



GROUND GRANULATED BLASTFURNACE SLAG

Ground granulated blastfurnace slag (GGBS) is manufactured from blast furnace slag, a by-product from the making of iron. The cementitious properties of blast furnace slag were discovered in the late 19th century and it has been widely used in cement manufacture for over 100 years. GGBS is supplied as a separate component for concrete and is added at the concrete mixer. It generally replaces between 20 and 80 per cent of the normal Portland cement.

Production of iron blast furnace slag

The blast furnaces used to make iron operate at temperatures up to 2000°C and are fed with a carefully controlled mixture of iron ore, coke and limestone. The iron ore converts to iron which sinks to the bottom of the furnace. The remaining materials form a slag that floats on top of the iron. The molten iron and slag are drawn off at regular intervals through tapping holes in the base of the furnace. As the slag is drawn off, its chemistry is monitored as a check on the performance of the furnace. This ensures that blast furnace slag is very consistent in chemical composition.

After being tapped from the furnace and separated from the iron, the slag is cooled. The cooling rate of the molten slag determines its physical characteristics. If the material is left to gradually air-cool, it is of no use as a cementitious material and is used as an aggregate. Where the blast furnace slag is to be used for the manufacture of GGBS, it has to be rapidly quenched in water. This process is known as granulation because it produces glassy granules, similar in appearance to a coarse sand. These have excellent cementitious properties.

Production of GGBS

To produce GGBS, this granulated blast furnace slag is dried and ground to a fineness similar to that of Portland cement. Sharjah Cement factory operates a sophisticated production facility, to produce GGBS to an accurately controlled fineness.

Typical physical properties for Sharjah cement factory GGBS

Fineness	~400m ² /kg
Bulk density	1000 to 1100kg/m ³ (loose) 1200 to 1300kg/m ³ (vibrated)
Relative density (specific gravity)	2.9
Colour	Off white

Typical chemical properties for Sharjah Cement Factory GGBS

GGBS contains the same principal oxides as Portland cement, but in slightly different proportions. The following table compares typical percentages of the principal oxides in GGBS with those in Portland cement:

	CaO	SiO ₂	Al ₂ O ₃	MgO	Fe ₂ O ₃
GGBS	35%	34%	16%	8%	1.5%
Portland cement	65%	20%	5%	1%	2%

Quality control

Throughout the manufacturing process, the physical and chemical properties of GGBS are carefully monitored and controlled. The finished product conforms to both:

- BS 6699, ground granulated blastfurnace slag for use with Portland cement¹
- Or the European Standard which has replaced it, BS EN 15167-1 Ground granulated blast furnace slag for use in concrete, mortar and grout²

Applications

GGBS is normally used in combination with Portland cement. The GGBS and cement are added into the concrete mixer as separate constituents. Where appropriate, the ratio of GGBS to cement can be varied according to the technical requirements for any particular application. The British Standard for Concrete (BS8500) uses the following notations for specifying the percentage of GGBS as a percentage of the total cementitious content:

Notation GGBS percentage

CIIA-S 6 to 20% GGBS
CIIB-S 21 to 35% GGBS
CIIIA 36 to 65% GGBS
CIIB 66 to 80% GGBS

CIIIA is the most widely used combination and is commonplace for ready-mixed, site - mixed and precast concretes in all types of applications. CIIB tends to be used for specialist applications such as those requiring low heat rise or high sulfate resistance. CIIB -S is used for applications such as power-floated floors, mortars, screeds and some precast concrete products that require a relatively high early-age strength. CIIA-S is rarely used.



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The benefits from using GGBS in concrete, include:-

- Greatly reduced carbon dioxide emissions
- Significantly improved durability
- Reduced early-age temperature rise
- Lighter colour

GGBS can replace a substantial portion of the Portland cement content, generally about 50%, but sometimes up to 70% or more. The higher the proportion, the better is the durability.

Concrete containing ggbs is less permeable and chemically more stable than normal concrete. This enhances its resistance to many forms of deleterious attack, in particular:-

- Disintegration due to sulfate attack •
- Chloride-related corrosion of reinforcement •
- Cracking caused by alkali silica reaction.

- 1 Withdrawn in January 2009
- 2 First published in October 2006



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