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The Effect of Utilization of Sugarcane Bagasse Ash as Partial Substitution of Cement with Silica Fume Added Materials on the Compressive Strength of Concrete

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Abstract: *Concrete is a very important material used in the construction sector. In this study, the concrete was made using bagasse ash added, which is known to contain high levels of silicates and pozzolans. In addition, to produce better quality concrete, silica fume concrete additive is used as an additional chemical for concrete mixtures. Silica fume itself is used to make better quality concrete. This study used bagasse ash for 3%, 6%, and 9% of the weight of cement, and silica fume concrete additive was used for 15% of the weight of cement. The dimension of the test object used is a cylinder measuring 15 x 30 cm with a concrete age of 14 and 28 days, for a slump value of 60-180 cm. Planning of concrete mix using SNI 03-2834-2000 method. The test carried out is the compressive strength test of concrete. Each variation made 3 specimens, so the total number of specimens was 24 test specimens. The results of the normal concrete research obtained a compressive strength of 21.08 Mpa, at the age of 14 and 30.11 Mpa at the age of 28 days. while the concrete which was mixed with 3% bagasse ash and 15% silica fume was 22.08 MPa at the age of 14 days and 33.46 MPa at the age of 28 days. than 6% bagasse ash concrete and 15% silica fume amounted to 26.1 Mpa at the age of 14 days and 35.13 Mpa at the age of 28 days. and concrete with a mixture of 9% bagasse ash and 15% silica fume was 29.11 MPa at the age of 14 days and 37.14 MPa at the age of 28 days. Optimum compressive strength results occur in concrete with a mixture of 9% bagasse ash and 15% silica fume, which is 38.09% MPa.*

Keywords: *compressive strength of concrete; utilization of sugarcane bagasse ash; partial substitution; cement; silica fume*

I. Introduction

Nowadays the development of construction in Indonesia is increasing. According to an article from the Ministry of Industry of the Republic of Indonesia due to an increase in the construction of concrete construction, the demand for cement has also increased, even cement consumption reached 48 million tons in 2011 or an increase of 17.7% from 2010. The high demand for cement is not accompanied by high cement production. balanced so that Indonesia still uses imported cement to meet development needs in Indonesia. Answering this need, it is necessary to remember an alternative cement substitute in concrete construction to reduce cement (Rompas et al., 2013).

Concrete is a mixture of cement, fine aggregate, coarse aggregate, water, and admixture if needed. Types and types of concrete according to the forming material are normal, reinforced, prestressed, precast, pre-stressed, lightweight concrete, unreinforced concrete, fiber concrete, and others. The addition of other materials will distinguish the type of concrete. Concrete consists of filler (filler) and binder (binder), a filler is a filler material consisting of coarse aggregate derived from crushed stone and fine aggregate in the form of sand, and a binder is a filler binding material so that it becomes a solid unit, this binder is a mixture of between cement and water. The process of forming concrete starts from the hydration process between cement and water which produces the Water Cement Factor (FAS), if FAS is added with fine aggregate then the mixture is called mortar, and if the mortar mixture is added coarse aggregate it will become concrete. Admixture is an additional material needed to add value to the concrete itself, such as to accelerate the hardening of concrete or to connect one concrete to another (Handoko, WF, Zulkarnain, 2020).

The use of industrial waste is a good alternative, therefore in this study, we tried to add bagasse ash and studied the compressive strength of concrete. Bagasse ash (AAT) is the residue from the combustion of bagasse. Bagasse itself is a waste product from the sugar-making process. From the porosity test in concrete research, it has been proven that AAT can function as a pozzolan. AAT contains SiO2, Al2O3, Fe_2O_3, C_aO, K_2O, Na_2O, MgO, and P_2O_5 which have the potential to be used as a cement substitute and are expected to increase the compressive strength of concrete because the grains are relatively small and able to fill the pores in the concrete (Setyawan et al., 2016).

The addition of *silica fume* in the study used 6 (six) variations, namely: 0%; 3%; 6%; 9%; 12% And 15% Silica Fume. The concrete mix was determined with f.a.s 0.45, sikamen NN 3.98, and plastimen vz 0.7 by weight of cement. Tests carried out on the compressive strength were carried out after the concrete was 56 days old. Data for each variation of the Silica Fume mixture was obtained from 3 (three) cylindrical specimens measuring 15 x 30 cm (Susilo, 2019).

