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Experimental Study on Use of Sugar Cane Bagasse Ash in Concrete by Partially Replacement with Cement

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I. INTRODUCTION

A. General

Concrete is a construction material basically mixture of coarse aggregate, fine aggregate and cement. Concrete plays a vital role in many structures such as buildings, bridges, canals etc. Concrete becoming a interior part of any type of construction works, the usage of concrete is becoming more due to development of construction industry. The performance of concrete is depend upon the properties of aggregates in order to reduce the consumption of concrete components. Usage of pozzolana such as flyash, rice husk ash, bagasse ash by replacing cement at a certain amount to produce good concrete. The usage of concrete is twice as compared to aluminium, plastic, wood etc. Concrete is a versatile material used in all type of structural works.

Portland pozzolana cement is recognized as a major construction material throughout the world. Researchers all over the world today are focusing on ways of utilizing either industrial or agricultural waste, as a source of raw materials for industry. This waste, utilization would not only be economical, but may also result in foreign exchange earnings and environmental pollution control. Industrial wastes, such as blast furnace slag, fly ash and silica fume are being used as Supplementary cement replacement materials. Currently, there has been an attempt to utilize the large amount of bagasse ash, the residue from an in-line sugar industry and the bagasse-biomass fuel in electric generation industry. When this waste is burned under controlled conditions, it also gives ash having amorphous silica, which has pozzolanic properties. A few studies have been carried out on the ashes obtained directly from the industries to study pozzolanic activity and their suitability as binders, partially replacing cement. It is also used in concrete without adverse effects in concrete durability. Therefore it is possible to use Sugarcane Bagasse Ash (SCBA) as cement replacement material to improve quality and reduce cost of construction and improve concrete properties

B. Need for Replacement of Cement

Ordinary Portland cement is recognized as a major construction material throughout the world. Portland cement is the conventional building material that actually is responsible for about 5% - 8% of global CO2 emissions. This environmental problem will most likely be increased due to exponential demand of Portland cement.

Researchers all over the world today are focusing on ways of utilizing either industrial or agricultural waste, as a source of raw materials for industry. This waste, utilization would not only be economical, but may also result in foreign exchange earnings and environmental pollution control. Utilization of such wastes as cement replacement materials may reduce the cost of concrete production and also minimize the negative environmental effects with disposal of these wastes

C. Alternatives for Partial Cement Replacement

Silica fume, rice husk ash, fly ash, metakaolin and ground granulated blast furnace slag are well established wastes with pozzolana because of high silica content in their chemical compositions. The calcium hydroxide (unfavorable product from the cement hydration) released during the hydration of OPC reacts with silica present in the pozzolana and water to form additional calcium silicate hydrate which is responsible for the compressive strength in concrete.

The various alternatives used as partial cement replacement are –

1) *Fly ash:* Fly ash is a pozzolana substance containing aluminous and siliceous materials which is the residue left from burning coal. Fly ash when replaced partially with cement, improves workability, cohesiveness, ultimate strength and durability. Fly ash of low quality when used in concrete has a negative effect on properties of concrete

2) *Ground Granulated blast Furnace Slag:* It is the by product from the blast furnace used to make iron, which is highly cementitious in nature. It increases the workability of concrete. It causes reduction in early temperature rise , high resistance to chloride, sulphate and other chemicals
3) *Silica Fumes:* Silica fume is a byproduct of producing silicon metal and ferrosilicon alloys. It is also known as micro silica and is used to improve compressive strength, bond strength, abrasion resistance, reduces permeability and therefore helps in protecting steel from corrosion.
4) *Wood Ash:* It is the residue from combustion done in boilers at pulp and paper mills and thermal power plant. Wood ash when used in concrete as partial replacement for cement, increases the compressive strength and workability of concrete.
5) *Ceramic Waste Dust:* It is a waste product obtained during dressing and polishing which when used as partial replacement of cement in concrete improves strength and durability factors. It is durable, hard and highly resistant to biological, chemical, and physical degradation forces.



Ceramic waste dust Silica ash Wood ash


Fly ash Ground Granulated Blast Furnace Slag

Fig 1.1 Alternatives for partial cement replacement

D. Use of Sugarcane Bagasse Ash as a Partial Replacement for Cement

Sugarcane is major crop grown in over 115 countries and its total production is over 1850 million tons. Sugarcane production in India is over 300 million tonnes per year. The processing of it in sugar-mill generates about 10 million tonnes of SCBA as a waste material. One tonne of sugarcane can generate approximate 26% of bagasse and 0.62% of residual ash. The residue after combustion presents a chemical composition dominates by silicon dioxide. In 2009, the total production of sugarcane in the world was estimated to be approximately 1661 million tons. The largest producer of sugarcane is Brazil and India is the second largest. After the extraction of all economical sugar from sugarcane, about 40-45% fibrous residue was 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, aluminium and calcium oxides. Bagasse is often used as a primary fuel source for sugar mills; when burned in quantity, it produces sufficient heat energy to supply all the needs of a typical sugar mill. The dumping of these industrial wastes in open land poses a serious threat to the society by polluting the air and waste bodies. This also adds the non availability of land for public use .

Fig 1.2 Sugarcane Bagasse

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Fig 1.3 Sugarcane Bagasse Ash

E. World Bagasse Ash Estimation

Extraction of juice through sugarcane crushing gives out about 25% to 30% of wet bagasse. Bagasse in wet condition contains about 40% to 50% of moisture. Sugarcane bagasse is used as a raw material for manufacturing of paper, also used as fuel to generate steam in mills and in cogeneration plants. Burning of bagasse gives out about 3% to 5% of ash which is a waste material dumped on open lands creating pollution.

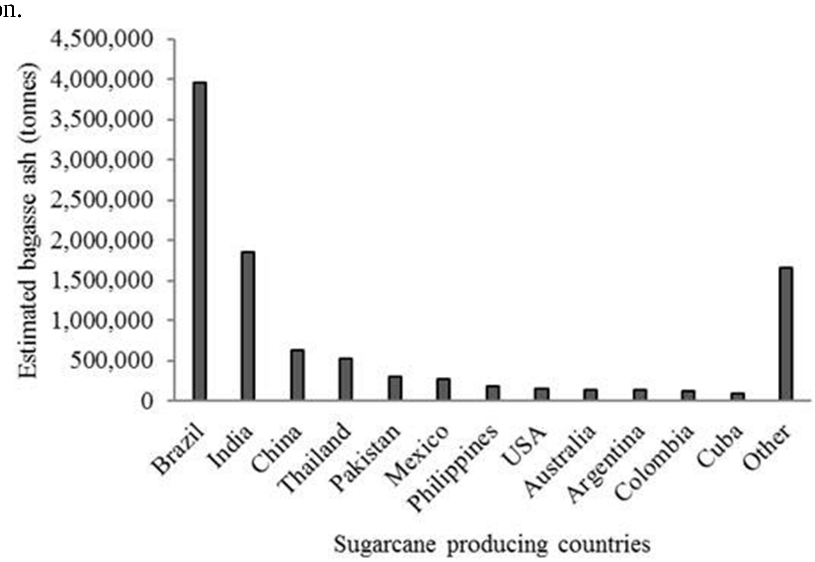

Fig 1.4 Sugarcane bagasse ash estimate for different countries.

Considering production of all sugarcane producing countries, SCBA waste is found out to be about 18 million tonnes. Such a large quantity of waste coming out from sugar industries is creating a challenge in front of researchers for proper waste management.

Statistics of 2010-11 as per ICAR, Sugarcane Breeding Institute, Coimbatore, India of sugarcane production highlights the increase in production by about 10 times in last 80 years. With increase in need of sugarcane, in future the sugarcane production is expected to rise based on the topographical and climatic conditions.

