Smart Foam Liquid Concentrate Solutions Series

WHITE PAPER

Improving Performance of Low-Slope Roof Assemblies and Systems

ABSTRACT

High-performing roof assemblies and systems provide a key line of defense against rain, snow, wind, hail, and fire, protecting building interiors, contents, structural components, occupants, insurers, and investors. This white paper shares roof design considerations in terms of value provided for building stakeholders and advances lightweight insulating cellular concrete as a key material for improving performance of low-slope roof assemblies and systems.

People who can benefit from reading this white paper include facility owners, executives, and managers; roof consultants; architects, designers, roofing contractors, and other construction professionals; students and educators interested in roofing-related issues; building appraisers, inspectors, and investors; and insurance company personnel.

Included in this educational white paper is information on roof assemblies and roof systems, roof deck (substrate) options, insulating roof assembly options, design considerations for high-performing, low-slope roofs, and the benefits of using lightweight insulating cellular concrete for low-slope roof systems and assemblies, including the environmental soundness of lightweight insulating cellular concrete roof decks. Performance comparisons and cost considerations of rigid insulation board and lightweight insulating cellular concrete are also provided.

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KEYWORDS
attachment; board bowing; board facer delaminating; board insulation; building envelope; cellular concrete; composite insulating roof deck component system; compressive resistance; condensation; cover boards; cupping; deflection; dimensional stability; energy codes; energy efficiency; engineered composite board systems; engineered foam liquid concentrates; environmental soundness; extruded expanded polystyrene board (XEPS); fiberglass facers; FM Approvals; foam generation unit; future roof iterations; gypsum; hail resistance; heat flow resistance; heat sinks; high-performing roof assemblies; high-performing roof systems; horizontal shearing strength; infiltration; insulating roof deck assemblies; insulation crush; integrated component roof system; life-cycle costs; lightweight insulating cellular concrete (LWICC); light-weight insulating roof deck assemblies; lightweight insulating roof deck systems; low-density concrete; low-performing roof assemblies; low-slope insulating roof deck assemblies; low-slope roofs; LWICC roof deck applications; mechanical attachment; membranes; MEPS bond coats; MEPS encapsulation; Mearlcrete 40™; molded expanded polystyrene board (MEPS); nailable roof deck; nail base; non-nailable roof deck; oriented strand board (OSB); plastic foam insulators; perlite boards; polyisocyanurate insulation board (ISO); polystyrene insulation board; polyvinyl chloride roof membranes (PVC); positive slope-to-drain; preformed foam; primary thermal insulation; R-Value; re-roofing; rigid board insulation; rigid board insulation assemblies; rigid board insulation systems; roof assemblies, roof assembly movement; roof deck; roof design considerations; roof functions; roof membrane compatibility; roof membrane integrity; roof membrane strain; RoofNav®; roof performance criteria; roofs; roof substrates; roof traffic loads; roof water tightness; screeding-to-slope; seismic lateral forces; seismic forces; seismic ratings; slope for positive drainage; solvent-based adhesives; stable air cells (bubbles); structural roof decks; tapered board designs; thermal drift; thermal insulation components; thermal mass; thermal resistance; uniform cellular structure of air voids (bubbles); vapor retarder; wet-cast density; wind uplift resistance; wood fiberboard.

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INTRODUCTION

As the first line of defense against weather and fire, roofing systems and assemblies impact facility operations, occupant usage, the environment, and investment performance. High-performing roof assemblies support facility functions (water-tightness, maintainability, health and safety, and appearance), protecting building interiors, contents, structural components, occupants, insurers, and investors and reducing energy usage, cost, and the building's carbon footprint.

Low-performing roof assemblies impede long-term facility performance, deplete facility maintenance resources, and place building interiors, contents, structural components, occupants, insurers, the environment, and investors at risk.

More than three billion square feet of low-slope roofing systems and assemblies are installed annually on commercial and industrial buildings. Though most low-slope roofing systems perform acceptably initially, low-performing roof systems account for a significant portion of all building litigation (with some estimates suggesting annual litigation involving low-slope roof systems exceeds the combined annual number of lawsuits for all other building systems).

Improving performance of low-slope roof membrane assemblies and systems enhances facility performance and management, adding value for building owners, occupants, facility managers, insurers, and investors.

ROOF ASSEMBLIES AND ROOF SYSTEMS

Though often used interchangeably, the term roof assembly includes the roof deck, air or vapor retarder (if present), thermal insulation (if present) and the roof covering, while the term roof system refers to the air or vapor retarder (if present), thermal insulation (if present) and the roof covering. Low-slope roof assemblies most often have three basic components – a structural deck, thermal insulation, and a membrane roof covering – though sometimes a vapor retarder component can also be required. In high-performing low-slope roof assemblies, these components function as an integrated system, with each component dependent on and complementing the high performance of the other components. For example, the integrity of high-performing membranes and thermal insulation are dependent on and complement stable, high-performing structural decks.

To emphasize the importance of compatible, high-performing components, the remainder of this paper will use the term roof assembly when describing one or more of the basic roof components or accessories and the term system when describing a multipart whole formed from integrated parts.

ROOF DECK (SUBSTRATE) OPTIONS

Also known as roof substrates, roof decks provide the underlying surface (base) on which the roof is built. In high-performing, low-slope roof assemblies, membrane roof coverings function best when supported by durable, stable, compatible structural roof decks.

