Application of Industrial Waste (copper slag and ceramic waste) for producing of self-compacting concrete

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Abstract - **Self-compacted concrete is high performance concrete which has high fluidity without segregation which does not required vibration and able to flow by own weight for filling purpose of mold. But use of expansive admixture and very large quantity of cement and its give low strength and difficult to obtain. India has serious challenge for disposing industrial waste as land filling which result in high cost and environmental problem. Utilize treated and untreated industrial waste as raw material in concrete is give clean and greener environment. Industrial waste like copper slag and construction & demolition (C&D) waste replacing by fine aggregate and coarse aggregate respectively in different proportion is economical. Copper slag is by product of matte smelting and retaining copper. Which can replace by fine aggregate in concrete and in C&D wastes major part ceramic waste can replace by coarse aggregate to improve workability and strength of concrete. In these paper we show that by replacing fine aggregate and coarse aggregate by copper slag and ceramic waste producing self-compacted concrete and performing test on them so we found which % they give maximum strength and flowability. The paper reports the results of flow test and hard test on replacement of fine aggregate and coarse aggregate by copper slag and ceramic waste respectively with different percentage. The results showed that copper slag and ceramic waste could be used successfully in producing self-compacted concrete with reduced segregation potential.**

Index Terms: **industrial waste, copper slag, ceramic waste, SCC, flow test, harden test**

1. INTRODUCTION

Self-compacting concrete (SCC) is an innovative concrete that does not require vibration for placing and compaction. It is able to flow under its own weight, completely filling formwork and achieving full compaction, even in the presence of congested reinforcement. The hardened concrete is dense, homogeneous and has the same engineering properties and durability as traditional vibrated concrete. Due to industrialization there is huge amount of copper slag and ceramic waste created. manufacture of copper slag and ceramic waste are industrial waste and causing threat to environment so the reduce the cost of the construction also to make structure more durable, reduce problem of this material the project has been undertaken so that it can be used for construction fashion following points attempted.

1] To study the properties of copper slag.

2] To study properties of ceramic waste.

3] To replace fine aggregate and coarse aggregate by different % of copper slag and ceramic waste respectively.

4] To study the flow test and result of flow test

5] To study the harden test and result of them

2. PROPERTIES OF COPPER SLAG

2.1 General:

Copper slag is an abrasive blasting grit made of granulated slag from metal smelting processes (also called iron silicate). Copper slag is a by-project created during the copper smelting and refining process. As refineries draw metal out of copper ore, they produce a large volume of non-metallic dust, soot, and rock. Collectively, these materials make up slag, which can be used for a surprising number of applications in the building and industrial fields. Contractors may also use copper slag in place of sand during concrete construction. The slag serves as a fine or binding agent, which helps hold the larger gravel particles within the concrete together.

2.2 Physical properties:

Table 2. Physical properties of copper slag

SR. NO	PROPERTIES	ANALYSIS
1.	Hardness, Mohr's scale	7
2.	Specific Gravity	3.83
3.	Electric Conductivity	4.8 ms/m
4.	Chloride content	<0.0002
5.	Particle size	0.2mm up to 3mm
6.	Granular size	Angular, Sharp edges, Multifaceted

2.3 Chemical properties:

Table 2. Chemical properties of copper slag

SR. NO.	COMPOUND	ANALYSIS RANGE IN %
1	Cu	0.6-0.70
2	FeO	42-48
3	SiO_2	26-30
4	Al_2O_3	1-3
5	S	0.2-0.3
6	CaO	1-2
7	MgO	0.8-1.5
8	Fe_3O_4	1-2

3. PROPERTIES OF CERAMIC WASTE

3.1 General:

Ceramic products are made from natural materials which contain a high proportion of clay minerals. These, through a process of dehydration followed by controlled firing at temperatures of between 700ºC and 1000ºC, acquire the characteristic properties of "fired clay". Thus, the manufacturing process involved in ceramic materials requires high firing temperatures which may activate the clay minerals, endowing them with pozzolanic properties and forming hydrated products similar to those obtained with other active materials.

