Influence of Water Absorption on Properties of AAC and CLC Lightweight Concrete Brick

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Abstract: Two types of lightweight concrete bricks that often used on the walls of the building are Autoclaved Aerated Concrete (AAC) and Cellular Lightweight Concrete (CLC). Both types of lightweight concrete brick are made from similar raw materials, but with the difference in the methods of manufacturing. Lightweight concrete brick have the risk of water absorption if it was used as exterior walls, however there was still few studies that discusses the resistance of lightweight concrete brick against water. This research aims to show the change of the properties of two types of lightweight concrete brick after subjected to water absorption. Tests that have been conducted in this study are compressive strength after immersion test, absorption test, drying test, capillarity test, and expansion test. The results showed that the compressive strength of all types of brick decreases after being soaked in the water. However after drying, it regain its initial strength. AAC brick has higher strength to weight ratio compared to CLC brick, however, AAC brick has a higher absorption and capillarity properties than CLC type.

Keywords: CLC, AAC, lightweight concrete, capillarity, absorption.

1 INTRODUCTION

There are two popular types of lightweight concrete brick currently used in construction industry, namely Autoclaved Aerated Concrete (AAC) and Cellular Lightweight Concrete (CLC). These lightweight concrete bricks were used to replace the traditional brick as infill material for wall in buildings. The advantage of using lightweight material to replace the traditional brick, was to reduce the dead load of the building, hence reduce the size and capacity of the structural member. Substantial saving was achieved for high-rise building, since the saving would include size reduction of beam, column and also loading on the foundation. (Short and Kinniburgh, 1978)

AAC and CLC both were made from similar material such as cement, sand and other materials with inclusion of air voids. The difference was in the method of manufacture. AAC was made by adding aerating agent that would react with the mortar and causing air void to appear after mixing of the mortar, while foam was added into mortar mixture to produce CLC (Kristanti and Tansajaya, 2008). This method of manufacturing would cause the difference in properties of the lightweight concrete produced. AAC have density around 500 - 700 kg/m^3, while for CLC the density was around 400 - 1200 kg/m^3 and as a comparison, traditional brick have density about 1400 - 1600 kg/m^3.

When used as external enclosing of building, the wall would be subjected to many environmental exposure such as solar heat, humidity, wind, rain and others. Even with exterior coating, there could be defects that would cause water to penetrate into the wall after some period of time. This could cause trouble such as dampness in the wall, water spot in the painting, leaking of water and fungi development.

This research aims to examine the change of the properties of the lightweight concrete brick namely AAC and CLC when expose to water. Change of compressive strength after immersing in water, absorption capacity and capillary suction as well as the expansion was investigated in this research. The change of the physical behavior after water exposure could be used as information in selecting the material for concrete wall, especially exterior wall.

2 METHODOLOGY

2.1 Materials

Two brand of commercially available lightweight concrete bricks used was obtained for each of the AAC and CLC, and traditional clay brick and pressed clay brick was added to compare the water absorption only. The properties of the brick tested are shown in Table 1.

The speciemen was then cut into cubical and prism sive for compressive, water absorption, capillary and expansion test. The specimen for compressive test is shown in Figure 1. For compressive strength test, specimen size of 75×75×75 mm and 100×100×100 mm was used. And for capillary and expansion test, the height of specimen was 220 mm.

Table 1. Properties of the Material

Specimen	Dimension (cm^3)	Dry Density (kg/m^3)
AAC1-0.60	60 × 20 × 10	590 - 630
AAC2-0.55	60 × 20 × 7.5	525 - 575
CLC1-0.95	50 × 20 × 10	950 - 1000
CLC2-0.50	60 × 20 × 7.5	500 - 520
PB-1.60 (Pressed Clay Brick)	20 × 10 × 5	1600 - 1700
TB-1-40 (Traditional Clay Brick)	18,5 × 9 × 4.5	1400 - 1500

Figure 1. AAC, CLC and clay brick used in testing.

2.2 Testing Conducted

Compressive testing was conducted on the cubical specimen, without water exposure and immediately after immersion in water for 3, 7, 14 and 28 days. The specimen was surface dried only before testing.

Absorption test conducted according to ASTM C 642 (1997). The weight gain was converted to %volume increase depending on the size of the specimen. The % volume increase was measured until 28 days. 4 specimen was used for each variable.

Natural drying test was conducted after the absorption test by leaving the specimen in the ambient condition of laboratory and the change of the weight was observed regularly.

Capillary suction test was conducted according to ASTM C1585 (2004). Two specimen was used for each brick type.

Expansion of the lightweight concrete brick was measured using dial gauge. The specimens were fully immersed in the water for the duration of the testing.

