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Study of Concrete by Partial Replacement of Cement with SCBA & GGBS

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***Abstract:** Manufacturing of every 1 ton of cement generates about 1.25 tons of CO_2 gas. Thus, new engineering materials have become a necessity at present construction age because the cement industry impacts largely to global warming, greenhouse effects etc. Sugarcane bagasse ash (SCBA) and ground granulated blast-furnace slag (GGBS) are waste materials comprising pozzolanic properties but their disposal is causing acute environmental setbacks. This experimental study represents the results of substituting cement with SCBA and GGBS as supplementary cementitious materials in M40 grade concrete and detecting workability, compressive strength for 7, 28, and 56 days, tensile strength and bond strength for 28 days respectively on comparison with conventional concrete. Concrete specimens were prepared with 100% OPC and 30% replacement of cement by weight having proportions 5, 10, 15, 20, 25% for SCBA & GGBS. It was found that concrete with 15% SCBA and 15% GGBS indicated further improvement in the properties than all other mixes. The use of SCBA & GGBS advances the properties of concrete, set aside plenty of waste disposal problems and also reduces the cement price rise and intensities of CO_2 release by the cement production. Also these materials make the concrete more sustainable, light weight and low energy emitting which is noble.*

***Keywords:** SCBA, GGBS, compressive strength, bond strength.*

I. INTRODUCTION

Over the past few years, many industrial waste materials like FA, rice husk, wallostonite, bottom ash, ggbs, etc. have been tested as pozzolanic cementitious materials. New engineering materials have become a necessity for today's construction world. These supplemental pozzolanic materials show a noteworthy role while amalgamated in OPC by certain proportions. Furthermore to its adverse environmental impact, cement is also one of the most expensive materials when compared to the other components of concrete. Manufacturing of each ton of cement generates about 1.25 tons of CO_2 gas. The cement industry alone is responsible for the 5% of CO_2 emissions worldwide. As a consequence, it is obligatory to use green materials for environmental protection. Sugarcane bagasse ash is a waste material obtained by burning of bagasse as a fuel product. It is about 8-10% of the bagasse and contains unburned matter, silica, and alumina. The bagasse ash (SCBA) is obtained by open burning followed by controlled burning at 600°C-1200°C for 5 hours resulting in a crystallization of the matter. Similarly, blast furnace slag (GGBS) is a waste of the iron production and is a glassy, non-metallic granular material which exhibits pozzolanic properties on its own. It contains less free lime, which in its presence forms efflorescence, and makes the resulting hardened cement more chemically stable. The disposal of these waste materials is again causing severe environmental setbacks. As a by-product using it effectively up to some extent serves as a step for a greener environment and at the same time keeping in mind that the strength of the concrete doesn't degrade by the usage. The benefits of these two materials used in combination in the concrete mix are still not known or further researched. In this paper, the main aim is to experimentally investigate the performance and behaviour of concrete in partial replacement of cement with SCBA & GGBS in terms of strength properties and comparison with conventional concrete.

II. MATERIALS & METHODS

A. *Material Properties*

1) *Cement*: Cement used of grade OPC 53 (Ultratech Cement) confirming IS 12269. Specific gravity is 3.15 and fineness is 2.5 %.
2) *Coarse Aggregates*: Coarse aggregates used were having nominal aggregate size 20 mm having fineness modulus 9.014. Specific gravity was determined as 2.82 and water absorption as 0.80%. Tests are confirmed to IS 383-1970 (12)
3) *Fine Aggregates*: Natural sand was used as a fine aggregate having fineness modulus as 3.76, specific gravity as 2.65 and water absorption as 1%. Tests are confirmed to IS 383-1970 (12)
4) *Sugarcane Bagasse Ash (SCBA)*: Bagasse ash was obtained from Wainganga Sugar Plant, Manas Agro Industries, Devhada, Dist. Bhandara, Maharashtra (India). The Specific gravity of bagasse ash was determined 1.16 and fineness as 12 %. The bagasse ash used in this experiment was sieved from the 90µ sieve.

5) *Ground Granulated Blast-Furnace Slag (GGBS)*: The ground granulated blast-furnace slag was supplied by Khemani Steel Co., Wardhamannagar, Nagpur, India. The specific gravity was found as 2.67 and fineness was 14%.
6) *Superplasticizer*: Auramix 200 was used as superplasticizer. It is a light brown liquid, immediately dispersible in water. The specific gravity was 1.21.
7) *Water:* Clean drinking water available in the college water supply was used for mixing.

