STONE WOOL INSULATION:

EUROPE'S GIFT TO THE NORTH AMERICAN ROOF DESIGNER

By Thomas W. Hutchinson, FRCI, RRC, AIA

Today's roof system designers rely on insulation for a variety of purposes: thermal protection, roof cover enhancement, wind-uplift protection, fire protection, sound attenuation assistance, rooftop drainage, and as appropriate surfaces upon which to place the roof cover. There are no insulation panaceas appropriate for all conditions, roof covers, and attachment methods. The North American roof insulation market has evolved from domination by Perlite insulation boards to expanded polystyrene (EPS) to extruded polystyrene (XPS) to today's material of choice—polyisocyanurate. While each of these products has its distinct advantages, none serves all conditions.

The appropriate selection of insulation by roof-system designers is extremely important to the long-term potential of the roof system's service life – the essence of sustainability. While the North American market is dominated by blown foam insulations, the European market (see *Photo 1*) and a good share of Eastern European and Asian markets are dominated by an organic and natural material called "stone wool," an insulation composed basically of stone fibers (see *Photo 2*). Stone wool has made small ripples in North America in the past, but this is about to change. A third European roofing material wave (the first wave being modified-bitumen roofing membrane and the second being thermoplastic olefin membranes, also known as TPO) is about to manifest itself in North America and provide roof-system designers with another option for their designs.

Stone wool has a 60-year history of performance as a roof insulation and substrate. Its dimensional stability provides for one of the most stable substrates available for long-term performance, which is the essence of sustainability.

HISTORY OF PERFORMANCE

Frank Lloyd Wright, America's architectural icon, often looked to nature for design solutions. Likewise, scientists in the early 1900s on the Hawaiian volcano Kilauea discovered strange wool-like material hanging from the trees, known in Hawaii as "Queen Pele's hair." Their analysis determined the material to be rock fiber with exceptional qualities, such as a core that will not combust into flames, and a low rate of expansion and contraction.

In 1937, Gustave Kahler set up his company, Rockwool, and his first factory in Copenhagen, Denmark, to investigate the volcanic result of molten rock and the potential for its use as insulation. Scandinavia, like most of North America, has climatic conditions that demand insulation. Kahler worked on a manufacturing process to replicate Mother Nature's vol-

Photo 1 – Five-inch-thick stone wool being installed on this 110-foot-high warehouse outside of Munich, Germany. Note the vapor retarder.

Photo 2 — Dubai International Airport, United Arab Emirates.

Photo 3 – Basalt stone.

canic rock-fiber creation.

Small cupola furnaces were built to melt rock, and a process was developed to turn molten rock into rock fiber: stone wool. The process was continually refined, and stone wool had its early beginnings. These early beginnings have evolved into 23 factories on three continents with a worldwide network.

Stone wool has been further developed for both roofing and façade panels and has become the product of choice for architects, builders, and owners around the world.

Stone wool has proven to be such a valuable roof system component in the European market for Soprema that Kevin Athmer, Soprema's national technical manager, comments,

> When you have an insulation product in the roofing industry that is 100% stable, will not absorb water,[1] and has good thermal resistance, you have a homerun! Show me another insulating product available today that can both make these claims and back them up with years of experience around the world in all climatic conditions.

MANUFACTURING

Stone wool raw materials are basalt stone (see *Photo 3*) and slag, with slag being a byproduct of the steel industry. Thus, from its manufacture, stone wool has in some cases recycled content up to 40%. The process is a complex one that involves converting raw rock and slag into stone wool and then into a product conducive to providing thermal, fire, and sound-resistant properties, all while being dimensionally stable and an appropriate surface for roofing.

Basalt, slag, and aged/used stone wool[2] brought to the plant for recycling (see *Photo 4*) are placed in a tall cylindrical tank called a cupola where the raw materials are heated to a molten state. The molten components are moved into blowers that spew out the thin stone fibers, to which oils and binders are added[3] ingredients that give the stone wool its water-repellent property. The fibers are layered into the varied production thicknesses on a conveyor belt that moves the product through curing ovens and cutting wheels to the packaging station. Cut-off excess stone wool is sent back to the cupola for reuse. Stone wool can be manufactured into any thickness that is required and workable in the field (see *Figure 1*). Also noteworthy, the stone wool is produced without any chlorofluorocarbons (CFCs) or hydrochlorofluorocarbons (HCFCs).

