

## Carbonized Biomass as a Bonding Agent for Non-Load Bearing CHB Production

Sally Grace B. OSORIO<sup>1</sup>, Daryl F. GENERAL<sup>2</sup>, John Ross B. MILANDA<sup>3</sup>, Rick Donald S. MANZON<sup>4</sup>, Estrelita L. BERNARDO<sup>5</sup>

<sup>1,2,3,4,5</sup> Nueva Ecija University of Science and Technology, Gen Tinio Street, Cabanatuan City 3100

**ABSTRACT:** One of the most prominent construction materials for walls in the Philippines is the concrete hollow blocks or CHB due to their lower cost than other available materials and the ease of production and installation. To manage our energy and resources, including waste, carbonized biomass as a bonding agent for CHB production was studied to aid in the country's growing need for construction materials. On-site fabricated CHB with several percent of carbonized biomass (CB) as substitutes for sand (0%, 20%, and 50% CB), including commercial CHB, are subjected to volume, weight, density determination, and ultimate compressive strength test. The gathered data undergo analysis through one-way ANOVA to determine the difference among the gathered compressive strength of CHB produced with different percentages of carbonized biomass. Cost analysis was also done to determine the costs and profitability of the CHB. As a result, the CHB with carbonized biomass as bonding agent produced CHB with low density, ultimate compressive strength better than commercially available CHB (with proper curing applied), and can be more profitable with increasing the carbonized biomass content.

**KEYWORDS:** Carbonized Biomass, Concrete Hollow Block (CHB), Waste Management

### I. INTRODUCTION

The Philippines has one of the most dynamic economies in Southeast Asia, with a gross domestic product of \$284.8 billion in 2017 and an average growth rate of more than 5% in the past decade. The construction industry is one of the top contributors to the country's growing economy, strengthened by the current government's "Build Build Build Program" that aims to usher in the "Golden age of Construction" and increase public infrastructure expenditure from an average of 2.9 percent of gross domestic product (GDP) during the Aquino regime to about 7.3 percent at the end of the Duterte administration. The rise in building projects means there will be a need for more construction materials.

One of the most prominent construction materials for walls in the Philippines is concrete hollow blocks or CHB. Though CHB is weak against lateral loads, as they are considered a non-load bearing part of the structure, the addition of steel bars for reinforcing is the common practice.

The Philippines is also an extensively agricultural country, with 23% of its workforce constitutes the country's agricultural sector and accounting for 8.1% of the 2018 GDP. This also became grounds for increased production of organic and agricultural wastes in the country. United Nations Summary report of waste management indicates the Philippines to constitute 52% of its municipal solid waste to food and organic wastes. Therefore, increased effort to

cultivate these organic wastes to a more productive output is a growing concern for the country.

The research will investigate the utilization of organic wastes such as plant biomass to aid in the country's growing need of construction materials. The study will focus on the use of carbonized biomass as a bonding agent for CHB production.

### II. OBJECTIVES

#### A. General Objective

The study was conducted to find the effectivity of using carbonized biomass as a bonding agent for CHB production.

#### B. Specific Objective

1. Determine the density of CHB produced with carbonized biomass as a bonding agent and compare it with CHB produced with a regularly used bonding agent.
2. Test the compressive strength of CHB produced with carbonized biomass as bonding agent and compare with CHB produced with a regularly used bonding agent.
3. Provide a cost analysis of CHB production with carbonized biomass as a bonding agent and compare it with CHB produced with a regularly used bonding agent.

**III. METHODOLOGY**

The standard size of CHB produced for the experiment is 40cm (length) x 20 cm (width) x 4 in (thickness). Three samples with different percentages of carbonized biomass as a binding agent were produced; namely, 50% carbonized biomass, and 20% carbonized biomass. The third sample is produced with a regular binding agent (lahar sand) to serve as the control group. Commercially bought CHB is also included in the samples for comparative study.

