National Slag Association

PI 207-1

GENERAL INFORMATION about NSA

At the turn of the Twentieth Century, producers of pig iron began to concern themselves with the limited places for disposal of the slag which was pouring out of their furnaces. In 1908 Carnegie Steel began an investigation "to ascertain what could be done to use this by-product of its blast furnaces". As early as 1911 a Carnegie report, "Furnace Slag in Concrete", established a position for slag as a suitable product for use as an aggregate in concrete.

In 1917, it was evident that slag had become a valuable product and producing companies would benefit from a more united promotional effort. It was also apparent that slag operators were having difficulty obtaining railroad cars due to the war effort, and a cooperative effort was needed to acquire them. In 1918 ten men met in Columbus, OH and voted to organize the NATIONAL SLAG ASSOCIATION. The U. S. Bureau of Public Roads concluded in a 1919 survey that there were 32 plants being operated by 14 companies producing slag.

During the years following, blast furnace slag became known as "the all purpose construction aggregate" due to its use in nearly every phase of construction, including: road base, asphaltic concrete and Portland cement concrete aggregate, hydraulic fill, cement manufacture and concrete products, glass manufacture, railroad ballast, mineral wool, sewage treatment, roofing, soil conditioning, ice control and other uses.

"slag: the MATERIAL of CHOICE"

Slags are produced in many metallurgical operations and blast furnace slag has been widely used for all types of construction in the US for more than 80 years. At annual Association meetings, extensive deliberation is conducted regarding the promotion of the materials, safe and productive plant operations, and responsible, environmentally sound uses of slag. Long time performance records in a variety of uses and climatic conditions have demonstrated its economy and durability and earned the title, Slag: The Material of Choice.

Iron & Steel Slags

IRON (BLAST - FURNACE) SLAG:

DEFINITION AND DESCRIPTION OF SLAG:

The American Society of Testing and Materials (C 125 Definition of Terms Relating to Concrete and Concrete Aggregate) defines blast furnace slag as "the non-metallic product consisting essentially of silicates and alumino silicates of calcium and other bases, that is developed in a molten condition simultaneously with iron in a blast furnace."

In the production of iron, the blast furnace is charged with iron ore, flux stone (limestone and/or dolomite) and coke for fuel. Two products are obtained from the furnace: molten iron and slag. The slag consists primarily of the silica and alumina from the original iron ore combined with calcium and magnesium oxides from the flux stone. It comes from the furnace as a liquid at temperatures about 2700 F, resembling a molten lava. Dependent upon the manner in which the molten slag is cooled and solidified, three distinct types of blast furnace slag can be produced: air-cooled, expanded and granulated.

CHEMICAL PROPERTIES:

Blast Furnace slag is produced from the melting of iron ore and limestone or dolomite. Therefore, blast furnace slag is a lime based material and has a basic pH.

The principal constituents of blast furnace slag are the oxides silica, alumina, lime and magnesia. These comprise 95 percent or more of the total. Minor elements include manganese, iron and sulfur compounds, and trace quantities of several others. It should be noted, however, that the major oxides do not occur in free form in the slag; instead they are combined to form various silicate and aluminosilicate minerals, such as melilite (a solid solution series of akermanite and gehlenite), merwinite, wollastonite, etc., as found in natural geological forms.

The chemical composition of slag from a given source (and, therefore, its mineralogic composition) varies within relatively narrow limits since raw materials charged into the furnace are carefully selected and blended.

PHYSICAL PROPERTIES:

The physical characteristics - weight, size of particles, structural properties, etc. - vary according to the type of slag processed. Accordingly, end-use recommendations for each type differ.

"the ALL-PURPOSE Construction Aggregate"

TYPES OF IRON - BLAST FURNACE SLAG by COOLING METHOD

AIR COOLED - The molten slag is permitted to run into a pit adjacent to the furnace or transported in large ladles and poured into a pit some distance away. Solidification takes place under the prevailing atmospheric conditions, after which cooling may be accelerated by water sprays on the solidified mass. After a pit has been filled and cooled sufficiently for handling, the slag is dug, crushed, and screened to desired aggregate sizes.

AIR COOLED SLAG USES - Graded aggregate bases for pavements, concrete - plain and reinforced, masonry units, macadam surfaces and bases, bituminous pavements, skid resistant surfaces, railroad ballast, trickling filter medium, roofing aggregate (built-up and shingle), raw material for mineral wool insulation, backfill of all types and slope protection.

EXPANDED - Treatment of the molten slag with controlled quantities of water accelerates the solidification and increases the cellular or vesicular nature of the slag, producing a light-weight product. Either machine or pit processes may be used to mix the water and molten slag. The solidified expanded slag is crushed and screened for use as a lightweight aggregate.

EXPANDED SLAG USES - Lightweight masonry units, lightweight concrete, fire resistant construction, floor fill, concrete masonry core fill insulation, lightweight base or fill and cement manufacture.

GRANULATED - Molten slag is chilled quickly to form a glassy, granular product. This process is the most rapid of the cooling processes and little or no crystallization occurs. The granulated slag may be crushed and screened, or pulverized for various applications.

GRANULATED SLAG USES - Highway base and subbase, pipe backfill, agricultural liming and soil conditioning, lightweight concrete block, cement manufacture, and concrete floor fill.

