Framework for Sustainability

A Guide to Extruded Polystyrene in Energy-Efficient Building Design

FOAMEX®

INTRODUCTION

Buildings account for over one-third of global energy consumption and nearly 40% of total direct and indirect CO_2 emissions.[1] As urban populations grow, so will the need for infrastructure and housing. A dependence on energy-consuming devices in the home, such as heating, ventilation, and air conditioning (HVAC) systems, will only lead to even greater energy consumption and adverse climate impacts.

In response to the global climate crisis, concepts such as the building envelope are becoming prevalent in building design. The building envelope is the physical interface between the conditioned interior environment and the unconditioned outside environment of a building. Passive design principles emphasising thermal mass, shading, ventilation, insulation and the use of renewable energy all focus on the envelope as a key factor in creating energy-efficient, comfortable homes that are less dependent on mechanical heating and cooling.

This shift in thinking is long overdue. Energy efficient, or even carbon neutral homes, have a major role in determining whether we meet the ambitious carbon reduction targets being set by most major economies for 2050 and beyond.

Designers and specifiers are increasingly aware of the importance of good insulation to the performance of the building envelope. The Victorian government notes that a fully-insulated home compared to a non-insulated home can reduce the cost of heating and cooling a home by around 40 to 50%.[2] By designing envelopes according to the climate, and making informed material choices for insulation, the load on mechanical heating and cooling can be drastically reduced.

There is a growing selection of innovative products that can help us achieve high-performing building envelopes. One of these products is extruded polystyrene (XPS) insulation – a cost-efficient way to help new buildings achieve six-star energy ratings and beyond through perimeter edge, under-slab and in-slab insulation.

This whitepaper takes a closer look at why XPS is a valuable material in the design of energy-efficient buildings, and how can we specify XPS insulation for maximum sustainability.

IMAGE: XPS suits a variety of applications, including traditional raft slab construction.

WHAT IS XPS?

As the name suggests, XPS foam is formed with polystyrene polymer and manufactured using an extrusion process that results in a rigid insulation material with a dense, close-knit cell structure.

The manufacturing process for XPS is similar to the process used to create expanded polystyrene (EPS) foam products. Polystyrene is a synthetic, hydrocarbon polymer derived from benzene and ethylene. Polystyrene resin beads or granules are fed into an extruder, where they are heated at very high temperatures until molten.

At this stage, additives are added to the mixture including colouring agents. Note that XPS products are often identifiable by a distinctive colour associated with a product brand.

A foam blowing agent is then added to enable the product to expand after extrusion. Using controlled heat and pressure, the plastic mixture is forced through a die (extruded), after which it is allowed to cool and expand into the desired shape. The resulting foam board is cut to the final product dimensions.

"In Australia, there are strict standards regulating the blowing agents that can be used in manufacturing locally-made building material. Buying XPS made offshore is accompanied with a risk that the product was made in a country that does not regulate the use of environmental pollutants in XPS products."

IMAGE: Extruded Polystyrene (XPS) perimeter and under slab insulation system for energy efficient buildings.

PERFORMANCE PROPERTIES OF XPS

Thermal Performance

Rigid foam insulation such as XPS delivers excellent R-Values. R-Value measures the ability of a material to resist heat transfer – the higher the R-Value, the better the material can insulate. The R-Value of XPS is approximately 1.8R per 50mm when manufactured in accordance with the relevant Australian Standards.

Moisture Absorption Resistance

Moisture is known to have an adverse effect on a material's ability to thermally insulate. An advantage of XPS is that, even in extreme weather temperatures, its thermal and physical properties are preserved thanks to its high-density cell structure which makes it resistant to moisture absorption. Due to this quality, XPS insulation is less susceptible to rot, mould or decay than standard glass wool insulation.

Compressive Strength

Due to its homogenous, closed-cell cross section, and lack of voids, XPS foam boards have high compressive strength yet remain lightweight and flexible. Different XPS products are available in a range of compressive strengths for any application. Where there is almost no compressive load, such as in walls, a lower compressive strength is suitable. With modest or increased load, intermediate to high strength XPS products may be used.