The roof deck functions as structural support, transferring the weight of live and dead loads to the building framing system and transmitting wind and seismic lateral forces to the building's structural support system. The roof deck also provides a dimensionally stable base to which other roof assembly components are attached and a degree of fire resistance for the structure. Classified as nailable or non-nailable (or sometimes both) regarding anchoring the vapor retarder (if present), thermal insulation (if present), or membrane to the substrate, structural roof decks are made of steel (most common), concrete, wood, or engineered composite materials. Structural roof deck selection cannot be done in isolation; deck selection impacts insulation and membrane integrity and roof assembly performance. Selection must also account for property insurance underwriting requirements. With obligations to owners to minimize property losses and reduce their impact, testing agencies have invested in extensive analysis of roof assembly materials and components and have developed and enacted provisions requiring the use of approved roof assembly configurations.

The roof deck also provides a dimensionally stable base to which other roof assembly components are attached, and a degree of fire resistance for the facility.

Roof assembly approvals cover more than 6,000 (and growing) roofing products and 180,000 (and growing) roofing-assembly configurations. RoofNav® and Miami-Dade County Approved Product Data Base are free, online tools and help architects, roofing consultants, and other construction professionals access roof design data and provide straightforward guidance to determine project requirements and methods for meeting them. See the **Resource** section of this white paper for the URLs for accessing RoofNav®, Underwriters Laboratories, and Miami-Dade County product approvals.

In high-performing low-slope roof assemblies, structural roof decks accommodate deflection, slope for positive drainage, attachment, and roof assembly movement, complemented by the performance characteristics of the assembly's thermal insulation components.

INSULATING ROOF ASSEMBLY OPTIONS

Thermal insulation is a key roof assembly component, supporting occupant comfort, reducing and managing building heating and cooling loads (and costs), preventing condensation on interior building surfaces, providing additional horizontal shearing strength and resistance from wind and seismic forces (and distributing membrane stresses across a wide area, lowering membrane strain below its breaking point), and – for steel decks – providing a level surface for membrane application.

There are many types of insulation available for use in insulating roof assemblies, including:

- Flexible batt insulation
- Sprayed-on-site, polyurethane foams
- Dual-purpose structural deck/insulating planks
- Rigid roof insulation boards, and
- Insulating concrete fills, made from cellular concrete or expanded aggregate concrete.

As related above, selection cannot be done in isolation. Compatibility issues can exist, for example, between roof deck selection and thermal insulation selection, and insulation thickness influences roof-top-equipment elevations.

In high-performing low-slope insulating roof assemblies, thermal insulation helps accommodate deflection, slope for positive drainage, attachment, roof traffic loads and roof assembly movement, complemented by the performance characteristics of the assembly's structural deck component.

To meet thermal needs, required compressive strengths for hail resistance and anticipated traffic loads, membrane compatibility, applicable fire, wind, and energy codes, and insurance underwriting requirements, most low-slope insulating roof deck assemblies use either rigid insulation board or lightweight insulating cellular concrete.

Rigid Insulation Board

Many types of rigid insulation board (RIB) are available for insulating roof deck assemblies. The two most commonly used RIBs for primary thermal insulation are plastic foam insulators, as detailed in the National Institute of Building Sciences' Whole Building Design Guide (WBDG), and include:

- Polystyrene Insulation Board – Polystyrene insulation comes in two types, Molded Expanded Polystyrene (MEPS, aka EPS)) and Extruded Expanded Polystyrene (XEPS, aka XPS), and each type has distinctive properties. A suitable separator is required between Polystyrene Insulation Board and polyvinyl chloride (PVC) roof membranes, according to the WBDG, as the plasticizer in the PVC can migrate over time into the Polystyrene Insulation Board, causing the MEPS or XEPS to soften and the PVC roof membrane to become brittle.

    - MEPS is a cost-effective, moderate R-Value insulation. MEPS cells are filled with air, so MEPS board does not thermally age – loose R-Value over time – like other plastic foam insulators. According to the WBDG, MEPS can decompose at high temperatures and is vulnerable to attack from solvent-based adhesives and hot asphalt. Suitable cover boards (see below) are required to be installed over MEPS board if it is used under a dark roof membrane or asphalt or solvent-based adhesives are used for attachment. MEPS board also has low resistance to water vapor, according to the WBDG.

    - XEPS is a high R-Value insulation with high compressive resistance and is resistant to water vapor. But like its MEPS cousin, according to the WBDG, XEPS should not be exposed to solvent-based adhesives, hot asphalt, or very high temperatures. In service, XEPS will thermally age.

Thermal insulation can help to accommodate deflection, slope for positive drainage, attachment, roof traffic loads, and roof assembly movement.

- Polyisocyanurate Insulation Board – Polyisocyanurate (ISO) Insulation Board is manufactured from liquid polyisocyanurate foam sandwiched between fiberglass reinforced organic felt, fiberglass mat (inorganic), or foil facers. A high R-Value insulation, ISO is used widely in low-slope roof assemblies. A study by the Energy Service Provider Group (ESPG) showed ISO insulation could save tens of thousands of dollars in installed costs, when compared to other plastic foam roof insulation materials. ISO board size can become an attachment issue, as larger boards may not conform well to deck irregularities. ISO insulation must be kept dry when stored at the job site. Cupping or board bowing – which can contribute to ponding water, premature delaminating, and loss of insulation component integrity and R-Value – can result if a facer gets wet. Repeated surface traffic or material storage over the installed insulation during ISO application can contribute to insulation crush and/or board facer delaminating. Though installation-friendly, custom-fitting ISO boards properly can be a challenge.

