Utilization of Rice Husk Fly Ash for Production of Non Steam Drying Light Weight Concrete

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Abstract: This paper presents a preliminary study on utilization of rice husk fly ash for production of non steam drying light weight concrete (referred to as LWC). An investigation of the effects of fly ash on strength and thermal conductivity of LWC was the first experiment. The results showed that it was possible to use an optimum ratio of fly ash to mix into conventional LWC. The maximum compressive strength of LWC was found at 12.5% wt. of mixing ratio of fly ash. Meanwhile, an investigation of the influences of fly ash on thermal conductivity of LWC was found that LWC’s thermal conductivity was decreased with an increasing in ratio of fly ash mixed into LWC. It was found to be 0.115 Wm\(^{-1}\)K\(^{-1}\) lower than that of conventional LWC of about 20% when fly ash of 12.5% wt was mixed. In the experiments for study of thermal insulating properties, the temperature in testing room built with LWC mixed with 12.5% wt of fly ash was found to be lower than that of brick in the range of 1.0 – 1.5°C.

Keywords: Fly Ash, LWC, Strength, Thermal Conductivity

1. INTRODUCTION
Among various energy conservation projects to increase the effectiveness of the energy use in the country, which have been launched in Thailand, the utilization of biomass as alternative fuel in the power sector (with the aim to save conventional, or fossil fuels) seems to be the most promising project [1]. Because of an agricultural foundation of the country, there are abundant reserves of agricultural residues available in Thailand.

Meanwhile, there are a couple kinds of biomass, such as rice husk, sugarcane bagasse, and wood residues, which have been considered to be the viable biomass in Thailand. These biomass fuels are used with the aim to substitute for fossil fuel in production of electricity, particularly in the private power plants, which have been promoted by the Thai government in the name of small power producers (SPPs) [2-3].

Although it seems to be satisfaction, the disposal of rice husk waste (i.e. fly ash) occurs instead. Therefore, some researches have studied to use fly ash as one component in the applications of cement for many structures to solve this problem [4-6].

There are two types of light weight concrete that have been used in the construction sector, namely, autoclave aerated concrete (AAC) [7-8] and non steam drying light weight concrete (LWC) [9]. The AAC that has been distributed by two main private companies is produced by using the imported technology from Germany whereas LWC relies on the domestic innovation. The cement, sand, calcium oxide (CaO) and gypsum are the main compositions of ACC whereas conventional LWC composes of cement, sand and using organic foam for generating the cellular pore in its structure [10].

Due to an excellent thermal insulating property of fly ash, therefore, it is considered to use fly ash as one composition for production of LWC with the aim to reduce heat transfer through the wall of buildings.

This paper presents the utilization of rice husk fly ash as a mixing component for production of LWC. Moreover, the utilization of LWC mixed with fly ash for comparison testing in general residence, are also included.

2. MATERIALS AND METHODS
In this research, Professional Block Co.Ltd, was selected and considered to be the representative of producer of conventional LWC. Meanwhile, rice husk fly ash was taken from the rice husk power plant in Chainat Province named Biomass Power Co.Ltd. This power plant is the first prototype of rice husk power plant in Thailand, which has been operated since 1997. The fluidized bed combustion is the technology for this power plant. Due to a high velocity of air during combustion, very fine and smooth size of fly ash is obtained. Their average particle sizes are smaller than 150 µm (over 100 mesh of screen size) as shown in Fig. 1 whereas Fig. 2 shows the scanning electron microscope (SEM) with 400x (e.p.) photograph of rice husk fly ash used in the study [11-12].

The chemical composition of rice husk is as followed: C = 37.90, H = 4.82, O = 34.90, N = 0.43, S = 0.07 and Ash = 21.88 (% wt. in dry basis).

![Graph of Size Distribution of Rice Husk Fly Ash](image)
2.1 Fly Ash Mixing Tests

To determine an optimum value of fly ash mixing ratio, it was varied in the range of 5-25% wt. With constant total weight control of LWC in each experiment, the amount of cement and sand were varied depending on ash mixing ratio in each experiment as shown in Table 1.

However, it was remarked that the value of ash mixing ratio was not over 25% wt. due to bonding property between cement and sand was found to be significant decreased until the concrete was not formed [4]. Two major properties of LWC, namely, strength and thermal conductivity, were investigated as followed to the standard for testing of compressive strength (ASTM C-192) and thermal conductivity (ASTM C-177) of concrete block, respectively [13-14].

2.2 Testing of Thermal Insulating Property

The investigation of thermal insulating property of LWC compared to that of brick that has been the most popular construction material in Thailand was the second step in the research. Two testing rooms with dimensions of 2.3×2.3×2.5 m³ were built with the same direction by using LWC mixed with 12.5% wt. of fly ash and brick.

Meanwhile, their ceilings were insulated with 2-inch insulator to avoid the influence of heat transfer through the roof. Eventually, their mean room temperatures were measured and compared during daytime (08.00 a.m.-05.00 p.m.).

Table 1. Compositions of LWC in each experiment varied to fly ash mixing ratios.

