Board of Lightweight Foaming Cement

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Abstract: In the building of ceilings, foam mortar can be utilized instead of cement board. This lightweight material may make installation and maintenance easier for users. This study aimed to determine the physical and mechanical properties of lightly foamed cement boards, investigate the influence of admixture on flexural strength, and determine the effect of admixture on flexural strength. The research method used is an experimental method by making cement board test objects. As an independent variable the composition of the mixture with a ratio of 1 Cement: 1.2 Sand: 0.47 phase, with a mortar ratio of 0.45: 0.55; 31% glass fiber and 1:30 foam agent as well as 6 different admixture variations, namely 0%, 0.2%; 0.4%; 0.6%, 0.8% and 1.0%. The dependent variable consists of density, specific gravity, nailing ability, and flexural strength. The results showed that the higher the admixture content, the easier the fresh foam mortar mix to work with. For the ability to nail all cement boards, it does not split and there are no surface cracks, and also the nails are easy to pull out. The density value tends to decrease from 0.902 to 0.719 and for specific gravity, it decreases from 0.944 to 0.749. The value of flexural strength tends to increase and the optimum value is obtained at 0.8% admixture variation of 60.44kg/cm2. The lightweight foamed cement board still meets the specifications and this lightweight foam mortar mix can be used as an alternative to the lightweight foamed cement board for ceilings.

1 INTRODUCTION

The ceiling, which serves as a cover for the room's top, is an important part of the construction process. Because it is intended to facilitate installation and maintenance, a ceiling made of cement board must be light. The incorporation of fiber in composite materials can boost flexural strength by up to 24.2 MPa, according to research.(Lukmanova et al, 2019).

The findings of a study on glass fiber in concrete show that the level of workmanship is difficult and it is necessary to use admixture to facilitate the concrete mixing process (Sharma et al, 2019).

When using portland cement for wood fiber cement (WFC) boards, it takes a long time to set and is difficult to compact. The water-cement ratio of WFC paste was found to be 1:1.3, while the wood-cement ratio was 1: 1. The water-cement factor, which affects the production of wood-fiber cement boards, has a magnitude of 1: 1. Working will become more challenging if the ratio used is 1:1,3 (Han, Tan and Zhao, 2017).

Cement board with 5:95, 15:85, and 25:75 fiber/cement ratios with pressures of 0, 1.4, 2.4, 4.2, 5.5, 6.9, and 8.3 MPa. As the amount of waste paper on the board increased, the results of the flexural strength test and the modulus of rupture fell. The fiber content and pressure optimal levels were 5% and 6.9 MPa, respectively. Under ideal circumstances, the cement board that has been tested meets the flexural strength requirements for the Grade 2 cement board according to ASTM C 1186 (Rashid, 2019).

The impact of foam agents on compressive strength is diminishing. The average compressive strength created by adding 0%, 20%, 40%, 60%, and 80% foam resulted in average compressive strengths of 21.68 MPa, 7.92 MPa, 4.53 MPa, 0.75 MPa, and 0.38 MPa, respectively(Karimah, 2017).

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The percentages of fly ash added to the sand weight are 0 percent, 15%, 30%, 45 percent, and 60 percent. According to the ratio of 1 foam agent: 40 water, the percentage addition of foam volume to the volume of concrete is 20%, 30%, and 40%. The findings of this study show that the inclusion of fly ash and foam has a significant impact on the density and compressive strength of lightweight concrete, as well as a moderate effect.

The use of lightweight bricks combined with foam technology is projected to lower the structure's dead load. There are numerous methods for making lightweight bricks, including employing lightweight pebbles like quicksand and gas bubbles (air) in the mortar mixture(Darwis et al, 2019).

Concrete with a foam agent content of 0.6 lt/m3, using quartz sand of 4.02 MPa, split tensile strength with a foam agent content of 0.6 lt/m3, using woro sand of 0.34 MPa, and strong flexural concrete blocks with a foam agent content of 0.6 lt/m3, using 0.738 MPa of Woro sand, had the highest average compressive strength (Murtono, 2015).

The higher cement portion increased the physical and mechanical properties of the cement bonded board. The average flexural strength value of cement board is 48.26 kg/cm2. This value indicates additional the bending strength of the board by 31% and with an average cement board density of 1.01 (Sulastiningsih, 2008).

