Rain Screen Principle In Design

Courtesy: National Research Council (NRC) of Canada.

This issue of aluminum curtainwalls is devoted principally to the exposition of an important development in curtainwall design, the *rain screen principle* and its application.

The rain screen principle may be defined as a theory governing the design of a building enclosure in such a way as to prevent water penetration due to rain; in other words, a scientific approach to eliminating water leakage.

What is referred to as the *rain screen* is the exposed outer skin or surface element of the wall, backed by an air space and so designed that it shields the wall joints from wetting. It is made resistant to water penetration, not by sealing its joints and openings but by eliminating the pressure differences-or equalizing the pressures-occuring on its inner and outer surfaces, while primary wall joint seals are removed from the outer wall face to the inner part of the wall, where they are kept dry. Thus, instead of the joint seals being subjected to both water and wind pressure, a two-stage protection is provided, the rain screen shielding against water penetration and the joint seals only against air penetration.

The theories involved are not new, but are, in fact, based on long recognized natural laws. The potential significance of the rain screen principle in curtainwall design, however, has become recognized only within the past several years and its design implications are still not well understood by many.

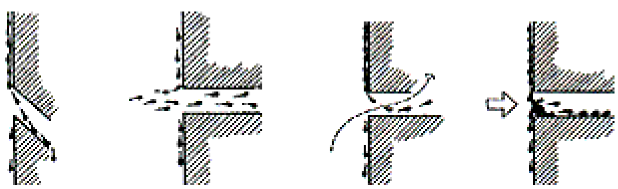
One of the most reliable ways of eliminating water leakage in metal curtainwalls and windows is to apply the rain screen principle in their design, providing pressure equalization. Yet, there seem to be relatively few designers who have a clear understanding of the full implications of this design theory, and probably most architects will confess to only general conception of the meanings of these terms. Even the few acknowledged experts who have pioneered in the application of these principles point out that they still have much to learn about them. It is the purpose of this article to clarify these principles and to explore their implications in aluminum curtainwall design; in short, a report on the state-of-the-art.

It should be recognized, to begin with, that the term *rain screen principle* and *pressure equalized design*, though closely related and in fact, interdependent, are not strictly synonymous. The *rain screen* is only the outer skin or surface of a wall or wall element - the part exposed to the weather. The *rain screen principle* is a principle of design which prescribes how penetration of this screen by rain water may be prevented. Thus the use of the rain screen principle is essential to achieving a pressure-equalized design depends on this principle.

It must be understood, too, that the provision of true pressure equalization may be difficult, and in some case impractical. With certain types of windows and glazing systems it is a rather simple matter, requiring little if any additional expense. In metal curtainwalls, however, the achievement of pressure equalization may become a complex problem, involving careful and often ingenious detailing, and often it may not be feasible. Pressure equalization should not be confused, as some designers may do, with the more conventional and long accepted 'theory of secondary defence', depending on a drainage system within a wall - a theory which, when properly applied, has also proven to be dependable.

Action of Rain on a Wall Surface

Before examining what causes water to enter a wall, and how the rain screen principle may be applied to prevent it, it would be well to review briefly how rain water acts on a wall surface, and what are the most vulnerable parts of a wall. An important factor, of course, is the absorptivity of the exposed wall material. On a masonry wall, unless its surface is well protected by a sealer, an appreciable amount of water is absorbed, in blotter fashion. This absorption is generally distributed over the entire masonry surface; the joints, if properly pointed, are no more vulnerable than the remainder of the surface. Subsequently, unless there are weaknesses in the wall which permit through penetration, this absorbed water evaporates as the wall dries out.. On non-porous materials such as metal and glass the action is quite different, and more critical. None of the rain water striking such materials is absorbed; it all has to be controlled if leakage is to be prevented. A substantial film of water flows down the wall surface and, if wind is present, as is often the case when it is raining, the water flows laterally, and on parts of the building facade it may flow upward as well. The taller the building, the greater will be the accumulated flow over the lower parts of its walls. Lateral flow under wind pressure is greatest near the windward corners of the building, and upward flow is maximum at or near the top of the building facade facing the wind.



