PARTIAL REPLACEMENT OF CEMENT WITH COMMERCIAL AVAILABE RICE HUSK ASH IN CONCRETE

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ABSTRACT
Natural coagulants are now proving to be good substitutes for chemical coagulants due to their availability, cost effectiveness, nontoxic and biodegradable natures. In this research work, the treatment of highly turbid surface water by coagulation method with sesame and peanut seeds as a natural coagulant has been investigated. This study investigates the potential, suitability, effectiveness and efficiency of sesame and peanut seeds as an environmental friendly and natural coagulant for the treatment of high turbid water, and the effect of each one of the coagulant on the pH of the water, as well as a comparison between the two natural coagulant as which one is more effective in removing the turbidity from water. The sesame and peanut seeds have been used after extraction of the active coagulation component by distilled water and salt solution. The results obtained from the jar test showed that peanut seeds extracted with KCL could effectively remove 88.3% of the 340 NTU turbidity using only dosage of 20 mg/l, while sesame seeds extracted could remove only 79.7% of the 344 NTU turbidity using dosage of 60 mg/l . Moreover, the results showed that the peanut seed is more effective in removing the turbidity from water more than the sesame seeds as it is not that effective in removing turbidity from water. So, it has been demonstrated, in this work, that peanut seed is one of the promising natural coagulants for water treatment Concrete is the world most used construction materials for many structural purposes due to its naturally high compressive strength but production of cement, one of its main ingredients which contribute to the concrete strength, require high amount of energy, costly and release tremendous amount of CO2 to the atmosphere causing global warming and climate change. Thus, by incorporating waste material which has pozzolanic properties as partial replacement of cement can contribute to a lower production cost and environmental friendly. Rice husk has been identified as having the greatest potential as it is widely available and, on burning, produces a relatively large proportion of ash, which contains around 80% - 90% of silica. There are 2 types of silica present in rice husk ash (RHA) which are amorphous and crystalline form. The former being more reactive towards pozzolanic activity and can be achieved through controlled burning. The purposes of this study are to determine the workability and compressive strength of concrete incorporating commercial based rice husk ash as well as the optimum replacement level of RHA based on the concrete compressive strength. Concrete grade M25 were used in this study without the addition of water reducing admixture. Cement is replaced by weight with rice husk ash at 10%, 15%, and 20%. Results showed that the slump value decreases as RHA content increase. Compressive test were done at 7 and 28 days of age. Optimum level of RHA replacement has been identified at 15% where the compressive strength of RHA concrete recorded almost similar value with control concrete.

Keywords:
compressive strength, concrete, optimum replacement level, rice husk ash, slump

INTRODUCTION

Milling of rice produce a by-product know as husk, which is the outer covering layer of paddy grain, commonly used as fuel for combustion in the rice mills to generate steam for the parboiling process. When the burning is done, what left of the husk has now turn into ash and is called as rice husk ash (RHA).

There are 2 types of silica in RHA which are amorphous and crystalline. Amorphous silica is softer, more chemically responsive and has a lower melting point than crystalline. Amorphous silica reacts more actively with lime from cement than those of crystalline form.. Early used of RHA mostly come from uncontrolled combustion which result in more crystalline structure than amorphous. Mehta (1977) published several papers dealing with utilization of RHA. He concluded that burning rice husk under controlled temperature – time conditions resulted in ash containing silica in more amorphous form.

According to the World Bank back in 2012, the worlds' cities produced 1.3 billion tonnes of solid waste such as industrial waste, agricultural waste and waste from rural as well as urban area per year. In the construction industry, some of this wastes had major contributions in the making of concrete such as fly ash, blast furnace slag, silica fume and rice husk (converted into ash) due to their pozzolanic properties. Rice husk has been identified as having the greatest potential as it is widely available and, on burning, produces a relatively large proportion of ash, which contains high amount of silica.

Production of cement, one of concrete main ingredients which contributes to the strength require high amount of energy, costly and release tremendous amount of CO2 to the atmosphere causing global warming and climate change. Thus, by incorporating waste material such as RHA which has pozzolanic properties as partial replacement of cement can contribute to a lower production cost and environmental friendly.

