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Strength Properties of M30 Grade Concrete with Various Mineral Admixtures

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Abstract: In present day scenario, one cannot imagine any structure without cement concrete. It is being extensively used for construction ranging from small scale to large scale as a key ingredient for fulfilling the aspect of strength and serviceability. But, due to the large scale production of cement, around 3% of air pollution in the world is solely because of its production and this material plays a key role in the cost of the construction which is a raising concerns. So, there is an on-going research to find a suitable alternative or partial replacement to cement so that the cost problem is addressed and pollution is controlled to the maximum extent. This paper deals with the effect of major concrete strength determining parameters like compressive, tensile and flexural strength when compared with conventional concrete mix of M30 when combinedly replaced the cement with admixtures Sugar Cane bagasse ash, Ground Granulated Blast Furnace Slag & WasteWoodAsh in increasing proportions equally (0%,30% (10+10+10), 36%, 42%,48%54%) in weight. And of all the results obtained the mix with 30% combined replacement showed better results because of better formation of CSH gel by which It can ensure better alternative replacement for the cement in concrete for infrastructure needs and minimising the environmental pollution.

Keywords: Sugar Cane bagasse ash (SCBA), Ground Granulated Blast Furnace, Slag (GGBS), Waste Wood Ash (WWA), concrete.

1. INTRODUCTION

Today researches all over the world are focusing on ways of utilizing either industrial or agricultural wastes as a source of raw materials for the construction industry[1]. These wastes utilization would not only be economical, but may also help to create a sustainable and pollution free environment, resulting in foreign exchange earnings from Industrial wastes, such as blast furnace slag, fly ash, silica fume, Waste wood ash etc. these are being used as supplementary cement replacement materials[2]

Sugar-cane bagasse is one such fibrous waste-product of the sugar refining industry, along with ethanol vapor. After the extraction of all economical sugar from sugarcane, about 40-45% fibrous residue is obtained, which is reused in the same industry as fuel in boilers for heat generation leaving behind 8 -10 % ash as waste, known as sugarcane bagasse ash (SCBA). The SCBA contains high amounts of un-burnt matter, silicon, aluminum and calcium oxides[1]

Ground Granulated Blast Furnace Slag(GGBS) is obtained by quenching molten iron slag (a by-product of iron and steel making) from a blast furnace in water or steam, to produce a glassy, granular product that is then dried and ground into a fine powder.[3] GGBS improves the general performance of Plain concrete like decreasing chloride diffusion, chloride ion permeability, reducing creep and drying shrinkage, increasing sulphate resistance, enhancing ultimate compressive strength, and reducing heat of hydration and bleeding. It has also been suggested that GGBS may increase concrete durability in the aggressive environments like silos[5]

wood waste ash (WWA) is the residue powder left after the combustion of wood. Main producers of wood ash are wood industries and power plants. It is a material rich in silica and alumina which in itself has little or no cementitious value but will, in finely divided form and in the presence of moisture, chemically react with calcium hydroxide at ordinary temperatures to form compounds possessing cementitious properties. Many studies already carried out on the use of waste wood ash as innovative construction materials have been very encouraging. Recent studies on the use of waste wood ash in concrete have shown that inclusion of the material in the matrix may not only lower the cost of concrete but also offer a large potential market for the utilization of WWA concrete as a cost-effective alternative to current disposal methods of the waste.[4]

In The present study The impact of Sugar Cane bagasse ash(SCBA), Ground Granulated Blast Furnace Slag(GGBS),Waste Wood Ash (WWA)content as a partial replacement of cement has been investigated on physical and mechanical properties of hardened concrete, including compressive strength, splitting tensile strength,

The objective of present study is to evaluate proportions of Sugar Cane bagasse ash(SCBA), Ground Granulated Blast Furnace Slag(GGBS),Waste Wood Ash (WWA), as supplementary cementitious material by partial replacement of cement at the ratio of 0%, 30%, 36%, 42%,48% and 54% by weight (Table-3) and to identify the optimal level of replacement in concrete formation to minimize the content of cement in the concrete with reference to physical and mechanical properties of hardened concrete, including compressive strength, split tensile strength, flexural strength in addition to reducing environmental problems associated with cement manufacturing and ash production. The main ingredients consist of Portland cement, SCBA, GGBS, WWA, river sand, coarse aggregate and water. After mixing, concrete specimens were casted and subsequently all test specimens were cured in water at 7, 28 and 56 Days.

