Creating markets for recycled resources

Waste Tyres Case Study - Summary

Powdered Car Tyre Rubber in Replica Roof Slates

Research & development shows that ultra-fine 80 mesh rubber powder derived from post consumer car tyres can be combined with post consumer plastics, in this instance polypropylene, to produce a mouldable composite suitable for an replica roofing slate.

Overview

This case study examines both a novel raw material, a novel combination of raw materials, and an as-yet largely untapped end market in the UK. The UK building industry is showing increasing demand for building materials which are more sustainable but which meet all current UK building standards and do not require new skills, tools or change of practice. This R&D project aimed to supply just such a product by developing a plastic-rubber compound, utilising a high proportion of recycled vulcanised rubber powder from a UK waste stream, for the manufacture of replica roofing slates.

A key part of this project was to use, wherever possible, materials which are recycled or would otherwise be disposed of. Initial estimates are that the product will supply potentially 5% of the English slate roof market equating to re-use of between 5,700 and 8,200 tonnes of used car tyres per year, depending on the thickness of the synthetic slate and the percentage rubber which can be incorporated into it.

The advantages of this product include:

- A use for a new combination of materials which would have been waste.
- An attractive replica product produced at a competitive cost.
- Production of a lightweight building material, with consequent improved handling.
- A replacement building material which may show some enhanced properties such as shatter resistance, durability, ease of fixing and aesthetic appeal, which should give this product a good potential market

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Case study

Queen Mary University of London (QMUL) undertook laboratory trials to compound ultra-fine powdered rubber derived from post consumer tyres with recycled plastics to produce a moulded replica roofing slate. Subsequently Airport Business Centre (ABC) trialled a production mould to ensure that the combination of the compound and the production method selected could effectively produce the slate. The vulcanised rubber powder, from ABC's subsidiary Crumb Rubber Ltd, has not previously been available in significant commercial quantities and so its performance and behaviour in commercial composites is not well known or researched. The project aimed to produce composite roofing slates with the highest possible rubber content while still possessing adequate mechanical properties.

Laboratory trials

A replica roofing slate from a US supplier was destructively analysed to establish base-line physical performance. This 'benchmark' slate contained 20-30% by volume (17-25% by weight) of rubber in a polyethylene matrix, and had a tensile modulus (toughness) of ca. 850MPa at room temperature and a strain-at-break (strength) figure of 14MPa.

Initial trials used a composite consisting of ultra-fine (80 mesh) car-tyre derived powdered rubber blended with recycled polypropylene (PP) and virgin high density polyethylene (HDPE) and wood flour (filler/stiffener). It was agreed that any new compound must include at least 20% rubber by volume, otherwise there would be no net improvement in the recycling potential for rubber powder.

A processing temperature of 180^{o}C was chosen, below the range at which the wood flour and powder rubber began to degrade, but above the melting temperature of PP and HDPE. The physical properties of the blends were assessed: Blends tested in the laboratory were able to exceed 20% powder rubber content while maintaining the 'benchmark' properties.

The trials established that two blends, of polypropylene and 40% and 60% ultra fine rubber powder, provided properties close to the 'benchmark' slate. Small-scale trials produced satisfactory injection moulded swatches, and a simple compression mould was constructed and trialled. There were no great flow difficulties when moulding roofing slate shapes using either compression or injection techniques. When de-moulded from the compression mould, replica slates looked very good, but were extremely "rubbery" with low stiffness. Wood flour, micaceous china clay and glass fibres were tried as stiffeners.

Production moulding

A desk-top study suggested injection moulding would provide the best production method to take forward to trial. A number of mouldings were made from the two batches of compound, at 40% rubber and 60% rubber mix. As expected the 40% crumb replica slates were stiffer than the 60% powder slates, but other than that there was little visible difference and both mouldings were a good copy of the original slate.

Funding has now been awarded for a full certification programme, taking the product through standards certification to the erection of six demonstration roofs. The next step is to commercialise the slate, starting with market research to identify precisely the segment of the roofing market best suited to this product. This will also inform decisions regarding the aesthetic requirements of the replica slate. Adjustments to temperature, pressure, dwell time, colour, flame retardant and stiffener are possible to optimise the slate for market requirements.

Commercialisation will involve taking the slate through a battery of tests in order to achieve the certifications needed for the UK market. Of particular importance to architects, planners and the building industry is flame spread BS 476 part 3, and British Board of Agrément certification. Certification should cover: Moisture absorption; Freeze/thaw cycling; Water permeation; Accelerated UV exposure; Fire rating; Hail impact; Wind-driven rain in deployment; Nail pull through; Nail tear strength; Heat cycling.

As the replica slate is significantly lighter than equivalent natural slate it is also important to test for wind effects such as lift and flutter at differing roof pitches, which may influence the type of nail used. It is possible to introduce slight curvature in the slate so that nailing provides a positive down pressure at the exposed edges.

Benefits

Technical: The replica slate produced weighed 25% of the natural slate it was moulded from: this lightness will allow lighter roof structures and ease of handling. Toughness makes the synthetic slates virtually unbreakable, reducing transit and site damage, as well as reducing fixing costs as they are simple to nail through without pre-drilling.

Cost: Production costs are about half those of a cheap natural slate, and considerably cheaper than other synthetic slate products. The product looks better than imported rubber composite tiles and slates. Because the replica can be fixed exactly as a natural slate, there is no requirement for skills training, new tools, techniques or systems.

Environmental: Once fully commercialised, this product will meet the demand for more sustainable construction products. Initial estimates are that the product could supply 5% of the English slate roof market, equating to 3,500 to 5,000 tonnes rubber per year, or around 5,700-8,200 tonnes of used car tyres (i.e. up to 1.1m tyres) per year.

Using wood flour as a stiffener may “add value” by permitting the growth of lichens and moss on the finished product, creating a more “natural” looking roofing solution.

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