Each of these RIB options is available in flat board and tapered board designs. Tapered board designs provide necessary slope for positive roof drainage, with custom layouts and installation shop drawings required for each roof installation.

Cover boards – thin layers of insulating material – are often placed over the primary insulation component to provide improved compressive resistance, to eliminate blistering, to accommodate deck and/or membrane compatibility issues, or to create a thermal barrier for fire protection between deck and insulation components. The three most common cover board materials include:

- Perlite Board – Perlite Board is a low R-Value insulation cover board with good fire resistance. According to the WBDG, if exposed to water, Perlite Board compressive resistance degrades and the material can be easily compressed. Because of a high ratio of organic material in half-inch Perlite Board, there is high potential for blisters when used in built-up and hot-applied modified bitumen membranes roof assemblies.

- Wood Fiberboard – Wood Fiberboard is a low R-Value insulation used primarily as a cover board. It has good compressive resistance, but, like Perlite Board, if exposed to water, Wood Fiberboard's compressive resistance degrades and the material can be easily compressed.

- Gypsum-based Cover Board – Gypsum-based Cover Board materials provide the highest compressive strength of all cover board materials and are used to enhance the fire rating of some roof assemblies. Gypsum-based Cover Board materials are heavy and require extra installation labor to cut, fasten, and finish.

A high R-Value insulation, polyisocyanurate insulation board (ISO) is used widely in low-slope roof assemblies.

A final category of RIBs is Engineered Composite Board Systems. Engineered Composite Board Systems include two layers of different types of insulation, bonded together at the manufacturing plant. ISO rigid insulation board or MEPS insulation board most often provides the primary insulation layer of the engineered system. The secondary layer (typically the top surface) can be made from perlite, wood fiberboard, gypsum, plywood, or oriented strand board (OSB). Composite systems made with OSB or plywood are sometimes called "nail base" and are primarily used in steep-slope roofing applications. The WBDG recommends mechanical attachment for engineered composite board systems to guard against potential in-service delaminating.

ISO rigid insulation board or MEPS insulation board most often provides the primary insulation layer of engineered composite insulation board systems.

Features and benefits highlighted in RIB promotional literature include durability, versatility, strength, low-density, energy efficiency, ease of installation, and environmental soundness. RIB insulation components provide:

- Thermal resistance
- Hail resistance
- Wind resistance
- Fire resistance
- Positive slope-to-drain (with tapered board design)
- Roof assembly compatibility
- Dimensional stability
- Moisture resistance
- A walking (compression) surface, and
- A level substrate for the roof system.

Lightweight Insulating Cellular Concrete (LWICC)

Low-slope insulating roof deck assemblies often use lightweight insulating cellular concrete (LWICC) to meet project thermal needs, required compressive strengths for hail resistance and anticipated traffic loads, membrane compatibility, applicable fire, wind, and energy codes, and insurance underwriting requirements.

Lightweight insulating cellular concrete helps roof designers meet project thermal needs, required compressive strengths, applicable fire, wind, and energy codes, and insurance underwriting requirements.

Lightweight insulating cellular concrete (LWICC) is a closed-cell, low-density concrete produced at the job site by the substitution of a uniform cellular structure of air voids (bubbles) for some or all of the aggregate particles found in traditional concretes (air voids of up to 80 percent of total volume are common). Typical LWICC roof deck applications create cellular concretes with precisely-controlled wet-cast densities ranging from 30 lb/ft^3 to 45 lb/ft^3 and compressive strengths ranging from 140 psi to 450 psi. Dry density ranges for typical LWICC roof deck applications are 25 lb/ft^3 to 38 lb/ft^3.

LWICC is manufactured on site by blending preformed foam into a cement slurry or grout. The preformed foam is produced at the job site by blending an engineered foam liquid concentrate with water and compressed air in predetermined proportions in a foam generation unit. The blended liquid expands in volume, creating preformed foam with a density range of about

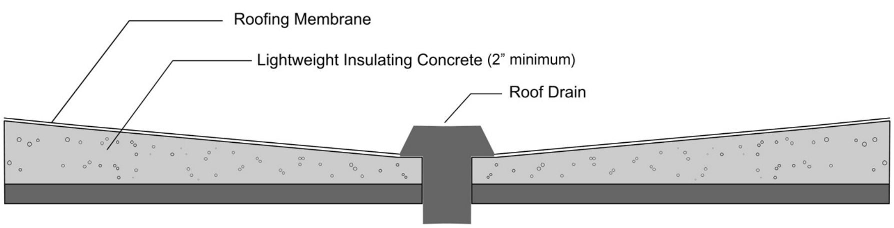
2.0 lb/ft³ to 3.5 lb/ft³. When designed specifically for lightweight insulating cellular concrete production, the chemical composition of the engineered foam liquid concentrates produces stable air cells, which remain unbroken during production, placing, and finishing phases and while the LWICC hardens.

LWICC is placed most often over galvanized steel (corrugated or fluted) or concrete (pre-cast or cast-in-place) structural roof decking, providing improved fire ratings and additional seismic resistance compared to other thermal insulation options. Though less typical, LWICC can also be cast over wood or engineered composite roof decking.

Positive slope-to-drain is easily cast-in-place by screeding-to-slope during LWICC installation (see FIGURE 1).

When designed specifically for LWICC production, the chemical composition of the engineered foam liquid concentrate produces stable air cells, which remain unbroken during production, placing, and finishing phases and while the cast-in-place hardens.

