

PAPER • OPEN ACCESS

## The effect of bagasse fibers material with pumice as a partial substitution of coarse aggregate to increase compressive strength and tensile strength on lightweight concrete

To cite this article: F Samosir *et al* 2021 *IOP Conf. Ser.: Earth Environ. Sci.* **878** 012046

View the [article online](#) for updates and enhancements.

You may also like

- [Preliminary Study of Immobilized of Cellulase in Silica from the Rice Husk Ash to Hydrolysis Sugarcane Bagasse](#)  
Yudhi Utomo, Nurakhma Yuniawati, Surjani Wonorahardo et al.
- [The Effect of Sugarcane Bagasse to Rubber Seed Oil Ratios on The Chemical Composition of Liquid Fuels Produced by Zeolite- \$\gamma\$  Catalyzed Pyrolysis](#)  
A Simanjuntak, W Simanjuntak, K D. Pandiangan et al.
- [Production and Characterization of Paper from Pineapple Leaves and Sugarcane Bagasse Pulp](#)  
Evelyn, Komalasari, R A Adegustias et al.



The Electrochemical Society  
Advancing solid state & electrochemical science & technology

242nd ECS Meeting

Oct 9 – 13, 2022 • Atlanta, GA, US

Abstract submission deadline: **April 8, 2022**

Connect. Engage. Champion. Empower. Accelerate.

**MOVE SCIENCE FORWARD**



Submit your abstract



# The effect of bagasse fibers material with pumice as a partial substitution of coarse aggregate to increase compressive strength and tensile strength on lightweight concrete

F Samosir\*, L E Hutabarat, C C Purnomo and S P Tampubolon

Civil Engineering Department of Universitas Kristen Indonesia (UKI), Jakarta, Indonesia

\*fernandessamosir1@gmail.com

**Abstract.** Based on data from the Indonesian Sugar Plantation Research Center (P3GI) bagasse produced 32% of the weight of ground sugar cane. Data obtained from the Indonesian Sugar Expert Association (IKAGI) shows the number of sugar cane milled by 57 sugar mills in Indonesia reaches around 30 million tons, so the bagasse produced is estimated to reach 9,640,000 tons. However, as much as 60% of the sugarcane bagasse ash is used by sugar factories as fuel, raw material for paper and others. Therefore, it is estimated that 40% of the sugarcane bagasse ash has not been utilized. In this research sugarcane bagasse used as fiber material with using pumice partial substitutions for coarse aggregate to increase compressive strength and tensile strength of lightweight concrete. The test is conducted on specimens with a diameter of 15 cm and a height of 30 cm at the age of 28 days. Result of test shows lightweight concrete with 0.25% sugarcane bagasse reach optimum compressive strength at 13.74 MPa, compare to 12.83 MPa without sugarcane bagasse; 13.40 MPa with 0.5% sugarcane bagasse, and 11.61 MPa with 1% sugarcane bagasse. Furthermore, the results of the tensile strength test show a significant increase up to 0.25% bagasse fibers reach 1.81 MPa, compare to 1.51 MPa without sugarcane bagasse; 1.72 MPa with 0.5%; and 1.56 MPa with 1% sugarcane bagasse.

## 1. Introduction

The use of lightweight concrete in various modern constructions is growing rapidly because several advantages using lightweight concrete technology [1]. Lightweight concrete has smaller density that can reduce the dead weight of the structural elements. This lower weight of the structural elements can also provide the advantage of reducing the required foundation size. One of the substitute materials that can be used to reduce the density of concrete is pumice [2]. Using pumice as a substitute for coarse aggregate is an option to lower density of concrete because pumice has a fairly light weight [3].

Industrial waste such as sugarcane bagasse can be used for raw materials for the construction industry as well [4,5]. Utilizing this waste material can help to create a sustainable and pollution free environment, besides the economic cost. Sugarcane bagasse is one such fibrous waste-product of the sugar refining industry. This waste material can be used for a mixture of concrete, bricks, concrete blocks that can actually increase compressive strength of lightweight concrete. In general, fibrous waste-product of sugar cane utilize as a reinforcing material to strengthen the composite material of concrete. Therefore, mechanical properties of composite material will be stiffer, tougher and stronger. In this study, bagasse ash can be used for a suitable replacement to fine aggregate [6].



