Minnesota’s Adoption of the
2012
International Energy Conservation Code
Plaster Assemblies:
Exterior Insulation on Framed Walls

Written by
Steven Pedracine CSI, CDT
Executive Director, Minnesota Lath and Plaster Bureau
And
David Bryan AIA, LEED
Third-Level Design

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10600 University Avenue NW
Coon Rapids, MN 55448
phone (763) 757–MLPB ((6572)
web: www.mnlath-plaster.com
e-mail: info@mnlath-plaster.com

The Minnesota Lath and Plaster Bureau has promoted the industry since 1953. It is recognized as an education and technical spokesman for the plastering industry. It provides services to architects, the construction community and the public on a variety of matters relating to the plastering trades.

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The text, drawings and related notes contained herein are based upon the requirements of the 2012 International Building Code and the 2012 International Energy Conservation Code. This text also refers to rule changes in the Minnesota State Building Code which reference the International Building Codes. Please see those documents for their full text and scope of information.

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Foreword

One of the hardest challenges of the construction community is staying informed on constantly changing materials, systems, techniques and code requirements. One recent change is the code mandated use of exterior continuous insulation to improve the energy efficiency and environmental impact of our building stock. The intent of this paper then is to inform the construction community about strategies that utilize plaster coatings over continuous insulation. We do this with some reservation because we believe the least imposing strategy already exists.

In 2005 the US Department of Energy (DOE), through the Office of Energy Efficiency and Renewable Energy’s Building Technologies Program began a “Wall Cladding Performance Study.” In this landmark 3 year field research project conducted by the Oak Ridge National Laboratory (ORNL) they concluded that Exterior Insulation Finish Systems (EIFS) with Drainage outperformed all other wall materials in terms of moisture management, while maintaining superior thermal performance. The Executive Summary of this study can be viewed and downloaded at www.eima.com.

This study it would seem is one of many reasons that point to EIFS with Drainage as the perfect “continuous insulation” plaster system to meet the requirements of Minnesota’s New Energy Code. Other systems, while well intentioned, are often concocted “Frankenstein” facsimiles where the plastering contractor’s experience and insight have been ignored. The unfortunate result is sometimes a contentious one, with finger pointing generally in the direction of the plastering contractor, even though he had no input or control over design decisions.

Arguments that dismiss or disparage EIFS with Drainage today as a defective product for problems that happened twenty years ago are unwarranted and misinformed. Notwithstanding these arguments, it is the opinion of the Minnesota Lath and Plaster Bureau that EIFS with Drainage is the best choice of continuous insulation systems. - The Minnesota Lath and Plaster Bureau, August 2015

“Lex parsimoniae: The simplest answer is often the correct one”

Loose translation; attributed to William Ockham, Scholastic Philosopher (c. 1287–1347)
PREFACE

During the last 20 years, it has become increasingly apparent that energy policy will be a central issue for this century. We have a rapidly growing world population accompanied by rapidly growing per capita energy use. About 80% of this energy is based on fossil fuels and has high environmental impacts in terms of air quality, water usage, global climate change and ocean acidification from CO2 pollution. Access to these resources is a major source of international tension. In the United States, buildings account for almost half of national energy use and greenhouse gas emissions, so it should come as no surprise that reduction in building energy use, like more stringent CAFE standards for automobiles, has become an important part of our national energy policy.

ASHRAE standard 90.1 is the basis for United States building energy codes. Every 3 years, a new version is issued. This is followed 2 years later by a corresponding version of the International Energy Construction Code (IECC). ASHRAE 90.1 applies to commercial buildings; the IECC applies to both commercial and residential buildings. These energy codes must pass the Department of Energy’s test for cost-effectiveness. Under public law 94-163, the Department of Energy (DOE) is mandated by the Energy Policy and Conservation Act to review new versions of proposed energy documents to determine if the code or standard reduces energy consumption from previous iterations. If the DOE determines that new generations of these documents are more energy efficient than previous versions, then Minnesota (and other states) have two years to certify that their energy codes meet the more stringent requirements.

There are other standards that take a more aggressive approach to reducing the environmental impact of our buildings. The LEED rating system (Leadership in Energy and Environmental Design), which is a voluntary standard that has been adopted by many building owners, municipalities and government agencies, is one of these. Like LEED, the International Green Construction Code and ASHRAE Standard 189.1 for the Design of High-Performance Green Buildings are voluntary standards that address a wide range of building environmental impacts including energy use. A popular approach to setting energy reduction targets is the Architecture 2030 Challenge which has been adopted by the American Institute of Architects. In 2003 an architect named Ed Mazria proposed that fossil fuel energy use in buildings should be compared to our existing building stock and reduced gradually by a combination of energy conservation measures and on-site renewable energy generation. 2030 buildings then would require no fossil fuels and thereby create no operational carbon emissions. In 2007 the “Energy Independence and Security Act for Federal Buildings” was signed into law. This mandate set in motion a similar trajectory of implementation of energy policies in the construction of federal buildings as Architecture 2030.

With all of this said, it seems clear that the way we design and build is transitioning at an ever increasing pace. Meeting the next generation of energy codes cost-effectively will require an integrated approach to building construction. Framed walls will require more insulation. In many cases exterior “continuous insulation” uninterrupted by framing will be added to minimize the effects of thermal short circuiting (thermal bridging) due to the conductivity of framing members. Air leakage will be minimized by requiring the use of air barrier systems and blower door testing. All components of walls, roofs, windows and foundations will have to be carefully designed and installed to work in unison to reduce energy consumption.

The sole intent and purpose of this document is an informational guide to assist building owners, designers, contractors and code authorities with the selection of plaster systems assemblies relating to the new energy code requirements for framed walls.

So where does Minnesota stand?

As of this writing the State of Minnesota is regulated by 2012 Minnesota Commercial Energy Code which garners most of its content components of the 2012 International Energy Conservation Code (IECC) and ASHRAE 90.1 (2010). This is even as newer energy code models are being reviewed by the DOE for more changes in subsequent code development cycles. According to the Department of Labor and Industry, the State of Minnesota adopted the 2012 International Energy Conservation Code and ASHRAE 90.1 (2010) in June 2015. These new energy codes are anticipated to create changes that will reduce energy consumption in commercial and residential buildings by roughly 25% to 30% relative to Minnesota’s 2009 Commercial Energy Code.
WALL R-VALUES, THERMAL BRIDGING AND CONTINUOUS INSULATION (CI)

IECC 2012/ASHRAE 90.1 (2010) defines what are referred to as “prescriptive” methods for meeting minimum thermal requirements that provide nominal insulation guidelines for the designer and contractor in the construction of framed walls. Alternatively the design can meet an equivalent maximum U-factor with thermal bridging from framing members accounted for. The designer is not however tied to these requirements. As an option the design can be “performance-based.” An approved energy modeling program can be employed to determine if a set of proposed envelope components and mechanical systems meet the minimum overall performance requirements for the building.

Table 1 illustrates changes in the equivalent U-factors and prescriptive values from the 2009 code to the 2012 IECC for Climate Zone 6, which includes the southern two thirds of Minnesota:

Table 1

Note: By Minnesota Rule the parameters for residential construction have been modified to what is indicated in red.

