Use of Sugarcane Bagasse Ash as partial replacement of cement in concrete - An Experimental Study

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Abstract

Nowadays the most important factor for any work or project is its effect on environment. As concrete is a major construction material mused globally. Cement is the main ingredient of conventional concrete and is responsible for a major amount of greenhouse gases such as carbon-dioxide emission in the atmosphere. So, to reduce the emission of greenhouse gases in production of concrete, various types of modern sustainable concrete using industrial waste like rice husk ash, slag, silica fume, blast furnace slag fly ash. By Re-using these waste materials t harm to the environment can be decreased. In Recent times due to rapid development in infrastructure very large amount of cement concrete is been in use. The consumption of Concrete is approximately thirty Billion tons per year that leads to high consumption of cement. In the present study partial replacement of Ordinary Portland Cement with Sugarcane Bagasse Ash in concrete will be done. The primary objective of this study is to determine properties of green concrete and hardened concrete. Ordinary Portland Cement of 43 grade will be used. The samples of concrete (Cubes) were made for M30 with variable mix Percentages of Sugarcane Bagasse Ash (i.e., 5%,10%, and 15%). The innovation in the present study is to find optimum replacement dose of Sugarcane Bagasse Ash for M30 grade of concrete. By using of waste material will help the Society by providing pollution free environment and decreasing the problem of landfills for waste materials. The different Design Mixes for M30 were calculated using IS codes 10262:2009 and 2016. Satisfactory results in case of fresh properties of concrete .The Compressive Strength Test for M30 grade of concrete, these values shoes that for M30 grade of concrete optimum value of Sugarcane Bagasse Ash is 5%. The results after conducting tests were compared to that of normal Concrete to find the suitability of Sugarcane Bagasse Ash mixed concrete for structural members of buildings.

Keywords*- Strength, SBA (sugarcane bagasse ash), compressive Strength, Sieve analysis, W/C ratio, OPC cement, Workability test.*

1 Introduction

Cement - based composite concrete material is most commonly used in construction material in world wide. Due to various factors like water resistance, including their ease of acquisition, thermal resistivity and mobility to be casted in various sizes and shapes. Concrete is use in all types of construction works in civil engineering. The main components of concrete are cement, aggregates (fine aggregate and coarse aggregate), and water.

Due to this cement production is increasing at a rate of 2.5% per year, having risen from 2300 million tons in 2005 to 3500 million tons in 2020and is expected to reach 3700–4400 million tons by 2050. Cement is the third most energy-intensive material in worldwide after steel and aluminum. Cement manufacture process results in massive emissions of pollutant as CO_2 into the air that causes climate change. Manufacture of cement alone generates 1350 million tons of greenhouse gases per year. Each ton of cement production requires approximately 80 units of electricity and raw materials of about 1500 kg.

Agriculture waste products such as sugarcane bagasse ash (SBA), sawdust ash, and rice husk ashes well as industrial by-products like fly ash, silica fume, red mud, tailing and slag, are presently being utilized as concrete in several applications. Non utilization of this products cause contamination of water, air and land. Using these materials as pozzolanic materials in concrete, these waste materials may improve durability and mechanical durability properties of the composites. Also, utilization of waste materials in concrete will promotes sustainability in construction. Sugarcane Bagasse Ash is a by-product of the sugar industry. After the sugar is extracted from sugarcane, a larger fibrous waste material called bagasse is left behind. When bagasse is burned at a specific temperature, a huge quantity of ash is produced, known as Sugarcane Bagasse Ash. After fibrous bagasse is burned at approximately 600–800 ◦C, the ash produced is rich in amorphous silica with excellent pozzolanic properties Bagasse ash's amorphous silica content makes it an excellent cement substitute in concrete. The amount of silica in the ash varies depending on a variety of factors, including the burning method and temperature, the type of soil used to grow sugarcane, and raw material properties After sugarcane juice is extracted, sugarcane bagasse waste is left behind, which contains nearly 50% of the sugarcane's quantity. Bagasse is frequently used as a fuel for power generation. SBA is the final waste product of this process. Thus, utilization of SBA is concrete would be a sustainable approach. In this study, experiment method has been adopted to find utilization of SBA in CBCs as a sustainable approach for construction materials.