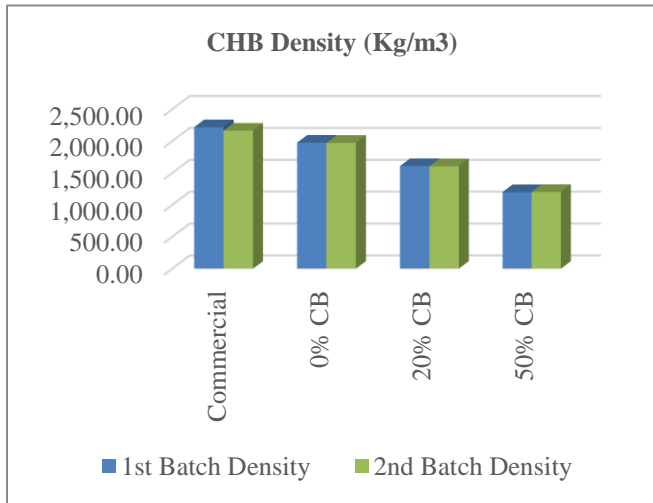
Two different batch production were conducted; the first batch with a 1:7 ratio of cement to sand and the second batch with a 1:5 ratio of cement to sand. They were subjected to volume and density determination:

$$\text{Density in kg/m}^3 = \text{Mass of block in kg} / \text{Mass of block in cm}^2 * 10^6$$

Samples are subjected to a compressive strength test using the Hydraulic Pressure Testing Machine. The gathered data underwent analysis through one-way ANOVA to determine the difference among the gathered compressive strength of CHB produced with different percentages of carbonized biomass. The sum and arithmetic means were also computed for the presentation and analysis of data gathered.

**IV. RESULTS & DISCUSSION**

**A. CHB Density**



**Figure 4-1.** Density of Samples

From the first and second batch of samples, the commercially bought CHB has the highest density (2,219.69 kg/m<sup>3</sup> and 2,165.77 kg/m<sup>3</sup>), followed by the CHB with 0% carbonized biomass (1,976.70 kg/m<sup>3</sup> and 1,975.05 kg/m<sup>3</sup>) and the CHB with 20% carbonized biomass (1,610.58 kg/m<sup>3</sup> and 1,608.89kg/m<sup>3</sup>). The sample with the least density is the CHB produced with 50% carbonized biomass.

The Law of Mixtures is the primary reason for the findings. Generally, carbonized biomass is the lightest of all the components in the CHB with a specific gravity of 1.80 (coal) compared to cement with 3.15 and sand with 2.44. Increasing the amount of carbonized biomass in the CHB mixture results in decreased density. The density is one of the

factors to determine the strength of the concrete hollow blocks. Shohana Iffat (2016) provided the study concluding denser concrete provides increased strength and the least amount of voids, decreasing the porosity of the concrete block.

However, the CHB commonly used in the country's construction industry is mainly non-load bearing and for decorative purposes only.

**B. CHB Compressive Strength**

**Table IV-1.** Compressive Strength Summary of CHB (Batch 1 & 2 Samples)

<i>Samples</i>	<i>1st batch (1:7 mix ratio) Ultimate strength, Psi (KN)</i>	<i>1st batch (1:7 mix ratio) Ultimate Strength, Psi (KN)</i>
<b>Commercial</b>	123 (19.63)	112 (17.87)
<b>0% (Original)</b>	263.67 (46.72)	372 (59.37)
<b>20% CB</b>	135.33 (23.95)	168 (26.75)
<b>50% CB</b>	173 (91.94)	55 (8.8)

Notably, the sample with 0% carbonized biomass CHB mixture has the highest compressive strength from both batches produced.

The second highest compressive strength varies between the two batches (20% CB and 50% CB). The CHB with 50% carbonized biomass has the second highest compressive strength test result of 173 Psi from the first batch of samples. The third highest compressive strength is the CHB produced with 20% carbonized biomass with 135.3 Psi.

However, in the second batch, the CHB with 50% carbonized biomass has the least compressive strength test result with only 55 Psi. The CHB with 20% carbonized biomass has the second-highest compressive strength test result with 168 Psi. One notable distinction between the two batch samples is the current moisture of the samples that undergo compressive strength testing. The second batch (50% CB) sample has more moisture content when tested because all the samples (of the 2nd batch) have been watered a day before testing.

The least compressive test result for the first batch (and third on the second batch) is the commercially bought CHB with compressive strength test results of 123 Psi and 112 Psi. Considering that the sample is bought at a local hardware store, it can be concluded that these CHB have a full 28 days (or even more) curing time completed. However, the composition, including additives to cement and sand, and the ratio of the cement and sand of the CHB mixture were not known for the sample.

**Table IV-2.** One way ANOVA Test Result for First Batch of Samples

	<i>Sum of Squares</i>	<i>df</i>	<i>Mean Squares</i>	<i>f</i>	<i>p-value</i>	<i>Critical F-Value</i>
Between Groups	26,108.6	2	13,054.33	48.4	<0.00	5.14
Within Groups	1,617.33	6	269.56	3	1	
Total	27,726	8				

The obtained data from the first batch (1:7 ratio of cement to sand) was subjected to one-way ANOVA to determine if there is a significant difference among the samples produced. The result shows a significant difference among the means of the ultimate compressive strength of the samples with  $F = 48.43$ ,  $p = <0.001$ .

