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Utilization of Recycled Paper Sludge (RPS) In Production of Sand Cement Bricks

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Abstract: As we know, Malaysia is a country that currently one of the fast developing countries in the world, so a lot of construction work is currently undergoing in Malaysia. Sand cement brick production was increased as linear with the growing of urbanization and economy in Malaysia. However, an issue of waste papers in Malaysia come out because a lots of waste paper been produce every day. The challenge was to find out the alternative way to use all the waste paper in the construction industries. There lots of studies have been conducted in order to replace the fine aggregate in sand cement brick mix with the waste materials. Therefore, this study was to promote utilization of Recycle Paper Sludge (RPS) with different percentages of RPS in producing sand cement brick. The main objectives of the study was to find the mechanical properties of the bricks mixture containing Recycled paper sludge (RPS) as replacement material of sand. In this study, we use 0%, 3%, 5%, 10% and 15% of RPS as a partial replacement to sand in the mixture of sand cement brick. The experiments that were conducted were density, water absorption, compressive strength, thermal conductivity and sound absorption coefficient. From the result obtained it can conclude that the used of the Recycled Paper Sludge (RPS) in the mixture of the sand cement bricks will save the cost of the production of bricks and produce an eco-friendly brick. Furthermore, recycled paper sludge in the mixture of sand brick material can increase the workability and the strength of the sand brick which will give the best recommendation for the construction industry.

Keywords: Sand Cement Brick, Recycle Paper Sludge (RPS), Replacement Material

1. Introduction

Various research has been undertaken in recent years to make strong and durable sand cement bricks by employing industrial waste materials as a brick-making resource. The cost of producing sand cement bricks can be decreased by using these waste resources. At the same time, Malaysia's growing industrial sector has prompted plenty of research aimed at reducing pollution. This involves repurposing waste resources as building materials. Malaysia is also one of the countries that are increasingly advanced in

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aspects of all fields which has made the development industry more rapidly until today. Thus, the rate of use and demand for bricks has increased to be used as one of the most important materials in the construction industry.

In Malaysia, sand cement bricks are extensively utilized in low- and medium-cost home developments as well as various commercial structures. Making cement and sand brick is simple and economical [1]. However, the expense of producing sand cement bricks from natural sources was a concern, particularly in underdeveloped countries where manufacturers struggle to acquire appropriate natural aggregate supplies. As a result, the cost of natural resources such as sand has risen, affecting the cost of sand cement bricks [2]. Much research are now focusing on the utilisation of waste materials in the manufacturing of brick concrete.

As a result, the use of recycled materials in the construction sector is essential for any country's long-term growth. In comparison to traditional sand cement bricks, recycled paper sludge (RPS) as fine aggregate was chosen as a replacement material for sand in the sand cement brick combination. From all of these potential benefits, it clearly answered the sustainable development goal number 9,11,12 and 13 respectively.[1]

2. Methodology

Laboratory studies were done to obtain data on the compressive strength of the sand cement bricks, density test, water absorption and other variables to determine the effectiveness of using recycle paper sludge as replacement materials for fine aggregate in sand cement bricks mixture. The data obtained from these tests were analysed to attain a result to achieve the goals and objectives of the study.

2.1 Materials Preparation

2.1.1 Cement

Cement is a material that is widely used in construction. Concrete and other Portland cement-based materials have long been utilized in civil engineering projects. However, the decomposition of civil infrastructure around the world has demonstrated that cement-based materials' technical qualities and strength must be enhanced. Besides, cement serves as a binder, which is between the sand grains, and aggregates that will be making a strong concrete. The cement used in this study is Ordinary Portland Cement (OPC). The standard OPC selected is compliant with the Malaysian Standard Specification MS 522: Part 1:2003 [3]. Figure 1 has shown the Portland cement that was used in the brick mixing.

Figure 1: Ordinary Portland Cement (OPC)

2.1.2 Sand

Sand particles consist of small grains of silica (SiO2). It's made up of sandstones that have decayed due to weathering. Depending on the natural resources employed to create it, sand is classed as pit sand, river sand, or sea sand. Fine, coarse, and gravel sand are the three categories depending on grain size. It is required that the fine aggregates comply to Malaysian Standard MS29 1995. According to

Malaysian Standard, "sand" refers to "fine aggregates" with a 4.75mm mesh B.S sieve. Figure 2 shows the fine aggregate.