3 RESULTS AND DISCUSSIONS

The relationship of the compressive strength and the density of the lightweight concrete brick used in this research is shown in Figure 2. The compressive strength was about 30-45 kg/cm^2 for AAC1, 20-30 kg/cm^2 for AAC2 and 15-25 kg/cm^2 for CLC2. At the right end there was compressive strength of 10-15 kg/cm^2 for CLC1. There was a direct relation between the density of the material and the compressive strength, as it was shown in the result of AAC1, AAC2 and CLC2, however was not followed by CLC1. For the two type of the AAC used, it has the higher compressive strength to density ratio when compare to its CLC counterpart. However, CLC2 also have higher strength to density ratio than CLC1, even its density was lower.

Therefore, for each type of the concrete brick, there was certainly a linear relationship of density and compressive strength, however, the curve cannot be used for all type of lightweight concrete, as each concrete have different strength to density relationship coefficient.

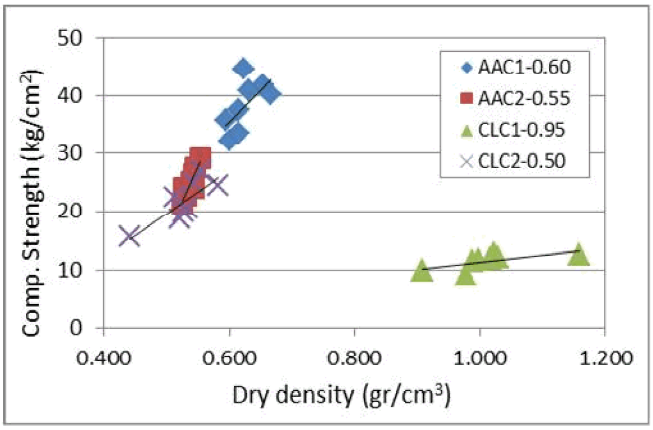


Figure 2. Relationship for compressive strength and density of the concrete.

When we considered the compressive strength required for 4 m height wall is only about 1-2 kg/cm^2, all of the lightweight concrete type used here have sufficient compressive strength to sustained its self weight. Showing that the compressive strength was not the most important factor in choosing the type of the material.

The change of compressive strength after immersion in water was shown in Figure 3. For all concrete it was shown that there was a decrease in compressive strength after immersion in water, but with difference reduction rate. This was common also for normal concrete since the water inside concrete would cause lateral pressure and reduce the concrete strength. Reduction of 8 kg/cm^2 was observed for CLC2, and 7 kg/cm^2 for both AAC. The reduction of the compressive strength was not affected by the duration of immersion, as the test result showing no linear reduction of strength with immersion time.

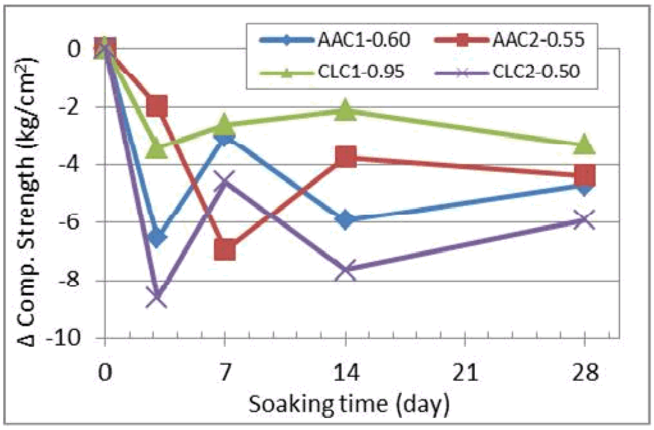


Figure 3. Change of compressive strength after immersion in water.

To be certain that the reduction of the strength was only due to moisture effect, specimen after 7 day water immersion was dried in the oven for one day and then tested for compressive strength. The result is shown in Figure 4. It was shown that the compressive strength was increase again after drying in the oven.

Figure 5 shows the result of the water absorption for all lightweight concrete with the addition of pressed clay brick and traditional clay brick. It was shown that there are two distinct trend. AAC lightweight brick have higher absorption rate than its CLC counterpart.

From the result of the absorption test, it was shown that traditional brick have the absorption up to 45% of its volume, while for pressed brick it was about 26%. Both AAC concrete have lower absorption then the traditional brick but have water absorption higher than pressed brick. Both of the CLC brick have lower water absorption rate than the pressed brick. CLC2 showing that there is increase of water absorption at later age, this condition is mainly due to its lower density than CLC1. CLC2 having lower density mean that there was a large amount of air void that could be filled with water, while CLC1 have higher density and less air void.

