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Use of Rice Husk and Coconut Shell Ash in Concrete Production

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Abstract: Rice husk and coconut shell are produced in large quantities that need to be burned in an open air to disposed it. Due to high quantities of silica in the rice husk and high activated carbon in the coconut shell, it will cause some disposal problems in order to dispose it. The objective of this study is to determine the suitable material between rice husk and coconut shell as a partial replacement of material in the production of concrete by comparing the data gathered from previous researchers. Rice husk ash contain around 85% to 90% of amorphous silica that can increase the strength of concrete due to pozzolanic reactions. Coconut shell ash can produce concrete that have good impact resistance and smooth surface on one surface of coconut shell can increase the workability strength of concrete. Data collected from previous researchers and compared the properties of rice husk concrete and coconut shell concrete to determine the suitable material as a partial replacement of material in concrete. The result obtained show that rice husk is suitable as a partial replacement of material in concrete as it does not show significant decrease the strength of concrete which is 41 MPa at 28 days compared to coconut shell which is 20 MPa. The recommendation is the partial replacement of rice husk and coconut shell suitable in the production of lightweight concrete as it can use under low loads and dry applications.

Keywords: Rice husk, coconut shell, agricultural waste, concrete strength comparison

1. Introduction

Concrete is one of the most used structural material in the construction. Concrete can be define as the material resulting from a mixture of cement, fine aggregates, coarse aggregates, and water according to the specific mixing ratio. For ordinary mixes, the rate of mixing cement is set according to the specific mixing ratio. Concrete is widely used in the construction of buildings especially on columns, beams, and floor slabs [1]. Furthermore, the demand of building's material increasing in Malaysia and the cost of material will be increasing too. Cement cost could go up by 10% per tonne year by year [2].

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Malaysia is one of the most developing country in Asia, increasing demand of food source especially wheat [3]. This causes the production of rice husk also increased and Rice husk is an agro-waste due to its abundance and will be burned in an open air to disposed it. The burning of rice husk can cause disposal problem due to higher quantities of silica in the rice husk [4].

This study is concerned about rice husk and coconut shell ash as a partial replacement of material in concrete mixing and make the comparison concrete structural strength based on data from previous researchers. The main objective of this study is to determine the suitable material between rice husk and coconut shell as a partial replacement of material in concrete production by comparing the data gathered from previous researchers.

1.1 Rice Husk

Rice husk is an easily available agricultural waste produced by millions of tons each year. Use of rice husk in concrete production can prevent the occurrence of open burning as well as helps in overcoming problems related to rice husk removal and air pollution that can threaten the environment. Rice husk ash is pozollanic material that can form a silicate hydrate in the concrete which can strengthen, adding impermeability and sulfate resistance to the concrete [5].

1.2 Coconut Shell

Coconut shell ash has been reported to have produced the highest activated carbon among the agro waste material [6]. The application of coconut shell ash is very sustainable to use in the concrete production. It also has been proved that substance for concrete is expensive, and this project has promising alternative replacement for the binder [7]. Coconut shell ash has contained lower cellulose which can produce a lower absorbing moisture concrete compared with other agro wastes.

2. Materials and Methods

2.1 Data Comparison

The first phase of conducting the comparison method is find the research paper that related with the study by identified the title and the abstract. Relevant keywords such as rice husk ash, coconut shell, partial replacement of material in the production of concrete and others related keyword were used to find the suitable research paper. The research papers that has been searched were classified according to the title of the study, namely rice husk ash and coconut shell.

The second phase of the method is comparison. Data were collected from the research paper based on the properties of concrete which are compressive strength, density of concrete and the workability of concrete. Determination of the value of correlation coefficient has been done by plotting the graph based on the data collected from the previous researches. The value of correlation coefficient obtained from the linear regressions of the graph and the purpose of it is to analysed the data collected. All of the results obtained then compared to determine the suitable material for partial replacement of material in concrete.

