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Recycled Paper Sludge (RPS) as Partially Replacement Material for Sand in Concrete.

Albright Lim[1], Mohamad Luthfi Ahmad Jeni[1,2*], Hilmi Kosnin[1]

[1]Department of Civil Engineering Technology, Faculty of Engineering Technology, University Tun Hussien Onn Malaysia, 84600, Panchor, Pagoh, Johor, Malaysia.

[2]Intelligent Construction Centre, University Tun Hussien Onn Malaysia, 84600, Panchor, Pagoh, Johor, Malaysia.

*Corresponding Author Designation

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Abstract: Many research have been done recently on the use of waste materials in place of fine aggregates while making concrete. When compared to normal concrete, which could harm the environment if used excessively and is more expensive down the road, the usage of recycled paper sludge (RPS) in concrete will promote the idea of eco-friendliness and increase the strength of concrete. In this investigation, RPS substituted for up to 15% of the sand that is typically used as fine aggregate in concrete. The effectiveness of the RPS replacement concrete was compared to that of regular concrete after that. According to the findings, 5% RPS as sand replacement produces a slump height that is the closest to that of the control sample. Moreover, the highest water absorption was reached at the 15% RPS replacement ratio, or 4.773%. The distribution of RPS aggregates increased the voids, and the paper used in the concrete cubes had a high water absorption rate. Additionally, the closest concrete cube with a compressive strength of 25.03 MPa at age 28 days was made of 5% RPS concrete. As a result, the compressive strength dropped as the replacement RPS percentage increased. According to DOE mix design, a replacement percentage of 5% RPS is still acceptable, however RPS should not be replaced with sand more than 10%. Finally, the optimum content for this RPS research is 5% of percentages since it is still within the specified range based on the DOE concrete mix design 28 days.

Keywords: Recycled Paper Sludge, Replacement Materials, Sand, Concrete.

**Corresponding author: luthfi@uthm.edu.my*
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1. Introduction

In Malaysia, approximately 57,000 tonnes of paper are thrown into landfills each month, equivalent to chopping down 680,000 trees of marketable size, filling 456,000 cubic metres of waste area [1]. Paper is a major component of the waste stream, and it ends up in drains and rivers, generating issues like flash floods. Meanwhile, sand are used extensively in construction. In the preparation of concrete, for each tonne of cement, the building industry needs about six to seven times more tonnes of sand and gravel Thus, the world's use of aggregates for concrete can be estimated at 25.9 billion to 29.6 billion tonnes a year for 2012 alone[2]. As a result, to protect the environment, paper waste will be converted into RPS through a series of operations and replace with sand partially. Furthermore, combining RPS in concrete will promote the concept of sustainability.

The Recycled Paper Sludge (RPS) have been used within the concrete mixture on this research. The Recycled Paper Sludge (RPS) have been gathered with SWM Environment SDN BHN. Each sample cube utilised is 100mm x 100mm x 100mm in length. The test has been performed at Universiti Tun Hussein Onn Malaysia (UTHM), Pagoh, inside the concrete laboratory. The test that had been conducted was slump test, concrete density test, water absorption test and compressive test. This concrete is synthetic through sand with Recycle Paper Sludge (RPS) in a predetermined ratio. The samples would be analysed for compressive strength at 7 and 28 days of age. The association for the guidance of tested samples is 0%,5%,10% and 15% of RPS.

This research aimed to determine the optimum percentage of RPS as a sand replacement in concrete mix and to compare the mechanical properties such as workability, density, water absorption and compressive strength of a concrete mix containing RPS and regular concrete.

2. Methodology

A stable and precise assessment is needed to acquire the study's goals. As an end result, the method used within the observe is an important issue to provide correct results and cover all factors, whether theoretical or practical, the study's method must be cautiously planned and compiled.

Laboratory studies were carried out to collect information on concrete compressive strength, slump tests, and different variables to determine the effectiveness of the usage of recycled paper sludge ash mix with cement in concrete mixtures. The results of these assessments will analyse to achieve the study's goals and objectives.

2.1 Materials

A significant stage before beginning concrete mixing is to determine suitable and standardized materials. Cement, recycle paper sludge, coarse aggregate, fine aggregate, and water are all require.

2.1.1 Cement

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. Figure 3.2 has shown the Portland cement that was used in the concrete mixing.

