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A Study on Mechanical Properties of SCC by Replacing Cement with Stone Dust

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Abstract: Self-compacting concrete (SCC) represents a milestone in concrete research. SCC is a highly flowable, non-segregating concrete that can spread in to place, fill the formwork and encapsulate the reinforcement without any mechanical vibration for consolidation. SCC was originally developed at the University of Tokyo, Japan during the year 1986 by Prof. Okamura and his team to improve the quality of construction and also to overcome the problems of defective workmanship.

Concrete technology has made significant advances in recent years which results in economical improvement of the strength of concrete. Generally SCC can be obtained by using mineral admixtures like fly ash as a filler material. Along with this more experimental works are done on the strength of the concrete by replacing the cement with GGBS, SILICA FUME etc. to make the concrete economical and strength gained. The one of the cheapest substitute for powder content is quarry dust.

Quarry dust, a by-product from the crushing process during quarrying activities is one of the materials being studied and fly ash is an artificial pozzolanic material, a finely divided Pozzolana form compounds which have cementitious properties, when mixed with hydrated lime and alkalies.

In this work, the fresh and compressive strength properties of self-compacting concrete when the cement is partially replaced with stone dust , when the filler materials used is fly ash in % of the total powder content and when both substituent's are implemented simultaneously. A compressive and split tensile strength comparison is given between NCC and SCC mix.

The results indicated that the incorporation of Stone dust into the self-compacting Concrete mix as partial replacement material to cement along with fly ash shows an increment in the strength takes place by increasing the % of replacement and the replacement of % used in this work is 15%, 25%, 40% respectively.

I. GENERAL

Casting concrete in heavily reinforced sections, such as those in columns, beams, moment-resisting frames, seismic areas and in some repair sections, makes the placement of concrete quite difficult. Providing proper consolidation requires internal or external vibration that can be critical in sections with high-density reinforcement. Ensuring thorough consolidation at critical sections with durability and safety concerns is essential and can often depend on the competence of the vibrating crew to ensure adequate consolidation. Using standard vibration techniques with conventional concrete, which is not workable enough may lead to surface and structural defects resulting from lack of proper bond development between the concrete and the reinforcement as well as the entrapment of air voids in the concrete.

Flowable concrete is normally used to reduce labour cost and construction time. Such concrete can have slump consistency close to 200 mm to facilitate placement and consolidation. However, special attention should be given at the time of vibrating and consolidation of the plastic concrete in order to avoid segregation and bleeding, which may further impair structural performance and surface quality.

II. LITERATURE REVIEW

S. N. Raman, M. F. M. Zain, H. B. Mahmud, K. S. 2004 Has done experiments to find the Suitability of Quarry Dust as Partial Replacement Material for Sand in Concrete The reduction in the sources of natural sand and the requirement for reduction in the cost of concrete production has resulted in the increased need to identify substitute material to sand as fine aggregates in the production of concretes. Quarry dust, a by-product from the crushing process during quarrying activities is one of the materials being studied in their experimental study. They have undertaken to investigate some properties of quarry dust and discusses the suitability of those properties to enable quarry dust to be used as partial replacement material for sand in concrete. The properties of quarry dust that were determined are aggregate crushing value, flakiness index, pH value, soundness, specific gravity, absorption and fineness modulus. Besides, the 28th day compressive strength of concrete specimens, in which partial replacement of river sand with quarry dust were practiced, is also reported for comparison purposes. Results obtained indicate that the incorporation of quarry dust into the concrete mix as partial replacement material to river sand resulted in lower compressive strength at 28th day of curing.

This can partly be attributed to the properties of the quarry dust which might contribute to the negative effects in the strength of the concrete. The results of the study also indicates that quarry dust can be utilized as partial replacement material to sand, in the presence of silica fume or fly ash, to produce concretes with fair ranges of compressive strength

S.Venkateswara Rao, M.V. Seshagiri Rao, P. Rathish Kumar 2010 has studied the Effect of Size of Aggregate and Fines on Standard and High Strength Self Compacting Concrete.

Their investigation aims at developing standard and high strength Self Compacting Concrete (SCC) with different sizes of aggregate based on Nansu's mix design procedure. The results indicated that Self Compacting Concrete can be developed with all sizes of graded aggregate satisfying the SCC characteristics. The mechanical properties viz., compressive strength, flexural strength and split tensile strengths were studied at the end of 3, 7 and 28 days for standard and high strength SCC with different sizes of aggregate. It was noted that with 10mm size aggregate and 52% fly ash in total powder content the mechanical properties were superior in standard SCC, while 16 mm size aggregate with a 31% fly ash in total powder content improved the properties of high strength SCC.

