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The Characteristic and Properties Lightweight Organic Bricks from Rice Husk

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ABSTRACT

In our cutting-edge environment, a lightweight organic brick is an optional revelation item that should be taken into consideration. The organic brick is superior to the traditional brick in terms of additional qualities. During assembly, it can reduce the exemplified energy of regular brick. Utilizing this organic brick could result in greater energy savings from a warm comfort perspective and help to protect the environment because it produces less pollution. The unused rice husks that are piling up in Perlis give rise to this item as a potential solution to the problem. In light of this idea, leftover rice husks can be used to create organic brick. In addition, Malaysia's rapid development would subsequently build the block requests. This fuels the primary objective of researching renewable and environmentally friendly alternatives to conventional brick. Since it is eco-friendly and easily obtainable in Malaysia, rice husk stands out among other optional lightweight options. By baking clay, rice husk, and cement together, lightweight organic brick is produced. The organic sample, which contains up to 80% rice husk, is added and put through an oven drying process so that it can dry entirely before the testing can begin. Because there was more rice husk in the specimen, there were more pores, which enhanced the compressive strength. As a result, the quality of the rice husk increases as more of it is added. Although the organic brick specimen doesn't meet the standard for compressive strength, it does so for low bulk density, which is much lower than the requirement for lightweight materials. It is therefore perfectly reasonable to use it as a light construction material.

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1. Introduction

The oldest building material that has been continuously utilised since its inception is probably clay brick. For a long time, ceramic bricks made from conventional brick clays have been a popular and predominant building material due to their durability and resistance to weathering [1]. The building bricks are presently being created to be more consistent and durable [2]. The raw material, shaping technique, drying and the sintering temperatures are the most important factors in the production of bricks, all of which have a direct impact on the properties of the finished product [3]. A responsible approach to natural resources is, nevertheless, critically needed given the current state of technological advancement. Utilizing renewable resources and cutting back on the use of primary natural resources are two answers to the issue. It can be successfully done in the case of ceramic bricks by reducing product weight and using renewable resources in place of natural clay as a raw material. One example of such renewable resources is rice husks, which are produced in considerable amounts each year.

Because rice husks contain a lot of silica—up to 18–22% by weight—their secondary uses are actually fairly restricted. As a result, rice husks in the environment burn and assimilate poorly. Because of this, only a very small number of rice husks are used to make industrial products, even though the amount of this silica-containing raw collected each year is comparable to the amount of silicate raw materials commercially produced [4].

The lightweight cement brick is one type of brick. One of the well-known building materials that is widely used in modern cutting-edge era across the globe is lightweight cement brick. The modern lightweight cement bricks that are often used are stronger, lighter, and more thermally insulated than the older, more conventional clay bricks, which are made from hot earth. Modern lightweight cement bricks are more thermally insulated and lighter than traditional clay bricks. Both clay and cement brick need a lot of energy to manufacture, and the process also produces a lot of carbon dioxide [5]. If this behaviour continued, it would eventually harm the ecosystem.

Hence, the contradiction between the significant amount of renewable silica resource and its very low consumption can be overcome by creating a special technology for processing silica obtained from rice husks ash into a competitive valuable product on the market.

2. Materials and Methods

2.1 Rice Husk

A rise in agricultural waste is a result of urbanisation and population growth. Sustainable use and efficient management of agricultural wastes are important due to the need to protect the ecosystem and reduce environmental waste. Nigerians consume 32 kilogrammes of rice each person, making it one of the most popular basic foods there [6].

Depending on the source of the rice husk, incineration of the husk produces between 17 and 20 percent of ash, which is made up of 87-9 percent opaline silica and various metallic oxide contaminants. It is quite unusual for silica to combine with plant fibres at such a high percentage in nature. The intimate admixture of silica and lignin has two effects: it makes the rice hull resistant to water penetration and fungal degradation, as well as to human disposal efforts. Since the hull makes up an average of around 22% of the weight of rough harvested rice (paddy), the world is rapidly being overpopulated with an abundance of this scaly residue [7].

