Better Aesthetics through Self-Consolidating Concrete (SCC) Technology

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Concrete continues to evolve as a versatile construction material through technological advancements in its constituent materials, the introduction of new materials, and innovation with regard to its use in various applications. One such innovation currently gaining rapid acceptance in North America is self-consolidating concrete (SCC), a technology that has been used quite extensively in Japan and Europe since it was first developed in Japan in the late 1980s. The use of SCC in North America has been facilitated by the introduction of polycarboxylate-based high-range water-reducing admixtures and viscosity-modifying admixtures (VMAs) that, in particular, provide exceptional stability to highly-fluid concrete mixtures. The inherent characteristics of SCC are a very high degree of fluidity and stability that eliminate, if not minimize significantly, the need for mechanical consolidation of the concrete. These characteristics coupled with an acute shortage of skilled labor have led to the rapid acceptance and use of SCC in the precast and precast/prestressed concrete market segments. The benefits obtained from using SCC in these market segments include increased productivity and more efficient use of resources in terms of labor deployment and equipment. In addition to reducing labor requirements for placement and consolidation of concrete in precast pieces, the use of SCC almost invariably also reduces the labor required for rubbing and patching. This is due to the reduction in surface voids and the significantly enhanced surface finish (Fig. 1) that is typically obtained with this concrete technology.

Outside of the impact of forms and release agents and with all else being equal, placement technique and the high level of fluidity are key factors in getting a smooth surface finish with SCC. However, the viscosity of the mixture also plays quite a role. In general, low-viscosity SCC mixtures will provide better surface finish, and this can be attributed to the ease with which the mixture can flow in the form and displace air, similar to how water will displace air in a vessel.

Relative to the precast and precast/prestressed concrete market segments, the use of SCC in ready-mixed concrete started slowly, but there has been a marked increase in the application of the technology within this market segment. The key drivers for the use of SCC in cast-in-place applications again include ease of placement and consolidation in highly reinforced/congested elements that have limited access for insertion of mechanical vibrators, faster placement, enhanced surface finish and lower in-place concrete cost. In addition, ready-mixed concrete producers are increasingly developing greater confidence in their abilities to produce SCC consistently and, therefore, a greater level of comfort with the technology. This has led to the use of SCC in several high-profile cast-in-place concrete projects, a number of which are highlighted in this article mainly from an aesthetic perspective.

The striking difference in surface finish that can be obtained with SCC relative to non-SCC concrete was demonstrated during reconstruction of the Padgett-Thomas Barracks at The Citadel in Charleston, SC, a few years ago. A major challenge on this project was placement of concrete into 6-in. wide formed walls with seismic code reinforcement that were 12 ft high by 12 ft deep with doorways, window casings, arches, block-outs for utilities, and other architectural details.

The photograph in Fig. 2 shows the surface finishes obtained with SCC that had a nominal slump flow (spread) of 24 to 26 in. and a 7-in. slump concrete. The 7-in. slump concrete had been accepted for use on the project by the design engineers in place of the typically specified 4-in. slump concrete in an effort to reduce surface voids and severe honeycombing. On previous projects with similar wall design, unacceptable surface finish had resulted in severe cost over-runs due to patching and repair costs. The dramatically improved surface finish obtained with SCC led to the use of the technology in the remaining sections of the Padgett-Thomas reconstruction project. The result was a cast-in-place concrete structure with extremely smooth surface finish and clean sharp edges. In addition, rubbing and patching costs were reduced by a factor of ten.

The successful use of SCC on the Padgett-Thomas Barracks project has resulted in the exclusive specification of SCC for the Law Barracks, now under construction at The Citadel.

SCC was also used successfully during construction of the Rosenthal Center for Contemporary Art building in Cincinnati, OH shown on the next page. Part of the design was a roll-up section that connected the wall to the floor, resembling a 96-ft skateboard ramp as can be observed in the lower right corner of Fig. 4(a). With no surprise, the form for the roll-up section provided no access for internal vibration. Therefore, to ensure proper consolidation of the concrete and to minimize surface blemishes SCC with a slump flow of 26 in. was used. The SCC provided a very smooth surface finish and led the contractor, Baker Concrete Construction based in Monroe, OH to use a similar SCC mixture in diamond-shaped columns that were cast using square steel column forms with plywood inserts to create the diamond shape, Fig. 4(b). The form detail for the columns resulted in "dead areas" on two sides that restricted access for proper vibration of the concrete and necessitated the use of SCC. Again, the SCC provided a smooth surface finish with few blemishes as shown in Fig. 4(c).

Over 250 cubic yards of SCC were placed in the diamond-shaped columns. To quote Greg Slaughter of Baker Concrete, "The SCC was a great benefit on this project, financially and aesthetically. As we learned how to take advantage of SCC properties we were able to improve our efficiency. The profitability impact on larger jobs could be very substantial!"

The projects highlighted in this article are a very small sampling of architecturally-appealing concrete structures where SCC has been used either primarily or partly because of the superior surface finish that it provides. Other significant cast-in-place projects where SCC has been used to showcase the aesthetic appeal of exposed concrete include the Minneapolis Central Library and the Atlanta Aquarium.
In a summary paper, presented at the "Second North American Conference on the Design and Use of Self-Consolidating Concrete" last year, Jack Holley of Lafarge North America, wrote that:
"Achieving classical and specialty finishes for structures is an important aspect of the architect's design. The use of a specifically designed and tailored SCC allows for an intricate surface illustrating the fine details required in a structure's hardened state. The concrete can produce a near flawless finish without the need for sandblasting, patching and or rubbing. Additionally, despite the constraints of heavy reinforcement, SCC does not require vibration."

Long established as the most versatile construction material, concrete continues to evolve, and it is clearly evident that SCC technology will further enhance the aesthetic appeal of concrete for years to come.

References:

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