build right

by Ian Cox-Smith, BRANZ
Building Physicist

Some of the rigid polystyrene foam available in New Zealand.

Rigid polystyrene foam insulation is widely used in the building industry as an insulation material but you need to be sure about what you're getting if you want to meet the energy-efficiency requirements of the building code.

Insulating with expanded polystyrene foam

Rigid polystyrene foam is available in two forms — extruded (XPS) and expanded (EPS). The extruded form is usually coloured and has a uniform texture, while expanded polystyrene (the most common) is usually white and has a clearly visible bead structure. XPS costs more than EPS for the same insulation performance (thermal resistance) but is not as bulky, e.g. 30 mm of XPS has about the same thermal resistance as 50 mm of EPS. Hence, XPS is more likely to be used in specialist applications.

Apart from cool-stores, which use polystyrene sandwiched between sheet metal, a common use for rigid polystyrene in the building industry has been exterior insulation for houses. Exterior insulation and finishing systems (EIFS) use polystyrene (usually EPS) in conjunction with a plaster coating as a cladding over timber framing.

The thermal conductivity of expanded polystyrene, or 'rigid cellular polystyrene — moulded (RC/PS-M)' as it is classified in AS 1366.3 — 1992: *Rigid cellular plastics sheets for thermal insulation*, ranges from 0.034 to 0.048 W/m °C at a mean temperature of 15°C. Thermal performance mostly depends on density and to a lesser extent other aspects, such as moisture content and bead size and shape.

Commonly available grades are S and H, but the standard also defines other grades, such as SL and VH.

The differences between S and H

For S grade, the typical density is 16 kg/m^3 and for H grade, 24 kg/m^3. Although actual densities may vary between individual plants, the ratio of densities should remain the same, so that 'S' grade material is about a third lighter than 'H' grade. In practice it is difficult to detect the difference by simply feeling the material.

AS 1366.3 also includes specifications for compressive stress, cross-breaking strength, rate of water vapour transmission, dimensional stability, and flame propagation characteristics. When a material is graded it must achieve or exceed all the specification limits for that grade. It is, therefore, quite probable that material within a particular grading may perform better than the specifications. A good example is thermal conductivity. A nominal S-grade material could, in practice, have almost as low a thermal conductivity as the nominal H grade. However, if a manufacturer's specifications state the grade and not the specific thermal conductivity, then a designer must use the nominal conductivity for that grade as an estimate of its performance. Since the nominal thermal conductivity of S grade is 0.041 W/m °C and H grade is 0.038 W/m °C, achieving the same thermal resistance requires 8% greater thickness for S grade than for H grade.

The thermal resistance (R-value) of 50 mm S-grade material is about 1.2 m^2 °C/W while the same thickness of H grade is 1.3 m^2 °C/W. This difference of 0.1 may seem small but it may be the difference between complying and not complying with the New Zealand Building Code for energy efficiency (H1) and control of interior moisture (E3).

From the manufacturing point of view, H-grade material weighs 50% more than S grade. This additional weight means a difference in price.

Meeting the specifications

Luckily there is a way to identify the grades since AS 1366.3 requires sheets to be colour coded along the side — brown for S grade and green for H. But unfortunately not all the manufacturers comply, making it difficult to estimate the thermal resistance without actually measuring it. Because equipment for measuring thermal conductivity is relatively expensive, manufacturers usually do not have the facilities for monitoring it during production. They regularly check the other properties of the material, such as compressive stress and cross-breaking strength, and simply assume that the thermal conductivity specifications are being met. Further confusion has been created by advertising/technical literature and websites that have erroneously quoted the thermal conductivity specifications from AS 1366.3. Just because a material meets *some* physical properties does not imply it meets them *all* and thermal conductivity is a case in point. Thermal conductivity needs to be monitored during production just the same as other properties since it is possible to meet all the other specifications for a particular grade and still not meet the minimum insulation performance.

Cavity construction means more insulation

With the shift to cavity construction behind polystyrene-based cladding systems, the effectiveness of EIFS insulation is significantly reduced. To make up for this, the thickness of the polystyrene must be increased (which is not always practical) or additional insulation could be inserted in the wall frame. Additional wall-frame insulation has always been required where there is a gap between the top of the cladding and the top plate/ceiling. A typical R1.8 wall insulation product would give R-values safely above the minimum and homeowners will benefit from more comfortable, energy-efficient homes.