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The Effect of Traditionally Combustion Method of Bamboo Leaves Ash in Concrete Mixtures

Susana M. Suratama, Elisabeth R. Febriyani, Albert Aun Umbu Nday#
Department of Civil Engineering, Politeknik Negeri Kupang
Jl. Adisucipto, Penfui - Kupang, Indonesia
#albertaun.umbunday@gmail.com

Abstract

Rapid industrialization, households, and commerce emerging waste problems. Not only in urban societies but also in rural communities. The rural communities receive waste from their environmental condition of agro-industrial waste such as bamboo leaves. The leaves are usually dried and burned in open spaces. Former studies concluded that silica content can be found in rice husks, bamboo leaves, sugarcane bagasse, and so on by combustion process. The traditional combustion method is a simple method by which burnt bamboo leaves can produce ash with contains more carbon. This study lifted a way to produce more silica by extracting the ash using citric acid. The citric acid supports quick combustion to reduce inorganic and organic material in bamboo leaves. This process resulted in BLA in white color. The BLA substitute the cement content of concrete with composition of 0%, 7%, 8%, and 9%. The parameter in this study is to measure the density of concrete mixtures by using UPV apparatus and to measure the strength of concrete compressive by using a compression machine. The results concluded that the BLA provides a sufficient density of concrete and The BLA concrete strength has decreased with the added amount of BLA. The strength of BLA has contrasted with other studies that described improving the strength of concrete by BLA substitute from 5% to 30%. Therefore, the combustion process is still necessary to improve by taking more time for extraction and combustion process. Also, controlling slump degradation can affect water/ratio which can also affect the concrete strength.

Keywords: bamboo leaves ash, concrete, ultrasonic pulse velocity, compressive, strength

Abstrak

Pesatnya industrialisasi, rumah tangga, dan perdagangan memunculkan permasalahan sampah. Tidak hanya pada masyarakat perkotaan, namun juga pada masyarakat pedesaan. Masyarakat pedesaan menerima limbah dari kondisi lingkungannya berupa limbah agroindustri seperti daun bambu. Daunnya biasanya dikeringkan dan dibakar di tempat terbuka. Penelitian terdahulu menyimpulkan bahwa kandungan silika dapat ditemukan pada sekam padi, daun bambu, ampas tebu, dan sebagainya melalui proses pembakaran. Cara pembakaran tradisional merupakan cara sederhana dimana daun bambu yang dibakar dapat menghasilkan abu dengan kandungan karbon lebih banyak. Penelitian ini mengungkap cara untuk menghasilkan lebih banyak silika dengan mengekstraksi abu menggunakan asam sitrat. Asam sitrat mendukung pembakaran cepat untuk mengurangi bahan anorganik dan organik dalam daun bambu. Proses ini menghasilkan BLA berwarna putih. BLA mensubstitusi kandungan semen pada beton dengan komposisi 0%, 7%, 8%, dan 9%. Parameter pada penelitian ini adalah mengukur massa jenis campuran beton dengan menggunakan alat UPV dan mengukur kuat tekan beton dengan menggunakan mesin tekan. Hasil penelitian menyimpulkan bahwa BLA memberikan kepadatan beton yang cukup dan kekuatan beton BLA mengalami penurunan seiring dengan bertambahnya jumlah BLA. Kekuatan BLA berbeda dengan penelitian lain yang menggambarkan peningkatan kekuatan beton dengan pengganti BLA dari 5% menjadi 30%. Oleh karena itu, proses pembakaran masih perlu diperbaiki dengan meluangkan waktu yang lebih lama untuk proses ekstraksi dan pembakaran. Selain itu, pengendalian penurunan kemerosotan yang dapat mempengaruhi rasio air yang juga dapat mempengaruhi kekuatan beton.

