Dry- and wet-mix process shotcrete

What are the differences?

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Dry-mix process shotcrete can be used advantageously in walls when the height is built up rapidly. A drier mix at the bottom of the wall is less likely to slump or sag under the weight of the shotcrete above it.

Shotcrete is mortar or concrete shot into place by means of compressed air. The two basic methods for applying shotcrete are the dry-mix process and the wet-mix process. The term gunite is frequently used when referring to the dry-mix method; other terms such as air-placed concrete, gunned concrete and sprayed concrete have also been used in the past to describe the processes.

Dry-mix process shotcrete

In this process, cement and moist aggregate are mixed and then placed into a device that meters the mixed material into a stream of compressed air. Material is carried by the compressed air through a delivery hose to the nozzle where water is added under pressure through a perforated ring. The water thoroughly wets the other ingredients as the mixture is jetted from the nozzle at high velocity onto the surface to be shotcreted. The amount of water added is under the control of the nozzleman or placing operator and can be varied by means of a valve to produce concrete or mortar ranging from extremely dry to extremely wet.

Wet-mix shotcrete

In the wet-mix process, all ingredients are first mixed to produce mortar or concrete. The mortar or concrete is then placed into delivery equipment which can be of a squeeze tube, pneumatic-feed or positive-displacement type. In any case, the material is forced through a delivery hose to the nozzle where compressed air is injected to increase velocity. The nozzleman can vary the amount of air introduced but has no direct control over the other properties of the concrete or mortar being placed.

The systems compared

Bonding ability of dry-process shotcrete is excellent because of the low water-cement ratio and high impact velocity. Test reports for repair projects have shown that in many cases, the bond strength is higher than the tensile strength of the material being repaired. Since the wet process hasn't been used as long, there are less data available concerning bond strength. For repair jobs especially, pre-job testing may be necessary to verify that acceptable bond strengths can be obtained when the wet process is used.

One of the more attractive features of the wet-mix systems is that the water-cement ratio can be controlled more precisely. Judgment is necessary in adjusting the water content when the dry-mix process is used and an *inexperienced* nozzleman could produce shotcrete of varying wetness and water-cement ratio. However, in some cases the ability to adjust water content at the nozzle and to shoot extremely dry mixes can be an asset. For example, in some underpinning and repair type work it's necessary to shoot directly beneath an existing footing, wall or grade beam. Structural sup-

port members several feet high may be shot. If the mix is too wet it can slump away from the overhead element to be supported leaving voids that later must be repaired by dry packing or shimming. This problem is avoided if, during shooting of the last foot or so of the support member, water content of the mix being shot is reduced to produce a dry pack consistency.

One other possible effect of low slump wet-mix shotcrete is the tendency to bridge on top of horizontal reinforcing steel in vertical wall sections and to slump away directly beneath those horizontal bars. This affects the concrete-to-steel bond which is particularly critical when the horizontal steel must resist bending stresses. Special placing techniques may overcome this problem and the use of accelerators has also been suggested as a means for correcting it. However, some accelerators that result in extremely fast initial set may reduce later age strengths by as much as 25 to 50 percent. More published test data are needed on this subject.

Costs

There is no question as to the relative costs of producing wet-mix and dry-mix shotcrete. The labor required to produce a given quantity of wet-mix shotcrete is approximately half that required to produce a similar quantity of dry-mix shotcrete. Equipment costs for the wet-mix process are also lower. One exception to the reduced labor requirement for wet-mix shotcreting can occur, however, when walls are shot. If the walls are built up too high too fast, the shotcrete in lower lifts can sag under the weight of material above them. Before building up the height to more than 3 to 4 feet, the wet-mix shotcrete must have attained an initial set. When walls are high but not very long, the nozzleman may have to wait for initial set of each lower lift before proceeding to the next. This slows the production rate considerably. The alternatives are to use set accelerators or to use the dry-mix process on these types of jobs.

Because use of the wet-mix process generally results in less rebound, there is less waste to be handled and disposed of. There is also less of a dust problem and this is an advantage whenever the material must be shot in a confined area. Finally, while placing techniques for both processes are similar, nozzlemen find it easier to master the wet process and this makes training of nozzlemen faster and easier.

More information needed

Steady growth in the number of wet-mix shotcrete jobs since the process was introduced in the early 1960s has been due primarily to the lower cost. Many successful projects have been completed. Further research is needed, though, to provide more information about bond strength and the effect of accelerators on ultimate compressive strength. The effectiveness of special placing techniques for overcoming the tendency of wet-process mixes to slump beneath horizontal reinforcing steel should also be investigated.

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