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Behaviour of M30 and M60 Grade Ternary Concrete by Partial Replacement of Cement with Sugarcane Bagasse Ash and Silica Fume

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Abstract: *Ordinary Portland cement is a major construction material throughout the world. Cement production is responsible for about 5% to 8% of global co2 emissions. Therefore the utilization of industrial waste has to be increased which is environmental friendly. Therefore utilization of one of the waste produced by industries and agriculture has been focused in the present study. The waste product from sugar factory i.e. Sugarcane Bagasse Ash (SCBA) is causing serious pollution problem. As Bagasse is a fibrous residue after crushing and juice extraction from sugarcane and is used as a biomass fuel in the boilers to generate power in the sugar industry or in the power station. The ash which is obtained from the boiler is a waste product of sugar industry known as Sugarcane Bagasse Ash. An attempt has been made in the present experimental study to evaluate the impact of shared utilization of Bagasse ash and silica fume on compressive strength, split tensile strength and flexural strength on both M30 grade and M60 grade ternary concrete with different weight percentages ranging from 0 to 25% in the production of ternary concrete. The test results indicate that strength of both M30 and M60 grade concrete reaches optimum value at 15% replacement of cement by BASF.*

Keywords: sugarcane bagasse ash, silica fume, cement

I.INTRODUCTION

Due to globalization there is an intense need of infrastructure development across the world. As India is a developing country we are looking out for good infrastructure like buildings, roads, bridges etc. This leads to an increased need for concrete which in turn necessitates large scale manufacture of cement and other contraction material. Unfortunately, India is not self sufficient in the production of cement, the main ingredient of concrete and the demand for cement exceeds the supply and makes the construction activities very costlier. Hence core construction industry is in search of a suitable and effective alternative that would considerably minimize the use of cements and ultimately reduces the construction cost. Few of such products have already been identified like Fly Ash, Silica Fume and Rice Husk etc. Amongst these fly ash is known to have good prospects in minimizing the usage of cement and for fine aggregates rock dust, quarry waste, siliceous stone powder are good alternatives. Recently several researches been done using sugarcane bagasse ash, which is a byproduct of sugar factory found after burning sugarcane bagasse as a alternative to cement. The silica and alumina content in the ash may vary from ash to ash depending on the burning and other properties of raw material like the soil on which the sugarcane is grown. Strength play an important role for sustainable development, as the failure of a structure will have several impacts on the environment. Further that might result in the loss of human life. Hence, in this study Compressive Strength, Split Tensile Strength and Flexural Strength Properties are studied on ternary cement concrete containing ordinary Portland cement, SCBA and Silica fume as partial replacement of cement in concrete with different weight percentages ranging from 0% to 25%with bagasse ash as partial replacement of cement and silica fume as admixture and the properties were determined for different proportions of these materials. The purpose of this analysis work is to search out the influence of the combined application of bagasse ash and silica fume on various strength properties of concrete. To acknowledge the behaviour of concrete the cement is replaced by bagasse ash and silica fume in the proportion of 0, 5, 10, 15, 20, 25% and 10%respectively. To accomplish this, M30 grade and M60 grade of concrete is used for the experimental work. To determine the compressive strength, split tensile strength and flexural strength of concrete with the addition of various proportions of Bagasse ash and the silica fume and the determined results are compared with conventional concrete.

