To Study the Mechanical Properties of Self Compacting Concrete Containing Copper Slag

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Abstract:- **This research paper is presented after observing beneficial utilization of copper slag which is industrial by-product. For production of 1 ton of copper, produced around 2.2 to 3 ton of copper slag. New by-products and waste materials are being generated by various industries and disposal of this by-products causes various environmental problems and it also causes health problems to living being. Recycling of these wastes has a great potential in concrete industry. Copper slag can be used in concrete because of its mechanical and chemical properties. Copper slag has good abrasion resistance and it also has low water absorption capacity when compared with fine aggregates. for these research work we used M25 concrete and various test conducted for various proportion of copper slag replacement with fine aggregates (sand) of 33, 36, 39, 42, 45 and 48 % in self compacting concrete. The results of these study shows that compressive strength of concrete are increased upto 45% replacement of copper slag as fine aggregates in self compacting concrete**.

Keywords: Compressive strength of concrete, toughness of concrete,

INTRODUCTION:

Self compacting concrete is a concrete of high performance and it has a high workability because of having low viscosity. Use of self compacting concrete eliminate the need for vibration by which wear and tear of formworks is reduced and its also reduced energy consumption from vibration equipment. self compacting concrete must have following characteristic in fresh states:

- **Deformability**:-The ability of concrete to flow between congested reinforcement while filling the formwork.
- **Flowability**:- The ability of concrete to flow without any external force.
- **Segregation Resistance:-** Due to the viscosity of SCC, it keeps all the particles in unified suspension to avoid segregation.

Copper slag has particle size range in similar of fine aggregates and it has also very good pozzolanic properties. Due to less water absorption of copper slag its provides good workability to concrete. use of copper slag has helped in waste management and dumping of industrial waste. as copper slag contains silica hence it has similar properties like river sand.

LITERATURE REVIEW:

Rahul S, Rasl mohammad rafeeq, et. al. (12 June, 2016) did experimental study on properties and effects of copper slag in self compacting concrete. For this research work he used M25 grade concrete and perform test at various proportion of copper slag as fine aggregates in SCC (0-50%). He concluded that upto 40% of replacement of copper slag in SCC the compressive strength, split tensile strength and flexural strength of concrete is increased compare to conventional concrete. The optimum value obtain for 40% replacement of CS as fine aggregates in concrete.

Rahul Sharma, Rizwan A Khan et. al.(10 February 2017) He carried investigation on the development of SCC using Copper slag as fine aggregates with partial replacement of sand. He concluded that filling and passing ability of SCC mixes improved with and increases in the replacement of sand by CS.

Shriver Padha, Ravi Kumar et. al.(7 July 2016) did his study on utilization of steel slag in concrete as a partial replacement to fine aggregates. By use of steel slag reduces

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 8 Issue 04, April-2019

the need of natural rocks as construction material.. It was observe that compressive and tensile strength increased with the increased in steel slag percentages upto certain limits.

G.C.Behrera. R.K.Behrerta et. al.(Jan, 2016) did perform various test to determine the fresh an mechanical properties of SCC mixture. There were six batches of concrete mixes, consists of 0%,10%,20%,40%,60% increment of slag aggregate replacement for a particular design mix.

MATERIALS:

COARSE AGGREGATE

Usually, the maximum size of the coarse aggregate used in production of SCC, ranges approximately between10mm and 20mm. 20mm-12.5mm size of aggregates is taken as 40% and 12.5mm-10mm size of aggregates is taken as 60% of total weight of coarse aggregates.

FINE AGGREGATE

fine aggregates(sand) is comes under zone II. Fines aggregates is taken which is pass through IS Sieve 4.75mm.

COPPER SLAG

Copper slag is a by-product of copper extraction by smelting.

CEMENT

Portland Pozzolana Cement of grade 43 of ultratech cement is used.

WATER

Portable water conforming to IS 456-2000 was used for making concrete and curing the specimen. Water should be free from alkalis and impurities.

SUPER PLASTICIZER

Master Glenium 51 is a super plasticizer having high range water reducer and it is based on high molecular weight polycarboxylic ether is used.

VISCOSITY MODIFYING AGENT:

The use of Viscosity Modifying Agent (VMA) gives higher possibilities of controlling segregation in SCC. Master Matrix II is used as a VMA.