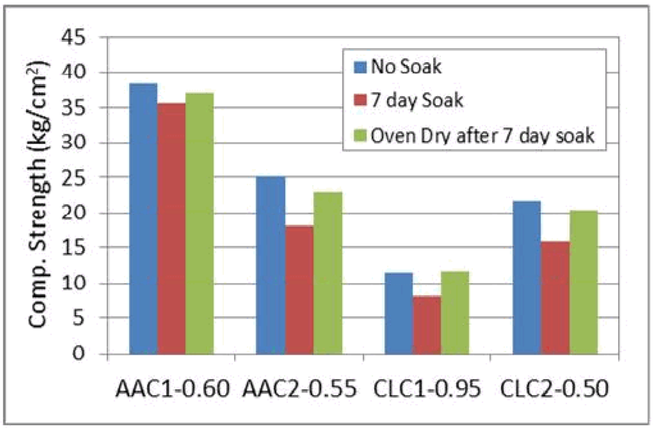


Figure 4. Compressive strength after drying the specimen in oven.

From Figure 5, it could also be seen that the absorption rate of the clay brick was very fast at early time and become constant immediatelly, showing that its pore was very connected. While for AAC the absorption rate was increasing with the increase of time, meaning that it could still absorbing water after longer period of time.

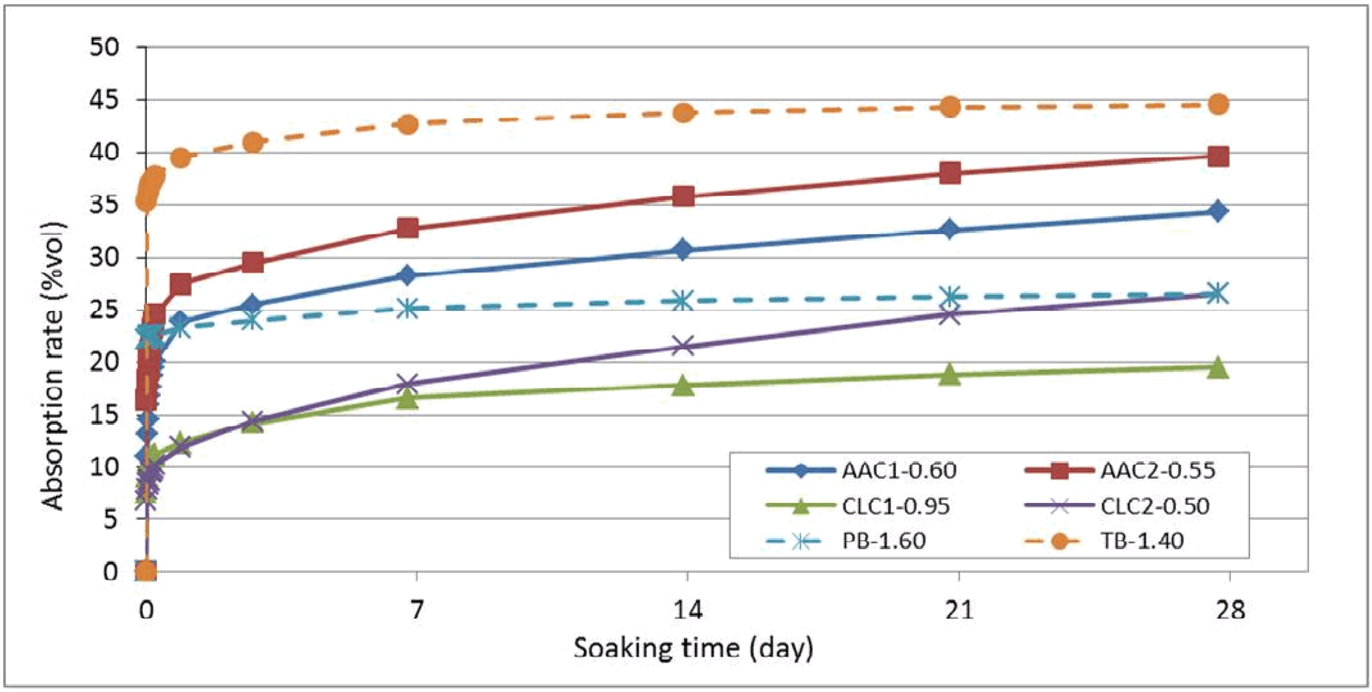


Figure 5. Result of the absorption test for different lightweight concrete brick and clay brick.

The drying rate of the specimen is shown in Figure 6. The drying rate of the clay brick was also faster compared to the lightweight concrete brick. It was shown that after 1 weeks, the clay brick and CLC brick would retain only 5% of its water absorption while it took about 2 weeks for AAC brick.

