2.3 Best Practices for Moisture-Resistant Wall Systems

2.3.1 Weather-Resistant Exterior Wall Envelope

OBJECTIVES: This best practice provides recommendations for selection of the weather-resistant wall envelope (e.g., siding, water barrier, etc). Current U.S. building codes don't distinguish the inherent performance differences between various weather-resistant envelope (WRE) systems. In addition, selection of a siding system generally focuses on attributes such as appearance, cost, and durability. The WRE selection procedure in this section considers the ability of different types of cladding systems to protect a building from rainwater penetration and accumulation in walls. Thus, trade-offs between moisture performance and other architectural considerations are more readily identified and resolved. This best practice is intended to enhance or help fulfill the basic objective for the weather-resistant wall envelope as found in the 2003 International Residential Code:

> **R703.1 General.** Exterior walls shall provide the building with a weather-resistant exterior wall envelope. The exterior wall envelope shall include flashing as described in Section R703.8. The exterior wall envelope shall be designed and constructed in such a manner as to prevent the accumulation of water within the wall assembly by providing a water-resistive barrier behind the exterior veneer as required by Section R703.2.

PRECAUTIONS: Selection of even the most weather-resistant wall envelope system does not diminish the need for proper installation, particularly in regard to flashing details at penetrations. In addition, use of roof overhangs provides performance benefits for all cladding systems by reducing the moisture load experienced over time and by allowing greater opportunities for walls to dry in the event of periodic wetting due to wind-driven rain. The life-expectancy of various siding materials may vary widely from 10 to as much as 100 years or more depending on type of material, climate exposure, maintenance, and other factors.

It should be noted that recent building codes, such as the 2003 International Residential Code (IRC), have not required secondary weather barriers (e.g., asphalt-impregnated felt paper or building wrap) under many types of horizontal lap siding. But requirements for secondary weather barriers are becoming more broadly required based on the 2004 Supplement to the IRC. This trend generally agrees with this guide's recommendations for the use of secondary weather barriers, particularly in areas with significant wind-driven rainfall.

BEST PRACTICE:

Design for a Weather-Resistant Envelope System

A drained cavity WRE system will provide fair to good protection in nearly all climates and building exposures, and should be considered as a broadly applicable wall design approach for moisture protection. In more severe cases like climates with severe wind-driven rain or openly exposed buildings with no overhangs, and for wall designs involving different types of materials (e.g., conventional stucco), alterative WRE systems can be selected based on climate and building exposure. A 3-step design process which accounts for these factors follows in this section.

The drained cavity system and other WRE approaches are illustrated in Figure 13 and described below.

ILLUSTRATED BEST PRACTICE:

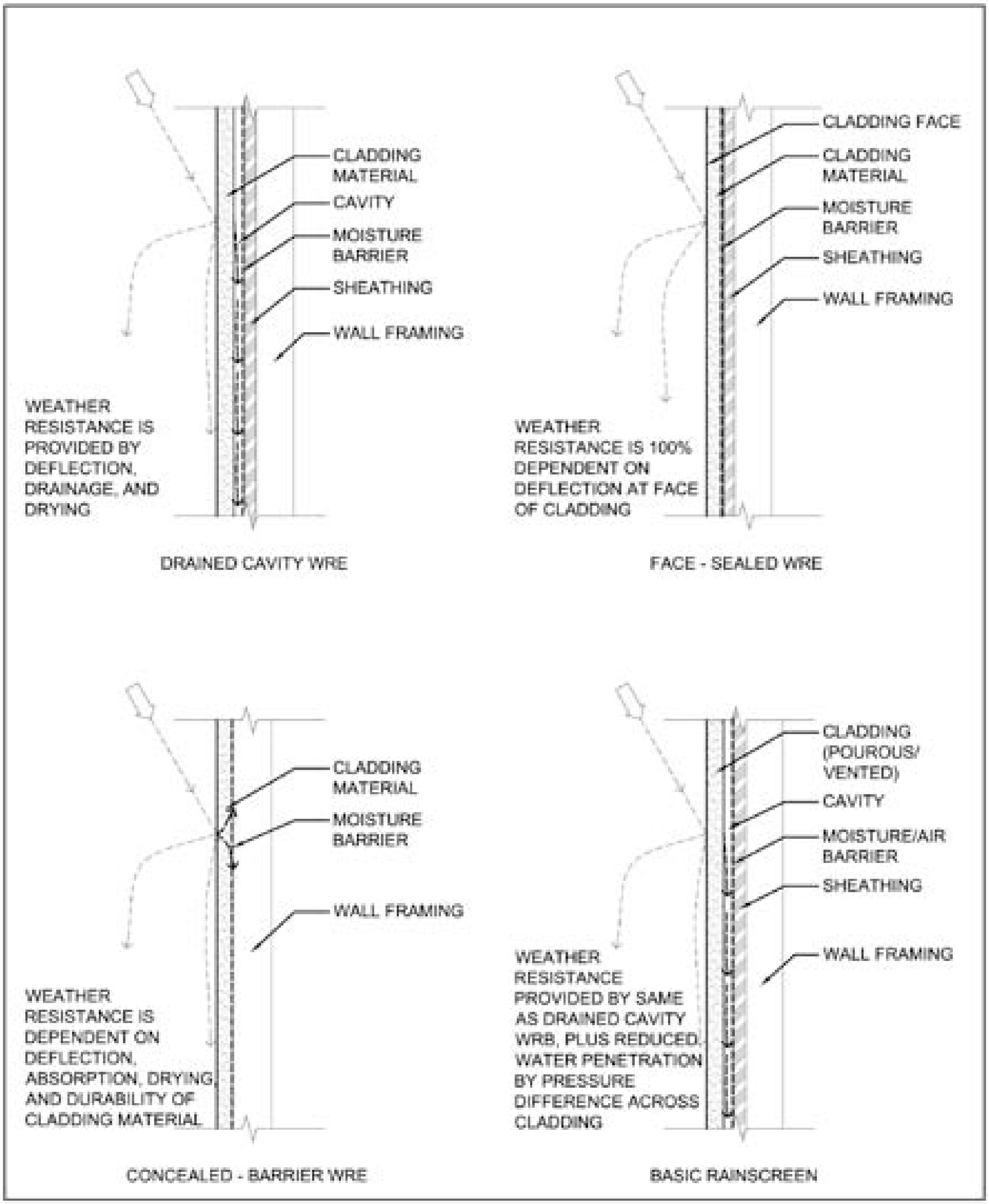

Figure 13 - Illustration of WRE Systems

Drained Cavity – A drained cavity WRE relies on deflection, drainage, and drying to protect the wall from moisture damage. There are many possible variations of this type of WRE. In general, a cavity exists to separate the cladding material from the surface of a moisture barrier placed on the structural wall behind the cladding. The depth of the cavity, however, may vary. For example, vinyl siding may be placed directly on the moisture barrier (e.g. building wrap, 15# tarred felt) and still provide a cavity only restricted at points of contact (e.g., nail flanges). A minimum cavity depth of 3/8” to ½” is sometimes recommended by use of vertical furring strips placed over the water barrier (drainage plane). Furring and flashing details around window and door openings must also be carefully planned and executed. Drained cavities increase the life of exterior finishes on wood surfaces and promote drying of wall assemblies after wetting episodes. For brick veneer, a larger 1” cavity depth is recommended to allow space for brick placement and mortar excesses.

Face-sealed – This type of WRE relies exclusively on the ability of the outer surface of the wall and joints around penetrations to deflect water and prevent it from penetrating the wall surface. If a defect in the wall surface or joint detailing (e.g., caulk) exists or occurs over time, then water will penetrate and potentially accumulate in the wall - causing damage to any moisture-sensitive materials within the assembly. One example of this type of system is known as conventional or barrier EIFS (exterior insulation finish system). However, current model building codes only allow the use of a new type of drainable EIFS (i.e., drained cavity) on residential construction.

