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A Study on self-Compacting Concrete Using Portland Slag Cement with Partial Replacement of Fine Aggregate by Foundry Sand

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ABSTRACT
Concrete plays a vital role as a construction material in the world. In the present scenario, waste materials from various industries are added to the mix. Over 400 million tons of waste materials are being produced by various industries every year. Foundries successfully recycle and reuse the sand many times in a foundry. When the sand can no longer be reused in the foundry, it is removed from the foundry and is termed as Foundry sand. Foundry sand production is nearly 6 to 10 million tons annually. There is a possibility of substituting natural fine aggregate with waste foundry sand which offers technical, economic and environmental advantages which are of great use in the construction sector. The construction industry is now slowly becoming aware of the environmental issues and other sustainable development issues for cement and concrete industries. It is looking for the ways and means to develop building products, which will increase the life span and quality. This thesis presents an experimental investigation on strength aspects like compressive, split tensile and flexural strength of Self Compacting Concrete (SSC) containing an industrial waste foundry sand. It is used as fine aggregate in varying proportions, replacing the fine aggregate with foundry sand as percentages of 0%, 25%, 50%, 75%, 100%. For this green SCC, all SCC tests are performed as per EFNARC guidelines i.e. slump flow, L-box, V funnel and T50 tests are carried out.

I. INTRODUCTION

One of the most outstanding advances in the concrete technology over the last decade is Self Compacting Concrete (SCC). Self Compacting Concrete (SCC) is one of the major branches of High Performance Concrete (HPC) which is a boon to the fast growing precast industry. The SCC as the name suggests, does not require to be vibrated to achieve full compaction. Self Compacting Concrete is a highly flowable. The use of SCC is it enhances surface finish characteristics, reduces labour costs and conserves energy. With the growth of construction activities in India there is severe cement crisis to meet the demands of the construction industry. To meet the demands now-a-days almost all the major cement manufacturers are producing blended cements consisting of Portland Pozzolana Cement (PPC) and Portland Slag Cement (PSC) where PSC has a significant presence in the Indian market as far as the production and usage is concerned. Now there is a need to design concrete using these blended cements to address the demands of the construction industry with different replacement of industrial wastes as fine aggregates. Therefore, evaluating selected industrial wastes for civil engineering construction is encouraged by many countries. Using industrial wastes helps in conserving natural resources, brings about a pollution free environment as well as reduces cost of construction. To conduct feasibility study of producing Self Compacting Concrete SCC of grade M30 by varying replacements of fine aggregate with foundry sand. To evaluate the fresh concrete characteristics in terms Slump flow, V-funnel flow time, L-box blocking ratio. To evaluate the compressive strength, split tensile strength and flexural strength of self compacting concrete at 3, 7 & 28 days by varying replacements of the fine aggregate with foundry sand as 0%, 25%, 50%, 75%, 100%. The scope of the present investigation is to study and evaluate the effect of replacement of fine aggregate with industrial waste foundry sand in the self-compacting concrete. Fresh concrete tests such as slump flow value, V-funnel flow time, L-box blocking ratio are investigated

II. LITERATURE REVIEW

Nan Su et al (2001**),** proposed a new mix design method for self-compacting concrete. The amount of aggregates, binders and mixing water, as well as type and dosage of super plasticizer to be used are the major factors influencing the properties of SCC. Slump flow, V-funnel, L-flow, U-box and compressive strength tests were carried out to examine the performance of SCC, and the results indicated that the proposed method could be used to produce successfully SCC of high quality. Sri Ravindrarajah et al (2003), made an attempt to increase the stability of fresh concrete (cohesiveness) using increased amount of fine materials in the mixes. The systematic experimental approach showed that partial replacement of coarse and fine aggregate with finer materials could produce self compacting concrete with low segregation potential as assessed by the V-Funnel test. The results showed that fly ash could be used successfully in producing self compacting high strength concrete with reduced segregation potential. It was also reported that fly ash in self compacting concrete helps in improving the strength beyond 28 days. Suraj N. Shah., Shweta S. Sutar, Yogesh Bhagwat (2008), carried out an experimental study on to find out the effect of addition of red mud, which is a waste product from the aluminium industries, and foundry waste sand, which is a waste product from foundry, on the properties of self compacting concrete containing two admixtures and experimentation combinations of admixtures which is taken Super plasticizer & VMA. Nima Farzadnia et al. (2012) explored the possibility of incorporating mineral admixtures in sustainable high performance concrete. It was found that mineral admixtures, whether industrial by products or agro-waste minerals, used to reduce cost of concrete. The previous efforts and attempts in the field of SCC were concerned with Ordinary Portland Cement (OPC) and with the replacement of fine aggregates with any industrial wastes. There is a lack of knowledge regarding the utilization of Portland slag cement (PSC) with replacement of fine aggregates with industrial waste like foundry sand in the development of Self compacting concrete. Therefore an attempt was carried out here to investigate the effect of replacement of fine aggregate with foundry sand on the properties of SCC when PSC was used.

