The Face Column:

A Systems Approach for WRB Evaluation

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ABSTRACT – A novel test apparatus is described for evaluating Water-Resistive Barriers (WRBs) and their system components. The 'Face Column' represents a thin layer of water expressed vertically against a continuous surface or interfacing component planes. It is designed specifically to convey a range of hydrostatic pressures simultaneously along a single vertical gradient. The concept is highly adaptable to accommodate preferred specimen size, column heights, and multiple component interfaces such as fasteners, joints, tapes, sealants, and liquid flashing. Applications are discussed in context with a proposed shift from current single-component testing to WRB System evaluation.

THE WRB SYSTEM

The modern Water-Resistive Barrier (WRB) has multiple functions. Primary among these is the ability to resist liquid water that has penetrated beyond the cladding system [1]. The building code also makes explicit the requirement for layer continuity, as we similarly expect for air barriers or jointly as Air and Water Barriers (AWBs). The implication here is that air- and water-resistive layers have joints, seams, and interfaces with a myriad of other enclosure components. Hidden in plain view is the intent that performance be defined not on the basis of a single component but rather as a 'WRB System'.

Since the dawn of building papers, we have treated the WRB as a distinct and infinitely continuous component. And still today it is largely tested as a membrane in isolation, wholly separate from its substrate and devoid of variables for continuity. This logic brazenly betrays the very attribute that we seek – continuous water resistance. Moreover, relevant test methods, even those intended for the membrane alone, lack rigor and resolution. They therefore offer poor predictive value of greater assembly durability. We are left with the naïve notion that short-term, anemic testing can somehow predict long-term, robust durability. Consider the need for continuity and the average enclosure life span of over 50 years and you have a sense of the enormous blind spot that our industry has willingly embraced.

> The WRB System consists of any and all components necessary to achieve continuity and water resistance along the primary WRB plane. Specifically, it includes all components prescribed by the WRB manufacturer to achieve the intent of the code and acceptance by the code.

It is tempting to dismiss the WRB System as an assembly-level concept best left to 'means & methods' and tested accordingly. But nothing could be further from the truth as there is clear precedence for this model. For example, treated joints for foam-based panels are tested to the same hydrostatic pressures (21.6 inches) as our best-performing WRB membranes [2]. Ancillary testing of fastener sealability, as outlined by ASTM D1970, assesses membrane continuity when held to five inches of hydrostatic pressure for 72 hours [3]. Not the perfect method by any means, but still one that appreciates continuity and the influence of time as important variables. Assembly tests such as ASTM E331 [4] go a step further by considering all relevant components at the exposed

WRB interface. Although the intent is on target, its lack of rigor, poor resolution, and short 15-minute duration make this method dreadfully imprecise.

There is immense insight gained in testing the WRB system in its totality of parts under common and controlled conditions. Examples of these codependent factors include adhesion, continuity, water absorption, chemical stability, plasticizer release, and fastener sealability. Such responses require refined assessment and no small amount of resolution – something that assembly testing and current component-based laboratory tests simply do not offer.

Current Testing Methods

Common test methods for liquid water resistance are broadly classified as follows:

- Ponding - CCMC 07193 [5]
- 100% relative humidity - ASTM D2247 [6]
- Hydrostatic pressure - AATCC Method 127 [7] per AC71 [2], AC38 [8] or ASTM E2556 [9]
- Assembly testing - ASTM E331 [4]

These methods are primarily concerned with the WRB as the sole test specimen. There is little or no consideration for continuity; and testing is typically devoid of substrate. Therefore, matters concerning surface tension, capillarity, and water absorption at the substrate interface go largely ignored. When continuity is considered, as in assembly testing, moisture penetration into the substrate is neither measured nor known. The same is true for hydrostatic pressure testing of integrated WRB panels. Again, water accumulation within the panel, an explicit criterion of building codes, is not assessed. This disregard for substrate moisture is perhaps the most egregious oversight of all because moisture penetration into the WRB's substrate is the same as water penetration into the building. Indeed, the sheathing or substrate is the most important element of the assembly, and it therefore warrants the greatest consideration when interpreting water resistance.

As a result, our current methods lack predictive value, and they certainly lack a margin of safety. Testing methods fail to accurately predict product performance when one or more of these conditions are lacking: A) stringency, B) duration, or C) resolution. I show conceptually that predictive value is ultimately determined by a combination of these factors (Fig. 1). As an industry, we have encouraged methodologies that are not particularly rigorous, are of short duration, and lack resolution.

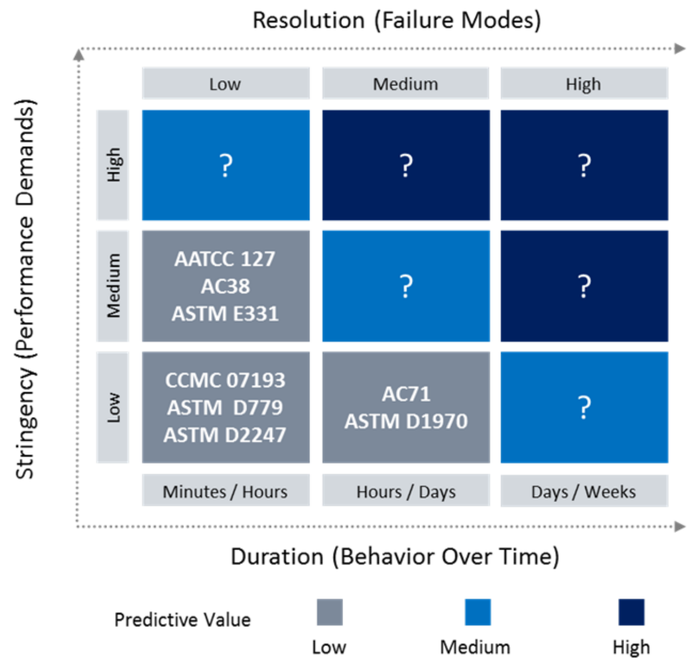


Fig. 1. Conceptual representation of WRB test methods and their corresponding predictive values.

Preferred methods push the boundaries of all three factors while also embracing continuity and uniformity in system performance. In other words, predictive value reflects an accounting of uncertainties in performance demands, failure modes, and system behavior over time.