Figure 2: Fine aggregate available in laboratory of concrete, UTHM

2.1.3 Water

Because it is involved in the chemical interaction with cement, water is a significant component of paper sludge. Both soaking and mixing of paper sludge should be done using potable water. It should be devoid of organic materials and have a pH of between 6 and 7. In addition, the water used should be free from contaminants such as floating solids, organic matter, and so on. Therefore, in this study, tap water is used in the cement mix.

2.1.4 Recycle Paper

Recycle paper can be found in various sources such as newspapers, magazines, old invitation cards, and paper tickets. In this study, we had some collaboration with SWM Environment Sdn. Bhd. They agreed to provide us with 100 kg recycle papers. Figure 3 shows the picture of our projects group with SWM Environment employee and some of the recycle papers.

Figure 3: Picture with SWM Environment employee and Recycle Papers

2.1.5 Paper Sludge Production

It is possible to use paper sludge as a raw material in the production of bricks. Paper sludge has a high content of organic matter, which can be beneficial for use in bricks because it helps to improve the bricks insulation properties. The first step to producing paper sludge is to tear the papers into small pieces. Next, the papers have been soaked in water and left for 2-3 days. After the paper has been made, the remaining water and solids from the process are separated and the solids are collected and dried to produce paper sludge Figure 4 shows the sample of the paper sludge.

Figure 4: Figure 3.5: The sample of paper sludge

2.2 Sample Preparation

Samples for this experiment are prepared based on the design of the mixture that has been prepared. Cement mixing was performed for both samples which are normal sand cement brick samples and sand cement brick samples using paper sludge for different percentages. Normal sand cement brick samples are made to make test comparisons between bricks using replacement materials of paper sludge. This study aimed to determine the mechanical properties of the brick before and after mixing the cement and fine aggregates with the paper sludge. Table below shows the total number of brick samples that were prepared.

Table 1: Number of samples of brick sample for water absorption and density test

Percentage of Recycle Paper Sludge (%)	Quantity of Sample	
	7 Days	28 Days
0	3	3
3	3	3
5	3	3
10	3	3
15	3	3
Total	30	

Table 2: Number of brick samples for Sound Absorption Coefficient Test

Percentage of Recycle Paper Sludge (%)	Quantity of Sample
0	2
3	2
5	2
10	2
15	2
Total	10

Table 3: Number of brick samples for Thermal Conductivity Test

Percentage of Recycle Paper Sludge (%)	Quantity of Sample
0	3
3	3
5	3
10	3
15	3
Total	15

2.2.1 Mould Preparation

After gathering all of the necessary ingredients and data, three mould was created. A 215mm x 102.5 mm x 65mm wooden modular brick mould was created. The brick moulds were formed according to the scale from MS 76 (1972) and BS 3921 (1985) For the thermal conductivity test the mould is form from a solid steel square plate (300mm x 300mm) and for sound absorption coefficient test, the moulds were created from PVC pipe with a diameter of 28 mm and a height of 90 mm. To prevent leaking, joints were built without any holes or gaps. The moulds are as show in Figure 5.