2.2 Methods

Figure 1 below show the flowchart diagram of the method used in this study. Selected research paper that related with the study used to collect the data and classified each data according to the properties of concrete. Graph plotted based on the data collected and visible the trendline on the graph to find the value of R^2. Then, analysed data and result and make conclusion for the study based on the result obtained.

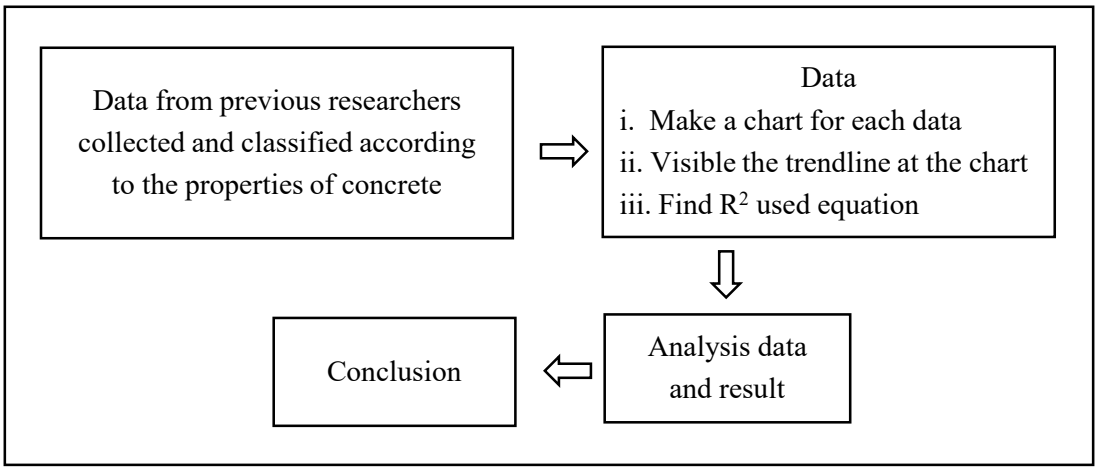

Figure 1: Method Flowchart

2.3 Equations

Analysis data used in this study is by determine the value of R^2. As Eq.1, R^2 can be define as the correlation coefficient and used to determine the correlation between two variables. The value of R^2 that near zero or at zero classified as low correlation while the value that near 1.0 indicates high correlation. The value of R^2 can be determine by **Eq. 1** below [8]:

$$r^2 = \frac{(\sum(x_i - x_{mean}) \cdot (y_i - y_{mean}))^2}{\sum(x_i - x_{mean})^2 \cdot \sum(y_i - y_{mean})^2} \quad \textbf{Eq. 1}$$

3. Results and Discussion

3.1 Data

According to Farah et al. [9], partial of fine aggregates has been replaced with coconut shell ash in the production of lightweight concrete. Fine aggregates had been replaced with coconut shell by 10%, 20% and 30% respectively. Partial replacement of ordinary Portland cement with coconut shell ash by 10%, 15%, 20% 25% and 30 % in the production of concrete had been made according to Utsev et al. [10]. Data obtained from both of the researchers show that the compressive strength of concrete reduce when the percentage of replacement increased.

Azunna et al. [11] studied the mechanical properties of concrete with 10%, 20% and 30% partial replacement of fine and coarse aggregates with coconut shell. Adana et al. [12] made an experimental study on partial replacement of coarse aggregate with coconut shell in the production of concrete by 10%, 20%, 30% and 40% respectively. Increasing the percentage of partial replacement caused the density of concrete reduced and the slump of concrete increasing according to Azunna et al. [11].

Compressive strength of concrete increased with 10% of partial replacement of ordinary Portland cement with rice husk ash but replaced 20% of rice husk ash caused the compressive strength reduced

[13]. According to Ghassan et al. [14], concrete with partial replacement of cement with 0%, 10% and 20% of rice husk ash respectively show the decrease of the workability when the percentage increased. The replacement of cement by 10%, 20% and 25% of rice husk ash significantly reduced the density of concrete cube at age of 7 and 28 days based on the data from John et al. [15].

