



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

WRT 177 / WR0115

Case Study:

## Foundry sand in facing bricks

Compiled by Dr Evaggelia Petavratzi  
Scott Wilson



November 2007

Funded by:



## Introduction

Foundry sand represents silica sand used in the production of moulds for ferrous and non-ferrous metal casting. It is estimated that the UK foundry industry uses and disposes of, over one million tonnes of foundry sand per year, with the majority arising in the Midlands, South and West Yorkshire<sup>1</sup>. Two variations of foundry sand are utilised to produce moulds into which metal is cast, greensand and chemically bonded sand. Greensand is the most common type and it consists of silica sand, bentonite clay (~ 10% by weight), 2 to 5% water and about 5% coal dust (improves casting finish)<sup>2</sup>. Greensand is normally reused and can therefore contain burnt fines, coke residues and residual clays. Chemically bonded sand involves the use of organic and inorganic binders in conjunction with catalysts and different hardening/setting procedures. Three types of chemically bonded sand are normally used the: alkaline phenolic, furan and resin shell. The type of sand used is dependent upon factors such as the type and size of casting being produced<sup>1</sup>.

This case study investigates the utilisation of chemically bonded foundry sand (alkaline phenolic) into facing bricks.



## Potential applications for foundry dust

Foundry sand can be reclaimed and reused internally, especially so in foundries that utilise green sand. During re-circulation, the properties of foundry sand degrade and the material eventually becomes a waste. Research investigated various end uses for foundry sand and a summary of potential utilisation routes corresponding to greensand and chemically bonded sand (alkaline phenolic type only), including references to case studies, is given in Table 1.

Table 1: Potential utilisation routes for foundry sand (modified after the, Aggregates Information Service, 2002)

Use	Notes	Type of foundry sand	Case studies
Hot rolled asphalt	Partial replacement in 50% mix of fine aggregate	Greensand; alkaline phenolic and resin shell sands	- <i>Optimising sand use in foundries</i> <sup>3</sup> - <i>The use of foundry sand as a fine aggregate in asphalt and aerated concrete blocks</i> <sup>4</sup>
Concrete block making	In low density (aerated) and dense blocks. Potential for phenol leaching from stockpiled material may require modification of process authorisation	Most sands	- <i>The use of foundry sand as a fine aggregate in asphalt and aerated concrete blocks</i> <sup>4</sup> - <i>Foundries find alternative to landfill that brings benefits to all</i> <sup>5</sup> - <i>The use of secondary aggregates in cement bound paving at a road/rail transfer facility</i> <sup>6</sup>
Cement manufacture	Logistical planning is required to secure supply of material. Foundry sand supplied from more than one sources could substitute by 100% primary SiO <sub>2</sub> -rich materials	Most sands	- <i>Foundry sand cements</i> <sup>7</sup>
Brick manufacture	Use as an aggregate filler	Most sands	
Foamed concrete	Flowable fill, aerated concrete and controlled low strength material. In some cases, 100% substitution has shown a slight decrease in strength of final products, attributed to residual particles of resin adhered on the surface of sand grains	A percentage of greensand, alkaline phenolic and resin shell sands	
Road base construction	Leaching of contaminants from unbound courses may pose problems; testing is required to ensure no adverse environmental impact	Chemically bonded sands may be used as fine aggregate substitute	- <i>The cost benefits of large scale usage of recycled and secondary aggregates on the A6 Alvaston Bypass</i> <sup>8</sup> - <i>The use of secondary aggregates in cement bound paving at a road/rail transfer facility</i> <sup>6</sup>
Roof felting		Furan sand (due to dark colour)	

## Brick manufacture

Brick manufacturing is a historic industry and the production process is well established. Brickworks commonly operate in close proximity to clay quarries, owned by the same company, so as to satisfy their needs for raw materials. The market of bricks underwent significant changes with the introduction of concrete blocks as the latter replaced common bricks in construction. This resulted in the industry focusing on production of facing bricks, used for aesthetic purposes.