While normal construction practice is generally guided by short term economic considerations, sustainable construction is focused on best practices which emphasize on long term affordability, durability and effectiveness. At each stage of the life cycle of the construction, it increases ease and quality of life, while minimizing the negative environmental impacts and increasing economic sustainability of the construction. Any infrastructure designed and constructed in a sustainable way minimizes the use of resources through the whole life cycle of the construction process in which the green concrete plays a vital role in achieving the sustainable construction. Having many of advantage has led to increased popularity in the construction world and is one of the emerging technologies in sustainable construction.

The present work is about studying the basic Characteristic of concrete mix using sugarcane bagasse ash as partial replacement of cement.

2 Research Objectives

To contribute in the society environment majorly is to making efforts to help in sustainable ecofriendly development. Utilization of waste products (locally available) that can make ecofriendly concrete can also be economical. Therefore, the Literature reviews are studied and the main objectives are:

1. To done comparative study of properties of fresh concrete produced by using Sugarcane Bagassae ash as partial replacement of Ordinary Portland Cement in different percentages with conventional concrete.
2. To done comparative study of properties of hardened concrete produced by using Sugarcane Bagassae ash as partial replacement of Ordinary Portland Cement inn different percentages with conventional concrete Like-7 days and 28 days Compressive strength.

3 Methodoloy

In this study waste materials used are sugarcane bagasse ash. The sugarcane bagasse ash is used to replace ordinary Portland cement by 5%, 10%, 15%, and 20% for every mixes that are prepared. These concrete mixes are prepared for M30 grade of concrete. For each grade replacement of mix concrete samples are made and nominal Mix is also made to compare the results. The Samples are prepared and tested for 7 Days and 28 Days Compressive Strength Tests.

3.1 Materials Used

3.1.1 Ordinary Portland Cement Ordinary Portland Cement (OPC GRADE 43) was used. Specific gravity test of OPC cement was performed in initial stage to get the data required to mix design the M-30 concrete. The ingredients of ordinary Portland cement are argillaceous and calcareous material in ration of 1:2. Production of ordinary Portland cement was done by mixing the argillaceous and calcareous materials in ration of 1:2, crushing and mixing them either dry or wet and the transferred in rotary kiln. In rotary kiln the mixture is burnt at a very high temperature in between 1400 degree C to 1500 degree C. This process results in clinker in kiln, after cooling them, it transferred to the ball mills to add retarding agent as gypsum and fine powdered ordinary Portland cement.

3.1.2 Sugarcane bagasse ash: Sugar cane bagasse ash is used for partial replacement of OPC. Sugarcane baggage was collected from various vendors as raw material, after that it was burned in uncontrolled environment to get sugarcane bagasse ash. Sieve Analysis is performed. Sugarcane bagasse ash passing 90 micron Sieve are taken for partial replacement with Cement. Sugarcane Bagasse Ash is available in three different colors: Reddish grey, Black & White. This variation in colors due to both

FIGURE 1 : SUGARCANE BAGASSE ASH

the degree in which the incineration process was done and the structural change of silica in the ash. Sugarcane bagasse Ash that are generated as waste material by power plants ranges in color from dark black to light. Dark black colors indicates a greater carbon amount because of inadequate incineration, gray color shows that incineration process was done at very high temperature (greater than 800^{o}C) and white colors when the incineration temperature is above 900^{o}C.

The chemical composition of sugarcane bagasse ashis as below table:

Table 1: Chemical composition of sugarcane bagasse ash

SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	SO_2	K_2O	N_2O	LOI
76.67	2.13	3.78	5.59	0.92	-	8.29	0.12	2-5
78.34	8.55	3.61	2.15	0.83	0.56	3.46	0.12	0.42
62.43	4.28	6.98	11.80	2.51	1.48	3.53	-	4.73
64.59	4.38	6.98	11.80	2.51	1.489	3.53	-	4.73

Table 2 Physical properties of ordinary Portland cement and sugarcane bagasse ash

Properties	**SBA**	**OPC**
Color	Reddish grey, black and white	Grey
Loose Bulk Density (kg / m^3)	575-578	1160
Compacted Bulk Density (kg / m^3)	1200-1561	1560
Specific Gravity	1.26-2.88	2.9-3.15
Specific Surface Area (m^2 / kg)	514-1250	309-373
Fineness Passing 45 microns	95-97	93

3.1.3 Coarse Aggregate: Normal or angular Crusher Stones passing 20 mm Sieve are taken into account for the study. Sieve analysis is done to get the fineness modules of coarse aggregate. Coarse aggregates are larger sized aggregate than fine aggregate. Coarse aggregates are bigger than 4.75mm in size..

