# Traffic Repairs Using Low-Dust Shotcrete Material

## MONITOR-MERRIMAC TUNNEL PROJECT

*By Thomas Brennan*

Flexibility, efficiency, and cost effectiveness drive dry-mix shotcreting as a popular application method for concrete repair, especially in tunnel and bridge applications. In high-pressure situations with a short turnaround, shotcrete contractors can mobilize with minimal equipment to complete structural repairs, both vertical and overhead, rapidly. Historically, the dust associated with dry-mix shotcreting caused hesitation in projects in urban or live traffic environments; however, recent innovations in low-dust materials have significantly changed planning considerations. The Monitor-Merrimac Tunnel project combined careful construction planning with new material technology to execute emergency repairs using shotcrete placement, without closing the tunnel for more than a few minutes at a time.

### WHAT CAUSES DUST IN SHOTCRETE?

Due to the nature of cementitious materials, dust prevention can be highly challenging. The small particles associated with cement, sand, and other cementitious powders are key contributors to dusty environments, especially in confined installation areas with shotcreting. In the case of dry-mix shotcreting, there are two clear avenues for dust to occur: At the dry-mix gun hopper and at the nozzle. As shown in Fig. 1, between the concrete material being dumped into the hopper and the agitation of the dry material once inside, the dry-mix hopper area traditionally emits quite a bit of dust. Predampening of the dry-mix materials can help to reduce the level of dust at the gun.