Maurice et al. [16] studied the compressive strength of concrete with partial replacement of ordinary Portland cement with rice husk ash by 10% and 20% respectively. The strength obtained at 7, 14 and 28 days increased but the addition of percentage replacement with rice husk ash reduced the strength. The workability of concrete decreased when the percentage replacement of cement with rice husk ash increased by 0%, 10% and 20% according to Ashwini et al. [17].

3.2 Workability

Table 1: Slump Result of CS and RHA

Author	Material	Percentage Replacement (%)	Slump (mm)
[12]	CS	0	120
[12]	CS	10	112
[12]	CS	20	103
[17]	RHA	0	72
[17]	RHA	10	89
[17]	RHA	20	97

The value of slump decrease when the percentage replacement for coconut shell is increase. Meanwhile, the increase of percentage replacement of rice husk ash make the value of slump increase. This show the material for rice husk ash in production of concrete is more workability than the coconut shell when the percentage replacement increase. The data can be see at **Table 1.**

As shown in the **Figure 2,** the R^2 trendline of the slump reading of rice husk ash is increasing significantly due to the addition of chemical admixtures which is super-plasticizers agents from rice husk ash. It shows that the workability of rice husk ash in the concrete production is increase as the percentage replacement of rice husk ash in the concrete increased. Meanwhile for the coconut shell, the workability obtained through the increasing of percentage in the concrete were decreased. It is because the size of coconut shell that coarse caused the coconut shell did not mixed well with other materials. This data shows that using rice husk ash in the concrete production is suitable to obtain high workability in the concrete.

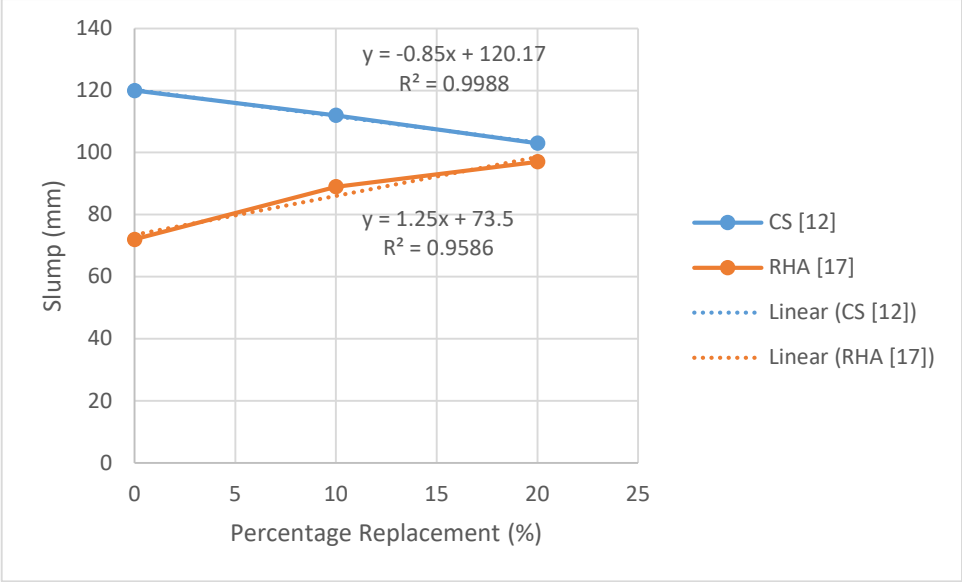

Figure 2: Graph for percentage replacement vs slump

3.3 Density

Table 2: Average Density of CSA and RHA

Author	Material	Percentage Replacement (%)	Average Density (kg/m^3)
[9]	CSA	0	2342
[9]	CSA	10	2274
[9]	CSA	20	2228
[9]	CSA	30	2170
[15]	RHA	10	2303
[15]	RHA	20	2297
[15]	RHA	25	2293

The average of the density that analysed from previous researcher are from 2170 (kg/m^3) until 2342 (kg/m^3) as shows in **Table 2.** When the percentage replacement of coconut shell and rice husk ash increase, the average density decrease due to the bond characteristic. During the secondary hydration, the consumption of Ca(OH) from the strength by calcium silica hydrate that cause the concrete less dense.