The rice hull, out of all cereal by-products, contains the lowest percentage of total digestible nutrients (less than 10%), according to Juliano [8], mentioning the ineffectiveness of rice husk as well. While nowhere could we ever find a grain by-product so high in crude fibre, crude ash, and silica while at the same time being so low in protein and accessible carbs, according to Olivier [9]. This claim supports the notion that rice husk is not even suitable for use as animal food. Even while rice husk has been used to make some organic products, such as furfural, its high ash and silica content has attracted a lot of study attention since it can be used to make a variety of products with added value [10]. Clay soil, rice husk, Ordinary Portland Cement (OPC), and tap water were the ingredients utilised to create this organic brick. The table below, Table 1, displays the material characteristics.

Table 1
Material Properties

Properties	
Size of clay soil	300µm
Size of rice husk	6mm
Type of cement	OPC
Water ratio	Adequately

2.2 Methodology of the Study

Figure 1 below shows the flow of the study methodology from the collection of raw materials until the final results are obtained.

Collection of Raw Materials

- 10 kg of rice husk from Simpang Empat in Perlis (Kilang Bernas KKB)
-10 Kg Ordinary Portland Cement, 30kg of clay soil, 10 pieces Cement bricks and clay bricks were obtained from Pusat Pengajian Jejawi 3

Preparation of Materials

- The clay soil and harvested rice husk dried out in the sun, a grinding mill was used to smash around 1 kg of rice husk and clay soil into powder (sieving mechanism was then used to sift the rice husk powder and clay powder into 63 m molecules).
- MS Standard sieving device into particles that were 300 m in size (The secondary use of rice husk, which has a standard particle size of 6mm, was not altered

Analysis of Materials

- X-ray Fluorescence (XRF), X-ray Diffraction (XRD), and Scanning Electron Microscopy
- Required 1 kilogramme of rice husk powder and 1 kg of clay powder with 63 m particle sizes (SEM).
- The treated rice husk was mixed with clay and cement that was prepared with varying compositions and dried in oven for 7days before being proceeded to the compression test
- After that, XRD and SEM were used to analyse the compressed specimen
-Results

Fig. 1. Methodology Chart

2.3 Collection of Materials

Kilang Beras Bernas (KBB), from Simpang Empat in Perlis Jalan Tambun Tulang. During harvest season, one of the Perlis rice industrial facilities produces about 1 tonne of rice daily from paddy fields in the surrounding area. It will be much easier to collect rice husk there because it was obtained during the manufacture of rice. We collected about 10 kg of rice husk from KBB Simpang Empat. In general, 10kg of Ordinary Portland Cement and 30kg of clay soil were obtained from Pusat Pengajian Jejawi 3 and Universiti Malaysia Perlis, respectively, in Jejawi and Bintong, Perlis. Cement bricks and clay bricks, overall total are 10 pieces each were taken from Pusat Pengajian 3 at Universiti Malaysia Perlis in Jejawi, Perlis. The brick samples were saved for use in future studies, including the compression test. It is preferable to use lightweight bricks with good compressive strength and minimal water absorption. Incorporating organic or inorganic pore-forming agents into the bricks is one technique to boost the capacity of bricks [11].

2.4 Preparation of Materials

The clay soil and harvested rice husk were completely dried out in the sun. From that point forward, a grinding mill was used to smash around 1 kg of rice husk and clay soil into powder [12]. The MS Standard sieving mechanism was then used to sift the rice husk powder and clay powder into 63 m molecules. The remaining clay soil was crushed using a grinding machine as a primary component, and it was subsequently sieved using an MS Standard sieving device into particles that were 300 m in size. The secondary use of rice husk, which has a standard particle size of 6mm, was not altered.

2.5 Analysis of Materials

The next tests, such as X-ray Fluorescence (XRF), X-ray Diffraction (XRD), and Scanning Electron Microscopy, required 1 kilogramme of rice husk powder and 1 kg of clay powder with 63 m particle sizes (SEM).

