
SLAG
Granulated Blast Furnace Slag (GBFS)
Ground Granulated Blast Furnace Slag (GGBFS)
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What Does Blast Furnace Slag Mean?
Blast furnace slag is a non-metallic residue usually obtained from steel plants or from the reduction of ores in a blast furnace. It is used as a mud cake modifier for the cementing of oil and gas wells.

It has been found that using a slag mix for cementing is beneficial economically and technically as well as better for the environment than Portland cement. Cement made with blast furnace slag has lower permeability than Portland cement and reduces the diffusion rate of ions through the hardened cement. This improves its durability in the presence of salts such as chloride and sulfate.

Blast furnace slag has a typical composition of:

- Silicon dioxide.
- Aluminum oxides.
- Iron oxides.
- Magnesium oxide.
- Sodium oxide.
- Calcium oxide.
- Sulfur.

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Granulated Blast Furnace Slag (GBFS)
Brief Description Granulated Blast Furnace Slag
GBFS is formed when molten blast furnace slag (BFS) is rapidly quenched from the furnace, rather than left to slowly solidify by air-cooling.

Physical Description
On casual examination, GBFS would pass for river sand, with a top size of about 6mm. It typically has a density of about 60 - 70% of natural sand.

Method of Manufacture
After separating molten BFS from the molten iron, the slag can be allowed to run into or to be transported to ground bays to air-cool. There it solidifies and becomes a rock or crystalline BFS.

Alternatively, the molten slag can be quenched rapidly by passing it through a trough of high pressure, high volume water sprays, during which the heat energy contained in the molten slag causes it to explode and instantly form GBFS. GBFS is transported to stockpiles where the material dewaters prior to collection using convention front end loaders.

Applications
GBFS may be used without further processing as a construction sand, soil/pavement stabilizing media or grit-blasting material.

Typical uses for GBFS are:
- As a general purpose construction sand in civil engineering applications
- As an ideal select fill behind reinforced earth wall construction. Within a relatively short time, the pozzolanic properties of granulate cause it to set and form a solid block
- As a source of alumina and silica in glass manufacture
- As a stabilising agent in road construction. There have also been examples where only granulate has been used as pavement material. Pavements now exist where granulate has been used in conjunction with steel slag to form very heavy-duty pavements.
- As a grit-blasting medium: granulate is particularly suitable for soft metals such as aluminum where a light etch is required

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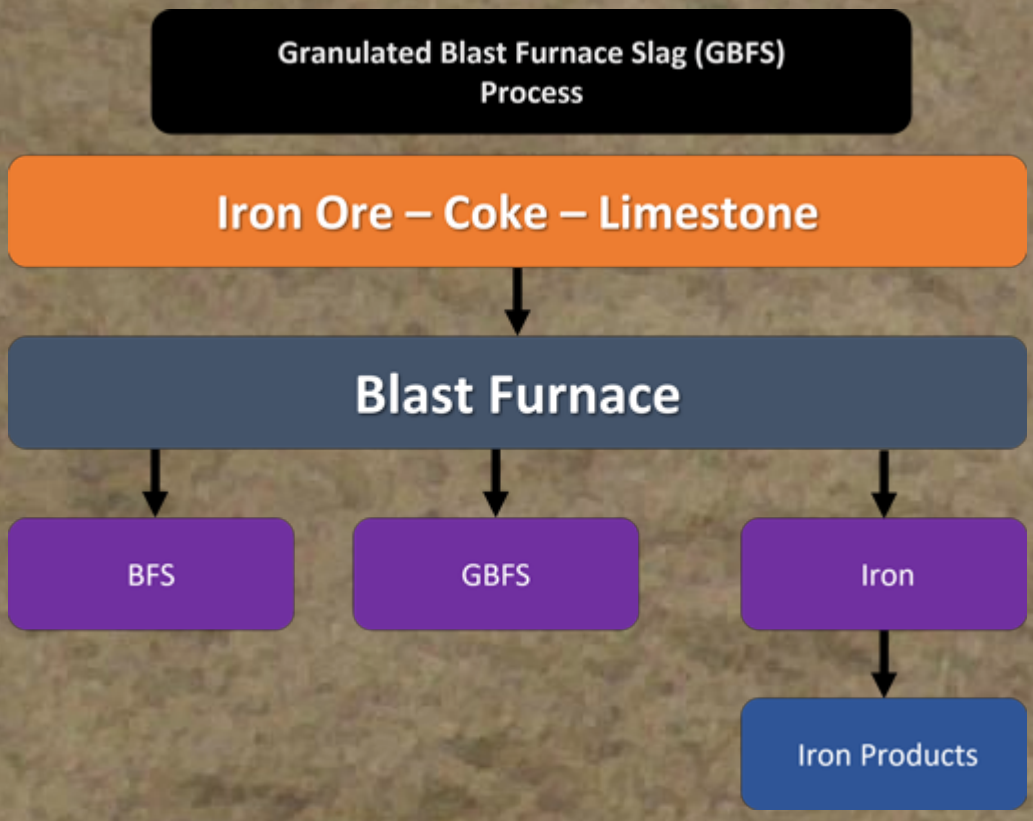
Diagram of Manufacture