2. MATERIALS

Cement
Ordinary Portland cement (Grade 43) was used.Its physical properties are as given in Table1.

Table 1 Physical Properties of Cement

Physical property	Results
Fineness (retained on 90µ seive)	2%
Normal Consistency	33%
Vicat initial setting time (minutes)	50
Vicat final setting time (minutes)	275
Compressive strength 28days(MPa)	45.6
Specific gravity	3.091

Aggregates & Admixtures

Fine Aggregate:
Those fractions from 4.75 mm to150 micron are termed as fine aggregate, and the bulk density of fine aggregate (loose state) is1292kg/m3 and rodded state is 1506kg/m3. Locally available free of debris and nearby riverbed sand from sankili (Nagavali River sand) is used as fine aggregate.The sand particles should also pack to give minimum void ratio, higher voids content leads to requirement of more mixing water. In the present study the sand conforms to zone III as per the Indian standards[6]. The specific gravity of sand is 2.67.

Coarse Aggregates: The crushed aggregates used were 20mm nominal maximum size and are tested as per Indian standards[6] and results are within the permissible limit. The specific gravity of coarse aggregate is 2.83; the bulk density of coarse aggregate (loose state) is 1683kg/m3 and rodded state is 1950kg/m3.

Water: Water available in the college campus conforming to the requirements of water for concreting and curing as per IS: 456-2000.

Sugarcane Bagasse Ash:
sugarcane bagasse ash was collected during the cleaning operation of a boiler operating in the parry's Sugar Factory, located nearby college, in the village named Singarayametta, Andhra Pradesh. Cooling, the ash was grounded before using in the same manner as a cement replacement material. Fineness is 98%, Specific gravity 1.68 chemical properties are given in Table-2

GGBS:
This was obtained from the Andhra cements in Visakhapatnam located at 150 kms away from the college. Its Fineness is 96%, Specific gravity 2.77. Chemical properties are given in Table-2

Waste Wood Ash:
It is obtained from the nearby brick industries which is being used for the burning the bricks. The ash was grounded before using in the same manner as a cement replacement material.Fineness is 92%, Specific gravity 2.70. Chemical properties are given in Table-2.

TABLE 2 CHEMICAL PROPERTIES OF SCBA[6], GGBS[6], WWA*

Composition	Proportion (%)		
	SCBA	GGBS	WWA*
SiO_2	55.76	35.34	12.56
CaO	1.68	41.99	6.43
Fe_2O_3	0.72	0.35	Nil
Al_2O_3	1.79	11.59	16.74
MgO	2.02	8.04	4.32

* Chemical compositions is analysed in the chemical department of the college.

3. EXPERIMENTAL WORK

The experimental work consists of performing the sieve analysis of SCBA,GGBS,WWA as per the Indian standard procedure and using the results for the mix design to achieve the concrete of required strength and quality. Thereafter the concrete is tested for workability parameters by performing the slump cone test on it, followed by casting the cubes of concrete for further investigations. For carrying out the strength investigations a total 56 number of 150mm side concrete cubes, 56 No's 150mm diameter and 300mm long cylindrical specimens and 56 numbers of 500mm x 100mm x 100mm size prisms were casted.

The mix design of concrete was done according to Indian Standard guidelines[7-10] for M 30 grade, the water cement ratio was kept 0.40 and polycarboxylic ether polymer–based super plasticizer was used as the super plasticizer in concrete mixtures the dose of super plasticizer was kept constant at 3.6 L/m^3. Based upon the quantities of ingredient of the mixes, the quantities of SCBA, GGBS, WWA, is for 0%,30%,36%,42%,48% and 54% replacement by mass in equal proportions as shown in Table-3 were estimated.

As per the previous mix proportions, materials were placed in a concrete pan mixer machine and mixed thoroughly after adding 80% water. Finally, the super plasticizer with the remaining 20% of water was added and mixed thoroughly to achieve the desired consistency. The concrete was compacted on a vibrating table. The top surface was finished by means of a trowel; the molds were covered after casting with wet gunny bags for 24 h. Then the specimens were demolded and cured.. The specimens were removed from the mould after 24h and then cured under water for a period of 7, 28 and 56 days. The specimens were taken out from the curing tank just prior to the test.

