

PAPER • OPEN ACCESS

Utilization of By Product *Kappaphycus alvarezii* as Earthquake Resistant Material Lightweight Concrete

To cite this article: A A Musthofa *et al* 2020 *IOP Conf. Ser.: Earth Environ. Sci.* **441** 012028

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

You may also like

- [Identification and determination of growth hormones of *Kappaphycus alvarezii* cultivated in Ekas Bay East Lombok](#)
N Cokrowati, Y Risjani, S Andayani et al.
- [Antibacterial activity of gel hand sanitizer from seaweed extract \(*Kappaphycus alvarezii*\)](#)
W K Putri, D Y Pujiastuti and E Saputra
- [Evaluation of land suitability of *Kappaphycus alvarezii* cultivation in the dry and rainy season](#)
M Aris and R Labenua



ECS
The
Electrochemical
Society
Advancing solid state &
electrochemical science & technology

DISCOVER
how sustainability
intersects with
electrochemistry & solid
state science research

Utilization of By Product *Kappaphycus alvarezii* as Earthquake Resistant Material Lightweight Concrete

A A Musthofa¹, M Z A Bahtiar¹, F M Ibrahim³ and A A Abdillah^{2,4}

¹ Fisheries Product Technology Study Program, Faculty of Fisheries and Marine, Universitas Airlangga, Surabaya 60115

²Department of Marine, Faculty of Fisheries and Marine, Universitas Airlangga, Surabaya 60115, Indonesia

³Undergraduate Program of Physics, Faculty of Science and Technology, Universitas Airlangga, Surabaya, 60115, Indonesia

⁴ Corresponding author:: annur.ahadi@fpk.unair.ac.id

Abstract. Increasing seaweed production in Indonesia is the result of industrial demand that continues to soar, especially *Kappaphycus alvarezii*, and has an impact on the accumulation of seaweed processing waste. The use of waste as a substitute for sand in making lightweight concrete can be done because there is a cellulose content that can make bonds between materials which can be used as earthquake-resistant building materials. The purpose of this study was to determine the industrial waste treatment of *K. alvarezii* can be used as a lightweight concrete for earthquake resistant building materials. This study uses a complete random range with six treatments and four replications by testing compressive strength, flexural strength, and water absorption. The best treatment is a substitution with a 60% waste concentration with the results of the compressive strength test of 1.15 MPa, the flexural strength of 5.37 MPa, and a water absorption capacity of 62.25%. The suggestion from this research is to do mass production with the substitution formulation of carrageenan waste by 60%.

1. Introduction

Seaweed is a commodity of fishery products whose production is continuously being improved. According to FAO [1] press release data, national seaweed production annually grows by an average of 11.8%, wherein 2017 it reached 10.8 million tons or an increase of 3 times that of 2010 whose production was around 3.9 million tons. This is because the condition of the waters in Indonesia is very supportive of the growth of seagrass. Things that affect the growth and development of seaweed in waters include the bottom of the water, salinity, pH level, temperature, water movement, and others [2].

The more raw materials produced, the more industries engaged in seaweed processing. The highest market demand for the seaweed industry is in carrageenan products and agar. According to the Ministry of Industry, around 36% of dried seaweed is processed by domestic industries into carrageenan and agar [3]. The more seaweed processing industries, the more waste is generated. Most industrial players still rarely use it in treating their waste. The utilization of seaweed is relatively limited. Thus, the lines are still open in the utilization of this waste [4].



One of the breakthroughs that can be used in the utilization of seaweed waste is lightweight concrete. Lightweight concrete is a lightweight but also sturdy concrete. Besides, lightweight concrete also has a concept that does not require much cement in its application. So, it can minimize costs when building a building [5]. In addition, lightweight concretes also have a soundproof, more resistant to natural disasters, more resistant to fire, and others [6]. The concept of utilizing this waste is carrageenan waste, which is expected to be a substitute for sand. This is possible because the level of cellulose is quite high, thus enabling stronger and lighter bonds [7]. Due to the stronger and lighter bond, this allows the use of solid waste as lightweight concretes can be used as earthquake-resistant building materials. That is because the compressive strength of lightweight concrete *K. alvarezii* is potentially very large so that it can receive pressure from the earthquake itself. [8] This lightweight concrete of *K. alvarezii* solid waste is very suitable for use in the territory of Indonesia.