II. Review of Literature

Concrete is a very important and dominant construction used in building structures. Buildings are erected using concrete as the main construction material, both buildings, water structures, transportation facilities, and other buildings. Transportation at this time has become a basic need for community activities (Agussani, 2020). In some cases, the concrete mix requires additional materials to support its performance. The purpose of adding additives is to change one or more of the properties of concrete, while it is fresh or after hardening. For example, to accelerate hardening, increase workability, increase compressive strength, increase ductility or reduce hardening cracks, and so on (Sukuri & F Zulkarnain, 2020).

Concrete is a structural element consisting of aggregate particles attached by a paste made of portland cement and water. The paste fills the voids between the aggregate particles and after the fresh concrete is placed, it will harden as a result of exothermic chemical reactions between cement and water and form a dense and durable structural material. (Fany & F Zulkarnain, 2020).

The optimum increase in the addition of banana stem ash occurred at a 15% condition of 255.18 kg/cm2, an increase of 11.67% from normal concrete with a compressive strength of 225.40 kg/cm2. The slump test was carried out 3 times in a row for each mixture, different results were obtained between the concrete mixtures, and the average decreased. This is caused by the addition of too much ash, so the concrete experiences a lack of water (Nazar & Zulkarnain, 2020).

This research was also carried out from several recent previous theses from the same supervisor. In their research on the compressive strength of concrete, they used SNI 03-2834-2000, with different mixtures of added ingredients. The use of lime water as a concrete mixture affects the average compressive strength because it produces a lower average compressive strength than the use of freshwater as a concrete mixture. (Ilham Sani & Zulkarnain, 2020). However, normal concrete with 28 days of sulfuric acid immersion resulted in lower average compressive strength than normal concrete with 28 days of freshwater immersion (Sukuri et al., 2020). This shows that normal concrete has a weak resistance to sulfuric acid solution compared to rice husk ash and viscocrete 3115 N added. (Derlangga Sinambela & Zulkarnain, 2020).

Optimum compressive strength results occur in concrete with a mixture of 6% banana stem ash and 0.8% sikacim concrete additive, which is 30.74 MPa. This shows that the concrete produced with sawdust and am 78 concrete additive 0.8% has a higher strength than normal concrete, so this mixture of sawdust and am 78 concrete additive 0.8% can be applied to structures. building (Fany & F Zulkarnain, 2020).

Concrete durability is one of the requirements in the construction world. Where concrete must be resistant and strong to chemicals that come from the environment such as beach constructions or buildings that are directly exposed to chemical substances. ACI Committee 201 defines the durability of concrete with Portland Cement as the ability of concrete to withstand weather, chemical attack, abrasion, or other destructive processes, thus the durability of concrete is the ability of concrete to maintain its original shape, quality, and ability when exposed to the environment. (Derlangga Sinambela & Zulkarnain, 2020).

Thus it can be stated that the increase in the addition of glass powder with Sikacim concrete additive in a fixed amount in the concrete mixture, the higher the compressive strength of the resulting concrete. It can be concluded that the compressive strength of normal concrete and the compressive strength of a mixture of palm shell ash and bondcrete decreased in compressive strength, and did not reach the design compressive strength of 25 MPa due to the influence of the percentage of palm shell ash and bondcrete addictive substances (Indra & Zulkarnain, 2020).

Figure 1. *Concrete weighing*

Bagasse is a residue or waste from the sugarcane (*Saccharum oicinarum*) milling process after being extracted or released from the sugar-making industry, a fibrous waste commonly referred to as bagasse (*bagasse*). In the sugarcane milling process, there are five times the milling process from sugarcane stalks to bagasse is produced (Savira & Suharsono, 2013).

Innovation in the field of concrete material technology, one of which is to improve the properties of concrete, which can be done by adding certain materials, namely admixtures or additives into the concrete mixture. One of the added ingredients is silica fume, which is a very fine, round material with a diameter of 1/100 times the diameter of portland cement grains and functions as a filler between cement particles. So that the addition of Silica Fume into the concrete mix with a certain level of distribution of the porosity of the concrete becomes small, the density of the concrete increases, and then the strength of the concrete will increase. (Riyanto, et al, 2017). Silica fume is a by-product of the reduction of pure quartz (SiO_2) with coal in an electric furnace in the manufacture of a mixture of silicon and ferrous silicon (ASTM.C.1240, 2003). Silica Fume contains high levels of SiO_2.

