Remediating Building Envelope Walls: Drainage Plane Designs

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Abstract

The benefits of incorporating a drainage plane into different exterior wall assemblies will be discussed based on the evaluation of existing building issues and the need for improved performance and moisture mitigation within walls. Building envelope remediation design examples from the San Francisco Bay area will be presented, each utilizing a different drainage plane method of design. Overall concepts behind material selection and wall system detailing will be reviewed, including details for rough openings, wall corners, parapets, floor levels, and wall base conditions. Examples of flashing sequences and construction installation procedures will also be provided in order to communicate the significance of appropriate and accurate detailing in drainage plane design.

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Buildings in the San Francisco Bay area with wood-framed exterior walls and wood-based sheathing have been problematic for some time. This is because of excessive moisture trapped within wall assemblies, in combination with insufficient waterproofing and drainage, causing decay and overall deterioration of the organic wood structures. Significant structural damage has resulted in building owners having to remove the existing wall cladding, repair the structure and waterproofing, and re-skin entire building façades. This makes for quite an extensive building envelope remediation project, and happens quite frequently within the first ten years following a building’s completion. Given these circumstances and the climate of the San Francisco Bay area, moisture mitigation through the use of drainage plane design is a top priority for exterior walls and their remediation.

Buildings with issues resulting from excessive water and moisture within the wall assembly typically consist of cement plaster finishing and have organic building paper installed over plywood or oriented strand board (OSB) sheathing. This conventional assembly, although code-compliant, has not proven to be sufficient for the life of some buildings. Cement plaster is known to crack over time, and one or two layers of building paper serving as the weather-resistive barrier (WRB) is simply not enough to protect the wood structure of some buildings. Screws and staple fasteners penetrate the building paper, which has poor tear resistance, and allows the passage of water directly through to the wall structure. Loosely lapped seams of the building paper may also allow water to bypass the waterproofing layer, resulting in a consistent supply of moisture in contact with the wood sheathing. Furthermore, rough opening flashings around windows, doors, and wall penetrations are critical junctures that may not have been correctly waterproofed. Numerous factors can lead to excessive moisture within a wall, and the deterioration of the structure behind the façade cladding will occur over time. This can remain unseen for many years.

DRAINAGE PLANE BENEFITS

Existing building walls with excessive moisture issues can benefit directly from a drainage plane. A drainage plane is a gap or space achieved by continuously offsetting the finish cladding a certain distance from the sheathing and WRB layer. This gap helps to avoid the accumulation of moisture within the wall assembly, and provides a means for water to exit from behind the cladding. A drainage plane also acts as a ventilation gap that provides the continual movement of air within the wall system and helps to dry out any moisture that is present behind the finish cladding. It prevents the compression of the cladding assembly materials directly against the WRB membrane, reducing the frequency of water penetration and absorption through to the structure of the building.

The implementation of a drainage plane design can lower the overall moisture content and relative humidity levels within a wall assembly. It is advantageous for such a system to be integrated during the new construction design of a building, and it can also be incorporated as a remedial building envelope measure after original construction. This type of remediation has been completed on numerous buildings in the San Francisco Bay area, and it requires that the existing exterior wall cladding be removed and replaced entirely.
In order to understand the magnitude of damage that water and moisture can cause to existing buildings, examples of deteriorated walls without a drainage plane assembly are provided in Figures 1 through 4.

The basic requirements for weather protection of exterior walls in the San Francisco Bay area are described in the current California Building Code (CBC) as:

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... and a means for draining water that enters the assembly to the exterior.

CBC 2013, Chapter 14, Exterior Walls, Section 1403.2, Weather Protection

For cement plaster assemblies, the WRB code requirements are as follows:

Water-resistive barriers shall be installed as required... and where applied over wood-based sheathing, shall include a water-resistant vapor-permeable barrier with a performance at least equivalent to two layers of Grade D paper. The individual layers shall be installed independently such that each layer provides a separate continuous plane and any flashing intended to drain to the water-resistive barrier is directed between the layers.

Exception: Where the water-resistive barrier that is applied over wood-based sheathing has a water resistance equal to or greater than that of 60-minute Grade D paper and is separated from the stucco by an intervening, substantially nonwater-absorbing layer or drainage space.

CBC 2013, Chapter 25, Gypsum Board and Plaster, Section 2510.6, Water-resistive Barriers

There is mention in the CBC of a drainage space provision for cement plaster assemblies, and it implies that there is a positive contribution to the performance of the wall system if one is inserted into the assembly. The code provision can be interpreted as one less layer of building paper being needed if a drainage plane is incorporated into the wall; however, there are really no specific details, materials, or configuration criteria as to what qualifies and is defined as a drainage space or how thick it needs to be.

The following drainage plane examples constitute design methodologies that can and have been implemented on existing exterior walls as remedial projects. They are moisture mitigation efforts that have enhanced the drainage capability and performance of building wall systems.