2.6 Characterization of Brick Specimen

The dimensions and weights of an organic specimen were used to determine its characteristics, such as water absorption, porosity, and bulk density. After the organic specimen has warmed up to room temperature, weigh the dried weight, G1 of the items using a measuring device. Drop the thoroughly dried specimen for at least 24 hours into clear, room-temperature water. When gauging the suspended submerged item after 7 hours, the suspended weight, G2, was obtained. The examined items will then be removed from the water and their surface will be dried with dry material before its saturated weight, G3, is measured. The proportion or ratio between the item's dried weight (G1) and its dried weight (G3) is known as the water absorption of the item in percent. The ratio of G3 to G1 and G3 to G2 was used to determine the specimen's porosity. The final results' bulk density, which was expressed in grammes per cubic centimetre, is calculated by dividing the dry weight (G1) by the final product's volume.

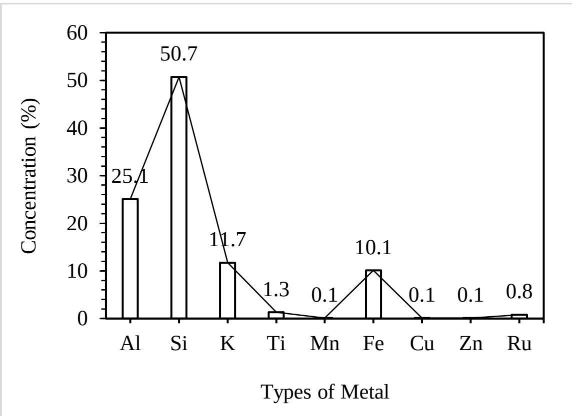
By using the compressive machine, the specimen's strength was determined. By using x-ray diffraction, the specimens' crystalline phases were managed (XRD). Using scanning electron microscopy, the crushed specimens' microstructure was examined (SEM).

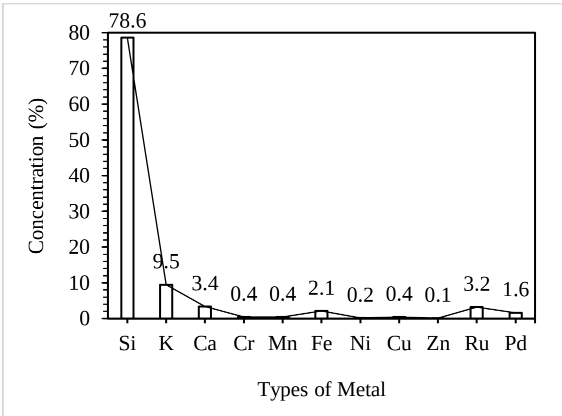
2.7 Experimental Process

In this experimental process, both clay and cement with size 300μm was used as binding materials for rice husk to produce organic bricks. The organic brick had a size of 200mm x 105mm x 65mm which is the nominal size of block as prescribed by MS 76:1972 and for that the moulds of the similar size was fabricated. Initially, the clay powder and rice husk powder were characterized by XRF. By doing this, the clay and rice husk were dried under sun for a few days until they completely dry. Then the clay was crushed and sieved into size of 300μm and the rice husk was sieved into size of 6mm. The treated rice husk was mixed with clay and cement that was prepared with varying compositions and dried in oven for 7 days before being proceeded to the compression test [13]. The strength at the curing time of 28 days can be larger than 2 times of that at the curing time of 7 days [14]. After that, XRD and SEM were used to analyse the compressed specimen [15]. Similar to XRD, the SEM examination was performed on a tiny portion of the specimen, but it is believed to be representative of the reaction process of the additive-aggregate mixture [16].

3. Results
3.1 Properties of Clay and Rice Husk

Figure 2(a) and Figure 2(b) below shows the XRF result for clay powder and rice husk powder. Both Figure 2(a) and Figure 2(b), which depict 75 m of clay powder and 75 m of rice husk powder, respectively, exhibit the concentration of metal contents (%). Si concentrations were 50.7% in clay and 78.6% in rice husk, respectively. Clay and rice husk were both identified as sources of K, with concentrations of 11.7% and 9.5%, respectively. Clay had a Fe concentration of 10.1%, while rice husk had a Fe concentration of 2.1%. Al was found in clay at a concentration of 25.1%, however it was not found in rice husk. The other metal that could be seen in both materials was fixated or concentrated to a very little extent (less than 5%).