FIGURE 1

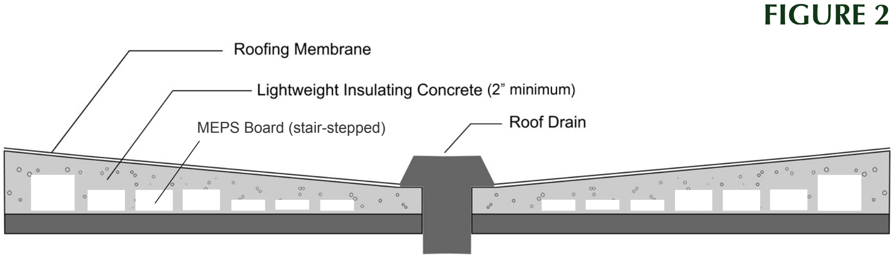


LWICC has excellent insulation properties (with thermal resistance almost four times greater than normal-density concretes) and is often used in underground thermal conduit lining applications. In roof assembly applications requiring high thermal resistance, molded expanded polystyrene (MEPS) is often encapsulated in LWICC, "sandwich-construction" style, over the structural roof deck, creating a job-site produced, composite, insulating roof deck component system.

The MEPS encapsulation process works like this: A layer of LWICC is cast on the roof deck, MEPS board is laid in the slurry and bonded to the structural deck, and the MEPS board is topped with a final layer of LWICC.

The encapsulated insulation design provides a monolithic, highly thermal-resistant, slope-to-drain insulation component (stair-stepped or constant thickness) ready for the roofing membrane. R-Values of R-50 are easily achieved (see FIGURE 2).

FIGURE 2



LWICC is an excellent material for use in re-roofing applications. In many re-roofing or drainage-correction instances, LWICC can be placed directly over the existing roofing, eliminating the cost and landfill debris associated with existing roof tear-off.

LWICC is typically purchased from and produced and placed by factory-trained roof deck contractors with specialized equipment designed specifically for job site cellular concrete production and expertise and experience in lightweight insulating cellular concrete applications. LWICC is a cast-in-place material most typically placed by pumping. MEPS bond coats, double casting, and two-density casting are acceptable installation methods. Finishing operations involve screeding the placed LWICC to specified thickness and slope and surface finishing to prepare a ridge-free substratum ready for membrane application.

Features and benefits highlighted in LWICC promotional literature include durability, versatility, strength, low-density, energy efficiency, ease of installation, permanence, and environmental soundness. LWICC insulation components provide:

- Thermal resistance
- Thermal mass
- Hail resistance
- Wind resistance
- Fire resistance
- Positive slope-to-drain (cast-in-place)
- Dimensional stability
- Roof assembly compatibility
- Moisture resistance
- A walking (compression) surface
- Competitive initial construction costs
- Low life-cycle costs, and
- A level substrate for the roof system.

DESIGN CONSIDERATIONS FOR HIGH-PERFORMING LOW-SLOPE ROOFS

Duke Medicine, Durham, North Carolina, which integrates the research, clinical care, and education missions of the Duke University School of Nursing, the Duke University Health System, and the Duke University of Medicine, has roof assets of almost 2.5 million square feet.

In late 2007, as part of Duke Medicine's Design and Construction Series, Tim G. Pennigar, project manager for structural systems with Duke University Health Systems, presented a paper titled *High Performance Buildings for Extraordinary Health Care*. In the paper, Pennigar shared four principles for roofing design to ensure high performance and durability for Duke Medicine facilities:

Lightweight insulating cellular concrete is an excellent material for use in re-roofing applications.

(1) Favor roof assemblies positioning the roof membrane directly over a permanent or semi-permanent substrate
(2) Favor roof designs prohibiting or discouraging the entrapment of water within the roof assembly
(3) Favor insulations and insulating assemblies highly resistant to water and physical damage
(4) Favor designs capable of in-place reuse or recycle in future roof iterations.

LIGHTWEIGHT INSULATING CELLULAR CONCRETE IMPROVES THE PERFORMANCE OF LOW-SLOPE ROOF SYSTEMS AND ASSEMBLIES

The use of lightweight insulating cellular concrete (LWICC) improves the performance of low-slope roof assemblies, providing an integrated component system with advantages in durability, fire resistance, heat flow resistance (when combined with encapsulated EPS), compressive strength, wind uplift, seismic ratings, positive drainage, dimensional stability, moisture resistance, and environmental soundness.

In terms of value provided for building owners, occupants, and investors, lightweight insulating cellular concrete roof deck assemblies embody Duke Medicine's four roof design principles, reliably ensuring the roof system will not detract from facility building envelope performance:

- Lightweight insulating cellular concrete roof deck assemblies are permanent insulation component applications, ready for direct roofing membrane installation
- Lightweight insulating cellular concrete roof deck assemblies discourage the entrapment of water within the roof system
- Lightweight insulating cellular concrete roof deck assemblies encapsulate EPS insulation, creating insulating assemblies highly resistant to water and physical damage
- Lightweight insulating cellular concrete roof deck assemblies are capable of reuse in future roof iterations – in most instances, only the roofing membrane must be replaced.

Performance comparisons of rigid insulation board and lightweight insulating cellular concrete roof deck systems, when used over metal decking, follow (page 12).

Lightweight insulating cellular concrete roof decks provide value for building owners, occupants, and investors, reliably ensuring the roof system will not detract from facility building envelope performance.