Following Table 1 shows the chemical composition of pozzolanic materials used in experiment tested from Indian Bureau of Mines, Hingna road, Nagpur. Amorphous SiO_2 present in bagasse ash react with the CaO present in GGBS and Fe_2O_3 improved the strength properties of concrete.

SR. NO.	OXIDES	SCBA (%)	GGBS (%)	CEMENT (%)
1	SiO2	74.76	38.01	20.1
2	Fe2O3	2.13	1.24	2.5
3	Al2O3	1.16	10.39	4.15
4	Cao	3.64	16.59	61.3
5	MgO	2.28	5.22	3.13
6	K2O	8.26	3.66	0.39
7	SO3	0.07	1.26	4.04
8	Na2O	0.15	0.66	0.24
9	LOI	3.67	0.41	1.63

Table 1 Chemical composition of material

MIX NO.	CEMENT %	SCBA %	GGBS %
Mix 1 (Control mix)	100%	0%	0%
Mix 2	70%	5%	25%
Mix 3	70%	10%	20%
Mix 4	70%	15%	15%
Mix 5	70%	20%	10%
Mix 6	70%	25%	5%

Table 2 Mix Proportions

B. Mix Proportions

In this experimental work, a total of 78 numbers of concrete specimens were cast. The mix design is done as per IS 10262-2009. Percentage dosage of superplasticizer is an additional parameter to be considered for designing an OPC mix. Percentage dosage of superplasticizer was fixed as per the mix design method described in IS 10262- 2009. The superplasticizer dosage was fixed as 1 % by weight of total cementitious material. The grade of concrete was M 40. The cement: fine aggregate: coarse aggregate ratio is fixed at 1:1.51:3.12 and the w/b ratio were fixed as 0.35. Total 6 mixes were prepared. Control sample consists of 100 % OPC only and other mixes were developed by varying the bagasse ash dosages as 5, 10,15,20,25 % and 25, 20, 15, 10, 5 % by ground granulated blast furnace slag keeping constant of total 30% replacement weight of cementitious material. The designations for the different mixes with varying bagasse ash dosages are as shown in Table2. The fresh and hardened concrete properties of each mix were studied. The tests conducted to determine the workability was slump test. The compressive strength was tested after 7, 28 and 56 days of water curing. The split tensile strength test and bond strength tests were conducted after 28 days of water curing. The optimum value for the combination of SCBA and GGBS was determined from compression test and split tensile strength on hardened concrete.

C. Test Methods

1) *Compressive Strength:* For compressive strength test 150mm cube specimens at ages of 7, 28 and 56 days were tested as per IS 516-1959. The testing was carried out on compression testing machine. The reported strength values are mentioned in the results.
2) *Split Tensile Strength:* For split tensile strength concrete cylinder of size 150mm×300mm at 28 days were tested as per IS 5816:1999.The results are mentioned below.
3) *Bond Strength:* The bond strength was carried out on the concrete cylinder of size 150mm×300mm as per ASTM C1583/C1583M – 13 specifications. The testing was done on the universal testing machine. The bond strength was determined for various mixes after 28-day water curing.

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III. RESULT & DISCUSSION

A. Workability

Slump test was carried out to measure the workability of various mixes. The workability of various mixes was assessed as per the IS 1199:1959 specification. The minimum workability for MIX I may be due to the lesser fine particle size of cement which can result in higher water consumption thereby reducing workability. Critical mix has high workability compared to other mixes which may be due to the particle size of SCBA and GGBS is lesser than cement. So in short, mixes with high percentages of bagasse ash are more workable than the control one.

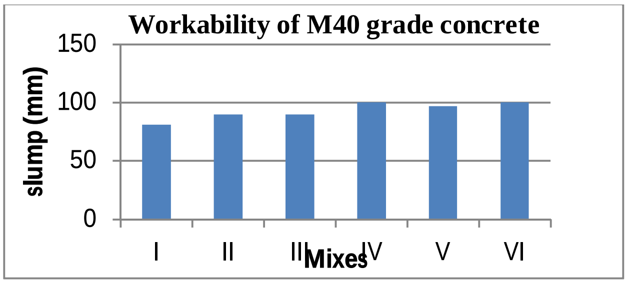

Fig.1 the variation of slump of different mixes.