**DRAINAGE PLANE DESIGNS**

Typical drainage plane designs that have been installed to remediate existing building walls include a drainage matrix or drainage core, vertical battens or furring channels, or a WRB material that has a raised profile and is integral to the nature of the membrane. The incorporation of any one of these design methods results in the creation of a drainage space and air gap...
behind the finish cladding of the wall. In exterior insulation and finish system (EIFS) wall assemblies, the adhesive applied to the backside of each EIFS panel is often tooled to provide vertical channels to allow water drainage. This can also be considered a type of drainage plane within a wall. With any of these configurations, the exterior wall design needs to be properly detailed to ensure that the overall drainage system performs well. The implementation of a new system as a remedial envelope project requires that the existing cladding be removed from the building façades.

A drainage matrix or drainage core consists of a continuous layer of material that is situated behind the wall cladding. The thicknesses of matrix or core products vary, and typically range from 3/16 to ¾ in. Drainage matrices are usually flexible and mesh-like in nature, and drainage cores are often rigid and formed as a corrugated sheet (Figure 5). The benefit of these materials used in a drainage plane design is that it provides a continuous and consistent layer of space for water to travel vertically behind the cladding and exit out at the wall base or floor line. The challenges of this method include overall wall alignment of the finish cladding and the blind penetrations of fasteners through the WRB layer behind the drainage plane. If fasteners are removed during construction, proper patching of the WRB may be complicated to achieve with the drainage plane already installed.

Drainage matrices and drainage cores are typically fabricated out of plastic formulas such as polypropylene, high-density polyethylene (HDPE), and nylon (Figure 6). Drainage core products are similar to what would be placed within a horizontal podium or plaza waterproofing assembly for a concrete split-slab configuration. The fire-resistant capabilities of these plastics are still evolving, as these drainage materials are rather new to the construction industry. It is important to know whether the specified material meets the flame spread and smoke index requirements per ASTM E84, Standard Test Method for Surface Burning Characteristics of Building Materials, which the project and exterior building walls need. Even as recently as five years ago, plastic formulas from some manufacturers were different for these types of materials compared to those available today.

Vertical battens or furring channels are often incorporated into the wall system as a drainage plane configuration for remedial building envelope projects. Battens are installed at regular intervals over the WRB and are aligned with the wall framing members for structural stability and fastening. This method is typically used for panelized wall cladding such as fiber cement panels, metal panels, or horizontal lap siding (Figure 7). The benefit of this method is the ease of installation and, sometimes, cost-effectiveness when compared to the drainage matrix or drainage core configuration. In the remediation of existing building walls, the challenge is the layout of the battens in accordance with the structural framing members of the walls. The existing layout needs to be understood and marked prior to the installation of the furring channels.

There is a selection of materials when it comes to battens or furring channels for drainage plane designs. Pressure-treated wood battens, polyvinyl chloride (PVC) furring strips, or metal hat channels are typically used. Often, pre-cut strips of drainage core materials are used as furring channels as well. The chosen material will need to be evaluated for compatibility with the WRB membrane, accessories, and cladding materials.

Drainage gaps achieved through WRB materials with a raised profile follow the concept of designing a drainage space within a wall, but are not a complete and continuous drainage plane. These materials may have a secondary or accessory material integrated or surface-mounted to the WRB membrane, or they can simply be a folded or “crinkled” version of the WRB material (Figures 8 and 9). These products are typically compressed and flattened like conventional building paper is during the installation of the wall cladding system, and they rely on the dimensional offset of the product to create a minimal gap for drainage. While this may be the most cost-effective way of introducing a drainage space within a wall, the benefits are not equivalent to the previous two methods of having a drainage matrix or furring channel layout to achieve a full and continuous drainage plane.

DRAINAGE PLANE DETAILING

Drainage plane designs for exterior walls require additional attention and prop-
er detailing at rough openings, corners, floor lines, roof parapets, and wall base conditions. They create a thickened wall assembly, and adjustments to the exterior building details are needed per the selected method of drainage plane design.

It is pertinent that the drainage material is consistently located behind the cladding assembly and its accessories in drainage plane design. Accessories include cement plaster screeds and casing beads, as well as reveal channels located between panelized cladding materials. In every section detail, the drainage plane shall be aligned to ensure that the travel path for water is direct and uninterrupted. This maintains that the plane for drainage is independent from the wall surface cladding, and is continuously open as it approaches the depth of the drainage plane design.

Rough opening detailing requires special attention for the design of drainage plane schemes. Especially critical are windowsills to make sure water is diverted via a sill pan flashing to the exterior of the wall cladding, and not channeled within the drainage plane of the wall. The drainage plane should never be installed behind window nailing flanges. A flashing sequence for rough openings is recommended and shall be provided in the construction documents for the contractor to review and mock-up in order to ensure that proper installation of the drainage plane details occurs.

It is important that the path for ventilation and air travel remain open at the top and bottom of the wall, or for each section of wall. This is critical to maintain constant air circulation within the cavity to avoid excessive levels of moisture or condensation that may accumulate within the wall assembly. Typical floor line weep joints shall be detailed and incorporated at each level of the building to provide regular intervals of drainage as a factor of the overall elevation height. If not, a large volume of water or moisture can be diverted to the wall base of each building façade.

