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AN EXPERIMENTAL STUDY ON PARTIAL REPLACEMENT OF FINE AGGREGATE IN CONCRETE WITH COPPER SLAG AND CEMENT WITH FLY ASH

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Abstract

Concrete is widely used material in the construction industry for building structures that are ordinary to those that involve highly specialized jobs. Experimental work was carried out to gather information about the properties of plain cement concrete with replacement of fine aggregate with copper slag and cement with fly ash. Copper Slag have been used by varying its percentage by weight of cement as 30%, 40% and 50% and also fly ash for M25 grade in the percentage of 15%, 20%, and 30% and for M35 grade in the percentage of 5%, 10% and 15% to cover the largest contribution to the construction industry using ordinary concrete as also substantially large component of the same using standard concrete. Effect of copper slag and fly ash as a replacement of fine aggregate and cement respectively on properties of concrete like workability, compressive strength, split tensile strength has been studied.

Keywords*- copper slag, fly ash, compressive strength, split tensile strength, standard concrete.*

I. INTRODUCTION

Concrete is one of the widely accepted construction material
in the development of infrastructure. It perfectly matches with several requirements like strength, durability, impermeability, and fire-resistance and abrasion resistance. Cement and fine aggregate is the main ingredient used to make concrete, which are obtained from natural resources. Cement is an artificial material manufactured with the naturally available limestone, silica and gypsum. Aggregates are considered one of the main constituents of concrete since they occupy more than 70% of the concrete matrix. As a result of increase in construction requirement, the usage of these natural resources increased a lot which will lead to scarcity of these materials in future. In order to reduce dependence on natural aggregates as the main source of aggregate in concrete, artificially manufactured aggregates and artificial aggregates generated from industrial wastes provide an alternative for the construction industry. Therefore, utilization of aggregates from industrial wastes can be alternative to the natural and artificial aggregates. The other main advantage of using such materials is to reduce the cost of construction. The new material should be environment–friendly and preferably utilize industrial wastes generated as a result of rapid industrialization.

Materials

Copper Slag

Aggregate is the main constituent of concrete, occupying more than 70% of the concrete matrix. In many countries, there is a scarcity of natural aggregate that is suitable for construction, whereas in other countries the consumption of aggregate has increased in recent years, due to increases in the construction industry. In order to reduce depletion of natural aggregate due to construction, artificially manufactured aggregate and some industrial waste materials can be used as alternatives. Copper slag (CS), the glassy material, produced during matte smelting and copper conversion was previously considered waste and disposed as landfill.
It has been estimated that for every ton of copper production about 2.2-3 tons of slag are generated.
Slag containing < 0.8% copper are either discarded as waste or sold cheaply. The copper slag, the by-product of the melting plant of copper, copper slag can be used successfully as Portland cement substitute in the cement industry, sand substitute in concrete plant and in different ways.

Fig 1: Physical View of Copper Slag

Fly ash

Fly ash is generally considered as a waste material that is produced as a by-product of coal combustion process. The physical and chemical properties of fly ash are similar to cement, which allows it to be used in concrete. The primary aim of this research is to determine the feasibility of using fly ash as a replacement of cement and fine aggregate in concrete and their effects on the mechanical properties of concrete.

Fly ash is a natural pozzolona, which means that it is a "siliceous or siliceous-and-aluminous material" which chemically reacts with calcium hydroxide (CH) to form composites having cementitous properties.

II. EXPERIMENTAL PROGRAMME

The Copper Slag and fly ash as a partial replacement of fine aggregate and cement respectively were used for the purpose of this dissertation work. The coarse aggregate used was 20mm maximum size. Naturally available fine aggregate were used for the study wok.

For fresh concrete, the standard slump cone test was conducted according to the IS: 1199-1959 for all mixes immediately after the mix was completed. Cubic samples 150 x150 x 150 mm were used for compressive strength. The concrete cube specimen were taken out from the tank, their surfaces were dried of excess water, cleaned and kept in the laboratory for a few minutes to obtain saturated dry surfaces specimens. Then their weight and dimensions were measured and noted.
The specimens were tested at various ages i.e. 7 days and 28 days (3 cubes at each age) for compressive strength. Control mix details are listed in the table 1 below

Table-1 Mix details

Contents				
Grade	Cement kg/m^3	Water kg/m^3	FA kg/m^3	CA kg/m^3
M25	372	197	811	1094
M35	448	197	783	1056

III. RESULTS AND DISCUSSIONS

3.1. Slump of the fresh concrete

Table-2 Slump in mm

Grade	Copper Slag percentage (%)		
	30%	40%	50%
M25	75	85	85
M35	55	60	60
Grade	Fly ash percentage (%)		
	15%	20%	25%
M25	55	55	45
	5%	10%	15%
M35	50	40	40

