The Utilization of Plastic Waste in the Matched Mixture of Concrete Brick

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Abstract: Plastic is widely used in daily life. Approximately 80% of garbage consists of plastic waste. Whereas plastic is a type of waste that is dangerous and difficult to be recycled therefore harmful to the environment. One of the solutions is the reuse of plastic waste. In this research, HDPE and PP plastic waste are chopped and then used as the substitute material as much as 10% of the weight of the sand on the matched mixture of concrete brick. The sample of this research is a brick with size of 40x20x10 cm and cube with size of 15x15x15 cm for each type of plastic. The addition of admixture materials is SikaPaver HC-1ID and additive material which is Silica Fume. In determining the classification of the quality of the specimens, this study uses based on SNI 03-0349-1989 as a reference. Judging from the visual appearance, the content weight and absorption, the two types of specimens are included in the quality I bricks while the compressive strength test against the sample of bricks both HDPE and PP type results in quality II bricks at age 28 days old.

1 INTRODUCTION

Plastic has become a dangerous waste and difficult to recycle. It takes a long time for the plastic to be decomposed completely. At the time of the decomposition process, plastic waste will contaminate the soil, air, and water. If plastics are buried in the soil, plastics will damage soil fertility and block the water flow in the soil, whereas if plastic waste is burned, toxic fumes resulting from burning will be harmful to living things. When plastics are discharged into the waters, the chemicals present in plastics will damage marine life (Saikia and Brito, 2012).

Reuse is the best way to solve plastic waste problems (Yang, 2015). Various efforts in tackling plastic waste can be done such as the reuse of waste in the field of civil engineering industry. The application of energy conscious construction materials, can be applied to one example, namely by using plastic waste as one of the substitutes of aggregate in the manufacture of lightweight concrete or brick. Plastics that have light physical properties may serve as one of the conventional aggregate substitutes in reducing the weight unit of the concrete (Akçaözog˘lu, 2009). In addition to reducing the use of natural resources, reuse of waste can safely reduce waste (Choi, 2009).

There has been considerable researches on the use of recycled plastic in concrete from 1994 to 2015 (Gu and Ozbakkaloglu, 2016). Some of them are: Choi, et al., 2009, undertook the development of lightweight aggregate concrete using fine aggregate made from PET (polyethylene terephthalate) bottle waste. In 2010Chidiac and Mihaljevic conducted a research that is by mixing waste in dry cast concrete block. Rahim, et al. in 2013 substituted the HDPE fragments which passed sieve no. 4.75-20 mm as coarse aggregate in a concrete mixture. Soebandono, et al., 2013, in his research on the strength of compressive strength and tensile strength of concrete using HDPE plastic waste as a c aggregate substitution. (Yang, 2015) modified PET plastic waste in variations of 10%, 15%, 20% and 30% of sand substitution in the manufacture of Self Compacting Lightweight Concrete (SCLC).

This research will discuss HDPE and PP plastic waste on concrete brick. HDPE plastic is a type of plastic used to manufacture bottles of milk, detergent bottles, shampoo bottles, moisturizing bottles, oil bottles, toys, and some plastic bags. HDPE plastic is very hard and not easily damaged of the heat of the sun, high heat, or cold temperatures. PP plastic has properties that are similar to HDPE plastic which are strong, lightweight, and heat resistant. PP appears as a wrapper on dry and fresh milk products. PP is also used as buckets, margarine

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boxes and yogurt, straws, straps, adhesive tapes, and paint plastic cans.

Nursyamsi, et al., 2017, and Kevin, 2017 studies have examined the effect of adding HDPE and PP plastic waste as a substitute of 10% of the weight of sand and produced concrete bricks or as known as batako, with class III quality. In the study of the addition of HDPE to construction materials have also been done by Rahim et al., (2013) and concluded that the addition of 10% HDPE variation has better compressive strength compared with other variations of addition.

This study adds admixture in the form of SikaPaver HC-1 ID and additive in the form of Silicafume. It is expected that the brick with 10% substitution of HDPE and brickwork with substitution of 10% PP produced can achieve higher quality compared to previous research.

Figure 1 : HDPE plastic chopping.

Figure 2 : PP plastic chopping.

2 LITERATURE REVIEW

2.1 Concrete Block

According to SNI 03-0349-1989, Conblock (concrete block; Concrete brick or as known as batako is a building component made from a mixture of Portland cement or pozolan, sand, water and / or other additives, molded in such a way as to qualify and can be used as material for brickworks.

Table 1 : Physical requirements of concrete bricks.