The Ring of Fire is the main factor that makes Indonesia an earthquake-prone region [9]. This series of fire rings is a very active plate in the world, namely the Eurasian plate, the Philippine plate, and the Pacific plate. The plates always move and collide towards stability. It was this shift that caused the earthquake. Hakim [9] also revealed that buildings that use concretes cannot support the burden caused by earthquake pressure, and suffer severe damage during an earthquake. That is because the compressive strength of concretes is small, so it cannot accept large loads. So that the use of lightweight concrete *K. solid alvarezii*, which has the potential to have a sizeable compressive strength can be used as earthquake-resistant building materials, so as to minimize damage caused by earthquakes.

2. Material and methods

2.1 Research tools

The tools used in this research include electric mixing, foam generator, measuring cup, scale, pail, mold, oven, and hydraulic compressive pump.

2.2 Research materials

The materials used as the primary material for making lightweight concrete include a solid by-product of the seaweed industry from PT. Kappa Carrageenan Nusantara (KCN) Pasuruan, sand, Portland cement, Semen Gresik brand, LN sikamen, water, and foam agent.

2.3 Research design

This research was conducted using a completely randomized design (CRD) with five treatments + control and four replications. The data obtained will then be processed with software to determine the effect of the addition by Product processing *Kappaphycus alvarezii* and the comparison with no additions. Data diversity was analyzed with a 95% confidence interval. To meet the assumptions underlying the analysis of variance, a homogeneity test, and a normality test was performed. Data analysis results will be continued. Duncan's Multiple Range Test if from the analysis, it is known that the treatment shows significantly different or very significantly different effects to compare which treatment produces the best results.

2.4 Work Procedure

2.4.1 Manufacturing cellular lightweight concrete

Make the mixture between cement and sand, filtered solid byproducts, water, and sikamen LN stirred until the mixture was mixed until homogeneous. After the mixture has met the requirements, added a foaming agent, and stirred until evenly distributed. Then check the density first.

The finished dough was then put into a lightweight cylindrical concrete mold. After reached three days, the lightweight concrete can be removed from the mold. Lightweight concrete then dried for 28 days. After reached 28 days, this lightweight concrete can be tested. The formulation in making lightweight concrete is in table 1.

Table 1. Formulation cellular lightweight concrete

Treatment	Concentration	Sand (Kg)	Waste (Kg)	Cement (Kg)	Water (L)	Foam Agent (L)	Polymax + Beston (mL)
T0	0%	5.10	-	2.55	4.5	4	22
T1	20%	4.08	1.02	2.55	4.5	4	22
T2	40%	3.06	2.04	2.55	4.5	4	22
T3	60%	2.04	3.06	2.55	4.5	4	22
T4	80%	1.02	4.08	2.55	4.5	4	22
T5	100%	-	5.10	2.55	4.5	4	22

2.4.2 Compressive strength test

Lightweight concrete that will be tested must be in dry air. The compressive plane of the test object is flattened. The direction of pressure in the test object is adjusted to the direction of the load pressure in use. Test specimens that are ready, the compressive strength is determined by a press machine that can adjust the pressure speed. The compressive strength of the specimens is calculated by dividing the maximum load when the specimens are destroyed, with the gross compressive area, and the results are expressed in units of N / mm² (MPa) using a digital compressive strength tool [10]. The formula for calculating the compressive strength of the lightweight concrete CLC is as follows equation (1):

$$f_c = \frac{P}{A} \quad (1)$$

Notes :

f_c = Compressive Force (N/mm²)
 P = Maximum force pressure (N)
 A = The cross-sectional area of the test specimen (mm²)

