

## Effect of HDPE plastic waste towards batako properties

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**Abstract.** Indonesia is the world's second largest producer of plastic waste to the sea, after China. Most of the plastic waste is polyethylene. Polyethylene is a polymer consisting of long chains of ethylene monomers. Moreover, polyethylene is plastic that has characteristics such as; thermoplastic, elastic, non-translucent, odorless, slightly opaque and transparent, resistant to impact and has a resistance of up to 135 degrees Celsius. The type of HDPE plastic (high-density polyethylene), which has been cleaned and chopped as a substitute of fine aggregate, is used in the brick's making process. HDPE has a stronger, harder, smoother and more resistant to high-temperature properties. In this study, a weight variation of 0%, 10%, and 20% of HDPE plastic wastes was used from the total weight of sand as a substitution. Furthermore, the tensile and compressive strength were tested on day 7. Based on the research, the quality of the specimen achieved was categorized in quality III according to SNI 03-0349-1989.

### 1. Introduction

Nowadays, the development of construction materials is focused on the use of wastes to produce something that is beneficial to humans. One of them is the plastic waste. In this study, plastics were used as the sand substitute material for the manufacture of concrete brick.

Indonesia is the world's second largest producer of plastic waste to the sea, after the China. Most of the plastic waste is polyethylene. Polyethylene is a polymer consisting of long chains of ethylene monomers. Moreover, polyethylene is plastic that has characteristics such as; thermoplastic, elastic, non-translucent, odorless, slightly opaque and transparent, resistant to impact and has a resistance of up to 135 degrees Celsius [3]. In this study, a type of HDPE plastic (high-density polyethylene) was used. HDPE has stronger material properties, harder, opaque and more resistant to high temperatures<sup>[2]</sup>. HDPE is commonly used for colored milk bottles, oil container, shampoo bottles, and much more. HDPE is one of the safe plastic materials because of the ability to prevent chemical reactions between HDPE plastic packaging and the packaged food or beverages. However, this type of plastic is recommended only for single use because of the release of antimony trioxide compounds that continue to increase over time.

The use of plastics in daily life is one of the main factors of waste production in Indonesia. Plastics have hard-to-decompose properties where it takes hundreds of years to decompose completely. Therefore, most of the Indonesian people disentangle plastic waste by burning it. In fact, the plastic will cause air pollution during the burning process, and it is quite dangerous to human health, where the burned plastic will release harmful substances into the air such as carbon monoxide, dioxin and furan, volatile and other harmful particles. One way to reduce the plastic waste is reusing the plastic waste itself.



In this study, the waste of HDPE plastic waste will be used in the process of making brick as a substitution of fine aggregate. This research was expected to produce something useful in the manufacture of bricks that have high quality and environmentally friendly.



**Figure 1.** HDPE plastic chopping

## 2. Literature Review

Concrete brick is a construction material in the form of alternative replacement of bricks composed of sand, cement, and water. Concrete brick is usually focused on non-structural building wall constructions [7].

According to general requirements of construction materials in Indonesia (1982) article 6, "Concrete brick is a brick made by molding and maintaining in humid conditions." According to SNI 03-0349-1989, "Conblock (concrete block) is a construction component made from a mixture of Portland cement or pozzolan, sand, water and other additives, molded in such way as to qualify and can be used as wall pair materials." While Frick Heinz and Koesmartadi (1999: 96) argued that: "Unburned stones, known as the brick (brick made in solidification of trass, chalk, water)."