TABLE-3 PROPERTIES OF FRESH CONCRETE

Sample Design-ation	Mix proportion Cement, Kg/m^3	Total % of (SCBA+ GGBS+ WWA)	SCBA % by wt (kg/m^3)	GGBS % by wt (kg/m^3)	WWA % by wt (kg/m^3)	Course Aggregate (Kg/m^3)	Fine Aggre-gate (Kg/m^3)	W/C ratio	Dosage of Super plasticizer (L/m^3)	Slump (mm)
P_0	450	0	0	0	0	1205	567	0.40	3.6	120
P_{30}	315	30	10% (45kg)	10% (45kg)	10% (45kg)	1205	567	0.40	3.6	25
P_{36}	288	36	12(54)	12(54)	12(54)	1205	567	0.40	3.6	20
P_{42}	261	42	14(63)	14(63)	14(63)	1205	567	0.40	3.6	12
P_{48}	234	48	16(72)	16(72)	16(72)	1205	567	0.40	3.6	10
P_{54}	207	54	18(81)	18(81)	18(81)	1205	567	0.40	3.6	8

4. TEST METHODS

At the end of each curing period, a total of 3 specimens were tested for each concrete property. The compressive strength test was carried out on the 150mm cube specimens, whilst the split tensile strength test was carried out on the 150mm diameter and 300mm height cylindrical specimens and flexural strength was conducted on 500mmx100mmx100mm prism specimens as per Indian standard specifications[7-11]. The tests for compressive, split tensile were conducted using a 2000kN compression testing machine, flexural strength was conducted using 100Ton universal testing machine. These tests were conducted as per the relevant Indian Standard specifications[8-10].

5. RESULTS

The strength results obtained from the experimental investigations are showed in tables. All the values are the average of the three trails in each case in the testing program of this study. The results are discussed as follows

The strength test results obtained for concrete cube, cylinder and prism specimens with partial replacement of (SCBA+GGBS+WWA) shown in Table 4. From the table, it is clear that the addition of (SCBA+GGBS+WWA) in plain concrete increases its strength under compression, tension, and flexure up to 30% of replacement after that strength results was decreasing.

Compressive strength

The results obtained from compressive strength test for all the mixes are given in fig 1. It can be seen from the figure that the compressive strength results of specimens at 30% replacement of Admixtures were higher than those of other sample mixtures and the strength obtained was greater than 30Mpa (M30). Further increase in percentages results in decreasing compressive strength along with significant fall in properties of fresh concrete. It is also indicated that the rate of increase of strength of mixes with admixtures is higher at later days that maybe due to pozzolanic properties of Admixtures.

TABLE 4 STRENGTH RESULTS OF PARTIALLY REPLACED CONCRETE AT 7, 28, 56 DAYS

Sample Designation	Total % of (SCBA +GGBS +WWA)	Compressive Strength (MPa)			Split Tensile Strength (MPa)			Flexural Strength (MPa)		
		7 Days	28 days	56 days	7 Days	28 days	56 days	7 Days	28 days	56 days
P_0	0	38.48	42.74	49.54	2.90	3.21	3.17	4.64	5.44	4.96
P_{30}	30	22.90	34.29	37.79	2.165	2.71	2.93	3.68	4.48	3.36
P_{36}	36	19.20	28.21	34.24	2.07	2.45	2.63	3.12	3.92	4.24
P_{42}	42	19.86	28.21	32.13	1.86	2.27	2.36	2.60	3.20	3.32
P_{48}	48	12.89	23.40	25.20	1.02	1.79	2.04	2.60	3.08	3.12
P_{54}	54	9.54	16.75	19.54	0.58	1.65	1.95	1.19	1.98	2.21