3.1.4 Fine Aggregates: River Sand is taken for the study passing 4.75 mm Sieve are taken into account for study. Initial tests like sieve analysis is done to get fineness modules and zone of the fine aggregate. Specific gravity is finding using Pycnometer.

3.1.5 Water: As it is known that water plays an important role in making concrete as the chemical reaction that occurs in between material that causes it cementious properties. Water having PH-7 is use for mixing purpose as well as for curing process.

3.2 Primary Tests Done

1 Sieve Analysis

1. For Fine Aggregates:
2. For Coarse Aggregates:
3. For cement.

2Specific Gravity of Coarse Aggregate

3 Specific Gravity of Fine Aggregate

4 Compaction Factor Test

5 Slump Cone Test

Table 3 Primary tests results

TESTS	VALUE/ RESULT
Fineness modulus of CA	7.359
Fineness modulus of FA	3.009
Fineness of Cement (Average)	0.950%
Specific Gravity of Sand	2.60
Specific Gravity of Coarse aggregate	2.80
Specific Gravity of Cement	3.17

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3.3 Process

The Cubes are casted for M30 grade of concrete for which Mix Designs are. After the weight of materials are calculated

1. In a pan take the weighted materials i.e. fine aggregate (sand), coarse aggregate, cement and sugarcane bagasse ash as in ratio found for mix design.
2. Mix the materials in dry state thoroughly.
3. Dry mix all the materials. After thoroughly mixing the materials make a hollow as crater in the Centre.
4. Start adding water in the mix at small amount at a time and start mixing them, water should be added as per the water cement ration taken in mix design.
5. After concrete is mixed start placing it in oil polished Cube molds up to 1 / 3 of its part. Now after this start temping the placed mixture in mould for 25 times, fill the mould up to 2 / 3 and repeat the temping process.
6. Now completely fill the mould and temping it for 25 times in last portion, level it then put on Table Vibrator for compaction.
7. Then keep for 24 hours. After 24 hours take the specimen out of the moulds and keep for Curing in curing tanks.
8. After 7 & 28 Days take out the specimens of curing tanks and leave them for some time to surface dry them. After this perform the Compressive Strength tests.

Table 4 Calculation for Weight of Materials required for casting M-30 Concrete

Percentage replacement of cement with SBA	Wt. of Cement (in Kg)	Wt. of Sugarcane Bagasse Ash (in Kg)	Wt. of Sand (in Kg)	Wt. of Coarse Aggregate (in Kg)	Wt. of Water (in ml)
0%	8.2	0	12.34	22.66	190.00
5%	7.79	0.41	12.34	22.66	190.00
10%	7.38	0.82	12.34	22.66	190.00
15%	6.97	1.23	12.34	22.66	190.00

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FIGURE 2: Dry Mix, Mixing Of Concrete, Filling In Mould, Compaction Factor, Casted Moulds and Compressive Strength Test

4 RESULTS & DISCUSSIONS

Table 5 Compressive Strength Test Results for M30 Grade of Concrete

%age Mix (Cement partially replaced SBA)	7 Days Compressive Strength (MPa)	28 Days Compressive Strength (MPa)
0%	25.55	39.00
5%	24.80	37.50
10%	22.56	34.22
15%	20.00	29.55