Types of Force and Their Control: The Rain Screen Principle

There are various forces which must be considered, and some of them do not result fro wind action. In some circumstances only one or two of these forces may be present, but in a windy rainstorm all of them will likely be acting to move the surface water through any available opening. For each type of force there must be a counter measure, if it is to be eliminated. Appropriate methods of counteracting most of these forces are well known and have long be used, but the means of combating the others, which are usually the most critical, is provided only by applying what is known as the rain screen principle.

All of the forces are illustrated schematically in figure 1. Probably the most familiar of these forces is the force of gravity (A). This has long been recognized in joint design, a knowledge of the means of controlling it is elementary, and leakage due to gravity action usually occurs as a result of ignorance or carelessness on the designers part. Another force is kinetic energy (B). Under the influence of wind, raindrops approach the wall with considerable velocity, and their momentum alone may carry them through openings of sufficient size. Cover battens, splines or internal baffles can be used to prevent rain entry due to this force. A third factor-not strictly speaking, a force - which sometimes contributes to leakage, as a result of improper design, is the surface tension of water, which causes it to cling to and flow along soffit areas, as indicated at (C), the preventative to this action, of course, is the use of a drip at the outer edge of the overhang. Still another recognized but too often overlooked force is capillary action (D), which is likely to occur whenever the space separating two wettable surfaces is small. The way to control flow by capillary action is to introduce a discontinuity, or air gap, in the joint, of grater width than the capillary path, as shown in figure 2. All of these first four forces and characteristics, then, are well recognized and quite readily controlled by conventional design methods.

It is the other two types of force shown in Figure 1, the forces caused by wind action, which are the most critical and most difficult to combat. Air currents (E) may result from differences in pressure over the wall surface, or from convection within wall cavities, and these may carry water into the wall. Also, when water is present on one side of an opening, and the air air pressure on that side is greater than that on the other side, the water will be moved through the opening, no matter how small, in the direction of the pressure drop (F). Such pressure differentials may be caused even by gentle winds. It is this latter type of force, differential pressure, which causes most of the leakage at wall joints. As previously mentioned, the conventional approach to combating it has been to attempt to eliminate all openings by a tight sealing, but the more effective and more reliable approach is to eliminate the pressure differential across the opening - to equalize the pressures on its opposite sides. It is this approach that is known as the rain screen principle.

As will be seen later this not simply a ventilated space, in which air currents may occur due to pressure differences within the space. To be effective it must be a confined air space, and it is this essential that imposes many of the design complexities encountered in the application of the rain screen principle.

This continuous interior barrier serves also, of course, to help control the environment within the building. The pressure-equalized wall consists essentially, then, of an outer open skin (the rain screen) and an inner tight wall, with an air space between the two. The pressure within this air space is maintained equal to that on the outdoor side by connecting the space between the two. The pressure within this air space is maintained equal to that on the outdoor side by connecting the space with the outdoors and sealing the joint inn the inner air barrier against airflow. Thus the pressure differential between the outdoors and the building interior occurs, not at the outer wall face but at the inner air barrier. Consequently this barrier must be more that simply and impervious film; it must be structurally capable of withstanding pressure due to wind loads. But because the inside barrier is protected from wetting, the seals at its joints do not have to protect against the flow of both air and water. To make construction generally acceptable as a building wall, insulation must be added on the indoor side of the air space. It should be noted that the air barrier may be a continuous membrane placed on either side of the insulation or either side of the interior wall element; it can be the interior finish of the wall, provided this contains no open joints.

The ideal leakproof wall employing the rain screen principle incorporates the essential elements:
1) an exterior rain screen or deterrent barrier to water penetration,
2) a confined air space, open to the outdoors
3) insulation, and
4) an interior barrier

These elements prevent the passage of air and vapour and is capable of withstanding wind pressures. As it should be assumed that some minor leakage may, on occasion, occur through the rain screen, the air space should always be drained to the outside. The basic objective is to provide a major deterrent to water leakage at the outside face of the wall, and the seal against air and vapour passage on the indoor side of the air space, where the *primary seal* is exposed to little if any water; not to attempt to seal against both water and air at the same point.