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Granulated Blast Furnace Slag (GBFS)

Test Items	Standard（+/-0.5%）	Typical
CaO	37%min.	42%
MgO	10%max.	5.5%
SiO_2	39%max.	33%
Al_2O_3	16%max.	11.6%
Fe2O3	1.0%max.	0.51%
TiO_2	2%max.	0.34%
Moisture	10%max.	7.50%
Basicity	1.65%min.	1.80%
Size	under5mm--95.0%min	97.10%
Cl	0.1% Max	0.04%
Glass	96%min	98.70%

PACKING : BULK

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Ground Granulated Blast Furnace Slag (GGBFS)

Brief Description

GGBFS is formed when granulated blast furnace slag (GBFS) is further processed or ground using conventional cement clinker grinding technology.

Physical Description

On a casual examination, GGBFS can be off-white in appearance and could pass for a powder fineness typically between 380m2/kg - 420m2/kg.

Method of Manufacture

After molten slag has been quenched rapidly by passing it through a trough of high pressure, high volume water sprays, the heat energy contained in the molten slag causes it to explode and instantly form granulated blast furnace slag (GBFS).

GBFS is then further processed or ground using conventional cement clinker grinding technology to form GGBFS.

Applications

GGBFS is typically used in activation of granular pavement materials and as a cementitious material in the manufacture of concrete, particularly where resistance to aggressive ground, water and aggressive environmental conditions are present.

Typical uses for GGBFS are:

•Activator for stabilising granular pavement materials as the only stabilising agent or in conjunction with small quantities of lime.

- As a general cementitious replacement 25 – 50% for Portland Cement in concrete construction.
- As a significant cementitious replacement min 65% for Portland Cement where long term durability in aggressive ground, water or air environments are required.
- As a high cementitious replacement > 80% in special grout mixes.

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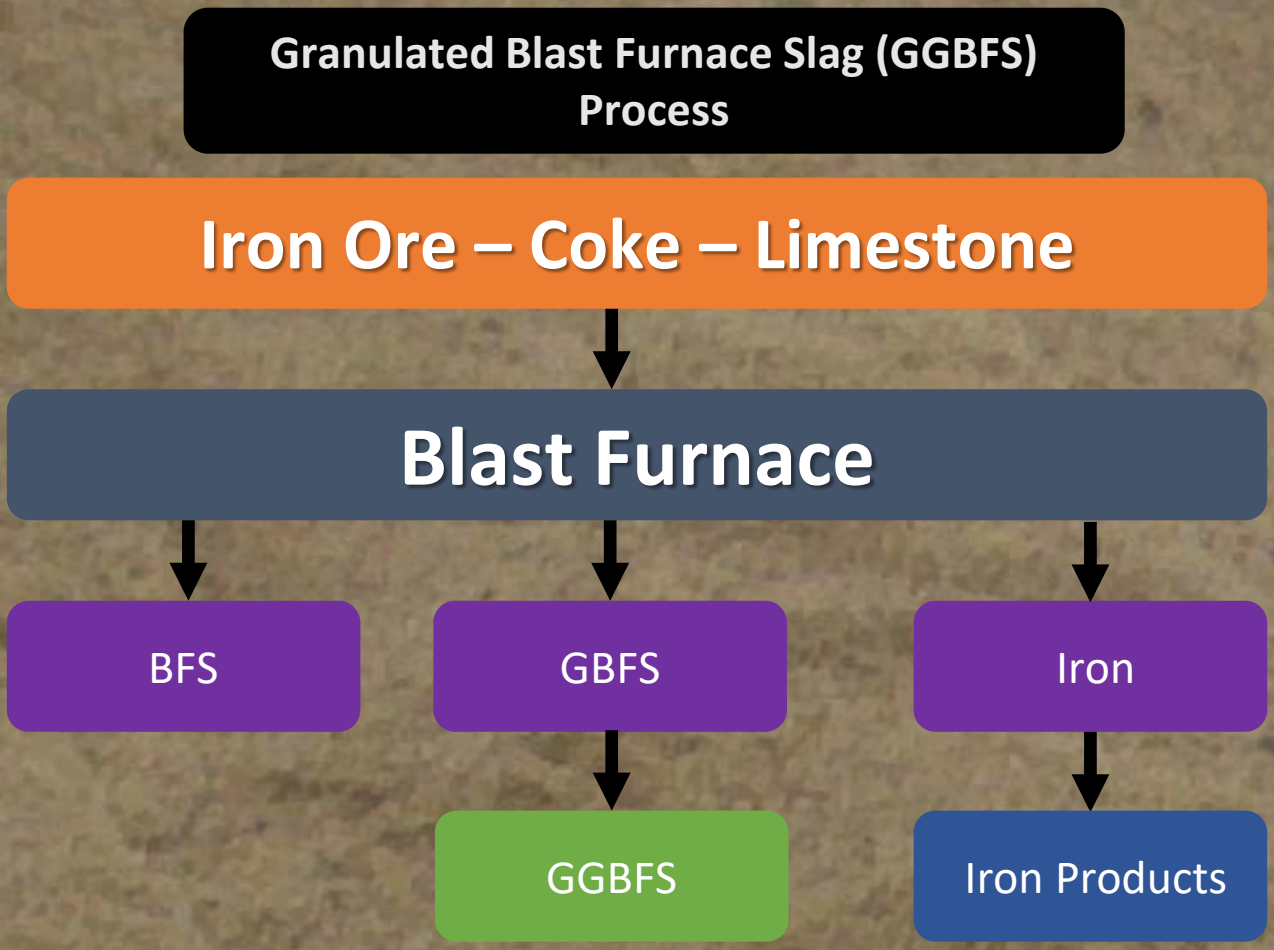
Diagram of Manufacture



