

II Types and Characteristics of Iron and Steel Slag

1 Blast Furnace Slag (Air-cooled and Granulated)

Blast furnace slag is produced when the components of iron ores other than iron, which are melted in blast furnaces to produce pig iron, along with limestone from the auxiliary raw materials and the ash content of coke, are collectively separated and recovered. Approximately 300 kg of blast furnace slag can be produced from one ton of pig iron. The slag removed from a blast furnace is in a molten state at approximately 1,500°C. Depending on the cooling method used, blast furnace slag is classified into air-cooled slag and granulated slag, each having different

properties.

[Air-cooled slag]

Crystalline and rocky air-cooled slag is produced when molten slag is poured onto a cooling yard and undergoes slow natural cooling with some water spraying.

[Granulated slag]

Glassy and granular granulated slag is produced when molten slag undergoes rapid cooling by quenching with pressurized water injected into it.

Air-cooled slag



Granulated slag



Blast furnace



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Steelmaking Slag (Converters and Electric Arc Furnaces)

Steelmaking slag is produced in the steelmaking process, which adjusts components of pig iron and scrap to produce steel, which has high toughness and machinability. Steelmaking slag is classified into converter slag produced from converters and electric arc furnace slag produced in the electric arc furnace steelmaking process using scrap as a raw material. Converter slag is processed after undergoing natural cooling or water spraying on a cooling yard, similar to air-cooled blast furnace slag, after which it can

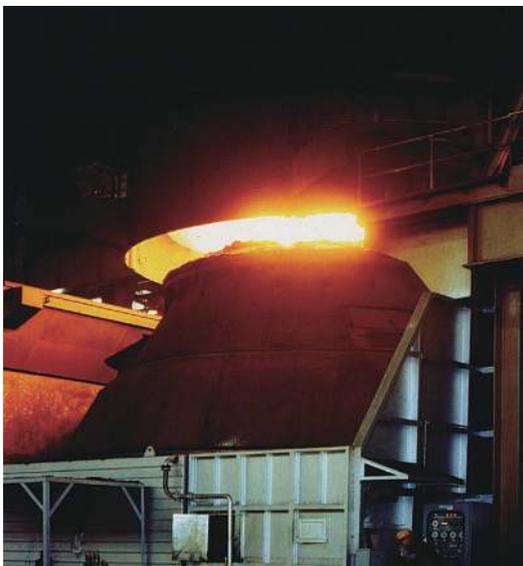
be used for various applications. Approximately 130 kg of converter slag can be produced from one ton of converter steel. In recent years, the hot metal pretreatment which removes phosphorate (P) and sulfur (S) in the converter refining pre-process has become widely adopted, and the slag produced through this process is also classified as converter slag.

Electric arc furnace slag is produced when melting and iron scrap and refining and it is classified into oxidizing slag produced through oxidation refining and reducing slag produced through reduction refining. Until around 1980, both oxidation and reduction refining were performed in one electric arc furnace, making it difficult to separate oxidizing slag and reducing slag. Since then, ladle refining furnaces have been widely adopted, allowing for a clear separation of the oxidation refining and reduction refining processes, making it possible to separately produce oxidizing slag and reducing slag. Currently, approximately 70 kg of electric arc furnace oxidizing slag and 40 kg of electric arc furnace reducing slag can be produced from one ton of electric arc furnace steel.

Steelmaking slag (converter)



Converter



Electric arc furnace



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Characteristics and Applications of Iron and Steel Slag

[Air-cooled blast furnace slag]

Air-cooled blast furnace slag has a hydraulic property in which the slag hardens through a reaction with water and increases its strength over time. Therefore, it is used as a base course material like gravel, as it is expected to have a large bearing capacity for civil engineering structures. With no risk of causing an alkali-silica reaction(*) and no inclusion of clay and organic impurities, air-cooled blast furnace slag is used as concrete coarse aggregate, just like natural aggregate.

[Granulated blast furnace slag]

Similar to air-cooled blast furnace slag, granulated blast furnace slag has a hydraulic property with no risk of causing the alkali-silica reaction. Due to its latent hydraulic property which can be significantly increased when finely granulated, it has been used in applications like making blast-furnace slag cement. When mixed with cement in approximately equal amounts, ground granulated blast furnace slag can be processed into

blast-furnace slag cement that is equivalent to ordinary Portland cement (Portland cement), with its strength increasing over a long period. Taking advantage of its characteristics such as a slow heat generation rate when reacted with water and high chemical durability, it has been widely used in large-scale civil engineering works such as port construction.

[Steelmaking slag]

Steelmaking slag also has a hydraulic property, and so can also be expected to have a large bearing capacity as civil engineering structures. For this reason, it is also used as a base course material. As it excels in abrasion resistance due to its high particle density and hardness, it has been used as asphalt concrete aggregate. Additionally, due to a large angle of shear resistance, high particle density, and high unit volume weight, steelmaking slag has been used as earthwork materials and ground improvement materials (such as a sand compaction pile material).

Major Characteristics and Applications of Iron and Steel Slag

		Characteristics	Application
Blast furnace slag	Air-cooled slag	Hydraulic property Free from alkali-silica reaction Low Na ₂ O and low K ₂ O Heat insulation, heat retention, sound absorbing characteristics when fiberized Fertilizer component (CaO and SiO ₂)	Base course material Concrete coarse aggregate Cement clinker raw material (alternative to clay) Rock wool raw material Calcium silicate fertilizer
	Granulated slag	Strong latent hydraulic property when finely granulated Low Na ₂ O and low K ₂ O Latent hydraulic property Light-weight, large angle of shear resistance, high water permeability Free from alkali-silica reaction Fertilizer component (CaO and SiO ₂)	Blast-furnace slag cement raw material Portland cement mixed material Mineral admixture for concrete Cement clinker raw material (alternative to clay) Earthwork material and ground improvement material (backfill, soil covering, embankment, roadbed improvement, ground drainage layer, etc.) Concrete fine aggregate Calcium silicate fertilizer Soil amendments
Steelmaking slag	Converter and electric arc furnace slag	Hardness and abrasion resistance Hydraulic property Large angle of shear resistance FeO, CaO and SiO ₂ content Free from alkali-silica reaction Fertilizer component (CaO, SiO ₂ , MgO and FeO) Absorption of sulfuric ions and phosphate ions Fe supply	Asphalt concrete aggregate Block and artificial stone aggregate (steel slag hydrated matrix, steel slag carbonated matrix) Base course material Soil stabilizer (Calcia-modified soil) Earthwork material and ground improvement material Cement clinker raw material Concrete fine and coarse aggregate (electric arc furnace oxidizing slag aggregate) Fertilizer and soil amendments Environmental improvement material (bottom sediment) Iron content supply unit for seaweed bed creation

* Alkali-silica reaction: A reaction between the alkali in cement and the aggregate causing the aggregate to expand, thereby leading to cracks in concrete structures and their collapse.