Properties of Self Compacting Concrete Made With Copper Slag

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Abstract – *Concrete is a hard, solid mixture of cement, sand, gravel, and water that is used as a construction material. For flow into very complex forms or forms with a lot of reinforcing bars, concrete must be heavily vibrated. As a result, self-compacting concrete is used to overcome these flaws. Self-compacting concrete is a liquid concrete mixture that can compact under its own weight. Without being heavily vibrated, the self-compacting concrete flows effortlessly into formwork at a suitable speed without blocking through the reinforcement. The results of using copper slag (CS) as fine aggregate in self-compacting concrete as a substitute for river sand are presented in this research paper (SCC). Copper slag (CS) is a large-scale industrial by-product produced during the matte smelting and refining of copper metal. Totally Eleven concrete mix proportions are made with different copper slag mix ratios ranging from 0% (for the control mix ratio) to 100%. The slump test, V-funnel, and L-box were used to investigate the qualities of fresh concrete. Workability, density, reliability, compressive strength, and tensile strength are all evaluated in concrete mixes. This research will attempt to prove that CS in combination with SCMs is a viable alternative to conventional sand in the construction industry.*

***Key Words*: Self compacting concrete, copper slag, Workability, Alternative to fine aggregate**

1. INTRODUCTION

The advantageous use of certain industrial byproducts in improving the properties of fresh and hardened concrete has been well known for many years. The use of some waste materials in design requirements is well known. Various industries produce new by-products and waste materials, and the dumping or disposal of these materials causes environmental and health issues. As a result, waste material recycling has a lot of potential in the concrete industry.

Concrete is a widely used building material all over the world. SCC (Self-Compacting Concrete) is a type of concrete with the ability to compact under its own weight.

Mineral admixtures are used in the production of SCC to provide economic benefits as well as minimize heat of hydration. These materials are also used to prevent segregation, bleeding, and to improve flow. Copper slag (CS) is known for its excellent soundness, abrasion resistance, and stability. When compared to Sand, Copper Slag has a lower water absorption capacity. Copper slag is analogous to river sand in terms of behavior. The use of Copper Slag as a Fine Aggregate in concrete mixes lowers the cost of the final product.

Copper slag in cement and concrete has the potential to benefit all related industries in terms of both environmental and economic benefits, especially in areas where a large amount of copper slag is produced. Despite the fact that copper slag is commonly used in the sandblasting industry and in the manufacture of abrasive tools, the majority of it is discarded without being reused or recycled. Copper slag has mechanical and chemical properties that make it suitable for use in concrete as a partial replacement for Portland cement or as an aggregate substitute.

2. LITERATURE REVIEW

Jose A., Albert De La Fuente, - In this paper six different mixes where produced in two different conditions-In concrete plant in order to verify the adaptability of the existing equipment to produce and pour this material under real boundary conditions. In laboratory controlled conditions, a physical and chemical characterization including 1100 specimens was carried out. The conclusion was, if the aggregates are properly pre-saturated, these do not alter the consistency of fresh concrete, and a more fluid consistency can even be achieved if recycled aggregates are introduced in the saturated state with dry surface.

N. Krishnamoorty, P.K.Sarkar - This paper focus on possibility of using industrial by-products Ground Granulated Blastfurnace slag (GGBS) And silica fumes in preparation of SCC. This powder is partially replaced for cement in production of SCC by using Nan Su et al. method for mix design. In this paper there is comparison of performance of GGBS and SF based SCC mix. The SCC mixes containing both powdered material tested for their fresh properties as per EFNARC, has satisfied the norms laid down by EFNARC. Hence we can conclude that achieving fresh SCC properties is by using Nan Su et al. method, when these industrial by-products are used as powders.

Mr. Gokulnath, Dr. B. Ramesh. In this paper, the impact of steel fibers with a length of 30 mm and with measurement of 0.5 mm was utilized as the part of possible self-compacting concrete. Due to this the functionality of solid get decreased. After 7 days 60% of quality will achieve. TECHMIX 550 was used as the plasticizer. By adding the steel fibers in self-compacting concrete with higher percentage increases the compressive strength of concrete. Obtained strength of river sand is greater than M-sand. But the M-sand is higher than the required level.

