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Experimental Studies on Concrete Made With Ceramic Waste, Copper Slag and Lathe Waste

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Abstarct: ***One of the most serious problems of the world today is related to removal of waste and to find solution of reusing it. Numerous waste materials are generated from manufacturing processes, service industries, construction and demolition works and municipal solid wastes. The increasing awareness about the environment has tremendously contributed to the concerns related with disposal of these generated wastes. There are numerous researches that are being carried out to utilize these wastes in the construction industry where most of them are related to using these wastes in concrete. This will lead to utilization of wastes as well as reduction of usage of naturally occurring construction materials which in turn are depleting the natural resources due to the increasing demand of construction materials, meanwhile making concrete economical and also will reduce the disposal problems associated with these waste materials. This study deals with concrete made with ceramic waste as partial replacement material for coarse aggregate and copper slag as partial replacement materials for fine aggregate. In addition lath waste is added to the concrete with various proportion. The result shows that, the inclusion of ceramic waste, copper slag and lath waste increase the compressive strength and split tensile strength significantly.***

Keywords: Ceramic waste, Copper slag, Lath waste, Compressive strength, Split tensile strength

I. INDRODUCTION

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. China is the largest ceramic tiles producer (5,200 million square meters) which is 46.6% of world production as well as consumer (4,250 million square meters) which is 38.9% of world consumption. Compared to China, India ranks third; accounting for 691 million square meters tiles production which is 6.2% of world production and also ranks third in terms of consumption accounting for 681 million square meters which is 6.2% of world consumption. This huge amount of productions has caused them to be among the most commonly-consumed materials in the world. Usually, the wastage related to tile, ceramic and sanitary ware are created in different forms some of which are produced in companies during and after production process due to errors in either construction, human activities, and also inappropriate raw materials. Some others are produced in transportation and distribution procedures and finally, the most bulk of them are created as a result of destroying constructions. It is predicted that about 30% of daily production of ceramic materials in India change into wastage and this amount reaches to millions ton per year. This waste is not recycled in any form at present. Therefore, they are useless in practiced and cause environmental and disposal problems. However, the 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 (Daniya and Ahmad, 2015)

Copper slag is a by - product obtained during matte smelting and refining of opper.For every tone of copper metal production, about 2 to 2.5ton of waste slag is generated. Dumping or disposal of such huge quantities of slag cause environmental and space problems. During the past two decades, attempts have been made by several investigators and copper producing units all over the world to explore the possible utilization of copper slag.

The physical and mechanical properties of granulated copper slag show that it can be usedfor following.

A. Copper slag can be used in building industry as a filling material. Copper slag is widely used in the sand blasting industry and it
B. has been used in the manufacture of abrasive tools.
C. Copper slag can also be used as a building material, formed into blocks

Hence in this experiment, these two waste materials viz., ceramic waste and copper slag is used to replace coarse aggregate and fine aggregate respectively in concrete. In addition, lath waste with varying proportion is added in the mix.

II. MATERIALS AND METHOD

The materials used in the projects are cement, Fine aggregate, coarse aggregate, copper slag, ceramic waste, lathe waste are detailed below

A. Cement

Cement is the essential ingredient to bind all other materials to form workable concrete. The Ordinary Portland Cement of 53 grades from Ramco cement brand conforming to IS: 12269:1987 and IS: 8112-1989 is used in this experimental project. The normal consistency of cement is 30% and the initial setting time of cement is160 minutes and the final setting time of cement are 320minutes. The specific gravity of cement is 3.15.

B. Coarse Aggregate

The fraction of aggregates used in the experimental work passed in 20mm sieve and retained on 10mm IS sieve comes under Zone II aggregates conforming to IS: 383-1970. Naturally available granite stones are crushed into desired size and used in this work hand broken stone jelly with angular edges and satisfying flakiness and elongation index are used in this experimental work.

C. Fine Aggregate

The river sand is used as fine aggregate in this project work conforms to the requirements of IS: 383-1970 and comes under zone II.

D. Water

Water used in making concrete should be free from impurities and PH of the water should be 6.5- 8. It is important that water is added based on the water- cement ratio as adopted in mix design or standards. Potable water available in the concrete laboratory was used for mixing of concrete materials.

E. Copper Slag

Copper slag is one of the materials that is considered as a waste material which could have a promising future in construction industry as partial substitute of either cement or aggregates Copper slag from Birla Copper unit was used for this project. Copper slag from Hindustan copper unit was used for this project

F. Ceramic Waste

Ceramic products such as European water closet and floor tiles were obtained from the ceramic product dealers and they are carefully broken into small pieces such that their size ranges from 5mm to 20mm.

G. Lathe Waste

The basic idea to provide randomly distributed steel fibers in the concrete is to prevent the occurrence of cracks in concrete due to heat of hydration or due to loading.

