IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE)
e-ISSN: 2278-1684,p-ISSN: 2320-334X, Volume 21, Issue 3 Ser. 2 (May. – June. 2024), PP 13-19
www.iosrjournals.org

Water Absorption Of Cellular Lightweight Concrete Using Rice Husk Ash As Additive Material

Nur Anny Suryaningsih Taufieq[1], Irma Aswani Ahmad[2], Nurlita Pertiwi[3]
[1,2,3]*(Department Of Civil Engineering And Planning Education / Universitas Negeri Makassar, Indonesia)*

Abstract:
Background*: Developments in the field of science continue to increase every year. The increasingly rapid growth of knowledge has given rise to new ideas, especially developments in the field of wall construction. Developments in the field of wall construction have discovered new construction materials, such as lightweight concrete. Lightweight concrete is an alternative building material to replace red brick when making walls. Lightweight concrete has a lighter specific gravity than bricks with a density of 600-1800 kg/m3 and is supported by a maximum absorption value of 25%.*
Materials and Methods*: This research used rice husk ash as an additional ingredient in the lightweight concrete mixture. The main aim of this research is to determine the effect of adding rice husk ash on water absorption in lightweight bricks. The research was carried out in several stages: making test objects with a variation of 0% rice husk ash added, 2.5%, 5%, 7.5%, and 10%. Furthermore, the Water Absorption Test was carried out using the SNI 8640-2018 standard.*
Conclusion: *The research results found that the highest water absorption value was in the 10% variation with a value of 28.81%, and the lowest was in the 2.5% variation with a value of 20.16%.*
Key word*: Rice husk ash; Cellular lightweight concrete; Water absorption; Porosity; Foam concrete.*

Date of Submission: 16-05-2024 Date of Acceptance: 26-05-2024

I. Introduction

Developments in the field of science continue to increase every year. The increasingly rapid growth of knowledge has given rise to new ideas, especially developments in the field of wall construction. In its development, brick walls have been one of the most popular. In general, concrete brick is a wall material made from a mixture of Portland cement, water, aggregate, or other added materials. This brick is intended for use in non-load-bearing partitions, but under certain conditions, it may be suitable for use in non-load-bearing external walls above ground level. The weight of this brick for the light category is less than 1680 kg/m3, with maximum water absorption ranging from 25% - 45% depending on the environmental humidity level [1].

The demand for lightweight construction gave rise to the type of lightweight concrete bricks used as walls. Lightweight concrete can be designed to meet the same strength as regular bricks. 2 types of lightweight concrete are often used in building walls: Autoclaved Aerated Concrete (AAC) and Cellular Lightweight Concrete (CLC). These two types of lightweight concrete are made from the essential ingredients of cement, sand, and lime; what is different is the way they are made. In the AAC type, the air bubbles in the brick are made by adding alumina flour, while in the CLC type, the air bubbles are created by adding a foaming agent.

Research is currently being developed on replacing non-renewable materials with waste materials to increase or improve quality and consider economic aspects. Fly ash (coal-burning waste) is used as a substitute for cement in making CLC-type lightweight concrete [2] [3] [4] [5] [6]. Bagasse, cement with white bagasse ash, and aluminum powder are also used to make lightweight concrete. The results showed significant improvements in compressive strength, dry density, and water absorption [7] [8]. Furnace slag (steel production waste) is a relatively new type of environmentally friendly construction material. This material is used to make lightweight concrete [9] [10] [11]. Furthermore, [12] [13] uses palm oil industry waste, namely palm oil fuel ash as a cement substitute and palm oil clinker as sand. The lightweight concrete products produced contribute to the sustainable development of the construction industry and the agricultural sector.

One modification that can be made to lightweight concrete is adding organic or non-organic materials available in abundance but not used optimally. Rice husk ash, agricultural waste, is the material chosen as additional material. Rice husk ash has a low bulk density and is resistant to weather changes, so it is the right choice as an additional material for lightweight concrete. Previous research has proven that the lightweight concrete produced has a high level of strength good thermal insulation properties, and are equivalent to thermoceramic blocks or lightweight concrete. By using rice husk ash as the primary raw material, this lightweight porous concrete-making technology can also help solve the problem of disposing of rice husk ash waste [14]. Furthermore, rice husk ash as a substitute material up to 60% by weight of cement succeeded in reducing water absorption. However, an increase in compressive strength did not accompany this, and the maximum strength was achieved when using a substitute of only 40% of the cement weight. To ensure harmony between water absorption and the compressive force of lightweight concrete, rice husk ash is used as an additional ingredient in the mixture without reducing the amount of cement.

The secondary hydration process due to rice husk ash is expected to increase the compressive strength of lightweight concrete. Besides that, it will not interfere with the pore formation process due to bubbles that occur from the foaming agent. The results of this research will produce lightweight concrete with good quality and reduce rice husk ash waste due to its use in the mixture.

