The influence of the usage of ldpe plastic waste as fine aggregate in light concrete bricks

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Abstract. It has been a long time that red bricks become the raw material for wall compilers. As the era develops, the bricks that are light, easy to compile and not time-consuming in manufacturing are invented. The composition materials for the building blocks are cement, sand and water. In this study, the use of sand in the bricks is reduced with LDPE plastic pellets. The reason for the use of LDPE plastic pellets as substitution of plastic materials is that LDPE plastic pellets have smaller density than sand does, so that it is expected that the brick becomes lighter although consists of the same composition and it can also reduce environmental problems as LDPE plastic waste is difficult to be decomposed by nature but gradually produced by humans that results in excessive waste. The LDPE plastic pellets utilized are used LDPE plastics that are recycled into plastic pellets. The sample in this study consists of cylinder with diameter of 15 cm and height of 30 cm as sample of trial mixes test, concrete bricks with size of 40 cm x 20 cm x 10 cm, cube with size of 5 cm x 5 cm x 5 cm and briquette. The trial mixes samples will be treated for 7 days and the brick, cube and briquette samples will be treated for 28 days prior to testing. Furthermore, the sample will be tested with visual, content weight, absorption, compressive strength and drag strength tests. The data analysis uses SNI 03-0349-1989 reference on Concrete Bricks as The Matching Composition for Walls. This study used a mixture of cement, sand and water with ratio of 1: 6: 0.24, this composition was obtained from experiments on several specified compositions. The composition of substitute of plastic pellets used is 20% to the sand, the composition of this substitution is obtained from the experiments on several specified compositions. From the visual appearance, the content weight and absorption, both of normal brick and 20% LDPE pellets are included in the quality I, while the compressive strength test against the sample of normal brick results in quality I and 20% LDPE pellets brick results in quality III.

1 Introduction

Concrete brick is a construction material made of a mixture of cement, sand and air which are then inserted into the mold according to standard and are pressed. It is used as an alternative to brick in constructing walls. Recently, the construction in Indonesia is growing rapidly, so that the need for building materials is increasing. As a result of the continuous increase in the construction industry, the need for building materials such as red bricks is also increased, therefore the need of alternative construction materials for making brick wall to substitute red brick, that is concrete brick.

Concrete brick is a non-structural wall building materials. The main raw material to manufacture concrete brick is cement and sand, however as sand has quite heavy load, so this time it is innovated to replace

or substitute the sand into plastic pellets with some variation of mixing. The use of sand in the bricks is reduced with LDPE plastic pellets. The reason for the use of LDPE plastic pellets as substitution of plastic materials is that LDPE plastic pellets have smaller density than sand does, so that it is expected that the brick becomes lighter although consists of the same composition.

LDPE plastic is a material that we often encounter which is usually found on food wrappers or tools that are usually disposed after usage. Because of the high increase of plastic waste in the world, the use of shredded plastics has known a growing interest as recycled materials in civil engineering construction. The incorporation of waste in concrete provides additional advantages in terms of environmental and potential economic considerations [3].

Plastic has become a dangerous waste and difficult to reprocess. It takes a long time for the plastic to break down completely. At the time of the decomposition process, plastic waste will contaminate the soil, air, and water. If plastics are dumped in the soil, plastics will damage soil fertility and block the rate of water 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, chemicals present in plastics will damage the marine ecosystem.

Plastics that have light physical properties can be used as one of the aggregate methods in reducing the weight unit of concrete or brick concrete [4]. Although these alternatives are feasible except for land-filling, recycling of plastic waste to produce new materials, such as cement composites, appears as one of the best solution for disposing of plastic waste, due to its economic and ecological advantages[5].

The development of concrete with nonconventional aggregate, such as polystyrene foam wastes, HDPE, polyethylene terephthalate (PET), and other plastic materials has been investigated for use in concrete in order to improve the properties of the concrete and reduce cost. The use of such plastic wastes in concrete will contribute to the sustainability of the concrete design and the natural environment [6].

Different types of plastic have been investigated these last years: polyethylene terephthalate (PET), high-density polyethylene (HDPE) and polypropylene (PP). These studies have focussed on the effect of plastic addition in the workability of the fresh composites and in the mechanical strength of the hardened mixtures[7-10]. Ismail and AL-Hashmi (2008) have found that, as the percentage of waste plastic (consists of 80% polyethylene and 20% polystyrene) increases, the workability increases and the bulk density decreases[11]. This last result is due to the low density of plastic aggregates comparing to conventional ones. Naik et al. (1996) have found that post-consumer waste HDPE plastic can be successfully used in concrete as soft filler. They have shown that chemical treatment has a significant effect on performance of the plastic filler in concrete [12]. Nursyamsi and Winner (2017) have found that by using PET plastic waste as substitution of coarse aggregate in concrete as an alternative to reduce self weight can be used for light structural [13].

