Reinforcing Bar Shadowing and What You Can Do

By Joey Bell

Nearly all shotcrete projects I come across in my travels consist of some form of steel reinforcement, such as reinforcing bars or welded wire reinforcement. It is sometimes overlooked how important reinforcement encapsulation can be on the job. Be it aesthetic, structural, or even safety reasons, preventing voids behind steel reinforcement is important on every job. If reinforcement is not properly encased, there are many negative effects on the structure and the potential for corrosion is increased.

When shotcrete is sprayed against reinforcing bar, a "shadow" area occurs behind the steel because the bar blocks the shotcrete material stream. The size of the shadow increases with an increase in the diameter of the bar. The shotcrete in the shadow area behind the bar is not compacted because the stream of material does not directly impact the shadow area. This shadow area is filled when using good shotcrete shooting technique to provide full encapsulation of the bar. This requires the nozzleman to keep sufficient velocity of the material stream to wrap fresh paste around the bar and fill the shadow areas. With poor velocity (too far away from the bar or too low an air flow), too dry or stiff a material, or inattention to proper shooting techniques, voids can develop.

Fig. 1: Improperly compacted concrete behind steel

Nozzle Angle and Slump

If a mixture is too stiff (wet-mix), too dry (dry-mix), or does not have sufficient impact velocity, the material will build up on the face of the reinforcing bar, creating a larger obstacle for the shotcrete spray to wrap around, thus forming a void behind the reinforcing bar. The stiff mixture, to some degree, can be overcome by using a high-impact velocity to cause the material to flow around the bar. Reducing the distance to the receiving surface will increase the velocity. In most applications, a distance of 2 to 4 ft (0.6 to 1.2 m) is advisable for adequate velocity. Also, adding more air at the gun (dry-mix) or nozzle (wet-mix) can increase impact velocity. Wet-mix shotcrete should have a slump of at least 2 to 3 in. (50 to 75 mm) to properly encase reinforcing bar.

The key to good encasement is a good paste content with proper plasticity.

When encasing bars that are larger than No. 6 (No. 19M), a higher slump is required. It requires less impact velocity to force flow of material around to the backside of a bar if a higher plasticity mixture with a 3 to 4 in. (75 to 100 mm) slump is used. On larger bars, the shadow can be reduced or eliminated by directing the shotcrete spray at a slight angle from both sides to force the material behind the bar.

Sometimes, the volume and nozzle stream should be directed to permit the material to hit more directly behind the reinforcement to reduce the size of the shadow area. It may be necessary to reduce the air volume so the nozzle can be held closer to the receiving surface.

The nozzleman can tell whether there is sufficient impact velocity and plasticity when the face of the reinforcing steel will glisten and remain clean. Reinforcing bar deformations will be visible and a ridge, rather than a valley, of material will develop behind the bar.

Mineral Additives

The use of thixotropic mineral additives in recent years has allowed suppliers and applicators to have slumps of 6 to 7 in. (150 to 175 mm) without sacrificing stability. When added to the fluid 7 in. (175 mm) slump, the additive stabilizes the mixture while at rest. But when energy is applied, the mixture becomes fluid again. The result is a 5 in. (125 mm) slump that acts like the 7 in. (175 mm) slump under shear or stress.

The additive is very effective at preventing shadowing because the nozzleman can have a very fluid mixture that will flow nicely behind the reinforcement yet remain stable enough to not sag or slough. The additive's thixotropic properties also add other benefits, such as reduced rebound, increased cohesion, and improved finishability.

There are many ways to prevent shadowing from occurring and causing headaches on the jobsite. Nozzle placement and a small dosage of a mineral additive are just a couple of easy ways to eliminate these problems and provide the industry with high-quality structural shotcrete that customers will continue to ask for.

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Fig. 2: Nozzleman shooting at a proper angle

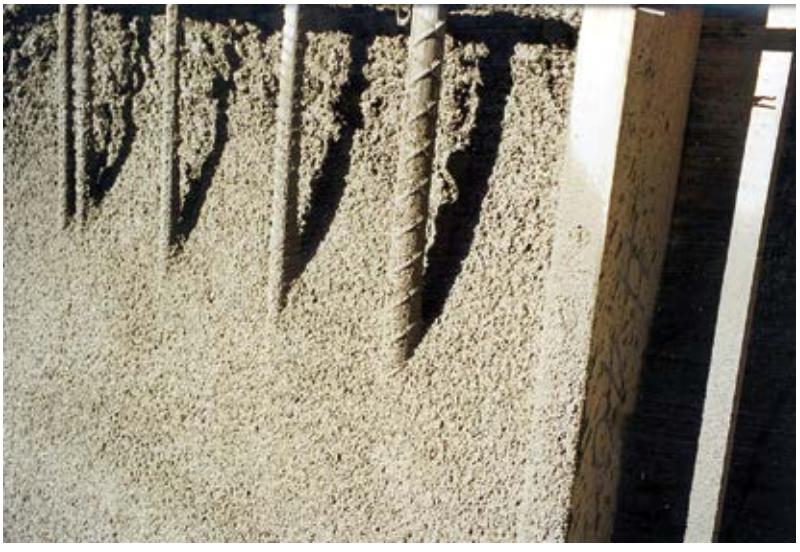

Fig. 3: Proper impact velocity and reinforcing bar encasement