Kata kunci: *abu daun bambu, beton, kecepatan pulsa ultrasonik, tekan, kuat tekan*

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I. INTRODUCTION

Rapid industrialization, households, and commerce emerging waste problems [1]. Waste impact problem to the environment puts pressure on people or societies of lower-middle-income countries [2]. The worsened situation in slum countries such as high-density population, traffic, air and water pollution, and open space disposal near bodies of people impact people's health [3]. Waste utilization to reduce the impact of waste generation and waste management due to recycling and energy recovery to produce waste products [4]. The benefit of recycling products is both in reducing waste problems and in enhancing the quality of products [5]. Recycling materials from waste in three main sectors the industrial sector, the agroindustrial sector, and the construction and demolition sector [6]. Agroindustrial waste from various cultivation crops such as bamboo leaf and sugarcane baggase is one of the wicked problems that is not noticed by the stakeholders of lower-middle income countries [2], [6]. Utilization of ash bamboo leaf in concrete mixtures can enhance the high performance of compressive strength and flexural strength of concrete [7].

Some methods of combustion progress of Bamboo Leaf Ash (BLA) are shown in the study of the production and characterization of BLA by collecting dry leaves that were calcined through combustion in a metallic drum then the ash from the combustion was ground a ball mill. The results of this study that a percentage of up to 30% of replacement of mortars due to the pozzolanic character [8]. The study of combustion of three bamboo residues: Bamboo Leaves (BL); Bamboo Shoot Leaves and Bamboo Branches (BB) of species "Phyllostachys pubescens" They were dried, 24-h indoors and pulverized by passed through a sieve with mesh size 74 μm. This study analyzed heating rates in the air using Thermogravimetric Analysis. The conclusion shows that bamboo residues have great potential as a clean and renewable feedstock for energy generation given the low levels of polluting gas from the combustion [9]. BLA is produced through an auto-combustion process in a furnace with no controlled temperature. The process begins when initially thermal is provided and then the leaves burn themselves in the furnace. After 1 min of auto-combustion, the leaves achieved a burning of 738 ^{0}C. This study concluded that BLA is a suitable and sustainable alternative for partial OPC replacement [10].

a. b.

Figure 1. (a) collecting ash bamboo leaves, (b) combustion process

The calcined combustion of bamboo leaves at 600 ^{0}C for 2 hours can produce highly pozzolanic reactivity [11]. However, the problems of combustion to the environment and periods to burn BLA necessary to reduce. A simple way based on alkaline extraction followed by acid precipitation was developed to produce pure silica about 91% of Rice Hull Ash (RHA) [12]. Similar concluded from the study of silica isolation using chloride acid [13]. Therefore, this study explored traditional combustion ash bamboo leaves using chloride acid extraction to produce pure silica in concrete mixtures. The specimens in cylinder shape were tested in destructive and non-destructive tests. The contribution of this paper is expected to offer a traditional method for people to substitute ash bamboo leaves as waste material reuse for enhance the capacity of concrete mixtures. This paper is different from the others regarding the burning method.

II. RESEARCH METHOD

A. Bamboo Treatment

The type of bamboo is "Gigantochloa apus" which was broadly scattered in the Indonesian region. Bamboo leaves were collected and dried in the sun then burned and became ash. After that, the ash was initially treated with citric acid about 5% then the ash was extracted for 15 min to reduce inorganic materials and further burned again for 30 min to reduce organic materials. The citric acid assists the combustion process to result in silica powder marked by the white color of silica [14].

B. Physical Material Tests

Physical characteristics of the material in fine and coarse aggregates were conducted in this study before the calculated mix design. Fine aggregate tests such as sieve analysis, specific gravity, water content ratio, sludge test, and weight content.

Coarse aggregate tests such as sieve analysis, specific gravity, water content ratio, sludge test, weight content, and abrasion test. The mix design plan was 25 MPa. This study is a material substitute in concrete mixtures by substituting the cement content with the ash bamboo leaves. The ash bamboo leaves have three variations such as 7%, 8%, and 9%. Each variation has three specimens of each age of concrete. The age of concrete were 7 days, 14 days, 21 days, and 28 days. The specification of specimen variation is shown in Table 1. The specimens were tested first in the non-destructive test and continued in the destructive test.

C. Workability Tests

A workability test is needed to measure to find the consistency of mixtures. Also, workability is comparable with water content value. To measure slump value using Abram's cone [15].

