Georgia-Pacific Gypsum presents:

Benefits of a Rigid Cover Board in Commercial Roofing Systems

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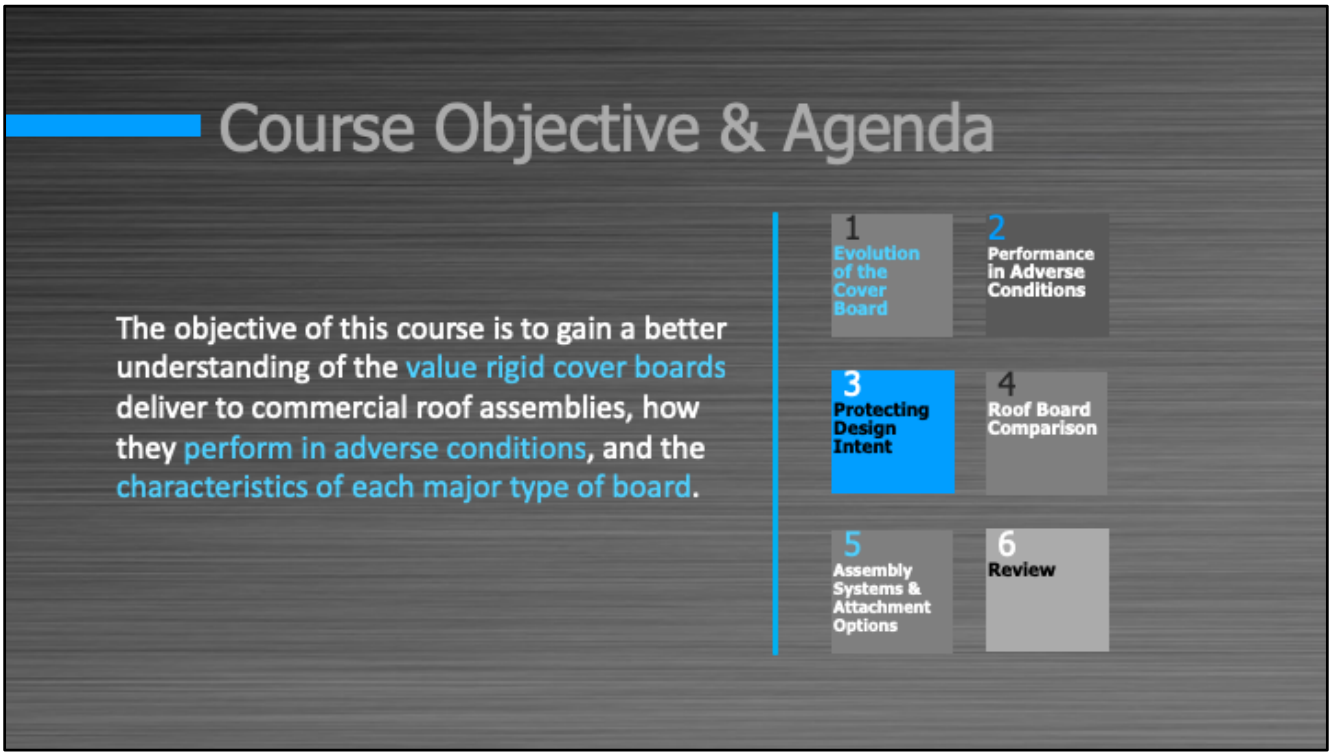


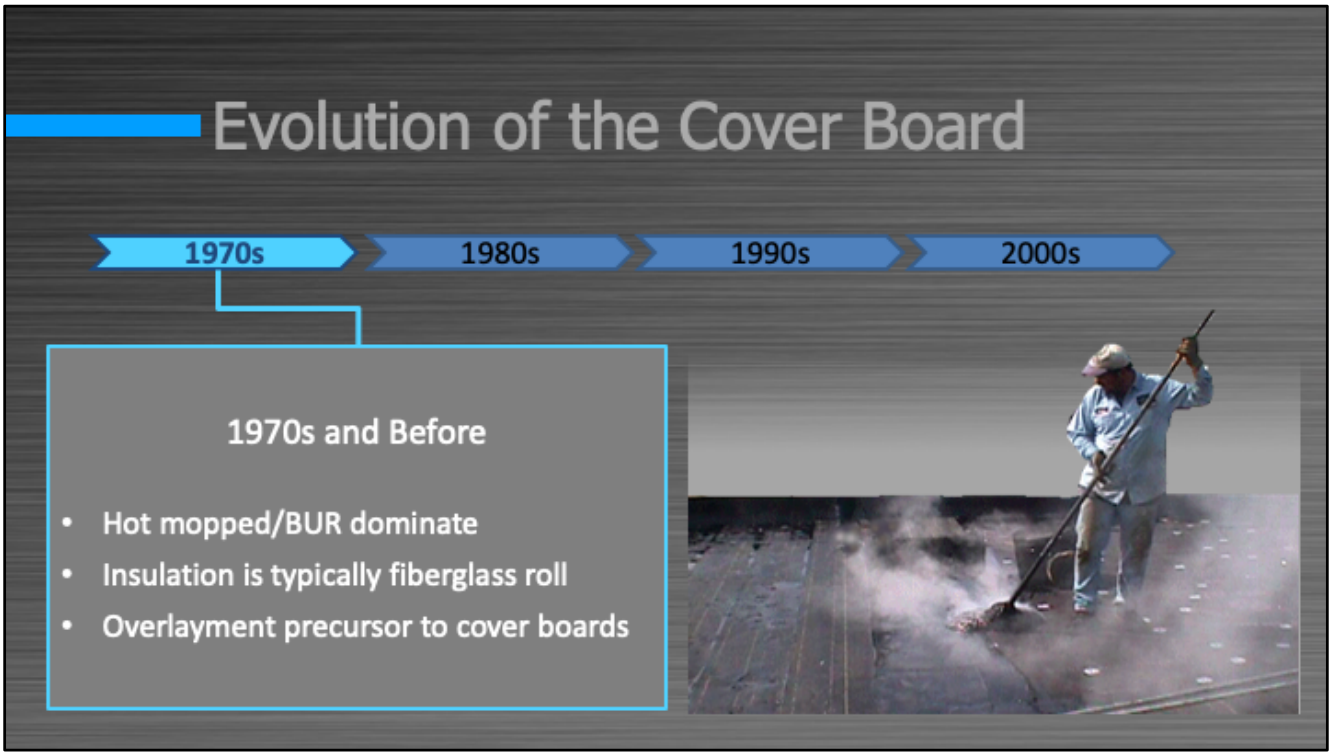
My goal is that after attending today's program, you will have a better understanding of the value rigid cover boards deliver to a commercial roof assembly, how they perform in adverse conditions, and how different types of cover boards compare to each other.

Learning Objectives

Upon completion of this course, participants should be able to:

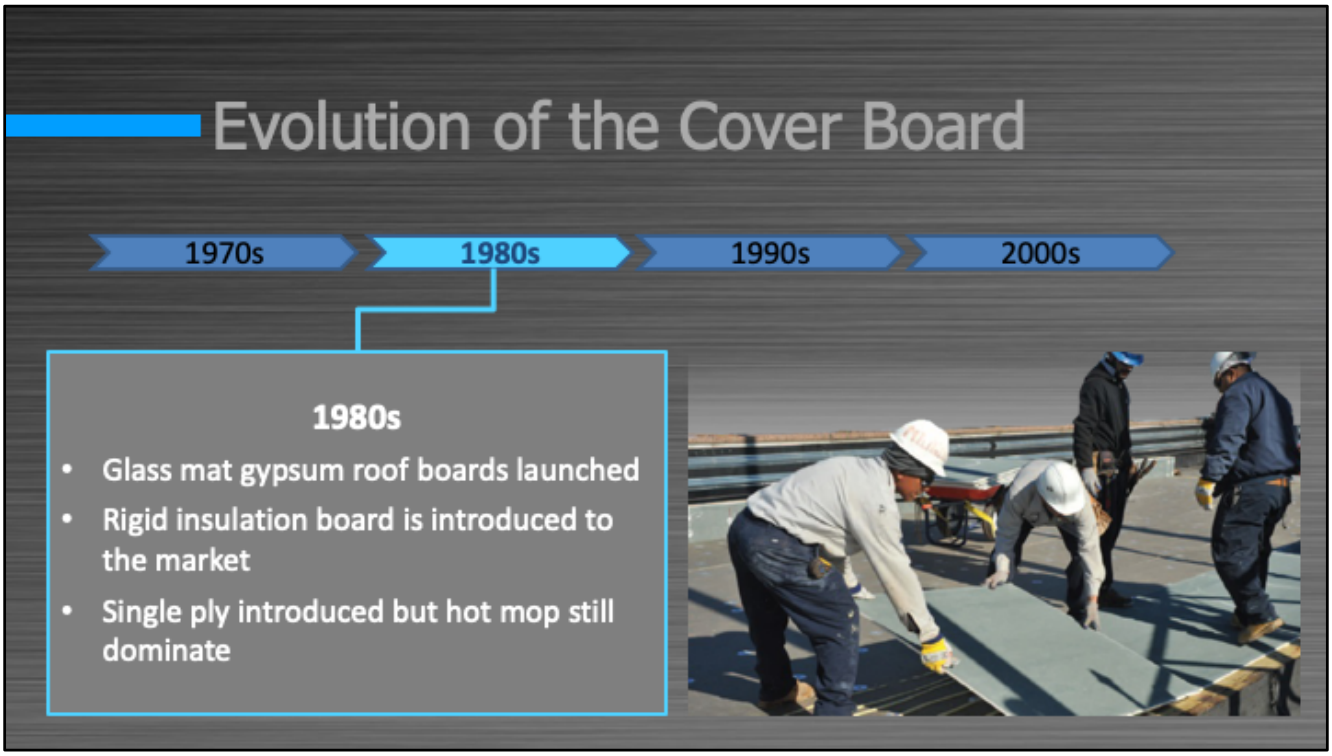
1. Discuss the evolution of roofing cover boards from the 1970s to present day, particularly in light of the use of single-ply membranes.
2. Explain how the forces of nature (i.e., fire, wind uplift, moisture, hail/puncture, foot traffic, and sound) affect roof function and durability of different types of roof cover boards.
3. Summarize the advantages related to the construction process and cost benefits when including a cover board in all types of commercial roof assembly design.
4. Identify the roof system types, specialty systems (i.e., photovoltaic and vegetative roofs), and attachment options that can be utilized specifically with glass mat gypsum cover boards.

Before discussing the performance of today's rigid cover boards, I thought it would be helpful to give some historic perspective to how covers boards have evolved over time to support new types of roof assemblies and meet the growing needs of building owners.



From the 1920s through the 70s, there was very little innovation in commercial roofing compared to the past 30 years. There were changes in material (for example, coal tar pitch to modified bitumen), but the process remained relatively unchanged, mopping the tar/asphalt between multiple layers of felt material.

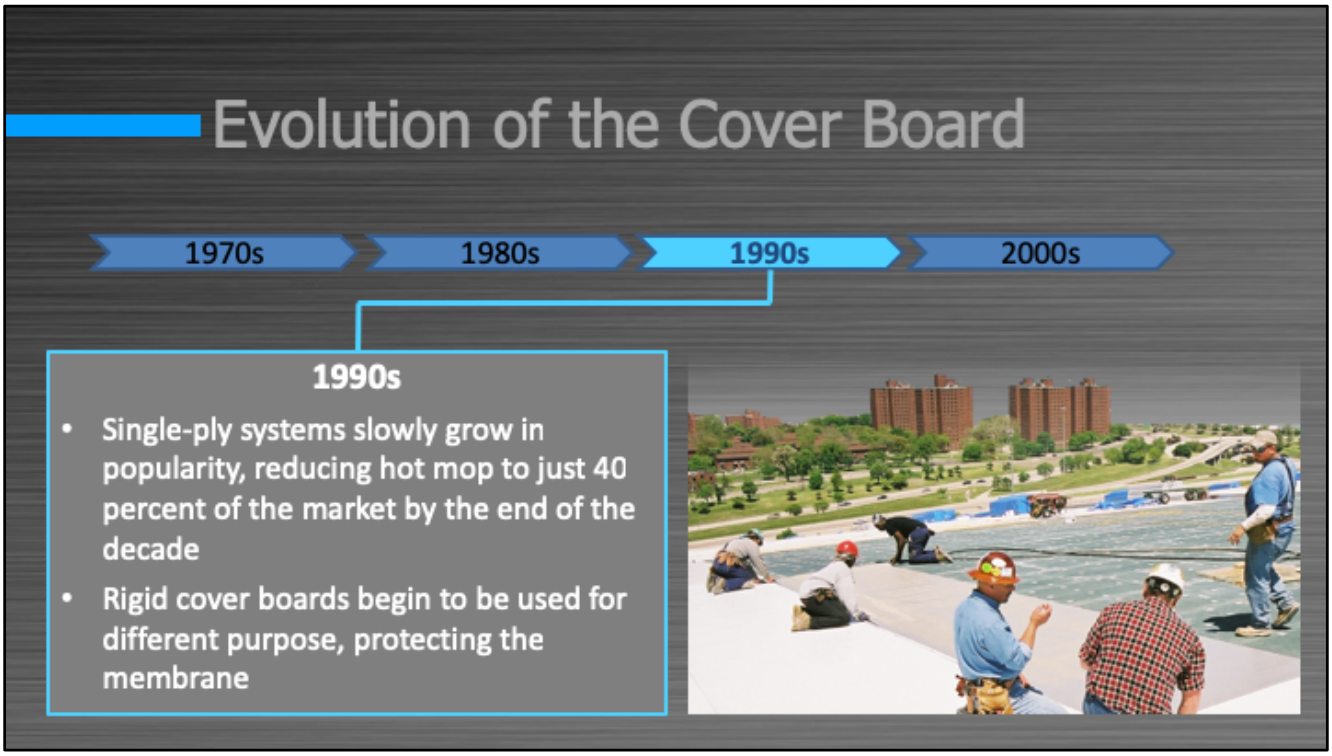
Insulation used in commercial roofing through the 70s was a soft fiberglass material that was rolled over the roof's deck. The main purpose of cover boards (which were called overlayments at the time) was to keep the asphalt from being absorbed into the insulation. Popular overlayment types included perlite and wood fiber boards.



The 1980s marked the start of three decades of innovation. The first glass mat gypsum fiber roof boards were introduced into the market place. These boards provided superior fire resistance, wind uplift performance, moisture resistance, and sound isolation compared to the traditional overlayments.

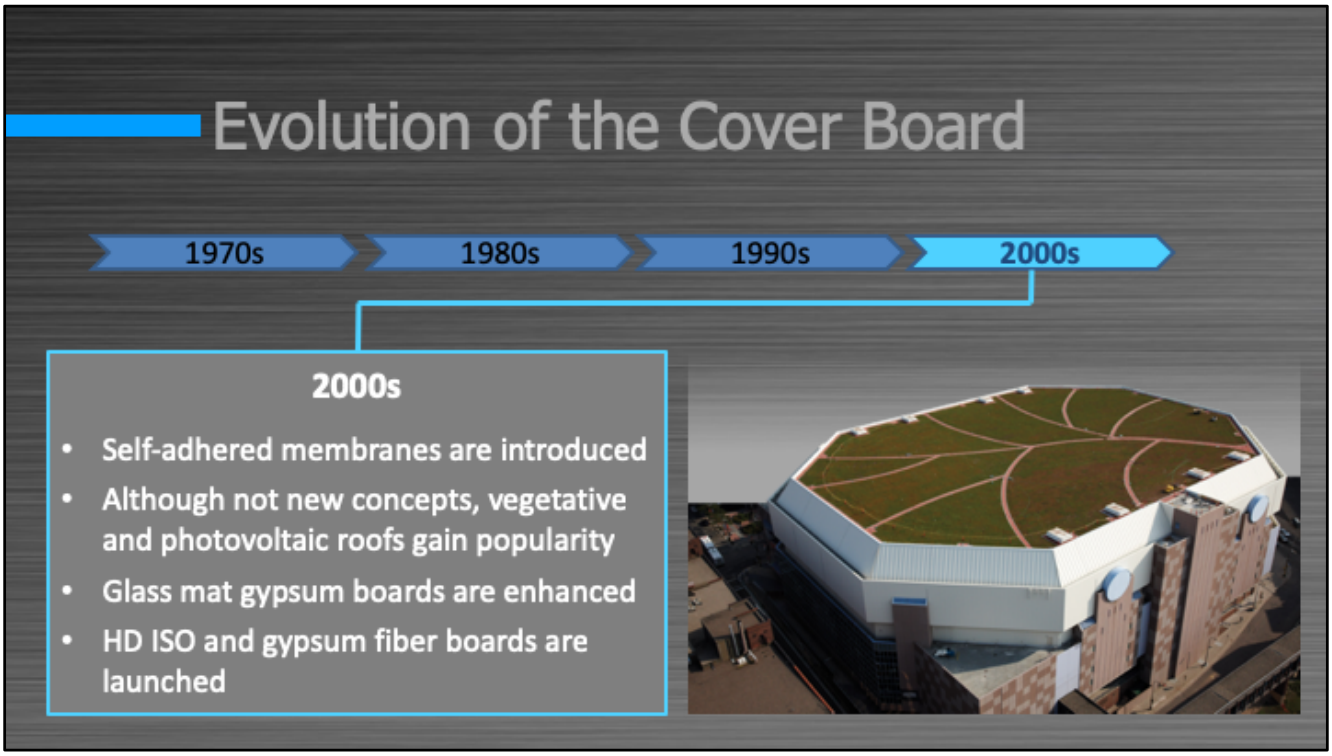
Also introduced in the 80s were the first rigid insulation boards, including ISO boards. These boards were easier to stage and install, provided better R-value, and did not absorb asphalt. There was a lot of innovation with these rigid insulation boards throughout the 80s, with several companies launching new, enhanced boards.

