Characteristics of Plastic Block Wall Materials (PBWM) Using Waste Engine Oil, Crackle Plastic, Mineral Water Plastic Cups Cover and Label of Plastic Bottle Without and With Rice Husk Ash and Natural Aggregates Filling Materials

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Abstract. The increase of waste in Indonesia has reached 38 million tons per year and about 30% of this waste are plastic. One of the efforts is to overcome this issue is by using thin plastic waste from packaging which is rarely recycled to become plastic blocks wall material (PBWM), where the plastic was melted in hot waste engine oil (WEO). The main purpose of this study was to analyze the characteristics of the PBWM. Variation of material proportion was based on trials. The plastic waste was initially shredded to sizes about 5-10mm. On sample productions, the WEO was heated to 200°C then the shredded plastic gradually added and evenly mixed, and poured into a metal mould. The mixture was cooled down to ideal temperature for compaction of 110°C to 125°C, then left to reach room temperature. It was obtained that the Initial Rate of Suction (IRS) test results range from 0.0982-0.1012 kg/ ^{2}.

1 Introduction

Demands on building materials increases, meanwhile the availability of natural materials decreases. Aggregate natural materials had been used widely for many years in many parts of the world. Some researchers had done studies to replace natural materials. Building blocks from waste aggregates can be produced using asphalt or bitumen as the binder. The compacted samples need to be heated at temperature between160-200°C for up to 16-24 hours. The product gave compressive strength in a range of 65-90 kg/cm^2 [1]. Meanwhile researcher [2], utilize various aggregate waste materials, bound with various unused or waste binder (asphalt penetration, asphalt emulsion, and used cooking oil). The block was compacted with low compaction level. The samples were put in oven at 160°C of 200°C for 12-24 hours. The products have compressive strength > 25kg/cm^2 in line with specification in Indonesia [3]. Experiments on brick contained fly ash, sugarcane bagasse ash (SBA), sand,

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cement, and waste marble dust gave average of 40.6-40.9 kg/cm^2 compressive strength that satisfy 3.5MPa targeted [4].

Many studies had been done, but production of wall block using waste materials in mass scale has not yet been done widely. This may cause by limitation on the production method, contamination, and the absence of related tandards. Many of those product need more promotion and support from government and the construction industry [5]. Furthermore join trial work, observation and evaluation should be done in collaboration among related parties.

The objective of this experiment was to study the potentials use of the waste thin plastics plastic wrap and waste engine oil, and to obtain the properties of Plastic Wall Block Material (PWBM) without and with rice husk ash and aggregate as the filling materials.

2 Literature Review

2.1 Thin Plastic Wrap

The global average plastic production per year, can be more than 300 million metric tons, about 200 times increase compared with data in 1950. It had become an environmental issue, where some type of plastics may take 500 years to decompose [6]. High quantity of those plastic are thin plastic of Low-Density Polyethylene (LDPE), which is commonly used for packaging, such as for: garbage bags, heat sealing packaging, plastic bags, coatings on beverage container and cartons, stretch film etc. Polyvinyl Chloride (PVC Vinyl) is another type of plastic can be used for packaging. It can resist oil and chemicals, and physically stable, strong and clear.

2.2 Aluminium Coated Sheet

Packaging using aluminum coated sheet suitable to minimize the evaporation of water content. It commonly used to reduce to effect of UV rays, and also widely used for food products covering. Aluminium coated sheet is impermeable hence it is very useful for food packaging and preservation [7]. The common utilization are for food wrapping of: cheese and butter; candies; pharmaceutical products container, and for wrapping foil. Waste on aluminum coated packaging largely from food covering, such as snack packaging, crisp wrap/packaging, candy/sweet packaging, cake wrapping etc. [8]. Recycling of waste of thin plastic wrap with aluminum coating are less demanded so it has less economic values. Development of rubbish bank in community areas in some developing countries have been initiated. Public are suggested to separate their non-organic waste. It can be sent to a rubbish bank nearby with certain value of money. Rubbish banks can receive most waste plastic, but thin plastic wrap as it has lower economic values can be accepted at certain rubbish bank only [9].

2.3 Used Engine Oil

Car ownership are high in many part of the world, so the availability of used engine oil is about 1.5 billion gallons per year. It contains toxic and harmful components, among others benzene, heavy metals, polycyclic aromatic hydrocarbons, and others, that can pollute water and soil. Nonetheless, using special refining technology it has a high recovery value. It can be regenerated into a diesel oil, base oil, and fuel oil [10]. Used oils can also be directly used as road oils for dust control. It also can be combined with new fuel oil for firing boilers for heat generation. However, its heavy metals components should handle properly, as it causes pollution [11].

