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Utilization of green shellfish (perna viridis) waste as an alternative material for brick production in sustainable construction

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ABSTRACT

Based on initial observations, information from green clam shell collectors that the production of green clams in Kampung Kerang Hijau, Cilincing, North Jakarta, can reach 5 tons/day when the condition of the clams is abundant and can reach 1 ton/day when the condition of the clams is declining. Based on this number, until now green mussels are only used for their meat to be consumed by the community and the waste accumulates in landfills and causes an unhealthy environment for the surrounding community. Based on this background, as an effort to reduce green clam shell waste, improvements need to be made. The purpose of this study is to be able to determine the optimal formulation/composition of green clam shell powder in the manufacture of bricks and to determine the characteristics/properties of bricks produced through testing rules. The method used in this study is an experimental method, carried out by making samples, testing samples, and drawing conclusions with comparative techniques against standards. The results obtained in this study are the optimal composition to produce good quality bricks, namely by using a mixture of 10% fine shell powder on sand. The characteristics or properties of the resulting bricks are with a compressive strength value of 10.26 N/mm2, water absorption of 16.45%, and resistance to nails (not broken or cracked)

Keywords: Brick; compressive strength; green clam shell; nail test; water absorption

1. INTRODUCTION

Green clam village is one of the areas at the northern end of Jakarta City, precisely in Kalibaru Village, North Cilincing. This area is located on the edge of Jakarta Bay. Most of the people of Kampung Kerang Hijau work as fishermen, green clam cultivators, green clam peelers, and salted fish artisans. Based on initial observations, information from green clam shell collectors that green clam production can reach 5 tons/day when clam conditions are abundant and can reach 1 ton/day when clam conditions are declining. Based on this number, until now green mussels have only been used for their meat for consumption by the public [1]. Based on observations, this causes green clam shell waste to accumulate in several landfills and even not a few have been mixed with scattered garbage [2][3]. Based on information from an interview with the head of the Kampung Kerang Hijau, so far there has been no follow-up from either the government or local residents to process green clam shells. The shell will be very useful and can help residents if it can be processed and utilized [4].

According to data from the Central Statistics Agency, shellfish production in 2020 reached 34,426.79 tons. Waste from this production, especially green clam shell waste, can cause various environmental problems if not managed properly. For example, research from the Bogor Agricultural University (IPB) shows that waste and garbage in waters can result in water conditions containing silicates of 52,156 tons, phosphate 6,741 tons, and nitrogen of 21,260 tons. Green mussels, which play a role in filtering seawater, are also polluted [5]. Therefore, the management of green clam shell waste is very important to maintain the balance of coastal and marine ecosystems.

The accumulated green clam shell waste can cause several negative impacts according to the statements of the surrounding community during the initial interview session. Shells actually do not have a bad direct impact, but in some coastal areas are often found shells that are piled up and left without proper management [6]. This condition results in a bad impact on the surrounding environment [7]. During the rainy season, the shellfish pile becomes a nest for the *escherichia coli* bacteria that causes vomiting or diarrhea outbreaks and becomes a nest for mosquitoes that cause dengue fever [8]. The community also revealed that the scattered green clam shell waste makes it unhealthy, can cause unpleasant odors, cause disease seeds, and can cause foot infections if stepped on by humans. Green clam shells have a calcium carbonate content [9]. However, in its use, it needs to be destroyed in the form of powder [10].

Based on this background, as an effort to reduce green clam shell waste, improvements need to be made. Based on previous research, according to Syamsidar et al. the problem that occurred in Kampung Kerang Hijau was the lack of environmental cleanliness due to the accumulation of waste which was then processed into chitin as a bio coagulant of river water [11]. Research by Karimah et al. utilizes shellfish waste processed into powder as a substitute for fine aggregate against the compressive strength of concrete [12]. Therefore, the novelty of this research is waste reduction in supporting innovation in the field of construction, the idea of brick making innovation with several compositions that are tested until bricks are produced with the best quality. To support sustainable research, this research is expected to provide ideas for mixing components compiler to make it easier and more efficient to make bricks with related raw materials.