2.4.3 Flextural strength test

Lightweight concrete that will be tested must be in dry air. Lightweight concrete that will be tested will be placed horizontally and will be pressed vertically using a hydraulic compressive pump. This flexural strength will be calculated until this light-weight weight concrete will split into two. The force that has been generated will be entered into the calculation formula with the results of the MPa (Mega Pascal) calculation [9]. The calculation formula is as follows equation (2):

$$\sigma = \frac{3PL}{2bh^2} \quad (2)$$

Notes :

σ = Flextural strength (N/mm²)
 P = Load (Kg)
 L = Footstool distance (cm)
 b = The width of the specimen (mm)
 h = The thick of the specimen (cm)

2.4.4 Water absorption test

According to [11], the absorption of lightweight concretes begins with preparing lightweight concretes in advance. Then this lightweight concrete will be dried in an oven until the water content is low. Furthermore, before immersing, lightweight concrete will be weighed in advance in order to know the

dry weight of the lightweight concrete. After that, the lightweight concrete will be immersed in water for 24 hours and weighed after being soaked [12]. After that, the calculation is done with equation (3):

$$\text{Water absorption} = \frac{w_2 - w_1}{w_1} \times 100\% \quad (3)$$

Note:

W_1 = Dry weight after 24-hour oven (gram)

W_2 = Wet weight after soaked 24 hours (gram)

3. Result and discussion

In table 2, there are the results of the compressive strength test results of the lightweight concretes produced. ANOVA test results in each treatment showed an influence on the results of the addition to the strength of the lightweight concrete produced ($p < 0.05$).

Table 2. Result Data of Quality Assay Cellular Lightweight Concrete

Treatment	Compressive strength (MPa)	Flexural Strength (MPa)	Water Absorption (%)
T0 - 0%	0.73 ± 0.10^c	4.84 ± 0.46^b	28.75 ± 0.83^a
T1 - 20%	0.45 ± 0.06^d	4.58 ± 0.06^b	41.75 ± 1.79^b
T2 - 40%	0.83 ± 0.11^b	4.77 ± 0.11^b	51.00 ± 1.58^c
T3 - 60%	1.15 ± 0.45^a	5.37 ± 0.10^a	62.25 ± 1.48^d
T4 - 80%	0.70 ± 0.06^c	4.18 ± 0.08^c	76.00 ± 1.87^e
T5 - 100%	0.35 ± 0.06^d	3.22 ± 0.07^d	83.25 ± 1.30^f

In the follow-up test, it was found that there was an effect on each additional amount of waste. In the compressive strength test, there is a significant effect and not significantly different in the treatment of T0 with T4 and T1 with T5. While the flexural strength test, there is a significant effect and not significantly different in the treatment of T0 and T1. In the water absorption test, there is a significant effect between each treatment.

The best compressive strength is in the T3 treatment with a large 1.15 ± 0.45 . This is due to the effect of increasing waste. The higher the amount of waste added, the better the strength level of the lightweight concrete produced. This is because the amount of cellulose added to the material is increasing. The more cellulose in the material can cause, the more hydrogen bonds produced and are present in the material. However, if too much amount of waste is added and less amount of sand is used, it can reduce the quality of lightweight concrete. This is because sand is a filler used in the making lightweight concretes [13]. Fewer fillers can reduce the quality of the lightweight concretes produced. Because the bond between aluminum and silica in the concrete will be lower (where the source of the main silica in the concrete is lightweight in the sand). So that it can make lightweight concretes produced brittle [14].

