Multidisciplinary Applied Research and Innovation Vol. 3 No. 2 (2022) 269-276
© Universiti Tun Hussein Onn Malaysia Publisher's Office

MARI

Homepage: http://penerbit.uthm.edu.my/periodicals/index.php/mari
e-ISSN : 2773-4773

Cockle Shell as An Additive in Cement Sand Brick Mixture

Mohamed Firdaus Abdul Aziz, Muhammad Azri Abdul Jabbar, Fatin Basirah Azman, Khairul Zaman Abdul Malek*

Department of Civil Engineering, Centre for Diploma Studies, Universiti Tun Hussein Onn Malaysia, 84600 Muar, Johor, Malaysia

DOI: https://doi.org/10.30880/mari.2022.03.02.030
Received 31 March 2022; Accepted 31 May 2022; Available online 28 July 2022

Abstract: This article explores the use of the cockle shell (CS) as an additive in cement-based material since the CS is high in calcium oxide (CaO), which can affect the behavior and properties of mortar. The waste cockle shells (WCS) dumped from restaurant retrieved from seafood menus might cause environmental pollution and also discomfort to the surrounding communities. The main goal of this project is to produce cement sand brick (CSB) by adding 10g, 20g and 30g of CS as an additive in mix design according to certain specifications BS 3921:1985 for density test, water absorption rate test with the standards BS 1881: 122 and compressive strength test were conducted on the 7th and 14th day. The standard by compressive strength is BS EN 772-1:2011. Density test, water absorption rate test and compressive strength test were conducted on the 7th and 14th day. The results were compared based on mix design and day of testing. It is interesting to find out that the existance of chemical composition in CS affect density, water absorption rate and compressive strength. Oyster shell is highly recommended for future study as an additive in CSB mixture.

Keywords: Additive, waste cockle shell, mix design

1. Introduction

The use of bricks in building construction is a necessity, as it has been shown to have a high durability, the cost is still low and it is very easy to obtain [1]. However, new technology systems such as Industrial Building System is becoming more popular. Green mortar is the mortar that had been produced using recycled or wasted natural materials. Cement plays the role of a binder, a substance that sets and hardens and might bind alternative materials along the way [2].

The WCS can be used as a raw addition material in concrete to strengthen the strength of the CSB. It can be used as material in the construction industry that can benefit humans and reduce the amount of them that end up as waste at landfills [3]. Besides, WCS also pollute the environment as of some irresponsible individuals dispose of rubbish in drainage systems.

The aim of this research to produce CSB by adding cockle shells with different amount as an additive in mix design. Besides, three tests will be conducted to determine the density, water absorption rate and compressive strength of CSB with CS. The results of density, water absorption rate and compressive strength will be compared among the different mix design of samples.

*Corresponding author: kzaman@uthm.edu.my

2. Materials and Methods

The materials and methods section, otherwise known as methodology, describes all the necessary information that is required to obtain the results of this study.

2.1 Materials

The raw materials used in this project are cement, sand, water and CS.

i) Ordinary Portland Cement

Throughout this project Ordinary Portland Cement (OPC) would be used. OPC is the most extensively utilised type of cement in modern construction projects because it requires only a minimal amount of mixed material and has a moderate cement strength.

ii) Sand

River sand extract from the rocks and it is accessible on riverbanks. The quality of natural river sand segregated based on its texture, which decided the grade and application in construction. The maximum sixe of aggregate will be taken is 2.36 mm.

iii) Water

Water-to-cement ratios of 0.45 – 0.60 are more commonly used. A mixture made with too much water will shrink more as the excess water separates, resulting in internal cracks and visible cracks (especially internal corners) that reduce final strength [4].

iv) Cockle Shell

CS is an edible of marine bivalve mollusk. They live in sandy and sheltered beaches throughout the world, and are heart-shaped when viewed from the end. In this study, CS were collected from a seafood restaurant. The maximum size of crushed cockle shell (CCS) will be taken is 2 mm.

2.2 Methods

Methods section consist of preparation and testing of samples.

2.2.1 Preparation of Samples

Samples of cement sand brick (CSB) were prepared and tested on the 7th and 14th day. 12 pieces of cement sand brick (CSB) were prepared for each mix design as shown in **Figure 1**. All samples were casted using 75 mm x 225 mm x 113 mm moulds. The interior surfaces of the moulds was coated with a layer of oil before placing the fresh mortar. After 24 hours, the specimens were demoulded and dried for 7 days and 14 days as shown in **Figure 2**.

