

PLASTIC WALL BLOCK FROM THIN WASTE PLASTICS WRAP AND WASTE ENGINE OIL WITHOUT AND WITH FILLING MATERIAL

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KEY WORDS: Plastic wall block, Waste plastic wrap, Waste engine oil

ABSTRACT:

In order to utilize waste materials as building component, waste of thin plastics wrap and waste engine oil without and with rice husk ash as filler can be used for producing Plastic Wall Block (PWB). The objective was to evaluate the PWB engineering properties. The waste plastic wrap was shredded or cut off to sizes about 5-10mm. The waste engine oil without or with rice husk ash were heated at 200°C, then the shredded plastic poured into hot oil and evenly mixed. The mixture was casted in a metal mould and compacted at temperature of 125-110°C using a Marshall hummer for one blow to give even and flat surface shape then cooled down to form sample with average size of 100x100x80mm. It was obtained that the soaked compressive strength can exceed 25kg/cm² which is the minimum value targeted, with initial rate of suction range about 0.0149-0.1012 kg/m².minute; porosity in a range of 0.62-1.48 %, and water absorption of 0.0481-2.2185 %.

1. INTRODUCTION

1.1 Background

Building construction industries grow up steadily every time as demands on housing increases. Meanwhile the availability of natural materials, such as natural sand and gravel for building construction decreases. Those natural materials had been used for various construction for many years (as a case in Bali-Indonesia). The source of natural aggregate materials were mostly from naturally occurring rock, and solidification of magma due to volcanic activities. Efforts to substitute natural materials had been done by some researchers. Forth et al. (2006), produced building blocks from waste aggregates using asphalt or bitumen as the binder. After compaction, the samples need to be heated at temperature of 160-200°C for up to 24 hours. The block could achieve sufficient compressive strength in a range of 65-90 kg/cm². Thanaya (2010, 2011a, 2011b, 2013, 2017, 2020), had done similar works using various aggregate waste materials, with various binder (left over asphalt penetration, left over asphalt emulsion, and waste cooking oil). Low compaction level was applied, as the product was intended for low quality block. The samples were heated at either at 160°C or 200°C for 12-24 hours. The samples can gave compressive strength more than minimum 25kg/cm² in line with the national specification in Indonesia (INS, 1989).

Meanwhile Venkatesh et al. (2022), investigated the use of marble dust (MD) and rice husk (RH) for substituting the use of soil. The MD used was 10 %, 20 %, 30 %, and 40 %. Meanwhile the RH content was 0.5 %, 1.0 %, and 2.0 %. It was obtained that 30 % MDP and 1.0 % RH incorporated within the soil gave better results. The compressive strength improve to about 29.46 %, with a range from 87.4-92.7 kg/cm². Priyadarshini et al. (2021), tried a composition of brick contained fly ash-25 %, 20% sugarcane bagasse ash (SBA), 30% sand, 5% cement, and 20% waste marble dust and for clay

bricks with clay of 65 % and SBA 35 %. The results gave average of 40.6-40.9 kg/cm² compressive strength that satisfy 3.5MPa targeted.

Some other researchers had done experiment on low quality bricks. Njau dan Park (2015) carried out experiment on sun dried clay brick that had been dried out for 28 days with and without sisal and coir fibres in Tanzania. The compressive strength obtained was between 17.4-68.5 kg/cm². These results meet the Tanzania Nasional Specification 1-7 N/mm² or 10-70 kg/cm². Al-Ajmi et al. (2016) did research on brick made of natural mud and sand in Saudi Arabia. The sample size were 100x100x100mm and sun dried for 25 days. Maximum strength was achieved when using sand and mud with ratio of sand to mud 0.15, with compressive strength 1.52 MPa (15.2 kg/cm²). Meanwhile Sasui et al. (2017) had done experiment in Thailand using combination of sand, clay and mud, that were dried out in shade for 28 days and gave compressive strength of 0.25-1.1 MPa (2.5-11 kg/cm²). Furthermore, Dawood et al. (2021) studied the compressive strength of unburnt clay brick and found to have compressive strength oh 1.1 MPa (11 kg/cm²). When the clay were added with straw, saw dust and rice husk, can improve the compressive strength to become 2.4, 2.85, and 2.4 MPa (24, 28.5, 24 kg/cm²).