Many research use of bagasse waste because only 60% of the bagasse was used by sugar factories as fuel, raw materials for paper and others. Therefore, it is estimated that as much as 40% of the bagasse has not been utilized. In this research sugarcane bagasse used as fiber material with using pumice substitutions for coarse aggregate to increase compressive strength and tensile strength of lightweight concrete. Other than that it is also expected sugarcane fiber and pumice as substitute for coarse aggregate can increase lightweight concrete split tensile strength as well. Thus, this research aim to examine the behavior of lightweight concrete using pumice substitutions for coarse aggregate with and without bagasse fiber [7].

## 2. Methods

The method used for this research is carried out from some previous study using sugarcane bagasse and pumice as substitute for coarse aggregate. The experiments process is conducting at Concrete Laboratory in Civil Engineering Universitas Kristen Indonesia, Jakarta

Research methodology for making the specimen test material of lightweight concrete with pumice coarse aggregate substitution as follow: (1) Studying of literature of sugarcane bagasse experiment for concrete technology, include the physical and chemical properties (2) Preparing sugarcane bagasse fiber in concrete with varying content of 0%, 0.25%, 0.5%, and 1% of the volume of the concrete mix, (3) Specimen used in this study is a specimen with a diameter of 15 cm and a height of 30 cm, 3 specimens each for various content of sugarcane bagasse fiber, (4) Curing, (5) Examining the weight and volume of the specimen, (6) Testing concrete specimens at the age of 28 days in normal condition compressive strength and tensile strength of the concrete.

Concrete will be hardened for at least one day in the mold. Along the hardening process, curing treatment are needed for the required time before testing by immersing the specimen in water. Testing of compressive strength and split tensile strength of concrete is carried out at the age of 28 days. Maximum loading test can be reached when concrete has the full-strength at 28 days, combining with reinforcement for column, beam, and wall [8,9]. The compressive strength value of concrete carried out with Compression Testing Machine (CTM). Hammer test should be done first to make a best approach of specimen compressive strength value. The compressive strength test using a hammer test is only done in horizontal axis (0°). Result for compressive strength of the specimen can be compared with two different testing method CTM and Hammer Test. Then, tensile strength of specimen is tested in the cylinder position using Compression Testing Machine (CTM).

## 3. Results and discussions

### 3.1. Properties of aggregates

In this study, testing of fine aggregate and coarse aggregate is carried out. The results are as follows:

**Table 1.** Coarse aggregate testing result.

	Test Result	ASTM C-33 Standard	Conclusion
Bulk Specific (SSD)	2.69 gr/cm <sup>3</sup>	2,5-2,7	Qualify
Absorption	3.68 %	-	-
Mud Content	1.5 %	-	-
Durability	9.08%	-	-

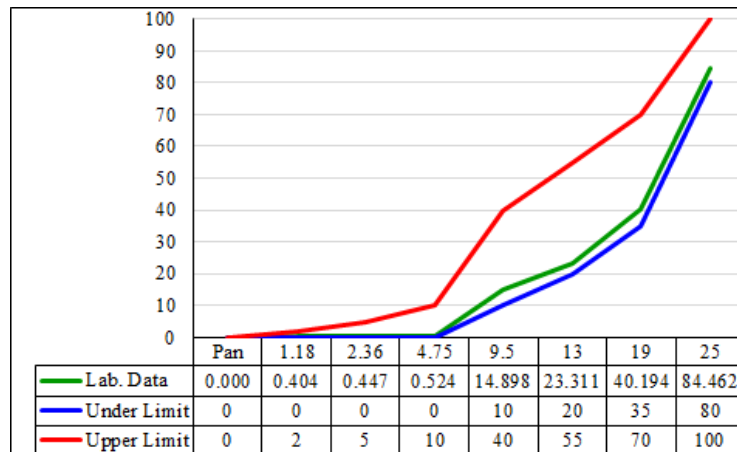


Figure 1. Sieve analysis for coarse aggregate.