Figure 1: Samples of cement sand brick with cockle shell

Figure 2: Drying process for 7 days and 14 days

Table 1: Mix Design of Sample

Type of Samples	Number of Samples	Cement (kg)	Sand (kg)	Cockle Shell (g)	Water (kg)	Water Cement Ratio
CSB + 0g CS	12	10.984	40.246	0	5.126	0.47
CSB + 10g CS	12	10.984	40.246	10	5.126	0.47
CSB + 20g CS	12	10.984	40.246	20	5.126	0.47
CSB + 30g CS	12	10.984	40.246	30	5.126	0.47

There were four types of sample prepared in this study. The number of samples by each type is produced with 12 samples. The first type is CSB without CS. Next type is adding the mixture with 10g, 20g and 30g of CS. The mix design of samples are as shown in **Table 1**.

2.2.2 Testing of Samples

2.2.2.1 Density Test

Density test is significant in measuring compressive strength. Density of hardened CSB is determined by calculating volume of sample then followed by weighing of sample. The standard used in the test is BS 3921:1985 [5]

2.2.2.2 Water Absorption Rate Test

Water absorption test was conducted in order to determine the percentage of the water absorption by the brick. The test was accordance to the BS 1881: 122 [6]. Porosity or void fraction is a measure of empty space in the CSB. Water absorption test is to determine the percentage of water absorption capacity in sample. All the sample were immersed in water for curing process 24 hours before the day of testing.

2.2.2.3 Compressive Strength Test

The compressive strength is the most important characteristic and normally used for the purposes of the specification. It was conducted based on BS EN 772-1:2011[7]. This test is the most knowledgeable, and is used as a method to measure the strength of the standard pressure for quality control purposes. Any excess moisture or any particles must be removed from the brick surface and the loading plate of the machine before conducting the test

3. Results and Discussion

The results and discussion in this section presents data and analysis of this study based on the test carried out. The results of density test, water absorption rate test and compressive strength test were carried out on the 7th and 14th day.

3.1. Density Test

Density is an important factor in the CSB manufacturing process because it affects the production cost as well as the physical and mechanical performance of a CSB. In general, the higher the density of a CSB will lead to a better physical and mechanical properties.

Table 2: Results of Density Test

Type of Samples	Average of CSB Density (kg/m^3) on 7th Day	Average of CSB Density (kg/m^3) on 14th Day
CSB + 0g CS	2096.5	2035.1
CSB + 10g CS	2184.2	2052.6
CSB + 20g CS	2105.3	2035.1
CSB + 30g CS	2078.9	1956.1

Based on the 7th day of observation, density of the CSB without CS classified as control samples were 1947.4 kg/m^3, 2105.3 kg/m^3 and 2236.8 kg/m^3 , so the average of this mixture is 2096.5kg/m^3 as listed in **Table 2**. Density of the CSB with 10g of CS were 2105.3 kg/m^3, 2210.5 kg/m^3 and 2236.8 kg/m^3 , so the average of this mixture is 2184.2kg/m^3. Density of the CSB with 20g of CS were 2052.6 kg/m^3, 2105.3 kg/m^3 and 2157.9 kg/m^3 so the average of this mixture is 2105.3 . Density of the CSB with 30g of CS were 2052.6 kg/m^3, 2078.9 kg/m^3 and 2105.3 kg/m^3, so the average of this mixture is 2078.9kg/m^3.

Based on the 14th day of observation, density of control samples were 1973.7 kg/m^3, 2000.0 kg/m^3 and 2131.6 kg/m^3, so the average of this mixture is 2035.1kg/m^3. Density of the CSB with 10g of CS were 2026.3 kg/m^3, 2078.9 kg/m^3 and 2052.6 kg/m^3 , so the average of this mixture is 2052.6kg/m^3. Density of the CSB with 20g of CS were 2000.0 kg/m^3, 2052.6 kg/m^3 and 2052.6 kg/m^3, so the average of this mixture is 2035.1 kg/m^3.. Density of the CSB with 30g of CS were 2105.3 kg/m^3, 1894.7 kg/m^3 and 1868.4 kg/m^3 , so the average of this mixture is 1956.1kg/m^3.

