A STUDY ON M-20 CONCRETE WITH PARTIAL REPLACEMENT OF STONE DUST AND SUGARCANE BAGASSE ASH

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Abstract- The construction industry is the largest consumer of natural resources which led to depletion of good quality natural sand (fine aggregate). This situation compels us to explore alternative materials and sugarcane bagasse ash, a waste industrial by product is one such material identified foe use as a replacement of natural sand and stone dust. Sugarcane bagasse ash (SCBA) generated from sugar mills is fibrous waste-product usually delivered to landfill for disposal. Using of sugarcane bagasse ash in concrete is an interesting possibility for economy and conservation of natural resources. This research work examines the possibility of using sugarcane bagasse ash as replacement of fine aggregate (natural sand, stone dust) in concrete. We partially replaced 10%, 20%, and 30% of natural sand, 20%, 40% and 70% stone dust combination of equivalent weight with SCBA. We compared compressive strength, tensile strength and flexural strength with those of concrete made with natural fine aggregate. We replaced natural sand by stone dust, chemical properties of SCBA. The test result indicate that it is possible to manufacture concrete containing sugarcane bagasse ash and stone dust with characteristics similar to those of natural river sand aggregate concrete, provided that the percentage of sugarcane bagasse ash as fine aggregate is limited to 30%+70% (equivalent weight of natural sand and stone dust) and 42.30 percent.

Keywords-Sugarcane bagasse ash, fine aggregate(natural sand, stone dust) replacement.

Introduction:

The Conventional concrete is a mixture of cement, natural sand and coarse aggregate. Properties of aggregate affect the durability and performance of concrete and the fine aggregate is an essential component of concrete. The most commonly used fine aggregate is natural river or pit sand. Fine and coarse aggregate constitute about 75% of total volume. It is therefore, important to obtain right type and good quality aggregate at site.

The demand of natural sand is quite high in the developing countries due to the rapid infrastructural growth. In this situation developing country like India is facing shortage of good quality natural sand. In India natural sand deposits are being depleted and causing serious threat to environment as well as the society. Increasing extraction of natural sand from river beds causes many problems such as loosing water retaining sand strata, deepening of the course and causing bank slides, loss of vegetation on the bank of rivers, exposing the intake well of water supply scheme, disturbance to the aquatic life and affecting agriculture doe to lowering of underground water table. In past decade variable cost of natural sand used as fine aggregate in concrete has increase the cost of construction many folds. In this situation research began for expensive and easily available alternative material to natural sand.

Some alternative materials have already been used as a part of natural sand. Fly Ash, slag, Lime stone and siliceous stone powder were used in concrete mixtures a partial replacement of natural sand. However, scarcity required quality is a major limitation in some of the above materials. Now a day's sustainable infrastructural growth demands the alternatives material that should satisfy technical requisites of fine aggregate and at the same time it should be available abundantly.

The Bagasse ash imparts high early strength to concrete and also reduce the permeability of concrete. The Silica present in the Bagasse ash react with component of cement during hydration and imparts additional properties such as chloride resistance, corrosion resistance etc. Therefore use of Bagasse Ash in concrete not only reduce the environmental pollution but also enhance the properties of concrete and also reduce the cost. It makes concrete more durable. Bagasse is the fibrous residue of sugarcane after crushing and extraction of

juice. In sugarcane bagasse it made up of water (about *50*%), fiber (above *48*%) and also some small amount of soluble solids. Mostly, Bagasse produced is burnt for energy needed for sugar processing.
Here we will try to find out the feasibility of sugarcane bagasse ash alternative for the fine aggregate and compare the strength of normal mix with the sugarcane bagasse ash mix concrete.
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NEED AND ADVANTAGES

Need of sugarcane bagasse ash (SCBA) usage:

1. Each ton of cement produces around about one ton of $CO_2$and cement industry is answerable for the release of about 5% of CO_2 worldwide.
2. Has an effective impact in the economical point of view.
3. When used as replacement for cement in concrete, it reduces the problem associated with their clearance.
4. Decrease in the release of greenhouse gases.

Advantages of sugarcane bagasse ash:

Land pollution

Predominantly the ash disposal problem from sugar industry is reduced since it is usually disposed off in open land area.

