Stucco and Exterior Insulation and Finish Systems (EIFS) – Latent Defects Leading to Failure

Numerous reports of accelerated failures in residential and commercial buildings exterior wall systems attributed to the accumulation of water in the exterior wall cavities are raising concerns about structural soundness and suitability for continued use of many properties. MDC® has investigated and analyzed numerous failure situations and has reached the following general conclusions for both cement and artificial stucco systems:

- Construction design details are often ignored in light construction
- Flashing is not properly specified or installed
- Penetrations are not properly closed
- Materials are not applied inside the temperature and moisture limits necessary
- Window and door openings are not carefully closed and caulked
- Other unique factors result in accelerated failure

Based upon our recent experience, MDC® has determined that there are three primary mechanisms which result in water damage to a typical home or commercial structure. These include:

- Exterior Joint Penetration
- Air Pressure Differential
- Entrapment of Internally Generated Water Vapor

Some or all of these mechanisms are at work in failure situations and depending on the severity of the condition the apparent deterioration can be delayed or accelerated.

Exterior Weather Surface

As temperature and humidity change, the exterior surface of a structure continuously contracts or expands. Differential expansion occurs whenever dissimilar materials are in direct contact. A wood door frame, a window, a metal penetration, or an EIFS base coat all expand and contract at different rates. As stated above, the gaps caused by the expansion or contraction of the dissimilar materials are typically controlled by sealants or caulking. Missing or improperly installed caulking will permit water to be drawn by either gravitational or capillary action forces into even the smallest opening in the exterior of the home. It is a simple fact that even homes which were initially properly sealed will eventually leak and fail. Thus, the weakest link for water intrusion in any home is the sealant or caulking used to close these openings. Historically, exterior wall cladding systems have recognized this condition and incorporated provisions to collect and drain this moisture, or allow it escape to the atmosphere back out through the cladding system as water vapor.

The typical EIFS system consists of (1) an acrylic based adhesive, (2) polystyrene insulation boards, (3) a polymer-modified cement stucco base coat and (4) an acrylic finish stucco coat. This combination of essentially impermeable exterior materials does not allow for the evaporation of water which will inevitably penetrate from the outside into the interior of the cladding system.

The typical cement stucco system is also built in layers and consists of a wire mesh with base coat, a following scratch coat and finally the finish coat that imparts the color and texture to the installation.

Any defects in the surface finish that remain open or failures to seal dissimilar materials allow water to enter.

Water Intrusion Pathways

Another physical force normally acting upon the exterior of buildings that can force water into the interior of the exterior wall system is that of pressure differential. Wind or other weather conditions can create a condition of positive

pressure on one side of a building while simultaneously creating negative pressure on the opposite side. Thus water can be simultaneously pushed into the wall surface on one side while it is literally sucked into the wall on the opposite side of the building. Under these conditions, the openings can be very small and virtually undetectable under calm conditions yet allow the intrusion of substantial amounts of water under high wind conditions. Since these pathways for moisture penetration may actually close when the weather changes, it becomes very important that the wall system incorporate a mechanism to collect and drain any such trapped moisture.

This pressure differential penetration condition is not unique to stucco or EIFS clad structures. However, the effect of this pressure differential acts differently on other claddings. More traditional wall coverings such as brick, lap siding, shingles and cement stucco allow air to infiltrate through the entire exterior wall surface rather than a few specific cracks. The positive force being applied to these buildings will be more balanced and less likely to trap rain or water vapor in the structural wall cavity.

The inevitable rain or water vapor from a pressure differential event will penetrate the stucco or EIFS system. The typical stucco system allows for water to drain down through the wall system. However, given the very low permeability of the EIFS materials, any intrusion of moisture caused by pressure differential conditions would result in moisture being trapped behind the EIFS barrier and thereby promote conditions leading to premature wood rot and mold growth in the wood sheathing and wall studs.

There is yet another source of moisture that is equally destructive and has gone virtually unnoticed – the potential effects of moisture generated inside the house that is trapped and unable to evaporate into the atmosphere.