Nowadays, in the practice of making concrete, additives and admixtures are materials that are considered important. The use of these materials is intended to improve and increase the properties of concrete by the desired properties. These additives are added to the concrete or mortar mixture, and with the presence of these additives, it is hoped that the resulting concrete will have better properties.

III. Research Method

The method used is the experimental method, namely conducting experimental activities to obtain data. The initial stages of research conducted at the Concrete Laboratory of the Civil Engineering Study Program of UMSU were collecting secondary data for testing the aggregate base material and testing the aggregate base material to be used in the concrete mix experiment. As a reference in completing this final project, it cannot be separated from supporting data. In the inspection of aggregates, both coarse and fine aggregates are carried out in the laboratory following the guidelines of SNI on aggregate inspection.

a. Sludge Content

According to SNI-03-4141-1996, the method of testing clay lumps and easily broken grains in the aggregate is intended as a reference and guide in carrying out tests to determine clay lumps and easily broken grains in aggregates.

b. Sieve Analysis

According to SNI-03-1968-1990, this method is intended as a guide in the examination to determine the grain division (gradation) of fine aggregate and coarse aggregate using a sieve.

c. Aggregate Moisture Content

According to SNI-1971-2011, this method of testing the total moisture content of the aggregate by drying includes determining the percentage of water that can evaporate from the aggregate sample by drying.

d. Density of Coarse Aggregate

According to SNI-1969-2008, coarse aggregate is an aggregate whose grain size is greater than 4.75 mm (sieve No.4). Specific gravity can be expressed by dry bulk density, bulk density at surface dry saturated conditions, or apparent density. Bulk density (surface dry saturation) and water absorption are based on conditions after (24+4) hours of water immersion.

e. Density of Fine Aggregate

According to SNI-1970-2008, fine aggregate is an aggregate whose grain size is smaller than 4.75 mm (No. 4). This test method is used to determine after (24+4) hours in water the dry bulk density and specific gravity. apparent density, bulk density in saturated surface dry conditions, and water absorption.

f. Aggregate Fill Weight

According to SNI-1973-2008, determination of the density of fresh concrete mix and several formulas to calculate the volume of mixture production, cement content, and air content in concrete.

III. Results and Discussion

Before the concrete is put into the mold, a slip test is carried out. After that then put the concrete mixture into the mold that has been provided, put the concrete mixture into the mold using a shovel. Each take from the pan must be able to represent the mixture, fill 1/3 of the mold with mortar and then compaction using ripping/stabbing using an iron rod with a diameter of 16 mm, with the number of punctures 25 times, this continues to be done for 2/3 and 3 /3 or until the mold is full then hit the outside of the mold using a rubber mallet so that the air trapped in the mixture can come out, after that flatten the surface of the mold and cover it with glass to keep water from evaporating from the fresh concrete. Remove the mold after 20 hours and not later than 48 hours after printing.

The slump test is carried out with the Abrams cone by filling the Abrams cone with fresh concrete in as many as 3 layers, each layer of approximately 1/3 of the contents of the cone in each layer is punctured 25 times, and the awl stick must enter the bottom of each layer after filling is complete level the cone surface and then lift the mold by a distance of 300 mm in 5 ± 2 seconds without lateral or torsional movement. Complete all test work from initial filling to uninterrupted mold release in no more than 2.5 minutes, and measure the height of the mortar, the difference between the height of the cone and the mortar is the value of the slump.

Table 1. Slump value test results

No.	Variation	Slump Height
1	Normal Concrete	11. 9 cm
2	Mixed Concrete of Sugarcane Ash3%	11 cm
3	Mixed Concrete of Sugarcane Ash6%	10.7 cm
4	Mixed Concrete of Sugarcane Ash 9%	10 cm

Based on Table 1 above, it can be explained that the comparison of slump values between normal concrete, concrete with 3% bagasse ash and 15% silica fume, concrete with 6% bagasse ash and 15% sikacim, concrete with 9% bagasse ash and 15% sikacim, where in normal concrete the highest slump value is 11.9 cm, while concrete with a mixture of bagasse ash and silica fume has decreased in slump value, it can be seen in Figure 2 below.