As wall R-values increase, insulation exterior to the framing becomes more important to reduce thermal bridging through framing members. This effect becomes pronounced when stud cavity insulation is interrupted by steel studs or exterior insulation is interrupted by steel framing members like Z-channels. For example, in a 2”x6” steel stud wall with studs 16” on center, the nominal R-value of 6” fiberglass batt insulation is reduced from R19 to an effective R7 (from ASHRAE 90.1 Table A9.2 B). The addition of exterior continuous insulation is used to both reduce and compensate for this effect. “Continuous insulation” is defined by ASHRAE 90.1 as exterior insulation “without thermal bridges other than fasteners and service openings” (Illustration 1 next page). If the insulation is interrupted by framing, appropriate correction factors must be applied in determining code compliance of the assembly.

The prescriptive requirements for walls in the IECC 2012/ASHRAE 90.1 2010 energy code can be satisfied with an assembly conforming to the example assemblies in the right hand column of the table above or by achieving the minimum R values (or maximum U-values) in the table using approved calculation methods. For an exterior cladding of EIFS, for instance, Figure A (next page) shows three possible alternative scenarios with varying combinations of exterior insulation and stud cavity insulation that meet the prescribed minimum R-value of 15.6 for commercial metal-framed walls.
**EIFS ALTERNATIVE 1**

Base Wall Materials  
R = 2.5
R21 Fiberglass (2x6 steel studs)  
R = 7.4
2” x R3.6 (Type I EPS)  
R = 7.2
Total = 17.1

**EIFS ALTERNATIVE 2**

Base Wall Materials  
R = 2.5
R13 Fiberglass (2x6 steel studs)  
R = 4.8
2.5” x R3.6 (Type I EPS)  
R = 9.0
Total = 16.3

**EIFS ALTERNATIVE 3**

Base Wall Materials  
R = 2.5
No cavity Insulation (2x6 studs)  
R = 0.8
3.5” x R3.6 (Type I EPS)  
R = 12.6
Total = 15.9

**STUCCO ALTERNATIVE 1**

Base Wall Materials  
R = 2.5
R21 Fiberglass (2x6 steel studs)  
R = 7.4
1.5 x R5.5 (polyiso.)  
R = 8.25
Total = 18.15

**STUCCO ALTERNATIVE 2**

Base Wall Materials  
R = 2.5
R13 Fiberglass (2x6 steel studs)  
R = 4.8
2” x R5.5 (polyiso.)  
R = 11.0
Total = 18.3

**STUCCO ALTERNATIVE 3**

Base Wall Materials  
R = 2.5
No cavity Insulation (2x6 studs)  
R = 0.8
6”x R5.5 (polyiso.)  x .41  
R = 13.5
Total = 16.8

The effective Polyiso. R-value includes a thermal bridging correction for thermally-broken Z-channels per ASHRAE 1365-RP
Historically, the Lath and Plaster Bureau has also seen contract specifications for wall assemblies that incorporate Continuous Insulation (CI) with stucco as the featured cladding (Illustration 2). Similarly alternative scenarios can be employed to meet the thermal R-value requirements with stucco. (Figure B).

In addition, each of these assemblies would include in their proper location a vapor retarder, an air barrier, a water-resistive barrier and a means for drainage of rainwater that bypasses the cladding. All things being equal and taken at face value it might be assumed that if each of these assemblies fulfilled the requirements of the energy and building codes, one would have a successful wall system; however, the code does not currently give enough guidance to control damage from mold, rot and corrosion. What is missing is a scientific assessment of the physical properties of wall materials, insulation ratios, interior and exterior climates and other variables. How they interact may impact the life cycle of the wall assembly.

For instance, hygrothermal analysis for EIFS ALTERNATIVE 1 show that for IECC Climate Zone 6, which includes the Twin Cities and the southern half of Minnesota, the fiberglass mat gypsum sheathing could absorb enough moisture to compromise its structural integrity, experience accelerated corrosion of fasteners and have significant risk of mold growth. This risk could be reduced by adding more exterior insulation, reducing the cavity insulation or both. The effect of increasing the exterior insulation relative to the cavity insulation is to make the sheathing warmer in winter. This is important because the sheathing generally is where moisture damage or mold is likely to occur, particularly when the sheathing temperature approaches the dewpoint of the interior air. Thus EIFS ALTERNATIVE 3 and STUCCO ALTERNATIVE 3 (Figures A & B) would have the least risk from moisture damage because they have no cavity insulation and the temperature of the sheathing is close to the interior room temperature.

Hybrid insulation systems like EIFS ALTERNATIVE 2 and STUCCO ALTERNATIVE 2, with a mix of exterior and cavity insulation, are often chosen because they are less expensive per actual R-value achieved; even after correction for heat loss through wood or metal studs, compared to systems that use only exterior insulation. In addition, hybrid systems currently have lower environmental and health impacts, caused by foam insulation blowing agents [1] and flame retardants [2], when the quantity of exterior insulation is reduced by the addition of fiberglass or cellulose in the stud cavity. Hygrothermal modeling shows that the EIFS ALTERNATIVE 2 and STUCCO ALTERNATIVE 2 have a high enough R-value ratio of exterior insulation to cavity insulation to be safe for Climate Zone 6. If the assembly were in a colder climate, like the northern half of Minnesota (IECC Climate Zone 7), a higher R-value ratio would be warranted. Note that these results are based on several important assumptions: interior winter relative humidity is below 40%; the assembly has a warm side vapor retarder; and air barrier compliant with IECC 2012 guidelines is present with flashing and caulking systems capable of keeping 99% of wind driven rain away from the sheathing. Furthermore, these examples assume the exterior insulation as well as the air and water-resistive barrier are somewhat permeable, so that moisture entering the assembly can dry to the outside. If the exterior insulation is foil-faced or if the air barrier is vapor impermeable (an asphaltic peel and stick membrane, for instance) the drying potential would be reduced as the ratio of exterior insulation to cavity insulation would need to be increased to mitigate the risk potential for moisture damage.

The Importance of Hygrothermal Analysis

Because of the complexity and interaction of these variables when cavity insulation and exterior insulation are both present, hygrothermal modeling is recommended by the Minnesota Lath and Plaster Bureau. Also as more insulation is added to the building enclosure, there is less heat energy available for drying and moisture control. Similarly, hygrothermal analysis is recommended when 6-inches of vapor permeable stud cavity insulation is used regardless as to whether exterior insulation is present or not.

