Temporary High Initial Air Content Wet Process Shotcrete

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The placement of high strength wet-mix shotcrete is sometimes complicated by the compromise required between obtaining suitable pumpability and shootability of the mixture. On one hand, we need a relatively fluid concrete that will be easy to pump, and on the other hand, we want a stiff in-place material that does not sag or slough on the wall. Most of the time the simple solution is to add a set accelerator at the nozzle. Alternatively, the contractor can apply the shotcrete in thin layers and arrange the application schedule so as to allow sufficient time for initial stiffening of the in-place material to take place before the next layer of shotcrete is added. However, due to the stringent quality requirements for shotcrete repairs exposed to freezing and thawing cycles and deicer salts and the potentially negative effect of accelerators, an alternative was sought to allow wet-mix shotcrete to be applied in relatively thick layers of about 4 to 6 inches (100 to 150 mm) without the use of set accelerators.

This is when the Temporary High Initial Air Content concept appeared. It was developed by Denis Beaupré during his doctoral research work in 1994. The Temporary High Initial Air Content concept is a clever and simple system by which the fluidity of the fresh wet-mix shotcrete is increased to meet the pumpability requirements by introducing a large amount of entrained air bubbles into the mixture to increase fluidity instead of relying solely on water reducers. The "trick" is that during the pumping, and particularly during the shooting processes, a large amount of air is lost due to compaction. The resultant lowered fluidity and reduced slump are instantaneously obtained by the compaction effect, thus increasing the shootability (ability of the shotcrete to stick and not slough) of the shotcrete (Figure 1). This air loss upon impact on the shooting surface is often referred to as a "slump-killing" effect. This method of shotcrete production has been used in a number of shotcrete construction projects in the province of Quebec with great success for the past three years, and in at least one underground mine in Northern Quebec.

The technical aspects of this concept are simple. Instead of adjusting the amount of plasticizer (normal or high-range water reducers and super-