B. Compressive Strength

For each mix, three cubes specimens of size 150mm×150mm×150mm were tested for compressive strength. Cubes were tested after 7, and 28 and 56 days of water curing. Fig.2 shows the cube compressive strength for various mixes at different ages. The highest compressive strength was found to be 69.04 MPa for mix IV. The percentage increases by 8.38% when compared to conventional concrete. At high replacement levels, the strength dropped.

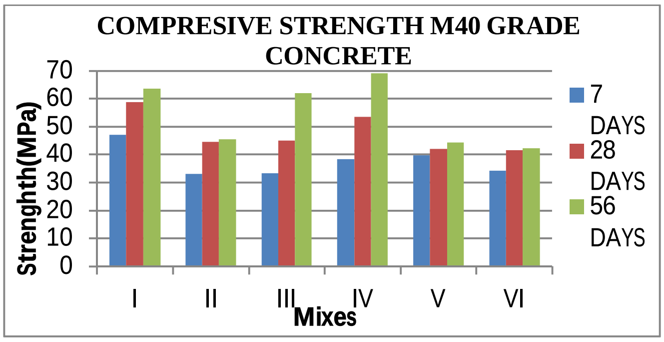

Fig 2. Compressive Strength variation for different mixes.

C. Split Tensile Strength

For each mix, 3 cylinder specimens of size 150mm×300mm were tested for determining the split tensile strength. The split tensile test was done after 28 days of water curing. Fig.3 shows the variation of split tensile strength for various mixes. Split tensile strength also showed a similar variation as that of compressive strength. The highest splitting tensile strength value is obtained for Mix IV.

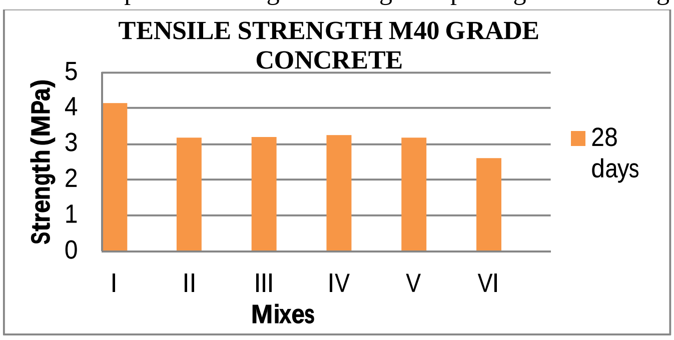

Fig 3. Split Tensile Strength for various mixes .

D. Bond Strength

For each mix, cylinder specimens of size 150mm×300mm were tested for determining the bond strength. Bond strength test was done after 28 days of water curing. A 10 mm dia bar was inserted to a depth of 150 mm. The bars were pulled out from each mix cylinders on the universal testing machine. Fig.4 shows the variation of bond strength for various mixes. Bond strength also showed a similar variation as that of compressive strength.

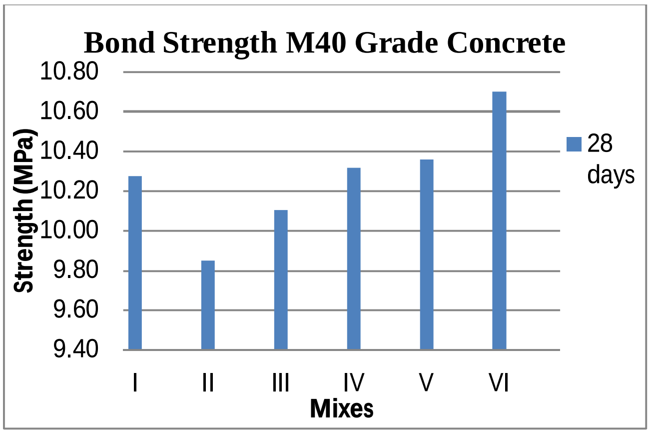

Fig 4. Bond Strength for various mixes

IV. CONCLUSION

A. The compressive strength, split tensile strength has got superior values for combibation of 15% GGBS and 15% SCBA. So the optimal value of replacement was selected as 15% for the combination.
B. The workability of fresh concrete improves with increase in bagasse ash content. This exists due to finer particle size of bagasse ash and ggbs than cement.
C. The bond strength exhibited improvement with bagasse ash replacement level. A 4.08 % increase in the strength was observed when compared with conventional concrete.
D. Light weight concrete as the unit weight of SCBA and GGBS is very low.
E. The highest compressive strength value i.e. 69.04 MPa, was obtained for Mix IV having 15% GGBS and 15% bagasse ash. GGBS in mix showed late strength gain.
F. The use of SCBA and GGBS combined is economic when compared to cement in concrete.
G. SCBA and GGBS are waste materials, when used as a cement replacing material to an optimal dosage of 15% .improves the properties of concrete.
H. Likewise saves a great deal of waste disposal problems and reduces the cement price rise and intensities of CO2 release by the cement production. Also these materials make the concrete more sustainable, light weight and low energy emitting which is noble.