Concealed Barrier – This type of WRE relies on porous cladding material adhered to or placed directly on an internal (concealed) water barrier or drainage plane. A common example is conventional stucco applied on a layer of tarred felt paper attached to a wood-frame

Specification and Installation of Drainage Planes (Moisture Barriers)

The secondary drainage plane (moisture barrier) is a key feature of any of the WRE systems that rely on drainage behind the exterior siding to improve moisture-resistant performance. Materials commonly used for this purpose include 15# tarred felt, various types of building wraps, and some water-resistant insulating sheathing products. It should be noted, however, that building wraps have varied levels of water resistance (as well as moisture vapor permeability). The primary role of these materials is as a secondary drainage plane. In general, non-perforated building wraps tend to exhibit better water resistance than other types that may be perforated to allow for vapor permeability. In humid climates, moderate vapor permeability along with adequate water resistance may be preferable. Limited testing demonstrates that material candidates meeting these criteria include Tyvek, R-Wrap, and 15# felt. Because the secondary drainage plane is intended to drain moisture that penetrates siding and joints, its installation must be properly coordinated with flashing and other WRE components (refer to Sections 2.3.2 and 2.3.3). In addition, all joints must be appropriately lapped (e.g., upper layer over top of lower layer). These features are hidden underneath the siding and must be properly installed prior to or in coordination with siding application. If water leaks behind the secondary drainage plane, it may cause more damage than if no drainage plain were present due to slower drying. Additional requirements when using building wraps as an exterior air barrier are discussed in Section 2.5.5.

Conversion of Existing WRE Systems

It is possible to adapt a drained cavity approach to many traditional concealed barrier or face-sealed claddings, such as conventional Portland cement stucco and EIFS. Drainable EIFS products (a drained cavity WRE) in lieu of barrier EIFS products (a face-sealed WRE) are the only types permitted for residential use under U.S. model building codes.

Details to convert conventional Portland cement stucco (concealed barrier) to a drained cavity system have been developed for use in British Columbia (Canada), where a high frequency of water intrusion problems has been experienced. Consult References and Additional Resources for more detailed information.

wall. This WRE system also relies primarily on deflection of rainwater (like the face-sealed system) but also has limited capability to absorb moisture to later dry and to drain moisture through weeps (e.g., weep screed) at the base of the wall. However, there is no open drainage pathway to allow water to freely drain from the concealed moisture barrier.

Rainscreen – A rainscreen can be considered as an incremental improvement of the drained cavity approach. This type of WRE is uncommon in the U.S. but has been used to some extent in Canada to address severe climate conditions. By the addition of some details to help reduce air-pressure differential across the cladding system during wind-driven rain events, water penetration into the drainage cavity is further limited. At a minimum, this approach involves use of an air barrier behind the cladding to resist wind pressures. Thus, wind pressure across the siding (which is vented and not air-tight) is reduced and is less likely to result in water being driven through the siding due to pressure differentials across the siding. Also, the cavity between the cladding and water/air barrier must be compartmentalized by use of air-tight blocking or furring at corners of the building as a minimum practice. This feature prevents pressure differences on different surfaces of the building from “communicating” through a continuous cavity behind the cladding, which can cause unintended pressure differences across the cladding that drive rain water through the cladding into the drainage cavity. Because many of the required components of a basic rainscreen system are already present in a simple drained cavity wall system, drained cavity systems are generally considered a more practical alternative for typical applications.

Drained cavity WRE systems incorporate a wide range of cladding systems and may be considered as a viable option for non-severe climates and building exposures. The design process below can be used to assess alternative WRE systems for severe climate or site conditions or when alternative systems are desired.

<u>STEP 1: ASSESS SITE CLIMATE CONDITION</u>

Climatic conditions are categorized on the basis of the potential for wetting of walls, especially wetting from wind-driven rain. The exposure categories are:

- *Severe* – severe climate conditions are conditions that result in frequent wetting due to wind-driven rain, such as coastal climates and areas prone to frequent thunderstorm events.
- *Moderate* – moderate climate conditions are those which are periodically exposed to wind-driven rain.
- *Low* – a low climate condition is associated with relatively dry climates with little rainfall or wind-driven rain.