(a) (b)

Fig. 2. Metal Content in 63μm of (a) Clay Powder, (b) Husk Powder

3.2 Properties of Specimens
3.2.1 Bulk density

The data for the average bulk density of finished items was displayed in Figure 3. 60% of the rice husk has an average bulk density of 1.28g/cm^3, while 70% and 80% had densities of 1.16g/cm^3 and 0.89g/cm^3, respectively. When the average bulk density of the finished product falls, the percentage of rice husk rises. Existing cement brick has an average bulk density of 1.94g/cm^3, whereas traditional clay brick has a bulk density of 1.73g/cm^3.

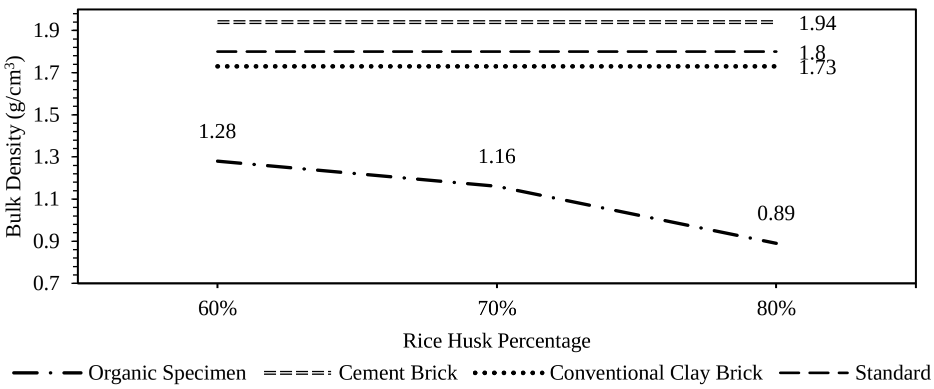


Fig. 3. Bulk Density Vs Rice Husk (%)

3.2.2 Water absorption and porosity

Figure 4 depicts the organic specimen's relationship between its water absorption and the amount of rice husk added to it. The water absorption rose from 18.5% to 45% when the proportion of rice husk was raised from 60% to 80%. When the amount of rice husk added increases, the porosity likewise rises; see Figure 5. This indicates that there is a direct proportionality between the two; the higher the water absorption, the larger the volume of pores.

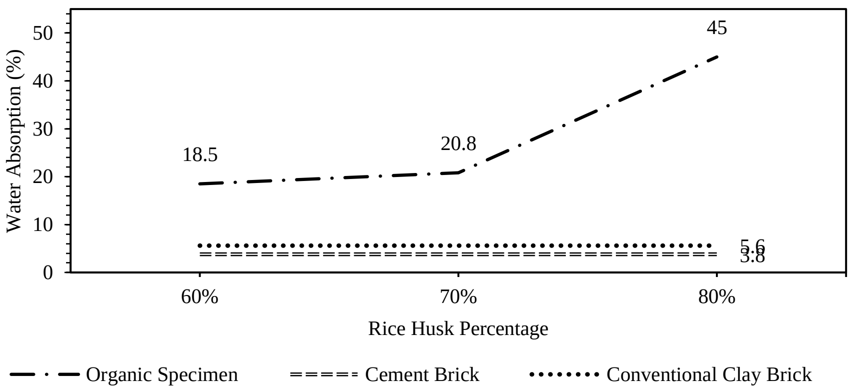


Fig. 4. Water Absorption Vs Rice Husk (%)

