Concrete in Practice
What, why & how?
NRMCA

CIP 37 - Self-Consolidating Concrete (SCC)

WHAT is Self Consolidating Concrete

Self-consolidating concrete (SCC), is a highly flowable, non-segregating concrete that can flow into place, fill the formwork and encapsulate the reinforcement without mechanical consolidation. The flowability of SCC is measured in terms of slump flow when tested in accordance with ASTM C1611. The slump flow of SCC typically ranges from 18 to 32 inches (455 to 810 mm) depending on the requirements for the project. The viscosity, which is the rate at which concrete flows, is an important characteristic of freshly mixed SCC and can be controlled when designing the mixture to suit the type of application being constructed.

WHY is SCC Used

Some of the advantages of using SCC are:

1. Can be placed at a faster rate with little or no mechanical vibration and less screeding, resulting in savings in placement costs.
2. Improved and uniform architectural surface finish of formed surfaces with little to no remedial 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 variability of operator-related consolidation.
7. Labor savings.
8. Reduced construction time with cost savings.
9. Quicker concrete truck turn-around time enabling more efficient delivery and placement schedule.
10. Reduction or elimination of vibrator noise that can increase 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.

Measuring Slump Flow of SCC

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) without adding extra mixing water. The stability or resistance to segregation of the plastic concrete mixture is attained by increasing the quantity of fines in the mixture and/or by using viscosity-modifying admixtures (VMAs) admixtures. Increased fines can constitute cementititious materials or mineral fillers. VMAs are helpful in minimizing bleeding and segregation, typically caused by a deficiency in fines or gap-graded aggregates, lower cementitious content and variations in aggregate moisture. An optimized combined grading of aggregate also helps with the stability of the mixture. SCC mixtures are typically developed with smaller size - 3/8 to 1 in. (9.5 to 25 mm) aggregate. Control of aggregate grading and moisture content during production is critical to producing uniform loads with the desired fresh concrete characteristics. SCC mixtures typically have a higher paste volume (including fillers), and a higher sand-to-coarse aggregate ratio than typical concrete mixtures.

Retaining the flowability of SCC until the load is discharged at the jobsite will require some flexibility for the producer. Hot weather, long haul distances, and delays on the jobsite will adversely impact the flow characteristics and associated benefits of using SCC. Workability retaining and hydration control admixtures may be needed to minimize loss of workability. Job site water addition to SCC should be minimized as it may not achieve the same flowability and causes stability problems.

Due to the fluidity of SCC mixtures and the possibility of spillage, full capacity truck mixer loads may not be feasible. In such situations a producer may choose 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. Conservative formwork design may consider full head pressure and there is guidance on this aspect. Alternatively, SCC may have to be placed in lifts in taller elements. As with conventional concrete freefall of SCC should be minimized to prevent segregation and surface defects. Once the concrete is in place it should not display segregation or bleeding/settlement.

For design considerations, hardened concrete properties of SCC mixtures are essentially similar to those of conventional concrete. Higher paste volume may impact some volume change characteristics.

HOW to Evaluate and Test SCC

Several test procedures have been standardized to measure the plastic properties of SCC. The slump flow test, ASTM C1611, uses the traditional slump cone inverted, and is a field test that measures the unconfined flow of SCC. The slump flow is the spread of the concrete after it stops flowing. Slump flow can range from 18 to 32 inches (455 to 810 mm). The dynamic stability is a qualitative observation of the resistance to segregation of SCC in the slump flow test and is recorded as the visual stability index (VSI). 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 evaluated by measuring the time in seconds for the concrete to reach a slump flow of 20 inches (500 mm) after the slump cone is lifted. This is referred to as the T_{20} (T_{50}) value and varies between 2 and 10 seconds for SCC. A more viscous mixture will have a higher T_{20} (T_{50}) value that is more appropriate placements with congested reinforcement or in deep sections. A less viscous mixture will flow longer distances without obstructions. The U-Box and L-Box tests are used when developing mixtures and involves filling concrete on one side of the box and opening a gate to allow the concrete to flow through the opening containing rebar. The J-ring test, ASTM C1621, is a variation to the slump flow, where a rebar cage is placed around the slump cone and measures the relative slump flow to evaluate the ability of SCC to flow through an obstruction without segregation. The U-box, L-box and J-ring tests measure the *passing ability* of concrete in congested reinforcement. Other tests for evaluating the potential for static segregation are the column segregation test, ASTM C1610 and a penetration test, ASTM C1712.

HOW to Order and Specify SCC

The type of member being constructed should be considered when ordering or specifying SCC. Ready mixed concrete producers develop SCC mixtures based on performance and applications. The required slump flow is based on the type and shape of member, placement method, and the amount of reinforcement. ACI 237R provides guidance on specifications, materials, mixtures, construction and testing of SCC. It recommends slump flow for various conditions. ASTM C94 provides tolerances for specified slump flow. The lowest slump flow required for placement should be specified so that SCC used has the required stability and at the lowest cost. The design professional specifies hardened concrete properties based on structural and service requirements of the structure. The properties of hardened concrete and test methods used are similar to those used for conventional concrete. SCC concrete mixtures are developed and submitted by the producer for approval by the designer when the specification requirements of SCC in its freshly mixed and hardened state are clearly defined.

References

1. ACI 237R, *Self-Consolidating Concrete*, American Concrete Institute, Farmington Hills, MI, www.concrete.org
2. ASTM C94, C1610, C1611, C1621, C1712, C1758. ASTM International, West Conshohocken, PA, www.astm.org
3. *Specification and Guidelines for Self-Compacting Concrete*, EFNARC, Surrey, UK, February 2002, www.efnarc.org/
4. ACI 237T, *TechNote: Factors Affecting Form Pressure Exerted by Self-Consolidating Concrete*, American Concrete Institute, Farmington Hills, MI, www.concrete.org

2004, 2018