THE FACE COLUMN

My work with integrated WRB panels previously demonstrated the shortfalls of current WRB test methods [10]. At that time, I was comparing two code-accepted systems, Securock ExoAir 430 and DensElement. The SE 430 panel possesses a factory-applied membrane intended to resist water and protect its gypsum substrate. In contrast, the DensElement panel relies on its glass mat facer and hydrophobic gypsum core. In other words, one is a true *integrated* WRB panel and the other is an *integral* WRB panel – two very different things. But in the eyes of the code, they are the same. Viewing it another way, the integrated system intends to protect the substrate whereas the integral system <u>is</u> the substrate. So by accepting the premise of an integral WRB panel, the code contradicts its very directive.

From this earlier work, emerged the 'Face Column', a simple technique for expressing a range of hydrostatic pressures simultaneously along a single column of water. This method proved instrumental in confirming what was inherently obvious but our conventional test criteria failed to discern: the integrated panel protected its gypsum substrate; whereas the integral system did not. Furthermore, by evaluating the integral panel with its associated liquid flashing, the face column method was the first to implicate released plasticizers as the primary mode of failure. Were it not for the face column, this failure mechanism would have gone unnoticed. It exposed not only the fallacy of the integral concept but also the importance of testing the WRB as a 'WRB System'.

Design

Face columns represent water columns established vertically against exterior faces of WRB-substrate specimens (Figs. 2 and 3). This approach achieves a broad range of hydrostatic pressures expressed simultaneously as a function of depth of the established water plane (Fig. 4). Column height is a matter of preference, but the most typical configuration establishes a maximum height/depth of 21.6 inches, which is consistent with common test specifications and acceptance criteria such as AC38 [8] and ASTM E2556 [9] when referencing AATCC Test Method 127 [7]. The 21.6 inches of water pressure is established at a finite point at the base of the water column. Remaining column pressures reflect a gradient of decreasing pressures from 21.6 inches to 0 at the column surface (Fig. 4).

The apparatus is formed by sealing 0.22-inch thick acrylic sheets (18" w x 24" h) to test specimens that are coated, adhered, or mechanically-attached to a preferred substrate (24" w x 28" h). The acrylic sheet and panel are held off from the WRB plane with spacers (0.16" – 0.375") but are otherwise sealed at the base and sides using a compatible sealant or water-proofing adhesive. Typical face columns (21.6 inches) are configured with a single reinforcing angle spanning the column's mid-height. This prevents undue shear stress that may otherwise lead to adhesion failures, leaks, or catastrophic failures.

System Components

The face column is intended to accommodate system components. Inherently, the apparatus includes a preferred substrate to which the WRB is either factory-integrated or otherwise applied. Typical components include tapes, liquid flashings, and exposed fastener heads. By any measure, considerations for these elements are necessary to achieve the intended continuity and water resistance along the primary WRB plane.

Tapes and liquid flashings may be evaluated with or without substrate joints. If joints are included, gap-spanning bracing is necessary and typically applied to the back face of the test apparatus (Fig.5).

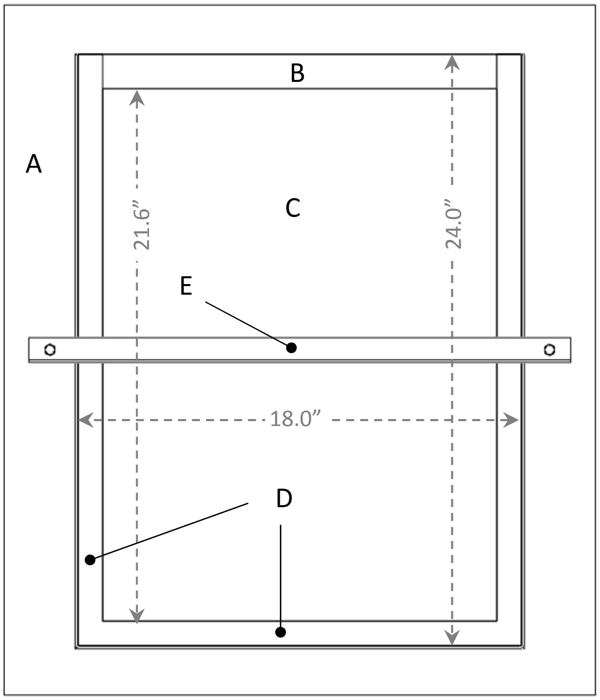


Fig. 2. Schematic of face column test apparatus. A. WRB applied to preferred substrate; B. Acrylic sheet; C. Water column; D. Sealant/adhesive; E. Reinforcing angle.

