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June 2023

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Self-Consolidating Concrete (SCC)

Introduction:
Self-Consolidating Concrete (SCC) is a high-performance concrete that flows into formwork under its own weight without vibration or consolidation. In the 1980s, it was first used in Japan to reduce labor costs involved in placing concrete [1]. Since then, it has gained international acclaim and is now a product being widely used in the concrete industry. In the U.S. many consider SCC to be one of the most remarkable innovations in concrete industry over the past two decades [2].

Advantages:
Compared to conventional Portland cement concrete, SCC is easy to place without mechanical consolidation. In terms of placement, SCC has many benefits, including resisting segregation of coarse aggregates from mortar. Further, it can encapsulate all reinforcements without honeycombing, and handle complicated pouring situations with ease [1-4]. As a result, SCC offers additional benefits, such as reduced labor costs associated with manual consolidation, a decrease in noise emitted by mechanical equipment, uniform surface finishes that are virtually free of imperfections, quicker construction, and many others.

Major Characteristics:
Filling ability, passing ability, and stability (static and dynamic segregation resistance) are the three main fresh properties that define SCC [3-7].

Filling ability: An unconfined flowability and the ability of SCC to flow into and fill completely all spaces within the formwork, under its own weight [8].

Passing ability: Confined flowability refers to the ease with which concrete can pass among various obstacles and narrow spacing in the formwork without blockage [8].

Stability: The ability of a material to maintain homogeneous distribution of its various constituents during its flow and setting. There are two types of stability characteristics that are important for SCC, dynamic and static stability. Dynamic stability is the resistance of concrete to the separation of constituents during placement into the form work, and static stability is defined as the resistance of concrete to bleeding, segregation, and surface settlement after casting while the concrete is still in a plastic state [8].

Mix Proportioning Requirements:
SCC is achieved by designing a mix that has a low yield stress and an increased plastic viscosity (see Figure 1). In other words, the mix should require minimal force to initiate flow, yet have adequate cohesion to resist aggregate segregation and excess bleeding. The yield stress is reduced by using an advanced synthetic high-range water-reducing admixture (HRWR), also known as superplasticizer. The viscosity of the paste is increased by using a viscosity-modifying admixture (VMA) or by increasing the percentage of fines incorporated into the SCC mix design. To satisfy the fresh-property

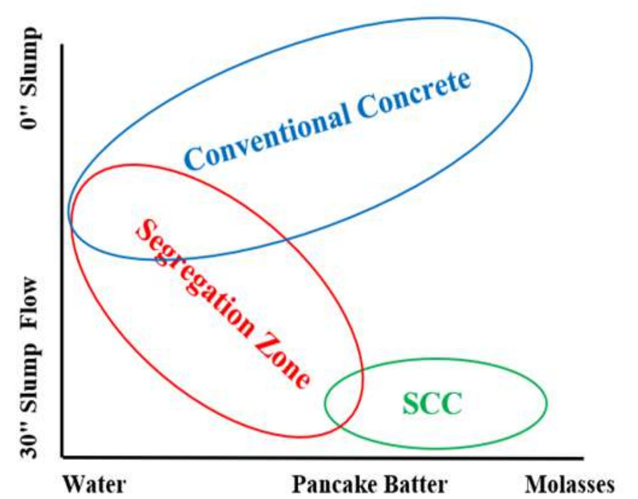

Figure 1. SCC Plastic Viscosity and Yield Stress.

requirements simultaneously, SCC composition and rheological properties should be closely controlled. It is usually possible to achieve flowable properties by combining one or more of the following mix design attributes: high cementitious material content (over 750 lb/yd3 or 445 kg/m3), superplasticizers (possibly combined with VMAs), mineral admixtures, and careful selection of aggregate volume and gradation [8]. It is often necessary to have a low aggregate volume and smaller coarse aggregates to improve flow around steel reinforcements in restricted areas. It is possible to reduce the potential for segregation by including mineral admixtures such as silica fume, fly ash, ground-granulated blast furnace slag (GGBFS), calcined clay, and pulverized limestone. Additionally, viscosity-modifying agents can improve segregation resistance. Cementitious material content impacts SCC's hardened properties, such as strength gain, elastic modulus, creep, shrinkage (autogenous and drying), and overall durability [2].

Standard Test Methods:

Compared with ordinary concrete, the composition and the rheological properties of SCC should be closely controlled to satisfy the three fresh property requirements (flowability, passing ability, stability) simultaneously. Small fluctuations of the plastic viscosity and yield stress of paste, and the size, volume, gradation, as well as moisture content of the fine and coarse aggregates could adversely affect workability, composition, and durability [10]. Due to its sensitive nature, SCC typically requires a higher level of quality control. A lack of robust mixture is one of the main reasons limiting large scale production of SCC in the field, where external sources of variability are difficult to monitor and control [9, 10]. Therefore, it is desired to have a robust SCC mixture, which is minimally affected by the variations in mix compositions [11].

