Hydraulic Conductivity of Cement-Bentonite-Slag Slurry Wall Barriers

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ABSTRACT: In both the United States and the United Kingdom slurry walls are used for the containment of contaminants and control of groundwater flow. The United States mainly uses a soil-bentonite slurry wall that is comprised of bentonite-water slurry mixed with a select soil to form a backfill. In contrast, in the United Kingdom the wall is comprised of a mixture of cement, blast furnace slag and bentonite-water slurry which is left to harden in place. This paper examines the hydraulic conductivity and unconfined compressive strength of three different cement-slag slurry mixtures prepared using materials originating in the US. Three ratios of cementitious material to bentonite-water slurry used were 10%, 15% and 20%. Slag replacement was incorporated in the cementitious in ratios of 0%, 20%, 40%, 60%, 80%, and 90%. Samples were cured for a period of 28 days at 100% humidity, after which samples of each mixture underwent permeability and unconfined compression tests. Permeability tests were repeated at two, three, and six months.

Unconfined compression tests were performed after one month of curing, while permeability testing was performed at one, two, three and six months. The data at six months shows that the mixture of 20% cementitious material with 70% slag replacement has the lowest permeability of 7 x 10^{-8} cm/sec. In general, the trend in the data shows that permeability is constant from 0-70% slag replacement, and then dramatically decreases as the slag content increases from 70 to 80%.

At one month**,** the permeability of each mixture dropped dramatically when 80% of the cementitious material was replaced with slag. From 0 to 70% slag replacement the permeability remains steady. From 70 to 80% the permeability decreases. Each of the 80% slag replacement mixtures dropped in permeability from 1 x 10^{-6} to 9 x 10^{-7} cm/sec. The samples were sensitive in the range of slag replacement from 70 to 80%. Mixtures with 90% slag replacement, additional slag seems to have a higher permeability than those with 80%, indicating the optimum range for slag replacement is 70 to 80%. The lowest permeability achieved by the 10% cementitious mixture was 8 x 10^{-7} cm/sec at 90% slag replacement. The hydraulic conductivity was 7 x 10^{-7} cm/sec at 80% slag for 15% cementitious mixtures. Finally the 20% cementitious mixture with 80% slag replacement achieved the lowest permeability, 6 x10^{-7} cm/sec. The order in permeability was expected based on the additional solids in the 20% cementitious mixture.

The hydraulic conductivity of each sample was expected to decline further with time. This relationship was examined through permeability testing at two, three, and six month curing. The trend for two month data was decreasing permeability with increasing slag replacement, the lowest permeability was 4 x 10^{-7} cm/sec at 20% cementitious material and 80% slag replacement. It was later found that samples with 80% slag replacement

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were not tested at two months. At three months, the lowest permeability was 1 x 10^{-7} cm/sec at 20% cementitious material and 70% slag replacement. The same mixture also exhibited the lowest permeability at six months of 7 x 10^{-8} cm/sec. Based on the one, two and three and six month data, the optimum mixture is one that contains 20% cementitious material with 70 to 80% slag replacement.

As expected, samples with 20% cementitious material had higher unconfined compressive strength than samples with 15% cementitious material, which likewise were stronger than samples with 10% cementitious material. The relationship between strain at failure and slag replacement was also examined.

In analyzing the Unconfined Compression strength tests, there was no apparent relationship between the unconfined compressive strength of permeated samples and slag content. However, there is a relationship between the unconfined compressive strength of nonpermeated samples and slag content. Mixtures that were not permeated exhibited the similar behavior. With increasing cementitious content the unconfined compressive strength increased. The slope continues to increase with increasing slag replacement to a maximum strength at 80% slag replacement. The maximum compressive strength obtained by mixtures with 10% cementitious material was 18 psi, and it was 36 psi for mixtures with 15% cementitious material. The mixture containing 20% cementitious material at 80% slag replacement obtained the highest compressive strength, which was 66 psi.

Although there is a relationship between strength and slag content, there is none between strain at failure and slag replacement for both permeated and non-permeated samples. It was shown, however, that percent strain at failure increases with increasing cementitious material. All samples reached their maximum strain at failure in the range of 70% to 80% slag replacement. The maximum strain at failure for the 10% cementitious material was 3% at 70% slag content, it was 3% at 80% slag content for the 15% cementitious material, and it was 4% at 70% slag content for the 20% cementitious material.