2. METHOD

This study uses several stages that are structured so that this research runs systematically and according to the limits. The stages of this research can be seen in Figure 1.

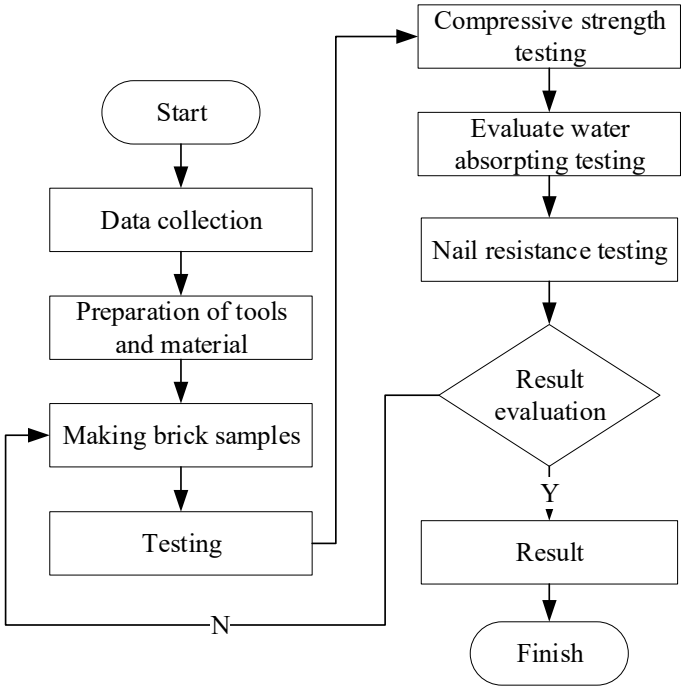

Figure 1. Research framework

a) Data Collection: Gathering all the data required for the brick sampling process.

b) Preparation of Tools and Materials: Prepare all the necessary tools and materials for the manufacture of brick samples.
c) Making Brick Samples: The process of making brick samples according to the appropriate composition.
d) Testing: Conducting tests on brick samples to evaluate water absorption, compressive strength, and nail resistance. Testing the mechanical properties of bricks is carried out based on SNI 03-0348-1989 standards and SNI Decree T-15-1991-03 Subsection 3.2.5 [13]. The quality parameters of the bricks tested for mechanical properties are in the form of compressive strength and nail tests. Testing for physical properties is carried out in the form of water absorption test.
e) Result Evaluation: The stage of checking and verifying the process and results of brick samples. Conclusions will be made by comparing the research results to the samples used. The comparison is carried out by paying attention to the standards of mechanical properties that apply to bricks.

The implementation method in this study is an experiment, with the research variables to be used as follows:

a) Bound variables: water, cement and sand.
b) Independent variable: comparison of the amount of green clamshell powder and sand.

3. RESULTS AND DISCUSSION

Data collection stage

On May 19, 2024, the PKM team conducted a routine visit to Kampung Kerang Hijau, Cilincing, North Jakarta. The team conducted interviews and observations with the head of RT, youth, and the ladies of Kampung Kerang Hijau. The team also collected green clam shell waste for materials for making experimental samples. Action collected green clam shell vol. 1 can be seen in Figure 2.

Figure 2. Collecting clam shells vol. 1

On June 16, 2024, the PKM team again made a routine visit to Kampung Kerang Hijau, to stay in touch with the children and the community of Kampung Kerang Hijau and collect green clam shell waste vol. 2 to be used in making phase 2 brick samples. This action can be seen in Figure 3.

Figure 3. Collecting clam shells vol. 2

Preparation of tools and materials

This study uses several tools and materials as support for testing. The tools used consist of main tools and supporting tools, while the materials used are consumables can be seen in the Table 1.