The results of fine aggregate testing can be seen in Table 2. and Figure 2. as follow:

Table 2. Fine aggregate testing result.

	Test Result	ASTM C-33 Standard	Conclusion
Bulk Specific (SSD)	2.65 gr/cm3	2,5-2,7	Qualify
Absorption	4.82 %	5%	Qualify
Mud Content	4.6 %	5%	Qualify
Durability	37.7%	Clear or light yellow	Qualify

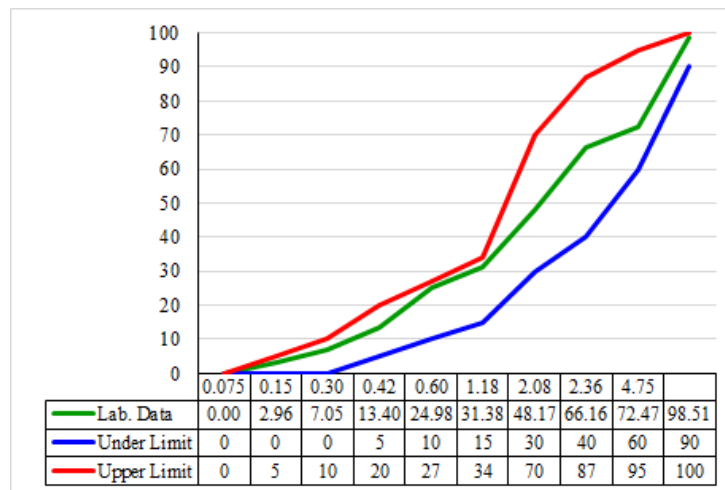
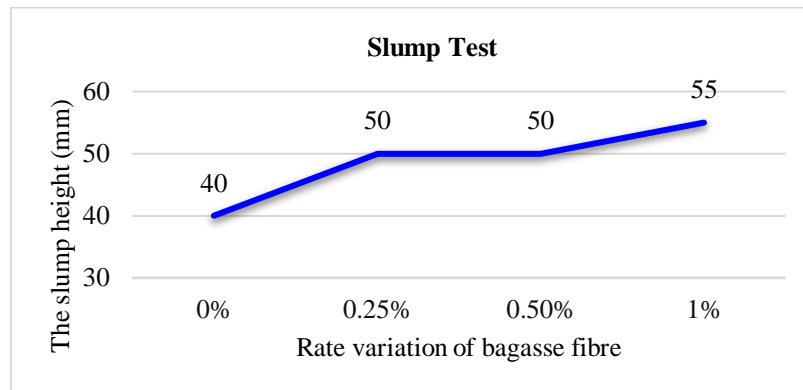


Figure 2. Sieve analysis for fine aggregate.

### 3.2. Slump

The results of testing the slump value in concrete with various types of mixtures of 0%; 0.25; 0.50%; and 1% bagasse fiber can be seen in figure 5 below:

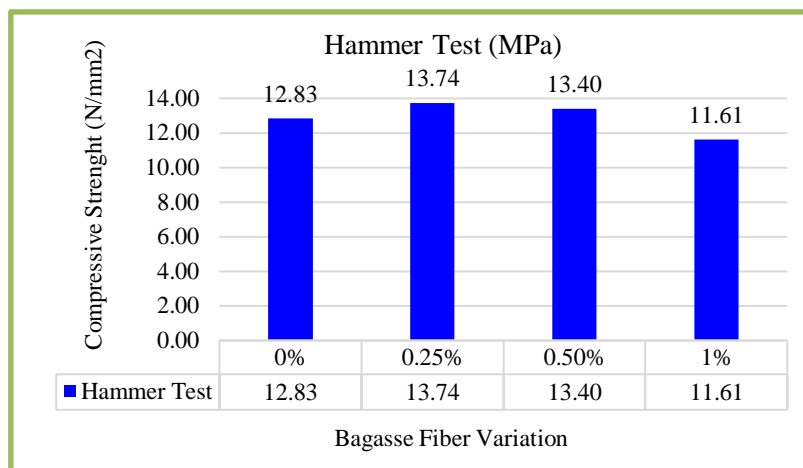


**Figure 3.** Slump test results.

In accordance with the concrete mix design plan  $f_c=10$  MPa with a slump test plan of 30-60 mm. Figure 3 shows the results of the lightweight concrete slump test on specimens with a diameter of 15 and a height of 30 cm at the age of 28 days. It can be seen that the test results meet the  $f_c=10$  MPa concrete mix design planning criteria.

### 3.3. Analysis of concrete compressive strength test results

The results of the concrete compressive strength from Hammer test can be seen in Figure 4.

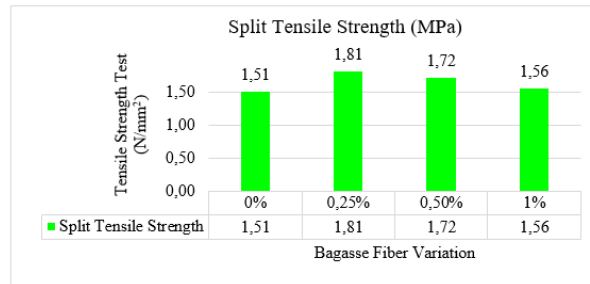


**Figure 4.** Compressive strength test results.

In Figure 4. shows the compressive strength increase for bagasse fiber content 0.25% of 13.74 MPa. Instead the compressive strength decrease 13.40 ,11.61 and 12.83 MPa respectively when 0%, 0.5%, 1% bagasse fiber. There is an increase of 7.09% of compressive strength for 0.25% bagasse fiber and a decrease 2.53% up to 15.41% for bagasse fiber more than 0.25%. This is because the bagasse fiber has a flat and slippery texture, causing weak adhesion to other materials and causes a decrease in the compressive strength of the concrete. According to SNI 03-3449-2002 compressive strength of lightweight concrete is 6.89-17.24 MPa. Thus, results of lightweight concrete tested meet the standards required.

### 3.4. Analysis of concrete tensile strength test results

The results from Compression Testing Machine (CTM) for Tensile Strength can be seen in Figure 5.

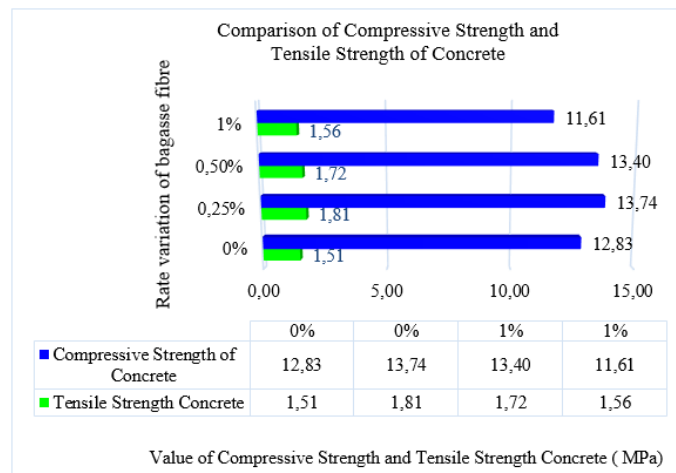


**Figure 5.** Tensile strength test results.

Figure 5. shows the results of the split tensile strength test of light concrete specimen with a diameter of 15 cm and a height of 30 cm at the age of 28 days. It can be seen that there is a significant increase in bagasse fiber content at 0.25% of 1.81 MPa. Instead there is a decrease of 1.51, 1.72 and 1.56 MPa when the bagasse fiber 0%; 0.5%; and 1% respectively. There is an increase 19.86% of tensile strength for 0% to 0.25% bagasse fiber and a decrease 5.2% up to 10.25% for bagasse fiber more than 0.25%.