III. MATERIAL AND METHODOLOGY

3.1 Materials Used

3.1.1 Cement

The cement used for the investigation was Ordinary Portland Slag Cement (PSC) with brand JAYPEE cement confirming to IS: 455-1989. The cement is fresh and is of uniform colour and consistency. It is free from lumps and foreign matter. The specific gravity was found to be 2.94.

3.1.2 FINE AGGREGATE

The fine aggregate used in the present experimental programme is conventional sand confirming to zone –II as per 383: 1970. It is clean, inert and free from organic matter, silt and clay.The specific gravity was found to be 2.45.

3.1.3 FOUNDRY SAND

The fine aggregate used in the present experimental programme is foundry sand confirming to zone - III as per 383: 1970. It is clean, inert and free from organic matter, silt**.** The specific gravity was found to be 2.39.

3.1.4 COARSE AGGREGATE

The coarse aggregate used, was from an established quarry satisfying the requirements of IS 383: 1970. In this experimental programme aggregates of only 10mm size are used. The parameters specific gravity, bulk density, water absorption and fineness modulus were determined. The specific gravity was found to be 2.76.

3.1.5 ADMIXTURE

Chemical admixtures reduce the cost of construction, modify the properties of concrete and improve the quality of concrete during mixing, transportation, placing and curing. Commercially available poly carboxylate ether(PCE)-based super plasticizer (SP) Master Glenium SKY 8630 was used in all the self-compacting concrete mixtures. It is an F-type high-range water reducer, in conformity with ASTM:C 494, IS 9103:1999 & IS 2645:2003.

3.1.6 Water

The water used for cement mixing was potable water collected from the laboratory taps conforming to IS 456-2000. Water from the same source was used for curing the specimens.

3.2 Methodology

Five different mixes (SCC0, SCC25, SCC50, SCC75 and SCC100) were employed to examine the influence of foundry sand in SCC on the fresh and hardened concrete when PSC cement was used. . SCC0 is the basic mix in which only conventional sand is used as the fine aggregate. In mixes SCC25, SCC50, SCC75 and SCC100 the fine aggregate is replaced by the foundry sand as 0%, 25% 50%, 75% and 100% (by mass) respectively. The essential component of SCC is a high range water reducer (HRWRA) which is also known as super plasticizer. Several trial mixes were conducted to determine the optimum dosage of superplasticizer for each of the mixtures in order to achieve the required self compacting properties as per EFNARC standards.

3.2.1 MIXING AND CASTING DETAILS

All the materials were mixed using pan mixer with a maximum capacity of 80litres. The materials were fed into the mixer in the order of coarse aggregates, PSC and sand. The materials were mixed dry for 1.5min. Subsequently three-quarters of the water is added, followed by the superplasticizer and the remaining water, while mixing continued for a further 6 min in order to obtain a homogenous mixture. Upon discharging from the mixer, the self compactibility tests were conducted on the fresh concrete for each mixture. Then the fresh concrete was placed into the steel cube moulds and allowed to compact without any vibration. Finally, surface finishing was done carefully to obtain a uniform smooth surface.

150 × 150 × 150 mm cubes were cast for compressive strength. For split tensile strength 150 × 300 mm cylinders were cast. For the flexural strength beams of 100 × 100 × 500 mm were cast. After casting, all the test specimens were kept at room temperature for 24 hours and then demoulded. These were then placed in the water curing tank.

3.2.2 TESTING OF THE SPECIMENS

(i) Fresh Concrete Tests

For determining the self-compatibility properties (slump flow, T50 time, V-funnel flow time, L-box blocking ratio) tests were performed on all the mixtures. These tests were performed in accordance with EFNARC standards.

(ii) Hardened Tests

The compressive strength was obtained, at a loading rate of 140 Kg/cm^2/min at the age of 3, 7 & 28 days on 3000KN Compression testing machine.

