Barking up the right tree!

Most sustainability talk about roofs over the last few years has tended to concentrate on the trendy 'green roof' and has barely wandered away from generalisations towards the specifics of composition, i.e. what is actually under the sedum or grass. The mainstream construction media has little or no regard for the composition of the waterproofing structure below the sexy exterior where insects buzz, logs rot, and rainwater can be captured. In this story, however, Paul Mallion of Conker Conservation takes us below the turf-line with a case study featuring the flat roof of the Friends of the Earth's London headquarters.

We are all well aware of the need to insulate buildings to the Building Regulations and beyond; to reduce running costs and fuel consumption, in order to reduce carbon emissions and improve the internal comfort for the occupants. Choosing an insulation product depends on a number of factors, such as:

1. U-value required
2. Thicknesses in which material is available
3. Moisture resistance
4. Compressibility
5. Location in structure
6. Cost and availability.

Sustainability must also be considered, but what does that mean in the context of an insulation product? We need to consider the raw material the product has been made from; the extraction process; the manufacturing process, how much pollution, global warming gasses or ozone depleting gases were released during production; will any noxious gases be released by the material in use or during a fire; and how can the material be disposed of at the end of its life, will it biodegrade or will it be classified as hazardous waste? Some natural materials absorb carbon during the growing process which is then locked into the material when it is made into a product. This is known as carbon sequestering.

Insulation materials generally fall into one of three categories (see Table 1), listed roughly in order of sustainability, lowest impact materials being at the top.

Often the specifier chooses the material based upon the ease of obtaining technical information and taking the least amount of technical risk. There are a number of specification tools and certification schemes available, including the British Board of Agrément (BBA) and BRE Certification Scheme. The cost of having new materials fully tested to BBA standards is extremely high and can therefore be prohibitive for small niche market manufacturers.

Manufacturers of petrochemical insulations will be quick to defend their products and go to some length to demonstrate that the energy saved over the life of the product outweighs the initial energy consumption and pollution created during manufacture. They also suggest that it is better to turn oil into a product, rather than burn it as fuel. Due to intensive marketing, and the economies of large scale production, sales of polyurethane insulations have been rocketing to the point where it is almost standard specification for many building professionals.

I don't dispute that the petrochemical materials have low thermal conductivity (k-value), and I use them as a last resort when there is insufficient thickness to use any other alternative or where the material must also be water resistant, such as below ground. However, if there are natural, renewable insulation materials which serve the same purpose, they will always be my first choice. The embodied energy for natural products tends to be very low as the Table 2 shows.

I have used most of the naturally derived or recycled materials on various projects over the last 10 years and can report that whilst contractors may be sceptical about using them at first, they soon 'warm' to them. For example, would you prefer crawling around a loft full of itchy glass fibre, or one full of harmless recycled paper or sheep's wool quilt? One contractor I deal with will pay the difference and use sheep's wool in lieu of mineral wool for loft insulation when tendering.

Cork

The main purpose of this article is a short case study in the use of cork insulation, based upon the re-roofing of the Friends of the Earth's London headquarters. Many older roofers will be familiar with cork as it was a popular roofing insulation material for flat roofing in the 1970s and 1980s. As it is heat resistant it was often used with torch on felt systems. It became less popular as polyurethane gained popularity in the 1990s. Roofing systems changed too, with the increase of single ply membranes reducing the need for heat resistant insulation.

History of cork

Cork is a totally natural and renewable product, which can be recycled and reused. When it is disposed of it will naturally degrade. It is used for thermal, acoustic and anti-vibration insulation (as well as being the best material to close bottles of wine, allowing ageing with the perfect amount of oxygen ingress, for those relaxing evenings after a hard day's work on site).

Cork is the under-bark of the cork oak tree (Quercus suber). It occurs under the outer bark of most woody plants as insulation against adverse climate conditions, but in much greater thickness in the cork oak. About half of the world supply of cork occurs in Portugal (with the balance being distributed around the Mediterranean).

Here, the cork oak tree is called 'sobreiro'.