The first single-ply membranes were also introduced in the 80s, but they were slow to catch on, as hot mop assemblies were still very much the norm.



Single-ply systems slowly became more popular in the 1990s, gaining acceptance in the market place due in large part to the ease of installation and overall cost. At the beginning of the 90s, hot mopping accounted for around 80 percent of commercial roof projects; that was cut in half by the end of the decade. Single-ply options provided several benefits, including enhanced energy efficiency and easier/quicker installation on larger roofs and easier to repair.

As the demand for single-ply systems increased, so did the demand for glass mat gypsum cover boards. The cover boards provided a structurally strong and smooth surface to adhere the membrane while protecting the ridged insulation boards from foot traffic, hail impact, wind, and fire.

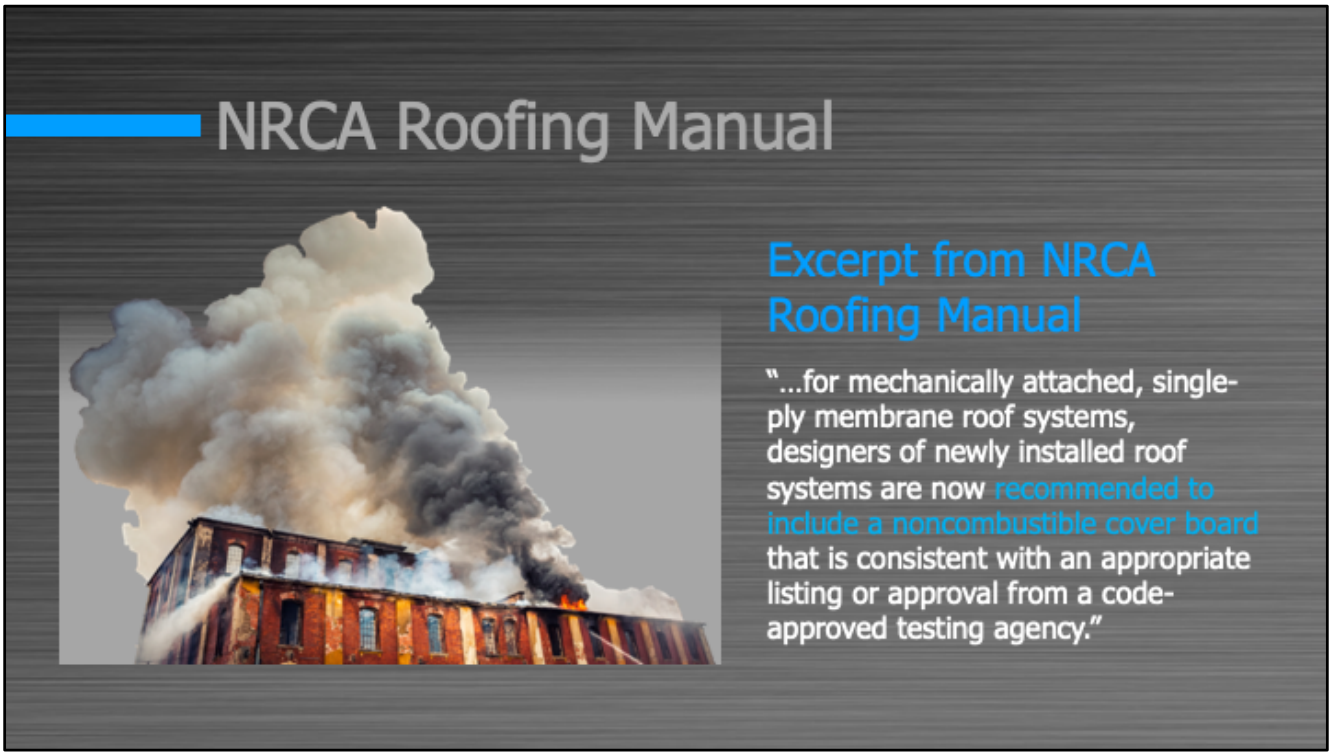


Single-ply membranes continue to grow in popularity through out the 2000s to around 80 percent of the overall market. In response, the demand for cover boards also increased. To feed this demand, HD ISO and gypsum fiber cover boards were introduced to the market and glass mat gypsum boards were enhanced to improve adhesive coverage.

The trend for companies to lower their carbon footprint by reducing their reliance on fossil fuels led to an increase in vegetative and photovoltaic roofs. These alternatives also benefited from federal and local tax incentives. We'll talk more about alternative systems toward the end of our presentation.

Roofing is a big investment—and it protects an even bigger investment in the building and its contents. That's why durability in any roofing system is so important: it translates directly into lower total cost of ownership. Given the number of low-slope commercial roofs found in today's metropolitan cities, it's key that architects/designers have an understanding of the forces that affect the durability of a roof assembly and the high-performance options that are available in order to choose the best solution for each project.

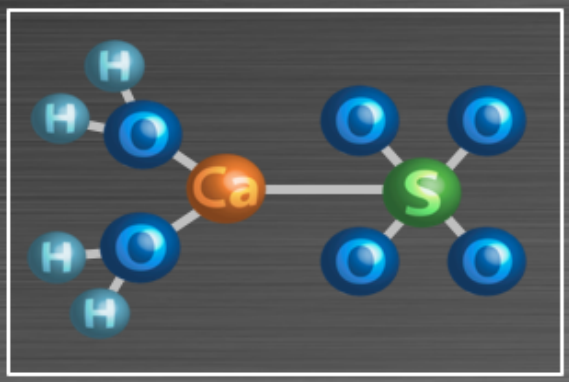

Performance in
Adverse Conditions
Fire



The NCRA recommends the inclusion of a noncombustible cover board for mechanically attached, single-ply membrane roof systems.

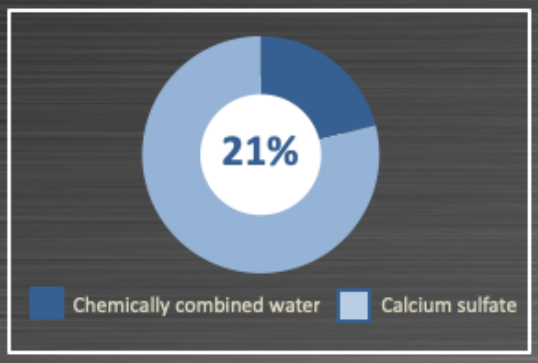
The Magic of Gypsum Based Roof Boards

Built-in Fire Resistance



- Pure gypsum crystal is $CaSO_4 – 2H_20$ and is known as Calcium Sulfate Dihydrate
- Gypsum naturally occurs in crystal form
- Includes two molecules of crystal water (H_20)
- Same properties with synthetic sources

The Magic of Gypsum-Based Roof Boards



Gypsum Contents

Gypsum: 21% chemically combined water
79% calcium sulfate

Calcium sulfate remains inert below a temperature of 2,200 degrees Fahrenheit

Chemically Combined Water

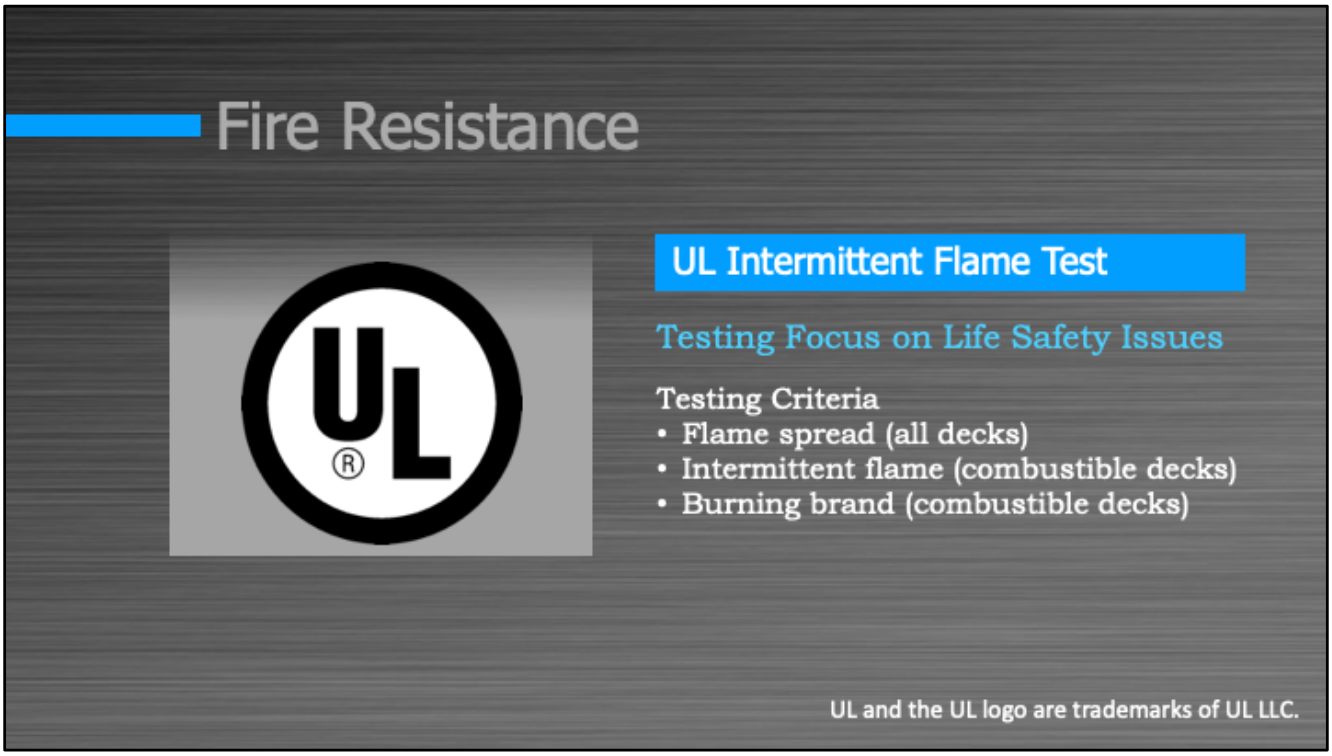
One 5/8-inch 4-by-8-foot gypsum roof board contains approximately 2 gallons of crystal water

Gypsum's Performance in a Fire

Fire resistance in a roofing system comes from all roof components working together—and the choice of cover board can either enhance or detract from fire resistance.

Where the decking, insulation, or membrane may be combustible, a noncombustible cover board can contribute to a better fire rating.

There are two predominate fire-testing bodies in the United States governing fire issues, such as external and internal exposure, code compliance, life safety issues, and insurance premiums.



UL is mainly concerned with life safety issues and provides interior and exterior classification ratings.

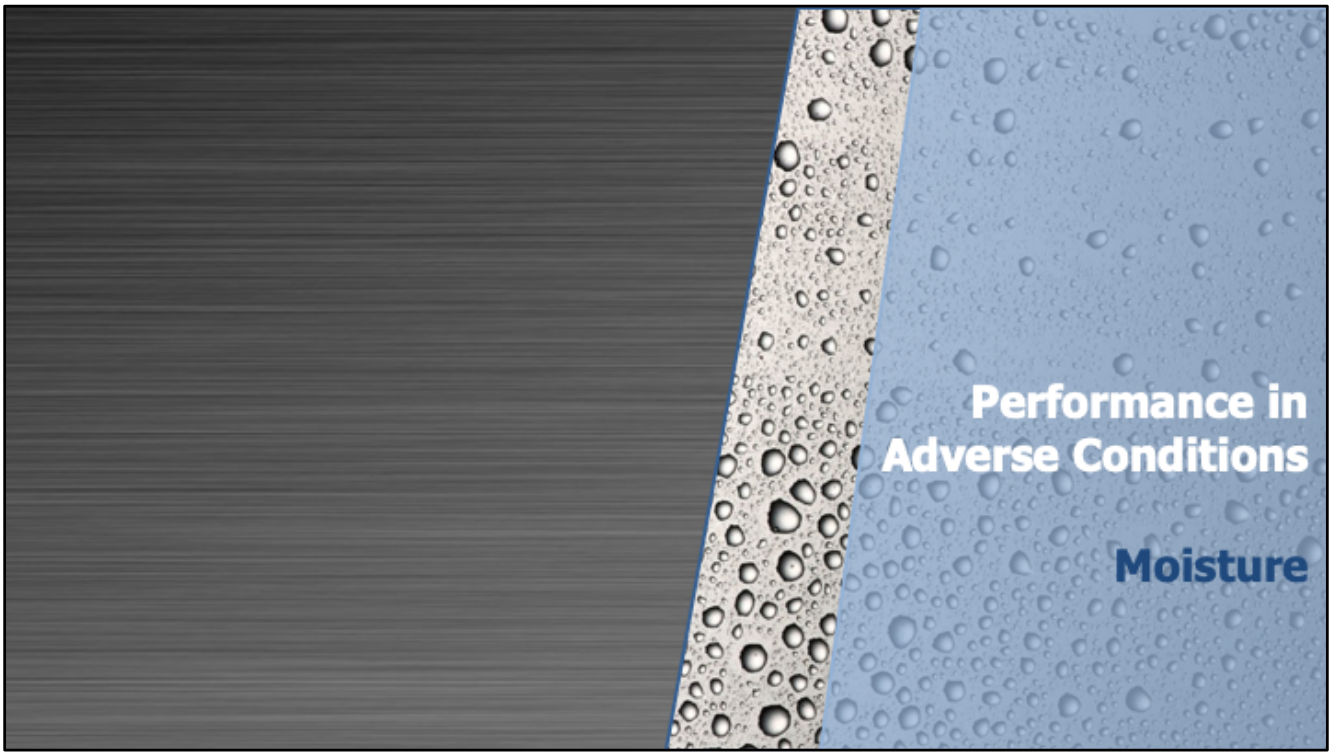
Note: For non-combustible decks, only the spread of flame test is required.