The second and more commonly identifiable source of dust

*Fig. 1: Dry-mix gun hopper*

*Fig. 2: Dry-mix shotcrete application*

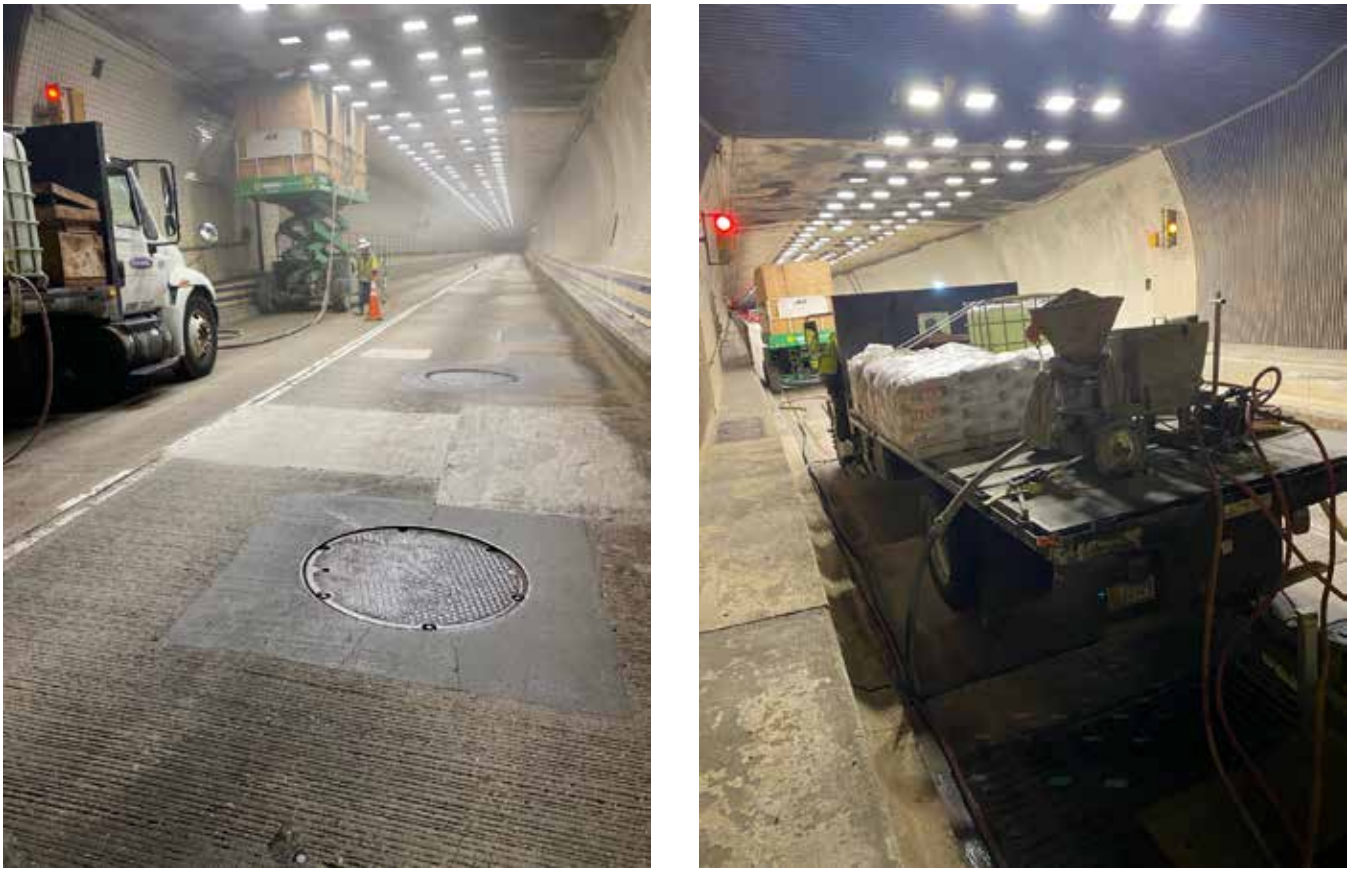

*Fig. 3: Shotcrete placement in the tunnel*

in shotcreting is the placement process, as illustrated in Fig. 2. The amount of dust generated at the nozzle and point of placement may necessitate additional oversight, specialized nozzles, and protective equipment. Proper use of a hydromix nozzle can significantly reduce dust produced at the nozzle.

When significant dust and high rebound occur, a lower quantity of concrete is retained in the repair area. Thus, in addition to the dust exposure, the concrete materials are not used as efficiently as possible. As ACI 506 details, coarse aggregate selection in a shotcrete mixture design plays a significant role in rebound (ACI PRC 506-22). Aggregate gradation, as well as the use of supplementary cementitious materials like silica fume, are key when discussing shotcrete mixture performance, as approved gradations have been designed to ensure proper compaction and account for the rebound of larger particles.

## STRIDES IN DUST REDUCTION TECHNOLOGY

The additional equipment and concrete delivery logistics often associated with wet-mix shotcrete placement can lead to selecting a lower-dust dry-mix material. The American Shotcrete Association (ASA) has published articles (**shotcrete.org/articles**) showcasing significant research aimed at reducing dust in dry-mix shotcrete. Historical tests have consistently shown that success in dust reduction is often accompanied by durability challenges, lower later-age strengths, or reduced early strengths (Clements & Fournier, 2020).

Over the last few years, however, there have been breakthroughs in the technology associated with dry-mix shotcreting additives that do not compromise other material properties. For example, proprietary admixtures recently became available that have been shown to reduce dust by up to 95% compared to traditional dry-mix shotcrete materials. When combined with properly graded aggregate, these admixtures function to reduce both dust and rebound.

The admixture has been included in the single component mix, which can be installed like any other dry-mix material for shotcreting, but results in significantly less dust and, consequently, rebound. As expected, less rebound equates to more material in place, reducing waste. By reducing dust without compromising other material properties, the resulting product is not only safer but also a more efficient for completing dry-mix repairs with shotcrete placement.

## SUCCESS AT THE MONITOR-MERRIMAC TUNNEL

Emergency repair needs were identified at the Monitor-Merrimac Tunnel when delamination was discovered during an inspection in July 2022. As inspections were completed, worry grew that the delaminated concrete, which was located on the ceiling of the tunnel, would endanger motorists driving through the tunnel. As a result, emergency priority was quickly given to closing lanes of traffic at night to complete the repairs and remove the threat to traffic.

Coastal Gunite Construction's recent track record of completing similar work with VDOT on a nearby tunnel made