The use of 'facing bricks', accounts for over 90% of demand and the production levels have been quite stable over the last seven years<sup>9</sup>. Bricks are produced either by extrusion or by the 'soft-mud' process, but extrusion comprises the commonest option. Bricks are dried prior to firing and fired in a linear kiln (tunnel kiln), which commonly operates on natural gas.

Alternative materials are considered for use by brick manufacture as a potential cost effective solution to access materials with desirable compounds/ properties that will satisfy the demand for large portfolios of products with different aesthetic properties. The sector's view is that customer demand and expectations have changed significantly and a market for 'green products' is currently present.

## **Benefits and Barriers (extracted from the Waste-Product Pairings database)**

The contribution of foundry sand in bricks and information regarding potential benefits, barriers and analysis requirements were extracted from the WPP database and are presented below.

### 1. Contribution to the end product.

Foundry sand represents primarily a filler material, but under certain circumstances and depending on the composition of the sand it may also comprise a colourant

### 2. Potential benefits:

- Material related
  - i. Foundry sand represents an alternative source for sand used in bricks
- Environmental:
  - i. Primary material resources are conserved due to substitution of primary silica sand with foundry sand
  - ii. Substantial quantities of waste could be diverted from landfill by using foundry sand
- Economic:
  - i. Foundry sand can represent a cheap alternative to primary sand. Economic advantages will be greater if foundry sand is not transported over long distances to the end user.
- Organisational
  - i. The inclusion of foundry sand in bricks allows the production of end products with recycled content.

### 3. Potential barriers:

- Material related:
  - i. Waste foundry sand may include heavy metals and soluble salts, which can adversely affect the end products (production of scumming and efflorescence).
  - ii. End users that utilise high volumes of sand (that is concrete manufacturers and the cement sector) may acquire foundry sand from more than one source to satisfy their demand.
- Environmental
  - i. Depending on the composition of foundry sand, the inclusion into bricks may cause an increase in adverse emissions during firing.

### 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.

- Testing on alternative materials:  
chemical analysis & particle size analysis

- Testing during lab-based experimentation: appearance of test bricks after firing; shrinkage; experimentation with different substitution rates; decision upon the type of clay body; firing temperature
- Testing on end products : in accordance with BS EN 771-1 on masonry products; colour; durability; green strength; water absorption; efflorescence; compression strength

## Foundry sand



### Samples

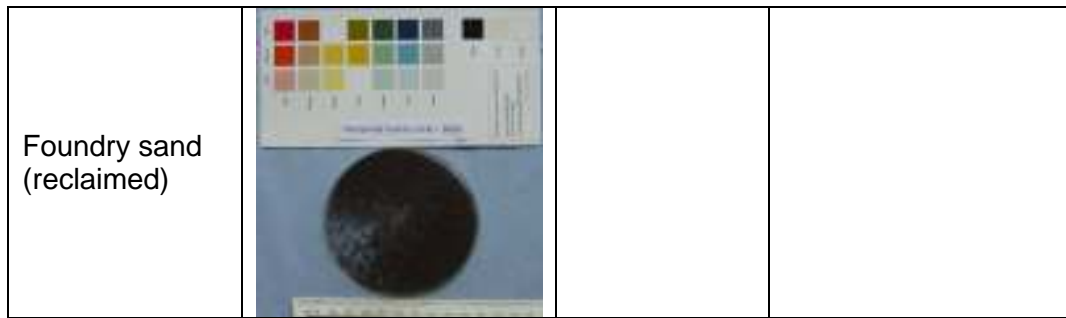
Samples of used foundry sand were provided by William Cook Cast Products in Leeds. The plant produces steel casts and end products are primarily for the rail industry. This plant uses alkaline phenolic chemically bonded sand, and prior to disposal foundry sand undergoes thermal treatment, which removes adverse substances (such as alkaline phenol, resins). Used foundry sand is produced during the separation of the cast from the mould and currently the plant in Leeds produces approximately 1000 tonnes per month. Used foundry sand is normally disposed of to landfill. William Cook operates two additional foundries in Sheffield. In the past, used foundry sand (greensand) from these sites was used in the production of aerated concrete blocks by Tarmac Topblock. Reuse and recycle opportunities for used foundry sand are actively sought by William Cook, in order to minimise the cost of disposal and to ensure that an alternative solution is in place once the nearby landfill site is closed. Also the space for waste storage on site is limited and depending on production, quantities of generated waste may exceed the volume of storage facilities, which is often seen as an obstacle to production, but also as a driver to develop synergies with other industries that could potentially use foundry sand as a resource. Routine analysis of foundry sand is carried out to ensure compliance with the Waste Acceptance Criteria of the Landfill Directive.