F. Physical characteristics of Sugarcane Bagasse Ash

The various physical properties of SCBA are :

Density - 2.52g/cm^3

Blaine surface area - 5140cm^2

Particle size - 28.9micron

Colour - Reddish grey

G. Chemical Composition of Sugarcane Bagasse Ash

Chemical compounds	Percentage by weight (%)
SiO_2	60-65
Al_2O_3	4-5
Fe_2O_3	6-8
CaO	10-12
MgO	2-3
SO_3	1-2
K_2O	2-4
LOI	4-6

Table 1.1 Chemical Composition of Sugarcane Bagasse Ash

II. OBJECTIVES

The project is to find the suitability of Sugarcane Bagasse Ash for obtaining the optimum amount of Sugarcane Bagasse Ash by performing various test on it and analyse the obtained test results

1) To replace cement in concrete (M25 grade) by Sugarcane Bagasse Ash((0%, 5%, 10%, 15% and 20%) and study their effect on concrete properties such as compressive strength and workability.
2) To arrive at an optimum quantity of Sugarcane Bagasse Ash for M25 concrete.
3) To compare the cost of conventional cement concrete and concrete with partial replacement of cement by Sugarcane Bagasse Ash

III. LITERATURE REVIEW

A. Jayminkumar A. Patel et al Experimental Study on Use of Sugar Cane Bagasse Ash in Concrete by Partially Replacement with Cement, International Journal of Innovative Research in Science, Engineering and Technology, Vol. 4, Issue 4, April 2015.

In this paper, sugarcane bagasse ash which is taken from one of the sugar mill of south Gujarat (INDIA) used in M25 grade of concrete by replacing cement 5% by weight and compared with normal M25 grade of concrete to check the feasibility of sugar cane bagasse ash in concrete. Ordinary Portland Cement of 53 Grade conforming IS 12600-1989(2009), sand confirms to zone I as per Indian standards. (IS: 10262, IS: 383, 10mm and 20 mm aggregate IS: 10262, IS: 383, sugarcane bagasse ash from Gujarat are used. For the experiment work concrete cubes of size 150x150x150mm, were prepared. The 53 grade OPC was replaced with 0% and 5% SCBA with w/c ratio of 0.49. A total of 36 concrete specimens were casted and tested. The experimental result shows the increase in the strength of concrete with use of sugar cane bagasse ash.

B. R. Srinivasan et al, Experimental Study on Bagasse Ash in Concrete, International Journal for Service Learning in Engineering, Vol. 5, No. 2, Issue 2010

The experimental study examines the compressive strength, split tensile strength, flexural strength, young's modulus and density of concrete. The main ingredients consist of Portland cement, SCBA, river sand, coarse aggregate and water. After mixing, concrete specimens were casted and subsequently all test specimens were cured in water at 7 and 28 Days. The mix design of concrete was done according to Indian Standard guidelines 6-9 for M 20 grade for the granite stone aggregates and the water cement ratio are 0.48. Based upon the quantities of ingredient of the mixes, the quantities of SCBA for 0, 5, 10, 15, 20 and 25% replacement by weight were estimated. All investigated SCBA mixtures had high slump values and acceptable workability. Addition of SCBA in plain concrete increases its strength under compression, tension, young's modulus, and flexure up to 10% of replacement after that strength results was decreases. Although, the optimal level of SCBA content was achieved with 1.0% replacement. The density of concrete decreases with increase in SCBA content, low weight concrete produced in the society with waste materials (SCBA).

C. Sagar Dhengare et al, Utilization of sugarcane bagasse ash as a supplementary cementitious material in concrete and mortar - A Review , International Journal of Civil Engineering and Technology (IJCIET), Volume 6, Issue 4, April (2015).

The paper conatins review of various aspects. The compressive strength of different mortar with 5% to 30% replacement of cement with bagasse ash in mortar as per ASTM Standards revealed that the bagasse ash improves some properties of mortar . The replacement of OPC by bagasse ash in 10% results in better compressive strength than control mortar. Higher replacement of cement by bagasse ash results in higher normal consistency and longer setting time.

The maximum compressive strength was obtained at 15% replacement of SCBA for M40 and M30 cement. The improvement in compressive strength of mortar by partially replacing cement by SCBA is due to filler effect and pozzolanic reaction between reactive SiO2 from SCBA and Ca (OH)2 from cement hydration.

D. Mrs.U.R.Kawade1 et al, Effect of use of Bagasse Ash on Strength of Concrete, International Journal of Innovative Research in Science, Engineering and Technology, Vol. 2, Issue 7, July 2013.

The paper analyses the effect of SCBA in concrete by partial replacement of cement at the ratio of 0%, 10%, 15%, 20%, 25% and 30% by weight. The main ingredients consist of Portland cement, SCBA, crushed sand, coarse aggregate and water. After mixing, concrete specimens were casted and subsequently all test specimens were cured in water at 7, 28, 56 and 90 Days. The results shows that the SCBA concrete had significantly higher compressive strength compared to that of the concrete without SCBA. It is found that the cement could be advantageously replaced with SCBA up to maximum limit of 15%. Although, the optimal level of SCBA content was achieved with 15.0% replacement. Partial replacement of cement by SCBA increases workability of fresh concrete; therefore use of super plasticizer is not essential.

E. T.S.Abdulkar et al, Evaluation of sugarcane bagasse ash as a replacement for cement in concrete works, Department of Civil Engineering, University of Ilorin, Ilorin, NIGERIA, July (2016)

This research evaluates the suitability of SCBA as a partial replacement for cement in concrete productions.. A total of 2.71kg of SCBA was obtained after passing the residual through 45µm sieve, standard size of ordinary portland cement (OPC).. It was then used to replace OPC by weight in ratio of 0%, 10%, 20% and 30%. Total of 48 pieces of 100mm concrete cubes of design mix ratio 1:1.66:2.77 were prepared.

The cubes were tested at 7, 14, 21 and 28days of curing ages for density and compressive strength. The results of chemical test showed that SCBA has pozzolanic properties having met ASTM595 (1985) with total sum of silica, alumina and ferric composition of 80.55%.

The results showed a decrease in concrete density with increase in % replacement of SCBA. Average compressive strength of 26.8N/mm2 was obtained for control specimens at 28days (i.e. 0% SCBA) while 22.3, 20.1 and 17.3N/mm2 compressive strength at 28days were obtained for 10%, 20% and 30% replacement respectively. It was concluded that SCBA is a low weight material and 10% replacement of SCBA has the highest PAI. Also, 10% and 20% replacement of SCBA with compressive strengths of 22.3N/mm2 and 20.1N/mm2 are recommended for reinforced concrete.

F. K Meeravali et al, Partial replacement of cement by sugarcane bagasse ash and there effect on concrete, Department of Civil engineering, Guru Gobind Singh College of Engineering and Research Centre Nashik (2014)

hey studied on, “Partial Replacement of Cement in Concrete with Sugar Cane Bagasse Ash-Behaviour in Hcl Solution”. In this paper concrete cubes are casted with different percentages of Sugarcane Bagasse ash replaced with cement by weight (i.e. 0%, 5%, 10%, 15%, 20%, and 25%), and this cubes are exposed to 5% HCL environment. Compressive strength of cubes for 7days, 28 days and 60days are observed. Higher grade of concrete was considered as a base sample for above all research. So an attempt has been made to find out the % of SCBA to be added to M20 grade concrete in order to increase its strength and make it competition with higher grade concrete with maintaining the economy of work.

G. Prof P.D.Maneeth, Experimental Investigation on Partial Replacement of Cement by Sugar Cane Bagasse Ash in Cement Concrete, International Journal for Scientific Research & Development, (May 2016)

In this work, they have made an attempt to study the compressive, split tensile and flexural strength of M20 grade concrete by utilizing Sugar Cane Bagasse Ash as partial substitution to cement.

