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# The Acceptance of Utilizing Rice Husk Ash (RHA) in Non-Autoclaved Aerated Concrete Among Construction Stakeholders

**Hamidun Mohd Noh[1,*] Nor Shahidah Azahar[1], Nur'ain Idris[2], Narimah Kasim[1], Rozlin Zainal[1], Syarifah Meryam Shareh Musa[1]**

[1]Department of Construction Management, Faculty of Technology Management and Business, Universiti Tun Hussein Onn Malaysia, Parit Raja, Batu Pahat, Johor, 86400, MALAYSIA
[2]Department of Civil Engineering, Centre for Diploma Studies, Universiti Tun Hussein Onn Malaysia, Muar, 84600, MALAYSIA.

*Corresponding Author

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**Abstract**: Recently, the use of aerated concrete is become popular among construction stakeholder due to the lightness, strength and the durability factor. However, the increase in demand of concrete. causes the price of raw material to increase as well. Moreover, the production of cement contributes significantly to air pollution which is the emission of carbon dioxide. On the other hand, rice husk ash is one of the waste material which have a big population and potential to be used in construction due to the high volume of silica content in this research, rice husk ash is used in the concrete as a partial cement replacement in order to reduce the dependency. The research objectives in this study are to identify the factors that influences the types of material used in producing a concrete cube in concrete manufacturing, to investigate the potential acceptance of rice husk ash as a sub-material in concrete among the manufacturer and to initiate in improving the products. This study was conducted by interviewing the people related in the construction industry or the manufacturer on the acceptance of the rice husk ash as a replacement in non-autoclaved aerated concrete. The result of this study is to prove that RHA could be used in the concrete mixture as a replacement to cement with a good structural strength and environmental friendly and create an awareness between the manufacturer regarding the matters. This study is also expected to educate the society in reducing and managing the rice husk waste and explore in the potential ways of using the waste as an alternative sub-material.

**Corresponding author: hamidun@uthm.edu.my*

**Keywords**: Rice husk Ash, Supplementary replacement, Compressive strength, Pozzolanic material, Autoclaved aerated concrete

## 1. Introduction

In most Asian and other countries, rice is mainly grown. Worldwide paddy production has risen from 2016 to 2017 by 2.9 million tonnes (FA0, 2018). Rice husk is the exterior layer of a rice grain that has lower nutritional value in the frying process, but rice husk is said to be fuel in the rice-processing industry boiler because it is highly calorific. Otherwise, this farm waste or biomass is used to substitute carbon in order to minimise and render less harmful the emission of greenhouse gases. Quispe *et al*., 2019, said the effect of 1 Mega Joule coal usage on global warming capacity is 34 times that of rice husk. Rice husk ash production is almost 20% by rice husk weight (Sensale, 2015).

The rice husk, however, has a commercial application but is typically disposed at the site because of the absence of guidelines and standards on the use of rice husk in developing countries. In a study by the developing world, S.M. Shefie, for example, obtained 0.48 million tonnes of rice husks with 3,176,593.2 tonnes of rice straw production a year and Malaysia will face a paddy residue or waste management issue if its production continues to increase. Sadly, the culture tradition of disposal in Malaysia is that after harvesting the entire paddy field is burned and the environment is affected. Rice Straw is seldom used by Binod *et al*. in 2010 as a renewable energy source. Roughly 80% of rice straw factories around the world use inappropriate pollution-producing disposal.