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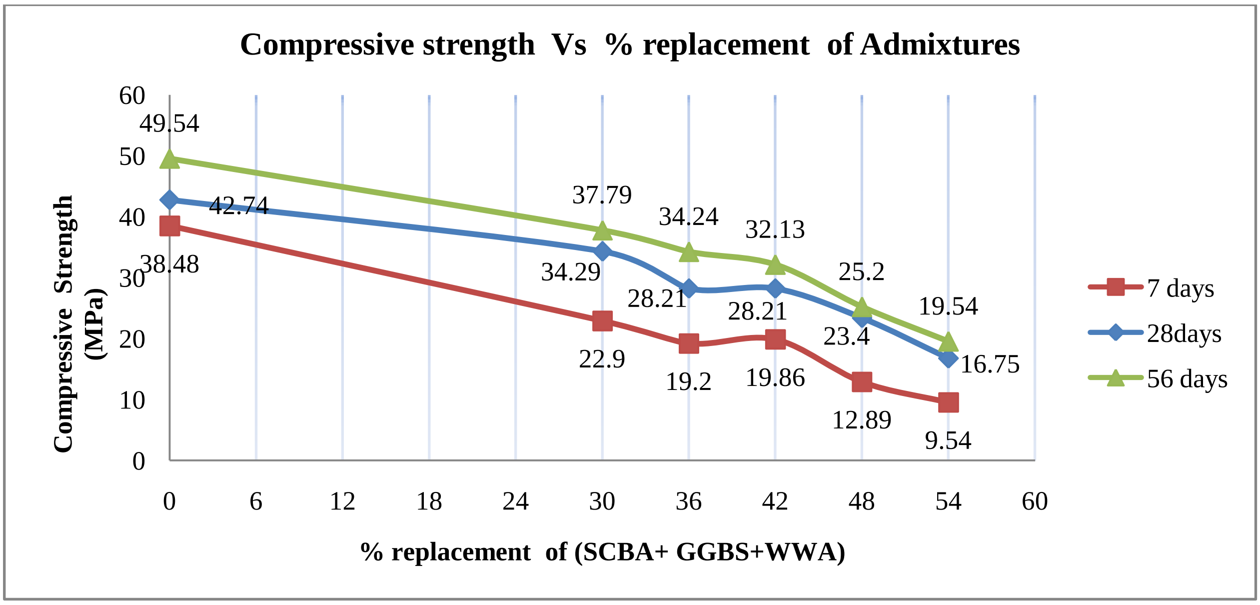

FIGURE 1 7, 28 & 56 DAYS COMPRESSIVE STRENGTH FOR ALL MIXES

Split Tensile Strength

The Split tensile strength results for all the mixes for 7,28,56 Days of curing are shown in fig.2. When the influence of admixture on the tensile strength of concrete was examined, it was observed that the development of tensile strength of mixes decreases as the replacement of Admixtures increases.

