Fallouts Can Be Deadly!

By Joe Hutter

Many years ago, when the use of shotcrete in an underground support system was not as popular as it is today, I witnessed a mine foreman walk into an underground opening to admire the job his shotcrete crew had done placing shotcrete only an hour or two earlier. He knew that the area had already been supported with screen and bolts (the shotcrete was placed over the screen as part of the ground control engineer's design) so he felt safe knowing that he was not entering an area of unsupported ground. Just as a member of the shotcrete crew warned him to step back from the area, a small section of shotcrete fell from above and landed about 15 ft (5 m) from where he was standing. This incident was a serious reminder that even though a shotcreted area may appear safe, there are many variables that impact the time required (after overhead placement) before shotcrete can be considered structurally sound.

To illustrate the danger posed by unexpected fallouts, it is important to understand the mass associated with even a small section of shotcrete. A 2 ft x 2 ft x 4 in. (0.6 m x 0.6 m x 100 mm) area of in-place shotcrete will weigh approximately 175 lb (80 kg). To drop a 175 lb (80 kg) slab of concrete from even a moderate height would most likely have fatal consequences if it directly impacted someone. No experienced miner would ever consider standing beneath freshly excavated and unsupported ground. For the same reason, no one should ever consider walking into an area of freshly placed, nonsupported shotcrete.

At the time when the fallout incident occurred, there was no way of knowing the value of the compressive strength of the shotcrete at an early age. There was an easy test method for determining final set time but to accurately measure early-age compressive strength, engineers would require that a test panel be shot, cored a minimum of 8 hours later, and the core broken to determine the compressive strength value. Although this test procedure provided accurate results, the time lapse before coring meant the earliest age result was 8 to 12 hours. Today, early-age compressive strength can be obtained using specialized equipment (end-beam testers) (Fig. 1) that allow compressive strength to be measured as early as 1 or 2 hours after placement. These results provide the ground control engineer with confidence that the in-place shotcrete has gained sufficient strength

Fig. 1: Today, early-age compressive strength can be obtained using specialized equipment (end-beam testers) that allow compressive strength to be measured as early as at 1 or 2 hours after placement

to do the job for which it was intended and will remain in place.

When measuring the risk of a fallout, consideration should also be given to other factors that can influence the early-age strength of recently placed shotcrete—one of the most important being temperature. The temperature conditions under which initial compressive strength values were obtained may be much different than those where the shotcrete is actually being placed. Cold ambient temperatures will always increase the final set time and reduce the rate of strength gain, as will the temperature of the material and the mix water.

Other factors that can influence the potential for a fallout are: surface preparation, nozzleman skill, application thickness, vibration, seismic activity, the presence of welded wire reinforcement, the process (wet- versus dry-mix), and of course the shotcrete mixture design. If changes are made to the shotcrete mixture design or there are changes in shotcrete supplier, early-age testing should be repeated to verify that the set times and early compressive strength results are meeting expectations.

Shotcrete mixtures using new cement technology that achieve compressive strengths as high as 2900 psi (20 MPa) after only 2 hours have recently been introduced to the mining and tunneling industries. Vale's Coleman Mine, located in Sudbury, ON, Canada, has used this technology in its underhand cut-and-fill mining process to accelerate the mining cycle and increase productivity (Fig. 2). As a safety precaution, Vale's shotcrete supplier offered to pigment the shotcrete mixture red so that shotcrete crews and other underground personnel could easily differentiate between this high-performance mixture and the conventional shotcrete used in other areas of the mine. Fallouts would be an obvious hazard if shotcrete crews were unable to easily distinguish if the material placed reached 2900 psi (20 MPa) at 2 hours or 24 hours.

We are all ultimately responsible for our own safety and understanding when a shotcreted area is safe to enter is an important part of that responsibility. The information needed to understand safe re-entry times, however, must come from a number of sources. The shotcrete material suppliers should be able to provide set times and early-age strength results for any mixture that is supplied to the shotcrete crew. In the case of mine and tunnel excavations, ground control engineers should establish guidelines for minimum compressive strength and correlate those strength values to minimum re-entry times. A safe re-entry time will depend on a number of previously mentioned factors. Ignoring those minimum re-entry times is a risk that can cause serious injury and, in some documented cases, cause workplace fatalities.

Fig. 2: Shotcrete mixtures using new cement technology that achieve compressive strengths as high as 2900 psi (20 MPa) after only 2 hours have recently been introduced to the mining and tunneling industries

***Joe Hutter** is the Vice President, Sales, for King Packaged Materials Company, Burlington, ON, Canada. He has more than 25 years of experience in the cement/shotcrete industry. He is a former President and an active member of ASA and has been Chair of the ASA Marketing/Membership Committee since its inception. Hutter is also a member of the American Concrete Institute.*