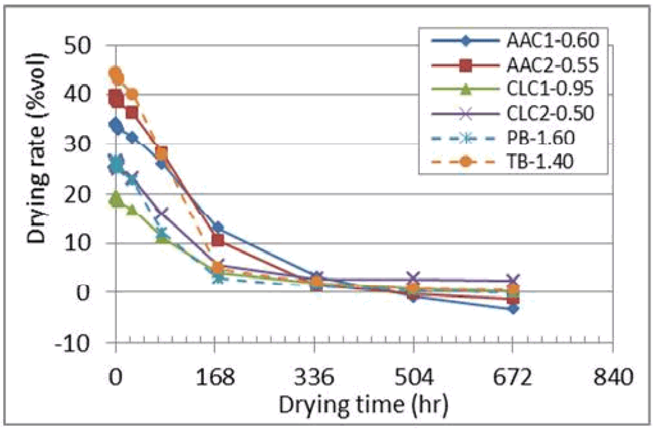


Figure 6. Drying rate of the specimen under ambient laboratory condition.

From the drying rate of the specimen, it is also known that the specimen was not returning to its initial weight. Figure 7 shows the detail of the drying rate at third and fourth week. From the figure, both of AAC brick have reduction of weight from its initial weight. The reduction was 3% for AAC1 and 1% for AAC2. Clay brick and CLC did not show reduction of weight after water immersion. This reduction of weight could be due to some of the particle in AAC could dissolve in water.

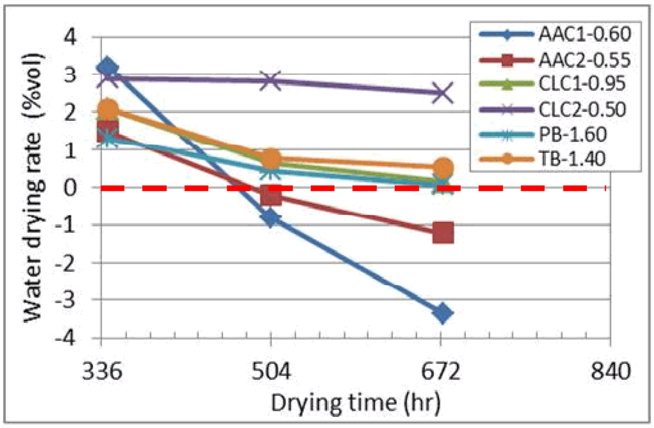


Figure 7. Detail of the drying rate at the third and fourth week.

Figure 8 shows the results of expansion test on the lightweight concrete brick immersed in water for 1 week. The result showed that there was two distinct expansion in the concrete when immersed in water. CLC have higher volume expansion when compared to AAC. The expansion strain of CLC2 was measured up to 800 μstrain after 1 week of water exposure, while for AAC2, it was measure 300 μstrain. This expansion strain could cause some expansion problem on the wall if there was no clearance. According to Manual of Concrete Practice-ACI Part 5 (1996), the limit for expansion strain is around 2500 - 3000 μstrain. This result show that the expansion of the concrete brick under immersion of water still acceptable if the AAC or CLC brick was used for infill wall.

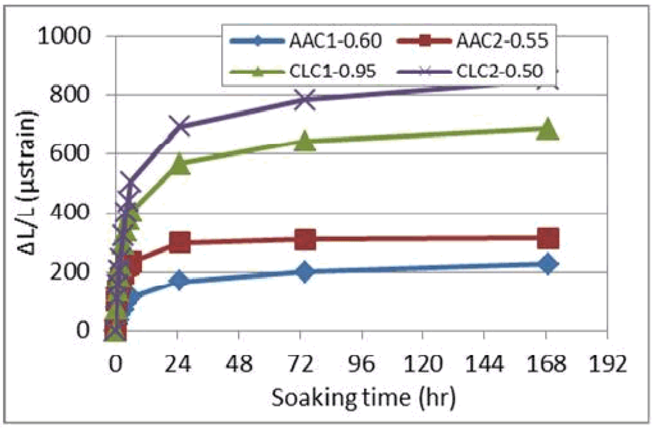


Figure 8. Expansion of the brick after immersion in water.

The result of the capillary absorption of the concrete was shown in Figure 9. AAC brick have 2.5 to 3 times higher absorption rate when compared to CLC brick. CLC2 have capillary absorption about 10%vol, while AAC2 30%. The different behavior in the capillary suction properties is due to the difference in the pore connectivity of the concrete. This difference was also due to the difference manufacturing method.