II. Material And Methods

The type of research used is experimental research in the laboratory. The lightweight concrete measures 10 cm x 20 cm x 60 cm. The percentage of rice husk ash used in the mixture is 0% - 10% of the cement weight. Rice husk ash is an additional material mixed with sand, cement, and water. A foaming agent is used to create bubbles, and Stronger and Plasticier additives are used to maintain viscosity and strength. Each percentage variation was made into 2 blocks, so there were 10 blocks.

The test carried out for all beams is an absorption test following the standards in [15]. A ventilated oven of appropriate size and capable of maintaining a constant temperature of 110 ± 5°C for at least 24 hours. Next, absorption is calculated using the formula:

$$\text{Absorption, lb/ft}^3 = [(w_s - w_d)/(w_s - w_i)] \times 62.4$$
$$\text{Absorption, kg/m}^3 = [(w_s - w_d)/(w_s - w_i)] \times 1000$$
$$\text{Absorption, \%} = [(w_s - w_d)/w_d \times 100$$

where:
w_s = saturated weight of specimen, lb [kg],
w_i = immersed weight of specimen, lb [kg], and
w_d = oven-dry weight of specimen, lb [kg].

III. Result

Material Preparation

The materials used for mixing lightweight bricks are sand (Figure 1), cement (Figure 2), water (Figure 3), and rice husk ash (Figure 4). Because the lightweight bricks made are of the Cellular Lightweight Concrete (CLC) type, additional materials are used in the form of Spectafoam Edema foam agent (Figure 5), Stronger Edema hardener (Figure 6), and accelerated mixing of WR Edema plasticizer (Figure 7).


Figure 1. Fine Aggregate **Figure 2**. PCC Cement


Figure 3. Water **Figure 4**. Rice Husk Ash

Figure 5. Foaming Agent **Figure 6**. Stronger **Figure 7**. Plasticizer

Making Light Brick Molds

The mold measures a square cross-section of 10 cm x 20 cm while the length is 60 cm. 9 mm plywood is used and assembled using nuts. Figure 8 shows a picture of the molds used.

Figure 8. Multiplex Molds

Making Light Bricks

Mixing is done per block, putting water into a bucket and then the edema spectafoam liquid. The two ingredients are stirred using a mixer (Figure 9) until the mixture becomes foamy. Stirring is stopped when the foam is really light, so if you put it upside down, it won't come loose. Next, cement, sand, and rice husk ash are added at a low mixer speed while continuing to stir (Figure 10). The mixer must be an electrically driven paddle-type mixer with a minimum capacity of 0.10 m^3 and an operating speed of 40 to 50 rev/min [16].

Finally, after mixing everything well, add the stronger, plasticizer solution and stir until evenly combined. The even mixture is immediately molded into a greased mold (Figure 11).

Figure 9. Mixer

Figure 10. Mixing Foaming, Fine Aggregate, Cement, and Water

Figure 11. Molding

Water Absorption Test

The specimen was cut with an electric saw (Figure 12) from two blocks at both ends, so the specimen size was 200 mm x 200 mm x 100 mm (Figure 13). The test specimen was placed in an oven (Figure 14) at 110ºC for 24 hours until the weight remained constant. After the oven-dried test object is weighed, the test object is then soaked (Figure 15) for 24 hours. The test object is then weighed before being wiped to remove water on the surface.

Figure 12. Specimens Preparation

Figure 13. Water Absorption Specimens

Figure 14. Drying the Specimens in the Oven

Figure 15. Submerge the Specimens Below the Water Surface

The results of the water absorption test can be seen in the graph in Figure 16. The absorption capacity of 0% ASP lightweight brick was 24.66%. Meanwhile, the absorption capacity of light bricks with 2.5% ASP decreased to 20.16%. Furthermore, the % absorption capacity of 5% increases again to 22.79% but is lower than light bricks without ASP. The absorption capacity of light brick with 7.5% increased slightly to 22.88% but was lower than light brick without ASP. Then, the absorption capacity of light bricks, at 10%, is 28.81% higher than the absorption capacity without ASP.

