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Self-Compacting Concrete - Robustness of SCC

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Abstract— *Self-compacting concrete (SCC) is an innovative concrete that does not require vibration for placing and compaction. It is able to flow under its own weight, completely filling formwork and achieving full compaction, even in the presence of congested reinforcement. In the sense of SCC the robustness can be defined as the property that resist the changes of SCC like segregation during and placement (dynamic stability) and post placement (static stability). In a broader and more practical sense robustness as the ability of a given mixture to maintain its fresh properties and uniformity during processing, casting.*

Keywords— Self-compacting concrete, consolidation, Slump flow, saturated surface dry, Robustness of SCC.

I. INTRODUCTION

Self-compacting concrete (SCC) is an innovative concrete that does not require vibration for placing and compaction. It is able to flow under its own weight, completely filling formwork and achieving full compaction, even in the presence of congested reinforcement. For SCC it is generally necessary to use super plasticizers in order to obtain high mobility. If large amount of powdered material or viscosity modifying admixtures are added then it also helps to eliminate the segregation. So SCC is designed to meet some specific application. This can be achieved by its some rheological properties which is Robustness of SCC. Self-consolidating concrete is a highly flow-able type of concrete that spreads into the form without the need of mechanical vibration. Self-compacting concrete is a non-segregating concrete that is placed by means of its own weight. The importance of self-compacting concrete is that maintains all concrete's durability and characteristics, meeting expected performance requirements. In certain instances the addition of super plasticizers and viscosity modifier are added to the mix, reducing bleeding and segregation. Concrete that segregates loses strength and results in honeycombed areas next to the formwork. A well designed SCC mix does not segregate**,** has high deformability and excellent stability characteristics

Benefits of Self Compacting Concrete:-

1. SCC can be placed at faster rate with no type of vibrating equipments.
2. Improved and more uniform architectural surface finish can be achieved.
3. Ease in filling in restricted sections and hard-to-reach areas.
4. Improved consolidation around reinforcement and good bond with reinforcement.
5. It saves time and labor cost.
6. Shorter construction periods which results in cost savings.
7. Increased jobsite safety by eliminating the need for compaction.
8. Minimizes the movements of ready mixed truck and pumps during placement.
9. Reduction in noise pollution and makes healthy nature at site.

Self-Compacting Concrete Uses

Self-compacting concrete has been used in bridges and even on pre-cast sections. One of the most remarkable projects built using self-compacting concrete is the Akashi-Kaikyo Suspension Bridge. In this project, the SCC was mixed on-site and pumped through a piping system to the specified point, located 200 meters away. On this particular project, the construction time was reduced from 2.5 years to 2 years. This type of concrete is ideal to be used in the following applications:

- Drilled shafts
- Columns
- Earth retaining systems
- Areas with high concentration of rebar and pipes/conduits

Self-Compacting Concrete Benefits:-

Using self-compacting concrete produce several benefits and advantages over regular concrete. Some of those benefits are:

- Improved constructability
- Labor reduction.
- Bond to reinforcing steel.
- Improved structural Integrity.
- Accelerates project schedules.
- Reduces skilled labor.
- Flows into complex forms.
- Reduces equipment wear.
- Minimizes voids on highly reinforced areas.
- Produces superior surface finishes.

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- Superior strength and durability.
- Allows for easier pumping procedure.
- Fast placement without vibration or mechanical consolidation.
- Lowering noise levels produced by mechanical vibrators. Produces a uniform surface.
- Allows for innovative architectural features.
- It is recommended for deep sections or long-span applications.
- Produces a wider variety of placement techniques.

Robustness of SCC- effects of ingredients on Rheology:-

A lack of robustness can be manifested in several ways that affects workability and the other assigned properties of SCC, i.e., flow ability, passing ability, and stability. Following is a review of the effects of ingredients on the rheological properties that affect robustness. The effects of entrapped air, silica fume, limestone, and moisture on the rheological properties. It has been shown that the air content increases the slump flow, reduces the plastic viscosity.

