

# The effect of the shape and size of HDPE plastic admixtures on to K125 concrete

*by* Tamrin Tamrin

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## The effect of the shape and size of HDPE plastic admixtures on to K125 concrete

Tamrin<sup>1</sup>, M Jamal<sup>1</sup> and P Ramadhani<sup>1</sup>

<sup>1</sup>Department of Civil Engineering, Faculty of Engineering, University of Mulawarman, Jl. Sambaliung No. 9, Samarinda, 749315, Indonesia

Email: fts\_tamrin@yahoo.com

**Abstract.** This research uses admixture, namely HDPE plastic waste and aims to determine the effect of these admixture materials with different shape and size pieces on compressive strength and collapse as well as crack patterns on each concrete design, then to find the difference in the results of the compressive strength of each concrete made from material admixture as well as the shape and size of the pieces of plastic that are appropriately used as the material concrete admixture. This research used an experimental method, which compares the results of the compressive strength of normal concrete and concrete with the addition of plastic pieces of HDPE material, which are distinguished by shape and size. HDPE materials are cut into cubes with 1x1cm, rectangles measuring 0,5x2cm, and long sticks measuring 0.25 x 4 cm. The compression of the percentage of material is added to the weight of cement which are equal to 5%. The results of compressive strength obtained respectively are, 136.915 kg/cm<sup>2</sup> or 13.691 MPa for cube-shaped plastic pieces, 138.347 kg/cm<sup>2</sup> or 13.835 MPa for concrete with rectangular plastic pieces which are the right shape and size to be used in concrete mix design, then 138,025 kg/cm<sup>2</sup> or 13,803 MPa for concrete with long sticks pieces of plastic shaped, and the results of the concrete strength with admixture material are higher than the planned compressive strength and standard concrete. After that, the results of crack patterns for normal concrete were obtained, concrete with cube-shaped plastic pieces, concrete with rectangular plastic pieces, and long sticks plastic pieces of concrete, namely shear crack, crack voids and honeycomb, crack honeycomb, and crack concrete crazing and honeycomb. Whereas the collapse occurs between the coral joints with cement paste, and the plastic pieces are not damaged or broken. Therefore, the results of the study are found that differences in the shape and size of plastic pieces affect the value of slump, compressive strength, and collapse.

### 1. Introduction

With the development of construction technology in Indonesia which continues to increase, it is also inseparable from the community's need for advanced infrastructure facilities, such as bridges and high-rise buildings and other facilities. Then according to the community needs described above, it encourages the need for construction technology, including one in the field of concrete that is both technically and economically.

Concrete is defined as a set of mechanical and chemical interactions of its constituent material (Nawy, 1985: 8). In other words, concrete is a mixture consisting of the main ingredients, namely cement, aggregate, sand, and water. However, sometimes other additives are also used which are expected to change the properties of concrete, increase the compressive strength of concrete, and improve the performance of concrete (Workability) as well as energy-saving, one of the added ingredients that is environmentally friendly, cost-effective and easy to obtain, namely the utilization of plastic waste which pollutes the environment a lot.



This environmental problem that is plastic waste is a problem that is difficult to overcome. Around 50 years ago plastic was used up to now, it is estimated that more than 500 million to 1 billion plastics are used by the world's population every year and it is estimated that it takes 100 to 500 years for plastic to decompose completely. Based on the Indonesian Journal of Applied Physick 2012, the addition of plastic waste to the concrete mixture can increase the compressive strength with a range  $(16 \pm 0.1) \times 10^6 \text{ N/m}^2$  to  $(21 \pm 0.2) \times 10^6 \text{ N/m}^2$  and for the highest value namely at 4% addition of  $(21.8 \pm 0.2) \times 10^6$ . With the study of "Making Concrete with Plastic Waste Mixes" in the journal, it is expected that concrete will be obtained with better mechanical properties than concrete without other added ingredients and can improve the properties of concrete without reducing its quality and help reduce plastic waste which has been polluting the environment (Indonesian Journal of Applied Physick 2012).

From the descriptions above, the use of plastic waste as one of the added ingredients is essential to do, including the utilization of household plastic waste into added material, because the material is easily obtained and has not been utilized optimally. In this study, we will use environmentally friendly added ingredients from waste plastic High Density Polyethylene (HDPE), a type of thermoplastic polyethylene that is widely used in daily life.

The following objectives of this study are:

- a. To find out the effect of ingredients added HDPE plastic waste with different shapes and the size of the piece of plastic against the compressive strength of each concrete using Mahakam and hammer local fine aggregates and hammer coarse aggregates.
- b. To find out the difference in the results of the compressive strength of concrete by using added plastic material HDPE by 5% on each concrete with pieces of HDPE plastic different in each concrete mixture.
- c. To find out the shape and size of HDPE plastic pieces that are most appropriate to use as added material for concrete that will function for base concrete and non-concrete structural.
- d. To find out the types of cracking and collapse patterns in normal concrete and concrete with materials add plastic pieces