Incorporating waste products such as rice husk ash as partial replacement of cement can greatly reduce the cost of concrete since production of cement is expensive. By reducing the use of cement, less greenhouses gases such as CO2 were released to the atmosphere. The use of waste product is an environmental friendly method of disposing large quantities of waste that would contaminate the surrounding. Unlike natural pozzolans, rice husk ash (RHA) is a renewable source of silica since it came from paddy grain which can be planted over and over again. Countries that are major rice producer could use this method to develop structure and infrastructure with cutting cost in cement production as well as releasing less greenhouses gases.

Ramezanianpour *et al.* (2009) studied the effect of rice husk ash (RHA) on mechanical properties and durability of sustainable concretes using homogeneous RHA produced by special designed furnace at 650°C and 60 minutes burning time. Results showed that concrete with addition of RHA had higher compressive strengths at various ages when compared with control concrete.

Nagrale *et al.* (2012) conducted a research on utilization of rice husk ash (RHA) in concrete with M20 mix proportion. Results showed that compressive strength increased with increasing water/cement ratio for different percentage of RHA in concrete. Ramasamy (2012) evaluated the compressive strength and durability properties of RHA concrete using commercially available RHA with cement was substituted at 5%, 10%, 15%, and 20% by weight with RHA.2 grades of concrete were prepared, M30 for medium strength concrete normally used in column design and M60 for high strength concrete widely used in prestressed concrete. Strength of concrete increased with levels of percentage of replacement of 10% at which increase in strength was 7.07% at 90 days compared control.

Ghassan and Hilmi (2010)) studied on properties of rice husk ash (RHA) and its use as a cement replacement material. Results showed that RHA concrete give maximum strength value (30.8% increment over control mix) at 10% replacement of concrete. RHA can be used up to 20% to replace cement without jeopardising the strength.

Ravande Kishore *et al.* (2011) investigated the mechanical properties of high strength concrete with different replacement levels of ordinary Portland cement with rice husk ash (RHA). Results showed that the optimum level of replacement is 10% for both grades of concrete.

Godwin *et al.* (2013) conducted a research of introducing rice husk ash as a partial replacement of Ordinary Portland Cement (OPC) on structural properties of concrete. Results showed that RHA concrete has a slump between 50 - 90 mm. They conclude that RHA can be replaced with cement up to 25% without loss in workability or strength. However, 10% replacement is optimal for structural concrete. Ayesha Siddika *et al.* (2018) studied the strength of concrete with RHA replacement. Cement was replaced with RHA at 10% and 15% by weight. Slump decreased with increasing content of RHA. M. Anwar *et al.* (2000) investigated the main characteristics of the Rice Husk Ash. RHA concrete shows similar or higher strength than OPC concrete mix.

Therefore, the primary purpose of this research is to investigate the application of commercial ready-made rice husk ash (RHA) as a partial substitute of cement due to its pozzo lanic properties. The two (2) main areas which would be focused on are the workability and compressive strength of RHA concrete.

METHODOLOGY

The methodology is the theory of how research should be undertaken, including the theoretical and philosophical assumptions upon which research is based and the implications of these for the method or methods adopted. To meet the objective of this paper, an intensive literature review was conducted to explore and discuss the evolution of materials management research in the construction industry. Results and findings will be discussed in the next sections.

Collection of Ingredients

i) Rice Husk Ash (RHA)
Rice husk ash was obtained from a local gardening supplier. The ash was sieved through BS standard sieve size 75μm and its colour was grey/black

Table 1: Physical properties of RHA

No.	Particulars	Properties
1	Colour	Grey/Black
2	Shape texture	Irregular
3	Mineralogy	Non crystalline
4	Mean particle size	10.61 μm
5	Odour	Odourless
6	Specific gravity	2.21

Table 2: Chemical properties of RHA

No.	Particulars	Proportion (%)
1	Silicon dioxide	90.16
2	Aluminium oxide	0.11
3	Iron oxide	0.41
4	Calcium oxide	1.01
5	Magnesium oxide	0.27
6	Sodium oxide	0.12
7	Potassium oxide	0.65

ii) Cement
Ordinary Portland cement (OPC) of 53 grade conform to IS: 8112-1989 was chosen due to generally recommended in general civil construction work such as residential, commercial and industrial structures, where the grade of concrete is up to M-30, as in this case, grade M-25.