Concrete brick must meet the physical requirements by the following table:

**Table 1.** Physical requirements of concrete bricks

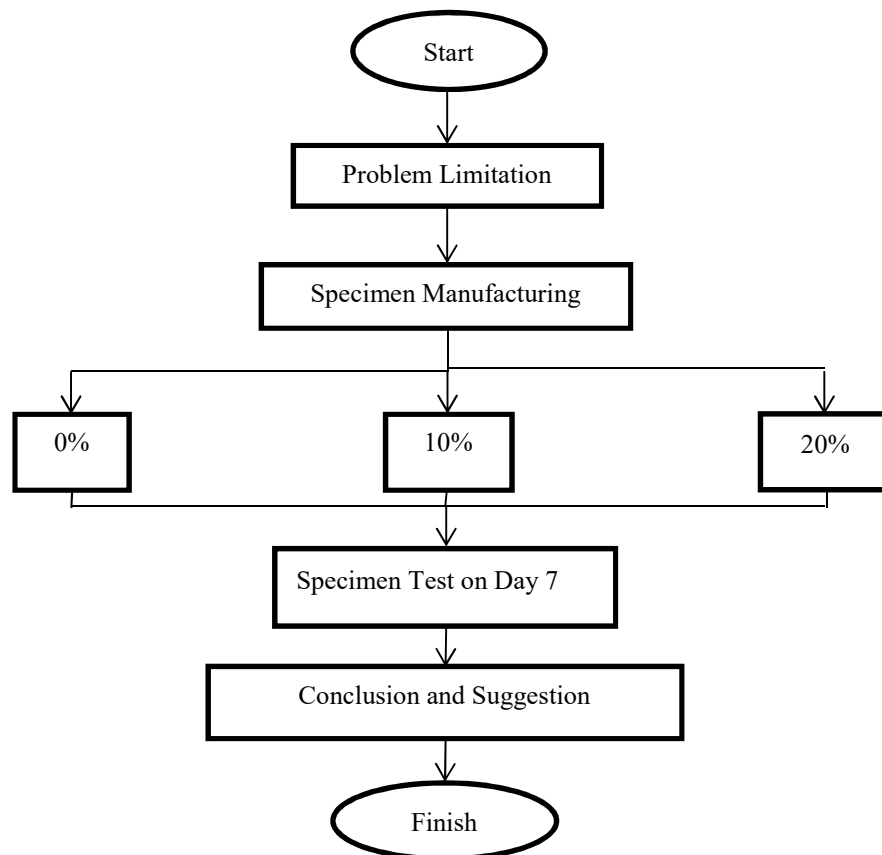
Physical Requirements	Unit	Solid concrete brick quality level				Hollow concrete brick quality level			
		I	II	III	IV	I	II	III	IV
1. Minimum average of gross compressive strength.	Kg/cm <sup>2</sup>	100	70	40	25	70	50	35	20
2. Minimum gross compressive strength for each specimens.	Kg/cm <sup>2</sup>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

Polyethylene is a polymer consisting of long chains of ethylene monomers. Polyethylene is plastic that has characteristics such as: thermoplastic, elastic, non-translucent, odorless, slightly opaque and transparent, resistant to impact and has a heat resistance of up to 135 degrees Celsius<sup>[3]</sup>. High-Density Polyethylene (HDPE) is one type of polyethylene plastic. HDPE has a density exceeding or equal to 0.941 g/cm<sup>3</sup>. HDPE has a low degree of branching and has a very high molecular strength and tensile strength. HDPE can be produced with chromium/silica catalysts, Ziegler-Natta catalysts, or metallocene catalysts. HDPE has stronger, harder, opaque and more resistant to high-temperature

properties. HDPE is commonly used for colored milk bottles, oil container, shampoo bottles, and many others<sup>[2]</sup>. HDPE is one of the safe plastic materials to use because of the ability to prevent chemical reactions between HDPE plastic packaging and the packaged foods/beverages. However, this type of plastic is recommended only for single use because of the release of antimony trioxide compounds that continue to increase over time [7].