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GROUND GRANULATED BLAST FURNACE SLAG CODE 2.1.8

Technical Parameters

Specification/Grade: ASTM C989/BS EN 1516-1: 2006

Chemical Properties	Unit	Min	Max	Typical Results %
Silicon Dioxide SiO_2	%	32,00	38,00	34,80
Iron Trioxide Fe_2O_3	%	0,70	1,50	0,92
Calcium Oxide CaO	%	32,00	38,00	35,40
Manganese monoxide MnO	%	0,30	0,90	0,58
Aluminum Trioxide Al_2O_3	%	14,00	18,00	17,12
Sulfur S	%	0,20	0,50	0,30
Magnesium Oxide (MgO)	%	6,00	10,00	8,10
Insoluble Residue (IR)	%	1,50	2,50	1,58
Loss of Ignition (LOI)	%	0,50	0,80	0,60
Specification Surface (CM_2/gm)	%	3800,00	4000,00	3895,00
Specific Gravity	%	2,70	2,95	2,82
Bulk Density T/M_3	%	1,10	1,30	1,28
Residue on 45 Microns	%	10,00	14,00	6,67
Glass	%	9,00	95,00	92,60
Testing Frequency	Monthly			

Safety

Hazard	Respirable dust may contain >0,1% respirable crystalline silica
Handling	Avoid contact with skin and eyes; Wear suitable protective cloting and gloves

Physical Properties

State:	Powder
Colour:	Whitish Grey

PACKING : Jumbo Bags, 50kg Bags

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GROUND GRANULATED BLAST FURNACE SLAG CODE #2.2.8
Technical Parameters

Physical Properties	Unit	Specification	Typical Range
		IS 16714 : 2018	
Specific Gravity	-	Not specified	2,86 ± 0,04
Bulk Density	Kg / m^3	Not specified	900 - 1100
Fineness (Surface Area) be Blain	m^2 / kg	320,00	380 - 410
Moisture Content (MC)	%	<=1	<0,5
Slag Activity Index	7 Days	>60% (Min. Strenthg of Control OPC 43 Grade	70 % to 95%
Slag Activity Index	28 Days	>75% (Min. Strenthg of Control OPC 43 Grade	80% to 110%
Setting Time			
Initial Minutes	Minute	Not specified	170 - 200
Final Minutes	Minute	Not specified	270 - 300
Soundness			
Le Chatelier Expansion (mm)	mm	Not specified	<5
Chemical Properties	**Unit**	**Specification**	**Typical Range**
Loss of Ignition (LOI)	%	3,0 Max	<2
Insoluble Residue (IR)	%	3,0 Max	<2,5
Silicon Dioxide SiO_2	%	Not specified	32% to 36%
Aluminum Trioxide Al_2O_3	%	Not specified	16% to 19%
Iron Trioxide Fe_2O_3	%	Not specified	1% to 2%
Calcium Oxide CaO	%	Not specified	36% to 40%
Magnesium Oxide (MgO)	%	17,0 Max	6% to 11%
Sulfur Trioxide SO_3	%	3,0 Max	<1,5
Sulfur S	%	2,0 Max	<1
Chloride (Cl)	%	0,10 Max	<0,05
Manganese monoxide MnO	%	5,5 Max	<4,0
Calcium Sulphide CaS	%	Not specified	<2,0
Glass Content	%	85 Min	94 to 97
(CaO + MgO + 1/3 Al_2O_3) / (SiO_2 + 2/3 $AI2O_3$)	-	1,0 Min	>=1
(CaO + MgO + Al_2O_3) / SiO2	-	1,0 Min	>=1
(CaO + CaS + 1/2 MgO + Al_2O_3) / (SiO2 + MnO)	-	1,5 Min	>=1.5