II.LITERATURE REVIEW

The following deals with literature review concerning the work done by different authors with regard to behaviour of ternary concrete and their strengths with varying percentages of replacements.. Few of them are mentioned below. **Ganesan[5] (2007),**studied the effects of SCBA content as partial replacement of cement (0-30%) on physical and mechanical properties of hardened concrete. The properties of concrete were investigated include compressive strength, splitting tensile strength, water absorption, permeability characteristics, chloride diffusion and resistance to chloride ion penetration. All tests carried out in accordance with Indian Standards. The test results indicated that SCBA is an effective mineral admixture up to 20% replacement was advantageous. The increase in strength may be partially due to the pozzolanic reaction [5]. **Murthi (2008),**investigated on an essential assumption that porosity variation plays a role in influencing Compressive Strength of hardened concrete. The normal strength concrete with W/C ratio of 0.55 was used for this experimental investigation. The partial replacement of cement by Fly Ash was done to reduce the porosity and make concrete with a dense microstructure. The initial strength development of Fly Ash based blended concrete was less compared to the normal concrete. An attempt has been made to overcome the delay in strength development of concrete during the early ages by making the Ternary Blended Concrete. Fly Ash (FA) and Rice Husk Ash (RHA) were used for preparing the binary blended concrete and Micro Silica (MS) was used for developing the Ternary Blended Concrete. The results of the porosity of the concrete obtained from absorption tests showed that the porosity of blended concrete was less than that of the normal concrete. The Compressive Strength of the blended concrete was determined and it was observed that the early strength of Ternary Blended Concrete improved more than that of binary blended concrete. **Channakeshavrao[10](2009),** in their paper entitled "Green concrete using Agro industrial waste (SCBA)". In this research, physical and chemical properties of fine aggregates, coarse aggregates and SCBA were properly characterized. In this research, OPC was replaced by Bagasse ash at 0%, 5%, 10% and 25%, were the water-cement ratio is 0.42. For the testing purpose, cubes of dimension 150 x 150 x 150mm, and cylinder size 150 x 300mm and beams of 100 x 100 x 150 are casted and cured in the curing tanks. Compressive strength, Tensile strength and Flexural strength was tested at 7, 28, 98 days. It is observed that compressive strength at 15% replacement at 28 days was shows good strength as compared to others. Where split tensile strength at 20 and 25% replacement at 28 days decreases.**Kartik[7] (2011)**, in their paper entitled "Studies on Mechanical properties of concrete using sugar cane Bagasse ash". This research concentrates to utilize industrial waste to avoid environmental problems. In this Bagasse ash was obtained from Bagalkot and comparing the compressive strength and split tensile strength of specimens with and without replacement of Bagasse ash. In this mix design of concrete was done by various grades like M20, M40, M60 and M80 and replacing the Bagasse ash up to 30%. The compressive strength and split tensile strength of the specimens are tested, results in increase in the percentage of Bagasse ash will increase the strength of concrete, but to improve the strength of concrete Gypsum was added.

III. EXPERIMENTAL SET UP

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In the present study SCBA is replaced with cement at 0%, 5%, 10%, 15%, 20%, and 25% and SF is replaced with cement at 10% along with each SCBA replacement and concrete cubes are casted.

Mixture Proportions

Cubes were casted by replacing cement with Sugar Cane Bagasse Ash by 0%, 5%, 10%, 15%, 20% and 25% and with 10% addition of silica fume on all replacement level. In this study the water cement ratio was maintained 0.35 by weight of cement for all proportions. For each replacement 6 cubes were casted and its average compressive strength was determined and tabulated for 7, 28, 60 and 90 days. All the materials used were batched by weight proportions. Cube moulds of size 100x100x100mm and cylindrical moulds of diameter 150 mm and height 400 mm and prisms of size 100mm x100mmx400 mm were used to cast the specimens. They were demoulded after 24hrs and cured in water under ambient temperature. After curing the specimens were placed in compressive testing machine and are tested. The compressive strength test was performed according to IS 516:1959. Hence a total of 6 series of 150x150x150mm specimens were casted one with conventional concrete and the other 5 with different percentage replacements and the same procedure is followed for both cylinders and prisms.

