NOT ALL GLASS-MAT SHEATHINGS ARE CREATED EQUAL

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**ABSTRACT**

Glass-mat gypsum sheathing has been the exterior sheathing of choice in commercial construction for more than two decades. Over the last few years, many sheathing manufacturers have introduced new glass-mat sheathings into the market. Differences have been noted in the performance of sheet- and liquid-applied air/vapor barriers installed over these glass-mat sheathings. This presentation examines specific characteristics of glass-mat sheathings from six manufacturers. Field and laboratory investigations of the sheathings are discussed, as are differences between these sheathings and how they impact the construction community.

**SPEAKERS**

**DAVID L. BOWEN, LEED GA — CARLISLE COATINGS AND WATERPROOFING, INCORPORATED**

DAVID BOWEN serves as technical services manager at Carlisle Coatings & Waterproofing, where he provides strategic direction and project and product management. He has more than 20 years of experience in the construction manufacturing industry, with a focus on the air/vapor barrier, waterproofing, and exterior insulation and finish systems (EIFS) markets. Bowen holds a BS in business administration from the University of Utah and an MA in organizational leadership from Gonzaga University. He is an RCI member and LEED® Green Associate.

**STEVE VELTEN — CARLISLE COATINGS AND WATERPROOFING, INCORPORATED**

STEVE VELTEN serves as a senior chemist at Carlisle Coatings & Waterproofing. With more than 30 years’ experience in the adhesive products industry, Velten has developed blindside waterproofing adhesives and heat-curable epoxy systems and has set up reactor systems for single-component liquid and solid urethane adhesives. Velten has extensive technical knowledge of the adhesives and waterproofing industries, operations, material requirements planning (MRP) implementation, and product health. Velten holds a BS in chemical engineering from the University of Dayton.
INTRODUCTION

As a manufacturer of air and vapor membranes, adhesion promoters/primers, and a variety of other commercial waterproofing and insulation products, Carlisle Coatings & Waterproofing (CCW) regularly receives inquiries regarding its products and application procedures. Recently, installers who were following the company's recommended procedures experienced unexpected or inconsistent field application issues. Our normal recommendations were not adequately addressing these concerns. Specifically, they noticed inconsistencies with coverage rates, adhesion, and durability.

Through myriad investigational techniques, we uncovered a common denominator among all of these concerns: Product performance varied by brand of glass-mat sheathing substrate. Through research, we discovered that non-apparent differences in brands of exterior glass-mat sheathings directly influence performance of the materials being applied to them. Our conclusion: Not all glass-mat sheathings are created equal.

History

The introduction of exterior insulation and finish system (EIFS) design principles led to a number of sheathing changes beginning in the mid-1980s. Increasingly, design professionals were asking manufacturers for sheathings that were more durable, weather-resistant, and cost-effective. The result was the introduction of the first glass-mat sheathing with an enhanced gypsum core. Throughout the late 1980s and early to mid-1990s, glass-mat sheathings were improved as manufacturers responded to user feedback. Gradually, glass-mat sheathing performance standards such as improved UV resistance, handling, and extended exposure time were implemented. Heightened focus in the mid-1990s on moisture and mold management led to development of glass-mat sheathings that were moisture- and mold-resistant. By early 2000, glass-mat sheathing became the exterior commercial sheathing of choice.

ASTM C1177

ASTM C1177 is the Standard Specification for Glass-Mat Gypsum Substrate for Use as Sheathing. This standard determines the composition, physical, and dimensional requirements of the board. Under this standard, the “glass-mat gypsum board shall consist of a noncombustible water-resistant core—essentially gypsum-surfaced with glass-mat partially or completely embedded in the core.” All glass-mat gypsum boards provide a measure of fire-resistance dependent upon the thickness. The flexural strength, water resistance, humidified deflection (deflection of gypsum board when horizontally suspended and subjected to high humidity), core, end and edge hardness, and nail-pull resistance are all specified in the standard. Further, the dimensional requirements and variability are also noted. The requirements for thickness, width, length, and end-squareness are all delineated.

While all commercial glass-mat sheathings satisfy the ASTM C1177 standard, we are presenting additional considerations beyond the scope of the specification. We believe that these differences are important not only to installing contractors but also to design professionals, since they influence performance and cost. We contend that knowing these differences will help avoid unforeseen project complications.