D. Non-Destructive Test by Ultrasonic Pulse Velocity Tests (UPV)

UPV tests were conducted on 7 days, 14 days, 21 days, and 28 days of age of concrete. The UPV tests read 7 observation points with emission waves repeatedly for 25 times. The specimen was given a wave ultrasonic frequency of about 54 kHz from the receiver and then went through again by the transmitter. The value of velocity and time travel were recorded on screen. This study uses a direct method to measure the pulse [16]. The UPV apparatus and UPV positions on the specimen are shown in Figure 2 and Figure 3. The quality of concrete for direct Non-destructive test is shown in Table 2 [17].

Table 1. Specimen types

Variation of BLA	Age of Concrete	Number of specimens
0%	7 days	3
	14 days	3
	21 days	3
	28 days	3
7%	7 days	3
	14 days	3
	21 days	3
	28 days	3
8%	7 days	3
	14 days	3
	21 days	3
	28 days	3
9%	7 days	3
	14 days	3
	21 days	3
	28 days	3

E. Destructive Test By Concrete Compressive Tests

A compressive test was measured using a compression testing machine as shown in Figure 4. The results of this study show the strength and crack pattern after the load working on the specimen.

Figure 2. UPV apparatus

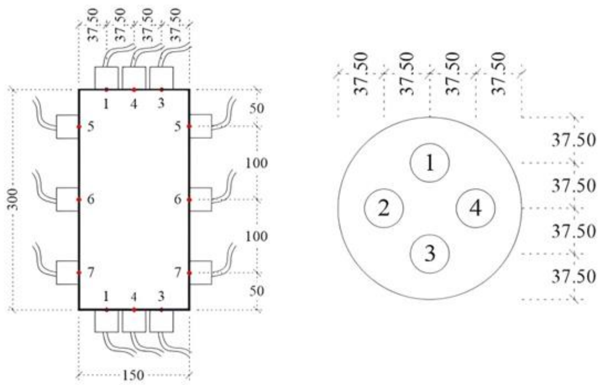

Figure 3. UPV positions on the specimen

Table 2. The quality of concrete for non-destructive test

Specimen number	UPV (km/sec)	Quality of concrete for the direct method
1	Above 4.5	Excellent
2	3.5 to 4.5	Good
3	3.0 to 3.5	Medium
4	Below 3	Doubtful

a. b.

Figure 4. (a) a compression testing machine, (b) specimens

a. b.

Figure 5. Combustion treatment of ash bamboo leaves

III. RESULT AND DISCUSSION

A. Texture of Ash Bamboo Leaves

There are two parts to the combustion process. Initially, parts of bamboo leaves burned and became ash. The ash texture is slightly rough and has a dark color. The darkness of color was the result of more carbon and inorganic chemicals. The ash is shown in Figure 5a. The continued treatment of ash was treated with citric acid about 5% then the ash was extracted for 15 min to reduce inorganic materials and further burned again for 30 min to reduce organic materials. This process results color of the ash being white and have texture slightly soft. The ash is shown in Figure 5b.

B. Result of Characteristics Physical Material Test

Physical tests of fine and coarse aggregate before making a mix design were conducted in this study. The result of each material was adequate for doing a mixed design. The result of each material is shown in Table 3 and Table 4.

Table 3. Physical characteristics of fine aggregate

Type of Test	Parameter	Result
Sieve analysis	Gradation zone	2
Specific gravity	SSD	2.2
Water content ratio	Max. Grade 6%	3.62%
Sludge tests	Max. Grade 5%	3.62%
Weight content	Min. 0.4-1.9 gr/cm^3	1.44 gr/cm^3

Table 4. Physical characteristics of coarse aggregate

Type of Test	Parameter	Result
Sieve analysis	Gradation zone	1
Specific gravity	SSD	2.2
Water content ratio	Max. Grade 1.3%	0.56%
Sludge test	Max. Grade <1%	0.63%
Weight content	Min. 0.4-1.9 gr/cm^3	1.49 gr/cm^3
Abrasion test	Max. 40%	29.61%

Table 5. Specimen composition for a specimen

Specimen	Water/ content	Cement (kg)	BLA (kg)
0% BLA	0.49	2.297	0
7% BLA	0.49	2.136	0.161
8% BLA	0.49	2.113	0.184
9% BLA	0.49	2.090	0.207

Table 6. Workability tests

Variation	7 days	14 days	21 days	28 days
0% BLA	9	9	9	9
7% BLA	8.5	8.5	8.5	8.5
8% BLA	12	12	12	12
9% BLA	8	8	8	8

Noted : in cm

The material substitute composition of a specimen in this concrete mixture by substituting cement with BLA is shown in Table 5. The workability result for each composition is shown in Table 6.