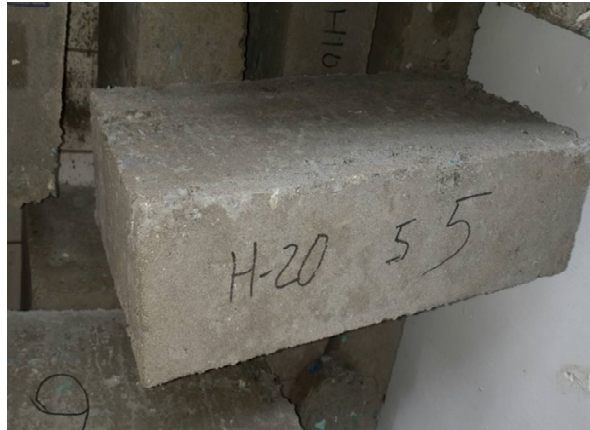
### 3. Research Methodology

The method used in this research was experimental research method. In this study, a weight variation of 0%, 10%, and 20% of HDPE plastic wastes was used from the total weight of sand as a substitution with a mixture of bricks was 1: 6 [5]. Furthermore, the tensile and compressive strength was tested on day 7.



**Figure 2.** Research Methodology Flowchart

The tensile and compressive strength test of concrete brick were tested at the Concrete Materials and Engineering Laboratory of the University of Sumatra Utara. It was tested on day 7, started from the manufacture of the specimen with three variations. Each of them was amounted to 7 specimens of concrete brick and nine specimens of briquette.



**Figure 3.** Sample with 20% of HDPE mixture



**Figure 4.** Sample with 10% of HDPE mixture



**Figure 5.** Commercial Concrete brick

#### **4. Result and Discussion**

The test was done on day 7 in which on the compressive test, it was acquired the maximum load which is when the bricks crushed after given the load. The number of test specimens in the compressive and tensile strength test is seven samples and nine samples for each mixed variation. From the tensile and compressive strength test of concrete brick obtained data as follows:

**Table 2.** Average compressive strength test result of commercial concrete brick

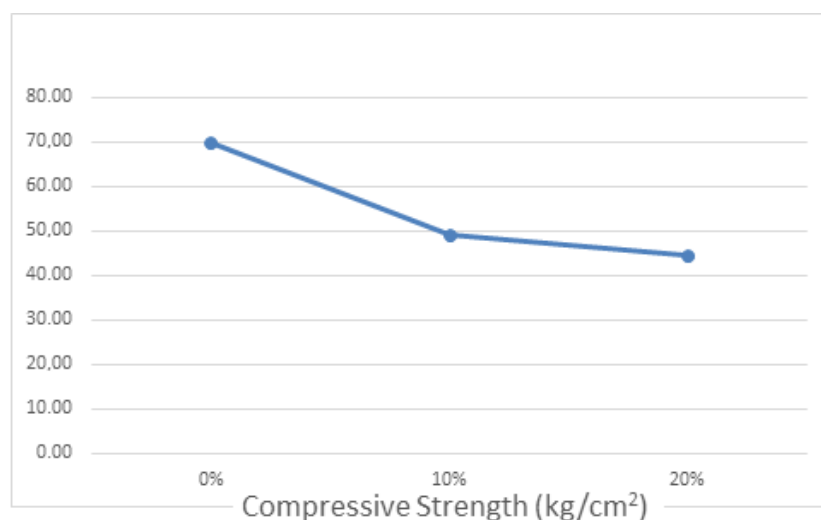
Weight (g)	P max (kN)	Compressive Area (cm <sup>2</sup> )	Compressive Strength (Kg/cm <sup>2</sup> )
16446	202	280	73.59
16322	185	280	67.39
16221	196	280	71.40
15971	185	280	67.39
16925	198	280	72.13
16644	190	280	69.21
16265	192	280	69.94
<b>16399.14</b>		<b>Average</b>	<b>70.15</b>

**Table 3.** Average compressive strength result of concrete brick with 10% HDPE mixture

Weight (g)	P max (kN)	Compressive Area (cm <sup>2</sup> )	Compressive Strength (Kg/cm <sup>2</sup> )
14221	130	280	47.36
14458	144	280	52.46
13609	128	280	46.63
13704	132	280	48.09
14461	144	280	52.46
13790	135	280	49.18
13785	134	280	48.81
<b>14004</b>		<b>Average</b>	<b>49.28</b>