2.4 Used Engine Oil

The properties of building blocks can be compressive strength (kg/cm^2), porosity (%), and water absorption based on water immersion for 24 hours (%). The Plastic Wall Block Material (PWBM) samples float in water, so the determination of volume cannot be done properly using water replacement method, hence the volume can be obtained by measuring the dimension of the samples to enable the determination of density. For the calculation of porosity (P) using Equation 2, can be done after calculating the Specific Gravity of the mix (SG_{mix}), i.e. the max theoretical density using Equation 1 [12].

$$SG_{mix} = \frac{100}{\frac{\%a}{SG_a}+\frac{\%b}{SG_b}+\frac{\%c}{SG_c}+\cdots\ldots\ldots+\frac{\%\,oil}{SG\,oil}} \quad (1)$$

$$P = \frac{SG_{mix}-D}{SG_{mix}} = \left(1-\frac{D}{SG_{mix}}\right) \times 100\ \% \quad (2)$$

where a, b, c are the percentage of the parts of the mixture by weight of total mix, and the SG is the specific gravity of each part of the mixture, and D is the density.

Initial Rate of suction (IRS) is another property that need to be determined. The IRS test was done by soaking the sample in water at 3mm depth for 60 second. The IRS is the weight of water absorbed divided by the area soaked in water. Typically IRS value on clay brick in the United Kingdom is 0.25-2.0 kg/m^2.minute. Samples with higher IRS value would absorb more water from sand cement mortar, hence the wall block material needs to be soaked before it is placed on a sand cement mortar layer [13].

3 Method

The materials used was: used engine oil was taken from car and motor cycles services; three type of thin plastic waste: plastic shopping bags (crackle plastics), aluminium coated thin plastic waste, and other type thin plastic waste, and rice husk ash from local sources. The waste plastics were cut into about 5-10mm sizes. For viscosity comparison, original engine oil of Honda E-Pro Turbo 0W-20 SAE 0W-20 was used as well as waste engine oil. Sybolt Furol viscosity testing equipment was used for viscosity testing. The specific gravity of the thin waste plastic, waste engine oil, and rice husk ash, were tested using pycnometer [14], meanwhile the viscosity of the oil was tested according to Indonesian Specification [15].

3.1 Trial

First trial was done using 500grams of waste thin plastic that consists of 250grams waste thin plastic of mineral water plastic cups cover, 250grams plastic bottle labels and 500 grams waste engine oil. It was found that the mixture was brittle as the mixture cannot stick together, so the mixture was added with waste plastic shopping bags that had been found to give better bonding [16]. Further experiment was done to include waste plastic shopping bags (crackle plastic) with mixture name and material proportion (the thickest mixture base on trials for best results and ease of manual mixing) as Mixture 1: 400 grams waste thin plastic (200 grams waste plastic shopping bags, 100 gram waste thin plastic of mineral water plastic cups cover, 100 gram plastic bottle labels), and 400 grams waste engine oil. Mixture 2: As Mixture 1, added with 100 gram rice husk ash. Mixture 3, as Mixture 1, added with 100 gram natural aggregate (5-10)mm.

The materials that had been proportioned, were sufficient for producing sample with size of 100x100x(80-90)mm. The sequence of the sample production is presented in Figure 1. Initially the materials were proportioned/weighed (A), then continued by heating the waste engine oil (without and with rice husk ash) at temperature of 200°C on a frying pan. After that the shredded/cut plastics were poured and manually and evenly mixed (B, C), followed by molding the mixture (D). The mixture was compacted using a Marshall hummer at 1 blow at temperature of 125-110°C, for light densification and to get even surface (E). It was intended to compact the mixture at lower temperature than mixing temperature to get the mixture in plastic state condition (not too sloppy). If compaction was done as at mixing temperature the mixtures were too sloppy. Then the samples were cooled down, and were taken out of the mold (F) and tested (density, porosity, Initial Rate of Suction (IRS), water absorption, and un-soaked and soaked compressive strength).

The density of the samples were less than 1, therefore the samples float in water, hence it was unable to measure volume by water replacement method (taking the difference of weigh in air and weigh in water) as commonly done for most other type of samples that do not float in water. The dimensions of the samples were then measured at two point on each side of the samples. After the weight of the samples were taken, the density (weight/volume) can be determined. The whole process took less than one hour. Respiratory musk had to be used because of the toxic nature of the sample productions, and extra care had been done where and the room was of sufficient air circulation, where ceiling fan and the doors and windows were opened. Only a few samples produced per day.

(A) (B) (C)

(D) (E) (F)

Fig. 1. Production of samples.

4 Result and Discussion

4.1 Specific Gravity and Viscosity

The specific gravity (SG) of the materials used is shown in Table 1. It shown that the SG of waste plastics were mostly less than 1, hence it floated in water.

