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Development of cement boards from coconut shell ash for energy and environment conservation

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Abstract

This research aims to develop the cement board from coconut shell ash. The Portland cement type1: fine sand: tap water ratio is equal to 1: 0.4: 0.33 by weight. The 5 ratios of Portland cement type1: coconut shell ash include 1: 0.12, 1: 0.13, 1: 0.14, 1: 0.15 and 1: 0.16 by weight. The cement board production uses the pressure casting in normal temperature (30 – 35 degree of Celsius) and controls the 0.75 g/cm^3 of density, then test the properties of cement-bonded fiberboard follow TIS 878-2537 standard (cement bonded particle board: high density). From the results, 1: 0.12 is the most suitable ratio of cement board from coconut shell ash. This developed cement boards can reduce the quantity of coconut shell ash waste and have the good thermal insulation.

Keywords: Cement board, Coconut shell ash, Thermal insulation, Environment

1. Introduction

Cement boards or cement bonded particle boards are a construction material for construction the prefabricated houses which used as the walls instead of bricks [1]. From the high volume of Thai coconut export, it leaves the wastes of coconut, especially the coconut shell (more than 222,000 tons per year). These wastes usually dispose by burning to generate the electricity. However, this disposal cannot eradicate all of coconut shell but it remains many coconut shell ash [2]. When analyzing the characteristics of coconut shell ash, there combine the chunk and powder of coconut shell which are light weight and high hardness. Therefore, it is possible to put coconut shell ash as the aggregates of cement boards. The objectives of this study are to develop and test the cement boards mixed with coconut shell ash. And these results can lead the utilization of coconut shell ash and preserve the environment from waste disposals.

2. Materials and methods

2.1 Sieve the coconut shell ash through sieve no.8 (2.38 mm) for size selection (see Figure 1) which the coconut shell ash has 1.97 of specific gravity and the chemical composition as show in Table 1.

2.2 Design the 5 ratios of cement boards mixed with coconut shell ashes by weight as Table 2.

2.3 Weight and mix the mixture by measure and concrete mixer.

2.4 Cast the mixture to cement board size 30x30x1.5 cm by using the vibrate compression machine (Figure 2) and flip stand. The cement board casting was controlled by density (must higher than 0.75 g/cm^3) [3].

2.5 Cure the cement board mixed with coconut shell ash in the air for 7, 14, 21, and 28 days that follow the testing standards.

2.6 Test the properties of cement board mixed with coconut shell ash with the TIS.878-2537 [4] and ASTM C177 [5]. There are consists of general characteristic, density, thermal conductivity, swelling, bending strength and elastic modulus (Figure 3), and tensile strength perpendicular with surface.

2.7 Analyze and conclude the results of cement boards mixed with coconut shell ash test.

Table 1 The chemical composition of coconut shell ash from XRF analysis

Element	%
SiO_2	47.30
MgO	16.05
Al_2O_3	15.34
Fe_2O_3	12.38
CaO	0.57
K_2O	0.53
Na_2O	0.49
ZnO	0.29
MnO	0.20

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Table 2 Mixture by weight of cement boards from coconut shell ash

Ratio	Cement	Fine sand	Coconut shell ash	Tab water
1:0:12	1	0.4	0.12	0.33
1:0:13	1	0.4	0.13	0.33
1:0:14	1	0.4	0.14	0.33
1:0:15	1	0.4	0.15	0.33
1:0:16	1	0.4	0.16	0.33

Figure 1 Sieving of coconut shell ash through sieve no.8 for size selection

Figure 2 Vibrate compression machine is used to cast the cement boards

Figure 3 Test of bending strength and elasticity modulus of cement boards

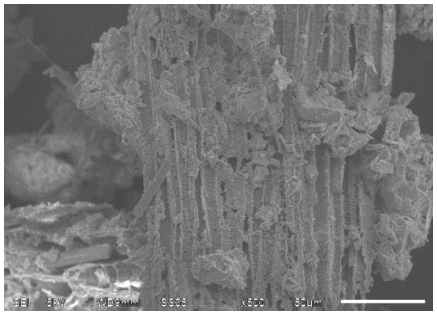

Figure 4 Image of coconut shell ash by SEM at zoom 500 times

3. Results and discussions

The test results of cement board mixed with different coconut shell ash quantities include the general characteristic, density, thermal conductivity, swelling, bending strength, elastic modulus, and tensile strength perpendicular with surface that show as following.

