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RESEARCH ARTICLE

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EXPERIMENTAL INVESTIGATION OF FRESH AND HARDENED PROPERTIES OF SCC WITH STEEL SLAG AND LIMESTONE POWDER

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ABSTRACT

In this study, the benefits of steel slag and limestone powder as partial replacement of SCC are established. Furthermore concrete occupies the major position among the modern construction materials, consisting of a hard, chemically inert substance, known as aggregate (usually made for different types of sand and gravel), that is bond by cement and water. Self compacting concrete (SCC) with steel slag and lime stone powder is a high performance concrete that can flow under its own weight to completely fill the form work and self consolidates without any mechanical vibration. Such concrete can accelerate the placement, reduce the labor requirements needed for consolidation finishing and eliminate environmental pollution. The so called first generation of SCC is used mainly for repair application and for casting concrete in restricted areas, including the sections that present limited access to vibrate. Such value added construction materials has been used in application justifying the higher material and quality control cost when considering the simplified placement and handling requirement of the concrete. Specially formulated high range water reducers are used to reduce the yield stress to point which allows the designed free flowing characteristics of the concrete. However, this alone may result in segregation if the viscosity of the paste is not sufficient to support the aggregate particles in suspension. The process of selecting suitable ingredients of concrete like steel slag and lime stone powder and determining their relative amounts with an objective of producing a concrete of required strength , durability and workability as economically as possible is termed as concrete mix design.

Keywords--- Coarse aggregate, Steel Slag, Limestone Powder

I. INTRODUCTION

Science and technology advances at a rapid rate and has revolutionalised every fields of day to day life. Construction industry also has equipped with many new technologies that replaces the outdated traditional methods. One of such innovation led to the formation of self compacting concrete (SCC) which does not require any manual or mechanical vibrators for its compaction. It flows under its own weight filling all the voids and spaces and achieving full compaction even in the presence of highly congested reinforcements. It was developed by Okamura and associates in Japan during 1988 and considered as a highly workable concrete that can flow through densely reinforced and complex structural elements and adequately fill all voids without segregation, excessive bleeding and the need for vibration or other mechanical consolidation. The unique characteristics of SCC are a rapid rate of concrete placement with very less time. SCC offers a very high level of homogeneity; minimize the concrete void spaces and have uniform concrete strength and also provides the superior level of finishing and durability of structure. SCC also achieves same engineering properties and durability as traditional vibrated concrete. In recent years, the use of SCC has gained a wider acceptance.

The SCC essentially eliminates the need for vibration to consolidate the concrete. This result in an increase in productivity, a reduction in noise exposure and a finished product with few if any external blemishes such as "bug holes". However, after completion of proper proportioning, mixing, placing, curing and consolidation, hardened concrete becomes a strong, durable, and practically impermeable building material that requires no maintenance. The reported study was undertaken to examine the effect of Steel slag and Limestone powder on fresh and mechanical performance of self compacting concrete. The use of Steel slag in the SCC is a relatively new research area on which a very limited scientific research has been carried out. This study discusses the experimental results of performance of steel slag aggregates in self compacting concrete

II. EXPERIMENTAL INVESTIGATION

The study follows a clear and planned methodology. The first step was to conduct the literature survey. The Steel slag aggregates were collected from a single source. It was first manually crushed and then jaw crushed. The aggregates so obtained were sieved to obtain coarse aggregates of the required size. Then grading of Steel slag aggregates was done as per the provisions in IS: 2386 (Part 1)-1963. The other materials required for the mix like fly ash, limestone powder, super plasticizer and polypropylene fibres were collected. Material properties were found for natural coarse aggregate, natural fine aggregate, Steel slag coarse aggregates and cement. Mix design was done for all the mixes. Fresh properties for all the mixes were studied. Cubes, cylinders and beams for three trials for all mixes ware casted. The various tests conducted were Compressive tests, flexural test, Splitting tensile tests, Water absorbtion test in Hardened property study and slump flow, V-funnel, L-box, U-box in fresh property study. Cost analysis of various mixes where calculated and a comparison statement is made between the properties and cost is made. Then report is documented by summarizing all the above details

1. Fresh Properties of SCC

Slump-flow and T_{500} time for SCC

The slump-flow and T_{500} time is a test to assess the flowability and the flow rate of self-compacting concrete in the absence of obstructions. The result is an indication of the filling ability of self-compacting concrete. Slump flow test is a sensitive test that will normally be specified for all SCC, as the primary check that the fresh concrete consistence meets the specification. The T_{500} time is also a measure of the speed of flow and hence the viscosity of the SCC.