<table>
<thead>
<tr>
<th>Ash ratio (% wt.)</th>
<th>Cement (kg)</th>
<th>Sand (kg)</th>
<th>Fly ash (kg)</th>
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<tbody>
<tr>
<td>-</td>
<td>342.5</td>
<td>342.5</td>
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<tr>
<td>5</td>
<td>325</td>
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<td>35</td>
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<td>25</td>
<td>257</td>
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<td>171</td>
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3. RESULTS AND DISCUSSIONS

Table 2 shows the influences of fly ash on the compressive strength and thermal conductivity of LWC. As seen, there is an optimum value of ash ratio (12.5% wt.) added into LWC, which is achieved the maximum value (i.e. 30.95 kg/cm²) of the compressive strength. Moreover, the strength of LWC was found to be increased with an increasing in fly ash mixing ratio up to 12.5% wt. After that, it’s rapidly decreased due to the reduction of bonding property between the cement and sand resulting from an increasing in fly ash ratio.

In addition, the amount cement and sand were found to be decreased of about 12-13% each compared to that of LWC without ash as shown in Table 1 (i.e. cement and sand were reduced of about 42.5 kg each whereas the amount of ash was replaced of about 85 kg). It means that the production cost for LWC can also be reduced simultaneously.

Compared to that of LWC without ash, which has the compressive strength of 32 kg/cm², it was found that the strength of LWC was slightly decreased when fly ash was mixed. This is due to the decreasing in two major mixing components (i.e. cement and sand).

However, the density of LWC was also decreased in the range of 10-16.5% resulting in the decreasing in the weights of cement and sand. Additionally, the value of LWC’s strength was also found to be similar to that of ACC.

For the influences of fly ash on thermal conductivity, it was found that the thermal conductivity of LWC was decreased with an increasing in ash mixing ratio. This was resulted from an increasing in thermal insulating property of ash. As seen in Table 2, the thermal conductivity of LWC was found to be 0.115 Wm⁻¹K⁻¹ whereas that of LWC without ash was found to be 0.150 Wm⁻¹K⁻¹. Meanwhile, thermal conductivity of AAC was found to be lower (i.e. 0.09-0.10 Wm⁻¹K⁻¹) because of gypsum and quicklime mixed into AAC. However, the production cost of AAC was higher than that of LWC in the range of 70-100%.

In the experimental tests for study of thermal insulating property of LWC, two testing rooms with the dimensions of 2.3×2.3×2.5 m³ (W×L×H) were built in the same directional location by using LWC mixed with 12.5% wt. of fly ash and brick. The comparison of their mean room temperatures was studied.

Fig. 3 and 4 show the temperature differences between outer and inner surface walls of testing rooms in the eastern and the western sides during the tests.
Figure 3. Temperature differences between outer and inner surface walls in eastern side.

Figure 4. Temperature differences between outer and inner surface walls in western side.

As seen, temperature differences between outer and inner surface walls of LWC room in eastern side was found to be in the range of 1-5°C whereas that of brick room is found to be lower of about 1-3°C depending on time interval (08.00 a.m.-05.00 p.m.). The similar results were found in the western wall.

Fig. 5 shows the measured data of room temperatures in LWC and brick rooms. As seen, the room temperature of LWC room was found to be lower than that of brick room in the range of 1-1.5°C (LWC room’s temperature was found to be 25°C on average while that of brick room was found to be 26.5°C on average). Meanwhile the average outer temperature of LWC room was higher than that of brick room in the range of 2-4°C depending on time interval. This is indicated that a good thermal insulating property of fly ash when it’s mixed into LWC.

4. CONCLUSIONS

A good result when fly ash of rice husk was used as one component for production of non steam drying LWC. It was found that the maximum value of LWC’s strength was obtained at the ash mixing ratio of 12.5% wt. Compared to those of conventional LWC and AAC, it was found that strength of LWC mixed with 12.5% wt. of fly ash was found to be similar.

Besides, thermal conductivity of LWC was found to be decreased to 20-22% when LWC was mixed with fly ash of 12.5% wt. Furthermore, thermal conductivity of LWC was found to be decreased with an increasing in fly ash ratio. It’s indicated to a good thermal insulating property of fly ash.

However, it was remarked that the size of fly ash, which can be used for mixing into LWC, should be smaller than 150 µm (> 100 mesh of screen size). Some experimental tests were shown that the concrete can’t be formed when 450-µm ash was mixed into LWC because of too coarse in particle size resulting in the reduction of bonding property.

In addition, an enhancement to larger scale of testing room with dimension of 10×10×3 m³ and wall thickness was set at 10 cm using Air-Pack V2.0 simulation program showed that the room temperature of LWC room was varied in the range of 33-35°C lower than that of brick room (i.e. 35-38°C for brick room).

Besides, the differences of temperature inside the room between LWC room and brick room were found to be greater with an increasing in their volume.

5. ACKNOWLEDGEMENTS

This work is a part of the research work funded by Industrial and Research Projects for Undergraduate Students (IRPUS). The authors would like to thank the Professional Block Co.Ltd. for supporting the materials and special equipments using in this work. Grateful thanks are also given to Biomass Power Co.Ltd. for supporting rice husk fly ash.
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