MIX DESIGN AND PROPORTIONING:

The procedures of the proposed mix design method can be summarized in the following steps:

Calculation of coarse and fine aggregate contents.
Calculation of cement content.
Calculation of mixing water content required by cement.
Calculation of mixing water content needed in SCC
Calculation of SP dosage.
Adjustment of mixing water content needed in SCC.
Trial mixes and tests on SCC properties.
Adjustment of mix proportions.
The mix proportioning was done based on the IS code mix design

S No	Required property	value
1.	Specific gravity of cement	3.12
2.	Specific gravity of Fine aggregate	2.59
3.	Specific gravity of coarse aggregate	2.82
4.	Specific gravity of superplasticizer	1.08
5.	Specific gravity of VMA	1.01
6.	Target slump	225-250 mm
7.	Zone of fine aggregate	Zone II
8.	Exposure condition	Moderate

STEP 1: Target mean strength

$$f'_{ck} = f_{ck} + 1.65\sigma$$

$$f'_{ck} = 25 + 1.65 \times 4$$

$$= 31.6 \text{Mpa}$$

Where, f'_{ck} = target mean compressive strength at 28 days

f_{ck}= characteristics compressive strength at 28 days

σ = standard deviation

STEP 2: W/C ratio

For moderate condition w/c = .5 (Table 5, IS456-2000)

But let's take w/c for SCC =.45

STEP 3: Determining water content

From table 2 IS 10262 (page 3),

For max 20mm size aggregate water required is 186 litre (for slump value of 25-50mm)

Our target for slump is225-250 mm (for pumping concrete)
Also IS code 10262 says, increase water content by 3% for every 25mm increase in slump value.
Hence, Actual water = 186 + (24/100)x186 = 230.64 litres
But, by using superplasticizer we can reduce water content by 15%
So, water content = 230.64 x .85 = 196.044 litre

STEP 4: Calculation of cement content

As per IS 456-2000 (page 20), for moderate condition minimum cement content for plane concrete should be greater than 300 Kg/m^3.

w/c = .45

Cement content = water content / (w/c ratio)

= 196.044 / .45 = 435.653 Kg/m^3 >300 Kg/m^3 (hence ok)

STEP 5: Calculation of percentage volume of coarse and fine aggregate

From table 3, of IS 10262 -2009, fraction volume of coarse aggregate corresponding to 20mm size aggregate, for fine aggregate of zone II and water cement ratio of 0.5 is 0.62

But actual w/c is 0.45

So, difference in w/c = 0.50 – 0.45 = 0.05

For this IS 10262 says that, as the w/c ratio is reduced, it is desirable to increase the coarse aggregate content by 0.01 for every decrease in w/c of 0.05

For w/c ratio of 0.45, coarse aggregate proportion = 0.62 + 0.01 = 0.63

Since it is a angular aggregate and pumped concrete, the coarse aggregate can be reduced by 10% (IS 10262 – 2009, page 3)

So, after reduction by 10%,

Actual fine aggregate = 1 – coarse aggregate proportion

= 1 – 0.567 = 0.433

STEP 6: Design mix calculation

1) Volume of concrete = 1 m^3
2) Volume of cement = $\frac{\text{mass of cement}}{\text{Specific gravity x 1000}} = \frac{435.653}{3.12 \times 1000}$ = 0.1396 m^3
3) Volume of water = $\frac{\text{mass of water}}{\text{Specific gravity x 1000}} = \frac{196.044}{1 \times 1000}$ = 0.196044 m^3
4) Volume of admixture = $\frac{\text{mass of admixture}}{\text{specific gravity x 1000}}$

   Assuming dose of 1.5% by weight of cement,

   Volume of admixture = $\frac{(0.015 \times 435.653)}{1.08 \times 1000}$ = 0.00605 m^3
5) Volume of entrapped air = 2% for 20mm coarse aggregate
   = 0.02 m^3

   (IS 10262: 2009 , % entrapped air is zero, but we take it as 2% of total volume)

6) Volume of all aggregate combined (CA + FA)
   = volume of concrete – (sum of volume of cement, admixture, water,air)
   = 1 – (0.1396+0.00605+0.004313+0.196044+0.02) = 0.6339

7) Mass of coarse aggregate
   = proportion of CA x volume of total aggregate x specific gravity x 1000
   = 0.6339 x 0.567 x 2.82 x 1000=1013.568Kg/m^3

8) Mass of fine aggregate
   = proportion of FA x volume of total aggregate x specific gravity x 1000
   = 0.6339 x 0.433 x 2.59 x 1000 = 710.899 Kg/m^3

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 8 Issue 04, April-2019

Step 7: Proportion of trial 1

1) Cement = 435.653 Kg/m^3
2) Water = 196.044 Kg/m^3
3) Coarse aggregate = 1013.568 Kg/m^3
4) Fine aggregate = 710.899 Kg/m^3
5) Super plasticizer = 6053.73ml ,
6) VMA = 4313.39ml

Cement	Fine aggregate	Coarse aggregate	Water	Plasticizer	VMA
1	1.875	2.318	0.45	0.0079	0.00348

Table design mix of M25 concrete.