C. Result of UPV Test

The UPV test resulting minimum pulse velocity of BLA 7%; 8%; and 9% are 3.5249 km/s; 3.3682 km/s; and 3.3558 km/s. And maximum pulse velocity of each variation is 4.1867 km/s; 4.2494 km/s; and 4.3963 km/s. The pulse velocity of concrete is shown in Figure 6, Figure 7, and Figure 8. Regarding the results of pulse velocity compared to the quality of concrete for direct non-destructive test in Table 2, the quality of concrete is Medium-Good. The output of pulse velocity can be described as the composition of BLA in concrete mixtures capable of a material substitute and also preserving the concrete density.

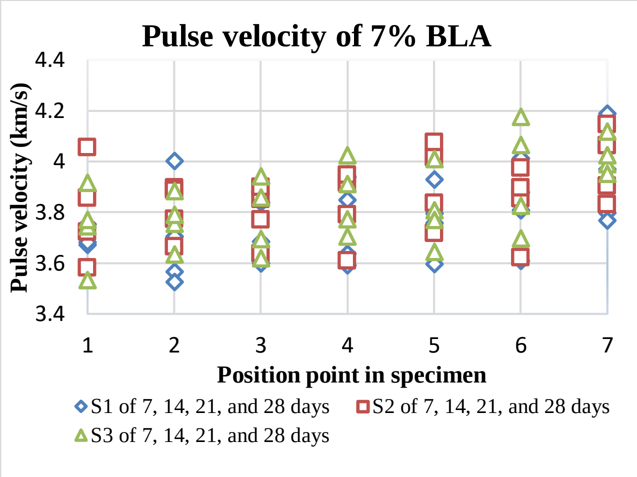

Figure 6. Pulse velocity of 7% BLA

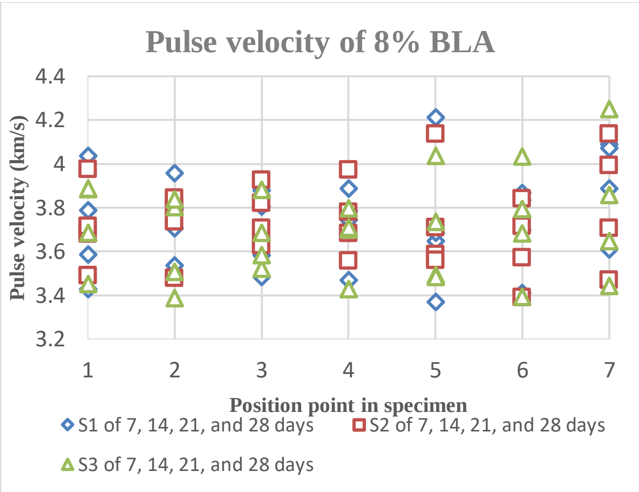

Figure 7. Pulse velocity of 8% BLA

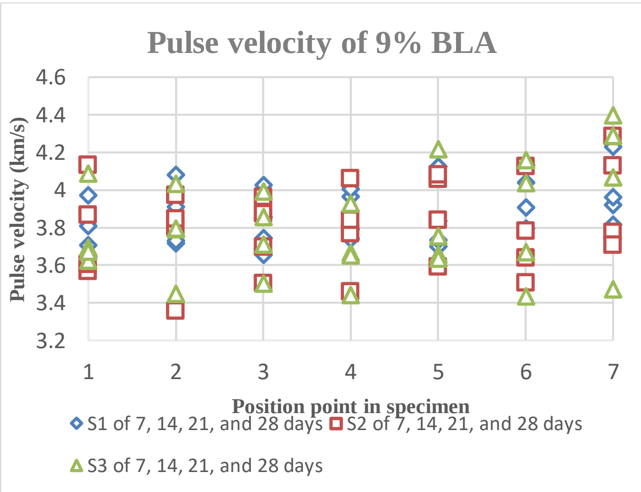

Figure 8. Pulse velocity of 9% BLA

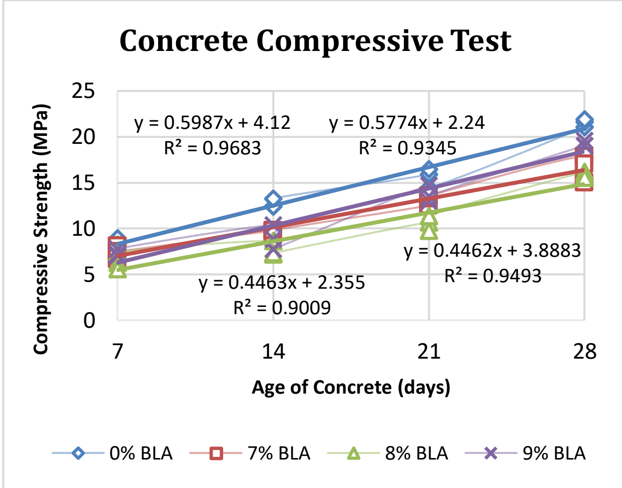

Figure 9. Concrete compressive strength

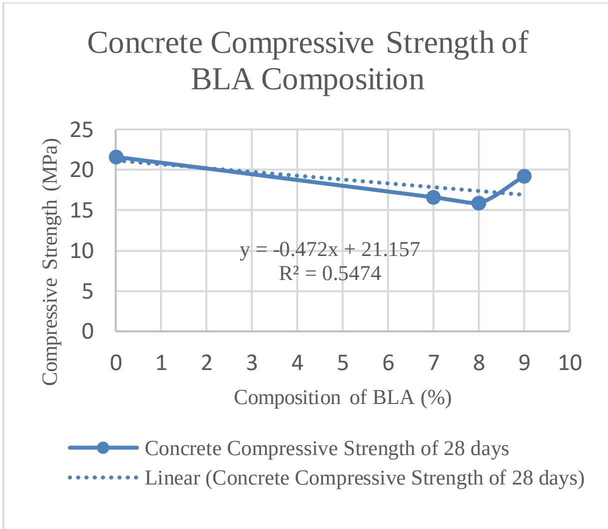

Figure 10. Concrete compressive strength of 28 days

D. Result of Concrete Compressive Test