The compressive strength test is studied for 14 and 28 days of curing period and the split tensile and flexural strength is studied for 14 and 28 days of curing period. The compressive strength of cement concrete is most elevated at 5% replacement of cement by SCBA with 19.348 N/mm2 at 14 days and 29.340 N/mm2 at 28 days of curing period, the split tensile strength of cement concrete is at 10% replacement of cement by SCBA is 2.876 N/mm2 at 28 days of curing period and the highest flexural strength of concrete is at 5% replacement cement by SCBA which is 4.108 N/mm2 at 28 days of curing period, which are higher than the typical traditional concrete. From this study it is concluded that the normal cement can be partially replaced by SCBA upto 25% of cement in M20 grade cement concrete.

IV. METHODOLOGY

A. General

In view of the proposed experiment study, the materials such as Cement,Sand, Aggregates and Sugarcane bagasse ash were required to be procured, tested on arriving upon the basic physical and chemical properties and thereafter put in for the further experimental works.

The fine aggregates were procured from the river bed and coarse aggregates and cement from Laxmi ceramics Pvt Ltd. Sugarcane Bagasse Ash (SGBA) was brought from Sant Tukaram Sugar factory, Pune .

The physical properties such as specific gravity ,water absorption, fineness and moisture content were tested on coarse aggregates and fine aggregates whereas for cement properties such as initial and final setting time were tested. The properties of ash were provided by the supplier.

The following tests were performed on the concrete:

1) Workability.
2) Compression strength test.

B. Physical Properties

1) *Cement:* Bharti Ordinary Portland Cement (OPC) of 53 grade was used and the physical properties were evaluated from the laboratory as below.

a) *Consistency:* The main objective of consistency is to determine the percentage of water required for preparing cement paste of standard consistency. It is conducted by using Vicat's apparatus. Cement paste of normal consistency is defined as percentage of water by weight of cement paste which produces a consistency which permits plunger of 10mm diameter to penetrate upto 33mm to 35mm from top of mould when cement paste is tested within 3 to 5minutes after the cement is thoroughly mixed with water. About 400 grams of cement sample is taken and placed in enamel trough. Add about 25% of potable water and mix it by means of spatula.care should be taken that the gauging time is not less than 3min & not more than 5 minutes. Apply thin layer of oil to inner surface of the mould. Fill the Vicat's mould with this paste in the mould resting on non porous plate and the level the surface with trowel. Place the mould together with non porous plate under the rod bearing the plunger so that it touches the surface of the test block. Release quickly the plunger allowing it to sink in the cement paste in the mould. Note down the penetration of plunger in the paste when it becomes stable in the mould. If the penetration of plunger in the paste is less than the 33 to 35 mm from the top of the mould, prepare the trial paste with increasing percentage of water & repeat the above procedure until the plunger penetrates to a depth of 33 to 35mm from the top or 5 to 7mm from the bottom of the mould.

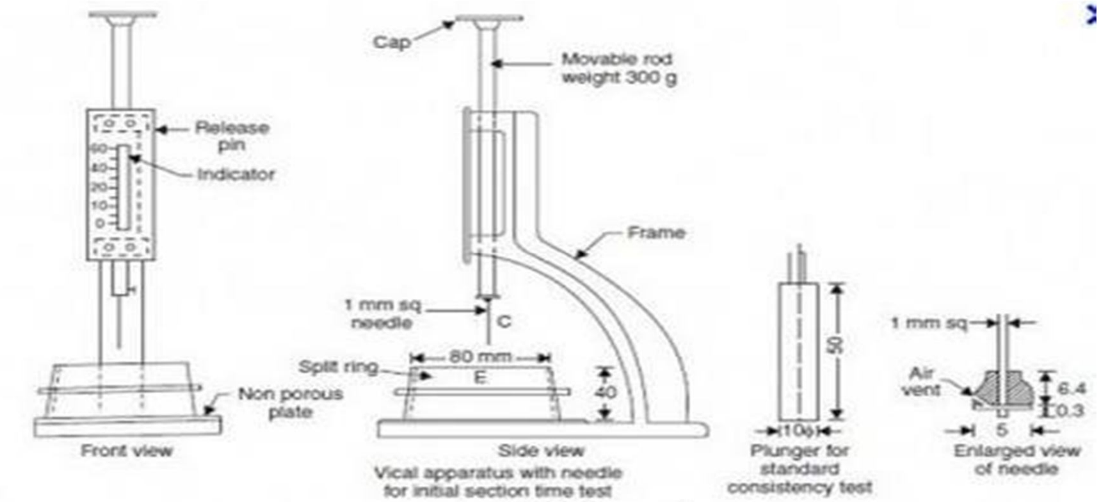

Fig 4.1 : Vicat's Apparatus

Observations

- Type & brand of cement: Bharti OPC
- Grade of cement: 53 grade

Sr. no.	Quantity of cement(gm)	Amount of water added (ml)	Plunger Reading		Percentage of water taken
			From top	From bottom	
1	400	180	27	13	42
2	400	200	35	5	45

Table No 4.1 Readings of Consistency Test of cement

The permissible values for consistency ranges between 35-50%. The standard consistency of cement sample is found to be 45%

b) *Fineness of Cement:* Fineness of cement is a measure of size of particles of cement. Finer cement has quicker action with water & gain early strength. Excessively fine cement deteriorates more quickly when exposed to air & is likely to cause more shrinkage. Fineness is conducted by sieving the cement sample through IS 90µ sieve. About 100g of cement is taken and placed on a IS 90µ sieve. Break down any air set lumps in the sample with fingers without rubbing them on sieve. Continuously sieve the sample for 15 minutes by holding the sieve in both hands & giving wrist motion. Weigh the residue left on the sieve, after sieving.

Observation Table

Sample no	1	2	3
Wt.of cement W(gm)	100	100	100
Wt. of cement retained after sieving through 90µ (W_1)gm	5	3	2
%wt of retained on the sieve W1/W*100	5%	3%	2%

Table no. 4.2: Readings for fineness test of cement.

The average fineness of given cement sample is found to be 3.33%

c) *Specific Gravity of Cement:* Specific gravity is defined as the ratio of unit weight of soil to the unit weight of water of equal volume, both the weights being taken in air. The specific gravity of the soil particles G shall be measured at room temperature. Specific gravity of cement was taken as 3.15 as provided by manufacturer

2) *Fine Aggregates*

a) *Specific Gravity and Water Absorption:* The specific gravity of an aggregate is considered to be measure of strength or quality of material. The method deals with the test for determination of specific gravity of soil which finds application in determining the degree of saturation and unit weight of moist soil. Water absorption gives an idea of strength of aggregates. Aggregates having more water absorption are more porous in nature and are generally considered unsuitable unless they are found acceptable based on strength, impact and hardness test.

Specific gravity $G = (M_2 – M_{1)} / ((M_4-M_1) – (M_3-M_2))$

Water Absorption $= (M_3 – M_4) / M_4 \times 100$

Weigh the density bottle and note down the reading (M_1). Fill the density bottle with sand sample completely and note down the weight of density bottle with sand (M_2).Empty the density bottle and fill it completely with water and weigh the bottle (M_4). Add sand sample to this bottle and note down the weight (M_3).

