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AN EXPERIMENTAL STUDY ON BEHAVIOUR OF RECYCLED AGGREGATE CONCRETE WITH GROUND GRANULATED BLAST FURNACE SLAG FLYASH

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ABSTRACT

Concrete is the single largest manufactured material in the world . The use of recycled materials in construction is an issue of great importance. Utilization of Recycled Aggregates (RA), Ground Granulated Blast Furnace Slag (GGBFS) and fly ash in concrete addresses this issue. In this project, strength, durability of Recycled Aggregate Concrete (RAC) with GGBFS was studied. M-50 grade concrete with 0.30 w/c ratio and maximum size of 16mm course aggregate was used for this study. Totally 16 mix combinations were prepared for this study with different replacements of Recycled aggregate (0%, 25%, 50%, and 100%) and GGBFS (0%, 20%, 30%, and 40%). Compressive & Tensile tests were conducted at 7, 14, and 28 days to study the strength characteristics and Sorptivity test were conducted to examine the durability characteristics. It was found that the replacements of Natural Aggregate (NA) and cement with Recycled aggregate and GGBFS respectively, significantly decrease both the compressive and tensile strength and cement with GGBFS replacement increases the resistance against permeability. Based on experimental results it was concluded that 40% replacement of GGBFS and 50% replacement of RA give satisfactory results and it is recommended for reinforced concrete works with proper mix design

KEYWORDS: GGBFS,RAC,COMP STRENGTH,WORKABILITY,CEMENT,NAC.

INTRODUCTION

Concrete is the single largest manufactured material in the world. The use of recycled materials in construction is an issue of great importance. Utilization of recycled aggregates, Ground Granulated Blast Furnace Slag (GGBFS) and fly ash in concrete addresses this issue. As the useable sources for natural aggregates for concrete are depleted utilization of recycled materials will increase. The Portland cement is replaced by fly ash or GGBFS reduces the volumes of Portland cement used is a major benefit. The reduction of Portland cement production will reduce carbon dioxide (CO2) emissions, reduce energy consumption and reduce the rate of global warming. Used the fly ash and GGBFS usually provides cost savings and also improved concrete properties. In this project, the properties of high strength Slag based recycled aggregate concrete of M50 grade has to be studied.

MATERIAL PROPERTIES:

CEMENT:Ordinary Portland cement was far most important type of cement. The OPC was classified into three grades namely 33 grade, 43 grade and 53 grade depending upon the strength of cement at 28 days when tested as per IS 4031-1988. If the 28 days strength is not less than 33 N/mm2 it is called 33 grade cement, if the strengtis 43 N/mm2, it is called 43 grades and if the strength is not less than 53 N/mm2, it is called 53 grades. Ordinary Portland cement of 53 grade was used to conforming a IS Code 8112 – 1989.

Table 1 Physical property of 53 Grade Portland cement

S.No	Physical property	Value of 4Grade cement
1	Specific gravity	3.1
2	Fineness	98
3	Initial setting time	48 minutes
4	Final setting time	320 minutes

5	Standardconsistency	31 %

FINE AGGREGATE:Natural river sand was used as fine aggregate. The properties of sand were determined by conducting tests as per IS: 2386 (Part- I). The results are shown in Table 2.2.2. The results obtained from sieve analysis are furnished

Table 2 Physical property of fine aggregate

S.No	Physical property	Values
1	Specific gravity	2.65
2.	Fineness modulus	2.6
3.	Bulk density(kg/m3)	1550
4.	Water absorption	70%
5	Free moisture content	0.2%

COARSE AGGREGATE :Coarse aggregate used here is 20 mm aggregate of good quality. The physical properties and the data's are given below:

TABLE:.3 PHYSICAL PROPERTY OF COARSE AGGREGATE

S.No	Physical property	Values
1	Specific gravity	2.73
2	Water Absorption	1%
3	Bulk density (kg/m3)	1290
4	Free moisture content (%)	0.5%
5	Aggregate Impact value (%)	35.58%

GGBS: Ground Granulated Blast furnace is a bi-product of the pig iron production. The waste slag formed during the process is poured into the cold water forms the clinkers powdered in the form of fine powder fineness same as that of the cement. The GGBS used here in this project will satisfy ASTM standard, BS and IS standard.