For cork insulation board, cork granules are heated under pressure in an 'autoclave' which makes the granules 'pop' like popcorn and they glue themselves together with their own, natural resin called 'suberin' – a very efficient process resulting in very low embodied energy. The material can be cut into any required thickness and can even be tapered to give a fall to flat roofs. It is usually supplied in 1.0m x 0.5m boards, shrink wrapped in packs which are easily handled.

Case study

The Friends of the Earth's (FOE) London HQ is a five storey 1950s concrete framed building with steel framed windows, brick cavity walls (recently injected width glass fibre insulation), and an un-insulated concrete deck with asphalt covering. The asphalt had reached the end of its life and was showing signs of solar degradation and cracking. The roof has been used as a terrace for many years by staff, adding to the surface erosion of the asphalt. The whole building has a poor thermal performance, something which the FOE is gradually addressing as funds become available.

The existing asphalt roof at the FOE headquarters in London.

My company, Conker Conservation Ltd, carried out an evaluation of various improvement measures, including external insulation to walls, replacement windows, and alternatives for recovering the roof. The FOE decided to prioritise the roof work, as the top floor was known as the freezer with staff resorting to wearing hats and scarves from November through to March. Under Part L2B of the Building Regulations, if more than 25% of a surface is being renewed then the whole area must be thermally upgraded to a minimum standard, in this case requiring a value of 0.25W/m^{2}K. Alternatives for the roof covering and insulation were considered, the main criteria being the following:

- membrane suitable for use with roof terrace
- insulation dense enough to sustain continuous access
- existing thresholds from access door and lift motor room door would require alteration, the thicker the insulation the greater the implications
- the existing handrail was at maximum 1.1m above the roof deck, therefore any increase in roof build-up would make the handrail ineffective under Building Regulations

Materials manufactured from natural, renewable materials or from waste.		
	Advantages	Disadvantages
Cork	Renewable, high compression strength, low water absorption, low embodied energy, locks up carbon, biodegradable.	Small scale production =high cost.
Sheep's wool	Renewable by-product, extremely low embodied energy, humidity regulator, biodegradable.	
Hemp/cotton/flax	Renewable, low embodied energy. biodegradable. Locks up carbon.	
Wood fibreboard	Low embodied energy, made from waste, biodegradable. Locks up carbon.	
Strawboard	Renewable, very low embodied energy, biodegradable. Locks up carbon.	Unstable in humid conditions.
Cellulose fibre	Low embodied energy, made from waste, cheap, biodegradable.	Needs to be contained, can slump in walls.
Materials manufactured from natural minerals.		
Foamed glass	High bearing capacity, impervious, durable, uses recycled glass.	Expensive, fairly high embodied energy.
Mineral wool	Versatile, fire proof.	High embodied energy, fibres are irritant.
Glass fibre	Versatile, fire proof.	High embodied energy, fibres are irritant.
Materials manufactured from petrochemicals.		
Expanded polystyrene	Cheap. Versatile, moisture tolerant, durable.	High embodied energy, non-biodegradable, toxic waste from manufacture and when burnt.
Extruded polystyrene	Versatile, high moisture resistance, low k-value, durable.	
Phenolic foam	Very low k-value, moisture resistance.	
Polyurethane	Low k-value, moisture resistance. Widely available.	
Polyisocyanurate	Low k-value, moisture resistance. Widely available.	

