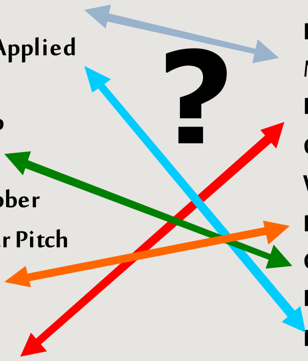
Building Envelope Technology

Roof System Selection - A Complicated Problem

EPDM
Liquid Applied
CSPE
Built-up
PVC
Hot Rubber
Coal Tar Pitch
SBS
APP
TPO



Expanded polystyrene
Fiberglass
Mineral wool
Extruded polystyrene
Cellular glass
Wood Fiberboard
Perlite
Gypsum
Polyisocyanurate
Lightweight Insulating Concrete

Structural Decks

Wood

Concrete

Steel

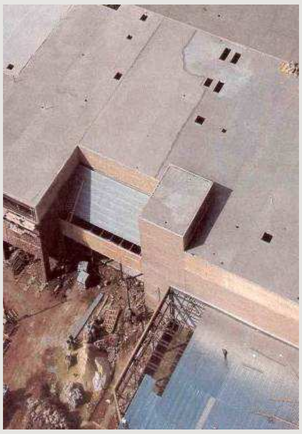
Typical Roof Assembly

- Structural deck.
- Insulation.

} Substrate Platform

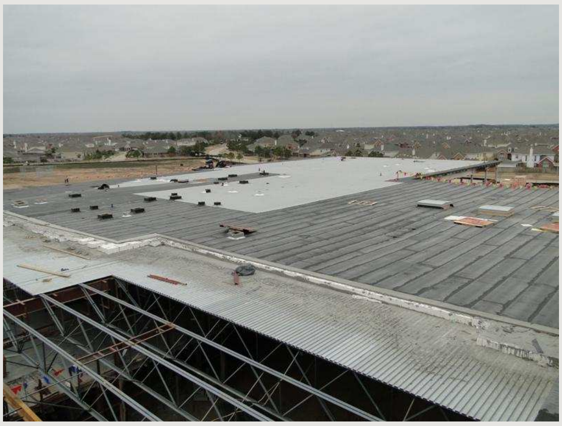
- Membrane.

The structural deck and the insulation combine to create the **substrate platform** for the roof membrane.



Roof Insulation

The Foundation Of The Roof Membrane



Substrate Platform Functions

- Resist applied loads both in-plane and out of plane.

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- Provide the most continuous surface possible for roof membrane placement.

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- Provide dimensional stability:
  - Under extreme temperature fluctuations.
  - In contact with moisture.

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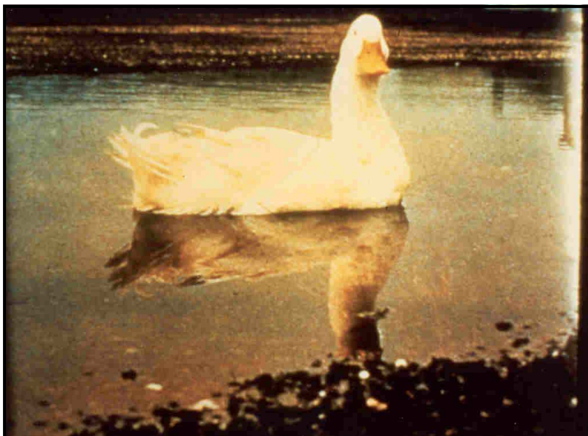
  - In contact with moisture.
- Provide slope-to-drain.



Substrate Platform Functions

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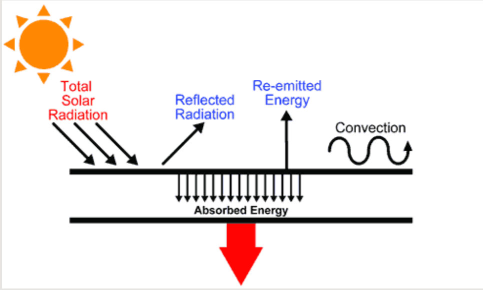
- Provide the most continuous surface possible for roof membrane placement.
- Provide dimensional stability:
  - Under extreme temperature fluctuations.
  - In contact with moisture.
- Provide slope-to-drain.
- Provide heat flow resistance.



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- Provide fire resistance.

Substrate Platform Functions

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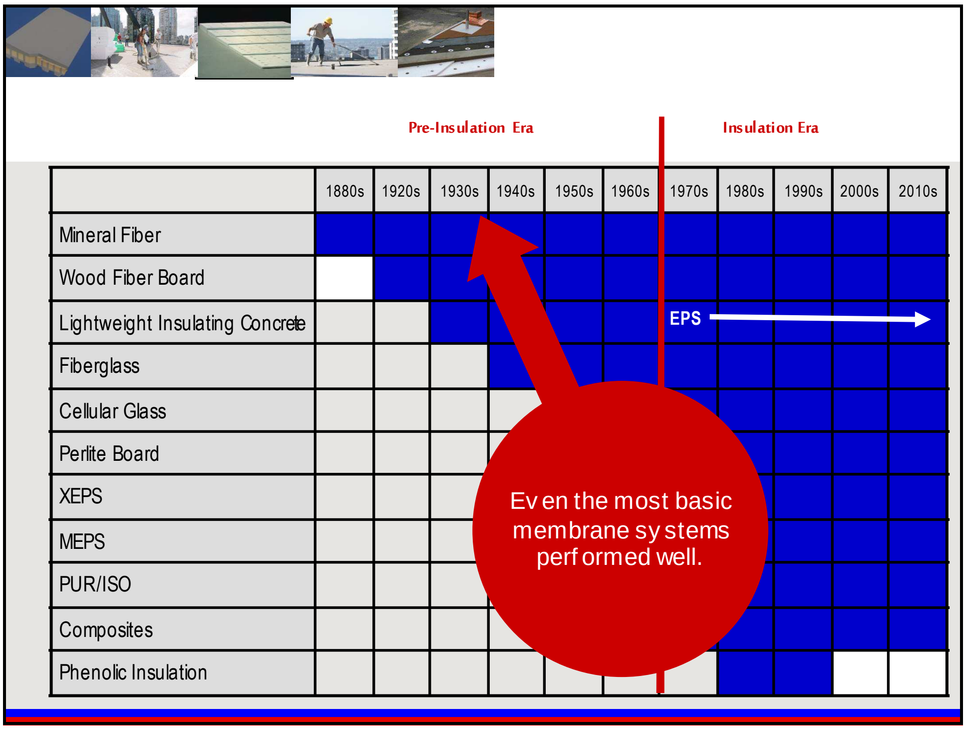
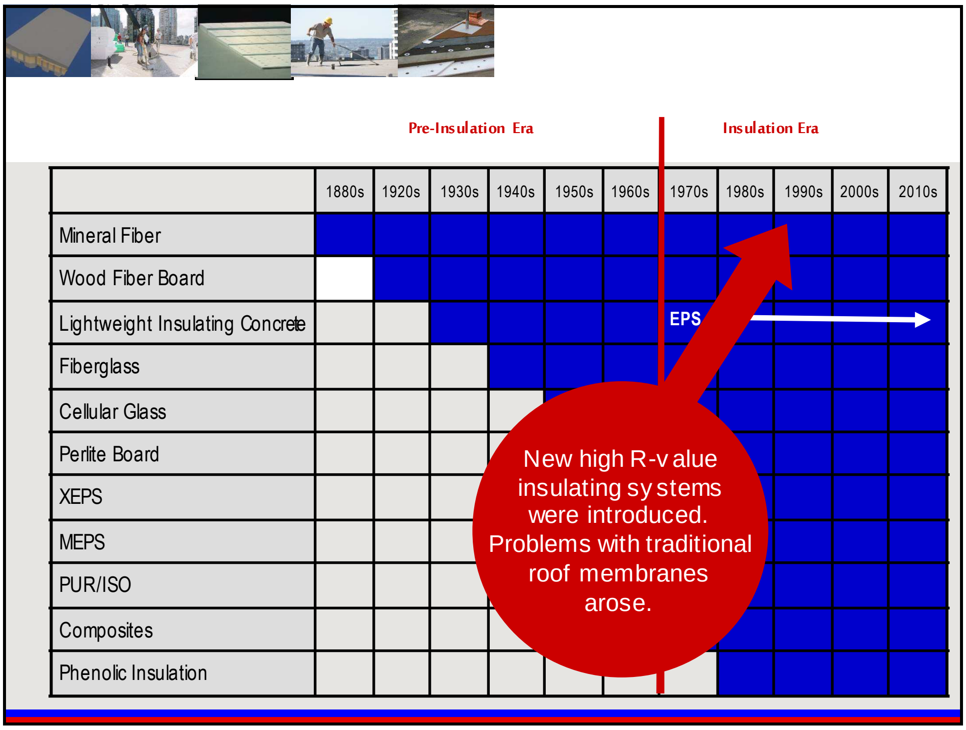
- Provide the most continuous surface possible for roof membrane placement.
- Provide dimensional stability:
  - Under extreme temperature fluctuations.
  - In contact with moisture.
- Provide slope-to-drain.
- Provide heat flow resistance.
- Provide fire resistance.
- Provide wind resistance.

Substrate Platform Functions

- Additional functions not related to the roof membrane include contributions to:
  - Sound reduction.
  - Building envelope sustainability.
  - LEED credits.


Pre-Insulation Era
Insulation Era
1880s
1920s
1930s
1940s
1950s
1960s
1970s
1980s
1990s
2000s
2010s
Mineral Fiber
Wood Fiber Board
Lightweight Insulating Concrete
Fiberglass
Cellular Glass
Perlite Board
XEPS
MEPS
PUR/ISO
Composites
Phenolic Insulation
EPS
Even the most basic membrane systems performed well.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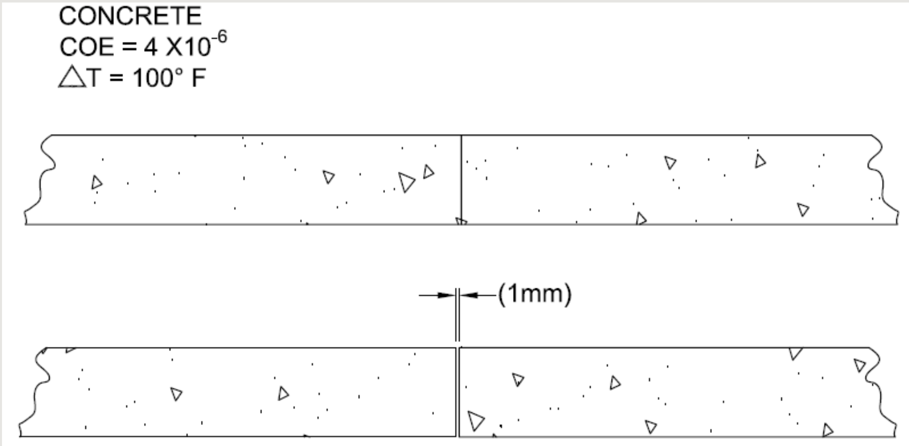
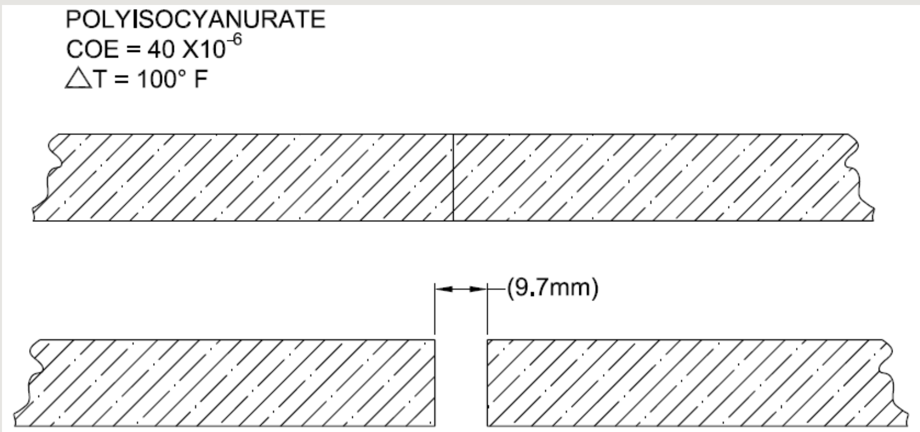
EPS
New high R-value insulating systems were introduced. Problems with traditional roof membranes arose.

