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MODELLING OF PLASTIC WASTE AS AN ALTERNATIVE BUILDING MATERIAL IN THE FORM OF BRICKS

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ABSTRACT

The existence of plastic waste is a global issue since plastic wastes are difficult to destroy and the recycling process causes air pollution and wastes energy. Building materials in the form of bricks produced from plastic waste can decrease wastes and can be used in building constructions. This plastic bricks met the requirement of light load-bearing walls, with a mass of 160g per brick that can withstand a capacity of 32 kN each.

Key Words: plastic waste, alternative building material, ecological

Introduction

The use of plastic has been increasing rapidly from hundreds of ton in 1930s to 150 million tons per year in 1990s and 220 million tons per year in 2005, and the number keeps getting higher (Dyrop, E., 2009). Plastic is considered a non-organic waste, whose waste can be dissolved and processed to become a packing material for various purposes. However, the outcome of the recycling process reduces the quality of the plastic. It may also contain hazardous chemicals resulted from changes in the chemical structures (Abts, G., 2010). Therefore, the research attempts to do recycling process without liquefaction and plastic heating. This plastic waste management process involves cutting plastic waste to pieces and mixing it with cement to produce a brick-like form. It is practical since builders are familiar with the shape. In addition, and the manufacturing process is similar to that of regular bricks. The research will bring ecological benefits in the recycling process and waste material utilization, as well as create new alternative building materials.

In his previous research(LMF Purwanto, 2017), resin casting was applied to plastic. There were several disadvantages: it contained hazardous chemical substances, the process was expensive and not environmentally friendly, and it is hard to be carried out by builders in Indonesia. However, this current research used an easier method in which plastic flakes were mixed with cement and then molded. Such a method is less complicated to implement for Indonesian people, and especially the builders.

Materials and Methods:

Plastic bottle wasteswascut into pieces of 0,25 cm wide and 5 cm long. The flakes were then mixed with cement and molded in brick-sized mold of 5 cm x 10 cm x 20 cm. Afterwards, a compressive test was conducted on the bricks in order to examine the strength and weight-bearing power. It was conducted in the laboratory of building materials, Soegijapranata Catholic University Semarang. This experimental research aims to find out the efficiency rate of cement and plastic compositions used. A testing of five selected samples coming from several mixed compositions of building materials was conducted for 6 months. The testing was intended to obtain an optimal composition mixture of cement and plastic flakes. The compressive test of the samples showed that they had the ability to bear weights and to form wall arrangements in a normal height of 3 m.

The test results were recorded to provide conclusions of this experiment. The Inclusion Criteria of the samples was all kinds of plastic waste, while the Exclusion Criteria only involvedbrick-sized samples are commonly used in Indonesia without other dimensions of panel.

Plastic waste chosen for the research are the types of Polyethylene Terephthalate (Fritshce, H., 2010). They are often called PET, made from glycol (EG) and terephthalic acid (TPA) or dimethyl ester (DMT). Their use vary from bottles of mineral water, soft drink, syrup, sauce, jam to cooking oil. Polyethylene Terephthalate has a high durability, stiffness, stable dimension, the ability to withstand chemical and high-temperature substances and good electrical characteristics.

Cement was used as a bonding substance. Each type of cement differs in characteristics based on its chemical structures and the level of smoothness. Cement consists of four main components, that is: Tricalcium Silicate, Dicalcium Silicate, Tricalcium Aluminate and Tetra-calcium Aluminoferrite. Tricalcium Silicate and Dicalcium Silicate fill up 70-80 percent of cement, therefore making them as two most dominant components. Once cement gets wet, Tricalcium Silicate will hydrate and produce heat. The concrete will harden within 14 days. Dicalcium Silicate will have a slower reaction to water; thus it makes the hardening of concrete within 7 days. Cement is considered as a hydraulic binder as it adheres to other materials when it absorbs water (Locher, F.W., 2000).

The strength of cement results from the hydration process. The process involves recrystallization of water in the form of interlocking crystals that will produce cement gel with high compressive strength once hardened.

There are two basic techniques in the installation process of wall constructions. They are masonry and mortar types of construction, both of which determine the quality of compressive strength and durability of the walls (Jager, W., 2010). Not only functioning as a binding material in the stirring and concrete making, cement also affects the technical and economical values of the related buildings. It is mainly connected with the quality, price and composition of the cement used. Cement for brick installations and wall plasters needs have certain characteristics and specifications. It is supposed to be easy to work on, have a low hydration and no concrete crack (Ramcke, R., 2001). Such factors are important to pay attention to while installing bricks made of plastic waste in the wall constructions.