TABLE 4 PHYSICAL AND CHEMICAL PROPERTIES OF GGBS

Characteristics	Requirement as perBS:6699	Test Result
Fineness(M^2/Kg)	275 (min)	400
Soundness LeChatelier Exp	10.0 (max) (mm)	NIL
Initial setting Time(min) Not less than OPC	Min 30 minute	220
Insoluble Residue(%)	1.5 (max)	0.05
Magnesia Content (%)	14.0 (max)	9.5
Sulphide sulphur (%)	2.0 (max)	0.6
Sulphite content (%)	2.50 (max)	0.1
Loss on ignition (%)	3.00 (max)	0.3
Manganese content (%)	2.00(max)	0.6
Chloride content (%)	0.10 (max)	0.003
Moisture content (%)	1.00(max)	0.005
Glass content (%)	67 (min)	94
Chemical Moduli $CaO+MgO+SiO_2$, $CaO+MgO+SiO_2$,CaO/SiO_2	66.66 (min),> 1.0.<1.40	84,1.3,1.05

RAC: Use of recycled aggregate in concrete can be useful for environmental protection. Recycled aggregates are the materials for the future. The application of recycled aggregate has been started in a large number of construction projects of many European, American, Russian and Asian countries. Many countries are giving

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infrastructural laws relaxation for increasing the use of recycled aggregate. This paper reports the basic properties of recycled fine aggregate and recycled coarse aggregate & also compares these properties with natural aggregates.

TABLE.5 PHYSICAL AND CHEMICAL PROPERTIES OF RAC

Specific gravity	1.32
Fineness –median particle size in mm	8.3 mm
Nitrogen absorption ,m2/g	20.6
Water requirement,%	104
Puzzolonic activity index,%	99
Silicon dioxide (SiO_2) %	90.7
Aluminium Oxide (Al_2O_3)	0.4
Ferric Oxide (Fe_2O_3)	0.4
Magnesium Oxide (MgO)	0.5
Sodium oxide (Na_2O)	0.1
Pottasium Oxide (K_2O)	2.2
Equivalent alkali (Na_2O +0.658K_2O)	1.5
PhosphorusOxide (P_2O_5)	0.4
Titanium Oxide (TiO_2)	0.03
Sulphur trioxide (SO_3)	0.1
Loss on ignition	4.8

V.MIX DESIGN: Mix design can be defined as the process of selection suitable ingredients of concrete and determining their relative quantities with the object of producing as economically as possible concrete minimum properties notable consistent strength and durability. Design stipulation as per aci 211.1-91.M50 Grade of concrete. Hence Mix design per m3.

TABLE 6:MIX PROPORTION IS 1:0.735:2.325 (M50 GRADE)

cement	Fine aggregate	Coarse aggregate	w/c
1	0.735	2.33	0.30

TYPES OF MIX GROUPS PREPARED FOR THIS WORK:
Mix 1 – 0% GGBFS replacement with 0, 25, 50, 100% RA replacements
Mix 2 – 20% GGBFS replacement with 0, 25, 50, 100% RA replacements
Mix 3 – 30% GGBFS replacement with 0, 25, 50, 100% RA replacements
Mix 4 – 40% GGBFS replacement with 0, 25, 50, 100% RA replacements.

VI.RESULT AND DISCUSSION

COMPRESSIVE STRENGTH TEST: Four sets of mix combinations with various replacements (0%,20%,30% and 40%) of cement with GGBFS were cast. In each set mix combination natural aggregate was also replaced with recycled aggregate for an amount of 25%, 50% and 100%. Size 100mm X 100mm X 100mm concrete cubes were cast for all above 16 mix combinations W/C ratio of 0.30. After specified period (7, 14, 28 and 56 days) curing, the specimens were tested for compressive strength using compressive testing machine of 3000KN capacity at a rate of loading of 140KN/min. The tests were carried out on triplicate specimens and average compressive strength values were recorded.

TABLE 7:AVERAGE VALUE OF COMPRESSIVE STRENGTH

Combination	Compressive strength (MPa)		
	7 Days	14 Days	28 Days
Mix-1:0% GGBFS replacement with 0, 25, 50, 100% RA	16.78	22.4	26.79
Mix-2:20% GGBFS replacement	16.85	25.24	28.93