Thermal Expansion – Concrete / High Mass



Thermal Expansion – Polyisocyanurate / Low Mass



The Effect Of COE

- Movement due to higher COE of substrate material (insulation) creates strain at board joints.
- The movement is caused by the inherent instability of some insulation products.
- The effect of this movement is distributed throughout the roof by the number of joints presented with board stock insulation.

Joints ?

100 squares of 4 x 8 foot board material has more than a half mile (3,650 linear feet) of board joints!

Roof Insulation Systems

Lightweight Insulating Concrete

Rigid Insulation

Re-Roofing vs New Construction

Metal Deck

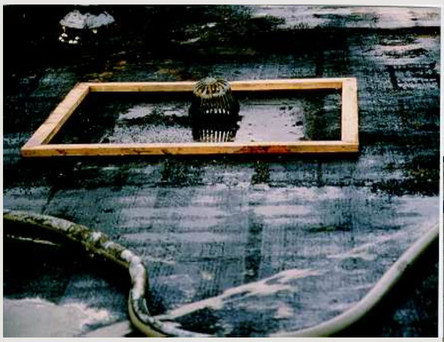
Structural Slab

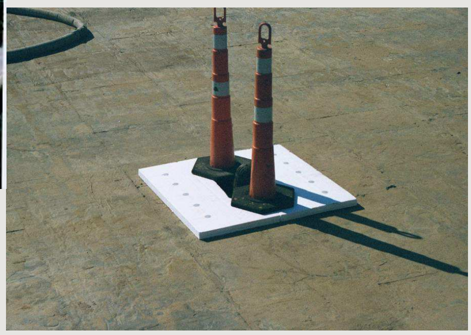
Existing Asphaltic Membrane

Existing Building Renovations

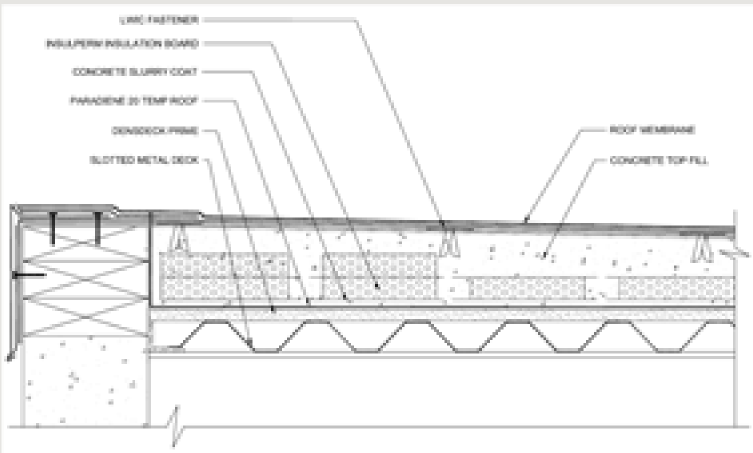
Placement of Slurry and EPS Insulation

Existing Drain Elevations



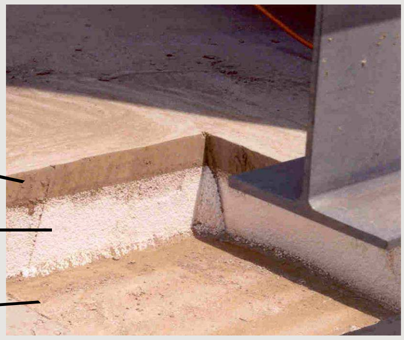


Roof Deck / Reroof Platform



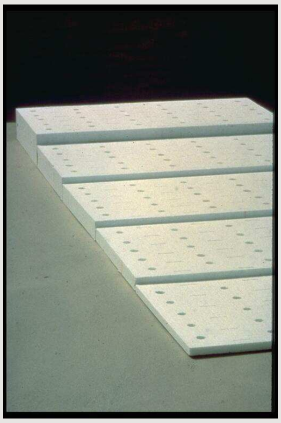
Components of a LWIC System

Lightweight insulating concrete top fill.
Molded expanded polystyrene insulation board.
Lightweight insulating concrete slurry.



Components of a NVS System

- Insulperm expanded polystyrene insulation board.



- High insulation value.
  - R=4 per inch
- Stable R-value over time.
- No blowing agents.
- Not affected by water.
- Lightweight material to build slope to drain.
  - 1 inch thickness = 0.1 lb / sq ft

Components of a LWIC System

Lightweight insulating concrete top fill.
Molded expanded polystyrene insulation board.
Lightweight insulating concrete slurry.

Definition – Lightweight Insulating Concrete (LWIC)

American Concrete Institute

ACI 523.1 R-06

Guide for Cast-in-Place Low-Density Concrete

"A concrete made with or without aggregate in addition to Portland cement, water and air to form a hardened material having an oven dry unit weight of 50 pcf or less."

Structural Lightweight Concrete

- What is Structural Lightweight Concrete?
  - Structural concrete (normal weight)
    - 150 pcf dry density / 3,500 psi
  - Structural lightweight concrete (SLC)
    - 100 pcf dry density / 2,500 psi
  - Lightweight insulating concrete
    - 35 pcf dry density for NVS / 300 psi

Aggregate-Based LWIC

- Aggregate.
- Air entrainment.
- Portland cement - Type I, II, or III.
- Water.

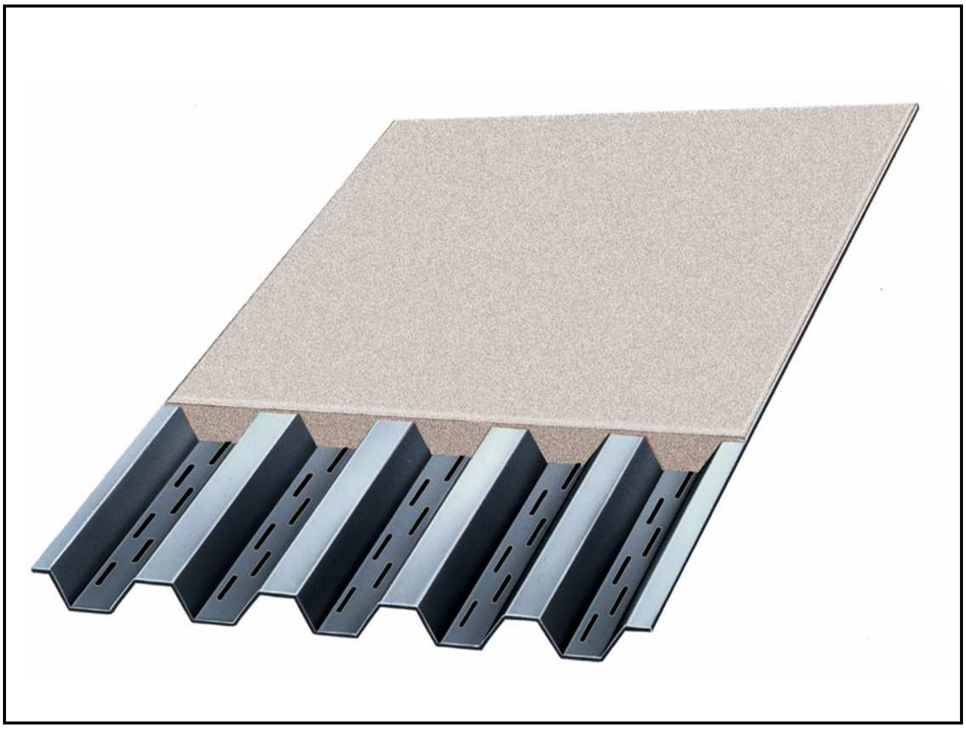
Cellular-Based LWIC

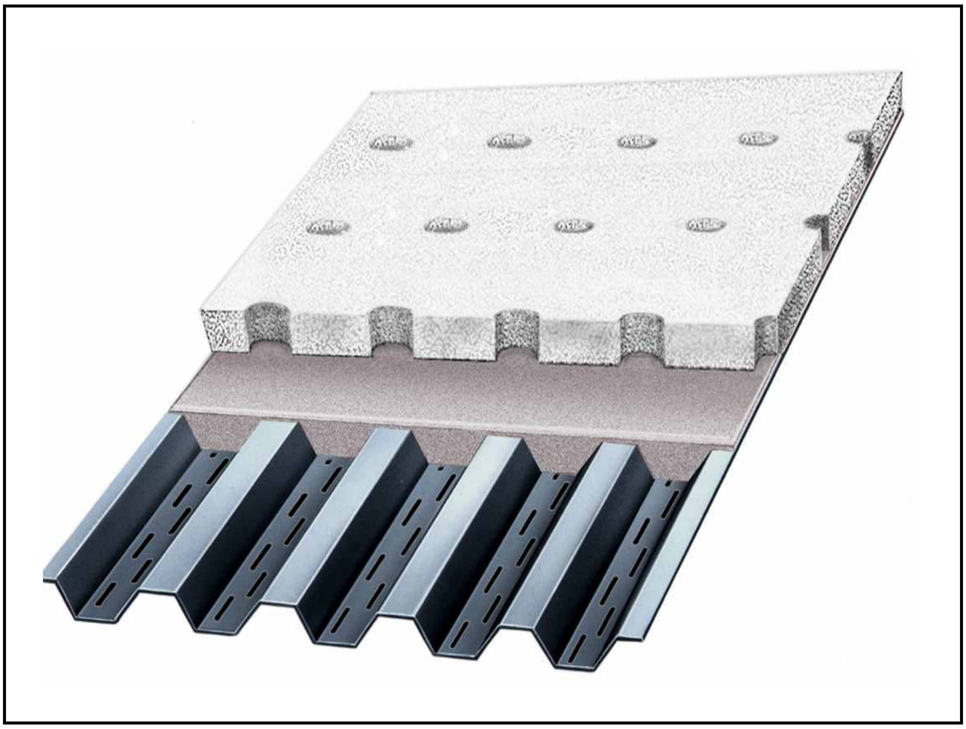
- Pregenerated foam.
- Portland cement - Type I, II, or III.
- Water.