Figure 1: Ordinary Portland Cement (OPC)

2.1.2 Coarse Aggregate and Fine Aggregate

The fine aggregate or sand utilised in this test was sand that met the requirements for concrete mix. This sand should be devoid of pollutants and spotless. Coarse aggregate is made up of granite particles, and this mortar cannot contain more than 1% clay by weight. This coarse aggregate must have a suitable form, and the size chosen in this study is in the 20 mm range. Both coarse aggregate and fine aggregate shown in Figure 2.

Figure 2: Coarse aggregate and fine aggregate (sand)

2.1.3 Recycled Paper Sludge

RPS will be produced by recycling old paper. It was then turned into fine aggregate after being sun dried. Newspapers, periodicals, used invitation cards, and paper tickets are just a few examples of sources that contain recycled paper. We worked in conjunction with SWM Environment Sdn. Bhd. on this project. They consented to give us 100 kg of recycled paper. The picture of recycled paper obtained SWM Environment shown in Figure 3.

Figure 3: Recycled Paper Sludge

2.1.4 Water

Water used in concrete mixes must be from a clean and approved source. In addition, the water used should be free from contaminants such as floating solids, organic matter, and so on [3]. Therefore, in this study, tap water is used in the concrete mix.

2.2 Sample Preparation

2.2.1 Concrete Cube Sample

For 7 and 28 days, a complete sample of 24 concrete cubes will be use in this investigation. In this study, cube samples will be used for density, water absorption, and compression testing. Table 3.2 illustrates the number of cube tests executed in 7 and 28 days. Furthermore, Recycled Paper Sludge (RPS) have been utilised as a substitute material in percentages of 5%, 10%, and 15%. The cube test has a scale of 100mm x 100mm x 100mm. As a end result, the trial mix employed is 0.0066 m3, as stated in Table 1 below.

Table 1: Amount of Cube Sample

RPSA Percentage (%)	Number of Concrete Cube
0%	6
5%	6
10%	6
15%	6
Total Concrete Cube	**24**

2.2.2 Design of Concrete Mix

Mix design refers to the method of determining the needed and described capabilities of a concrete mixture. The concrete blend layout is by following the procedure from Department of Environment (DOE). This concrete cube blend is meant to attain a compressive strength of 25 N/mm^2 in 28 days and an entire disintegrate slump test drop of 30mm to 60mm. The scale size for the concrete cube tests 100mmX100mmX100mm. Every cube mixture will comprise an additional 10%, for every proportion, it must be done to ensure the possibility of a shortage of mixture is not happening while doing the test. Table 2 show to compute the amount of material need for concrete mix design calculations by using the DOE method. To preserve the volume of concrete in every trial mix will be at 0.0066 m^3, each aggregate will be combined and divided into six cubes, each with a different percentage by following the scope of the study.

Table 2: Amount of Material Used Based on Concrete Mix Design Calculation

Percentage of RPA (%)	Weight of Material (Kg)					Number of Samples
	Cement	RPS	Fine Aggregate	Coarse Aggregate	Water	
0	2.11	0	2.67	9.50	1.06	6
5	2.11	0.13	2.54	9.50	1.06	6
10	2.11	0.27	2.4	9.50	1.06	6
15	2.11	0.40	2.27	9.50	1.06	6
						24

3. Results and Discussion

3.1 Slump Test Result

Figure 4.1 demonstrates that while the slump value of new concrete has dropped, the proportion of RPS has grown. Due of RPS's ability to provide higher water absorption values than regular concrete, the slump test seems to have a lower slump value. This situation develops as a result of RPS, which absorbs water faster than sand [4]. Therefore, the workability of new concrete decreases as the percentage of RPS replaces sand increases in the concrete mixture.