Observation Table

Mass of density bottle (M_1) in gms	621
Mass of bottle and dry sand (M_2) in gms	1316
Mass of bottle, sand and water (M_3) in gms	1871
Mass of bottle when full of water (M_4) in gms	1439

Table No 4.3.Readings of Specific Gravity and Water Absorption Test for fine aggregates

Specific gravity of fine aggregates ranges between 2.6- 2.9 and water absorption. Ranges between
Specific gravity of fine aggregates sample is found to be 2.64 and Water absorption of fine aggregates is 3.7%

b) *Moisture Content:* The measurement of moisture content of fine aggregates is required for mix design. Since aggregates contains some porosity, water can be absorbed into the body of the particles or retained on the surface of the particle as a film of moisture. Place fine aggregate sample in a drying pan of know tare weight. Weigh and record the weight of the sample and pan as W_1 to the nearest 0.1g. Place pan containing the sample in the oven at a temperature of 100-110° C for 24 hours. Cool the pan and dried material until the pan can be handled without gloves. Weigh the pan with the material as W_2.

Observation Table

Weight of sample (W_1)	500
Weight of oven dried sample (W_2)	491
Moisture Content = $W_1 – W_2 / W_2$ x 100	1.88%

Table No 4.4 Readings of Moisture Content test for fine aggregates

The moisture content of fine aggregates is obtained as 1.88%

c) *Sieve Analysis:* The sieve analysis, commonly known as the gradation test, is a basic essential test for all aggregate technicians. The sieve analysis determines the gradation (the distribution of aggregate particles, by size, within a given sample) in order to determine compliance with design, production control requirements, and verification specifications. The gradation data may be used to calculate relationships between various aggregate or aggregate blends, to check compliance with such blends, and to predict trends during production by plotting gradation curves graphically, to name just a few uses. Weigh the sample to the nearest 0.1 g by total weight of sample. IS Sieves of size 10mm, 4.75mm, 2.36mm, 1.18mm,600µ, 300µ, 150µ are arranged in order of decreasing size from top to bottom and place a pan at the bottom and begin agitating and shaking the sample for a sufficient amount of time by placing on mechanized sieve shaker for 15minutes. Weigh the material retained on each sieve size to the nearest 0.1 g. Ensure that all material entrapped within the openings of the sieve are cleaned out and included in the weight retained.

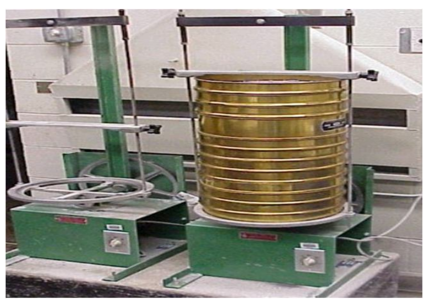

Fig 4.2 : Sieve Shaker for fine aggregates

Observation Table
Weight of sample- 5493g

IS Sieve (mm)	Wt. Retained (gm)	Cum. Wt. Retained.	% Retained	% Passing	Limits	
10	0	0	0.00	100.00	100	100
4.75	105	105	1.91	98.09	90	100
2.36	760	865	15.75	84.25	75	100
1.18	1250	2115	38.50	61.50	55	90
0.600	1368	3483	63.41	36.59	35	59
0.300	1507	4990	90.84	9.16	8	30
0.150	399	5389	98.11	1.89	0	10
Pan	104	5493	100.00	0.00		
		FM =	3.09			

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Table No 4.5 Readings of Sieve Analysis for fine aggregates

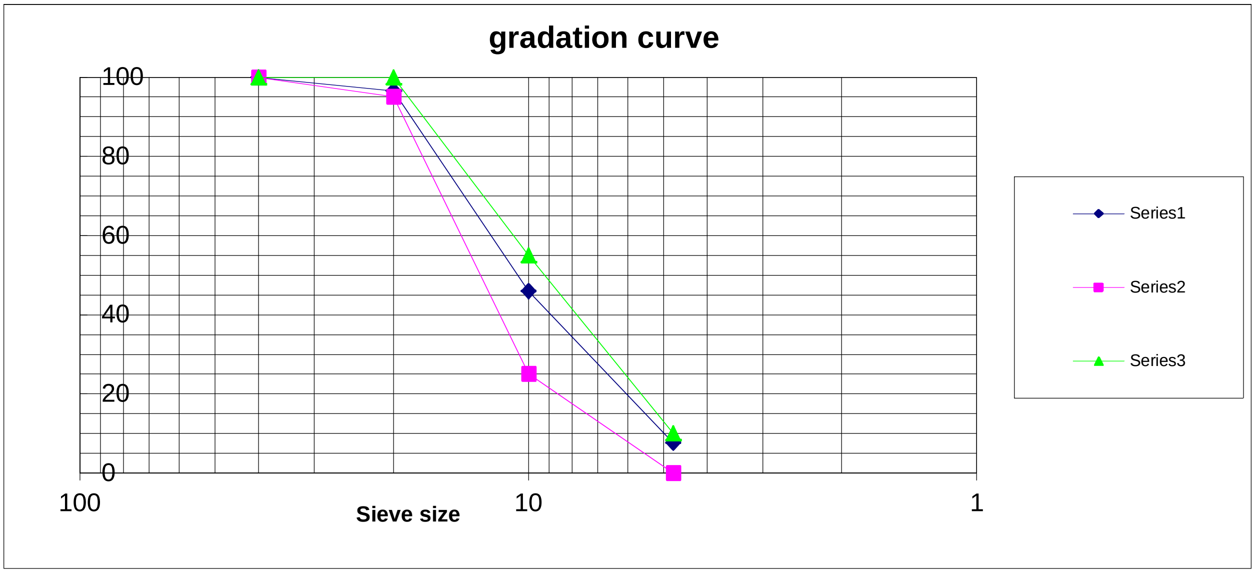

Fig 4.3 Gradation Curve for Fine Aggregates

The fineness modulus of fine aggregate is 3.09.

3) *Coarse Aggregates*

a) *Specific Gravity and Water Absorption Test:* The specific gravity of an aggregate is considered to be measure of strength or quality of material. The method deals with the test for determination of specific gravity of soil which finds application in determining the degree of saturation and unit weight of moist soil. Water absorption gives an idea of strength of aggregates. Aggregates having more water absorption are more porous in nature and are generally considered unsuitable unless they are found acceptable based on strength, impact and hardness test. About 2 kg of aggregate sample is washed thoroughly to remove fines, drained and placed in wire basket and immersed in distilled water at a temperature between 22- 32º C and a cover of at least 5cm of water above the top of basket. The entrapped air is removed from the sample by lifting the basket containing it 25 mm above the base of the tank and allowing it to drop at the rate of about one drop per second. The basket and aggregate should remain completely immersed in water for a period of 24 hour afterwards. The basket and the sample are weighed while suspended in water at a temperature of 22° – 32°C. The weight while suspended in water is noted $=W_1$g. The basket and aggregates are removed from water and allowed to drain for a few minutes, after which the aggregates are transferred to the dry absorbent clothes. The empty basket is then returned to the tank of water jolted 25 times and weighed in water$=W_2$g. The aggregates placed on the absorbent clothes are surface dried till no further moisture could be removed by this cloth. Then the aggregates are transferred to the second dry cloth spread in single layer and allowed to dry for at least 10 minutes until the aggregates are completely surface dry. The surface dried aggregate is then weighed $=W_3$ g The aggregate is placed in a shallow tray and kept in an oven maintained at a temperature of 110° C for 24 hrs. It is then removed from the oven, cooled in an air tight container and weighted$=W_4$ g.

b) *Observation Table*

For 20mm aggregates

Weight of saturated aggregate suspended in water with basket (W_1)	1523.9
Weight of basket suspended in water (W_2)	537.1
Weight of saturated surface dry aggregate in air(W_3)	1516.2
Weight of oven dry aggregate (W4)	1488
Specific gravity = $W_3 / (W_3 – (W_1 – W_2))$	2.86
Water Absorption = $((W_3 – W_4) / W_4)$ X 100	1.90%

Table No 4.6 Readings of Specific Gravity and Water Absorption of 20mm coarse aggregates