V. ACKNOWLEDGMENTS

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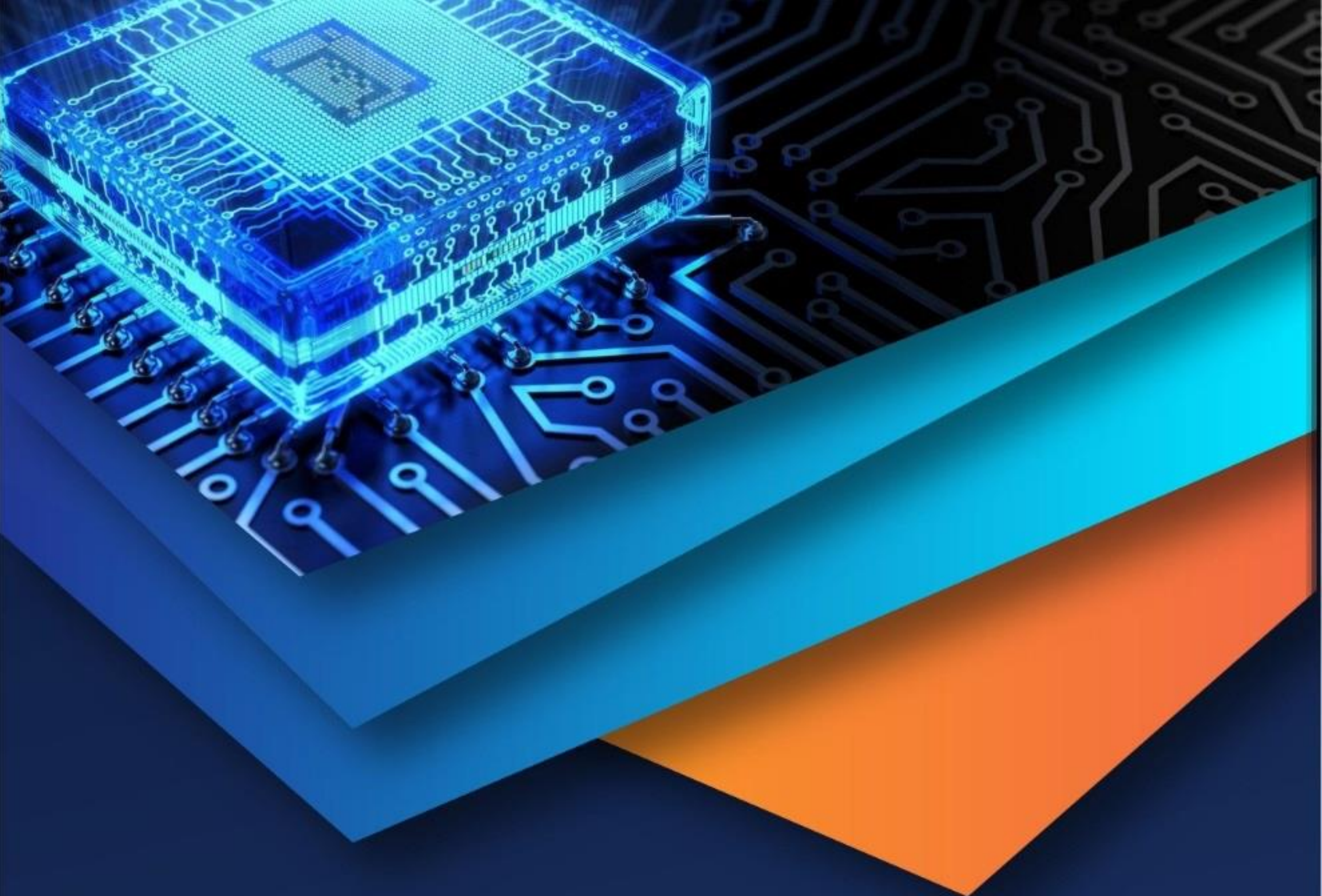

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