The characteristic of Rice Husk Ash depends on the composition of the rice husks, the burning temperature and burning time. Rice Husk Ash produces amorphous silica under a controlled burning that is known for its high pozzolanic reactivity. Having pozzolanic properties means the RHA will create a cementitious material if its finely grind, then combined with chemical such as calcium hydroxide [Ca ($OH_2$ )] in ordinary temperature with the presence of moisture (Cook D J et. al., 1977). The RHA is known to be set as big potential of a renewable alternative source for a sustainable cementitious material if the production of rice increases. According to research done by Mehta in 1973, it is stated that high reactivity of ash can be obtained by controlled combustion and the pozzolanicity of the RHA greatly depends on the burning temperature and its specific surface and this was supported by Al-khalaf et. al., 1984 and Nair et. al., 2008. Bhupinder Singh, 2018, said that RHA has a highly microporous structure, and due to that specific surface determined by the Brunauer-Emmett-Teller (BET) nitrogen absorption method can range from 20 to as high as 270 $m_2$ /g, while that of silica fume, for example is in the range of 18-23 $m_2$ /g. The ash obtained from uncontrolled combustion as in open-field burning or industrial furnaces at temperature greater than 700°c may contain significant amounts of cristobalite and tridymte which are non-reactive silica minerals.

Moreover, majority of researchers shows a trend to incorporates RHA as a supplementary cementitious material in concrete. Thus, using Rice Husk Ash (RHA) as a supplementary material that is used to replace cement in the mixture of non-autoclaved aerated concrete (NAAC) to create sustainable concrete and saves cost alongside with reducing pollution.

### 1.1 Research Background

Over the past years, research had been done worldwide in developing a sustainable building materials to ensure that the environment is still cared and the company can raise the income by reusing the waste material as a source in their product. Several industrial by-products are found beside Rice Husk Ash (RHA) such as Palm Oil Fuel Ash (POFA) that can be used in production of concrete.

POFA is a waste material produced by the combustion of waste for the manufacture of electricity from palm oil industries in power plants. Over and above possible health risks and environmental pollution, POFA are normally able to open fields that cause road hazards. Because of its high pozzolan properties, several researchers had assessed it as a possible building material. This effort will increase efficiency by replacing cement with ash for a waste product that can mitigate global warming, and shows that the total cost of building is decreased when the expensive cement is superseded by waste ash.

Some research has demonstrated the use of the palm oil covers in place of traditional granite aggregates as a possible lightweight aggregate (Alengaram UJ *et al*., 2013). Other research have demonstrated the use of palm oil clinkers to build sustainable green concrete ( Abutaha F et, al., 2016).

Johari *et al*. and Zeyad *et al*. clarified that the greater the silica content obtained by the kernel combustion of the palm tree was due to the chemical composition of POFA. With the increased fineness of POFA the volume of silica increases. POFA concrete's strength and durability are aimed at the quantity of reactive silica in the POFA. POFA loss inflammation is more significant. It can be noted. The ignition loss should be less than 10 according to the ASTM C168. POFA produces more potassium oxide ($K_2O$). Thus POFA is shown to be a perfect additional material for concrete goods.

## 1.2 Problem Statements

Today, the whole world is suffering from two types of problem which is extinction of virgin sources and the production of excess waste. From the economic view, energy needs and developing environment and also developing nation, the only solution to the problems are to utilize waste into the main streams of production. In order to do that, a lot of companies in different sector are trying to raise the income by using waste as a resource in their products. Many research had been conducted in the past few years to achieve this goal of the construction industry which is facing issues in getting raw material to build new structure.

In my research, cement is known as an important part of making a concrete and cement is obtained from limestone and based on Malaysia Statistic Cement Production that is approximately 16.1 million metric tons is being produced in Malaysia from 2013 to 2019. Cement production is and energy and carbon-intensive process. Hence, they are a noteworthy contributor to global anthropogenic $CO_2$ emissions. The cement industry has always been among the greatest $CO_2$ discharge sources with 900 kg $CO_2$ released with each production ton of cement.

Besides, the shortage of raw materials in the construction sector would lead to price instability, affecting the entire value chain if it’s not addressed holistically. Shortage and delay in materials supply is argued to be one of the most important factors that lead to delay in construction project delivery globally. However, the relevant underlying reasons vary from country to country.