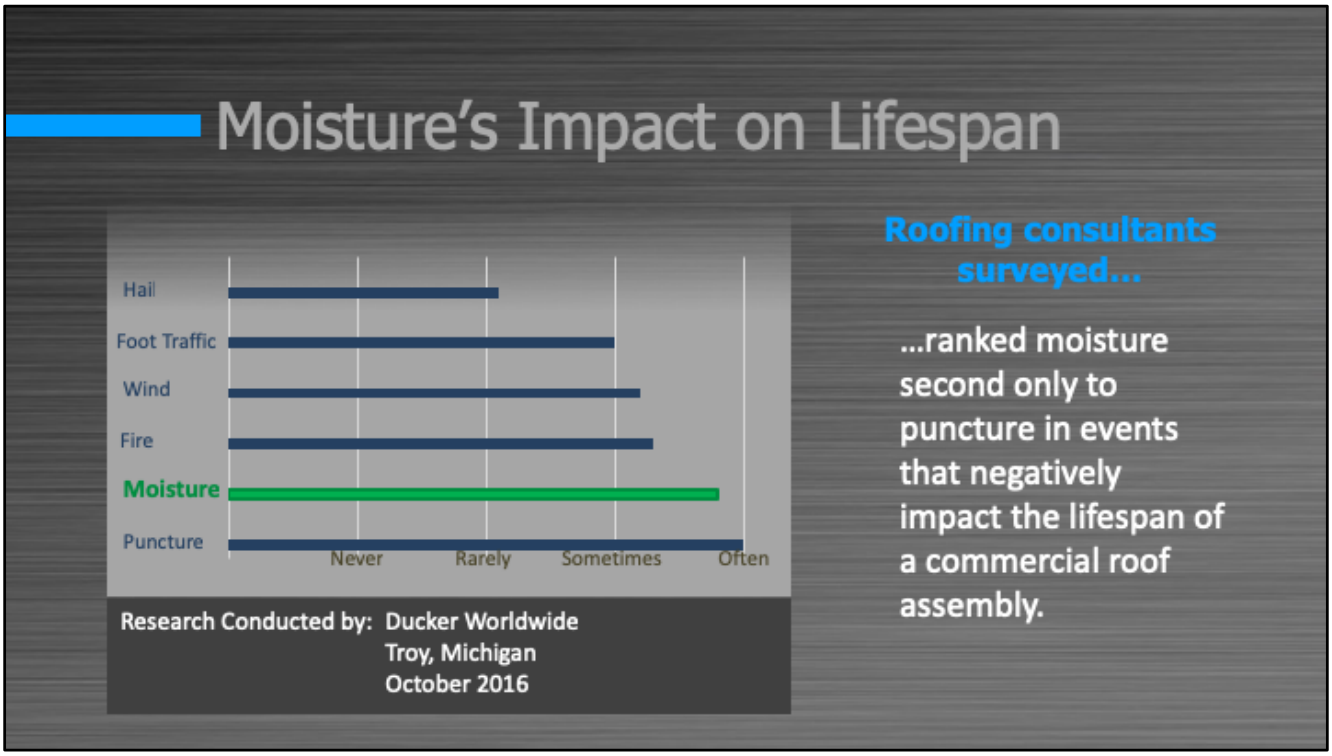
The interior classification “P” assemblies test the resistance to fires that start within the building.

FM classifications 1, 2, and 3 are concerned with loss prevention issues including fire, wind uplift, foot traffic and hail damage resistance.

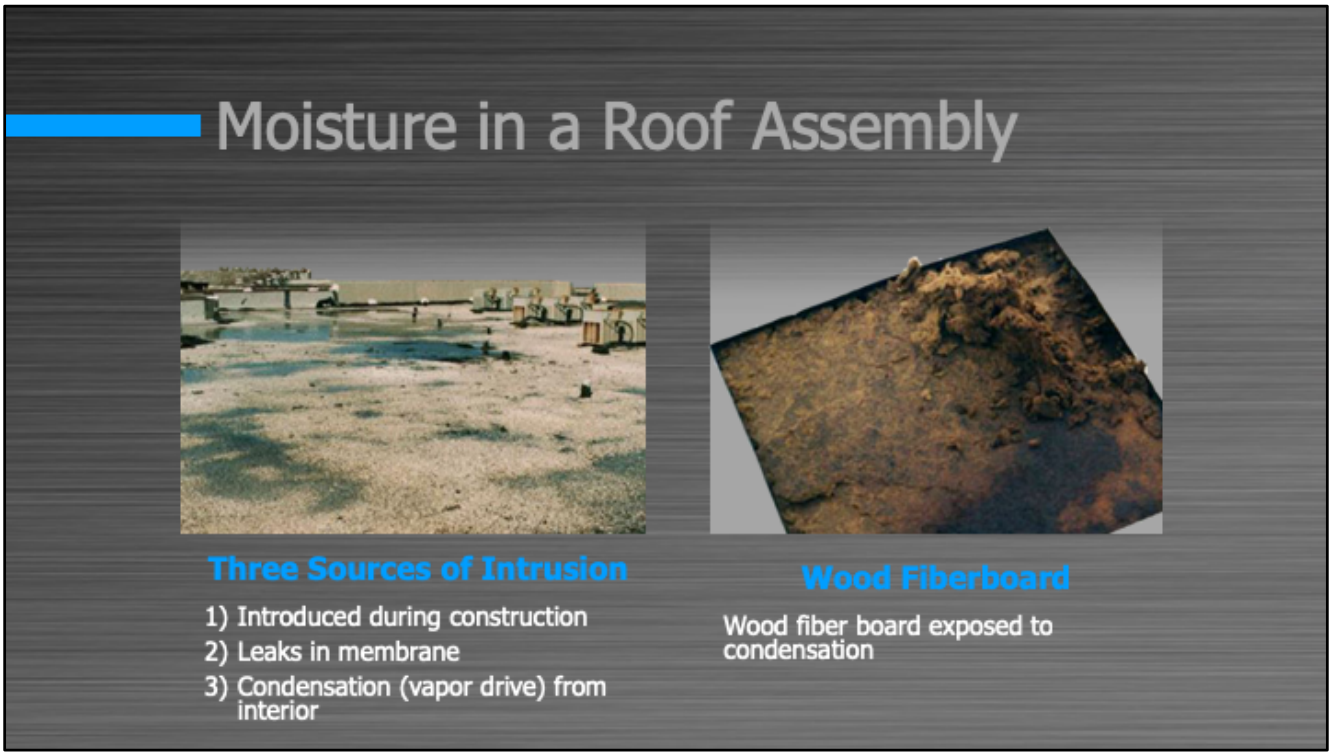
Additionally, the Calorimeter (Class 1) test measures the fuel contributed by the assembly from inside the building.

Keep in mind, that lower-risk fire ratings can both ensure code compliance and help reduce insurance premiums. For example, roofing systems that qualify for a FM Class 1 rating will qualify for the lowest insurance rates from FM affiliated insurance companies. A UL Class A rating (for external fire exposure) can also help qualify for lower premiums.


Performance in
Adverse Conditions
Moisture



In a recent survey of roofing contractors, participants ranked moisture second only to puncture as events that have the largest effect on the lifespan of a roof assembly.



1. **Introduced During Construction**
   Since roof construction is completed outdoors and the weather conditions can't be controlled, a contractor may need to work under damp conditions to satisfy construction schedules or protect the building's interior. In these instances, rain and dew may become trapped and retained in roofing materials.

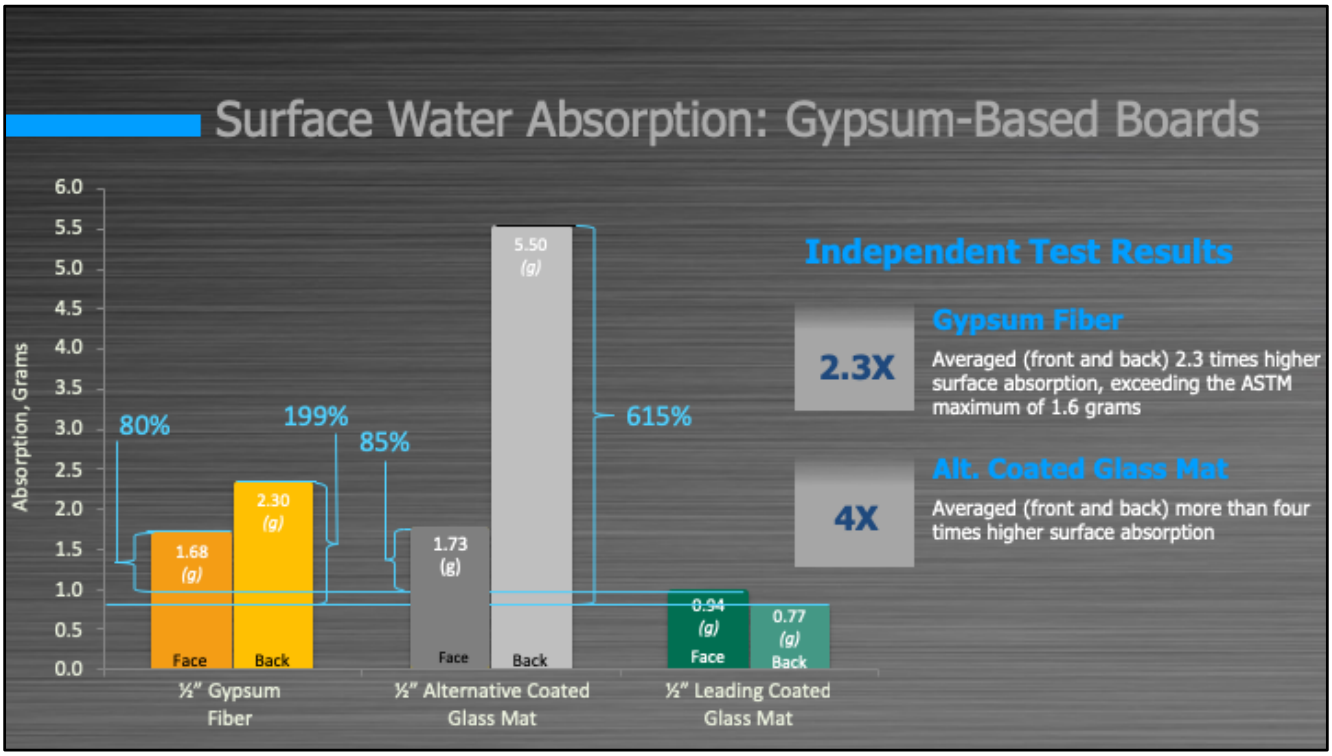
2. **Roof Leaks**
   Even the smallest penetration in a roof allows water to enter the roof assembly.

3. **Condensation**
   Not only do roofing products get wet from the outside—from rain and leaks in the membrane—but also from condensing water vapor from inside the building. When high-humidity indoor air meets the cooler underside of the roof membrane, the water vapor reaches dew point and condenses to a liquid. There are always opportunities for the water vapor to enter the roof assembly.

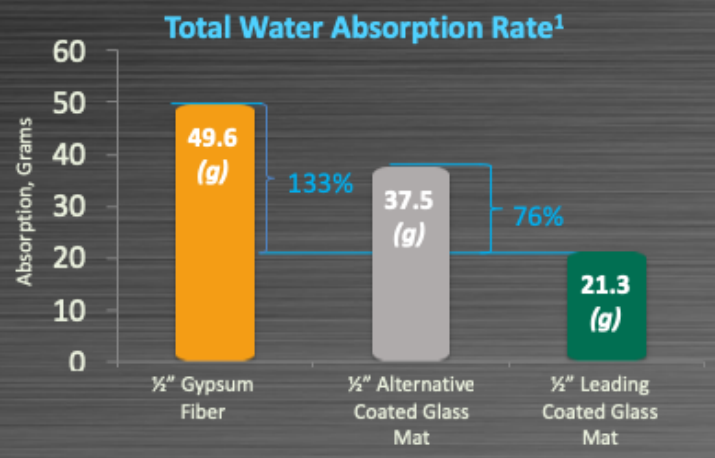
When water enters a roof assembly, it can adversely affect the performance of many components. Insulation can lose its R-value, fiber-type boards can lose their strength, and even plywood and OSB can warp and delaminate.

Products that hold up to water intrusion can survive and continue to perform.

Pictured is an example of wood fiberboard that has been exposed to condensation. The board has turned into wet pulp, resembling oatmeal.


Surface Water Absorption: Gypsum-Based Boards
Absorption, Grams
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
80%
199%
85%
615%
1.68 (g)
2.30 (g)
1.73 (g)
5.50 (g)
0.94 (g)
0.77 (g)
Face
Back
Face
Back
Face
Back
½" Gypsum Fiber
½" Alternative Coated Glass Mat
½" Leading Coated Glass Mat
Independent Test Results
2.3X
Gypsum Fiber
Averaged (front and back) 2.3 times higher surface absorption, exceeding the ASTM maximum of 1.6 grams
4X
Alt. Coated Glass Mat
Averaged (front and back) more than four times higher surface absorption

Total Water Absorption: Gypsum-Based Boards



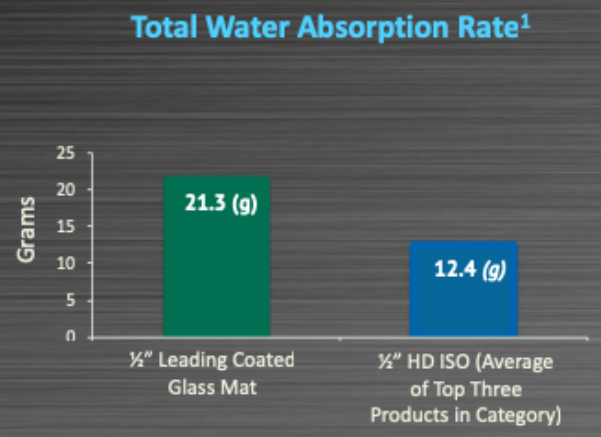
Independent Test Results[1]

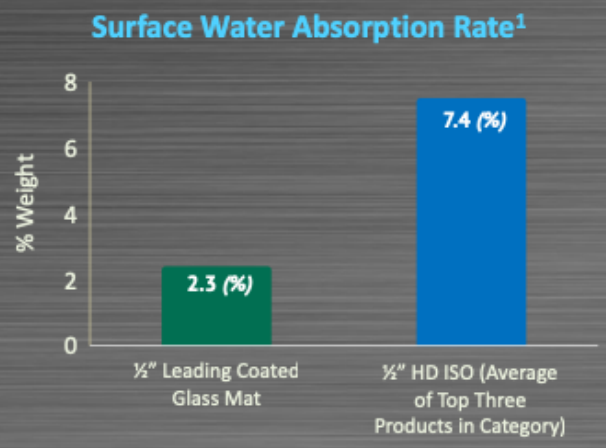
133% — **Gypsum Fiber**
Absorbed 2.3 times more water than the highest-performing coated glass mat gypsum board

76% — **Alt. Coated Glass Mat**
Absorbed 76 percent more water than the leading coated glass mat

1) Independent, third-party testing conducted by PRI Construction Materials Technologies concluding in October 2017. Test conducted in accordance to ASTM C473 to meet ASTM C1177.

Total & Surface Water Absorption: HD ISO Comparison





1) Independent, third-party testing conducted by PRI Construction Materials Technologies concluding in October 2017. Test conducted in accordance to ASTM C473 to meet ASTM C1177.

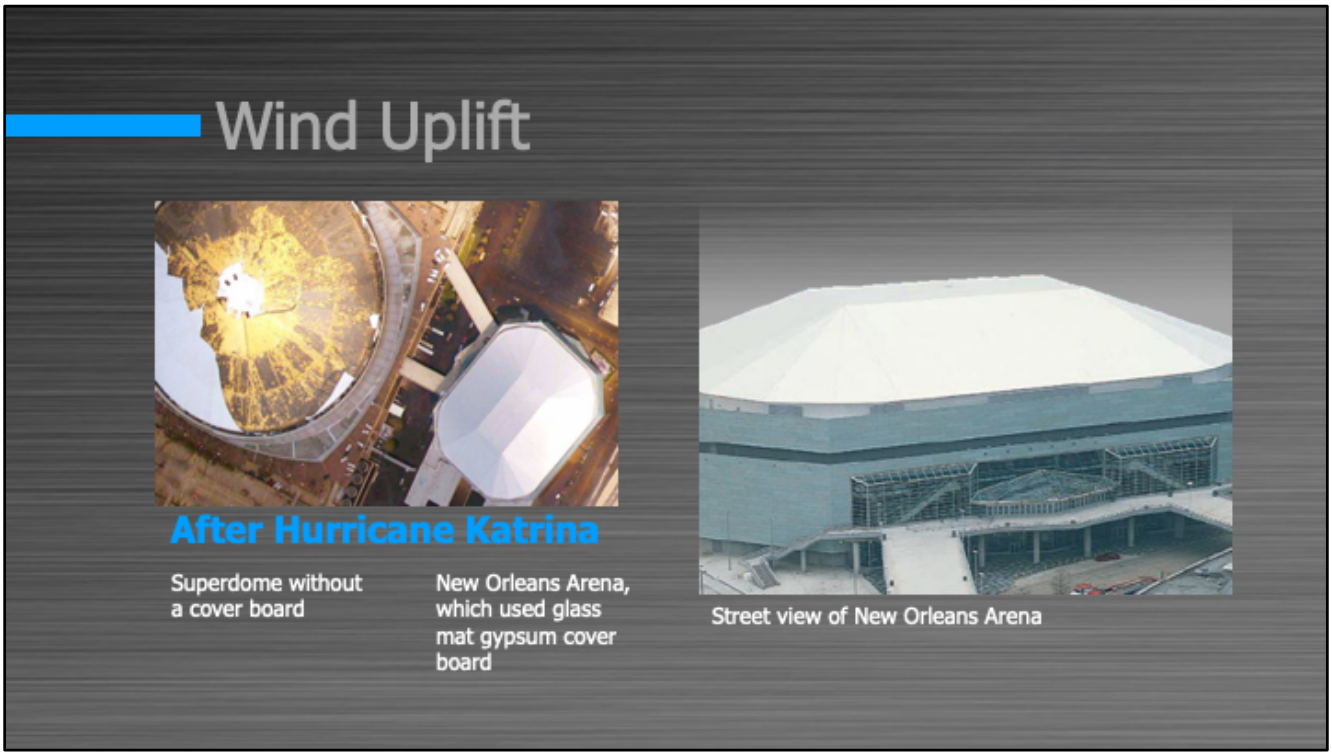
Moisture-Related Manufacturing Specifications

High-Performance Specifications

Look for roof boards with manufacturing specifications that include:

- 5 percent maximum total water absorption by weight
- 1 gram surface water absorption (face and back)

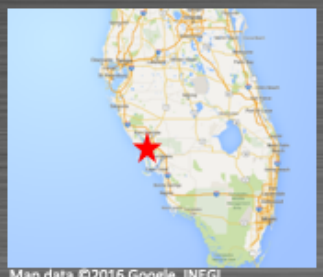

Performance in
Adverse Conditions
Wind Uplift



This aerial photographic is of the Superdome and New Orleans Arena after the devastation caused by Hurricane Katrina. The superdome, which did not include a cover board, obviously has endured a complete loss when it comes to the roof. Compare that to the New Orleans Arena, which used a glass mat gypsum cover board and did not experience any noticeable loss.

