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Influence of Properties of Coarse Aggregates on Self Compacting Concrete Mixes

B.H.V. PAI, KIRAN BHAT P., SHREELAXMI PRASHANTH, DHANALAKSHMI
Department of Civil Engineering, Manipal Institute of Technology, Manipal, India
Email: pkbhatbe@gmail.com

Abstract: Self-compacting concrete (SCC) is a flowing concrete mixture that consolidates under its own weight. The highly fluid nature of SCC makes it suitable for placing in difficult conditions and in sections with congested reinforcement. Properties of coarse aggregates is one of these factors that has a significant influence on behaviour of SCC. In this study, two SCC mixes have been designed using two kind of aggregates. It was found that the rheological tests conducted on fresh SCC such as slump flow, L-box, U-box and V-funnel are sufficient to ascertain SCC attributes. Compressive strength of the mixes were tested after water curing for 28 days. Comparative study on performance of SCC mixes with the two different types of coarse aggregates is also made.

Keywords: *SCC, Rheology, Coarse Aggregates, Compressive Strength.*

Introduction:

Self-compacting concrete (SCC) is a flowing concrete mixture that is able to consolidate under its own weight. The highly fluid nature of SCC makes it suitable for placing in difficult conditions and in sections with congested reinforcement. Use of SCC can also help minimize hearing-related damages on the worksite that are induced by vibration of concrete. Another advantage of SCC is that the time required to place in large sections is considerably reduced.

SCC allows the construction of more slender building elements and more complicated and interesting shapes [1]. The use of chemical admixture is an essential ingredient of SCC in order to increase the workability and reduce segregation. Coarse aggregate content and the water to binder ratio in SCC are usually lower than those of normal concrete. Therefore SCC contains large amounts of fine particles such as, blast-furnace slag, fly ash and lime powder in order to avoid gravity segregation of larger particles in the fresh mix [2-3].

The aggregate size, shape and surface texture plays a vital role in the design and performance of concrete mixes. The aggregate size has a direct effect on the properties such as the density, voids, strength, workability etc., of the concrete mixes. It also influences the concrete mix properties such as powder content, air voids, voids filled with powder, stability, flow values durability, fatigue life etc. it may therefore be mentioned that almost all the mix properties depend on the size and proportions of coarse and fine aggregate in the mix. It is also necessary to provide the concrete with the ability to pass between the steel reinforcing (especially in congested reinforcements) bars to make it self-compacting, this is achieved by controlling the rheological properties of mortar and volume of coarse aggregate [4]. Many researchers have been able to produce self-compacting concrete with locally available aggregate. There have been several studies on the effect of coarse aggregate content on the flow behaviour of SCC [5-6-7]. Fly ash and rice husk ash have also been used in making of SCC [8].

Five different coarse aggregate types such as basalt, marble, dolomite, limestone and sand stone were used to produce SCC containing fly ash. The water to binder ratio was maintained at 0.33 for all mixture [9].

In this study, two SCC mixes have been designed using two kinds of aggregates. It was found that the rheological tests conducted on fresh SCC such as slump flow, L-box, U-box and V-funnel are sufficient to ascertain SCC attributes. Compressive strength of the mixes were also tested after water curing for 28 days. Comparative study on performance of SCC mixes with the two different types of coarse aggregates has also been made.

Experimental methodology:

SCC mixes were designed using the method proposed by Nan su, et al. (2001) [10]. The brief procedure of mix design is as follows:

Step 1: calculation of coarse and fine aggregate contents

Step 2: calculation of cement content

Step 3: calculation of mixing water content required by cement

Step 4: calculation of fly ash (FA) and ground granulated blast-furnace slag (GGBS) contents

Step 5: calculation of mixing water content needed in SCC

Step 6: calculation of SP dosage

Step 7: adjustment of mixing water content needed in SCC

Step 8: trial mixes and tests on SCC properties

Trial mixes are carried out using the contents of materials calculated as above. Then, quality control tests for SCC were performed.

