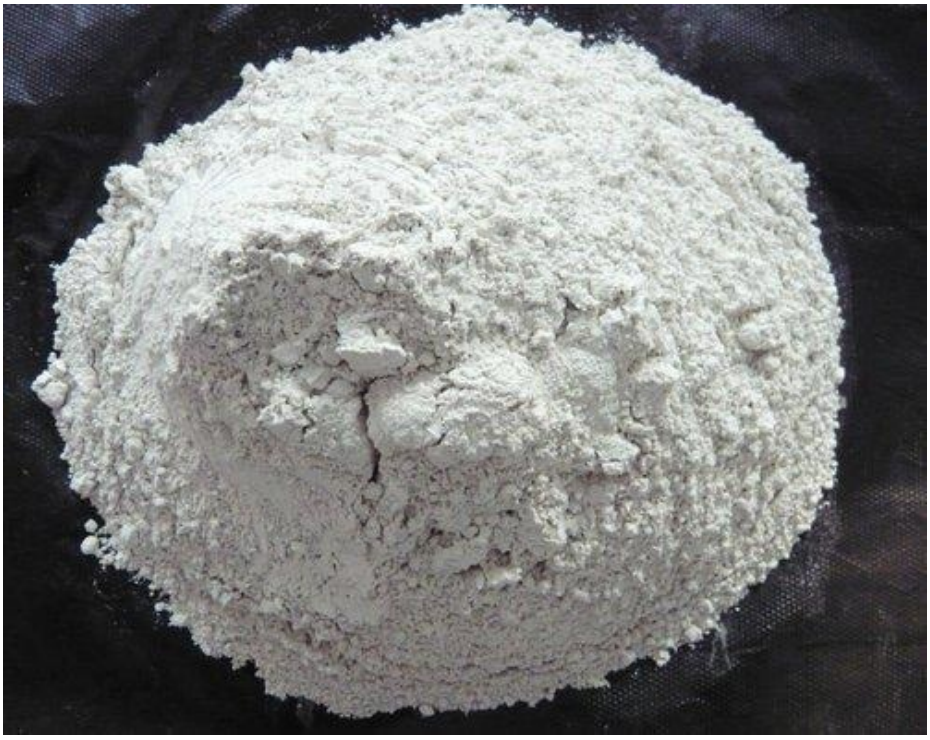
HAHN READY MIX

All About Slag

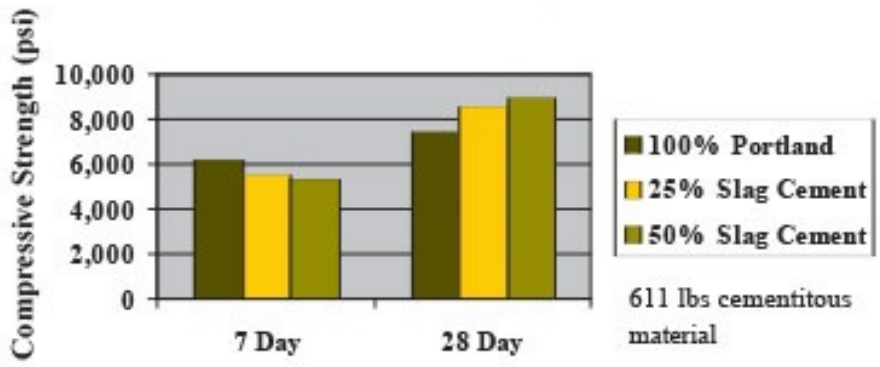
Technical Bulletin #8 - August 2022



What is Slag?
Slag, sometimes known as ground granulated blast furnace slag (GGBFS), or Slag Cement, is a byproduct from the manufacture of iron in a blast-furnace. In a blast furnace, scrap metal, limestone, and iron ore are melted down. The molten iron collects at the bottom, and the unwanted materials float to the surface. These materials are called slag, and are scraped off to cool. The method of cooling creates slag products for a multitude of uses, but cementitious quality slag is rapid cooled in water to form glassy granules. The cooled granules are dried and then ground to a fineness greater than cement. Chemically, slag is high in calcium oxide and silica.