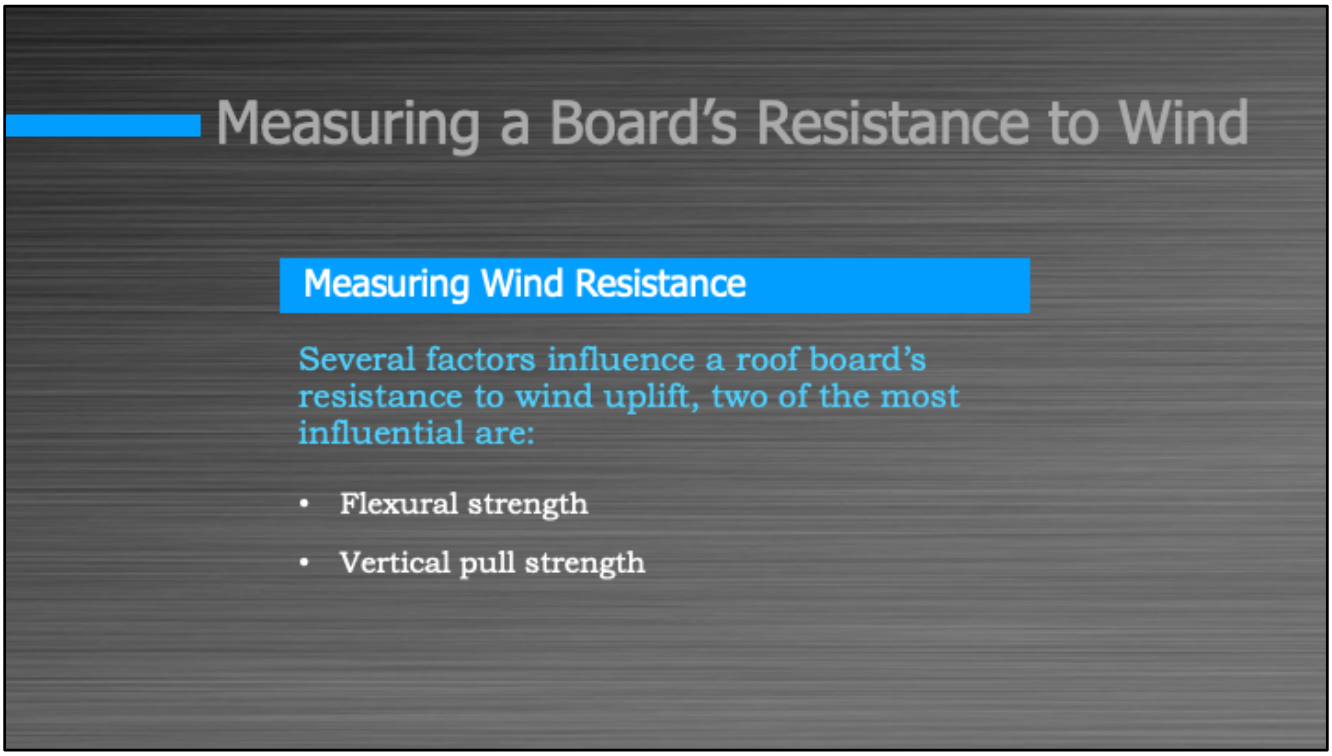
Is this a completely fair comparison? No. Even though the roofs were roughly the same age, the Superdome has a much larger roof surface, at a different pitch and height. But, the contrast in the level of damage is so stark, I think it stands as a good visual representation of how a gypsum cover board can enhance a roof assembly's wind-uplift performance.

Wind Uplift



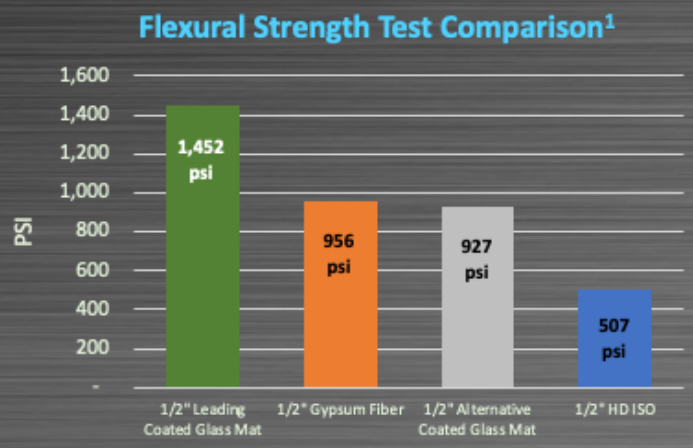
Hurricane Charley

Damaged commercial roof in Port Charlotte, Florida



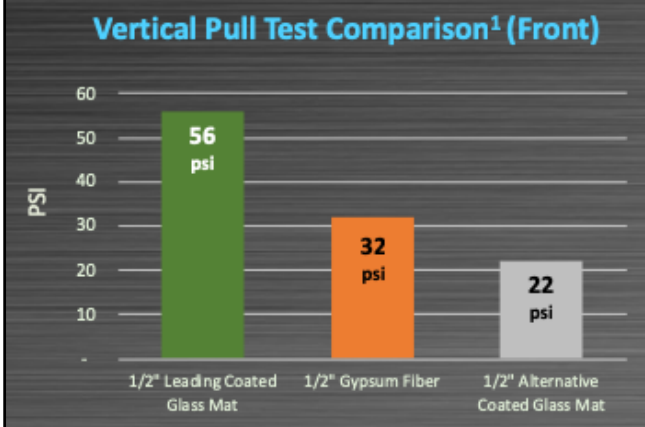
Flexural strength is more critical for mechanically attached, and vertical pull strength is more critical for fully adhered.

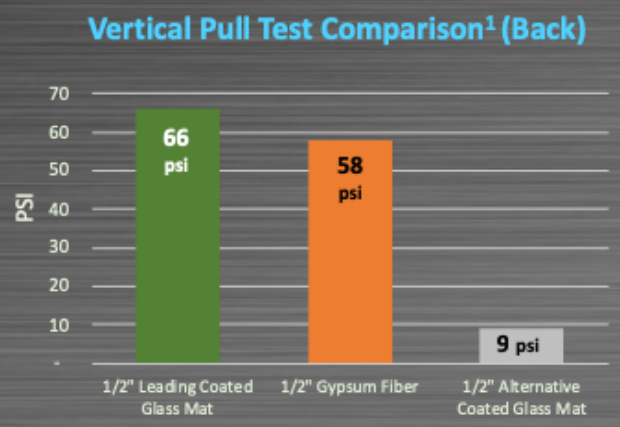
Measuring a Board's Resistance to Wind



1) Independent, third-party testing conducted by Trinity ERD in Columbia, South Carolina, concluding in October 2016 and December 2017. Test conducted in accordance to ASTM C1177

Measuring a Board's Resistance to Wind





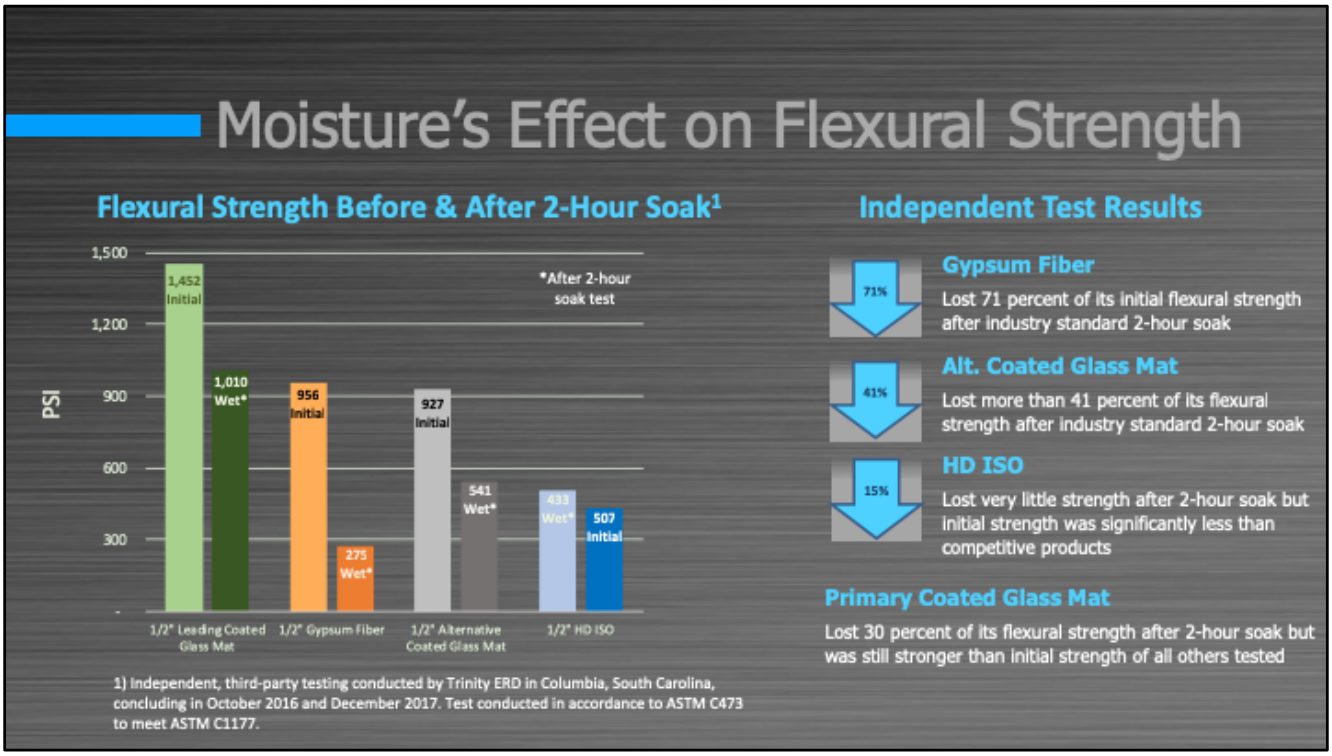
1) Testing conducted by PRI Construction Materials Technologies in October 2017 and in accordance to ASTM C 209.

Moisture's Effect on Wind Resistance

The Truth about Moisture

All roof boards lose strength when exposed to moisture, which is why you should avoid exposure before, during, and after installation.

The amount of strength loss varies greatly for each type of board.



Change to graph format in flyer

Another force that tests roof system durability is puncture due to hail or equipment. Reducing or preventing roof damage from hail impact can save hundreds of thousands of dollars in a single storm.

Without a protective cover board, impact from hail can damage both the insulation and the membrane and may result in loss of roof use and loss of contents.

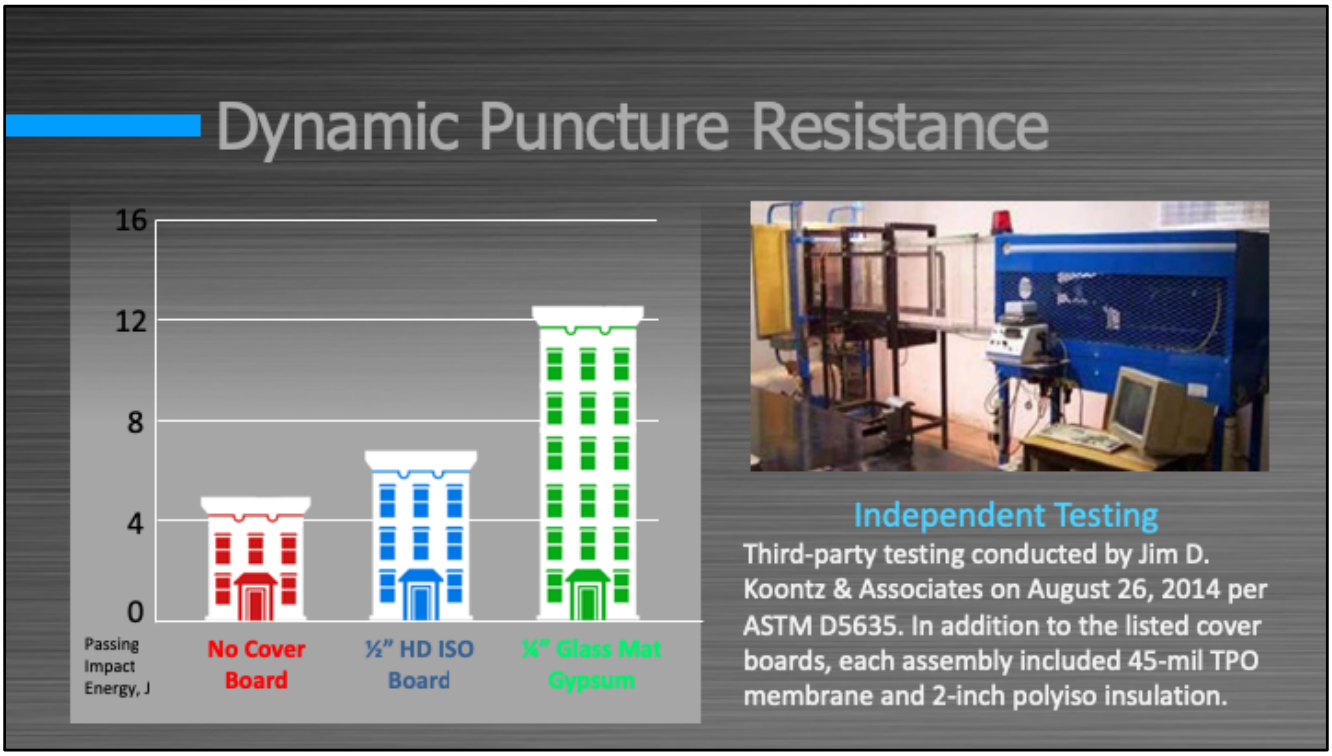
Note: Click on image to start the video, Cover Boards Distribute Impact and Improve Puncture Resistance.

Adding a cover board as a protective substrate between the foam insulation and the roofing membrane can moderate both these problems.

A rigid cover board with good compressive strength distributes impact to prevent insulation compression. Cover boards also help improve puncture resistance by supporting the membrane. But the board requires the right degree of compression strength.

Wood fiberboard typically resists compression loads of 20 to 30 psi. That's too low to protect the foam insulation from large hail.

For installations where hail is a concern, a better choice would be a cover board that can handle compression loads in the 500–900 psi range (e.g., fiberglass mat gypsum board), which is hard enough to protect the foam insulation from the impact of very large hailstones but can still flex to cushion the membrane itself.



The protection cover boards deliver to roof assemblies in areas prone to hail activity is sizeable. Independent testing revealed that ¼-inch glass mat gypsum cover boards delivered 2.5 times or 150 percent more puncture resistance then no cover board at all per ASTM D5635. This is the test that shoots ice balls at the test assemblies using the machine you see here.

½-inch HD ISO delivered 67 percent greater puncture resistance then no cover board at all.