Physical Requirements	Unit	Solid concrete brick quality level				Hollow concrete brick quality level			
		I	II	III	V	I	II	III	IV
Minimum average of gross compressive strength.	Kg/cm^2	100	70	40	25	70	50	35	20
Minimum gross compressive strength for each specimens.	Kg/cm^2	90	65	35	21	65	45	30	17
Maximum average of water absorption	%	25	35	-	-	25	35	-	-

2.2 Portland Cement

The main function of cement is to bind aggregate granules so that it will form a dense composition as the cement fills the air cavities among the aggregate grains

2.3 Sand

Sand is a natural material in the form of small grains in addition to mud or soil. Sand grains are generally sized between 0.0625 to 2 millimeters. Good sand is the sand that comes from rivers and does not contain more than 5% clay soil as it can lead to cracks, and also must meet the specifications that are defined by ASTM

2.4 Water

One of the materials needed in the formation of bricks is water. Water serves to trigger the cement's chemical processes so that it binds and hardens, moistens aggregates and to facilitate its execution.

2.5 HDPE and PP

High Density Polyethylene (HDPE) is one type of polyehtylene. HDPE is characterized by a density exceeding or equal to 0.941 g/cm^3. In addition to the type of HDPE there is a polypropylene (PP) polymer type, also called polypropene, which is a crystalline polymer produced from the propylene gas of polymerization process. The specific gravity of polypropylene is low within the range of 0.90 - 0.91 gram/cm³. Polypropylene is included in the lightest groups among other polymeric materials.

2.6 Admixture (SikaPaver HC-1 ID)

SikaPaver HC-1 ID is a highly efficient and high performing compact auxiliary (admixture) material designed especially for concrete with cement and low slump (semi-dry). This admixture is product of PT. Sika.

2.7 Additive (Silicafume)

According to the "Specification for Silica Fume for Use in Hydraulic Cement Concrete and Mortar" standard (ASTM.C.1240,1995:637-642), Silica Fume is a fine pozzolan material, wherein the silica composition is more of a blast furnace or production residue silicon or silicon iron alloy (known as a combination of micro silica and Silica Fume).

3 RESEARCH METHODOLOGY

The HDPE and PP plastic waste that has been chopped and cleaned was substituted for the weight of sand by 10% for each type of brick. Both types of brick mixture use a ratio of 1pc: 6ps with water ratio 0.32, and 0.4% SikaPaver HC-1ID and 10% SilicaFume of total weight of cement. After 28 days, visual view tests, content weight, absorption, and compressive strength of brick samples were performed.

3.1 Content Weight, Absorption and Compressive Strength Formula

In order to calculate the content weight of one test object, below equation is used:

$$\text{Content Weight (CW)} = \frac{W}{V} \quad (3.1)$$

Description :
CW= Content Weight (kg/m^3)
W = Test Object Weight (kg)
V = Test Object Volume (m^3)

For measurement of water absorption of brick, referring to SNI 03-0349-1989 standard, it can be calculated by the following equation:

$$Wa = \frac{Mj - Mk}{Mk} x100\% \quad (3.2)$$

Description :
Wa = Water Absorption (%)
Mk = Dry object mass (gr)
Mj = Object mass in saturated condition (gr)

For measurement of compressive strength of brick, it refers to SNI 03-0349-1989 standard and is calculated by the following equation:

$$P = \frac{Fmaks}{A} \quad (3.3)$$

Description
P = Compressive Strength (kg/cm^2)
Fmaks = Maximum Force (kg)
A = Surface area of the test object (cm^2)

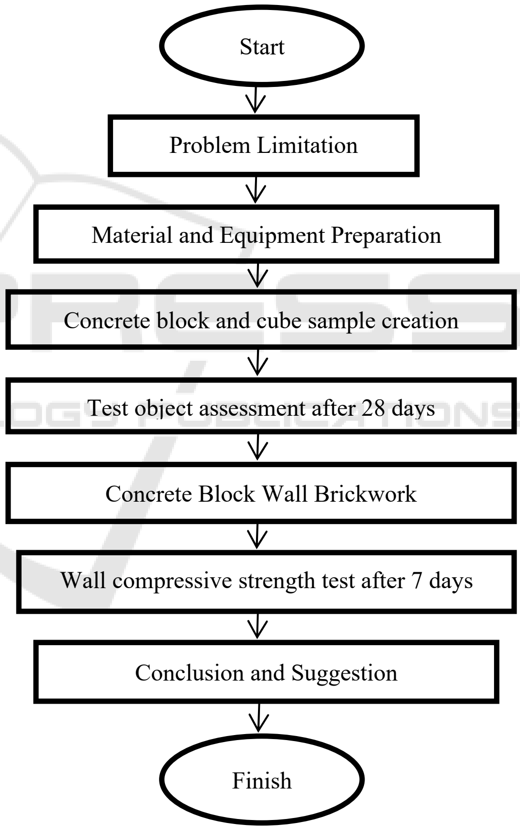

Figure 3: Research methodology flowchart.