For 10mm aggregates

Weight of saturated aggregate suspended in water with basket (W_1)	1545.4
Weight of basket suspended in water (W_2)	537.1
Weight of saturated surface dry aggregate in air(W_3)	1568
Weight of oven dry aggregate (W4)	1538.5
Specific gravity = W_3 / (W_3– (W_1– W_2))	2.80
Water Absorption = ((W_3 – W_4) / W_4) X 100	1.92%

Table No 4.7 Readings of Specific Gravity and Water Absorption of 10mm coarse aggregates

Specific Gravity was found to be :

i) For 20mm coarse aggregates- 2.86

ii) For 10mm coarse aggregates- 2.80

Water Absorption was found to be :

i) For 20mm coarse aggregates- 1.90%

ii) For 10mm coarse aggregates- 1.92%

c) *Moisture Content:* The measurement of moisture content of coarse aggregates is required for mix design. Since aggregates contains some porosity, water can be absorbed into the body of the particles or retained on the surface of the particle as a film of moisture. Place coarse aggregate sample in a drying pan of know tare weight. Weigh and record the weight of the sample and pan as W_1 to the nearest 0.1g. Place pan containing the sample in the oven at a temperature of 100-110° C for 24 hours.Cool the pan and dried material until the pan can be handled without gloves. Weigh the pan with the material as W_2.

Observation Table

For 20mm coarse aggregates

Weight of sample (W_1)	500
Weight of oven dried sample (W_2)	495.1
Moisture Content = W_1 – W_2 / W_2 x 100	1.00%

Table No 4.8 Readings of Moisture Content test for 20mm coarse aggregates

For 10mm coarse aggregates

Weight of sample (W_1)	500
Weight of oven dried sample (W_2)	495
Moisture Content = W_1 – W_2 / W_2 x 100	1.01%

Table No 4.9 Readings of Moisture Content test for 10mm coarse aggregates

The moisture content is obtained as follows

- 20mm coarse aggregates- 1.00%
- 10mm coarse aggregates- 1.01%

d) *Sieve Analysis:* The sieve analysis, commonly known as the gradation test, is a basic essential test for all aggregate technicians. The sieve analysis determines the gradation (the distribution of aggregate particles, by size, within a given sample) in order to determine compliance with design, production control requirements, and verification specifications. The gradation data may be used to calculate relationships between various aggregate or aggregate blends, to check compliance with such blends, and to predict trends during production by plotting gradation curves graphically, to name just a few uses. Weigh the sample to the nearest 0.1 g by total weight of sample. This weight will be used to check for any loss of material after the sample has been graded. Place the IS Sieves of size 12.5mm, 10mm, 4.75mm, 2.36mm for 10mm coarse aggregates and 40mm, 20mm, 10mm, 4.75mm for 20mm coarse aggregates in order of decreasing size from top to bottom and place a pan at the bottom and begin agitating and shaking the sample for a sufficient amount of time by placing on mechanized sieve shaker for 15minutes. Weigh the material retained on each sieve size to the nearest 0.1 g. Be sure to remove any aggregate trapped within the sieve openings by gently working from either or both sides with a trowel or piece of flat metal until the aggregate is freed.

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Fig 4.4 Sieve Shaker for coarse aggregates

Observation Tables

For 10mm coarse aggregates

Weight of sample- 2071g

IS Sieve (mm)	Wt. Retained (gm)	Cum. Wt. Retained. (gm)	% Retained	% Passing	Lower limit	Upper lomit
12.5	0	0	0.00	100.00	100	100
10	152	152	7.34	92.66	85	100
4.75	1543	1695	81.84	18.16	0	20
2.36	351	2046	98.79	1.21	0	5
Pan	25	2071	100.00	0.00	-	-

Table No 4.10 Readings for Sieve Analysis of 10mm Coarse aggregates

For 20mm coarse aggregates

Weight of sample- 2177g

IS Sieve (mm)	Wt. Retained (gm)	Cum. Wt. Retained. (gm)	% Retained	% Passing	Lower limit	Upper lomit
40	0	0	0.00	100.00	100	100
20	128	128	5.88	94.12	85	100
10	1726	1854	85.16	14.84	0	20
4.75	312	2166	99.49	0.51	0	5
PAN	11	2177	100.00	0.00	-	-

Table No 4.11 Readings for Sieve Analysis of 20mm Coarse aggregates

Combined Gradings

% in mix	60	40			
IS Sieve (mm)	20mm	10mm	Total % Passing	Lower Limits	Upper limit
40	60.00	40.00	100.00	100	100
20	56.47	40.00	96.47	95	100
10	8.90	37.06	45.97	25	55
4.75	0.30	7.26	7.57	0	10

Table No 4.12 Readings for Combined Gradings

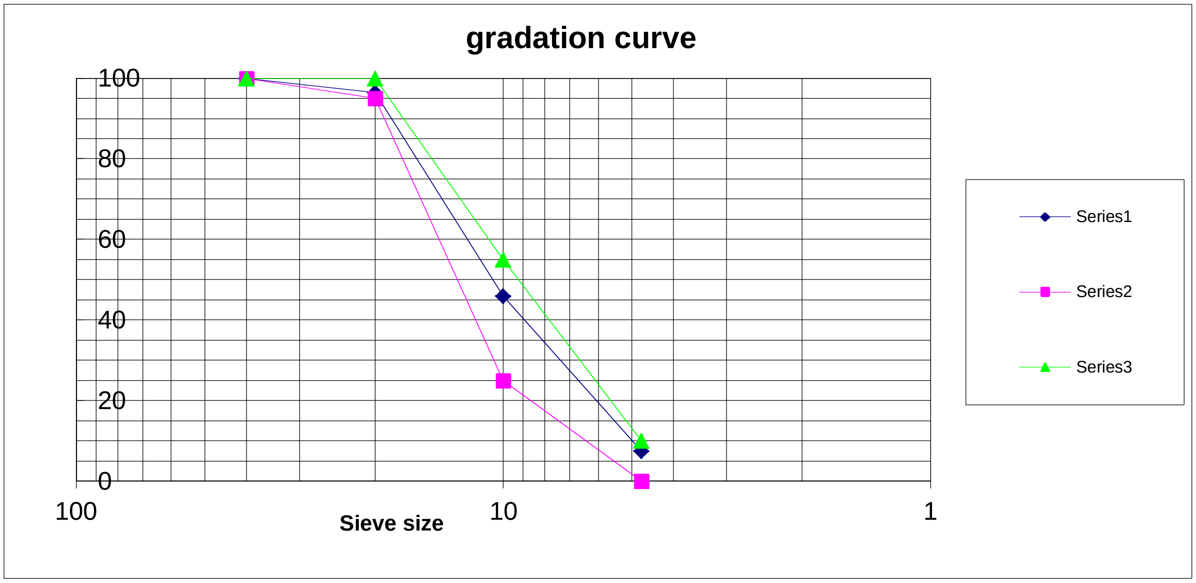

Fig 4.5 Gradation curve for Coarse aggregates

4) *Sugarcane Bagasse Ash*

The following details of Sugarcane Bagasse Ash was provided by the manufacturer :
Density - 2.52g/cm^3
Particle size - 28.9micron
Colour - Reddish grey

C. *Casting & Testing Procedure*

1) *Casting Procedure*

a) *Batching:* Batching is the process of measurement of specified quantities of cement, aggregates, water in correct proportion. It is preferred to do weigh batching and it is more accurate. In the project work, weight of the materials was taken with a digital weighing balance.
b) *Mixing:* Thorough mixing is essential for production of uniform quality of concrete. Concrete was mixed in a pan type concrete mixer. The ingredients were added in proper sequence in the mixer.The reason for proper sequencing is to homogenize the mix. Homogenization prevents the local concentration of voids and helps in dispersion of fine particles uniformly in the mix.

