Material Classification for Iron Blast Furnace Slag (BFS) - Inert

Blast Furnace Slag

Iron Blast Furnace Slag (BFS) is a by-product of the iron making process. Iron is manufactured from Iron Ore which is a mixture of oxides of iron, silica and alumina. The crushed ore is systematically fed into a blast furnace with limestone and dolomite, (fluxing agents); fuels consisting of coke, natural gas, oxygen and pulverised coal to heat the ore and flux until molten.

Flux is a term that describes minerals used to collect residual oxides from within the iron and steel-making process. Typical fluxes used include limestone and dolomite. The flux causes a chemical reaction and the elements not required in the iron or steel combine to form slag.

The liquid slag is tapped separately from the iron stream to produce either rock or granulated slag. In its molten form, BFS can be transformed into a range of products by varying the rate and conditions of solidification. Air Cooled Blast Furnace Slag (ABFS), predominantly a crystalline structured rock, has very similar properties to igneous rock (Basalt), although more vesicular, and forms when the molten slag is allowed to solidify slowly in ground bays.

Granulated Blast Furnace Slag (GBFS) is formed when the molten slag is rapidly quenched with high volume high-pressure water sprays. GBFS is essentially an alumino-silicate glass.

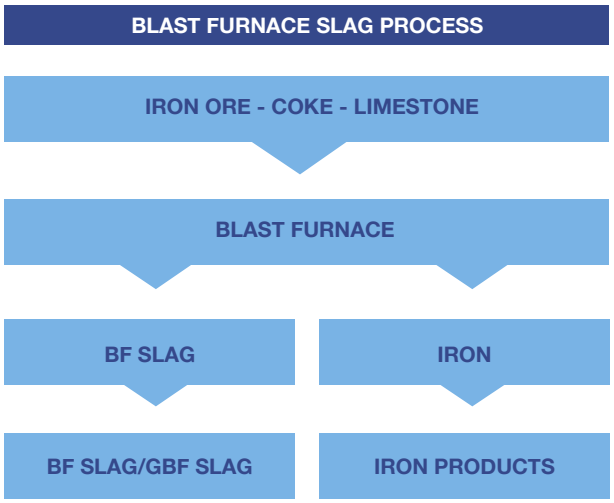

Figure 1 Blast Furnace Slag Process Streams

Air Cooled Blast Furnace Slag (ABFS)

Once cooled, ABFS is typically recovered from large cooling bays located near the furnace using either conventional front-end loaders or mechanical excavators from the ground bays (no requirement for blasting or removal of overburden). The material is then transported to a processing area where it is crushed and screened into various finished products using conventional quarry processing equipment. ABFS products have comparable properties and similar end uses to conventional quarried products such as; fine and coarse aggregate in concrete, road construction products and other similar applications. ABFS can also be referred to as Rock Slag or Air Cooled Slag.

Granulated Blast Furnace Slag (GBFS)

GBFS, because of its chemistry and glassy structure, has become a highly valued cementitious material when further processed. On observation, GBFS resembles a coarse river sand with top size of 8 mm. The unprocessed form GBFS can be used as a fine aggregate and binder in road and hard-stand pavement products. GBFS is also referred to as Granulate.

Figure 2 Air Cooled Blast Furnace Slag Aggregate

Figure 3 Granulated Blast Furnace Slag

GBFS can be further processed into a fine powder to produce Ground Granulated Blast Furnace Slag (GGBFS), using traditional cement milling equipment. GBFS and GGBFS is typically used in cement and concrete manufacture, or as binders to stabilise insitu gravels for road pavements and hard-stand areas. GGBFS is a highly valued product. GGBFS is also referred to as Slag Cement.

Figure 4 **Ground Granulated Blast Furnace Slag**

Quality Systems

Slag products are controlled by a range of well established quality systems, from the selection of the raw materials through to the finished aggregates or cementitious materials.

For example, raw materials and slag products are subject to quality systems including: composition determination prior to production; process and chemical monitoring during and post production. Cooling regimes and materials handling as well as stockpile management, are also carried out under the slag processors quality systems.

ABFS, GBFS and GGBFS products are produced to comply with relevant Australian Standards & State Authority specifications, and are referenced in numerous industry based technical publications. From a resource use perspective, slag is a quality controlled, competent alternative for virgin raw materials.

Environmental Classification

Whilst slag products are produced, marketed and sold on a commercial basis, (equal to virgin raw materials), from an environmental classification perspective, slag is deemed to be 'waste' in most States of Australia.

State Environmental legislation typically deem by-products from any process to be 'wastes' due to outmoded definitions, for example, a substance [by-product] is not precluded from being waste, merely because it can be reprocessed, re-used or recycled.

State Environmental Agencies typically do not classify wastes into categories. The generator determines the classification according to developed Environmental Guidelines where they exist in each State. For example, the NSW EPA operate Environmental Guidelines allocating wastes into one of four categories (inert, solid, industrial, or hazardous) based on the nature and mobility of the chemical species they contain. Each category requires different material handling & management practices.

Research Results

Numerous research studies have quantified the environmental performance of Iron Blast Furnace Slag. For example, in 1994 Golder & Associates carried out extensive trials on experimental leachates including chemical and ecotoxological studies. Methodology design and conduct of these trials were carried out in agreement with the NSW EPA. **This major study in 1994 found ABFS to be environmentally benign, in other words inert.**

The Golder & Associates study has been validated in a study by Moeyan & Associates conducted during 2003/2004. The aim being, to investigate the chemical nature of iron and steel furnace slags of three different metallurgical processes. Each of these by-products were analysed and the results assessed against the NSW Environmental Guidelines (EG's).

The methodology consisted of collecting differently aged samples from the product range. Samples were tested for total metal concentrations followed by leachate analysis according to the process contained in the Environmental Guidelines, and then assessed against acceptance criteria.

The majority of results for total metals were within the initial total concentration acceptance levels. For those elements exceeding these initial acceptance levels (total concentration), investigations were conducted using the TCLP method.

Using the 95% UCl, all results were found to be below the accepted concentration levels for Inert classification.

These results are consistent with previous investigations by Golder Associates in the mid 1990's, further confirming the stable and consistent nature of these respective metallurgical processes.

Conclusion

Based on experimental results ABFS and GBFS can be classified by producers as INERT

Further reading

A copy of the full report, Australasian (iron and steel) Slag Association Inc. Material Classification of Iron and Steel Slag By-product Waste Classification Investigation Report 2004, can be obtained by contacting the Association.

Published by: Australasian (iron & steel) Slag Association Inc.

PO BOX 1194
Wollongong NSW 2500
AUSTRALIA

Further copies of this document can be obtained by contacting the Association on +612 4225 8466 or via email info@asa-inc.org.au