Table 3: Cement composition

No.	Contents	Percentage (%)
1	CaO	60 - 67
2	SiO_2	17 - 25

3	Al_2O_3	3 – 8
4	Fe_2O_3	0.5 - 6.0
5	MgO	0.1 - 4.0
6	Alkalis ($K_2O_3Na_2O$)	0.4 - 1.3
7	SO_3	1.0 - 3.0

iii) Coarse aggregates
Crushed granite according to ASTM Standard with maximum aggregate size of 20 mm is used.

iv) Fine aggregates
Natural sand according to ASTM Standard with maximum aggregate size of 4.75 mm is used.

v) Water
Water free from impurities is a must to mix with cement in order to form pastes which bind all the ingredients together.

Mix Design

Table 4: Without RHA replacement

Material	1 cube (kg)	6 cubes (kg)
Cement	1.62	9.72
Sand	3.38	20.28
Coarse aggregate	4.59	27.54
Water	0.81	4.86

Table 5: With 10% RHA replacement

Material	1 cube (kg)	6 cubes (kg)
Cement	1.46	8.76
Sand	3.38	20.28
Coarse aggregate	4.59	27.54
Water	0.81	4.86
RHA	0.16	0.97

Table 6: With 15% RHA replacement

Material	1 cube (kg)	12 cubes (kg)
Cement	1.38	8.26
Sand	3.38	20.28
Coarse aggregate	4.59	27.54
Water	0.81	4.86
RHA	0.24	1.46

Table 7: With 20% RHA replacement

Material	1 cube (kg)	12 cubes (kg)
Cement	1.30	7.78
Sand	3.38	20.28
Coarse aggregate	4.59	27.54
Water	0.81	4.86
RHA	0.32	1.94

Preparation of specimens

Cement and fine aggregate is mixed in a dry drum mixer until the mixture is thoroughly blended and is uniform of colour. Coarse aggregate is added and mixed with the mixture until it is uniformly distributed in the mixer. Water is added to the mix until it appears to be homogenous and of the desired consistency. The mixture is mixed for at least 5 minutes. Total of 36 cubes with size 150mm x 150mm x 150 mm were prepared. Figure 1 shows the sample preparation and Table 8 shows detail of the specimens.

Figure 1: Sample Preparation

Table 8: Detail of the specimens

Percentage	7 days	14 days	28 days
0% RHA Replacement	3	3	3
10% RHA Replacement	3	3	3
15% RHA Replacement	3	3	3
20% RHA Replacement	3	3	3
Total	12	12	12

Slump Test

The inner side of the mould is cleaned and applied oil. The mould is placed on a smooth horizontal non- porous base plate. The mould is filled with the prepared concrete mix in 4 approximately equal layers. Each layer is tamped with 25 strokes of the rounded end of the tamping rod in a uniform manner over the cross section of the mould. For the subsequent layers, the tamping should penetrate into the underlying layer. Excess concrete is removed and the surface is levelled with a trowel.Any mortar or water leaked out between the mould and the base plate is removed. Figure 2 below shows slump test.

Figure 2: Slump Test

Compressive Strength Test

The compressive strength of concrete is the most common performance attribute used when designing structures. Compressive strength is measured by breaking cube concrete specimens is a compression-testing machine. Compressive strength is calculated from the failure load divided by the cross-sectional area resisting the load and reported in units per square meter. Figure 3 shows the specimen before and after compression test.

(a) (b)