PERFORMANCE COMPARISONS WHEN USED OVER METAL DECKING
Lightweight Insulating Cellular Concrete (LWICC) & Rigid Insulation Board (RIB)

	LWICC	RIB
Slope	Positive slope to drain is custom cast during placement and can be achieved with or without stair-stepped insulation. Low spots or other irregularities can be easy corrected with LWICC, ensuring positive slope. Special pieces are not required for crickets and saddles, as they are in RIB component applications.	Positive slope-to-drain is achieved using tapered RIBs, a complex system of numbered, color-coded, pre-fabricated shapes and sizes requiring exacting job site layout and placement. Prompt, complete drainage can be difficult to achieve, as tapered RIB systems do not compensate for deflection in existing substrates.
Hourly Fire Ratings	LWICC systems provide a fire-resistant thermal barrier, with more than 50 UL hourly assembly fire ratings available for complete LWICC roof insulation systems.	Most rigid board insulations have few UL hourly ratings without the costly addition of a separate thermal barrier to the underside of the metal decking.
Attachment	Permanent attachment of LWICC to the substrate is achieved without using fasteners and results from the interaction of the LWICC with the substrate. This attachment method provides excellent wind uplift resistance.	Hot asphalt, special adhesives, ballast, or mechanical fasteners are typically used to affix RIBs. Mechanical attachment can contribute to thermal bridging, reducing the R-Value of the system.
Mechanical Stresses	The encapsulated insulation design of LWICC systems provides a stable, monolithic surface to accept the roof membrane.	Inherent in RIB applications is a pattern of continuous joints, which impart mechanical stresses to the roof membrane when the RIB moves.
Thermal Stresses	Acting as a heat sink, LWICC is slow to release heat. This “thermal inertia” or “thermal-mass effect” reduces extreme temperature fluctuations and the resulting thermal stresses, which cause membrane-fatigue failure and are the primary cause of most roof failures.	The low density and low thermal conductivity of RIB can produce extreme temperature fluctuations in the roof surface – daily roof surface temperature changes exceeding 100° F can be common – causing thermally-induced stress on the roof membrane.
Stable Insulation R-Values	LWICC does not contain chemicals that dissipate over time, resulting in stable insulation R-Values from LWICC placement until the end of the roof system’s service life.	Many RIBs contain HCFC or other chemicals, which, though they provide high initial R-Values, can dissipate over time, reducing RIB insulation R-Value (thermal drift).
Re-roofability	Because LWICC is highly resistant to moisture damage, in most cases, it is re-roofable	Most RIB becomes permanently damaged when exposed to moisture and requires costly replacement in re-roofing applications.
Environmentally Sound	In re-roofing applications, existing LWICC stays in place, eliminating waste disposal problems. LWICC does not contain material components harmful to the Ozone layer. See next section for more information about the environmental soundness of lightweight insulting cellular concrete roof deck systems.	In re-roofing applications, existing RIBs are usually removed and are transported to and disposed of in solid waste facilities. Some RIBs contain material components harmful to the Ozone layer.

COST CONSIDERATIONS, RIGID INSULATION BOARD AND LIGHTWEIGHT INSULATING CELLULAR CONCRETE

Because of the many variables involved in roof assembly design and construction, cost comparisons can be confounding. Material and labor costs vary worldwide, as do specifications, building codes, construction practices, and insurance underwriting requirements. Meaningful comparisons can also be problematic due to desired in-place performance, as some materials and roof assembly components are better suited for creating integrated, high-performing roof systems than other materials and roof assembly components. Components best suited for high-performance in a LWICC roof deck system can be different from components best suited for high-performance in a RIB system. Cost as a concept must also must be defined and applied consistently to the compared roof deck systems. Is the comparison of initial cost investment only? Or does the comparison include both initial cost considerations and expenditures incurred over the lifetime of the structure?

Life cycle cost analysis provides the more powerful economic tool for selection of building design and materials, but – lacking meaningful data for a given structure to accurately model building shell and equipment service life and projected energy and maintenance expenditures – is beyond the scope of this white paper. In most situations, the use of durable materials and roof assembly components, like those used in LWICC roof deck systems, will have lower life-cycle costs than roof deck systems using less durable materials. Because a LWICC roof deck system provides a permanent insulation component application, capable of reuse in future roof iterations, it will have lower life cycle costs than a RIB roof deck system, which typically will require costly RIB removal, disposal, and replacement in re-roofing applications.