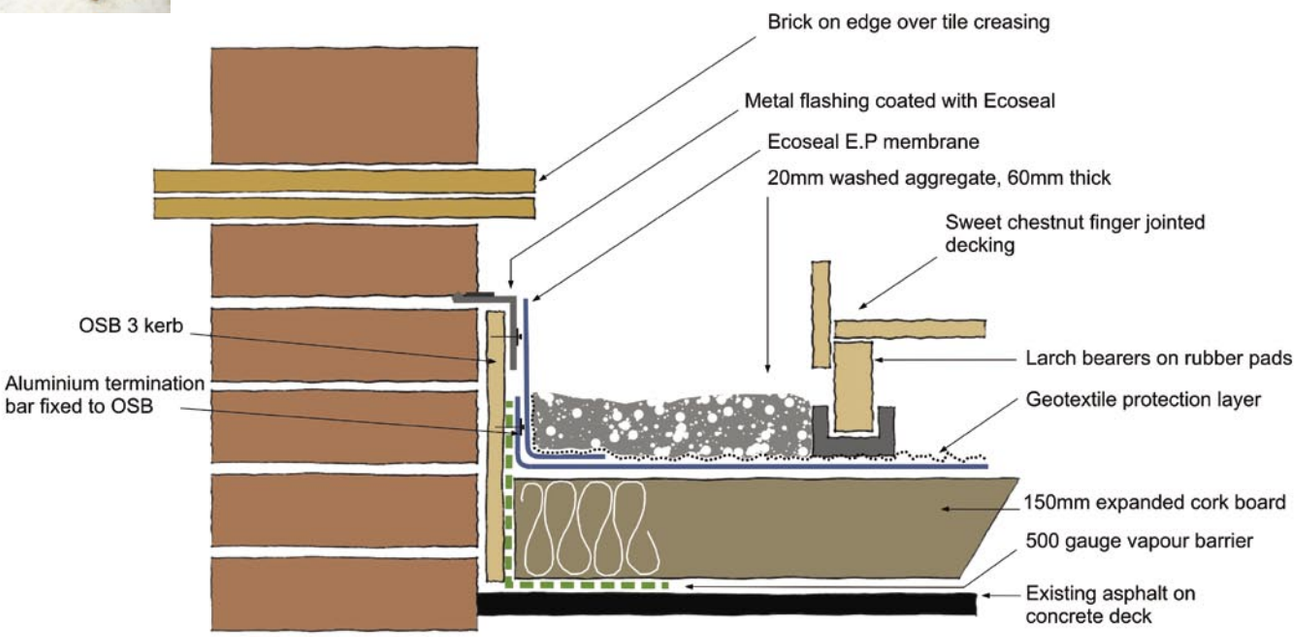
Table 1. Advantages and disadvantages of a range of insulation materials.

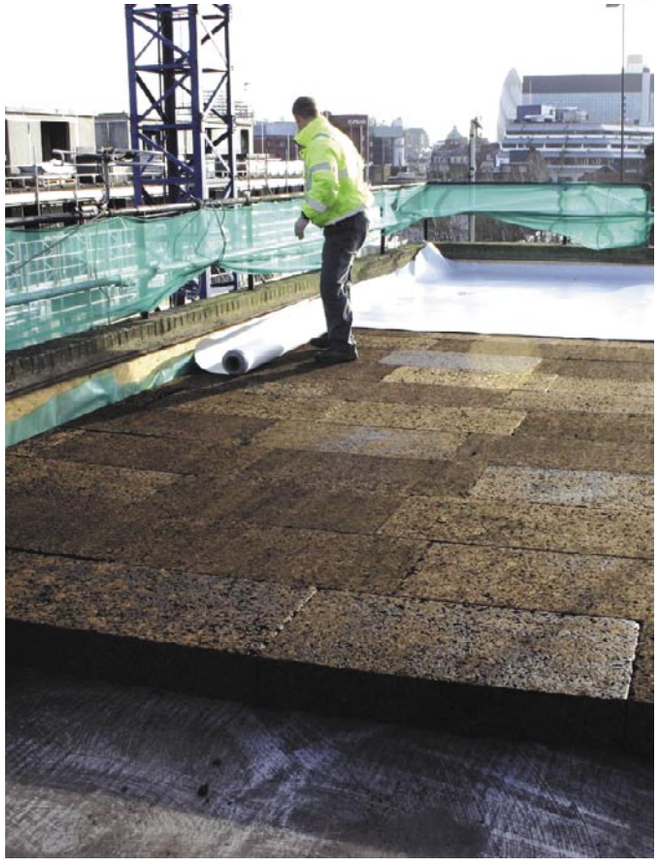
Material	Embodied energy MJ/kg
Cork, expanded board	4
Cellulose fibre	0.94 to 3.3
Mineral wool	16.6
Glass fibre	28
Polyurethane	72.1
Expanded polystyrene	88.6

Table 2. Embodied energy of various insulation materials. Source: University of Bath, Dept of Mechanical Engineering, Professor Geoff Hammond & Craig Jones, version 1.5a, 2006.

Membrane edge detail with retaining bar to maintain taughtness of covering. Metal coated flashing dressed into wall, membrane welded between flashing and main roof covering.

