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Recycle with High Performance

The evolution of the asphalt industry has included advancements to pavement thickness design and mixture selection methodology, improvements to mix design methods, enhancements to production facilities, and improvements with construction equipment and techniques. This evolution has taken decades and it isn't over–continued ingenuity by the asphalt industry makes asphalt pavements last longer and perform better from high to low volume applications. The past decade has seen the increased and successful use of Reclaimed Asphalt Pavement (RAP), Warm Mix Asphalt (WMA), Reclaimed Asphalt Shingles (RAS), and Ferrous; Iron and Steel Slag (Slag). The successes seen today have come from the hard work of agencies, contractors, consultants, academia, and equipment and material suppliers.

Mix Design Philosophies

The asphalt mix design philosophies used over the past several decades—such as Hveem, Marshall, Texas Gyratory and Superpave—each brought strength to the roadway and runway building industry. These improvements occurred as traffic volumes and loadings continued to climb throughout the industrial world.

With added stress due to loading on asphalt pavements, improved aggregate quality, strength and classification measurements became the norm in conjunction with a better understanding of the importance of voids, voids in the mineral aggregate (VMA), and voids filled with asphalt (VFA); aka Volumetrics. The overuse of inexpensive beach sands, dirty aggregates and single aggregate stockpile production were identified as the primary causes for

premature pavement failures. Each has been fazed out of standards and specs over the years. The use of engineered sharp sands; clean, hard aggregates; and multiple stockpiles of aggregate for input now ensure that longer lasting roadways are built.

In addition to stronger asphalt pavements is the need to provide safer roadways. Agencies have recognized this for years and most now have updated geometric criteria and higher frictional requirements of the coarse aggregate as well as improved design, production and construction standards. As stability and friction are typical needs of high speed, high volume asphalt facilities, many asphalt contractors look for one product to fill both needs. Stability and friction ability come from aggregates that are high in crush, hard, durable and reusable. According to the Industrial Resources Council (IRC), air cooled blast furnace slag and steel slag in particular provide good rutting resistance and superior friction properties, making them a choice aggregate for the surface course. The cost-benefit analysis of the past, present and future continue to lead slag producers to supply iron and steel slag for this important safety feature.

Slags

Blast furnace (BF) slag is formed when iron ore or iron pellets, coke and a flux (either limestone or dolomite) are melted together in a blast furnace. When the metallurgical smelting process is complete, the lime in the flux has been chemically combined with the aluminates and silicates of the ore and coke ash to form a non-metallic product called blast furnace slag. During the period of cooling and hardening from its molten state, BF slag can be cooled in several ways to form any of several types of BF slag products.

In a blast furnace, combustion material and ore are supplied from the top while an air flow is supplied from the bottom of the chamber. This forces the chemical reaction to take place throughout the ore, not only at the surface.

 Steel furnace slag is produced in a basic oxygen furnace (BOF) or an electric arc furnace (EAF). Hot iron and/or scrap metal are the primary metals to make steel in each process. Lime is injected to act as a fluxing agent. The lime combines with the silicates, aluminum oxides, magnesium oxides, manganese oxides and ferrites to form steel furnace slag, commonly called steel slag. Slag is poured from the furnace in a molten state. After cooling from its molten state, steel slag is processed to remove all free metallics and sized into products.

Basic oxygen furnace (BOF): Oxygen is blown into the furnace vessel through a water-cooled oxygen lance, oxidizing carbon and the other unwanted elements in the molten iron. Fluxes are added to remove other unwanted elements yielding high quality steel.

Electric arc furnace (EAF): Charged material is heated to a liquid state by means of an electric current. The electricity has no electrochemical effect on the metal making it perfectly suited for melting scrap.

Steel slag is processed as an air-cooled material. The National Slag Association states the metallics are magnetically separated and the remaining slag is sized into construction aggregates, used as an agricultural soil amendment, as a raw ingredient in Portland cement production, as an environmental remediation material and many other uses.