STEEL SLAG

DEFINITION AND DESCRIPTION OF SLAG:

Steelmaking slags are the by-products of the processing of iron and scrap with lime into the desired type and grade of steel in furnaces such as the basic oxygen [BOF] and electric arc [EAF] furnaces.

CHEMICAL PROPERTIES:

The principal constituents of steelmaking slags are calcium silicates and aluminoferrites with fused oxides of calcium, iron, magnesium and manganese.

Like blast furnace slag, steel slag oxides are combined when cooled to form various forms of minerals common to both lime and silica based materials. Free lime or free oxides of calcium and/or magnesium is available which is dissolved with water as it percolates through the slag after cooling.

PHYSICAL PROPERTIES:

Processed steel slag is strong, hard, durable, dense and roughly cubical particles which make it especially suitable for use in road construction.

Not all steel slag is expansive, but water quenching is the first step in weathering of steel slag which may be essential to provide a stable, non-expansive construction material. In the cooling process, some of the lime in the slag may be “hard burnt”. The lime has a hard outer shell or surface which masks an unsound soft inner core of unhydrated lime. This lime must be saturated by water for the particle to be stable. It is important that steel slag used in construction is obtained from a producer who has a quality control program in place and minimizes the amount of unsound particles by exercising necessary quality control procedures.

Steel Slag End Uses

Steel Slag Hot Mix Asphalt Aggregate Provides a Sustainable Pavement

Chicago Speedway

Designed for strength and durability, the Indianapolis Motor Speedway in Indianapolis, IN used steel slag coarse aggregate SMA pavement for its new surface in 2005. Like DOT’s and many other users, they chose steel slag because of its long life, tenacity and exceptional friction properties. No ordinary pavement can withstand the horizontal shear stresses from cars rocketing at 200 mile per hour into the turns at Indianapolis. But steel slag can, which is why the track officials chose steel slag as the coarse aggregate for the pavement. Similarly, when Colorado state transportation officials wanted to repave scenic I-70 through Glenwood Canyon they chose steel slag coarse aggregate because they wanted a long lasting, stable, durable, high friction pavement. The long climb and long descent over the mountains surrounding Glenwood Canyon can hold up to the truck traffic pounding and straining the I-70 corridor. Only steel slag SMA pavement can withstand the truck traffic outside the largest stone quarry in Illinois, near Chicago. The Asphalt Institute called the steel slag SMA pavement placed at the intersection of Williams and Margaret Streets as the “the world’s strongest intersection”. The next time you choose an asphalt pavement for your access road, parking area, driveway or parking lot, choose steel slag as the aggregate, a sustainable renewable recycled material.

Cement Mfg Raw Feed

Portland cement producers are always on the lookout for resource efficiency, and steel slag fills that role in the manufacture of Portland cement. Steel slag can be introduced directly into the feed end of the kiln, bypassing the preheater and precalciner stages, thereby saving energy. Steel slag also reduces CO_2 emissions because it is calcined in the steel making process. It also saves valuable raw materials for another day and the CO_2 pt that would be emitted from the clinkering process. Another benefit to the cement manufacturer from using steel slag is iron oxide in steel slag needed in the chemistry of Portland cement. Using 10 -15% steel slag will save a corresponding amount of CO_2 and provide the cement industry with real energy savings. Synergy of locations between the cement industry and the steel industry provide a local source of raw materials for the cement industry that can use a recycled, sustainable material top increase production without negatively affecting the environment.

Road base and shoulders for highway construction

The predominant use for steel slag, besides returning as raw materials to the steel furnaces, is road base. Steel slag

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(Steel Slag End Uses continued)

is highly stable and will bridge over soft soils due to the angularity and interlocking nature of the aggregate. Steel slag exhibits excellent compaction when graded for the correct application and with a small amount of free lime available, water percolating through the steel slag picks up the lime and provides a week cementing action that enhances its CBR value.

Waste water treatment (Phos removal)

Removal of contaminants from waste water is a new and potentially important application for steel slag. Steel slag contains oxides of Aluminum and Iron combined with a calcium base which reacts to neutralize the pH of the waste water. Studies done by university professors at renowned universities have researched the use of steel slag, a renewable recycled material, to treat waste water. Field applications have proven the lab science and now steel slag is being used in treatment zones or permeable reactive barriers to treat contaminated groundwater. This is important to farmers who are under extreme pressure to limit the amount of nitrogen and phosphorous from non point source areas. Re-circulating water through steel slag at fish farms eliminates nitrogen and phosphorous from the water, reduces costs and proves to be effective.

Unpaved parking areas and pathways

Steel slag is the ideal material for unpaved parking lots or driveways. Steel slag properties include high angularity that provides stability, heavy unit weight to stay in place and “free lime” that provides for a weak cementing effect aiding compaction and is ideal for areas prone to heavy truck traffic. Material with a top size of 25mm is appropriate and commonly available for parking lots and steel slag with a top size no larger than 12.5 mm is best for bike or cart paths and walking trails. Be certain to ask for the appropriate size when using steel slag for your parking lot or roadway.

TYPES OF SLAG:

Steel Slag Coarse Aggregate AASHTO #8

Air Cooled Blast Furnace Slag Rip Rap

Pelletized Blast Furnace Slag

Air Cooled Blast Furnace Slag, Smaller Gradation AASHTO#8

Air Cooled Blast Furnace Coarse Aggregate AASHTO #67

Granulated Blast Furnace Slag

Slag Cement ASTM #989

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