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Single-Line-Barrier vs. Rain Screen Wall Systems And Insulated Metal Panels

Introduction

In recent years there has been an intensified interest and promotion of rain screen wall systems. Much of the interest has been driven by the publicizing of high profile moisture related construction failures. In North America, the Canadian National Research Council (CNRC) has led the research of rain screen systems design and application in response to construction failures primarily caused by poor performing construction methods in high humidity coastal areas and use of low rise construction methods for high rise applications.

Unfortunately, the design concepts and design requirements of rain screen systems have not always been fully understood and sometimes misrepresented. In some instances, rain screen systems have been promoted as the cure-all for all building applications while ignoring or even disparaging other systems, such as single-line-barrier systems. This has resulted in misleading information and improper applications of the rain screen concepts, including misapplications on insulated metal panels.

The intent of this discussion is to clarify differences between rain screen and single-line-barrier systems and clarify how those systems relate to insulated metal panels.

Systems Descriptions

Single-Line-Barrier Wall (also referenced as Barrier Wall and Face Sealed Wall)
A single-line-barrier system consists of the wall's water, air and vapor barrier functions being fully contained within the wall's cladding. The primary feature of the single-line-barrier concept is that the wall's exterior cladding directly prevents the penetration of water, air and vapor into the wall construction and building interior.

(simple illustration)
A single-line-barrier wall is an appropriate application under the following conditions:

- Facing material is not permeable to water, air and vapor transmission.
- Joints between facing units may be effectively sealed
- Low frequency of joints reduces joint exposure liability

Common examples of single-line-barrier wall systems are solid metal wall cladding, single skin metal wall panels, insulated metal panels and precast concrete panels.

Rain screen Wall (also referenced as Cavity Wall and Back Drained Wall)
A rain screen system consists of the wall's vapor barrier and final air and water barrier functions being contained within wall construction which is separated from the exterior cladding by an air space (air cavity). The primary function of the air cavity is to provide drainage and evaporation of moisture penetrating through the exterior cladding before it can attempt to infiltrate through the final water/air/vapor barrier.

A secondary function is to protect water/air/vapor barrier materials which cannot withstand direct exposure to weathering, wind pressure and abrasion/impact abuse.

A rain screen wall is the appropriate application if any of the following conditions exist:

- Facing material is permeable to water, air or vapor transmission
- Joints between facing units cannot be effectively sealed*
- Unacceptable joint exposure liability due to high joint frequency
- Water/air/vapor barrier material must be protected from direct exterior exposure

* The following are the typical reasons for ineffective joint seals:
    - Joint material permeable to water, air or vapor transmission
    - Differential expansion/contraction of dissimilar joint materials
    - Complexity of effective joint design is not practical or cost effective
    - Incompatibility of cladding material or joint design with available sealing materials

Traditional examples of the rainscreen concept are brick or masonry veneered stud wall constructions. In such constructions, the vapor barrier and final air and water barrier is incorporated in a membrane or sheathing covering the framing and insulation, and the water/air/vapor barrier is separated from the brick or masonry veneer by a drained and ventilated air space.

Pressure Equalized Rain Screen Wall
Exterior/interior air pressure differentials, such as caused by wind forces on the wall, is often the most critical driving force for moisture and air infiltration into the wall assembly and building interior.

Pressure equalized rain screen systems attempt to eliminate the air pressure differentials by intentional venting through the exterior cladding to equalize the air pressure within the cavity. In addition, the air cavity is compartmented to eliminate lateral dispersion of equalizing air pressure when subjected to wind pressure variations across the wall surface.

Single-Line-Barrier System Advantages

A rain screen system is an appropriate solution when the exterior cladding material is permeable or its joints cannot be effectively sealed. However, for many applications, the single-line-barrier system is more appropriate and offers the following advantages over rain screen systems:

Cost Effectiveness
Single-line-barrier systems are often more cost effective than rain screen systems because the design complexity, materials and labor for the following is eliminated:

- The separate water/air/vapor barrier and its backing
- The air cavity and its drainage and venting provisions
- The interconnections between the cladding and the interior construction, and the sealing of the connection penetrations through the water/air /vapor barrier

When using self supporting panels, such as structural metal panels, insulated metal panels and precast concrete panels, the interior stud framing may also be eliminated which further reduces design and construction costs and increases usable floor space.

Accessibility
In the rain screen system, there is a significant potential of unseen failure of the water/air/vapor barrier and cavity drainage systems. Hidden from inspection and inaccessible for repair, moisture and its damaging effects such as rot, corrosion, mold and ice formation can accumulate over long periods before manifesting itself as visible conditions on the outside of the wall construction.

With its metal facing functioning as the water/air/vapor barrier, the single-line-barrier wall is not dependent upon concealed barrier materials and concealed cavity drainage systems and is typically more accessible for inspection and repair.