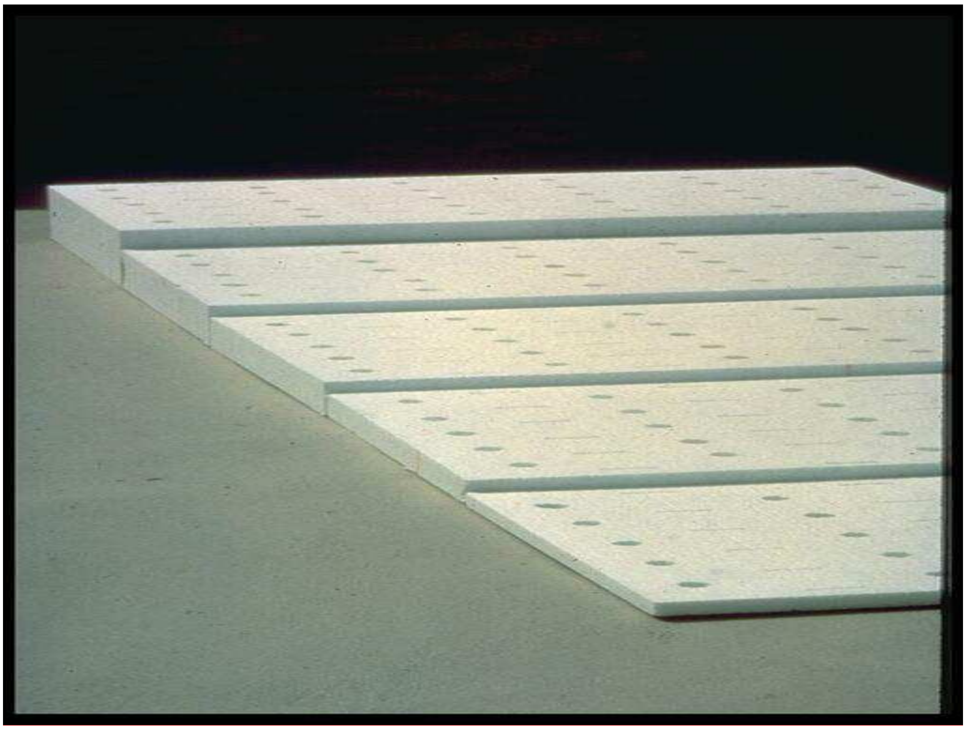
Aggregate vs. Cellular

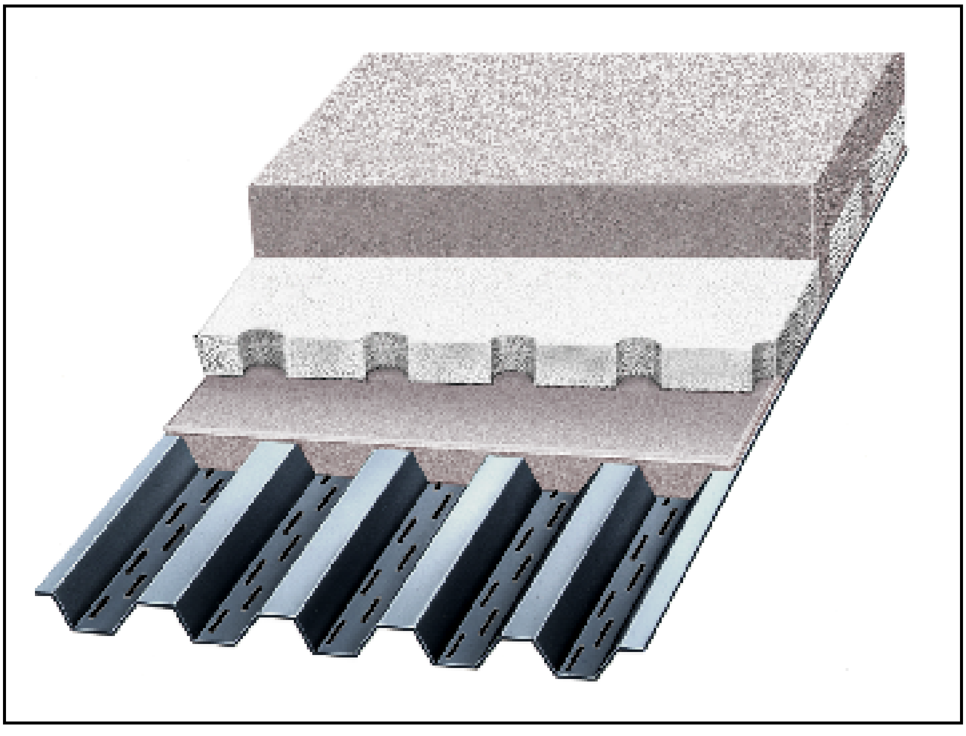
- **Aggregate.**
  - 125-300 psi.
  - Top-fill thickness 2” (or 1”).
  - Drying Shrinkage.
    - 0.20 – 0.45 (ACI 523.1R-06).

Cellular.
  - 200 psi.
  - Top-fill thickness 2”.
  - Drying Shrinkage.
    - 0.30 – 0.60 (ACI 523.1R-06).

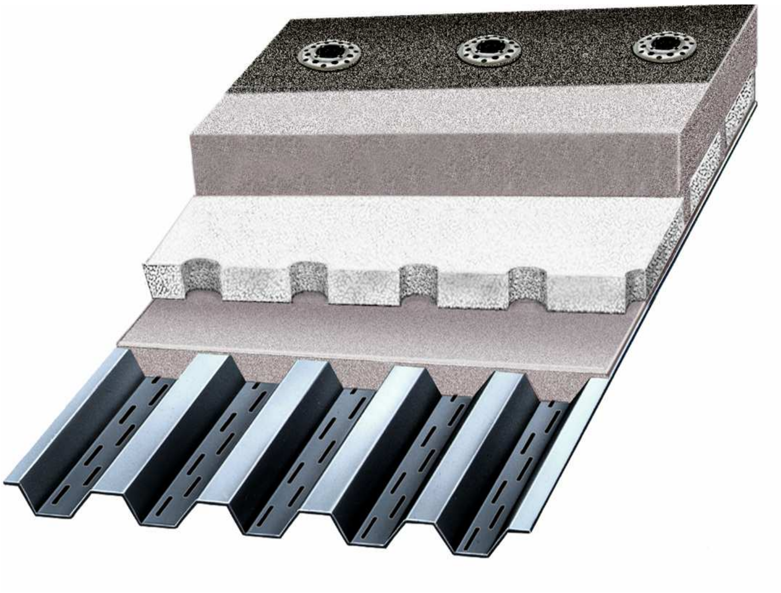








Top Fill Finishing



Attachments Methods for Roof Membrane over LWIC

Different technologies for roof membrane attachment

Slope to Drain

Get the water off the roof

Stable Insulation Value

LTTR

LONG TERM THERMAL RESISTANCE

What is long-term thermal resistance (LTTR)?

LTTR is a 15-year time weighted average R-value for permeably faced polyiso, commonly used as roof insulation. LTTR represents the most advanced scientifically supported method to describe the long term thermal resistance (R-value) of polyisocyanurate foam insulation products.

Stable Insulation Value

Tech Today | Professional Roofing magazine

Sample number	R-value, per inch thickness (2-inch specimens)			
	25 F	40 F	75 F	110 F
1	3.765	4.757	5.774	5.118
2	3.909	4.719	5.444	4.958
3	4.737	5.350	5.371	4.810
4	3.506	4.509	5.828	5.227
5	4.221	5.269	5.522	4.929
6	3.775	4.854	5.889	5.247
7	4.431	4.878	5.058	4.581
Average (mean)	4.049	4.905	5.555	4.981
Standard deviation	0.432	0.302	0.297	0.239

Data from NRCA's 2014 polyisocyanurate R-value testing

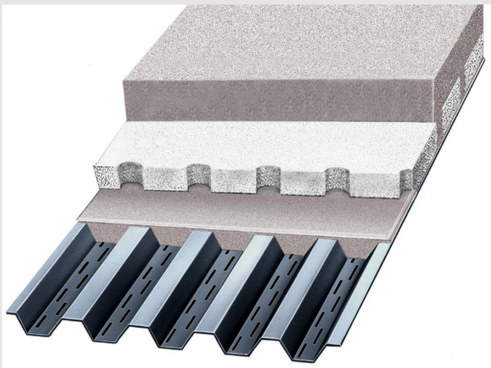
New values for 2014 for polyisocyanurate foam insulation products.

Iso R-Value For 2014

Thickness	LTTR (2004-2013)	New LTTR (2014 -)
1 inch	6.0	5.6
1.5 inches	9.0	8.6
2 inches	12.1	11.4
3 inches	18.5	17.4
4 inches	25.0	23.6

LWIC R-value is constant

- LWIC R-value
  - LTTR is not applicable
    - Both lightweight insulating concrete fill and molded expanded polystyrene board have thermal resistance values that do not decrease over time.