Hail Impact: Cover Board Performance

Hail Stone Size Required to Fracture

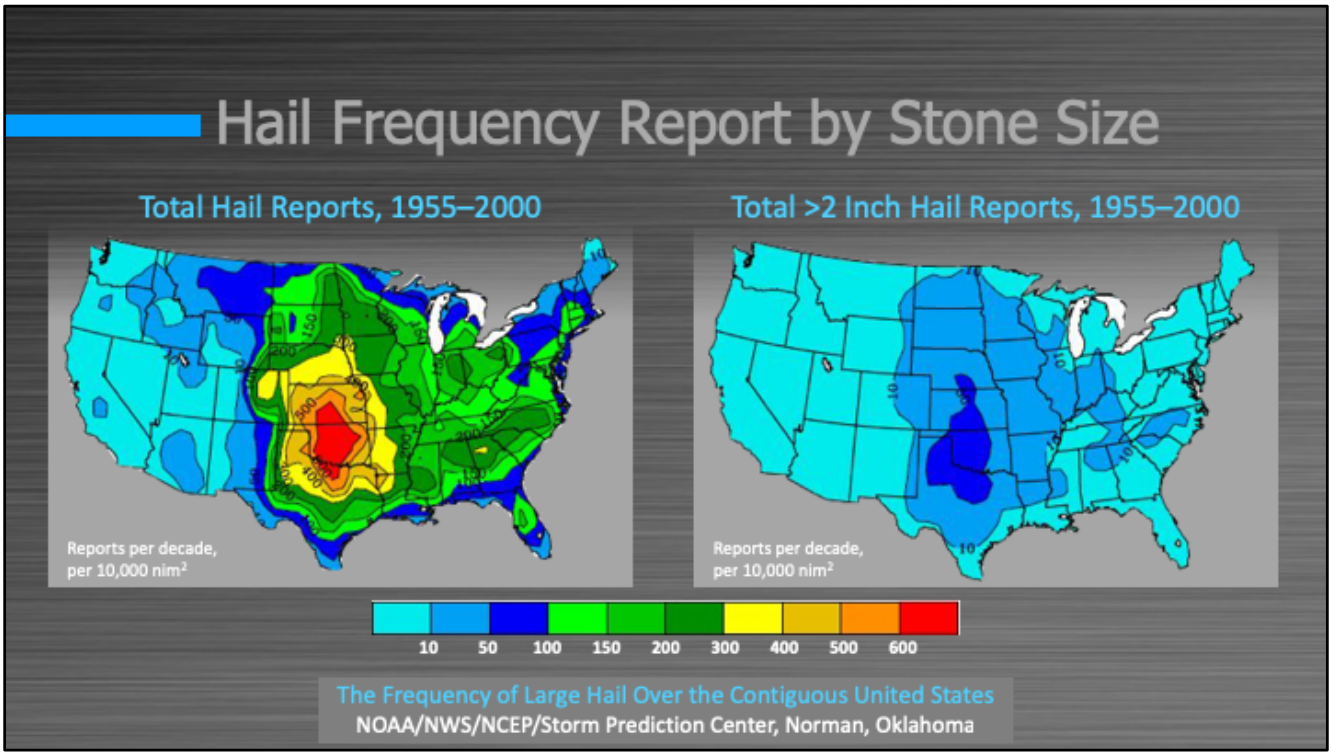
Cover Board Type	Hail Stone Size Required to Fracture Cover Board	Hail Stone Size Required to Fracture Insulation Board
HD ISO	1.5 Inches	1.5 Inches
Gypsum-Fiber	1.0 Inches	1.5 Inches
Glass-Mat Gypsum	2.0 Inches	2.0 Inches

Hail Size Comparison Chart

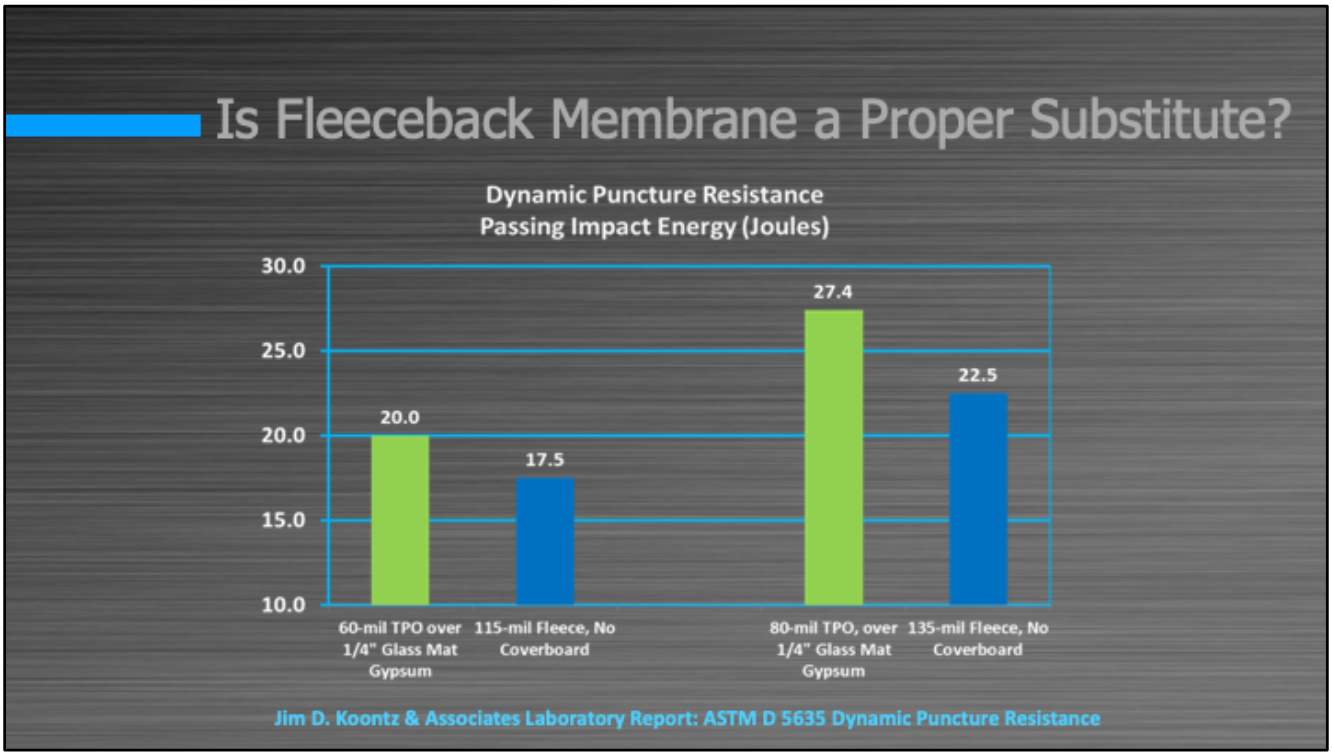
Test performed by Jim D. Koontz & Associates, Laboratory Report: Ice Sphere Impact Testing, August 26, 2014.

This testing, conducted in August of 2014 at Jim D. Koontz & Associates lab, measured the size of hail needed to fracture a cover board and fracture the insulation board beneath the cover board. As you can see, glass mat gypsum cover boards performed best in this testing, requiring a 2-inch hail stone (comparable to a hen's egg) to fracture the cover board and/or insulation board. In contrast, either a 1-inch or 1.5-inch hail stone (comparable to a quarter or a walnut) was needed using gypsum fiber cover boards or HD ISO.

A 1- to ½-inch difference does not sound like a huge swing in performance, but the frequency of hail storms that includes stones less than 2 inches is dramatically higher than storms with stones 2 inches or larger.



These comparison maps provided by the Storm Prediction Center in Norman, Oklahoma, and their partners provide a great visual representation of the decreased likelihood of a roof being exposed to a hail storm with stones 2 inches or greater. Thus, choosing a cover board that can withstand 1.5-inch stones provides a huge advantage.



Fleeceback membranes are a great way to increase the performance of a roof assembly but they are not an adequate substitute for a cover board. Third-party testing results using ASTM D 5635 Dynamic Puncture Resistance has shown a glass mat gypsum board out performs fleeceback membranes by 12.5–17.8 percent pending membrane mil.

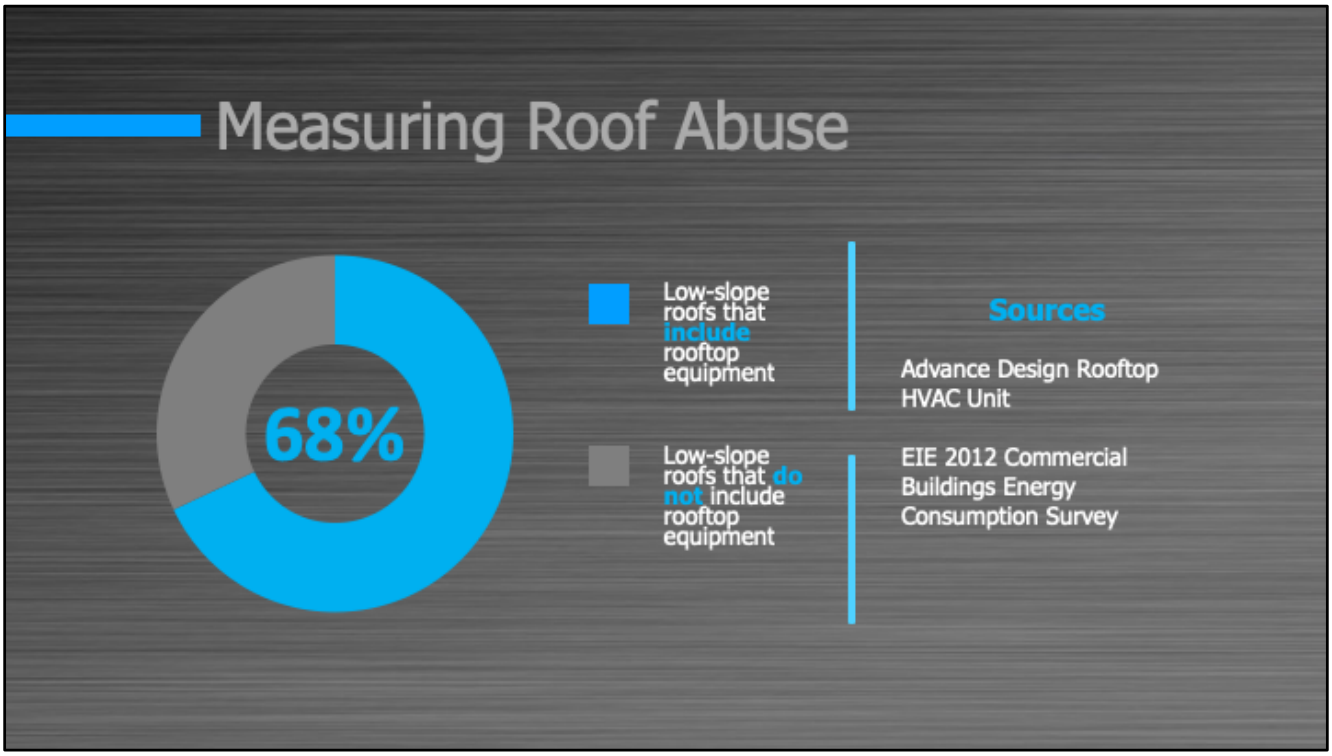

Performance in
Adverse Conditions
Foot Traffic

Although insulation damage from hail impact is obvious, the impact damage caused by foot traffic is less immediately noticeable but more pervasive. While a building is under construction, various trades involved can end up using the roof deck to store materials, causing potential damage. Multiple trades use the completed roof as a staging and storage area. It is easy to see how such practices can lead to a damaged roof assembly.

Foot traffic, wheel barrows, and equipment carts all generate loads that compress unprotected insulation and threaten the membrane with stretching and punctures.

Traffic damage occurs first during installation of the roof itself, then from installation of HVAC, antenna systems, and other roof-top equipment.

Post-construction, routine building maintenance continues the stress, and this is why some roofing system warranties place a limit on the amount of rooftop traffic that can be tolerated.



Building owners rarely realize how much foot traffic their roofs are exposed to.

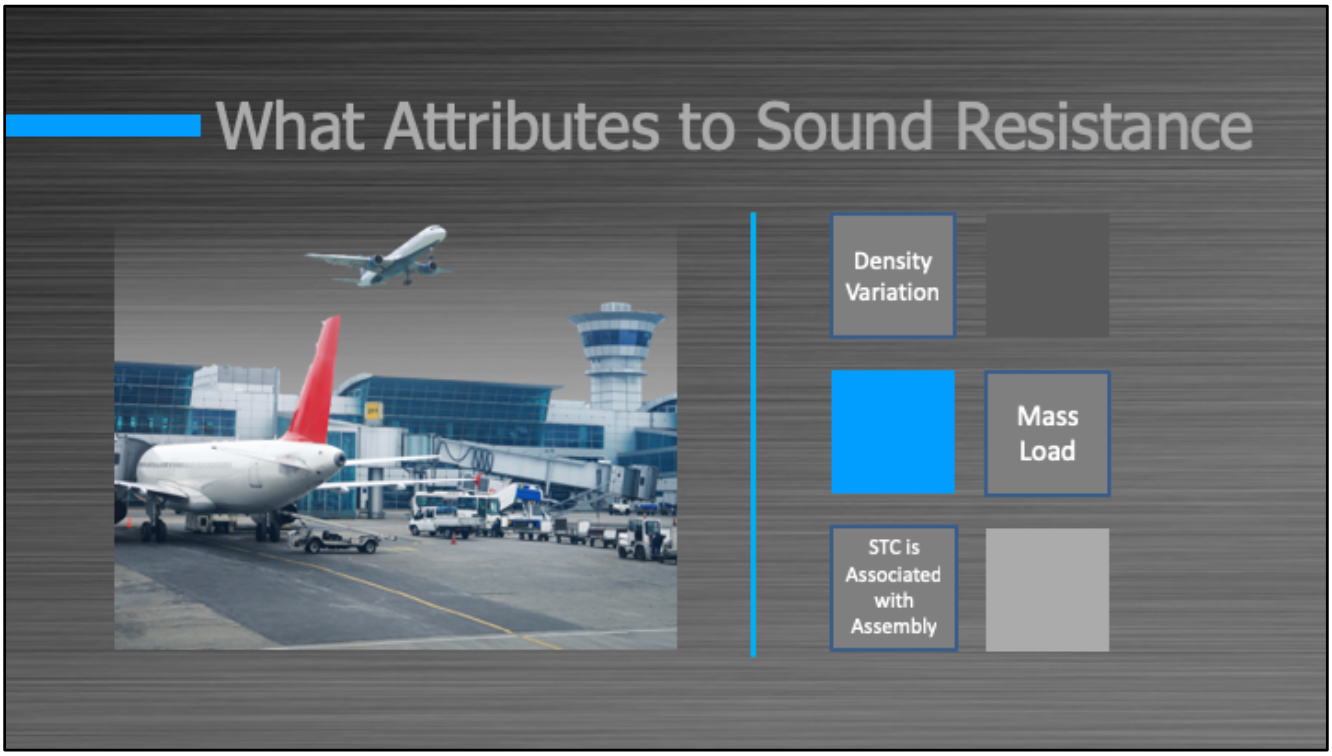
With 68 percent of low-slope systems hosting HVAC and other equipment, the maintenance, emergency servicing, and inspection visits all create foot traffic by individuals who are unaware of the damage caused by their boots and tools.

- Foot traffic on roofs stress the adhesive bond between the membrane and cover board as the materials deflect under load.
- HD ISO has much more deflection under foot-traffic loads and thus has greater stresses on the membrane/HD ISO interface then other gypsum-based cover boards.
- This can cause loss of adhesion leaving the membrane unattached across sections of the roof, which compromises wind-uplift resistance.
- For the contractor, this can result costly callbacks.

Note: The black path is the designed and reinforced maintenance path, and the red path is the most likely path maintenance personnel would take.

Rooftop equipment requires scheduled maintenance, which means personnel with tool boxes and equipment increase the likelihood of impact damage to the insulation caused by foot traffic.