Figure 3: Compressive Strength Test (a) Before Compress, (b) After Compress

RESULTS AND DISCUSSION

Slump Test

Table 9: Slump Test Results

Concrete Mixture	Slump (mm)
Control	62
RHA (10%)	53
RHA (15%)	46
RHA (20%)	35

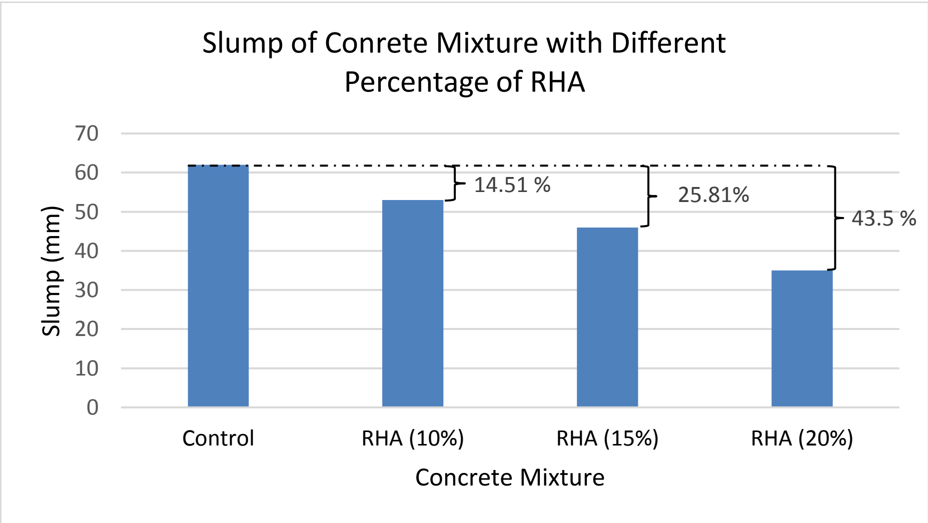

Figure 4: Slump Test with Different Percentage of RHA

The fresh properties of concrete mixtures are given in Table 9 and Figure 4; the design slump is between 50 - 75 mm, bleeding was negligible for the control mixture. For concretes incorporating RHA, no bleeding or segregation was recorded. OPC control mixture and RHA 10% recorded slump values of 62 and 53 mm respectively, which falls 14.51 % in the range of design slump. However, when the percentage of RHA increases, the slump value continue to decrease as shown by RHA 15% and RHA 20% concrete mixture which resulted in 46 and 35 mm in that order. The percentage increase 25.81% for RHA (15%) and 43.5% for RHA (20%). The results showed a good agreement with Nagrale (2012) in the study of the utilization of rice husk ash (RHA) in concrete. Adding RHA to the concrete increases the cohesiveness of the mixture and stiffness because of the high fineness of RHA. RHA has a much higher surface area compared to cement which resulted in higher water demand. To maintain the workability, it is absolutely recommended to use water reducing admixtures in RHA concrete mixtures. It is clear that slump decreased with the increase in RHA content.

Compression Test

Table 10: Compression Test Results

Concrete Mixture	Strength at 7 days (MPa)	Strength at 28 days (MPa)
Control	19.05	25.72
RHA (10%)	16.24	22.28
RHA (15%)	18.66	25.12
RHA (20%)	17.76	24.43