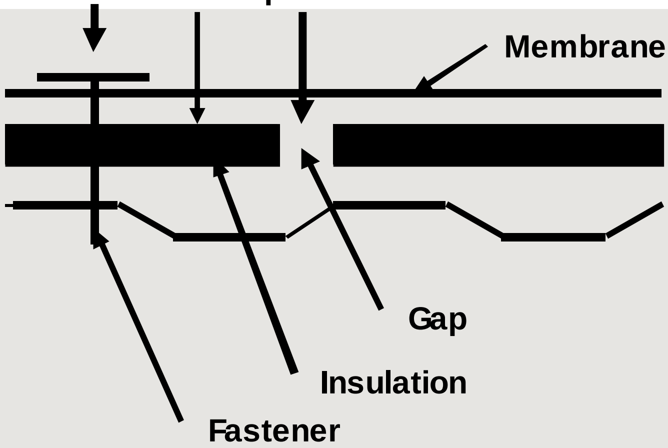
Stable Insulation Value

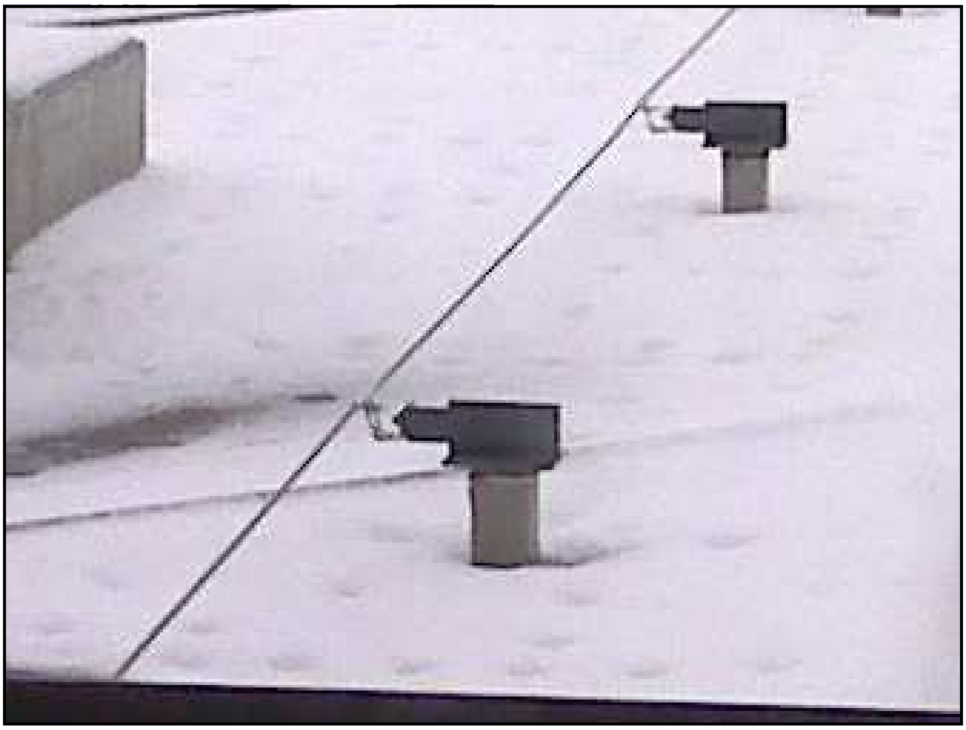
"The R-value of EPS is stable and does not change over time. The R-value performance for EPS insulation is discussed in the report. The report shows that samples of EPS insulation had no deterioration in R-value. The test results at 70° F for thermal resistance of EPS insulation samples taken from roof systems of various ages indicated no deterioration in the R-value over time. The following table compares two examples of published R-values to samples taken from actual roof decks:"

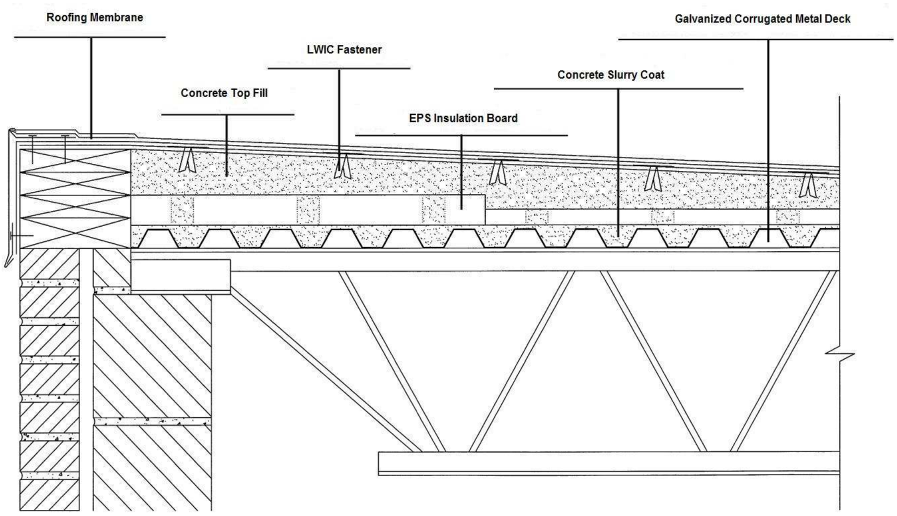
	Age	Density	R-Value
Published Initial Values	At time of manufacture.	1.00 pcf 1.25 pcf	3.85 3.92
EPS Insulation Samples	13 Years 15 Years	1.28 pcf 1.09 pcf	3.94 4.07

"Report on Expanded Polystyrene Insulation for Use ASTM C 578 In Built-Up and Single Ply Roofing Systems" by Rene M. Dupuis and Jerome G. Dees, dated August 1984."

Parallel Heat Flow Concept







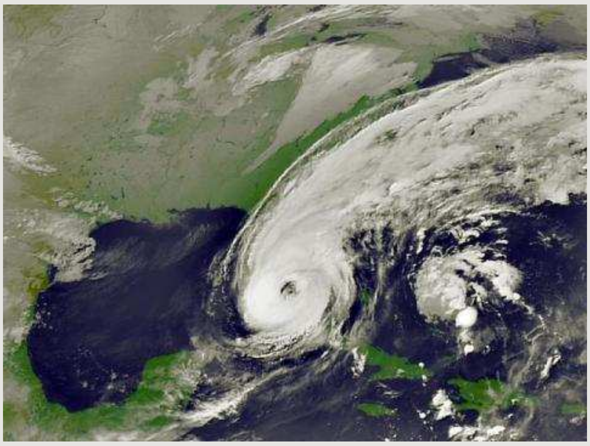
Fire Resistance

Lightweight insulating concrete systems are non-combustible.

UL fire resistance designs.
- Cost effective roof-ceiling designs.

Wind Uplift Resistance

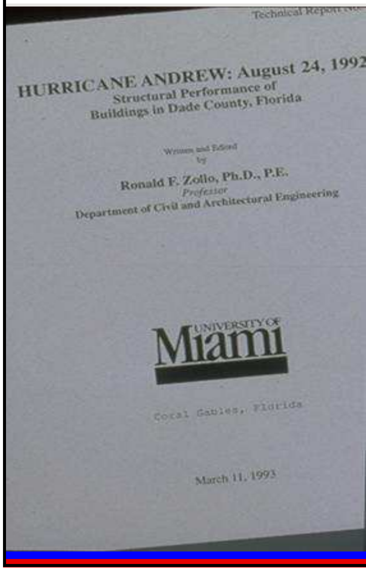
- 80 years of wind resistance performance for LWIC.
- Comprehensive, current FM, UL & Dade testing and approvals.



Hurricane Ike

Hurricanes

Documented Field Wind Performance



10.01.1 Metal Deck Over Bar Joists

"Metal Decks over bar joists were generally one of two types: metal deck with rigid insulation or metal deck with lightweight insulating concrete. In each of these systems the metal deck was attached to the bar joists by welding or by self tapping screws.

Of the two system types observed, **the system using lightweight concrete performed best**, all other factors considered equal."

High Mass & Low Mass Substrates

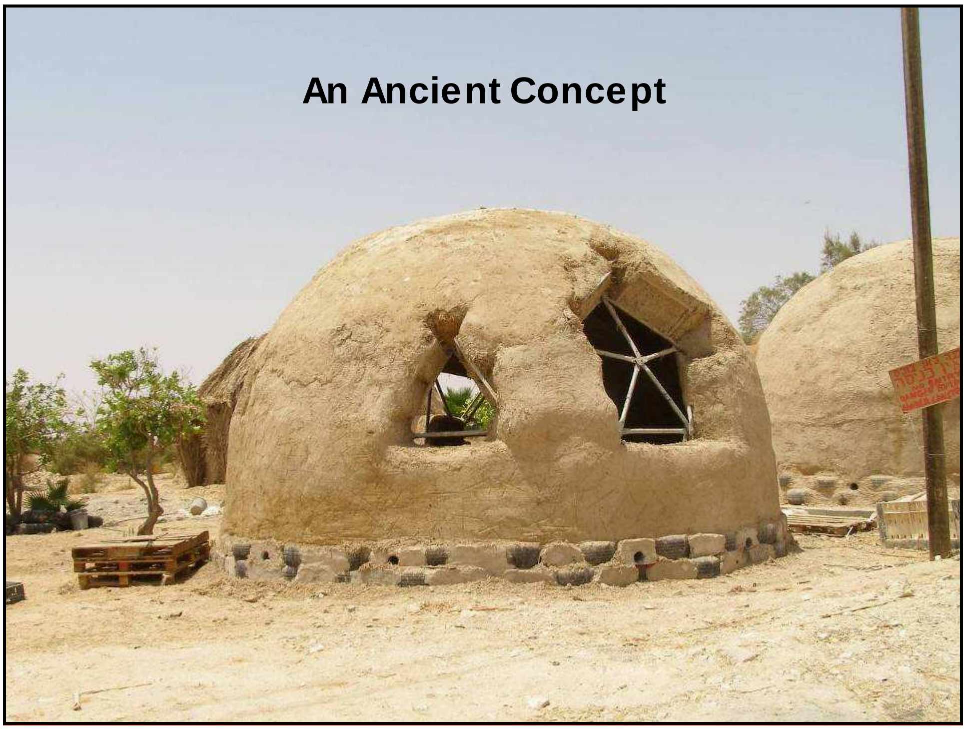
High Mass

- Wood.
- Concrete.
- Lightweight Insulating Concrete.

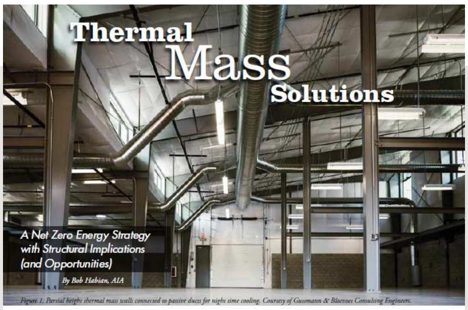
Low Mass

- Wood fiber board.
- Perlite board.
- Cellular glass.
- Extruded polystyrene.
- Molded polystyrene.
- Polyisocyanurate.
- Glass fiber board.

An Ancient Concept



The Mass Effect



Thermal Mass Solutions

A Net Zero Energy Strategy with Structural Implications (and Opportunities)

By Bob Habian, AIA

Figure 1. Partial height thermal mass walls connected to passive ducts for night time cooling. Courtesy of Gussmann & Blaevoet Consulting Engineers.

The Jess S. Jackson Sustainable Winery building (JSWB) project team, led by Siegel and Strain Architects, set out to design a Net Zero Energy, LEED Platinum building, at the University of California, Davis, where summer temperatures exceed one hundred degrees on a regular basis. Concrete masonry, as seen in *Figure 1*, not only saved the day, but it opened the door for IDA Structural Engineers of Oakland, CA to take a more active role in energy optimization at the earliest stages of a project.

Energy Management is Mandatory

The production of energy is the leading contributor to carbon footprint and climate change and, in the U.S., the Building Sector consumes more energy than any other sector (*Figure 2*). In response, a number of stricter energy code requirements are being enforced across all building types. The cost of energy is rising and is a matter of growing concern for building owners. The JSWB project team set out to not only reduce their energy consumption, but together decided to reach a level of Net Zero Energy (NZE), in which the total energy consumed is offset by renewable energy production on site. The most important factor in achieving NZE is reducing the overall energy consumption to the lowest possible level.

Figure 2. U.S. energy use by sector. Data source: US Energy Information Administration (2012).

The Basics of Thermal Mass

The goal of every building design is to achieve internal comfort regardless of outside temperatures. In climates like Davis, California, where there are high diurnal swings from hot to cold in a 24-hour period, exposed interior thermal mass, in the form of concrete masonry, can radically decrease the overall energy consumption. As shown in *Figure 3*, interior comfort is achieved using two primary strategies, time lag and damping. Insulation by itself can only achieve time lag. Thermal mass, however, contributes to both time lag and damping. Achieving the proper balance of both is the shortest path to achieving internal comfort.