The Oregon Department of Transportation Research Report No. OR-RD-00-09 of April 2000 stated: “After the steel slag has been crushed and graded into the sizes desired it is stockpiled for delivery. Asphalt concrete has been

produced and the pavement constructed readily in Oregon when crushed steel slag is used as a portion of the aggregate."

As discussed in the article titled "Mix in Slag" in the February 2013 issue of AsphaltPro, before an aggregate is considered for use on an agency project, whether it is for aggregate base, HMA or other, the quality of the mined materials must go through rigorous agency evaluation to determine a variety of qualitative measures, including:

- Safety – Friction testing
- Angularity – Fracture testing
- Hardness – LA Abrasion
- Durability – Soundness
- Absorption – Specific Gravity

Slag meets and exceeds all of these quality (ASTM D5106) measures time and again. (See Table)

Slag Success Stories

Slag has been used as the aggregate of choice in the construction of many long lasting asphalt pavements. Around the globe, slag exceeds aggregate requirements for asphalt use and the transition to Superpave only highlighted slag's features:

1. Coarse aggregate is produced at 100 percent two-faced fractured faces, rough surface texture, good particle shape, and meets the flat and elongated requirements.
2. Fine aggregate at a minimum of 45 percent fine aggregate angularity.

In addition slag "may be used as a friction aggregate" in its first and subsequent uses. At the Williams and Margaret intersection in Thornton, Ill., a sign reads: "Home of Thornton Quarry; Largest Limestone Quarry in the World." There a successful steel slag, stone matrix asphalt (SMA) rehabilitation of the intersection got the state's attention. The Illinois Department of Transportation (IDOT) has adopted this mixture as the standard for use on interstates in Chicagoland and at high load, high traffic situations where a high friction coarse aggregate is required.

Several slag projects are now more than 20 years old and still performing. The extensive use and success of slag in perpetual asphalt pavements has presented another opportunity; that the slag coarse fraction from these cold millings (RAP) are now used a second time in new surface course mixtures and again, demonstrating the global stewardship of resources. For their continuous long-term efforts, IDOT was awarded the 2012 Green Governments Award for education and outreach, transportation, efficiency and conservation.

Society, Sustainability, Future

Because of the size of the iron and steel industry in the United States, there are thousands of people employed in the slag industry. Additionally, slag is a sustainable (green) material that can be reclaimed and reused multiple times. Using iron and steel furnace slag will help preserve our natural resources. Based on numerous environmental tests, studies and reviews by governmental agencies and the iron and steel industry, we know that iron and steel slag is a safe and valuable resource, and we encourage its continued use as a viable environmentally friendly product for building and maintaining the United States' infrastructure.

Because slag is a co-product that comes from the manufacturing of iron and steel; both slag products score high on first use per the Greenroads™ Rating System (Manual v1.5, p. 396). Slag is a regional material that reduces trucking emissions and the need to import aggregates from far away, and it works well with recycled materials such as RAP, ground tire rubber and asphalt shingles.

Due to the successful performance and numerous uses of slag over the past several decades, IDOT allows RAP slag to be used in all mixes and all lifts of asphalt. Additionally, IDOT counts the coarse aggregate slag in high volume surface mixes as part of the friction aggregate requirement, because of both the fracture strength and friction supplied to the pavement structure.

Finally, as the drive for Total Recycle Asphalt continues, IDOT recently awarded several projects that allow the use of up to 100 percent recycled aggregates where one project uses 72 percent slag and 28 percent RAP.

"We recycle and use over a million tons of reclaimed materials on our highways annually as a matter of everyday practice," Illinois Transportation Secretary Ann L. Schneider said. "We believe Total Recycle Asphalt will take Illinois to a new level of environmental sustainability, and we hope it will inspire others to follow our lead."

These new generation mixes use locally available materials, encourage ingenuity, reduce the overall carbon footprint, and provide for long lasting, strong and durable asphalt roadways time and again when using slag as a component. It is quite possible that these new generation mixes using slag are the most recycled hot mix asphalt pavements ever produced on the planet.

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The original article “Recycle with High Performance” can be found at http://theasphaltpro.com/mix-it-up/recycle-with-high-performance