building
BLOCKS

So Many Admixtures

How Do They Impact Structural and Other Key Properties?

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Admixtures are used to modify and improve the properties of fresh and hardened concrete. The use of the proper admixtures can result in increased workability, cementitious efficiency (psi per pound of cement), and optimum setting time with mixes, even those with low water/cementitious ratios. The setting time of concrete can be modified or extended for long distance transportation of concrete by using retarding admixtures or can be modified or accelerated to provide rapid set and/or high early strength concrete by using accelerating admixtures. Today, concrete mixes contain water reducing and/or high-range water reducing admixtures. The concrete mix designs for slump or slump flow (spread) and self-consolidating concrete (SCC) can be proportioned with the setting time for the agreed upon placement program and modified as the season changes. The goal in all cases is to minimize water of convenience.

Selection of Concrete Admixtures

Concrete admixtures should be selected per the specifications and should be used as recommended by the manufacturer or the project testing laboratory.

- Air-entraining admixtures are used to create stable uniform air bubbles properly spaced to provide long-term freeze/thaw resistant concrete. Proper air content, 6% +/- 1½% and low water/cement ratios (< 0.50), are essential for long-term durable concrete. Conversely, trowel finished slabs require air content < 3%. Concrete with high air content creates a sticky surface and is therefore very difficult to properly trowel. Air meters or unit weight measurements must regularly be made to ensure proper air content. Unit weights are always the best choice since air meters can give false readings.
- Water reducing and high-range water reducing admixtures are used in all concrete today to minimize water of convenience, which was often added in the past to allow concrete to be easily placed or pumped. Typically, they can increase a 2-inch to 3-inch slump to 5½-inch to 7-inch slump. That is the target slump envelope for laser screed strike offs for industrial slabs-on-grade. Trowel finished floors require consistent slumps and setting times. The finishing process of strike off, floating, and troweling must follow the placing process. In other words, if the slump or slump flow varies significantly, the finishing process does not flow smoothly. The concrete does not stiffen and set in order of placement. This is a significant problem for concrete crews.
- The owner of the project and his design team must clearly specify the concrete requirements. The specification and drawings must be clear and identical. In many cases, the specification updates are not transferred to the drawings.
- Exposed industrial floors are designed to achieve the 3 Ms, "Minimal Joints, Minimal Cracks, and Minimal Curling." (*Concrete Construction*, April 2015 Issue). The industry today wants joints only at the column lines (60 feet +/-).
- High-range water reducing admixtures are used at low dosages in slabs and toppings. Higher dosages are used to achieve flowing concrete (9 inches +/- 1 inch of slump) or are used to achieve self-consolidating concrete with spreads of 20 to 30 inches. The target spread is typically +/- 2 inches. In heavily reinforced members, the mixes require a 28-inch or higher spread.
- High-range water reducing or high-range water reducing retarding admixtures are required in high-performance concrete. High-performance concrete mixes are used for a wide range of concrete mixes from towers to slabs-on-grade. Today, the range of strengths is 4,000 psi to 16,000 psi at 28 or 56 days.
- The concrete producer must provide a re-dosage chart for high-range water reducing admixture usage on site. The chart provides guidance for high-range water reducing admixture additions required to ensure that concrete is in the agreed-upon slump or spread range (self-consolidating concrete (SSC)). It is imperative in reinforced, formed concrete members that the target spread is achieved for each placement. Lower spreads may result in blockages.
- Today, SCC should be used for reinforced formed members. Vertical members are as thin as possible and heavily reinforced since maximum rental space is required for all floors. It is imperative in reinforced members to have a consistent spread for self-consolidating concrete mixes. Lower spread mixes could hang up concrete in congested areas.
- Shrinkage reducing admixtures are increasingly being used. Clients are not happy with cracks in their high-performance concrete. High-performance concrete specifications should have a maximum shrinkage requirement of 0.04% at 28 days. Owners of high-performance concrete industrial slabs want joints only at column lines (60 feet +/-). Their shrinkage requirements should be < 0.02% at 28 days. Shrinkage tests are to be in accordance with ASTM C157 Modified, 7-day moist cure. Bridge decks and parking decks should also require low shrinkage mix designs.
- Macro-synthetic fibers today are specified and used in many non-reinforced slabs-on-grade, slabs-on-metal deck, and toppings in lieu of welded wire mesh. (The Steel Deck Institute requires 4 pounds/cubic yard for shrinkage and crack control).
- Proposed mix designs should be submitted to the design team for review. If they conform to the specification, a test placement is recommended to be scheduled.

