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Comparative study on replacement of silica fumes and steel slag with conventional concrete

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Abstract— **Every structure constructed includes concrete in one or other ways at any part of construction. The concrete is a composite material made of water, aggregates (fine and coarse), and cement mostly, in order to make them more economical and sustainable some of replacement materials are added. Out of these Silica fumes and steel slag are most common materials used as replacement for cement and fine aggregate these two materials serve as good replacement and gives maximum strength at optimum percentages. The main objective of this paper is to compare the concrete cubes casted by replacing along with conventional concrete and obtain results of various strength characteristics. The silica fume was replaced by 0%, 5%, 10%, 15% and 20% for water-cementitious materials (w/cm) ratio for 0.40 and steel slag was replaced by 0%, 25% and 50%. The compressive strength and slump of these materials are tested and results are obtained. The materials are chosen based on economical and effects on concrete.**

Keywords— steel slag, silica fumes compressive strength and slump.

I. INTRODUCTION

Concrete is one of the essential material in construction which is composite and uses many types of constituents , the main reason for this is it is adaptable and can be used with various types of replacement materials. Nowadays we use either waste or other by products from various industries and other areas like medicinal agricultural etc., these products have more or less same density weight and other durable properties which are used for increasing the strength of the concrete by reducing the defects in conventional concrete. By knowing the demand of concrete we must chose the replacement materials wisely since the natural materials used in olden days are depleting and are becoming more costly nowadays which forced the researchers to find alternatives. In this paper we are about to study about two replacements for cement and natural aggregates. To meet the proper demand of concrete in future by using natural aggregates for preparing concrete by the continues use of natural sands and that leads to depletion of river beds and becomes costly so they uses natural sand from waste by products like from steel industries and the disposed in the form of landfill and it causes land pollution so some position of waste is added to natural aggregates with steel slag in various percentage and that leads to ecological friendly. Mainly steel slag is a byproduct obtained either from conversion of iron to steel in a BASIC OXGYEN FURNACE (BOF), or by melting of scarp to make steel in the ELECTRIC ARC FURNANCE (EAF). This substance is produced during smelting process in many ways. Firstly slag has some undesirable impurities along with metals so it melts and oxidize and forms as a protective crust and more over it is an aging material so it is exposed to weather and brake down slightly before it is used. Replacing cement by silica fume in various percentage so that will increase the strength, durability and high performance strength. Durability and other mechanical properties are improved my pozzolanic materials. Extra calcium silica hydrated gel(C-S-H) forms when silica present between pozzolanic and calcium hydroxide. A part replacement of cement by silica fume at varying percentage has improved the performance of concrete in strength and durability. The incorporation of silica fume in concrete is useful to increase the compressive strength, decrease the drying shrinkage, and the permeability. Also the incorporation of silica fume in concrete is effective to increase the bond strength with the steel reinforcement, and abrasion resistance. Consequently, the use of

silica fume concrete in civil structures is wide spreading. Nevertheless, the loss of workability due to the use of silica fume creates the difficulty to utilize silica fume concrete accurately. The smaller sizes (10 mm and 5mm) and rounded shape aggregates should be used for high strength of concrete than other sizes and shape respectively. Incorporation of silica fume in concrete has an adverse effect on workability and higher percentage of super plasticizer is needed for higher percentage of cement replacement by silica fume By using silica fume in concrete it will reduce the drying shrinkage and permeability value. Water cement ratio is uniformly maintained as 0.40. Ordinary Portland Cement 53 and M30grade concrete is used for mix proportions. Steel slag and silica fume is used to give high strength and high performance concrete.

STEEL SLAG

II. EXPERIMENTAL INVESTIGATION

A. Materials and methodology

The basic tests are conducted on various methods like OPC53 grade cement, fine aggregates, coarse aggregates, steel slag and silica fume to check their suitability of making concrete. The experimental investigation is carried out on cylinders, beams each to study the strength characteristics by replacing fine aggregate by steel slag in various percentage namely 0%, 25%, 50% of steel slag and silica fume by replacement of cement in various percentage namely 0%, 5%, 10%, 15%, 20%. Specimens are cast as per mix design and tests are conducted after proper curing, the tests are compressive strength of cubes (100mm*100mm*100mm).

a) Cement: Ordinary Portland cement of ACC brand of 43 grade was used in the present study which surpasses BIS specifications (IS 8112-1989) on compressive strength. The specific gravity of cement used is 3.14.

b) FINE AGGREGATE: Natural river sand with fractions passing through the 4.75 mm sieve and retained on 600 micron sieve was used and tested as per IS: 2386. The fineness modulus of sand used was 3.0 with a specific gravity of 2.67..

c) COARSE AGGREGATE: Crushed aggregate confirming to IS: 383-1970 was used. Aggregates of size 12.5 mm of specific gravity 2.83 and fineness modulus 6.28 were used.

d) SUPERPLASTIZIER: In this investigation super plasticizer-CONPLAST-SP 430 in the form of sulphated Naphthalene polymers complies with IS: 9103-1999 and ASTM 494 type F was used to improve the workability of concrete. Conplast SP 430 has been specially formulated to give high water reductions up to 25% without loss of workability or to produce high quality concrete of reduced permeability. The properties of super plasticizer are specific gravity 1.224 and there is no chloride content.