The above classifications are intentionally subjective, as there are no clearly defined criteria in the U.S for assessing wind-driven rain and its effects on building wall systems. However, wind-driven rain climate data - as well as other related climate indices - may help guide the classification of a local climate based on the categories above. Climate maps for this purpose are provided in Figures 14 and 15. The reader should consult the referenced sources of the maps for additional information. In addition, the Decay Hazard Index map of Figure 10 may also provide some guidance.

STEP 2: ASSESS BUILDING EXPOSURE

The terrain surrounding a building impacts its exposure to wind driven rain. The ratio of roof overhang width to the height of the protected wall below also alters the exposure of a building to weather and wind-driven rain. Long roof overhangs relative to wall height effectively reduce the exposure. Similarly, increased shielding of the site against wind tends to reduce the effects of climate.

Table 7 may be used to determine a building's exposure level, based on the climate condition

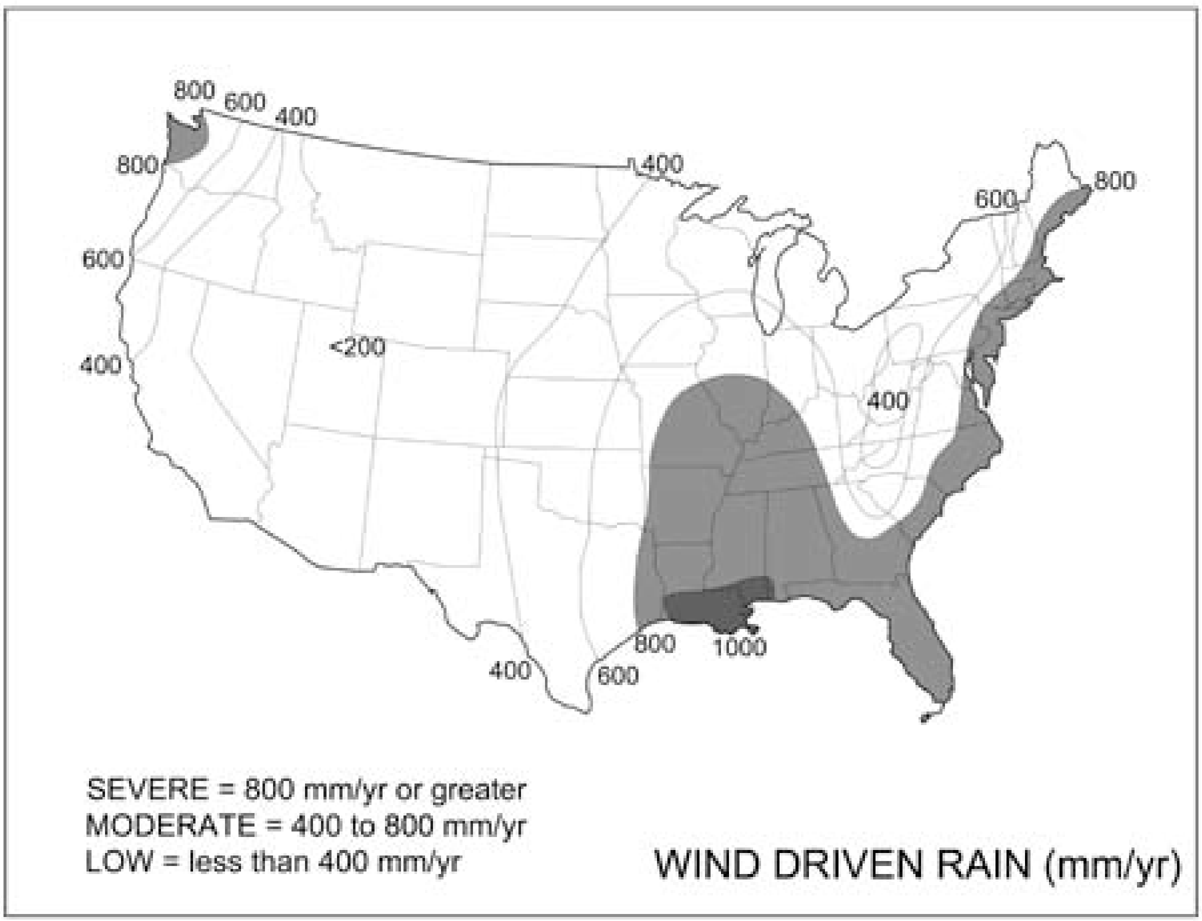

Figure 14 - Wind-driven Rain Map of the United States
(Source: Underwood, University of Georgia, 1999)

determined in Step 1, the roof overhang ratio, and the wind exposure. The exposure level then leads to a reasonable weather-resistant envelope approach in Step 3. The exposure levels in Table 7 can also be used on a smaller scale to get a sense of the exposure for particular faces of a building or even for specific envelope elements like a window. Understanding the exposure in this manner can guide decisions on flashing details, potential use of greater overhangs, etc.