To ensure the consistency and reliability of SCC mixes, different fresh and rheological test methods should be employed. Table 1 represents a list of standard tests for quality control of SCC mixes.

Test Method	Acceptable Values
Slump Flow	18-34 (in)
T50	≤ 5 (sec)
VSI	0 or 1
J-Ring	≤ 1 (in)
Column Segregation	≤ 10%
L-Box	75% ≥
V-Funnel	≤ 25 (sec)

Table 1. Typical SCC test methods and their values

Testing methods such as slump flow (Figure 2), T50 time, and J-ring (Figure 3) are utilized to evaluate the flowability and workability of SCC. The visual stability index (VSI) measures the apparent stability of a slump flow patty, and it ranges from 0 (highly stable) to 3 (highly unstable) [12]. The VSI provides a quick but approximate indication of the stability of the mixture; however, an acceptable VSI does not ensure adequate stability nor does an unacceptable VSI mean the concrete will be unstable [12]. Figure 4 represents differ-

Figure 2. Slump flow test

Figure 3. J-Ring test

ent VSI for SCC mixes. Commonly used static segregation tests include Column Segregation [13]

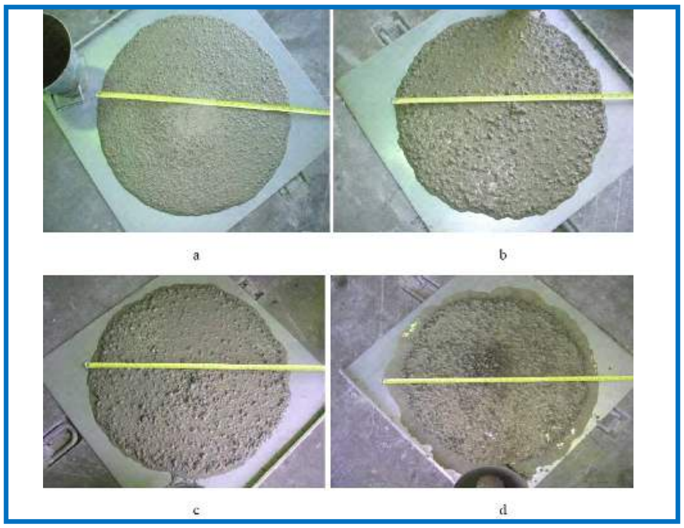

Figure 4. VSI Test: a) VSI=0; b) VSI=1; c) VSI=2; d) VSI=3

Figure 5. Column Segregations (left) and V-Funnel (right) Test Apparatus

and V-Funnel test [1]. The V-funnel test is incorporated as a Japanese standard test, for static segregation and it shows how quickly SCC passes through a constricted area [1, 14]. The column segregation measures the coarse aggregate content as an indication of stability or resistance to segregation [9]. Figure 5 shows the V-Funnel and column segregation test apparatus.

Applications in Industrial Projects:

SCC finds extensive application in a wide range of industrial projects, including high-rise and mid-rise buildings, bridges, tunnels, and precast concrete elements. CalPortland provides a full line of specialty concrete solutions to your toughest design requirements, including SCC. For instance, our

Figure 6. Hercuwall Wall System using SCC

ready-mix plants in Arizona regularly produce SCC for the Phoenix Metro area, primarily for high

Figure 6. Hercuwall Wall System using SCC

strength applications (greater than 7000 psi). One example is a new building concept called Hercuwall, invented by Hercutech company [15] shown In Figure 6, which consists of a panelized wall system filled with a 4000 psi 3/8” rock SCC mix that is being used in the Phoenix and Tucson metro areas. Additionally, CalPortland supplied self-consolidating concrete for the following projects:

McKinley Green

A mixed-use, multi-family high-rise building with over 30 stories in downtown Phoenix, Arizona, using 8 ksi and 10 ksi self-consolidating concrete (Figure7).

601 N. Central Phoenix

A mixed-use building project with 1,306,935 square feet area and 30+ levels in downtown

Figure 7. McKinley Green multi-family, high-rise building proect, Phoenix, Arizona.