Regarding on the above text, the increasing demand for producing a sustainable construction material is the outcome of the fast polluting environment. Supplementary cementitious materials prove to be effective to meet the most of the requirements of a sustainable concrete. Moreover, a lot of potential waste material identified to be supplementary replacement in the production of concrete such as fly ash, bottom ash, silica fumes, blast furnace slag, bamboo ash, bagasse ash and rice husk ash.

According to M.F.M Zain *et al*., 2009, although the studies on pozzolanic activity of RHA, it’s use as a supplementary cementitious material, and its environmental and economic benefits are available in many literatures but very few of them deal with the rice husk commercialization as a supplementary material due to the combustion and grinding method.

In this study, the Rice Husk Ash (RHA) will be used as a substitute to cement in a non-autoclaved aerated concrete (NAAC) production as RHA is found to be the most promising waste to serve as a potential silica source.

### 1.3 Research Questions

The research questions of the study are as follows:

i. What is the optimum percentage RHA to be used as cement partial replacement in a concrete?
ii. What is to compare the compressive strength of RHA non-autoclaved aerated concrete mixture than Ordinary Poland Cement?
iii. Does the concrete manufacturer prefer to use RHA as a cement replacement in non-autoclaved aerated concrete mixture?

### 1.4 Research Objectives

The research objectives of the study are as follows:

i. To identify the factors that influences the types of material used in producing a concrete cube in concrete manufacturing.
ii. To investigate the potential acceptance of rice husk ash (RHA) as a sub-material in concrete among the manufacturer.
iii. The initiative in improving the products.

### 1.5 Scope of the Study

The scope of study are as follows:

I. The scope of research only focuses on the use of Rice Husk Ash (RHA) in a non-autoclaved aerated concrete (NAAC).

II. This research focuses on finding the acceptance of Rice Husk ash (RHA) as a partial replacement to cement according to ASTM C143 as replacement to OPC.

### 1.6 Significance of the Study

By using Rice Husk Ash (RHA) as cement replacement in Non-Autoclaved Aerated Concrete (NAAC) in this study is aim towards the society and environment.

i. To commence the contractors, manufacturer or those stakeholders in construction industry to follow this method.

ii. To lead an experiment that uses waste material in the replacement of cement in the construction industry.

iii. Create an awareness and educate people to use a friendly way and lessen the pollution in construction industry toward the environment to the community.

## 2. Literature Review

### 2.1 Aerated concrete

Calcium or cement, silica and occasionally pozzolanic materials are made from ventilated concrete into which air-lift is trapped in a mortar matrix by means of a suitable airing agent. They are known as light concrete. It is categorized in three classes according to the method of pores formation: air training (gas concrete) method, foaming (shoaling concrete) method and a mixed method. Non-autoclaved aerated concrete (NAAC) or autoclave (AAC) concrete can be aerated on the basis of the curing technique. The strength of the compressor, droughts, absorbent properties etc. depend directly on the process and the length of the treatment. The concrete foam is separated from its mould and cut into blocks or slabs of the required size when healed enough (Tayibi H. *et al*., 2009).

#### 2.1.1 Non-autoclaved aerated concrete

Aerated concrete not autoclaved is not an entirely the recent material. The first use recorded date dates from the beginning of the 20s. It wasn't until the late 1970s that foamed concrete had been used for construction work. (K. C. Brady et coll., 2001). Sparkling concrete is created by injecting preformed stable foam into a base blend of cement paste or morter (cement + water or cement + sand + water), or by applying a special air-training mixture known as a sparkling agent. Foam cement has a high flow capacity, low self-weight, low aggregate consumption, regulated low strength, and outstanding thermal insulation properties. The density of foam-plated concrete (1600-400kg/m3) can be achieved for use in structures, partitioning, insulation and filling levels with the required control in the dosage of the foam (F. Zulkarnain *et al*., 2011). Non- autoclaved aerated concrete has the same process as autoclaved aerated concrete but the autoclaved concrete doesn’t go through the autoclaving process where the cube is not cured in a chamber under high pressure and high temperature within an amount of time.

