Water Resistance of Integrated WRB Panels

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ABSTRACT - Two integrated sheathing systems were assessed for water resistance under prolonged hydrostatic pressure. Findings revealed stark contrasts in moisture performance based largely on material composition of exterior overlays, one representing a glass mat facer and the other a factory-applied fluid membrane. Water staining through glass mat-faced panels occurred at 18 to 24 hours in association with sealed wall interfaces and as a function of hydrostatic pressure. Conditions progressed over a typical seven-day test period culminating with panel saturation and uncontrolled water entry. Membraned-based panels showed no evidence of moisture accumulation or liquid water penetration after 30-days.

INTRODUCTION

Water-resistive gypsum panels represent exterior sheathing systems that also function as air and water-resistive barriers. Resistance to liquid water is offered by factory-applied membranes or by integral components of the panel itself, including glass mat facers, gypsum core layers, and hydrophobizing additives. Membrane continuity at panel joints is achieved through product-specific treatments involving sealants, tapes, or liquid flashing.

As with other water-resistive barriers (WRBs), code acceptance of integrated WRB panels requires demonstrated performance as an effective barrier to liquid water. Panels are typically evaluated by means of hydrostatic pressure testing in accordance with recognized standards and acceptance criteria [1,2,3]. Evaluation of panel systems, inclusive of joint treatments, employs assembly-based test methods such as those specified by ASTM E331 [4].

Standard methods for hydrostatic testing examine water penetration through the entire test specimen, a limitation not exclusive to integrated WRB panels. Water entry into pore structures of membranes and substrates is therefore unassessed and unreported. When evaluating membrane-based systems, it is preferred to test the membrane independently of its substrates. In this manner, test results are aligned with the fundamental intent of protecting the gypsum core from episodic wetting. However, when the membrane is evaluated separately from its substrate, the effects of capillarity and surface tensions at interfacing planes are ignored. Likewise, integrated WRB systems lacking true membranes are evaluated on the basis of water penetration through the entire panel, not merely into the panel's core. These inherent discrepancies have created industry-wide confusion due to conflicts with code definitions and explicit requirements for: a) resistance to liquid water and b) prevention of moisture accumulation within the assembly.

> Test methodologies that ignore potential water accumulation within the sheathing core not only belie the fundamental intent of building codes but also vastly underestimate the ramifications to real-world durability.

The purpose of this study was to compare water resistance of two integrated WRB panels under extreme conditions. The results indicate vastly different outcomes based on inherent water resistive properties of the respective systems. It is demonstrated that a factory applied membrane offers superior protection of the panel core. In contrast, panels reliant on integral attributes, including glass mat facer and hydrophobic core layers, show poor performance under prolonged hydrostatic pressure.

THE INTEGRATED WRB PANELS

Test methods compared water resistance of two gypsum-based integrated WRB panels: 1) Securock ExoAir 430 (USG Corporation and Tremco Commercial Sealants and Waterproofing); and 2) DensElement (Georgia-Pacific, LLC). Securock ExoAir 430 represents a 5/8” gypsum-based panel with a 20-mil thick factory-applied fluid membrane. The membrane is broadly classified as a permeable acrylic [5]. DensElement represents a 5/8” gypsum-based panel without a true membrane overlay. Water resistance relies on whole panel composition of the exterior glass mat facer, a proprietary gypsum-based layer (‘AquaKor’), and the remaining gypsum core. Claims regarding water resistance are described by the patent filing [6].

THE FACE COLUMN

Face columns refer to water columns established vertically against exterior faces of panel specimens (Figs. 1 and 2). This approach achieves a broad range of hydrostatic pressures expressed simultaneously as a function of depth of the established water plane. In this particular study, the maximum water column height was maintained at 21.6 inches consistent with current standards and acceptance criteria (e.g. ASTM E2556 and AC38).

Water columns were formed with 0.22” thick acrylic sheets (18” w x 24” h) sealed to panel specimens (24” w x 28” h). The acrylic sheet and panel were held off from the WRB panel with 0.16” spaces but otherwise sealed at the base and sides using the system-approved sealant or water-proofing adhesive. The primary configurations involved Dymonic 100 (Tremco Commercial Sealants and Waterproofing) and FastFlash (Prosoco, Inc.). Face columns were also configured with alternative sealants to assess selective wetting behaviors at sealant-panel interfaces. Verified cure times of 7 to 14 days were employed for perimeter column seals.