How does Slag work in Concrete?
Slag is kind of unique, in that it is dual natured. Initially, water, heat, alkalis and leftover C-H from the cement hydration activate slag's latent hydraulic properties, forming it's own C-S-H just like cement, but on a delay. However, if the slag has more silica than calcium, the excess silica can bond with the leftover C-H from the cement hydration, acting like a pozzolan, similar to fly ash. These reactions result in a strength gain curve that is much lower than a cement only mix for the first few days or

so, but can significantly outperform a cement only mix over a longer term. Some slags are highly reactive and can catch up to the strength curve of cement in 7-14 days. Others, that perhaps have not been ground as fine, or were not cooled as rapidly, may not catch the cement strength curve until 56 days. Slag is typically used at a replacement level of 15-50% the cement. However, it may be appropriate to replace up to 80% of cement with slag in a mass concrete mix design.



How does Slag effect plastic concrete?

Water demand - As slag does not react with water as quickly as cement, the initial water demand for a mix utilizing slag will be lower. This allows concrete to either be placed at a lower water/cement ratio or at a higher slump. One option benefits concrete performance, the other concrete workability.

Workability - At higher replacement levels (above 50%), slag can make the concrete feel “sticky”. In this case, workability and pumpability are compromised for the other objectives that may be achieved using high amounts of slag.

Slipping - Machines such as slip form pavers and curb machines often find slag mixes finish exceptionally well, as the particle size and shape of slag will help prevent poor consolidation in these environments.

Bleed - Slag mixes may tend to bleed more, particularly in cold weather, as the slag does not react and subsume the water as quickly.

Set time - In cooler or moderate temperatures, slag will set similar to fly ash, and extended finishing times should be expected. In warmer temperatures, slag may react more quickly, similar to portland cement. With high slag mixes, set times are significantly extended.

How does Slag effect hardened concrete?

Strength - Concretes utilizing slag tend to have a lower initial strength (1-5 days) but similar intermediate strength (7-14 days) and greatly improved long term strength (28 days+) in relation to cement-only mixes. Slag produces a denser paste and improved aggregate bond.

Permeability - Slag's finer particle size and increased C-S-H production results in a significantly less permeable concrete matrix. This is key to improving resistance to salt intrusion, sulfate attack, rebar corrosion, chemical attacks, and freeze-thaw actions.

Alkali-Silica Reaction (ASR) - Slag can help mitigate ASR in potentially reactive aggregates. In this regard, slag is more effective than a class C fly ash and less effective than a class F fly ash.

Temperature - Slag can help reduce the heat of hydration in concrete. This happens when the hydraulic reaction of slag occurs at a different time from the hydraulic reaction of cement, normalizing the heat output over a longer period of time. This is especially true of high replacement levels of slag (>50%), where the heat of hydration can be *significantly*

reduced.
Color - Concrete mixes with slag tend to be lighter in color than mixes using only cement. Also, one may notice that if the interior of a slag cement concrete is exposed, it will be a bright greenish-blue color for a short time until the slag oxidizes in the air. This is normal and nothing to be concerned about.

Are there different grades of slag?
Indeed, concrete quality slag is categorized in three grades: 80, 100, and 120.

able 1: ASTM C 989 standard for the classification of different grade sla

		Minimum Slag Activity Index %	
Day Index	Grade Type	Average of last five consecutive samples	Any individual sample
7 Days	Grade 80	-	-
	Grade 100	75	70
	Grade 120	95	90
28 Days	Grade 80	75	70
	Grade 100	95	90
	Grade 120	115	110

These grades are based on the strength of a mix with 50% slag vs the strength of a mix with only cement at different ages. Newcem, the slag used by Hahn Ready Mix, is marketed as a grade 100 slag, but easily exceeds the strength requirements of a grade 120 slag.

Is Slag supply a concern?
Unlike fly ash, slag supply is not under threat. However, the growing scarcity of fly ash is adding significant demand to the slag market, exceeding what supply is available. These forces are driving up the price of slag beyond that of cement, and could eventually make slag a “luxury” concrete material.

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