Fig. 1 Slump flow test

V-funnel test

The V-funnel test is used to assess the viscosity and filling ability of SCC. A V shaped funnel as shown in Fig. 6.3 is filled with fresh concrete and the time taken for the concrete to flow out of the funnel is measured and recorded in second is the V-funnel flow time. It is expressed as t_v and reported to the nearest 0.1 sec.

Fig. 2 V-funnel test

L-box test

The L-box test is used to assess the passing ability of self-compacting concrete to flow through tight openings including spaces between reinforcing bars and other obstructions without segregation or blocking. There are two variations; the two bar test and the three bar test. The three bar test simulates more congested reinforcement. A measured volume of fresh concrete is allowed to flow horizontally through the gaps between vertical, smooth reinforcing bars and the height of the concrete beyond the reinforcement is measured.

Fig. 3 L-box test

U-Box test

The test is used to measure the filling ability of a self compacting concrete. The apparatus consists of a vessel that is divided by a middle wall into two compartments; an opening with a sliding gate is fitted between the two sections. Reinforcing bar with nominal diameter of 134mm are installed at the gate with center to center spacing of 50mm. This creates a clear spacing of 35mm between bars. The left hand section is filling with about 20 L of concrete, then the gate is lifted and the concrete flows upwards into the other section. The height of the concrete in both the sections is measured.

2. **Hardened Properties**

Compressive Strength Test

150mm x 150mm x 150mm moulds were used to cast cubes to determine the compressive strength of the concrete.

Fig. 4 Compression Test

Split Tensile Test

150mm x 300mm moulds were used to cast cylinders to determine split tensile strength and modulus of elasticity of the concrete.

Fig. 5 Split tensile test

Flexural strength Test

100mm x 100mm x 500mm moulds were used to cast beams to determine the flexural strength of concrete.

Fig. 6 Flexural test

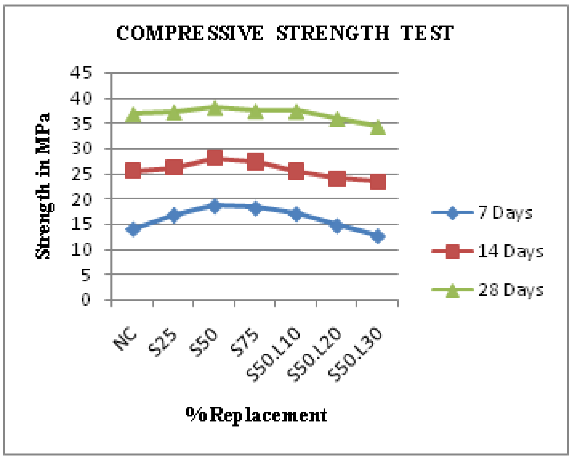

Fig. 7 Graphical representation of compressive strength at 7day, 14 day and 28day

III. RESULTS AND DISCUSIONS

1. Fresh Properties of SCC

Table I Fresh Property Details

Mix ID	Slump (mm)	T_{500} Slump (s)	V Funnel (s)	L Box	U Box (mm)
NC	710	4	20	0.91	1
S25	680	4	21	0.88	2
S50	670	5	22	0.85	4
S75	645	4	21	0.87	2
S50.L10	630	6	23	0.83	2
S50.L20	695	5	22	0.85	1
S50.L30	660	6	21	0.87	3

2. Hardened Properties

Compressive Strength Test

Table II Compressive strength (N/mm^2)

Cube designation	Compressive strength (N/mm^2)		
	7 day	14 day	28 day
NC	14	25.64	36.8
S25	16.78	26.3	37.2
S50	18.6	28.14	38.12
S75	18.15	27.4	37.45
S50.L10	17	25.5	37.4
S50.L20	14.67	24	35.92
S50.L30	12.6	23.5	34.25

Flexural Strength Test

Table III Flexural strength (N/mm^2)

Prism designation	Flexural strength (N/mm^2)		
	7 day	14 day	28 day
NC	3.12	4.8	6.2
S25	2.98	4.64	5.85
S50	2.8	4.59	5.93
S75	3.02	4.6	5.52
S50.L10	3.22	5.1	5.9
S50.L20	3.14	4.96	5.84
S50.L30	3.09	4.84	5.76

