Construction CANADA

Feature

All images courtesy Roxul and Rockwool International

Stone Wool Solutions for Fire-rated Sandwich Wall Panels

By Jim Miller

Despite core advantages and unique benefits, stone wool insulation remains relatively unknown to those specifying sandwich wall panels (SWPs) in Canada and the United States. (Most products tend to be expanded polystyrene [EPS], polyurethane foam [PUR], or polyisocyanurate [PIR].) This is unfortunate considering the material can offer most of the key attributes required for these applications. In addition to possessing outstanding thermal properties, it is non-combustible, moisture-resistant, dimensionally stable, an excellent barrier to sound transmission, and easy to assemble and install.

While stone wool is recognized by design professionals for use in commercial and industrial buildings for interior walls, curtain walls, cavity walls, and low-sloped roof applications, it has yet to gain any real traction with SWP manufacturers.

Stone wool can withstand temperatures up to 1172 C (2150 F), and does not contribute to the development and spread of fire.

Sustainability of Stone Wool

With green building rating programs becoming more influential in the design/construction industry, the onus is on manufacturers to ensure their products, as well as their manufacturing processes, are environmentally responsible.

As the demand for sustainable, environmentally conscious building products grows, so too does the appeal of stone wool insulation. It is one of few products that can save more energy than is used to manufacture it. Once installed, it conserves scarce energy resources, and reduces air pollution and carbon dioxide (CO_2) emissions by minimizing fuel combustion over the long term.

Long-term studies conducted in the United Kingdom by this author's organization indicate stone wool insulation has been able to save 128 times more energy over the course of 50 years than was used for its production, transport, and disposal. This translates into an average energy payback of only five months after installation.

Waste created during the production of stone wool insulation can be recycled back into the manufacturing process to create new products. In some instances, manufacturers have been able to achieve zero manufacturing waste to landfill.

Depending on the SWP's core thickness, one-, two-, and three-hour fire-rated wall systems can be achieved using the insulation material. With these panels, 26-gauge steel is generally used.

Advantages with non-combustibility

North America's demand for stone wool lags behind Europe, primarily because the need for SWP with a non-combustible core is substantially different across the Atlantic than it is here.

European demand accelerated significantly as a result of numerous fires in the United Kingdom involving SWP with combustible core insulation in the 1990s. Total fire losses in the U.K. food processing industry, where SWP with combustible insulation was used, were more than $37.6 million Cdn in 1995 alone.

One dramatic example occurred at the Bordeaux Meat Packing Plant in France. Fire within the combustible insulation in the sandwich wall panels spread at a remarkable rate of 2.1 m (6.9 ft) per minute. Firefighters arrived on the scene within 10 minutes after the first alarm—by that time, 1858 m² (20,000 sf) had been destroyed.

Due to these sorts of catastrophic losses, the European market introduced a series of regulations and test methods specifically targeted at the design and use of SWP. The fire test methods range from small to intermediate and large-scale tests. Such initiatives, along with correct specifications and good fire safety management procedures, have significantly reduced the number of fires involving SWP products in Europe.

As a result of the extensive losses attributable to combustible insulation in SWP, the U.K. insurance industry only certifies products that have been subject to large-scale fire tests, encouraging use of panel products with non-combustible cores such as stone wool insulation.

Sandwich wall panels manufactured using combustible insulation materials pose a unique set of challenges. Most notably, the metal sheeting on the surface typically shields the insulation from the effects of sprinkler or other extinguishing systems so a fire inside the panel itself can spread rapidly and quickly engulf an entire building. Further, many combustible insulation materials release large quantities of toxic gases and particulate matter into the atmosphere during a fire that can endanger occupants, firefighters, and the environment.

While non-combustible, fire-rated SWPs have historically been a niche market in North America, there are signs of change. Building owners are becoming more conscientious and aware of the devastating effects fire has on their livelihood and the environment. At the same time, the migration of European manufacturers familiar with the advantages of stone wool is increasing the material's presence.

In 2009, German car manufacturer Volkswagen committed to the construction of a new mid-sized manufacturing facility in Chattanooga, Tenn. The project required about 92,900 m² (1 million sf) of wall panels; although the walls did not require a specific hourly fire rating, the company insisted on a two-hour fire-rated wall using stone wool SWPs.

As these changes in the market occur, pressure on the specifying community to respond is mounting. It is becoming increasingly clear practices that have become institutionalized over time must evolve. The status quo mindset that automatically opts for the traditional insulating materials is being challenged to consider alternatives offering a better solution.

For SWP applications, stone wool not only offers non-combustibility, but also several other benefits, ranging from sound absorption and moisture resistance to dimensional stability and long-term thermal performance.

Acoustic advantages

Stone wool insulation delivers superior acoustical performance compared to other, conventional insulating materials. Unlike plastic and foam insulations, it has a non-directional fibre structure that creates millions of tiny voids that are effective at trapping and dissipating sound waves, preventing sound from travelling from one side to the other. The higher density of stone wool also delivers dramatically better airflow resistance to further diminish sound transmission.