Research using waste plastic as building block material had been done by some researchers. Shrimadi (2017), made plastic block using various thin waste plastic. The plastic were put in a metal mould, then compressed with a tamping rod, then heated at 175-200°C up to 2 hours. The samples with size of 19x9x9mm then cooled down. The compressive strength achieved were in a range of 30-150 kg/cm². Bhushaiah et al. (2019), carried out study on plastic brick, in which the materials proportion were varied, that consists of sand, cement, fly ash and melted LDPE waste plastics. The plastics was melted at temperature 90-110°C. The melted plastic was added and mixed with the other materials, then casted into a mould of

19x9x9mm, and tamped. The samples were left into mould for 24 hours, then taken out and cured for 28 more days at room environment. The compressive strength of the samples were around 18-19 MPa. Additionally, published in Jakarta (2020), an entrepreneur produced paving blocks from mixtures of sand, cement, and shredded thin waste plastics with size from 5-10mm. The waste plastic added up to 20% that gave compressive strength about 200 kg/cm².

Many researches had been done, however production of bricks from waste materials in wider scale has not yet widely done. This can be due to the production method, the potential of contamination, and the in availability of standards. This product need to be more widely promoted and supported by the construction industry (Zhang, 2013). This matter had also expressed by Al-fakih et al. (2019) in which educating and to give awareness the public regarding the benefit of using waste materials for brick production. Additionally trial scale work and evaluation need to be done in collaboration among related institutions or parties.

1.2 Objective

The objective of this study was to evaluate the potentials use of the waste thin plastics, to analyse the engineering properties of the Plastic Wall Block (PWB) that was produced using waste thin plastic wrap, waste engine oil, without and with rice husk as the filling materials, and to compare the results with other researchers.

2. LITERATURE REVIEW

2.1 Thin Plastic Packaging

The current global average plastic production per year, can be more than 300 million metric tons, several times increase compared with the amount of 1.5 million metric tons in 1950. The waste of those plastic had become an environmental issue. Plastic may decompose after 500 years (Tiseo, 2022).

Large percentage of those plastic are thin plastic of Low-Density Polyethylene (LDPE). This plastic is usually used to make plastics that has ability to resist oils, acids, and bases. The product is rigid, flexible, transparent, and simple to make. LDPE is suitable option for making food and drink packaging. The general uses covers: heat sealing packaging, garbage bags, plastic bags, coatings on beverage container and cartons, stretch film etc. The other plastic type generally used for this packaging is Polyvinyl Chloride (PVC, Vinyl). It is usually used as it can resist oil and chemicals. Physically it is stable, strong and clear. The general uses covers: clamshells, blister packs, medical wrap, and food packaging (PPCI, 2021). Among type of plastic waste, it is the thin plastic waste is less attractive to be collected for recycling in developing countries, as it has less economic values. Therefore efforts is much needed to utilize these thin waste plastic types.

2.2 Aluminium Coated Packaging

This packaging provides a good barrier to prevent moisture and escape of subtle flavours. It can prevents the UV rays, used in many forms of lighting, and other utilization in food products. Aluminium foil is not permeable that can retain aromas and give proper folding while the high gloss metallic print surface may be used to convey product quality. This type of packaging is suitable for food preservation. Food nutritional content when

protected from light and gases, would remain for longer time. The ease of folding and good barrier properties of aluminium foil make it very popular for wrapping food stuff. The utilization can be for food wrapping of: chocolate, butter and cheese; as kitchen foils, wrapper of pharmaceutical products, and wrapping foil. Waste from households on aluminium coated packaging are mostly from food packaging, such as snack packaging, candy/sweet packaging, crisp wrap/packaging, cake packaging etc. (FPPL, 2022).

Thin plastic packaging recycling effort had been done to recycle waste plastic. Recycling non thin plastic wrap packaging had been more attractive and has higher economic values. But waste of thin plastic wrap packaging with or without lamination or coated with aluminium has less economic values especially in developing countries. In some developing countries have been initiated the development of rubbish bank in community areas. Member of the community are encourage to separate their non-organic waste and send or sell them to a rubbish bank nearby with small value of money. Most plastic waste can be accepted in rubbish banks. But thin plastic wrap packaging only can be accepted in some rubbish bank only, as it has lower economic values. Facilities and technology for recycling in developing countries is generally still limited (Jojonomic, 2020 and Smash, 2022).