Ceramic materials contribute the highest percentage of wastes within the construction and demolition wastes i.e. about 54%. The global production of ceramic tiles during 2011-12 in the world is about 11,166 million square meters

Ceramic waste is durable, hard and highly resistant to biological, chemical and physical degradation forces. The properties of these materials make them a good and suitable choice to be used in concrete. The use of waste ceramic tiles in concrete effects the properties of fresh and hardened concrete, and makes it economical and also solves some of the disposal problems.

3.2 Physical properties:

Table 3. Physical properties of ceramic waste

SR. NO	PROPERTIES	ANALYSIS
1.	Specific gravity	2.50
2.	Water absorption in %	0.18
3.	Impact value in %	22
4.	Crushing value in %	20
5.	Abrasion value in %	19
6.	Bulk Density in kg/m3 Loose state Dense state	 1069 1188

3.3 Chemical property:

Table 4. Chemical properties of ceramic waste

SR. NO	COMPOUND	ANALYSIS RANGE IN %
1.	SiO_2	63.29
2.	Al_2O_3	18.29
3.	Fe_2O	4.32
4.	CaO	4.36
5.	MgO	0.72
6.	P_2O_5	0.16
7.	K_2O	2.18
8.	Na_2O	0.75
9.	SO_3	0.10
10.	CL^-	0.005
11.	TiO_2	0.61
12.	SrO_2	0.02
13.	Mn_2O_3	0.05
14.	L.O.I	1.61

4. MIX DESIGN

A mix was designed as per Indian Standard method (IS 10262-2009) and they was used to prepare the test samples. The specimen used are given below.

Table 5. Type of specimen for scc

Group	Replacement
SCC1	0% fine aggregate and coarse aggregate by copper slag and ceramic waste respectively
SCC2	15% fine aggregate and coarse aggregate by copper slag and ceramic waste respectively
SCC3	25% fine aggregate and coarse aggregate by copper slag and ceramic waste respectively
SCC4	35% fine aggregate and coarse aggregate by copper slag and ceramic waste respectively

5. SLUMP FLOW TEST

5.1 Introduction:

The slump flow is used to assess the horizontal free flow of SCC in the absence of obstructions. It was first developed in Japan for use in assessment of underwater concrete. The test method is based on the test method for determining the slump. The diameter of the concrete circle is a measure for the filling ability of the concrete.

5.2 Assessment of test:

This is simple, rapid test procedure, though two people are needed if the T50 time is to be measured. It can be used on site, though the size of the base plate is somewhat unwieldy and level ground is essential. It is most commonly used test, and gives a good assessment of filling ability. It gives no indication of the ability of the concrete to pass between reinforcement without blocking, but may give some indication of resistance to segregation. It can be argued that the completely free flow, unrestrained by any boundaries, is not representative of what happens in practice in concrete construction, but the test can be profitably be used to assess the consistency of supply of ready-mixed concrete to a site from load to load.

5.3 Equipment.

The apparatus is show in figure;

- Mold in the shape of a truncated cone with the internal dimensions 200 mm diameter at the base, 100mm diameter at the top and a height of 300 mm.

- Base plate of a stiff non-absorbing material, at least 700mm square, marked with a circle marking the central location for the slump cone, and a further concentric circle of 500mm diameter
- Trowel
- Scoop
- Ruler
- Stopwatch(optional)

5.4 Procedure:

About 6 liter of concrete is needed to perform the test, sampled normally. Moisten the base plate and inside of slump cone. Place base plate on level stable ground and the slump cone centrally on the base plate and hold down firmly. Fill the cone with the scoop. Do not tamp, simply strike off the Concrete level with the top of the cone with trowel. Remove any surplus concrete from around the base of the cone. Raise the cone vertically and allow the concrete to flow out freely. Simultaneously, start the stopwatch and record the time taken for the concrete to reach the 500mm spread circle. (This is T50 time).Measure the final diameter of the concrete in two perpendicular directions. Calculate the average of the two measured diameters. (This is Slump flow in mm).

5.5 Flow test result

The table 6 give the recommended value for different % of replacement and table 7 give the test results.