Air and Vapor Barrier Manufacturers

Glass-mat gypsum sheathings are an important part of a wall construction, but are not the only component of the wall. Manufacturers provide other components to the wall assembly that help ensure overall performance. Manufacturers must look to the careful integration of their products with those that come in contact or impact the use of their component that creates the modern wall. Performance criteria that air and vapor barrier manufacturers consider critical to the characteristics of their products and interaction with glass-mat sheathing are adhesion, coverage rates, exposure, and drying time.
Adhesion

Manufacturers measure adhesion for short- and long-term durability. Short-term durability addresses initial application. Will the product withstand the normal environment found on a construction site? Long-term durability addresses the sustainability and adhesion of the product throughout service life. Adhesion is measured to ensure a product stays in place and clings to the glass-mat sheathing during and after application.

- **Peel Adhesion** – As referenced in various ASTM standards (D903, D1876, D6862, etc.), peel adhesion covers the stripping force of a product that has been applied to another product. In this case, it measures adhesion of air and vapor barrier material applied over glass-mat sheathing. (See Figure 1.)
- **Shear Adhesion** – As referenced in various ASTM standards (C961, D1144, D2619, etc.), this covers the resistance to force applied in a tangential direction. It is most commonly tested by hanging a weight in a static condition. (See Figure 2.)
- **Pull-Off Adhesion** (flat-wise tensile) – As referenced in ASTM D4541, The Standard Test Method for Pull-Off Strength of Coatings Using Portable Adhesion Testers, this test determines the normal or perpendicular resistance of a membrane when a force is applied. (See Figure 3.)

Coverage Rates

All commercial air and vapor barrier material manufacturers that produce liquid products publish coverage rates. In some cases, coverage rates are a theoretical calculation based upon percent solids and optimum application rate assumptions. Actual application rates are often determined by the physical application of products over glass-mat sheathings. Typically, only one sheathing-manufactured product is tested to determine the coverage rate. This is why air and vapor barrier manufacturers often state that coverage rates may vary depending on substrate porosity, moisture uptake, and other factors.

Drying Time

The drying times of air and vapor barriers and adhesion promoters/primer vary with ambient temperature and humidity. Substrate temperature and dampness also affects drying time. The physical make-up of the glass-mat sheathing has a significant effect on the drying times. For example, rough and porous sheathing can increase the amount of material applied, thus creating longer drying and wet-out times.

Exposure

All construction products must withstand a minimum degree of exposure. Air and vapor barrier manufacturers run a battery of tests attempting to simulate long-term exposure under lab conditions, as well as actual field tests to determine product resistance to environmental factors and conditions. There are many environmental standards referenced in ASTM publications.
accelerated aging, simulated weathering,
and temperature exposure are examples of
such evaluations.

Additional tests are performed depend­ing on the air and vapor barrier material
characteristics and other special conditions
such as construction specifications and
local code requirements. For example, non­
routine test—such as NFPA 285 and Miami­
Dade County's high-velocity wind test—rely
on effective interactions between the glass­
mat sheathing and air and vapor barriers to
evaluate performance.

UNDERSTANDING GLASS-MAT
SHEATHING

Discovering Differences

For many years, there was a single
predominate manufacturer of glass-mat
sheathing. Industry-wide product perfor­
manence criteria were based on this product.
Once that patent expired, other manufac­
turers introduced new glass-mat sheath­
ings into the market. CCW and its installers
began noticing differences in performance
of CCW sheet- and liquid-applied products
over these new substrates. Reports from the
field indicated unexpected performance in
comparison to past findings. This included
variations in coverage rates, atypical drying
times, and differences in physical perfor­
manence and adhesion. These observations
led CCW professionals to conduct both field
and laboratory investigations to determine
which factors caused these unexpected
challenges. We attempted to investigate
many avenues to discover the cause of this
unforeseen variation. This led us to sys­
tematically examine the differences in the
performance of our products on the vari­
ous commercially available glass-mat-faced
sheathing products.

Our investigation was aided by the fact
that we had available CCW materials from
identical production lots. These materials
performed as designed on one project but
did not satisfy expectations on another
project. A root-cause analysis revealed the
primary difference was the sheathing to
which the products were being applied.
That discovery led to systematic side-by­
side testing using our products applied to
multiple glass-mat sheathing. We evalu­
ated adhesion, coverage rates, drying time,
and exposure effects. The results revealed
apparent differences in performance among
the glass-mat substrates tested. However,
the results didn’t reveal why the differences

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occurred. All of the glass-mat sheathings met ASTM C1177. We needed to investigate beyond our normal protocols.

