



Characterisation of Mineral Wastes, Resources and Processing technologies – Integrated waste management for the production of construction material

WRT 177 / WR0115

Case Study:

Crushed waste stone and production waste in concrete landscaping products

DRAFT FOR COMMENT

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Introduction

This case study describes the use of both natural stone waste and production waste as coarse aggregates in concrete landscaping products. Many of these concrete products routinely include industrial by products and recycled/secondary aggregates. Examples include recycled concrete aggregates (from crushed production waste), furnace bottom ash (FBA), ground granulated blastfurnace slag (ggbs), pulverised fuel ash (pfa), china clay sand, china clay stent, or slate waste. These are all well known and there is a great deal of supporting information on aggregate materials provided by the WRAP AggRegain website(1).

After a general introduction to the materials, products and relevant standards, the case study focuses on the use of production waste and stone waste by Marshalls (a major manufacturer of landscaping products).

Waste stone

The extraction of quarried stone which has been cut or dressed into regular pieces generates by-products that are suitable for aggregate use. Companies that produce stone products such as natural stone setts, as well as concrete products, are well placed to utilise these materials within their own businesses to achieve better resource efficiency.

Production waste

The manufacturing of concrete products inevitably generate production wastes (for example, damaged or imperfect concrete units). Increasingly, manufacturers of landscaping products crush this material into recycled concrete aggregate (RCA) at the manufacturing site and recycle into new production as a partial replacement for primary aggregates. This is the main high value use for the production waste, although undoubtedly it is used as fill or low grade unbound material by some manufacturers.

Potential uses for waste stone

Other than use in concrete products, waste stone would typically be crushed as a general purpose aggregate or roughly broken for use as fill, which is a low value use.

Concrete landscaping products

Concrete landscaping products are factory produced products which include block pavers, slabs, kerbs etc. Concrete block pavers are one of the major manufactured concrete landscaping

products. It is estimated by the concrete industry (source: The Concrete Centre), that the market for block pavers in the UK is approximately 23 million sq metres per annum.

The manufacturers of concrete landscaping products are willing to utilise by-products as aggregates. An example of this is the recycling of concrete production waste from manufacturing or quarry wastes natural stone operations. Utilising production wastes in this way assists manufacturers in meeting their environmental policy objectives and reassuring customers and shareholders that they are sustainable businesses.

Marshalls sources aggregates derived from the Marshalls Group’s own stone quarries to partially replace their normal sources of primary aggregates (2).

Manufacturers of concrete block pavers are known to utilise crushed concrete production waste, stone waste, china clay waste, copper slag and cement replacement materials such ggbs or pfa (2, 3).

Concrete block pavers and paving slabs need to conform to product performance specifications (4). In contrast to the situation with ready-mixed concrete, the specifications for the constituent materials are not prescribed which gives the manufacturers greater scope to use industrial by-product materials. Block pavers and paving slabs also provide opportunities for alternative materials in non-structurally critical applications. Table 1 summarises some of the critical performance requirements for coarse aggregates and the properties of the end-product.

Table 1: Feedstock and end product properties for mineral wastes as aggregates in concrete pavers

| Feedstock properties | Handling properties (manufacture/process related) | End product properties (block pavers and paving slabs) |
|--|---|--|
| <u>As coarse aggregate:</u> Particle grading and shape, chloride content, sulfate content, effects on setting of cement, aggregate strength, water absorption | Particle size, moisture content, Mixing compatibility with other constituents | Issues such as strength properties, drying shrinkage within defined limits, frost resistance, abrasion resistance. |

Standards and specifications for aggregates

The physical and chemical properties of aggregates and methods/procedures for their assessment are set out in the European Standard for concrete aggregates and associated documents, the WRAP quality protocol for aggregates from inert waste (5, 6). The European standard does not treat secondary or recycled aggregates any differently to primary aggregates.

Benefits and Barriers (extracted from waste product pairing database)

The Waste-Product Pairings (WPP) database includes information relevant to the benefits, obstacles and analysis required for determining the potential for the use of waste stone and concrete production waste in the manufacture of block paving and paving slabs has been examined.

1. Contribution to the end product.
As an aggregate material to provide strength
2. Potential benefits:
 - Material related:
 - i. Saving on waste transport costs
 - ii. Avoid landfill charges
 - iii. Environmentally acceptable way for dealing with production waste
 - Environmental – Organisational - Social:
 - i. Avoidance of material going to landfill
 - ii. Helps Company to meet requirements of its sustainability policy
 - iii. Allows re-use of a waste (stone waste from quarry operations) elsewhere in the business
 - Economic:
 - i. Saving on landfill tax and disposal costs
 - ii. Saving on the Aggregates Levy on primary aggregates
 - Legal:
 - i. Aggregates from Inert waste that meet the requirements of the WRAP Quality Protocol can be regarded as products and therefore not subject to waste management regulations
3. Potential barriers:
 - Material related:
 - i. Effects of water absorption of material on the mix water demand
 - ii. Possible contamination
4. Analysis requirements:
Testing is carried out to identify the properties and characteristics of alternative materials and end products, as well as to determine that the inclusion of certain alternative materials provide desirable results during lab-based experimentation.