RESULT:

CEMENT

Portland pozzolana cement [IS: 1489-1993 part 1, Specifications for Portland pozzolana cement] has been used in the study. It was procured from a single source and stored as per IS: 4032 – 1977.

S No.	Property	Test method	Test result	IS specification
1	Normal Consistency	Vicat Apparatus (IS: 4031 Part - 4)	33%	-
2	Specific gravity	Sp. Gr bottle (IS: 4031 Part - 4)	3.12	-
3	Initial setting time	Vicat Apparatus (IS: 4031 Part - 4)	44 min	Not less than 30 minutes
4	Final setting time	Vicat Apparatus (IS: 4031 Part - 4)	610 min	Not less than 10 hours
5	Fineness	Sieve test on sieve no.9 (IS: 4031 Part – 1)	6%	10%
6	Soundness	Le-Chatlier method (IS: 4031 Part – 3)	6mm	Not more than 10 mm

Table. Test result of test on cement(PCC)

S. No	Property	Method	Fine Aggregate	Coarse Aggregate
1.	Specific gravity	Pycnometer IS:2386 Part 3-1986	2.59	2.82
2.	Flakiness Index	(IS:2386 Part 2-1963)	--	27.7%
3.	Elongation Index	(IS:2386 Part 2-1963)	--	2.82%

Table. Test result of tests on fine aggregate and coarse aggregate

COMPRESSIVE STRENGTH

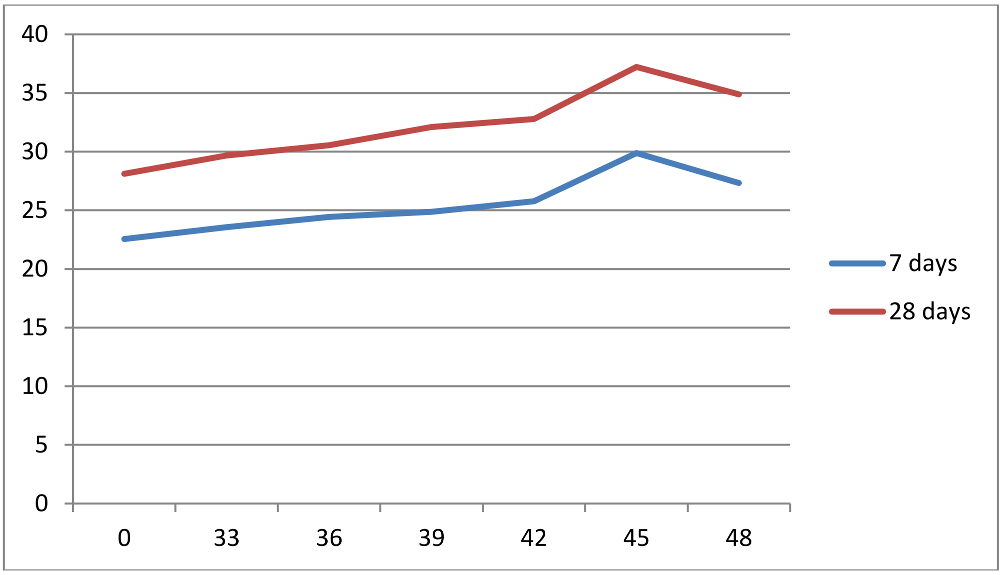
Compressive strength of a material is defined as the value of uniaxial compressive stress reached when the material completely fails. In this investigation, the cube specimens of size 150 mm x 150 mm x 150 mm are tested in accordance with IS:516–1969 [Method of test for strength of concrete]. The testing was done on a compression testing machine of capacity 2000KNwith least count of 10KN.

In the present investigation, the compressive strength test has been conducted on concretes with different sizes of coarse aggregate. M 25 grade of SCC at 7 and 28 day were tested.

S.NO	% OF COPPER SLAG	COMPRESSIVE STRENGTH AT 7 DAYS(N/mm^2)	COMPRESSIVE STRENGTH AT 28 DAYS(N/mm^2)
1.	0	22.55	28.11
2.	33	23.55	29.66
3.	36	24.44	30.55
4.	39	24.88	32.11
5.	42	25.77	32.77
6.	45	29.88	37.22
7.	48	27.33	34.88

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 8 Issue 04, April-2019

Table : compressive strength of concrete



CONCLUSION

- As the percentage of copper slag increases workability increases
- The slump value increases in all samples as percentage of copper slag increases.
- The strength of concrete is increased due to high toughness of copper slag.
- It is concluded that copper slag performs similar or better compared to natural sand concrete.
- Compressive strength of concrete is maximum at 45% of copper slag in replacement of fine aggregate.

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