Framed Structures Lack Sufficient Mass

The building industry in the Western U.S. has shown a long-standing preference for framed, insulated, low-mass buildings that shake and don't fall down in earthquakes. A common belief in the west is that heavy mass buildings perform poorly in seismic conditions. Most often, the building failures referenced are unreinforced or poorly constructed. In addition, the historic abundance of wood has influenced our appetite for low mass, framed solutions. As a result, we traditionally rely on a combination of insulation and air handling systems to achieve interior comfort. To that end, most project participants believe the architect and the mechanical engineer are the only ones needing to be at the table to determine an optimal comfort strategy. As conventionally framed designs move in the direction of increased interior exposed thermal mass, the structural engineer becomes a necessary participant in the discussion.

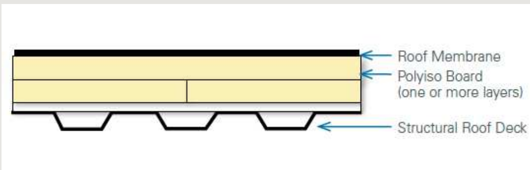
STRUCTURE magazine 26 May 2015

The Mass Effect

Heat
is the single biggest factor
in the aging of
roof membranes.

Think About It

- Rigid foam plastic board stock insulations with high R-values are intended to decrease heat transfer between the interior and exterior of a building.
- They have less ability to absorb and release heat than traditional substrates such as wood and concrete.
- Therefore, the roof membrane is exposed to higher heat for longer periods of time.

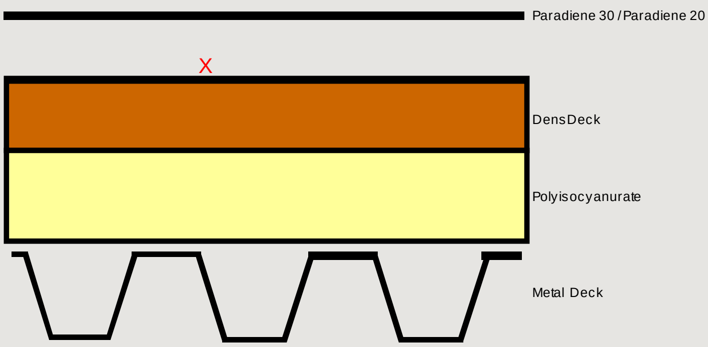


Aging By Arrhenius Equation

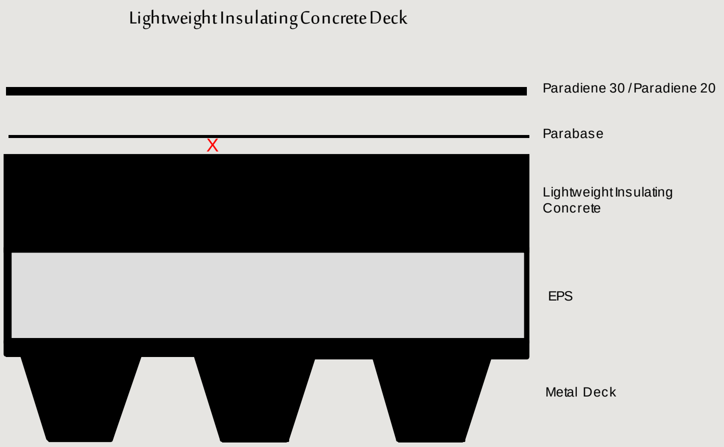
Increasing the membrane temperature 18°F (10°C) doubles the aging rate, based on the Arrhenius Equation.

The Mass Effect Study: Thermocouple Placement

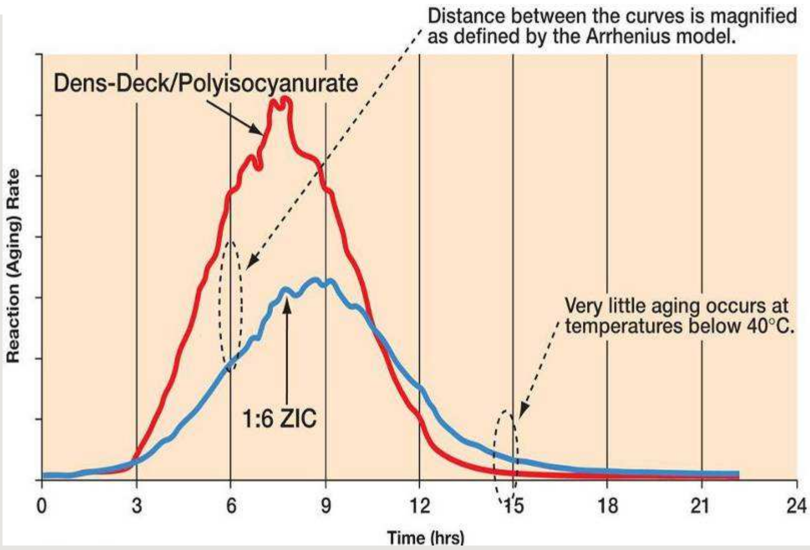
DensDeck/Polyisocyanurate Deck



The Mass Effect Study: Thermocouple Placement

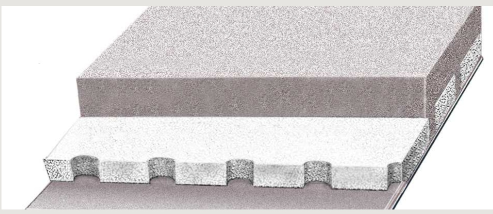


The Mass Effect Study Results



Aging By Arrhenius Equation

- Increasing the membrane temperature 18°F (10°C) doubles the aging rate, based on the Arrhenius Equation.
- By encapsulating rigid foam plastic board stock insulation in lightweight insulating concrete, lightweight insulating concrete systems provide both high insulating values and higher heat capacity.



The Mass Effect Study Results

Substrate	Percentage Increase In Aging In Relation To 1:6 ZIC
1:6 ZIC Aggregate (2 inches thick)	**Baseline (Best Performer)**
1:4 ZIC Aggregate (2 inches thick)	7.2%
DensDeck Cover Board (1/4-inch thick) With Polyiso	49.1%
Perlite Cover Board (3/4-inch thick) With Polyiso	53.1%

The Mass Effect Study Results

ASHRAE GreenTip #6: Night Precooling

GENERAL DESCRIPTION

Night precooling involves the circulation of cool air within a building during the nighttime hours with the intent of cooling the structure (see Figure 7-5). The cooled structure is then able to serve as a heat sink during the daytime hours, reducing the mechanical cooling required. The naturally occurring thermal storage capacity of the building is thereby utilized to smooth the load curve and for potential energy savings. More details on the concept of thermal mass on building loads are included in Chapter 4, "Architectural Design Impacts."

There are two variations on night precooling. One, termed *night ventilation precooling*, involves the circulation of outdoor air into the space during the naturally cooler nighttime hours. This can be considered a passive technique except for any fan power requirement needed to circulate the outdoor air through the space. The night ventilation precooling system benefits the building IAQ through the cleansing effect of introducing more ventilation air. With the other variation, *mechanical*

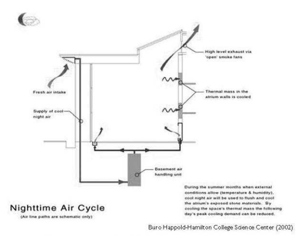


Figure 7-5 Schematic example of nighttime air cycle.

The Damping Effect

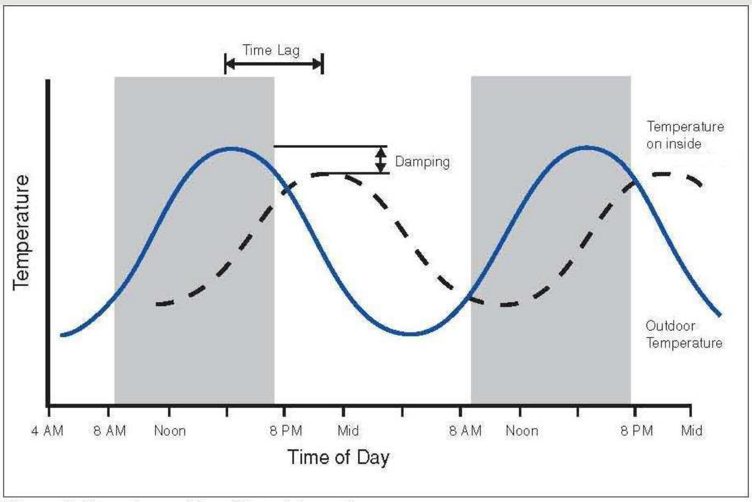


Figure 2. Damping and lag effect of thermal mass.

ASHRAE Time Lag / Damping

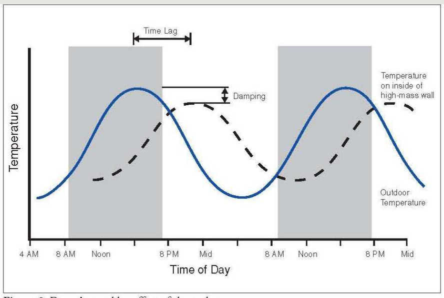
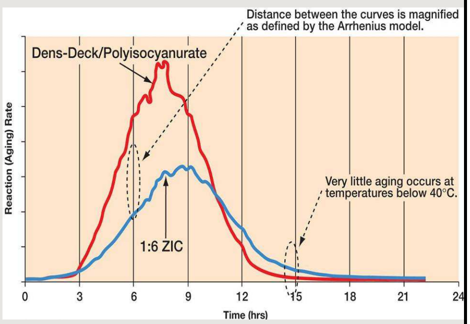


Figure 2. Damping and lag effect of thermal mass.



The Mass Effect

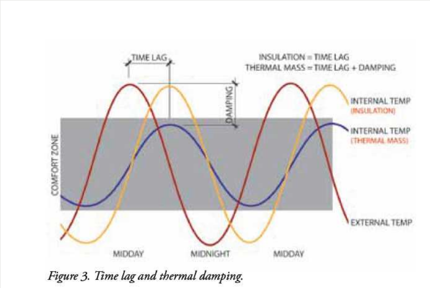


Figure 3. Time lag and thermal damping.

Goal – achieve a balance of time lag(insulation) and temperature damping(thermal mass).

Thermal Mass Solutions

A Net Zero Energy Strategy with Structural Implications (and Opportunities)

By Bob Habian, AIA

Figure 1. Partial height thermal mass walls connected to passive ducts for night time cooling. Courtesy of Gusmann & Blaevoet Consulting Engineers.

