Summary
Maybe the least technically sophisticated strategy to prevent rainwater penetration, but also throughout history the most widely used, is to create a barrier consisting of sufficient mass and low permeability. Multiple wythe solid masonry buildings are an example of such a system. The north half of the Monadnock Building in Chicago is a perfect example, it was built in 1891 and the architects were Burnham & Root. This Best Practice shall examine the basics of how a mass barrier system works; examples of common mass systems; and design considerations in using mass systems as a barrier against rainwater penetration.

How a Mass System Works
There is little difference between how a mass barrier system works and how a "Face-Sealed" barrier system works except that in a mass barrier system the principal materials are not impervious. A mass system does not rely upon a cavity or drainage system behind the principal exterior mass materials; if such exists then the system is a cavity or drained system of some type. In a mass system rain water shall penetrate the exterior surface of the wall due to the porosity of the exterior materials. Generally this movement is by diffusion where the water within the system spreads from areas of higher concentration of water to areas of lower concentration of water. These exterior materials have a certain capacity to store water within the exterior wall system. The success of these systems is dependent upon sufficient storage capacity combined with a low absorption rate offsetting the rain penetration from an extended wind-driven rain. If rainwater penetrates the system and damages materials within the system fails. After a rain the wall system begins to dry out by evaporation. So in mass systems the exterior wall materials are subject to cycles of various degrees of wetness and dryness.

Permeability is the measure of the ability of a porous material to transit fluids. Thus, the higher the permeability of a particular material the greater the thickness necessary to resist rainwater flow compared to a material with a lower permeability. This is complicated where there are multiple materials such as masonry and mortar or multiple layers of materials with different rates of absorption.

Materials of Mass Systems
Solid multi-wythe masonry, single-wythe split face concrete block, precast, cast-in-place concrete, adobe and stone (limestone and granite) are all materials which have been used in mass barrier system construction. Again, in construction where cavities or drainage systems are a part of the construction then the wall is not considered a mass wall system. In the case of the Monadnock building which is 16 stories high the masonry is 6 feet thick at the base of the building and 18 inches thick at the top of the building and with good solid brick construction and tight joints there is sufficient storage capacity and relatively low permeability. Solid multiple-wythe masonry has also been used in many historic building constructed in the nineteenth century and in the early decades of the twentieth century successfully. Generally when these historic buildings have had rain penetration failures the problems can be tied back to poor maintenance. These buildings require diligence and routine maintenance of system joints, cracks and at system
interfaces. Examples of common failures in these historic buildings are deterioration of steel window lintels, terra cotta parapet support failures and deterioration of other concealed cast-iron or steel components. Failures of historic building copings and parapets is generally related to repeated cycles of water penetration and freeze/thaw cycles at the face of the wall, along the top of the parapet wall or on the backside of the parapet which all could have been avoided with continual routine maintenance.

Split-face concrete block has often been used, and is still used, as a mass system material typically in low-rise multi-family apartment buildings or similar structures do to the low cost. However, an exterior wall system with a single wythe split-face concrete block exterior with materials susceptible to water damage directly attached to the inside surface of the CMU is often subject to failure. This can be a case where there is insufficient mass combined with higher permeability permitting wind-driven rain to penetrate fully through the system damaging materials on the inside. Mold growth can also result. The suggestion here is that unless the environment is very dry with little chance of extended rain single-wythe split-face concrete blocks could successfully be a component of a cavity or rain screen system but should probably not be considered sufficient as a mass system if water penetration is a concern.

Limestone and precast are materials which generally can have fairly low permeability combined with good uniformity and relatively tight construction tolerances. Limestone, denser stones such as granite, and precast concrete are increasingly designed as components of drainable systems but can also be detailed as mass systems. Limestone is generally two to three inches thick and solid-concrete precast panels can be five to eight inches thick; these materials would have a reasonable storage capacity which might be sufficient from a rain penetration perspective. However, there are a number of considerations which would need to be addressed. The stability of the construction and proper maintenance of joints are concerns. As in the Face-Sealed systems a joint failure can be a system failure. There is also the debate (not being addressed in this Best Practice) whether to apply some type of sealer to the precast concrete. The primary benefit of a sealer may be to help shed more water off the surface rather than act as a waterproofing membrane; the flip side is that with a sealer there is continual maintenance and concerns regarding uniformity of appearance and absorption.

Exposed cast-in-place concrete has been widely used in high-rise construction especially in residential and hotel projects. However, cast-in-place concrete cracks, some of these cracks can be barely visible hairline cracks and others can be obvious. Thus, even if the mass of the concrete is sufficient and the permeability is generally low cast-in-place is problematic as a mass system due to cracking therefore cast-in-place concrete is generally coated with some type of a waterproof membrane. This mean that the cast-in-place concrete acts more as a substrate and back-up system and the waterproof coating and the sealant joints function more as a “Face-Sealed” system. Regular maintenance, maybe yearly inspections and recoating every five years or so, is key to success of this type of construction.

Design Considerations

In designing a mass system it’s important to understand the storage capacity, thickness and permeability of the materials of the system. This includes the principal materials as well as the joint materials. It is also important to understand the uniformity and the potential for cracking within the system. As noted above in the case of cast-in-place concrete without cracking in many instances the thickness of concrete necessary for structural purposes and the permeability of the concrete may be sufficient to perform well as a mass system, but due to the potential for cracking the system does not work without a waterproofing coating and sealed joints. Crack prevention needs to be addressed in detailing any mass barrier system. If there are multiple layered components then the sum of the storage capacities needs to be understood; for example a solid multiple wythe masonry system with a low permeability outer wythe and thicker higher permeability masonry backup might prove to have sufficient storage capacity and function quite satisfactorily as a mass system. Such a system, however, is probably not cost efficient in comparison to a cavity or other type of drainable system.
Mass barrier and face-sealed systems are similar since there is no cavity, drainage system or backup barrier in a mass barrier system. This means that the detailing of the joints within the system and the joints at system interfaces is critical to the performance of the system. There are several detail considerations to consider when detailing the joints between systems; these include material compatibility, expansion / contraction and other types of joint movement, dimensional coordination, and continuity of the rainwater barrier between systems.

**Visual Observations**

Non-destructive exterior visual observations of historic mass barrier masonry and stone faced structures often can foretell the condition of such construction. Blotchy, discoloration and spalling are indication of deterioration of masonry and stone materials due to water penetration. Spalling results when the rain water which has penetrated the material forces the surface to peel, pop or flake off; generally this is a result of salts and/or freeze/thaw cycles. Deteriorating mortar and sealant joints can also be observed from the exterior. Cracking of the materials and/or visual buckling of surfaces are indicators of potential serious problems.

In some precast concrete buildings in the hours after a hard rain it is possible to observe uneven discoloration of precast surfaces suggesting differences in wetness, water penetration and evaporative rates. This is not necessarily problematic but such observations can be useful in monitoring building maintenance programs or as an investigative tool if there is a problem.

**Conclusion**

In this Best Practice the focus is on mass barrier wall systems as the barrier against rainwater penetration. These wall systems have many similarities to the Face-Sealed barrier systems in that there is no back-up system. Water penetrating the mass could be a failure of the system. Most exterior materials that have both mass and low permeability can also function in drained, cavity or rain screen wall systems. So one should careful weigh whether a mass system is the right approach or whether the exterior material can be a component of a system which provides a backup drainage system. Maybe the single greatest factor weighing against mass barrier systems is that they require heavy materials, routine maintenance and can be more expensive than drainable systems.

**About Our Contributor**

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**References**

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