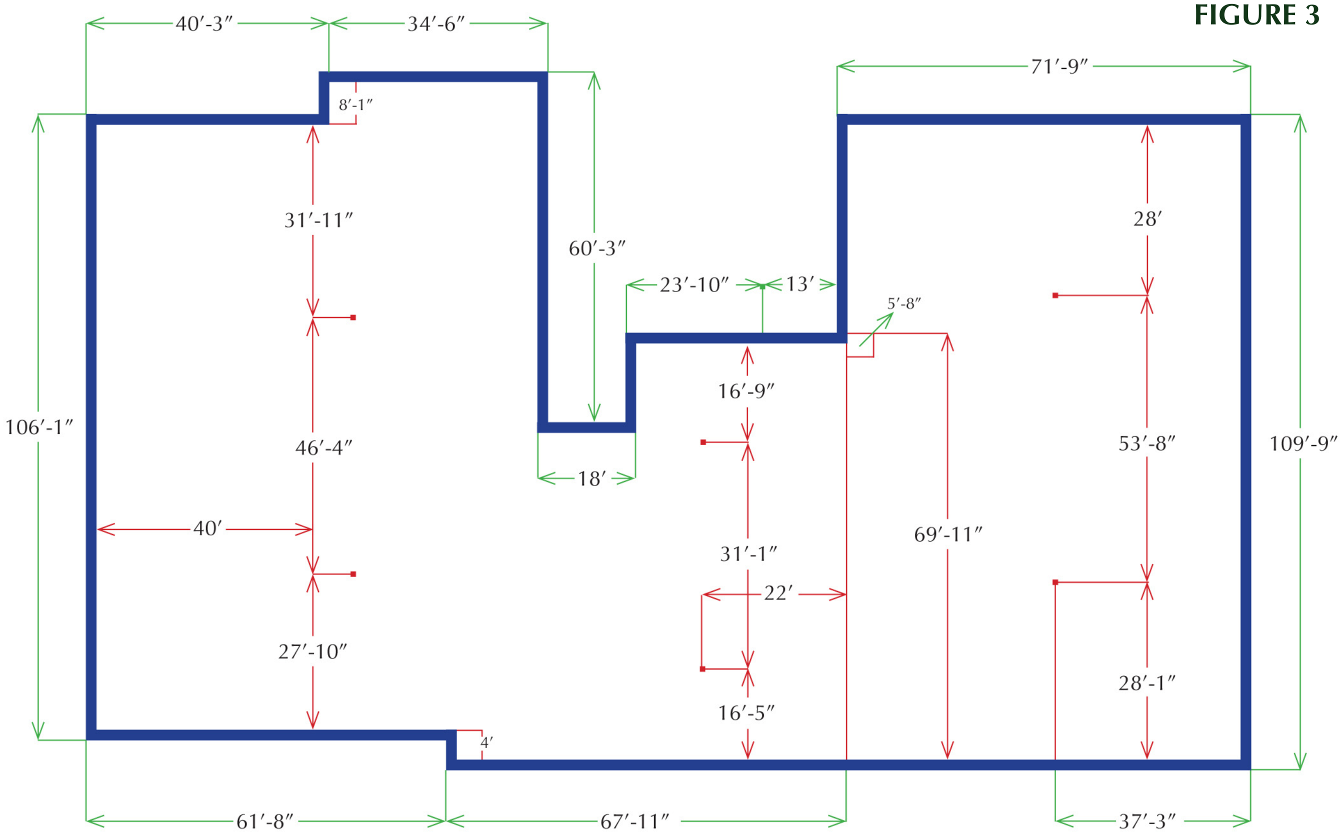
Sample Roof Deck Cost Comparison (196 Squares)

The roof deck represented by the schematic in FIGURE 3 (page 14) is located in the Southeastern United States and competitive bids were acquired from RIB and LWICC contractors for three types of low-slope roof applications. Initial cost savings for the LWICC roof deck application options, as summarized below, were dramatic:

- For a 4-Way Slope, Minimum R-20 application option, initial cost savings for a LWICC roof deck application over a RIB application option were $120,540
- For a 4-Way Slope Minimum Thickness application option, initial cost savings for a LWICC roof deck application over a RIB application option were $95,844
- For a Slope in Structure, Minimum R-20 application option, initial cost savings for a LWICC roof deck application over a RIB application option were $22,540.

The cost-savings information provided above is for general comparison purposes only, and may not be reflective of actual costs for specific projects arising from competitive proposals within your marketplace.

FIGURE 3



But this project-specific example demonstrates dramatic initial cost savings can often be realized with LWICC roof deck systems. On roof deck projects with simple drainage patterns, few penetrations, and less squares, RIB roof deck systems may compare more favorably in initial cost investment to LWICC roof deck systems than the savings detailed above.

As stated earlier, LWICC roof deck systems will almost always provide the lowest life-cycle costs, even on roof deck projects with simple drainage patterns and few penetrations. When your goal is to provide improved low-slope roof assembly performance over the life of a structure, the long-term cost and environmental benefits (see below) of LWICC roof deck systems are evident.

To obtain pricing for specific projects, contact roofing contractors in your area. For a listing of experienced, factory-trained roof deck contractors with specialized equipment designed specifically for job site cellular concrete production and expertise and experience in lightweight insulating cellular concrete applications, contact John Sedenquist: 888.235.5015 | jsedenquist@cellular-concrete.com.

Information on the environmental soundness of LWICC roof deck systems follows.

ENVIRONMENTAL SOUNDNESS OF LIGHTWEIGHT INSULATING CELLULAR CONCRETE ROOF DECK SYSTEMS

Studies show the most significant facility environmental impacts come from the use of natural resources to heat, cool, and operate buildings, accounting for, over the life of the structure, 85 to 95 percent (85% – 95%) of total energy and emissions. The combined embodied energy of all construction materials used for the facility account for the remaining energy use and emissions. Though a low-slope roof assembly can constitute a large percentage of the building envelope, it is only one part of an integrated system designed to control structural and environmental loads, keeping weather out and the interior, conditioned climate in.

LWICC is only one material in low slope roof assemblies and highlighting its many environmental advantages in isolation can obscure how it functions as part of an integrated system of materials and components, dependent on and complementing the environmental performance of other system parts.

But acknowledging this should not distract from this fact: Lightweight insulating cellular concrete roof decks do support facility environmental soundness and are proven and valuable components of sustainable structures.