Because the production of cement boards is not difficult, it can be done by hand or by machine. By pushing on a cement board that has been printed with multiplex and clamps, the manual approach can be used (Wiyono and Susilowati, 2011).

With the inclusion of chopped mineral water bottle waste, the flexural strength of the cement board does not exceed the required level of 100 kg/cm2 (Anggraini, Ramadian and Susilowati, 2019).

The findings of the coconut fiber analysis revealed that the more coconut fiber utilized, the lower the density and specific gravity, increased thickness development, moisture content, and water absorption, and increased flexural strength up to a variation of 0.7 coconut fiber content.

Low-density particleboard is used for ceilings, sound absorbers, and ornamental functions in public buildings, whereas high-density cement boards are used for doors, flooring, insulation, and exterior and interior walls (Saputra, 2014).

Cement boards must meet certain quality specifications. Without generating cracks or other faults, sheets must be easily cut, sawed, drilled, and fastened. The ability to be nailed and pulled is good if no more than 20% of the nailing creates faults or cracks for each sheet based on the number of tests nailed. 100kg/cm2 is the typical minimum flexural strength. Low, medium, and high density cement boards with density values of 0.4gr/cm3; 0.4 to 0.84 g/cm3 and 0.84gr/cm3 are the requirements for physical and mechanical qualities.

Cement board has both benefits and drawbacks, including fungus, insect, and fire resistance, as well as strong internal stability. With high dimensions, the cost of maintaining a house made of cement boards will be cheaper (Hendrik, 2005).

The cement board is a light weight material. In high-rise building applications, this can cut transportation and installation costs, as well as construction loads, resulting in structural and foundation cost reductions. Another disadvantage is that cement board has a high density, which makes cutting and installing it difficult (Husin and Agustiningtyas, 2008).

A foam agent is a concentrated surfactant solution that needs to be dissolved in water. Surfactants are chemicals that cling to the surface of the interface and activate it. Foam agent 11 (trademark NAPTHA) was employed as an ingredient in a mix of high-quality cement boards for brick mixtures in this investigation. 1 liter of Foam Agent is mixed with 30 liters of clean water for use. This foaming agent's job is to keep air bubbles from forming during the mixing process, resulting in lightweight concrete. This foaming agent can also be used as a liquid raw material to make high-quality foam for lightweight brick combinations, and it can help to speed up the drying and hardening process.

Making foam necessitates a certain amount of air pressure and works to move the air mass in each unit area. The effect of air pressure on the mixing of water and foam ingredient is significant. A foam generator and compressor are used to create foam. Due to the higher alkaline nature of the foam, the higher the air pressure, the lighter the foam created, and vice versa (PU-net, 2017).

Foam mortar is made up of cement, water, fine aggregate, admixtures, and particular foam fluids, and it works by trapping a lot of gas or air bubbles in the cement mixture, resulting in a lot of air pores in the concrete (Hidayat, 2018).

Foam liquid (foam agent) is a material formed by trapping a large number of gas bubbles in a liquid or solid, mainly in the form of surface-active raw materials and vegetable protein, in the form of a liquid mixed with water and stirred with a foam generator until produce foam.

Glass Fiber is a brittle solid material that is clear and translucent (translucent). Glass fiber has the

potential to survive for hundreds, if not thousands, of years. The phrase "fiberglass" comes from glass fiber. Glass fiber is created by stretching molten glass to a diameter of 0.005 mm - 0.01 mm. Glass is made up of silicon dioxide (SiO2), sodium oxide (Na2O), calcium oxide (CaO), and other components.

The inclusion of a foam ingredient in this mortar reduces the weight of the mortar and provides numerous pores for water absorption. Meanwhile, the use of this accelerator helps to speed up the drying/hardening of the foam mortar, but it also has an effect on the volume of the foam mortar.

From the reference above, the initial hypothesis is that the use of admixture on foam mortar can facilitate the work of this cement board. Another thing is the percentage of fiber used at the optimum value, which is 31% and the ratio of mortar and foam is 0.45 and 0.55 with foam agent ratio is 1:30.

This study aimed to determine the physical and mechanical properties of lightly foamed cement boards, investigate the influence of admixture on flexural strength, and determine the effect of admixture on flexural strength

2 RESEARCH METHOD

This research was conducted at the Civil Engineering Materials Test Laboratory of the Jakarta State Polytechnic. The materials used in this study were cement, sand, foam agent, and admixture with the trademark Naptha.