## 2. Literature review

Concrete material consists of cement material, fine aggregate (sand), coarse aggregate, water, and added ingredients. Cement is a material that acts as a binding agent for aggregate. if mixed with water, the cement will turn into a paste. Then the aggregate is granular material such as sand, gravel, broken stone and incandescent furnace crust used together with a binding medium to form concrete or hydraulic cement mortar. The aggregate is divided into fine aggregates and coarse aggregates. Fine aggregate is natural sand as a result of natural disintegration of rocks or sand produced by the stone-breaking industry and has the largest grain size of 5.00 mm. Whereas coarse aggregates are gravel as a result of the 'natural' disintegration of rocks or in the form of broken stones produced by the stone-breaking industry and have the largest grain size of 5.0-40.0 mm. In addition, there is water that functions to dissolve the cement so that it can be mixed with sand and coarse aggregates, then sometimes added materials are used, one of which functions to save costs.

### 2.1. Properties of fresh concrete

#### 2.1.1. Segregation (gravel separation)

Segregation is the tendency of coarse grains to escape from the concrete mixture, in other words, it can be interpreted that segregation is an event where coarse aggregates are not evenly mixed on a concrete mixture so that coarse aggregates will loose and accumulate at one point or part, this can be seen clearly when concrete mixture is put into concrete molding.

#### 2.2. Bleeding

Bleeding is the tendency of water to rise to the surface of the concrete that has just been compacted or in other words it can be interpreted that bleeding is a condition where the water in the concrete comes

out and floats on the concrete surface, and this bleeding event can be seen when the concrete is in the mould.

### 2.3. Crack pattern and collapse on concrete

Cracks can be broadly classified as structural and non-structural cracks. Structural cracks can occur due to design errors or can also occur due to a load that exceeds capacity so that it can endanger the building. In addition, structural cracks also occur after the concrete hardens. Then non-structural cracks mostly occur because of the voltage induced internally in building materials and generally, this does not directly result in weakening the structure. (Journal, Saputra, Gunawan, et al.; Identification of the causes of damage to concrete and its prevention). As for the collapse, it is an event where the concrete is damaged starting from the crack until the concrete is damaged or until the concrete is split. From the collapse that occurs, it can be seen how the bonding and dissemination of the materials inside. Crack Types can be shown below.

- a. Flexural Crack
- b. Web Shear Crack
- c. Flexural Shear Crack
- d. Torsion Crack
- e. Sticky Cracks
- f. Plastic Cracks Due to Depreciation
- g. Cracked Plastic Due to Decline
- h. Drying Shrinkage Cracking
- i. Concrete Cracking
- j. Thermal Cracking
- k. Cracking due to Chemical Reaction
- l. Theory Voids and Honeycomb

### 2.4. Plastic material

Plastic is a material that can be softened and has lower Christianity than fiber. Plastics can be made according to desired properties by copolymerization, lamination, or extrusion. The main components of plastic before forming polymers are monomers, which are the shortest chains. Use of Plastic as Food Packaging. The use of plastic as a pack of food can be divided into various types, namely:

- a. Polyethylene Terephthalate (PET, PETE). This type of material will melt when heating at a temperature of 110OC, has properties low permeability and good mechanical properties. As for the usefulness of this material generally used for clear or translucent plastic bottles and only for single use.
- b. High Density Polyethylene (HDPE) This material has good chemical properties which are stronger, harder, opaque and more resistant to high temperatures. And it is commonly used in bottles that are not given pigments are translucent, rigid, and suitable for packaging products that have age short like milk.
- c. Polyvinyl Chloride (PVC) LDPE material is a content of PVC namely DEHA contained in plastic wrap can leak and get into greasy food when heated. PVC potentially dangerous for kidney, liver and weight. Have a stable and physical character resistant to chemicals, the influence of weather, flow, and electrical properties. Generally used for pipe and building construction.
- d. Low Density Polyethylene (LDPE) This material cannot be destroyed but is still good for food. Under temperature of 60 °C is very resistant to most chemical compounds. LDPE can be used as a place for food and soft bottles (honey, mustard).
- e. Polypropylene (PP) Stronger and lighter with low vapor permeability, good resistance to fat, stable to high temperatures and quite shiny. Generally used as a place to store food, drink bottles, a place for medicine and bottles for babies.
- f. Polystyrene (PS) Very amorphous and translucent, having a high refractive index is difficult to penetrate by gas except water vapor. Generally used for Styrofoam-based food places.

- g. Other (usually polycarbonate) Polycarbonate can release its main ingredient, Bisphenol-A, into food and drinks that have the potential to damage the hormone system. Generally used in places food and drinks like sports drinking bottles.

### 2.5. *Polimer HDPE*

Strong and rigid HDPE type plastic waste originates from petroleum, which is often formed by blowing it. The molecular formula is  $(-CH_2-CH_2)_n$ . HDPE is a plastic that is safe to use because of its ability to prevent chemical reactions between plastic packaging made from HDPE and the food or drink it packs. Even so, this type of plastic is recommended for just one use because of the release of antimony trioxide compounds which continue to increase over time. Because of the small divisions, HDPE has high tensile and force strength between molecules. HDPE is also harder and can withstand high temperatures (120°C). HDPE is very resistant to chemicals and has a wide application. HDPE is usually used for milky white milk bottles, oil jerry cans, shampoo bottles, and others.

