PCA Portland Cement Association

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Going with the Flow

By Martin McGovern

Self-consolidating concrete can flow between and around reinforcement without requiring vibration.

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Advances in admixture technology and mix proportioning have spawned the industry's latest development: self-consolidating concrete

The construction industry has always longed for a high-performance concrete that can flow into tight and inaccessible spaces without requiring vibration. This desire has grown over the years as more designers specify concrete members that are heavily reinforced and require complex formwork.

Until recently, the closest the industry came to developing "self-consolidating" concrete was to add a superplasticizer to a conventionally proportioned concrete mix. Although superplasticizers allow for the use of concrete with a slump of 200 mm (8 in.) or more, such concrete still requires some vibration for adequate consolidation. High doses of superplasticizer create a very fluid concrete, but the mix often segregates because the mortar is too thin to support the coarse aggregate.

Today, advances in admixtures and mix proportioning are making self-consolidating concrete a reality. Developed in Japan in the 1980s, this technology is now gaining considerable attention in Europe and North America.

Balancing Flowability and Stability

The key to creating self-consolidating concrete is to produce a very flowable mortar (low yield value) that still has a high enough viscosity to support the coarse aggregate. To produce the desired flowability, superplasticizers based on polycarboxylate ethers work best. Developed in the 1990s, they produce better water reduction and slower slump loss than superplasticizers based on sulfonated melamines and naphthalenes. However, these more conventional superplasticizers can be used for SCC as well.

To increase the viscosity of the mortar, self-consolidating concrete contains more fine material, but essentially the same amount of water, as conventional concrete. The total content of materials (including cementitious materials) finer than the 150 µm (No. 100) sieve must be high, usually about 520 to 560 kg/m^3 (880 to 950 lb/yd^3). In some cases, a viscosity-modifying admixture can be used instead of, or in combination with, an increased fine content.

Fresh Concrete Properties

Fig. 1. The J-ring simulates reinforcement.

Because self-consolidating concrete has unique rheology, the slump test (ASTM C 143) is not an adequate method for measuring its workability. The most common way has been to perform a slump test, but to measure the concrete's *spread*– the diameter of the concrete "puddle" formed. (A conventional slump cone base is too small for this test.) A spread of 700 mm (28 in.) is common for self-consolidating concrete.

A German guideline (DAfStb 2001) combines the spread test with a *J-ring*, which simulates reinforcement (Fig. 1). Well-proportioned self-consolidating concrete should be able to flow between and behind reinforcement and should have about the same spread with and without the J-ring.

Seward Power Plant, New Florence, Pa. Self-Consolidating Concrete

Mix Proportions

Material	**Quantity**	
Portland cement (Type I)	297 kg/m^3	(500 lb/yd^3)
Slag cement	128 kg/m^3	(215 lb/yd^3)
Coarse aggregate[1]	675 kg/m^3	(1,137 lb/yd^3)
Fine aggregate	1,026 kg/m^3	(1,729 lb/yd^3)
Water	170 kg/m^3	(286 lb/yd^3)
Superplasticizer[2]	1.3 L/m^3	(35 oz/yd^3)
AE admixture	as needed for 6% +/- 1.5% air content	

[1]Size: #8 (AASHTO M 43), 100% passing 12.5-mm (½-in.) sieve.
[2]ASTM C 494, Type F (Polycarboxylate-based)

Segregation resistance is a critical property for self-consolidating concrete. Unfortunately, it is difficult to measure objectively. AFGC, a French civil engineering association, has developed the Screen Stability Test in which concrete is poured onto a 5-mm screen to see how much of the mortar falls through (AFGC 2000). The less mortar that falls through, the less likely the concrete is to segregate.

In June 2001, ASTM created a self-consolidating concrete committee (C09.47). Martin Vachon, committee chairman, says that a goal of the committee will be to establish standard test methods to measure the relevant properties of fresh self-consolidating concrete and to set performance requirements for the material.

SCC in Action

In April, Fihoff Concrete, Johnstown, Pa., supplied self-consolidating concrete for construction of a 12 x 12-m (40 x 40-foot) turbine table at the Seward Power Plant in New Florence, Pa. The heavily reinforced elevated table has 1.5-meter (5-foot) deep grade beams and was poured in 0.3-m (1-foot) lifts.

The mix proportions for the concrete are shown in the box (left). "We essentially switched the amount of coarse and fine aggregate that you'd add to a normal concrete mix," said Von Parkins, president of Fihoff.

The superplasticizer was added at the jobsite. According to Parkins, no special batching sequence was required at the plant. Fihoff delivered the concrete to the jobsite at a 25-mm (1-in.) slump, added the superplasticizer, revolved the drum 100 times, then measured the spread of the concrete. The spread averaged 635 mm (25 in.).

Rick Huss, quality control manager for Fluor Constructors, Seward, Pa., was pleased with the fresh concrete properties. "The concrete traveled like they said it would, and it carried the coarse aggregate with it," he said. Huss also said the concrete pumped well without segregating. The only drawback came at the end of the pour. "Finishing the concrete was tough," said Huss. "The surface was sticky and it set up pretty quickly."

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References

Association Francaise de Genie Civil, "Screen Stability Test, Annex 3," *Betons Auto-Placants (Self-Consolidating Concrete)*, Bagneux, France, July 2000.

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1st North American Conference on the Design and Use of Self-Consolidating Concrete (SCC)

The Center for Advanced Cement-Based Materials (ACBM) and nine associated organizations* will hold the 1st North American Conference on Self- Consolidating Concrete (SCC) at Northwestern University, Evanston, Illinois, on November 12–13, 2002. The conference is a forum to disseminate information on SCC, discuss its applications, and promote its use. The registration fee is $195.00 and includes all handout materials, continental breakfasts, and lunches on the two meeting dates. To register for the conference, call ACBM at 847.491.3858, or register online at http://acbm.northwestern.edu/scc02.html.

A block of rooms has been set aside at the Omni Orrington Hotel, 1710 Orrington Ave., Evanston, IL 60201. For room reservations, contact the hotel directly (phone: 800.843.6664 or 847.866.8700; e-mail: orrez@omniorrington.com).

* Associated Organizations: Master Builders Inc., W.R. Grace Inc., Lafarge North America, Holcim U.S., Cemex USA, Axim Concrete Technologies, Portland Cement Association, Precast/Prestressed Concrete Institute, Federal Highway Administration

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