Section through parapet edge detail showing the roof buildup





The cork board being laid over the existing asphalt roof with the new waterproof membrane being laid over it.

The finished roof with leisure terrace area and gravelled drainage area.

- tight budget and timescale.

Of all the natural or mineral derived insulation materials considered (see table on page 33) our selection fell between cork and foamed glass. Both have similar insulation properties, foamed glass has a higher compressive strength, but cork was more economic. The tendering contractors suggested using polyurethane insulation, as 80 or 90mm would have sufficed. However, on this occasion, the use of any insulation material would have resulted in thresholds being bridged.

Portuguese Cork Supplies provided the best quotation for supplying the cork, which was delivered direct from Portugal to our specification and quantity. We allowed 10% for wastage, but this proved to be too pessimistic, the actual figure being closer to 2%, as the offcuts remained useable for filling gaps and awkward shapes.

We would like to have used 200 or 250mm of insulation, but were limited by cost and practicality to 150mm thickness, giving a U-value of 0.24W/m^{2}K. The difference in thermal performance was felt almost immediately by the occupants of the 'freezer', finding that hats and scarfs could be dispensed with, and two radiators which had never worked properly could be left alone.

The cork was delivered in an articulated lorry. Portuguese Cork Supplies work with a haulage company to make the most benefit from any delivery to the UK. As cork is very light but bulky, the consignment was combined with another delivery of small but heavy goods, bound for Wales. It would certainly have been preferable for the insulation material to have been manufactured in the UK, or at least be transported from Portugal by sea.

Previous research had led us towards EPDM for flat roofing, in preference to asphalt, built up bituminous felt, PVC or other single ply membranes. We finally selected Trelleborg's 'Ecoseal' environmental roofing system as it offered the best combination of performance, minimum environmental impact and cost in this instance.

Terrace decking being laid on protective geotextile and rubber pads. Larch bearers support sweet chestnut decking. Inset: new porch for easier access by staff.

To provide the accessible terrace we created a timber deck from untreated UK grown Larch, sitting on recycled rubber feet usually used in acoustic flooring, thus keeping the timber clear of the roof deck. 90 x 25mm sweet chestnut was used for the decking, supplied finger jointed in 6m lengths to virtually eliminate wastage due to knots or defects. Inwood Developments in East Sussex provided the timber. Stainless steel screws were used throughout to avoid corrosion in contact with the tannin from the chestnut. However, care must be taken as the screw heads are easily damaged by over-enthusiastic insertion.

To overcome the threshold problem at the junction of the roof and access door a new porch was formed beyond the existing door. To speed construction we opted for high performance prefabricated softwood units. We obtained quotes from a UK manufacturer and a UK based distributor for Danish windows. The Danish Vrogum units, supplied by Ecomerchant Ltd, proved to be 50% cheaper than UK sourced units, yet equally well made. The issue of sustainable timber was carefully considered, the UK supplier offered fully certified timber through the Forest Stewardship Council. Vrogum could offer windows Pan European Forestry Council (PEFC) certified, but not FSC.

The softwood used by the factory is all Northern Scandinavian slow grown pine and from managed forests but not yet all PEFC registered. Scandinavia is generally considered a low risk area with well managed forests, which is why the forest owners and mills have been slow in adopting the schemes.

I feel it is far more important to use FSC certification for timber which may have come from South America, Africa or the far east, as this is where illegal logging and deforestation is occurring on a huge scale, often just to make plywood used in shuttering or the core of fire doors, a terrible waste of resources. FSC European plywood is available through most national merchants now.

Conclusion

This project was very successful but did involve more research than a standard reroofing project, but the effort was worthwhile. I therefore urge all surveyors, architects and specifiers to look beyond the glossiest brochures in your literature library and seriously consider the more sustainable alternatives. You will be surprised how well they perform and how pleasant they are to handle, compared to some of the alternatives.

Paul Mallion

Contacts

Main contractor: Conker Conservation Ltd

Cork supplier: Portuguese Cork Supplies

Roofing membrane: Trelleborg

Roofing contractor: TRC

Porch units and larch: Ecomerchant Ltd

Sweet chestnut decking: Inwood Developments