Bearing the above in mind, the general sequence to be followed is given below:

- Add first coarse and fine aggregates in the mixer.
- Add the cementitous materials
- Then add 50% of water.
- Add Sugarcane Bagasse Ash in the mixer.
- Start the mixer and add the remaining water slowly and uniformly.
- Increasing the mixing time may result in more uniform distribution of hydration product resulting in higher compressive strength however, over mixing should be avoided.

Fig 4.6 Concrete Mixer (Pan type)

c) *Preparation of Moulds:* The cube mould is of metal 3mm thick. Each mould is capable of being opened longitudinally to facilitate removal of the specimen and is provided with a means of keeping it closed while in use. The mean internal size of the mould is 15cm. Each mould is provided with a base plate and is coated internally with a thin film of mould oil before use, in order to prevent adhesion of concrete.

d) *Placing in Mould:* The concrete is poured in the mould and tempered properly so as not to have any voids.A standard tamping bar is used for compacting and the stroke of the bar should be distributed in an uniform manner. The tamping bar is a steel bar of 16mm diameter, 60cm long and bull pointed at the lower end. The number of strokes for each layer should not be less than 30 and the concrete mould is filled in 3 such layers. After the top layer has been compacted, the surface of the concrete should be finished level with the mould, using a trowel and covered with a glass or metal late to prevent evaporation After 24 hours, these moulds are removed and tests specimens are put in water for curing.

Fig 4.7 Placing of concrete in moulds

e) *Curing:* Poor curing practices adversely affect the desirable properties of concrete. Proper curing is essential to obtain maximum durability, especially if the concrete is exposed to severe conditions where the surface will be subjected to excessive wear, aggressive solutions or severe environmental conditions. After 24 hours of casting, the cubes were carefully removed and were immersed in water tank. Each set of cubes were then removed from the water tank on testing days i.e 3, 7, 28 days. The concrete block was not allowed to dry at any time until they have to be tested

- For experiment, total 45 cube specimens were prepared
- For each proportion of Sugarcane Bagasse Ash(SGBA) for cement replacement, 9 cubes were casted and have been tested after 3,7,28 days.

2) *Testing Procedure*

a) *Slump Cone Test:* The slump cone test is used to determine the workability of concrete mix. Slump is the measure of subsidence of the concrete field form in the mould of the shape of a frustum of cone. The decrease in the height of concrete slurry is slump. Workability is the very important property of fresh concrete. The ease in transportation, placement, compaction, filling and resistance to segregation is defined as workability. The workability depends on water/ cement ratio. It is also affected by various ingredients of concrete. Slumps can be categorized as follows:

- *True Slump:* If the concrete slump expands alround, then it is called true slump.
- *Shear Slump:* If one side of cone slides down, then it is called as shear slump.
- *Collapse Slump:* If the concrete slides as soon as cone is removed and it is difficult to measure the slump.

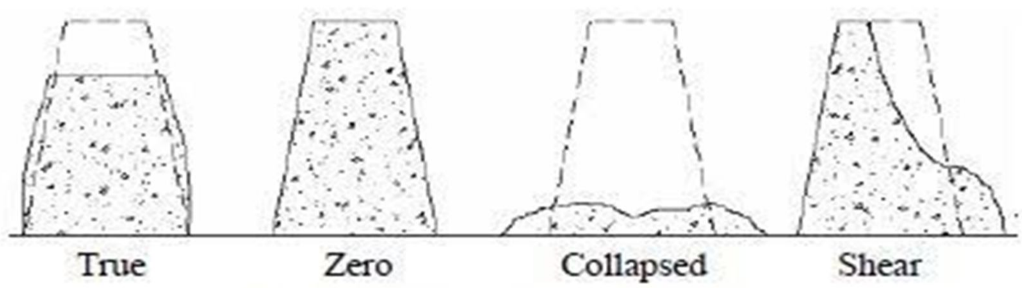

Fig 4.8 Different types of slumps

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Place the slump cone on base plate and place the first layer of concrete, approximately equal to 1/3rd of the slump cone height. Compact the layer by giving 25 blows of 16mm tamping rod, uniformly distributed over the surface. Fill the cone completely by placing remaining two layers in the same way. Level the top surface with trowel and remove the mould from the fixed base by lifting it upwards without giving any jerk. Observe the flow of concrete and measure the decrease in height of concrete. This ts the slump of concrete.

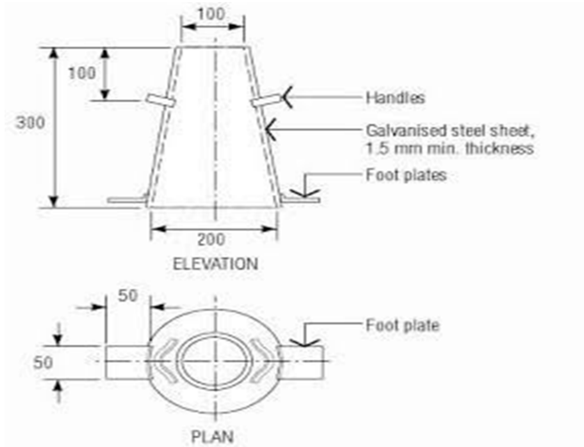

Fig 4.9 Slump Cone

b) *Compressive Strength Test:* Out of many test applied to concrete, this is the utmost important as it gives an idea about all characteristics of concrete. Cubical moulds of concrete of size 15cm x 15cm x 15cm are tested commonly for determining the compressive strength. Remove the specimen from water after specified curing time and wipe out the excess water from the surface and allow the cube to dry for some time. Take all the dimensions of the specimen to nearest 0.2mm. Measure the weight of cube to nearest 0.001g. Clean the bearing surface of the testing machine and place the specimen in the machine in such a manner that the load shall be applied to the opposite sides of the cube cast.Align the specimen centrally on the base plate of the machine and rotate the movable part gently by hand so that it touches the top surface of the specimen. Apply the load gradually without shock and continuously at the rate of 140kg/ cm^2 / minute till the specimen fails and record the maximum load and note down any unusual features in the type of failure. Minimum three specimens should be tested at each selected stage and the average value is taken. If the strength of any specimen varies by more than 15% of average strength, recasting and retesting of specimen should be done.

Fig 4.10 Compressive Testing Machine

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V. MIX DESIGN

In pursuit of the goal of obtaining concrete with certain desired performance characteristics, the selection of component materials is the first step; a process called mix proportioning by which one arrives at the right combination of the components. Mix design may be defined as the process of selection of suitable ingredients of concrete and determining their relative proportions with the object of producing concrete of certain strength and durability as economically as possible. The purpose of design is twofold. Aggregates and paste are the two essential ingredients of concrete. Workability of the mass is provided by lubricating effect of the paste and is influenced by the amount of dilution of paste. The strength of concrete is limited by the strength of paste. Also the permeability of concrete is governed by the quality and continuity of the paste. The more dilute the paste, the greater the spacing between the cement particles and thus weaker will be the ultimate paste structure. Four variables to be considered in connection with specifying concrete mixes are-

1) Water cement ratio.
2) Cement content or cement aggregate ratio.
3) Gradation of aggregates.
4) Consistency.

Mix design was prepared using IS 10262: 2009. This standard provides the guidelines for proportion.