Addition of steel fibers is expected to increase ductility, tensile strength, flexural strength, resistance to shrinkage of concrete. Waste lathe generated in the form of shavings from the automotive industry has the potential to be used as fibers in concrete, steel shavings wastes are available at low price so that they can be used as fibers in concrete instead of commercially available expensive concrete fibers. Lathe waste was collected from local lathe shop and used in this work.

Fig.1. Copper slag, Broken ceramic tiles and Lath waste

H. Concrete Mix Design

In this investigation work M25 grade mix was designed as per Indian Standard method IS 10262-1982 and A Mix ratio of 1:1.95: 3.9:0.5 is arrived for extreme exposure condition The copper slag is used as partial replacement for fine aggregate varying in range of 5%,10%,15%, 20%, 25% in normal concrete and the ceramic waste also used as partial replacement for coarse aggregate varying in range of 5%,10%,15%,20%,25%. In additional lathe waste is used in range of 0.25%,0.5%,0.75%,1%,1.25% by weight of cement. These mixes are given in table 1 with their designation.

Table 1

Mix No	F.A by C.S	C.A by C.W	L.W
Normal Mix	0%	0%	0%
Mix 1	5%	5%	0.25%
Mix 2	10%	10%	0.5%
Mix 3	15%	15%	0.75%
Mix 4	20%	20%	1%
Mix 5	25%	25%	1.25%

F.A – Fine Aggregate,C.S – Copper Slag,C.W – Ceramic Waste C.A – Coarse Aggregate, L.W – Lathe Waste

III. ZRESULT AND DISCUSSION

A. Compressive Strength Test

Totally 36-cubes of size 150mm x 150mm x 150mm were casted and tested at 7, 28 days from curing.In this investigation for each mix 3-samples were tested and the average strength is taken as compressive strength and is compared with nominal mix of M25 grade.

The compression test on concrete is done by applying constant load after placing concrete between plates and the failure load is note down after the load reversal occurs, cracks appears on concrete shows the compressive strength of concrete. The normal mix strength is compared with the replaced concrete by copper slag for sand and ceramic waste is replaced for coarse aggregate strength. The testing of cube for compressive strength is shown in figure 2. The compressive strength of concrete is calculated by using following expression

Compressive strength (N/mm^2) = Applied Load (N) / Area of cross section (mm^2)

Fig.2. Compressive strength Test

Table 2

Mix ID	Compressive Strength (N/mm^2)	
	7 days	28 days
Normal Mix	32.59	36
Mix 1	27.78	40.29
Mix 2	30.74	47.26
Mix 3	40.44	52.15
Mix 4	41.11	44.44
Mix 5	40.74	57.33

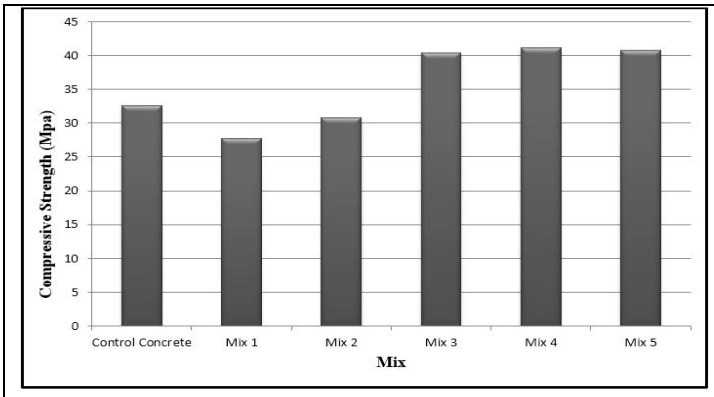

Fig.3. Compressive strength at 7 days

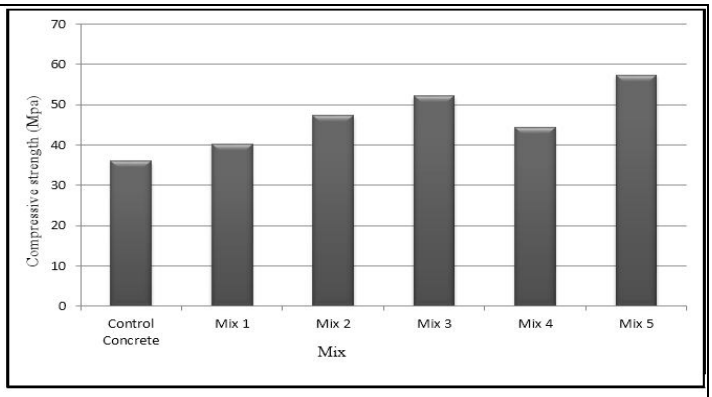

Fig.4. Compressive strength at 28 days

The compressive strength value at 7 and 28 days is shown in table 2 and and figure 3 and 4.By increasing the replacement of ceramic tiles aggregate ,copper slag and by incorporating a smaller percentage of lath waste, compressive strength of 57.33 N/mm^2 is achieved for the mix 5 which is 59% higher than the normal concrete. Being a waste material, by incorporating these materials in concrete, a 59% percentage increase in strength can be achieved.