Table3.1 Mix proportion of M60 Grade ternary concrete

Ratio of mix proportion by weight:

Mix grade	Cement	Fine Aggregate	Coarse Aggregate	Water/Cement
M 60	1	0.96	2.06	0.33

Table 3.2: Mix proportion of M30 Grade ternary concrete

Ratio of mix proportion by weight:

Mix grade	Cement	Fine Aggregate	Coarse Aggregate	Water/Cement
M 30	1	1.91	3.4	0.4

Table 3.3 Replacement of cement with SCBA and Silica fume in different proportions

S.NO.	Series	SF Replacement for OPC	SCBA Replacement for OPC
1	BASF0	0%	0%
2	BASF5	10%	5%
3	BASF10	10%	10%
4	BASF15	10%	15%
5	BASF20	10%	20%
6	BASF25	10%	25%

Mixing and Casting of specimens

Initially sand, coarse aggregate and fine aggregate are weighed in required quantities. The materials such as cement, sugarcane bagasse ash and silica fume are weighed in required proportions and are mixed thoroughly for a minimum time period of forty-five minutes in order to obtain a homogeneous mixture. Preparation of specimens is carried out by initially mixing sand, coarse aggregates and fine aggregates in the concrete mixer. Now cementitious mixture is added and again mixing is carried. Water and admixture which are weighed are added and thorough mixing is done till homogenous concrete is obtained. This concrete is placed in the moulds which are subjected to vibration on vibrating table to attain good compaction and specimens are prepared. They were demoulded after 24hrs and cured in water under ambient temperature. A total of 6 series of specimens are prepared (BASF0, BASF5, BASF10, BASF15, BASF20, and BASF25). For all the series BASF a total of 144 specimens of cubes ,144 specimens of cylinders and 144 specimens of prisms are casted for normal temperature for all the 7, 28, 60 and 90 days curing.

IV.RESULTS AND DISCUSSIONS

COMPRESSIVE STRENGTH

In this experimental work a total number of 144 cubes of sample sizes of 150mmx150mmx150mm of both M30 grade and M60 grade ternary concrete are casted with partial replacement of cement with BASF as 5%, 10%, 15%, 20% and 25% by weight of the cement and the compressive strength tests are done at 7, 28, 56 and 90 days respectively. The test results are presented as follows.

Table 4.1: Compressive strength of M30 grade ternary concrete

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SERIES	SCBA %	SF %	COMPRESSIVE STRENGTH IN MPa			
			7 days	28 days	56 days	90 days
BASF 0	0	0	26.66	38.66	40	41.33
BASF 5	5	10	27.55	39.11	41.33	42.66
BASF 10	10	10	28.88	40.44	42.22	44
BASF 15	15	10	30.22	42.22	44	46.22
BASF 20	20	10	25.77	37.33	39.11	40.88
BASF 25	25	10	24.88	36	38.22	39.11

Fig 4.1: Compressive strength of M30 grade ternary concrete

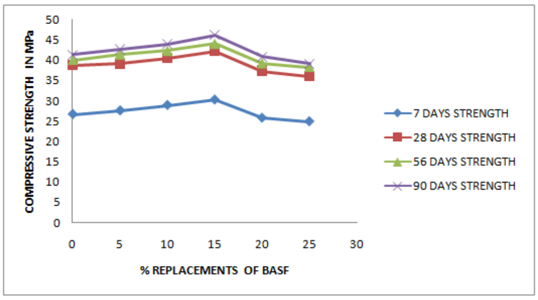
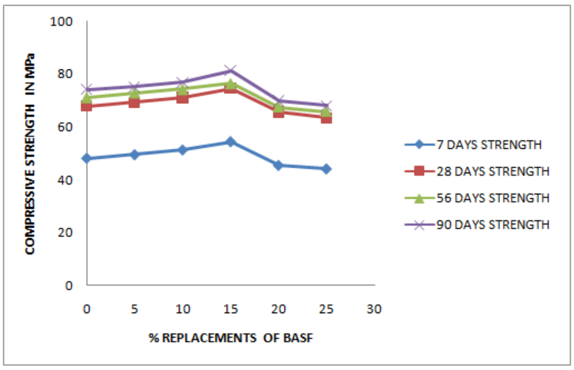