### 2.2 Rice Husk Ash (RHA)

#### 2.2.1 Origin of RHA

Agricultural by-products content is Rice Husk (RHA). It is approximately 20% of rice weight. It contains approximately 50% cellulose, 25%-30% lignin and 15%-20% silica. Rice husk (RHA) is created when burnt rice husk is made. In the course of combustion, the silica ash leaves cellulose and lignin. The regulated burning temperature and atmosphere gives the rice husk ash better quality as it is burning based on particles and a special surface. The use of rice husk ash as pozzolanic material in cement and mortar has many advantages, such as increased strength and toughness properties, decreased material costs due to cement savings, and environmental benefits related to waste material processing and reduced carbon dioxide emissions. Rice husk ash (RHA) is a very fine pozzolanic material The reactivity of RHA is due to its high amorphous silica content and its very wide area of the particle structure (Cook, 1989; Mehta, 1992).

#### 2.2.2 Chemical properties of RHA

Rice husk ash is very rich in silica content. Silica content in RHA is generally more than 80-85%. Chemical composition of RHA as reported by few authors is given in figure 4 that shows the chemical properties in RHA. for RHA to be used as pozzolan in cement and concrete, it should satisfy requirements for chemical composition of pozzolans as per ASTM C618. The combined proportion of silicone dioxide ($SiO_2$), aluminium oxide ($A1_2O_3$) and iron oxide ($Fe_2O_3$) in the ash should not exceed 12% as stipulated in ASTM requirement.

#### 2.2.3 Physical properties

The typical chemical composition and physical properties of RHA according to previous research (Smith *et al*., 1989: Antiohos S. K. *et al*., 2013: Ravande K. *et al*., 2011: Shatat M. R. *et al*., 2016: Mehta P.K, 1992: Satish H. S. *et al*., 2013: Galuh C. *et al*., 2017) are given in figure 3. RHA contains around 80-90% amorphous silica and it showed eco-friendly behaviour with cement as a supplementary cementing material in concrete (Panda K.C. *et al*., 2015). Pozzolanic property is very important for any supplementary cementing material. RHA is a very fine material. The average particle size of rice husk ash ranges from 5 to 10 μm.

2.3 Pozzolanic activity

Rice husk contains considerable amount of silicone dioxide. Well burnt and well-ground rice husk ash is very active and considerably improves the strength and durability of cement and concrete. This pozzolanic material with good and consistent properties can be obtained only by burning rice husk under well-defined conditions. The sensitivity of burning conditions is the primary reason that prevents the widespread use of this material as pozzolan (Hewlett, 1998; Real *et al*., 1996). These result confirm that the presence of amorphous silica is concentrated at the surfaces of the rice husk and not within the husk itself. Amorphous silica concentrated on the interior and exterior surfaces of un-calcinated husk promote a pozzolanic action on the surface of the husk and therefore enable its use in cement or concrete.

2.3.1 Sugar Cane Bagasse Ash

As a combustion by-product from the sugar cane industry, Sugar Canned Bagasse Ash (SCBA) is made. Hernandez *et al*. note that calcium silicate hydrates (C–S–H) are the key products of the reaction between the calcium hydroxide and SCBA. So, Mangi and Mangi. Al(2017) carry out research on using the SCBA as a partial cement substitute. Mangi and Mangi. The two forms of M20 (1:11/2:3) and M15 mix were used by al (2017) (1:2:4). Substitute SCBA in percent of 0 per cent, 5 per cent and 10 per cent as cement for each mix proportion. Mangi and Mangi. Compared to the regular strength concrete, at the end of this study the SCBA in concrete provides the highest compression strength. Thus, optimum results have been found with 5% ceiling substitution with SCBA.

2.4 Non-autoclaved aerated concrete material

2.4.1 Cement

A cement is a binder, a building substance that binds, hardens and connects other materials together. Cement is rarely used alone; sand and gravel (aggregate) are rather joined together. Cement, combined with fine aggregates, creates concrete for the purposes of masonry or sand and gravel. Beton is the most commonly used commodity in nature and is the most consumed resource of the earth, just behind water (Rodgers, *et al*., 2018). The cement is partly substituted in this experiment by rice husk ash.

