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AN INVESTIGATION OF THERMAL BEHAVIOR OF SBA CONCRETE

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ABSTRACT

The present research shows the results of an investigation on compressive strength of concrete after heating to different temperature ranges. The main focus of study is to understand the thermal behavior of concrete containing sugarcane bagasse ash. The five mixes were prepared by replacing cement with SBA. Three cubes from each mix were subjected different temperature ranges and their compressive was determined at 28 days. It is quite obvious from the data that as the temperature increases, there is a huge decline in compressive strength. Where as, the SBA replacement also effects the workability characteristics of concrete. Thus it can be concluded that there is no significant change in thermal behavior with the inclusion of SBA in concrete when heated at higher temperature.

KEYWORDS: Concrete, Compressive Strength, Replacement, Waste Materials, Sugarcane Bagasse Ash (SBA), Elevated Temperature, Water Cement Ratio, Workability

INTRODUCTION

`Energy plays an important role in era of developing countries like India. Therefore, it is essential to save energy and earn carbon credit for the betterment of mankind. Carbon credit can be earned by using industrial waste for building materials like cement. Concrete is a composite construction material composed of cement, aggregate, water. Concrete is made by mixing: Cement, water, coarse and fine aggregates. During the cement manufacturing, the limestone and clay are used. While production of cement large amount of CO_2 is released. Apart from it, combustion of fossil fuel is also responsible for the emission of CO_2 by 5%. In order to mitigate the problem of environment pollution various possible alternatives for OPC is being considered. Several materials like rice husk ash, pulverized fuel ash, lime, sugarcane bagasse ash (SBA), volcanic ash etc can be used as a replacement of cement in concrete up to certain extent.

After the production of agriculture products various kinds of wastes are generated like Bagasse from Sugarcane, wheat husk and wheat straw from Wheat, groundnut shell from Groundnut, and rice husk from Paddy. Most of these wastes are used by power industry as a fuel in power generation. Byproduct of this utilization is ash, which creates the disposal problem. However, this ash can be used as a useful material in concrete industry because of its chemical composition. Apart from above mentioned agro waste ashes, some researchers identified that the sugarcane bagasse ash can also be used as pozzolan in concrete. Atomic spectrometry (AAS) confirmed Sugarcane bagasse ash (SBA) to be a good pozzolana since the sum of SiO_2, AL_2O_3 and $Fe_2 O_3$, thus meeting the requirement of 70% minimum recommended by ASTM C618 (1992) (Outuozw *et a*l 2012). The use of SBA as a supplementary cementitious material helps to reduce the utilization of cement up to certain extent. Thus the use of bagasse ash not only helps to overcome the problem of emission of CO_2 but also mitigates the problem of environmental pollution that arises during disposal of ash from power industry.

Concrete structures are massive durable structures. During their life time they may be exposed to high temperature for example nuclear reactor, furnaces or sometimes buildings exposed to fire etc. Therefore fire resistance is also an important parameter. As we know concrete has properties to depend upon moisture and porosity. Most of the concrete structures are sometimes exposed to fires. As a result of which their strength and durability is decreased. Mainly the fire resistance of concrete is affected by the type of aggregates, cement and the duration of fire. The non-uniform high temperature of aggregates develops internal pressure in aggregates, is the major cause of spelling of aggregates. At elevated temperature concrete looses its strength due to formation of cracks between cement paste and aggregates thus form thermal incompatibility between these two ingredients Furthermore many other factors may contribute like damaging of aggregates due rise in temperature, weakening of cement paste due to an increase in porosity on dehydration, breakdown of the C-S-H chemical transformation on hydrothermal reactions and development of cracks (Nimyat and tok, 2013). Moreover, this research data relates the mechanical and thermal properties of SBA concrete.

MATERIALS PROPERTIE

The most common cement Ordinary Portland Cement (OPC) 43 grade was used in this study. All basic tests were conducted some of them are like specific gravity, standard consistency, setting time, and compressive strength was conducted.

Table 1: Properties of OPC 43 Grade Cement

Sr. No.	Properties	Values Obtained	Values Specified By IS: 8112-1989
1	Specific gravity	3.15	-
2	Standard consistency	31	-
3	Initial setting time	135	30 Minute (Minimum)
4	Final setting time	220	600 Minute (Maximum)
5	Compressive strength 3 Days 7 Days 28 Days	 25.54 N/mm^2 36.12 N/mm^2 49.53 N/mm^2	 23 N/mm^2 33 N/mm^2 43 N/mm^2

Locally available natural sand of grading zone II was used as fine aggregates. It was collected from the nearly river bed and their sieve analysis was done. Fine aggregates were brown in color with coarser shape of particles and have specific gravity 2.71 conformed to BIS: 383-1970. The crushed gravel of two stone sizes of 10 mm and 20 mm, with equal proportions was used as coarse aggregates. It was collected from Pathankot quarry. As per Indian standard all required properties was determine. Their specific gravity was 2.65 and it was gray in color. Natural and clean water free from suspended impurities was used for casting concrete cubes. It was free from organic matter, silt, oil, sugar, chloride and acidic material as per IS: 456-2000. That fibrous residue material (Bagasse) is the major industrial waste from sugar industry. The sugarcane bagasse consists of 50% of cellulose, 25% of hemicelluloses and 25% of lignin. When this bagasse is burned under controlled temperature conditions, it results into ash. Bagasse ash was collected from the boiler of a sugar mill situated at village Budhewal on Ludhiana-Chandigarh road.