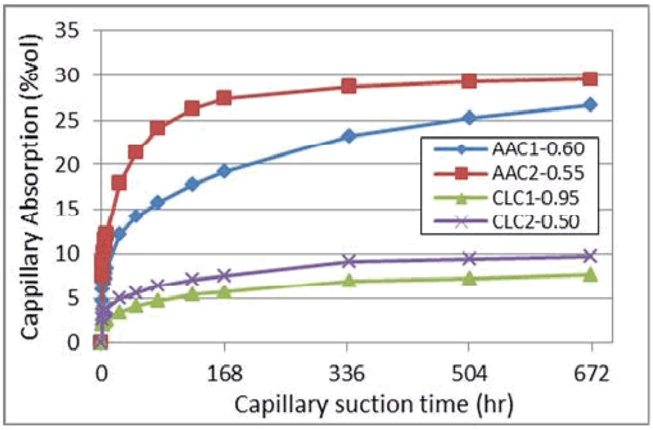
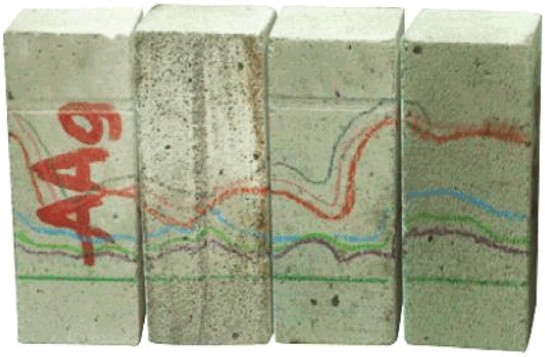


Figure 9. The capillary absorption of the specimen.

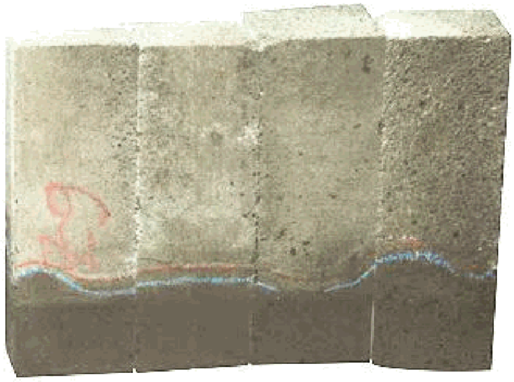
Figure 10 shows the specimen of capillary suction test for AAC1, AAC2, CLC1 and CLC2. The lines drawn on the specimen was the capillary rise of the water at the same period of time. AAC2 have very high capillary suction rate that almost all specimen was wet under 1 week period.



(a)

(b)

(c)



(d)

Figure 10. Capillary rise on the specimen after 28 days (a) AAC1-0.60, (b) AAC2-0.55, (c) CLC1-0.95 and (d) CLC2-0.50.

4 CONCLUSIONS

From this research, it was shown that different type of lightweight concrete brick have different water absorption properties and care should be given when selecting material for exterior wall of the building. The following conclusions were drawn from this research:

a) Compressive strength of the concrete brick was influenced by the type of the concrete and its density. The compressive strength mostly determined by the manufacturing process of the lightweight concrete brick.
b) For all type of concrete brick, the compressive strength was reduced after immersion with water. However, after drying again, it regains its initial strength.
c) Traditional clay brick absorb the most water at immersion (44%vol) , and followed by AAC (34-39%vol), pressed clay brick (26%vol) and CLC (19-26%vol).
d) Drying rate for clay brick and CLC was faster than AAC as it only need 1 week for clay brick and CLC to dry up to 5% from its initial weight, compared to 2 weeks time for AAC to dry up.
e) AAC brick particle could have been dissolved in the water as it showed reduction of 1-3% weight after immersion in water for 28 days.
f) AAC have higher capillary suction than CLC, this property could have some serious implication to the wall structure as water could rise up along the wall by the capillary suction.

REFERENCES

American Society for Testing and Materials (1997) C642-97 "Test Method for Density, Absorption, and Voids in Hardened Concrete"

American Society for Testing and Materials (2004) C1585-04 "Test Method for Measurement of Rate of Absorption of Water by Hydraulic-Cement Concretes"

Kristanti, N., Tansajaya, A. (2008). *Studi Pembuatan Cellular Lightweight Concrete (CLC) dengan Menggunakan Beberapa Foaming Agent.* Undergraduate Thesis. Petra Christian University. Surabaya.

Manual of Concrete Practice-ACI Part 5, (1996) *Farmington Hills*

Short, A. and Kinniburgh, W. (1978). *Lightweight Concrete*. Applied Science Publishers Ltd.