Table4.2: Compressive strength of M60 grade ternary concrete

SERIES	SCBA %	SF %	COMPRESSIVE STRENGTH IN MPa			
			7 days	28 days	56 days	90 days
BASF 0	0	0	48	68	71.11	74.22
BASF 5	5	10	49.33	69.33	72.88	75.11
BASF 10	10	10	51.11	71.11	74.22	76.88
BASF 15	15	10	54.22	74.66	76.44	81.33
BASF 20	20	10	45.33	65.77	67.56	69.77
BASF 25	25	10	44	63.55	65.76	68

Fig 4.2: Compressive strength of M60 grade ternary concrete



FLEXURAL STRENGTH

In this experimental work a total no of 144 prisms of sample sizes of 100 mmx100 mm x 500 mm of both M30 and M60 grade ternary concrete are casted with partial replacement of cement with BASF as 5%, 10%, 15%, 20%and 25% by weight of cement and flexural strength tests are done at 7, 28, 56 and 90 days respectively. The test results are presented as follows.

Table 4.3: Flexural strength of M30 grade ternary concrete

SERIES	SCBA %	SF %	FLEXURAL STRENGTH IN MPa			
			7 days	28 days	56 days	90 days
BASF 0	0	0	3.72	4.12	4.2	4.4
BASF 5	5	10	3.8	4.4	4.6	4.8
BASF 10	10	10	3.92	4.6	4.72	4.88
BASF 15	15	10	4.2	4.92	5	5.2
BASF 20	20	10	3.6	4	4	4.2
BASF 25	25	10	3.2	3.8	3.92	4

Fig 4.3: Flexural strength of M30 grade ternary concrete

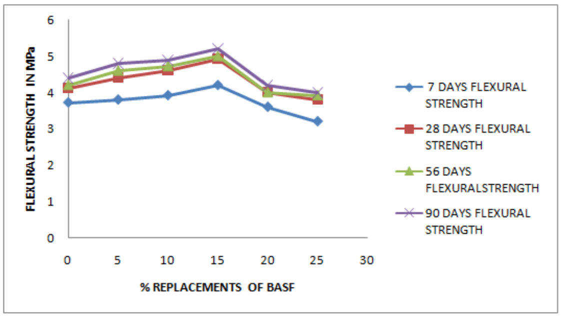
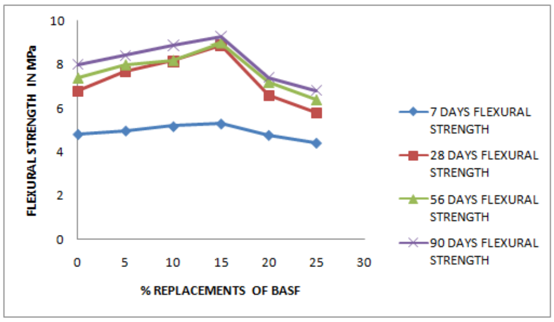


Table 4.4: Flexural strength of M60 grade ternary concrete

SERIES	SCBA %	SF %	FLEXURAL STRENGTH IN MPa			
			7 days	28 days	56 days	90 days
BASF 0	0	0	4.8	6.8	7.4	8
BASF 5	5	10	4.96	7.68	8	8.44
BASF 10	10	10	5.16	8.16	8.2	8.88
BASF 15	15	10	5.28	8.88	9	9.28
BASF 20	20	10	4.76	6.6	7.2	7.4
BASF 25	25	10	4.4	5.8	6.4	6.8

FIG 4.4: Flexural strength of M60 grade ternary concrete



SPLIT TENSILE STRENGTH

In this experimental work a total no .of 144 cylinders of sample sizes of diameter 150mm and height 300 mm of both M30 grade and M60 grade ternary concrete are casted with partial replacement of cement with BASF as 5%, 10%, 15%, 20% and 25% by weight of cement and split tensile strength tests are done at 7, 28, 56 and 90 days respectively. The test results are presented as follows.