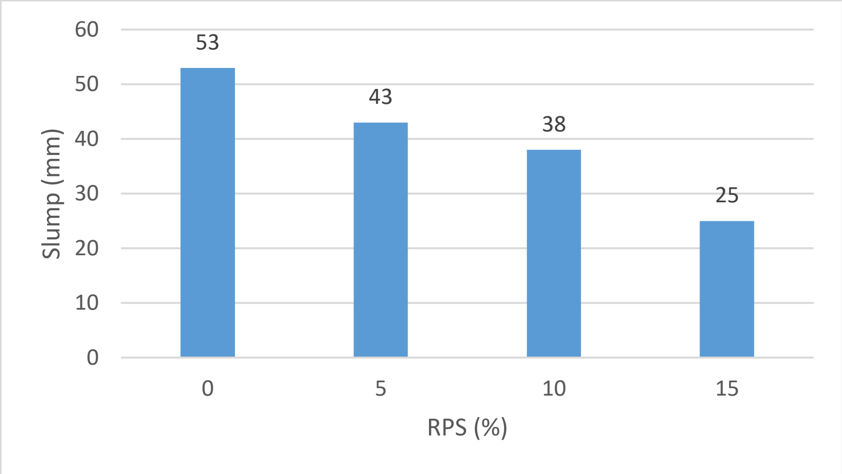
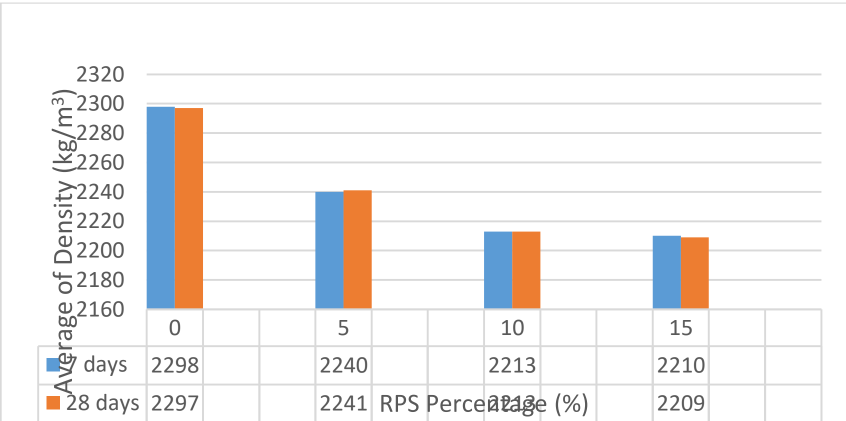


Figure 4: Graph of Slump Test Result Between Different Percentages of the RPS

3.2 Density Test Result

Based on Figure 5, it shows that the density of concrete decrease when the percentage of RPS increases. According to [5], RPS have a lower density than sand which could lead to a decrease in the overall density of the concrete mixture. The figures 4.2 also show the density of concrete at 7 days is not significantly different from the density at 28 days. This is because the concrete is already fully hardened and cured at 7 days, and the density does not change significantly after that point. Therefore, the density of concrete does not have a significant impact on the overall curing duration of the material.



	0	5	10	15
7 days	2298	2240	2213	2210
28 days	2297	2241	2213	2209

Figure 5: Graph of Density Test Between Different Percentages of the RPS

3.3 Water Absorption Test Result

Figure 6 show the percentage of water absorption at 7 and 28 days which had the different percentages of RPS content in each mixture. During this process, some of the water is absorbed into the cement and aggregate and the concrete begins to harden. As a result, the water absorption of concrete may change slightly as it cures. However, the change in water absorption is typically not significant [6] as shown in Figure 4.3, there only slightly change in water absorption between concrete cure at 7 days and 28 days. The water absorption of concrete is largely determined by the porosity of the material, which is influenced by factors such as the type and amount of cement and aggregate used, the water-to-cement ratio, and the method of curing. In this study samples, the water absorption percentage increased with the increase in the use of RPS. The higher of RPS percentage in the sample, the higher the percentage of water absorption rate for the sample of 7 and 28 days. The water absorption of normal concrete was 2.977% for 7 days and 3.062% for 28 days which was the lowest percentage compared to the concrete cubes samples that had replacement materials of RPS. Maximum water absorption was attained at the replacement ratio of 15% RPS, which was 4.773% in 7 days and 4.675 % in 28 days. This was due to the distribution of RPS increasing the voids within the concrete cubes. To conclude, the percentage of water absorption increased with the percentage of RPS as the age of the sample increased.

