

## Quarry Fines and Waste

Clive Mitchell, British Geological Survey, Keyworth, Nottingham, NG12 5GG

Email: [cjmi@bgs.ac.uk](mailto:cjmi@bgs.ac.uk) website: [www.mineralsuk.com](http://www.mineralsuk.com)



**Clive Mitchell**

### Introduction

Quarrying, and the associated processing operations, inevitably leads to the production of quarry fines. The amount produced depends upon the geology, the rock type quarried, the efficiency of the extraction and processing operation and the local market for quarried products. Quarry fines, defined by BS EN standards, are the inherent fraction of an aggregate passing 0.063 mm (63 microns). Many quarries also refer to their (sub-economic) fine aggregate (finer than 4 mm) as quarry fines (or quarry dust). The term is used here to denote both fine aggregate and quarry fines (material <63 microns). Quarry fines can be considered a mixture of coarse, medium and fine sand material, and silt / clay (silt and clay are often known collectively as 'filler').

The taxes on waste disposal and on production of primary aggregate materials have encouraged the use of secondary materials as aggregate, but have depressed the market for quarry fines. Many quarries in the UK have large stockpiles of fines they cannot sell. Also, large demand for high-specification fine aggregate, and aggregate with specific shape characteristics, has resulted in an increase in fines production.



**Quarry fines stockpile** Photograph: BGS ©NERC

## Production of quarry fines

Quarry fines are generated by processes related to blasting, processing, handling and transportation. Particle shape, as well as grading and fines content, are a function not only of the crushing process but also of the mineral composition and texture of the rock. As a rule of thumb, a coarse-grained rock will generate fewer fines than a fine-grained rock. This is because it takes less energy to separate individual mineral particles than it does to crush them. Also, minerals with low abrasion resistance (i.e. softer materials) will breakdown more readily than harder materials and produce more fines.

The amount of fines generated during blasting may be as high as 20%; adapting the blasting process to produce larger broken rock fragments can reduce the generation of blasting-related fines. However, this may lead to an increase in secondary breakage, downstream crushing costs and equipment maintenance costs. If fragmentation is too great, an excess of fines could result. Blasting tends to be optimised according to handling and crusher efficiency criteria rather than fines minimisation.

Most quarry fines are produced during the crushing, milling and screening of quarried rock to produce single-size aggregate (ranging from 20 mm to 6 mm) and other products. Crushing of quarried rock is carried out in stages, with the primary crushing stage typically carried out using jaw crushers or gyratory crushers and subsequent (secondary and tertiary) stages by cone or impact crushers. Fines production increases with an increase in the number of crushing stages. Multiple (three or four) stages are often used to keep the reduction ratio at each stage relatively low. Although, this minimises fines generation at each stage, the cumulative fines production may be higher than a process using fewer stages with higher reduction ratios. Table 1 indicates the fines content generated at each stage of the crushing process. The proportion of fines produced varies with the type of rock and also the type of crusher used. The figures are estimates, largely based on operator experience and gathered during a survey of quarrying operations.

**Table 1: Quarry fines produced at each crushing stage**

Production Stage	Quarry fines produced by hard rock quarries	
<b>Primary crusher</b>	Igneous	3 – 6% (Jaw) to 10-15% (Gyratory)
	Limestone	6 – 7% (Jaw) to 20% (Impact)
	Gritstone	1 – 2% (Jaw) to 15 – 20% (Jaw & Gyratory)
<b>Secondary crusher</b>	Igneous	10 – 23% (Cone)
	Limestone	<10% (Cone) to <20% (Impact)
	Gritstone	4 – 5% (Jaw & Cone)
<b>Tertiary crusher (&amp; further)</b>	Igneous	5 – 30% (Cone) to 40% (Impact)
	Limestone	<20% (Impact) to 40% (Hammer mill)
	Gritstone	~15% (Cone) to 40% (Impact)