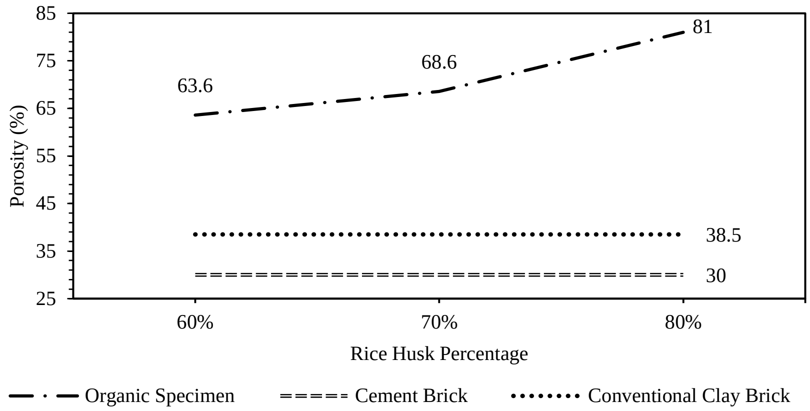


Fig. 5. Porosity Vs Rice Husk (%)

3.2.3 Compressive strength

Figure 6 displays the obtained average compressive strength. Rice husk has an average compressive strength of 2.3N/mm^2 at 60%, 3.3N/mm^2 at 70%, and 4.7N/mm^2 at 80%. Since the average compressive strength rises as the percentage of rice husk increases, the outcome is directly proportionate. The typical traditional clay brick produced 8.8 N/mm^2, whereas cement brick produced 16.8 N/mm^2.

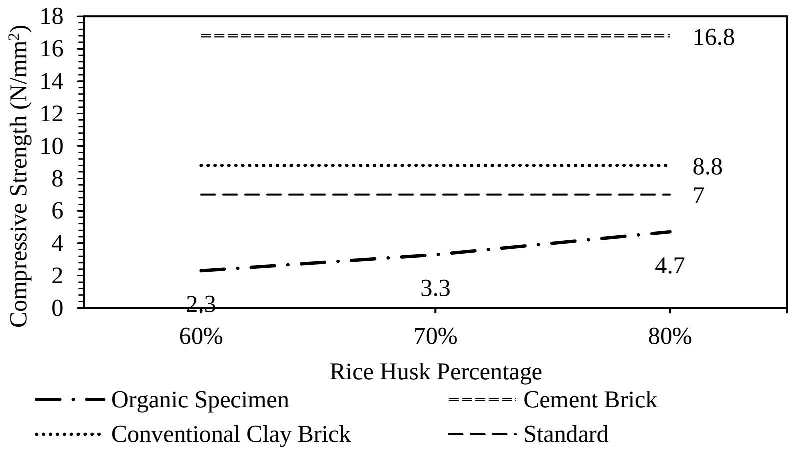


Fig. 6. The Compressive Strength Vs Rice Husk (%)

3.3 Micro-Structural Analysis of Specimens
3.3.1 X-ray diffraction data

The results of the XRD diffractogram for rice husk percentages of 60%, 70%, and 80% are shown in Figure 7. At 20° to 70°, there were no significant changes in the crystalline phase. The primary crystalline phases of the chemical were silicon dioxide, aluminium oxide, and ferric oxide.