Figure 5: Moulds for testing

2.2.2 Mixing

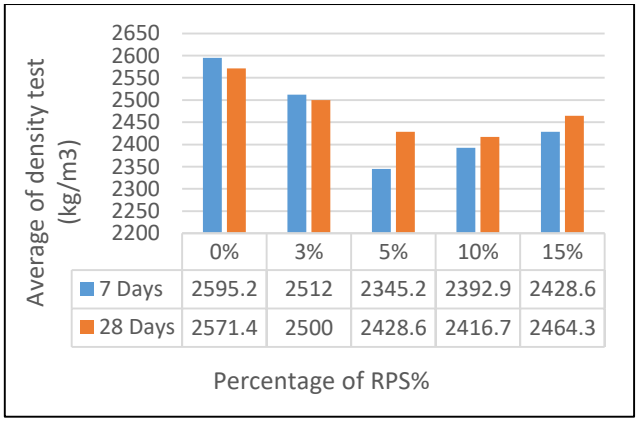
After all of the components were ready, the mixing began. The mixing in this project was done by hand. The mix proportion of the bricks for RPS is 0%, 3%, 5%, 10% and 15% as a partial replacement to sand respectively. The ratio of cement and sand for sand cement brick is (1:3) was employed in this project according to BS 5628-3-2005. While the water cement ratio used was 0.5. The size of the brick sample in this study is 215mm x 102.5 mm x 65mm. Within 30 minutes after mixing, it should be forced into the mould and tamped with a tamping rod, and the surface of the brick should be finished with a shovel. Then, the brick samples was allow for 7 and 28 days in wet curing tank before start the testing. Figure 6 shows the samples of sand cement bricks with 10% paper sludge after casting.

Figure 6: The sample of sand cement bricks with paper sludge

3. Results and Discussion

3.1 Density Test

Figure 7, the graph shows the pattern of the density value of brick samples. It can be observed that the more percentages of RPS in the brick, the less density of the brick. The density test was conducted after specimens were hardened after curing process at 7 and 28 days. The highest density recorded by control sample (0% RPS) is 2750 kg/m3 at 7 days and 2571.43 kg/m3 at 28 days. While the lowest density recorded was brick contained 5% of RPS which is 2345.24 kg/m3 for 7 days and RPS 10% is 2416.67 kg/m3 for 28 days. Control sample with contained 0% RPS recorded the highest density over of another samples. The decrease in water density for 7 days of 5% RPS and 10% RPS are 9.63% and 7.8% respectively. However, the decrease of water density for 28 days for RPS5% and RPS 10% are 5.56% and 6.02% indicating that by adding RPS would be possible to produce lighter weighting sand cement brick.

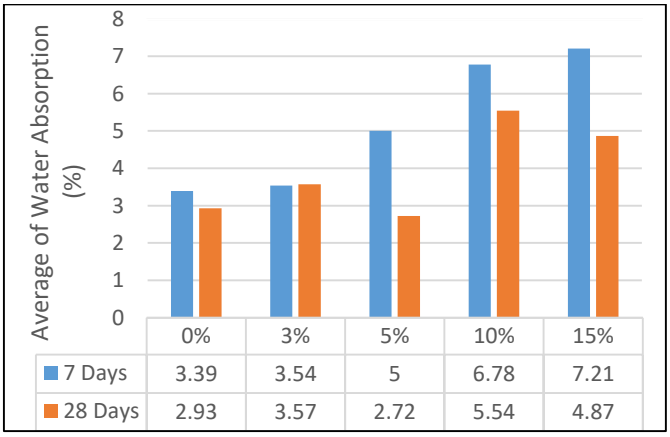


	0%	3%	5%	10%	15%
7 Days	2595.2	2512	2345.2	2392.9	2428.6
28 Days	2571.4	2500	2428.6	2416.7	2464.3

Figure 7: Graph of Density Test in the Different Percentages of RPS

3.2 Water Absorption Test

As shown in Figure 8, the graph shows that the highest percentage of water absorption for 7 days curing time is 7.21% (15% RPS) and for 28 days is 5.54% (10% RPS). Meanwhile, the lowest percentage for water absorption for 7 days is 3.39% (normal brick) and for 28 days is 2.72% (5% RPS). The maximum requirements of water absorption are 240 kg/m3 (ASTM C90). Based on the result obtained, it shows that the 5% of RPS sand cement brick exceed the maximum requirement of water absorption which is 2.72%.



	0%	3%	5%	10%	15%
7 Days	3.39	3.54	5	6.78	7.21
28 Days	2.93	3.57	2.72	5.54	4.87

Figure 8: Graph of Water Absorption Test in the Different Percentages of RPS

3.3 Compressive Strength Test

From Figure 9, it shows that the data recorded for compressive strength for 7 and 28 days contained in difference percentage of RPS replacement. The highest compressive strength value recorded are at control sample (RPS 0%) at 7 days and 28 days which is 43.73 MPa and 47.62 MPa respectively. While the lowest strength recorded for brick at 7 days is 10.43 MPa which contains 15% RPS and for 28 days is 10.03 MPa contains 15% RPS. Each mix design has showed that the compressive strength becomes decreased. it can be concluded that by increasing the percentage combination of replacement of RPS, the result of the compressive strength values of sand cement brick mixture become decreased. The decreased of strength is generally due to the high absorption rate from the paper sludge as it natural characteristic and lack of adhesion between the papers and cement paste. Crack will develop quickly around the papers sludge at the time of loading which result in rapid rupture of concrete.