Results:

The findings from the experiment showed that the ideal composition of cement for 100 g of plastic flakes is 60 g. Using less than 60 g cement results in a low-binding quality while using more than 60 g will be less efficient and more expensive. 100 g of plastic flakes are obtained from five 500 ml used plastic bottles, two 1500 ml used plastic bottles and one 500 ml used plastic bottle. A bag of 40 kg cement can produce approximately 66 bricks while a bag of 50 kg cement can produce about 83 bricks.

Picture 6. A 160 g brick out of plastic waste

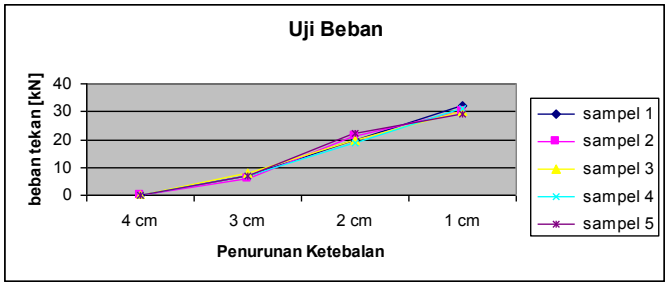
Once the brick was molded, a compressive test was conducted in the laboratory of building materials, Soegijapranata Catholic University Semarang. The test was performed with Load Gauge Compression Machine Manual with maximum weighing capacity of 250 kN.

Picture 7. Preparing the test with Load Gauge Compression Machine Manual

Table 1. The Compressive Test Result

	sampel 1	sampel 2	sampel 3	sampel 4	sampel 5
4 cm	0	0	0	0	0
3 cm	7	6	8	7	7
2 cm	20	21	20	19	22
1 cm	32	30	30	31	29

The results shown in Table 1 were explained in a greater detail in the following graph.



Graph 1. The Compressive Test Graph Result

The test showed that bricks shrank from 4 cm to 3 cm wide when compressed by 6 to 8 kN.When the compression test increased from 19 to 21 kN, the bricks shrank to 3 cm and they became 1 cm for 29 to 32 kN.

The bricks remained intact even when their thickness was only 1 cm. Plastic flakes were still bound together tightly. However, the quality decreased as they became mushy and brittle.

Picture 8. Plastic waste bricks when compressed by 29 to 32 kN

Regardless, bricks are destroyed until the bonds between the plastic flakes break down when the compression continues beyond 32 kN.

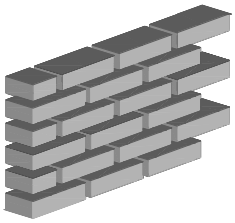
Picture 9. Plastic flakes break down once compressed beyond 32 kN

In conclusion, the maximum compressive strength needed for plastic waste bricks is 32 kNin order for the bricks to be used for non-bearing wall constructions.

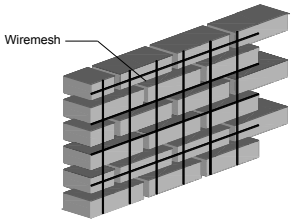
Afterwards, an experiment was conducted to bind the units of plastic waste bricks with the mixture of by 1 PC : 5 Ps and plastering with similar composition. The bound was strong as it was using the same installation system as that of regular bricks. Plastering helped elevate the wall strength.

Picture 10. The bound of plastic waste bricks with species and plastering

There are several weaknesses of this material. Plastic waste bricks required more strength during the plastering. This can be attained through the instalment of wire mesh before the plastering process began on one side of the wall surface.
Some ways to install this type of bricks are classic mounting system, cross-installation system, vertical installation system and Vlaam connection system.



Picture 11. Plastic waste bricks installation with classic mounting system



Picture 12. Wire mesh installation on one side of the wall surface during the plastering process

Discussion:
Using plastic waste bricks for wall constructions has some advantages. First, the materials are easy to obtain. Second, it is simple to produce since there are only two materials to be mixed. Both plastic and cement are two well-known materials in Indonesia. Previous research (LMF Purwanto, 2017) showed that plastic can be used only as a partition, while this wall can be used for regular rooms, interior, and exterior. Similar to normal bricks, plastic bricks require plastering. The construction of buildings, apartment, complex, shops, homesare the basic requierements of human being. In this construction area, plastering is necessary for wall decoration. Plastering works refer to construction or ornamentation done with plaster. (Quang Ha, 2002).
Plastic waste bricks for wall constructions are accepted as alternative lightweight construction materials. They can even fulfill the requirements for sustainable construction materials and components, such as Impact of the construction Industry, Ecological Requirement and Economic Requirement (Ramachandran, A., 1991). From ecological perspectives, materials resulted from recycling process are non-toxic and ideal for reprocessing.
From the perspectives of compressive strength, the materials meet the criteria of wall building materials with plastering reinforcement.

Conclusion:
The ideal composition of cement needed to create plastic waste building materials is 60 g for every 100 gr of plastic flakes If they are used for building materials, plastering is a must for reinforcement and decorative purposes

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