Durability is a prerequisite for sustainable building design. As permanent insulation components not affected by moisture, lightweight insulating cellular concrete roof decks exemplify durability. At the end of roof membrane service life, lightweight insulating cellular concrete roof deck systems require only roof membrane replacement, eliminating the need to install new insulation and removing damaged rigid board insulation from the waste stream. In many re-roofing or drainage-correction cases, LWICC can be placed directly over the existing roofing, eliminating the energy use, emissions, and landfill debris associated with existing roof tear-off. Lightweight insulating cellular concrete roof decks provide a stable, monolithic substratum, positive slope-to-drain, outstanding fire resistance, and exceptional wind uplift resistance, enhancing roof membrane (and roofing assembly) service life.

Lightweight insulating cellular concrete roof decks act as heat sinks, reducing extreme temperature fluctuations and their resulting thermal stresses, which can limit the service lives of roof membranes and roofing assemblies. When encapsulating EPS insulation within the system, lightweight insulating cellular concrete roof decks – in concert with other building envelope components – conserve energy use over the lives of the structures they serve, reducing overall environmental impacts. Unlike some RIB systems, which experience thermal drift over time and use mechanical fasteners to attach to the roof deck (which promotes thermal bridging), lightweight insulating cellular concrete roof deck systems bond to roof decks and provide consistent R-Values for the lives of the structures they serve.

The use of advanced foam generation systems for on-site LWICC production reduces project mobilization, trucking, and material storage and protection

Lightweight insulating cellular concrete roof decks support facility environmental soundness and are proven and valuable components of sustainable structures.

requirements, and their associated energy usage and emissions. Lightweight insulating cellular concrete roof decks have been used on many LEED-certified projects and can contribute to the satisfaction of the following LEED Credits:

Materials and Resources Credits –

- MR Credits 1.1 and 1.2: Consider reuse of existing, previously occupied buildings, including structure, envelope, and elements. Maintain 75% of existing walls, floors & roof (Maintain 95% for MR Credit 1.2). [1 or 2 points possible]
- MR Credits 3.1 and 3.2: Use salvaged, refurbished, or reused material, products, and furnishings for at least 5% (10% for Credit 3.2) of building materials. [1 or 2 points possible]
- MR Credits 4.1 and 4.2: Use materials with recycled content such that the sum of post-consumer recycled content plus one-half of the pre-consumer content constitutes at least 10% (for MR Credit 4.1, 20% for MR Credit 4.2) of the total value of materials on the project (based on cost). [1 or 2 points possible]
- MR Credits 5.1 and 5.2: Use building materials or products that have been extracted, harvested, recovered, or manufactured within 500 miles of the project site for a minimum of 10% (for MR Credit 5.1, 20% for MR Credit 5.2) of the total materials value (based on cost). [1 or 2 points possible]

Energy & Atmosphere Credits –

- EA Prerequisite 2: Design the building to comply with ASHRAE/IESNA Standard 90.1-1999 (without amendments) or the local energy code, whichever is more stringent. [Required]
- EA Credit 1: Reduce design energy cost compared to the energy cost budget for energy systems regulated by ASHRAE/IESNA Standard 90.1-1999 (without amendment), as demonstrated by a whole building simulation using the Energy Cost Budge Method. [1-10 points possible, depending on improvement in proposed building performance rating over baseline building performance rating.]

Setting aside LEED certification specifics, the environmental soundness of LWICC helps achieve sustainable building solutions, including **disaster resistance** (fire, wind, hail, and seismic ... see above); **indoor air quality** (the absence of VOC emissions from cellular concrete can support indoor air quality in roofing applications); **locally produced** (the raw materials used to make the cement slurry for LWICC production are abundant in most areas of the world and are usually obtained or extracted from sources within 300 miles of the project ... local production reduces shipping distances for thermal insulation materials, minimizing fuel requirements for both transportation and handling, and associated noise, energy, and carbon dioxide emissions); **recyclable** (as permanent insulation components not affected by moisture, lightweight insulating cellular concrete roof decks stay in place during re-roofing applications ... and in instances of building

The environmental soundness of lightweight insulating cellular concrete helps achieve sustainable solutions.

demolition, inert LWICC can be safely removed and reused ... including as aggregate in vegetated roof construction); **recycled content** (LWICC can incorporate ground granulated blast-furnace slag or fly ash in the slurry mix design without adversely affecting material performance ... the use of these post-industrial by-products eliminates the need to landfill the materials and reduces the need for virgin materials in LWICC production – and the environmental impacts from the extraction and processing of these virgin materials); and **thermal performance** (see above, pp. 9 and 13).

CONCLUSION

There are no documented cases of building stakeholders requesting low-performing roofing assemblies. But a significant portion of all building system litigation involves low-slope roofing systems, suggesting improving low-slope roof assembly performance is key to adding true value for building owners, occupants, facility managers, insurers, and investors.

The use of lightweight insulating cellular concrete (LWICC) improves the performance of low-slope roof assemblies, providing an integrated component system with advantages in durability, fire resistance, heat flow resistance (when combined with encapsulated MEPS), compressive strength, wind uplift, seismic ratings, positive drainage, dimensional stability, moisture resistance, and environmental soundness.

LWICC supports facility functions (water-tightness, maintainability, health and safety, appearance), protecting building interiors, contents, structural components, occupants, insurers, and investors and reducing energy use, cost, and the building's carbon footprint. LWICC also supports the four roofing design principles for ensuring high performance and durability.

To improve the performance of your low-slope roof assembly, specify a lightweight insulating concrete roof deck system for your building.

NEXT STEPS

(1) Learn more about insulating concrete roof deck systems or request help for a specific roofing project – including identifying a qualified, experienced roofing contractor – by contacting John Sedenquist, COO of Cellular Concrete LLC: 888.235.5015 | jsedenquist@cellular-concrete.com.

