A Study on Mechanical Properties of Concrete With Partial Replacement of Coarse Aggregates With Sintered Fly Ash Aggregates

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Abstract- *Sintered fly ash aggregate is a group of material that can vary significantly in composition. Sintered fly ash is the residue left out after burning the coal, which is collected from electrostatic precipitator.*

Concrete using sintered fly ash aggregate & GGBS has been prepared at water-cement ratio of 0.45. The various Mechanical properties such as Compressive strength, Flexural strength, splitting tensile strength, have been determined.

In present study, a mix design has been done for M55 Grade of concrete by IS method. Ordinary Portland cement of 53 Grade is selected and sintered fly ash aggregates were prepared by mixing sintered fly ash with cement and water for making low cost concrete.

Keywords- Sintered Fly Ash, Compressive strength, Flexural strength, splitting tensile strength,

I. INTRODUCTION

Concrete is a material synonymous with strength, durable and longevity. It has emerged as the dominant construction material for the infrastructure needs since ages. In addition to being durable, concrete is easily prepared and fabricated from readily available constituents and is therefore widely used in all types of structural systems.

Energy is the major distinct of modern civilization of the world over, and constant power generation from thermal power stations is a major source of energy. In India, over 70% of electricity generated in India, is by combustion of fossil fuels, out of which nearly coal-fired plants produce 61% being of coal in thermal plants, roughly 100 ton of ash.

Sintered Fly ash based artificial lightweight aggregate offer potential for large-scale utilization in the construction work. Apart from using it in concrete industry as cement replacement, fly ash usages by other related industries have been for cube (Bricks) manufacture, cellular concrete, prefabricated items and road construction. Yet about 75% of fly ash remains unutilized, thus offers wide hope for research activity in this area.

II. ALTERNATIVE MATERIALS

The following are the few alternative materials in Construction Industry.

a) Ground granulated blast furnace slag as a cementitious material
b) M-SAND as a Replacement of Fine Aggregate
c) Sintered Fly Ash as replacement of coarse aggregate

III. THE PRESENT STUDY

It is proposed to conduct a detailed study on the characterization of sintered fly Ash samples manufactured form RDB Boulevard, 8thFloor, Plot K1, Block EP &GP, Salt Lake City, sector V, Kolkata -700091, west Bengal, India, and to study its workability by different tests like Slump test and Compaction Factor test for different cement contents to study its behavior as a constituent for concrete of different Sintered fly ash content. The concrete mix is arrived by IS Method and is re-proportioned with a known full replacement percentage of Sintered fly ash aggregate, from previous studies. It is proposed to study the compressive strength of concrete cubes of Standard size (150mm*150mm*150mm) for seven different cement content at curing periods of 7days, 14days and 28days. Tensile strength of cylinders of standard size (Diameter 150mm and length 300mm). Flexure strength of Beam standard size (500mm*100mm*100mm).

IV. AIM OF THE PRESENT INVESTIGATION

Most of the investigations on concrete with various alternative materials for cement or as Fine Aggregate carried

out to study and understand the dual characteristic properties of concrete in fresh state as well as in the hardened state.
It is very essential to evaluate strength and durability performance of concrete in its hardened state for the surrounding environmental conditions for the appropriate design and quality control of concrete, when an alternative material is used in it.

Since it is difficult to predict the performance of concrete various investigations were carried out on different aspects of concrete throughout the world using new material as constituent. This study is aimed at evaluating the performance of concrete in terms of its strength characteristics with sintered fly ash as full replacement to coarse aggregate in concrete and comparing its behavior with that of a control concrete. i.e. concrete with M-sand as fine aggregate.