A. Test Data for Materials

Various tests were conducted on materials, and the following observations were recorded:

1. Cement- Bharti OPC 53 Grade
2. Specific gravity of cement - 3.15
3. Slump required- 50-100mm
4. Specific gravity-

Coarse aggregates (20mm) - 2.86
Coarse aggregates (10mm) – 2.80
Fine aggregates- 2.64

5. Water absorption-

Coarse aggregate (20mm) – 1.90%
Coarse aggregate (10mm) – 1.92%
Fine aggregates- 3.70%

6. Moisture content-

Coarse aggregates (20mm) – 1.00%
Coarse aggregates (10mm) – 1.01%
Fine aggregates – 1.88%

B. Target Strength for Mix Proportioning

$\mathbf{f'_{ck} = f_{ck} + 1.65s}$

where f'_{ck} = target average compressive strength at 28 days
f_{ck} = characteristic compressive strength at 28 days
s = standard deviation

Grade of concrete	Standard deviation(s) N/mm^2
M10, M15	3.5
M20, M25	4.0
M30, M35, M40, M45, M50	5.0

Table No. 5.1 : Table for standard deviation

Target Strength = 25 + 1.65 x 4 = 31.6 N/mm^2
Adopt water cement ratio as 0.45
Maximum water content for 20mm aggregates= 186 l
Cement content – 400 kg/m^3
Greater than minimum content therefore O.K.
Proportion of volume of coarse aggregate and fine aggregate is 0.62 : 0.38

The Mix calculation per unit volume of concrete shall be as follows.

Volume of concrete = $1m^3$

Volume of cement = (400/3.15) x (1/1000)
= $0.127m^3$

Volume of water = (180/1) x (1/1000)
= $0.18m^3$

Volume of all in aggregates = 1-(0.127+0.180)
= $0.693m^3$

Mass of coarse aggregates = 0.693x0.62x2.83x1000
= 1145.21kg

Mass of fine aggregates = 0.693x0.38x2.64x1000
= 710.70kg

The following conclusions are made from the mix design:

	Wt./m^3		Wt./Bag		Volume/Bag	
Cement Content	400	Kg/m^3	50	kg	35.00	Lt.
Fine Aggregate (Natural Sand)	710.70	Kg/m^3	88.84	kg	59.62	Lt.
Coarse Aggregates (20mm)	692.94	Kg/m^3	86.62	kg	66.63	Lt.
Coarse Aggregates (10mm)	452.27	Kg/m^3	56.53	kg	38.46	Lt.
Admixture	0.00	Kg/m^3	0.000	kg	0.000	Lt.
Water	180.00	Lit./m^3	22.50	Lt.	22.50	Lt.

Table No 5.2 Design Mix Proportion

VI. RESULTS & DISCUSSION

A. Test Results

The observation from slump cone test and compressive strength have been analysed t o study SGBA on basis of economical and strengthening aspects It can be seen that there is considerable increase in workability and compressive strength due to partial replacement of cement by Sugarcane Bagasse Ash in concrete. The analysis of the observations are discussed in the subsequent aspect.

1) *Workability Analysis:* The ease in transportation, placement, compaction, filling and resistance to segregation is defined as workability. The slump cone test is used to determine the workability of concrete mix. Slump is the measure of subsidence of the concrete field form in the mould of the shape of a frustum of cone. The decrease in the height of concrete slurry is slump

Amount of replacement of cement by SGBA	Initial height (mm)	Final height (mm)	Slump (mm)	Type of slump
0%	300	230	70	Low
5%	300	225	75	Low
10%	300	220	80	Medium
15%	300	210	90	Medium
20%	300	210	90	Medium

Table No 6.1 Results of Slump Cone Test

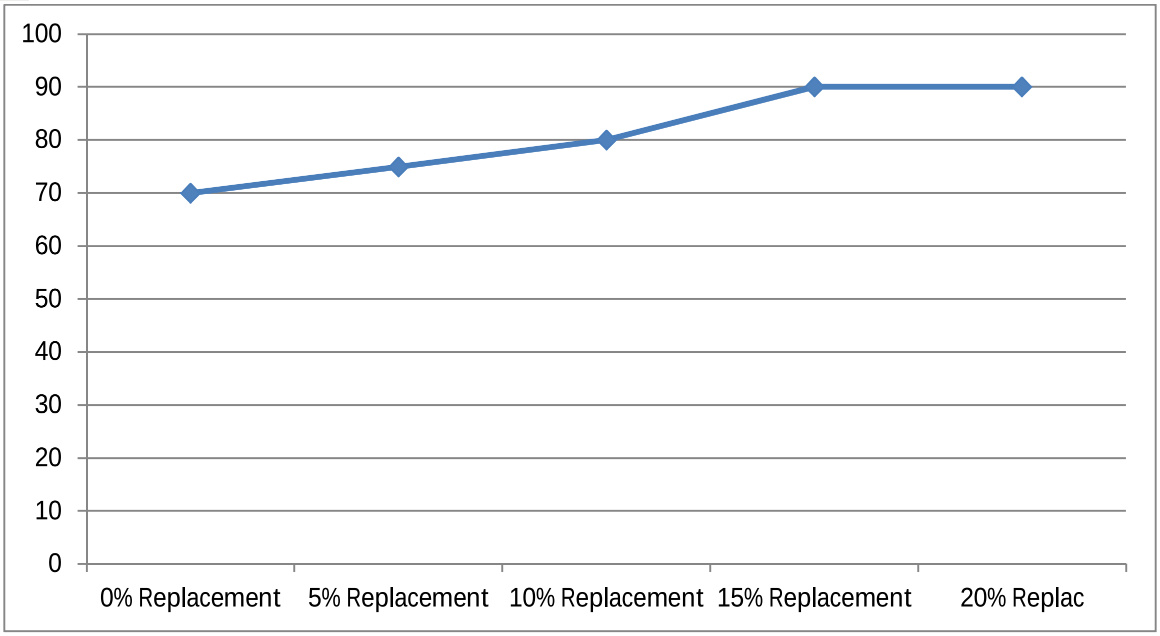

Fig 6.1 Results of Slump Cone Test

- *Discussion:* It can be observed from the results that, use of Sugarcane Bagasse Ash in concrete as partial replacement of cement improves tha workability of concrete. The workability of nominal mix with 0% SGBA has low slump whereas use of SGBA increased the slump value upto 15% replacement.

2) *Compressive Strength Analysis:* Compressive strength test is the most important test as it gives an idea about all characteristics of concrete. Cubical moulds of concrete of size 15cm x 15cm x 15cm were tested

Loading Area of cube – 150mm x 150mm

a) *Compressive Strength of cubes at 3 days*

Amount of replacement of cement by SGBA	Weight			Load P (kN)		
	1	2	3	1	2	3
0%	8.268	8.298	8.286	298	310	305
5%	8.012	7.986	8.025	299	298	307
10%	8.108	8.089	8.127	321	322	317
15%	8.111	8.108	8.146	324	320	328
20%	8.028	8.067	8.069	294	303	305

Table No 6.2 Load values for cube at 3 days

Amount of replacement of cement by SGBA	Compressive Strength P / A (MPa)			Average
0%	13.28	13.78	13.56	13.54
5%	13.31	13.25	13.63	13.40
10%	14.25	14.32	14.09	14.22
15%	14.38	14.22	14.59	14.40
20%	13.05	13.48	13.54	13.36

Table No 6.3 Compressive Strength of cubes at 3 days

b) *Compressive Strength of cubes at 7 days*

Amount of replacement of cement by SGBA	Weight			Load P (kN)		
	1	2	3	1	2	3
0%	8.292	8.318	8.306	560	590	580
5%	8.146	8.134	8.168	555	542	544
10%	8.210	8.113	8.127	543	544	546
15%	8.180	8.210	8.222	553	546	559
20%	8.157	8.185	8.204	493	452	501

Table No 6.4 Load values for cube at 7 days

Amount of replacement of cement by SGBA	Compressive Strength P / A (MPa)			Average
0%	24.89	26.22	25.78	25.63
5%	24.67	24.08	23.69	24.15
10%	24.12	24.17	24.56	24.28
15%	24.56	24.28	24.87	24.57
20%	21.91	20.09	22.31	22.10