3.2 Water Absorption Rate Test

Water absorption rate of a CSB is influenced by the type of raw materials and design of mix.

Table 3: Results of Water Absorption Rate Test

Type of Samples	Average of CSB Water Absorption Rate (%) on 7th Day	Average of CSB Water Absorption Rate (%) on 14th Day
CSB + 0g CS	6.48	6.89
CSB + 10g CS	2.46	2.47
CSB + 20g CS	3.13	3.33
CSB + 30g CS	2.11	2.13

Based on the 7th day of observation, water absorption rate test of the CSB without CS classified as control samples were 5.41%, 6.25%, 7.79% , so the average of this mixture is 6.48% as listed in **Table 3**. Water absorption rate test of the CSB with 10g of CS were 2.50%, 3.70% and 1.19% , so the average of this mixture is 2.46%. Water absorption rate test of the CSB with 20g of CS were 2.50%, 2.56% and 4.88% , so the average of this mixture is 3.13%. Water absorption rate test of the CSB with 30g of CS were 2.56%, 2.53% and 1.25% ,so the average of this mixture is 2.11%.

Based on the 14th day of observation, water absorption rate test of the control samples were 6.67%, 6.58%, 7.41% , so the average of this mixture is 6.89%. Water absorption rate test of the CSB with 10g of CS were 1.2%, 2.5% and 3.7% , so the average of this mixture is 2.47%. Water absorption rate test of the CSB with 20g of CS were 2.5%, 2.6% and 4.9% so the average of this mixture is 3.33%. Water absorption rate test of the CSB with 30g of CS were 1.3%, 2.5% and 2.6% , so the average of this mixture is 2.13%.

3.3 Compressive Strength Test

Cement content in the mix design, type of raw materials, value of density and technique of compaction will give a significant impact on compressive strength.

Table 4: Results of Compressive Strength Test

Type of Samples	Average of CSB Compressive Strength (N/mm^2) on 7th Day	Average of CSB Compressive Strength (N/mm^2) on 14th Day
CSB + 0g CS	14.01	14.96
CSB + 10g CS	22.72	27.02
CSB + 20g CS	20.62	24.77
CSB + 30g CS	22.61	18.13

Based on the 7th day, compressive strength test of the CSB without CS classified as control samples were 14.05 N/mm^2, 13.92 N/mm^2 and 14.05 N/mm^2, so the average of this mixture is 14.01 N/mm^2 as listed in **Table 4**. Compressive strength test of the CSB with 10g of CS were 21.53 N/mm^2, 22.67 N/mm^2 and 23.97 N/mm^2 , so the average of this mixture is 22.72N/mm^2. Compressive strength test of the CSB with 20g of CS were 18.69 N/mm^2, 18.91 N/mm^2 and 24.26 N/mm^2 so the average of this mixture is 0.62N/mm^2. Compressive strength test of the CSB with 30g of CS were 22.11 N/mm^2, 22.59 N/mm^2 and 23.13 N/mm^2, so the average of this mixture is 22.61N/mm^2.

Based on the 14th day, compressive strength test of the control samples were 15.05 N/mm^2, 14.95 N/mm^2 and 14.87 N/mm^2, so the average of this mixture is 14.96N/mm^2. Compressive strength test of the CSB with 10g of CS were 27.23 N/mm^2, 28.17 N/mm^2 and 25.65 N/mm^2, so the average of this mixture is 27.02N/mm^2. Compressive strength test of the CSB with 20g of CS were 24.94 N/mm^2, 21.44

N/mm^2 and 27.94 N/mm^2, so the average of this mixture is 24.77N/mm^2. Compression strength test of the CSB with 30g of CS were 19.50 N/mm^2, 19.03 N/mm^2 and 15.85 N/mm^2 so the average of this mixture is 18.13N/mm^2.

3.2 Discussion

Density test is an important factor in the brick manufacturing process because it affects the production cost as well as the physical and mechanical performance of a brick. Water absorption rate test of a brick is heavily influenced by the type of material used in the mixture and mixing ratio, the reaction of shells, cement, and soil in the mixture can effect the workability of the brick. Finally, compressive strength is an important factor in determining a brick's load-bearing capacity. Relation between compressive strength test and water absorption rate test can stability and strength of a soil is greatly affected by the presence of moisture. High moisture content will affect the compressive strength of a brick.