Economy

Due to the non-availability of fine aggregate, the worth of natural sand which is used as fine aggregate has increased by three wrinkles in the past few months. Hence the overall price involved in the construction is reduced.

Future demand

Partial replacement will also help in meeting the increasing demand for fine aggregate in future.

SCOPE OF WORK

Laboratory tests on cement, fine aggregate, coarse aggregate, bagasse ash, water. Whatever may be the type of concrete being used, it is important to mix design of the concrete? The same is the case with the industrial waste based concrete or bagasse ash replacement. The major work involved is getting the appropriate mix proportions. In the present work, the concrete mixes with partial replacement of stone dust with bagasse ash were developed using OPC 43 grade cement. A simple mix design procedure is adopted to arrive at the mix proportions. After getting some trail mix, cubes of dimensions 150mm x 150mm x 150 mm was casted and cured in the curing tank. Compressive strength, Split tensile strength and Flexural strength of concrete were conducted to know the strength properties of the mixes. Initially, a sample mix design was followed and modifications were made accordingly while arriving at the trail mixes to get optimized mix which satisfies both fresh, hardened properties and the economy. Finally, a simple mix design is proposed.

Material Details

The materials used in the investigations are

Cement

The cement is used as a binding material. In this study, the cement used as OPC 43 grade cement available from ACC Cement Company and it conforming as per IS 12269-1987.

Fine Aggregate

Aggregates for the concrete were obtained from approved suppliers conforming to the specifications of IS 383 - 1970 and were chemically inactive(inert), spotless and robust. The fine aggregate was tested as per the limits which is specified in IS: 2386 (Part-3) :1963. In this study, fine aggregate having a fineness modulus of 2.46 which is carried out by using sieve analysis and it confirming to zone 2.

Coarse Aggregate

Coarse aggregates will be machine-crushed one of black trap or equivalent black tough stone and shall be stiff, robust, dense, durable, spotless or procured from quarries approved by the consultant. In this study, crushed aggregate of size 20 mm in angular shape is used and it conforming to IS 383.

Sugarcane Bagasse Ash

It comprises high volume of sio2. Therefore, it is classified as a good pozzolanic material. SCBA can be used as aadd-on for cementitious material due to its pozzolanic property. Sugarcane bagasse ash was collected M/s K M Sugar Mills Private Limited No.11, Moti Bhawan, Collectorganj, Kanpur 224001, Uttar Pradesh, India.
SCBA contains approximately 25% of hemicellulose, 25% of lignin and 50% of cellulose. Each tons of sugarcane generates approximately 26% of bagasse (at 50% moisture content) and 0.62% of residual ash. The residue after combustion gives a chemical composition dominated by silicon dioxide. The Specific gravity of SCBA was found to be 2.17. Chemical properties of SCBA are shown in Table-1.

Table – 1

Sno.	Component t	Mass%
1	Silica (SiO_2)	71
2	Alumina (Al_2O_3)	1.9
3	Ferric Oxide (Fe_2O_3)	7.8
4	Calcium Oxide (CaO)	3.4
5	Magnesium Oxide (MgO)	0.3
6	Potassium Oxide (K_2O)	8.2
7	Sodium Oxide (Na_2O)	3.4
8	Phosphorus Pentoxide (P_2O_5)	-
9	Manganese Oxide (MnO)	0.2

Water

Good potable water available in the site is used for the construction purpose which conforming to the requirements of water for concreting and curing as per IS: 456-2009.

METHODOLOGY

Firstly we studied the material and data required for the research, we estimated the quantity of material needed for the research and afterward started searching for the locally available materials in this process we get cement, coarse aggregate and fine aggregate but sugarcane bagasse has to be retrieved from Kanpur sugar mill viz M/S K.M. Sugar mill. We collected the sugarcane bagasse ash and its chemical properties data from them and started our work own our project:-

1. Firstly we tested the cement by IS method which includes:- Fineness test, Consistency test, Setting test (initial and final), Compressive strength test, We used the cement of OPC 43 grade cement.
2. Secondly we have done sieve analysis test of fine aggregate and coarse aggregate according to IS 383-1970 and accordingly grading of coarse and fine aggregate.
3. Thirdly we determined the specific gravity, apparent specific gravity and water absorption of stone dust, coarse aggregate and fine aggregate.
   Fineness modulus test was also done of fine aggregate used in the research.
4. Fourthly we calculate the specific gravity, apparent specific gravity and water absorption, fineness modulus and grading of the SCBA is done.
5. After it we have design concrete of M-20 grade by SP 23: 1982 by replacing different amount of natural sand and sand dust with SCBA and afterward we calculated and compared compressive strength of these replaced material concrete at 7 days and 28 days.
6. In this project, casting and curing of specimen were done using potable water free from deleterious materials.