B. Split Tensile Strength Test

The split tensile strength of concrete casting cylinder of size 150mm x 300mm and is continuously cured for 7 days & 28 days testing. Totally 36 cylinders were casted for normal M25 grade and each test is carried out with 3 samples for every mix ratio each mix samples are tested and the average values is taken as tensile strength of concrete. The testing of cube for compressive strength is shown in figure 2. The split tensile strength of the concrete is calculated by using an empirical equation:

$$\text{Tensile Strength} = 2P / (\pi \times d \times l)$$

Where P- maximum Load at failure, l - Length of the Cylindrical Specimen in mm, d - Diameter of Cylindrical specimen in mm.

Fig.5. Split tensile strength test

Table 3.

Mix ID	Split tensile strength(N/mm^2)	
	7 days	28 days
Normal Mix	2.6	3.03
Mix 1	2.73	3.54
Mix 2	3.36	3.66
Mix 3	2.75	3.55
Mix 4	2.30	3.63
Mix 5	2.31	4.03

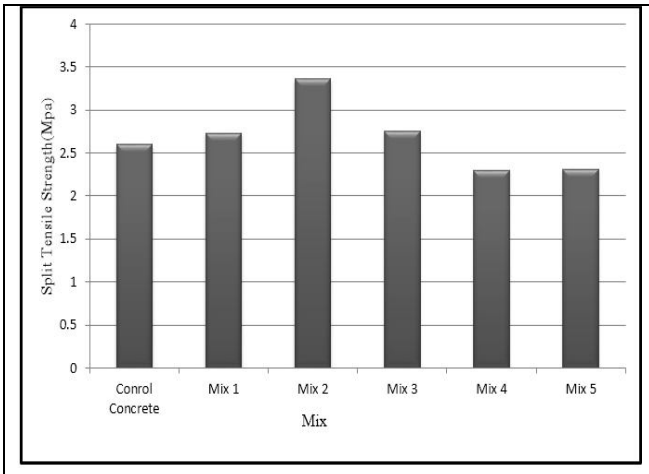

Fig.6. Split tensile strength at 7 days

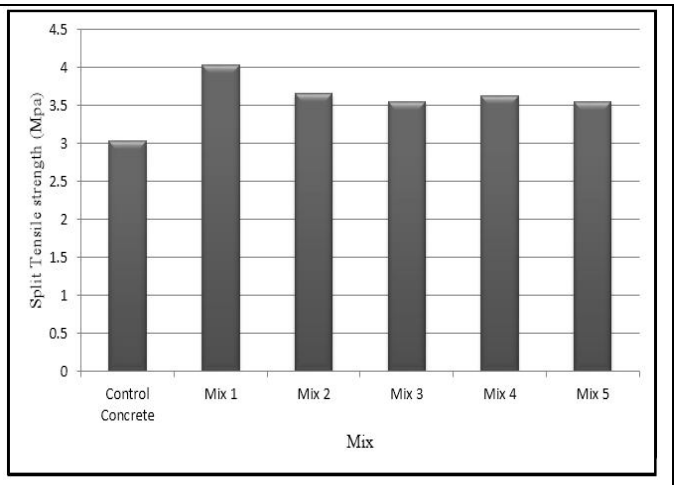

Fig.7. Split tensile strength at 7 days

The Split tensile strength value at 7 and 28 days is shown in table 3 and and figure 6 and 7. A maximum split tensile strength of 4.03 N/mm^2 is obtained for the mix 5 which is 7 % of the corresponding compressive strength of the mix which satisfy the codal requirement of IS456-2000.For normal concrete, the approximate split tensile strength is observed as 10%. But in this case an average split tensile strength of 8% of the corresponding compressive strength of concrete is obtained. Hence, the inclusion of these waste materials reduces the split tensile strength by 20 % than normal concrete.

IV. CONCLUSION

The aim of this experimental investigation is to find the effects of copper slag and ceramic waste on the characteristic strength of M25 grade concrete. Natural fine aggregate was replaced with 5%, 10%, 15%, 20%, 25% of copper slag, like wise natural coarse aggregate was also replaced. Additionally 0.25%, 0.5%, 0.75%, 1%, 1.25% of lathe waste was added to enhance the strength and stiffness of concrete.