Step 9: adjustment of mix proportion

Adjustments were made until all properties of SCC were satisfied the requirements specified in the design.

The mix proportion was done based on the method proposed by Nan Su, et al. (2001). The mix designs were carried out for concrete grade of M25. This method was preferred as it has the advantage of considering the strength of the SCC mix. All the ingredients were first mixed in dry condition. Then 70% of the calculated amount of water was to be added to the dry mix and mixed thoroughly. Then, 30% of water was mixed with the super-plasticizer and included in the mix. Then, the mix was checked for self compactability by flow test, V-funnel test, L-Box test and U-Box test. The results of these tests have been shown in table 1.

By trial and error method the mix was optimized to the right proportion.

Tests conducted on fresh SCC

In order to ascertain the properties of SCC following test were conducted on the concrete;

1. Slump Flow test
2. L-Box test
3. V-Funnel test
4. U-Box test

Casting and Curing

The mix proportions has been shown in table 2, The cube moulds made of metal and of split type with a metal base plate having a plane surface and having inner dimensions of 150mm x 150mm x 150mm were used. Care was taken that there is no gap left from where there is any possibility of leakage of slurry. Careful procedure was adopted in the batching, mixing and casting operations. The coarse aggregates and fine aggregates were weighed first to an accuracy of 0.5 grams and the concrete mixture was prepared. No compaction or vibration was given while placing the concrete. Before placing the concrete in the mould its interior surface and base plate was cleaned and lightly oiled. The curing process started with the mould being left in place at temperature of 27° ± 2°C for 24hrs, to allow sufficient bonding between the aggregate particles. After de-moulding the specimens were allowed for curing. The specimens were cured until the day of testing and the specimens were tested wet as per Indian standards.

After 28 days of water curing the cube specimens were tested for their compressive strengths.

Table 1 *- Properties of Fresh Concrete*

Fresh properties of SCC mix M25 grade								
S.No.	Type of coarse aggregate	Slump Flow		V Funnel	L-box			U-box
		Slump mm	Time in s	Time in s	T20 in s	T40 in s	Blocking Ratio	(H_2 - H_1) in mm
1	Trap	710	8	8	2	4	0.882	20
2	Dolomite	750	9	10	2	4	0.857	15

Table 2 *- Mix proportion for M25 grade SCC*

Coarse Aggregates (kg/m^3)	Fine Aggregates (kg/m^3)	Cement (kg/m^3)	GGBS (kg/m^3)	Water (kg/m^3)	Super-plasticizer (l/m^3)	Retarder (l/m^3)
715	892	430.2	86	256.986	8.04	2.68

Results and discussions:

Table 1, shows the properties of two SCC mixes prepared by using two different aggregates. Slump of the SCC mixes satisfy the EFNARC guidelines, which means that both the mixes have filling ability. Maximum slump was obtained for dolomite aggregates. The results of L-box test signifies passing ability of the concrete mix in congested reinforcements. The values of the blocking ratio falls within the range prescribed by EFNARC.

Compressive Strength

Compressive strength being the most desired property of any concrete mix, need to be tested for the suitability for any prescribed mix.

Table 3 shows the compressive strength of SCC mixes prepared with two kinds of aggregates. The mixes were designed for the compressive strength of 25MPa. SCC mix prepared by Trap and Dolomite aggregates possesses a compressive strength of 35.23 MPa and 33.63 MPa respectively.

Table 3*: Compressive strength for M25 grade SCC.*

S.No.	Type of coarse aggregate	28 – days compressive strength in N/mm^2
1	Trap	35.23
2	Dolomite	33.63

Conclusions:

SCC prepared with both the aggregates satisfy the recommendations provided by EFNARC. Higher slump was obtained for SCC with dolomite aggregates. Dolomite aggregate exhibits slightly better compressive strength characteristics compared to trap aggregate. Dolomite aggregate being an igneous rock perform better in fresh as well as hardened state.

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