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Concrete Performance Using Rice Husk Ash as Partial Cement Replacement: A Review

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Abstract: A review on the Concrete performance using rice husk ash as partial cement replacement. The objective of the study it to review the properties of concrete and rice husk ash. Due to high demand of concrete use in the world, there is excessive emission of carbon dioxide causing environment pollution. Modification of concrete using waste material can help to reduce the environment pollution. Rice husk ash (RHA) are organic agriculture product that can help to reduce the pollution in an eco-friendly way. The properties of the concrete on compressive strength, water absorption and thermal conductivity are reviewed. The research proved that with the help of rice husk ash is able to improve the performance of the concrete. The data of the concrete with 0.00 %, 10.00 %, 15.00 % and 20.00 % is being compared to achieve the best ratio of rice husk ash replacement. From the research, the optimum value for the replacement is 10.00 %

Keywords: Cement Replacement, Concrete, Rice Husk Ash (RHA),

1. Introduction

Concrete are the mixture of cement, fine aggregate and coarse aggregate. Due to the characteristic of high compressive strength, low maintenance cost, resistant to weathering effect, economical, it's had good structural performance that can turned virtually into any shape. Concrete is a building material that is not only strong and durable but can also be produced in ways that are environmentally friendly and architecturally mouldable in aesthetically pleasing forms. Concrete is the most common building material that can be seen in the construction industry. The concrete structures, pavements, airfield runways, bridges, sidewalks, that constitute our built environment [1]. Excessive carbon emission from OPC production is expected due high demand for concrete/cement used in the construction industry. Therefore, it requires an addition to the concrete mixture to help on reducing the emission of Carbon Dioxide

Rice husk was long considered as agriculture by product and was often dumped causing an increment of organic waste [2]. There are about 20.00 % of silica content can be found in rice husk. Beside that 60.00~65.00 % volatile matter, 10.00-15.00 % fixed carbon can also find in rice husk. This

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makes it a good additive for the steel and concrete industries. To a lesser degree, rice husk ash is used as soil conditioner, activated carbon, insulator, and others.

Rice husk ash are the byproduct of rice husk after burning under high temperature. According to [3] the uses of rice husk ash in cement as a based material is able to reduce heat of hydration, improves strength and also reduction in building cost. The pozzolanic material in rice husk ash is able to improve the microstructure of the cement which helps to increase the strength and durability of the concrete.

2. Rice Husk

Rice production in the world is able reach approximately 678 million tons of rice a year, and the value is increasing as the world population and the consumption of rice increases. It is estimated that 90.00 % of the rice is produced in the Asia. [4]. Data of Asia rice production is shown in Table 1 The milling of rice produces rice husk, which is type of agriculture waste material. Rice husk is generated on average at a 20.00 % rate by production of the rice. Most of the husk is burned or dumped as waste. Rice husk ash can be form with an average of 18.00 % by weight of the husks [5].

Table 1: Data of Asia rice production [6]

Country	Rice Production in 2010 (million tons)	Husk Produced (20% of total) (million tons)	Ash Produced (18% of husk) (million tons)
Bangladesh	51.50	10.21	1.84
Cambodia	9.39	1.88	0.34
China	205.21	41.04	7.39
India	159.20	31.84	5.73
Indonesia	71.28	14.26	2.57
Myanmar	28.77	5.75	1.04
Pakistan	6.80	1.36	0.25
Philippines	18.44	3.69	0.66
Thailand	36.06	7.21	1.30
Vietnam	44.04	8.80	1.58
Total	630.69	126.04	22.7

Rice husk (RH) is a potential by-product of rice milling where it is abundantly available waste material in all rice producing countries, and it contains about 30.00 %-50.00 % of organic carbon, where it turns to a more valuable material [7].