PREPRATION OF SAMPLES

In present research, five concrete mixes were prepared by replacing SBA by 0%, 5%, 10%, 15%, and 20% for constant water/cement 0.55 as per BIS 10262:2009. Rest parameters like coarse aggregates, fine aggregates and water was constant for all mixes. The remaining detail of mix design per cubic meter of concrete was shown in Table 2. Concrete cubes of sizes 100mm x 100mm x 100mm were cast for each mix. Compressive strength was calculated at 28 days by increasing the temperature in steps. After casting, concrete cubes were cured for 28 days. Their after, these cubes was dried at room temperature and then moved to muffle furnace for temperature stability. Cubes were heated up to temperature 150^0C, 300^0C and 600^0C from room temperature. To attain uniform temperature through out, they were heated for two hours. After heating, muffle furnace was turned off and samples were cooled down to room temperature. At the end compressive test was conducted under universal testing machine (UTM). Workability of all concrete samples was determined in terms of slump values.

Table 2: Mix Proportions of Concrete Mixes

Mix	SBA (%)	Cement (Kg/M^3)	SBA (Kg/M^3)	Fine Aggregates (Kg/M^3)	Coarse Aggregates (Kg/M^3)	Water (L/M^3)
S1	0	358.47	0	728.20	1113.77	197.16
S2	5	340.55	17.92	728.20	1113.77	197.16
S3	10	322.62	35.85	728.20	1113.77	197.16
S4	15	304.70	53.77	728.20	1113.77	197.16
S5	20	286.78	71.69	728.20	1113.77	197.16

TEST RESULTS

Workability of concrete mixtures is measured as slump vales in mm. As we see in Figure 1, the slump value was decreased with the increase in percentage replacement of SBA with cement. This decline was continuous from 110 mm to 91 mm with replacement of 0% to 20% respectively. At SBA level 20% of cement, workability was the lowest stage. This is mainly due to the higher water absorption, porous structure of SBA partials. The compressive strength of all five concrete mixes was calculated at Room temperature (RT), 150^0C, 300^0C, 600^0C respectively. From Table 4, it is quite obvious that there was a huge decline in compressive strength with increase in temperature. The compressive strength at room temperature was the highest while as the temperature increases from RT to 600^o, it significantly loses its strength about 57.99%. As the percentage of SBA increased loose in strength first decreased then attaint their maximum value at all temperatures. The percentage loose was maximum at 20% replacement level. This is mainly due to the evaporation of water. As water evaporates from cubes, cracks are developed due to pressure. Moreover, the other reason behind this cracking is the expansion of aggregates at higher temperature due to evaporation of water. As water evaporates it also contracts the cement paste, thus ultimately affect the bonding of concrete ingredients. As shown in Figure 2, compressive strength of all mixes decreases as temperature increases.

Table 3: Workability of Concrete Mixtures

Mix	SBA (%)	Slump (mm)
S1	0	110
S2	5	107
S3	10	103
S4	15	95
S5	20	91

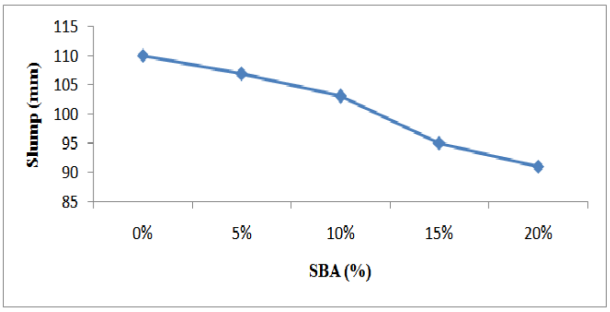

Figure 1: Slump Values of Concrete Mixtures

Table 4: Compressive Strength of Concrete Mixtures at Different Temperature Range

Mix	Compressive strength (N/mm^2)			
	Room Temperature (R. T)	150^0	300^0	600^0
S1	29.35	26.71	24.66	11.45
S2	30.26	26.93	25.11	12.41
S3	31.38	28.86	26.36	13.18
S4	30.22	26.59	24.78	12.09
S5	29.02	26.12	24.09	11.32

Table 5: Percentage Loss in Compressive Strength of Concrete Mixtures at Different Temperature Range

Mix	Percentage loss in compressive strength		
	R. T - 150^0	R. T - 300^0	R. T - 600^0
S1	8.99	15.97	60.98
S2	11.00	17.01	58.95
S3	8.03	15.99	57.99
S4	12.01	18.00	59.99
S5	9.99	16.98	60.99

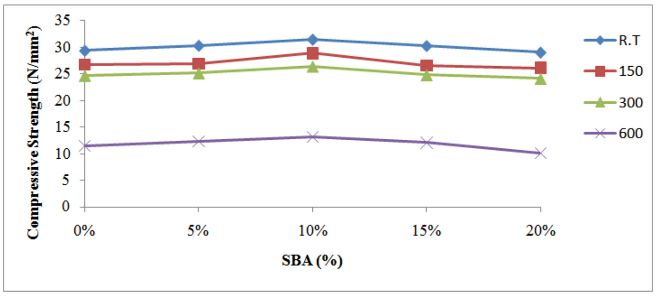

Figure 2: Compressive Strength of Concrete Mixes at Different Temperature Range

CONCLUSIONS

- The workability of concrete decreases with the increase in percentage SBA content.
- At elevated temperature, SBA is unable to improve the thermal properties of concrete. There is a huge decline in compressive strength as the temperature is hiked.
- As the temperature is raised up 150^{0}C, the loss in strength is minor.
- An obvious reduction is observed when concrete was heated at 300°C.
- At 600°C, strength properties of concrete become critical due to internal cracks. The concrete loosed almost 60%

of its original strength.

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