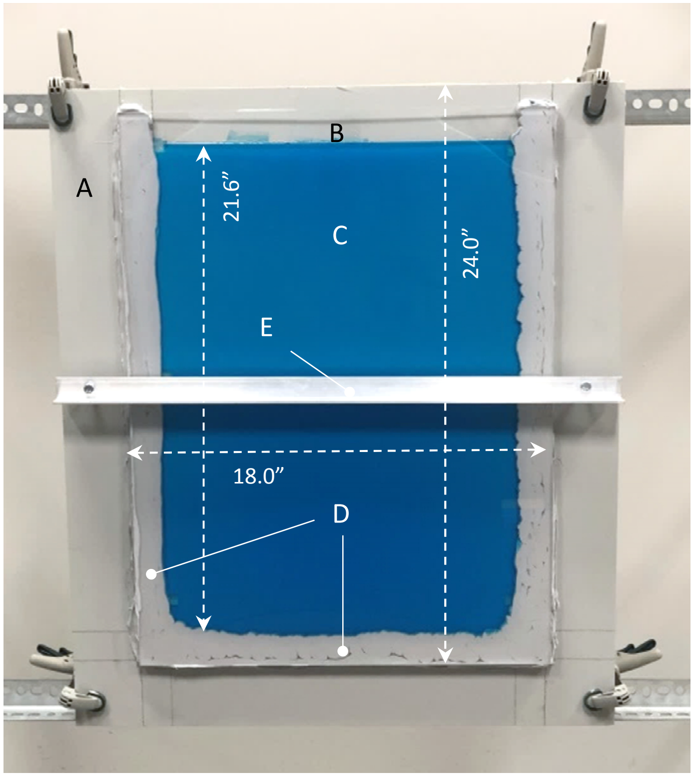
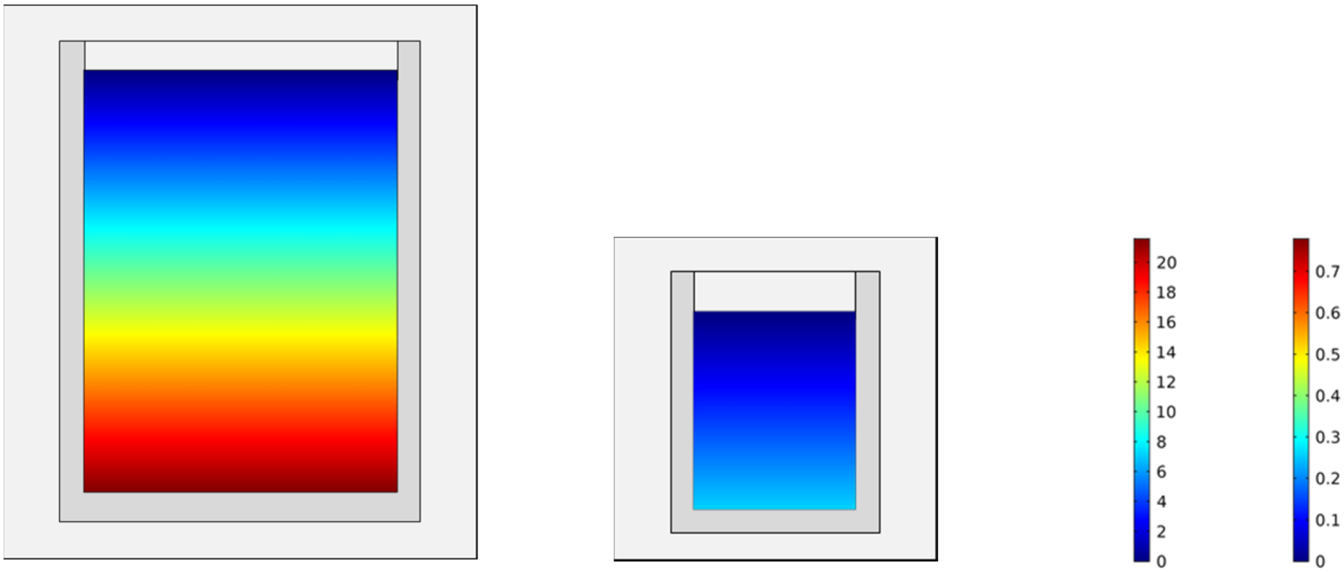


Fig. 3. Assembled face column. A. WRB applied to preferred substrate; B. Acrylic sheet; C. Water column; D. Sealant/adhesive; E. Reinforcing angle.



A. Full Column (21.6” w.c.) B. Mini-Column (7.2” w.c.) wc (inches) psi

Fig. 4. Simulated pressure fields associated with the face column apparatus as shown with typical 21.6-inch column height (A) and smaller 7.2-inch ‘mini-column’ (B).

Systems requiring treated substrate joints should be evaluated accordingly as the intent is to evaluate the WRB system as typically installed. Joint placement within the column depth is a matter of preference and may further assume vertical or horizontal assignment, or both, as bracing allows.

Omitting the substrate joint is considerably more convenient and is particularly relevant when assessing water resistance of the WRB itself or when evaluating bond characteristics of tapes, membrane flashings, and liquid flashings. Indeed, there are numerous applications of tapes and liquid flashings that do not involve substrate joints, such as fasteners, WRB seams, and transitions. The joint-less substrate therefore remains the preferred configuration in lieu of explicit requirements for joints.

Post-immersion adhesion testing of common flashing materials often employs just one inch of hydrostatic pressure – a condition often referred to as ‘ponding’. The face column and its variants therefore offer an alternative to current standards such as AAMA 711 [11] and AAMA 714 [12] while also offering a range of hydrostatic pressures. Additional advantages include a vertical test apparatus and a realistic WRB-specific substrate, as opposed to standard anodized aluminum strips.

Common configurations are shown in Figures 6-14. Modification is essentially limitless as virtually any component may be integrated into the apparatus, assuming suitable column dimensions. Alternatively, superfluous aspects of components that project beyond the plane of the column face may be cut or sized appropriately (e.g. cladding attachment angles). Evaluations of fastener penetrations may necessitate realistic conditions involving thread contact or anticipated movement at interfaces between the fastener, substrate, and stud. Additional back-up components, such as blocking or studs may be applied to the back side of the apparatus to accommodate these conditions.

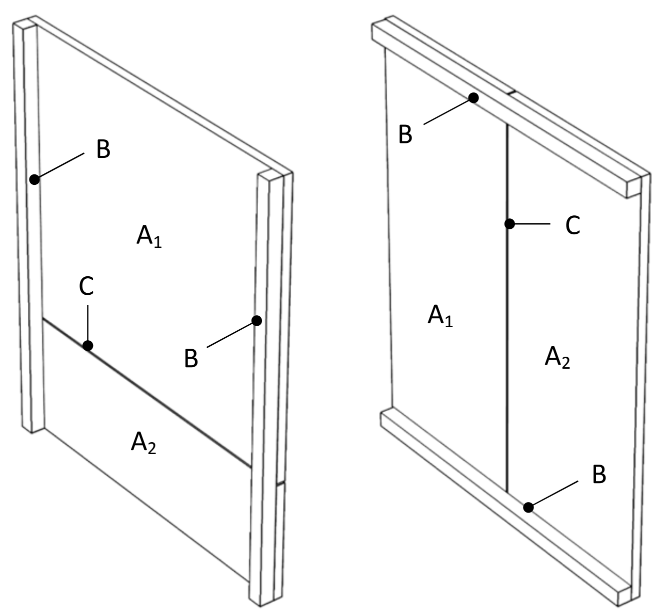


Fig. 5. Apparatus bracing of horizontal and vertical joints. A. Back face of substrate; B. Wood bracing; C. Substrate joint.