Standardized Performance
Rain screen wall systems are generally designed on a per project basis with the wall components often from various sources and even subject to different installation trades. Because of the great variations of design and component options, performance testing of the total wall system is not feasible except for very large projects where the cost of project specific lab testing or field testing is justifiable.

This is especially the case for pressure equalized rainscreen systems where the wall design is almost always job specific because of the critical influence of variations in building geometry, site conditions and climatic conditions upon the actual design of the air cavity size, venting, compartmentalization and drainage details.

In a single-line-barrier system, the water/air/vapor barrier is incorporated into the exterior cladding system which is provided by a single source, and there is not a job specific air cavity design involved. This allows the exterior cladding manufacturer to standardize the cladding and joint designs and prequalify performance by standard water and air infiltration tests.

Insulated Metal Panel Systems

Insulated metal panels are ideally suited for single-line-barrier wall systems, because of the following features:

- Metal facing provides the non-permeable barrier to water/air/vapor infiltration
- Exceptionally effective tongue & groove edge joints
  - Factory controlled, precision formed, optimized design
  - Formed directly into the facing material without secondary joinery or dissimilar materials
  - Joint's sealant cavity controls sealant thickness and protects sealant
- Continuous panel lengths and wide panel widths minimizes joint frequency
- Durable steel facing (water, air and vapor barrier) does not require protection from direct weathering

In addition to the previously described advantages of a single-line-barrier system, insulated metal panels also provide the following benefits:

- Thermal insulation efficiency
  - Cellular core provides unparalleled insulating performance
  - Unitized panel provides maximum performance per total wall thickness
  - Factory control of the insulation material and its installation
  - Verifiable thermal insulating performance of total wall, per standard tests
- Cost effective construction
  - Unitized panel simplifies wall design and installation requirements
  - Composite panel load/span strength reduces secondary framing requirements
  - Single source and single trade installation for the total wall
- Total wall quality control and performance - unitized panel provides factory controlled design, assembly and prequalified performance of total wall
- Aesthetics - popularity of metal facing materials and wide range of exterior profiles and factory finish options

Misapplication of Rain Screen Concepts to Insulated Metal Panels

When insulated metal panels are functioning as the total wall (rather than as the exterior cladding of an actual rain screen system) the wall is clearly a single-line-barrier wall with its water/air/vapor barrier contained within the wall panels. However, misunderstanding of the rain screen concepts have resulted in misleading applications on insulated metal panel systems.

An example is insulated metal panel systems with intentionally vented joints. On such panel systems, the venting only provides moisture drainage and pressure equalization within the joints themselves. It is still a single-line-barrier system with the wall panels providing the total water/air/vapor function. This is unlike true pressure equalized rain screen systems with the cavity behind the cladding (wall panels) to provide for drainage of moisture that has penetrated completely through the wall panels, and provide pressure equalization between the wall panels and the water/air/vapor barrier.

Simply venting the joints does not qualify the wall system as a pressure equalized rain screen system and in some cases may unnecessarily subject the system to critical performance disadvantages.

With typical insulated metal panel systems, the horizontal joint's weather/air/vapor seal is at the panel's exterior face. However on panels with vented horizontal joints, the vent holes allow the direct penetration of moisture into the panel interior. This potentially leads to trapped moisture along the horizontal surfaces, possibly resulting in mold, corrosion and ice formations which are concealed within the panel interior and inaccessible for inspection and corrective action.

To accommodate the vented horizontal joint design, a relatively large vertical space, open to the exterior, is required between the opposing edges of the exterior panel faces. This subjects the wall to direct exterior exposure deeper within the panels, and removes a significant volume of insulating foam from the critical joint areas. The result is an unnecessary reduction of thermal efficiency and a greater potential of interior condensation and frost formation.

Some of theses vented joint panel systems are also claimed to have rain screen system performance verified by standard tests, such as the AAMA 508 "Voluntary Test Method and Specification for Pressure-Equalized Rain Screen Wall Cladding Systems".

In accordance with the scope of AAMA 508-07, a pressure equalized rain screen wall system is "A wall system that functions to limit air leakage and water penetration through use of an exterior rain screen, a compartmented drainage and ventilation cavity and an air and water barrier". To attempt to adapt this test to a vented joint insulated metal panel system without the separate water/air/vapor barrier and drainage/venting cavity, the test must be severely modified to the extent that it is no longer valid as a performance test for either a rain screen wall or pressure equalized rain screen wall.

Summary

Both rain screen systems and single-line-barrier systems have design features which cause them to be the more effective wall solution depending upon the project's specific design requirements. Insulated metal panels are single-line-barrier systems that are often the more effective design solution because of their exceptional energy and cost efficiencies

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