The average compressive strength of three specimens was considered at each age. The split tensile strength was also tested on the same machine at the age of 3, 7 & 28 days. The flexural strength was tested on the Universal testing machine at the age 3, 7 & 28 days. All these three tests were performed according to the Bureau of IndianStandards516:1959.

IV. RESULTS AND DISCUSSIONS

4.1 Compressive Strength

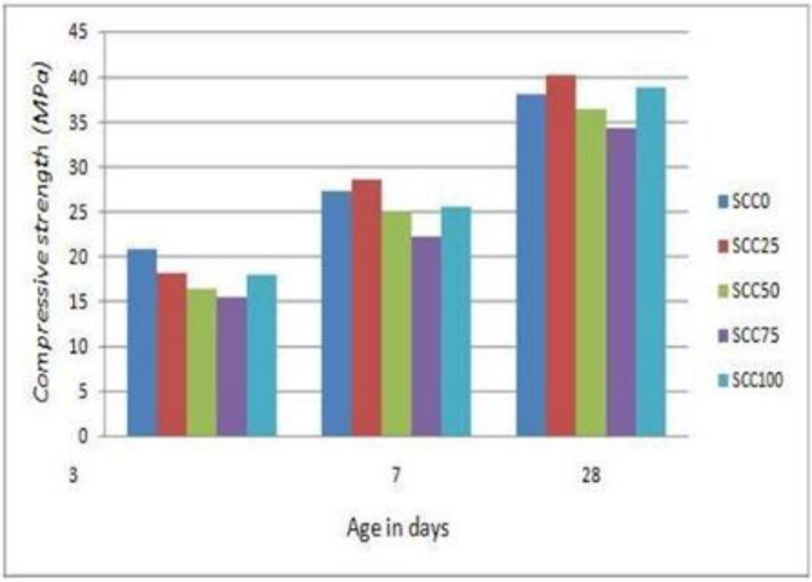
From the Table 2 and Chart 1, it is clear that with the increase in percentage of foundry sand as fine aggregate, the compressive strength have been increasing from 0% to 25% and it is steadily decreasing for 50% and 75% and again increasing for 100% foundry sand. It is observed that the SCC with foundry sand as 25% replacement of the fine aggregate has shown better performance.

Table – 1: Concrete mixture proportions in Kg/m^3

Constituent	SCC0	SCC25	SCC50	SCC75	SCC100
PSC	450	450	450	450	450
Water	202.5	202.5	202.5	202.5	202.5
Water/Binder Ratio	0.45	0.45	0.45	0.45	0.45
Conventional Sand	836.5	627.35	418.23	209.11	0
Foundary Sand	0	204	408	612	816
10 mm	770.1	770.1	770.1	770.1	770.1
Chemical Admixture 0.9%	4.05	4.05	4.05	4.05	4.05
Slump Value in mm	640	600	400	320	300
Density of concrete	2259.1	2253.9	2248.8	2243.7	2238.6

Table-2: Compressive Strength of Different Mixes at Different Ages of Concrete:

Mix notation	Compressive Strength (MPA)		
	3rd day	7th day	28th day
SCC0	20.89	27.33	38.1
SCC25	18.22	28.66	40.29
SCC50	16.44	25.11	36.45
SCC75	15.55	22.22	34.33
SCC100	18	25.55	38.89



CHART–1: Compressive strength of different mixes at different ages

4.2 Split Tensile Strength

From the Table 3 and Chart 2, it is clear that with the increase in percentage of foundry sand as fine aggregate, the split tensile strength have been increasing from 0% to 25% and it is steadily decreasing for 50% and 75% and again increasing for 100%. It is observed that the SCC with foundry sand as 25% replacement of the fine aggregate has shown better performance.

Table – 3: Split Tensile Strength of Different Mixes for Different Ages of Concrete:

Mix notation	Split Tensile strength (MPA)		
	3rd day	7th day	28th day
SCC0	2.05	2.37	3.18
SCC25	1.98	2.44	3.39
SCC50	1.63	2.37	3.11
SCC75	1.52	2.24	2.88
SCC100	1.95	2.51	3.36