Table 1. Tools and materials

Main Tools	Supporting Tools	Materials
1. Machine JTM-100HS (serial 8635) 2. Drying *Oven Machine – Memmert UN 260 Universal* 3. Crusher *Machine*	1. Shovel 2. Rubber Hammer 3. Iron Hammer 4. Brick Mold 5. Bucket 6. Copper Wire	1. Sand 2. Shell Powder 3. Water 4. Cement

Green clam shell waste in its use needs to be made into powder first. Several *pre-treatment* activities are carried out for waste which can be detailed as follows:

a. Green clam shell waste washing

Phase 1 washing activities will be carried out on May 25, 2024 using water and soap to clean it. Phase 2 washing activities will be carried out on June 10, 2024 in the same way as phase 1. This activity was carried out to support the making of brick samples in phases 1 and 2. Action green clam shell waste washing can be seen in Figure 4.

Figure 4. Washing clam shells

b. Drying of green clam shell waste

This drying activity is carried out after the washing stage. Green clam shell waste is dried in the open area by being dried under the hot sun or can only be aired. The purpose of waste drying is to remove water from the washing residue. Phase 1 drying activities will be carried out on May 25, 2024 and phase 2 drying activities will be carried out on June 10, 2024. Action drying of green clam shell waste can be seen in Figure 5.

Figure 5. Drying of green clam shell

c. Green clam shell waste crusher

Shell waste that has passed the washing and drying stages, then the shell is broken into powder. This cracking process uses a crusher machine and will get the result of shells that have been destroyed but still have different sizes. Specifically, the clams from this crusher have a size of no more than 10 mm. Phase 1 crusher activities will be carried out on June 1, 2024 and phase 2 crusher activities will be carried out on June 22, 2024. Action crusher of green clam shell waste can be seen in Figure 6.

Figure 6. Crusher of green clam shell

e. Filtration of green clam shell powder

Powder filtration activities are carried out using a 3 mm filter. Powder results with a size of less than 2.36 mm are categorized as fine powders and powders with a size of 2.36 – 10 mm are categorized as coarse powder. The difference in size will be used for the sampling stage with different variations of brick powder. Phase 1 screening activities will be carried out on June 9, 2024 and phase 2 screening activities will be carried out on June 23, 2024. Action filtration of green clam shell powder can be seen in Figure 7.

Figure 7. Filtration of green clam shell

f. Making brick samples

The brick samples to be made are 11 bricks, with the details of the components that make up each brick listed in Table 2.

Table 2. Details of the components samples

Sample Name	Percentage of Shell Powder Content	Sand Volume (kg)	Cement Volume (kg)	Shell Powder Volume (kg)
S1	0%	7	1.4	0
S2	10% (fine powder)	6.3	1.4	0.7
S3	25% (fine powder)	5.25	1.4	1.75
S4	50% (fine powder)	3.5	1.4	3.5
S5	75% (fine powder)	1.75	1.4	5.25
S6	100% (fine powder)	0	1.4	7
S7	10% (coarse powder)	6.3	1.4	0.7
S8	25% (coarse powder)	5.25	1.4	1.75

Sample Name	Percentage of Shell Powder Content	Sand Volume (kg)	Cement Volume (kg)	Shell Powder Volume (kg)
S9	50% (coarse powder)	3.5	1.4	3.5
S10	75% (coarse powder)	1.75	1.4	5.25
S11	100% (coarse powder)	0	1.4	7

The brick sample making activity was carried out on June 9, 2024 for the #1 phase of sample making and on June 30, 2024 for the second phase of sample making. Action making brick samples can be seen in Figure 8.

Figure 8. Making brick sample

Testing

The testing stage of brick samples is carried out with 3 types of tests. In detail, the tests carried out are as follows.

a. Compressive strength test

Compressive strength testing is carried out using the JTM-100HS Engine (serial 8635). The compressive strength test requirements, which are based on *SNI 03-0349-1989,* are starting from the application of the load until the test piece is destroyed so that it is not less than 1 minute and not more than 2 minutes. This test was carried out to determine the compressive strength value of each brick with a different composition. Mathematically, the compressive strength of the tested brick can be calculated by the formula [14].

$$\text{Compressive Strength (Mpa)} = \frac{P}{L} \quad (1)$$

When:
P = Maximum compressive load (Newtons) L = Length (mm^2)

Compressive strength testing was carried out on each brick sample. The test result data is listed in Table 3.

