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An Experimental Investigation on Partial Replacement of Copper Slag as Fine Aggregate in Paver Block

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Abstract : In present situation plenty of copper slag has been extracted as waste material from the copper industry. Here an attempt has been made to utilize the waste from copper industry as in the form slag for fine aggregate to study the behavior of paver block under this replacement. Utilization of copper slag as a partial replacement considerably reduces the consumption of natural river sand. This paper presents the effect of copper slag when added in concrete as a partial replacement of material for sand. The objective of this investigation is to study the effect of copper slag on behavior of paver block. Experimental investigations were carried out by replacing sand with copper slag of 10%, 20%, 30%, 40%, 50% and 60%. It is observed that the optimum content of copper slag that can be used as replacement material is 30% beyond which the strength starts decreasing.
Keywords : Copper Slag, natural river sand, Concrete, compressive strength.

I. Introduction

At present waste from industries can be used as one of the raw material or replaced the concrete ingredients so that these will be certain advantage of strength enhancement. Before we use these waste it should be checked for both chemical and physical tests. Hence the chemical ingredients in the waste should not react with concrete.Hence it will give an adverse effect in strength. So these waste materials to be checked for strength and durability for its better suitability for concrete. Utilization of waste material as a partial placement will minimize the problem of waste disposal and also reduces the consumption of natural resources. An experimental investigation was conducted on the effect of copper slag on the mechanical strength of concrete. Optimum percentage of copper slag was found to be 40%. Further addition of copper slag reduces compressive strength [1]. Beyond 40% addition of copper slag as a partial replacement sand shows increase in strength and reduces the water absorption. Segregation and bleeding effect of copper slag and fly ash mixed concrete and also increases the water absorption capacity [2]. Utilization of copper slag as a partial replacement explores the possibility reducing environmental impact [3]. Silica content in copper slag is about 30% and which is similar to the natural river sand [4]. Grain size of copper slag matches with sand. The specific gravity of copper slag is slightly higher than sand due to increasing its self weight [5].

2. Materials and Properties

2.1Cement

The cement used for this investigation is Ordinary Portland Cement of 43grade.

2.2 Coarse aggregate and Fine aggregate

Coarse aggregate of 20mm size and fine aggregate of Zone II isadopted for this investigation.

2.3 Copper Slag

Copper slag is an industrial-product obtained during the matte smelting and refining of copper. It is an industrial by-product abundantly available near copper producing industries having similar physical and chemical properties of Sand, considered as an alternative to the river sand.

3. Physical and Chemical properties

3.1 Physical properties of OPC

Ordinary Portland cement used for this investigation.

The Physical properties of Ordinary Portland Cement is given in Table 3.1

Table 3. 1 Physical properties of Cement

S.No	Physical Properties	OPC
1.	Fineness modulus	2%
2.	Initial setting time	31min
3.	Final setting time	230min
4.	Specific gravity	3.15

3.2 Chemical Properties of Copper Slag

The Chemical Components of Copper Slag are given in table Table 3.2

Table 3.2 Chemical components of Copper Slag

S.No	Component	Copper slag
1.	Silica (sio_2)	29.84
2.	Alumina(Al_2so_3)	0.22
3.	Iron oxide (Fe_2O_3)	68.29
4.	Calcium oxide (Cao)	0.15
5.	Magnesium oxide (MgO)	0.39
6.	Sulfuric trioxide (So_3)	0.56

3.3 Replacement of Copper Slag and Fine Aggregate

The various replacements of Copper Slag and Fine Aggregate given in Table 3.3

Table 3.3 Replacement of Copper slag and Fine Aggregate

S.No	Fine Aggregate (%)	Copper slag (%)
1.	100	0
2.	90	10
3.	80	20
4.	70	30
5.	60	40
6.	50	50

4. Testing of Materials

4.1 Sieve Analysis

The sieve analysis is conducted to determine the particle size distribution for sample of aggregate. The aggregate used for producing concrete are 4.75mm, 2.36mm, 1.18mm, 600micron, 300micron and 150 micron. The aggregate passes through 40mm and retained at 4.75mm at coarse aggregate and the aggregate passes through 4.75mm and retained on 150micron as fine aggregate. Sieve analysis can be done manually or mechanically. The fineness modulus of copper slag (4.491) is more than the fineness modulus of fine aggregate (2.524).