Figure 4:HDPE and PP bricks and cubes sample.

4 RESULT AND DISCUSSION

4.1 Visual Testing

4.1.1 Outward-looking Assessment

Table 2 : Visual testing result.

Description	Sample Condition in General	
	Batako HDPE	Batako PP
1. Fields		
a. Flatness	Flat	Flat
b. Crack	No Crack	No Crack
c. Smoothness	Smooth	Smooth
2. Sides		
a. Elbow	Elbow	Elbow
b. Sharpness	Sharp	Sharp
c. Strength	Strong	Strong

Batako (concrete block) with utilization of HDPE and PP plastic waste using SikaPaver HC-1 ID and Silicafume has fulfilled the outward-looking requirements according to the provisions set forth in SNI 03-0349-1989, ie the non-defective surface area, the sides of the elbow against each other , and the corner of the sides is not easily tidied with the strength of the fingers (not brittle).

4.1.2 Size Assessment

After the examination of the size, the data of dimension measurement of batako sample is obtained. The data has been copied from the size that has been adjusted to the provisions of SNI 03-0349-1989.

Table 3: Comparison of mean deviation of batako

No.	Test Object Type	Average Length		Average Width		Average Height	
		Test Object (mm)	SNI 03-0349-1989	Test Object (mm)	SNI 03-0349-1989	Test Object (mm)	SNI 03-0349-1989
1.	Batako 10% chopped HDPE	400,06	5mm Tolera-nce Limit	200,04	2mm Tolera-nce Limit	100,04	2mm Tolera-nce Limit
2.	Batako 10% chopped PP	400,07		200,05		100,03	

(concrete block) test objects to quality requirement.

Based on the size tolerance of SNI 03-0349-1989, the data of the concrete block measurements indicates that the resulted concrete blocks meet the average size requirements. This is because in the process of making bricks made manually was compacted properly. Strong molds of bricks are also one of the factors that cause the size of the brick in accordance with the expectation.

4.2 Content Weight and Absorption Testing

4.2.1 Content Weight Testing

Table 4: Average weight comparison of average batako test items.

No.	Batako Type	Volume (m^3)	Average Weight (Kg)	Content Weight (Kg/m^3)
1	Normal Batako*	0,008	16,399	2049,875
2	HDPE Batako	0,008	14,293	1788,831
3	PP Batako	0,008	14,908	1862,913

*Based on the results of research that has been conducted by Theresa (2017) and Kevin (2017).

From Table 4, the test specimen using PP plastic waste substitution has higher content weight than the test specimen using HDPE plastic waste substitution. It proves that test specimens using PP plastic waste contain better average density.

From the results of the conducted content weight examination, both HDPE batako and PP batako have smaller content weight compared with normal brick. Therefore, it can be said that the use of substitute types of HDPE and PP plastic can reduce the weight of the concrete block. In addition, the influence of addition of HC-1ID attitudes as admixture and sikafume with silicafume type as additive adds the content weight of HDPE batako as well as PP batako.

4.2.2 Absorption Testing

Table 5: Batako Absorption Test

No.	Specimen Type	Wet Weight (Kg)	Dry Weight (Kg)	Average Absorption (%)		Quality
				Test Object	SNI 03-0349-1989	
1	Batako +10% Chopped HDPE Plastic Waste	15.241	14.311	6.509	25	I
2	Batako +10% Chopped PP Plastic Waste	15.829	14.903	6.211	25	I

From table 5, it can be seen that the absorption capacity of the concrete block and cube with the utilization of HDPE and PP plastic waste using SikaPaver HC-1 ID and Silicafume has fulfilled the requirement with the tolerance limit of quality 1 batako that is listed on SNI 03-0349-1989, which is lower than 25%. Greater water absorption occurs in the type of batako with 10% of PP plastic substitution. The specific gravity of PP plastic (0.90 - 0.91 gram / cm^3) is smaller than the one of HDPE (0.94 gram / cm^3) which results in the specimens with substitution of 10% PP plastic from the weight of sand on the batako having a greater absorption value.