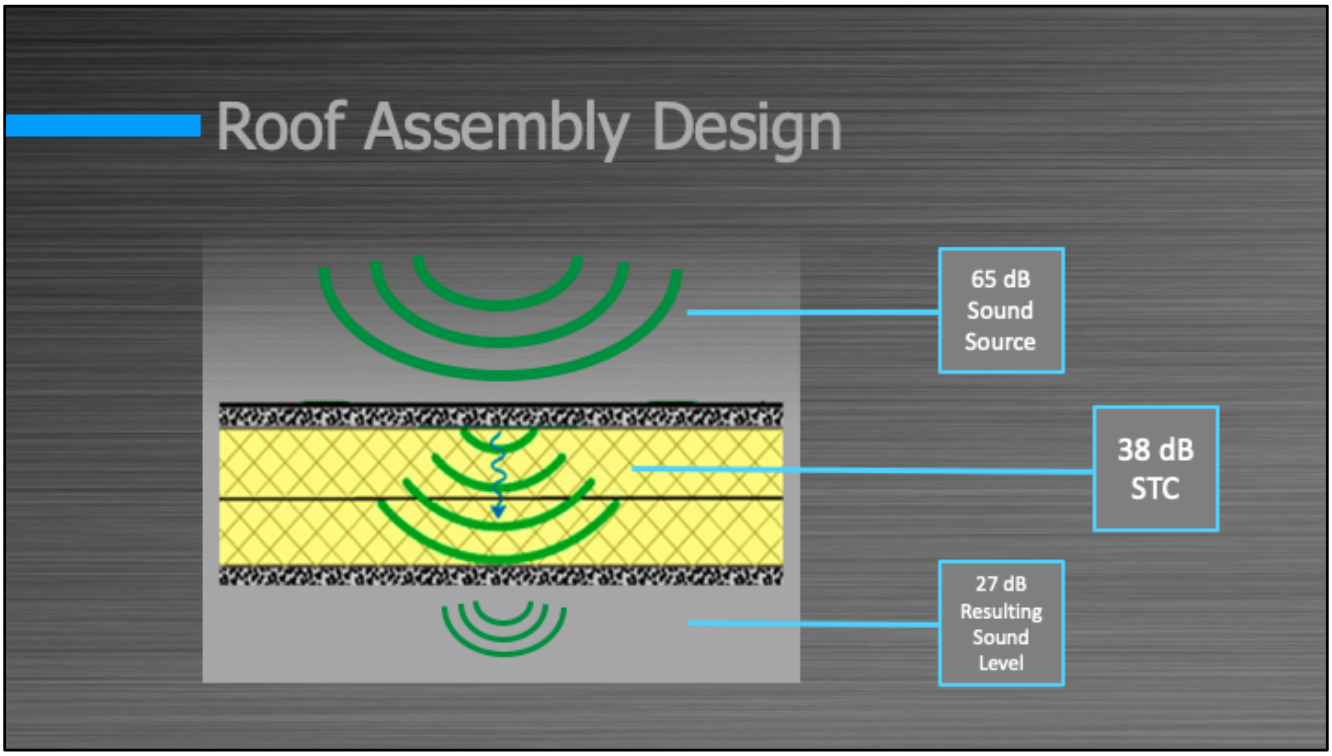

Performance in
Adverse Conditions
Sound



Although sound transmission properties of a roofing system are not part of the physical protection of the roof, sound transmission does affect the quality of life inside the building.

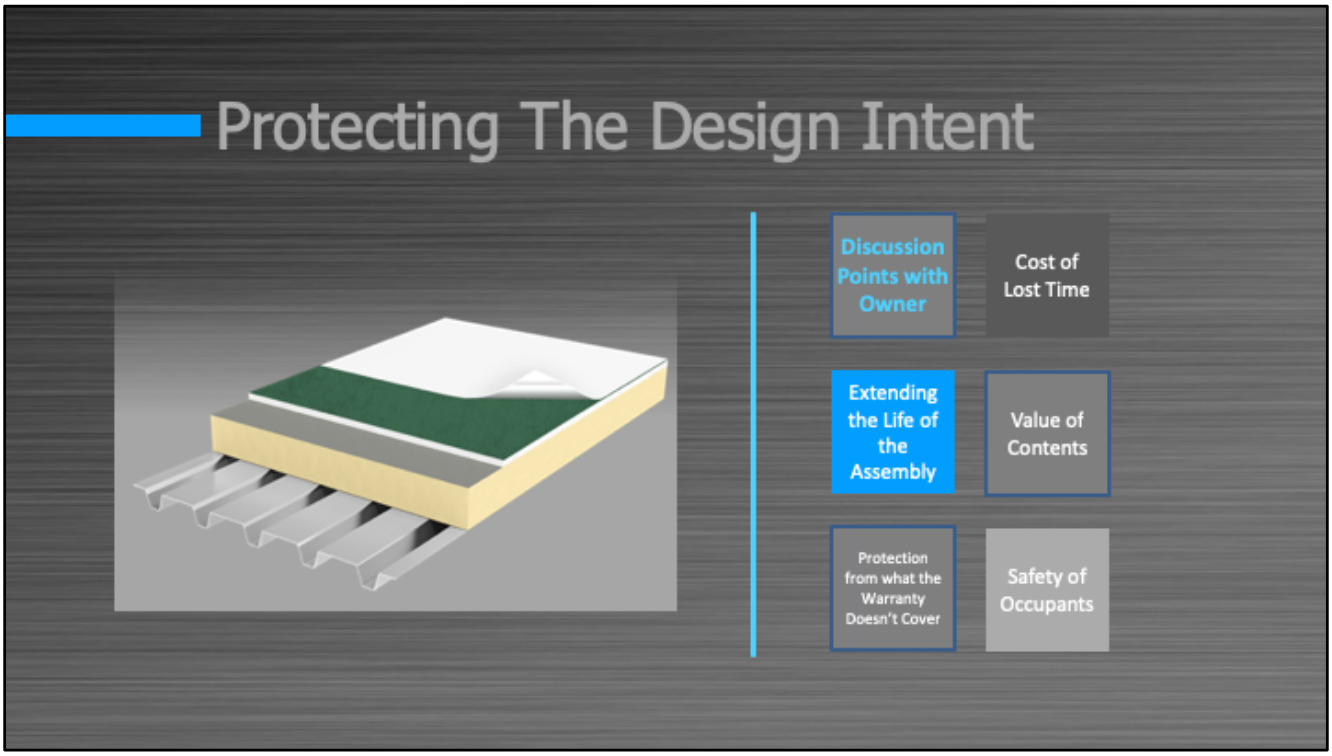
Reducing the noise from traffic, equipment, and aircraft can be a vital function of a roof system.

Adding one or more layers of high density material between the roof insulation and membrane can help attenuate outside noise and significantly increase the sound transmission class (STC) of the roof assembly.



Adding one or more layers of high-density cover board can provide greater sound isolation and reduce the disruption of high-level noise intrusion. In the example shown, the 38-dB STC-rated roof assembly, incorporating 5/8-inch fiberglass mat gypsum underlayment and cover board, reduces the 65-dB outside sound source to 27 dB, which should be below the background sound level within the space. To calculate, subtract the Resulting Sound Level from the Sound Source to determine the Sound Transmission Class (65 dB - 27 dB = 38 dB).


Protecting Design
Intent from
Value Engineering



Protecting the intent of your design from value engineering is obviously more of a concern for architects then consultants, but it's worth mentioning here.

Cover Board Value Creation

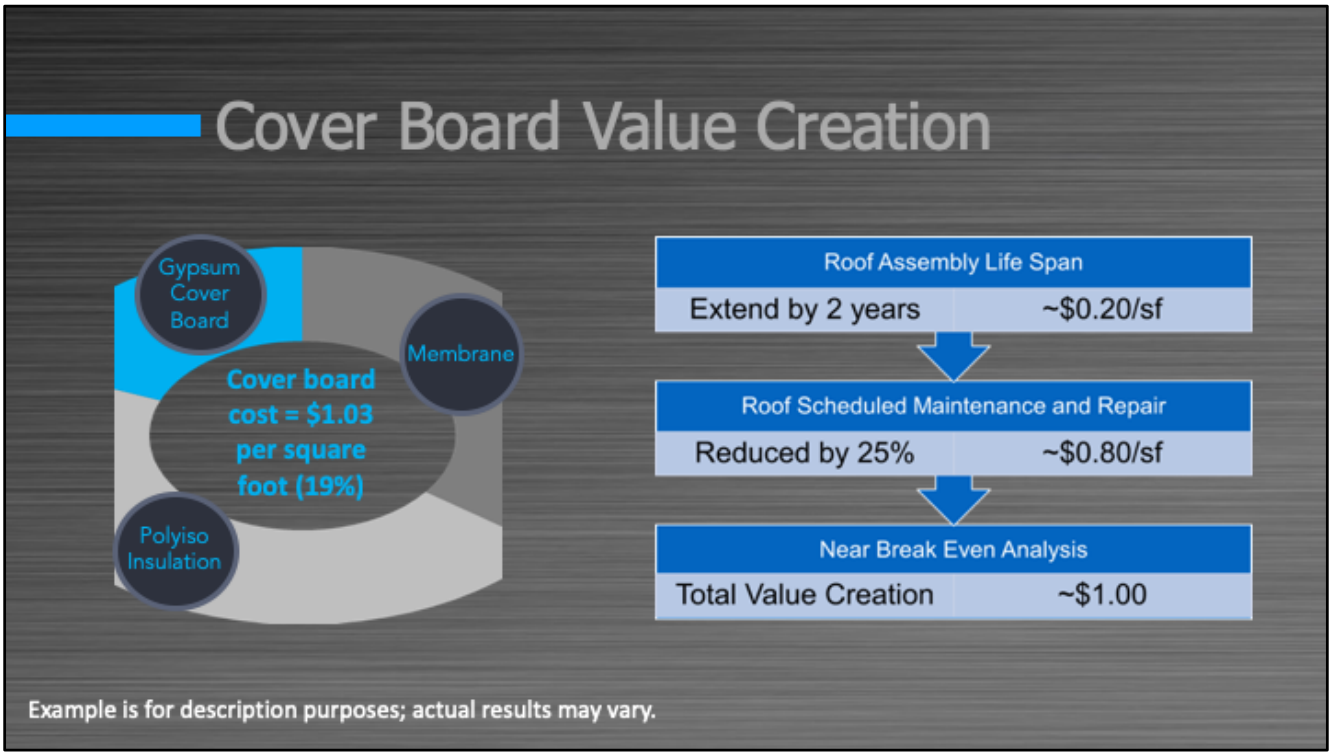
Fully Adhered System	45 Mil Membrane			60 Mil Membrane		
	PVC (48)	TPO (45)	EPDM (45)	PVC (60)	TPO (60)	EPDM (60)
Membrane (incl. attachment)						
Materials	$1.53	$0.78	$1.11	$1.58	$0.90	$1.25
Labor	$0.44	$0.45	$0.44	$0.44	$0.45	$0.44
Equipment	$0.07	$0.08	$0.07	$0.07	$0.08	$0.07
Profit	$0.52	$0.47	$0.48	$0.54	$0.48	$0.50
Total	**$2.56**	**$1.78**	**$2.10**	**$2.63**	**$1.91**	**$2.26**
Polyiso Insulation (3.5")						
Materials	$1.95	$1.95	$1.95	$1.95	$1.95	$1.95
Labor	$0.19	$0.19	$0.19	$0.19	$0.19	$0.19
Equipment	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
Profit	$0.36	$0.36	$0.36	$0.36	$0.36	$0.36
Total	**$2.50**	**$2.50**	**$2.50**	**$2.50**	**$2.50**	**$2.50**
Gypsum Cover Board (1/2" Primed Face)						
Materials	$0.62	$0.62	$0.62	$0.62	$0.62	$0.62
Labor	$0.19	$0.19	$0.19	$0.19	$0.19	$0.19
Equipment	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
Profit	$0.22	$0.22	$0.22	$0.22	$0.22	$0.22
Total	**$1.03**	**$1.03**	**$1.03**	**$1.03**	**$1.03**	**$1.03**
Total						
Materials	$4.10	$3.35	$3.68	$4.15	$3.47	$3.82
Labor	$0.82	$0.83	$0.82	$0.82	$0.83	$0.82
Equipment	$0.07	$0.08	$0.07	$0.07	$0.08	$0.07
Profit	$1.10	$1.05	$1.06	$1.12	$1.06	$1.08
Total	**$6.09**	**$5.31**	**$5.63**	**$6.16**	**$5.44**	**$5.79**
Percent of Assembly from Coverboard	**17%**	**19%**	**18%**	**17%**	**19%**	**18%**

Example are for description purposes; actual results may vary.
Data shows estimated cost per square foot.

Let's take a look at the economic advantages of including a cover board

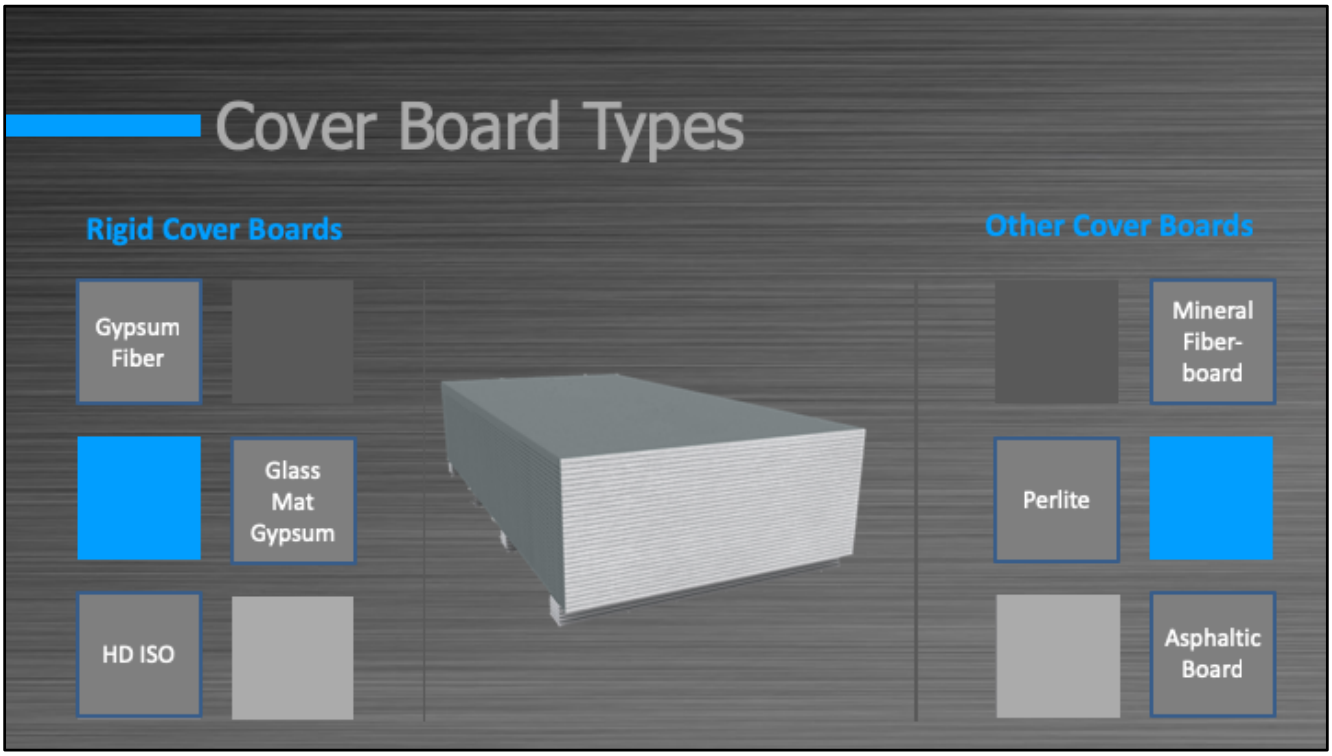
What you're looking at is a overview of costs by line item for fully adhered systems using various membrane types and mils. (Click forward for animated column.)

For the purposes of our discussion, lets take a closer look at one of the options: 60 Mil TPO Membrane.