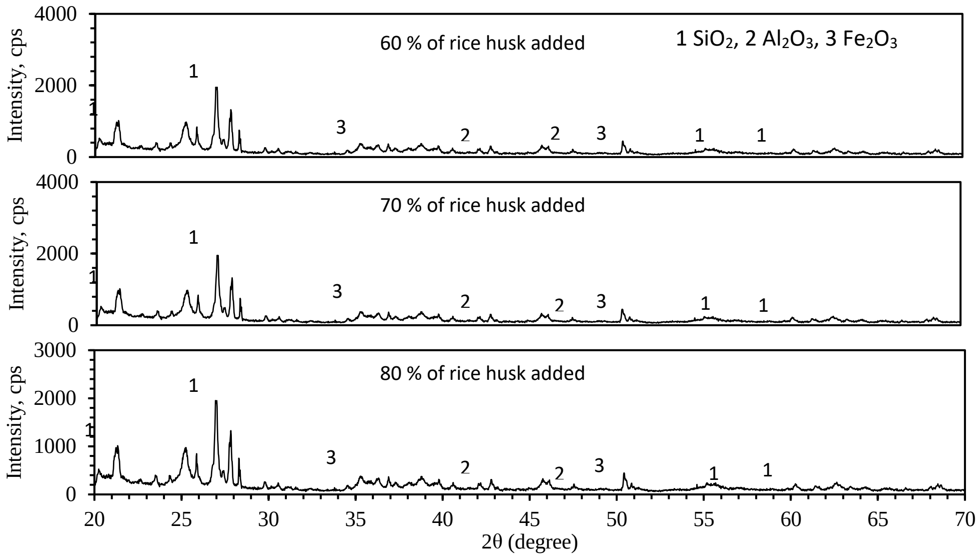
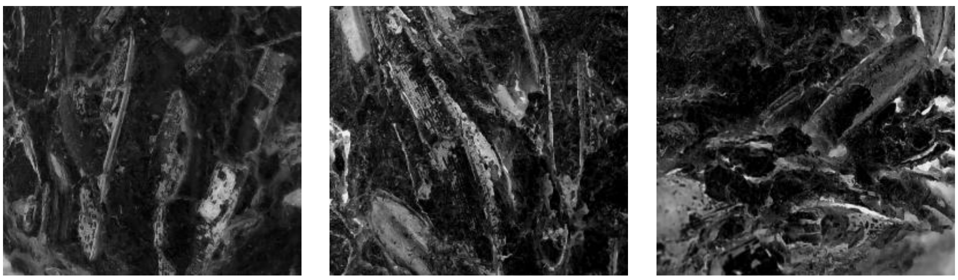


Fig. 7. XRD Diffractogram Vs Organic Specimen (%)

3.3.2 Micro-structure analysis

Images captured by utilizing the digital microscope 200MP by 50 times;(x50).

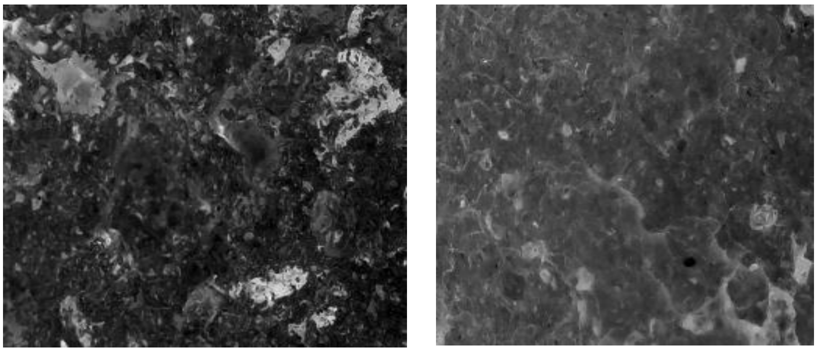
The microstructure of the biological specimen with various ratios of rice husk is shown in Figure 8. The microstructure pattern of rice husk for the 60% and 70% of ratio indicated essentially no variation. These are indications of loose, pore-filled matrixes found in organic material. The organic specimens also had low bulk densities, which allowed for the production of typical lightweight brick. The microstructure objective of loose matrix material, which was caused by the monopolisation of big size pores, was visible in the 80% of rice husk ratio.



(a) (b) (c)

Fig. 8. Organic Specimen Images, rice husk ratio; (a) 60%, (b) 70%, (c) 80%

The microstructure of the extant specimen is depicted in Figure 9. In the microstructure patterns, clay brick displays a very dense matrix of material while cement brick displays a small number of open holes, indicating a dense matrix of material. This extant specimen has excellent strength, a low water absorption rate, and was made entirely of clay.



