Influence of rice husk ash (RHA) on performance of green concrete roof tile in application of green building

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Abstract. This paper studies on the development of green concrete roof tiles by using rice husk ash (RHA) as a partial replacement of cement as a green material. Rice husk is a product of agricultural waste that can be found easily and in large quantities due to increased annual paddy production in Malaysia. Demand for cement in construction has increased over the years as a result of over dependence on the modern building materials, which are so expensive that low income earners cannot afford building houses of their own. Besides, the satisfaction of building users is closely related to thermal comfort which is a complex dynamics of temperature and humidity. In this study, cement was replaced by the RHA at 0% until 20% by weight. Roof tiles performance were assessed based on Malaysian Standard (MS) requirement comprised of transverse strength, water absorption and water permeability. Results show that up to 10% of RHA give a good performance of concrete roof tiles which comply with Malaysia Standard.

1. Introduction

An environmental issue is commonly discussed as a one of criteria associated with green buildings. Compared with conventional buildings, green buildings generally provide higher performance which in this research directly to carbon emission reduction [1]. Usman Aminul et al. [2], also stated that the design of green buildings should thus begin with the selection and use of eco-friendly materials with related or better features than traditional building materials.

According to Food and Agriculture Organization of the United Nations, rice production in Malaysia is 2.4 million tons, 2.5 million tons, and is 2.6 million tons approximately for year 2011, 2012, and 2013 respectively [3]. Due to the increment in rice paddy demand, about 0.52 tons of rice husks, an agro-waste are produced annually. In building material, cement as the major classical binder in construction industry is very costly. This is because of the highly development of the countries especially buildings construction due to the population growth and urbanization [4].

Therefore, the need to reduce the gap between demand and high price has brought to the need to investigate the use of cheaper alternative sources and rice is appropriate as it is consumed worldwide and is grown on every continent except Antarctica [5]. Therefore, this research aims to explore the ability of using rice husk ash, as an agricultural waste with a mixture of cement to produce roofing tiles as an alternative in providing affordable concrete roof tiles. The aim of this research is to study the performance of waste rice husk ash (RHA) as a partial cement replacement to produce a green concrete roof tiles.
2. Material
In this study, five different RHA ratios were investigated which are normal concrete roof tiles (control), concrete roof tiles with 5% of RHA, concrete roof tiles with 10% of RHA, concrete roof tiles with 15% of RHA and concrete roof tiles with 20% of RHA. Rice husk was collected from local rice mills.

Figure 1. Sample of rice husk ash.

3. Methodology
Rice husk was collected from local mill was burnt in a muffle furnace which located in the EV laboratory under fixed controlled temperature of 600°C and 700°C for two hours respectively. The percentage weight of RHA was recorded for reference purpose. According to Tashima et al. [6], about 20% of RHA can be obtained from the unburned rice husk. Table 1 shows the mixture proportion of green concrete roof tile used in this study.

Table 1. Mix design of green roof tile.

| Sample  | Cement (kg) | RHA (kg) | Sand (kg) | Water (kg) |
|---------|-------------|----------|-----------|------------|
| GCT 0   | 30.0        | 0        | 90        | 15         |
| GCT 5   | 28.5        | 1.5      | 90        | 15         |
| GCT 10  | 27.0        | 3.0      | 90        | 15         |
| GCT 15  | 25.5        | 4.5      | 90        | 15         |
| GCT 20  | 24.0        | 6.0      | 90        | 15         |

Concrete roof characteristics studied with respect to the Malaysian Standard MS 797 specification for concrete roof tiles are transverse breaking strength, water absorption and water permeability. All the production process is done at the concrete roof tiles factory.

4. Results and Discussion

4.1. Density
The sample of concrete with the replacement of GCT 10, GCT 15 and GCT 20 shown density dropped from 1416.67 kg/m³, 1286.67 kg/m³ and 1230 kg/m³ respectively. The change of difference replacement of RHA is effect on the density value. This can be attributed to the increasing the percentage of rice husk ash by weight of binder could reduce the density of the tile to the properties of RHA. This happened due to the weight of RHA which is has less density combined with cement to produce tiles. Based on previous paper, the contemplated of the density is in the extent of 2251-2400 kg/m³ for a comparable kind of density of ordinary concrete [7].
4.2. Transverse breaking strength
Inclusion of RHA as partial replacement of cement enhanced the transverse of the produced concrete tile with the maximum transverse strength which was recorded at GCT 5 replacement of cement to be 2163.67N based on table below grew slightly higher than the normal sample with an average strength of 2024N. The strength recorded by other researchers like Mahmud et al [5]. M H Zhang et al. [7], reported 15% partial replacement by RHA as an optimal level for achieving the maximum strength. Besides that, they also suggested 10% of RHA replacement exhibited upper strength more than the normal concrete tiles.

4.3. Water absorption
Based on Figure 4, the highest of water absorption obtains by GCT 20 of RHA with 15.19% while the lowest water absorption obtains by GCT 5 of RHA with 4.11%. In Malaysia Standard specification, the value of water absorption must be less than 10%, the GCT 20 of RHA has failed with respect to the MS. Water absorption is increases when RHA content is higher. Water absorption of conventional roof tiles (0% of RHA) remains as 8.45% where in GCT 5, GCT 10, GCT 15 and GCT 20 of RHA tiles have reached to a value of 4.11%, 4.23%, 7.28% and 15.19% respectively. However, when water absorption is higher, more water remains in the tile will cause the growth of small plants and moss on the roof which can reduces the durability and aesthetic appearance.
4.4. Water permeability
For water permeability test, the GCT 5, GCT 10 and GCT 15 of rice husk ash have no drops of water fallen from the underside of the tile and it is pass the specification of concrete roof tile while for 20% of RHA has a drop and failed to fulfil the MS specification [8]. So in this testing, the sample of GCT 5, GCT 10 and GCT 15 of RHA are according to MS and can be used as a roof covering for building.

Table 2. Water permeability result.

| Sample | GCT 0 | GCT 5 | GCT 10 | GCT 15 | GCT 20 |
|--------|-------|-------|--------|--------|--------|
| Water Permeability | Pass | Pass | Pass | Pass | Fail |

4.5. Costing
Based on Figure 5, the increases of RHA replace with cement can save a lot of material cost in large amount of roof tiles. This can conclude that the rice husk ash is a really good material to be used in the concrete roof tile industry because it is definitely can reduce the production cost of a roof tile and also can reduce this waste material.

Figure 5. Costing of concrete roof tiles.

5. Conclusion
Based on the Malaysian Standard referred, it shows that waste rice husk ash has a potential to be used as a partial cement replacement in concrete roof tiles. Farther than it performed well as a roof covering, it is also lowered the construction cost and also reduce the CO₂ emission which establish the green construction and green building in the industry.

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