In this study, the use of sand in the bricks is reduced with LDPE plastic pellets. The sample in this study consists of cylinder with diameter of 15 cm and height of 30 cm as sample of trial mixes test, concrete bricks with size of 40 cm x 20 cm x 10 cm, cube with size of 5 cm x 5 cm x 5 cm and briquette. The cylinder spesimens are used for compression strength for the trial mixes samples will be treated for 7 days and the brick, cube and briquette samples will be treated for 28 days prior to testing [14-15].

About the classification of the quality of concrete bricks based on SNI-3-0349-1989 for the use of the percentage of substitute of LDPE plastic waste with various percentage as the material to reduce the weight of the concrete bricks. From this standard, the author will also make a visual outcome test, content weight test,

compressive strength test and tensile strength tests of that concrete brick that uses substituted materials of LDPE plastic waste.

1. Research Method

This research uses experimental research method. The factor of this research is the use of LDPE recycled plastic pellets composition as added ingredient in concrete brick by reducing the amount of sand, in this research the percentage of LDPE plastic pellets of 0%, 20%, 25%, 30% and 50% of the weight of sand is used. The production of the test object of concrete bricks uses the research design of mixing comparison 1pc: 6ps that is obtained from the experimental comparison of 1pc: 6ps, 1pc: 7ps and 1pc: 8ps and for water content is also determined by experimental way with the first set of comparison of water used is 0.2%, 0.24% and 0.28%.[1,2] The overall stages of this study are summarized as follows

Fig. 1. Stages of Research Flowchart

2 Result

2.1 Trial Mixes

Prior to making a comparative test object from the addition of pellets, we must first determine the ratio of the casting mixture. To determine the ratio of cement sand and water we use trial mixes. The test results are as follows:

Fig. 2. Average Test Result of Trial Mixes aged 7 Days

Fig. 3. Average Test Result of Trial Mixes aged 7 Days

Compressive strength on substitution of 20% of LDPE plastic pellets in sand was 41.27 Kg / cm². This value is sufficient to enter on the 3rd quality on the quality requirements of concrete bricks quality SNI 03-0349-1989, therefore the use of substitution of 20% LDPE plastic pellets as a mixture of test specimens to be tested next are set.

3.1 Test Result

Table 1. Comparison of Visual Checking Result with Quality Requirement

Description	Average Sample Condition		
	Normal Concrete Bricks	Concrete Bricks + LDPE Plastic	According to SNI 03-0349-1989
1.Fields			
a. flatness	Flat	Flat	Flat
b. fracture	Not cracked	Not cracked	Not cracked
c. smooth	Smooth	Smooth	Smooth
2.Ribs			
a. Elbow	Elbow	Elbow	Elbow
b.Sharpness	Sharp	Sharp	Sharp
c. Strength	Strong	Strong	Strong

Table 2. Comparison of Deviation of Average Device Size of Batako Tests against Quality Requirements

No.	Sample	Average Length (mm)		Average Width (mm)		Average Height (mm)	
		Test Object	SNI 03-0349-1989	Test Object	SNI 03-0349-1989	Test Object	SNI 03-0349-1989
1	Normal	5mm Tolerance Limit	+ 1.4	5mm Tolerance Limit	+ 0.2	100.6	5mm Tolerance Limit
2	20% LDPE Plastic Pellets	5mm Tolerance Limit	+ 1.6	5mm Tolerance Limit	+ 1.2	101	5mm Tolerance Limit

Table 3. Content Weight of Normal Brick Test Object

No.	Volume (cm ³)	Weight (g)	Content Weight (g/cm ³)
1	8000	14102	1.762
2	8000	14004	1.751
3	8000	13956	1.745
4	8000	15063	1.883
5	8000	14460	1.808
Average		14317	1.789

Table 4. Content Weight of 20% LDPE Plastic Pellets Concrete Bricks Test Object

No.	Volume (cm ³)	Weight (g)	Content Weight (g/cm ³)
1	8000	13123	1.640
2	8000	12749	1.594
3	8000	12640	1.580
4	8000	12836	1.605
5	8000	12879	1.610
Average		12845.4	1.606