In North America, there are several manufacturers: Fibrex and Roxul in Canada; and IIG (owned in part by Johns Manville), Therm-Fiber, and Rockwool Leeds in the United States. The Milton, Ontario, Roxul plant recycles its waste: water used in the process is captured and reused; stormwater onsite is captured, retained, and used in the production; and heat from the process is recycled and used to augment the required heating.

STONE WOOL PROPERTIES

As with all insulation, stone wool has key features that benefit the roof-system designer, contractor, and building owner. The most notable features are the product's fire resistance to well above 1000°F, a char-

Photo 4 – Aged, used, and reclaimed stone wool for recyling.

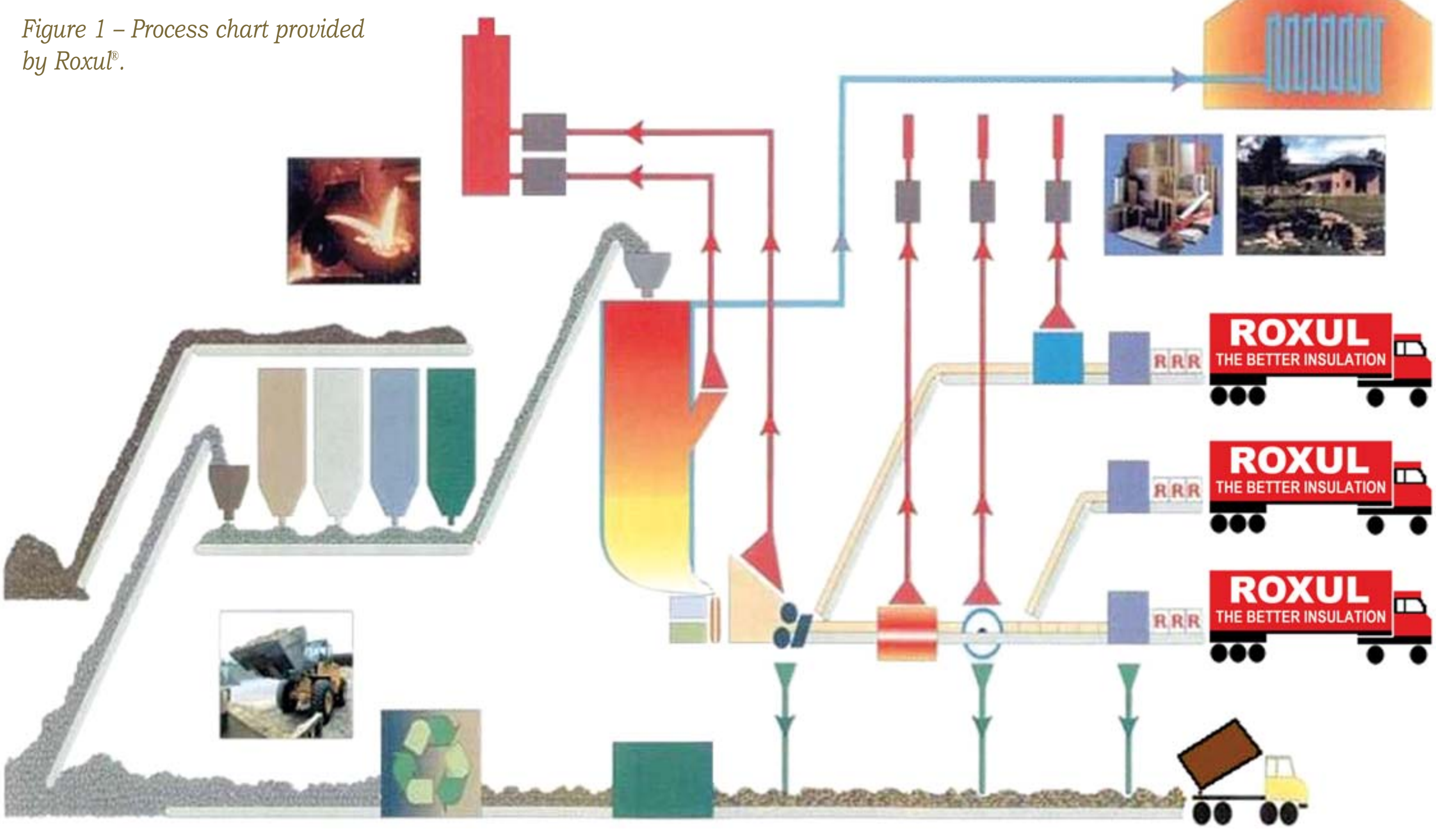
acteristic that often results in stone wool being used as a "fire stop," and the material's long-term dimensional stability. Stone wool:

- Is a zero flame- and smoke-spread material.
- Is dimensionally stable – the material will not shrink, curl, deteriorate, or warp.
- Has a constant thermal value (R) [λ lambda] that does not lower (drift) over time.
- Is impervious to moisture.
- Is sound-absorptive (a nondirectional fiber structure dissipates sound waves).
- Can be manufactured in dual densities.
- Is recyclable.
- Will not support mold or fungus.
- Has no facer.
- Is manufactured in required thicknesses without dimensional change concerns.
- Has a high mass density that allows the boards to stay on the roof as placed until anchored.[4]
- Is chemically inert.
- Possesses a high cantilevering ability (can cantilever roof-deck flutes without being damaged under foot traffic).

Some concerns at this time are that

- The product has a lower R-value per inch than blown foam.
- The material is softer underfoot than is experienced when walking on roofs composed of blown foam; however, the material's resistance to point loads and the ability to "rebound" minimize this concern.
- A dual-density potential on the top surface serves to spread the load across the board. On dual-density product, the compressive strength is 20.1 psi. This density, comparable to isocyanurate, deters concerns when used directly below single-ply membranes.

Figure 1 – Process chart provided by Roxul®.



CASE STUDY

The Northwest Suburban Special Education Organization (NSSEO) is an educational cooperative that accepts children with special needs from eight surrounding school districts. In the spring of 2009, Hutchinson Design Group, Ltd. was commissioned to participate in the removal and replacement of the roof at NSSEO's administrative office. The facility is composed of two distinct and separate roof areas, a one-story and two-story area.

As an educational entity, the NSSEO was open to the idea of installing stone wool insulation on the higher two-story roof. This roof area lent itself to a case study installation due to its rectangular shape, minimal penetrations, and challenging tapered insulation design. Olsson Roofing of Aurora, the contractor, agreed to provide feedback to the stone wool manufacturer after installation.

With all parties on board, the roof system, which was originally designed with a tapered polyisocyanurate, half-inch DensDeck® cover board and 90-mil EPDM, was redesigned. For the case study, the roof design was revised to tapered Roxul®5 insulation.

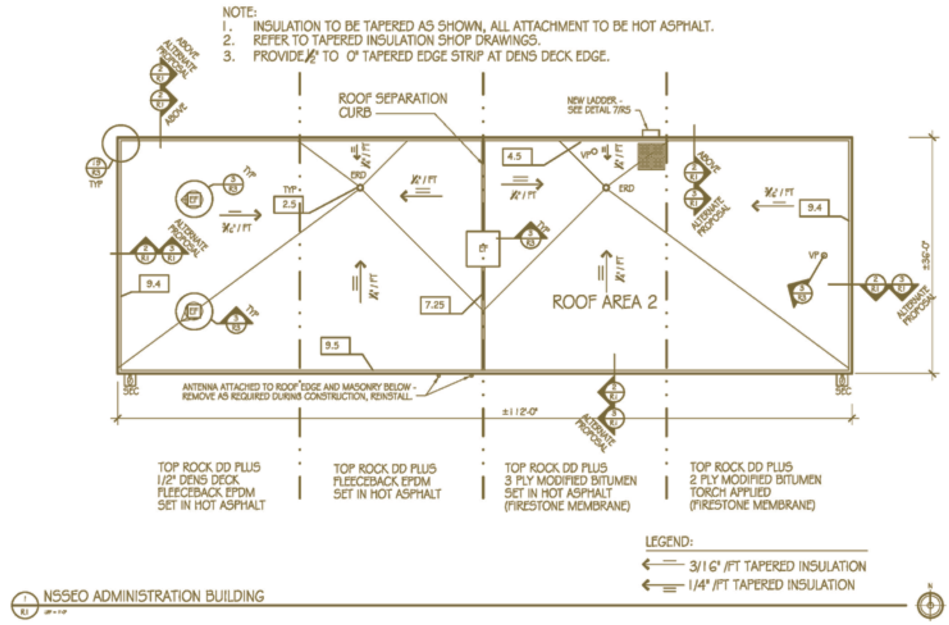


Figure 2

The eastern half was then designed with a two-ply modified bitumen roof system while the western half was designed to be covered with half-inch DensDeck® and 90-mil EPDM (see *Figure 2*).