Each test was conducted on cubes, beams and cylinders were prepared as per IS 456:2000, BS 1881: Part 108:1982

Based upon the quantities of ingredient of the mixes, quantity of sugarcane bagasse ash for 0, 10, 20, and 30 percent replacement by weight of fine aggregate (natural sand and stone dust) were estimated. The water cement ratios used were 0.50, 0.52, and 0.55. the cast concrete specimen were cured under condition in the laboratory and compressive strength test, flexural strength test and split tensile test were done in the hardened state of the concrete after 7 days and 28 days.

Some terminologies which we will use are as follow:-
N.S = Natural sand **A**= weight of natural sand after its maximum replacement with stone dust without loss in compressive strength.
S.D = stone dust **B**= weight of stone dust which can be replaced maximum with natural sand without losing its compressive strength. **SCBA** = sugarcane bagasse a

EXPERIMENTAL WORK

Specific Gravity of SCBA- Specific gravity of SCBA is calculated by density bottle method as per IS 2386 part III.
In this research work three different samples of SCBA is taken to find out the specific gravity and we got the following result.

Specific gravity of SCBA is calculated by density bottle method as per IS 2386 part III-

S.no.	Content of test	sample	sample	sample
		I	II	III
1	Weight of density bottle w_1	16.94	16.94	16.94
2	Weight of sample SCBA + wt. of density bottle w_2	31.60	32.50	30.50
3	Wt. of density bottle + wt. of SCBA +wt. of water W_3	75.62	76.72	74.10
4	Wt. of density bottle +water completely full W_4	69.99	71.20	68.48
5	Specific gravity of sugarcane bagasse ash $G = W_d/\{W_d- (W_3-W_4)\}$	1.63	1.65	1.67
6	Average of specific gravity of SCBA	(1.63+1.65+1.67)/3 =1.65		
7	Specific gravity of SCBA at 27^0 c	1.65		

Specific gravity of sugarcane bagasse ash

Fineness modulus of sugarcane bagasse ash as per IS 2386 (part I)-1963:-

Weight of sample of SCBA = 200 grams

S.no.	Sieve size (mm)	Weight of retained(grams)	Cumulative retained	%of cumulative retained= [cumulative retained /weight of sample]×100
1	4.75	-	-	-
2	2.36	-	-	0
3	1.18	5	5	2.5
4	600	42	47	23.5
5	300	49	96	48.00

6	150	57	153	76.5
7	pan	47	sum	150.50

Fineness modulus of SCBA

Fineness modulus of SCBA = sum of percentage of cumulative retained / 100

= 150.50 /100 = **1.505**

Compacting factor test for concrete:-

Compacting factor of fresh concrete is done to determine the workability of fresh concrete by compacting factor test as per IS 1199-1959.

The ratio of the weight of partially compacted concrete to the weight of the concrete when fully compacted in the same mould. The Compacting Factor Apparatus is used to determine the compaction factor of concrete with low, medium and high workability.

Compacting factor of concrete= weight of partially compacted concrete/ weight of fully compacted concrete

Apparatus required:-compacting factor apparatus, cylinder, weighing machine etc.

S.no.	Description	weight
1	Proportion of sample used by weight M-20	1:1.56:3.32
2	Water cement ratio	0.50
3	Weight of cylinder W_1	21.50kg
4	Weight of cylinder + concrete filling through standard W_2	32.85kg
5	Weight of partially compacted concrete $W_3= W_2-W_1$	11.350kg
6	Weight of fully compacted concrete + cylinder W_4	34.80kg
7	Weight of fully compacted concrete $W_5= W_4-W_1$	13.30kg

Observation compaction factor of concrete as per replacement of fine aggregate with replacement of SCBA

Hence compacting factor of concrete = W_3/ W_5
= 11.35/3.30=0.85

Results are more accurate when done by slump test.