Each face column was configured with a single reinforcing angle which spanned the mid-point to prevent undue shear stress at interfacing seals.

Water absorption and evaporation necessitated replenishment of water loss from the test column at approximately four- to six-hour intervals for the entirety of each 7-day test. Face columns for 30-day tests were replenished daily until terminated at 30 days.

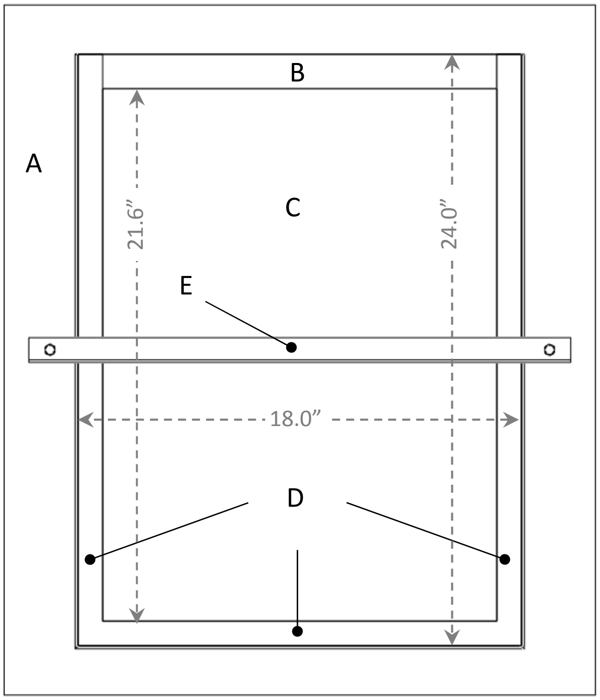

Fig.1. Schematic of face column test apparatus. A. panel; B. acrylic sheet; C. water column; D. sealant/adhesive; E. aluminum reinforcing angle

Fig. 2. Face column test apparatus.

WATER PENETRATION

Representative 7-day face columns are compared in Fig 3. The Securock ExoAir 430 panels remained highly resistant to water penetration for the duration of each test (Fig. 3-A). These panels showed no evidence of water penetration beyond the factory-applied membrane or within the gypsum core. Extended 30-day tests yielded similar results with gypsum moisture contents never exceeding 0.5% for the full 30-day period. Water penetration to the back side of the panel was not observed.

Securock ExoAir 430 – Results from 30-day face columns yielded unexpected findings. These panels continued to remain dry and free of liquid water penetration. These extended tests were not achievable for DensElement panels due to uncontrolled water leakage.

DensElement panels revealed very different findings under the same face column conditions (Fig. 3-B). Moisture levels within the gypsum core increased during the first 12 hours, exceeding 3% moisture content at the face column base and adjacent column side walls. Localized saturation of the interior facer was noted within 18 to 24 hours. By the end of each seven-day test, moisture content of gypsum cores exceeded 6% at all face column heights.

Water penetration through a representative DensElement panel is shown in Figure 4. At 24 hours, dampness and water staining were expressed as a function of hydrostatic pressure and in association with column seals. At Day Two, Water droplets and associated water streams had formed near the column base and adjacent side walls. This became significantly more apparent on Day Three. Localized saturation was also observed at interfaces between the outer seals and glass mat facers. These conditions indicated that water was transported within pore structures of the facer and outer gypsum layer. By Day Four, gypsum cores were saturated throughout the lower two-thirds of the test specimen, including areas where the interior facer was not visibly stained. Further development of visible water droplets and water streams were associated with column seals from the fourth day through termination of the seven-day test.

FAILURE MECHANISMS

Water penetration through DensElement panels involved bulk flow through pore structures of the glass mat facer and gypsum core, including the blue-colored outer gypsum layer referenced as AquaKor. The effect of hydrostatic pressure was confirmed by conventional vertical water column tests showing similar water entry when maintained at 21.6 inches for 24 hours. Dye tracing experiments have also documented depth of penetration over time under various hydrostatic conditions.