Esraa Emam Ali et.al - has studied the effect of using recycled glass waste, as a partial replacement of fine aggregate, on the fresh and hardened properties of Self-Compacting Concrete (SCC). A total of 18 concrete mixes were produced with different cement contents (350, 400 and 450 kg/m3) at W/C ratio of 0.4. Recycled glass was used to replace fine aggregate in proportions of 0%, 10%, 20%, 30%, 40%, and 50%. The experimental results showed that the slump flow increased with the increase of recycled glass content. On the other hand, the compressive strength, splitting tensile strength, flexural strength and static modulus of elasticity of recycled glass (SCC) mixtures were decreased with the increase in the recycled glass content. The results showed that recycled glass aggregate can successfully be used for producing self-compacting concrete.

A.S.E. Belaidi et.al - has studied the effect of substitution of cement with natural pozzolana and marble powder on the rheological and mechanical properties of self-compacting mortar (scm) and self compacting concrete (scc). Ordinary portland cement (opc) was partially replaced by different percentages of pozzolana and marble powder (10–40%). The workability of fresh scc was measured using slump test, v-funnel flow Time test, j-ring, l-box and sieve stability tests. Compressive strength was determined on prisms at the ages of 7, 28, 56 and 90 days. The results indicate an improvement in the workability of scc with the use of pozzolana and marble powder. Compressive strength of binary and ternary SCC decreased with the increase in natural pozzolana and marble dust content, but strength at 28 and 90 days indicate that even with 40% (natural pozzolana + marble powder), suitable strength could be achieved.

OBJECTIVES OF THE STUDY:

- Determining the effect of copper slag as partial replacement of fine aggregates on the properties of SCC in
  FRESH STATE (Filling ability and Passing ability)
  HARDENED STATE (Compressive strength)
- To study the workability characteristics using slump flow test, V-funnel test, L-box test and compressive strength characteristics.
- To determine the optimum percentage of copper slag in the self compacting concrete.

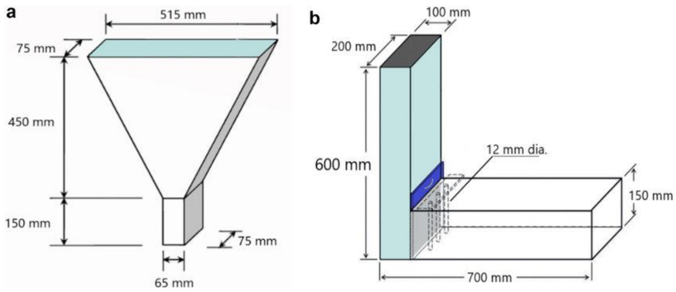

Fig -1: Apparatus of V-funnel and L-box.

3. METHODOLOGY & EXPERIMENTAL PROGRAMME

Materials Used:

The Materials used in SCC are the same as in conventional concrete except that an excess of fine material and chemical admixtures are used. Also, a viscosity-modifying agent (VMA) will be required because slight variations in the amount of water or in the proportions of aggregate and sand will make the SCC unstable, that is, water or slurry may separate from the remaining material. The powdered materials are fly ash, silica fume, lime stone powder, glass filler and quartzite filler. The use of pozzolanic materials helps the SCC to flow better.

The factors which dominates the selection of materials are-

i. Aggregates amount used.
ii. Type of super plastizer & VMA used.
iii. Percentage of powder content in concrete mix.
iv. Water/Cement ratio.

Cement:

Ordinary Portland Cement (OPC) conforming to IS: 12269 to be used. The physical and chemical property of cement is to be identified.

Fine Aggregate:

Locally available river sand is used as fine aggregate. The sand was dried before use to avoid the problem of bulking.

Coarse Aggregate:

Locally available granite with a size ranges from 20 mm to 8 mm and down was used as coarse aggregate.

Water:

Potable water is used for mixing and curing of concrete.

Copper Slag: Copper slag is a by-product obtained during matte smelting and refining of copper. The slag is a black glassy particle and granular in nature and has a similar particle size range like sand. It has good pozzalonic properties. The copper slag was brought Ernakulam, India.

Mineral Admixtures:

Mineral admixtures are used to improve the fresh and hardened properties of concrete and at the same time reduce the cost of concrete materials. In order to achieve the necessary viscosity to avoid segregation, additional fine materials are used. Various fine materials such as fly ash, silica fume, lime stone powder, rice husk ash, glass filler and quartzite filler etc. can be used .

Chemical Admixtures:

The various types of chemical admixtures are used in the production of SCC viz., super plasticizers and Viscosity Modifying Agents (VMA).