Our next step was to conduct an in-depth examination of adhesion promoters/primers over the glass-mat sheathings, which revealed a different response to the applications. Specifically, we discovered primer absorption rates were different among the various glass-mat sheathings. These primer variances appeared to affect both the coating rate and the primer performance. For example, one glass-mat sheathing performed as intended using a solvent-based primer, but not as expected using a water-based primer. In addition, we observed that more primer was needed on some glass-mat sheathings to achieve desired adhesion. In some cases, the use of a primer proved detrimental to the expected performance. Coverage rate and drying variations with liquid-applied air and vapor barriers were also observed.

Differences in the glass-mat sheathing did affect the performance of primers and liquid-applied air and vapor barrier products. We believe this was due to differing physical interactions with the various carrier vehicles. As stated above, different levels of water repellency in the glass-mat facer did affect water-based products, prolonging drying time and interfering with anchorage. Additionally, some glass-mat facers demonstrated different absorbency rates, creating less-than-optimum conditions for adhesion and drying. Figures 4, 5, and 6 show the variances observed during our evaluation.

### Understanding Differences

At this stage of the investigation, we knew that we could demonstrate the differences; however, we still did not fully understand why. Samples of various glass-mat sheathings from various suppliers were procured and sent for analytical chemical scrutiny, including scanning electron microscopy (SEM), energy dispersive X-ray (EDX), atomic absorption (AA), and infrared analysis. Another set of samples coated with both water- and solvent-based products was also subjected to analysis. A synopsis of our findings follows.

### Chemical Analysis

Table 1 depicts the basic chemical analysis of sample specimens. The gypsum components are very similar. We believe these results confirm why these products satisfy the ASTM C1177 standard. While helpful, these results did not point to any significant differences in the makeup of the gypsum component of the subject glass-mat sheathings. Further, we believe the variations noted in the table can be attributed to the natural and synthetic gypsum sources.

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<th>O (%)</th>
<th>Mg (%)</th>
<th>Ca (%)</th>
<th>S (%)</th>
<th>Al (%)</th>
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*Non-Detect (ND)

C = Carbon – O = Oxygen – Mg = Magnesium – Ca = Calcium – S = Sulfur – Al = Aluminum – Si = Silicone – Pb = Lead
Examination of the Glass-Mat Facers

SEM images were taken of various glass-mat facers at 50 times magnification. The following are typical of what we observed. Figures 7 through 10 depict four different glass-mat sheathing facers under magnification. Each facer contains fiber-like structures with a chemical matrix. Figures 7 through 9 show a chemical binder connecting these fiber structures and creating a compact, closed matrix. These surfaces have different profiles; however, the fibers appear to be fully incorporated in the chemical binder. Figure 10 has what we characterized as an open matrix. A layer of unincorporated fibers is shown, indicating a highly porous, textured surface.

After examining the micrographs, obvious surface differences were apparent. We then hypothesized that if these differences could be correlated to our test results and field observations. To answer this question, we conducted a side-by-side evaluation of two glass-mat sheathing specimens on a jobsite mock-up. The applicator, general contractor, third-party inspector, architect, and owner were all present during this evaluation. A water-based AVB membrane was spray-applied onto the two sheathing at a nominal 80-wet-mil thickness. After the product dried, one specimen was measured at 40 to 45 dry-mils thick, while the second specimen was measured at 30 dry-mils thick. All mil thickness measurements were performed using a 1- to 80-mil scale comb gauge. (Though this gauge does not give high-precision measurement, it is acceptable for comparative measurements.) The difference in dry-mil thickness was attributed to higher absorption into the facer of one specimen compared with the other. Both produced sheathings with acceptable air and vapor barriers, but the visible and measurable difference in dry-mil thickness had to be explained.

We also saw a correlation between our laboratory evaluations and the open or closed nature of the glass-mat facer. More open-cell matrixes revealed greater test result variations. Due to this apparent correlation, we submitted additional samples for microscopic examination.