Table 1. The specific gravity of materials

Property	**Type of waste materials**				
	Plastic shopping bags	Plastic of mineral water plastic cups cover	Plastic of bottle labels	Waste engine oil	Rice husk ash
Specific Gravity (SG)	0,875	1.018	0,882	0,960	2,055

The viscosity of the new and waste oil is given in Table 2, where it is shown that the waste engine oil has lower viscosity than the new oil as it had lower lubricating ability after it is used (more fluid). This indicates that after used the oil losing its lubricating properties.

Table 2. Viscosity of oil

Oil	**Temperature (°C)**	**Flow time (sec)**	**Viscosity (Centistokes)**
Waste engine oil	30	258	54,43
New engine oil	30	436	93,00

4.2 Density and Porosity

This data are shown in Figure 2 and 3. The density of the samples were less than one as shown in Figure 2, where the samples float in water. As had been mentioned in the previous sections that the volume was measured to enable the determination of density. Mixture 2 and 3 were denser as it contain filling materials of rice husk ash and aggregate respectively. The density of the samples were far lower than commonly produced concrete block which has density vary from 1.100 to 2.300 kg/cm^3. Medium weight concrete block, can be of 2.150kg/cm3 and for light weight concrete 1.100kg/cm^3. The density is affected by the material used and the compaction level applied.

The density as shown in Figure 2, was used for the determination of porosity, using Equation 2. The porosity is sown in Figure 3. The trend of porosity were generally in line with the density, where the samples with lower density gave higher porosity. The porosity of the samples were generally low, as the melted plastic within the mixture undergo self-densification and hardening during cooling down, hence left very less space. There is no strict porosity requirement on the national Indonesian specification for building block. Comparing with concrete blocks, porous concrete blocks may contain void of 15-25% [17].

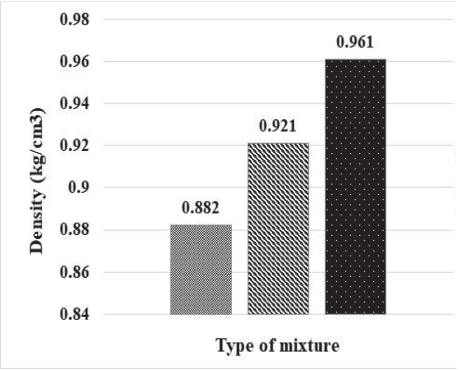

Fig. 2. The density of the mixtures

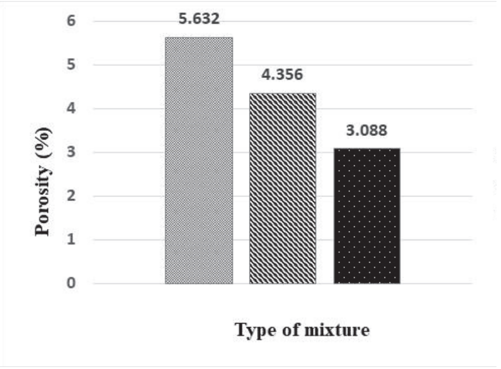

Fig. 3. The porosity of the mixtures

4.3 Initial Rate of Suction (IRS) and Water Absorption

The trend in Figure 3, is also represented and in line with the IRS values in Figure 4. The IRS values were low compared with the typical IRS value on clay brick in the United Kingdom (0.25-2.0 kg/m^2.minute). Samples with higher IRS value commonly absorb more water from sand cement mortar, so it needs to be soaked before it is placed on mortar layer and vice versa [13]. The IRS results indicated that the samples would not require soaking before it is laid on sand cement mortar. Meanwhile, there is no universal water absorption values recommended especially for this type of mixture. Nonetheless the water absorption were very low as shown in Figure 5. Similar trend was also obtained on the water absorption of the samples, after 24 hours soaking in water as presented in Figure 5. The water absorption is far lower than concrete, studied by [18] that the absorption of their interlocking concrete blocks can be of 7-16%.