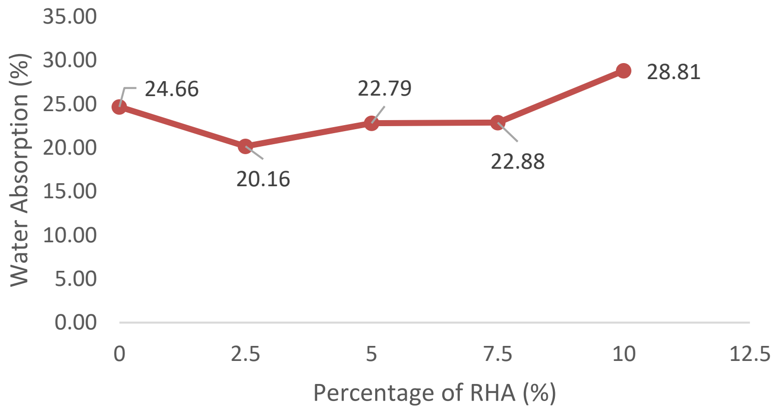

Figure 16. Relationship Between Percentage of RHA and Water Absorption

IV. Discussion

Foaming Agent Mixing Process

Mixing the foaming agent is done in the first part of the mixing. Water is added first, and then the foaming agent solution is added. The next stage is to mix with a mixer until air bubbles (foam) form evenly. Mixing with this mixer is stopped if the foam sticks to the palm even though the palm is turned upside down (Figure 17). Next, sand, cement, and rice husk ash are added while stirring with a mixer. After the mixture is homogeneous, add a chemical solution in the form of a stronger and plasticizer. The solution can be poured into the mold when it is mixed well.

Figure 17. The Density of the Foam

The Proportion of Foaming Agent, Sand, and Rice Husk Ash

The proportions of the mixture of lightweight brick-forming materials in this research were carried out by trial and error. First, trial and error is carried out to determine whether the brick's specific gravity is light.

The trial results for 1 light brick measuring 10 cm x 20 cm x 60 cm were 4.5 kg of cement, 10 grams of foaming agent, 3 liters of water, and 5 kg of sand. The weight of 1 liter of mixture is 1140.6 kg (Figure 18). This shows that the specific gravity of the mixture is 1140.6 kg/m^3. This value meets the requirements of SNI 2847-2013, namely, the density is between 1,140 kg/m3 to 1,840 kg/m^3.

Figure 18. Wet Solution Weight

Absorption

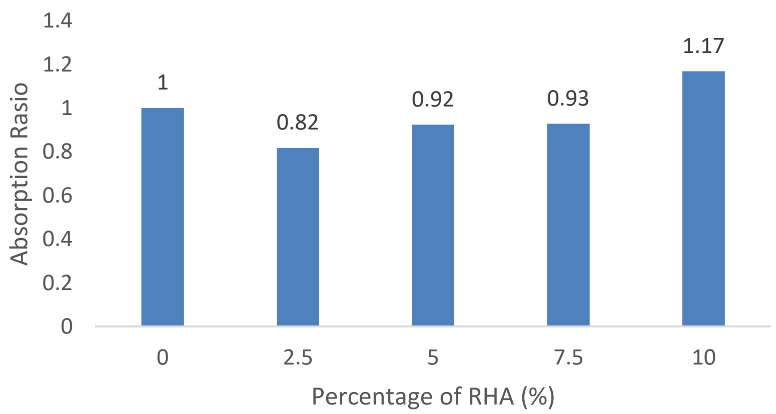

Figure 19. Comparison of Water Absorption with Percentage of RHA Variations

Figure 19 compares the absorption capacity values of lightweight bricks with and without ASP. This research showed variations in the value of absorption capacity increasing and decreasing. Increases and decreases do not provide a specific trend. Light brick with 2.5% ASP has the lowest absorption capacity, 0.82 times the absorption capacity without ASP. There was a decrease in absorption capacity of 18% for lightweight bricks without ASP. Meanwhile, light bricks with 5% ASP and 7.5% ASP also experienced a decrease but below 10% compared to light bricks without ASP. Using 10% ASP causes an absorption capacity value of 17% above lightweight brick without ASP. This illustrates that adding ASP below 10% has a better impact.

But if you want to relate it to the thermal conductivity of lightweight brick as a wall material, the more voids, the more profitable it is. The greater the absorption capacity, the greater the number of cavities filled with air. This space can reduce the thermal conductivity properties of the wall. This condition prevents heat from entering the room from outside [17]. Here, the presence of ASP significantly affects the porosity and density of lightweight bricks. Water absorption is strongly influenced by ASP percentage, particle size, and surface area [18].

The same thing happened in research [19], the water absorption value decreased as the ASP percentage increased. Improved ASP presentation improves brick cohesion and stiffness due to the high grain fineness of ASP. The water absorption rate increases as the porosity increases. When 50% ASP is used as a substitute for quartz in lightweight bricks, the porosity and water absorption increase by about 20%, 18%, and 22%, respectively. ASP also creates air cavities that are trapped within the paste during mixing. In addition, because ASP is more porous than quartz aggregate, lightweight bricks' porosity and water absorption increase [20].