Figures 11A, 11B, and 11C are a set of views of different glass-mat sheathings at 100 times magnification. The “A” view is the flat view of the glass-mat surface. The “B” view in each series is the cross-sectional view of the glass-mat. The “C” view is
a cross-sectional view of the glass-mat facer after application of equal coating amounts of primer/adhesion promoter. The “A” view depicts a variation in the facer matrix and how the matrix can vary from fully closed to virtually open. The “A” views in each figure, however, show fibers with a chemical matrix to bind them together. By examining this fiber and chemical matrix, it is clear that each glass-mat facer exhibits its own degree of openness. This openness is directly related to the porosity of the facer. View “B” depicts how the fiber and chemical binder interact. Figures 11B and 12B show the interaction and chemical binder creating a more compact and closed matrix. The fiber and chemical binder in Figure 13B depicts a loose and open matrix. The depth of penetration of the primer/adhesion promoter is depicted in Figures 11C, 12C, and 13C. The bars have been added as a visual aid to show the relative depth of penetration. In Figure 13C, the primer/adhesion promoter fully saturated the glass-mat facer. The fiber and chemical binder interaction has obvious visible effects on the materials on which the sheathing is applied.

Repeated physical tests were performed, and the results substantiated the fact that the visible differences correlated with the observed performance differences. While all of these glass-mat-faced gypsum sheathings satisfy specification criteria, unique differences were observed in their interactions with air and vapor barrier materials and primers/adhesion promoters. While acceptable overall performance could be achieved with materials applied to all of the glass-mat faced sheathings we tested, this was achieved only by understanding and addressing the specific characteristics that each glass-mat-faced sheathing exhibits.

WHAT DOES THIS MEAN TO YOU?

Applicators/Estimators
It’s important to understand that the type of glass-mat sheathing can affect factors very important to the installer. Differences in sheathing can have a direct effect on coverage rates, which influence labor and material costs. Estimators and applicators must understand the porosity and absorption of the sheathing substrates over which materials will be applied to ensure accurate estimates and successful installations. For example, while magnified views of the facers have similarities, some performance differences were noted during adhesion testing. Installers who understand how each brand of sheathing reacts to products being applied to them will avoid negative impacts related to coverage rates, drying time, and performance.

Design Professionals/General Contractors
In the age of cost-conscious construction, it is important that design and construction professionals understand the impact sheathing choice has on overall job cost. Choosing a less expensive sheathing up front can create more expensive back-end application costs. Applicators and installers provide estimates with specific expectations that products they use will work as intended. If an exterior sheathing is changed and the properties have not been considered previously by the installer, added costs and construction difficulties are likely results.

Selecting installers with experience in using the different glass-mat-faced sheathings will assist in proper application and will ensure that long-term performance is achieved.

Third-Party Investigators/Inspectors
Knowing that differences exist in glass-mat sheathings should aid in finding causes and addressing issues that may arise during application. Inspectors and investigators who understand glass-mat sheathings and the interactions that they may have with other construction materials are bet-
ter able to provide guidance and help make decisions to avoid potential deficiencies that would require expensive remediation.

Manufacturers
We believe that glass-mat sheathing manufacturers must appreciate the importance their product has in construction wall assemblies. They must recognize that modifications to their product or process can have far-reaching effects on the assembly process and long-term wall performance.

Manufacturers of products that will be applied to or used with glass-mat sheathings have a responsibility to understand how their products will interact with all glass-mat sheathings. Further, they need to be able to recommend application techniques or product variations that will work successfully with the specified glass-mat sheathings.

CONCLUSION
We observed physical differences in glass-mat sheathings that have measurable effects on performance. These differences constitute a significant impact on wall assembly construction, which if not understood and adapted to, will result in undesired field issues.

The difference in glass-mat facers can significantly impact the measurable dry thickness of fluid-applied air and vapor barrier products. Further, the variable porosity of glass-mat facers may require extra primer/adhesion promoter or multiple coats to help adequate adhesion of self-adhered membranes and flashings. The increased amount of primer/adhesion promoter and the substrate porosity can affect drying times. The high absorption rate of the primer/adhesion promoter into the facer of sheathing creates higher risk of membrane delamination if extended drying time is not followed.

As a construction material manufacturer, we have a goal to provide products that are consistent and reliable. To achieve this goal, we must examine how our products are used in combination with materials manufactured by other suppliers. This fact became very apparent through our investigation of glass-mat sheathings. While many products look and appear to act the same, it is evident that that not all glass-mat sheathings are created equal.