Regards of equation of linear regression of each composition of 0%; 7%; 8%; and 9% are y = 0.5987x + 4.12; y = 0.5774x + 2.24; y = 0.4462x + 3.8883; and y = 0.4463x + 2.355. Also, the coefficients of determination of each composition of 0%; 7%; 8%; and 9% are R^2 = 0.9683; R^2 = 0.9345; R^2 = 0.9493; and R^2 = 0.9009. From statical analysis, hypothesis x is strongly dependent on the hypothesis y. Accordingly, the results of concrete compressive strength described that there is a correlation between concrete strength and with age of concrete. The age of concrete will improve the strength of concrete. This statement is visualized in linear regression analysis in Figure 9.

The average of concrete compressive strength in 28 days of each composition of 0%; 7%; 8%; and 9% are 21.6 MPa; 16.6 MPa; 15.9 MPa; and 19.2 MPa. This analysis to compare the hypothesis x have related to the hypothesis y is shown in Figure 10. There is no correlation between this analysis.

Described in the coefficient of determination from the linear regression is R^2= 0.5474. However, the compressive strength decreased from a composition of 0% to 8% and improved again to 9%. The mystifying results contrast with the result from another study that concluded about 5% to 30% BLA can improve the compressive strength [10]. Also, the silica extraction takes more time about 1 h [12].