V. EXPERIMENTAL INVESTIGATION

The initial part of work after collection of sample is detailed characterization of materials used for the study. This chapter includes the details of sample collections of materials used for the investigation, characterization of materials, analysis, and mix- design based on its characteristics as per relevant codes of practice.

i. CEMENT

Physical Properties of Cement

Sl No	Properties	Results	Requirements as per IS:12269-1987
1	Setting time: Initial Final	30 minutes 600 minutes	Not less than 30 min Not more than 600 min
2	Normal Consistency	31%	----------
3	Specific gravity	3.15	----------

ii. FINE AGGREGATE

Physical Properties of M-Sand or Fine Aggregates

Sl no.	Properties	Crushed stone
1	Specific gravity	2.65
2	Sieve analysis	
3	Sieve sizes	% passing
4	4.75mm	93.8
5	2.36mm	70.8
6	1.18mm	30.8
7	600 micron	16.8
8	300 micron	9.2
9	150 micron	3.1
10	75 micron	0
11	Pan	0
12	Zone	II

GRADING ZONES FOR FINE AGGREGATES

By comparing the percentage passing of sand with above table, the sand used for the experimental work falls under Zone II.

iii. SINTERED FLY ASH

Physical Characteristics Sintered Fly Ash

Sl no.	Properties	Results
1	Specific gravity	1.5
2	Water Absorption	0.86 %
3	Crushing Value	33.42%
4	Impact strength	26.42%

iv. COARSE AGGREGATE

Properties of Coarse Aggregates

Sl. No.	Properties	Crushed Stone
1	Specific gravity	2.66
2	Crushing Value	32.1%
3	Impact strength	21.2 %
4	Sieve analysis	
	Sieve sizes	%passing
	80mm	100
	40mm	100
	20mm	100
	10mm	54.5
	4.75mm	0
	Pan	0

v. CHEMICAL ADMIXTURE

Liquid plasticizer namely CONPLAST and velocity modifying agent used to enhance the workability of concrete mix and also to lesser stiffness of mix due to presence of Fly Ash.

vi. MIX DESIGN –CALCULATION AS PER IS10262-2009

Mix Design is a process of selecting suitable ingredients and determining their relative proportions with the objective of producing concrete of having certain minimum workability, strength and durability as economically as possible concrete to achieve the desired characteristics.

In this work, M 55 Concrete Mix Design for Normal Concrete and for different replacement levels of sintered fly ash aggregates (25%,50%, 75%, 100%) have been calculated.

Mix Proportions for One Cum of Concrete

Mix	W/C ratio	Cement (kg/m^3)	GGBS 35% (kg/m^3)	FA (kg/m^3)	CA (kg/m^3)	SFA (kg/m^3)
NC	0.45	440.96	-	1028.7	790.641	-
SA25		322.87	107.62	1068.7	448.63	149.58
SFA50		322.87	107.62	1068.7	299.1	299.1
SFA75		279.82	150.670	1050.38	121.83	365.44
SFA100		279.82	150.670	1050.38	-	487.25

- NC- Normal Concrete
- SFA- Sintered Fly Ash Concrete

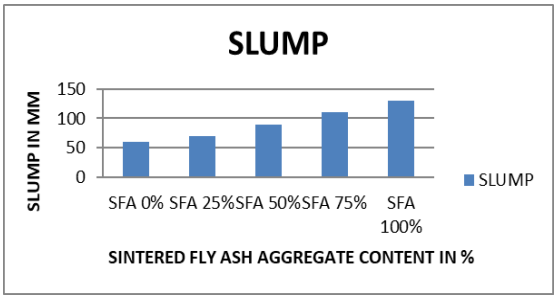
VI. RESULTS AND DISCUSSION

This chapter presents the results of the experimental investigations, in which results of slump test and compaction factor test results as fresh concrete properties followed by, compressive strength test, Split Tensile Strength Test, and Flexural Strength Test and measurement of density of concrete, in hard state.

i. SLUMP TEST

Slump of Different Grades of Concrete

SL.NO	MIX DESIGNATION	ACTUAL W/C RATIO	SLUMP IN MM
1	SFA0GGBS0	0.45	60
2	SFA25GGBS30	0.45	70
3	SFA50GGBS30	0.45	90
4	SFA75GGBS30	0.45	110
5	SFA100GGBS30	0.45	130