Robustness of SCC- effects of ingredients on segregation:-

Aggregate segregation, which is also referred to as sedimentation, is controlled by the viscosity and yield stress of the mixture, the binder density, aggregate size, aggregate density, as well as the content of fines. This implies that the stability of SCC (of low yield stress) can be enhanced by increasing both the viscosity and density of the matrix and by decreasing the maximum size and density of the aggregate. higher w:c ratio and/or SP:c ratio increase the susceptibility to segregation and vice-versa, lower w:c ratio and SP:c ratio increase stability and therefore robustness. The tendency of the aggregate to segregate depends on the properties of both the aggregate and the homogeneous matrix. Large aggregate size and high density decreases stability and vice-versa. However, within common ranges of SCC mixtures and densities of aggregate. Compared with ordinary concrete, the segregation resistance of self-consolidating concrete (SCC) are more sensitive to small variations of mix proportions such as dosage of super-plasticizer, and the size, volume, and gradation, as well as moisture content of the fine and coarse aggregates. To design a SCC mixture, which is robust against small variations in raw materials, it is critical to understand the mechanism of how mix proportions affect robustness. In this paper, modified segregation probe was used to study the effects of various mixture properties on static stability robustness of SCC. It was found that a static segregation rate equation is helpful to explain how paste rheology and aggregate properties affect robustness. Mixture properties, such as higher paste volume, lower super-plasticizer % by weight of cement, lower slump flow, smaller aggregate size, better gradation, and higher aggregate packing density may improve robustness. Among the aggregate properties, smaller aggregate size and better gradation seem to have more significant effects than higher aggregate packing density.

Robustness of SCC - Effect of Aggregate Moisture Content

The natural moisture content of aggregate affects the mixing water content in two ways:

1. If the moisture content of the aggregate is higher than saturated surface dry (SSD), then the amount of (free) mixing water in the mixture is reduced.
2. If the natural moisture content of the aggregate is lower than SSD, then the amount of mixing water is increased.

A strong influence on slump flow was observed by Sakai et al when the amount of water was changed by ± 5 kg/m^2. These effects were reduced when a viscosity agent was added to these mixtures. From slump flow test performed by the Japanese scientist Sakai et al it is observed that slump flow will increase by 100 mm if aggregate moisture content is increased by 1%.

Thus it can be concluded that the slump flow value tends to prominently decrease with an increase in natural moisture content of fine aggregate for mixtures with 0.35 w:c ratio as opposed to 0.5 w:c ratio.

The quality control manual for the National Precast Concrete Association (NPCA) states that surface moisture content shall be physically tested once a day prior to the first SCC batch, even when moisture probes are in use. If inline moisture meters are not used, both the Precast/Prestressed Concrete Institute and NPCA require that the moisture be manually measured at the beginning of each batching operation and every four hours of continuous batching or at any time a change in moisture content becomes apparent. A very robust mixture should be developed for production facilities that do not use in line moisture meters.

Robustness of SCC - Effect of mixing equipments

SCC is more sensitive from the point of view of designed target and mixing technique. Due to high cement content SCC requires more time in mixing than the ordinary concrete. Generally concrete is mixed with two mixers:

1. Tilting or forced pan mixers
2. Non-tilting or pug mill type mixers.

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II. TEST METHODS

Self compacting concrete is distinct by its certain properties like filling ability, passing ability, robustness and resistance to segregation. Many different methods are available for characterize the property of SCC but there is no only single method that will give all the property of SCC. The following tables show the different limits stated by researchers:

Sr. no.	Property	Range
1.	Slump flow diameter	500-700 mm
2.	T50cm	2-5 sec
3.	V-funnel	6-12 sec

Slump flow test:-

The slump flow test is used to assess the horizontal free flow of SCC in the absence of any obstruction. When the slump cone is lifted filled with the concrete the concrete flows. The average diameter of the concrete circle is a measure for the filling ability of the concrete. It measures the time taken in seconds from the instant the cone is lifted to the instant when horizontal flow reaches diameter of 500 mm.

Fig.1: Slump Flow

V-funnel test:-

This test is measured to measure the flow ability of the fresh concrete. In this test the funnel is filled about 12 liters of concrete and the time taken for it to fl9ow through the apparatus is measured. If the concrete shows the segregation, the flow time will increase significantly.

Fig.2: V-funnel test

L-box test:-

The passing ability is determined using the L- box test. The vertical section of the L-Box is filled with concrete, and then the gate lifted to let the concrete flow into the horizontal section. The height of the concrete at the end of the horizontal section is expressed as a proportion of that remaining in the vertical section (H2/H1). This is an indication of passing ability.

Fig.3: L-box test

4C – Rheometer test:-

The 4C-Rheometer is a system for automatic determination of the yield stress and plastic viscosity of Self-Compacting Concrete (SCC). The system is a PC automated slump flow test where the flow curve (spread vs. time) is determined using digital image analysis. The flow curve is subsequently compared to a database of simulated flow curves to give the yield stress and plastic viscosity.

Fig.4: Rheometer test

III. CONCLUSION

From the study of the paper we can conclude that the Self Compacting Concrete is the concrete of 20th century. The robustness is the most important property of SCC that makes it distinct and makes it possible to achieve its characteristics properties of consolidation.

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