Comparing the three on-site fabricated CHB (0%, 20%, and 50% carbonized biomass content), the CHB with 0% carbonized biomass has significantly higher ultimate compressive strength than both mixtures with carbonized biomass.

On the other hand, comparing the result of ultimate compressive strength, the CHB produced with different percentages of carbonized biomass (20% and 50%) has higher compressive strength test results than the commercial CHB. The exception is the case of the CHB with 50% carbonized biomass from the second batch that has the lowest compressive strength of all the samples (as reasoned earlier to be a case of increased moisture content during testing). CHB with carbonized biomass produced in the study can be stronger than the commercially bought CHB.

Also, regardless of the decreased density of the CHB produced with carbonized biomass content, the ultimate compressive strength of the CHB was not compromised. We can see from Figure 4-1 that the commercial CHB has the highest density among the samples.

The carbonized biomass proposes a potential additive for the production of CHB with decreased density but uncompromised compressive strength, following the proper curing time.

**C. CHB Cost Analysis**

**Table IV.3.** Cost Analysis

	<b>0% CB</b>	<b>20% CB</b>	<b>50% CB</b>
Cement	(4kgs) P22.00	(4kgs) P22.00	(4kgs) P22.00
Sand	(30kgs) P13.65	(24kgs) P10.92	(15kgs) P6.83
Carbonized Biomass (CB)	-	(1kg) P2.00	(2.5kg) P5.00
Labor Cost (15% MC)	P5.35	P5.24	P5.07
No. of CHB produced	(3pcs) P41.00	(3pcs) P40.16	(3pcs) P38.90
Price per piece	P13.67	P13.39	P12.97

Results show that the Original CHB mix (0% CB) has the highest cost per piece with Php13.67, and the lowest cost per piece is the CHB with 50% CB with Php12.97. The commercial CHB was bought for 14 pesos, and this includes the profit for the sold CHB. It can be generalized that the production cost for the commercial CHB was lower than the on-site fabricated CHB. Several factors can be attributed to the pricing, such as the cost of raw materials and labor, the ratio of cement and sand used in the CHB mixture, etc.

**Table IV.4.** Projected Profit for 2,000 pcs CHB

	<b>0% CB</b>	<b>20% CB</b>	<b>50% CB</b>
Price per piece	P13.67	P13.39	P12.97
SRP per piece	P16.00	P16.00	P16.00
Profit per piece	P2.33	P2.61	P3.03
Profit for 2,000 pcs	P4,660.00	P5,220.00	P6,060.00

If the CHB is sold at Php16.00 per piece, CHB with 50% CB yields the highest profit with Php 3.03 per piece. To better show the differences in profit, the researchers assumed order of 2,000 pieces of CHB. With this, the profit difference between the three CHB ranges from Php560.00 to Php840.00.

**CONCLUSIONS**

The study aimed to determine the feasibility of using carbonized biomass as a bonding agent for CHB production. The research was conducted by on-site fabrication of CHB with several percent of carbonized biomass as substitutes for sand (0%, 20%, 50% CB). Commercial CHB was also included as one of the samples of the study.

The study determined the volume, weight, and density of the CHB samples and determined the commercial CHB to have the highest density. A decreasing trend is also concluded in the volume and density as the percentage of carbonized biomass increases. In terms of density, the commercial CHB is the densest of all the samples, while the CHB with 50% CB is the least dense.

The study subjected the four CHB samples in two batches (commercial, 0% CB, 20% CB, 50% CB) to the ultimate compressive strength test and found that the fabricated CHB with 0% CB has the highest compressive strength of all the samples. This is followed by the CHB with 50% CB for the first batch tested and the CHB with 20% CB for the second batch. The CHB with the least compressive strength is the commercially bought CHB. This concludes that the CHB with the carbonized biomass has better compressive strength than commercial CHB, despite the decreased density due to the carbonized biomass in the CHB composition.

The study also provided a cost analysis of the CHB production and found that the additive of carbonized biomass is more profitable, especially the 50% CB mixture, compared to the CHB with 0% CB. However, the commercially bought CHB still generates the lowest price per piece.

The CHB with carbonized biomass as bonding agent produced CHB with low density, ultimate compressive strength better than commercially available CHB (with proper curing applied), and can increase the carbonized biomass content.

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