(a) (b)

Fig. 9. Extant specimen images, (a) clay brick, (b) cement brick

4. Discussion

The research used oven-dried clay and rice husk to create the light organic bricks. It has been demonstrated that there are more pores the higher the rice husk ratio. A more constrained path along the molecules is all that is required for this to cause gas dispersion. Consequently, the organic specimen's bulk density decreased. As can be shown in Figure 5, the porosity of the organic specimens increased with the ratio of rice husk. When the percentage of rice husks was increased from 60% to 80%, the porosity improved from 63.6% to 81.0%.

Bulk density and rice husk content are negatively related. Figure 3 illustrates the maximum bulk density of 1.28g/cm^3 for organic specimens. As the amount of rice husk rises from 60% to 80%, the bulk density falls from 2.4g/cm^3 to 0.89g/cm^3. The bulk density for the addition of rice husk in the range of 60%, 70%, and 80% was 1.28g/cm^3, 1.16g/cm^3, and 0.89g/cm^3, which was significantly less than the typical bulk density of 1.8g/cm^3 for lightweight materials. As a result, the bulk density of organic specimens, which is 1.94g/cm^3 for cement brick and 1.73g/cm^3 for clay brick, is lower, thereby fulfilling the study's goal.

Regarding water absorption, it is inversely correlated with a decrease in bulk density but directly proportionate to the porosity of the organic specimen. As rice husk increases from 60% to 80%, the result displayed in Figure 4 increases in terms of water absorption from 18.5% to 45%. Because of this, the organic specimen absorbed more water than cement and clay bricks, which had water absorption rates of 3.8% and 5.6%, respectively.

Because of the high rate of water absorption, some people are being careful; not ideal for outdoor uses. It is still seen as being utilised for inside buildings, such as internal walls. This is because they unquestionably have excellent thermal insulation, which lowers energy use and makes them perfect for eco-friendly structures.

Compressive strength was shown to be inversely correlated with water absorption. Similar to Figure 6, compressive strength is inversely correlated with the amount of rice husk. It is still less expensive than clay and cement brick, though. The organic specimen is doing extremely well thanks to its improved thermal insulation and low bulk density, but it still requires more research due to its insufficient compressive strength even though it meets the minimal requirement of 7N/mm^2.

5. Conclusion

According to the study, organic specimens have a bright future. This is due to the requirement for low bulk density and high porosity brick in green construction materials. The study's conclusion is displayed below:

i. When comparing the organic specimen with the recommended percentage of rice husk to the standard value for lightweight materials, a bulk density less than the standard of 1.8g/cm^3 was reached. The bulk density, however, decreases as the amount of rice husk increases. This is because there are more open pores in organic specimens now. The bulk densities of cement and clay bricks, which were measured at 1.94g/cm^3 and 1.73g/cm^3, respectively, were higher than those of the organic material. This indicates that both of the currently available goods had less porosity than the organic specimen.
ii. Compared to cement bricks and regular clay bricks, the mixture of clay and rice husk results in an increase in pore volume. This makes it far better for thermal insulation than standard bricks. Future green construction materials will greatly benefit from this advantage because it could lower environmental pollution.
iii. Compared to the currently used brick, the compressive strength of the light organic brick is directly related to the percentage of rice husk. The organic specimen with 80% of the rice husk had the highest compressive strength of 4.7N/mm^2, compared to 2.3N/mm^2 and 3.3N/mm^2 for 60% and 70% of the rice husk, respectively. Overall, the compressive strength for all of the proposed percentages of rice husk was lower than the brick criteria; 7N/mm^2. Therefore, more research is need to be done in order to increase the compressive strength of the lightweight organic brick.

