INVESTIGATION ON THE USE OF UNGROUND RICE HUSK ASH FOR PRODUCING UNFIRED BUILDING BRICKS

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Abstract- The primary aim of this study is to investigate the possibility of using unground rice husk ash (URHA), an agricultural by-product, for producing unfired building bricks (UBB) with applying densified mixture design algorithm (DMDA) method. In this investigation, blended fly ash (FA), rice husk ash (RHA) and little amount of cement (5%) was used as the binder material, whereas URHA was used as partial aggregate replacement (10–30%) in the mixtures. By following Vietnamese standard (TCVN 1451:1998), solid building bricks of 220×105×60 mm in size were prepared for investigating the effect of URHA content on hardened properties of the bricks including compressive strength, flexural strength, water absorption, bulk density and void volume. Forming pressure of 35 MPa was applied to form the bricks in the steel mold. The test results show that compressive strength, flexural strength and water absorption of brick samples were respectively in range of 8.4–13.8 MPa, 1.2–2.3 MPa and 9.8–18.2% while the other properties of the bricks were well conformed to corresponding Vietnamese standards. Furthermore, it was definitely proved many potential applications of URHA in the production of UBB.

Keywords- Unfired Building Brick, Unground Rice Husk Ash, Forming Pressure, Densified Mixture Design Algorithm.

I. INTRODUCTION

Bricks have been widely used for a long period as the major building material. The worldwide annual production of bricks is currently about 1391 billion units and the demand for building bricks is expected to be continuously rising. There are many different types of building bricks in the world. Most of them are conventional bricks, which are produced from agricultural clay usually with high temperature kiln firing or mainly from ordinary Portland cement (OPC) through cementing method, while the rest minorities are produced from various sources of solid waste materials with or without kiln-fired. The production and use of OPC has generated a significant amount of carbon dioxide (CO2) to the environment, which accounted for around 5% of global man-made CO2 emissions.

Therefore, an effective way of reducing the contribution to greenhouse gas emission is increasing the utilization of supplementary cementitious materials (SCM) by partially or fully replacing OPC used. Recently, there are many studies on the application of FA, RHA and other sources of SCM as main binder for producing building bricks, However, just few researchers study on the application of URHA as aggregate in bricks production. Additionally, Vietnam has abundant amount of URHA, which is a by-product from agricultural activities. Moreover, it was found that the use of UBB highly contributes to save natural resources as well as reduces environmental pollution and low down wastes disposal cost. Due to these advantages, using UBB has become the trend of many countries in the world. On the other hand, it is noted that although many studies about the building bricks, which made from solid waste materials, meet the various standard requirements, so far their commercial production and application has still limited. Therefore, for wide production and utilization of UBB, further research is necessary. The primary aim of this research is to evaluate the possibilities of using URHA as the aggregate for producing UBB.

II. EXPERIMENTAL PROGRAM

A. Material Properties

Type I Taiwan Portland cement was used. The RHA and FA were used as main binder materials in UBB production. The physical and chemical characteristics of cement and the both ashes are given in Table 1. Natural sand and URHA were used as fine aggregates in the mixtures. Natural sand (density 2.6, absorption capacity 1.4%) was provided from local quarries, whereas URHA (density 2.1 and absorption capacity 27.5%) was prepared from Vietnam. Scanning electron micrograph (SEM) of URHA was given in Fig. 1. It is important to notice that the all aggregates used should be in saturated surface-dry (SSD) condition. Mixing water was local tap water. All materials conform to the related ASTM standards.

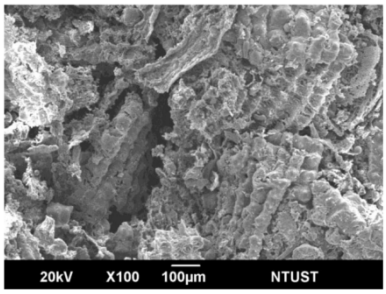


Fig. 1 Scanning electron micrograph (SEM) of URHA

B. Testing Program

Blended FA, RHA and cement was used as binder materials in bricks production, whereas 10–30% URHA was added into the mixtures as partial replacement of natural sand. DMDA method was applied for brick mixture design. The same water-to-binder ratio (W/B) of 0.35 and forming pressure of 35 MPa were applied in this investigation. Table 2 shows the mixture proportions of bricks in weight of materials. The bricks were tested for compressive strength, flexural strength, water absorption, bulk density and void volume to evaluate the effect of URHA content on the hardened properties of bricks. These tests were carried out by preparing brick specimens with a standard dimension of 220×105×60 mm. After casting, all the brick samples were cured at ambient temperature until the testing ages. The preparation and test of brick specimens were based on TCVN 1451:1998 and TCVN 6355:2009 Part 2–6, respectively.