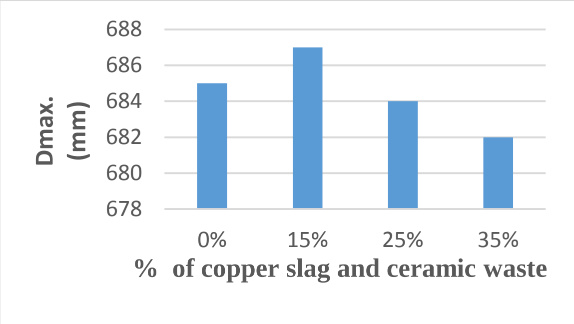
Table 6: recommended values for different method

SR. NO.	METHOD	UNIT	TYPICAL RANGE VALUE	
			MINIMUM	MAXIMUM
1	Slump flow	Mm	600	800
2	T50cm slump flow	sec	2	5

Table 7: Results of fresh SCC tests

SR. NO	% of copper slag and ceramic waste	SLUMP TEST	
		T-50 (sec)	Dmax. (mm)
1.	0%	5	685
2.	15%	4.5	687
3.	25%	5	684
4.	35%	5.5	682

GRAPH 1: % of copper slag and ceramic waste vs slump value



6. HARDEN PROPERTY TEST

The experimental program consists of casting and testing sixty (100 mm x 100 mm x 100 mm) cubes for determining compressive strength (fcu) and sixty cylinders (100 mm x 200 mm) for determining indirect tensile strength (fct). Moulds were cleaned and oiled before casting. Then put on a level area. Filling moulds by SCC. Concrete surface was leveled by trowel, and then marked. After casting, the molds were put on the level ground without vibration or compaction, and they were put in the laboratory for 24 hours. After 24 hours molds were removed, and SCC specimens were put into the curing tank for 28 days.

Tests for hardened SCC:

6.1. Compressive strength test:

This test is the most common of all tests on hardened concrete and it is the most important parameter in structural design.

For cube test most of the works cubical moulds of size 15cm x 15cm x 15cm are commonly used. This concrete is poured in the mould and tempered properly so as not to have any voids. After 24 hours these moulds are removed and test specimens are put in water for curing. The top surface of these specimen should be made even and smooth. This is done by putting cement paste and spreading smoothly on whole area of specimen. These specimens are tested by compression testing machine after 7 days curing or 28 days curing. Load should be applied gradually at the rate of 140 kg/cm2 per minute till the Specimens fails. Load at the failure divided by area of specimen gives the compressive strength of concrete.

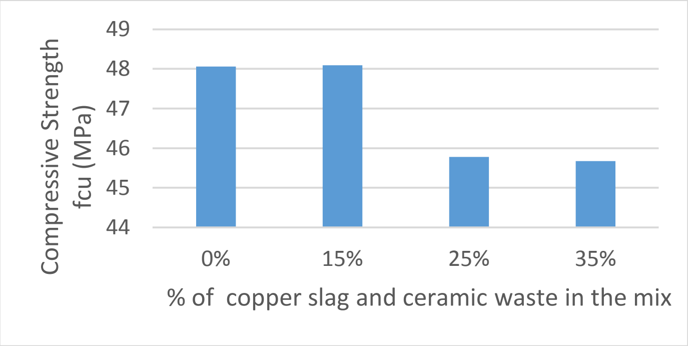
Fig 1: compressive strength test

6.1.1 Result:

Table 8: result of compressive strength test

Type of specimen	% of copper slag and ceramic waste in the mix	Compressive Strength fcu (MPa)
SCC1	0%	48.06
SCC2	15%	48.09
SCC3	25%	45.78
SCC4	35%	45.67

Graph 2: % of copper slag and ceramic waste vs compressive strength



6.2. Indirect Tensile Test:

The tensile strength of concrete is one of the basic and important properties. Splitting tensile strength test on concrete cylinder is a method to determine the tensile strength of concrete. The concrete is very weak in tension due to its brittle nature and is not expected to resist the direct tension. The concrete develops cracks when subjected to tensile forces. Thus, it is necessary to determine the tensile strength of concrete to determine the load at which the concrete members may crack. The specimen is the conventional 100mm x 200 mm, cylinder. The cylinder is loaded in compression along two axial lines which are diametrically opposite through bearing strips of plywood.

