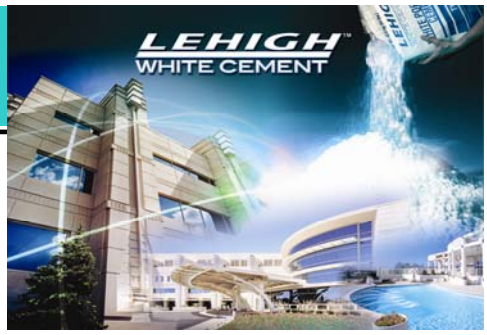
TECHNICAL BULLETIN



Admixtures & White Cement

Introduction
Lehigh White Cement Company is committed to your success, with technical personnel who understand the interactions between white cement and common chemical admixtures ready to assist you. This technical bulletin discusses considerations experienced users of gray portland cement may overlook when making the switch to white cement. It is not intended to supplant the role of admixture suppliers who are the authorities on their products. Admixture company personnel have a comprehensive understanding of their products and we encourage you seek out these professionals early and often.

Admixtures
Modern portland cement concrete, including white cement-based mixes, rely on chemical admixtures to optimize their performance and reliability. Chemical admixtures are liquid solutions or dry compounds that when added to concrete during the mixing process can improve and/or control set times, workability, air content and hardened properties of the mix. They most often achieve these goals by altering the physical and chemical interactions of the cement and water to modify the paste portion of the mix.

Admixtures are powerful tools that aid placement and enhance a structure's service life; however, they are not a substitute for sound concrete mix designs and placement practices. In addition to contacting your admixture supplier and Lehigh technical representatives, we recommend the following references for more information on admixtures:

- ACI Education Bulletin E4-03, Chemical Admixtures For Concrete
- ACI 212.3R-04, Chemical Admixtures for Concrete
- ACI 212.4R-04, Guide for the Use of High-Range Water-Reducing Admixtures (Superplasticizers) in Concrete

Admixture Interactions - Low, Mid and High Range Water Reducers
Chemical admixture/cement interactions normally correlate to the admixture base chemistry. Section 4.1 of ACI Education Bulletin E4-03 explains that it is appropriate to categorize chemical admixtures by basic or primary ingredients.

Common types include lignosulfonic acids and their salts or "lignin-based", sulfonated naphthalene formaldehyde condensates or "naphthalene-based", and polyether-polycarboxylates or "polycarboxylate-based" admixtures. Any of these three basic types can be combined with carbohydrate-based or sugar derivatives which have some water reduction properties but are most often used as retarders to delay set times.

Lehigh white cements have very good track records when combined with lignin and naphthalene-based admixtures. At standard doses, cement interaction with these classes of admixtures tends to be predictable and consistent. High doses of lignin-based admixtures or admixtures containing sugar derivatives have caused severe delay of set times in some cases.

In recent years, polycarboxylate-based admixtures have become the most widely used class of concrete admixtures in North America. These engineered materials usually feature high water reduction and good early strength development. They come in a wide range of formulas that tend to be very cement specific in their interactions and mix performance. Polycarboxylate and naphthalene-based admixtures should never be combined, as these products are not compatible.

ASTM C494-08, the Standard Specification for Chemical Admixtures for Concrete indicates, "Mixtures having a high range water reduction generally display a higher rate of slump loss. When high-range admixtures are used to impart increased workability… the effect may be of limited duration, reverting to the original slump in 30 to 60 minutes, depending on factors normally affecting rate of slump loss." Rapid slump loss, especially during warm and hot periods, has been a significant issue with some white cement and polycarboxylate admixture combinations.

Polycarboxylate admixtures, proven most successful when combined with white cement, are formulated to provide extended slump life and are sometimes referred to as "long acting." Slump retention is often improved by adding low to moderate doses of hydration stabilizers which delay hydration activity and are preferable to traditional retarders because they have minimum effect on initial strength gain.

Lehigh White Cement strongly encourages personnel designing mixes which utilize polycarboxylate-based admixtures to consult their admixture company and inquire what products work best with the white cement available in their market. Lehigh White Cement's technical sales representatives typically have excellent insight into this issue and should be consulted as well. This is especially true if your admixture sales representative has limited experience with white cement.

Self-Consolidating Concrete, aka Self-Compacting Concrete

Self-Consolidating Concrete (SCC) is a highly fluid yet cohesive form of concrete. It will flow around congested areas of reinforcement and into tight sections and complicated forms, allowing air bubbles to escape without the need for using vibrators – all while resisting segregation.

Most SCC employs specialized high-range water reducers (superplasticizers) or several chemical admixtures combined with well-graded aggregates to achieve a balance between fluidity and cohesion. Typical admixture combinations include low or mid-range water reducers, along with superplasticizers for flowability and viscosity modifiers for cohesion. *Note: Mixes combining multiple admixtures are sometimes hard to control and may become unstable. We advise white cement users planning to produce SCC to first consult with a Lehigh White technical representative.*

Supplemental Cementitious Materials

Supplemental Cementitious Materials (SCM's) are used successfully in many white cement applications. When used appropriately, they can improve workability, strength and durability in white or gray cement concrete. *Note: SCMs such as silica fume, fly ash and GGBFS (slag cement) are all industrial by-products and are produced with no regard to color.*

Many slag cements are light colored; however, they can impart a bluish-green hue that will usually dissipate in time. Slag intended for use with white portland cement should be pre-tested to ensure it meets the color needs of the job. Fly ash is a combustion by-product of coal-fired power plants and has a high potential to discolor white or decorative concrete. Silica fume imparts a very dark gray color to any concrete; we therefore do not recommend using it in white cement mixes.

Finely ground limestone ($CaCO_3$) is often available in white or off-white colors. It can slightly increase concrete strength and durability. It does this by improving particle packing, increasing the paste portion of the mix and chemically reacting with portland cement's aluminate phases to form carboaluminate compounds. Metakaolin is produced by pyroprocessing amorphous, alumino-silicate kaolin clays to make it reactive in cement-based mixes. It can impart good durability and increase ultimate concrete strength. It is often used in color sensitive concrete due to its light cream to gray color. Color consistency of metakaolin and ground limestone depends on the reliability of the raw material source, which can vary.

If you do not have a good working history with a given SCM, Lehigh White recommends mock-up panels be produced to see what effect the SCM may have on the finished product color. We also advise requiring the SCM supplier to produce historical samples for an extended period or otherwise demonstrate that the product supplied will be a consistent color.

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