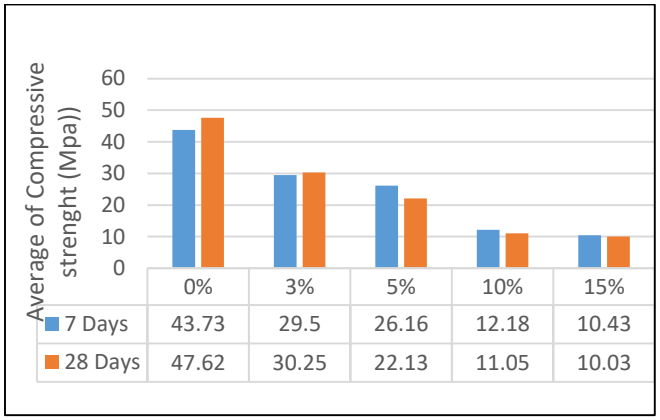


Figure 9: The Average of Compressive Strength Value

3.4 Thermal Conductivity Test

From Figure 10, the value of thermal conductivity for overall percentages of RPS are not too high and mostly the average value of the thermal conductivity is low. The highest value of thermal conductivity is brick with 3% RPS which is 0.44 W/m℃ and the lowest value of the thermal conductivity is brick with 10% RPS which is 0.25 W/m℃. Special Insulating Bricks are sometimes required for thermal insulation in structures. Common red bricks have a thermal conductivity of 0.6 W/mK. For insulating bricks, the value is even lower 0.15 W/mK [4]. It conclude that the brick with RPS is still have a low thermal conductivity which is good for building construction.

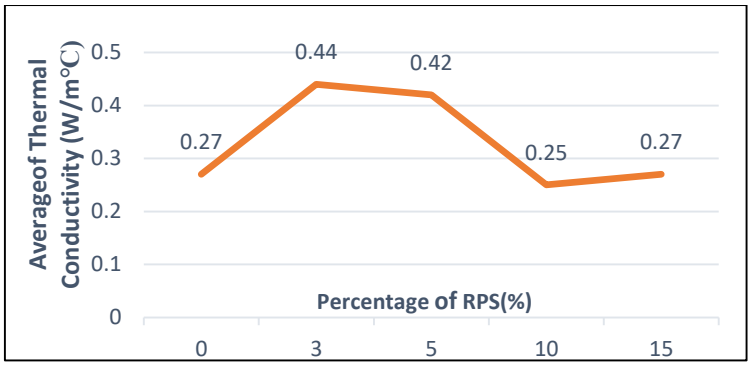


Figure 10: Thermal Conductivity Test Result

3.5 Sound Absorption Coefficient

Based on Figure11, it showed that the sound absorption coefficients for all samples were different from each other and kept varying against the frequency. A value of 1 is the best sound absorption value.

According to the results that we gain from the testing, there is no sample that achieve the maximum value of 1 which is full absorption coefficient. The amount of sound that can be absorbed at range 1000 – 1250 Hz, 5% RPS get the value at 0.02. While the 10% RPS only get the value of 0.02 at 1000 Hz. The maximum value of sound absorption in this test was at 15% RPS at frequency 3150 Hz for sample 1. The maximum value of sound absorption value that we analysed is from RPS15% which is only 0.46 at 3150 Hz. The best optimum frequency (Hz) that we analysed for all RPS percentages is 3150 Hz.