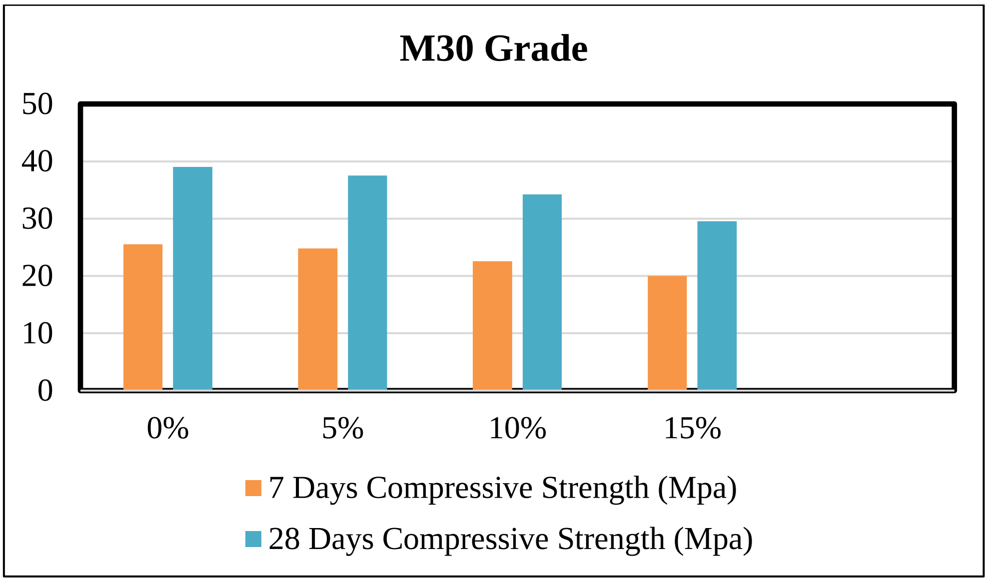

Fig. 3: Compressive Strength of M30 grade of Concrete

Table 6 Slump Cone Test Results

%age Replaced	For M30 (in mm)
0%	40
5%	40
10%	30
15%	30

Table 7 Compaction Factor Test Results

%age Replaced	For M30
0%	0.90
5%	0.90
10%	0.89
15%	0.88

5 Conclusion

In fresh concrete the slump cone test and compaction factor tests were performed to find the effect of SBA in workability of concrete. In hardened concrete 7 days and 28 days compressive strength test was performed. Test results shows that the workability of concrete decrease with the increase of SBA content in concrete as the specific surface area of SBA is very high compare to cement. Thus it requires more water. The compressive strength test result shows that the strength in compression in concrete mix decreases as the SBA content in mix increases more than 5% of cement.

SBA can make a good pozzolanic material as it has a higher amount of amorphous silica in it. Because of which, it can decreasing cement demand thus reduce CO2 emissions, protect various natural resources and solve waste management problems. These reasons can make SBA a sustainable construction material product in concrete with lower cost.

The strength properties of concrete improved with SBA addition up to an optimal amount, after which addition of SBA can decrease the strength of concrete. Study it was found out that increase in SBA content more than 5% negatively affects the compressive strength of concrete

1. The lower workability is due to the higher specific surface area of SBA which increases the water requirement thus decreasing the fluidity thus the slump value and compaction factor is reduced.
2. Another reason of low workability is that SCBA contains no spherical glass grains but many porous grains that decrease the workability of fresh-state cement-based materials.
3. The design mix for M30 grade of concrete made with SBA partially replacing cement in concrete for 5%, 10% and 15%that shows that compressive strength of concrete decreases for 10% and 15%.
4. SBA contains more unburned carbon and potassium, as vegetable ash formed under a lower combustion temperature. That is a main reason of lower value of percentage replacement of cement with SBA; by incineration with higher temperature for complete incineration we can achieve white colored SBA that poses lower value of carbon content and higher pozzolanic properties.
5. With the use of sugarcane well-burnt bagasse Up to 20% of ordinary Portland cement can be optimally replaced with without any adverse effect on the desirable properties of concrete.
6. The use of SBA as partial replacement of cement in reduction in water permeability and resistance to chloride permeation and diffusion up to some percentage can be achieved.
7. As sugarcane bagasse ash is a waste material, its utilization as a cement replacing material reduces the levels of CO_2emission by the cement industry and also the material consumption for making of cement and at the same time it helps in disposal problem of the sugar industries.
8. Due to the lower density of SBA, concrete with partial replacement of cement by SBA has slightly less density so that it can be used at the place at which strength is of less importance and low density concrete density is required.
9. In the economic point of view, the cement partially replaced by SBA can be economical.

The reason for reduced strength that the exceed amount of pozzolanic material that required to combine with $Ca(OH)_2$. Another reason in decrease in strength can be due to defects generated during SBA dispersion that causes weak zones in concrete. Therefore it is recommended to use the SBA as replacement of cement in concrete in lower proportion.

6 Future Scope:

- Evaluation of effect of SBA in long term effects on concrete such as creep, drying shrinkage etc.
- Effects of SBA in R.C.C and pre-stressed concrete.
- Find the commercial utility of SBA in construction
- To learn the behavior of SBA in concrete computer software of model approach can be done.
- Researches can be conduct to achieve higher replacement ratio of SBA.

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