2.1 Rice husk ash (RHA)

Rice husk ash are produced through burning the husk with temperature of below 800 ^{o}C. According to Siddika, A et al (2018) [8], Rice Husk Ash contains a lot of non-crystalline silica that is suitable to be added in to the Portland cement. The study also shows that the high-carbon content in Rice husk Ash can affect the properties of concrete on causing a high crystalline form in the structures. A table of the chemical properties of rice husk ash is being tabulated in Table 2

Table 2: chemical properties of rice husk ash (RHA)

	SiO_2 (%)	Al_2O_3 (%)	Fe_2O_3 (%)	CaO (%)	MgO (%)	SO_3 (%)	Na_2O (%)	K_2O (%)	Loss on ignition (%)
Bui.L.A. et al [10]	92	0.25	0.14	0.81	1.05	0.96	0.99	3.44	3.62
Saraswathy, et al [11]	92.95	0.31	0.26	0.53	0.55	-	0.08	2.06	1.97
Siddika. An et al [9]	78-86	0.1-0.2	0.16-1.85	0.55-4.81	0.35-4.5	0.24-1.18	1-1.14	2.54-3.68	4-8.55
Chao-Lung, H et al [12]	91	0.35	0.41	-	0.81	1.21	0.08	3.21	8.5
Farah A.W.C et al [13]	90	0.39	0.37	0.46	0.88	-	0.07	3.10	3.03

According to the Table.2 shown, silica content in the rice husk ash is very high which is able to make it a highly pozzolanic material. The concrete mixed with rice husk ash needed more amount of water to present the consistency due to the absorptive characteristics of the cellular in rice husk ash particles [9].

3. Results and Discussion

The data was obtained from research paper of different researcher. The data on compressive strength, water absorption, thermal conductivity of the concrete after adding on different amount of rice husk ash. To achieve the objective of this study, the comparison method is being used to compare the data of the concrete performance with different amount of rice husk ash added in to the concrete mixture. The characteristic of the concrete on compressive strength, water absorption and thermal conductivity were conducted.

3.1 Compressive Strength

Compressive strength is one of the important properties of concrete. There are many factors that can affect the strength of the concrete such as the quality of materials used, mixture proportion ratio. Compressive strength is the ability of material or structure to carry the loads on its surface without any crack or deflection. A material under compression tends to reduce the size, while in tension, size elongates. Figure 1 shows a comparison of data on the compressive strength of concrete on 28 days with different percentage of rice husk ash.

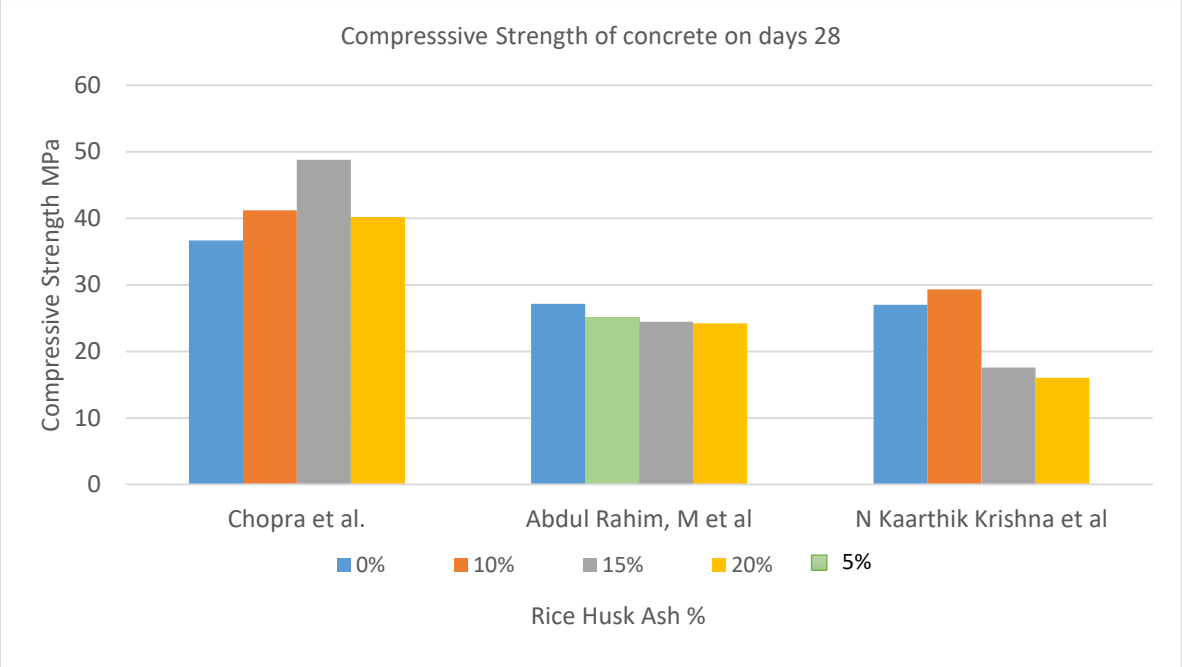

Figure 1: The compressive strength of concrete on 28 days with different RHA % by different research