Stucco Installation over Foam Plastic Insulation

Based upon experience and current industry practice, the recommended foam plastic insulation board thickness behind the lath should be limited to a maximum 2”. Factors considered for this recommendation include the length of the fastener necessary to attach the lath through to the structural framing as well as the weight of the subsequent stucco. This approach simplifies the assembly installation and limits the imposed stresses on the stucco membrane (Illustration 2).
Insulation Board Thickness Greater than 2"

For insulation board thickness greater than 2”, the lath should not be attached to the studs by screwing directly through the insulation board. Thicker foam plastic insulation is typically interrupted by framing members that are attached to the studs through the sheathing (Illustration 3). For this reason, insulation that is placed between the framing members is no longer “continuous” and correction factors must be applied to determine its effective insulation value. STUCCO ALTERNATIVE 3 (Figure B) represents this situation. The thickness of the exterior insulation exceeds the ability of the system to deal with imposed stresses, so that interruption of the continuous insulation with framing members is required. Steel Z-furring is often used for this purpose. The result is thermal bridging of the exterior insulation by the framing, resulting in a large reduction in the effective R-value of the exterior insulation. If the furring is oriented parallel with the wall studs, the thermal bridging is severe and can easily result in a 70% loss of thermal R value of the exterior insulation. If the furring is oriented horizontal (Illustration 4), the area overlap between the furring and the studs is smaller and the thermal bridging penalties are lower. There are also proprietary products for reducing the heat loss through metal furring such as the thermally-broken Z-channel system assumed in stucco alternative 3 and described further under "Alternate Z-Furring Options" below. For a discussion of the alternatives, refer to ASHRAE 1365-RP.[3] In residential buildings and Type 5 commercial buildings, wood framing members can be used to interrupt the continuous insulation; the heat loss penalties are significantly lower than for steel furring strips.

There is concern and some anecdotal evidence that foam plastic insulation friction-fitted between furring channels could experience enough thermal contraction or long term shrinkage to reduce the thermal resistance of the wall system. This issue is discussed at greater length later in this paper, however more study is needed.

Additional Concerns (Illustration 4)

1. Since attachment points for vertically oriented z-furring run parallel with the framing, they can be continuous and closely spaced, however horizontally placed z-furring attachment points are regulated by the spacing of the framing. Therefore if both the framing and the z-furring are placed at 16” centers, the reliance is on one fastener positioned every 256 square inches to support the weight of both the sheathing (2.5 lbs. s.f.) and the stucco (10.4 lbs s.f.) or approximately 22.8 lbs./ fastener, compared to 9.9 lbs. for vertical furring. By placing the framing and/or the furring at greater on center spacing the induced load on the fasteners would be proportionately even more substantial.

2. It is advisable that Z-furring should be installed with the outer leg facing downward. Even with this precaution being taken, horizontally positioned z-furring creates shelves that could potentially trap moisture if rain water penetrates beyond the insulation board.

3. The gauge of the z-furring needs to be selected so that it meets the stucco system’s deflection criteria of L/360.

4. According to ASTM C 1063, “Lath shall be applied with the long dimension at right angles to the supports, unless
otherwise specified.” By this action the “cups up” or cleating of the lath are in the correct orientation for the subsequent placement of the stucco in an upward arcing and downward setting motion. If the z-furring is installed horizontally, the lath must now be installed vertically to meet the requirement of the standard. This would defeat the cleating and holding power of the lath by positioning the cups 90° (sideways) from where they should properly be.

5. Lath is manufactured in sheets 27” x 96”. There have been a couple of recent instances where the designer and the plasterer have been at an impasse on the orientation of the lath in relation to horizontal z-furring. This led to the extraordinary action of cutting the lath sheets down from 27” widths to 16” to orient the lath “cups up” on the 16” spacing of horizontal z-furring. The result, besides the incredible waste of 11” of sheet lath was that the installation was no longer code compliant; Moreover this created more lath overlaps, subject to thinner stucco and more stress at these locations.

Alternate Z–Furring Options

Illustration 5 presents an alternative option when considering the use of z-furring as part of “continuous insulation “assembly strategy. While clearly thermal bridging remains an issue because the z-furring aligns with the wall framing, this is thermally broken by the additional layer of insulation board positioned over the furring flanges. Additional advantages of this approach are:

1. The secondary layer of insulation board also overlaps the gaps between board joints of the primary layer of insulation board. This is important in minimizing any thermal loss from the primary layer of insulation board, and is consistent with installation methods of foam board manufacturers for maximizing the insulation value in a continuous insulation assembly.

2. The second layer of insulation is restrained by mechanical attachment to the z-furring. This reduces the thermal movement of the insulation board which can impose stress on the stucco.

3. Shorter fasteners can be used to attach the lath to the z-furring. This also aids in restraining the insulation board and provides less induced sheer load on the fasteners with less stress on the stucco.
4. Considering the placement of all of the insulation value to the outside of the framing, either a vapor permeable or vapor impermeable air and water barrier could be utilized at the outside face of the sheathing.

5. With all of insulation to the outside of the sheathing, no vapor retarder membrane is necessary between the drywall and the framing.

6. The drainage mat between the insulation board and the sheathing provides the primary drainage plane for the assembly.

7. Building paper breaks the bond between the stucco and the insulation board aiding in the control of cracking and allows for additional redundancy for moisture control and drainage.

Disadvantages

1. Moisture could find its way between the (secondary outer layer) of insulation and the primary layer of insulation. Trapped moisture at this location could potentially cause corrosion of the z-furring and the fasteners.

2. Deeper z-furring to attain higher insulation value could make this assembly untenable. This creates a strong argument to consider using batt insulation in the stud cavity as well. This would negate the opportunity to use a vapor impermeable air and water barrier at the outside face of the sheathing.

3. Impermeable foil faced foam plastic insulation presents its own challenges, in that permeable batt insulation in the stud cavity could not be utilized.

4. There currently appears to be a problem using non-foil faced polyisocyanurate insulation board to create a permeable wall that complies with the fire constraints of NFPA 285. Research from manufacturers indicates that either foil faced polyisocyanurate insulation boards, or fiberglass faced insulation board used in conjunction with an impermeable air and water barrier at the outside face of the sheathing are the only assemblies that have been tested.

Non-Conductive Intermittent Clips

Advantages

1. (Illustration 6). This may be a more desirable way to maximize insulation board on the outside without cavity insulation.

2. Conventional lath attachment can be employed.

3. Advantages 4-7 listed above.

Disadvantages

1. With no cavity insulation the insulation board would require a greater thickness to compensate for the thermally broken discontinuous insulation board.

2. The insulation board would have to be cut and fitted around the non-conductive clips.

3. It may be less cost effective because of the additional expense of the non-conductive clips and installation costs.

4. The insulation board would not be restrained by mechanical fasteners.
MOISTURE VAPOR CONTROL STRATEGIES

Vapor Diffusion

Vapor diffusion is water-vapor movement from areas with a high concentrations of water vapor molecules to areas of low concentration through microscopic pores in building materials. In cold climates building interiors in winter generally have higher moisture concentrations than the outside air, so interior water vapor is forced into building assemblies where it can create damage. To reduce this moisture migration, the building code typically requires Class I or II vapor retarders on the interior side of framed walls in Climate Zones 5, 6, 7, 8 and Marine 4. Classifications of vapor retarders are determined based upon a materials permeance, a measure of the ease of water vapor transmission through a material. Class I vapor retarders are <0.1 perm, Class II are >0.1 ≤ to 1.0 perm and Class III are > 1.00 perm ≤ 10.0 perms. For example, polyethylene plastic sheeting is considered a Class I vapor retarder, kraft (paper) backed fiberglass is considered Class II and latex paints are considered Class III.