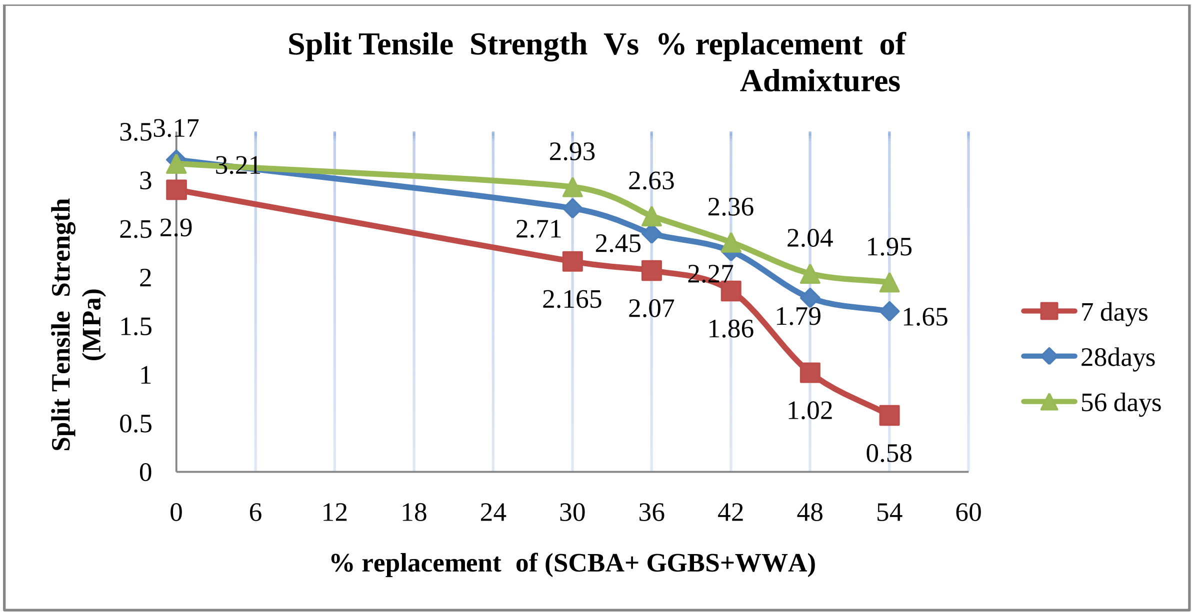

FIGURE 2 7, 28 & 56 DAYS SPLIT TENSILE STRENGTH FOR ALL MIXES

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Flexural Strength

The Flexural strength results for all the mixes for 7,28,56 Days of curing are shown in fig.3. When the influence of admixture on the Flexural strength of concrete was examined, it was observed that the development of felxural strength of mixes decreases as the replacement of Admixtures increases but for 36% replacement 56day strength was higher.

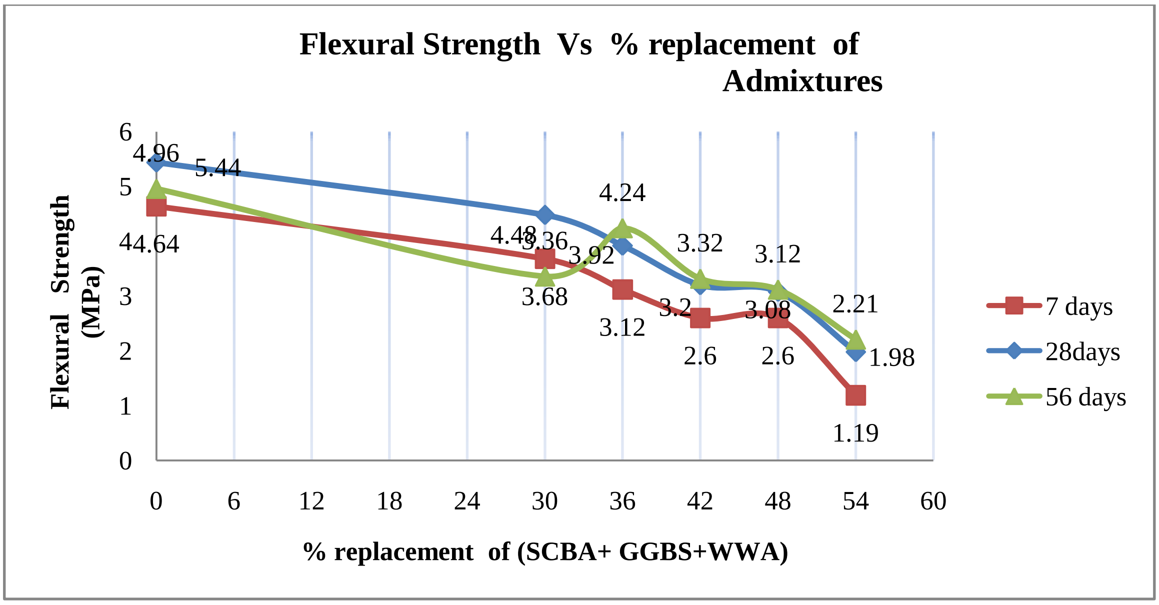

FIGURE. 3 7, 28 &56 DAYS FLEXURAL STRENGTH FOR ALL MIXES

6. CONCLUSION

From the present investigation, the following conclusions can be drawn Up to 30% Portland cement can be optimally replaced with well-burnt Admixtures without any adverse effect on the desirable properties of concrete. The specific advantages of such replacement are the development of characteristic strength, less early heat of hydration resulting in less thermal shrinkage cracks.producing the concrete in the society with waste materials (SCBA+GGBS+WWA). The results indicate that (SCBA+GGBS+WWA) can be used as a pozzolanic material in concrete with an acceptable strength, lower heat evolution, with respect to the control concrete.

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