Increasing the percentage of copper slag (by weight of cement) as a replacement of fine aggregates leads to a increase in slump. This is mainly due to the fact that copper slag increases the flow ability of fresh concrete and results in a decrease in workability. But as the percentage of fly ash as a replacement of cement as increases w

Strength of the concrete

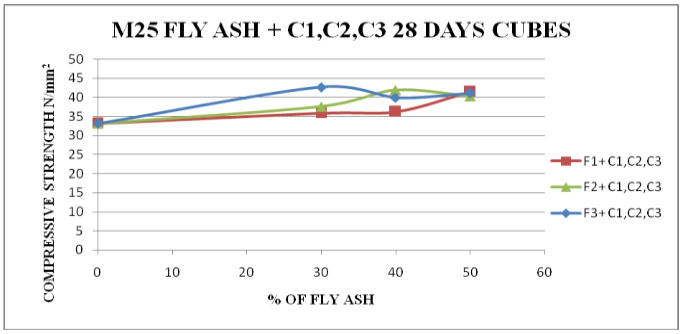
- **Compressive strength**

Table-3 Compressive Strength of M25 grade at the age of 7 days and 28 days

NO.	MIX	COMPRESSIVE STRENGTH	
		(7 Days) N/mm^2	(28Days) N/mm^2
1	PLAIN	21.73	33.11
2	F1(15 % FA)	22.54	32.23
3	F2 (20 % FA)	25.38	33.45
4	F3(25 % FA)	16.08	32.04
5	C1(30 % CS)	21.95	31.2
6	C2(40 % CS)	21.85	30.24
7	C3(50 % CS)	20.89	31.23
8	F1C1(15% FA + 30 % CS)	25.48	23.54
9	F1C2(15% FA + 40 % CS)	26.45	32.25
10	F1C3(15% FA + 50 % CS)	25.04	34.86
11	F2C1(20% FA + 30 % CS)	28.91	34.42

12	F2C2(20% FA + 40 % CS)	27.18	35.71
13	F2C3(20% FA + 50 % CS)	26.86	34.96
14	F3C1(25% FA + 30 % CS)	26.04	34.52
15	F3C2(25% FA + 40 % CS)	22.72	36.19
16	F3C3(25% FA + 50 % CS)	24.37	31.8

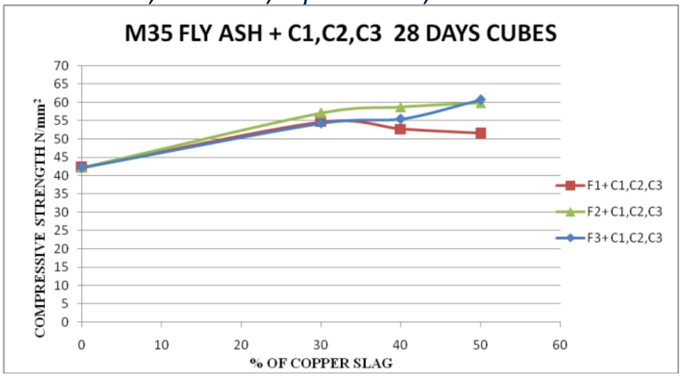
Results of 7 days and 28 days indicate the increase in the compressive strength at various copper slag and fly ash percentages added for almost all grades of concrete.



Graph-1 Compressive strength of M25 grade concrete at the age of 28 days

Table-4 Compressive Strength of M35 grade at the age of 7 days and 28 days

SR. No	MIX	COMPRESSIVE STRENGTH	
		(7 Days) N/mm^2	(28Days) N/mm^2
1	PLAIN	32	42.24
2	F1(5 % FA)	34.44	44.57
3	F2 (10 % FA)	29.79	42.56
4	F3(15 % FA)	30.01	43.56
5	C1(30 % CS)	32.09	42.85
6	C2(40 % CS)	28.04	46.25
7	C3(50 % CS)	26.11	54.29
8	F1C1(5% FA + 30 % CS)	23.99	54.64
9	F1C2(5% FA + 40 % CS)	31.38	52.72
10	F1C3(5% FA + 50 % CS)	31.69	51.53
11	F2C1(10% FA + 30 % CS)	31.69	57.16
12	F2C2(10% FA + 40 % CS)	32.36	58.75
13	F2C3(10% FA + 50 % CS)	33.12	59.85
14	F3C1(15% FA + 30 % CS)	28.5	54.3
15	F3C2(15% FA + 40 % CS)	34.86	55.46
16	F3C3(15% FA + 50 % CS)	36.16	60.74