### Characterisation results

Foundry sand samples were collected in 5 kg bags from different stockpiles and an example of the samples is shown in Table 2. Characterisation of foundry sand samples was carried out, and parameters such as the mineralogy, the particle size distribution, the particle density, the acid soluble chloride, the moisture content and the loss of ignition were determined. The characterisation results are summarised in Table 3.

Table 2: Foundry sand samples collected from William Cook Rail plant in Leeds.

Waste Producer: William Cook Cast Products / Material: foundry dust			
Sample source		Sample source	
Foundry sand (white)		Foundry sand (pale)	



Characterisation data have shown that foundry sand samples are consistent, with very small discrepancies only for the results that correspond to white foundry sand. This conclusion is of great importance to end users, who utilise foundry sand as feedstock material. In order to establish the temporal variability of used foundry sand, additional sampling and characterisation should be carried out over longer periods.

Table 3: Foundry sand characterisation results.

Quantity (tonnes) in given location: 1000 tonnes/ month			
Current fate : reclaimed and reused internally otherwise sent to landfill			
Legal status: non-hazardous / EWC code 10 09 06			
Source	Foundry sand (white)	Foundry sand (pale)	Foundry sand (reclaimed )
Visual description	Medium-dark grey coloured powder	Pale-medium grey coloured powder	Black-dark grey coloured powder
Mineralogy	Quartz (SiO <sub>2</sub> ), orthoclase (barium aluminium silicate), cristobalite (SiO <sub>2</sub> )	Quartz (SiO <sub>2</sub> ), orthoclase (barium aluminium silicate), cristobalite (SiO <sub>2</sub> )	Quartz (SiO <sub>2</sub> ), cristobalite (SiO <sub>2</sub> ), aluminium, silicon carbide, orthoclase (barium aluminium silicate)
Particle size distribution	100% passing 31.5 mm; 97% passing 16.0 mm; 91% passing 8.0 mm; 88% passing 4.0 mm; 86% passing 2.0 mm; 85% passing 1.0 mm; 83% passing 0.5 mm; 39% passing 0.25 mm; 13% passing 0.125 mm; 7.1% passing 0.063 mm.	100% passing 1.0 mm; 98% passing 0.5 mm; 40% passing 0.25 mm; 1% passing 0.125 mm; 0.3% passing 0.063 mm	100% passing 1.0 mm; 97% passing 0.5 mm; 25% passing 0.25 mm; 3% passing 0.125 mm; 0.9% passing 0.063 mm
Particle density	2.64 Mg/m <sup>3</sup>	2.72 Mg/m <sup>3</sup>	2.75 Mg/m <sup>3</sup>
Water absorption	15%	10%	11%
Acid soluble chloride (%)	0.006	0.006	0.006
Total sulphur (%)	0.10	0.10	0.10
Moisture content (%)	11.32	11.32	11.32
Loss on ignition (%)	0.10	0.10	0.10

## Results of Laboratory/Pilot Production

Laboratory tests investigated the use of foundry sand as filler in bricks. Foundry sand represents a substitute for primary sand and the latter is added at percentages (weight) up to 30% in the clay body. Lab-based trials investigated the use of foundry sand at much lower percentages, namely 2.5 and 5%, using a brickshale (clay body). Trials with this material have not been undertaken in the past therefore its performance and effect on the aesthetic properties of bricks had to be investigated, initially by adding small amounts of foundry sand. The control material comprised a brickshale (100%) and laboratory characterisation was undertaken by *Hargreaves Mineral Services*. The appearance after firing, the moisture content, the loss on ignition, the fired temperature and the water absorption were recorded for all different samples.