Analysis on alternative materials:

- i. Visual description
- ii. Particle size distribution/grading/shape
- iii. Water absorption
- iv. Oxide analysis (%) and trace mental analysis
- v. Acid soluble chloride (%)
- vi. Total sulphur (%)

Analysis on end products:

- i. Compressive strength
- ii. Density
- iii. Colour / visual appearance
- iv. Durability

Table 2: Benefits and constraints to the use of stone waste and crushed concrete as aggregates in landscaping products (source, Marshalls)

| Recycled material | Product Type | Progress | Potential Benefits | Potential Barrier |
|--|-------------------------------|-------------------------------------|---|---|
| Crushed concrete from concrete production | Paving slabs Paving blocks | 10-15% routinely used in production | Saving on waste transport costs Avoid landfill charges Environmentally acceptable way for dealing with production waste | Effects of water absorption of material on the mix water demand Possible contamination |
| Crushed stone from natural stone manufacturing | Paving slabs Paving blocks | 10-15% routinely used in production | Saving on waste transport costs Avoid landfill charges Environmentally acceptable way for dealing with production waste | Effects of water absorption of material on the mix water demand Possible contamination |

The properties of the crushed stone and recycled concrete aggregate (water demand), limits the amount that can be used in paving products to 10-15% of the total coarse aggregate content. Quarry wastes generally meet the waste acceptance criteria for “inert waste” within the meaning of the Waste Framework Directive (7, 8, and 9) unless processed in accordance with the WRAP Quality Protocol (5).

Specific materials characterisation

The following test assessments (Table 3) may be used as a means of illustrating suitability for a particular end use. Many of the properties are not required (nr) as the materials (in this example, from the company’s own stone quarries or concrete production) are derived from well known/characterised sources. For less well known sources of material the entire suite of tests would be needed initially to ensure no deleterious effects were seen in the final product. If

materials was to continually used from this source then some form of on going quality assurance testing may be required from time to time.

Table 3: Materials characterisation

| Material source: | Waste stone | Production waste (RCA) |
|--|---|------------------------|
| Mineral phases | n/r | n/r |
| Visual description | n/r | n/r |
| Particle size distribution/grading/shape | Yes | yes |
| Water absorption | Yes | yes |
| Oxide analysis (%) | n/r | n/r |
| Acid soluble chloride (%) | n/r | n/r |
| Total sulphur (%) | n/r | n/r |
| F | n/r | n/r |
| Moisture content (%) | n/r | n/r |
| Loss on ignition (%) | n/r | n/r |
| Comment | Only grading and water absorption are key if the material is from a well known source | |

Results of Laboratory / Pilot product demonstration test-work

These materials are routinely used in production without significantly affecting the performance of the end product. The End products still meet the required standard

Conclusions and further work required

The use of waste stone and production waste in landscaping products is becoming increasingly widespread. The increasing emphasis of companies on corporate social responsibility, influenced by documents such as the Green Guide to Specification (10) and bodies such as WRAP is likely to lead to increasing recycled content becoming more widespread among manufacturers.

References

1. <http://www.aggregain.org.uk/>
2. Marshalls Sustainability Statement: landscaping products (September 2005)
3. Choosing construction products (WRAP)
http://www.wrap.org.uk/downloads/Const_Product_Guide_Version_3.1.1a.eeb9a77b.pdf
4. BS 6717: Precast paving blocks Part 1: Specification for paving blocks

5. WRAP, Quality Protocols for the productions of recycled aggregates from inert waste in England, Scotland and Northern Ireland, 2004 and 2005, WRAP, Banbury. Available online at www.aggregain.org.uk/quality
6. BS EN12620: 2002, aggregates for concrete
7. Office of Public Sector Information, "The Landfill (England and Wales) Regulations 2002", Statutory Instrument 2002 No. 1559, OPSI (online). Last accessed 25 March 2006 at www.opsi.gov.uk
8. Office of Public Sector Information, "The Landfill (England and Wales) (Amendment) Regulations 2004", Statutory Instrument 2004 No. 1375, OPSI (online). Last accessed 25 March 2006 at www.opsi.gov.uk
9. Office of Public Sector Information, "The Landfill (England and Wales) (Amendment) Regulations 2005", Statutory Instrument 2005 No. 1640, OPSI (online). Last accessed 25 March 2006 at www.opsi.gov.uk
10. The Green Guide to Specification 3rd Edition. Blackwell, 2002