Meanwhile, CreaSolv Process introduced by Fraunhofer Institute for Process Engineering and Packaging. This process separate plastic composites, in which contaminants, odorous are easily removed. For obtaining high-purity materials from waste, the CreaSolv Process is combined with mechanical process. This process gives recycled plastic with properties closely as the original material. The solvent-based CreaSolv Process would removes contaminants and additives so it's quality better than the conventional recycling process. This process would recover a wide variety of good quality plastics recycling products (SIU, 2022 and FI, 2022).

2.3 Waste Engine Oil

The production of waste engine oil per year is estimated 1.5 billion gallons. Waste engine oil may contain toxic and harmful substances, such as polycyclic aromatic hydrocarbons, benzene, heavy metals and others. This can cause water and soil pollution. However, waste engine oil has a high recovery value and require special refining technology. The engine oil recycling machine would do water removal, acid pickling, alkali washing, adsorption of activated clay, and filtration. The waste engine oil can be regenerated into a fuel oil, base oil, and diesel oil. The price of the engine oil recycling machine is generally affordable (Yangjiang, 2022).

Waste engine oils can be straightway used without any process as road oils for dust control, or can be mixed with virgin fuel oil to be used in boilers for heating or electrical power generation. The release of heavy metals should be carefully checks. Waste oil and its impurities can cause pollution to the environment (Jain et al., 2022).

Waste engine oil can be used as fuel in cement industry for the combustion in a cement kiln. However, it is contaminated by metallic particles from wear, particles from internal combustion engines. Waste engine oil can also be used to get de-metalization of the oil by the taking of the soluble, inorganic, or dispersed components (Audibert, 2006).

2.4 Properties of Building Blocks

Common properties of building blocks are compressive strength (kg/cm^2), density hence porosity (%), water absorption after soaking for 24 hours (%). As the samples float in water, the volume was measured, to enable the determination of density, for calculating porosity (P) using Equation 2, after calculating the Specific Gravity of the mix (SG_{mix}), i.e. the max theoretical density using Equation 1 (Krebs and Walker, 1971).

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

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

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

One other property is Initial Rate of suction (IRS). The initial rate of suction (IRS) test was done by immersing the sample in 3mm depth of water for 60 second. The IRS is the weight of water absorbed by the sample divided by the area in contact with water. The typical IRS value on clay brick tested in England is 0.25-2.0 kg/m^2 .minute. Samples with higher IRS value would absorb more water from sand cement mortar, therefore it needs to be soaked before it is placed on a mortar layer (Vekey, 2001).

3. MATERIALS AND METHOD

3.1 Materials and Mixture Designation

The materials used was: waste engine oil obtained from local motor vehicles services; three type of thin waste plastic namely: plastic shopping bags (crackle plastics), aluminium coated thin plastic waste, and other type thin plastic waste, and rice husk ash locally available from traditional clay brick firing industry that uses rice husk to burn the brick. The waste plastics were cut/shredded into about 5-10mm sizes. Original engine oil of Honda E-Pro Turbo 0W-20 SAE 0W-20, was used for viscosity comparison with the waste engine oil. The viscosity was tested using a Sybolt Furol viscosity testing equipment. The specific gravity of the thin waste plastic, waste engine oil, and rice husk ash, were tested using pycnometer (BSI, 1975), meanwhile the viscosity of the oil was tested according to INS (2002).

The type of mixtures were designated as follow:
Mixture Aa (waste engine oil + crackle plastic); Mixture Ab (as Mixture Aa + rice husk ash)
Mixture Ba (waste engine oil + aluminium coated plastic); Mixture Bb (as Mixture Ba + rice husk ash)
Mixture Ca (waste engine oil + thin waste plastic that is different from thin crackle and aluminium coated plastic); Mixture Cb (as Mixture Ca + rice husk ash).