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References
[1] Gömze, László A., Ludmila N. Gömze, Emese Kurovics, and György Benedek. "Conventional brick clays as a challenge of materials science-New explanation of drying sensitivities." In *IOP Conference Series: Materials Science and Engineering*, vol. 613, no. 1, p. 012005. IOP Publishing, 2019. https://doi.org/10.1088/1757-899X/613/1/012005
[2] Kazmi, Syed Minhaj Saleem, Muhammad Junaid Munir, Yu-Fei Wu, Asad Hanif, and Indubhushan Patnaikuni. "Thermal performance evaluation of eco-friendly bricks incorporating waste glass sludge." *Journal of Cleaner Production* 172 (2018): 1867-1880. https://doi.org/10.1016/j.jclepro.2017.11.255
[3] Heniegal, Ashraf Mohamed, Mohamed Ahmed Ramadan, Ahmed Naguib, and Ibrahim Saad Agwa. "Study on properties of clay brick incorporating sludge of water treatment plant and agriculture waste." *Case Studies in Construction Materials* 13 (2020): e00397. https://doi.org/10.1016/j.cscm.2020.e00397
[4] Ketov, Aleksandr, Larisa Rudakova, Iakov Vaisman, Iurii Ketov, Viktors Haritonovs, and Genadijs Sahmenko. "Recycling of rice husks ash for the preparation of resistant, lightweight and environment-friendly fired bricks." *Construction and Building Materials* 302 (2021): 124385. https://doi.org/10.1016/j.conbuildmat.2021.124385
[5] Barbuta, Marinela, Roxana Dana Bucur, Sorin Mihai Cimpeanu, Gigel Paraschiv, and Daniel Bucur. "Wastes in building materials industry." *Agroecology* 1, no. 1 (2015): 81-99. https://doi.org/10.5772/59933
[6] Alfimova, N. I., S. Yu Pirieva, and A. A. Titenko. "Utilization of gypsum-bearing wastes in materials of the construction industry and other areas." *Construction Materials and Products* 4, no. 1 (2021): 5-17. https://doi.org/10.34031/2618-7183-2021-4-1-5-17
[7] Ugheoke, Benjamin Iyenagbe, Othman Mamat, and B. Ari-Wahjoedi. "A direct comparison of processing methods of high purity rice husk silica." *Asian Journal of Scientific Research* 6, no. 3 (2013): 573-580. https://doi.org/10.3923/ajsr.2013.573.580
[8] Juliano, Bienvenido O. Rice: Chemistry and Technology. American Association of Cereal Chemists, 1985.
[9] Olivier, P. "The rice hull house." *The Last Straw*. Accessed January 1, 2023. http://www.thelaststraw.org/backissues/articles/Rice%20Hull%20House.pdf.
[10] Punsuvon, Vittaya, Pilanee Vaithanomsat, and Kenji Iiyama. "Simultaneous production of α-cellulose and furfural from bagasse by steam explosion pretreatment." *Maejo International Journal of Science and Technology* 2, no. 1 (2008): 182-191.
[11] Zhang, Zipeng, Yat Choy Wong, Arul Arulrajah, and Suksun Horpibulsuk. "A review of studies on bricks using alternative materials and approaches." *Construction and Building Materials* 188 (2018): 1101-1118. https://doi.org/10.1016/j.conbuildmat.2018.08.152

[12] Bacher, G. "Rice Husk Technology." *Pörner Group* (2007). http://www.poerner.eu.
[13] Arshad, Mohammad Shahid, and P. Y. Pawade. "Reuse of natural waste material for making light weight bricks." *International Journal of Scientific & Technology Research* 3, no. 6 (2014): 49-53.
[14] Jongpradist, Pornkasem, Watee Homtragoon, Raksiri Sukkarak, Warat Kongkitkul, and Pitthaya Jamsawang. "Efficiency of rice husk ash as cementitious material in high-strength cement-admixed clay." *Advances in Civil Engineering* 2018 (2018). https://doi.org/10.1155/2018/8346319
[15] Kumar, Ajay, Kalyani Mohanta, Devendra Kumar, and Om Parkash. "Properties and industrial applications of rice husk: a review." International Journal of Emerging Technology and Advanced Engineering 2, no. 10 (2012): 86-90.
[16] Barman, Dharmendra, and Sujit Kumar Dash. "Stabilization of expansive soils using chemical additives: A review." *Journal of Rock Mechanics and Geotechnical Engineering* 14, no. 4 (2022): 1319-1342. https://doi.org/10.1016/j.jrmge.2022.02.011