Results were positive regarding the inclusion of foundry sand (at 2.5 and 5%) as a primary sand substitute into bricks. The aesthetics of the test tiles and bricks did not present any significant differences when compared with the control sample. Also none of the recorded properties presented any significant change. Foundry sand could replace primary sand in brickworks, but further work must be carried out to determine if 100% substitution of the primary material is possible.

Used foundry sand was often found in large lumps and thus required crushing and screening to break down the bonded particles. These additional comminution steps may comprise a barrier to utilisation, as brickworks (or possibly the waste producer if volumes justify) would need the appropriate infrastructure in place. However the benefits seen from replacing primary sand (such as profit from using low-cost filler) can recover addition costs related to crushing and screening of foundry sand. Parties involved in synergies often have to work together to overcome such barriers. A feasibility study should be undertaken to determine the above.

## Conclusions and further work requirements

The use of foundry sand into facing bricks as filler was successful at small substitution rates (primary sand substitution at 2.5 and 5%), and it is envisaged that higher replacement is feasible but further work is needed to confirm this. The influence of parameters such as additional processing (for example, crushing and screening) and transport of material to the end user, should also be examined. Finally, industrial scale trials should be undertaken to evaluate any effects to the manufacturing process and to examine properties of the end product such as durability, which cannot be determined otherwise.

## References

---

<sup>1</sup> Aggregates Information Service. (2002). The re-use of foundry sand as an aggregate - Digest 67. URL< [http://www.wrap.org.uk/downloads/enl-Digest\\_67\\_Version\\_1.03.9cdac0db.pdf](http://www.wrap.org.uk/downloads/enl-Digest_67_Version_1.03.9cdac0db.pdf) >. Access date:[07-11-2007]

<sup>2</sup> TFHRC (Turner-Fairbank Highway Research Centre) (2007). Foundry sand. URL< <http://www.tfhrc.gov/hnr20/recycle/waste/fs1.htm>>. Access date:[07-11-2007]

<sup>3</sup> The Environmental Technology Best Practice Programme (1998a). Optimising sand use in foundries. Envirowise.

<sup>4</sup> WRAP (The Waste and Resources Action Programme) (2003). The use of foundry sand as a fine aggregate in asphalt and aerated concrete blocks. URL< [http://www.aggregain.org.uk/case\\_studies/2714\\_the\\_use\\_of\\_.html](http://www.aggregain.org.uk/case_studies/2714_the_use_of_.html)>. Access date:[07-11-2007].

<sup>5</sup> The Environmental Technology Best Practice Programme (1999). Foundries find alternative to landfill that brings benefits to all. Envirowise.

<sup>6</sup> WRAP (The Waste and Resources Action Programme) (1999). The use of secondary aggregates in cement bound paving at a road/rail transfer facility. URL< [http://www.aggregain.org.uk/case\\_studies/2687\\_the\\_use\\_of\\_.htm](http://www.aggregain.org.uk/case_studies/2687_the_use_of_.htm) >. Access date: [07-11-2007].

<sup>7</sup> The Environmental Technology Best Practice Programme (1998). Foundry sand cements profitable partnership. Envirowise

---

<sup>8</sup> WRAP (The Waste and Resources Action Programme) (1999). The cost benefits of large scale usage of recycled and secondary aggregates on the A6 Alvaston Bypass. URL<[http://www.aggregain.org.uk/case\\_studies/2684\\_the\\_cost\\_be.html](http://www.aggregain.org.uk/case_studies/2684_the_cost_be.html)>. Access date: [07-11-2007].

<sup>9</sup> British Geological Survey (2007). Mineral Planning Factsheet - Brick Clay.: URL<<http://www.mineralsuk.com/britmin/mpfbrickclay.pdf>>. Access date:[16.10.2007].