It is shown that the R^2 value of the coconut shell ash density decreasing significantly with the percentage replacement of the substance in the concrete production. It is because the result from **Figure 3** for the R^2 value in the graph for the coconut shell ash is 0.9948 which is nearer to 1, compared to the R^2 value for the rice husk ash which is 0.9944.

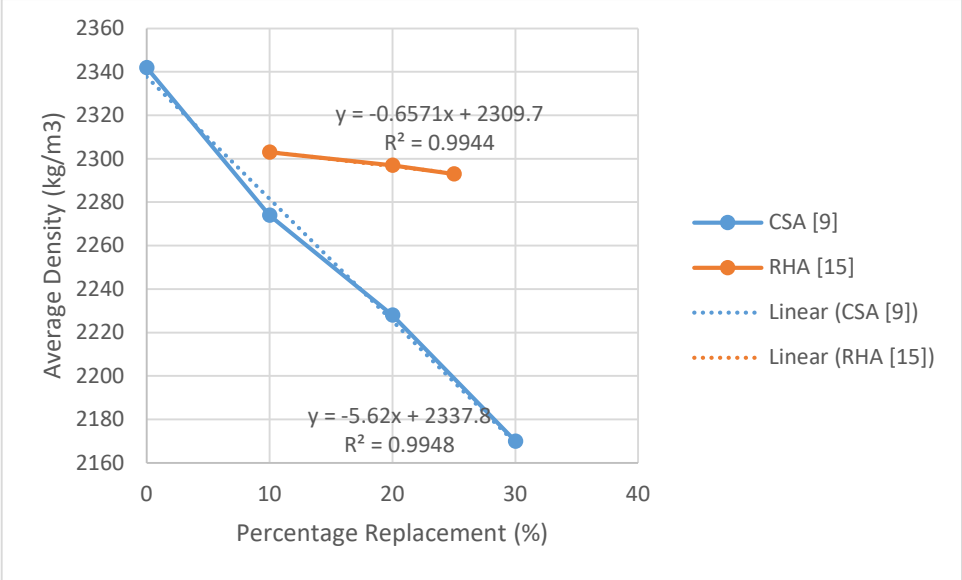

Figure 3: Graph for percentage replacement vs average density

3.4 Compressive Strength

Table 3: Compressive Strength of CSA and RHA

Author	Material	Percentage Replacement (%)	Compressive Strength (MPa)		
			7 days	14 days	28 days
[10]	CSA	0	14	19	34
[10]	CSA	10	13	18	32
[10]	CSA	20	9	12	20
[13]	RHA	0	40	43	49
[13]	RHA	10	38	43	50
[13]	RHA	20	33	35	41

Most of the result for the compressive strength data are decrease when the percentage of coconut shell ash and rice husk ash increase as shows in **Table 3.** Day by day, the value for compressive strength increase but it become decrease due to increase of percentage replacement.

As shown below in **Figure 4,** most of the trendline for the data are above 0.9. This indicates that the data are represent to a smaller differences between the observed data and fitted data. R^2 can be meant as coefficient of determination, or multiple determination for multiple regression [18].

At **Figure 4,** the value of compressive strength against curing days at the graph for rice husk ash are higher than coconut shell ash. It shows that the strength for concrete production of rice husk ash stronger than the concrete made form coconut shell ash.