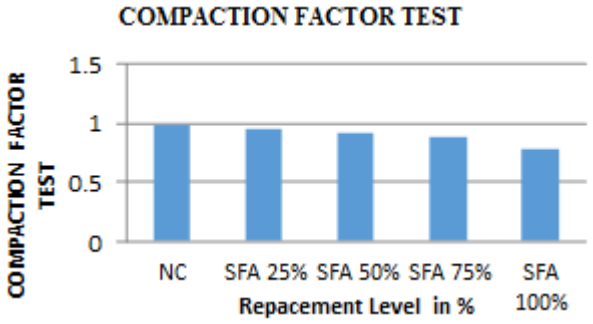
DISCUSSIONS

- Slump of sintered fly ash concrete (SFA) mixes is slightly better than that of normal concrete (NC). This may be because of finer particles of pond ash which increases flow of mix.
- As the sintered fly ash aggregate increases, the slump was found decreasing. This may be due to the increased coarse content of the mix.

ii. COMPACTION FACTOR TEST

Compaction factor test SFA& NC mixes with different cement contents.

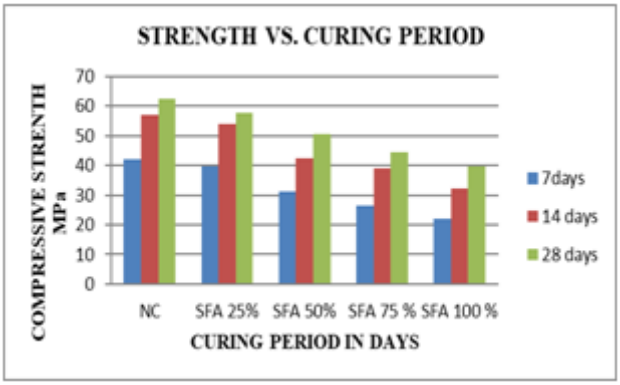
Sl.no	Mix designation	W/c ratio	Compaction factor
1	SFA0 GGBS0	0.45	0.98
2	SFA25 GGBS30	0.45	0.945
3	SFA50 GGBS30	0.45	0.919
4	SFA75 GGBA30	0.45	0.88
5	SFA100GGBS30	0.45	0.79



PROPERTIES OF HARDENED CONCRETE-COMPRESSIVE STRENGTH

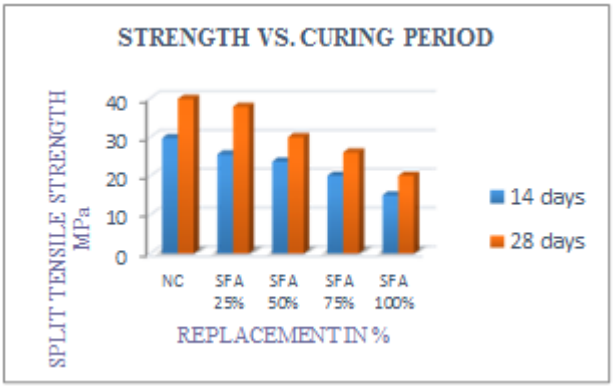
a) COMPRESSIVE STRENGTH

Sl No	Mix designation	Compressive Strength in MPa at Curing Periods of		
		7days	14 days	28 days
1	NC	42.12	56.95	65.50
2	SFA 25%	39.77	53.85	57.50
3	SFA 50%	31.25	42.5	50.50
4	SFA 75%	26.5	38.9	44.50
5	SFA 100%	22.00	32.13	39.80



b) SPLIT TENSLIE TEST

Sl No	Mix designation	Split tensile Strength in MPa at Curing Periods of	
		14 days	28 days
1	NC	29.72	39.82
2	SFA 25%	25.50	37.80
3	SFA 50%	23.20	30.0
4	SFA 75 %	20.00	26.0
5	SFA 100 %	15.0	20.0



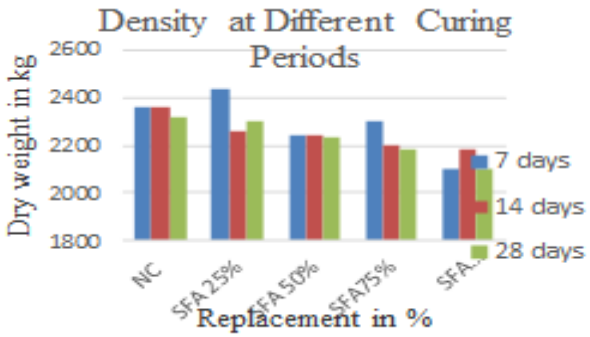
c) FLEXURAL STRENGTH TEST

Sl No	Mix designation	Flexural Strength in MPa at Curing Periods of	
		14 days	28 days
1	NC	7.0	7.56
2	SFA 25%	6.75	7.30
3	SFA 50%	6.35	6.90
4	SFA 75 %	5.15	5.90
5	SFA 100 %	4.45	5.00