From the limited experimental investigation conducted with 36- cubes, 36- cylinder and 12- beams, the following conclusions were drawn

A. The addition of ceramic waste and copper slag found to increase the compressive strength of concrete.

B. Based on the compressive strength and split tensile strength performance, The Mix 5 is identified as best mix where 25% replacement of coarse and fine aggregate was done respectively. In mix 5, 1.25% of lath waste also included.

C. Mix 5 exhibited a compressive strength of 57.33 N/mm^2 which is 59% higher than the normal concrete.

D. Addition of ceramic waste and copper slag found to generally increase the split tensile strength of concrete and maximum of 4.03 N/mm^2 is achieved in the mix 5 which is 33% higher than the control concrete.

E. It is concluded that, by incorporating the waste materials viz., Ceramic aggregate, copper slag and lath waste, without having any extra cost a 59% increase in compressive strength and 33 % increase in split tensile strength of concrete can be achieved.

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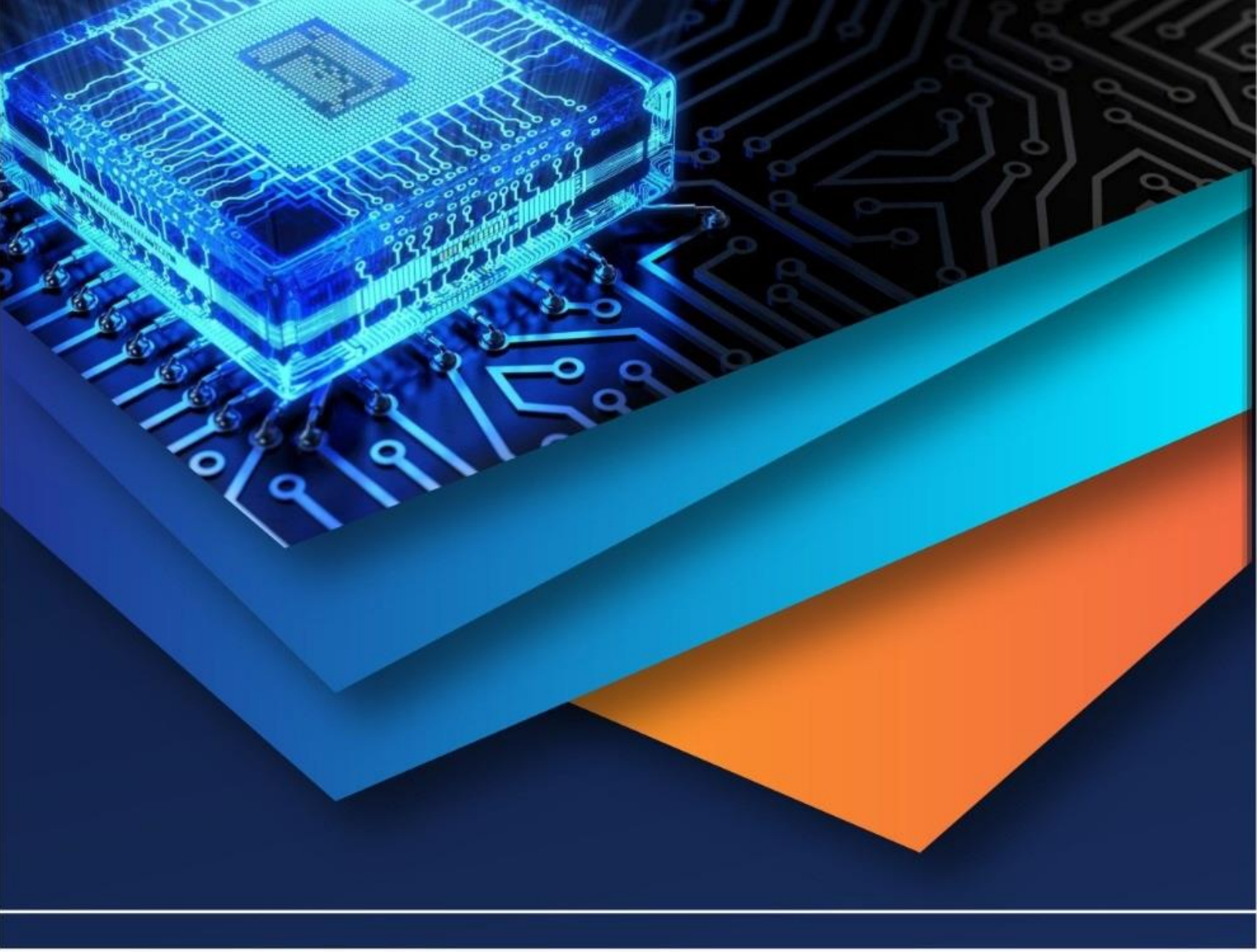

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