The average of concrete compressive strength in 28 days of each composition of 0%; 7%; 8%; and 9% are 21.6 MPa; 16.6 MPa; 15.9 MPa; and 19.2 MPa. This analysis compares the hypothesis x have related to the hypothesis y. There is no correlation between this analysis. It is described in coefficients of determination from the linear regression as R^2= 0.5474. However, the compressive strength decreased from a composition of 0% to 8% and improved again to 9%. The mystifying results contrast with the results from other studies that concluded about 5% to 30% BLA can improve the compressive strength [10]. Also, the silica extraction takes more time about 1 hour [12], producing silica content takes more time to combustion process about 2h [18], and the time about 30 min of combustion process reduces silica content [14]. Based on Table 3 the slump test affected the water/ratio which can also affect the concrete strength.

E. Correlation of UPV Results with Concrete Compressive Results

Statistical analyses were conducted in this case to compare the result of the Non-destructive test with the Destructive test. Data from each composition was calculated in average value based on the age of the concrete and concrete strength. The correlation is shown in Figure 11, Figure 12, and Figure 13 that it shown the accretion of age of concrete can improve the pulse velocity and the concrete strength.

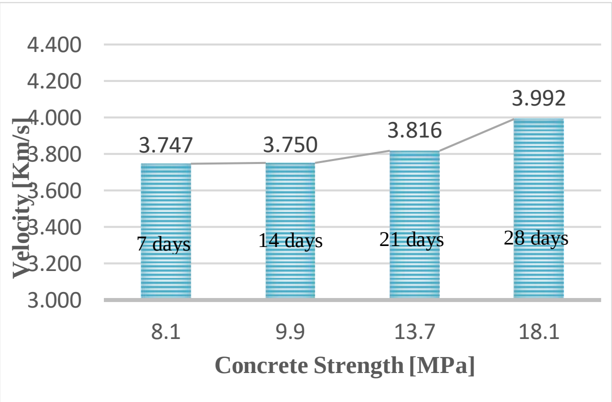

Figure 11. Correlation UPV and compressive test on 7% BLA

IV. Conclusion

This study gives an alternative manner to produce silica from the traditional combustion method of rural communities with limited apparatus and by using inexpensive materials such as citric acid. The novelty of this study also helps rural people to use agroindustrial waste such as bamboo leaves in concrete mixtures to enhance the concrete capacity. The conclusion of this study, namely: takes more time to produce silica content from the process of extraction and combustion, the results of the UPV test that the BLA concrete provides sufficient density, more attention to slump controlling that can affect the result of concrete strength, and there is a correlation of age of concrete with pulse velocity and concrete strength.

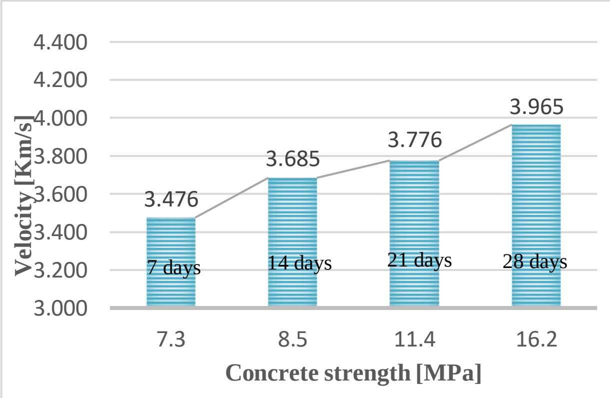

Figure 12. Correlation UPV and compressive test on 8% BLA

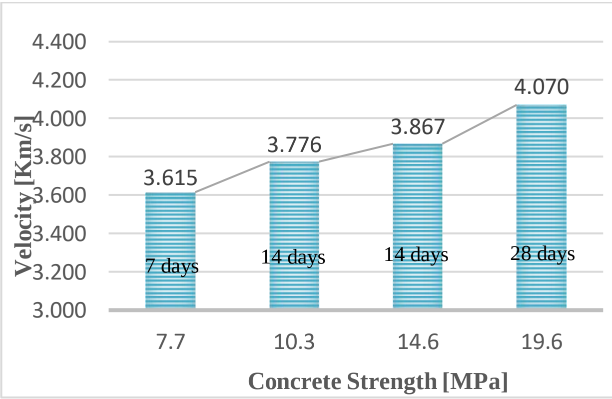

Figure 13. Correlation UPV and compressive test on 9% BLA

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