Specified Dilemmas

by Roland Heere

On shotcrete sites, it is not unusual to hear comments starting with "In a perfect world, ..." Of course, in a perfect world, there wouldn't be any shotcrete because there wouldn't be anything to repair or strengthen. Fortunately, there are plenty of imperfections in the jurisdiction where most of my work comes from. We find them on cracked and fissured rock slopes next to highways, in ground to be tunneled for infrastructure improvements, in old masonry walls, washed-out bridge foundations, and in marine piers where the chloride concentration at the rebar level in the concrete exceeds the reasonable limit set for the onset of corrosion.

Commonly, such imperfections are identified by owners or engineers, who subsequently hire a contractor to improve the situation by following a performance specification. Then, in the contract, the contractor will often read that he needs to hire an independent laboratory to provide quality control testing and quality management services.

In theory, the sharing of duties would be as follows:

- The owner specifies the performance of the product he wants;
- The contractor provides it; and
- The laboratory evaluates the quality of this product to certify that it meets the owner's specifications.

In reality, there are gray zones where it appears reasonable that these duties transgress party boundaries. One of the more common transgressions occurs when the contractor, or his quality control laboratory, identifies clauses in the specification that don't appear to be of any net benefit to the parties involved.

Below are three such examples and some suggested, workable solutions, which are, of course, far from perfect. Yet, in my experience, they have provided beneficial short- and mid-term results for all parties. (A follow-up article on the long-term effects will probably be published in a 2095 issue of *The Shotcrete Daily*.) The fourth example describes a small, but currently unresolved, dilemma:

1. The specifications require wet-mix shotcrete to be placed within 90 min after batching. The transport time between batch plant and site is 60 min. The batch plant is a small outfit with a very limited number of trucks available to deliver shotcrete to the site (say, 1 or maybe 2). Further, on-site work requires partial, or occasionally full, closure of the adjacent two-lane highway, which is highly undesirable for the owner. It would appear reasonable to apply for permission to extend the 90-min working window under the following conditions: (a) the batch plant produces ready mixed shotcrete of a uniform quality; (b) the quality control manager (that is, the testing laboratory) is familiar with the shotcrete mixture proportions and the effect of various admixtures on the fresh and hardened shotcrete properties; and (c) a hydration control admixture that has a proven track record in the particular shotcrete mixture is available. When working with an owner who has a knowledgeable representative with the power to make technical decisions on site, we have been able to extend narrow specified working windows on short notice and have not observed any detrimental results in the hardened shotcrete.
2. It is not uncommon during highway rock slope stabilization for the shotcrete application to be on the critical path. The contractor, as well as the owner, will not welcome any interruptions in the shotcreting work, particularly when it is conducted from spider cages or crane baskets 100 ft (30 m) above the road. Tender specifications, however, often require that the quality control inspector test every truckload for as-shot air content. That would require an approximately 7-min work interruption of otherwise smooth operations high up on the rock face, right? (Quality control laboratories know that one of Murphy's Laws stipulates that a shotcrete hose plug requiring work stoppage will not occur when the tester actually needs one.) Fortunately, over time we have gained confidence that for any given mixture and admixture combination, there is a reasonably reliable relationship between as-batched and as-shot air content (typically, around 2:1). With some owners, we now have the understanding that we conduct as-batched air content measurements for every truck load; and for mixtures delivered near target as-batched air content, determine the as-shot air contents only when it can be done

without lengthy interruptions of work. This, of course, is subject to having some data to support the estimated ratio between as-batched and as-shot air content.

3. Most shotcrete specifications we have seen locally require shooting one test panel each day for quality control testing of the hardened shotcrete. Frequently, the specification requires keeping the test panel on site for a minimum of 48 h. This does not seem onerous on first examination. But, when the site is 250 mi (400 km) from the testing laboratory, and the contractor starts demobilizing immediately after shooting the last hopper of shotcrete, the following question arises: "Who is going to pick up the latest test panel and deliver it to the laboratory?" Under some circumstances, and given a high-performance shotcrete mixture, it may be possible to negotiate a shorter than specified panel retention time on site. Considering that early transport of a shotcrete panel will not be beneficial to performance of the shotcrete, it reflects a worse-case scenario; therefore, test results will be conservative. To deal with the dilemma of either transporting a test panel from a demobilized site or risking overly conservative test results, we occasionally produce two shotcrete test panels on the last day of shotcreting operations: The quality control inspector takes Panel No. 1 with him to the laboratory, while Panel No. 2 remains on site in a safe location. In the event that the shotcrete from Panel No. 1 fails to meet the performance specifications, and there is reason to assume that the early transport was at fault, a second panel would be available for repeat testing (albeit at a fairly high cost of retrieval).
4. Here is a dilemma we have not yet solved to everybody's satisfaction: The quantification of rebound. Some specifications stipulate that the contractor is reimbursed only for the shotcrete actually placed on the substrate. That effectively means that the contractor bills the owner for the shotcrete trucked to the site minus any rebound and other losses. But, how do you measure rebound from shotcrete sprayed on a rough rock slope? Some of the rebound accumulates on outcrops, some disappears between boulders in the ditch, and only some of it falls on ground where its volume can be measured. Further, due to the undulations of the substrate, the determination of in-place shotcrete volumes is a rather nonexact science. Consequently, we must resort to a "guesstimate" or "educated guess."

This is a rather unsatisfactory way to determine payment items that have been bid at a precision of four to six significant digits.

You probably know of many examples to augment the previous list. What are your examples of reasonable-sounding clauses in technical specifications that, on site, proved to be unworkable? How did you resolve the ensuing dilemma? *Shotcrete* would like to hear from you.

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