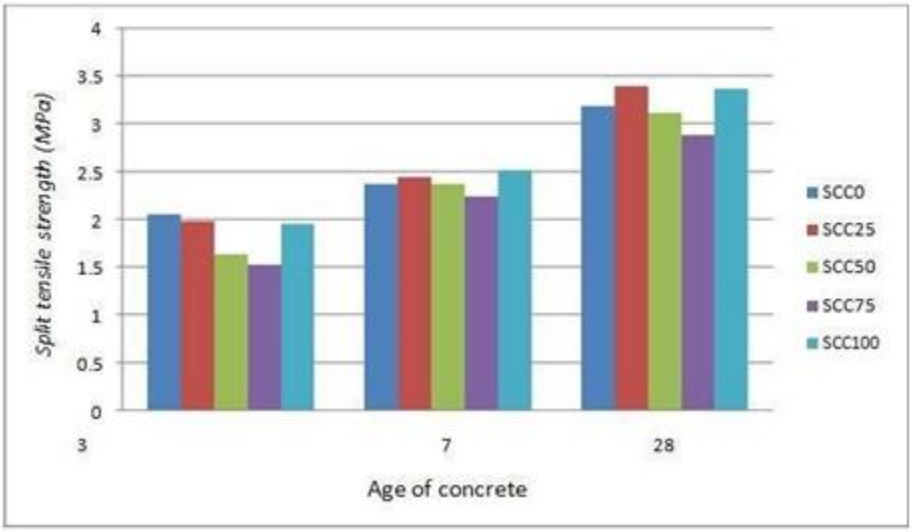


Chart – 2: Split tensile strength of different mixes at different ages

4.3 Flexural strength

From the Table 4 and Chart 3, it is clear that with the increase in percentage of foundry sand as fine aggregate, the flexural strengths have been increasing from 0% to 25% and it is steadily decreasing for 50% and 75% and again increasing for 100%. It is observed that the SCC with foundry sand as 25% replacement of the fine aggregate has shown better performance.

Table – 4: Flexural Strength of Different Mixes for Different Ages of Concrete:

Mix notation	Flexural strength (MPA)		
	3rd day	7th day	28th day
SCC0	3.22	4.82	6.48
SCC25	3.92	4.97	6.57
SCC50	3.65	4.61	5.97
SCC75	3.49	4.57	5.78
SCC100	3.23	4.55	6.23

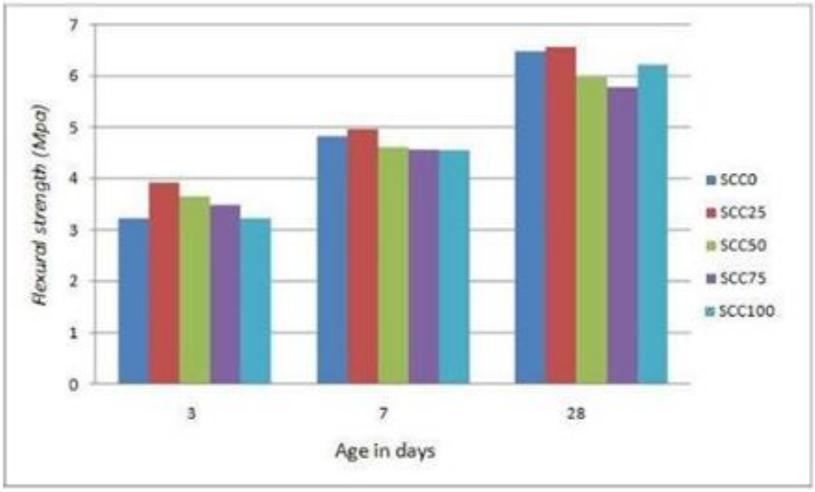


Chart – 3: Flexural strength Vs Age in days

IV. CONCLUSION

1. It is observed that when conventional sand is used as fine aggregate, the characteristic strength and workability are achieved. With the increase in percentage of foundry sand the characteristic strengths are achieved but workability is decreased.
2. It is observed that the workability tests on fresh concrete such as slump flow, V-funnel, L-box are measured. As the percentage replacement of foundry sand is increasing in the fine aggregate from 0% to 100%, the slump value is decreasing. There is almost no slump flow indicating that SCC with foundry sand as fine aggregate doesn't exhibit workability with this mix design.
3. With the increasing replacement of foundry sand percentage in the fine aggregate, V-funnel values are increasing and L-box blocking ratio are decreasing.
4. When 25% conventional sand is replaced by foundry sand, the compressive strength is maximum and increased by 5.75%.
5. When 25% conventional sand is replaced by foundry sand, the split tensile strength is maximum and increased by 6.60%.
6. When 25% conventional sand is replaced by foundry sand, the flexural strength is maximum and increased by 1.4%.
7. It is also observed that the values are increasing in age of SCC for Compressive, Split tensile strength and flexural strength the maximum strength is obtained with 25% replacement of foundry sand.

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