Durability

The inherent properties of XPS makes it a robust and long-lasting building material. XPS foam products do not decompose or rot over time, nor do they attract pests or vermin as a source of food. It is chemically inert, and resistant to most acids, bases and aqueous solutions of salts and alkalis. XPS foam board is also quite dense, adding to its robustness and durability.

Longevity

Rigid foam boards such as XPS provide energy efficiency and constant insulation over their long 50-year lifespan. Good quality, long-term insulation performance is needed to correctly design a building's heating and air-conditioning systems.

Cost Savings

In the rigid foam board category, XPS foam board is a very economical option. As we will see below, XPS can also contribute to energy-efficient buildings, saving on energy costs and prolonging building life.

Some XPS products can be used in conjunction with any slab design to improve the overall thermal efficiency of a building. It is customisable to suit varied construction systems and slab profiles. In addition to saving energy, installing XPS insulation on foundations and slabs has a range of benefits that can protect a building from damage including, reduced interior condensation on foundation walls and protection from slab movement and heave.

BUILDING ENVELOPE APPLICATIONS

According to the Australian Government, HVAC systems account for approximately 40% of total building consumption.[3] Increasing the quality of insulating material is seen as an effective way of increasing the thermal resistance of the building envelope, making it is easier to maintain comfortable indoor temperatures with minimal use of mechanical HVAC systems. This was traditionally done by increasing the thickness of the insulating material, but the thicker the material, the higher the cost.[4] Another issue was the higher possibility of surface condensation on walls with thermal insulation, which can promote microbial growth that can adversely impact the health of occupants as well as reduce the life of the building.

Rigid foam boards, such as XPS and EPS, were innovative solutions that addressed these issues as they provided insulating properties and energy savings alongside durability and moisture control. When properly installed, rigid foam boards provide a layer of protection against moisture, and effectively seal gaps and close air leaks, all of which contribute to improving the thermal performance of a building. Such boards were also versatile in that they could be used in foundation walls, regular walls, roofs, and attics depending on the product.

Between XPS and EPS, XPS provides superior performance in several key categories. For example, XPS offers better long-term thermal performance than EPS.[5] The blowing agent used in XPS boards reduces the capability of air transfer through the material. Compare this to EPS, in which the blowing agent leaves the beads quickly resulting in thousands of tiny cells full of air. The interconnected voids in EPS allow water to penetrate, which leads to a reduction in insulation performance. XPS also has better compressive strength than EPS and can be used indoors under floors subjected to heavy loads and constant foot traffic, and on a variety of roofing applications.

The sustainability of a building is directly related to the ability of the insulation to function properly over its useful life without physical or performance degradation. XPS offer advantages in this respect due to its inherent durability, strength and water resistance. Compare this to traditional insulation, such as wool, which can absorb water thus compromising its performance over time.

A well-insulated concrete slab will contribute to the building's thermal envelope. XPS is suitable for perimeter slab insulation and under-slab insulation where water resistance is important. This application can be useful in preventing thermal bridging around the perimeter as well as preventing thermal loss through the ground.

IMAGE: XPS meets a number of key requirements in structural and civil engineering with superior compressive strength and higher, long-term R-Values.

SPECIFYING FOR SUSTAINABILITY

Environmentally-Friendly Production

Over recent decades, increased regulation of XPS blowing agent compounds and other manufacturing practices and industry innovations has led to products that are more environmentally friendly – but you have to know what to look for.

Some XPS products are manufactured without chlorofluorocarbons (CFCs), and hydrochlorofluorocarbons (HCFCs) in their chemical make-up. Leading XPS manufacturers in Australia predominantly use blowing agents commonly found in automotive air-conditioning units, combined with other non-CFC producing expansion additives in the manufacturing process. The amount of volatile organic compounds in these compositions is negligible.

In Australia, there are strict standards regulating the blowing agents that can be used in manufacturing locally-made building material. Buying XPS made offshore is accompanied with a risk that the product was made in a country that does not regulate the use of environmental pollutants in XPS products. Toxic input materials may be used to improve thermal value of different building products, but the product may continue to pollute the environment after installation via natural off-gassing over the lifetime of the building.

The manufacture of XPS also creates minimal pollution, as the energy used to produce the products comes from steam and water. It is also possible to recycle XPS up to seven times without deteriorating the product, allowing manufacturers to reuse used XPS in new XPS products (discussed further below).