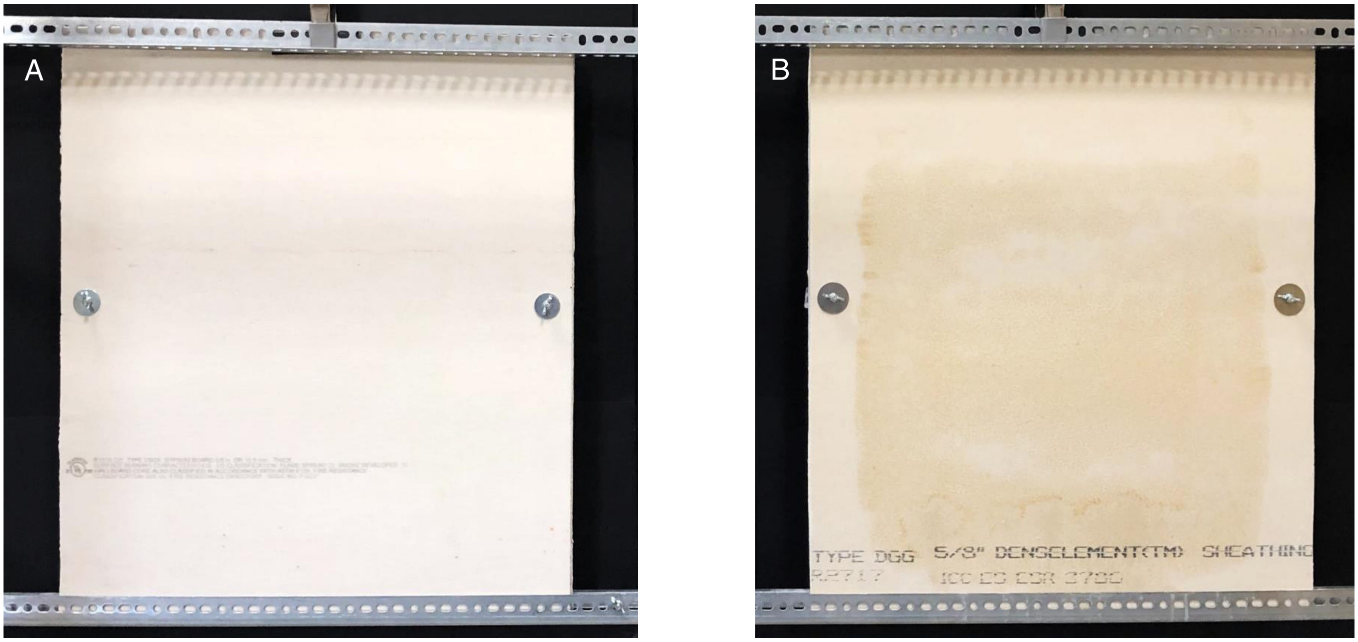

Fig. 3. Back side of Securock ExoAir 430 panel (A) and DensElement panel (B) following a seven-day face column test.