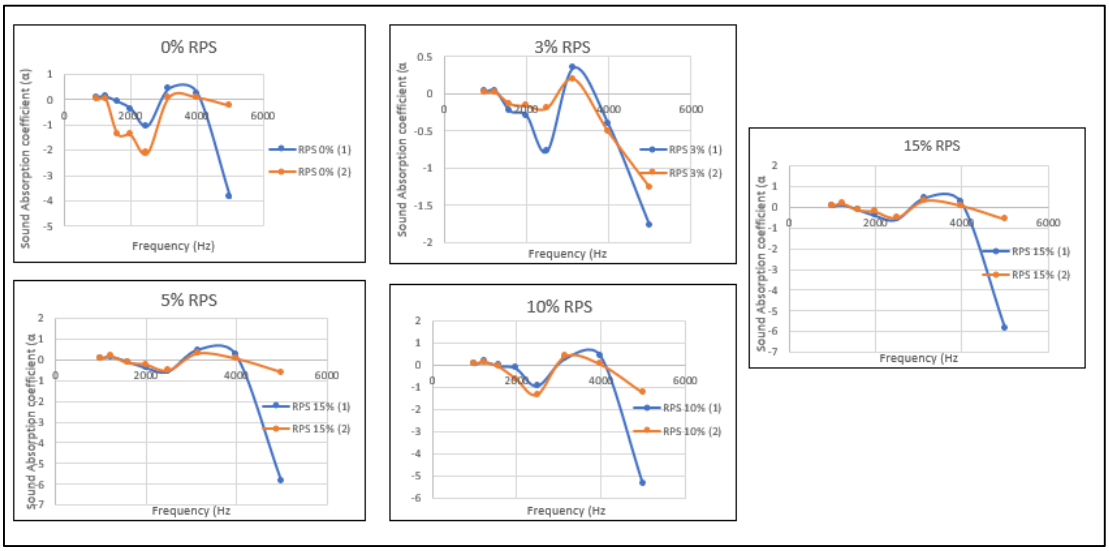


Figure 11: Sound Absorption Coefficient for RPS 0%, 3%, 5%, 10% and 15%

4. Conclusion

Compared to control brick, RPS has a different impact on mechanical properties. The three goals of this study were accomplished, according to the analysis and discussion in methodology part. Replacement of Recycle Paper Sludge (RPS) to sand in the mixture of sand cement brick respectively produces an optimum mix ratio in lightweight bricks, which have become an important trend for green building. This is because lightweight bricks possible to reduce the building weight. Furthermore, lightweight bricks have a relatively low thermal conductivity property that can be applied to reducing the building's energy use. For overall, it can conclude that this study had achieve the objectives. For overall, the range between 3% RPS is the best effective proportion of cement brick with a density 2500 kg/m3, the thermal conductivity value is 0.44 W/m℃ which is a good thermal conductivity and for sound absorption the maximum value achieve is about 0.4 It could lead to good performance of brick that suitable for construction activity according to the situation and appropriate place and also good to be used as an internal partition wall for construction industry.

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References

[1] Sustainable Development Goals | United Nations Development Programme. (2015). UNDP. https://www.undp.org/sustainable-development-goals

[2] W. Kubissaa, R. Jaskulskia, A. Kopera, and J. Szpetulski, Properties of concretes withnatural aggregate improved by RCA addition, Procedia Engineering, 108, 30-38 (2015) [2] L. Stein,

"Random patterns," in Computers and You, J. S. Brake, Ed. New York: Wiley, 1994, pp. 55-70 (Example for a chapter in a book)

[3] Ismail, S., & Zaiton Yaacob. (2010, September). The possibility use of recycled fineaggregate in production of cement and sand bricks. ResearchGate; Inderscience. [4] J. U. Duncombe, "Infrared navigation - Part I: An assessment of feasibility," IEEE Trans. Electron. Devices, vol. ED-11, pp. 34-39, Jan. 1959 (Example for a journal article)

[4] MALAYSIAN STANDARD Mixing water for concrete -Specification for sampling, testing and assessing the suitability of water, including water recovered from processes in the concrete industry, as mixing water for concrete (Second revision) DEPARTMENT OF STANDARDS MALAYSIA FOR SALE WITHIN MALAYSIA ONLY. (n.d.).

[5] Thermal Conductivity. (2023). Gsu.edu. http://hyperphysics.phy-astr.gsu.edu/hbase/Tables/thrcn.html