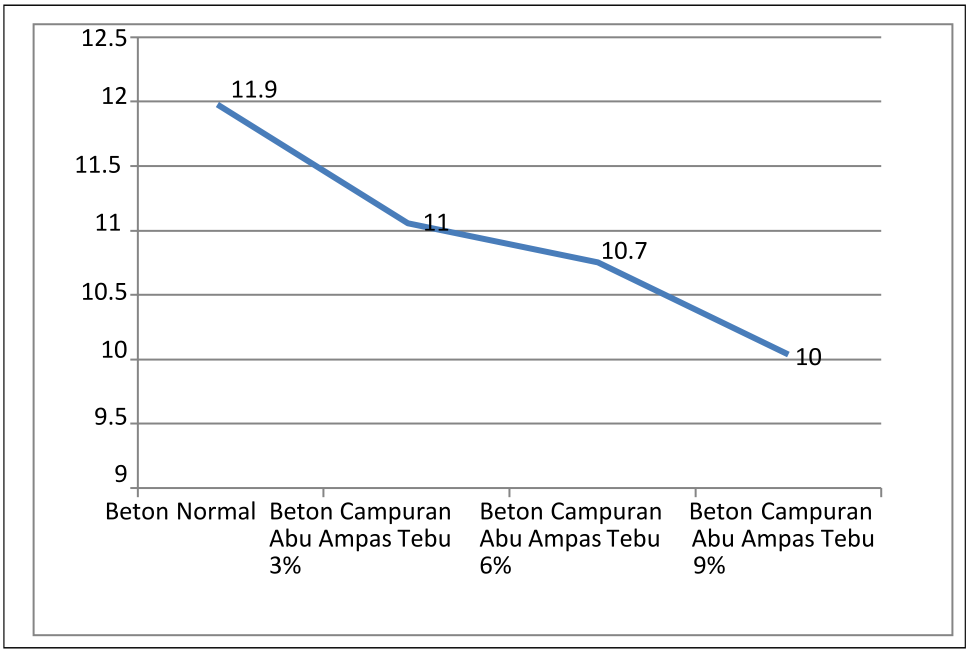

***Figure 2**. Slump value comparison chart*

The concrete compression test was carried out when the concrete was 14 days and 28 days using a press machine with a capacity of 1500 KN. The specimens to be tested were in the form of cylinders with a diameter of 15 cm and a length of 30 cm as many as 12 pieces at the age of 14 days of immersion and 12 more at the age of 28 days of immersion.

Table 2. The results of the normal concrete compressive strength test

Load Test Object	Load (P) (kg)	$f'_C = \frac{P}{A}$ (MPa)	Cylinder Factor F_{ct}/ 0,83 (MPa)	f'_C average (MPa)
14 days old				
1	31500	17.49	21.07	21.08
2	30000	16.66	20.07	
3	33000	18.32	22.08	
28 days old				
1	43500	24.16	29.11	30.11
2	45000	24.99	30.11	
3	46500	25.83	31.12	

4.1 Compressive Strength of 3% Sugar Cane Ash and 15% Silica Fume

Testing of 3% bagasse ash concrete and 15% silica fume was carried out when the concrete was 14 and 28 days old with 3 specimens each. The results of the compressive strength of 3% bagasse ash and 15% silica fume for 14 and 28 days can be seen in Table 3.

Based on Table 3, it is explained that the results of the compressive strength test of 3% bagasse ash concrete and 15% silica fume for 28 days. From each of the 3 specimens of 3% bagasse ash concrete and 15% silica fume which were tested for compressive strength, the average compressive strength value of concrete was 22.08 MPa 33.46 MPa at the age of 14 and 28 days.

Table 3. The results of testing the compressive strength of concrete at 3% and silica fume at 15%

Load Test Object	Load (P) (kg)	$f'_C = \frac{P}{A}$ (MPa)	Cylinder Factor F_{ct}/ 0,83 (MPa)	f'_C average (MPa)
14 days old				
1	34500	19.16	23.09	22.08
2	33000	18.33	22.08	
3	31500	17.49	21.08	
28 days old				
1	48000	26.66	32.12	33.46
2	52500	29.16	35.13	
3	49500	27.49	33.12	

In the research conducted, it was found that the compressive strength of 3% bagasse ash concrete and 15% silica fume in the 14-day test with an average of 22.08 MPa and on the 28-day test with an average of 33.46 MPa, there was an increase from normal concrete.

