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WATER - The Necessary Evil

Welcome to Concrete Solutions, a quarterly publication of concrete related topics.

Water is both a friend and a foe of concrete…a necessary evil. Water is the most inexpensive ingredient in concrete. The other ingredients (cement, rock, sand) are turned plastic and workable by the addition of water. This material then hardens and gains strength due to a reaction between the portland cement and the water called hydration. Curing (water retention) is required for an extended period of time after the concrete is placed to allow this hydration process to continue and develop the full potential strength and durability of the concrete mix.

Water is also the eternal enemy of concrete. If concrete could be kept dry, it would be immune to cycles of freezing and thawing, deicing salts and almost all chemical attacks such as sulfates, and even immune to internal chemical damage such as alkali aggregate reaction.

Relatively little water is required to hydrate portland cement. Concrete produced with this minimal amount of water will not be job friendly. Concrete with such a low water cement ratio cannot be placed. Extra water is necessary for workability (water of convenience). This extra water re-acts with the portland cement and dilutes the cement paste and lowers strength. This is the principle of the well-known water/cement ratio relationship established by Duff Abrams in 1917.

To increase workability (slump) it is common to add more water. The impact on workability as measured by slump means an increase of one inch of slump for each gallon of water added per cubic yard of concrete. This water dilutes the binder and decreases the compressive strength. Excessive water is also harmful to concrete qualities such as shrinkage and durability. An increase in the water/cement ratio of only 0.1 can increase drying shrinkage by more than 50%. Even with air-entrained concrete, water will control the durability of the concrete regarding freezing and thawing. Concrete with reduced strength and durability and increased drying shrinkage cannot be expected to have the service life of concrete manufactured and placed with the same ingredients with a lower water content.

It becomes obvious from the preceding information that water reduction is desirable in all concrete. Concrete compressive strength and quality can be increased by placing concrete with the lowest possible water content. This can be aided by properly proportioning the aggregates and by utilizing conventional water reducing admixtures, mid-range water reducers and high-range water reducers (superplasticizers). On a cost/performance basis, conventional water reducers and mid-range water reducers are more suited to everyday concrete. Where very high and ultimate strength and quality are required or where high slump with minimum water content must be used, a high-range water reducer (superplasticizer) should be used.

In either case, all the advantages of water reduction will be realized.

During the time fresh concrete is in the plastic state, the lower the water content the better. After concrete begins to set all attempts should be made to prevent water loss. If the concrete is allowed to dry out there will be no water available for cement hydration and strength development will cease. Concrete must be cured, not only to attain its potential strength but also to attain its potential durability.

The durability of concrete will become greater as the cement hydration process proceeds. The hydrates formed occupy a volume greater than the volume of the original portland cement. As curing continues, hydrates progressively reduce capillary voids thus reducing permeability and absorption and consequently increasing durability.

Many methods of concrete curing are available. Water sprays, wet burlap, plastic sheeting or liquid membrane curing compounds may be used. Water spraying or wet burlap are quite often impractical. Plastic sheeting can be very difficult to place over large areas, especially in windy conditions. Liquid membrane curing compounds meeting ASTM Specification C309 can be easily sprayed on the concrete surface and will retain moisture necessary for proper curing. Note that the manufacturer's rate of application must be followed. These curing compounds are not affected by winds or construction activities. White pigmented compounds (ASTM C309, Type II) will reflect the radiant energy of the sun and are ideal for use in hot weather. Where esthetics are a consideration, a clear curing compound (ASTM C309, Type I or I-D) should be used.

As you can see, water can be concrete's friend or foe, depending on how it is used and managed during the mixing, placing and curing operations. Modern chemical technology utilized in the mixing and curing process will help control water requirements in today's modern concrete.

Concrete Tip: Get What You Pay For!

Every cubic yard of commercially produced ready mix concrete is batched to a pre-determined mix design. All ingredients have a specific design weight. More specifically, the cement and water contents are designed to make a desired water/cement ratio and final compressive strength result. Once each component is weighed and combined there is a potential maximum compressive strength and durability which that concrete will achieve. While there is nothing that can be done to increase that ultimate compressive strength, there are numerous things that can be done that will decrease the maximum compressive strength that will be achieved. You are purchasing potential compressive strength and durability performance. To make sure the concrete achieves that potential make sure that any additional mix water added at the job is closely monitored, that concrete be protected from excessive temperatures and moisture loss during the placing and finishing procedures and that appropriate curing procedures are utilized. This way your concrete can more closely achieve the compressive strength and durability for which you are paying.

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