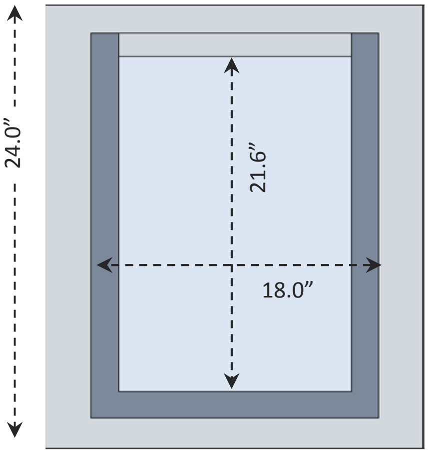


Fig. 6

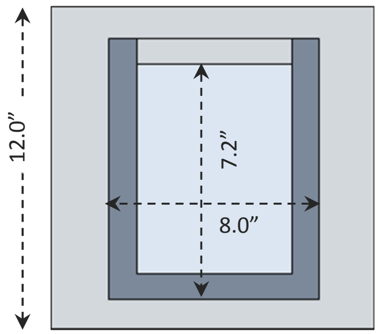


Fig. 7

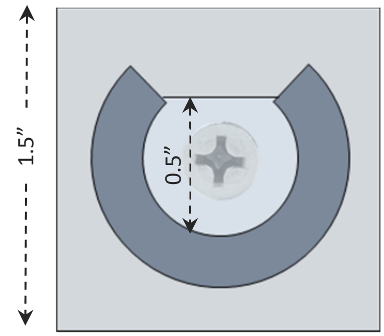


Fig. 8

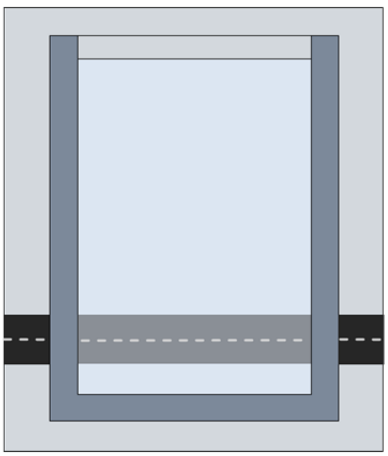


Fig. 9

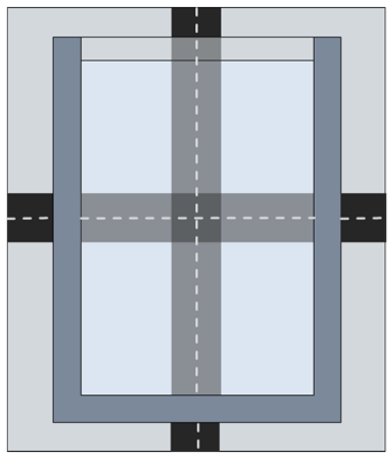


Fig. 10

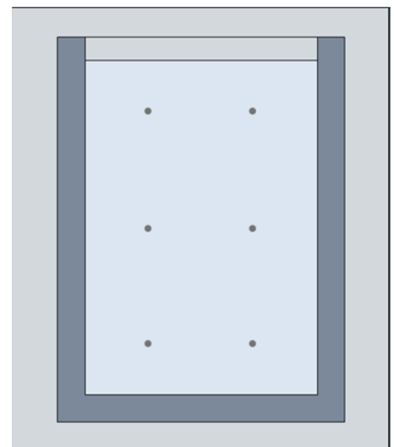


Fig. 11

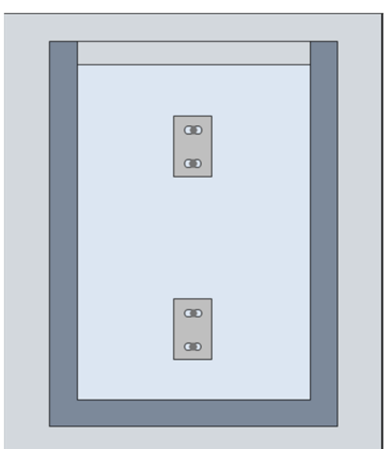


Fig. 12

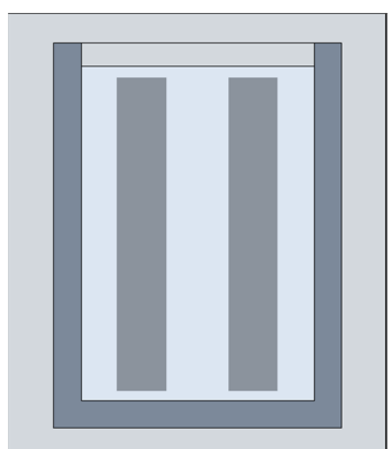


Fig. 13

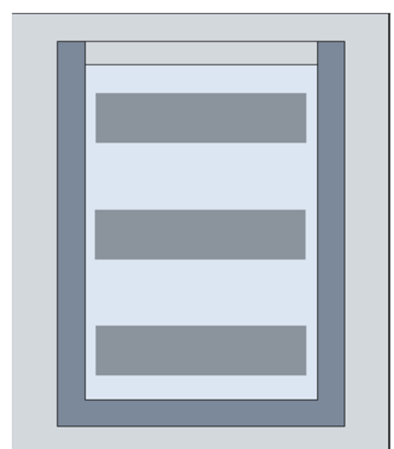


Fig. 14

Figs 6-14. Common variation in face column configurations. 6. Typical configuration with 21.6 inches of water column (reinforcing bracing not shown for clarity); 7. Mini-column (7.2 inches w.c.); 8. Fastener column; 9. Horizontal substrate joint; 10. Horizontal and vertical substrate joint; 11. Fasteners; 12. Brackets with fasteners; 13. Adhered tape or flashing (vertical); 14. Adhered tape or flashing (horizontal).

The Mini-Column

The smaller 'mini-column' accommodates up to eight inches of water. The most common configuration utilizes a water column of 7.2 inches or one-third of the typical 21.6-inch column. Advantages of the mini-column include smaller size, fewer resources, and no explicit requirement for reinforcing angles. It is intended for first-tier assessments where lower hydrostatic pressures are preferred. For many WRBs, the mini-column represents the maximum performance range, especially for test durations beyond five hours.

As with the typical face column, the mini-column may accommodate a variety of system components, such as tapes, flashing, treated joints, and fasteners (Fig. 15). It is particularly useful for evaluating fastener sealability at pressures similar to that employed by ASTM D1970 (i.e. five inches). However, the mini-column has several advantages, including: 1) vertical test apparatus; 2) accommodates all substrate types; 3) accommodates treated or untreated joints or laps; and 4) improved monitoring.

An example of the mini-column is demonstrated in Fig 15 in which foil-faced polyisocyanurate is used as a WRB. With this particular example, the specimen is configured to assess intersecting joints. Adhesion and water-resistance at the tape-to-foil, tape-to-tape, and corresponding lap interfaces are assessed simultaneously.