4.2 Compressive Strength of Sugar Cane Ash Ash Concrete 6% And 15% Silica Fume

Testing of 6% bagasse ash concrete and 15% silica fume was carried out when the concrete was 14 and 28 days old with 3 specimens each. The results of the compressive strength of 6% bagasse ash and 15% silica fume for 14 days and 28 days can be seen in Table 4.

Based on Table 4, the results of the compressive strength test of 6% bagasse ash concrete and 15% silica fume for 28 days are described. From each of the 3 specimens of 6% bagasse ash concrete and 15% silica fume which were tested for compressive strength, the average compressive strength value of concrete was 26.1 MPa 35.13 MPa at the age of 14 and 28 days.

In the research conducted, it was found that the compressive strength of 6% bagasse ash concrete and 15% silica fume in the 14-day test with an average of 26.1 MPa and on the 28-day test with an average of 35.13 MPa, there was an increase from normal concrete and concrete. bagasse ash 3% and silica fume 15%. Table 4, below.

Table 4. The test results of the compressive strength of concrete at 6% and silica fume at 15%

Load Test Object	Load (P) (kg)	$f'_C = \frac{P}{A}$ (MPa)	Cylinder factor F_{ct}/ 0,83 (MPa)	f'_C average (MPa)
14 days old				
1	40500	22.49	27.10	26.1
2	39000	21.66	26.09	
3	37500	20.83	25.09	
28 days old				
1	51000	28.33	34.13	35.13
2	54000	29.99	36.13	
3	52500	29.16	35.13	

4.3 Compressive Strength of 9% Sugar Cane Ash Concrete And 15% Silica Fume

Testing of 9% bagasse ash concrete and 15% silica fume was carried out when the concrete was 14 and 28 days old with 3 specimens each. The results of the compressive strength of 9% bagasse ash and 15% silica fume were 14 and 28 days.

Based on Table 5, explains the results of the compressive strength test of 9% bagasse ash concrete and 15% silica fume for 28 days. From each of the 3 specimens of 9% bagasse ash concrete and 15% silica fume which were tested for compressive strength, the average compressive strength value of concrete was 29.10 MPa 37.14 MPa and the concrete age was 14 and 28 days.

Table 5. The test results for the compressive strength of concrete at 9% and silica fume at 15%

Load Test Object	Beban (P) (kg)	$f'_C = \frac{P}{A}$ (MPa)	Cylinder factor F_{ct}/ 0,83 (MPa)	f'_C average (MPa)
14 days old				
1	42000	23.33	28.10	
2	43500	24.16	29.10	
3	45000	24.99	30.11	29.11
28 days old				
1	57000	31.65	38.14	
2	54000	29.99	36.13	
3	55500	30.82	37.14	37.14

In the research conducted, it was found that the compressive strength of 6% bagasse ash concrete and 15% silica fume in the 14-day test with an average of 29.11 MPa and on the 28-day test with an average of 37.14 MPa, there was an increase from normal concrete, concrete bagasse ash 3% and silica fume 15% and bagasse ash 6% and silica fume 15%.

Figures 3 and 4, show that the addition of bagasse ash and silica fume 3%, 6%, 9%, and 15% silica fume can increase the compressive strength of concrete than normal concrete. Concrete that has the optimum compressive strength occurs in concrete with a mixture of 3% bagasse ash and 15% silica fume in the immersion at the age of 28 days with a value of 33.46 MPa. The lowest average compressive strength results were obtained in concrete with a mixture of bagasse ash and silica fume at 3%, and 15% and 9% and 15% in immersion at the age of 14 days and 28 days with a value of 22.08 MPa, 25.09 MPa. The use of bagasse ash and silica fume as a concrete additive affects the compressive strength of concrete.