V. Conclusion

Based on the test results and discussions that have been carried out regarding the test results of lightweight bricks with the addition of rice husk ash, several conclusions have been obtained as follows:

1. The results of comparing the average value of water absorption with the addition of various variations of rice husk ash decreased because the rice husk ash content in the lightweight brick mixture bonded well so that the bricks did not easily absorb water.
2. The lowest water absorption value was from adding 2.5% rice husk ash, resulting in an average absorption value of 20.16%, and the highest absorption value from a variation of 10% with a resulting value of 28.81%. From the various variations that have been tested, it can be seen that adding rice husk ash decreases the water absorption value. It can be seen that the greater the variation in the addition of rice husk ash, the decrease in water absorption by the lightweight brick. This happens because the rice husk ash content in the lightweight brick mixture bonds well, so the bricks do not easily absorb water.

References

[1] C. Specification, "Standard Specification For Nonloadbearing Concrete Masonry Units 1," Changes, Vol. 4, Pp. 1–3, 2003.

[2] K. Jitchaiyaphum, T. Sinsiri, And P. Chindaprasirt, "Cellular Lightweight Concrete Containing Pozzolan Materials," 2011, Doi: 10.1016/J.Proeng.2011.07.145.

[3] R. K. Majhi, A. Padhy, And A. N. Nayak, "Performance Of Structural Lightweight Concrete Produced By Utilizing High Volume Of Fly Ash Cenosphere And Sintered Fly Ash Aggregate With Silica Fume," Clean. Eng. Technol., Vol. 3, P. 100121, Jul. 2021, Doi: 10.1016/J.Clet.2021.100121.

[4] X. Liu, C. Ni, K. Meng, L. Zhang, D. Liu, And L. Sun, "Strengthening Mechanism Of Lightweight Cellular Concrete Filled With Fly Ash," Constr. Build. Mater., Vol. 251, P. 118954, 2020, Doi: 10.1016/J.Conbuildmat.2020.118954.

[5] F. A. Turkey, S. B. Beddu, A. N. Ahmed, And S. K. Al-Hubboubi, "Effect Of High Temperatures On The Properties Of Lightweight Geopolymer Concrete Based Fly Ash And Glass Powder Mixtures," Case Stud. Constr. Mater., Vol. 17, No. July, P. E01489, 2022, Doi: 10.1016/J.Cscm.2022.E01489.

[6] A. P. Wibowo And M. Saidani, "The Effect Of Fly Ash As Coating Powder On Compressive Strength Of Lightweight Concrete," 2023, Doi: 10.1016/J.Matpr.2023.05.250.

[7] S. A. Khawaja, U. Javed, T. Zafar, M. Riaz, M. S. Zafar, And M. K. Khan, "Eco-Friendly Incorporation Of Sugarcane Bagasse Ash As Partial Replacement Of Sand In Foam Concrete," Clean. Eng. Technol., Vol. 4, P. 100164, Oct. 2021, Doi: 10.1016/J.Clet.2021.100164.

[8] P. To-On, N. Wichapa, And W. Khanthirat, "A Novel Topsis Linear Programming Model Based On Response Surface Methodology For Determining Optimal Mixture Proportions Of Lightweight Concrete Blocks Containing Sugarcane Bagasse Ash," Heliyon, Vol. 9, No. 7, P. E17755, Jul. 2023, Doi: 10.1016/J.Heliyon.2023.E17755.

[9] G. Bejan, M. Barbua, R. S. Vizitiu, And A. Burlacu, "Lightweight Concrete With Waste - Review," Procedia Manuf., Vol. 46, Pp. 136–143, Jan. 2020, Doi: 10.1016/J.Promfg.2020.03.021.

[10] H. Zhang Et Al., "Statistical Mixture Design For Carbide Residue Activated Blast Furnace Slag Foamed Lightweight Concrete," Constr. Build. Mater., Vol. 342, P. 127840, Aug. 2022, Doi: 10.1016/J.Conbuildmat.2022.127840.

[11] J. Jofrishal, M. Adlim, E. Yusibani, A. Akhyar, R. F. I. Rahmayani, And R. Fajri, "Preparation And Characterization Of Indoor Heat Blockage Panel Composites Made Of Polyurethane-Hybrid-Foam-Concrete And Rice-Husk-Ash," Heliyon, Vol. 9, No. 8, 2023.

[12] M. A. O. Mydin Et Al., "Performance Of Lightweight Foamed Concrete Partially Replacing Cement With Industrial And Agricultural Wastes: Microstructure Characteristics, Thermal Conductivity, And Hardened Properties," Ain Shams Eng. J., Vol. 14, No. 11, P. 102546, 2023.

[13] O. Gencel Et Al., "Properties Of Eco-Friendly Foam Concrete Containing Pcm Impregnated Rice Husk Ash For Thermal Management Of Buildings," J. Build. Eng., Vol. 58, P. 104961, Oct. 2022, Doi: 10.1016/J.Jobe.2022.104961.