Thermal conductivity of aerated concrete containing rice husk ash as partially sand replacement

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Abstract. Limited natural energy sources give impact on the selection of the material that can subtract energy consumption. Regarding to conservation energy, in the field of building and construction, the selection of concrete with good heat capacity is a requirement, besides light in weight. The objective of this study was to investigate the thermal conductivity of Foamed Concrete containing Rice Husk Ash (FCRHA). Rice husk ash (RHA) is the type fly ash that can absorb heat due to moisture. RHA The measurement of thermal conductivity on FC and FCRHA was conducted using box insulation and recorded using thermal data logger. The result showed that FCRHA absorb heat from the beginning when the heat is distributed, while FC slow absorb the heat. Modification FC by replacing sand partially with RHA provides an evolution to profitable use of construction materials in the heat absorption.

1. Introduction

In the last several years, some countries give special attention to energy consumption on the building that related to enhance the comfort. For that reason, building industry focus on the improvement and efficiency of building heating and insulation [1][2]. Furthermore, the use of materials in accordance with maximum heat transfer will be used to reduce loss of heat. Therefore, knowledge of physical property of materials is essential to the engineer, because conservation energy is very important policy strategy to all countries [3]-[5].

The application of concrete as thermal mass materials in buildings is regarded as a strategy to reduce energy consumption. Thus, thermal conductivity analysis on material concrete is a way to get information about heat transfer. Essentially, thermal conductivity is a calculation about the profile of the heat and the flow of heat through a material [6]. Analyzed thermal conductivity on the concrete for the purpose of the green technology building is very important, however, heat transfer analysis on concrete is very complex. Analysis of thermal conductivity depends on the variables of the material, density, pressure and temperature, the structure of the material, and moisture [6]-[8]. While concrete is a material that is not homogeneous and is influenced by all the thermal conductivity variables. Therefore, to identify the phenomena of heat transfer on concrete have to consider material in the form of the concrete itself [6],[7],[9],[10].

Related to the type of concrete used in green building and consideration large sum of money then required concrete that can reduce energy consumption and light in weight. Therefore, the present study

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is using aerated concrete namely foamed concrete (FC) that fulfills those needs. The objective this study to find out the thermal conductivity of FC and FC containing rice husk ash as a partial sand replacement (FCRHA) \[11\]. The previous researcher resulted that the materials constituent of FC influences the thermal behavior of FC \[12\]-\[14\]. FC as a lightweight concrete very potential in thermal resistance \[13\]. However, the use of FCRHA for green materials for low-rise buildings gives hope in the evolution of the construction materials and building a reliable.

2. Mix Proportion and Experimental method

2.1. Mix Proportion and Material Preparation

Aerated concrete that is intended in this experiment is the type of foamed concrete, as used in previous experiments include the use of RHA \[15\] to replacement sand partially \[16\]. Specimens produced by two densities specifically 1600 kg/m\(^3\) and 1800 kg/m\(^3\) for curing 28 days. The blending of ingredients slurry used the pre foamed method. A mixture of mortar stirred first was then added RHA. After a mixture of mortar and RHA mixed with evenly, next added foam. Foam made separate formerly of a mixture of foam agent and water. Comparison material that is used for mixing foamed concrete with rha as in Table 1.

| No | Property          | FC   | FCRHA |
|----|-------------------|------|-------|
| 1  | Cement-sand ratio | 0.25 | 0.25  |
| 2  | Water-cement ratio| 0.6  | 0.6   |
| 3  | Cement-sand-RHA   | NA   | 1:3:1 |
| 4  | RHA-water ratio   | NA   | 1.25  |
| 5  | Foam agent ratio  | 0.05 | 0.05  |
| 6  | Foam density (Kg/m\(^3\)) | 50 | 50 |
| 7  | Dimension (mm\(^3\)) | 150x150x150 | 150x150x150 |
| 8  | Curing days       | 28   | 28    |
| 9  | Curing Temperatures ºC | 23 ± 2 | 23 ± 2 |

2.2. Thermal Conductivity Test

Test of Thermal conductivity used heat transfer apparatus as shown in Figure 1. Each sample of FC and FCRA was put into the box heat transfer apparatus, which its interior incrust by insulation. The thermal conductivity test illustrated as shown in Figure 2. Quantity of heat transfer was produced by power supply channeled into the sample for 300 minutes. Furthermore, the temperature difference was recorded by temperature data logger. A difference in temperature was obtained from to differences of temperature between channel enter with the channel out.

![Figure 1. Box insulation and temperature data logger.](image-url)
3. Result and Discussion

3.1. Thermal Conductivity

The difference in materials and their density on the test gives results of thermal conductivity varying as shown in Figure 3. The result shows that higher material density improves heat transfers. This agrees with the previous investigation [17]. The thermal conductivity of 1800 Kg/m³ material density is higher than 1600 Kg/m³. FCRHA transfers the heat better than FC due to fly ash in FCRHA is good thermal conductivity and affect the concrete overall [14]. The RHA as the fly ash in FCRHA keeps moisture and increased thermal conductivity [18]. Heat transfer behavior of FC is different from FCRHA, Figure 3 shows, that heat absorption of FC was delayed. At first, FC 1600Kg/m³ very slowly absorb heat, this is due to the low density and more porous [17]. In 240 until 300 minutes reach the stable absorption.

![Figure 2. Schematic thermal conductivity test](image)

### Figure 2. Schematic thermal conductivity test

![Figure 3. Thermal conductivity of FC and FCRHA](image)

### Figure 3. Thermal conductivity of FC and FCRHA.

3.2. Thermal Resistance

Thermal resistance is the inverse of thermal conductivity, which heat transfer occurs at a lower rate in materials. Figure 4 shows thermal resistance of FC is higher than FCRHA. This indicates, that density and humidity gives an important role in the insulation of material aerated concrete.
Obviously, FC with 1600Kg/m$^3$ of density is the higher thermal resistance than other materials. At the start, FC has a high thermal resistance, then decreases with increasing heat capacity. FCRHA 1800 Kg/m$^3$ has a low heat capacity. When the heat was distributed all heat be accommodated and streamed.

3.3. Temperature

Figure 5 shows that the temperature of material influences the thermal conductivity. The thermal conductivity of all materials tends to increase when increasing the elevation of temperature. FCRHA with 1800 Kg/m$^3$ accommodates the heat when the temperature reaches 39.33°C and channeled the energy heat. It has low heat capacity [17] due to the density and presence of RHA as fly ash.
4. Conclusion
Increasing the difference temperature, increase the value of thermal conductivity, then decreased the heat resistant material. FCRHA as foamed concrete modification is lighter weight than FC. FCRHA is good heat transfer properties and high thermal conductivity compared to FC. The higher density FCRHA improves thermal conductivity. RHA in FCRHA content is very influential to the thermal conductivity. RHA as fly ash took overheat and influence heat capacity FCRHA overalls.

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