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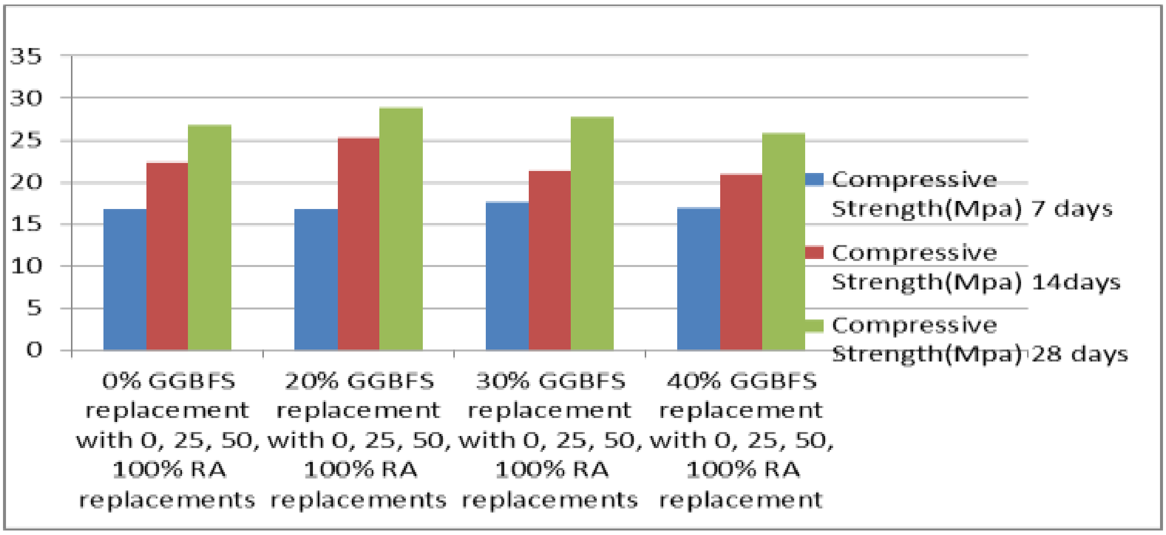
with 0, 25, 50, 100% RA			
Mix-3:30% GGBFS replacement with 0, 25, 50, 100% RA	17.7	21.45	27.75
Mix-4:40% GGBFS replacement with 0, 25, 50, 100% RA	16.95	20.95	25.9



AVERAGE VALUE OF COMPRESSIVE STRENGTH

SPLIT TENSILE STRENGTH TEST: Size 100mm dia X 200mm height concrete cylinders were cast for all above 16 mix combinations. After specified period of curing, the specimens were tested for split tensile strength using compression testing machine of 3000KN capacity at a rate of loading of 140KN/min. The tests were carried out on triplicate specimens and an average split tensile strength values were recorded.

TABLE 8: AVERAGE VALUE OF TENSILE STRENGTH

Combination	Tensile strength (MPa)		
	7 Days	14 Days	28 Days
Mix-1:0% GGBFS replacement with 0, 25, 50, 100% RA	1.525	2.55	2.625
Mix-2:20% GGBFS replacement with 0, 25, 50, 100% RA	11.42	2.2	2.505
Mix-3:30% GGBFS replacement with 0, 25, 50, 100% RA	1.375	2	2.4
Mix-4:40% GGBFS replacement with 0, 25, 50, 100% RA	1.375	1.84	2.025

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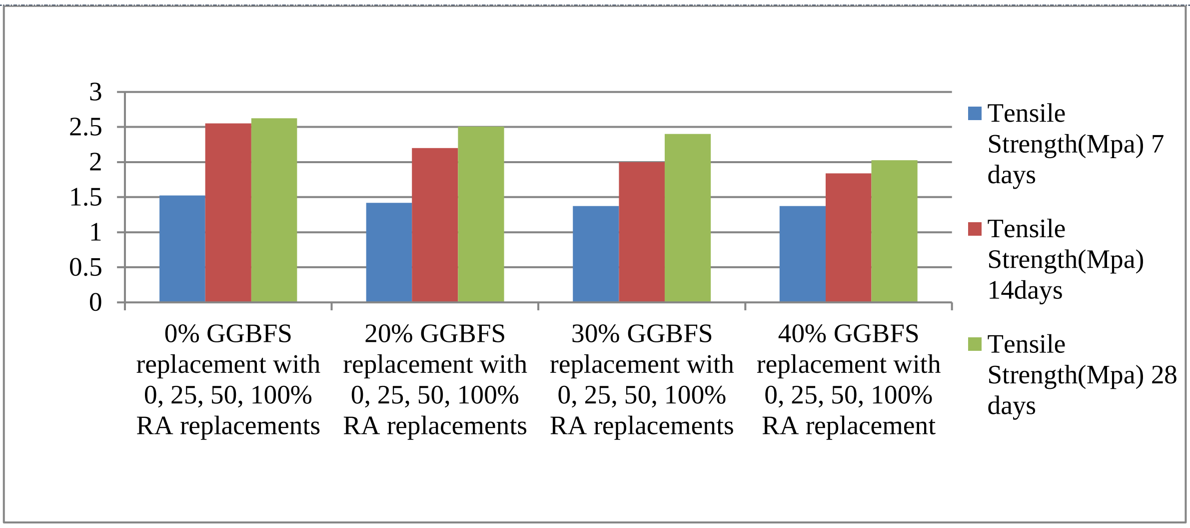