The Jess S. Jackson Sustainable Winery building (JSWB) project team, led by Siegel and Strain Architects, set out to design a Net Zero Energy, LEED Platinum building, at the University of California, Davis, where summer temperatures exceed one hundred degrees on a regular basis. Concrete masonry, as seen in *Figure 1*, not only saved the day, but it opened the door for IDA Structural Engineers of Oakland, CA to take a more active role in energy optimization at the earliest stages of a project.

climates like Davis, California, where there are high diurnal swings from hot to cold in a 24-hour period, exposed interior thermal mass, in the form of concrete masonry, can radically decrease the overall energy consumption. As shown in *Figure 3*, interior comfort is achieved using two primary strategies, time lag and damping. Insulation by itself can only achieve time lag. Thermal mass, however, contributes to both time lag and damping. Achieving the proper balance of both is the shortest path to achieving internal comfort.

Energy Management is Mandatory

The production of energy is the leading contributor to carbon footprint and climate change and, in the U.S., the Building Sector consumes more energy than any other sector (*Figure 2*). In response, a number of stricter energy code requirements are being enforced across all building types. The cost of energy is rising and is a matter of growing concern for building owners. The JSWB project team set out to not only reduce their energy consumption, but together decided to reach a level of Net Zero Energy (NZE), in which the total energy consumed is offset by renewable energy production on site. The most important factor in achieving NZE is reducing the overall energy consumption to the lowest possible level.

The Basics of Thermal Mass

The goal of every building design is to achieve internal comfort regardless of outside temperatures. In

Building 44.6%
Transportation 34.3%
Industry 21.1%

Figure 2. U.S. energy use by sector. Data source: US Energy Information Administration (2012).

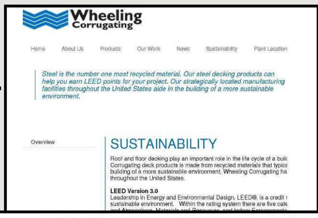
Framed Structures Lack Sufficient Mass

The building industry in the Western U.S. has shown a long-standing preference for framed, insulated, low-mass buildings that shake and don't fall down in earthquakes. A common belief in the west is that heavy mass buildings perform poorly in seismic conditions. Most often, the building failures referenced are unreinforced or poorly constructed. In addition, the historic abundance of wood has influenced our appetite for low mass, framed solutions. As a result, we traditionally rely on a combination of insulation and air handling systems to achieve interior comfort. To that end, most project participants believe the architect and the mechanical engineer are the only ones needing to be at the table to determine an optimal comfort strategy. As conventionally framed designs move in the direction of increased interior exposed thermal mass, the structural engineer becomes a necessary participant in the discussion.

STRUCTURE magazine 26 May 2015

Siplast LWIC System Sustainable Components

- **Metal deck.**
- **Portland Cement.**
- **EPS.**



Wheeling Corrugating

Home About Us Products Our Work News Sustainability Plant Location

Steel is the number one most recycled material. Our steel decking products can help you earn LEED points for your project. Our strategically located manufacturing facilities throughout the United States aide in the building of a more sustainable environment.

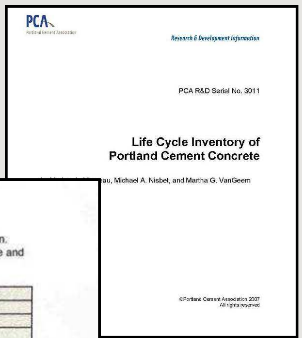
Overview

SUSTAINABILITY

Roof and floor decking play an important role in the life cycle of a buil
Corrugating deck products is made from recycled materials that typica
building of a more sustainable environment, Wheeling Corrugating ha
throughout the United States.

LEED Version 3.0

Leadership in Energy and Environmental Design, LEED®, is a credit r
sustainable environment. Within the rating system there are five cate



PCA Portland Cement Association

Research & Development Information

PCA R&D Serial No. 3011

Life Cycle Inventory of Portland Cement Concrete

eau, Michael A. Nisbet, and Martha G. VanGeem

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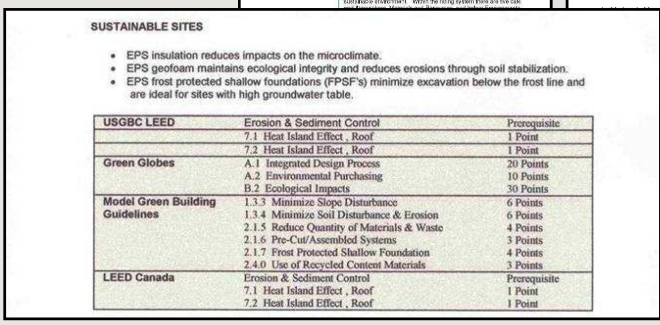


SUSTAINABLE SITES

- EPS insulation reduces impacts on the microclimate.
- EPS geofoam maintains ecological integrity and reduces erosions through soil stabilization.
- EPS frost protected shallow foundations (FPSF's) minimize excavation below the frost line and are ideal for sites with high groundwater table.

USGBC LEED	Erosion & Sediment Control	Prerequisite
	7.1 Heat Island Effect , Roof	1 Point
	7.2 Heat Island Effect , Roof	1 Point
Green Globes	A.1 Integrated Design Process	20 Points
	A.2 Environmental Purchasing	10 Points
	B.2 Ecological Impacts	30 Points
Model Green Building Guidelines	1.3.3 Minimize Slope Disturbance	6 Points
	1.3.4 Minimize Soil Disturbance & Erosion	6 Points
	2.1.5 Reduce Quantity of Materials & Waste	4 Points
	2.1.6 Pre-Cut/Assembled Systems	3 Points
	2.1.7 Frost Protected Shallow Foundation	4 Points
	2.4.0 Use of Recycled Content Materials	3 Points
LEED Canada	Erosion & Sediment Control	Prerequisite
	7.1 Heat Island Effect , Roof	1 Point
	7.2 Heat Island Effect , Roof	1 Point

Sustainable Roofs

- Highlights Lightweight Insulating Concrete Roof Insulations.
  - Produces low roof membrane temperature.
  - High thermal efficiency.
  - More stable and durable.

Roofing Contractor

Sustainable Roofs and Institutional Buildings

By Kenneth A Klein P.E.
June 04, 2012

Sustainable roofing systems can be many things, but primarily they are assemblies that provide a covering protecting a building from the elements (i.e., water, sun, cold, and heat) while minimizing their burden on the environment and conserving energy. Considerations such as low environmental impact, initial cost, life-cycle cost, as well as recycled content are all very important when assessing roof sustainability. There is presently not an accepted, all inclusive definition for a sustainable roof. This article provides the basic tenants of roof sustainability and cites recent examples where sustainable roofs were used on institutional buildings.

Sustainability

A sustainable roof needs to consider functionality service life and durability, environmental life-cycle impacts and in-service sustainability benefits. By optimizing these three items, the most sustainable roof system can be selected. For specialized institutional buildings, the roof system must meet the architectural intent as well as having the greatest durability and longest service life to offset its higher initial installation cost.

Sound Reduction

Structural Substrate	ZIC System	Roofing	STC
26 ga. Corrugated Steel	2" 1:6 ZIC Above Flutes	BUR/Gravel	41
26 ga. Corrugated Steel	1" Insulperm 2" 1:6 ZIC Above Insulperm	BUR/Gravel	36
22 ga. Corrugated Steel	2" 1:4 ZIC On Flutes 7" Insulperm EPS 2" 1:4 ZIC Above Insulperm	Paradiene 20/30	43
22 ga. Corrugated Steel	2" 1:4 ZIC On Flutes 7" Insulperm EPS 4" 1:4 ZIC Above Insulperm	Paradiene 20/30	44
22 ga. Corrugated Steel	2" 1:4 ZIC On Flutes 12" Insulperm EPS 4" 1:4 ZIC Above Insulperm	Paradiene 20/30	46
4-inch Structural Concrete	3" Insulperm 1 ½" NVS Concrete Above Insulperm	Modified Bitumen/ Gravel	55

Structural Lightweight Concrete

- Roofing over newly poured structural lightweight concrete slabs (SLC) has become an issue for general contractors, roofing contractors, consultants and roofing manufacturers.
- This is a sequencing, performance, and liability issue for the roofing contractor, roof consultant, and general contractor.
- Not a new issue.

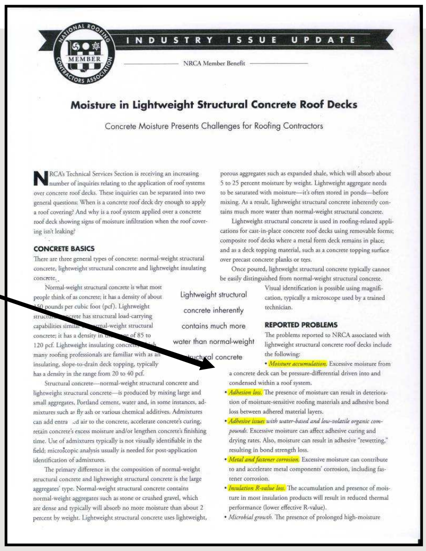
Structural Lightweight Concrete

- This is a sequencing, performance, and liability issue for the roofing contractor, roof consultant, and general contractor.
- Not a new issue.

What Is The Concern?

- Latent moisture in newly poured structural lightweight concrete (SLC) creates problems.

“Moisture accumulation”
“Adhesion loss”
“Adhesive issues”
“Metal and fastener corrosion”
“Insulation R-value loss”



INDUSTRY ISSUE UPDATE

NRCA Member Benefit

Moisture in Lightweight Structural Concrete Roof Decks

Concrete Moisture Presents Challenges for Roofing Contractors

NRCA's Technical Services Section is receiving an increasing number of inquiries relating to the application of roof systems over concrete roof decks. These inquiries can be separated into two general questions: When is a concrete roof deck dry enough to apply a roof covering? And why is a roof system applied over a concrete roof deck showing signs of moisture infiltration when the roof covering isn't leaking?

CONCRETE BASICS

There are three general types of concrete: normal-weight structural concrete, lightweight structural concrete and lightweight insulating concrete.

Normal-weight structural concrete is what most people think of as concrete; it has a density of about [illegible] pounds per cubic foot (pcf). Lightweight [illegible] has structural load-carrying capabilities similar [illegible] normal-weight structural concrete; it has a density in [illegible] of 85 to 120 pcf. Lightweight insulating [illegible], many roofing professionals are familiar with as an insulating, slope-to-drain deck topping, typically has a density in the range from 20 to 40 pcf.

Structural concrete—normal-weight structural concrete and lightweight structural concrete—is produced by mixing large and small aggregates, Portland cement, water and, in some instances, admixtures such as fly ash or various chemical additives. Admixtures can add entra[illegible]ed air to the concrete, accelerate concrete's curing, retain concrete's excess moisture and/or lengthen concrete's finishing time. Use of admixtures typically is not visually identifiable in the field; microscopic analysis usually is needed for post-application identification of admixtures.

The primary difference in the composition of normal-weight structural concrete and lightweight structural concrete is the large aggregates' type. Normal-weight structural concrete contains normal-weight aggregates such as stone or crushed gravel, which are dense and typically will absorb no more moisture than about 2 percent by weight. Lightweight structural concrete uses lightweight, porous aggregates such as expanded shale, which will absorb about 5 to 25 percent moisture by weight. Lightweight aggregate needs to be saturated with moisture—it's often stored in ponds—before mixing. As a result, lightweight structural concrete inherently contains much more water than normal-weight structural concrete.