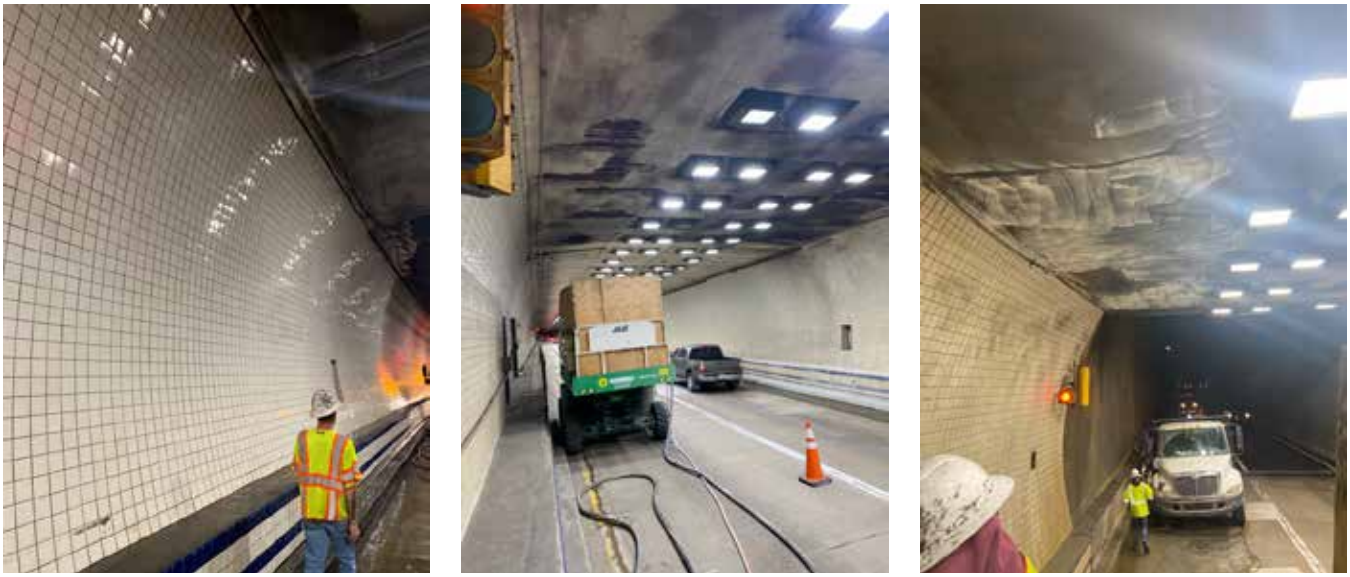

*Fig.4: Mobile staging allowed quick move in and move out*

them an outstanding candidate to complete the job. Once the project characteristics were established, shotcrete placement using the novel dustless admixture technology was identified as a perfect fit, given the traffic stoppages would only be 15-20 minutes in lieu of a total closure.

To ensure safe removal and shotcrete placement next to traffic, a scissor lift was boxed in with plywood. A demolition hammer was used to remove all the loose and delaminated concrete, embedded corroded utilities were replaced, and deteriorated steel was repaired or replaced. After the repair locations were cleaned and the existing concrete surfaces were properly prepared, a Piccola rotary gun was used for shotcrete placement of a low-dust dry-mix, as shown in Fig. 3. Emergency preparedness in the tunnel required a procedure for rapid tunnel evacuation. With the compact nature of the dry-mix shotcrete process, all equipment and materials can be quickly loaded onto a truck for evacuation (also shown in Fig. 3).

The use of low-dust shotcrete material provided several benefits to the team throughout the project's duration. Given the short window of time to pause traffic, it was vital that as much concrete be placed in as short a window as possible, cleanup of rebound be minimized, and the shotcrete placement have minimal impact on visibility. The low-dust shotcrete material ensured that all three of these key execution items were possible.

The increase in productivity and decrease in cleanup ensured the repairs were complete when the outage time had expired. Similarly, motorists were never impacted by unsafe road conditions associated with lowered visibility. The use of low-dust dry-mix shotcrete material ensured that the Monitor-Merrimac Tunnel project was an efficient and effective repair, minimizing regional traffic impacts.

## CONCLUSION

Understanding what causes dust on a concrete repair site allows for the proper mitigation measures to be put in place, minimizing crew exposure. In dry-mix shotcrete placement, understanding the relationship between the manufacturer's mixture design and rebound can significantly impact dust exposure, enabling optimal material selection. Every project is different, but reducing dust in confined spaces, such as the Monitor-Merrimac Tunnel, offers an advantage from both safety and construction planning perspectives. On projects with higher complexity, collaboration between the material supplier and the contractor can make a difference, in the success or failure of the job.

## REFERENCES


1. ACI PRC 506-22 Shotcrete - Guide. *American Concrete Institute*.
2. Clements, W., & Fournier, C. (2020). Developing Dust Reduced and Low Cracking Potential Dry-Mix Shotcrete Mixes. *American Shotcrete Association*.



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