Renewable Energy Use

Leading XPS manufacturers have established renewable energy targets that have had a positive impact on the sustainability of their manufacturing operations. There are now factories operating using renewable energy sources such as wind farms and solar energy, and energy-efficient technology to reduce waste and energy consumption.

Recycled Content

The increasing use of recycled materials in building products reduces the environmental footprint of construction, diverts waste from landfills and lessens our dependence on non-renewable resources. Some XPS products are manufactured using input material from recycled EPS and XPS. It is advisable to check whether the manufacturer clearly states the minimum amount of recycled content in its XPS products, and that any recycled content claim is verified and supported by independent certification.

Some companies are proactive in this area, with programs in place to collect XPS waste from building sites, packaging clients and the public. This waste is then fed back into the manufacturing process and repurposed as new product.

Waste-Free Manufacturing

As XPS is recyclable, it is important to consider whether the manufacturer has good solutions in place to handle waste XPS. You may consider whether the company feeds offcuts or rejected product back into the production process or have established a waste collection program that helps reduce the overall waste footprint of XPS.

Green Building Certification

Over a long period of time, the energy efficiency payback of insulation with high R-values exceeds the energy used to manufacture the product. This was proven in relation to XPS by a 2000 study by Franklin Associates over the 50-year life of a home that used XPS foam insulation.[6] Other studies support this assertion in relation to plastic foam insulation generally.[7]

Due to these energy efficiency characteristics, XPS insulation can help builders achieve green building certifications. For example, Passive House is a voluntary standard for energy efficiency in a building of which high performing thermal insulation is a critical component. Passive House buildings allow for energy savings of up to 90% compared with typical existing buildings and over 75% compared with average new best-practice constructions.[8]

A leading XPS rigid insulation board was used in the Jerrabomberra Tennis Facility,[9] which is a showcase of Passive House design. The XPS board was used as seamless under-slab insulation solution, due to its resilience, high compressive strength and superior thermal performance. The project delivered a building that was able to regulate temperature and manage weather extremes without relying on artificial heating or cooling.

"XPS foam boards provide up to two times more thermal resistance than most other insulating materials of the same thickness."

STYROBOARD XPS

Another engineered solution from Foamex

Styroboard XPS by Foamex is the material of choice for home builders, specifiers, architects and engineers due to its high compressive strength and superior thermal performance. A resilient and robust construction material, Styroboard XPS can be used across a wide range of residential and commercial building applications. Unlike other insulation materials that degrade when wet, Styroboard XPS is impervious to water. It will always preserve its thermal and physical properties under all conditions, thanks to its high-density closed cell structure.

Dimensionally stable, organically inert, moisture resistant, Styroboard XPS meets a number of key requirements in structural and civil engineering. Offering superior compressive strength and higher long-term R-Values, Styroboard XPS is suitable for use on floors subjected to engineered loads and constant traffic, as well as insulation for inverted roofs, rooftop gardens, parking decks and as commercial purlin roof spacers.

The Styroboard XPS range includes:

- **StyroTherm.** A highly compressive and durable construction material for building and creative applications such as in a robust slab edge insulation system, which helps prevent thermal bridging around the perimeter of a home, or under residential or commercial concrete slabs to provide additional insulation benefits.
- **StyroLink.** Highly compressive commercial roof spacers that help deliver thermal efficiency on commercial metal deck roofing applications by avoiding thermal bridging.
- **StyroRoof.** The preferred choice for inverted roofs and green roof systems that are subjected to engineered loads or constant foot traffic.

Fire Safety

All Styroboard XPS products are manufactured from a fire-retardant raw material and do not present as a fire hazard when correctly installed. Like other organic materials, polystyrene will burn when in contact with a flame, but it will self-extinguish when the fire source is removed.

Zero Ozone Depleting Potential

Styroboard XPS is produced in Australia and complies with regulations relating to Ozone Depleting and Global Warming Substances. The product is HCFC free and does not use in its manufacturing process any Ozone Depleting Substances (ODP) as defined under the Emi-9 criterion, polyvinylchloride (PVC) as defined under Mat-7 criterion and formaldehyde as defined under IEQ-14 criterion. Blowing Agents used in Styroboard XPS have zero ozone depleting potential.

Styroboard® XPS

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