In both the drainage matrix and vertical batten schemes, the overall fastening of the exterior wall cladding assembly needs to comply with the manufacturer’s requirements in order to achieve a warranty. In preparing drawings and details, it is the responsibility of the architect to make sure the design of the drainage plane is feasible and that the details are properly laid out to meet the requirements of the finish wall system.

For battens and furring channels, the bearing capacity of the wall cladding material through the battens may need to be reviewed by a structural engineer. Similar to where a drainage matrix is configured...
within the wall assembly, battens shall be detailed behind the wall cladding in order to create a uniform plane for drainage.

Depending on the assembly in which raised-profile WRB products are used, the materials may or may not be configured at the same interface or wall plane compared to drainage matrices or furring channels. If a single layer of the membrane is specified, the exterior wall details will typically follow that of a conventional wall system because the drainage capability of the product is an integral part and characteristic of the membrane material. The raised profile cannot be separated and detailed as an additional layer.

If additional layers of WRB are specified over a raised-profile product, this may revise the detailing, and the permeance of the material and overall vapor permeability of the wall system may need to be reviewed. In most cases, the detailing of this scheme is quite similar to conventional wall assemblies, but it will provide improved performance in terms of wall drainage.

**DRAINAGE PLANE INSTALLATION**

Drainage plane materials appear to be straightforward in terms of construction; however, there are many details to consider, and the reality is that they take some skill and experience to install.

For remedial building envelope projects, the existing cladding is removed first, followed by the existing WRB layer(s). If damage has been caused to the existing sheathing and structural framing members, these repairs need to be addressed prior to the installation of the drainage plane. It is difficult to predict how much of the existing sheathing and structure need to be repaired or replaced prior to the actual construction of the project; therefore, a contingency and percentage of construction cost need to be allocated in anticipation of this scope of work.

Drainage plane materials are typically stapled or fastened using screws or nails. Additional penetrations through the WRB are created when a drainage plane is introduced; therefore, the specified WRB product should have some sealing capability around each fastener and at least have passed the requirements of a modified test based on the requirements of ASTM D1970, *Standard Specification for Self-Adhering Polymer Modified Bituminous Sheet Materials Used as Steep Roofing Underlayment for Ice Dam Protection*, to ensure that the membrane will remain watertight. Corrosion-resistant...
fasteners, such as stainless steel or hot-dipped galvanized, shall be used due to the added exposure to water and moisture when the thread of the fastener passes through the drainage plane cavity.

Drainage matrices are typically unrolled and fastened directly over the WRB of the wall. Depending on the flexibility of the product, it is often a challenge to maintain a uniform plane and provide an even substrate for the next layer of material or cladding to be installed over it (Figure 10). Additional review and provisions for alignment must be taken in the field, especially for cement plaster wall assemblies, in which the layout of accessories will occur over the drainage matrix.

A minimal amount of fasteners shall be used to hold the drainage matrix in place. Since additional fasteners for the cladding system will be installed, they will also help to further secure the drainage matrix in place.

With drainage matrices, the challenge during installation is to make sure the material does not get fully compressed and flattened into a form that will block the drainage of water behind the cladding. Wall bases and the head above rough openings are critical junctures that may require shimming of the cladding accessories that are installed directly over the drainage matrix (Figures 11 and 12).

For drainage plane configurations consisting of battens or furring channels, the main challenge is to ensure that the battens are properly fastened to the structural members of the wall, since the wall cladding is typically fastened through these members (Figure 13). If an existing building has framing members that do not align from floor to floor, the layout of the battens will need to be adjusted in the field, and possibly the cladding layout, if it consists of panelized products with specific fastening requirements.

The installation focus for WRB materials with a raised profile is similar to that of building paper or conventional WRB materials (Figure 14). Construction sequencing does not necessarily need to be changed when installing these materials. Often, the amount of drainage space achieved by a WRB’s raised profile or “crinkling effect” is not much; however, it is better than not having a gap for drainage at all.

CONCLUSION

Although the current California Building Code does not require it, the installation of a drainage plane within an exterior wall can enhance the performance of the assembly. Moisture and relative humidity levels within the wall are decreased when a drainage plane is present, and the gap allows the channeling of water and moisture behind the wall cladding so that it will not accumulate and cause deterioration to the building’s structure.

California’s requirements, as well as those of the United States, fall behind that of Canada, which requires that a drainage plane be incorporated into the exterior wall assembly per code. California has not reached that mandate yet; however, synthetic WRB materials are more frequently specified and installed in lieu of organic building paper compared to ten years ago. The insertion of a drainage plane into the wall system of existing buildings within the San Francisco Bay area has been a solution for many buildings with walls that have been damaged by water. Various design methods have been utilized and implemented. With the advent of new energy code requirements, provisions for exterior continuous insulation within the wall assembly are becoming a necessity, and the drainage design for walls is expected to become more and more complex.