

Combining Shotcrete Mixes for Maximum Performance

by J. Denis P. O'Donnell, Sr.

Would you ever use standard shotcrete, mesh reinforced shotcrete, and steel fiber-reinforced shotcrete (SFRS) in the same heading?

In mining environments, reinforced shotcrete is generally used to withstand the level of deformation imposed upon our excavations. In this day and age, we rarely use unreinforced shotcrete. There are applications, however, where it is appropriate. Applying SFRS over mesh causes bridging of the fibers over the mesh and may create shells of improperly supported rock.

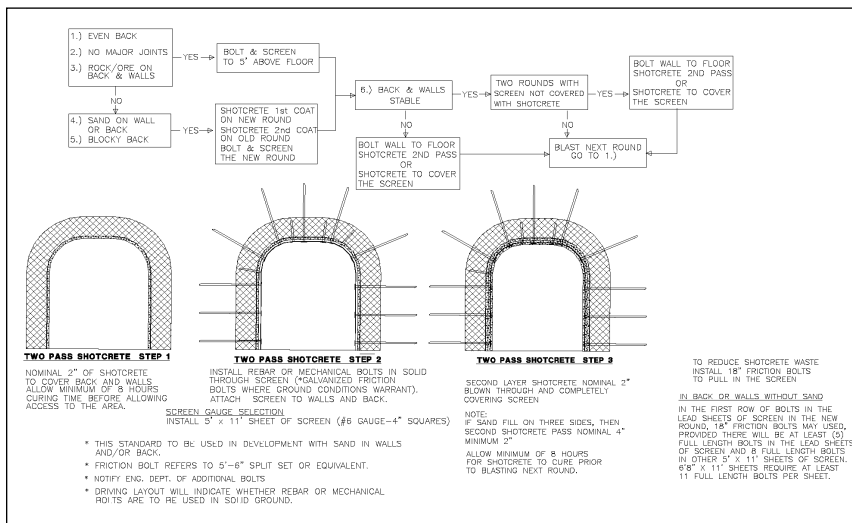
In severe conditions or in excavations where the mining process will impose large deformations, we apply what is locally called two-pass shotcrete. Approximately 2 in. (50 mm) of standard shotcrete is applied on the walls and back using a robotic arm.¹ Once the first layer has achieved the required strength,² welded wire mesh is installed using specific types of bolts suited for the ground conditions. These can vary from 5.5 ft (1.7 m) long friction bolts (Split Sets®)³ to 6 or 8 ft (1.8 to 2.4 m) mechanical bolts, resin grouted rebar, or a combination thereof. Drilling into the ground to install standard length bolts may be restricted due to the potential presence of undetonated explosives. In these headings, the mesh is secured to the shotcrete using concrete anchors. A second layer of shotcrete is then applied over the mesh giving a nominal 4 in. (100 mm) total thickness.

Two-pass shotcrete has been used to mine through broken ore, fault zones, poorly consolidated back fill, even partially oxidized muck piles (Langille, Palkovits, and O'Donnell 1997).⁴ In these cases, we are in the final phase of ore recovery, accessing remnants that were written off prior to the use of shotcrete to stabilize the ground. To improve ground stability in these extreme conditions, we apply SFRS for the first pass of shotcrete. This procedure greatly improves conditions during the bolting phase.

Where shotcrete is being applied over mesh, we use 18 in. (450 mm) friction bolts, where required, to pull in the mesh and eliminate shotcrete waste. It is more effective to pull in the mesh as it is being installed. Once mesh is completely fastened into place, it is very difficult to pull it into hollows in the wall or back. The shorties, as they are called, must be added in addition to the required number of standard length support elements.

In reconditioning severe areas where the original support has been damaged and there is a significant amount of loose material, SFRS is used to stabilize the back and walls prior to bolting and screening. The final coat over the mesh is unreinforced shotcrete.

Therefore, the answer to the question posed at the beginning of this discussion is "yes." Shotcrete, with and without reinforcement, is a valuable solution to the problem of controlling underground deformations.



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¹When only handheld equipment is available, advance is generally restricted to 6 ft (1.8 m).

²We generally assign an 8-h no entry period.

³Split Set® is a trademark of Ingersoll Rand.

⁴Langille, C.; Palkovits, F.; and O'Donnell D., 1997, "Mining Through Semi-Consolidated Material Using Shotcrete as Primary Support at INCO's Froid Mine," *CIM Operators Conference*, Sudbury, ON, Canada.