The Minnesota Lath and Plaster Bureau co-sponsored research with Certainteed in conjunction with the Energy Systems Design Program, College of Design, University of Minnesota [4]. Among other issues, testing looked at the effect of vapor on stucco wall assemblies over a one year time frame. This research showed that air infiltration also plays a critical role in moisture condensation issues. In particular it was demonstrated that kraft backed fiberglass batts do not provide the best vapor retarder characteristics because of vapor bypass at the seams. It was also demonstrated that sheet retarders can also suffer the same fate if all of the seams are not carefully taped and isolated.

In the same study, polyamide (smart) vapor retarders were shown to outperform polyethylene and kraft paper vapor retarders for typical interior moisture conditions in our climate (excluding high humidity uses like swimming pool enclosures). A smart vapor retarder is a sheet membrane that looks similar to polyethylene but whose permeability is dependent upon the interior humidity. For typical indoor humidity conditions, it behaves like kraft paper and retards vapor flow in the winter months, while in the summer months it behaves like latex paint and allows increased drying of the wall cavity to the interior. Certainteed MemBrain is an example of a smart vapor retarder [5].

Air Transport

Until recently few buildings were systematically designed and built to control air leakage through the building enclosure. A 2005 NIST study [6] concluded that existing commercial buildings in Minneapolis would save 26% to 37% in annual heating and air conditioning costs if they had been built to readily achievable air tightness standards. Air leakage can also carry large quantities of water vapor into the building envelope with mold, rot and corrosion being possible results. Not only can moist air create damage to materials, but mold growth can pose health risks and reduce indoor air quality. Air barrier materials must have low air permeability and must be stiff enough to resist billowing during air pressure fluctuations from wind gusts. When formed into assemblies, like walls with changes in plane, mechanical, electrical and plumbing penetrations, window and door openings and all joints must be caulked, taped or sealed to resist air leakage. Continuity must be maintained between assemblies like roofs, walls and foundation elements to form the full building enclosure. The architect is responsible for specifying air barrier materials, detailing air barrier assembly joints and showing how continuity is to be achieved between assemblies. The energy code defines maximum air leakage under blower door pressure increasing by factors of 10 from air barrier materials (.004 cfm/ft² @75 Pa) to assemblies (.04 cfm/ft² @ 75 Pa) to the entire building enclosure surface (0.4 cfm/ft² @ 75 Pa). Under the IECC 2012/ASHRAE 90.1 (2010) energy code, for commercial buildings, 0.4 cfm/ft² @ 75 Pa is the guideline for maximum blower door leakage. This is a recommendation not a requirement. However, blower door testing will be required for 1 and 2 family residential buildings to meet an air leakage standard based on building volume (a maximum of 3 air changes per hour at 50 Pa). We believe that through blower door testing, contractors will quickly learn how to build airtight buildings and that this regulation will provide a substantial and cost-effective benefit to residential energy conservation.

Selection and Location of Air Barriers

The selection of the air barrier location depends on the wall type and material details. In frame walls it is generally located either at the interior finish layer, often gypsum board, or at the sheathing layer, usually OSB, plywood or fiber-
glass-faced gypsum sheathing. If the interior gypsum board is used as the air barrier, it must be caulked at its perimeter, electrical boxes and other penetrations must be sealed and continuity must be maintained where it is interrupted by interior walls and by floor structure. It can be made airtight on the interior with closed cell spray polyurethane foam or one of several proprietary spray-on air barrier systems. The same sealing method could be used to maintain continuity between floors and at intervening interior walls. Since spray foam cannot seal very small gaps, some joints need to be caulked separately, like those between stud wall bottom plates and subflooring or between multiple framing members.

Because of these complexities, the exterior sheathing is emerging as the preferred air barrier location. Alternatively, the sheathing could be made airtight on the exterior by sealing joints with compatible tapes; by using proprietary spray/roller/trowel-on air barrier systems or with adhesive-backed sheet membranes. The exterior location has the added advantage of automatically maintaining continuity between floors and at interior walls. Consideration must also be given to the vapor permeability of the air barrier. Use of a rubberized asphalt membranes or closed cell spray foam will limit the drying potential of the wall to the exterior. If vapor-permeable insulation is to be placed inside an air barrier with low water vapor permeability an analysis should be performed to assess moisture damage risk.

PHYSICAL PROPERTIES OF FOAM PLASTIC INSULATIONS [7]

There are several different types of insulation used in CI assemblies. Type I Expanded Polystyrene (EPS) is the exterior insulation most commonly used in EIFS assemblies and Type IV Extruded Polystyrene (XPS) is the exterior insulation most commonly used in stucco assemblies. Figures C & D compare common physical material properties based on GSA specifications [8]:

On face value of Figures C and D it appears that XPS presents better physical properties in every category, however some additional discussion is warranted:

**Figure C**

<table>
<thead>
<tr>
<th>EPS Type I</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Minimum Density: 0.9 lb/ft³</td>
<td></td>
</tr>
<tr>
<td>Thermal Resistance (R-Value): 3.6 per inch @ a mean temp. of 75°F</td>
<td></td>
</tr>
<tr>
<td>Compressive Resistance @ 10% deformation: 10.0 psi</td>
<td></td>
</tr>
<tr>
<td>Flexural Strength: 25.0 psi minimum</td>
<td></td>
</tr>
<tr>
<td>Water Vapor Permeability: 5.0 perm-in. max.</td>
<td></td>
</tr>
<tr>
<td>Max. Water Absorption: 4.0% of volume max.</td>
<td></td>
</tr>
<tr>
<td>Max. Dimensional Stability: 2.0%</td>
<td></td>
</tr>
<tr>
<td>Coefficient of Linear Thermal Expansion: 0.000035 in./in./°F</td>
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</tr>
</tbody>
</table>

**Figure D**

<table>
<thead>
<tr>
<th>XPS Type IV</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Minimum Density: 1.6 lb/ft³</td>
<td></td>
</tr>
<tr>
<td>Thermal Resistance (R-Value): 5.0 per inch @ a mean temp. of 75°F</td>
<td></td>
</tr>
<tr>
<td>Compressive Resistance @ 10% deformation: 20.0 psi minimum</td>
<td></td>
</tr>
<tr>
<td>Flexural Strength: 50.0 psi minimum</td>
<td></td>
</tr>
<tr>
<td>Water Vapor Permeability: 1.1 perm-in. max.</td>
<td></td>
</tr>
<tr>
<td>Max. Water Absorption: 0.3% of volume max.</td>
<td></td>
</tr>
<tr>
<td>Max. Dimensional Stability: 2.0%</td>
<td></td>
</tr>
<tr>
<td>Coefficient of Linear Thermal Expansion: 0.000035 in./in./°F</td>
<td></td>
</tr>
</tbody>
</table>

Expanded Polystyrene (EPS)

- EPS is made by expanding loose polystyrene resin beads by steam heat in a closed mold. Although polystyrene beads contain a small amount of liquid pentane as a foaming agent, this is displaced by air. As a result, it is benign compared to current blowing agents most commonly used in XPS and closed cell spray foam insulations.

- EPS contains HBCD, a brominated fire retardant that bio-accumulates in the food chain, is toxic to aquatic organisms and has negative impacts for human health. All foam plastic insulations currently contain fire retardants. EPS contains approximately .5% to .7% HBCD by weight, which is lower than the HCBD concentration found in XPS. Manufacturers are looking for safer alternatives.
• EPS has an open-cellular structure. Air in the cellular structure of EPS gives it a more stable long term R-value compared to foam plastic insulations that depend upon retaining a blowing agent in their cells to maintain their initial R-value.