3.2.1 Density Test

Based on density against type of CSB bar graph (**Figure 3**), the CSB density decreases with increasing day and CS content. 10g of CS being at its optimum as evidenced by the highest density records compared to bricks that used more CS. CSB with 30g of CS shows a drop on both the 7th and 14th day as much as 0.83% and 3.88% respectively compared to control samples. However, control sample and CSB with 20g of CS have similar compressive strength value on the both of observation.

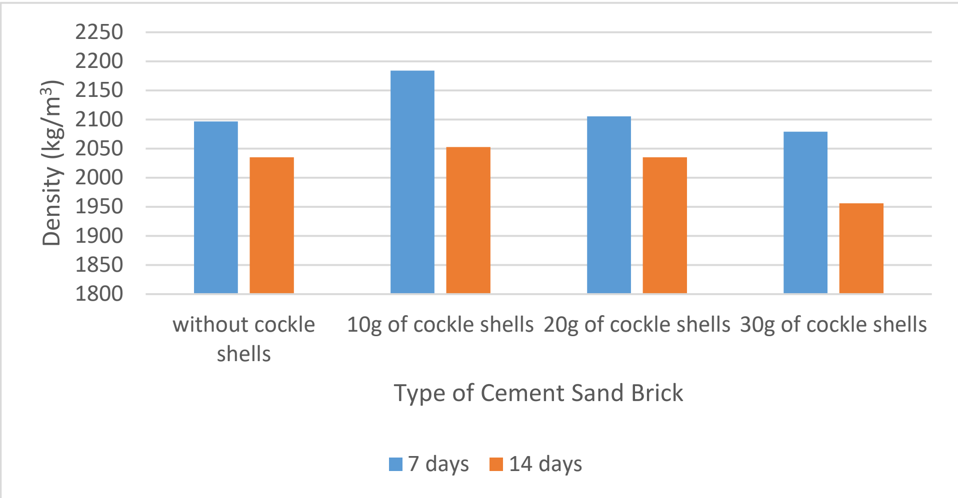

Figure 3: Comparison of cement sand brick density

3.2.2 Water Absorption Rate Test

Based on water absorption rate against type of CSB bar graph (**Figure 4**), generally the water absorption rate decreases with increasing day and CS content. 30g of CS being at its optimum as evidenced by the lowest water absorption rate records compared to other samples. CSB with 30g of CS shows an improvement on both observation day as much as 67.4% and 69.09% respectively compared to control samples.

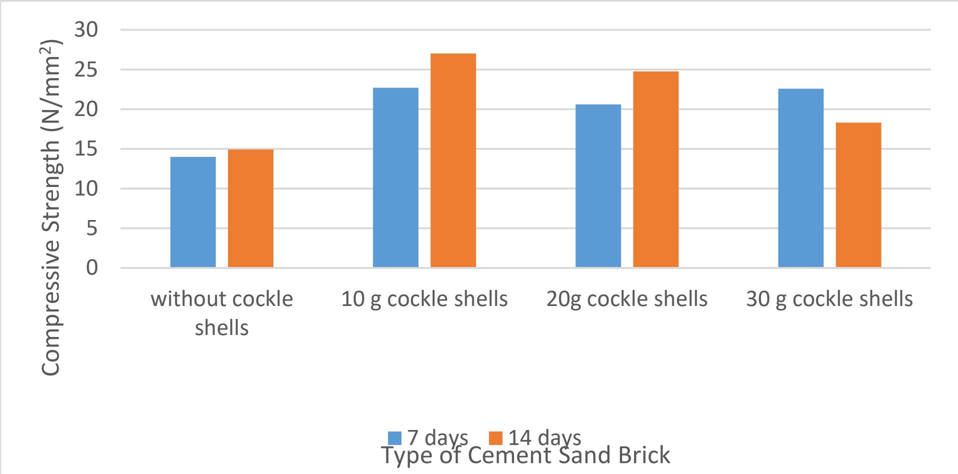

Figure 4: Comparison of cement sand brick water absorption rate

3.2.3 Compressive Strength Test

Based on compressive strength against type of CSB bar graph (**Figure 5**), generally the compressive strength increases with increment of observation day and CS content. 10g of CS being at its optimum as evidenced by the highest compressive strength records of 62.17% (7th day) and 80.61% (14th day) compared to control sample. However, 10g of CS and 30g of CS have similar compressive strength value on the 7th day wherein the value is 22.71 N/mm^2 and 22.61 N/mm^2.

