Retarders versus Set Stabilizers

By Dan Millette

When concrete is cast, a retarding admixture is often used to keep the mixture workable until finishing is completed. This seems most common with concrete used in flooring applications where more finishing time is required. If concrete is being used a considerable distance from the ready mix plant, or the ambient temperature at the construction site is very warm, these are good reasons to use a retarder. Even at normal or lower temperatures, concrete loses its workability with time. A retarder can be dosed at a specific amount depending on the extended time of setting that is required to give some flexibility to the operation. As seen in Fig. 1, temperature has a very significant effect on the rate of cement hydration.

Then why can we not use retarders for shotcrete? But we can and do. Retarders are great for shotcrete for many of the same reasons as for concrete, because shotcrete is concrete: extended travel distances; time required for placement, especially if you need to move a pump during placement; hot weather at the job site, and so on.

But what must be considered is if we are using an accelerator at the nozzle for any particular reason—are retarders still suitable? It seems counterintuitive to use both a retarder and an accelerator for the same mixture, but many situations can arise, such as in mining or tunneling, where a mixture is batched, travels over an hour to the work site, is then sent underground, and must be transported from the point of underground delivery to the work area. I have seen this take up to 5 hours in many cases. And what if, for example, there is a further delay while the sprayer is being repaired? And when you are finally ready to use the mixture, you need to accelerate it at the nozzle. This is fine if the retarder is wearing off, but if the retarder was dosed to hold off the set time for 6 hours and you are ready to use the mixture in 2 hours, it would be correct to assume you would need a lot more accelerator to overcome the effect of the retarder. That is why set stabilizing admixtures or set stabilizers are used in many shotcrete mixtures.

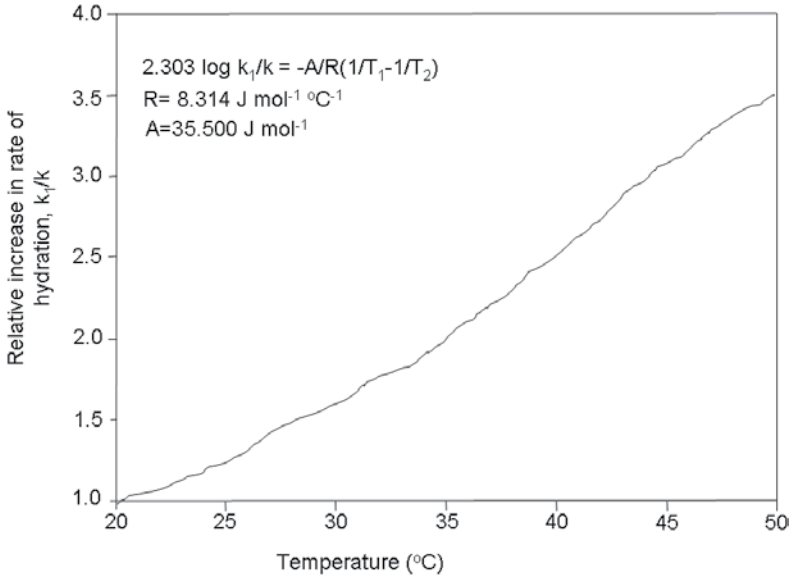

Fig. 1: Effect of temperature on the rate of hydration (Rixom and Mailvaganam 1999)

First, let's take a look at how retarders work. The purpose of the retarder is to delay the setting time of the cement paste in the mixture. When water is added to cement, there is a rapid initial reaction (hydration) that occurs, after which there is very little formation of further hydrates for approximately 2 to 3 hours. This is called the dormant period but can be significantly shortened due to cement type and/or temperature. The hydration rate increases at the end of the dormant period and a lot of calcium silicate hydrate and calcium hydroxide forms relatively quickly, which is what corresponds to the setting time of the mixture.

A retarder added to the mixture will delay the end of the dormant period and therefore the start of setting and hardening. This is done by a mechanism based on absorption. The larger admixture anions and molecules are absorbed by the surface of the cement particles to hinder reactions between cement and water. In other words, the retarding admixture coats the cement particles. Most retarding admixtures are made with sugars or sugar derivatives while others contain lignosulfonate, which is a waste product from the pulp and paper industry. Many retarders are also water reducers. ASTM C494 Type B designates that the admixture is a retarder only. Sugars retard the

formation of silicates, thereby getting rid of calcium molecules and putting them into solution; and this, along with the coating on the cement particle, keeps the nozzle accelerator from being able to reactivate the mixture.

Retarders are normally added to the initial mix water in the mixer. One must be careful when using retarders for applications in hot temperatures. Depending on the cement and the admixture used, there have been instances of excessive retardation or flash setting.

Unlike retarders, it is not known exactly how set stabilizers work but there is a lot that is known about their application. Stabilizers can be used at high dosages without the adverse effects such as flash set and poor strength development characteristics that can occur when using conventional retarders. Stabilizers are commonly made from carboxylic acids and/or phosphorous-containing organic acid salts, and as a result, often have a low pH in the 2 to 3 range.

The way a stabilizer works is thought to be related to the inhibition of calcium silicate hydrate and calcium hydroxide nucleation. Many will claim that the stabilizer will do a much better job of controlling the nucleation process than retarders. This claim has been supported in laboratory trials using calorimetric data and by viewing under a scanning electron microscope the surfaces of both stabilized and activated alites. As mentioned earlier, retarders will retard the formation of silicates, which is just one phase of cement hydration, while a stabilizer will act on all phases of cement hydration, including the C3A fraction.

Stabilizers also coat the cement particles but it is thought that they can be penetrated by shotcrete accelerators to restart the hydration process. The addition of a stabilizer is different than that of a retarder. To be completely effective, a stabilizer should be added to the mixture only after the cement has had a chance to completely wet out with the water in the mixture, thereby starting the hydration process. If a stabilizer is added to the mixture water up front, before the cement is added, it will only have approximately half the effectiveness of adding it after the cement has wetted out. Another advantage to using a stabilizer is that it can be added again to the same mixture if the job is further delayed and a longer retardation of the set time is required.

When using either retarders or stabilizers, it must be realized that the purpose of these admixtures is to hold off the setting time of cement, or more specifically to extend the dormant period of the cement hydration process. They are also often mistakenly used in an attempt to decrease slump loss. This was never the intended purpose of these admixtures. In hot temperatures, extending the set time can in some applications give the mixture more time to lose water due to evaporation, causing slump loss.

If there is a need to hold off the setting time of your shotcrete mixture, make sure that you do some initial investigation or trials to make sure that you are using the proper admixture or combination of admixtures to attain the objective required for the project.

References

Rixom, R., and Mailvaganam, N., 1999, *Chemical Admixtures for Concrete*, third edition, Taylor and Francis Group Publishing, 456 pp.

Whiting, D., and Dziedzic, W., 1992, "Effects of Conventional and High-Range Water Reducers on Concrete Properties," *Research and Development Bulletin RD107*, Portland Cement Association, Skokie, IL.

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