BinuSukumar, K. Nagamani, R. SrinivasaRaghavan 2008 has studied the Evaluation of strength at early ages of self-compacting concrete with high volume of fly ash. Self-compacting concrete (SCC) demands large amount of powder content and fines for its cohesiveness and ability to flow with out bleeding and segregation. In their investigation part of this powder is replaced with high volume fly ash based on a rational mix design method developed by the authors. Because of high fly ash content, it is essential to study the development of strength at early ages of curing which may prove to be a significant factor for the removal of formwork. Rate of gain in strength at different periods of curing such as 12 h, 18 h, 1 day, 3 days, 7 days, 21 days and 28 days are studied for various grades of different SCC mixes and suitable relations have been established for the gain in strength at the early ages in comparison to the conventional concrete of same grades. Relations have also been formulated for compressive strength and split tensile strength for different grades of SCC mixes

III. EXPERIMENTAL PROGRAM

A. Materials Used

1) *Cement:* Cement used in the investigation was 53 Grade ordinary Portland cement (fly ash free) confirming to IS: 1489(part-1). The cement was obtained from a single consignment and of the same grade and same source. Procuring the cement it was stored properly.
2) *Fine Aggregate:* The fine aggregate conforming to Zone-II according to IS: 383 were used which was later corrected to Zone-III in the mix design. The fine aggregate used was obtained from a nearby river source. The test results on cement are shown below.
3) *Coarse Aggregate:* Crushed granite Aggregate was used as coarse aggregate. For each concrete strength level, there is optimum size for the coarse aggregate that will yield the greatest compressive strength per unit mass of concrete. In general smaller size aggregate will result in a higher compressive strength concrete on the other hand largest possible size of aggregate important in increasing the modulus of elasticity (or) reducing the creep and shrinkage.

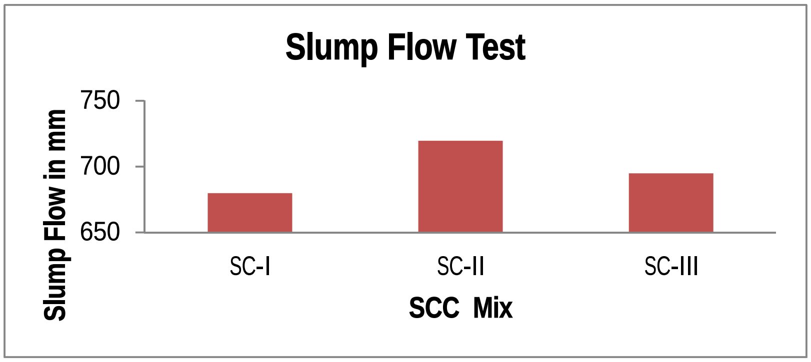
The coarse aggregate was obtained from a local crushing unit and size of aggregates used are 20mm and 10mm according to IS: 383. In order to do corrosion test small cubes have to be casted .According to IS: 383 the maximum size of the aggregate used should be 5 times the aggregate size.

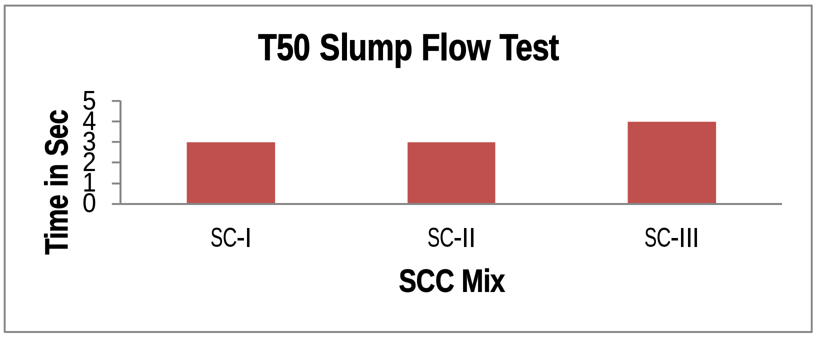
The enormous flow ability of the SCC stipulates two changes in the composition of the SCC-mix. These concern the amount of powder and the admixtures. The amount of powder (particles with grain size 0, 25 mm) rises up to 600 kg/m³ while the amount of coarse aggregate decreases. As additional powders quartz- and limestone or latent hydraulic (blast furnace slag) or pozzolonic additives (fly ash) may be used. Fly ash is a fine inorganic material with pozzolonic properties, which can be added to SCC to improve its properties.