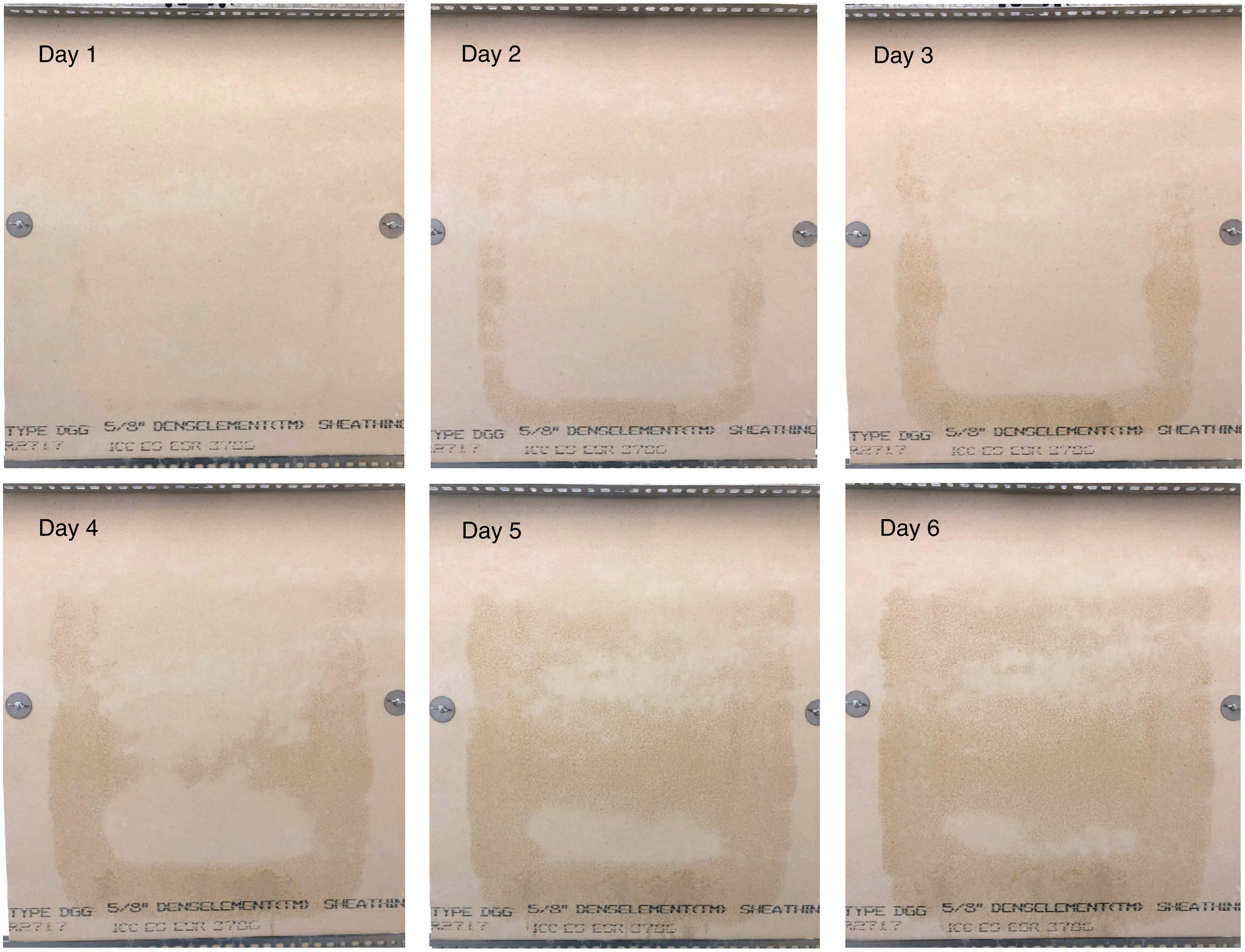

Fig. 4. Progression of water penetration through a representative DensElement panel.

The observed association between water penetration and column walls suggests additional mechanisms involving STPE-sealed interfaces but not necessarily adhesion itself as the liquid flashing/adhesive showed excellent adhesion well beyond the seven-day test duration. Face columns established using alternate sealants, including polyurethanes, silicones, and a similar silane-modified polymer revealed no such correlation between water entry and sealed interfaces. Instead, water penetration occurred solely on the basis of hydrostatic pressure and time.

Studies involving inverted float tests of sealant ribbons demonstrate a similar causal relationship even in the absence of hydrostatic pressure (Fig. 5). After 24 hours, water penetrated behind the leading edge of STPE sealants/adhesives but not at interfaces of the similar silane-modified polymer, silicones, and polyurethane. By 48 hours, water had penetrated through the entire panel.

Face columns configured with Securock ExoAir 430 exhibited the same water resistance when sealed with FastFlash, Dymonic 100, Spectrem 1 or other commonly used sealants.

It is unresolved what role curing products or possible plasticizer release may serve in this wetting process. Interactions involving hydrophobizing agents within the facer or gypsum core are also unclear. Nonetheless, at least three factors expressed at the sealant-WRB interfaces are implicated. These involve: 1) hydrostatic pressure, 2) flashing-associated wetting at interfaces between the facer and gypsum core layers, and 3) localized disassociation of the AquaKor layer. These processes are the subject of ongoing investigations to further resolve the dynamics of this selective wetting.