Table 1. Physical and chemical analysis of cement, FA, RHA

Items		Cement	FA	RHA
Physical properties	Specific gravity	3.15	2.08	2.18
Chemical compositions (%)	SiO_2	22.0	63.9	95.6
	Al_2O_3	5.5	20.0	-
	Fe_2O_3	3.4	3.4	0.2
	CaO	62.8	3.8	0.7
	MgO	2.6	1.3	-
	K_2O	0.8	1.1	2.7
	Others	-	1.7	0.5

Table 2. Brick mixture proportion

Mix.	Mix-proportion, kg/m^3					
	FA	RHA	C	Sand	URHA	W
C05U00	341.5	227.7	30.0	1452.8	-	209.7
C05U10	341.5	227.7	30.0	1307.5	145.3	209.7
C05U20	341.5	227.7	30.0	1162.2	290.6	209.7
C05U30	341.5	227.7	30.0	1017.0	435.8	209.7

Note: *C = cement, W = water*

III. RESULTS AND DISCUSSION

A. Compressive Strength

Compressive strength is considered as one of the most important properties of bricks and as a principal indicator of general quality control. Fig. 2 presents the effect of URHA content on the compressive strength development of brick specimens at various ages. As can be seen, the brick specimens achieved the compressive strength higher than the required strength as required by TCVN 1451:1998. It was determined that the addition of URHA as fine aggregate in the mixtures created a significant effect on compressive strength of bricks (Fig. 2). In fact, higher level of URHA replacement caused lower compressive strength of bricks. Actually, up to 30% URHA replacement, there was about 40% decrease in compressive strength of bricks compared to that of the bricks without URHA added. Because of highly porous particles of URHA (Fig. 1) caused less compact structure, which resulted in the reduction in compressive strength of the bricks. However, according to TCVN 6477:2011, all the brick samples can be classified as the good quality of solid bricks.

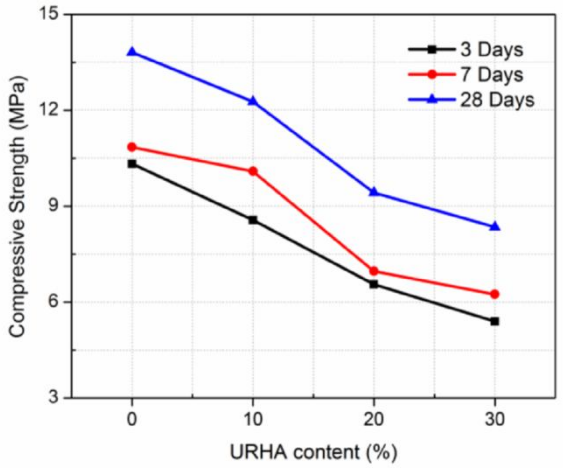


Fig. 2 Effect of URHA content on compressive strength of brick specimens

B. Flexural Strength

The effect of URHA content on flexural strength of bricks at various ages is presented in Fig. 3. As consistence with compressive strength development, the addition of URHA as fine aggregate in the mixtures also caused a remarkable effect on the flexural strength of brick specimens (Fig. 3). The fact that the bricks containing more URHA content provided lower flexural strength compared to the bricks containing less URHA content. This was also consistent with the compressive strength development as discussed above.

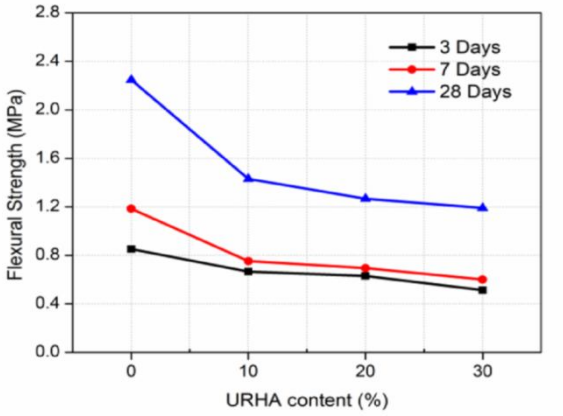


Fig. 3 Effect of URHA content on flexural strength of bricks

C. Water Absorption

Water absorption is an important parameter, which strongly affecting the durability of bricks. The fact that the less infiltration of water in the bricks, the more durable of the bricks. Fig. 4 presents the effect of URHA content on water absorption of bricks samples at the age of 28 days. Up to 20% of URHA replacement, the brick specimens registered water absorption of lower than 16%, which was required by TCVN 1451:1998. It was found that water absorption of bricks increased significantly with URHA content (Fig. 4). Absorption capacity of the bricks tended to exceed the requirement of TCVN 1451:1998 when higher than 20% of sand was replaced by URHA. This was mainly due to high porous URHA particles as shown in Fig. 1 and much higher absorption capacity of URHA compared to that of sand. On average, with 10%, 20% and 30% of sand replaced by URHA, there was respectively around 28%, 52% and 85% increase in water absorption of bricks compared to the bricks without URHA content. The result was consistent with strength development of the bricks as already discussed above.

