Position Statement #1
ASA Pool and Recreational Shotcrete Committee

american shotcrete association

Compressive (Strength) Values of Pool Shotcrete

Pool and shotcrete contractors have a responsibility to provide a pool structure that not only meets certain design specifications, but also meets basic durability values expected with shotcrete applications. The American Shotcrete Association's (ASA) Pool and Recreational Shotcrete Committee and ASA Board of Direction have reaffirmed a 4000 psi (27.6 MPa) minimum for in-place compressive strength pool concrete.

Concrete in field installations has a variety of different exposure conditions. Concrete used in water-retaining pool and recreational structures is expected to have a low permeability under any potential exposure. The American Concrete Institute (ACI) 318-08, "Building Code Requirements for Structural Concrete," durability requirement provisions for concrete are covered in Chapter 4. ACI 318-08 specifies concrete "in contact with water where low permeability is required" is a Category P1 exposure. Table 4.3.1, Requirements for Concrete by Exposure Class, requires for a P1 exposure a minimum compressive strength of 4000 psi (27.6 MPa) with water-cementitious material ratios (*w*/*cm*) no greater than 0.50. These values are ACI 318-08 Building Code required minimums. Consideration of key factors will yield higher strengths when concrete is placed via the shotcrete method.

Normally, good-quality concrete placed by the shotcreting process will substantially exceed the 4000 psi (27.6 MPa) minimum ACI 318-08 Building Code requirement. Key factors that increase the likelihood of the compressive strength significantly exceeding the minimum of 4000 psi (27.6 MPa) have to do with the material itself and the high velocity (350 to 400 ft/s [106 to 122 m/s]) with which the material is applied onto the surface. After being strongly accelerated by high air pressure in the nozzle, the concrete strikes the receiving surface with such force that it is compacted. This results in consolidation of all the concrete rather than the sometimes haphazard consolidation that can occur with cast-in-place concrete. Fully consolidated concrete provides greater strength and lower permeability than poorly consolidated concrete. The compacted, low-permeability concrete created by shotcreting is the ideal concrete for structures intended to hold water.

The resulting structure's concrete porosity and resulting compressive strength will easily exceed 4000 psi (27.6 MPa) using the shotcrete (wet) process. Further, due to cement content and lower *w*/*cm* inherent in dry-mix (gunite) shotcrete, concrete compressive strengths will normally far exceed the 4000 psi (27.6 MPa) ACI 318-08 Building Code minimum. Barring significant errors in material batching in application of the shotcrete or in curing, one simply cannot avoid producing water-retaining shells with these higher compressive strengths.

To further understand the properties of the shot product, you must also analyze its material matrix on a particle-to-particle basis. Shotcrete mixtures differ from typical concrete mixtures. With shotcrete, the aggregate size is decreased while the surface area of all aggregates/particles is increased. This increase in surface area demands an increase in the binder (cementitious materials such as portland cement, fly ash, and slag), that fills the voids between the aggregate and glues this matrix together. The resulting lower *w*/*cm* gives shotcrete its increased strength.

Couple this matrix with proper velocity in placement (high velocity = full compaction = strength and low porosity) and you get 28-day compressive strengths ranging from 4500 to 9000 psi (31 to 62 MPa) or more.

In summary, properly designed concrete placed via the shotcrete process with in-place values less than 4000 psi (27.6 MPa) is the result of an unintentional or intentional breakdown in material production or shotcrete application. Though the pool industry has seen shotcrete specified with less than the ACI 318-08 Building Code required 4000 psi (27.6 MPa) minimum 28-day compressive strength, lower strength could only result from significantly reduced material quality or poor application procedures. Specifying a lower compressive strength would result in increased porosity of the in-place shotcrete and thus greatly reduce the pool shell's basic ability to hold water.

Unfortunately, the pool industry often suffers from the distribution of incorrect information on minimum compressive strength values of in-place shotcrete/concrete. ASA continually works to educate all who are in and related to the pool industry regarding proper placement and in-place properties of concrete placed with the shotcrete process. ASA also works to ensure that the shotcrete industry understands and implements the guides, specifications, and codes of ACI and its shotcrete information. Together, ASA and ACI form the primary sources of shotcrete education and documentation. We firmly maintain that the 4000 psi (27.6 MPa) minimum 28-day compressive strength that meets the ACI 318-08 Building Code requirements is necessary to produce durable, water-containing pool shells that our owners deserve and expect. Specifying any lower compressive strength does a disservice to the owner and the pool industry.

References

ACI Committee 318, "Building Code Requirements for Structural Concrete and Commentary (ACI 318-08)," American Concrete Institute, Farmington Hills, MI, 2008, 473 pp.

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