d) DENSITY OF CONCRETE

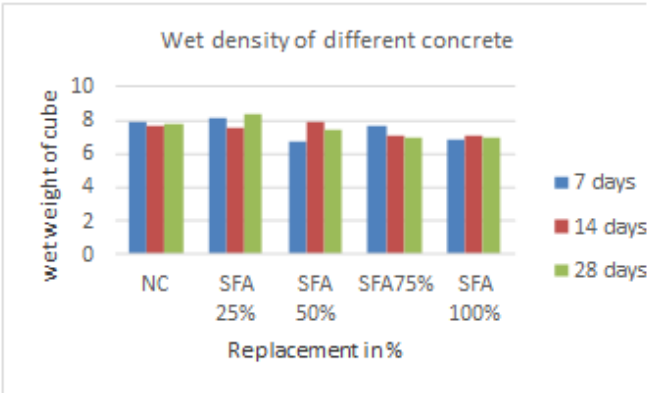
Dry Weight of Specimens at Different Curing Periods of cube

Dry Weight of NC and SFA specimens for different cement contents in kg	Dry weight in kg at curing periods of					
	Dry wt 7 days	Dry density in kg/m³	Dry wt 14 days	Dry density in kg/m³	Dry wt 28 days	Dry density in kg/m³
NC	7.976	2363.26	7.976	2363.25	7.820	2317.03
SFA 25%	8.208	2432	7.624	2258.96	7.760	2299.25
SFA 50%	7.564	2241.18	7.560	2240	7.538	2233.48
SFA 75%	7.764	2300.44	7.426	2200.29	7.364	2181.92
SFA 100%	7.094	2101.92	7.368	2183.11	7.096	2102.51



Wet Weight of Specimens at Different Curing Periods of cube

Wet Weight of NC and SFA specimens for different cement contents in kg	Wet weight in kg at curing periods of		
	7 days	14 days	28 days
NC	7.914	7.714	7.810
SFA 25%	8.116	7.538	8.362
SFA 50%	6.720	7.892	7.456
SFA 75%	7.664	7.084	6.916
SFA 100%	6.866	7.080	6.952



VII. CONCLUSIONS

- Results of Crushing and Impact values indicate that light weight aggregate shall not be used for concrete in

applications of wearing surface, however the corresponding Crushing and Impact values are satisfactory for the coarse aggregate to be used in other concrete.

- Low specific gravity compared to natural gravel proves it to be a light weight aggregate material and Sintered fly ash has been consumed in large volume when it is used as a coarse aggregate replacement material due to its occupation of large volume in concrete. This in turn reduce the problem of dumping as landfills to great extent.
- The minimum slump found 60mm from replacement of sintered fly ash 0%and maximum slump found 130mm from the replacement of sintered fly ash 100%.
- The maximum compressive strength of 57.50 N/mm^2 is attained at 25% replacement of Sintered fly ash aggregate in concrete while the minimum strength of 39.80N/mm^2 is attained at 100% replacement.
- The split tensile strength of 37.80N/mm^2 is found at 25% replacement of Sintered fly ash aggregate in concrete, while the minimum strength of 20.00 N/mm^2 was attained at 100% replacement of Sintered fly ash aggregate in concrete.
- The maximum flexural strength of 7.30N/mm^2 is found at 25% replacement of Sintered fly ash aggregate in concrete, while the minimum strength of 5.00 N/mm^2 was attained at 100% replacement of Sintered fly ash aggregate in concrete.
- The maximum dry density in 2484.2 Kg/m^3 attained at 25% replacement and maximum dry density 1967.6 kg/m^3 of Sintered fly ash aggregate in concrete attained at 100% SFA.
- The maximum wet density in cube is 11.938 Kg/mm^3 attained at 25% replacement of Sintered fly ash aggregate in concrete while the minimum dry density 6.720 Kg/mm^3 is attained at 50% replacement.

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