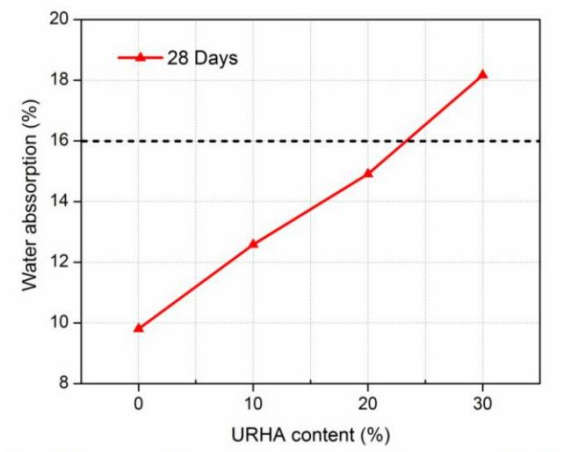


Fig. 4 Effect of URHA content on water absorption of bricks

D. Bulk Density

Bulk density is the indicator whether the brick can be classified as a solid building brick. The effect of URHA content on bulk density of brick specimens at the age of 28 days is presented in Fig. 5. As the result, all the brick samples registered bulk densities of higher than 1600 kg/m3, which was a requirement for solid building bricks. It was clearly observed that the addition of URHA resulted in the remarkable reduction of brick density (Fig. 5). The more the URHA content, the lower the bulk density of the bricks. It also means that the lighter weight of bricks would be obtained. This could be easy explained by the much lower specific gravity of URHA compared to that of natural sand. On average, with 10%, 20% and 30% of sand replaced by URHA, there was respectively around 6%, 13% and 20% increase in density of bricks, in comparison to the bricks without URHA content.

E. Void Volume

Void volume is one of the important indications of good quality of building bricks. Fig. 6 shows the effect of URHA content on void volume of brick specimens at the age of 28 days. As the result, all brick samples registered void volume of significantly lower than 65%, which was a requirement for building bricks in general. This clearly indicated that the brick specimens were more compact.

The trend was found similarly to water absorption that void volume increased noticeably with the increase in URHA content. Fig.6 indicated that the more URHA content, the greater the void volume obtained. This was possibly because of high porosity due to consist of high porous particles of URHA as mentioned above. As the fact, void volume has tight relationship with the strength development and water absorption capacity of the bricks. Actually, the lower the void volume inside, the lower the water absorption and the greater the strength obtained.

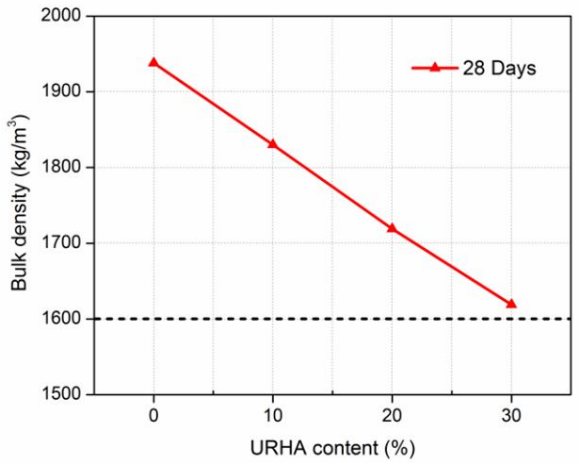


Fig. 5 Effect of URHA content on bulk density of bricks

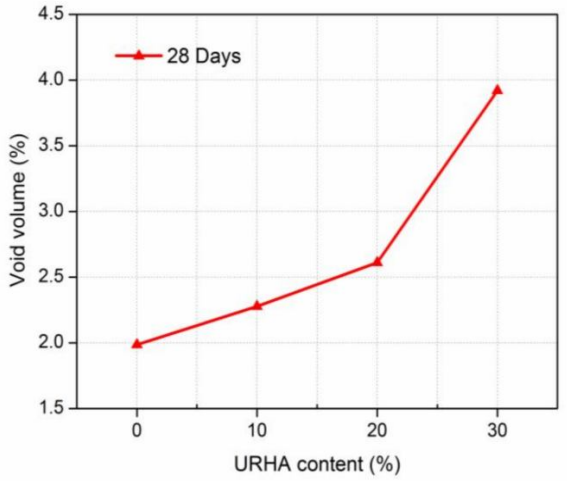


Fig. 6 Effect of URHA content on void volume of bricks

CONCLUSIONS

It was feasible to produce UBB with the application of URHA as fine aggregate in the mixtures up to a certain level. It is hoped that this research investigation will open possibilities of utilization of URHA as well as other solid waste materials in construction materials production.

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