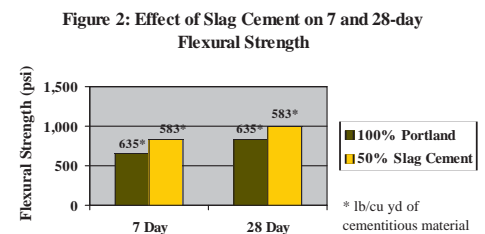
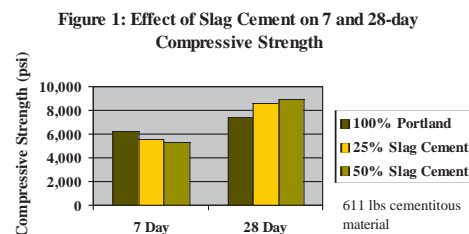


WHY ARE IMPROVED STRENGTHS IMPORTANT?

Concrete made with slag cement provides higher compressive and flexural strengths compared with straight portland cement concrete. Improved strengths make it easier to achieve specified safety factors of the concrete mixture and can provide engineers with a tool to optimize concrete element designs. It provides enhanced material properties allowing producers to optimize concrete mix designs. Owners may realize decreased life cycle costs.

HOW DOES SLAG CEMENT IMPROVE STRENGTH?

Slag cement increases the compressive and flexural strength of conventional concrete (Figures 1 and 2) and is often a vital component in producing high strength concrete. 28-day strengths generally increase as the percentage of slag cement increases, up to about 50 percent slag cement as a percent of cementitious material. When portland cement reacts with water, it forms calcium silicate hydrate (CSH) and calcium hydroxide ($\text{Ca}(\text{OH})_2$). CSH is the glue that provides strength and holds concrete together, $\text{Ca}(\text{OH})_2$ is a byproduct of portland cement hydration that does not contribute to strength. When slag cement is used as part of the cementitious material in a concrete mix, it reacts with water and $\text{Ca}(\text{OH})_2$ to form more CSH. The additional CSH densifies the concrete matrix, enhancing strength.



HOW DOES SLAG CEMENT AFFECT STRENGTH DEVELOPMENT?

When slag cement is used in concrete mixes, early strength development may be slower while ultimate strengths will be higher than straight portland cement mixtures. If more rapid strength development is required, the concrete mixture can be modified with conventional technology, for example, the use of accelerating admixtures, or use of heated materials or curing conditions. Concrete made with slag cement will have higher strength growth over the lifetime of the concrete element compared with straight portland cement concrete mixtures. Several factors influence the strength development of the mixture. They include:

- Chemical composition of the slag.
- Proportions of the slag component.
- Temperature of the curing environment.
- Chemical composition of the cement component.
- Temperature of the concrete.
- Fineness of the slag component.
- Availability of soluble alkali.

Concrete made with slag cement provides higher compressive and flexural strengths compared with straight portland cement concrete.

The additional calcium-silicate hydrate made with slag cement densifies the concrete matrix, enhancing strength.

COMPRESSIVE AND FLEXURAL STRENGTH

Slag cement has a particularly significant effect on the flexural strength of concrete. Flexural strength (or modulus of rupture) is one of the principal factors in concrete pavement design. Increased flexural strength is evident in Figure 2, where 50 percent slag cement achieved a 20 percent strength improvement, even though total cementitious content was decreased by 52 lb/cu yd. Improved flexural strengths are attributed to the increased denseness of the paste and improved paste-aggregate bond.

WHAT ARE THE BENEFITS OF IMPROVED STRENGTH?

Feature	Benefit Compressive Strength	Benefit Flexural Strength
Improved Safety Factor	Greater reliability	Greater reliability
Optimized element design	Thinner members Lighter members Fewer members Less dead load More usable floor space	Thinner section
Optimized mix designs	Lower cementitious factors Less shrinkage Lower heat	Lower cementitious factors Less shrinkage Less curling
Life cycle cost	Increased service life	Increased service life Lower maintenance costs Greater ability to handle unexpected increases in traffic volumes

As with all concrete mixtures, trial batches should be performed to verify concrete properties. Results may vary due to a variety of circumstances, including temperature and mixture components, among other things. You should consult your slag cement professional for assistance. Nothing contained herein shall be considered or construed as a warranty or guarantee, either expressed or implied, including any warranty of fitness for a particular purpose.

Slag cement increases the ratio of flexural to compressive strength in concrete.



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About the Slag Cement Association...

The Slag Cement Association is the leading source of knowledge on blast-furnace slag-based cementitious products. We promote the increased use and acceptance of these products by coordinating the resources of member companies. We educate customers, specifiers and other end-users on the varied attributes, benefits and uses of these products.