Lightweight structural concrete is used in roofing-related applications for cast-in-place concrete roof decks using removable forms; composite roof decks where a metal form deck remains in place; and as a deck topping material, such as a concrete topping surface over precast concrete planks or tees.

Once poured, lightweight structural concrete typically cannot be easily distinguished from normal-weight structural concrete. Visual identification is possible using magnification, typically a microscope used by a trained technician.

Lightweight structural concrete inherently contains much more water than normal-weight [illegible]tructural concrete

REPORTED PROBLEMS

The problems reported to NRCA associated with lightweight structural concrete roof decks include the following:

- *Moisture accumulation.* Excessive moisture from a concrete deck can be pressure-differential driven into and condensed within a roof system.
- *Adhesion loss.* The presence of moisture can result in deterioration of moisture-sensitive roofing materials and adhesive bond loss between adhered material layers.
- *Adhesive issues with water-based and low-volatile organic compounds.* Excessive moisture can affect adhesive curing and drying rates. Also, moisture can result in adhesive “rewetting,” resulting in bond strength loss.
- *Metal and fastener corrosion.* Excessive moisture can contribute to and accelerate metal components' corrosion, including fastener corrosion.
- *Insulation R-value loss.* The accumulation and presence of moisture in most insulation products will result in reduced thermal performance (lower effective R-value).
- *Microbial growth.* The presence of prolonged high-moisture

Lightweight Insulating Concrete LEED Contribution

LEED v4

November 2013

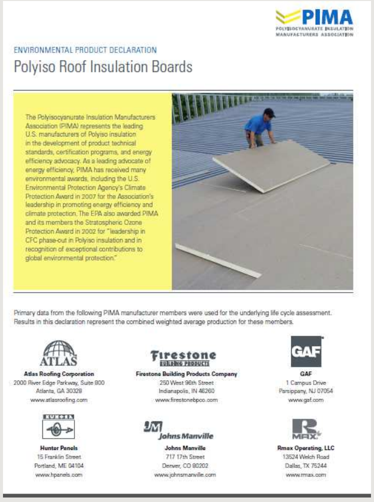
U.S. GREEN BUILDING COUNCIL
LEED
USGBC®

Lightweight Insulating Concrete LEED Contribution

	APPLICABLE PRODUCTS	LEED CREDIT	AVAILABLE POINTS	INTENT	REQUIREMENTS/COMMENTS
Materials & Resources	Siplast Lightweight Insulating Concrete combined with Paradiene Re-Cover Program projects using Paradiene 40 CR FR.	LEED 2009 NC Version 3 Materials & Resources MR Credits 1.1 & 1.2 Building Reuse	MR Credit 1.1 1 point (75%) MR Credit 1.2 1 point (95%)	Extend life-cycle of existing building stock. Reduce waste & environmental impacts as they relate to materials manufacturing & transport.	Maintain at least 75% (based on surface area) of existing building structure (including structural floor and roof decking) and envelope (...non-structural roofing materials). Maintain an additional 20% (95% based on surface area) as referenced above.
Indoor Environmental Quality	Siplast Lightweight Insulating Concrete	LEED 2009 NC Version 3 Indoor Environmental Quality IEQ Credit 7.1 Thermal Comfort	1 point	Comfortable thermal environment that supports productivity and well-being of occupants.	Design HVAC and building envelope systems to meet ASHRAE Standard 55-2004 Thermal Comfort Conditions for Human Occupancy.
		LEED 2009 EBOM Version 3 Indoor Environmental Quality IEQ Credit 7.1 Thermal Comfort	1 point		
	Siplast Lightweight Insulating Concrete	LEED 2009 for Schools NC and Major Renovations	1 point	To provide classrooms that facilitate better teacher-to-student and student-to student communications through effective acoustical design.	Sound Transmission Design the building shell, classroom partitions and other core learning space partitions to meet the Sound Transmission Class (STC) requirements of ANSI Standard S12-60-2002, Acoustical Performance Criteria, Design Requirements and Guidelines for Schools, except windows, which must meet an STC rating of at least 35.

Lifecycle Design

PIMA Environmental Product Declaration



PIMA
POLYISOCYANURATE INSULATION MANUFACTURERS ASSOCIATION

ENVIRONMENTAL PRODUCT DECLARATION

Polyiso Roof Insulation Boards

The Polyisocyanurate Insulation Manufacturers Association (PIMA) represents the leading U.S. manufacturers of Polyiso insulation in the development of product technical standards, certification programs, and energy efficiency advocacy. As a leading advocate of energy efficiency, PIMA has received many environmental awards, including the U.S. Environmental Protection Agency's Climate Protection Award in 2007 for the Association's leadership in promoting energy efficiency and climate protection. The EPA also awarded PIMA and its members the Stratospheric Ozone Protection Award in 2002 for "leadership in CFC phase-out in Polyiso insulation and in recognition of exceptional contributions to global environmental protection."

Primary data from the following PIMA manufacturer members were used for the underlying life cycle assessment. Results in this declaration represent the combined weighted average production for these members.

Atlas Roofing Corporation
2000 River Edge Parkway, Suite 800
Atlanta, GA 30328
www.atlasroofing.com

Firestone Building Products Company
250 West 96th Street
Indianapolis, IN 46260
www.firestonebpco.com

GAF
1 Campus Drive
Parsippany, NJ 07054
www.gaf.com

Hunter Panels
15 Franklin Street
Portland, ME 04104
www.hpanels.com

Johns Manville
717 17th Street
Denver, CO 80202
www.johnsmanville.com

Rmax Operating, LLC
13524 Welch Road
Dallas, TX 75244
www.rmax.com

Lifecycle Design

PIMA Environmental Product Declaration
Life Cycle Stages of Polyiso

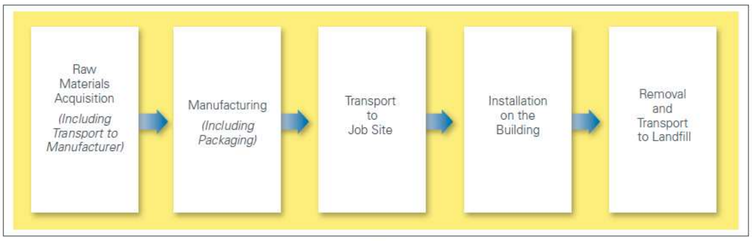


Figure 4:
Life Cycle Stages and System Boundaries for Polyiso Roof Insulation

Sustainability

718 tons (3,184 cubic yards of solid waste) of old roof insulation debris diverted from the local landfill.

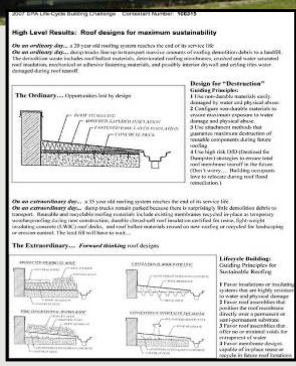
Equals 15 rail cars this size of old roof insulation.

Dollar value of salvaged roof insulation: $133,600 (2007 dollars).

Actual landfill disposal fees avoided: $29,797 (2007 dollars).

Heavy vehicle transportation miles avoided: 2,120 miles / 265 gallons of fuel.

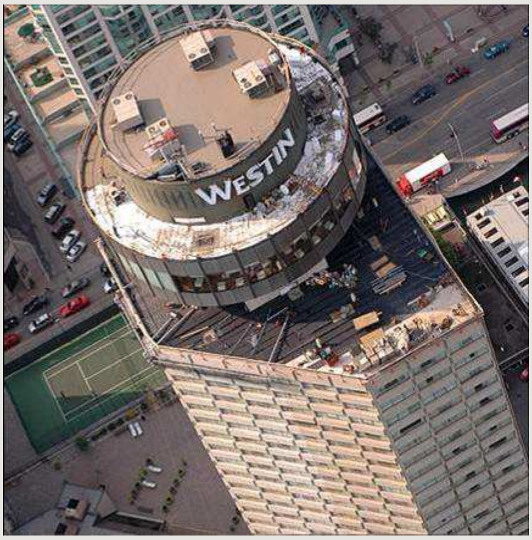
Tim G. Pennigar, Project Manager, Structural Systems Engineering & Operations Division Duke University Health System.



Sustainability

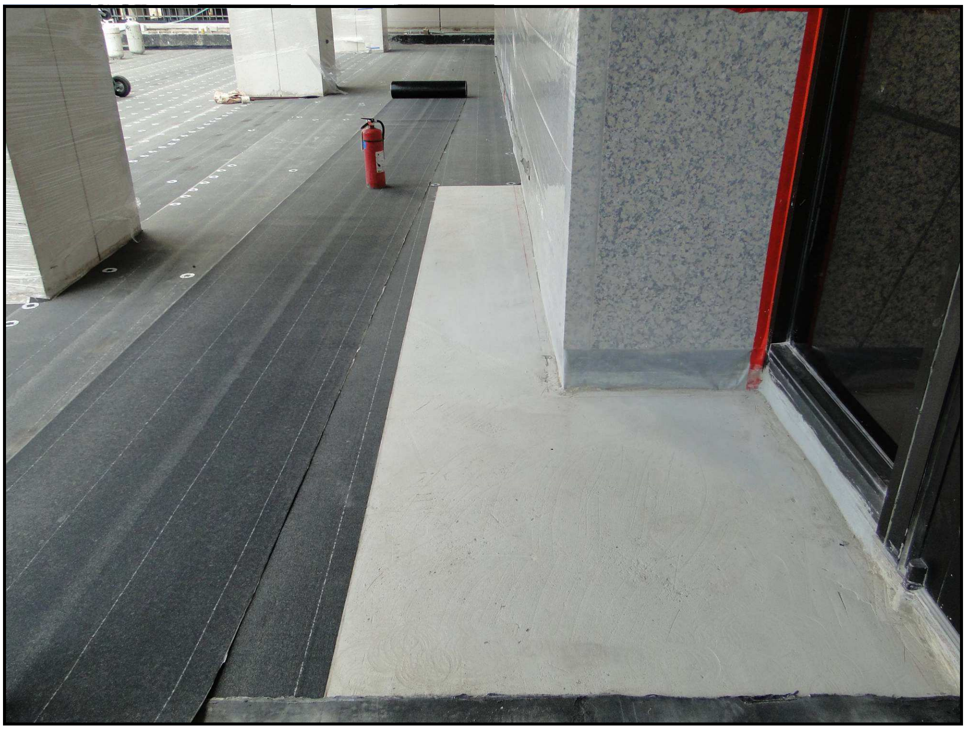
- Original roof system was lightweight insulating concrete and a two-ply, torch-applied SBS-modified bitumen membrane, installed in 1974.
- In the summer of 2011, test cuts showed the existing system was suitable for a re-cover.
- The owner saved over $200,000 by not removing the existing insulation and membrane.

Application is not limited by height.