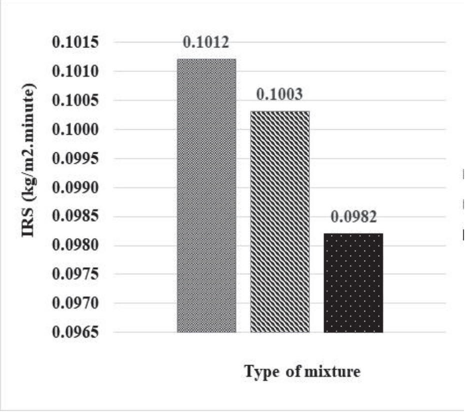

Fig. 4. The IRS of the mixtures

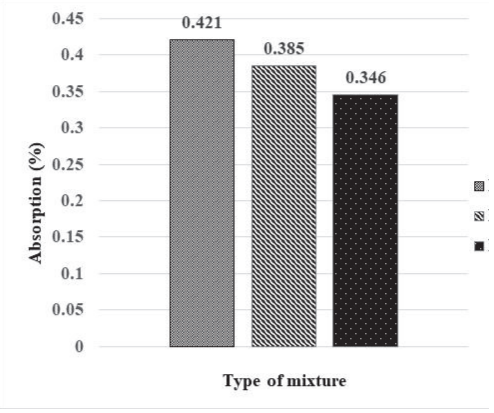

Fig. 5. The Water absorption of the mixtures after 24 hours of water soaking

4.4 Compressive Strength of the Mixtures

With the manual sample production mechanism using simple equipment and method, the compressive strength are shown in Figure 6. All un-soaked mixture can achieve compressive strength of more than 25 kg/cm^2 which is the minimum value in line with the Indonesian Standard, for concrete block [5], where concrete block uses cement as the binder, meanwhile the samples produced within this experiment were of different kind. Some researchers had done experiment on low strength brick. Researchers [19] carried out trials on clay brick that naturally air dried for 28 days without and with natural sisal and coir fibers in Tanzania. The compressive strength achieved were of 17,4-68,5 kg/cm^2, that is in line with the Tanzanian National Standard of 10-70 kg/cm^2.

Experiment by [20] in Thailand, that composed of variation of sand, clay, and mud sediment then dried out for 28 days. The compressive strength found was about 2,5-11 kg/cm^2. Considering the results of other type of building blocks done studied by some researchers, the samples within this experiment were somewhat with better compressive strength, and can be made much faster. The heat required to produce samples was not high and can be done using simple heating equipment. However, more trials are needed to simplify and safe production, and the use of waste thin plastic combination and incorporation of other filling materials to maintain the expected compressive strength. Join experiment for long term performances and evaluation of the samples need done wider.

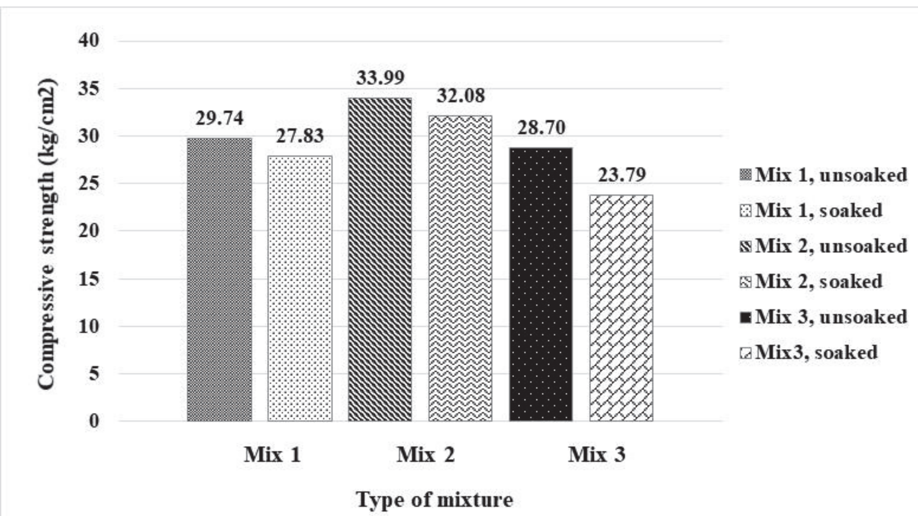

Fig. 6. The compressive strength of the mixtures

5 Conclusions and Suggestions

Referring to the results and discussion, conclusions can be withdrawn as follow:

- The thin waste plastic is potential materials to be used to produce building block in combination with waste engine oil, and rice husk and aggregate filling materials.
- The combination of thin waste plastic bags, waste thin plastic of mineral water plastic cups cover, and plastic bottle labels can gave compressive strength within the strength ranges of low quality brick studied by other researchers.
- The other properties i.e. porosity, IRS and Water Absorption was found relatively low. It was obtained that the Initial Rate of Suction (IRS) test results range from 0.0982-0.1012 kg/m^2.minute, Water absorption 0.346%-0.421%; porosity 3.088%-5.632%;

Compressive strength without immersion 28.70-33.99kg/cm^2; and Compressive strength with immersion 23.79-32.08kg/cm^2.

- In general, the average compressive strength of the PBWM can achieve ≥ 25 kg/cm^2.

It is suggested to produce a mixture that contains combination of the thin waste plastics used, with higher portion of waste plastic bags as it gave higher bonding. It is also suggested to do tests at different temperature in line with the surrounding environment local temperature.

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