The wind exposure conditions in Table 7 are explained as follows:

- *No Shielding (Open)* – site receives no or little protection from surrounding buildings and natural obstructions to wind flow (e.g., grassy field or waterfront exposure).

- *Partial Shielding* – site receives protection from typical suburban development including surroundings of homes and natural or man-made landscaping (e.g., interspersed trees of similar or greater height than buildings).

- *Full Shielding* – site receives significant protection from surrounding dense

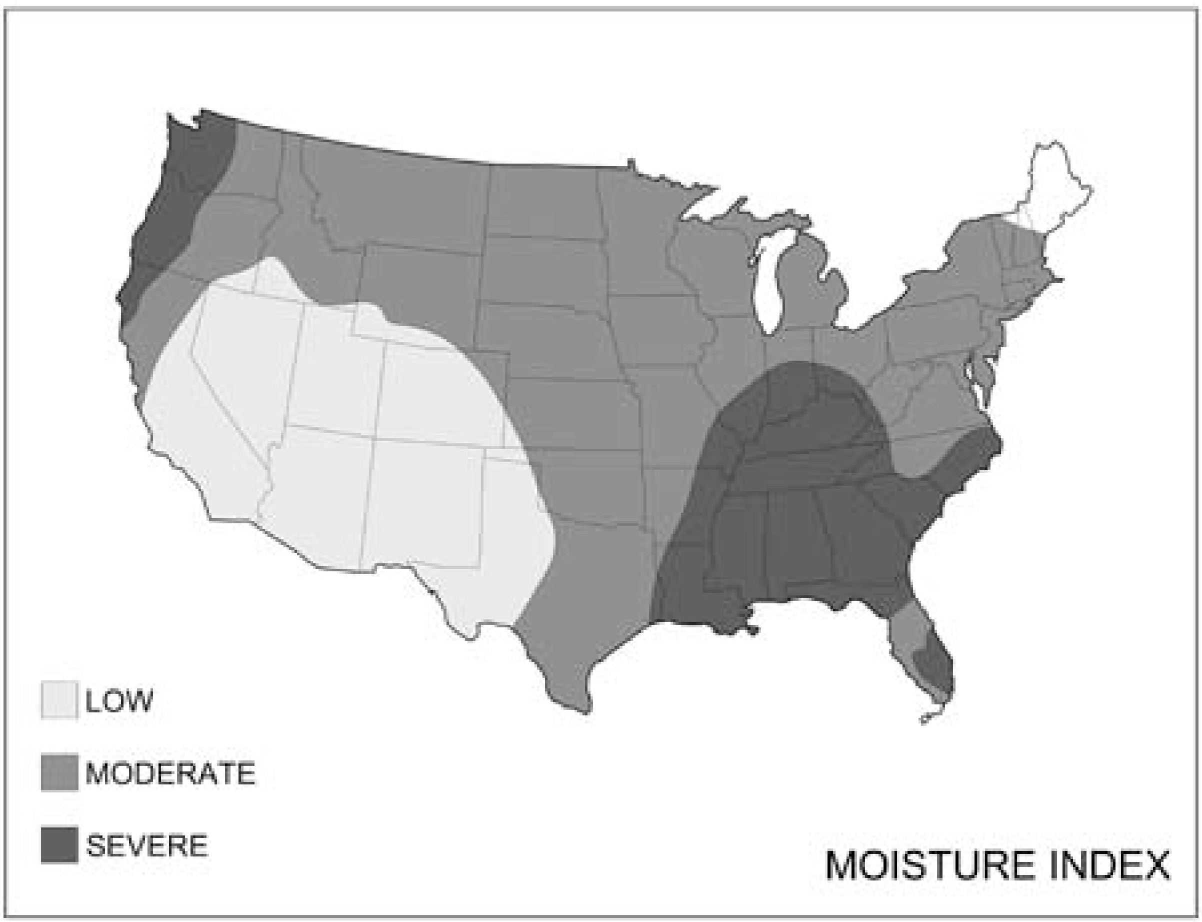

Figure 15 - Moisture Index for North America
(Based on *Keeping Walls Dry, Kerr D., CMHC, 2004)*