**Table 4.** Average compressive strength result of concrete brick with 20% HDPE mixture

Weight (g)	P max (kN)	Compressive Area (cm <sup>2</sup> )	Compressive Strength (Kg/cm <sup>2</sup> )
14034	124	45.17	45.17
14343	130	47.36	47.36
13268	118	42.99	42.99
12783	125	45.54	45.54
12497	113	41.16	41.16
11756	126	45.90	45.90
11754	118	42.99	42.99
<b>12919.29</b>		<b>Average</b>	<b>44.44</b>

**Figure 6.** Concrete brick compressive strength graphic

**Table 5.** Tensile strength test result of the commercial briquette

Weight (g)	Tensile Strength (kN)	Area (cm <sup>2</sup> )	Tensile Strength (Kg/cm <sup>2</sup> )
119.000	0.825	6.350	13.252
109.000	0.825	5.240	16.059
99.000	0.700	5.110	13.973
110.000	1.100	5.800	19.345
115.000	1.250	6.860	18.586
106.000	0.800	5.820	14.021
110.000	0.900	6.320	14.525
108.000	1.100	5.200	21.577
104.000	1.200	6.240	19.615
108.889	<b>Average</b>		<b>16.773</b>

**Table 6.** Average tensile strength result of the briquette with 10% HDPE mixture

Weight (g)	Tensile Strength (kN)	Area (cm <sup>2</sup> )	Tensile Strength (Kg/cm <sup>2</sup> )
114.000	0.550	6.030	9.303
99.000	0.550	5.270	10.645
93.000	0.450	8.025	5.720
103.000	0.500	5.950	8.571
96.000	0.550	5.280	10.625
110.000	0.650	5.250	12.629
91.000	0.550	5.360	10.466
102.000	0.550	5.860	9.573
97.000	0.600	6.025	10.158
100.556	<b>Average</b>		<b>9.743</b>

**Table 7.** Average tensile strength result of the briquette with 20% HDPE mixture

Weight (g)	Tensile Strength (kN)	Area (cm <sup>2</sup> )	Tensile Strength (Kg/cm <sup>2</sup> )
109.000	0.650	5.650	11.735
110.000	0.625	5.460	11.676
106.000	0.700	5.900	12.102
111.000	0.750	6.525	11.724
112.000	0.625	5.540	11.507
107.000	0.900	5.360	17.127
118.000	1.025	5.420	19.290
113.000	0.650	5.930	11.180
108.000	0.550	6.370	8.807
110.444	<b>Average</b>		<b>12.794</b>

## 5. Discussion and Analysis

From the data above, the average compressive strength analysis of concrete brick with 10% and 20% HDPE had a smaller average compressive strength compared to the compressive strength of normal concrete brick. This occurred because the concrete brick with plastic had more cavities than the normal concrete brick. As for the case with the compressive strength of concrete brick, the average tensile strength of the briquette with the plastic waste mixture was also smaller compared to the normal briquette.

## 6. Conclusion

1. According to SNI 03 - 0349 - 1989, the quality of normal concrete brick in the study was included in the second quality of 70.15 kg/cm<sup>2</sup>.
2. According to SNI 03 - 0349 - 1989, the quality of concrete brick with the composition of 10% HDPE plastic mixture in the study was included in the third quality of 49.28 kg/cm<sup>2</sup>.
3. According to SNI 03 - 0349 - 1989, the quality of concrete brick with the composition of 20% HDPE plastic mixture in the study was included in the third quality of 44.44 kg/cm<sup>2</sup>.
4. The average tensile strength for the normal briquette, briquette with the composition of a plastic mixture of 10% and 20% were 16.773 kg/cm<sup>2</sup>, 9.743 kg/cm<sup>2</sup>, and 12.794 kg/cm<sup>2</sup> respectively.

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