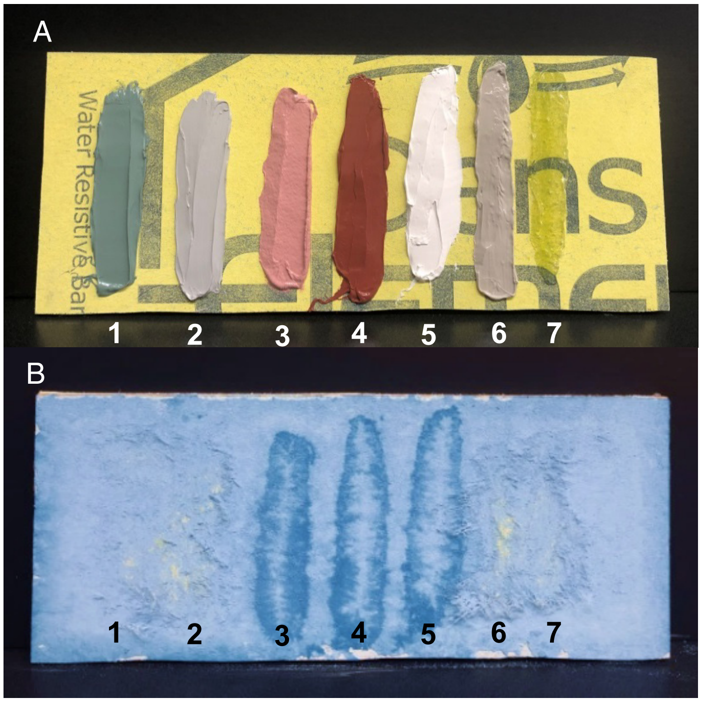

Fig. 5. Water absorption associated with STPE-based sealants/adhesives (ribbons 3, 4, and 5). Note that the glass mat facer (A) has been removed from the gypsum core (B) at the AquaKor interface. 1) Tremco Dymonic 100; 2) Tremco Spectrem 1; 3) Prosoco Joint & Seam Filler; 4) Prosoco FastFlash; 5) Prosoco AirDam; 6) GE Silicone; and 7) OSI Quad Max Clear

It is recognized that sealants and water-proofing adhesives employed in this investigation are not intended for continuous water immersion. Furthermore, column seal thicknesses were well beyond the 12 to 15 mil thicknesses typically applied for the DensElement joint treatment (i.e. Prosoco FastFlash). These factors, combined with containment by the acrylic sheet presented atypical conditions with possible ramifications to curing. Still, adhesive-associated wetting was consistent for face columns configured with DensElement panels and corresponding FastFlash adhesive. Supporting evidence for this phenomenon was obtained by the inverted float tests that assessed sealant ribbons at typical thicknesses (Fig. 5). The implications of this associated wetting are significant as both the integrated WRB panel and preferred joint treatment are implicated in water penetration.

CONCLUSIONS

This study has compared water resistance of two integrated WRB panels under varied and prolonged hydrostatic pressures. The inherent advantages of a factory-applied membrane were made clear while also demonstrating the overt shortfalls of integral panels reliant on glass mat facers and porous gypsum cores. Face columns and inverted float tests further identified failure mechanisms that implicate not only the DensElement panel but also the preferred STPE adhesive.

Code acceptance of WRBs, including integrated WRB panels, relies on short-term evaluation criteria to predict long-term performance under diverse conditions. These practices offer poor indicators of true performance as exemplified by these findings. Although both integrated WRB panels are accepted by model codes, and are often similarly specified as approved equals, the panels depict vastly different outcomes.

Comparative product tests employing such robust ‘stress tests’ have usefulness in demonstrating not only performance under extreme conditions but also the inherent strengths and weakness of the respective systems. The findings described in this study were not altogether surprising as I have compared a membrane-faced panel to a panel that is comprised entirely of porous layers and hydrophobic additives. Ultimately, these contrasting attributes must be reconciled against the intents of model codes involving: a) resistance to liquid water and b) prevention of moisture accumulation within the assembly. Based on this comparison, the Securock ExoAir 430 system meets these intents whereas the DensElement system does not.

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FUNDING

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