SWPs with stone wool can attain an acoustic rating of 28 to 30 decibels (dB) in a standard metal-skinned panel and upward of 35 dB when a perforated metal skin is applied. In contrast, a traditional SWP with a plastic core will attain an acoustic rating of around 23 dB.

Moisture resistance

When tested to ASTM C 1104, *Standard Test Method for Determining the Water Vapor Sorption of Unfaced Mineral Fiber Insulation*, stone wool receives a moisture sorption rating of 0.03 per cent. This means the material does not absorb water, but is vapour-permeable. This unique combination enables moisture that has penetrated the outer membrane to disperse within the insulation, effectively preventing blister formation and bulging of the exterior metal skin.

Additionally, the insulation is completely resistant to rot and corrosion, and promotes neither fungal nor bacterial growth. The result can be a safer, healthier indoor environment.

Dimensional stability and thermal performance

A significant challenge for plastic insulation is linear shrinkage caused by thermal cycling and/or off-gassing. Linear shrinkage causes gaps to occur between insulation panels resulting in diminished thermal values, heat loss, and increased energy consumption. Many conventional insulation materials shrink significantly within a relatively short time frame as a result of off-gassing.

Stone wool insulation does not off-gas, and it is not affected by thermal cycling. It does not shrink, warp, curl, or cup; the fit remains stable and flush, minimizing thermal bridging. The material achieves 0.01 per cent at 177 C (350 F) under ASTM C 356, *Standard Test Method for Linear Shrinkage of Pre-formed High-temperature Thermal Insulation Subjected to Soaking Heat.* Further, it does not experience linear shrinkage. This means the integrity of its thermal performance is maintained, resulting in a stable R-value over the long term (Figure 1).

The thermal performance of Stone Wool insulation is tested as per ASTM C 518, *Standard Test Method for Steady-state Thermal Transmission Properties by Means of the Heat Flow Meter Apparatus* (ASTM C 177, *Standard Test Method for Steady-state Heat Flux Measurements and Thermal Transmission Properties by Means of the Guarded-Hot-Plate Apparatus)* R-value per inch at 24 C (75 F). It achieves a rating of 4.0 hr.sf.F/Btu (with an equivalent RSI value of 25.4 mm @ 24 C 0.71 m² K/W). The thickness of completed wall panels typically relates to the fire rating required:

- 76 mm (3 in.)—non-combustible rating;
- 102 mm (4 in.)—one-hour fire rating;
- 152 mm (6 in.)—two-hour fire rating; and
- 203 mm (8 in.)—three-hour fire rating.

Compressive strength is tested as per ASTM C 165, *Standard Test Method for Measuring Compressive Properties of Thermal Insulations.* At 10 per cent, a 102-mm (4-in.) stone wool insulation board achieves a compressive resistance rating of 45.8 kPa (6.64 psi).

Delamination tests are performed by the panel manufacturer after the steel skin is applied. The sheet steel exterior skins are permanently bonded to the stone wool insulating core with a heat polymerizing adhesive ensuring a lasting bond between the steel & the insulation that will not delaminate over time.

Code requirements

There are numerous requirements in Canadian building codes applied to SWPs, depending on where and how they are used. The appropriate fire tests are governed by many factors. Considerations include building type, size, and use, along with distances to adjacent property lines and percentage of unprotected openings in the exterior wall.

While the 2005 *National Building Code of Canada* (*NBC*) contains specific provisions for SWP applications incorporating "foamed plastics," they do not apply generically to all sandwich wall panel products, particularly those that do not contain foamed plastic cores.

In terms of fire performance, code requirements are separated into three groups:

- flame spread, combustibility, and interior fire growth;
- exterior wall applications; and
- fire-resistance-rated assemblies.

There are rules based on the types of materials used in the SWP and the purpose of the wall. SWP incorporating foamed plastics have various additional restrictions related to building height, sprinkler protection, use of thermal barriers, and distance between adjacent property lines. In contrast, SWP products with non-combustible cores such as stone wool are far less restricted and complicated to use from a code perspective. This means much of the confusion, complexity, and uncertainty can be eliminated simply by specifying SWPs with a stone wool core rather than a combustible material.

Figure 1 Material Shrinkage

Material	Expansion Co-efficient 10^{-6} m/m C	Actual Expansion at Temperature Difference of 50 C on a 10-m Board (mm)
Plywood (dry)	3.5	2
Basalt	5.4	3
Stone wool	5.5	3
Marble	7	3.5
Granite	8	4
Perlite	8.5	4
Slate	9	4.5
Concrete	12	6
Steel	12	6
Copper	17	8.5
Aluminum	23	12
Expanded polystyrene	70	35
Extruded polystyrene	80	40
Polyurethane	100	50
Polyisocyanurate	120	60

Changes for various materials under testing in accordance with the procedures of ASTM C 356.

The properties of stone wool insulation can make the material an ideal 'filling' for sandwich wall panels (SWPs).

Conclusion

The North American building industry is entering an exciting new era in which green building practices are taking precedence. Going forward, sustainable building products delivering solid long-term returns—both economically and socially—will increasingly be the preferred option. Sandwich wall panel products with a non-