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ARCHITECTURAL CONCRETE CONTRACTORS

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MIXTURES FOR DECORATIVE CONCRETE

When selecting concrete for use in decorative concrete flatwork, one can specify several properties of both the materials used in the concrete and the concrete itself. These include:

- *Nominal maximum size of the aggregate;*
- *Type of portland cement and other cementitious materials;*
- *Amount of cementitious material per cubic yard (cubic meter), or compressive strength;*
- *Air content for air-entrained concrete;*
- *Concrete slump;*
- *Type and amount of pigment for integrally colored concrete;*
- *Admixtures, such as shrinkage reducing and water reducing admixtures; and*
- *Type and amount of fibers.*

Nominal Maximum Size of Aggregate

Concrete mixtures that contain 70% sand and 30% pea gravel are an example of concrete mixtures that may exhibit a large amount of shrinkage due to a relatively high water-cementitious materials ratio. Contractors often use such mixtures for ease of placement, but the durability and structural capacity of the concrete could be compromised.

The larger the nominal maximum aggregate size, the lower the water requirement to produce a given slump. Because higher water contents increase concrete shrinkage—and the possibility of random cracks—it's best to use as little water as possible in the concrete while still getting the needed slump. That means using the largest possible nominal maximum size aggregate. The most commonly used nominal maximum aggregate size for decorative concrete is 1 in. aggregate. Pea gravel (3/8" diameter aggregate) mixtures contain a high water and cement content and are likely to shrink and crack more than concrete mixes made with larger coarse aggregates. Pumping larger aggregate sizes that require a larger diameter line is more expensive, but the concrete quality will generally be better.

Portland Cement and Other Cementitious Materials

Portland cements are the most common cementitious materials used in decorative concrete. They are hydraulic cements, which means they set and harden by reacting with water, and they aren't soluble in water after hardening. They come in several types, but the most commonly used in decorative concrete are Type I and Type II. Type I is a general-purpose portland cement suitable for all uses where the special properties of other types are not required. Type II portland cement has a moderate resistance to sulfate attack and is used when soils and ground water in contact with the concrete have higher concentrations of sulfate than normal but are not unusually severe. Type II cement is made with less of the compound that is attacked by sulfates, and it also puts off less heat when it reacts with water. Because of its increased availability, Type II cement is sometimes used for all concrete construction in an area, regardless of the need for sulfate resistance or moderate heat generation. Some cements may be labeled with more than one type designation, for example Type I/II or Type II/V. This simply means that such a cement meets the requirements of both cement Types I and II or Type II and Type V. Most cements are a shade of gray.

Cement Powder Truck

In areas with very high sulfate concentrations, Type V cement—which has a higher sulfate resistance than Type II cement—may be needed and should be used in concrete that also has a lower water-cementitious materials ratio. This will typically result in a higher strength concrete than is normally used for decorative work.

Other cement options are using white cement or Type III cement. White cement combined with a given pigment produces more intense colors for integrally colored concrete. Type III cement produces higher early strengths and is especially useful in cold-weather concrete placing. Type III or white cements are considerably more expensive than Type I or Type II cement, but are sometimes used to get early strength or the color desired by the customer.

Concrete Mixer Truck

Other cementitious materials that may be used in decorative concrete include fly ash and slag cement. Fly ash is the very fine by-product of burning coal in power plants. It is a *pozzolan*, which means it has cementitious properties when combined with calcium hydroxide and water. Calcium hydroxide is a by-product of the portland cement and water reaction, so when fly ash is added as a concrete ingredient it can increase the strength by combining with the calcium hydroxide. Adding fly ash to a given concrete mixture usually increases the workability, pumpability, and durability of the concrete.

Material hauler getting loaded with aggregate.

Slag cement is made by grinding granulated blast furnace slag to a very fine powder. Slag cement is hydraulic. That is, when added to water, they react and harden. Usually some of the portland cement is replaced by fly ash or slag cement to increase durability and to reduce the greenhouse gas emissions resulting from the manufacture of portland cement. The strong environmental movement has resulted in strong pressure on producers to use more fly ash and slag cement. However, this can have some harmful effects on decorative concrete due to color variation.

Fly ashes produced at different power plants or at one plant with different coal sources may have different colors. Fly ash color and the amount used can influence the color of the resulting hardened concrete—making it darker or lighter—in the same way as changes in cement or fine aggregate can change the color. Variability of fly ash color should be monitored by concrete producers who supply concrete for decorative work. There is a test for doing this. Color changes are checked by comparing the color of the fly ash with that of a reference fly ash. The two fly ashes are spread side by side on a white surface and the color is compared under daylight or a controlled light source. The producer can save a sample from each fly ash delivery for a period of several months. A color comparison of a new delivery with previous deliveries from the same source can then provide an immediate indication of changed conditions. Concrete contractors are unlikely to see the fly ash being used, so they depend on the concrete producer to notice these changes.

The use of slag cements in a concrete mixture also may darken or lighten the color or produce erratic color variation. Fly ash and slag cement can also slow the setting time of the concrete.

Amount of Cementitious Materials

For many years, concrete cement content was described by referring to sacks of cement used in the concrete. A sack of cement weighs 94 lb, so a 5-sack mixture contains 470 lb of cement per cubic yard and a 6-sack mixture contains 564 lb of cement per cubic yard. Typically, a 5-sack mixture produces a 2000 to 3000 psi concrete depending on the water and aggregate content and a 6-sack mixture produces 3000 to 4000 psi concrete. Many contractors still order designated sack mixtures from their concrete producer, but what they usually want is either a 3000psi or 4000 psi concrete that may contain portland cement, fly ash, and perhaps slag cement.