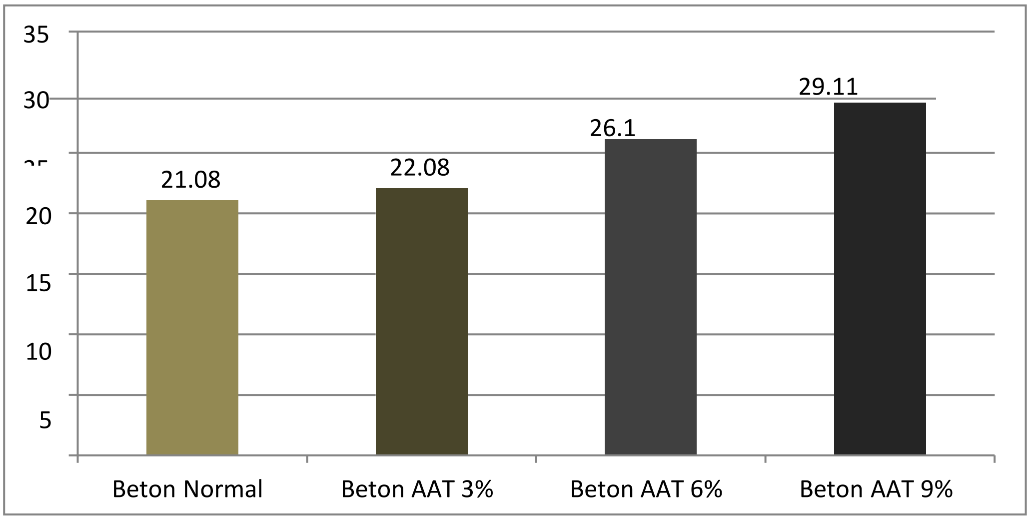

Figure 3. *The compressive strength of concrete aged 14 days of immersion*

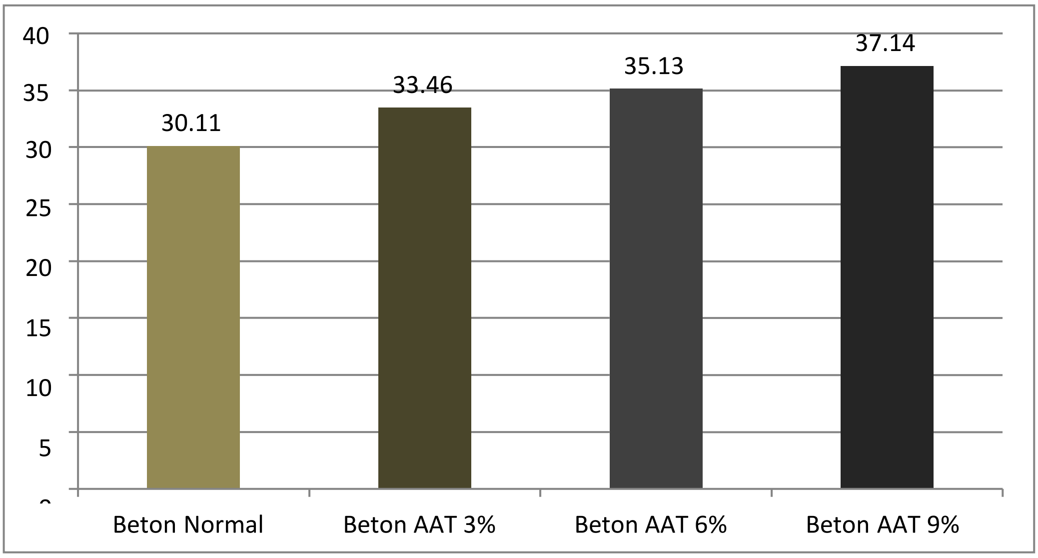

Figure 4. *The compressive strength of concrete aged 28 days of immersion*

IV. Conclusion

From the results of research on concrete using bagasse ash and silicafume, there are several conclusions as follows:Pada penelitian kali ini hasil perpaduan antara beton abu ampas tebu ditambah *silicafume* seluruhnya berpengaruh positif pada kekuatan tekan beton.

1. The results obtained in this study are that the concrete which was given bagasse ash plus silica fume had a better compressive strength than normal concrete.
2. The results of the average compressive strength of normal concrete are 21.08 MPa at the age of 14 days and 30.11 MPa at the age of 28 days, while the concrete mixed with 3% bagasse ash and 15% silica fume is 22.08 MPa at the age of 14 days and 33.46 MPa at the age of 28 days. Then the 6% bagasse ash concrete and 15% silica fume were 26.1 MPa at the age of 14 days and 35.13 MPa at the age of 28 days, and the concrete with a mixture of 9% bagasse ash and 15% silica fume was 29.11 MPa at the age 14 days and 37.14 MPa at 28 days.
3. In this study, the comparison of the compressive strength of normal concrete and a mixture of bagasse ash plus silica fume has increased significantly.

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