• EPS is available in a range of densities up to about 3 lbs/ft3. As density increases, so does compressive strength, tensile strength, stiffness, R-value and cost, while water absorption and water vapor permeability decrease. The coefficient of thermal expansion is constant regardless of density. The EPS commonly used in EIFS assemblies is Type I, the least dense formulation. Type IX EPS has compressive and flexural strength similar to XPS and an R-value of 4.2. Its water absorption is 2%, half that of Type I but still much greater than XPS. Type IX EPS permeability is more than twice that of XPS making it a good replacement for XPS in wall systems that benefit from the extra drying ability to the outside and do not need the low water absorption rate of XPS. Its value then is its lower environmental impacts relative to XPS.

• The open cell structure of EPS bonds tenaciously to cementitious materials. This is beneficial in the initial suction (grab) and retained holding power of adhesives to substrate sheathings and ease in which thin veneer cementitious coatings are applied.

Extruded Polystyrene (XEPS aka XPS)

• XPS is made by melting EPS granules into a mass, then injecting it with an inert gas that causes it to foam as it passes through a die set. The current hydrofluorcarbon blowing agent is a strong greenhouse gas. There is concern about how much of the blowing agent is released into the atmosphere over the lifetime of the product. Manufacturers are looking for new blowing agents that will eliminate this problem. Section 612 of the Clean Air Act calls for elimination of HFC-134a, the most common blowing agent used in XPS by 2021.

• XPS contains HBCD, a brominated fire retardant that bio-accumulates in the food chain, is toxic to aquatic organisms and has negative impacts for human health. All foam plastic insulations currently contain fire retardants. XPS contains approximately 2.5% HBCD by weight. Manufacturers are looking for safer alternatives.

• A Class II Vapor Retarder is accepted as any material >0.1 but ≤ 1.0 perm. XPS is 1.1 perm max./ in. thickness. In thicknesses greater than about 1”, depending on the manufacturer’s specifications, XPS can act like a Class II vapor retarder. For this reason caution needs to be exercised to the risk of moisture condensation within the wall assembly.

• In the manufacture of XPS a continuous smooth skin is developed. Because of this closed cell structure, cementitious adhesives and coatings do not bond well to XPS. As a result mechanical fasteners and lath attachments are used in portland cement plaster assemblies.

OTHER TYPES OF INSULATION BOARD
Polyisocyanurate

Polyisocyanurate foam board apparently has a higher R-value than XPS or EPS; manufacturers typically state an R-value of between 6.0 and 6.5 per inch. These R-values are based on the loss of blowing agent expected over a 15 year life; a time span that may be appropriate for commercial roofing but which understates the service life expected for walls. As blowing agent is replaced by air, the R-value slowly decreases, so the average R-value for a service life of 50 or 100 years would be lower than the currently stated “long term” R-value. The foam plastic insulation industry has not published estimates for the expected loss of R-value over the life of a building. This concern applies to XPS and closed cell spray foam as well as to polyisocyanurate.

A recent study by Building Science Corporation [9] indicates that at low temperatures, the R-value of polyisocyanurate decreases. In most other insulations, the R-value increases in cold weather, which is beneficial for use in cold climates. The hypothesis is that at low temperature, the pentane blowing agent condenses, decreasing the R-value. The Building Science results are generally consistent with recommendations from the National Roofing Contractors Association to use an R of 5.0 for cold climates and an R of 5.6 for warm climates.
Polyisocyanurate has comparable compressive and flexural properties to XPS. A sampling of major manufacturers reveals dimensional stability characteristics in a range of 1.5% - 4%. The board exhibits good surface burning characteristics (flame spread <75, smoke developed <450), however it contains 2.5% to 5.5% TCPP by weight. TCPP is a fluorinated flame retardant that is defined as a suspected carcinogen by the World Health Organization and is being investigated by the National Institute for Environmental Health Services for genetic and reproductive toxicity. Regarding quality control, on a recent project it was noted that it was up to a 1/2" thicker at its ends than the manufacturer’s published tolerances, however this may have been an anomaly and not indicative of what is generally seen in the field. On a positive note, the pentane blowing agent used in polyisocyanurate has a very low global warming potential, unlike the blowing agents used in XPS and most closed-cell spray polyurethane foams.

Polyisocyanurate is available with felt, fiberglass or foil facings. When used as exterior insulation, the facing will determine how well the wall assembly can dry to the outside. The foil-faced product is essentially impermeable to water vapor (<.03 perm, Class 1 vapor retarder) whereas felt or fiberglass facings will allow some drying to the exterior (between .1 and 1 perm, Class 2 vapor retarder). The additional drying capability of the felt or fiberglass facers can be important in cold climates when vapor-permeable stud cavity insulation is also present.

Mineral Wool
There are actually two types of insulation referred to as mineral wool. Rock wool insulation is truly made from rock. Actually from basalt, a volcanic type rock. Slag wool insulation is made from the vitreous bi-product of smelting ore in steel making. Mineral Wool has gained wide acceptance in Europe and Canada but has seen limited use in the United States. Much like Type I EPS, its limitation is in its relatively low R-value of 4.0 R per inch of thickness. Unlike most foam plastic insulation board, mineral wool is a stable material and will have minimal expansion or contraction due to thermal cycling. Also it is not subject to diminishing thermal value because it uses no blowing agents in its manufacture. Moreover it contains no potentially hazardous flame retardants. Where it really delivers is in its ability to shed moisture; in its ability to let walls dry (30-40 perms for 1” thick material); and perhaps most importantly in its surface burning characteristics (flame spread 0, smoke developed 0) [10].

A 2011 Building Science Corporation report [11] investigated furring strip deflection when cladding was installed directly over high density mineral wool (8 pcf and up to 3” thick), with furring fasteners extending through the mineral wool into the wall studs. Furring strip movement was considered “negligible” for the configurations tested. However, the report recommended the need for multi-year field testing for stucco and simulated stone systems applied directly over mineral wool before they are ready for widespread use.

Spray Polyurethane Foam (SPF)
SPF is made in low density open cell formulations and higher density closed cell formulations. The open cell product is commonly used as cavity insulation in wall and roof systems. It has an R-value of up to 4 per inch; is very permeable to water vapor; and from a moisture transmission standpoint behaves like fiberglass or cellulose loose fill insulation. It is more effective than sprayed fiberglass or dense pack cellulose at reducing air movement and at thicknesses typically greater than 4”, meets air barrier requirements. Water is used as an activator to create CO2 that expands the foam which has a relatively low global warming impact compared to hydrofluorocarbon blowing agents. Like polyisocyanurate, open cell SPF contains the fire retardant TCPP (12.5% by weight).