PACKING : Jumbo Bags, 50kg Bags

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GROUND GRANULATED BLAST FURNACE SLAG CODE #2.3.8
Technical Parameters

Physical Requirements	Unit	Obtained Results	Standard Limits Values	Test Methods
Specific Gravity	gr /cm^3	2,9	-	TS EN 196-6
Specific Surface	cm^2 / g	5990	≥2750	TS EN 196-6
Initial Setting Time	minute	181	≤ Test Clim, P. Bas.Sur.2 Kati	TS EN 196-3
7 Days Activity Index	%	59,5	≥45	TS EN 196-3
28 Days Activity Index	%	84,5	≥70	TS EN 196-1

Chemical Requirements	Unit	Obtained Results	Standard Limits Values	Test Methods
Sulfur Trioxide SO_3	%	0,52	Max 2,5	TS EN 196-2
Sulfide S^{-2}	%	0,53	Max 2,0	TS EN 196-2
Chloride (Cl)	%	0,0106	Max 0,1000	TS EN 196-2
Loss of Ignition (LOI)	%	0,09	Max 3,0	TS EN 196-2
Magnesium Oxide (MgO)	%	7,69	Max 18,0	TS EN 196-2
Titanium Dioxide TiO_2	%	1,24	-	TS EN 196-2
Moisture Content (MC)	%	0,1	Max 1,0	-
(CaO + MgO) / SiO2	%	1,06	Min 1,0	TS EN 196-2

PACKING : Jumbo Bags, 50kg Bags

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Micronized GGBS

GROUND GRANULATED BLAST FURNACE SLAG CODE #2.5.8
Technical Parameters

Physical Properties	Unit	Specification	Typical Range
		IS 16715 : 2018	
Specific Gravity	-	Not specified	2,86 ± 0,04
Bulk Density	Kg / m^3	Not specified	800 -900
Fineness (Surface Area) be Blain	m^2 / kg	1500,00	3200 (Computed Blain Based on PSD)
Particle Size Distribution (PSD)			
(a) D_{50}	µm	5 Max	less than 4
(b) D_{95}	µm	15 Max	less than 10
Moisture Content (MC)	%	<=1	<0,5
Slag Activity Index	7 Days	not less than >60%	80 % to 110%
Slag Activity Index	28 Days	not less than >75%	90% to 120%
Setting Time			
Initial Minutes	Minute	Not specified	100 - 180
Final Minutes	Minute	Not specified	150 - 220
Soundness			
Le Chatelier Expansion (mm)	mm	Not specified	<5
Chemical Properties	**Unit**	**Specification**	**Typical Range**
Loss of Ignition (LOI)	%	3,0 Max	<0,50
Insoluble Residue (IR)	%	3,0 Max	<0,70
Silicon Dioxide SiO_2	%	Not specified	32% to 36%
Aluminum Trioxide Al_2O_3	%	Not specified	16% to 19%
Iron Trioxide Fe_2O_3	%	Not specified	1% to 2%
Calcium Oxide CaO	%	Not specified	36% to 40%
Magnesium Oxide (MgO)	%	17,0 Max	6% to 11%
Sulfur Trioxide SO_3	%	3,0 Max	<0,50
Sulfur S	%	2,0 Max	<0,70
Chloride (Cl)	%	0,10 Max	<0,05
Manganese oxide Mn2O3	%	Not specified	<1,0
Manganese monoxide MnO	%	5,5 Max	<3,0
Calcium Sulphide CaS	%	Not specified	<2,0
CaO + MgO + SiO2	%	Not specified	75 to 80
CaO + MgO / SiO2	%	Not specified	1,2 to 1,3
CaO / SiO2	%	Not specified	1,0 to 1,2
Glass Content	%	85 Min	94 to 97
(CaO + MgO + 1/3 Al_2O_3) / (SiO_2 + 2/3 Al2O_3)	%	1,0 Min	>=1
(CaO + MgO + Al_2O_3) / SiO2	%	1,0 Min	>=1
(CaO + CaS + 1/2 MgO + Al_2O_3) / (SiO2 + MnO)	%	1,5 Min	>=1.5

PACKING : 50kg Bags, 25kg Bags

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sales@bodovaltd.com
https://www.bodovaltd.com/