3.2 Materials Proportion and Sample Production

The materials proportion was based on trials that gave the thickest mixture that can be mixed manually. Mixture Aa, Ba, and Ca were of 500 grams plastic and 400 grams of waste engine oil (ratio of 1.25:1). For Mixture Ab, Bb, and Cb were of 400 gram plastic, 400 gram waste engine oil, and 100 gram rice

husk ash (ratio of 1:1:0.25). Those amounts of materials were sufficient for producing sample with size of 100x100x (80-90) mm. The sample production was started with step 1, proportioning by weighing materials, then step 2 heating the waste engine oil (without and with rice husk ash) at temperature of 200°C, then the shredded plastics with were gradually poured and manually and evenly mixed. On step 3, the mixtures were poured into metal mould and compacted using a Marshall hummer at 1 (one) blow at temperature of 125-110°C, to give light densification effect and even surface. Lower temperature during compaction was taken in order to obtain the mixture in plastic state condition (not too sloppy) and in order to enable additional densification. If compaction was done as at mixing temperature the mixtures were too sloppy. Then the samples cooled down to room temperature. Those process took less than one hour. On the last step, the samples were taken out of the mould and tested for their density, porosity, Initial Rate of Suction (IRS), water absorption, and un-soaked and soaked compressive strength.

It was found that the density of the samples were less than 1, so the samples floated in water, therefore it was unable to measure volume by 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 dimension of the sample was then measured at two point on each side of the samples. After the weight of the samples was taken, the density (weight/volume) can be determined. Due to the toxic nature of the sample productions, extra care had been done where respiratory mask had to be used and the room was of sufficient air circulation, using ceiling fan and the doors and windows were opened. Limited number of samples produced per day. The samples are shown in Figure 1.



Figure 1. The Plastic Wall Block (PWB) Samples

4. RESULTS 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 plastic is less than 1, hence it floated in water. The viscosities of the oil are shown in Table 2.

Property	Type of waste materials				
	Plastic bags (A)	Aluminium coated plastics (B)	Other plastic type(C)	Waste engin e oil	Rice husk ash
Specific Gravity(SG)	0,909	0,915	0,898	0,865	2,055

Table 1. The specific gravity of materials

Oil	Temperaturee (°C)	Flow time (sec)	Viscosity (Centistokes)
Waste engine oil	30	259	54,43
New engine oil	30	435	93,00

Table 2. The viscosity of oil

The viscosity of the new and waste oil as given in Table 2, showed 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.

4.2 Density

The density of the samples were less than one as shown in Figure 2.

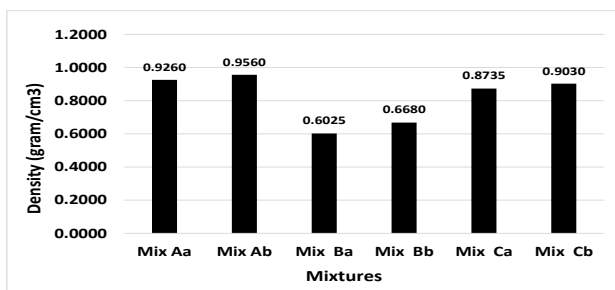


Figure 2. The density of the mixtures

The density of the samples were less than 1, so the samples float in water. As had been mentioned in the previous sections that the volume was measured to enable the determination of density. It was noted that the production of mix B which incorporate thin aluminium coated waste plastic was of lower workability than others, so the density was also slightly lower that cause the porosity higher.

4.3 Porosity

For the calculation of porosity, using Equation 2, the density as shown in Figure 2 was used. The porosity data is sown in Figure 3. The trend of porosity were generally in line with the density, i.e. the samples with lower density gave higher porosity. It is reasonable to mention that the porosity of the samples were generally low, as the melted plastic within the mixture left very less space within the finished samples produced.

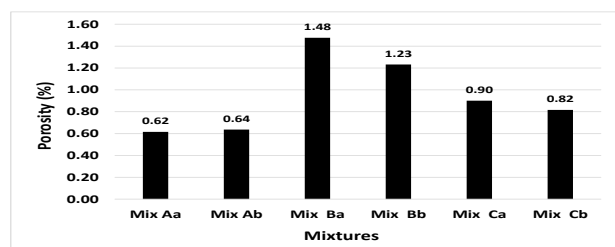


Figure 3. The porosity of the compacted mixtures

4.4 Initial Rate of Suction (IRS)

The trend in Figure 3, is also represented and in line with the IRS values in Figure 4.