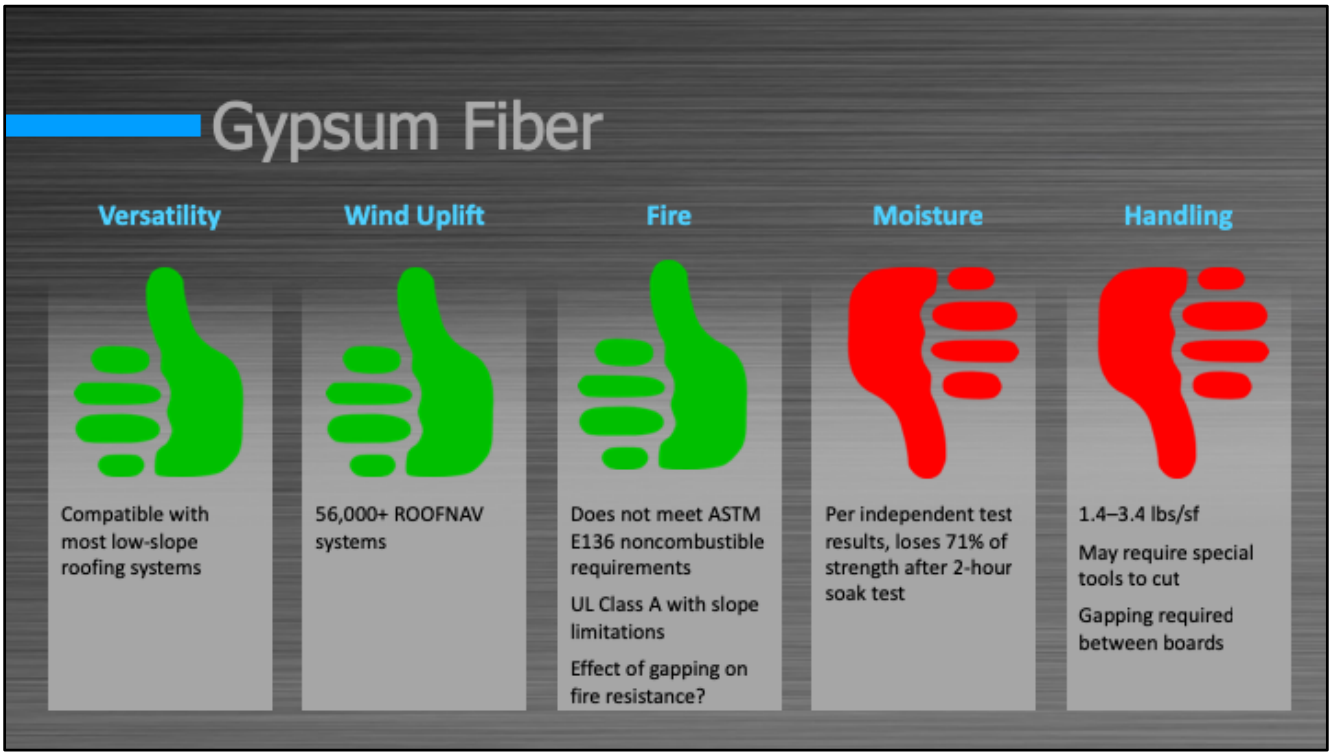


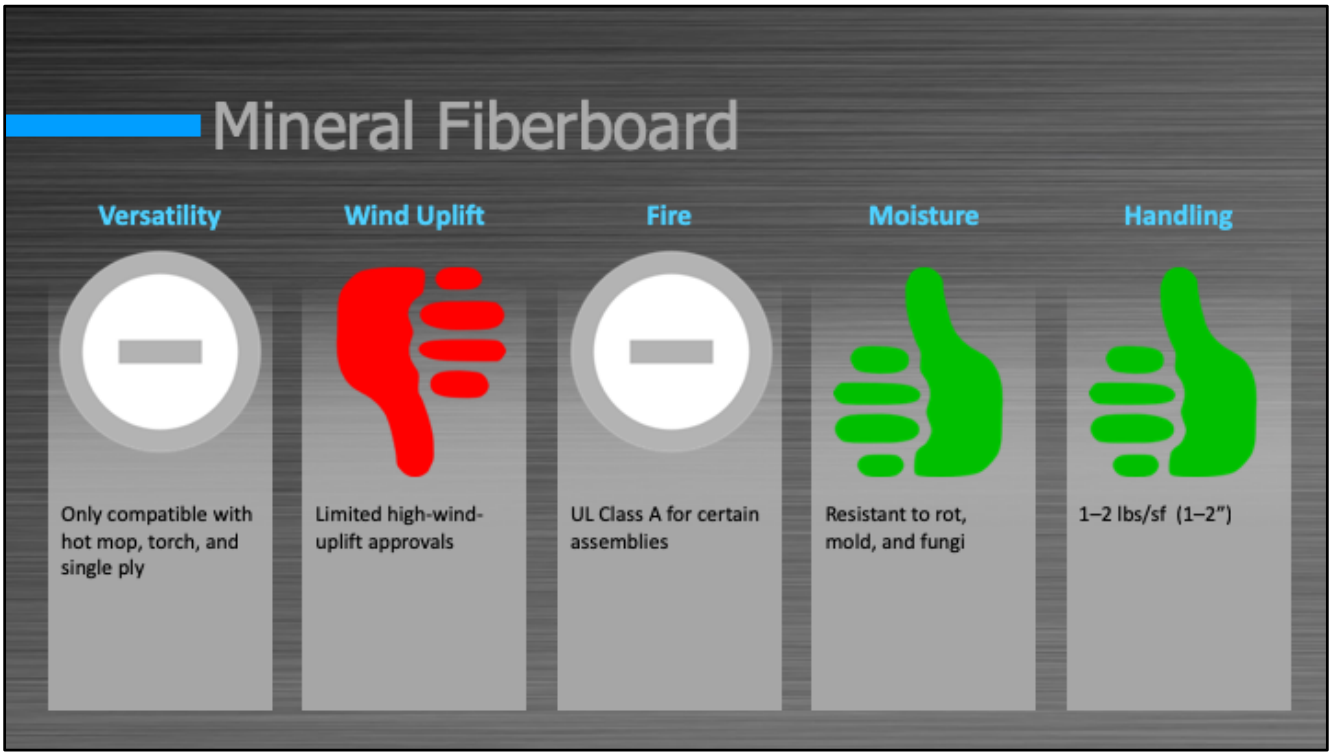
A cover board on this assembly example is only 19 percent of the entire cost at $1.03. A conservative, near-break-even analysis would include extending the roof's life by two years and reducing the scheduled maintenance and repair cost by only 25 percent.

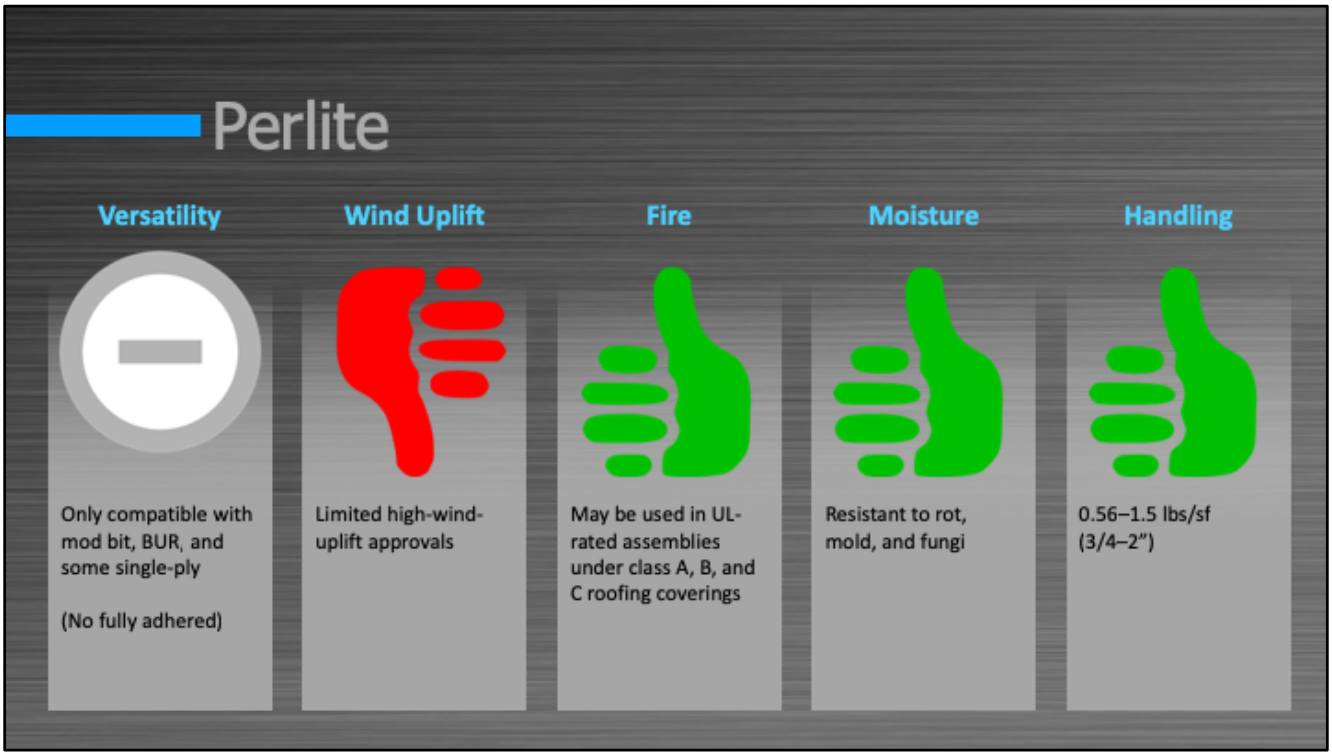

Roof Board
Comparison

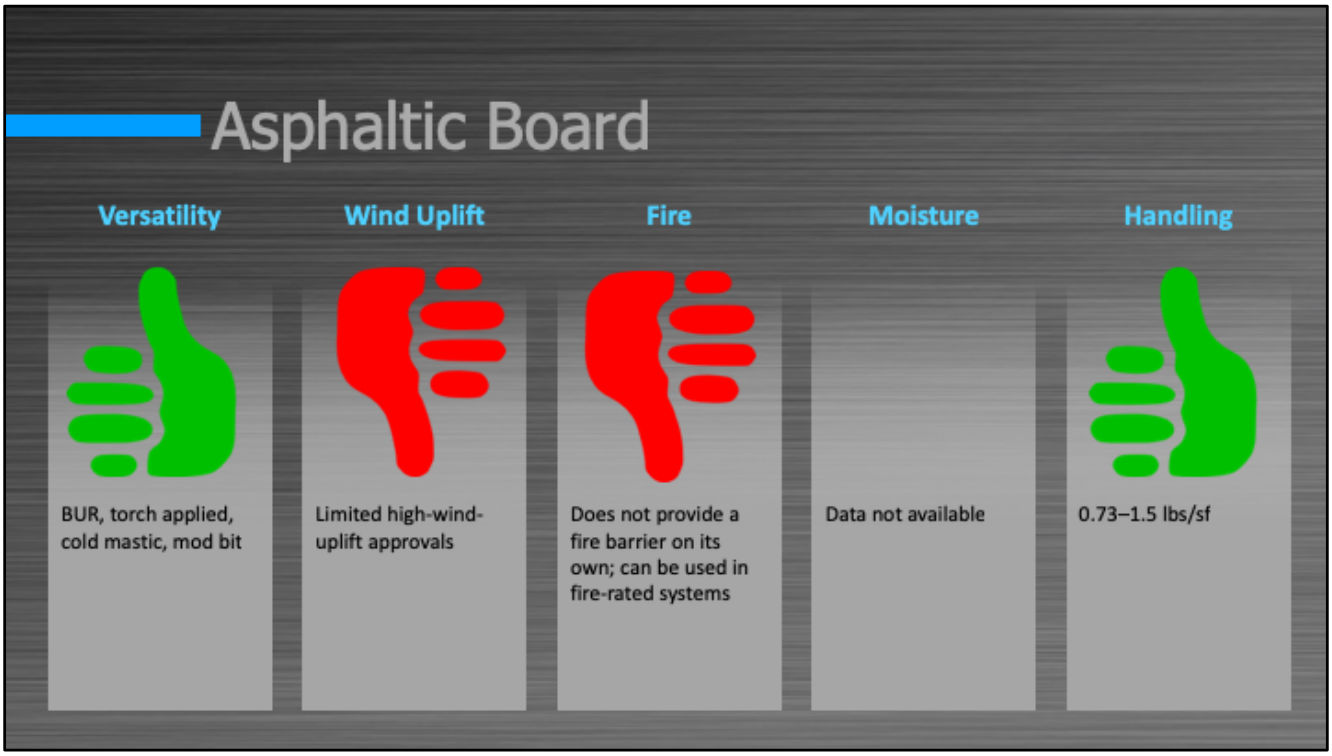

Cover Board Types
Rigid Cover Boards
Other Cover Boards
Gypsum Fiber
Glass Mat Gypsum
HD ISO
Mineral Fiber-board
Perlite
Asphaltic Board

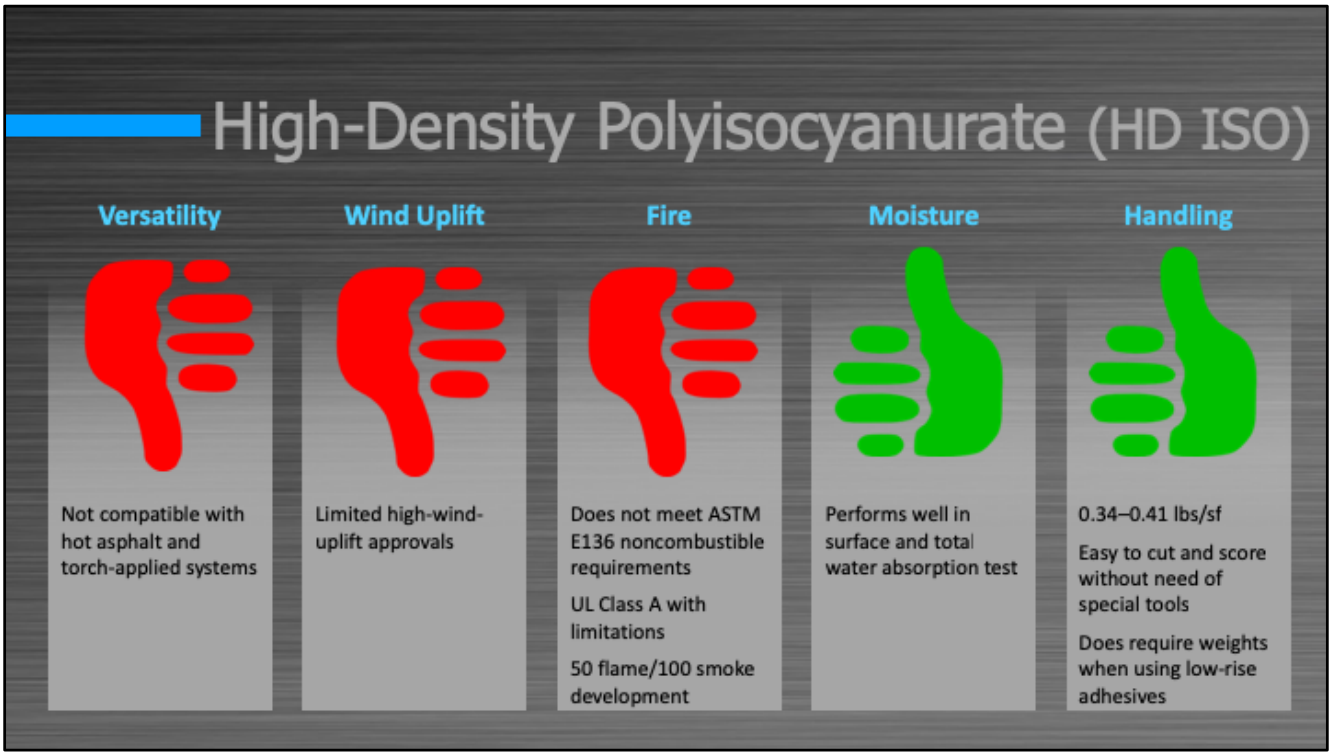
=


Gypsum Fiber
Versatility
Compatible with most low-slope roofing systems
Wind Uplift
56,000+ ROOFNAV systems
Fire
Does not meet ASTM E136 noncombustible requirements
UL Class A with slope limitations
Effect of gapping on fire resistance?
Moisture
Per independent test results, loses 71% of strength after 2-hour soak test
Handling
1.4–3.4 lbs/sf
May require special tools to cut
Gapping required between boards


Mineral Fiberboard
Versatility
Only compatible with hot mop, torch, and single ply
Wind Uplift
Limited high-wind-uplift approvals
Fire
UL Class A for certain assemblies
Moisture
Resistant to rot, mold, and fungi
Handling
1–2 lbs/sf (1–2")


Perlite
Versatility
Wind Uplift
Fire
Moisture
Handling
Only compatible with mod bit, BUR, and some single-ply
(No fully adhered)
Limited high-wind-uplift approvals
May be used in UL-rated assemblies under class A, B, and C roofing coverings
Resistant to rot, mold, and fungi
0.56–1.5 lbs/sf (3/4–2")


Asphaltic Board
Versatility
Wind Uplift
Fire
Moisture
Handling
BUR, torch applied, cold mastic, mod bit
Limited high-wind-uplift approvals
Does not provide a fire barrier on its own; can be used in fire-rated systems
Data not available
0.73–1.5 lbs/sf


High-Density Polyisocyanurate (HD ISO)
Versatility
Not compatible with hot asphalt and torch-applied systems
Wind Uplift
Limited high-wind-uplift approvals
Fire
Does not meet ASTM E136 noncombustible requirements
UL Class A with limitations
50 flame/100 smoke development
Moisture
Performs well in surface and total water absorption test
Handling
0.34–0.41 lbs/sf
Easy to cut and score without need of special tools
Does require weights when using low-rise adhesives