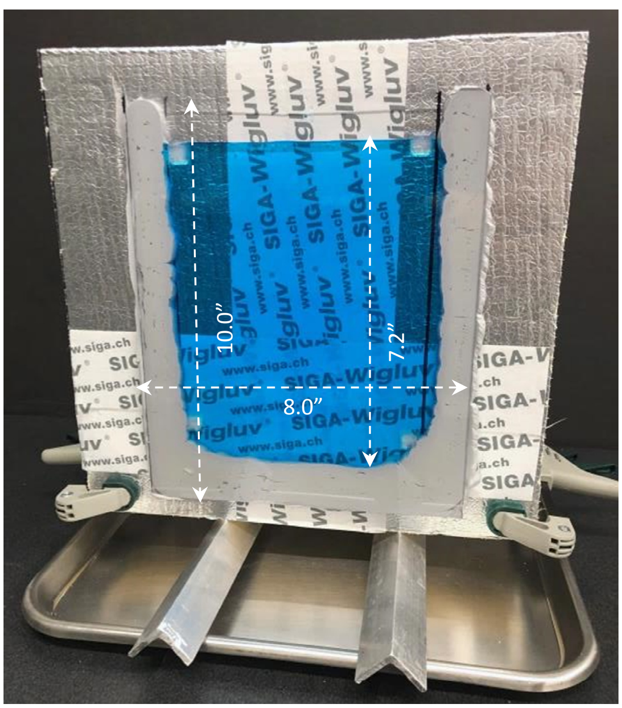


Fig. 15. Assembled mini-column illustrating treated vertical and horizontal joints on foil-faced foam panel.

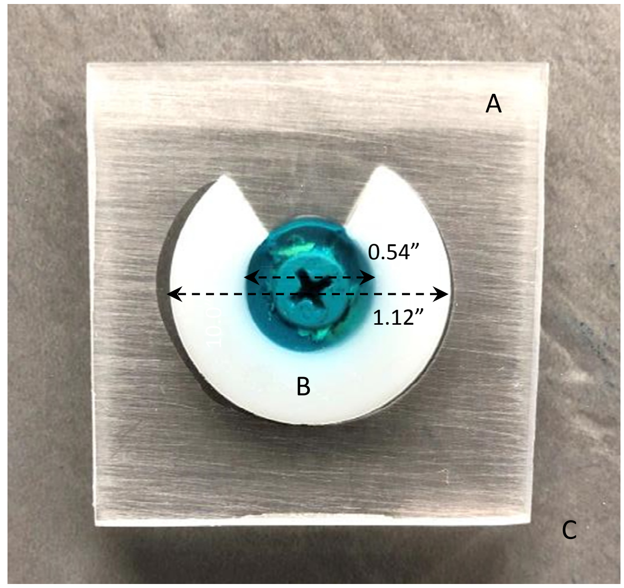


Fig. 16. Fastener column apparatus. A. Acrylic face; B Slotted neoprene washer; C. Integrated WRB panel.

The Fastener Column

The fastener column represents an important variant of the original face column concept. By intent, face columns highlight the combined effects of hydrostatic pressure, capillarity, and gravity. But with a head pressure of only 0.25 inch to 0.5 inch the fastener column emphasizes capillary flow and gravity as the primary transport mechanisms. And it does so around a localized, but important interface, the fastener.

Assembly of the fastener column is simple and involves nothing more than a slotted neoprene washer sealed to the WRB specimen. The acrylic face is then sealed to the outer surface of the neoprene washer (Fig. 16).

Although the fastener column is applicable to all WRBs, it was designed with a particular type in mind, wood-based WRB panels. System manufacturers and applicable criteria such as AC310 [13] do not address treatment of fastener heads unless overdriven by 50%. This omission exposes wood strands and interconnecting voids, rendering the panel vulnerable to moisture degradation.

When applied to the OSB-based Zip panel (Huber Engineered Woods), the fastener column has proven instrumental in demonstrating water absorption and widespread migration within the OSB matrix. Water is not localized to surfaces adjacent to the fastener but is instead transported several inches (i.e. 3-9 inches) over the course of a 96-hour study. The fastener column confirmed that capillarity and gravity, not hydrostatic pressure, are the mechanisms in play.

Considerations & Limitations

Face columns have several important considerations and limitations. Most of these involve the materials and methods necessary to achieve proper adhesion and containment of the water column. Nuance and some trial and error are inherent given the multitude of materials and test conditions to which the face column may be applied. Below I offer some critical insights for materials, apparatus setup, and failure detection.

Column Face

The typical face column and the smaller mini-column require a rigid, transparent face. Although glass may be used, acrylic sheets provide consistent results and are considerably safer than glass. Note that polycarbonate sheets should be avoided due to poor bonding with many sealants used in constructing the column walls. When using acrylic, the preferred sheet thickness is 0.22 inch. Sealant adhesion to acrylic requires surface preparation by roughening interfaces that are intended for bonding. This is achieved by moderately sanding with coarse sanding paper or sanding sponge. Panels should be thoroughly rinsed and dried before assembling the test apparatus. Avoid the use of detergents as any residues may reduce the surface tension of water thereby potentially altering water resistance of the test specimen.

Unlike other configurations, the fastener column face is subject to very little shear stress. Virtually any sheet material may therefore be used, assuming its compatibility and adhesion with column walls. Various adhesives, sealants, and even cyanoacrylate glues may be applied to seal the washer to the substrate and the washer to the column face. The washer may be comprised of materials other than neoprene to achieve the necessary compatibility with preferred adhesives.

Column Walls

A variety of materials are used in forming face column walls. Typical configurations involve common sealants and liquid flashings. Structural silicones offer excellent adhesion to prepared acrylic surfaces but do not bond well to many WRBs. It is therefore important to consider specific materials that offer desired compatibility and adhesion for a particular test apparatus. Furthermore, proper lead time must account for product curing, which may require 5 to 10 days. Avoid sealants and flashing materials that are known to absorb excessive amounts of water, which in turn could affect adhesion during the course of study.

Effective face columns have been assembled using sealant tapes and pre-formed solid plastics. The latter has notable advantages as solid materials offer faster assembly and improved adhesion to the column face. Bonding to solid walls also utilizes less sealant; thus cure times are reduced considerably. Lastly, by first adhering the solid wall to the WRB, the remaining field of the column is still accessible prior to assembling the column face. This has advantages in reinforcing the inner wall-WRB interface or for integration of WRB components.