Table No 6.5 Compressive Strength of cubes at 7 days

c) *Compressive Strength of cubes at 28 days*

Amount of replacement of cement by SGBA	Weight			Load P (kN)		
	1	2	3	1	2	3
0%	8.308	8.294	8.314	763	754	775
5%	8.192	8.178	8.210	765	770	781
10%	8.327	8.334	8.340	768	774	776
15%	8.305	8.255	8.235	781	772	786
20%	8.286	8.310	8.280	717	721	714

Table No 6.6 Load values for cube at 28 days

Amount of replacement of cement by SGBA	Compressive Strength P / A (MPa)			Average
0%	33.91	33.51	34.44	33.96
5%	34.01	34.23	34.72	34.32
10%	34.13	34.39	34.93	34.48
15%	34.72	34.33	34.97	34.67
20%	31.91	32.04	31.73	31.90

Table No 6.7 Compressive Strength of cubes at 28 days

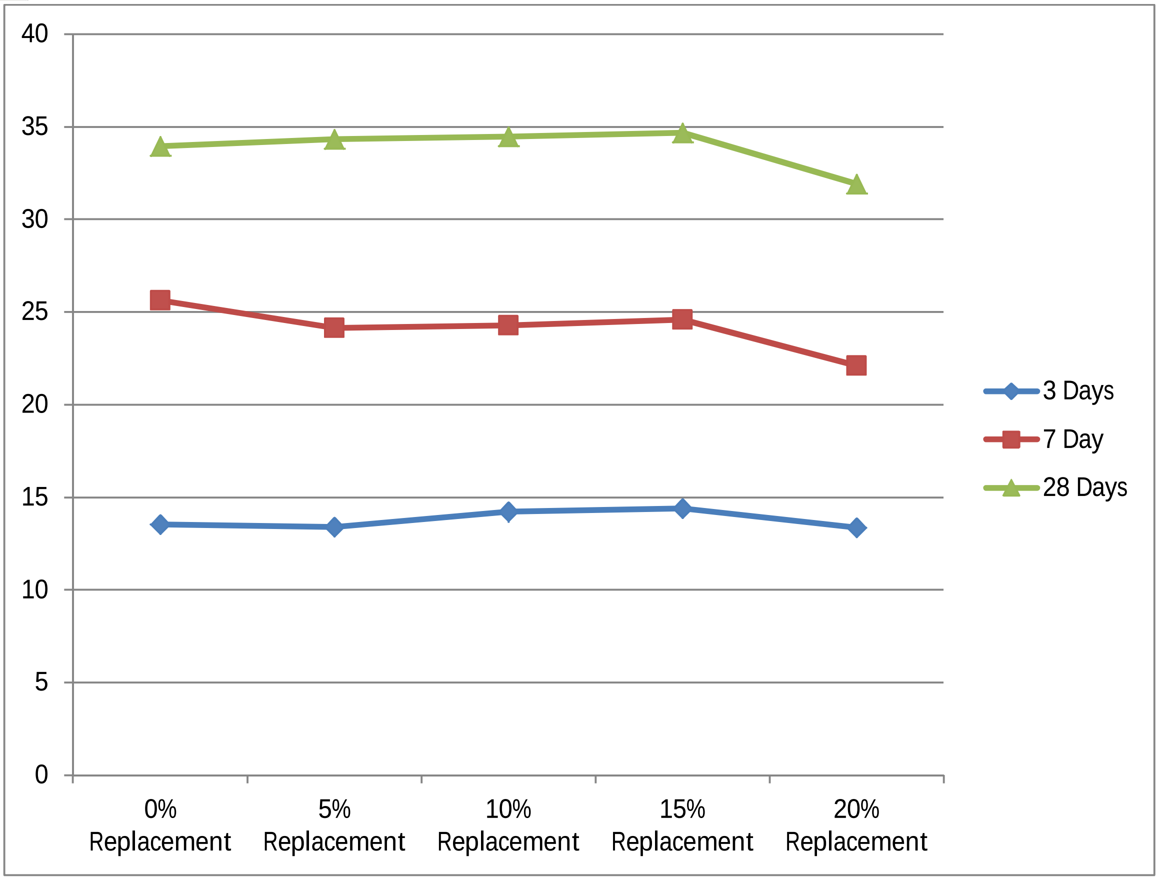

Fig 6.2 Results of Compressive Strength Test

- *Discussion:* It can be seen that the use of SGBA as partial replacement of cement increases the compressive strength of concrete by a significant amount. The 28 days strength of concrete can be increased upto 15% of replacement of cement after which there is a fall in compressive strength with further increase in SGBA content. Thus, the optimum content of SGBA is 15%

B. Cost Comparision Analysis

In order to find if the concrete is economical when Sugarcane Bagasse Ash is added as a partial replacement, cost comparision of normal concrete and concrete with 15% replacement of cement by SGBA was carried out. It can be seen that use of SGBA makes the concrete economical.

1) Normal Concrete (M25)

For 1 m^3 of concrete with ratio 1 : 1.78 : 2.86.

Dry volume of concrete = 1.54 m^3

Quantity of cement = 1.54 / (1+1.78+2.86)

= 0.273m^3

No of cement bags = 0.273 / 0.035 = 7.8 – 8 bags

Quantity of Fine Aggregates = 710.7 kg

Quantity of Coarse Aggregates = 1145.21 kg

Weight of 1 m^3 concrete = 1 x 1 x2500 = 2500kg

Material	Quantity	Rate	Unit	Amount
Cement	8	350	Bag	2800
Fine Aggregates	711	3	kg	2133
Coarse Aggregates	1146	2	kg	2292

Table No 6.7 Cost Analysis for normal concrete

Total amount = 7725/-

2) Concrete with 15% SGBA replacement for cement

For 1 m^3 of concrete with ratio 1 : 1.78 : 2.86.

Dry volume of concrete = 1.54 m^3

Quantity of cement = 1.54 / (1+1.78+2.86)
= 0.273m^3 – 15%
= 0.233 m^3

No of cement bags = 0.233 / 0.035 = 6.65 – 7 bags

Quantity of SGBA = 0.041m^3 = 103.32 kg

Quantity of Fine Aggregates = 710.7 kg

Quantity of Coarse Aggregates = 1145.21 kg

Weight of 1 m^3 concrete = 1 x 1 x2500 = 2500kg

Material	Quantity	Rate	Unit	Amount
Cement	7	350	Bag	2450
Fine Aggregates	711	3	kg	2133
Coarse Aggregates	1146	2	kg	2292
Sugarcane Bagasse Ash	103.32	50	Tonne	5

Table No 6.8 Cost Analysis for concrete with 15% SGBA replacement for cement

Total amount = 6880/-

VII. CONCLUSION

From the test results, the following conclusions can be drawn:

1) According to the tests performed, it is observed that there is remarkable increment in the properties of concrete on replacement of cement by Sugarcane Bagasse Ash.
2) When the Sugarcane Bagasse Ash was added to concrete by replacing cement upto 15% in M25 concrete, it is found that there is considerable increase in workability by 28.5% and increase in compressive strength by 3.07% , when compared with plain cement concrete of M 25 grade.
3) It can be concluded that the optimum amount of SGBA replacement for cement for M25 Concrete is 15%.
4) When the cost comparision of plain cement concrete of M25 grade and concrete with 15% replacement of cement by SGBA, it is found that there is a significant reduction in cost by 12.28% for one cubic metre of concrete.

VIII. FUTURE SCOPE

A. Scope for Future Study

1) Further studies can be done on flexural strength, permeability of concrete for SGBA replacement.
2) Future study on the effect of SGBA replacement can be done to use it in light weight concrete.
3) The effect of SGBA replacement for coarse aggregates in concrete can be studied to check the performance of concrete.