MIX PROPORTIONS:

A total of 6 concrete mixtures were designed as per IS10262-2009 having a constant water- cement ratio of 0.45. The control mixture of grade M30 included ordinary Portland cement alone as the binder and Copper Slag as Partial replacement for Fine Aggregate. The replacement levels of Copper Slag as Fine Aggregate are in the percentages 0%, 10%, 20%, 30% and 40%, 50% respectively.

Fig -4: Casting of Cube Specimens

4. RESULTS AND DISCUSSIONS

Slump Flow Test and Slump Flow T50cm Test Results:

Table 1 shows the outcome of the slump flow test and the slump T50 flow test. For slump flow, the acceptable range of SCC standards is 650mm to 800mm. The greater its ability to fill formwork under its own weight, the higher the slump value. The slump flow T50 results for samples SCC-0, SCC-10, SCC-20, SCC40, and SCC-60 are all within the SCC criteria's acceptable ranges. The T50 moment is a secondary flow indicator. A lesser time means a higher rate of flow.

MIX	Slump flow test(mm) (500-700)mm	Slump flow T50 test (sec) (2-5 sec)	Concrete condition	Remarks
SCC+0% CS	692	3.4	Flow	Satisfied
SCC+10 % CS	685	3.5	Flow	Satisfied
SCC+20 % CS	680	3.5	Flow	Satisfied
SCC+40 % CS	677	4	Flow	Satisfied
SCC+60 % CS	670	4.7	Flow	Satisfied

Table.1 Slump Flow Test Values

L-Box Test Results:

The sample S5 and S6 L-Box test results show a high blocking ratio (H2/H1), which is within the SCC acceptance criteria. Table-7 summarizes the results of the experiments. A higher blocking ratio shows that the concrete is highly flowable, has excellent passing ability through closely spaced barriers without blocking, and flows freely as water until it reaches horizontal at rest.

MIX	H1 (mm)	H2(mm)	H2/H1 (0.8-1.0)	T20 (1-2sec)	T40 (2-3 sec)
SCC+0 % CS	42	42	1	2	3
SCC+10% CS	41	39	0.95	7	9
SCC+20% CS	40	37	0.92	6	8
SCC+40% CS	40	34	0.85	4	6
SCC+60% CS	38	32	0.84	2	3

Table.2: L-Box test results

V- Funnel Test & V-Funnel T5 Minutes Test:

The sample SCC-0's V-Funnel test results show higher flow ability, which is within the SCC acceptance criteria. Table-8 summarizes the results of the experiments. Greater flow ability is indicated by shorter flow times. Table-7 shows the results of the V- funnel test. We can quantify concrete segregation by performing V-funnel at T5 minutes. If the concrete segregates, the flow time will greatly increase.

MIX	V- Funnel Test (sec) (6- 12 sec)	V- Funnel T5 minutes test(≤6 sec)	Remarks
SCC+0% CS	7.5	3.4	Satisfied
SCC+10% CS	8	3.9	Satisfied
SCC+20% CS	9.3	4.3	Satisfied
SCC+40% CS	10	4.5	Satisfied
SCC+60% CS	10.4	5	Satisfied

Table.3: V-Funnel test results

Compressive Strength

Compressive strength tests were conducted on cured cube specimen at 7 days and 28 days age using a compression testing machine of 200 kN capacity. The cubes were fitted at center in compression testing machine and fixed to keep the cube in position. The load was then slowly applied to the tested cube until failure.

Sl.no	Mix (days)	CS Content	Cube Compressive strength (N/mm²)
1	7	NVC	29
		0%	30.5
		10%	31.7
		20%	35
		40%	37.5
		60%	41
2	28	NVC	41.25
		0%	41.37
		10%	41.6
		20%	43
		40%	44.7
		60%	46.98

Table.4: - Compressive Strength Values

Split Tensile Strength

The split tensile test were conducted as per IS 5816:1999. The size of cylinder is 300mm length with 150mm diameter. The specimen were kept in water for curing for 7 days and 28 days and on removal were tested in wet condition by wiping water and grit present on the surface.

The test is carried out by placing a cylindrical specimen horizontally between the loading surfaces of a compression testing machine and the load is applied until failure of the cylinder along the vertical diameter.