2.4.2 Aluminium Powder

Aluminum powder is a foaming agent to be used in the non-autoclaved concrete aggregate to create air voids.

2.4.3 Aggregate

A term used for any single substance is aggregate. It contains gravel, sand, slag, gravel and all geo-synthetic compounds. Aggregate can be generated or recycled naturally. Aggregates constitute a cement mix of up to 60-80 percent. They are compressive and bulky for concrete. Add-ons for their longevity, strength, workability and capacity to receive finishes are chosen in any particular concrete mix. Aggregates should be solid, tough, free of absorbed chemicals or clay coatings for a good concrete mixture and other fine materials that could result in concrete degradation.

The aggregates are classified into two fine and coarse aggregate groups. Fine aggregates are typically sand or crushed stone with a diameter of below 9.55mm, whereas coarse aggregates are larger than 4.75mm. The standard scale of 9.5 mm to 37.5 mm is used. The standard size for the building aggregate, however, is 20mm. In a larger scale, the use of 40 mm in mass concrete is more common, as larger aggregate diameters appear to minimize the amount of cement and water required. The aggregate examples include dirt, sand, lightweight, recycled concrete and so on.

Aggregate that would be use in this study are gravel as coarse aggregate and rice husk ash as a replacement for fine aggregate.

### 2.5 Compressive Strength

According to Seong *et al*., (2005), the compressive strength if concrete is used as the most basic and important material property when reinforced concrete structure are designed. It has also become an issue to use this as value, due to the control on specimen sizes and shapes may vary from country to country.

The ultimate strength of concrete is also influence by the water-cementitious ratio (w/cm), the design and the mixing, placement and curing methods employed. Concrete with lower water-cement ratio makes the concrete stronger than that with higher water-cement ratio.

In this study, the compression test is done to analyse the strength of concrete with the mixture of Rice Husk Ash (RHA) as a cement replacement and how many percent of RHA as the replacement affects the durability percentage comparing to without RHA concrete.

## 3. Research Methodology

### 3.1 Introduction

Methodology is important to help achieve the goals and objectives of the study which has been set. In this chapter will be explained in detail related by the way this study was conducted. Methods and methodology selection used it is very important to get accurate and accurate research results. This section is divided into six stages, namely the planning stage, information collection and literature review stage, data collection stage, data analyst stage, decision expectation stage and conclusion stage.

### 3.2 Planning stage

For the beginning of this study, the first stage is the planning stage. Inside this stage occurs the selection of the title and area of the study as well as the selection of objectives research.

### 3.3 Stages of information collection and literature review

Collection of theoretical materials as well as materials that are helpful in this study are very important. This is because this method helps a lot in further understand the study to be studied. Also, through collection of these theoretical materials can help in giving more ideas about the implementation of the study and the needs of the study to be conducted later. The collection of these theoretical materials are conducted through reference book, theses, networks international information (internet) and more.

3.4 Data collection

Data collection is very important process in this study, the information was obtained before the analysis of the study created. For this study, which is the use of rice husk ash in non-autoclaved aerated concrete is done by qualitative data which is interview. Quality-based qualitative approach. This method is descriptive, less structured and more to the 'meaning' of the matter studied. This qualitative method does not prioritize numerical and more focused on the research process (Crawson, 1987).

3.5 Data analyst

Stages of data analysis on relevant information were conducted to achieve the objectives of the study. interview method, data analysis process using method content analysis. After data collection, all data has been recorded and recorded will be typed back into the computer in the form of a transcript (Omar, 2015) Interview data was transcribed to facilitate researchers analysing data. In addition, data from this interview method as well presented in the form of conversation excerpts.