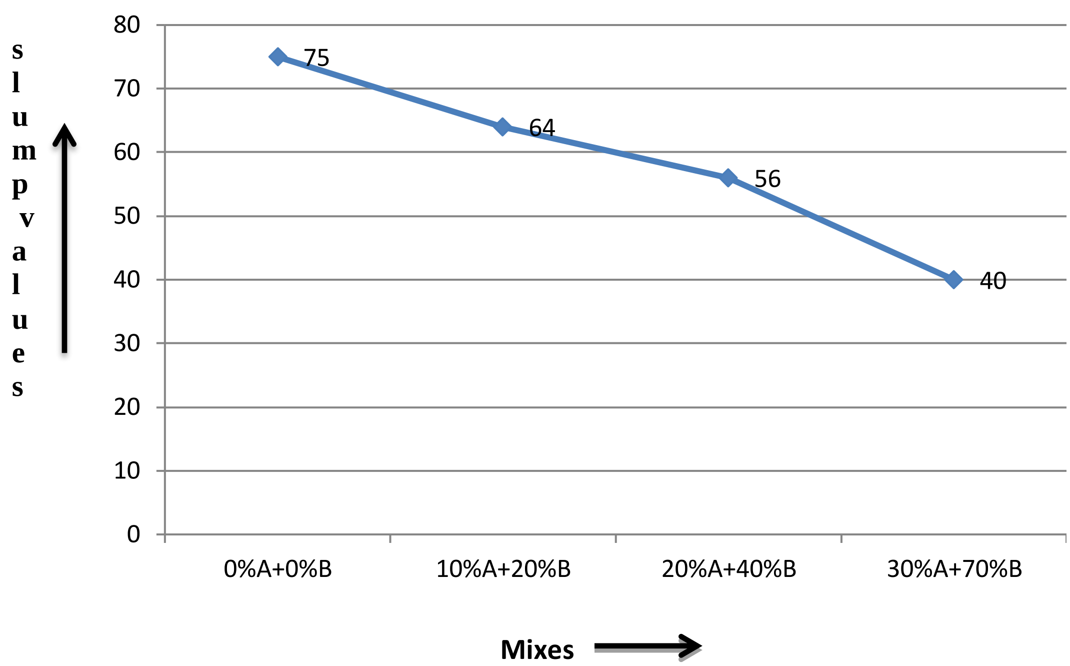
Workability of concrete by slump test method:-

The concrete slump test measure the consistency of fresh concrete before it sets. It is performed to check the workability of freshly made concrete, and thereof the ease with which the concrete flows. It can also be used as an indicator of an improperly mixed batch. Slump is used to determine the workability of fresh concrete. Slump test as per IS 1199-1959 is followed:-

Apparatus required:-Slump cone, tempering rod, non-porous base plate measuring scale etc.

S.no.	particulate	Slump value (mm)
1	0%A+0%B	75
2	10%A+20%B	64
3	20%A+40%B	56
4	30%A+70%B	40

Slump test value as per replacement of fine aggregate with SCBA



Compressive strength test of concrete after replacement of fine aggregate with stone dust:-
Compressive strength of concrete depends on many factors such as water-cement ratio, cement strength, quality of control during the production of concrete etc.