Both the installing contractor and the design team worked with Roxul® to select the appropriate stone-wool product for the roof covers. The varied tapered insulation designed into the project1/4 in and 3/16 in per ft (which was required to accommodate roof heights)—was a challenge. The stone wool panels coming from the Ontario plant were 4 ft x 3 ft; thus, creating a 45º valley

Photo 5 – Full-thickness stone wool panels are set into place.

Photo 6 – Tapered stone wool panels set in hot asphalt.

was a bit of a challenge.

The existing roofing was removed, a two-ply vapor retarder installed, roof drains removed and replaced, and a roof curb installed around the perimeter to accommodate the tapered insulation height. The first area to have the stone wool (Roxul® Top Rock DD Plus) installed was the fully adhered EPDM area. The roofing foreman organized the insulation bundles according to the approved tapered insulation shop drawing.

The most challenging part of the installation was setting up the valley lines with 3-ft x 4-ft boards. Once that was accomplished, both the1/4-in-per-ft and the 3/16-in-per-ft materials were installed in a full mopping of type IV asphalt (see *Photo 5*).

Stone wool can be fabricated in greater thicknesses; consequently, where other insulation systems would require that two to four layers of material be set in hot asphalt, the stone wool was full thickness and required installation of only one panel,[6] not only saving time and adhesive material, but also diminishing voids (see *Photo 6*).

The boards were dimensionally all the same size, and they fit together without open joints. Cutting of the material at the roof curbs and perimeter was quickly accomplished with a 12-in serrated stainless-steel knife. (Thicknesses of less than three inches can be cut with a utility knife.)

Following installation of the stone wool, a layer of half-inch DensDeck® Prime was installed in hot asphalt. Following the installation of the DensDeck® Prime, 90-mil EPDM was installed in bonding adhesive.

On the second day, the east half of the roof area designed with modified bitumen was installed. The tapered Roxul® Top Rock DD was installed at the west side in a full mopping of hot asphalt to the tapered design prescribed by the architect, which was a combination of 1/4 in per ft and 3/16 in per ft. With the dimensional stability of the material and accurate cuts, all boards were exactly 3 ft x 4 ft, as ordered (4-ft x 4-ft boards are available, standard in North America) and provided for a quick installation with little need to come back and in-fill joints. Once the tapered stone-wool insulation was installed, the two-ply modified bitumen roofing membranes were installed. Due to the stone wool's extreme fire resistance and dimensional stability, there is no need for a cover board, thus a time and budget saver.

The top surface of the stone wool (approximately 1 inch) in the manufacturing process is compressed to a greater density and is saturated with an asphaltic binder to reduce absorption of the asphalt, much like DensDeck® Prime. This top surface provides an excellent surface on which to install asphaltic products. As such, the base layer

Photo 7 – Modified bitumen is installed directly on the stone-wool insulation in hot asphalt.

of smooth-surfaced modified bitumen was set in hot asphalt directly on the stone wool (see *Photo 7*). Following the installation of the base sheet, a granulated, modified-bitumen cap sheet was installed via heat welding.

The use of one-piece, dimensionally stable, and accurately sized insulation as opposed to multiple panels, many of which are "off" in dimension, resulted in a quick, efficient, and airtight installation. The roofing foreman, Justin Wulfrost, commented, "This was our first experience with stone wool, and once we became acquainted with the material, our installation time was far quicker than the lower roof area where multiple panels were required."

As the designer of the roof system assembly and observer of the stone-wool installation, this author is left with a few impressions:

1. The one-piece boards were definitely a positive attribute, based on the fact that when properly installed, the boards had no open gaps between them.
2. The 3-ft x 4-ft board size differs from the norm and required the tradesmen to acclimate to a new installation layout, which takes time. When the promised 4-ft x 4-ft panels become available, the installation time will be improved once again.
3. The boards were delivered in precise measurements (3 ft x 4 ft), cutting down drastically on open joints. The dimensional stability of the product also will keep the joints tight (see *Photo 8*).
4. The stone-wool boards, being of one piece and thickness up to 6 in, have an overall mass such that they are not lifted off the deck by high winds that would have blown foam boards from the roof.
5. The material feels less dense than foam, but its actual overall density allows the insulation to recover from impact. By way of example, a hailstone would create a depression in a foam board, but the same hailstone impact on stone wool would not be discernable, as the board would take the impact, then return to its shape. Recent hail tests on stone wool had favorable, passing results. In general, stone wool suffered less damage than other common insulations and coverboards when tested per FM 4470 and FM 4473.
6. Stone wool cuts with ease and can be shaped to conditions.
7. Adhesion with the hot asphalt to the vapor barrier was outstanding.[7]