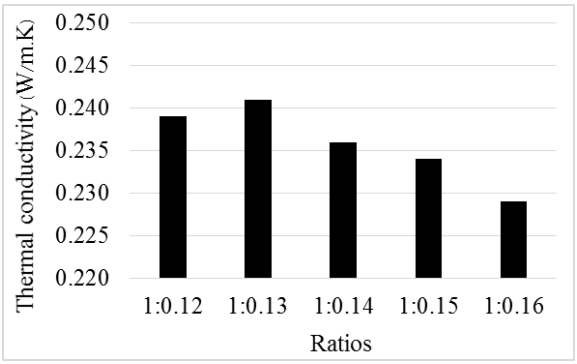

Figure 5 Thermal conductivity of cement boards mixed with coconut shell ash at 28 days

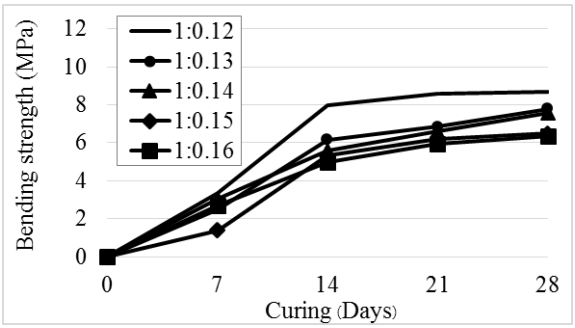

Figure 6 Bending strength of cement boards mixed with coconut shell ash

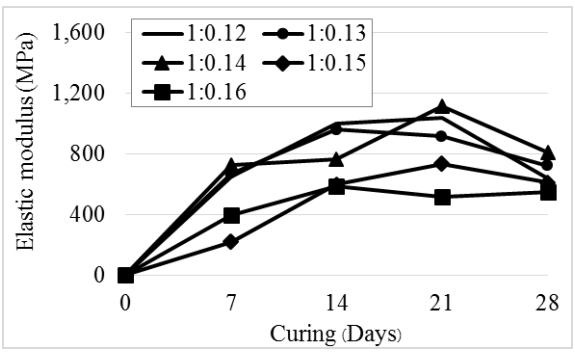

Figure 7 Elastic modulus of cement boards mixed with coconut shell ash

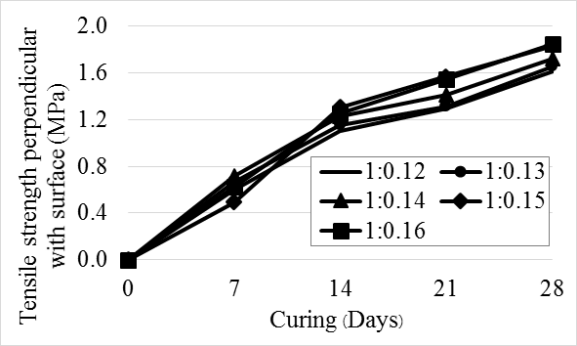

Figure 8 Tensile strength perpendicular with surface of cement boards mixed with coconut shell ash

From the results, 5 ratios of the cement board mixed with coconut shell ash had the good characteristics both of thickness and surface as the requirement of TIS.878-2537 standard [4]. When mixed the different ratios of coconut shell ash into the cement board, there were many effects to the properties including: the thermal conductivity, bending strength, elastic modulus, and tensile strength perpendicular with surface. The porosity of coconut shell ashes (Figure 4) in cement boards had affecting to decrease the thermal conductivity (Figure 5) and prevent the heat transfer [6]. The thermal conductivity of every ratios of cement board mixed with coconut shell ash can pass the TIS.878-2537 standard (no greater than 0.25 W/m.K) [4]. Moreover, the coconut shell ash also decreased the bending strength and elastic modulus of cement boards (see Figure 6 and 7) which lower than the TIS.878-2537 standard (must higher than 9 and 3,000 MPa, respectively) [4]. The values of elastic modulus were confused from the uncertain distribution of porous coconut shell ash that affected the strength behaviors, especially the values related with the defection as elastic modulus. According to Figure 8, the tensile strength perpendicular with surface of cement boards were increased by coconut shell ash which all the cement boards mixed with coconut shell ash can pass the TIS.878-2537 standard (must higher than 0.5 MPa) [4]. The tensile strength of cement boards mixed with coconut shell ash were increased because the characteristic of some chunk in coconut shell ash had the tapered shape [7] as see in Figure 4. When compared the density of cement boards mixed with coconut shell ash and the standard of TIS.878-2537, there are 2,280 to 2,330 kg/m^3 [4] of cement boards mixed with coconut shell ash which higher than the standard almost 2 times (the density must be 1,100 to 1,300 kg/m^3). While the swelling of all cement boards were in range of the TIS.878-2537 with the values less than 2% (0.79 to 0.83% were the swelling values of the every sample) [4].

4. Conclusions

The development of cement board from coconut shell ash for energy conservation and environmental shown that coconut shell ash could cast by using the vibrate compression machine and flip stand. Result of testing properties when compared with TIS. 878-2537 found that the some properties of cement boards mixed with coconut shell ash still could not pass the standard. According to the porous surfaces and tapering shape of coconut shell ash, the increasing of this ash can improves the thermal insulation and tensile strength perpendicular with surface of the cement boards. The suitable ratio of cement board mixed with coconut shell ash is 1:0.12 which had highest bending strength. Although the density, bending strength, and elastic modulus of cement board mixed with coconut shell ash could not pass the standard, there are possibility to produce as the cement board products because this standard is not perfect controlling for every markets. Moreover, the production of cement board mixed with coconut shell ash is more quickly (1 minutes of casting process) and low investment cost (use the machine as same as concrete block production) when compare to common cement board production (12 hours of casting process). Furthermore, this cement board product can lead the utilization of coconut shell ash and preserve the environment from waste disposals.

5. Acknowledgements

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