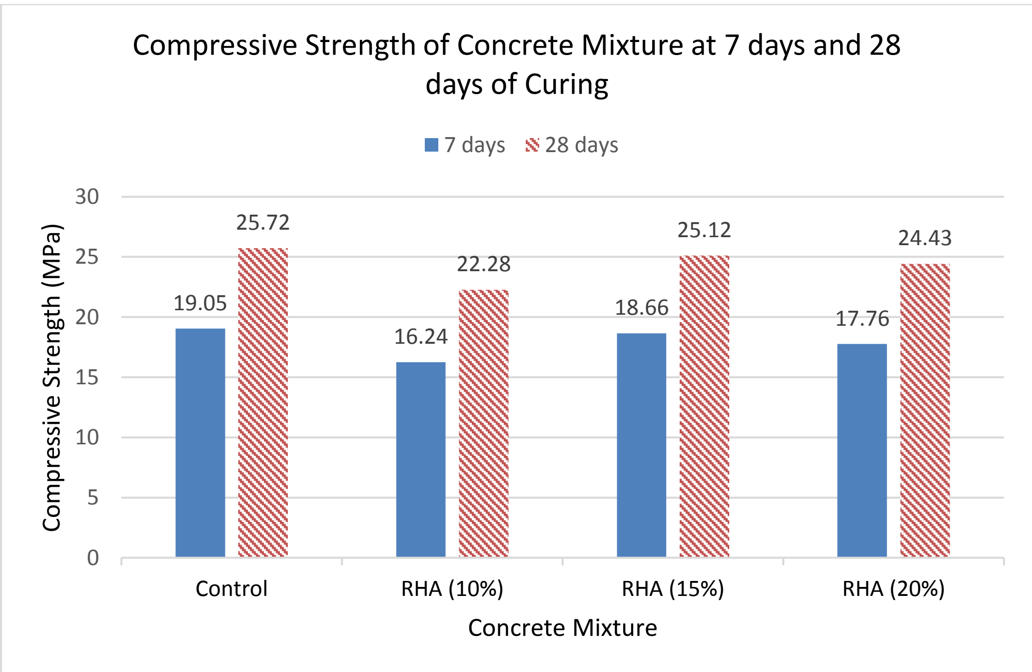

Figure 5: Compressive Strength of Concrete Mixture at 7 days and 28 days of Curing

Figure 5 shows, in terms of replacement level, the 10% achieved lower values of compressive strength at both 7 and 28 days. Based on that, it can be noticed that the amount of RHA present when 10% replacement is used not adequate enough to enhance the strength of concrete. The available silica from the 10% RHA reacted with only a small portion of calcium hydroxide (C-H) released from the hydration process and thus, the calcium silicate hydrate (C-S-H), which is responsible for the strength of concrete, released from the pozzolanic reaction was relatively limited.

The strength increased with RHA for up to 15% which resulted in achieving the maximum value compared to other replacement level. RHA (15%) mixture resulted in 14.90 % and 5.07 % increment compared to RHA (10%) and RHA (20%) at 7 days of curing. As for 28 days, RHA (15%) mixture recorded 12.75 % and 2.82 % increment compared to RHA (10%) and RHA (20%). At 15% replacement level, the amount of silica from RHA is proportionate to react with the amount of C-H available from the hydration process, thus undergoing optimum pozzolanic reaction. When compared to OPC control mix tested at 7 and 28 days age, RHA (15%) falls just slightly below the control strength.

The strength values when RHA was replaced by 20% were found to be higher than 10% but lower compared to 15%. In this case, the amount of silica available in the hydrated blended cement matrix is probably too high and the amount of the produced calcium hydroxide (C-H) is most likely insufficient to react with all the available silica and as a result of that, some amount of silica was left without any chemical reaction. The decrease in strength by increasing the RHA replacement level can also be due to the reduction in the cement amount and as a result of that, the released amount calcium hydroxide of (C-H) due to the hydration process is not sufficient to react with all the available silica from the addition of RHA and thus, the silica will act as inert material and will not contribute to the strength development.

CONCLUSION

To achieve desired strength with economy, the use of RHA as partial replacement of cement in concrete up to a certain level are satisfactory and useful in accordance with the present study and previous researches. From the results, it can be concluded that:

1) RHA is a highly pozzolanic material composed around 80% - 90% of silica. There are 2 types of silica in RHA which are amorphous and crystalline, the former being more reactive towards pozzolanic. Uncontrolled combustion result in more crystalline structure than amorphous and controlled combustion give vice versa.
2) Incorporating waste material such as RHA which has pozzolanic properties as partial replacement of cement can contribute to a lower production cost and environmental friendly.
3) RHA has a much higher surface area compared to cement which resulted in higher water demand. Adding RHA to concrete decreases slump value, hence lower workability.
4) It is observed that 15% of rice husk ash by mass of cement as the optimum dose of replacement in concrete production of M25 particularly as found in compressive strength test. The strength of RHA 15% concrete are comparable to the control M25 OPC mix. 10% replacement of RHA is not enough to increase the strength of concrete while 20% replacement does not contain adequate cement to enhance concrete strength.

RECOMMENDATIONS AND FURTHER STUDIES

1) The rice husk ash obtained can go through a lab test to determine the percentage of silica it composed and to check the structure of silica whether it amorphous or crystalline.
2) Water reducing admixture has to be used in order achieve the desired slump when incorporating rice husk ash to the concrete.

3) Using a vibrating table to compact instead of doing it manually during concrete casting will produce a much denser and evenly distributed specimens.
4) Aggregates both coarse and fine should be kept protected from the weather as raining would affect the moisture content.
5) Curing tank should remain free from other impurities and filled with clean water only.

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