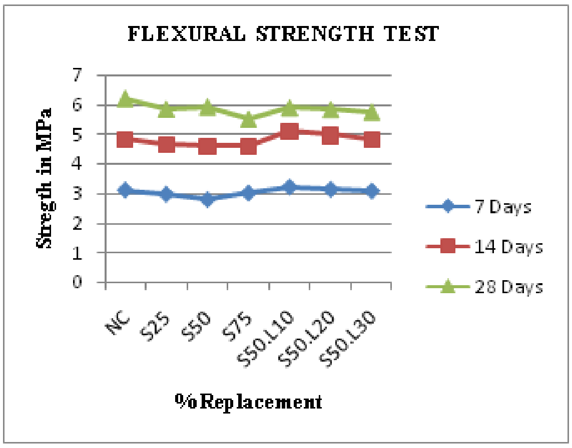

Fig. 8 Graphical representation of flexural strength test at 7day 14 day and 28day

Split Tensile Strength Test

Table IV. Split tensile strength (N/mm^2)

Cylinder designation	Split tensile strength (N/mm^2) 7 day	14 day	28 day
NC	2.08	2.4	3.12
S25	1.9	2.33	2.8
S50	1.86	2.31	2.7
S75	1.67	2.14	2.63
S50.L10	1.88	2.41	2.89
S50.L20	1.96	2.65	2.92
S50.L30	1.85	2.43	2.57

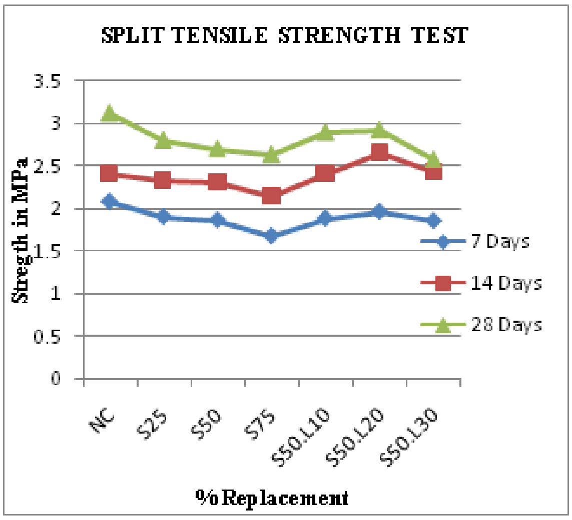

Fig. 9 Graphical representation of split tensile strength at 7day, 14day and 28day

IV. CONCLUSION

The main aim of this study is to investigate the fresh and hardened properties of SCCs with steel slag and lime stone powder. On the basics of Slump flow test, it seems limestone is filler that requires less amount of water to initiate flow. The results for durability property also increased by lowering w/c ratio. Flexural strength decreases by use of steel slag as coarse aggregate in its hardened state. Developed the mix flow by repeated trial mixes by slump flow analysis. No specific mix design procedures for SCC is available and mix design can be done by suitable adjustments. Trial mixes have to be made for maintaining flow ability, self compatibility and obstruction clearance. The use of limestone powder content enhances the rheological properties of self compacting concrete. The passing ability of SCC is increased with addition of limestone powder in to the mix. It also improves the filling capacity and fluidity than normal SCC. It can be said that the effect of mineral additives on fresh properties seems to be more dominant than the effect of aggregates. The SP ratio decreases with the increased quantity of total powder. Thus, low cost SCC can be made by incorporating some percentage of LP along with the main ingredients of concrete.

Compressive strength shows a 10% hike when steel slag is added at 50% replacement to the coarse aggregate and 2% decreased when limestone powder is added at 10% replacement to that of cement. Split tensile strength and flexural strength both shows a slight decrease when steel slag and lime stone powder is added to it. Cost analysis shows normal SCC is 12% low in cost than normally vibrated concrete. A comparative study is made between normal SCC, SCC with steel slag and SCC combined with steel slag and limestone powder and it shows a mix id S50 (SCC with 50% steel slag as replacement of coarse aggregate) shows a better mix in all its way. From this thesis work its clear that the steel slag can be used in SCC as a coarse aggregate replacement material which will increase the compressive strength of the concrete and which will also be an efficient way of waste utilisation.

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