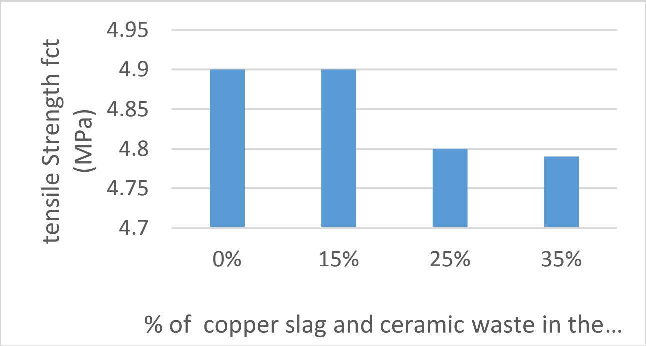
Fig 2:.Indirect Tensile Test

6.2.1 Result:

Table 9 result of Indirect Tensile Test

Type of specimen	% of copper slag and ceramic waste in the mix	tensile Strength fct (MPa)
SCC1	0%	4.9
SCC2	15%	4.9
SCC3	25%	4.8
SCC4	35%	4.79

Graph 3: % of copper slag and ceramic waste vs tensile strength



7. CONCLUSION

By performing the test we get result are shown in below.

By using upto 15% replacement of fine aggregate and coarse aggregate by copper slag and ceramic waste respectively the slump value increase.

Upto 15% replacement of fine aggregate and coarse aggregate by copper slag and ceramic waste respectively the compressive strength and tensile strength increase after that they have been decrease.

Upto 15% replacement of fine aggregate and coarse aggregate by copper slag and ceramic waste is successfully useful for producing of self-compacted concrete with reduction of segregation.

REFERENCES

[1] Amitkumar D. Raval, Dr.Indrajit N. Patel, Prof. Jayeshkumar Pitroda," Ceramic Waste: Effective Replacement of Cement for Establishing Sustainable Concrete*"," International Journal of Engineering Trends and Technology (IJETT)*", - Volume4 Issue6- June 2013

[2] V. Giridhar, H. Sudarsana Rao, P. Suresh Praveen Kumar," INFLUENCE OF CERAMIC WASTE AGGREGATE PROPERTIES ON STRENGTH OF CERAMIC WASTE AGGREGATE CONCRETE"," *IJRET: International Journal of Research in Engineering and Technology*", Volume: 04 Special Issue: 13 | ICISE-2015 | Dec-2015

[3] Dr. R. Sri Ravindrarajah, D. Siladyi and B. Adamopoulos," DEVELOPMENT OF HIGH-STRENGTH SELF-COMPACTING CONCRETE WITH REDUCED SEGREGATION POTENTIAL"," *RILEM Publications*", 17-20 August 2003

[4] M. C. Nataraja, G. N. Chandan, T. J. Rajeeth," CONCRETE MIX DESIGN USING COPPER SLAG AS FINE AGGREGATE","*INTERNATIONAL JOURNAL OF CIVIL ENGINEERING AND TECHNOLOGY (IJCIET)*"- Volume 5, Issue 9, September (2014), pp. 90-99

[5] O. Zimbili, W. Salim, M. Ndambuki, "A Review on the Usage of Ceramic Wastes in Concrete Production", "*International Journal of Civil, Environmental, Structural, Construction and Architectural Engineering*"- Vol:8, No:1, 2014

[6] Ghasan Fahim Huseien, Mohammed Yahya Al-Fasih, Shariwati binti Mansor, Hussein Kadhim Hamzah, "Performance of Self-Compacting Concrete With Different Sizes of Recycled Ceramic Aggregates", "*International Journal of Innovative Research and Creative Technology*"- 08 December 2016.

[4] Pratik D Viramgama, Prof. S. R Vaniya, Prof. Dr. K.B.Parikh, "Effect of Ceramic Waste Powder in Self Compacting Concrete Properties: A Critical Review", IOSR Journal of Mechanical and Civil Engineering- Volume 13, Issue 1 Ver. V(Jan. - Feb. 2016), PP 08-13

[5] Sama T. Ali, Amr S. EL-Dieb, Sherif H. Aboubakr and Mahmoud M. Reda Taha, "Utilization of Ceramic Waste Powder in Self-Compacting Concrete", Sustainable Construction Materials and Technologies- SCMT4 Las Vegas, USA, August 7-11, 2016