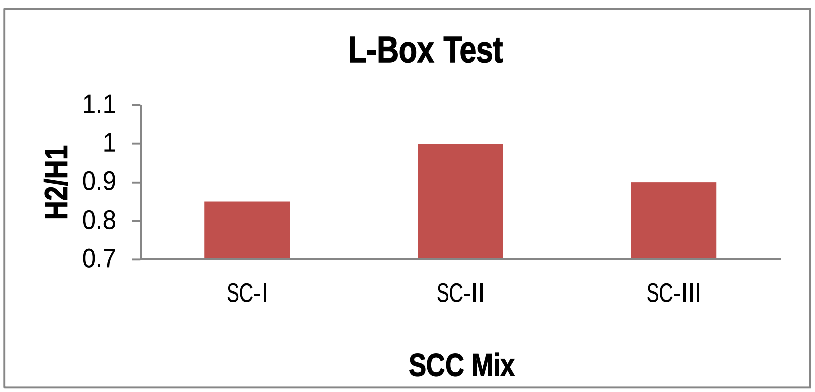
However the dimensional stability may be affected and should be checked. The content of water to be used is equal to ordinary concrete. The high flow ability is obtained by the addition of super plasticizer with an extreme high efficiency based on polycarboxylate ether or with a combination of admixtures enhancing flow ability, viscosity and stability. Since the extremely high flow ability should remain as long as possible, the interaction of fillers and admixtures is very important for the performance of the SCC

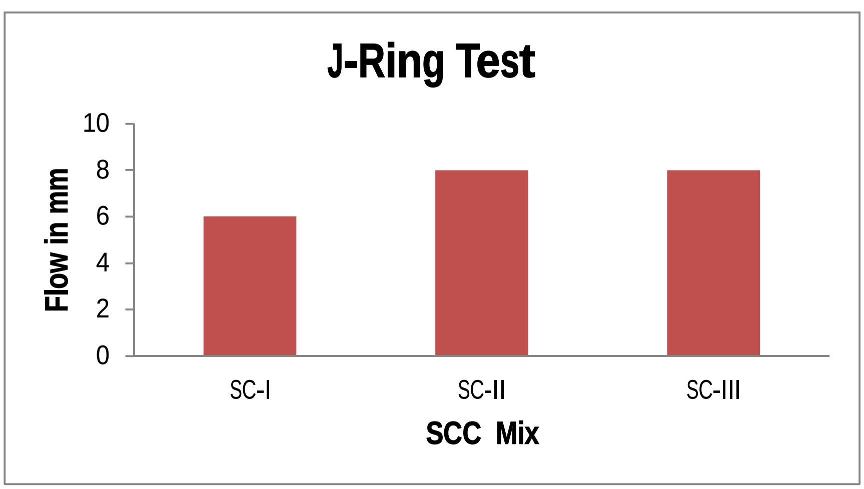
IV. RESULTS AND DISCUSSIONS

A. *Test Results of Fresh Properties OF SCC*









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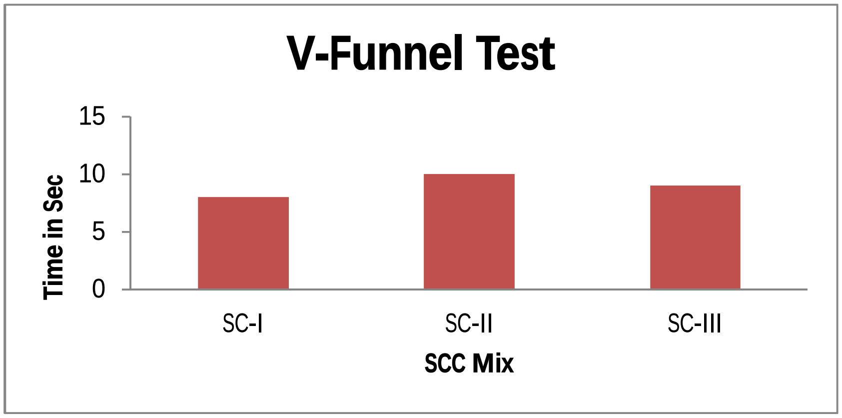
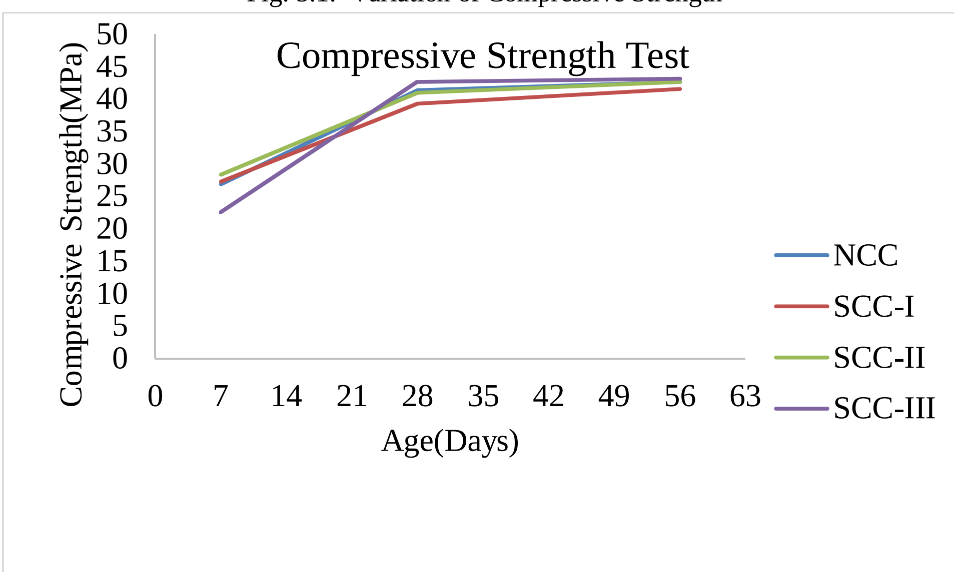