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Table 4.5: Split tensile strength of M30 grade ternary concrete

SERIES	SCBA %	SF%	SPLIT TENSILE STRENGTH IN MPa			
			7 days	28 days	56 days	90 days
BASF 0	0	0	1.69	2.68	2.83	2.9
BASF 5	5	10	1.84	2.83	2.97	3.11
BASF 10	10	10	1.98	2.9	3.04	3.18
BASF 15	15	10	2.19	3.04	3.18	3.32
BASF 20	20	10	1.62	2.76	2.83	2.9
BASF 25	25	10	1.55	2.61	2.76	2.83

Fig 4.5: Split tensile strength of M30 grade ternary concrete

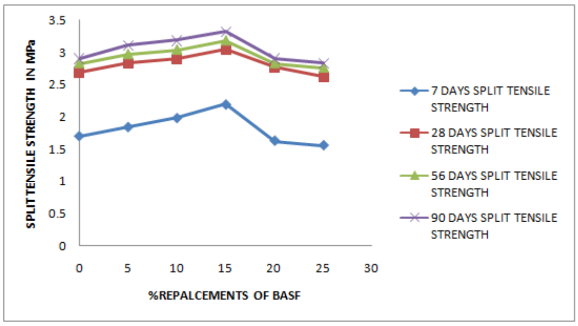
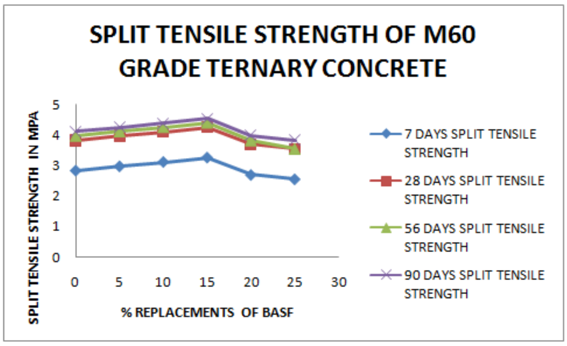


Table 4.6:Split tensile strength of M60 grade ternary concrete

SERIES	SCBA %	SF %	SPLIT TENSILE STRENGTH IN MPa			
			7 days	28 days	56 days	90 days
BASF 0	0	0	2.83	3.82	3.96	4.1
BASF 5	5	10	2.97	3.96	4.1	4.24
BASF 10	10	10	3.11	4.1	4.24	4.38
BASF 15	15	10	3.25	4.24	4.38	4.52
BASF 20	20	10	2.68	3.68	3.82	3.96
BASF 25	25	10	2.54	3.53	3.53	3.82

Fig4.6:Split tensile Strength of M60 grade ternary concrete



V.CONCLUSION

Based on the experimental investigation carried out and with the results and discussions there on the following conclusions are drawn

1. The compressive strength of (BASF) M60Grade ternary concrete is comparatively higher than that of control mix (BASF0).
2. The compressive strength of (BASF) M60 Grade ternary concrete is comparatively greater than of that of control mix (BASF0) by 9.57%. The optimum value occurs at (BASF15) replacement i.e. 81.11 MPa.
4. The compressive strength of (BASF) M30 Grade ternary concrete is comparatively higher than that of control mix (BASF0).
5. The compressive strength of (BASF) M30 Grade ternary concrete is comparatively greater than that of control mix (BASF0) by 11.83%. The optimum value occurs at (BASF15) replacement i.e. 46.22MPa.
6. The compressive strength of (BASF) M60 Grade ternary concrete is comparatively greater than that of control mix (BASF0) by 9.57%& the compressive strength of (BASF) M30 Grade ternary concrete is comparatively greater than that of control mix (BASF0) by 11.83%.
7. The split tensile strength of M60 Grade ternary concrete (BASF) is comparatively greater than of that of control mix (BASF0) by 16% & the split tensile strength of (BASF) M30 Grade ternary concrete is comparatively greater than that of control mix by 18.18%. The optimum value occurs at (BASF15) replacement.
8. The flexural strength of (BASF) M60 Grade ternary concrete is slightly higher than that of control mix (BASF0) by 10.24% & the split tensile strength of M30 Grade ternary concrete is comparatively greater than that of control mix by 14.4%. The optimum value occurs at (BASF15) replacement.

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