The fastener column is distinct for having walls comprised of solid materials such as neoprene washers. Assembly is therefore achieved in a matter of minutes, not hours or days. However, care is still required for proper adhesion. Best results are achieved by sanding both faces of the washer with coarse sand paper or sanding sponge. And as with any adhesion process, bonding surfaces must be clean and dry.

Plasticizers & Wetting Agents

Plasticizers represent additives in formulations of sealants, liquid flashings, and coatings. They impart certain attributes such as flexibility, workability, and softness. When exposed to water, some plasticizers may be released into solution, reducing the surface tension of the surrounding water.

This phenomenon can have profound effects on the performance of many WRB systems as shown with the integral WRB panel DensElement [10]. Evidence of plasticizer influence is often manifested as water penetration through the entire substrate matrix, especially at surfaces in proximity to primary sources such as column walls and treated joints (Fig. 17). In such cases, wetting occurs irrespective of hydrostatic pressure.

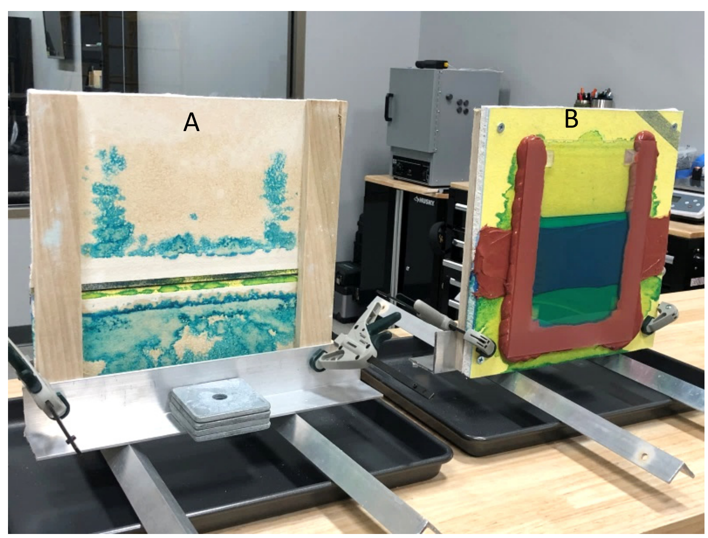


Fig. 17. Mini-columns illustrating flashing-associated wetting at column walls and treated joint. A. Back face of test specimen; B. Front face of test specimen.

Any WRB system may be affected by wetting agents, especially membranes having micro-porous structures. Coatings are also vulnerable where applied discontinuously or where otherwise defective. It is important to recognize that imperceptible defects will allow water to penetrate when the surrounding water has been tainted by these agents. Perhaps more perplexing is the finding that some fluid-applied WRBs will also leach plasticizers. Included in these materials are many of the Silyl Terminated Polyethers (STPE) and even some acrylics.

Materials that are suspected of releasing plasticizers should be avoided unless they represent an intrinsic component of the face column study.

Multi-Layered Polymeric WRBs
Many polymeric WRBs are comprised of multiple layers in which the outer layer often serves as a protective scrim. Adhesion to these polypropylene or polyethylene layers can be a challenge. The greater problem rests with the three-dimensionality of the scrim's mesh. Although microscopic, this matrix allows water to migrate through the fibrous matrix with relative ease. Tapes and sealants adhere only to the scrim's outer surface. Under typical face column conditions, water will simply migrate beneath the sealant thereby causing the column to leak at perimeter walls. This problem is resolved with a low-viscosity coating that penetrates into the mesh and creates continuity between the WRB layers (Fig. 18).

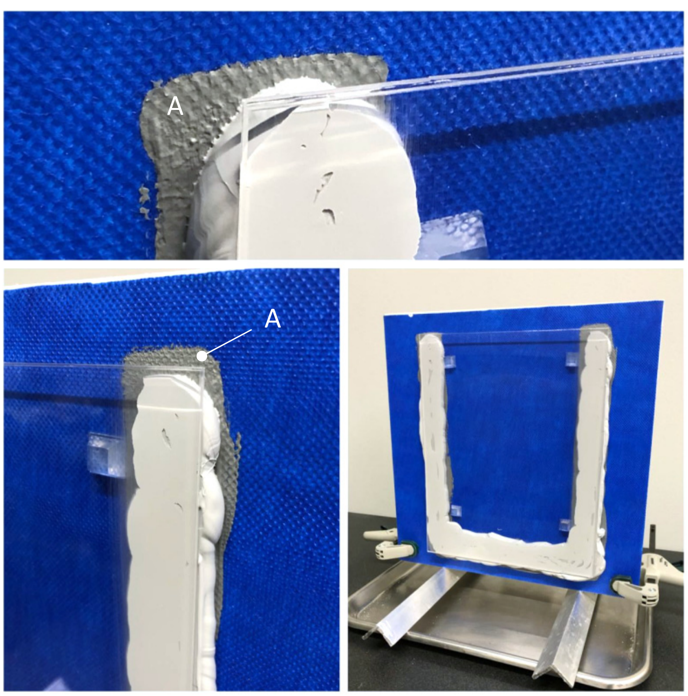


Fig. 18. Low-viscosity coating at interface between polymeric WRB and structural sealant (A).

This coating is pre-applied in several coats and allowed to cure prior to column assembly. The benefits are two-fold: leaks are prevented while providing an optimal surface for adhesion to structural sealants.

Fluid-Applied WRBs
Coating characteristics play an important role in water resistance. Thin-mil acrylics show particular vulnerability when applied too thin or inconsistently. Conversely, coatings having a single thick coat may show poor adhesion with resulting consequences to water resistance. Applications of two or three thinner coats, each with the prescribed dry/cure time, offer more consistent outcomes.

Studies involving fluid-applied WRBs with micro-aggregates should consider the possibility of aggregate release due to abrasion or localized sloughing. This may cause the substrate to be partially exposed. Although not discernable at the macroscopic level, these imperfections may still facilitate water penetration, especially in the presence of wetting agents. Coatings containing grit, clumps, or other inconsistencies may behave similarly.