Closed cell SPF has a higher R-value (6 per inch) and lower permeability than open cell SPF.[12] At thickness greater than one inch, it functions as a Class II vapor retarder. It can be applied at thicknesses up to 2” per pass. When sprayed on the inside of wall sheathing, it
serves as an air barrier and since it is relatively impermeable, increases the condensation temperature of the sheathing in cold climates. It has good dimensional stability (<1.0%), similar compressive and flexural properties to XPS, and moderate surface burning characteristics (flame spread 20, smoke developed <450). It can be used as exterior insulation but because of its spray-applied wavy surface, is not generally suitable for direct application of cladding. Like XPS, its current hydrofluorocarbon blowing agent is a strong greenhouse gas. There is concern about how much of the blowing agent is released into the atmosphere over the lifetime of the product. New blowing agents with lower global warming potentials are expected to be available soon. Like polyisocyanurate, closed cell SPF contains the fire retardant TCPP (4% by weight).

**DIMENSIONAL STABILITY AND COEFFICIENT OF LINEAR THERMAL EXPANSION IN EPS AND XPS**

Type I EPS is the insulation most commonly used in EIFS systems, XPS is the continuous insulation most commonly used behind stucco. Expanding on an issue not covered by the preceding commentary and often overlooked but inherent to both EPS and XPS are dimensional stability and coefficient of linear thermal expansion. Dimensional stability (ASTM D2126), measures the insulation board’s ability to resist dimensional change due to temperature and humidity variations over time. In Figures C & D given previously, the Maximum Dimensional Stability of both EPS and XPS is 2.0%. This means that under the right conditions an unrestrained piece of EPS (2’ x 4’) could change in the width dimension 0.48” and in the length direction 0.96”. Depending on the size of the insulation board, XPS dimensional stability is no less severe: Assuming 4’x8’ dimensions, an unrestrained piece of XPS could be expected to change dimensionally under the right conditions 0.96” in the width dimension and 1.9” in the length direction. While dimensional stability is mostly accounted for in post production age drying or heat drying methods before it is cut into boards, it is important in the overall integrity of the plaster system. EPS for instance is aged 6 weeks or heat dried (kiln) at 140°F for five days to process the board more quickly. The term commonly used in the EIFS Industry for EPS that is not stable is called “Green Board.” The end result being that these boards will shrink in situ causing cracks in the finished EIFS lamina. For quality assurance the code requires a third party certification labeling of the EPS in EIFS installations.

Coefficient of linear thermal expansion (ASTM D 696) measures the insulation board’s ability to expand or contract relative to temperature extremes. Assuming a temperature drop from a mean temperature of 70°F to -30°F, an unrestrained 4’x8’ piece of XPS can be expected to contract in the length direction 0.336” (.000035 x 96” x 100°F = 0.336) or in fractional terms approximately 5/16”+. In the opposite direction going from a mean of 70°F up to say 110°F an unrestrained piece of XPS can be expected to expand in the length direction 0.13” or approximately 1/8”+. Using a 2’x4’ piece of unrestrained EPS as an example the results are 0.17” (5/32”+) and 0.07 (1/16”+) respectively. The same methodology used in the above can be applied to EPS and XPS insulation board in the thickness direction. The thicker the insulation, the greater will be the forces involved in expansion or contraction in this direction.

The key then to this discussion lies in the terminology “unrestrained.” This simply means that no mechanism is in place to control the board’s expansion and contraction movement. This of course differs from performance of the insulation board in an assembly which in most cases is either mechanically attached to the framing or adhesively attached to the sheathing substrate. The question then is which performs better? As has been demonstrated, the stability of EPS board is less severe primarily because of its dimensional size versus XPS. In its use in Exterior Insulation Finish Systems, specially formulated adhesive is installed in a notched trowel pattern on the back face of the board. This adhesion uniformly reduces board movement compared to mechanical fastening. Also in an EIFS system, a thin polymer modified base coat membrane with embedded reinforcing mesh provides resiliency in accommodating any residual movement stresses.

Although XPS insulation can be adhered to sheathing with specifically formulated adhesives, cost often prohibits its use. For this reason in stucco installations, mechanical fasteners consisting of a polypropylene disc and corrosion resistant screws are used to temporarily anchor the insulation board through the sheathing and into the structural framing. The subsequent fastening of the lath 7” on center through the field of the XPS and into the framing meets the attachment criteria for ASTM C1063 and is regarded as sufficient restraint for the insulation board.
ADDITIONAL CONSIDERATIONS WHEN INSTALLING STUCCO OVER FOAM PLASTIC INSULATION

The most commonly heard complaint about stucco is cracking. Cracks occur because stresses exceed the restraint capacity of the stucco. Considering the preceding commentary, dimensional stability and coefficient of linear thermal expansion stresses can present challenges in ensuring the integrity of a stucco installation over foam plastic insulation. If the insulation is itself not functionally restrained with the right number of fasteners, this instability may cause the fasteners to undergo a toggling action. This can create internal tensile and compressive stress which may in turn transfer through to the stucco. Considering the fact that Minnesota temperatures typically can range from -30°F to 100+°F, this is a serious concern.

The strength of stucco to resist tensile stress is closely related to cracking potential in the plaster membrane. This is generally regulated by the proportion of sand to cementitious materials, densification (floating) and curing of the stucco membrane. Choosing a stucco mix then that is durable and compatible with foam plastic insulation is crucial.

The thickness of the insulation and design wind pressures are also factors that need to be considered when designing with stucco over foam plastic insulation. The insulation thickness, dictates how long the screw needs to be to support the lath and pass through the insulation, sheathing and finally penetrate the framing. Three-coat stucco weighs in excess of 10.4 lbs. per square foot. As a result the downward load creates a deflection arm force on the fasteners. For this reason great care should be assigned to engineering calculations that take into account the size, number and spacing requirements of the fasteners. Interestingly, AWCI (Association of Walls and Ceilings Industry) concluded a test that determined that 4" of foam plastic insulation would support lath and stucco in climate zone 7. The test however was not conducted in Climate Zone 7, which unfortunately did not account for linear thermal expansion and contraction movement. For more information on foam insulation board fastening see the “Guide to Attaching Exterior Wall Coverings through Foam Sheathing to Wood or Steel Wall Framing.” [13]

Bulk Water Drainage Considerations

For stucco, it has been shown by testing that the effective drainage plane is between the stucco and the building paper in conventional applications. [14] A recent national amendment to the 2012 International Building Code has called that into question; as the new requirement calls for water-resistive barriers (i.e. building paper, housewrap) to be installed in two layers, with flashing elements directing moisture between the layers. While two layers of building paper have been a requirement over wood base sheathings since 1982, this is the first directive that calls for the drainage plane to be between the layers. This amendment has not been adopted by Minnesota Building Codes.

When exterior insulation is present, the issue becomes even more convoluted: Should the effective drainage plane be between the insulation board and the sheathing or should it be between the stucco and the insulation board, or in both locations?