The research method used is the experimental method by making a light foamed cement board test object in the form of a 32 x 32 cm cement board, then cut into pieces to test the characteristics of the cement board. 1 Cement : 1.2 Sand : 0.47 phase, with a mortar ratio of 0.45 : 0.55; 31% glass fiber, and foam generator with a pressure of 4 bar for foam 1:30 and using 6 variations of 0.0 admixture; 0.2 ; 0.4 ; 0.6 ; 0.8 ; 1.0% by weight of cement. The dependent variable consists of density, specific gravity, water absorption, nailing ability, and flexural strength. Each variable has 3 test objects. With 6 variations, the number of test objects is 90 and can be seen in Table 1. as follows.

Table 1: Number of sample in *Admixture*.

Type of Test	Number of Test Object *Admixture* (%)						Quantity test obejct
	0,0	0,2	0,4	0,6	0,8	1,0	
Density	3	3	3	3	3	3	18
Specific Gravity	3	3	3	3	3	3	18
Water Absorption	3	3	3	3	3	3	18
Nailing ability	3	3	3	3	3	3	18
Flexural Strength	3	3	3	3	3	3	18
Quantity	15	15	15	15	15	15	90

Stages of making lightweight foamed cement board test specimens:

1. After the equipment and materials are prepared, a trial mix is carried out to get the right mixture by making a mixture of foam agents with water at a ratio of 1: 30.
2. Put the mixture of water + foam agent into the sticky foam gun that is already in contact with the compressor
3. Mixing the mortar with the foam that has been made and stirred using a mixer or mixer until the mixture is homogeneous
4. The mold is coated with oil so that the cement board mixture is easy to remove from the mold
5. Pour the mixture into the mold and followed by installing a layer of glass fiber on top of the mortar in 3 layers. The cement board is leveled with the help of a spatula until smooth and covered with plastic and multiplex.
6. Pour the mixture into a 5x5x5cm cube mold.
7. After 7x24 hours the cement board is removed from the mold and treated by placing the cement board in a clean and dry place for 14 or 28 days before testing.
8. After 14 and 28 days, the cement board is cut to the specified sizes according to the test standards.

Figure 1: Resulted foam.

Figure 2: Fiber glass layers.

3 RESULT AND DISCUSSION

The test results of fine aggregate and cement meet the requirements, as shown in Table 2.

Table 2: Sand and Cement properties.

Tests	Unit.	Results of Testing	Specification Min	max
FINE AGGREGATE			-	-
-Bulk Specific Gravity		2.51	2.5	-
Water Absorption	%	0,88	-	3
Loose Volume Weight	Kg/m3	1211,67		
Solid Volume Weight	Kg/m3	1448,15		
Fine Modulus		2,45	Zone 1	
Sludgelevels	%	0,48		
CEMENT				
Specific Gravity		3,07		
Loose Volume Weight	Kg/m3	1150,33		
Solid Volume Weight	Kg/m3	1225,41		

From table 2 it can be seen that the specific gravity of either cement (3.07) or sand (2.51) has a value that is still within the normal limits.

3.1 Density

The addition of admixture variations has a strong effect on the board density value. The value of R square is 0.914, which means that the addition of admixture variation has an effect of 91.4% on the board density value. The resulting significance value is 0.003 < 0.05, which means that the addition of admixture variations has a significant effect on the density value of the cement board. The regression coefficient has a negative effect so that the higher the addition of admixture variations, the lower the density value of the resulting board.

This cement board is included in the high-density category, for admixture variations 0.2 and 0.4, while for admixture variations 0.6 to 1 is included in the medium density category with values from 0.4 to 0.84 gr/ cm3.

The difference between this cement board and the results of Sulastiningsih (2008) is 16.42% lower in the high-density board category. This investigation belongs to the medium density cement board category

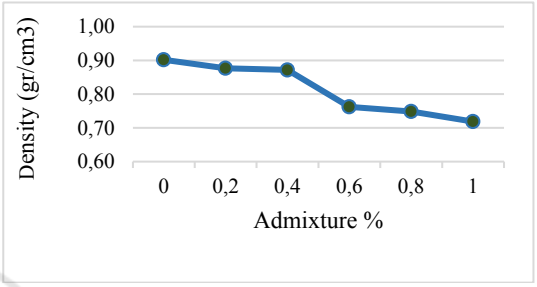

Figure 3: Density.

