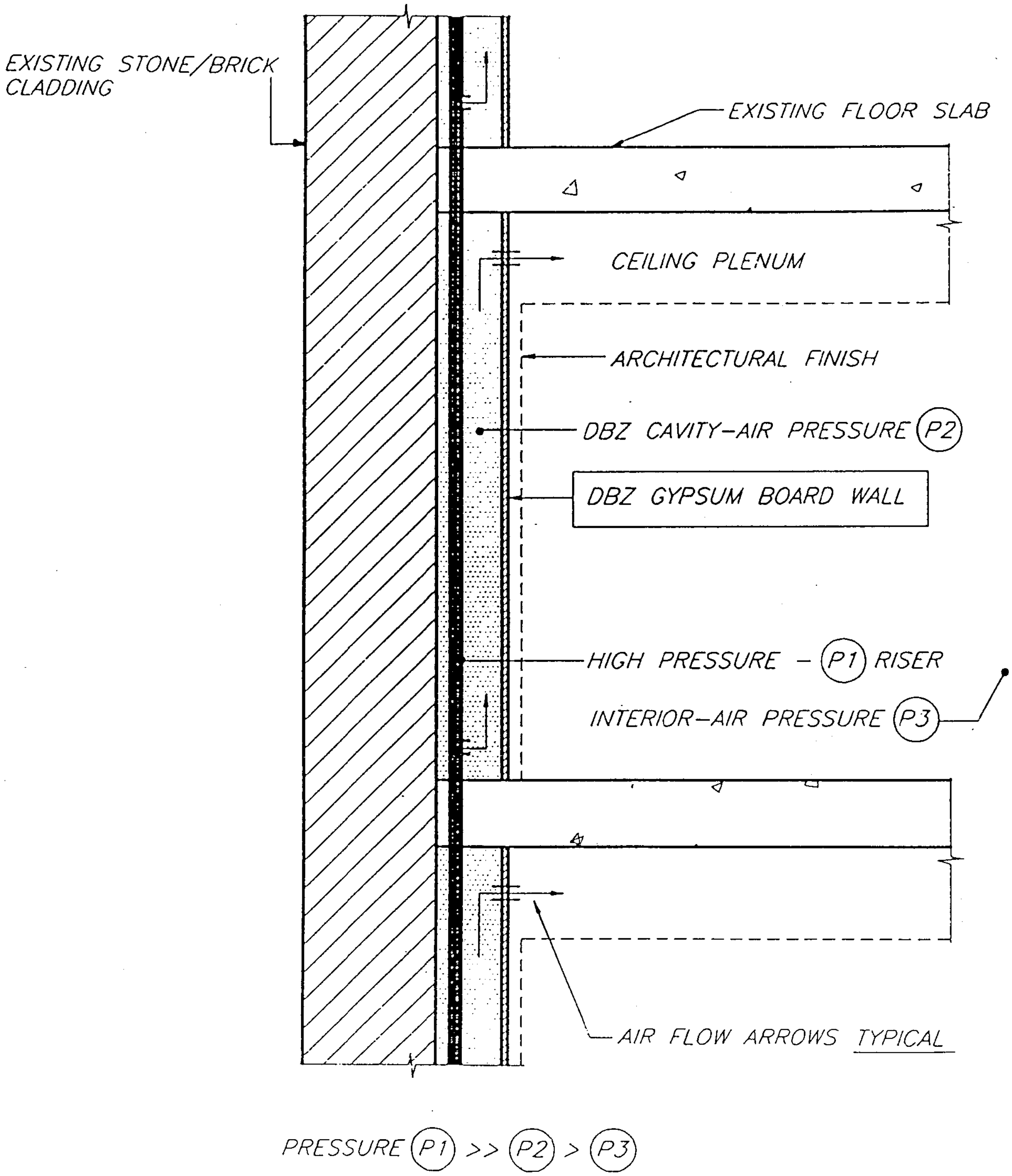

Fig. 1 Dynamic Buffer Zone - Schematic Section

effectively controlled. The DBZ need not only be applied to exterior walls, but it is also applicable to interior walls to provide for containment and control of air.

CONCLUSION

The new approach to wall design should extend the service life of existing buildings which will undergo a major retrofit requiring them to operate under conditions different than the original conditions, without changing the exterior architecture. Energy efficiency is still a concern, but it should be achieved without the addition of insulation. With respect to new buildings, the main considerations are still occupant health and comfort, durability of the building enclosure, energy efficiency, and environmental friendliness.

The DBZ, introduced for the Canada Life building restoration, reduces the impact of the interior humid environment on the exterior stone/brick building envelope to a minimum. The DBZ is used as an air supply plenum for the new ventilation system. The configuration allows for the seasonal conditioning of the perimeter wall surfaces while utilizing thermal mass and promoting energy recycling.

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