Table 5.2: Compressive Strength of cubes

No. of days / MIX	7 days (Mpa)	28 days (Mpa)	56 days (Mpa)
N.C.C.	26.90	41.36	42.62
S.C.C.-I	27.25	39.32	41.58
S.C.C.-II	28.36	40.92	42.65
S.C.C.-III	22.56	42.58	43.15

Fig. 5.1: Variation of Compressive Strength



B. Split Tensile Strength Test on Cylinders

This test was developed in Brazil in 1943. Sometimes this test is also called as Brazilian test. However at about the same period this test was also developed in Japan independently.

The Cylinder specimen is of the size 150 mm diameters and 300 mm length. The test is carried out by placing a cylindrical specimen horizontally between the loading surfaces of the compression testing machine and the load is applied until failure of cylinder, along the vertical diameter. The cylinder specimens are tested at 7 days, 28 days and 56 days. The average of three specimens was reported as the split tensile strength provided the individual variation is not more than 15% of average value.

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Table 5.3:SplitTensile Strength of Cylinders

No. of days / MIX	7 days (Mpa)	28 days (Mpa)	56 days (Mpa)
N.C.C.	2.17	3.05	3.27
S.C.C.-I	2.66	3.24	3.50
S.C.C.-II	2.73	3.52	3.74
S.C.C.-III	2.82	3.42	3.73

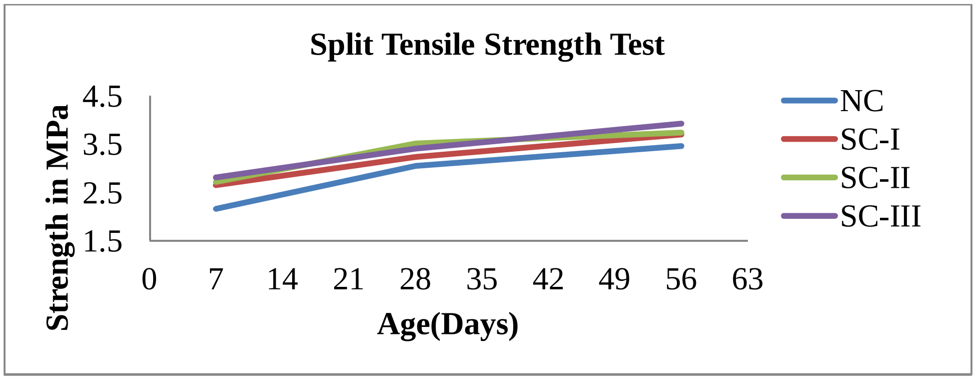

Fig. 5.2 : Variation of Split Tensile Strength

V. CONCLUSIONS

The following are the conclusions obtained after performing the above experiments

A. From the above study it was concluded that increasing the amount of stone dust decreases the slump flow value, v-funnel value and T_{50} value due to the irregular shape and flakiness of stone dust.
B. By observing above results we can conclude that by increasing the percentage of replacement of cement with stone dust strength is also increases. And With increase in Fly ash content in the total powder the rate of increase in strength is observed as the days of curing increases.
C. The workability of SCC is equilibrium at fluidity, deformability, filling ability and resistance to segregation. This equilibrium has to be maintained for a sufficient time period to allow for transportation, placing and finishing.
D. The maximum 28 days split tensile strength was obtained with 25% replacement of powder content and the strength is about 13% more at 28 days of curing compared to the NCC mix.
E. From the results obtained we can conclude that the maximum workability and strength properties can be obtained by 25% replacement of powder content.

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