Premium Coated Glass Mat Gypsum

Versatility

Compatible with all lo- slope roof assemblies

Wind Uplift

75,000+ ROOFNAV approvals

Fire

Noncombustible per ASTM E136

Comprehensive Class A unlimited slope

0 flame/0 smoke development

UL Class A, B, C

Moisture

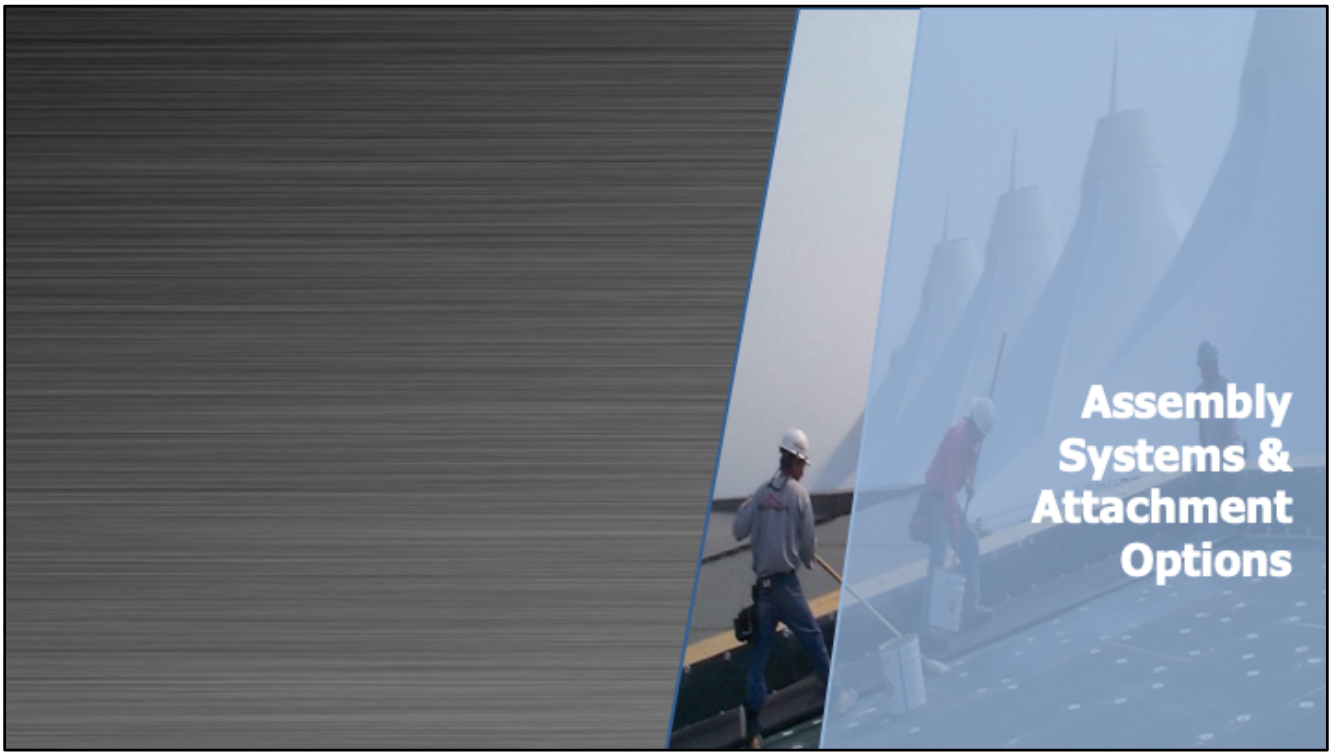
Manufacturing specifications that include 5% max total water absorption by weight and 1 gram surface water absorption (front and back)

Handling

1.2–2.7 lbs/sf

Easy to score and cut without need of special tools

No gapping required


Assembly
Systems &
Attachment
Options

Systems Used with Cover Boards

Single Ply

Mod Bit

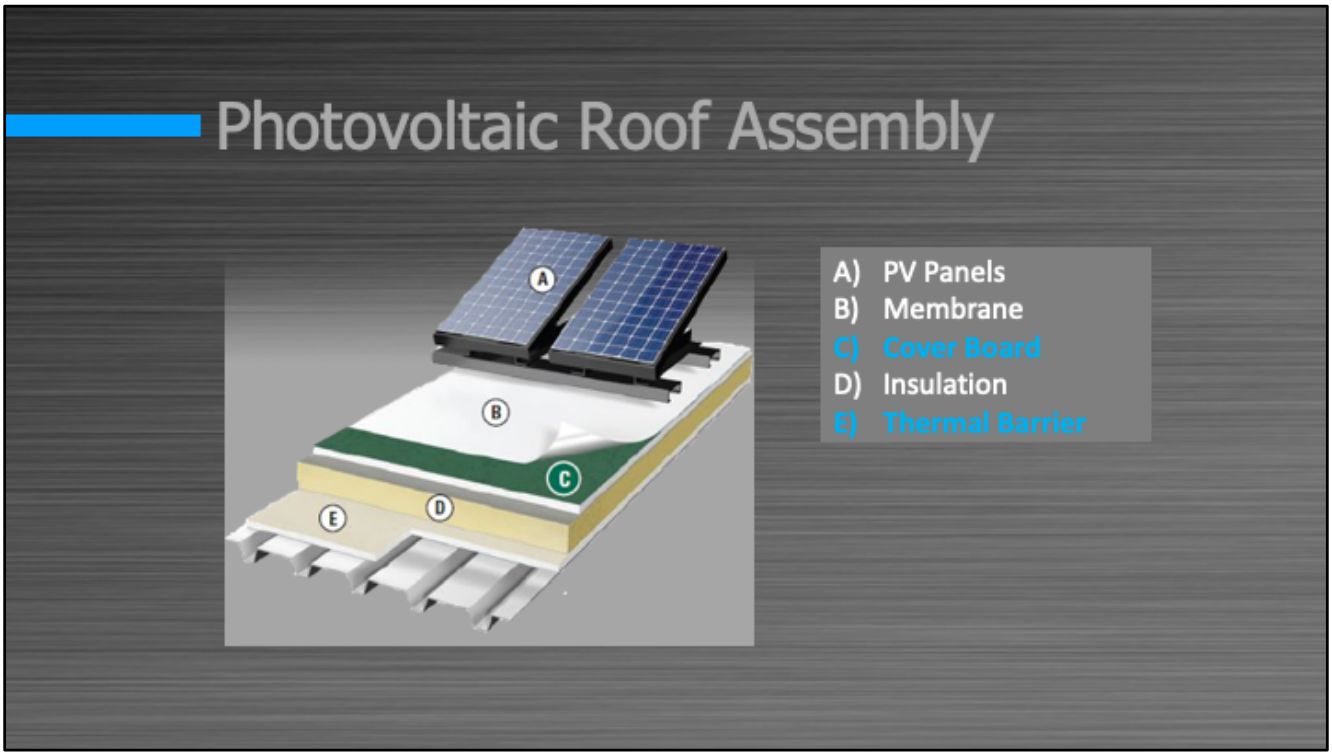
Liquid Applied

Built-up

Metal

Vegetative and P/V


Attachment Options with Cover Boards
Mechanically
Adhered
Torched
Mopped
Ballasted
Liquid Applied



Even though some of the federal incentives to build photovoltaic systems are expiring, solar power continues to be a popular alternative energy source. This is due in large part to new technologies driving down once prohibitive initial costs. In 2013, the Solar Energy Industries Association reported a new PV system was installed in the United States every four minutes.

Low-slope commercial roofs continue to be a popular location for PV systems for several reasons:

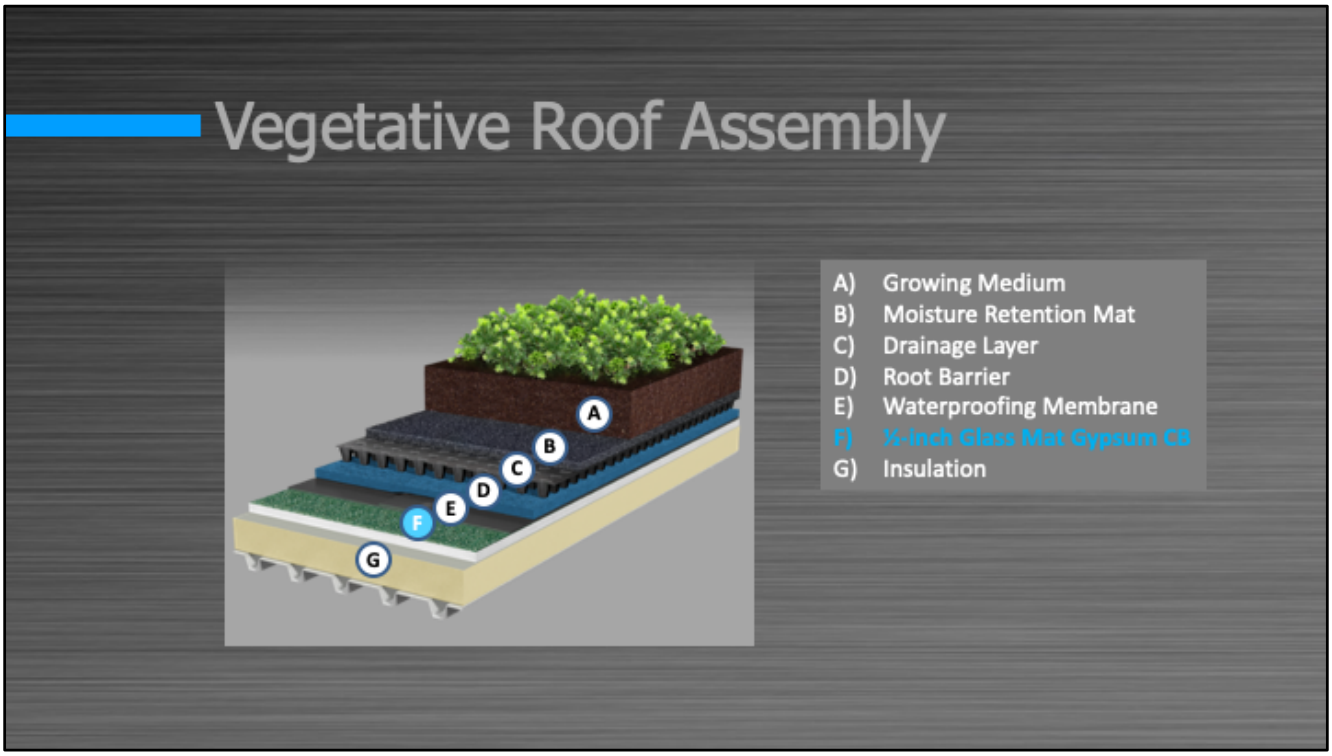
- They offer a secured location with no access by the general public.
- The roofs are more likely to be unobstructed.
- They allow for the generation of energy close to the consumption point.
- There is a large inventory of existing low-slope buildings.

Although PV systems are a great source of renewable energy, hazards associated with placing them on roofs including fire, wind, and structural issues result in several design related challenges. Using a gypsum-based board as a cover board and thermal barrier can help in designing an roof assembly that meets needed fire and wind uplift specs.

Pictured here is the remains of a roof assembly in Littlestown, Pennsylvania, after a P/V-related fire. In this case, a faulty maximizer (a device that amplifies DC current to the inverter) overheated and caught fire. A quick response by the local fire department kept the fire localized to just this one area of the 100,000-square-foot roof. This assembly included a metal deck, ISO insulation, and a TPO membrane.

This is a aerial view of Hewlett Packard corporate headquarters in Silicon Valley. Eighty-five percent of this 300,000-square-foot roof is covered with solar panels. When reroofed to accommodate the massive system of panels, a ½-inch glass mat gypsum board was included to provide compressive strength and durability.

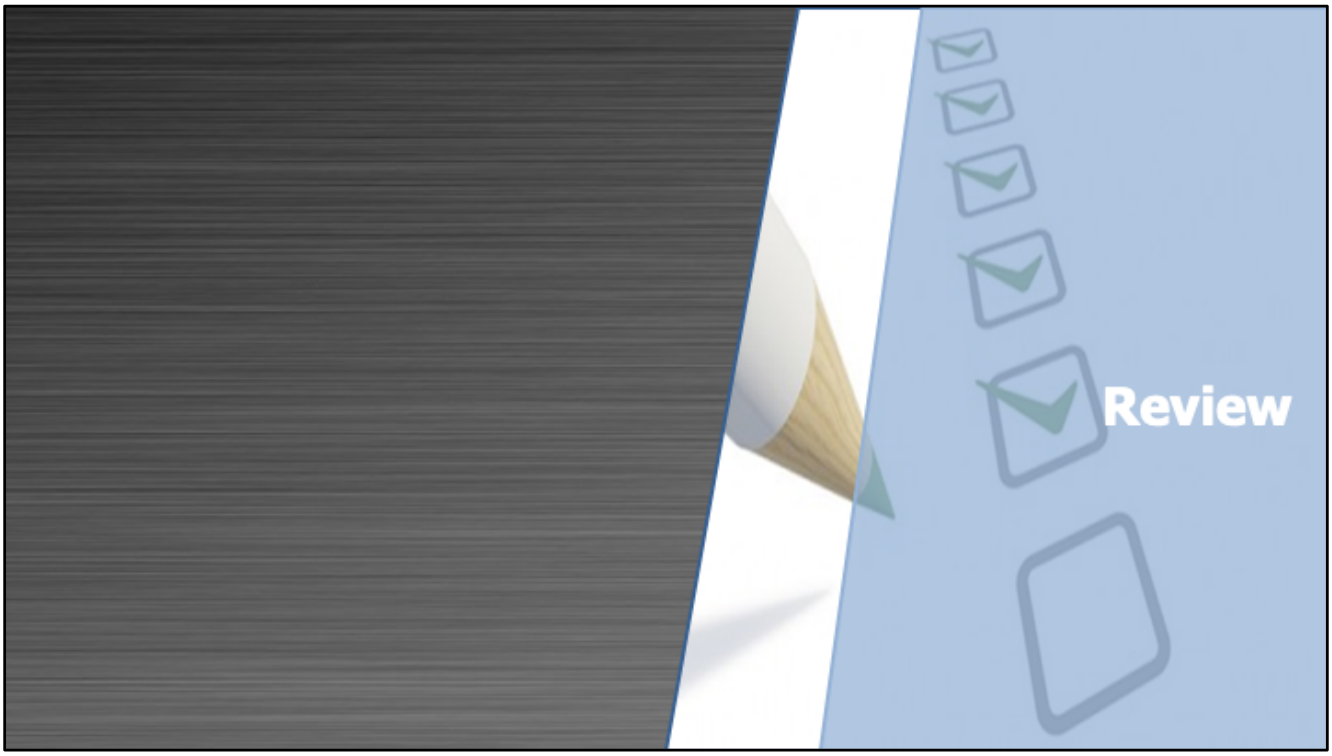
An additional consideration was the extra cost associated with removing portions of the PV system to accommodate any unscheduled roof maintenance or repair. Two roofing consulting firms partnered together in an attempt to design a roof assembly that was virtually maintenance free and would have a lifespan comparable to the PV system.



Vegetative roof assemblies continue to grow in popularity due to their ability in increase energy efficiency, manage water discharge, reduce facility operational costs, enhance buildings' appearance, and help building owners position themselves as environmentally friendly organizations.

The ability for vegetative roofs to hold water helps a building owner's efforts to minimize stormwater runoff but also adds a considerable amount of weight to the roof assembly, up to more than 200 pounds per square foot. Choosing a cover board with high marks in compressive strength helps the assembly support the extra weight.

This is the Target Center in Minneapolis, which serves as the home for the city's NBA team and countless concerts and many other large events. The recent reroof project included adding a vegetative system for the 115,000-square-foot main roof area. In order to add additional strength and extend the lifespan of the assembly, the consultant included in his spec a ¼-inch glass mat gypsum cover board.


Review

Learning Objective Review

Today's objective is to gain a better understanding of the value rigid cover boards deliver to commercial roof assemblies, how they perform in adverse conditions, and bring clarity to the characteristics of each major type of board.

This Concludes the AIA Presentation

DensDeck Roof Boards

Jobsite Performance

Contractors prefer DensDeck

- Easy to score and cut
- Does not require gapping
- Even adhesive coverage
- Unmatched versatility
- Reduces risk of installation-related damage

DensDeck Roof Boards

Long-Term Performance

Design community prefers DensDeck

- Performance in adverse conditions
- Meets most demanding moisture-related manufacturing specifications
- Performance as thermal barrier
- Protection from foot traffic
- Strength and dimensional stability
- Sound mediation
- Time-tested performance