As modern homes have strived to become “tighter” and more energy efficient there have become an increasing concern of poor air quality and the inability of controlling moisture in newer homes. It is a perverse paradox that the very improvements that enhance the energy efficiency of homes built using modern

construction techniques and materials simultaneously set the stage for conditions of interior moisture damage that were previously unknown.

Rates of air infiltration in newer homes have been significantly reduced from historic levels. Twenty-five years ago, a new home would have an air infiltration rate of 2 or more air changes per hour (ACH) and low moisture levels during the heating season. Today a new home can have a 0.4 ACH with some "high efficiency" homes having as low as 0.1 ACH. This condition results in increased moisture levels within the house. Obviously this moisture must be dissipated somehow to prevent the interior from becoming like a steam bath.

It is a well established fact that warm air is capable of holding more water vapor than cold air. This condition is known as a higher "vapor pressure". When a vapor-pressure differential exists, suspended water vapor will naturally and inevitably move from areas of high vapor pressure (warm air) to areas of low pressure (cold air) until equilibrium is established. Significantly, this transfer is not dependent upon any air movement but is simply the result of the tendency of water vapor to flow from areas of higher to lower vapor concentration.

In cold weather conditions, the difference in vapor-pressure between the inside (wet) and outside (dry) air will cause water vapor to move migrate through every available crack and directly through materials permeable to water vapor. If this water vapor is restrained from permeating to the outside (cold) air the vapor-pressure can build up to a point where condensation occurs within the wall cavity.

Thus, as discussed above in the context of water penetration arising from gravity and capillary forces, wind driven pressure differential forces, the effects of vapor pressure differential caused condensation make the provision of a mechanism for the collection and drainage of moisture from within the wall system critically important. If the wall construction assembly does not allow for such drainage and drying, the resulting trapped moisture can cause mold, dry rot and even structural damage.

Moisture inside a home can come from a variety of sources. The average daily living activities from a family of four can contribute to over 18 gallons of water per week. An example of the quantity of water which can be transported by air leakage is provided by the Canadian Wood Council[1]:

> *An opening caused by an electrical outlet has a net opening area of 1 square inch. In one month, 1.1 cubic feet of air would enter the wall cavity under a 0.002 pounds per square inch pressure difference is equivalent to a 10 mph wind. This would amount to 6600 lbs of air and 30 lbs of water. Even if only 10% of this water condenses out in the cavity, this would mean a deposition of 3 lbs of water.*

This is the equivalent of almost 1½ quarts of water a month being deposited in one small area of the wall cavity (i.e. behind a single electrical outlet). Obviously, if this water is not allowed to dissipate to the outside air, damage to the surrounding wall construction will soon result.

The primary locations in wood frame construction where interior water vapor is vulnerable to migrate are window and door frames. This is not necessarily the result of any defect in the design or construction of these items. Rather, it is because the insulating properties of windows and doors are not the same as the surrounding wall construction or cold (or hot) air infiltration as doors or windows are opened or closed in normal use. Some types of windows, such as bow or bay windows are more likely to collect interior water vapor and cause condensation. Other locations where condensation can occur are basement wall sill plates, headers or band joists, the top of exterior walls and any other location where the exterior walls are penetrated by services, vents, and pipes.

When a low-permeable exterior cladding such as the faced-sealed EIFS is installed on wood frame construction, the possibility of water encapsulation in the wall cavity needs to be considered and dealt with. While the EIFS may reduce exterior air infiltration and increase exterior wall insulation values it fails

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[1] Canadian Wood Council March 2004 website – www.cwc.ca/design/tech_topics/building_science/barriers/air_and_vapour/air.html

completely in dealing with the excessive moisture generated within the building that eventually finds its way into the wood framed wall cavity.

These facts and observations have serious implications for the future useful life of all typical residential or commercial structures using either natural or artificial stucco systems. Failure conditions will occur; the only question is at what rate the deterioration will advance.