Low-Velocity Spraying of Cementitious Materials—Is It Shotcrete?

by Mark R. Lukkarila

The American Concrete Institute (ACI) defines shotcrete as "mortar or concrete pneumatically projected at a high velocity onto a surface."[1] By this definition, a mortar or concrete applied using low velocity would not fit this description and, therefore, cannot be classified as shotcrete.

Shotcrete, as defined in ACI 506R-05, "Guide to Shotcrete," is not merely a method of placing concrete or mortar onto a surface. The high velocity part of the definition is an important aspect of the process. The impingement of shotcrete particles onto the surface at high velocity imparts good strength, permeability, and durability characteristics as a result of the high-impact forces. The bond to substrates, especially those with fine surface irregularities, and encasement of reinforcement are enhanced because of the forces associated with impact at high velocity.[2]

What velocity is considered high velocity? Armelin et al.[3] conducted an extensive study using dry process shotcrete equipment and high-speed film imaging to document the average velocities of different aggregate sizes at air flow volumes of 100, 200, 300, and 400 cfm. They found that "for a given hose size, there is a linear dependence between aggregate velocity and air flow, thus indicating that particle velocities are directly proportional to the nominal air speed." This relationship was the same regardless of vertical or overhead shooting, although particles in overhead shooting had consistently lower velocities when compared with vertical applications at the same air flow. In their study, at the lowest air flow of 100 ft^3/min (2.8 m^3/min), the average particle velocities ranged from 5.2 ft/second (1.6 m/second) [overhead with a 2 in. (50 mm) diameter hose] to 62 ft/second (18.9 m/second) [wall with a 1.5 in. (38 mm) diameter hose]. The air flow requirements for low-velocity spraying were only 16 ft^3/min (0.45 m^3/min), which may not produce sufficient particle velocity to achieve proper in-place compaction.

Historically, applications of low-velocity methods involve placing mortar associated with plastering or rendering with small plaster pumps. A relatively new wall system, the structural foam core panel wall, or sandwich panel, comprises an expanded polystyrene core sandwiched between wire mesh. Mortar is then applied at low velocity to both the interior and exterior sides of the foam core. There has been considerable debate recently over whether the application of mortar in this fashion is considered to be shotcrete. There in no question that with this application, low-velocity spray would be the appropriate method of placement because the high-velocity impact of particles associated with shotcrete could damage the expanded polystyrene core. The debate centers on what to label the low-velocity method. Referring to the process simply as plaster implies a non-structural application;

however, because these sandwich panels are integral parts of wall systems, they need to meet certain structural requirements.

It should be noted that the International Concrete Repair Institute (ICRI) refers to similar low-velocity applications as "low-pressure spraying" in the ACI RAP Bulletin 3.[4] In this document it states, "Successful applications have included structural repairs to bridges, bridge and building piers, structural slab underside, tank walls (interior and exterior), stadiums, tunnels, and retaining walls."

Where do we go from here? There needs to be further discussion on a national level at ACI and ASTM International to determine what this relatively new construction method (reinforced foam panels with low-velocity spraying) should be labeled and what properties are required for the intended use.

References

1. ACI 506R-05, "Guide to Shotcrete," American Concrete Institute, Farmington Hills, Mich., 2005, 40 pp.

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3. Armelin, H.S.; Banthia, N.; and Mindess, S., "Kinematics of Dry-Mix Shotcrete," *ACI Materials Journal*, V. 96, No. 3, May-June 1999, pp. 283-290.

4. Watson, P., "Spall Repair by Low-Pressure Spraying," ACI RAP Bulletin 3, *Concrete Repair Bulletin*, May-June 2005, pp. 17-21.

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