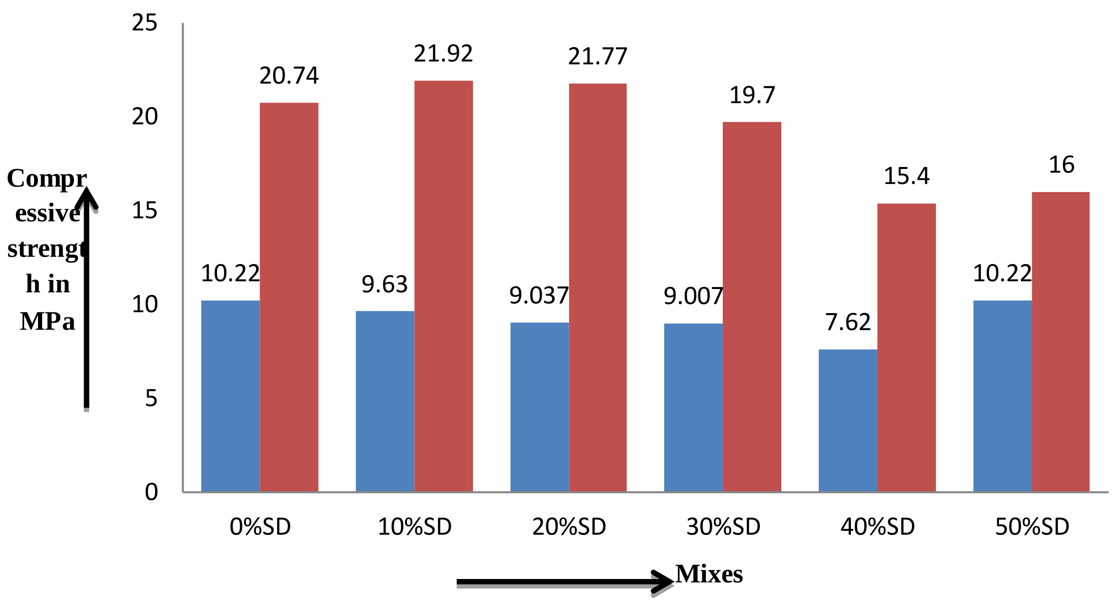
Compressive strength can be calculated by following formula

Compressive strength= Average load of concrete cube failure / area of concrete cube

Compressive strength was performed on a cube specimen of size 150mm x150 mm x 150 mm. Compressive strength for concrete with replacement of natural sand replaced with stone dust 0%,10%,20%,30%,40%,50% at the age of 7 days and 28 days are shown in below.

S.no.	Mix M-20	Avg. compressive strength At 7 days (N/mm^2)	Avg. compressive strength At 28 days (N/mm^2)
1	Standard control	10.22	20.74
2	10%SD	9.63	21.92
3	20%SD	9.037	21.77
4	30%SD	9.007	19..7
5	40%SD	7.62	15.40
6	50%SD	10.22	16

Compressive strength of concrete with replacement of NS and SD according tomix proportion



Comparison of compressive strength after 7 days and 28 days for different % of stone dust replacement

<u>Result:-</u>the result shows that the maximum replacement of 30% by weight of natural sand with stone dust.

Compressive strength test of SCBA mixed concrete:-

As from above result of comparison of compressive strength for 7 days and 28 days for different % of stone dust replacement we found that more than 30% of stone dust replacement is not showing any increase in strength of concrete, we will use 30% as maximum strength for stone dust in concrete.

So now we will replace natural dust and stone dust combination with SCBA up to 30% of stone dust weight i.e.175.5 kg.

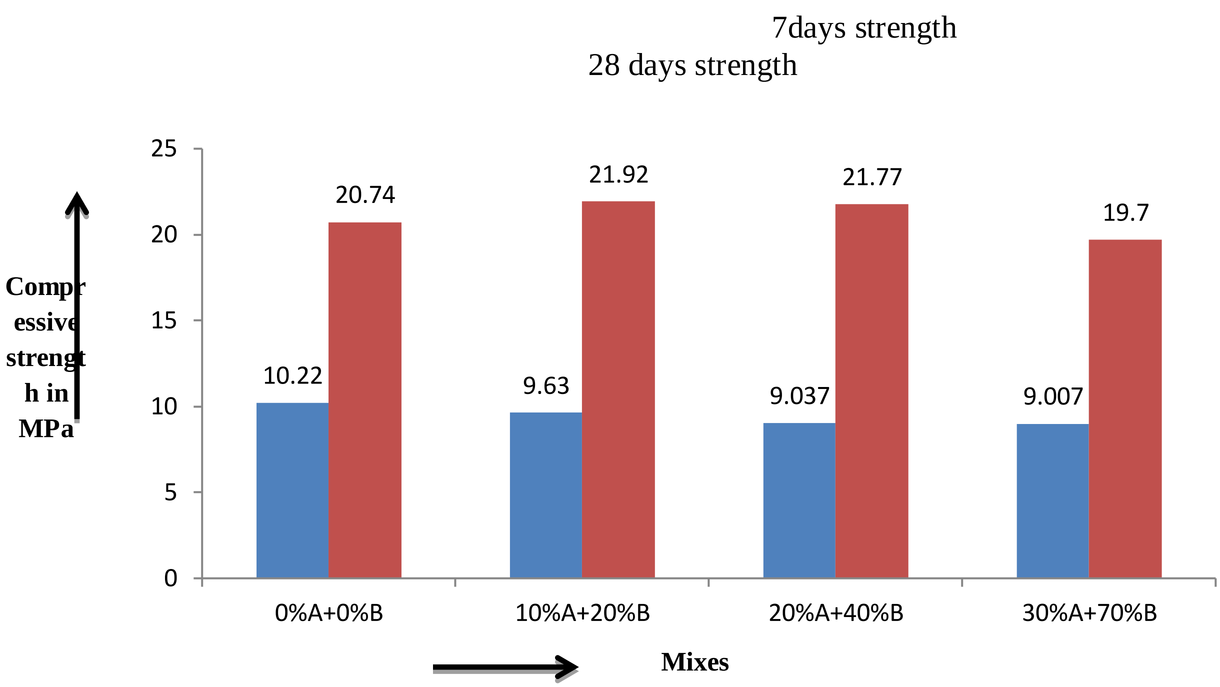
If A = weight of natural sand after its maximum replacement with stone dust without loss in compressive strength , B= weight of stone dust which can be replaced maximum with natural sand without losing its compressive strength.