Discussion

In 1995 the EIFS industry was confronted with a series of class action lawsuits. As EIFS was represented as a barrier cladding, it had to defend itself against plaintiffs who contended that bulk water that bypassed the insulation board became trapped and as a result manifested in mold and rot issues. Since that time the EIFS industry has developed drainage systems that incorporate spray/roller/ trowel fluid applied membranes that function as both air and water-resistive barriers over sheathing substrates (Illustration Reprise next page). The expanded polystyrene is adhered over the air and water barriers with specially formulated adhesive in a vertically-oriented notched trowel pattern to allow a drainage plane for incidental moisture. These products were substantially vetted by a study from January 2005 through June 2007 by researchers at Oak Ridge National Laboratory, U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy’s Building Technologies Program. [15, 16]

We present the above information with the intention of provoking some debate in this matter. This is because we have seen local construction documents for stucco over foam plastic insulation that have demonstrated drainage
planes between the foam plastic insulation and the sheathing, but also between the stucco and the foam plastic insulation. Both circumstances present challenges in their design and construction. As an example of this issue, how should stucco corner accessory attachment accommodate the thickness of the foam plastic insulation at returns around windows? Or vice-versa, how should an opening be framed to bring a window out flush with the stucco when foam plastic insulation is employed? In both cases the detail needs to be carefully designed and flashed to be successful. Perhaps this issue is more a function of how the foam plastic insulation is attached. EPS used in EIFS installations lends itself well to notched trowel adhesive. XPS does not, unless the adhesive is specially formulated or the board is planed or rasped. For these reasons XPS is mechanically attached with screws and plastic washers. And, if the designer chooses to put the drainage plane between the insulation board and the sheathing, the insulation board needs to be profiled with drainage channels or an intervening drainage mat/medium must be employed.

Fire Considerations

According to the International Building Code sections 2603.5 and 2603.5.5, exterior walls for buildings of non-combustible building types I, II, III, IV greater than 1 story and containing foam plastic insulation must comply with NFPA 285. NFPA 285 requires separate testing for each detailed assembly and it is quite expensive. There have been some stucco walls that include proprietary foam plastic insulation as part of a fire rated assembly that have passed testing for NFPA 285 compliance. It can be interpreted that no testing exists with generic field mixed stuccos and foam plastic insulation because of the variety of materials that would have to be evaluated. Section 2603 has additional requirements for exterior walls containing foam plastic insulation.

Note: NFPA 285 testing is required for non-combustible construction that uses EIFS. Please refer to manufacturer’s current data sheets and/or ICC Evaluation Report for further information.

HISTORY OF STUCCO OVER CI IN MINNESOTA

In the early 1970’s - 80’s the Minnesota Lath and Plaster Bureau promoted a Continuous Insulation assembly known as Minne-Wall. This was marketed as a wall system comprised of steel studs, tongue and groove extruded polystyrene, metal lath and three-coat stucco. Earlier generations of these assemblies did not include any sheathing however later installations included gypsum sheathing substrates. Thickness of insulation board varied from 1-2”. 15# felt was a recommended option over the insulation board prior to the lath. Advantages promoted in the use of the system included:

- Economy. 40-50% savings over masonry and brick.
- Weight. Panels weighed less than 50% of precast and 75% less than masonry.
• Panels minimized thermal transfer. Energy Loss.
• Speed of Erection. Prefabricated walls could be built on or off site.

With the advent of EIFS in the late 70’s, the use of Minne-Wall faded into the past. In 2006 the Minnesota Lath and Plaster Bureau conducted an informal review of some of these older buildings and concluded that some projects seemed to have fared better than others over the years. It was obvious that those buildings in reasonable condition had been maintained or in fact remediated. Those buildings in poor condition exhibited color retention loss, dirt, mildew and algae growth, spalling of stucco and in most cases severe cracking issues among other problems.

COMPOSITIONAL STRATEGY FOR STUCCO OVER FOAM PLASTIC INSULATION

Table 1 of ASTM C926 provides guidance on permissible stucco mixes over metal plaster bases (lath). Table 2 provides guidance on compositional mixes. Deviation from generally accepted physical properties of the end mix design should be realized and anticipated depending on what is specified. Some of these mixes may be more appropriate than others with respect to their application over foam plastic insulation. As a note of caution, it should never be assumed that just any stucco mix is appropriate for a fire rated assembly specifically sourced through UL or other tested model. The stucco mix illustrated in the assembly must be followed to the letter to meet the criteria established by the fire rating value assigned to that assembly.

Proprietary Stucco Options

Many EIFS manufacturers now offer proprietary stucco systems that feature continuous insulation (Example 1). The inherent advantages in specifying a proprietary stucco system over a non-proprietary system are many:

• Integrated system components are engineered for compatibility.
• Portland cement plaster is tolled and mixed in a plant eliminating any field mixing guesswork.
• Systems and components are compliant with rigorous test standards.
• Most systems are warrantable.
• Plastering contractors that install these systems are trained by the manufacturer.
• Features can include an additional EIFS base coat and reinforcing mesh over the stucco brown coat for crack control.
• Unlimited color choices in texturable acrylic top coats.
• New aggregated finish options that assimilate the look of granite and limestone.
• Water drainage designs that evacuate incidental moisture.

Note: The Minnesota Lath and Plaster Bureau does not recommend the use of “One-Coat” stuccos for Climate Zones 6 and 7. Unlike traditional three-coat stucco applied 7/8” thick, proprietary one-coat mixes are typically installed 3/8”-1/2” thick. Anecdotal evidence suggests that these unmodified thinner coatings cannot accommodate the severe thermal changes in this environment. Unless and until these products can be qualified to withstand the physical demands of this environment we stand by this recommendation.
Crack Mitigation Strategy for Stucco over Foam Plastic Insulation

Cracking occurs because stresses exceed the restraint capacity of the stucco. Once this has happened the stress is relieved by splitting/cracking open of the stucco membrane. Because stucco is exposed and other components of the wall assembly are concealed, the stucco is often blamed for cracking that may in fact be the direct result of problems behind it. This fact holds true regardless of the substrate that the stucco is installed over. Many of the Minne-Wall installations completed in the 70’s and 80’s have been maintained and others have not. Some of these older projects have been repaired over the years by installing a fiberglass mesh reinforced EIFS PB type cementitious base coat lamina over the stucco. This provides better stress resistance to the wall, minimizing the number of cracks that may come through and enhances the overall aesthetic appeal of the exterior. With the prevalence of use of stucco over foam plastic insulation the benefits of this strategy should not be overlooked.

Many stucco manufacturers are now offering EIFS mesh reinforced brown coat (example 2) as an upgrade to featured proprietary stucco systems and this type of application is also actively being discussed by the ASTM Committee C11 on Gypsum and Related Building Materials and Systems.

EIFS

EIFS has now been a part of the U.S. construction market for over 45 years. Today’s EIFS can legitimately claim the title as the “original continuous insulation system.” Fear of moisture intrusion in today’s EIFS systems is unwarranted, because of the inherent drainage capability built into these systems. Research confirmed by Oak Ridge National Laboratory, U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy’s Building Technologies Program concluded that EIFS “outperformed walls of brick, stucco, concrete block and cementitious fiber board in moisture handling with superior performance” [15, 16].