Table 5. Content Weight of Normal Cube Test Object

No.	Volume (cm ³)	Weight (g)	Content Weight (g/cm ³)
1	125	250	2.000
2	125	245	1.96
3	125	244	1.952
4	125	246	1.968
5	125	245	1.960
6	125	250	2.000
7	125	236	1.889
8	125	241	1.928
9	125	239	1.912
10	125	242	1.936
11	125	237	1.896
12	125	240	1.920
Average		242.92	1.943

5	1584	1446	9.56	25	1
Average		1564	1431	9.25	25
		1	7		1

Table 8. The Result of of 20% LDPE Plastic Pellets Concrete Brick Absorption Test

No.	Specimen Type	Wet Weight (g)	Dry Weight (g)	Absorption (%)		Quality
				Test Object	SNI 03-0349-1989 Tolerance Limit	
1	20% LDPE Plastic Pellets	14114	13123	7.55	25	1
2		13549	12749	6.27	25	1
3		13441	12640	6.34	25	1
4		13851	12836	7.91	25	1
5		13843	12879	7.48	25	1
Average		11.788	10.158	7.11	25	1

Table 6. Content Weight of 20% LDPE Plastic Pellets Cube Test Object

No.	Volume (cm ³)	Weight (g)	Content Weight (g/cm ³)
1	125	207	1.656
2	125	215	1.720
3	125	195	1.560
4	125	212	1.696
5	125	202	1.616
6	125	203	1.624
7	125	204	1.632
8	125	180	1.440
9	125	202	1.616
10	125	203	1.624
11	125	210	1.680
12	125	212	1.696
Average		203.75	1.630

Table 9. Compressive Strength of Normal Bricks Test Object to Quality Requirement

No.	Dial Reading (kN)	Compressive Area Width (cm ²)	Compressive Strength (Kg/cm ²)		Quality
			Measured Compressive Strength	SNI 03-0349-1989*	
1	280	280	101.97	90	1
2	270	280	98.33	90	1
3	275	280	100.15	90	1
4	278	280	101.24	90	1
5	272	280	99.06	90	1
Average			100.15	100	1

*According to SNI, the compressive strength of the concrete brick of quality I, has a compressive strength requirement of each specimen is 90 Kg/cm² with average Compressive Strength is 100 Kg/cm²

Table 7 The Result of Normal Concrete Brick Absorption Test

No.	Specimen Type	Wet Weight (g)	Dry Weight (g)	Absorption (%)		Quality
				Test Object	SNI 03-0349-1989 Tolerance Limit	
1	Normal	15087	14102	6.98	25	1
2		15088	14004	7.74	25	1
3		15682	13956	12.37	25	1
4		16506	15063	9.58	25	1

Table 10. Compressive Strength 20% LDPE Plastic Pellets Concrete Bricks to Quality Requirement

No.	Dial Reading (kN)	Compressive Area Width (cm ²)	Compressive Strength (Kg/cm ²)		Quality
			Measured Compressive Strength	SNI 03-0349-1989**	
1	120	280	43.70	35	3
2	118	280	42.97	35	3
3	115	280	41.88	35	3
4	120	280	43.70	35	3
5	118	280	42.97	35	3
Average			43.05	40	3

**According to SNI, the compressive strength of the concrete brick of quality III, has a compressive strength requirement of each specimen is 35 Kg/cm² with average Compressive Strength is 40 Kg/cm²

Table 11. Compressive Strength of Normal Cubes Test

No.	Dial Reading (kN)	Compressive Area Width (cm ²)	Compressive Strength (Kg/cm ²)		Quality
			Measured Compressive Strength	SNI 03-0349-1989**	
1	15	25	61.18	35	3
2	15	25	61.18	35	3
3	10	25	40.79	35	3
4	15	25	61.18	35	3
5	12	25	48.95	35	3
6	12	25	48.95	35	3
7	12	25	48.95	35	3
8	10	25	40.79	35	3
9	12	25	48.95	35	3
10	12	25	48.95	35	3
11	15	25	61.18	35	3
12	15	25	61.18	35	3
Average			52.68	40	3

Object to Quality Requirement

Table 12. Compressive Strength of 20% LDPE Plastic Pellets Cube Test Object to Quality Requirement