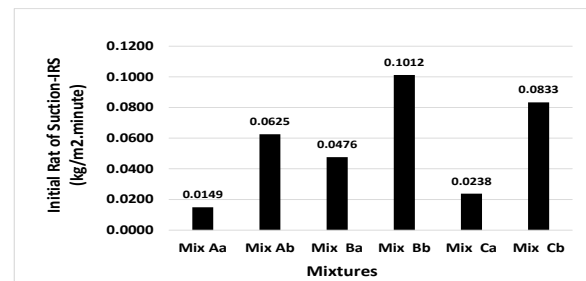


Figure 4. The IRS of the mixtures

The IRS values were low compared with the typical IRS value on clay brick (0.25-2.0 kg/m²·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 (Vekey, 2001). 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.

4.5 Water Absorption

Similar trend was also obtained on the water absorption of the samples, after 24 hours soaking in water as presented in Figure 5.

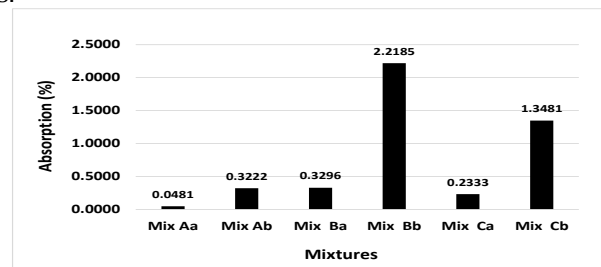


Figure 5. The Water absorption of the mixtures after 24 hours of water soaking

4.6 Compressive Strength of the Mixtures

With manual sample production mechanism using simple equipment and method, the compressive strength are shown in Figure 6.

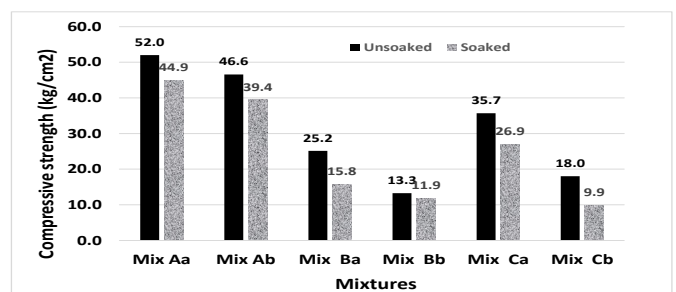


Figure 6. The compressive strength of the mixtures

Mixture Aa, Ab and Ca, can achieve compressive strength of more than 25 kg/cm² which is the minimum value in line with the Indonesian Standard, for concrete block (Indonesian Standardization Institution, 1989), where concrete block uses cement as the binder, meanwhile the samples produced within this experiment were of different kind. Mixture Aa and Ab

which used plastic shopping bags that can be of Low-density polyethylene (LDPE) or Polyvinyl chloride (PVC) appear to give higher bonding effect compare to other thin waste plastic used when it is melted with hot waste engine oil.

Some researchers had done experiment on low strength building block. Njau dan Park (2015) did experiment on brick that naturally air dried for 28 days without and with natural fibers (sisal and coir fibres) in Tanzania. They obtained compressive strength of 17,4-68,5 kg/cm², that can meet the Tanzanian National Standard of 10-70 kg/cm². Meanwhile, Al-Ajmi et al. (2016) carried out study in Saudi Arabia. They produce brick from mud and sand with size of 100x100x100mm, and sun dried for about 25 days. The average compressive strength found was 15.2 kg/cm². Sasui et al. (2017) produced brick 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/cm². Dawood et al. (2021) investigated the compressive strength of unfired clay break and found to have compressive strength oh 1.1 MPa (11 kg/cm²). When the clay were added with straw, saw dust and rice husk, it improved the compressive strength become (24- 28.5kg/cm²).

Considering the results of other type of building blocks done by some researchers, the samples produced within this experiment were of sufficient and somewhat gave better compressive strength, and can be produced much faster. The heat required to produce samples was not difficult to achieve using simple heating equipment. However, more works still need to be done in order to simplify and safe production, and the use of waste thin plastic combination to maintain the expected compressive strength by utilizing more waste plastic bags in material combination in the mixture as it gave highest compressive strength. Join trials for the evaluation of long term performances of the samples need to be encouraged.

5. CONCLUSIONS

Referring to the result 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. The thin waste plastic bags gave highest compressive strength. The samples compressive strength are within the range of low quality brick studied by other researchers, even slightly better and can exceed 25 kg/cm². The other properties i.e. porosity, IRS and Water Absorption was found relatively low.

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