Table 7 - Building Exposure Levels

(H-high; M-moderate; L-low; N-negligible exposure)

Wind Exposure	Overhang Ratio [a] (w/h)	Climate Severity [b] (from Step 1)		
		Severe	Moderate	Low
No Shielding (Open)	0	H	H	M
	0.1	H	M	L
	0.2	M	L	L
	0.3	M	L	N
	0.4	L	L	N
	≥0.5	L	N	N
Partial Shielding (Typical Suburban)	0	H	H	M
	0.1	H	M	L
	0.2	M	L	N
	0.3	L	N	N
	0.4	L	N	N
	≥0.5	N	N	N
Full Shielding	0	H	H	M
	0.1	M	M	L
	0.2	L	L	N
	0.3	L	N	N
	0.4	N	N	N
	≥0.5	N	N	N

Table Notes:

a. Overhang ratio should account for both roof overhangs and overhangs from cantilevered floors. For a given wall, use the worst case overhang ratio (w/h) where 'w' is the overhang width and 'h' is the height of wall below the overhang.

b. For buildings located near the top of topographic features such as ridges, bluffs, and escarpments, the building exposure level should be increased by one level.

development (e.g., more than 4 homes/ acre) and/or closely spaced trees (e.g., generally more than 15 to 20 large trees/ acre) extending for a horizontal distance of at least 10 building heights from the building.

STEP 3: SELECT WEATHER-RESISTANT ENVELOPE APPROACH

Based on the building exposure level determined in Step 2, a WRE approach may be selected based on relative performance

Table 8 - Relative Performance of WRE Approaches

Exposure Level (from Table 7)	Face-sealed	Concealed Barrier	Drained Cavity	Basic Rainscreen
High (H)	Poor	Poor	Fair	Good
Moderate (M)	Poor	Fair	Good	Good
Low (L)	Fair	Good	Good	Good
Negligible (N)	Good	Good	Good	Good

Table Note:

a. See discussion below on "mass wall" systems used as a weather-resistant barrier.

expectations. Alternatively, other factors may be reconsidered in the building and site design to improve protection from rain, like the use of larger overhangs to protect walls.

The approximate ratings used in Table 8 to describe relative performance are explained as follows:

- *Good* – the WRE system is likely to meet or exceed acceptable performance expectations and has a low risk of failure during the likely service life with a reasonable level of installation quality and maintenance.
- *Fair* – the WRE system is considered adequate, but may require careful attention to detailing, installation quality, and maintenance. The wall has a tolerable risk of failure during the likely service life.
- *Poor* – the WRE system has a relatively high risk of not meeting acceptable performance expectations.

These ratings don't consider numerous factors including the variation in constructability of various systems, the durability of cladding and other wall components, or the reliability of expected maintenance. Therefore, the ratings may be subject to adjustment by experience.

Solid or mass walls, such as masonry and concrete wall systems without a separate exterior cladding, are not addressed in Table 8. These walls rely on deflection of rain as well as the ability to absorb moisture in a sufficiently thick and durable wall system. However, even these "mass" walls can become overwhelmed with moisture intake during extreme wind-driven rain episodes (e.g., hurricanes and tropical storms). Water-repellent surface treatments or coatings like latex paint may be applied to these walls to improve rain deflection and minimize absorption of moisture; however, such coatings should be semi-permeable to allow for drying towards the outside. Various water-repellant treatments are available for concrete and masonry, but they vary in cost, performance, and effective service life. Limited research indicates that polysiloxane-blended water repellents may provide the best water repellency and durability.