Dyes
Columns may be filled with any preferred water source including dilute dye solutions. Dyes significantly improve the ability to trace water transport; however, many dyes will bond to the WRB or substrate. Therefore, they should not be relied upon as the sole indicator of water transport. A secondary means for detection, such as moisture testing, is advised. In many instances, the presence of water precedes the dye. Such wetted materials may appear darkened or otherwise discolored prior to the dye's appearance.

I have utilized several effective materials, including food and craft coloring, crystal violet, fluorescent dyes, and commercially available tracers. Fluorescent dyes offer high-resolution tracing within many substrate types, particularly gypsum-based sheathing panels.

Column Replenishment
Processes such as water absorption, face deflection, and evaporation necessitate replenishment of water columns to maintain consistent heights and pressures. Replenishing rates depend on test conditions, duration, and attributes of the WRB, column wall materials, and substrates.

Barring notable transport through the WRB system, or absorption by column wall materials, appreciable replenishing is not necessary. Although evaporative loss is relatively insignificant for short-term studies (<24 hours), it becomes more relevant when considering longer test durations.

Test Duration
The face column method is not defined by any single test duration but rather by the goal of understanding how WRB systems behave over time and over a range of hydrostatic conditions. Conventional testing practices reflect 5-hour performance at 21.6 inches of hydrostatic pressure [2, 8, 9]. Face column studies employing the same 5-hour period often yield outcomes that contradict manufacturers' claims. These discrepancies are especially pronounced when performance is resolved by moisture accumulation within the substrate, not through it. Even greater insights are gained from longer run-times such as those spanning 24 hours, 5 days, 7 days, and even 30 days.

Test durations spanning several days or even weeks under continual hydrostatic pressure may seem extreme. But when placed in proper context with expected service life, the benefit of such testing becomes clear. Water resistance, system durability, and component compatibility are resolved over time under conditions that exceed their expected services conditions. A margin of safety also emerges from longer test durations, especially when combined with increased rigor and resolution. For example, studies involving the WRB panel, Securock ExoAir 430, have shown remarkable water resistance under conditions that far exceed conventional test criteria. When exposed to continual hydrostatic pressure at 21.6 inches, a jointed panel resisted water for over five months before voluntarily terminating the study. The panel alone has surpassed one-year exposure under the same conditions (Fig. 19). These outcomes challenge assumptions that shorter durations such as 7 or 30 days are excessive.

Over the course of method development, I have learned that test periods less than 24 hours are generally insufficient for evaluating key processes such as water absorption, surface adhesion, and hydrolytic reactions.

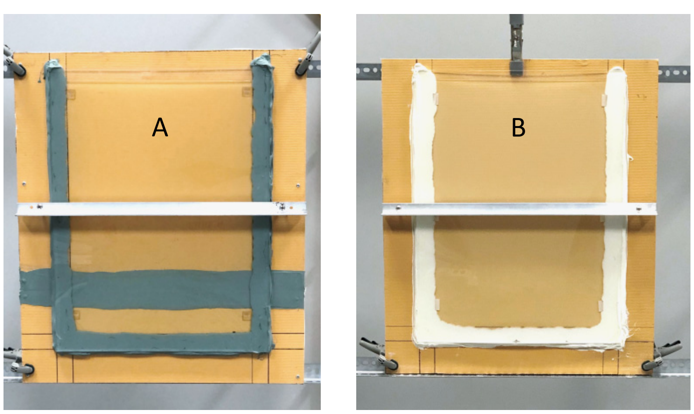


Fig. 19. Long-term face column studies of the Securock ExoAir 430 system: A. Panel with treated joint (5 months); B. Panel without joint (>1 year).

My practices therefore embrace a tiered approach involving 24 hours, 7 days, and 30 days, each at 7.2 inches, 10.8 inches, and 21.6 inches. The same target durations are employed when assessing water resistance, adhesion, and sealability of taped and flashed interfaces. The 7-day test is aligned with conventional test methods that assess adhesion following 7-day immersion (e.g. AAMA 711, AAMA 714).

Failure Detection
The WRB system has failed when water has breached the primary WRB plane. Failure mechanisms may involve just the WRB, any of the system components, or all of them. The intent of the code serves as the primary failure criterion: water accumulation within the substrate – a benchmark that is blatantly disregarded by prevailing test standards. By simply complying with the intent of the code, we have increased resolution and significantly improved predictive value.

In no instance, should water passage through the whole substrate serve as the primary failure criterion. When assessing interfaces such as joints and fastener penetrations, failures may be detected visually by the presence of water on the back face of the test apparatus. However, failures at these penetrations reflect water migration at discontinuities as opposed to water penetration through the substrate matrix itself.

Failures may also manifest as leaks beyond column walls. As previously described for multi-layered polymeric WRBs, it is important to recognize the difference between leaks through the outer scrim versus water penetration through the membrane. Similarly, failures of WRBs applied to gypsum-based sheathing are often expressed at the base of the column where water is released between the glass mat facer and gypsum core.

The most definitive approach for failure detection involves destructive assessment of the test apparatus. Several face columns terminated in time series can elucidate approximate time of failure. As noted previously, water migration is better resolved by incorporating dyes or fluorescent tracing (Fig. 20). Destructive evaluation entails removal of the column's face followed by lateral or longitudinal sections of the test specimen. When testing adhered or mechanically attached WRBs, the WRB should be removed prior to sectioning as water present at this interface offers the clearest depiction of failure.

In-situ monitoring of water content within the substrate also offers important insight into potential failures. Water accumulation may be monitored by non-invasive moisture meters, fixed probes, and infrared thermography.

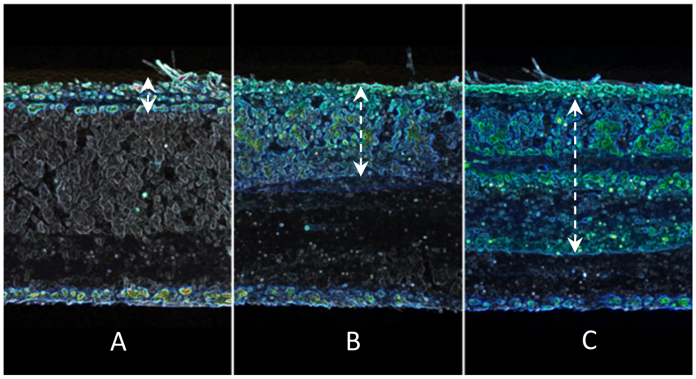


Fig. 20. Time series of water migration through DensElement at 1 hour (A), 8 hours (B), and 16 hours (C).