In the flexural strength test, the best treatment is in the T3 treatment with a value of 5.37 ± 0.10 . This is due to the increasing amount of waste added to making lightweight concretes. The higher the amount of waste contained in the material, the better the strength of the lightweight concrete. This is because the hydrogen bonds produced by cellulose in the waste can help the bonds built by cement to tighten the bonds in the lightweight concrete [13]. However, too much amount of waste added can affect the quality of the concretes produced. This is because the number of filler bonds by sand is disturbed by the number of bonds produced by cellulose. This causes the more flexible lightweight concrete produced, but the strength in holding the load owned by the lightweight concrete is lower (the smaller the bond between Si and Al in the lightweight concrete) [9].

In the test of water absorption, the best treatment is at T0 with a value of 28.75 ± 0.83 . This is caused by the nature of the industrial carrageenan waste that is hydrophobic. The more waste that is

added to the lightweight concrete, the higher the absorption capacity of the lightweight concrete water. The more water absorbed inside the lightweight concrete, it can interfere with the strength of the lightweight concrete when applied (the more porous the building is when, the more material absorbs water from outside) [12].

Based on the lightweight concrete quality standard produced, the T0, T2, and T3 treatments in compressive strength tests are in accordance with SNI standards. According to [15], the standard type 1 compressive strength concrete is more than 0.70 MPa. Whereas the flexural strength, all treatments are by the flexural standard in lightweight concrete. This is because, according to the Judge, the strength of flexibility in lightweight concrete is at least 2.5 MPa. In addition to the water absorption resistance test, the T0 rain treatment (without the addition of waste) is the appropriate standard. According to Nugroho, the maximum amount of water content absorbed by lightweight concretes is 35%. So that all treatments in the water absorption test do not meet the standards.

4. Conclusion

The addition of carrageenan industry waste in the manufacture of lightweight concrete CLC influences the quality of lightweight concrete produced. The more carrageenan waste added to the lightweight concrete, the better the quality of the lightweight concrete produced. The best treatment was on T3 with a large compressive strength of 1.15 ± 0.45 , a flexural strength of 5.37 ± 0.10 , and a water absorption of 62.25 ± 1.48 .

5. References

- [1] FAO 2018 FAO. Roma
- [2] Alba K and Kontogiorgos V 2018 In *Reference Module in Food Science*. Elsevier
- [3] Be Miller J N 2019 *Journal of Carbohydrate Chemistry for Food Scientists*. 223–240
- [4] Zhao S and Zhang S 2018 In *IOP Conference Series: Earth and Environmental Science*. 113 1
- [5] Budiarto A and Purwanto A 2016 *Jurnal Riset Teknologi Pencegahan Pencemaran Industri*. 7, 23-30
- [6] Rasheed M A and Prakash, S S 2018 *Construction and Building Materials*. **162**, 857-870
- [7] Alamsjah M A, L Sulmartiwi, K T Pursetyo, M N G Amin, K A K Wardani and M D Afrianto 2017 *Journal of the Indian Academy of Wood Science*. **14**, 32–45
- [8] Onoue K, H Tamai and H Suseno 2015 *Journal if Construction and Building Materials*. **83**, 261–274
- [9] Hakim L, P Yulianto, Prihatmaji, Y Andik, W Davis, W Aji and A Billy 2010 *Jurnal Sains dan Teknologi Lingkungan*. **2**, 97–110
- [10] Wang X F, Fang C, Kuang W Q, Li D W, Han N X and Xing F 2017 *Construction and Building Materials*. 155 867-879
- [11] Fernández-Fanjul A, Tenza-Abril A J and Baeza-Brotons F 2018 *Construction and Building Materials*. **165**, 596-607
- [12] Liu X, Chia K S and Zhang M H 2011 *Construction and building Materials*. **25**, 335-343
- [13] Jitchaiyaphum K, T Sinsiri and P Chindaprasirt 2011 *Journal of Procedia Engineering*. **14**, 157–1164
- [14] Helepciuc C, Marinela B and Adrian A S 2018 *Journal of Procedia Manufacturing*. **22**, 154–159
- [15] Nugroho F I 2009 *Konduktifitas dan Ketahanan Api Batako Papercrete Sebagai Material Dinding Bangunan*. 1–10