No.	Dial Reading (kN)	Compressive Area Width (cm ²)	Compressive Strength (Kg/cm ²)		Quality
			Measured Compressive Strength	SNI 03-0349-1989*	
1	28	25	114.21	90	1
2	26	25	106.05	90	1
3	26	25	106.05	90	1
4	26	25	106.05	90	1
5	24	25	97.89	90	1
6	28	25	114.20	90	1
7	22	25	89.73	90	1
8	24	25	97.89	90	1
9	24	25	97.89	90	1
10	26	25	106.05	90	1
11	22	25	89.73	90	1
12	24	25	97.89	90	1
Average			101.97	100	1

Table 13. Comparison of Tensile Strength of Normal Briquette Sample

No.	Measured Tensile Strength		Cross Section Area(cm ²)	Tension (MPa)
	kN	Kg		
1	1.2	122.36	8.61	1.39
2	1.05	107.07	8.02	1.31
3	1.1	112.17	7.39	1.49
4	1.35	137.66	7.05	1.92
5	1.5	152.96	8.52	1.76
6	1.5	152.96	7.07	2.12
7	1.25	127.46	7.02	1.78
8	1.5	152.96	7.23	2.07
9	1.6	163.15	7.91	2.02
10	1.45	147.86	6.89	2.10
11	2	203.94	11.74	1.70
12	1.575	160.60	8.91	1.77
Average	1.42	79.24		1.79

Table 14. Comparison of Tensile Strength of 20% LDPE Plastic Pellets Briquette Samples

No.	Measured Tensile Strength		Cross Section Area(cm ²)	Tension (MPa)
	kN	Kg		
1	0.65	66.28	7.84	0.83
2	0.7	71.38	7.29	0.96
3	0.85	86.67	8.96	0.95
4	0.75	76.48	8.4	0.89
5	0.9	91.77	10.53	0.86
6	0.6	61.18	8.37	0.72
7	0.65	66.28	7.7	0.84
8	1.025	104.52	7.56	1.36
9	0.75	76.48	7.28	1.03
10	0.8	81.58	7.83	1.02
11	0.95	96.87	7.16	1.33
12	0.7	71.38	7.15	0.98
Average	0.78	79.24		0.98

4 Result Analysis

From the results that have been obtained, substitution of LDPE plastic pellets to the sand can reduce the content weight of the brick as well as the compressive strength of the test material when the addition of LDPE plastic pellets decreased that is worth 57.02%, the compressive strength test on the brick and cube test object has different values although still in the same quality because due to the effect of shape. In the test of tensile strength of the specimen with the addition of 20% of LDPE plastic pellets it decreased by 45.15%, the absorption test also decreased by 23.09%, which means that if it was added with the plastic pellets, the concrete brick has fewer cavities than the normal brick. The absorption test does not reflect porosity, but the interconnectivity of voids.

5 Conclusions

From the research results the conclusions obtained are as follows:

1. The average weight for normal brick is 1.789 g/cm³.
2. The weight of the average contents for the brick using 20% LDPE plastic is obtained at 1.606 g/cm³.
3. The average content weight for normal cube is 1943 g/cm³.
4. The average content weight for cubes using 20% LDPE plastic pellets is 1,630 g/cm³.
5. The average absorbance of normal bricks test specimens obtained is 9.246% and the brick test object using LDPE 20% plastic substitution material was 7.111%, both of which were less than 25% and included the classification of quality I.
6. The average compressive strength of normal brick object test obtained is 100.15kg/cm² including the classification of quality I and concrete brick test specimen using substitute materials of LDPE plastic substitution material of 20% as much as 43.05 kg/cm² included in the classification of quality III.
7. The strength of the average cubical specimen object is 101.97 kg/cm² including the classification of quality I and the cube test object using 20% LDPE plastic substitution material of 52.68 kg/cm² including the classification of quality III.
8. The average tensile strength of a normal briquette test object obtained was 18.22 kg/cm² while on LDPE 20% substitute plastic pellets test object 9.99 kg/cm² was obtained.
9. The content weight on LDPE 20% plastic pellets substitution can reduce up to 11.515% and in the cube it can reduce up to 16.123%.

6 Suggestions

Based on the conclusions and previous discussion it can be suggested that:

1. The entire process of designing, preparation of materials and tools as well as the process of concrete brick construction until the maintenance process need to be taken care of very carefully, so as to produce concrete bricks with good quality.

2. There are numerous limitations in this study, therefore it is expected that for further research the following things could be conducted:
 - a. Brick molding needs to use compressor tool, as in this research the molding used is manually by using pounder.
 - b. Need to compare the use of LDPE plastic in other forms.
 - c. Need to investigate the amount of water needed as a material of cement reactor, for the optimum amount of water to be used to be obtained, as in this study the amount of water used was only based on trial mixes.

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