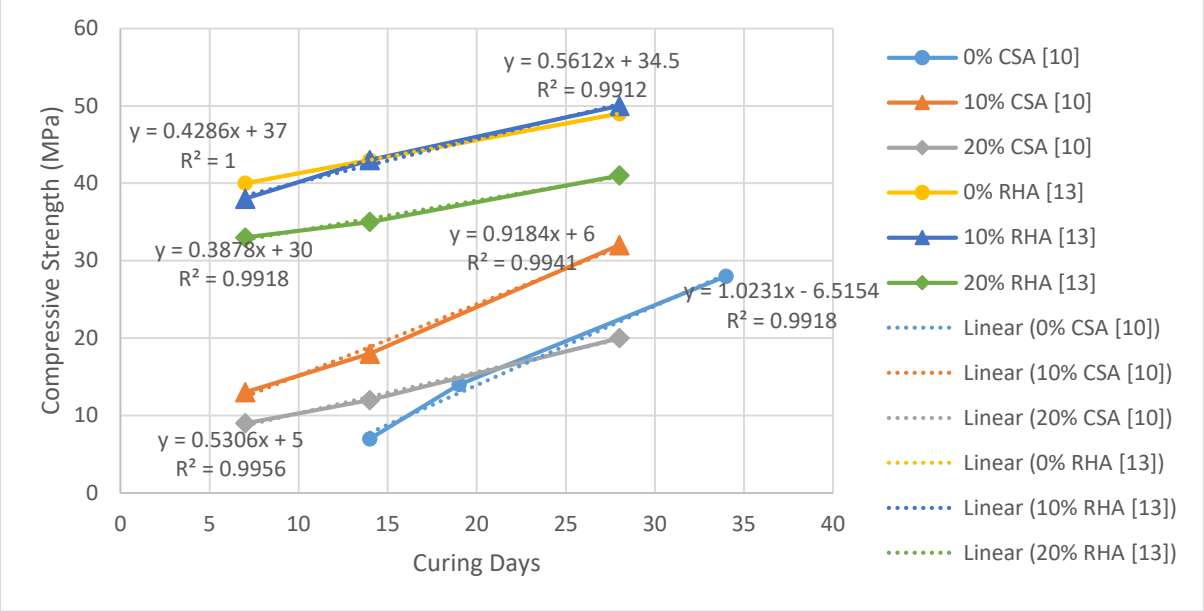

Figure 4: Graph for curing days vs compressive strength

4. Conclusion

Based on the analysis of data from previous researchers and discussion in this study, it can be concluded that overall strength of concrete with partial replacement of material with rice husk ash and coconut shell decreased compared with the control concrete. Rice husk ash concrete show better workability of concrete compared with the workability of coconut shell concrete. It is because the slump reading of rice husk ash concrete increasing compared with coconut shell concrete which is decreasing.

The density of rice husk ash concrete and coconut shell ash concrete decreased when the addition of material increased. Based on the R^2 value, it shows that the density of coconut shell ash concrete significantly reduced compared with the rice husk ash concrete.

The compressive strength of a control concrete at 7 days and 28 days is 16.25N/mm^2 and 25N/mm^2 respectively. Additional of rice husk ash and coconut shell ash decreases the strength of the concrete as the percentage replacement of the substance increases. However, based on the data and discussion, partial replacement with rice husk ash concrete suitable for concrete grade of M30 and M35 because the value of compressive strength of rice husk ash concrete achieved the standard compressive strength of M30 and M35 concrete which are 30 N/mm^2 and 35 N/mm^2 respectively.

In the conclusion, rice husk ash is a suitable material to partial replacement material in the production of concrete because the decrease in strength shown by rice husk ash is not significant compared to coconut shell. However, the large addition value of replacement percentage can also reduce the strength of concrete. Therefore, the percentage replacement is suggested to be in a low value such as 1% to below 10% and concrete produced with the replacement of such materials is suitable for use under low loads and dry applications.

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