Phoenix, Arizona. CalPortland is supplying a variety of high strength SCC (8, 10, and 12 ksi at 28

Figure 8. 601 N. Central Phoenix, a mid-rise building project, Phoenix, Arizona

days) to this project. It should be mentioned that a special 3/8” basalt aggregate was used in the

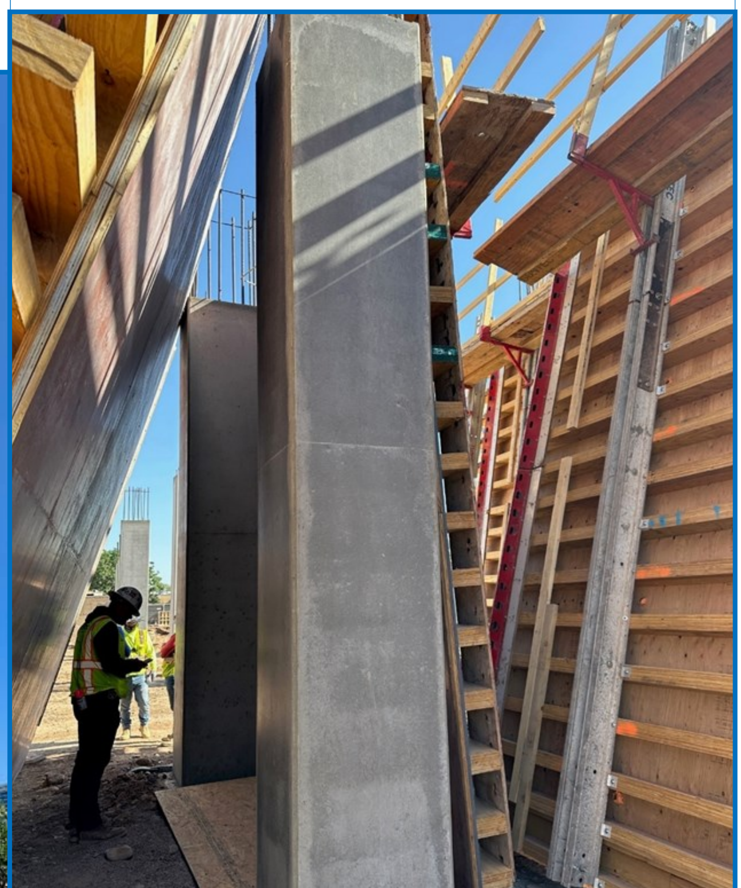

Figure 9. 601 N. Central Phoenix, a mid-rise building project, Phoenix, Arizona.

SCC mix constituent for the 12 ksi strength (Figures 8, 9).

SCC is a proven, quality material for use in a variety of applications. Consult with your local CalPortland representative to see how SCC can benefit your next project.

References:

[1] Japan Society of Civil Engineers. Recommendation for self-consolidating concrete. In: Omoto T, Ozawa K, editors. JSCE Concrete Engineering, vol. 77, series 31; 1999.

[2] Hamed Bahrami, Testing Segregation and Other Rheological Properties of Self-consolidating Concrete (SCC), PhD. Thesis, University of Hawaii at Manoa, July 2015.

[3] NENARC. European SCC guidelines, <http://www.efnarc.org/pdf/SCCGuidelinesMay2005.pdf 2005>.

[4] Zedi Zhang, Jia Xiao, Qing Zhang, Kaidong Han, Jialei Wang, Xiaoyan Hu, A state-of-the-art review on the stability of self-consolidating concrete, Construction and Building Materials. September 2020.

[5] Emilio Garcia-Taengua, Fundamental Fresh State Properties of Self-Consolidating Concrete: A Meta-Analysis of Mix Designs. Hindawi, Advances in Civil Engineering, Volume 2018, Article ID 5237230, 13 pages.

[6] Xuhao Wang, Proportioning and performance evaluation of self-consolidating concrete. PhD. Thesis, Iowa State University. 2014.

[7] Missouri Department of Transportation Construction and Materials, Self-Consolidating Concrete (SCC) for Infrastructure Elements. August 2012.

[8] ACI Committee 237, Report on Self-Consolidating Concrete. Reapproved 2019.

[9] NRMCA. (2021). Self-consolidating concrete (SCC). National Ready Mixed Concrete Association.

[10] Bonen D, Shah SP. Fresh and hardened properties of self-consolidating concrete, concrete construction. Prog Struct Eng Mater 2005; 7:14–26.

[11] Bonen, D., et al. "Robustness of self-consolidating concrete." 5th Int. RILEM Symp. on Self-Compacting Concrete, RILEM, Bagneux, France, (2007) 33–42.

[12] Kwan, A., and Ng, I.. "Optimum superplasticiser dosage and aggre- gate proportions for SCC." Mag. Concr. Res., 61(4), (2009) 281–292.

[13] ASTM C1610/C1610M-10. Test method for static segregation of self- consolidating concrete using column technique.

[14] :: Self Consolidating High Performance Concrete :: SCC Self Consolidation and Highly Flowable Concrete :: (selfconsolidatingconcrete.org)

[15] Panelized Wall System Manufacturers | HercuWall (hercutech.com)