Therefore we will take A = 409.5 kg and B= 175.5 kg (refer to table no. 29)

In below x% A +y% B means x percent of A plus y percent of B.

S.no.	Replacement of NS(A)+SD(B)	Average compressive strength at 7 days(N/mm^2)	Average compressive strength at 28 days(N/mm^2)
1	0%A+0%B	10.22	20.74
2	10%A+20%B	9.63	21.92
3	20%A+40%B	9.037	21.77
4	30%A+70%B	9.007	19.70

Compressive strength of concrete after replacement of fine aggregate with SCBA according to mix proportion



Comparison of compressive strength after 7 and 28 days for different % of SCBA replacement

Result:- Compressive strength continued to increase as the curing period increased. The control mix had a compressive strength of 21.925 MPa at 28 days. Addition of increasing amount of SCBA generally decreased the strength at a given age due to greater porosity of the material as indicated by high water requirement. The greatest compressive strength was achieved when the mixture contained SCBA of 10%+20% of fine aggregate (natural sand and stone dust) replacement with the water cement ratio of 0.52. Improvement stemmed from the void filling ability of the smaller particles and was more pronounced at lower w/c ratio. On the basis of above result maximum replaced fine aggregate at 30%+70%.

DISCUSSION AND CONCLUSION

The results reveals that SCBA as partial replacement of fine aggregate in concrete has resulted in significantly higher compressive strength compared to that of concrete without SCBA. 20% of SCBA decreases the compressive strength to a value which is near to the control concrete. This may be due to the fact the quantity of SCBA present in the mix is higher than the amount required to the combine with the liberated lime during the process of hydration thus leading to the access silica leaching out and causing deficiency in the satrength by R. Srinivasan and K. Sathiya (2010) [22]. Also, it may be due to the defects generated in dispersion of SCBA that causes weak zone.

From the experiment and analysis of result of finding in the research work, we established the following facts. Due to non-availability of natural sand at reasonable cost as finer aggregate in cement concrete for various reasons, search for alternative materials like SCBA qualify itself as a suitable substitute for sand at low cost. Fineness modulus of natural sand and SCBA were 2.79 and 1.42 respectively. SCBA belongs to zone IV as per IS code. Water requirement increased as the percentage of SCBNA increased. Unit weight of the mixture produced decreased as the percentage of SCBA increased. Workability of mixture depends primarily on the percentage of SCBA used. This is consistence with the porous nature of SCBA particles whereby a greater surface area and larger average particle size serve to enhance absorption of water. Only the slump properties of the control and 10% of SCBA were acceptable, while the other mixtures were compromised by a decrease in slump relative to the amount of SCBA present.

The compressive strength results represent that the strength of the mixes with 10% and 20% bagasse ash increased at later days (28 days) as compared to 7 days that may be due to pozzolanic properties of bagasse ash. The greatest compressive strength, split tensile strength and flexural strength were achieved when the mixture contained 10% of fine aggregate replacement of SCBA with the water cement ratio of 0.43.
Hence we concluded that the fine aggregate up to 10% can be effectively replaced with sugarcane bagasse ash without considerable loss of workability and strength.

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