Figure 1: Schematic of Temporary High Initial Air Content

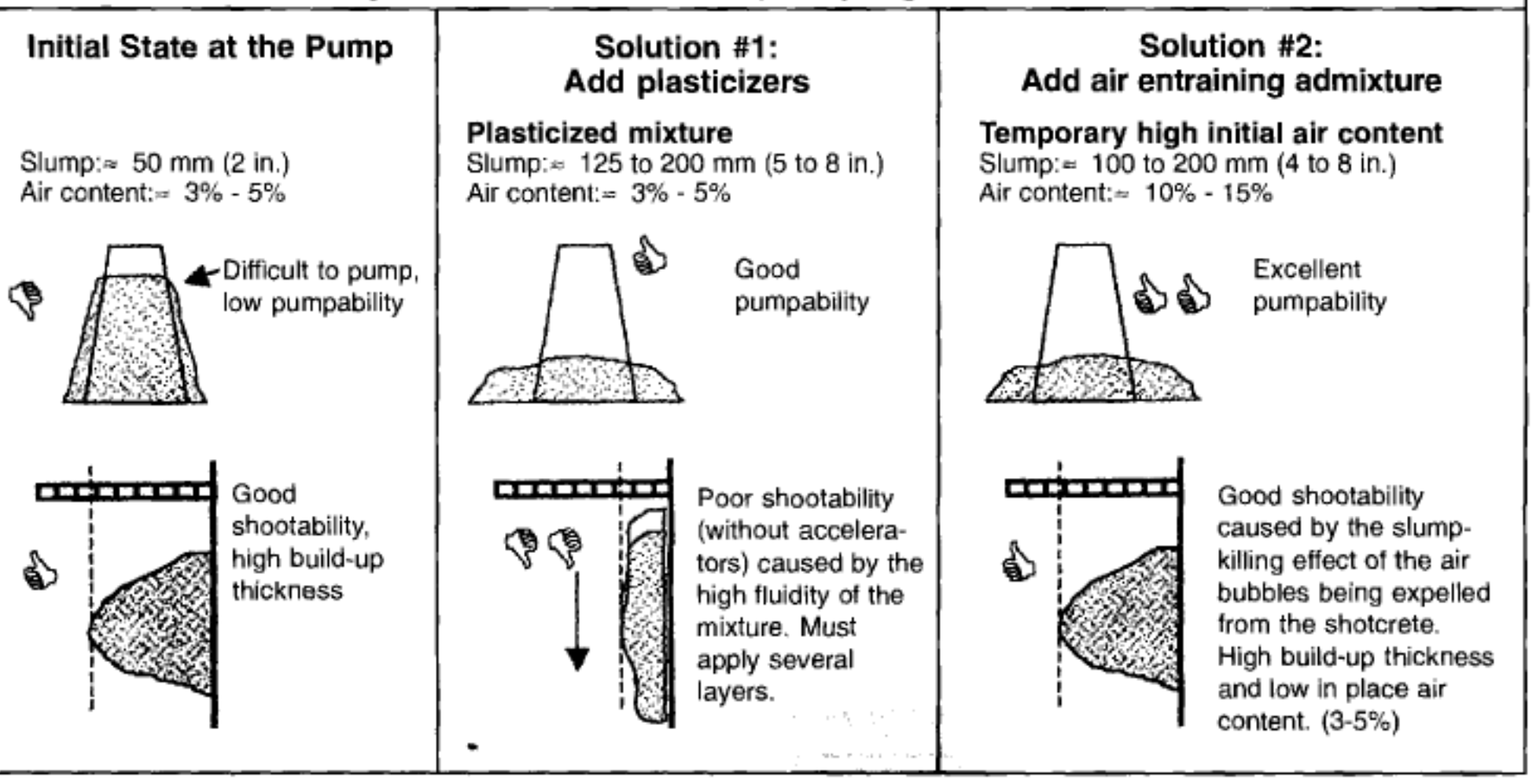

Table 1: Typical wet-mix shotcrete composition using *Temporary High Initial Air Content concept.*

	Quantity for 1 m³	1 c.y.
Cement	400 kg	882 lb
Silica Fume	40 kg	88 lb
Sand	1110 kg	2448 lb
Coarse aggregate (max 10 mm) (⅜ in.)	460 kg	1014 lb
Water	180 kg	397 lb
Water reducer	1500 ml	53 oz
Superplasticizer	5000 ml	176 oz
Air entraining admixture	2500 ml	88 oz

Table 2: Example of test results on the mix described in Table 1.

Slump before pumping	220 mm (8¾ in.)
Air content of fresh concrete before pumping	17 %
Air content of hardened in-place concrete	5.3 %
Compressive strength	48 MPa (6960 psi)

(This mix was actually shot at the Webster parking structure in Sherbrooke (Quebec, Canada).

plasticizers) to produce a 3 to 4 inch (75 to 100 mm) slump at the pump, the admixture dosage is reduced so as to produce a 1 to 2 inch (25 to 55 mm) slump. The air-entraining admixture is then added to produce the slump required for pumping, typically between 4 ½ inches and 8 inches (120 and 200 mm). The slump-killing effect only works if there is a high initial air content at the pump. Values of around 10% to 15% are typically used, although values as high as 20% have been used. Since this high air content will go down to 4% to 6% in the in-place shotcrete due to the compacting effect, the negative effect of high air content on the compressive strength is not a factor.

The added benefit of this system is that the residual air content in the in-place shotcrete typically results in an air void system (spacing factor and specific surface). That provides good freeze-thaw durability and resistance to deicing salt scaling in the hardened in-place shotcrete.

The next time you have a wet-mix shotcrete project, why not try the high initial air content method? Air entraining admixtures are typically much cheaper than superplasticizers or accelelerators and you might just be pleasantly surprised at how well the "slump-killing" effect works.

Second ASA Nozzleman Certification

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Optional Class - April 5 & 6, 2000
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(See pages 28 and 29)