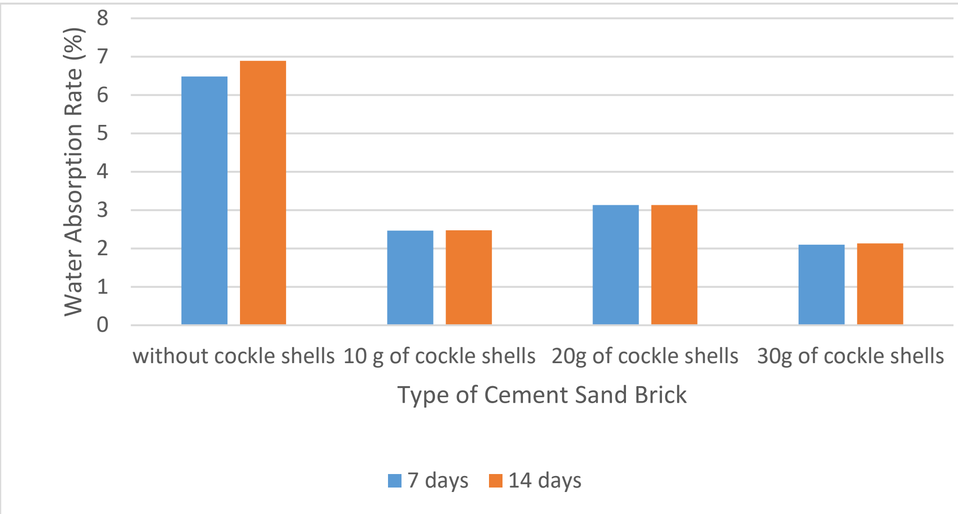

Figure 5: Comparison of cement sand brick compressive strength

4. Conclusion

The general findings written are based on the laboratory research reported in this paper. The specific conclusion that can be drawn from this study is that this study proves the additional result of 10g of cockle shell is able to improve the performance of bricks compared to bricks that use more cockle shell. In addition, the interaction of shell, cement and soil in the mixture was found to be beneficial as it could improve the workability of the mixture, however, the addition of many shells can interfere with workability due to the presence of microscopic air spaces in the brick, which increases the rate of absorption. Moisture has a great influence on the stability and strength of the soil. The moisture content of a brick affects its compressive strength. Usually the compressive strength increases in proportion to the content of the day of observation and the shell of the shell. 10g of cockle shells were at the optimum level as evidenced by the record of the highest compressive strength compared to the control samples due to the high CaO content.

References

[1] A. Konak, D. W. Coit and A. E. Smith. “Multi-Objective Optimization Using Genetic Algorithms” Reliability Engineering & System Safety, 2006.

[2] A.M. Neville, “Properties of Concrete.” 4th Edition. England: Addison Wesley Longman Limited, 1996.

[3] M. Mohamed, et al., “Effects of Experimental Variables on Conversion of Cockle Shell to Calcium Oxide Using Thermal Gravimetric Analysis”, vol.37, pp. 394-397, 2012.

[4] S. Shan. “Civil Engineering Materials.” Upper Saddle River: Prentice Hall. P, 2001.

[5] Ashraf et. al, and N. Abdullah. “Evolution of Bricks and Brick Masonry in the Early History of its Use in the Region of Today’s Serbia.” Journal of Materials in Civil Engineering, vol.18, no.5, pp. 692-699, 2010.

[6] O. H. Mohammed, R. B. Hamid and M. R. Taha. “A Review of Sustainable Supplementary Cementitious Materials as an Alternative to all-Portland Cement Mortar and Concrete.” Australian Journal of Basic and Applied Sciences, vol.6, no.9, pp. 287-303, 2012.

[7] BS EN 772-1 “Methods of Test for Masonry Units.” Determination of Compressive Strength. (London: British Standard) pp 1-18, 2011.