3.2 Specific Gravity

The addition of admixture variations has a strong effect on the specific gravity. The value of R square is 0.960, which means that it has an effect of 96% on the specific gravity. The resulting significance value is 0.001 < 0.05, which means that the addition of admixture variation has a significant effect on specific gravity and indicates that the regression coefficient has a negative effect.

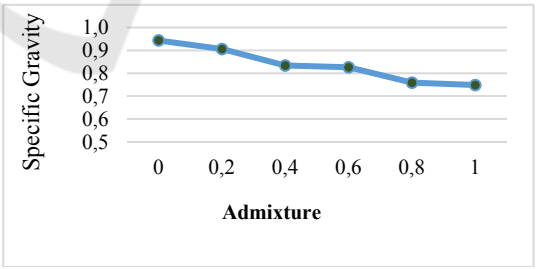

Figure 4: Specific Gravity.

The higher the addition of admixture variations, the lower the specific gravity produced. All mixtures had an average density of 0.944 to 0.749. When compared to the results of Rahmadanti and Susilowati's (2019) research, the specific gravity is 58.1 percent lower. Because the foaming ingredient causes pores to form in the cement board mixture, the specific gravity of the cement board decreases, making it lighter.

3.3 Nailled Abillity

Nailing ability is the ability of cement boards to be nailed with the condition that no more than 20% of the surface will cause defects/cracks. The test results, in the admixture variation of 0.0 to 1.0, the cement board is not split, there are no surface cracks and the nails are easily removed. The research findings of Irvan et al (2020) are comparable in that this cement board is simple to nail.

3.4 Flexural Strength

The standard three-point loading test is ASTM C78 being observed for flexural strength testing. The flexural test evaluates the tensile strength of concrete indirectly.

The addition of admixture variations has a strong effect on the flexural strength. Based on the R square value of 0.995, which means that the addition of admixture variations has an effect of 99.5% on the flexural strength. The resulting significance value is 0.007 < 0.05, which means that the addition of admixture variations has a significant effect on the Flexural Strength. The regression coefficient has a fluctuating effect, that is, it rises and falls depending on the amount of variation of the added admixture. In the admixture variation of 0 to 0.8, the flexural strength increased and decreased in the 1% variation.

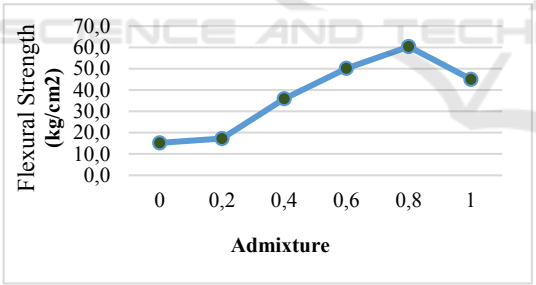

Figure 5: Flexural Strength.

The optimum level of flexural strength occurred at the admixture content of 0.8%, the value was 60.438kg/cm2. This value still meets the requirements of cement board for ceilings. Because the cement board mixture does not employ admixture, the Flexural Strength that occurs is 20 percent higher when compared to the results of Sulastiningsih (2008) and the Flexural Strength that occurs is 60 percent higher when compared to the results Lukhmanova (2019). Meanwhile, as compared to Murtono and Suhendro (2015)'s findings, the flexural strength is 17.6 percent lower. This is due to the fact that the foam agent and additive utilized are not the same.

4 CONCLUSIONS

Statistical test results show that:

The variation of admixture 0 to 1% by weight of cement has a strong and significant effect on the value of density, specific gravity and flexural strength, because the R square value is > 90% and the significance value is < 0.05.

In addition, the addition of admixture to the nailing ability test, can make the cement board not split, there are no surface cracks and the nails are easy to remove.

The optimum admixture content is 0.8% with a density value of 0.749 kg/cm3; Specific Gravity 0.759; Flexural strength of 60.44kg/cm2 and all mixtures of lightweight foamed cement boards still meet SNI standards for medium density boards and for ceilings.

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