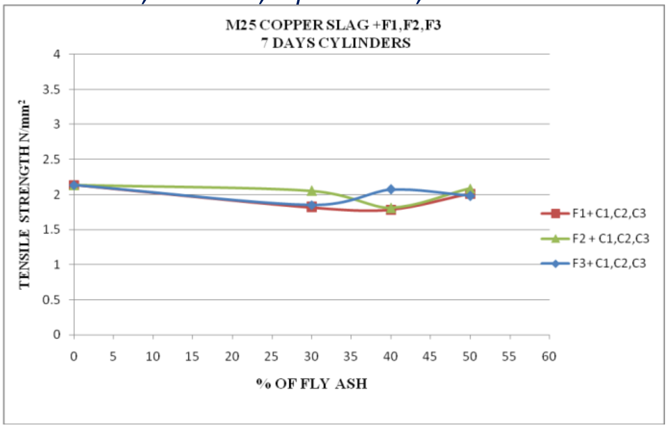


Graph-2 Compressive strength of M35 grade concrete at the age of 28 days

- **Split tensile strength**

Table-5.Split tensile strength of M25 grade at the age of 7 days

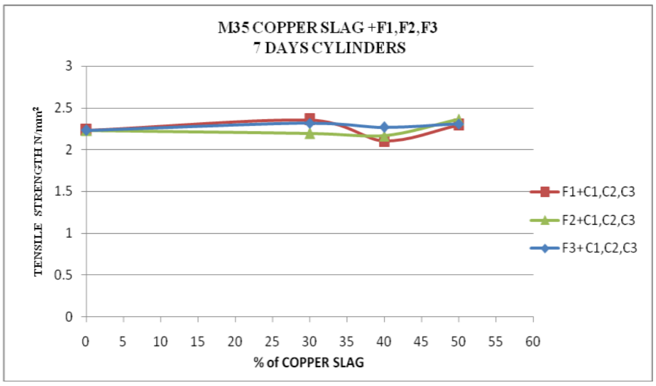
SR. No	MIX	SPLIT TENSILE STRENGTH (7 Days) N/mm^2
1	PLAIN	2.14
2	F1(5 % FA)	2.52
3	F2 (10 % FA)	2.65
4	F3(15 % FA)	1.92
5	C1(30 % CS)	1.74
6	C2(40 % CS)	1.99
7	C3(50 % CS)	2.03
8	F1C1(5% FA + 30 % CS)	1.82
9	F1C2(5% FA + 40 % CS)	1.79
10	F1C3(5% FA + 50 % CS)	2.01
11	F2C1(10% FA + 30 % CS)	2.05
12	F2C2(10% FA + 40 % CS)	1.81
13	F2C3(10% FA + 50 % CS)	2.09
14	F3C1(15% FA + 30 % CS)	1.85
15	F3C2(15% FA + 40 % CS)	2.07
16	F3C3(15% FA + 50 % CS)	1.98



Graph-3 Split Tensile strength of M25 grade concrete at the age of 7 days

Table-4 Split Tensile strength of M35 grade at 7 Days

SR. No	MIX	SPLIT TENSILE STRENGTH (7 Days) N/mm^2
1	PLAIN	2.23
2	F1(5 % FA)	2.35
3	F2 (10 % FA)	2.5
4	F3(15 % FA)	2.4
5	C1(30 % CS)	1.85
6	C2(40 % CS)	2.24
7	C3(50 % CS)	2.22
8	F1C1(5% FA + 30 % CS)	2.35
9	F1C2(5% FA + 40 % CS)	2.1
10	F1C3(5% FA + 50 % CS)	2.29
11	F2C1(10% FA + 30 % CS)	2.19
12	F2C2(10% FA + 40 % CS)	2.17
13	F2C3(10% FA + 50 % CS)	2.36
14	F3C1(15% FA + 30 % CS)	2.32
15	F3C2(15% FA + 40 % CS)	2.26
16	F3C3(15% FA + 50 % CS)	2.31



Graph-4 Split Tensile strength of M35 grade concrete at the age of 7 days

IV. CONCLUSION

- Fresh properties results showed that with increase in amount of Fly Ash (FA) and Copper Slag (CS) workability decreased for all grade of concrete.

For M25 grade,

- The compressive strength of concrete with 25% of Fly Ash and 30% of Copper Slag as a partial replacement of cement and fine aggregate respectively increase about 20% in comparison with normal concrete.

- The split tensile strength of concrete with Fly Ash and Copper Slag as a partial replacement of cement and fine aggregate are almost same in comparison with normal concrete.

For M35 grade,

- The compressive strength of concrete with 15% of Fly Ash and 50% of Copper Slag as a replacement of cement and fine aggregate respectively increase about 27% in comparison with normal concrete.

- The split tensile strength of concrete with 10% of fly ash and 50% of copper slag as a replacement of cement and fine aggregate respectively about 6% in comparison with normal concrete.

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