**3.5. Results**

The tensile strength of concrete is relatively low, about 10% -20% compared to compressive strength of concrete. From previous study result of tensile strength experimental is varying because is more difficult to measure for compressed cylinders' concrete materials.



**Figure 6.** Value of compressive strength and tensile concrete.

In Figure 6 and Table 3. shows that the percentage ratio of the compressive strength value of concrete and split tensile strength meets the requirements in the ratio of compressive strength and split tensile strength of 10% - 15%.

**Table 3.** Comparison value of compressive strength and tensile concrete.

Parameter	Bagasse Fiber			
	0%	0.25%	0.5%	1%
Compressive Strength (MPa)	12.83	13.74	13.40	11.61
Split Tensile Strength (MPa)	1.51	1.81	1.72	1.56
Ratio %	11.75	13.21	12.84	13.40

#### 4. Conclusion

The highest compressive strength of concrete is bagasse fiber 0.25% and decrease if more than 0.25%. The highest compressive strength value of concrete at the age of 28 days occurs in the bagasse fiber content 0.25% of 13.74 MPa or increase 7.09%, while the highest split tensile strength in the bagasse fiber content 0.25% of 1.81 MPa or increase 19.86%. Thus, it can be concluded that bagasse fibers have a significant effect on lightweight concrete strength in about content bagasse fiber 0.25%. The greater the fiber content used in the concrete mixture will stimulate balling effect which is coagulation of fibers in forms like a ball. There is an increase in the slump test as well for 40 mm, 50 mm, 50 mm, 55 mm with variations bagasse fiber of 0%; 0.25%; 0.5%; 1% respectively. It can be concluded that using bagasse fiber at certain percentage will increase workability of concrete mixture.

#### Acknowledgments

First, I want to thank my bachelor thesis advisor Ir. Lolom Evalita Hutabarat, MT who has helped and guided me while doing my research in the Department Civil Engineering Universitas Kristen Indonesia, and for my first academic paper publication as well. Hopefully the results of this paper will benefit the academic world, especially civil engineering

#### References

- [1] Corr D and Shah S P 2005 Concrete materials science at the nanoscale *In Applications of Nanotechnology in Concrete Design: Proceedings of the International Conference* University of Dundee, Scotland, UK on 7 July 2005 (pp 2-12) Thomas Telford Publishing
- [2] Gündüz L 2008 The effects of pumice aggregate/cement ratios on the low-strength concrete properties *Construction and Building Materials* **22** 5 pp 721-728
- [3] Hossain K M A, Ahmed S and Lachemi M 2011 Lightweight concrete incorporating pumice based blended cement and aggregate: Mechanical and durability characteristics *Construction and Building Materials* **25** 3 pp 1186-1195
- [4] Modani P O and Vyawahare M R 2013 Utilization of bagasse ash as a partial replacement of fine aggregate in concrete *Procedia Engineering* **51** pp 25-29
- [5] Bahurudeen A, Kanraj D, Dev V G and Santhanam M 2015 Performance evaluation of sugarcane bagasse ash blended cement in concrete *Cement and Concrete Composites* **59** pp 77-88
- [6] Shafiq N, Hussein A A E, Nuruddin M F and Al Mattarneh H 2016 Effects of sugarcane bagasse ash on the properties of concrete *Proceedings of the Institution of Civil Engineers-Engineering Sustainability* **171** 3 pp 123-132
- [7] Rajasekar A, Arunachalam K, Kottaisamy M and Saraswathy V 2018 Durability characteristics of Ultra High Strength Concrete with treated sugarcane bagasse ash *Construction and Building Materials* **171** pp 350-356
- [8] Tampubolon S P, Wang C Y and Wang R Z 2020 Numerical simulations of the bond stress-slip effect of reinforced concrete on the push over behavior of interior beam-column joint *IOP Conference Series: Materials Science and Engineering* **725** 1 pp 012028
- [9] S. Tampubolon 2020 Analisa Perilaku Balok Beton Bertulang dengan Menggunakan Simulasi VecTor2 *Jurnal Rekayasa Konstruksi Mekanika Sipil* **3** 2 pp 55-64