Table 3. Data on compressive strength test

Sample Name	Diameter (mm)	Ao (mm^2)	Yield Conditions	
			Yield (N)	Y'S (N/mm^2)
S1	100	2979	11157.2	3.75
S2	100	2979	30561.1	10.26
S3	100	2979	11866.8	3.98
S4	100	2979	14335	4.81
S5	100	2979	4320	1.45
S6	100	2979	4400	1.48
S7	100	2979	18181.7	6.10
S8	100	2979	12286.1	4.12

Sample Name	Diameter (mm)	Ao (mm^2)	Yield Conditions	
			Yield (N)	Y'S (N/mm^2)
S9	100	2979	9218.64	3.09
S10	100	2979	2090	0.70
S11	100	2979	3440	1.15

Based on the table above and based on the conditions *of SNI-3-0349-1989* states that the best compressive strength value of bricks is at 10.26 N/mm^2 [14]. Therefore, it can be concluded that the S2 sample is the sample with the best compressive strength test results.

b. Water absorption test

The water absorption test was carried out by soaking the bricks in clean water for 24 hours at room temperature and the bricks were dried in an oven with a temperature of 105°C for 24 hours [15]. Then data recording and data processing are carried out using the following formula.

$$\text{Water Absorption}\,(\%) = \frac{Mb-Mk}{Mb}\ x\ 100 \quad (2)$$

When:

Mb = Wet mass from sample (gr) Mk =

Dry mass of the sample (gr)

The water absorption testing was carried out on each brick sample. The test result data is listed in Table 4.

Table 4. Data on water absorption test

Sample Name	Mb (kg)	Mk (kg)	Water Absorption (%)
S1	9.15	7.55	21.19
S2	8.99	7.72	16.45
S3	9.38	7.84	19.64
S4	9.44	7.62	23.88
S5	9.23	7.72	19.56
S6	9.55	7.82	22.12
S7	9.44	7.59	24.37
S8	9.75	7.92	23.11
S9	9.27	7.96	16.46
S10	9.16	7.53	21.65
S11	9.34	7.64	22.25

Based on the table above and by reviewing the standard that has been set, namely *SNI 3-0349-1989* with the maximum condition of water absorption in bricks, which is 25% to for quality class I [16]. Therefore, it can be concluded that all samples are eligible for the standard.

c. Nail test

Nail testing was carried out to see the effect of different nail sizes on each brick sample. The following qualitative data for nail testing is presented in Table 5.

Table 5. Data on nail test

Sample Name	Effect of Sample Conditions
S1	No Breaking and No Cracking
S2	No Breaking and No Cracking
S3	No Breaking and No Cracking
S4	No Breaking and No Cracking

Sample Name	Effect of Sample Conditions
S5	Breaking and Cracking
S6	Breaking and Cracking
S7	No Breaking and No Cracking
S8	No Breaking and No Cracking
S9	No Breaking and No Cracking
S10	Breaking and Cracking
S11	Breaking and Cracking

Based on the table above, it can be concluded that all samples with different specifications have good resistance to nails.

Research Implications

The implications of this study are that it can be divided into three parts. The following are details of the implications of the research conducted.

a. Practical Implications: 1) It can reduce the waste of green clam shells. 2) It has the potential to build MSMEs in brick production. 3) In terms of economy, it has the potential to improve people's living standards. 4) Providing innovation in the world of construction. 5) As a form of community service.
b. Theoretical Implications (research contribution to science), 1) Reference for testing in the processing of green clams for brick making. 2) Reference for development considerations in the realization of green clam processing in brick making. 3) Reference in contribution to provide innovation in the world of construction with composition/formula on the basic material of green clam shell waste.

4. CONCLUSION

The conclusions that can be drawn based on the research that has been carried out are the way to use green clam shell waste into bricks is to crush the shell into powder first, then mix the shell powder with cement, sand, and water which is then molded into dough and dried until it becomes bricks. The optimal composition to produce bricks of good quality is by using fine shell powder with a percentage of components that is as much as 75% sand; cement 17%; and 8% clamshell powder. This composition produces a water absorption test value of 16.45%, a compressive strength test value of 2.6 MPa, and bricks that can be nailed with a nail size of 3 inches.

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