Sl.no	Mix (days)	CS Content	Cylinder Split Tensile strength (N/mm²)
1	7	NVC	2.6
		0%	2.68
		10%	2.76
		20%	2.8
		40%	2.86
		60%	2.97
2	28	NVC	3.44
		0%	3.6
		10%	3.7
		20%	3.78
		40%	3.8
		60%	3.82

Table.5: Split Tensile Strength Values

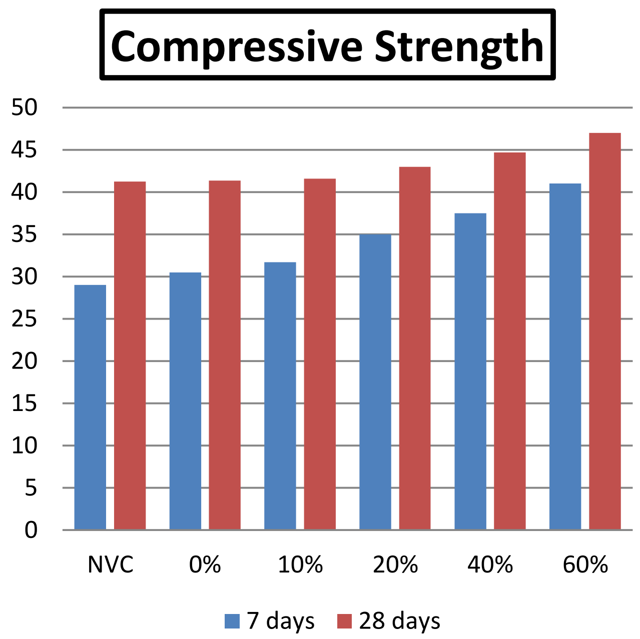

Fig.2: - Compressive Strength Values

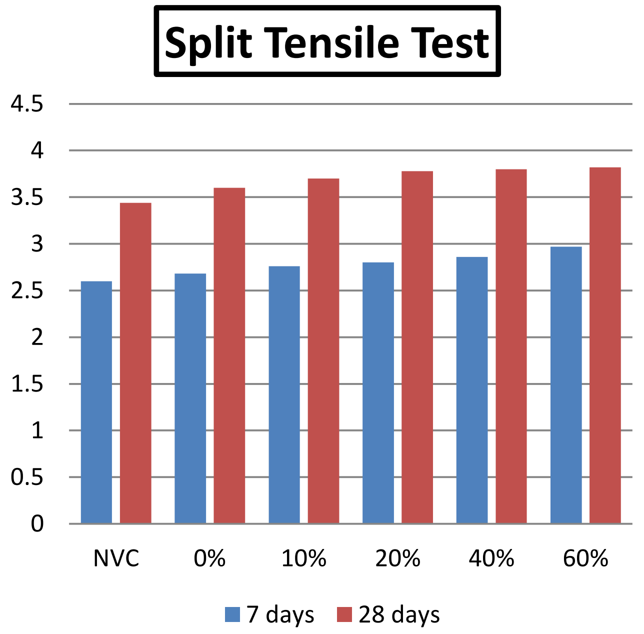

Fig.3: - Split Tensile Test Values

5. SUMMARY AND CONCLUSIONS

The tests were carried out to ascertain the fresh and mechanical properties of Self-Compacting Concrete mixtures, with the following findings.

1. In the fresh state, all self-compacting concrete mixes with up to 60% slag substitution as coarse aggregate performed satisfactorily.

2. As the proportion of slag increases, the T50 time value increases.

3. As the proportion of slag increases from SCC0 to SCC-60, the slump value decreases from 690 mm to 670 mm.

4. As the proportion of slag in the mix increases, so does the compressive strength.

5. The compressive strength of SCC-60 is 13.82 percent higher than that of SCC-0.

6. The split tensile strength increases as the proportion of slag increases, but the increase is not as noticeable as the compressive strength increase.

7. The increase in divided tensile strength over self-compacting concrete SCC-0 with natural aggregate for 60% substitution is up to 6.70 percent.

9. With natural aggregate for 60% substitution, the rise in split tensile strength over SCC-0 is up to 8.07 percent.

10. The properties of NCA and slag are found to be nearly identical up to a 20% substitution of NCA with slag.

ACKNOWLEDGEMENT

We are thankful to **Dr. Mohammed Masood,** Principal, ISLEC, for his encouragement throughout the project. We would also like to express our heartfelt thanks to **Ms. K. Nanchari,** Head of Civil Engineering Department, ISLEC for her help and unending cooperation with us during completion of this work.

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BIOGRAPHIES

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