From Chopra et al [14], the compressive strength obtained was in the range of 29.0 and 36.2 MPa at 7 days and 36.7 and 48.2 MPa at 28 days. All of these data are mix with w/b ratio of 0.41. The highest value of compressive strength obtained was with 15.00 % rice husk ash mixed at both 7 days and 28 days. According to Abdul Rahim, M et al [15], the compressive strength of concrete, at 5.00 % of replacement is increased along with the curing age, from 20.15 MPa at 7 days, to 25.24 MPa at 28 days. From N Kaarthik Krishna et al [16], the increase in compressive strength from the controlled concrete to different ratio of RHA. The compressive strength increases from 27.00 MPa to 29.30 MPa on 10.00 % of RHA on the 28 days. With the aid of pozzolanic action from RHA, there is an 8.51 % of increment on the compressive strength.

3.2 Water Absorption

One of the durability of the concrete main sources of contamination of concrete in structures is water absorption which influences [3]. To achieve the target of a good quality concrete water absorption must be less than 5.00 % and this can be done by increasing density and reducing pore size so that there is poor pore connectivity and decreased porosity of concrete. A comparison data on Figure 2 shows the water absorption rate of concrete with different percentage of rice husk ash.

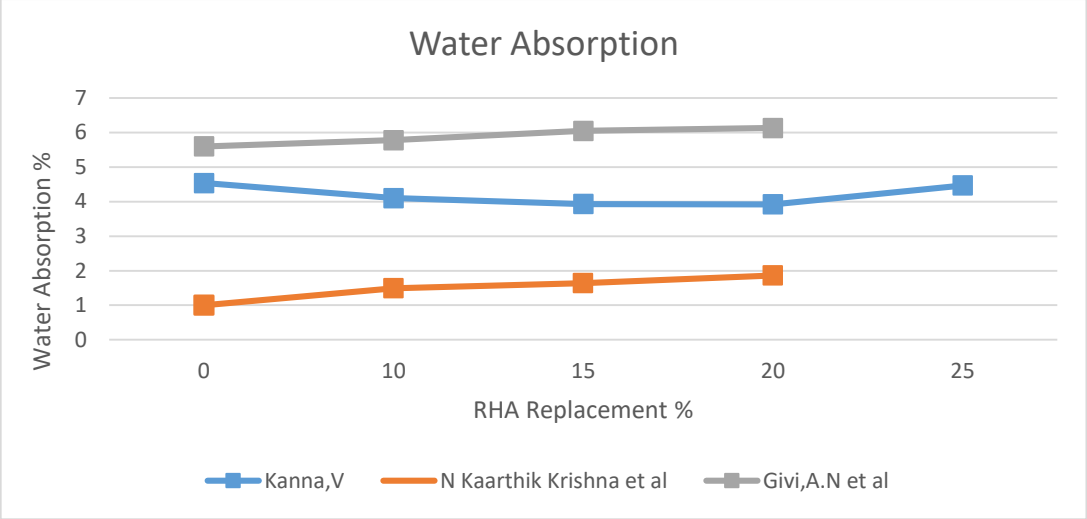

Figure 2: Water absorption rate varies by RHA % by several researcher

According to Kannan, V et al [17], the water absorption of concrete on the partial replacement of cement to rice husk ash from 5.00 % to 30.00 % at 28 days is observed. The water absorption of the concrete decreases to 3.93 % water absorption on 15.00 % of RHA content when compared to the controlled concrete on 4.54 % of water absorption. From the study of N Kaarthik Krishna et al [16], the water absorption of the concrete is found increases as the percentage of RHA increased. The factor of the increment in water absorption are the properties of rice husk ash. According to Givi, A.N et al [18], the water absorption of the concrete increases to 5.94 % when 5% of RHA is mixed in. But when 10.00 % RHA is added the water absorption dropped to 5.78 %. The water absorption rate continues to rise while the RHA ratio increases.