4.2 Specific gravity

The specific gravity is calculated as the ratio between the weight of a given volume of the material and weight of an equal volume of standard material. Specific gravity of aggregate is required in calculating the factor in connection with the workability measurements. The specific gravity of materials are given in Table 4.2

Table 4.2 Specific gravity of materials

S.No	Material	Specific gravity
1.	Cement	3.15
2.	Fine Aggregate (Sand)	2.48
3.	Copper Slag (F.A)	4.04
4.	Coarse Aggregate	2.75

5. Test on Hardened Concrete

5.1 Weight density test

The weight density of paver blocks using copper slag is heavier than the conventional and the increase in weight density is for proportion CS0, CS10, CS20, CS30, CS40, CS50,CS60 respectively. This indicates that the copper slag specific gravity is high so the weight density of copper slag paver block is increased compared to the conventional paver block.

Table 5.1Weight density of paver block

S.No.	Specimen	Weight density (kN/m^3)
1.	CS0	19.62
2.	CS10	21.05
3.	CS20	20.45
4.	CS30	21.60
5.	CS40	22.20
6.	CS50	22.44
7. `	CS60	23.50

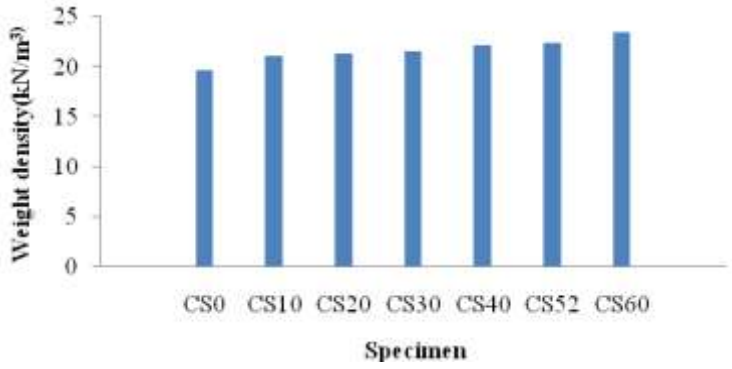

Fig 5.1 Weight density of paver block

6.1 Compressive strength of paver block

Fig.6.1 Testing of paver block

Paver block Specimens were cast for different percentage of copper slag varies from 0% to 60%. The mould is cleaned and oiled properly. Paver block specimens were cast. The paver block specimens are kept curing for 3days, 7days and 28days. After 3days, 7days and 28days of curing the specimens are tested by using compression testing machine. The test results obtained after 3days,7days and 28days of curing shown in Table 6.2

Table 6.2Compressive Strength of paver blocks after curing

S.No	Specimen	Copper slag in %	Compressive strength in N/mm^2		
			3days	7days	28days
1.	CS0	0%	19.90	26.24	41.39
2.	CS10	10%	19.81	21.62	42.55
3.	CS20	20%	21.37	22.65	43.73
4.	**CS30**	**30%**	**27.46**	**31.72**	**45.46**
5.	CS40	40%	24.28	27.68	39.64
6.	CS50	50%	23.25	26.84	38.33
7.	CS60	60%	21.03	23.56	37.15

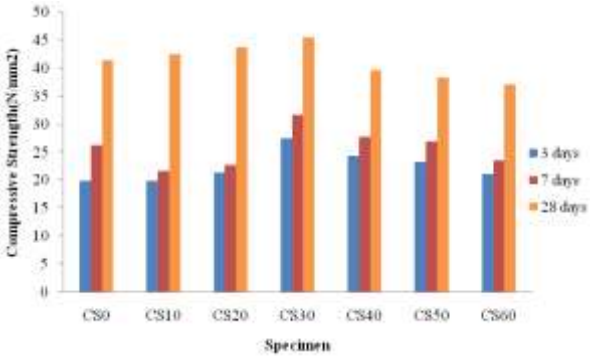

Fig.6.2 compressive strength of paver block

Conclusions

1. The addition of copper slag considerably improves its density continuously whereas the compressive strength increases upto 50% of replacement of copper slag.
2. The results of compressive test shows thatstrength of paver block increases with respect to the percentage of copper slag added by weight of fine aggregate upto 30% of replacement. Therefore optimum percentage of fine aggregate by copper slag is 30%.
3. Compared to the conventional specimen the copper slag based paver block shows an increase in density upto 10%.
4. It is concluded that the paver block with copper slag gains 10% strength more than to that of paver block with conventional (concrete).
5. After 30% increase in copper slagfine aggregatestrength of concrete mainly based on the combined effect of specific gravity of material that is reflected in the interfacial zone of concrete,Hence there after 30% replacement the strength decreases of paver block.

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