- Test placement of trowel finished floors must be large enough to allow a riding trowel machine. The test placement must confirm that the concrete placing procedures and finishing process are satisfactory.
- Non-chloride, non-corrosive accelerating admixtures are used in many concretes. They are required to "normalize" set and achieve early strength gain in concrete placed at temperatures below 40°F. They are also used at high dosages (onsite) to achieve rapid set and/or high early strength for high-performance concrete for bridge decks and other locations where out of service time must be minimized. Freeze-resistant concrete is often selected in areas where cold weather concrete procedures are difficult to achieve. This concrete is not required to conform to the requirements of ACI 306, *Cold Weather Concreting*.
- A specially formulated accelerator is used in freeze-resistant concrete. This concrete is chosen for many cold weather concrete applications. The contractor should prepare a plan for placing, finishing, and curing to assure that the specified hardened properties are achieved.
- High-performance concrete generally requires multiple admixtures to ensure proper workability, slump or slump flow, optimum setting time, and early final strengths.
- Very high early strength concrete (4,000 psi in 12 hours) requires an onsite dosage of a specially formulated accelerating admixture.
- Hydration control admixtures are increasingly used in major cities and other locations where the time frame from batching to discharge onsite can be lengthy. They are used to extend the time for proper workability and/or spread by several hours.

Set Retarding Admixtures

Set retarding admixtures help extend the working time of concrete by slowing down the hydration process of cement. Set retarding admixtures prolong the dormant period, allowing increased workability and slump life.

Silica Fume

The use of silica fume in concrete has increased significantly in recent years. The benefits are:

- High compressive and flexural strength for structural capacity
- Low permeability for greater resistance to water
- High early strength gain for faster turnaround time
- Improved freeze/thaw and scaling resistance
- Increased abrasion and chemical resistance

Admixture Benefits

The use of the cited admixtures results in maximum mix enhancements in both the plastic and hardened concrete. Plastic concrete benefits are:

1) Slump or slump flow SCC of choice
2) Rapid or extended set times and increased workability.

Hardened concrete benefits are:

1) Increased compressive and flexural strengths
2) Lower shrinkage

Successful Sequencing

Key sequencing activities include:

- The key elements of the project are agreed upon by the owner, the design team, and the construction team.
- Proper plans and specifications are prepared, reviewed, and accepted by the construction manager and the concrete team.
- The construction manager assembles the concrete team.
- The construction schedule is discussed and agreed upon.
- The concrete contractor outlines his detailed concrete construction schedule. The required mix designs are submitted for review. They should be agreed upon, and any changes should be discussed. High-performance concrete mixes often end up being resubmitted since one or more types of information are usually missing or unclear.
- Successful test placements onsite are mandatory for high-performance concrete. The floor placements must be large enough to confirm that the required floor finishing process is satisfactory. Formed member placements should be one story high and as wide as the construction team requires. Floor finishes vary to some degree. A large test placement requires the actual placing, finishing, and curing methods and procedures to be in accordance with the specification.
- The contractor should prepare minutes of the pre-concrete meeting and distribute within 5 days to all parties, including the owner/owner's representative, architect, and engineer.
- The concrete contractor should state that his proposed mix designs will enable him to properly place, pump, finish, and achieve the concrete quality required by the specifications.
- The concrete producer should provide a high-range water reducing re-dosing chart onsite to ensure that every mix is within the approval slump or spread envelope.
- Heavily reinforced formed members require self-consolidating concrete with a spread of 28 inches +/- 1 inch.

The majority of concrete mixes have a water content higher then what is needed to hydrate the cement properly. Proper mix designs minimize this water of convenience and optimize the slump or slump flow with approved water reducing and/or high-range water reducing admixtures.

In general, high strength concrete for reinforced formed members has a negative water slump. The required slump or slump flow is entirely achieved with higher than normal high-range water reducing admixture dosages. This is undoubtedly true of high strength concrete, i.e., 8,000 psi to 16,000 psi.

Example:

10,000 psi at 28 or 56 days is required
The w/cm is 0.30
The water content is 250 lbs/cy (0 or negative slump)
The cementitious content is 833 lbs/cy
The mix is designed to be flowing (9 inches +/- 1 inch slump) or SCC
The high-range water reducing admixture provides the slump or spread.

Trowel finished floors and slabs are often placed with slumps of 5½ inches to 7 inches at the point of deposit. These mixes must have a water slump of 2 inches to 3 inches. Lower water slumps present finishing problems.

A negative water slump means that the water content alone would not allow the concrete to be properly mixed. All of the slump or spread is achieved by the use of the high-range water reducing admixture.

Summary

All concrete today contains admixtures to enhance the concrete performance in the plastic and hardened state. Proper air-entrained concrete is necessary to provide resistance to freeze-thaw cycles. Water reducing and high-range water reducing admixtures are used to enable the user to select the optimum slump or slump flow for their project. While maintaining a low water content, shrinkage is related directly to water content, paste content, and water/cement ratio.▪