3.3 Thermal Conductivity

Thermal conductivity of the concrete on partial replacement of cement with rice husk ash are determine. The thermal properties of the concrete enable it to be insulated from external heat sources. The control sample of concrete with 0.00 % replacement was used to compare with different ratio of RHA replacement. Figure 3 shows the thermal conductivity of concrete with different replacement of cement with rice husk ash.

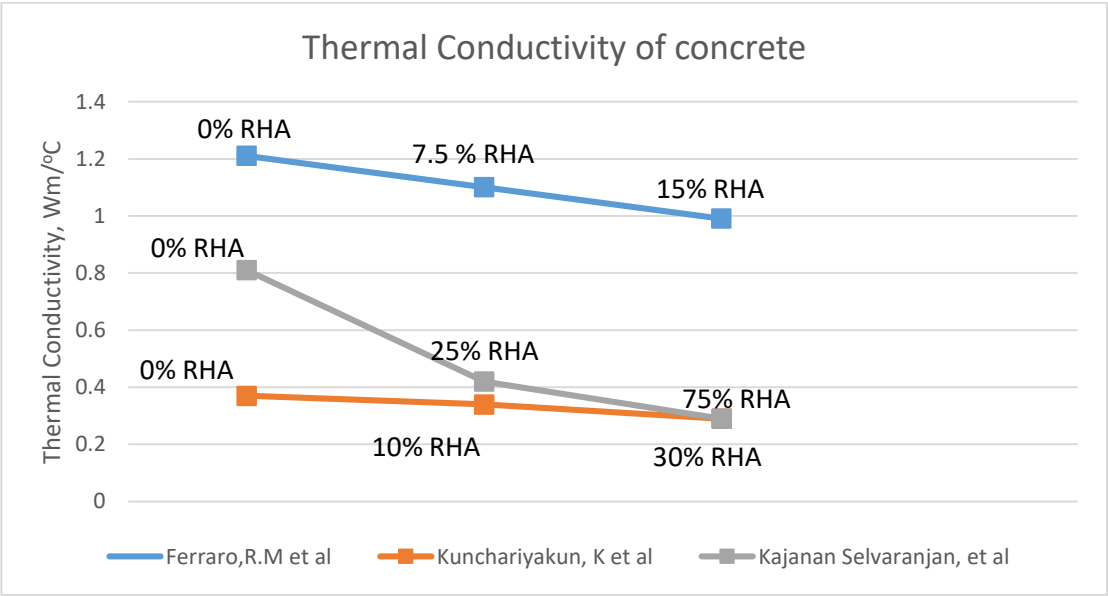

Figure 3: Graph of Thermal conductivity varies on RHA % by several researcher

According to Ferraro, R.M et al [19] study, the concrete sample prepared undergo the thermal conductivity test and density by the system of ASTM C332. After 28 days of curing, the partial replacement of cement with 7.50 % and 15% of RHA show a reduction on the thermal conductivity and the density of the concrete. From the study of Kunchariyakun, K et al [20], By the comparison of the control samples, the thermal conductivity values recorded for the replacement of RHA on 25.00 %, 50.00 %, 75.00 % and 100.00 % which show a significant drop of 7.00 %, 11.00 %, 22.00 % and 28.00 % on the thermal conductivity. From Kajanan Selvaranjan[21], the thermal conductivity of the controlled concrete was approximately 0.81 Wm/^{o}C. The 30.00 % replacement of RHA shows a 0.29 Wm/^{o}C.

4. Conclusion

The uses of rice husk ash in concrete as a replacement for cement can assist on decreasing the emission of green-house gases to a larger extent by increasing the possibility for gaining a greater number of carbon credits. To determine the suitability of using Rice husk ash as a replacement of cement partially. The suitability of rice husk ash as a cementitious material was assessed by conducting the properties of concrete on compressive strength, water absorption and thermal conductivity. From the review on the properties of the concrete, the optimum replacement of Rice Husk ash in cement was 10% in terms of workability and strength.

Acknowledgement

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