4.3 Compressive Strength Test

The test specimens used were 40 x 20 x 10 cm batako and 15 x 15 x 15 cm cubes which had 28 days treatment with two mixed variations ie, samples using 10% of chopped HDPE plastic and samples using 10% of chopped PP plastic from the weight of the sand. The test object is given pressure until the maximum load can be retained by the concrete block and cube. Test results can be seen as follows:

Table 6: Test specimen compressive strength test result

Specimen Type	Sample	Dial Reading (KN)	Compression Area (cm^2)	Compressive Strength (Kg/cm^2)		Quality
				Speci-men	SNI 03-0349-1989	
Batako +10% Chopped HDPE Plastic Waste	B1.1	206	280	75.04	65	II
	B1.2	184	280	67.03	65	II
	B1.3	190	280	69.03	65	II
	B1.4	182	280	66.30	65	II
	B1.5	188	280	68.49	65	II
Average		190	280	69.21	70	II
Batako +10% Chopped PP Plastic Waste	B2.1	236	280	85.97	65	II
	B2.2	254	280	92.53	90	I
	B2.3	230	280	83.79	65	II
	B2.4	236	280	85.97	65	II
	B2.5	228	280	83.06	65	II
Average		236.8	280	86.26	70	II
Cube +10% Chopped HDPE Plastic Waste	K1.1	154	225	69.81	65	II
	K1.2	176	225	79.79	65	II
	K1.3	164	225	74.35	65	II
	K1.4	182	225	82.51	65	II
	K1.5	158	225	71.63	65	II
Average		166.8	225	75.62	70	II
Cube +10% Chopped PP Plastic Waste	K2.1	254	225	115.15	90	I
	K2.2	226	225	102.45	90	I
	K2.3	270	225	122.40	90	I
	K2.4	264	225	119.68	90	I
	K2.5	238	225	107.89	90	I
Average		250.4	225	113.51	100	I

Analysing from the test results data from the compressive strength in Table 6, the compressive strength of HDPE batako, PP batako, and HDPE cubes are included in the classification of quality II batako, while the PP cube is included in the classification of the quality I batako. This is stated in the requirements of SNI 03-0349-1989, where the average compressive strength of the concrete block with the quality of I is 100 kg / cm^2 and the average compressive strength of quality 2 block is 70 kg / cm^2. The compressive strength of batako with 15x

15x15 cm cube shape has a higher compressive strength compared with the one with the size of 40 x 20 x 10 cm. This is because the smaller the dimension of a specimen, the greater the load can be accepted by the specimen (Talinusa, et al., 2014).

A plastic substitution concrete block with a higher compressive strength is achieved by a 10% PP block that achieves an average compressive strength and 86.26 kg / cm^2 (form of brick) and 113.51 kg / cm^2 (cubic shape). Whereas the 10% HDPE substitution batako achieved a lower average compressive strength of 75.62 kg / cm^2 (form of brick) and 69.21 kg / cm^2 (cubic shape).

5 CONCLUSIONS

1. Batako as the result of substitution of chopped waste of HDPE and PP have visual appearance that is in accordance with the requirement of SNI 03-0349-1989, that is surface area which is not defective, elbow corner and side, and deviation of measure does not exceed the tolerance limit of quality requirement.
2. The average content weight of the concrete block with the substitution of chopped HDPE plastic waste is 1788.831 kg / m^3. While the average content weight of the batako by substitution of chopped PP plastic waste is 1862.913 kg / m^3. The average content weight of the of the cube-shaped brick with the substitution of HDPE plastic waste count is 26284.44 kg / m^3. While the substitution of chopped PP plastic waste is 27680.00 kg / m^3.
3. Analysing from the absorption capacity of the batako (absorption) of the average specimens, the HDPE batako and PP batako may be classified as a quality I batako
4. The percentage of absorption (absorption) occurring in HDPE cube block (15 x 15 x 15 cm) is 15.68% and 6.509% happened to brick (40 x 20 x 10 cm). While percentage of absorption (absorption) that happened in cube-shaped PP batako is 14.32% whereas 6.211% happened in batako (40 x 20 x 10 cm).
5. Batako with higher compressive strength is achieved by a PP batako that reaches an average compressive strength and 86.26 Kg / cm^2 (form of brick) and 113.51 Kg / cm^2 (cubic shape). Whereas in HDPE substitution batako reaches a lower average of compressive strength of 75.62 Kg / cm^2 (form of brick) and 69.21 Kg / cm^2 (cubic shape).
6. Compressive strength of HDPE batako and PP batako are included in the classification of quality II batako based on SNI 03-0349-1989.

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