CONCLUSION

The specification of any new products by roof-system designers is always fraught with trepidation. Prudent designers ask questions prior to specifying new materials:

- Will it work?
- Will it provide the same performance to which one is accustomed?
- Will it bring about premature roof system failure?
- Will it prove to be an environmentally friendly and sustainable product?

They are all legitimate questions that need to be answered.

It is not often that a material has been field tested by others (Europe and Asia) for years with various roof-system assemblies and then brought to the North American market virtually unchanged in material composition.[8] Additionally, stone wool has been taken off old roofs and recycled into new product, providing designers with some confidence in specifying stone-wool prod-

Photo 8 – Dimensionally stable stone wool arrived on site with exact dimensions.

ucts. An added incentive is that the material also provides for substantial LEED point credits.

Every project is an opportunity for a designer to improve upon the previous design. While not for every project, stone wool does appear to offer the material characteristics, long-term performance history, dimensional stability, and sustainability for consideration. As with all decisions, the designer should review the benefits and drawbacks of all materials and make an educated decision that is best for the owner.

FOOTNOTES

1. Specific moisture levels should be determined per ASTM C209, Cellulosic Fiber Insulating Board Moisture Absorption test.
2. The recycling of aged and used stone wool is commonplace in European plants but has yet to be implemented in North American plants.
3. While phenolic resins are used as one of the binders, the amount is minimal and historically has no corrosive effect on steel decks.
4. With a weight approximately twice that of isocyanurate, stone wool panels have a greater capacity to stay in place as opposed to being blown out of position or off the roof.
5. Rockwool International operates in North America through its wholly owned subsidiary, Roxul, Inc.
6. The use of multiple layers of insulation is considered good practice and is recommended to prevent thermal shorts brought on by gaps in rigid insulation, both at the time of installation and/or as it ages. Stone wool, due to its stable nature, has dimensionally "square" boards, fits tightly, and will not shrink. While it may not be required, two layers of materials or a cover board certainly can be used.
7. Adhesion and uplift resistance will vary by product and adhesive type. Designers are encouraged to contact stone-wool manufacturers for uplift testing data.
8. The material make-up of both modified bitumens and TPOs was significantly altered to comply with American code requirements.

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NRCA and the Center for Environmental Innovation Launch RISE and CSRP Certification

The National Roofing Contractors Association (NRCA) and the Center for Environmental Innovation in Roofing have launched Roof Integrated Solar Energy (RISE), Inc., an entity created to provide a means of evaluating and certifying solar roofing professionals in order to support the widespread use of rooftop solar energy.

RISE evaluates and certifies solar energy installers for their knowledge of critical roof construction and maintenance practices necessary to support successful rooftop solar energy installation and maintenance without adversely affecting roof system performance and service life. Individuals who successfully complete the requirements set out by RISE will receive the RISE Certified Solar Roofing Professional (CSRP) certification.

The RISE CSRP certification is a voluntary certification for professionals who plan and oversee the installation of PV systems on roofs. The credential evaluates whether candidates have the underlying knowledge required for a successful roof-mounted PV system installation—one that recognizes the importance of both the roof system and the PV system for a building's value and uninterrupted use. Candidates will be asked to demonstrate basic knowledge about different PV system types, key components, benefits and risks applicable to building owners, PV systems' integration with electricity, installation guidelines, building codes, and postinstallation considerations.

For more information, visit **www.riseprofessional.org** or contact Jeanne Schehl, NRCA university's program development director, at 800-323-9545, ext. 7566 or jeaschehl@nrca.net.

The Center for Environmental Innovation in Roofing is a not-for-profit 501 (c)(6) organization whose mission is to promote the development and use of environmentally responsible, high-performance roof systems and technologies. Headquartered in Washington, D.C., the center serves as a forum to draw together the entire roofing industry to the common cause of raising public awareness of the strategic value of our nation's roofs in reducing energy consumption, mitigating environmental impact, and enhancing the quality of the buildings in which we live and work. More information about the center is available at **www.roofingcenter.org**.