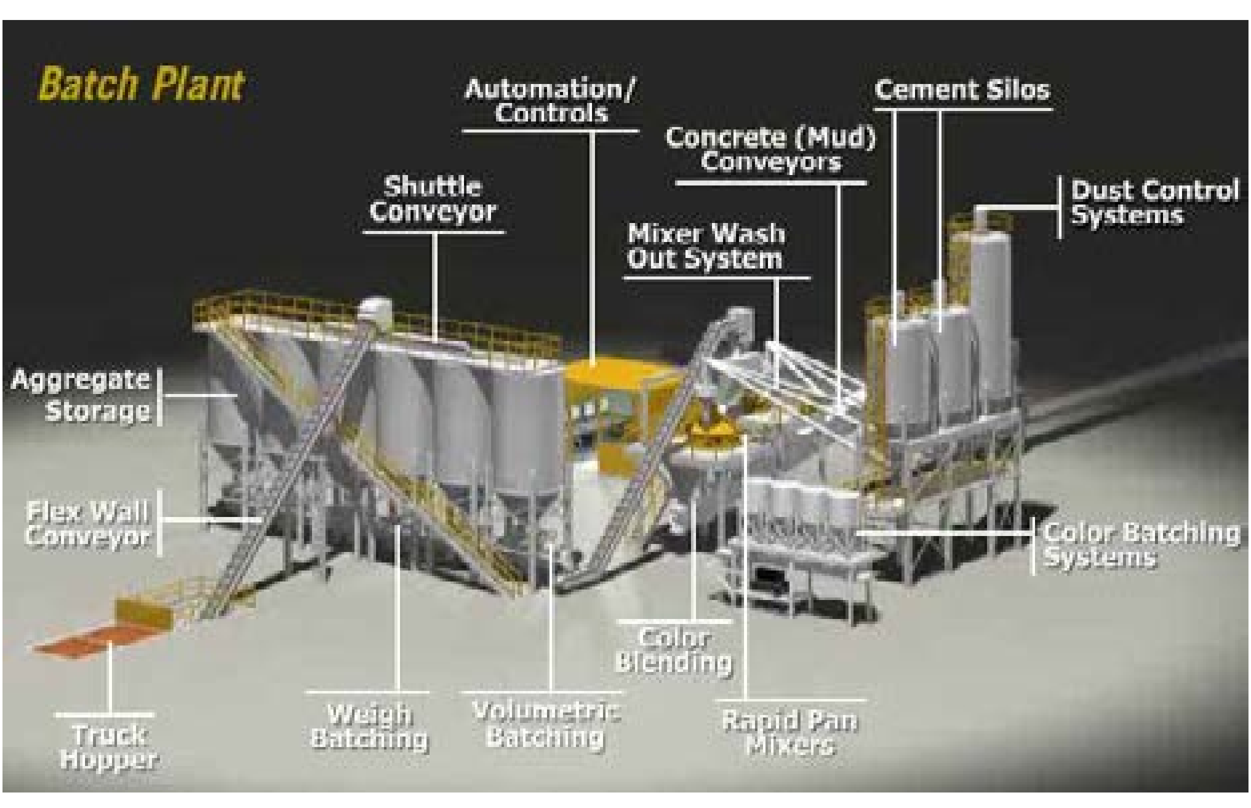
For areas of the country that experience cycles of freezing and thawing, a minimum strength of 4500 psi and a water-cementitious materials ratio of 0.45 is usually required to produce durable concrete. In warmer climates, 3000 psi concrete may be adequate as long as there is enough paste (also called "cream") in the concrete to permit good finishing results. Sulfates may require a lower water-cementitious materials ratio, thus resulting in a higher concrete strength. In addition, a structural engineer may specify a higher compressive strength due to loading requirements.

Concrete Slump and Use of Admixtures

Slump is an indicator of the consistency of concrete. Because it was believed for many years that high slumps indicated high water contents, low strengths, and increased shrinkage, the slumps required for concrete flatwork were often set very low—in the range of 2 to 4 inches. Admixtures that increase slump without increasing water content (called water reducing admixtures) are now commonly use d and allow good quality concrete flatwork to be placed at 4 to 5 in. slumps. That is also the slump range for many decorative concrete flatwork jobs.

Admixtures can also be used to slow the setting of concrete if there is a delay in delivery or a breakdown, or during hot weather when concrete sets faster. These admixtures are called retarding admixtures. Most water-reducing admixtures also retard set by up to an hour. Other admixtures speed the setting of concrete, which is helpful in cold weather. These are called accelerating admixtures. The most common accelerating admixture is calcium chloride, which affects color and should not be used. Non-chloride accelerating admixtures are available and are recommended for use in decorative concrete.

Shrinkage-reducing admixtures are liquid admixtures that reduce concrete shrinkage caused by drying. They should be used with caution in air-entrained concrete. Shrinkage reducing admixtures act chemically to reduce some of the internal forces that cause early shrinkage and curling.



Tune in next month for our discussion of Forming, Reinforcement, and Dowels where we will delve into the details of forming, expansion joints, control joints, dowels, and steel reinforcement.

Please contact us if you have any questions or comments regarding the above. In addition, Trademark can review mix designs for your projects at your request.

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