**NB** These figures are weight percentages of the feed to the crusher.



**Sandstone aggregate stockpile** Photograph: BGS ©NERC

The type of crusher used also directly controls the amounts of fines produced. It is well known that impact crushing produces more fines than compressive crushing. Impact crushers, such as horizontal and vertical shaft impactors, tend to produce 25 - 30% more fines than compressive crushers, such as jaw crushers and cone crushers. The type of impact applied in a vertical shaft impact crusher also influences the production of fines. Rock-on-rock interaction helps to improve particle shape and reduce crusher wear but leads to increased fines production. Rock-on-metal interaction produces fewer fines while maintaining a cubical product but leads to greater crusher wear.

In the past, quarries produced a range of single-size aggregate products up to 40 mm in size. However, the recent trend has been for highly specified aggregate, typically finer than 20 mm. It is not unusual for material coarser than 10 mm to be stockpiled and recrushed on demand. The production of aggregate with a smaller particle-size has had a dramatic effect on the proportion of fines produced; a 40 mm top size results in 5 to 10% fines, 20 mm top size, 15 to 20% fines and 10 mm top size, 35 to 40% fines.



**Limestone quarry fines close up** Photograph: BGS ©NERC

### **Quarry fines statistics**

The quantity of quarry waste and quarry fines produced in the UK is unclear with little information in published literature and limited access to known data due to commercial sensitivity. Quarry waste consists of overburden, rock or processed material, which has no economic value and is stored temporarily or permanently at the extraction site. Quarry waste and quarry fines originate in all rock types including sedimentary (sand and gravel, sandstone, limestone and dolomite), igneous (diorite, dolerite, granite and lava) and metamorphic (marble and slate). Estimated values for the production of aggregate, quarry waste and quarry fines are shown in Table 2. The total annual production of quarry waste in the UK is estimated at 28.4 million tonnes; this is based on a waste to saleable product ratio of 1:9 as used by Defra

([www.defra.gov.uk/environment/statistics/waste/wrmineral.htm](http://www.defra.gov.uk/environment/statistics/waste/wrmineral.htm)). The annual production of quarry fines is estimated at 52.6 million tonnes; this is based on fines production of 20% for limestone, and igneous and metamorphic rock, 10% for sand and gravel, and 25% for sandstone. The estimates use the mineral production figures in the UK Minerals Yearbook 2006 (available to download from [www.mineralsuk.com/britmin/ukmy2006.pdf](http://www.mineralsuk.com/britmin/ukmy2006.pdf) )



**Table 2: Quarry fines production estimates**

<b>Rock Type</b>	<b>Production</b> (Mtpa, 2006e)	<b>Mineral Waste<sup>1</sup></b> (Mtpa, 2006e)	<b>Quarry Fines<sup>2</sup></b> (Mtpa, 2006e)
<b>Limestone</b>	90.0	10.0	22.5
<b>Igneous + Metamorphic</b>	54.0	6.0	13.5
<b>Sandstone</b>	19.0	2.1	6.3
<b>Sand + Gravel</b>	93.0	10.3	10.3
<b>Total</b>	256.0	28.4	52.6

**NB 1** = Defra : Waste : Product ratio of 1 : 9 ; **2** = UKMY: Fines : Product ratio 1 : 9 for Sand + Gravel (<0.063mm), 1 : 4 for Limestone, Igneous + Metamorphic and 1 : 3 for Sandstone; **2006e** = estimated production

The distribution of quarry fines stockpiles is not uniform across the country. The markets for bulk materials are usually local to urban centres and quarries in remote areas may have problems finding markets for fines. This is further complicated if there are local sources of alternative materials; such as slate waste in North Wales and china clay sand in south-west England. Fines are a particular problem in quarries producing aggregates with a high Polished Stone Value (>55) from sandstones or certain igneous rocks.



