Concrete in Practice
What, why & how?
NRMCA

CIP 37 - Self Consolidating Concrete (SCC)

WHAT is Self Consolidating Concrete?

Self consolidating concrete (SCC), also known as self compacting concrete, is a highly flowable, non-segregating concrete that can spread into place, fill the formwork and encapsulate the reinforcement without any mechanical consolidation. The flowability of SCC is measured in terms of spread when using a modified version of the slump test (ASTM C 143). The spread (slump flow) of SCC typically ranges from 18 to 32 inches (455 to 810 mm) depending on the requirements for the project. The viscosity, as visually observed by the rate at which concrete spreads, is an important characteristic of plastic SCC and can be controlled when designing the mix to suit the type of application being constructed.

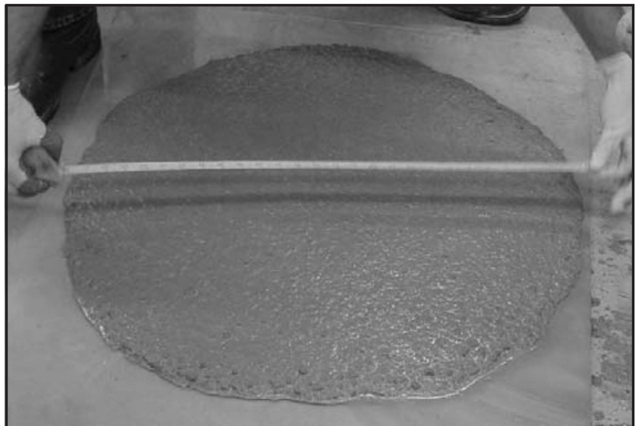

Figure 1: SCC with a slump flow of 29-inches (725-mm) tested by the slump flow test

WHY is SCC Used?

Some of the advantages of using SCC are:

1. Can be placed at a faster rate with no mechanical vibration and less screeding, resulting in savings in placement costs.
2. Improved and more uniform architectural surface finish with little to no remedial surface work.
3. Ease of filling restricted sections and hard-to-reach areas. Opportunities to create structural and architectural shapes and surface finishes not achievable with conventional concrete.
4. Improved consolidation around reinforcement and bond with reinforcement
5. Improved pumpability.
6. Improved uniformity of in-place concrete by eliminating variable operator-related effort of consolidation.
7. Labor savings.
8. Shorter construction periods and resulting cost savings.
9. Quicker concrete truck turn-around times enabling the producer to service the project more efficiently.
10. Reduction or elimination of vibrator noise potentially increasing construction hours in urban areas.
11. Minimizes movement of ready mixed trucks and pumps during placement.
12. Increased jobsite safety by eliminating the need for consolidation.

HOW is SCC Achieved?

Two important properties specific to SCC in its plastic state are its *flowability* and *stability*. The high flowability of SCC is generally attained by using high-range-water-reducing (HRWR) admixtures and not by adding extra mixing water. The stability or resistance to segregation of the plastic concrete mixture is attained by increasing the total quantity of fines in the concrete and/or by using admixtures that modify the viscosity of the mixture. Increased fines contents can be achieved by increasing the content of cementititious materials or by incorporating mineral fines. Admixtures that affect the viscosity of the mixture are especially helpful when grading of available aggregate sources cannot be optimized for cohesive mixtures or with large source variations. A well distributed aggregate grading helps achieve SCC at reduced cementitious materials content and/or reduced admixture dosage. While SCC mixtures have been successfully produced with 1½ inch (38 mm) aggregate, it is easier to design and control with smaller size aggregate. Control of aggregate moisture content is also critical to producing a good mixture. SCC mixtures typically have a higher paste volume, less coarse aggregate and higher sand-coarse aggregate ratio than typical concrete mixtures.

Retention of flowability of SCC at the point of discharge at the jobsite is an important issue. Hot weather, long haul distances and delays on the jobsite can result in the reduction of flowability whereby the benefits of using SCC are reduced. Job site water addition to SCC may not always yield the expected increase in flowability and could cause stability problems.

Full capacity mixer truck loads may not be feasible with SCCs of very high flowability due to potential spillage. In such situations it is prudent to transport SCC at a lower flowability and adjust the mixture with HRWR admixtures at the job site. Care should be taken to maintain the stability of the mixture and minimize blocking during pumping and placement of SCC through restricted spaces. Formwork may have to be designed to withstand fluid concrete pressure and conservatively should be designed for full head pressure. SCC may have to be placed in lifts in taller elements. Once the concrete is in place it should not display segregation or bleeding/settlement.

SCC mixtures can be designed to provide the required hardened concrete properties for an application, similar to regular concrete. If the SCC mixture is designed to have a higher paste content or fines compared to conventional concrete, an increase in shrinkage may occur.

HOW to Test SCC?

Several test procedures have been successfully employed to measure the plastic properties of SCC. The slump flow test (see Figure 1), using the traditional slump cone, is the most common field test and is in the process of being standardized by ASTM. The slump cone is completely filled without consolidation, the cone lifted and the spread of the concrete is measured. The spread can range from 18 to 32 inches (455 to 810 mm). The resistance to segregation is observed through a visual stability index (VSI). The VSI is established based on whether bleed water is observed at the leading edge of the spreading concrete or if aggregates pile at the center. VSI values range from 0 for "highly stable" to 3 for unacceptable stability.

During the slump flow test the viscosity of the SCC mixture can be estimated by measuring the time taken for the concrete to reach a spread diameter of 20 inches (500 mm) from the moment the slump cone is lifted up. This is called the T_{20} (T_{50}) measurement and typically varies between 2 and 10 seconds for SCC. A higher T_{20} (T_{50}) value indicates a more viscous mix which is more appropriate for concrete in applications with congested reinforcement or in deep sections. A lower T_{20} (T_{50}) value may be appropriate for concrete that has to travel long horizontal distances without much obstruction.

The U-Box and L-Box tests are used for product development or prequalification and involve filling concrete on one side of the box and then opening a gate to allow the concrete to flow through the opening containing rebar. The J-ring test is a variation to the slump flow, where a simulated rebar cage is placed around the slump cone and the ability of the SCC mix to spread past the cage without segregation is evaluated. The U-box, L-box and J-ring tests measure the *passing ability* of concrete in congested reinforcement. Another test being standardized is a column test which measures the coarse aggregate content of concrete at different heights in a placed columnar specimen as an indication of stability or resistance to segregation.

HOW to Order or Specify SCC?

When ordering and/or specifying SCC, consideration must be given to the end use of the concrete. Ready mixed concrete producers will generally have developed mixture proportions based on performance and applications. The required spread (slump flow) is based on the type of construction, selected placement method, complexity of the formwork shape and the configuration of the reinforcement. ACI Committee 237 is completing a guidance document that will provide guidelines to select the appropriate slump flow for various conditions. The lowest slump flow required for the job conditions must be specified. This will ensure SCC can be attained easily with required stability and at the lowest possible cost. The hardened concrete properties should be specified by the design professional based on structural and service requirements of the structure. For the most part, hardened concrete properties of SCC are similar to conventional concrete mixtures. Based on the requirements of each project, SCC concrete designs can be submitted by the producer only after specification provisions regarding the performance of the concrete in its plastic and hardened state are clearly defined.

References

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National Ready Mixed Concrete Association • 900 Spring Street, Silver Spring, MD 20910 • www.nrmca.org • 888-84NRMCA