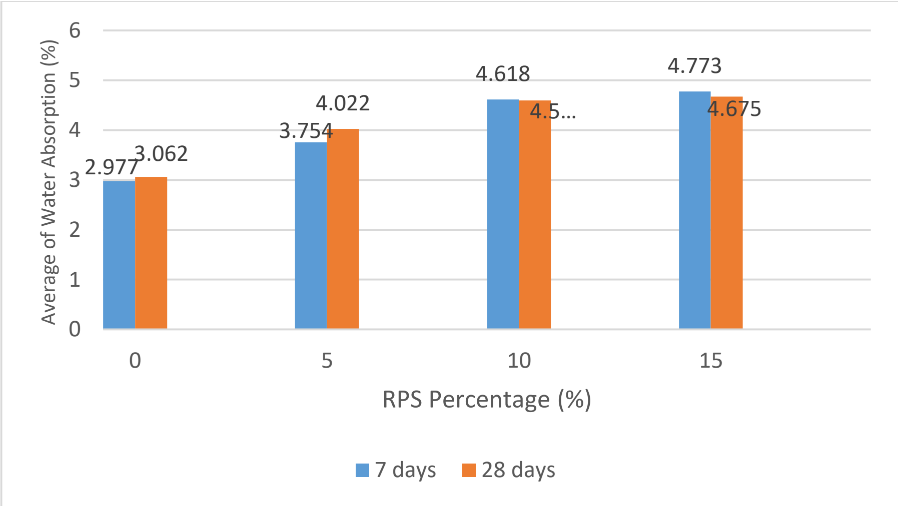


Figure 6: Graph of Water Absorption Test Between Different Percentages of RPS

3.4 Compressive Strength Test Result

Figure 7 showed the compressive strength of concrete cubes with the replacement of 0% RAP. After 7 days and 28 days, the compressive strength of normal concrete was 16.66 MPa and 25.25 MPa respectively. After 28 days, the highest compressive strength value was 0% of RPS which is 25.25 MPa, while the lowest compressive strength value is 15% of RPS concrete which is 17.03 MPa. This occurred because the concrete did not reach sufficient maturity in 28 days of the curing process. The compressive strength of concrete cubes decreased as the RPS replacement percentages increased. Besides that, the compressive strength of concrete cubes samples with 5% and 10 %, RPS replacement were 25.03 MPa and 20.49 MPa after 28 days respectively. While the highest compressive strength concrete cube which containing RPS at age 28 days is 5% with compressive strength of 25.03 MPa. This compressive strength corresponds to the grade of the design concrete mix.

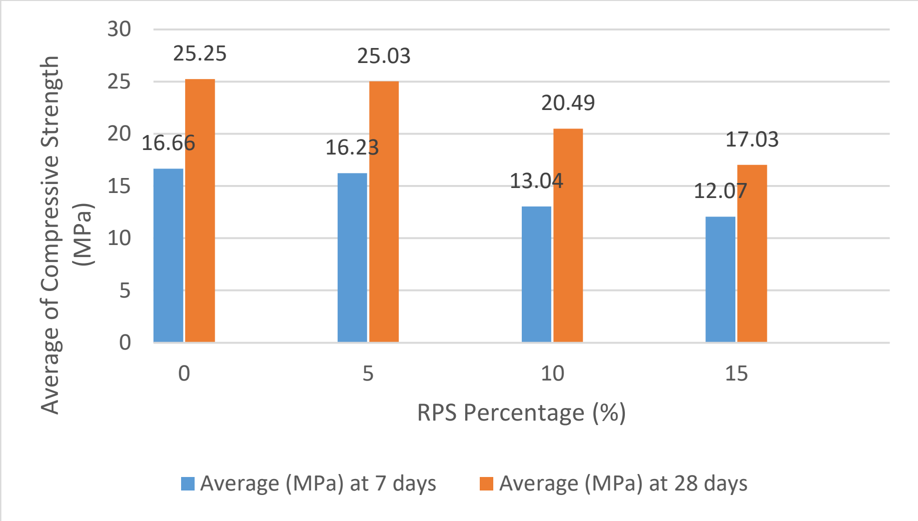


Figure 7: Graph of Compressive Test Between Different Percentages of RPS

4. Conclusion

The results of this study show that replacing 5% of sand with RPS in concrete has a positive effect on the strength and durability of the concrete. The 5% RPS replacement mix had a compressive strength that was still acceptable since it was within the proposed range based on the DOE concrete mix design. These improvements in performance suggest that the use of RPS as a partial replacement for sand in concrete has the potential to be a cost-effective and environmentally friendly alternative. Further research is needed to optimize the amount of RPS replacement and to investigate its use in other types of concrete mixes.

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