AVERAGE VALUE OF TENSILE STRENGTH

SORPTIVITY TEST

Table 8: Average value of Sorptivity Result

Combination	Sorptivity Coefficent ($mm^3/mm^2/mim^{0.5}$)			
	0% RA	25% RA	50% RA	100% RA
0% GGBFS	0.131	0.158	0.204	0.266
20% GGBFS	0.121	0.148	0.195	0.24
30% GGBFS	0.112	0.137	0.182	0.226
40% GGBFS	0.103	0.135	0.172	0.215

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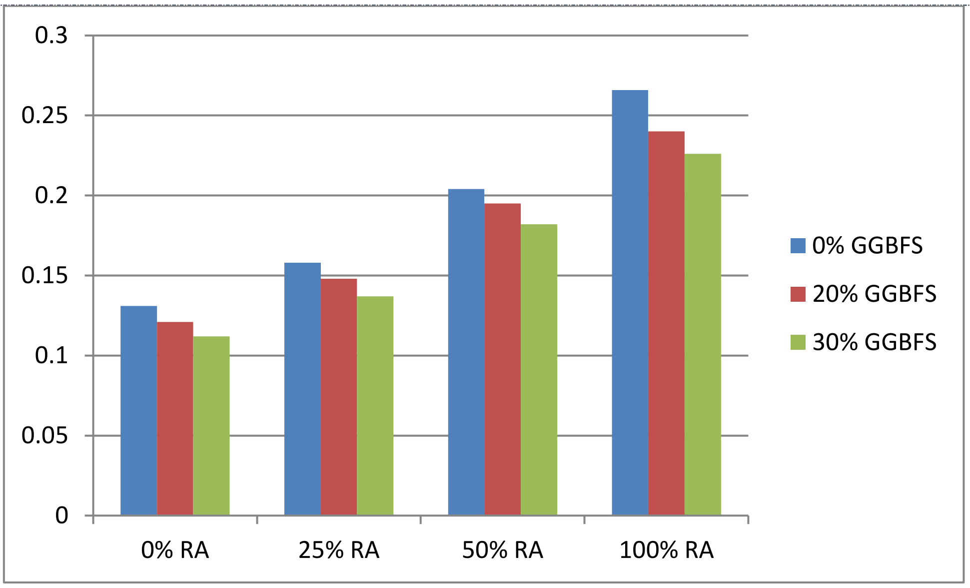

AVERAGE VALUE OF SORPTIVITY TEST

CONCLUSION

From the experiments results, following conclusion are arrived:
Aging of the specimens increased the compressive and tensile strengths irrespective of the mix proportion increases and further increase in RA and slag percentage, decreased the compressive and tensile strengths of the specimens. Cement replaced with 20, 30 & 40% GGBFS and NA replaced with 25, 50,100%RA, reduces the strength of concrete and the percentage reduction in the concrete was observed in the range of 25 to 50%. Concrete with 50% RA and 40% GGBFS gives reasonable compressive strength of 32.9 MPa at the age of 28 days comparing to desired value of 50 MPa. Hence it is suggested that construction engineer can do mix design for 50 MPa concrete to obtain 30 MPa when replacing 50% NA and 40% cement in the field.

In RCPT and Sorptivity test, it was found that, water absorption and chloride iron penetration was increases, when increasing the replacement of NA with RA. Similarly water absorption and chloride iron penetration was decreased when increasing the replacement of Cement with GGBFS. An Ultimate load carrying capacity of GGBFSRAC beam is about 85 % of an Ultimate load carrying capacity of control beam. The Moment ratio between Experimental and Theoretical at Ultimate load are 1.66 and 1.43 for control and GGBFSRAC beams.

REFERENCES

[1] ASTM C1202, 2003. Standard test method for Electrical Indication of Concrete's Ability to Resist Chloride Ion Penetration, 04.02, 650-655.
[2] IS: 456-2000, Indian Standard Code of Practice for Plain and Reinforced Concrete, Indian Standard Institution, New Delhi.
[3] Etxeberria, M., Vázquez, E., Marí, A., and Barra, M. 2007. Influence of amount of recycled coarse aggregates and production process on properties of recycled aggregate concrete. Cement Concrete Research, 37(5), 735–742.
[4] IS: 456-2000, Indian Standard Code of Practice for Plain and Reinforced Concrete, Indian Standard Institution, New Delhi.
[5] IS: 383-1970. Indian standards specification for coarse and fine aggregates from natural sources for concrete. New Delhi, India: Bureau of Indian Standards.
[6] IS: 4031-1988, Methods of physical tests for hydraulic cement (Part 1–6). Bureau of Indian Standards (BIS), New Delhi, India.