With proper application, fixed moisture probes offer improved results, especially when probes are placed at different column heights and at various substrate depths. Pin-style meters may be used in 'spot-checking'; however, re-using pinholes from prior probes is discouraged as pin contact with the substrate is reduced. Excessively deep or repeated penetrations may also alter test results by offering unintended pathways for water migration.

Industry Acceptance of Hydrostatic Pressure

Ponding and hydrostatic pressure testing have long served as the basis for WRB evaluation. Although often referenced as distinctly different approaches, the two assess essentially the same phenomenon, pore flow of liquid water through porous and micro-porous matrixes. Ponding assesses bulk water resistance under minimal hydrostatic pressure, generally at one inch of standing water. Emphasis is placed on the importance of osmotic and capillary flow.

Hydrostatic pressure is favored as a more rigorous means for evaluating modern WRBs. Methods range in complexity from simple water columns and RILEM tubes to hydrostatic testers and pressure chambers. Overall, these methods enjoy wide application and high confidence.

The intent of hydrostatic testing is to determine pressures necessary to overcome the surface tension of water through micro-pores and membrane interfaces. Applicable test methods originate from the textile industry as AATCC Test Method 127. When applied to building materials, further specifications for test duration (5 hours) and pressure (21.6 inches) are offered by AC38, AC71, and ASTM E2256. Likewise, the precedence exists for applying hydrostatic testing to component interfaces such as fasteners (e.g. ASTM D1970) and treated joints of foam sheathing panels (e.g. AC71). Treated joints employ the standard 21.6 inches for five hours [2] whereas fasteners are typically evaluated at five inches of water column for 72 hours [3].

Hydrostatic pressure is also employed as a diagnostic tool, most commonly as RILEM tubes used in assessing water absorption by concrete, brick, and stone masonry. Although face columns are often compared to RILEM tubes, the two methods differ remarkably. By design, RILEM tubes asses just a single hydrostatic pressure at any point in time. Face columns assess a range of pressures simultaneously. The two methods also differ in coverage size. Where the typical RILEM tube covers only 0.78 in^2, the interfacing areas of mini-columns and 21.6-inch columns are typically 43 in^2 and 2.4 ft^2, respectively. Face columns may be further customized to accommodate any dimension and any hydrostatic pressure range. In contrast, RILEM tubes are usually configured with a maximum hydrostatic pressure of only six inches.

Critics of hydrostatic testing argue that test pressures such as 21.6 inches, equated to a wind load of approximately 210 mph, are grossly unrealistic and do not reflect in-service conditions for WRBs. Test pressures are further obfuscated with those intended for waterproofing materials having minimum performance ratings of 10 psi (23 ft). Never mind that waterproofing membranes are often tested to a pressure of 100 psi, equating to a water column of 230 feet! But a worthy comparison is still served as systems intended for below-grade waterproofing have long embraced a margin of safety whereas those intended for above-grade water resistance have not. This discrepancy is made more profound when considering that WRBs are generally tested as isolated membranes without their intended substrates and system components.

Summary

The face column is described as a novel and highly effective method for evaluating WRBs and WRB systems. The groundwork has been laid for further development as a test method having immense potential across all facets of the industry, including product testing, research & development, quality control, Failure Mode and Effects Analysis (FMEA), and even field diagnostics.

The idea was born out of inadequacies of existing methods and criteria that do not reveal inherent strengths and weaknesses of WRB systems. Indeed, a legacy of failures has demonstrated the fallacies of current approaches. Fault is too often placed on imperfect installation of systems that require nothing less than perfection. And rarely is a system's innate short comings brought squarely into focus

The Arbiter of Quality
Testing must offer the ability to discern quality for those seeking quality. And it should do so without obfuscation, agenda, or bias. Present test standards are bent on inclusion of products, not the distinction of those that truly excel. On paper, the most inane of systems are seen as equals to the best. Confusion of methods and misrepresentation of results are rampant – in other words, our test methods and their criteria have lost meaning. And all of this has emerged during a time when our wall assemblies have become arguably more complex and infinitely more specialized.

High Predictive Value
Predictive value must account for conditions that are not completely known, installation practices that have reasonable variances, and service lifespans that may see many decades. High predictive value cannot emerge from simply emulating expected service conditions or even extremes that might befall fully exposed assemblies. Instead, testing methodologies must reflect greater rigor, longer duration, and increased resolution. This path leads to intrinsic margins of safety and truer indicators of WRB performance.

The WRB System
The WRB must be evaluated in its intended whole form. The idea of a 'WRB System' emerges from appreciation of continuity and uniformity in performance. In other words, why must the membrane or coating perform at one level, but its cobbled transitions and interfaces at another? In considering the WRB in its totality of parts, system integration converges with margin of safety to define our predictive value (Fig. 21).

The face column offers a comprehensive first step towards reforming outdated test methods. By default, it weds the WRB to its substrate, which reflects prevailing assembly types throughout most of the world. And it offers a straightforward path towards systems-level evaluation from a relatively simple benchtop apparatus. All matters of compatibility, adhesion, and water-resistance may be evaluated in a single, highly adaptable method.

Current voids in our predictive value matrix (Fig. 1) are seemingly filled by the face column concept. While it is not intended to replace existing methods, the face column fundamentally improves on what they bring to bear. Further development will offer new applications and creative adaptations that will hone acceptance as a relevant and reliable method.

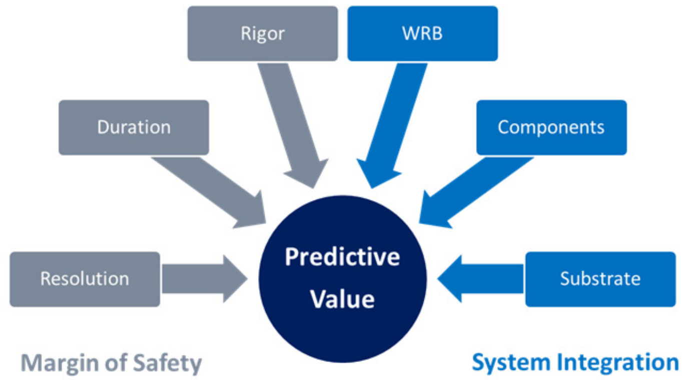


Fig. 21. Factors affecting the predictive value of WRB performance testing.

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