B. Mix Propotions

mat Concrete mix design in this experiment was designed as per the guidelines specified in I.S. 10262-1982. But some restriction is imposed by restricting the amount of cementitious material content is equal to 450 Kg/m3.

C. Steel Slag

Steel slag is a byproduct obtained either from conversion of iron to steel in a Basic Oxygen Furnace (BOF), or by the melting of scrap to make steel in the Electric Arc Furnace (EAF).

PHYSICAL PROPERTIES OF STEEL SLAG

SL.NO	DESIGNATION	PROPERTIES
1	Color	Light to dark brown
2	Shape	High angular
3	Bulk density	1911.11 kg/m
4	PH	8
5	Surface texture	Rough
6	Specific gravity	2.93
7	Combustibility	Non-combustible

CHEMICAL PROPERTIES OF STEEL SLAG

SL.NO	CONSTITUENT	COMPOSITION%
1	Calcium oxide	40-52
2	Silica	10-19
3	Iron oxide	10-40
4	Manganese oxide	5-8
5	Magnesium oxide	5-10
6	Aluminium oxide	1-3

D. Silica fumes

Silica fume used was confirming to ASTM- C (1240-2000) and was supplied by "ELKEM INDUSTRIES" was named Elkem – micro silica 920 D. The Silica fume is used as a partial replacement of cement. A Scanning Electron Microscopy and EDAX Spectrum to support the particle morphology with elemental existence.

PHYSICAL PROPERTIES OF SILICA FUME

SL.NO	CHEMICAL ANALYSIS	ANALYSIS
1	SIO2	95.00%
2	SO3	0.18%
3	CL	0.12%
4	Total alkali	0.66%
5	Moisture content	0.16%
6	Loss of ignition	1.92%
7	pH	7.90%

E. CONCRETE

The tests conducted in concrete are in two stages namely

- FRESH CONCRETE
- HARDENED CONCRETE

Fresh concrete consists of slump test and compaction test and Hardened concrete consists of compression strength test, spilt tensile test and flexural strength test.

1) Compressive Strength of Concrete:

In compression strength test 6 concrete cube were casted and it is allowed for 7 days and 28 days curing. After drying, cubes were tested in Compression Testing Machine (CTM) to determine the ultimate load. Replacing fine aggregate by steel slag in various percentage namely 0%, 25% and 50 %. Water cement ratio of 0.45 is maintained uniformly. After testing of cubes in M30 grade of concrete under Compression Testing Machine (CTM) for varying percentage of steel slag by volume of fine aggregate.

% USED	7 DAYS COMPRESSIVE STRENGTH (N/mm^2)		28 DAYS COMPRESSIVE STRENGTH (N/mm^2)	
	STEEL SLAG	SILICA FUME	STEEL SLAG	SILICA FUME
0%	25.81	28.16	55.84	66.01
5%	25.92	28.94	56.44	67.06
10%	26.18	30.11	57.06	68.87
15%	27.01	32.47	57.87	69.11
20%	28.41	34.48	58.11	70.43
25%	29.96	33.82	59.68	68.82
30%	27.91	32.67	57.82	68.00
35%	26.61	30.80	57.00	67.32

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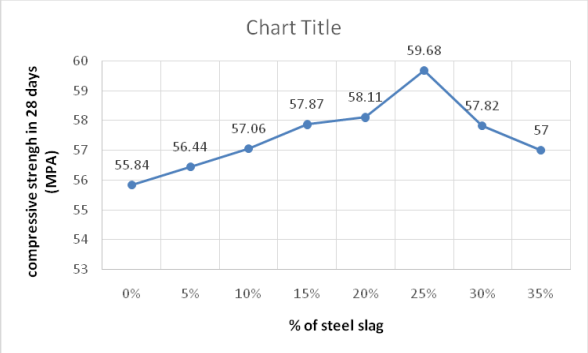
Conclusion

When the compressive strength increases by increases in % of steel slag to 25% by the weight of fine aggregate and strength decreases when it exceeds beyond 25% and maximum strength obtained in silica fume is at 20% and thereafter it starts decreasing. From the above test values when we start increasing the value of steel slag and silica fume it will loses its

strength, durability and workability. Curing for 7 days and 28 days curing, 25% replacement of fine aggregate by steel slag and 20% replacement of cement by silica fume will decrease the drying shrinkage and permeability and it will increase the value of strength by 28.16% for 100 mm size cubes is the optimum percentage of replacement of M30 grade concrete and decreases considerably in further replacement of slag in concrete. Eco-friendly and Mass utilization of waste material is possible in construction by using steel slag and silica fume as partial replacement material for partial replacement in concrete.



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