## 4. Results and Discussion

4.1 Introduction

This section describes the analysis of the data that has been made based on the method studies used to achieve the first objective, the second objective and the objective the third that has been set. Research methods that have been used for data collection is through interview method. This method is use to achieve all three objectives. The respondents that are involved in this study are mainly workers from construction industry.

4.2 Results and discussion

4.2.1 Respondents background

Background information Respondents interview is important to ensure each data obtained by the researcher is from the appropriate respondent to answer all the questions posed with possible answers believed based on the experience and position held by the respondent. Table 1 shows the background of each respondents.

**Table 1: Respondents Background**

| No. of respondents | Company name | Position | Working experience |
|---|---|---|---|
| R1 | Teras Sari Resources Sdn Bhd | Site engineer | 1 ½ months |
| R2 | M&T Construction | Plant engineer | 10 months |
| R3 | A.C.E Concrete supplier | Operational Manager | 5 months |

Based on the Table 1, Responden 1 is a site engineer at Teras Sari Resources Sdn Bhd. He has been working there for about 1 ½ months now. Responden 2 is a respondent working in M&T Construction. He has been working for about 3 months now as a plant engineer and before that he was a site engineer at a small company in Selangor. Responden 3 is working as an operational manager at A.C.E Concrete Supplier for 5 months now.

4.2.2 First Objective: To identify the factors that influences the types of material used in producing a concrete cube in concrete manufacturing.

According to R1, R2 and R3, the main influence on the types of material to be used in producing a concrete mix are demands. They said if there are no demand regarding that material by clients then there would be no supply for it. Besides, R1 had mentioned that he was working under JKR before and he suggested that these rice husk ash as a sub-material might get attention if it is introduced to JKR with a throughout research. All 3 of the respondents are not the main producer of concrete but they have experience working with one and they said that the concrete strength might get affected as rice husk ash are known to be high in silica so the strength of the concrete may vary either it is stronger or it is lesser than the standard concrete strength.

4.2.3 Second Objective: To investigate the potential acceptance of rha as a sub-material in concrete among the manufacturer.

According to the results of the compression strength by 28 days given by interviewer to interviewee, R1 and R2 said that they think there is a potential of getting a better result as it shows a fall in the beginning and increment after that. That shows that if a new study is done maybe there is an improvement to the results. R3 said he doesn't really know regarding this matter as he is a operational manager only but as he was further explained, he said that if the strength is achieved then there might be chances for these materials gain an acceptance into the construction industry market and it may survive as long as the results of the strength are great.

4.2.4 Third Objective: The initiative in improving the products.

R3 mentioned that the quality might not really affects the profitability of the company especially long-term as the production of rice milling is large in Malaysia and there would be no problem to gain raw material and it is also cheaper than usual material used. The platform our company use is usually by face to face and also internet. Face to face are a better way to promote it as it spread fast like fire. R1 agrees that government are supposed to provide subsidiary to researchers in order to produce a good quality concrete cubes and his way also helps to lift the burden of the company in producing new products and more company are willing to do so. R1, R2 and R3 agreed that by using these material, there might be a slight chance to protect and preserves the environment as they have been told that the milling field always burn their excess husk ash and that has contributed to carbon dioxide gas emission, so by doing this it might lessen the emission and the rice husk ash are being used in a good way.

## 5. Conclusion

The interview indicates an interest in pozzolanic material such as RHA for concrete material mixing as a concrete producer in the construction sector. All these results begin to show that RHA is likely to be perceived as a commodity that does not pollute the environment and therefore lowers production costs. Finally, this by-product can be used well by the rice husk milling company. At the same time, it would also be possible to reduce the use of cement in building. These results are supposed to inspire researchers to make use for the good of mankind and the environment by using industrial or agricultural waste.

Through this chapter has explained related data analysis which has been achieved by researchers. The data analysis is very important for a research in order to make sure every objective has been achieved. In conclusion, the respondents had greatly accepted the new ways where using a sub-material into concrete mixture and had shown positive feedback towards a greener product that is profitable.

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