(2) Share the information included in this white paper with others within your sphere of influence.

Improving low-slope roof assembly performance is key to adding true value for building owners, occupants, facility managers, insurers, and investors.

Improve the performance of low-slope roof assemblies with lightweight insulating cellular concrete.

RESOURCE SECTION

Book – Chapter 47: *Fouad H. Fouad on Cellular Concrete* in **Significance of Tests and Properties of Concrete and Concrete-making Materials**, by Joseph F. Lamond, and J. H. Pielert; edition: 5, published by ASTM International, in 2006; ISBN 0803133677, 9780803133679; pp 561 to 569.

Online – Visit www.cellular-concrete.com. Be sure to check out the "Links", "Support", and "White Paper" sections and sign up for the free, quarterly eNewsletter, "Smart Foam Liquid Concentrate Solutions for Construction, Mining, and Manufacturing Applications."

Other Smart Foam Liquid Concentrate Series White Papers:

White Paper 1 –
What is Cellular Concrete … and If It is So Great, Why Doesn't Everyone Use It?

White Paper 2 –
Improving Stormwater Runoff Management

White Paper 3 –
Revolutionizing Mine Tailings Disposal and Backfilling

White Paper 4 –
Simplifying Construction On Marginal Lands

Design Resources
RoofNav® –
Visit: www.fmglobal.com/page.aspx?id=50050000

Miami-Dade County Approved Product Data Base –
Visit: www.miamidade.gov/buildingcode/pc-search_app.asp

Associations –
National Roof Deck Contractors Association (NRDCA)
The National Roof Deck Contractors Association represents contractors who install engineered roof deck substrates that provide structural support and insulation to roofing system applications.
Visit: www.nrdca.org

Florida Roof Deck Association (FRDA)
The Florida Roof Deck Association (FRDA) represents Florida's lightweight insulating concrete industry and it's associated manufactures, applicators and suppliers.
Visit: www.frdaonline.com

Roof Consultants Institute (RCI) –
The association of professional roof consultants, architects, and engineers.
Visit: www.rci-online.org

Product Approval Organizations –
Underwriters Laboratories (UL)
Visit: http://www.ul.com/global/eng/pages/offerings/industries/buildingmaterials

MEARLCRETE 40™

One of the industry's most trusted engineered-liquid-foam-concentrate brands, and specified worldwide for over 60 years, Mearlcrete 40™ enables the production of superior lightweight insulating cellular concretes (LWICC). Its composition produces highly-stable air cells (bubbles), which remain unbroken during production (blending, mixing, pumping), placing, and hardening of the material, resulting in precise control of in-place material density and strength. Mearlcrete 40™ LWICC has excellent workability and can be pumped more than 500 feet vertically and over 1,000 feet horizontally without breakdown or segregation issues.

Designed specifically for job site LWICC production, Mearlcrete 40™ is approved by Factory Mutual (FM – the accepted world leader in the testing and approval of commercial roofing systems) and Underwriters Laboratory (UL – the independent, not-for-profit, product safety testing and certification organization, which tested and evaluated Mearlcrete 40™ and determined it meets UL's published Standards for Safety requirements). Mearlcrete 40™ is included in guides for Dade County, Florida (#08-0902.06), the New York City Board of Standards and Appeals (Docket 680-58-SM), and the U.S. Army Corps of Engineers (CEGS-03510 – Roof Decking, Cast-in-Place Low Density Concrete).

Designed specifically for job site LWICC production, Mearlcrete 40™ is specified worldwide.

ABOUT CELLULAR CONCRETE LLC

Cellular Concrete LLC engineers integrated, smart foam liquid concentrate solutions for construction, mining, and manufacturing applications, applying research, innovation, and technical expertise and support to help specifiers, contractors, mining professionals, and manufacturers expand markets, improve quality and job site safety, and reduce project and environmental costs.

The innovative Cellular Concrete LLC product line includes protein, synthetic, and protein/synthetic blend liquid foam concentrate formulations for use in insulated concrete roof deck and floor construction, low slump and lightweight concrete applications, and mining and geotechnical applications, including pervious cellular lightweight concretes.

The engineered foams are designed to release their unique physical properties only when mixed with the cementitious materials and a chemical reaction occurs. Construction professionals find Cellular Concrete LLC's smart foam liquid concentrates to be the most stable preformed products in the cellular concrete industry, durable cell structures not affected by long pump runs, extended mixing, or most fly ashes or ground granulated blast-furnace slags.

Smart foam liquid concentrate products include:

Geotechnical Solutions

- Mearl Geofoam 60 Non Pervious™
- Mearl Geofoam 40 Non Pervious™
- Mearl Geofoam 60 Pervious™

Roof Deck and Floor Solutions

- Mearlcrete 40™

Precast Solutions

- Mearlcell 3532 40™

Ready-Mix Solutions

- Cellflow™

Material Transport

- Mearl Transport™

Cellular Concrete LLC also sells foam generation systems designed specifically for producing consistent foam for cellular concrete production, including jobsite-tough tank generators, tankless auto generators, and portable, lab-foam generators for producing accurate results in the laboratory.

More information about smart foam liquid concentrates and Cellular Concrete LLC is available online at www.cellular-concrete.com

cellularconcrete SOLUTIONS

Tap into our research, innovation, and technical expertise and support and expand markets, improve quality and job site safety, and reduce project and environmental costs.