**Sand tower and stockpile** Photograph: BGS ©NERC

Some areas (such as the limestone quarries in the Mendips or igneous rock quarries in Leicestershire) produce a large volume of quarry fines due to the massive scale of the operations and there may be a substantial excess of fines. In other locations, however, there may be a local shortage of fines for a specific market (such as limestone fines for a block plant) and local quarries may work to increase fines production by the use of impact crushers. Alternatively, fines may be imported from other quarries or regions (where commercially viable) or a quarry fines substitute may be used to meet a local demand.



**Quarry fines arising from blasting** Photograph ©Aggregate Industries plc

### **Quarry fines minimisation**

Production and quarry managers focus on aggregate production and may not have the opportunity to take a critical look at the performance of their operation. In most cases, this is carried out by regional performance managers, consultants or experts working for equipment suppliers. A performance review requires a thorough audit of the production process; as part of this, a process flowsheet is devised which summarises the throughput tonnage figures, crusher and screen settings, and product gradings. Flowsheet analysis is aided by the use of proprietary computer software such as AggFlow 2006 ([aggflow.com](http://aggflow.com)) and JKSimMet ([www.jktech.com.au](http://www.jktech.com.au)) or software, developed in house by equipment suppliers (such as Bruno as used by Metso Minerals). These software tools enable the planning and simulation of the crushing process, with the ability to use different machine combinations and settings. The software models the behaviour of crushers with different rock types based on laboratory and process plant data. The simulation can be fed with theoretical or real information on the feed material; the accuracy of the simulation can be increased by the use of real feed variables. Adjustments made to the settings or by changing the type of equipment may optimise the process to give the maximum aggregate production and minimise fines production. Several case studies are given in the 'Quarry Fines + Waste' section on [www.goodquarry.com](http://www.goodquarry.com) which illustrates the importance of process optimisation ([www.goodquarry.com/article.aspx?id=50&navid=11#mqf](http://www.goodquarry.com/article.aspx?id=50&navid=11#mqf)).

## Discussion & conclusions

Quarry fines are a direct consequence of aggregate production. However, in recent years fines stockpiles have been increasing and this has created a problem for many companies. The rise in the Aggregates Levy to £1.95 per tonne will likely encourage the greater use of alternatives and these stockpiles may be set to grow ever larger. Many companies are focused on finding uses for quarry fines but as yet, this has not created a market demand that will consume the many millions of tonnes of quarry fines being produced annually.

Quarry fines minimisation is an alternative approach; this would help to tackle the problem by reducing the amount of quarry fines produced to a more manageable amount. The key benefits of quarry fines minimisation include a reduction in waste production, an increase in mineral resource use efficiency and an increase in the production of saleable aggregate.



**Natural reed bed in lagoon** Photograph: BGS ©NERC

Quarrying operations should regularly conduct process optimisation audits to ensure that they produce the lowest achievable proportion of quarry fines. Ongoing process optimisation is also important including: maintaining closed side settings and choke feeding conditions in compression crushers, using reduction ratios of 6:1 or lower, maintaining uniform feeding conditions for impact crushers and monitoring the condition of crusher wear parts. Where particle shape is important quarrying operations should consider replacing vertical shaft impact crushers with cone crushers; this is likely to reduce fines production by up to 50%.

Inevitably, over time the products demanded by society will require raw materials with higher quality. Aggregates will be no exception and it is up to the quarrying industry to demonstrate that it can devise the technology to minimise fines production and optimise resource utilisation.

This article is adapted from the website content entitled 'Quarry Fines + Waste' (by the same author) on the website **[www.goodquarry.com](http://www.goodquarry.com)**. This article is published by permission of the Director, British Geological Survey (NERC).



**British  
Geological Survey**

NATURAL ENVIRONMENT RESEARCH COUNCIL

British Geological Survey, Keyworth, Nottingham, NG12 5GG  
e-mail: [cjmi@bgs.ac.uk](mailto:cjmi@bgs.ac.uk)

As published in: Quarries & Mines 2009: <http://www.quarriesandmines.co.uk/ebook/>