EIFS With Drainage Highlights

- Insulation board that is relatively benign in relation to blowing agents used in other insulation products.
- Thermal R-value of 3.6/ inch of thickness.
- A dual functioning air and water-resistive barrier.
- Substantially reduces air leakage which is a major source of energy inefficiency.
- Vapor permeable. This allows better drying potential for the wall assembly.
- A drainage plane is achieved between the insulation board and the air and water-resistive barrier with vertical ribbons of adhesive that are applied with a notched trowel.
- Adhesive used to attach insulation board does not puncture or compromise the air/water barrier or contribute to thermal bridging.
- Insulation is not interrupted by framing or furring which contributes to thermal bridging. EIFS is truly “continuous.”
- Different weights of specially treated fiberglass reinforcing mesh can be embedded in the base coat lamina to

Example 2: Reinforcing Mesh Embedded in Brown

![Diagram of EIFS system with reinforcing mesh embedded in brown coat.](image-url)
Innovation continues with new high performance base coat formulations for increased impact and puncture resistance. This improvement will allow high impact classification EIFS to be installed utilizing a single layer of intermediate weight reinforcing mesh, rather than two layers of reinforcing mesh and a double pass of base coat. While substantially reducing material and labor, this feature will allow designers to consider using EIFS at ground floors and other areas where pedestrian traffic may come in contact with the wall. Other innovation comes in new finishes with hydrophobic and photocatalytic properties that are self-cleaning and help break down atmospheric pollutants that accumulate on wall surfaces. Finally, there is a renaissance of color and aggregate finish options that mimic the look of granite and limestone (Example 3).

**Example 3: Finish Options, Courtesy of Dryvit**

> Freestyle™
> Mojave E™
> Sandpebble® Fine

**Insurance for EIFS**

The EIFS Industry Members Association (EIMA) offers a comprehensive listing of Insurance Access Points to all interested parties in the EIFS industry. The listing was developed from results of a survey taken of insurance agents throughout the United States that have access to EIFS coverage [17]

**BUILDING MOCK-UPS**

The mantra of the Construction Specifiers Institute is to provide “concise, clear, complete and correct specifications”. The same holds true for the contract drawings and details of the project. Collectively these parts of the contract documents provide an information bridge between the designer and the contractor. With the complexity of today’s projects, a building enclosure mock-up provides additional assurance that the specified materials function as they are designed under the site conditions anticipated. Mock-ups also afford the opportunity to test details in three dimensions, determine installation sequencing, locate potential conflicts between trades and time considerations for construction scheduling. Most importantly mock-ups provide the opportunity for the designer and the contractor to be on the same page and confront potential issues that may cause failures from non-conventional building techniques before construction actually begins.

**Third Party Inspection**

Another action that should be considered seriously is bringing in a third-party inspector knowledgeable in the industry and trade to make observations and notations as to the extent that materials are installed per the contract documents. Consider the inspector as:
NEW PRODUCTS

The processes of constructing assemblies that meet the energy code requirements continue to evolve. At the time of this writing we note a couple of promising new products, but would suspect there are more on the horizon.

InsoFast (Example 4) is an R-10 closed-cell, injection molded polystyrene panel with embedded studs made from non-conductive copolymer plastic that are recessed by a ½ inch of insulation. According to the manufacturer, EX panels actually outperform R-15 insulated walls that are assembled with traditional framing methods. What separates InsoFast from other insulation board panels is the unique built-in drainage planes on the front and back of the EX panel which simplify the multiple processes of a rain screen assembly. The panels interlock on all 4 sides and have engineered capillary breaks to prevent water migration through the insulation. Because the embedded studs are of thermoplastic, fasteners used to attach the insulation board to the substrate melt to seal around the fastener. In a stucco installation an intermediary facer such as building paper or Tyvek would have to be stapled to the face of the insulation board; however, the simplicity of the installation would be in the attachment of the lath to the embedded studs in the board. Because the embedded studs are positioned 1/2" below the surface and clearly marked, shorter fasteners can be used. This is beneficial not only in the economy of the installation, but also in eliminating any second guessing of lath attachment with long screws to framing members.

Another product that has been on the market actually for a number of years now is City Mix Stucco. City Mix has developed an ultra-light stucco base coat featuring 35% weight reduction with improved flexibility and crack resistance. Cost-saving contributions are realized in improved wall coverage rates per man hour, reduced worker fatigue and less “fall-off” waste.

SUMMARY DESIGN STRATEGIES FOR STUCCO SYSTEMS UTILIZING EXTERIOR INSULATION

- Stucco installed directly over foam plastic insulations may increase the risk of cracking. For this reason it is suggested that the designer consider insulation boards that exhibit minimal or neutral dimensional stability characteristics.
- Avoid foam plastic insulations with HFC blowing agents if possible.
- Because of materials innovations, increasing insulation requirements and the diversity of indoor and outdoor climate factors, a hygrothermal analysis should be considered to control the risk of mold, rot and corrosion.
- Consider warrantable and proven exterior insulation systems consisting of proprietary materials such as insulation board, pre-blended stucco and finish coats in lieu of cherry picking materials and attributes for contract documents.
- Installation of stucco over wood base sheathing requires two layers of Grade D Type I Building Paper. Foam plastic insulation may substitute for one of those layers.
• Install dual-functioning air and water barriers and provide drainage between the foam board and the sheathing.
• Building enclosure performance is very sensitive to material properties, construction practices and interior relative humidity, so designs should be “fault tolerant.”
• When mating exterior insulation with permeable cavity insulation, choose the most vapor-permeable components that do the job.
• Install a layer of building paper or felt over exterior insulation in stucco assemblies, unless otherwise directed by stucco system manufacturer.
• Protect window and door openings with appropriate flashing materials. Provide window sill drainage pans or sill flashing with end dams.
• Vapor retarders integral to fiberglass batts, like Kraft paper, can suffer vapor bypass at their edges and don’t perform as well as sheet products with taped seams that cover the entire wall.
• Smart vapor retarder systems with taped seams (polyamide films) perform better in Minnesota than polyethylene. Except in environments with high interior relative humidity.
• Control Infiltration – detail, specify & test.
• Stand alone mock-ups or mock-ups integrated to the project wall should encompass the full variety of design factors that may need clarification in the field.
• Avoid interrupting exterior insulation with Z-furring.
• If Z-furring must be part of the design, consider installing insulation board in two layers. With outermost layer installed over the flange of the furring or consider using a thermally-broken furring system.
• Foam plastic insulations are best installed in an overlapping running bond pattern in two layers in lieu of a single thickness installation. This will reduce energy loss due to dimensional instability.
• Limit lath attachment to no more than 1.5” to 2” thick foam plastic insulation in assemblies under stucco.
• Fasteners: For information on foam insulation board fastening for stucco see the “Guide to Attaching Exterior Wall Coverings through Foam Sheathing to Wood or Steel Wall Framing.” Foam Sheathing Coalition, September 2010 [13]
• Control and expansion joints: Follow ASTM C 1063 criteria for installation of control and expansion joints.
• Stucco mix: Use field or proprietary mixes conforming to ASTM C926 with a record of success over foam plastic insulation.
• Optional EIFS basecoat and embedded mesh can be used over stucco brown coat to minimize cracking potential.
• Observe deflection criteria for the system you are using: Stucco l/360, EIFS l/240.
• Avoid using horizontally oriented Z-furring when using stucco in exterior insulation assemblies.
• The Minnesota Lath and Plaster Bureau does not recommend 24” on center spacing for framing members used as a part of a wall assembly in stucco over exterior insulation.

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R Max. Durasheath . Product Data Sheet.

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ASTM C1063

ASTM C926


City Mix. http://citymix.com/


Parex USA http://www.parex.com