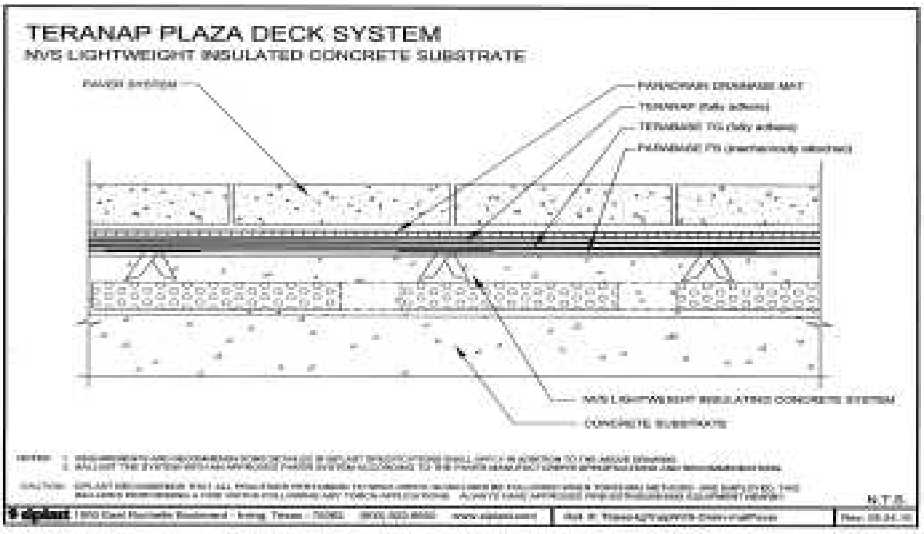


LWIC Solution

- Plaza Deck

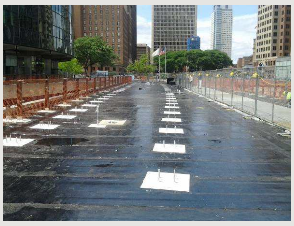


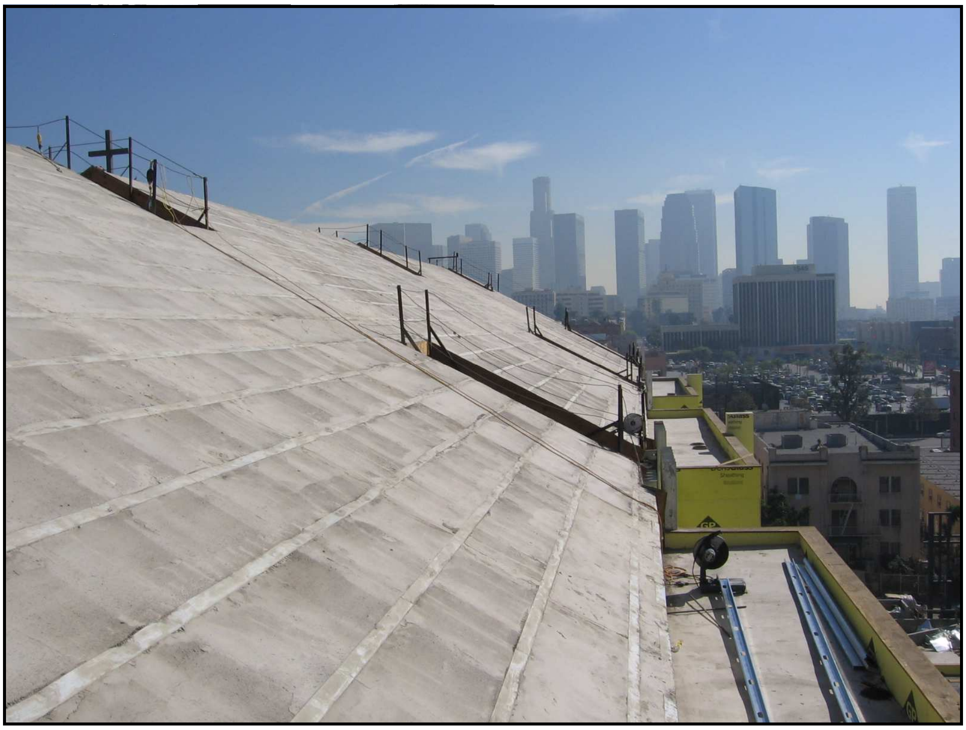
LWIC Solution

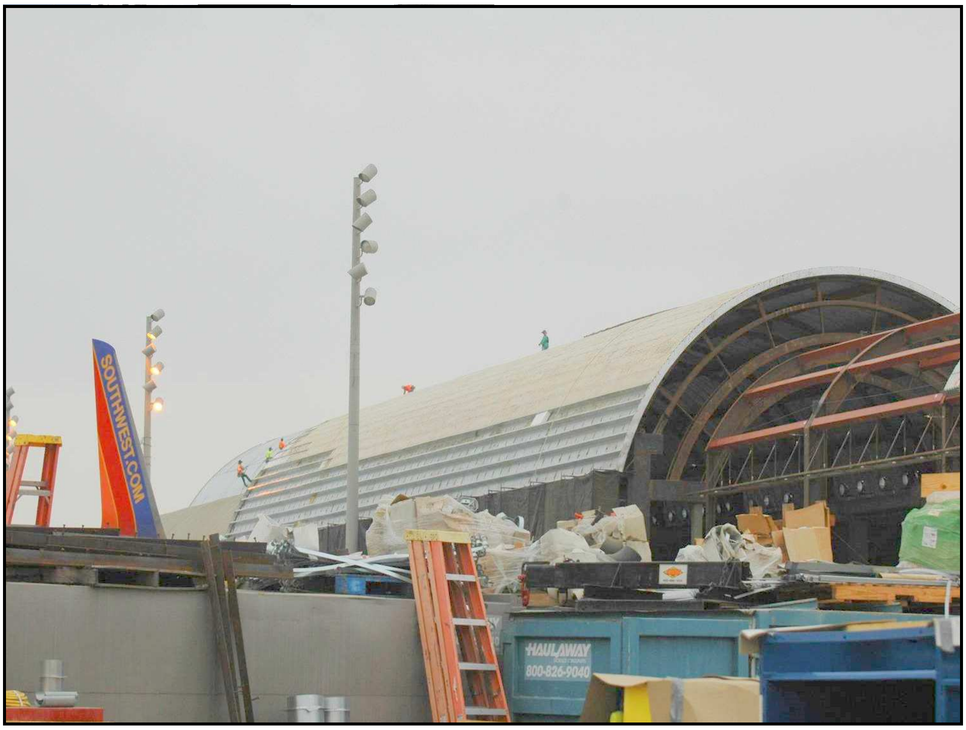


Non Roofing Applications

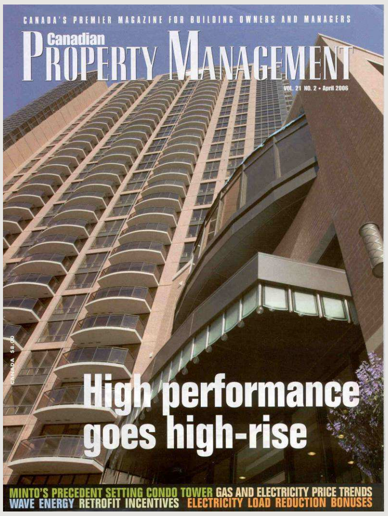
- Phoenix Plaza, Hartford, Conn.




SOUTHWEST.COM
HAULAWAY
800-826-9040

Canadian Resources



retrofitprofile

Roof Retrofit Minimizes Waste, Maximizes Performance

Revised Specifications Achieve Owners' Objectives and Cost Savings

By Tom Shreeve

before

EARLY IN 2003, Ontario Power Generation Inc. budgeted for the replacement of a warehouse roof covering 136,000 square feet of building space at its Kipling Complex in the west end of Toronto. Numerous leaks had developed on the existing 30-year-old built-up roofing assembly, causing ongoing problems, and the owner was considering vacating the building and offering it for lease.

Design factors were established with priorities established:

- eliminating standing water on the roof,
- energy conservation matching or increasing the thermal resistance (R-value) of the roof assembly;
- minimizing disruptions to the occupants; and
- developing a long term serviceable trouble-free roof.

The original precast tee structural deck had settled over time with ponded water evident in many locations. The original roof was not sloped to drains – something common to the vast majority of flat roof construction in Ontario today.

The new assembly had to match or exceed the original in terms of R-value and provide a trouble-free roof for years to come. OPG called for tenders on a design proposal to double the roof drains from 12 to 24 to assist a fully sloped roofing system, along with interior drain laterals that would be tied into the existing drainage system. It also stipulated that the existing roof, containing moisture where leakage had occurred, would be removed and disposed of in its entirety to ensure that the new system would provide the anticipated performance for its complete service life of some 20 years or so.

The implications of the proposed drain installations – with concrete coring through the deck, coupled with disruptions to the interior space for the installation of the lateral lines – were problematic. The costs would be high, and the new system, although fully tapered, would not guarantee the elimination of standing water on the roof due to normal structural settlement in the deck.

WORKABLE ALTERNATIVE

The contractor's competitive bid led to further exploration of how to meet the design goals. The R-value of a suggested optional system was approximately double that of the specified conventional replacement system.

Lightweight insulating concrete has been used for a number of years in Canada, having originally been developed in the United States. It allows for flexibility in accommodating existing drain locations and settled structures, to achieve a completely sloped to drain assembly, with no residual standing water on the roof. With this option, the requirement to add additional drains was discarded, eliminating disruptions and construction to the interior operations of the building.

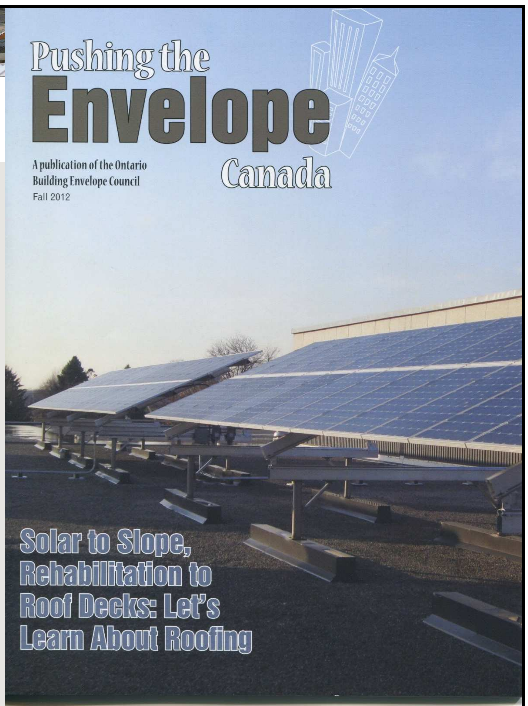
after

The contractors also advocated a thermal scan to identify and replace only the existing wet insulation, reusing the sound insulation, and installing the lightweight insulated concrete assembly. The option achieved success in eliminating standing water on the roof, as well as substantially reducing impacts on landfill.

A professional engineer assessed the weight and determined that loose gravel had to be removed from the existing assembly to accommodate the

30 April 2006 | Canadian Property Management

Performance



Lightweight Insulating Concrete Roof Insulation Systems

Innovative Roof Insulation Systems

One of the oldest, most versatile, and sustainable roof insulations on the planet