### 2.6. *Portland cement (PC)*

Portland Cement (PC) or cement is a material that acts as an aggregate binder when mixed with cement water into a paste. With the process of time and heat, the chemical reaction due to a mixture of water and cement results in the nature of the cement paste pavement. The inventor of cement (Portland Cement) was Joseph Aspdin in 1824, a British national mason. Named Portland cement, because initially, the cement produced has a color similar to natural clay on Portland Island. Portland cement is made through several steps, so it is very smooth and has both adhesive and cohesive properties. Cement is obtained by burning carbonate or limestone and argillaceous (containing alumina) with a certain ratio. The material is mixed and burned at a temperature of 1400° C-1500° C and becomes clinker. After that it is cooled and mashed until it looks like powder. Then cast or calcium sulfate (CaSO<sub>4</sub>) is added about 2-4% per cent as the binding time control material. Other added ingredients are sometimes added to form special cement such as calcium chloride to make the cement harden quickly. Cement is usually packaged in bags of 40 kg / 50 kg. According to SII 0031-81 portland cement is divided into five types, as follows:

Type I: Cement for general use, no need special requirements.

Type II: Cement for sulfate resistant concrete and has moderate hydration heat.

Type III: Cement for concrete with high initial strength (fast harden).

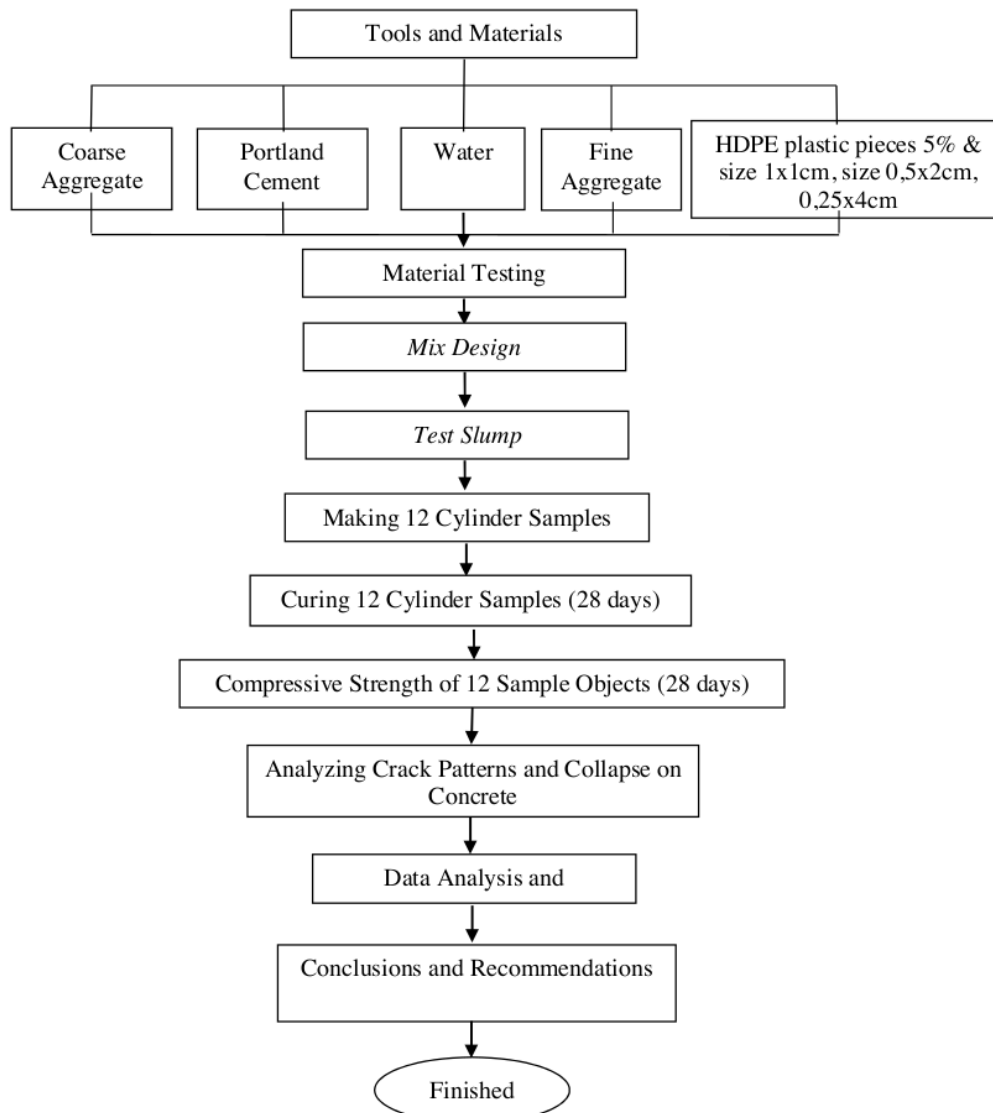
Type IV: Cement for concrete that requires low heat hydration.

Type V: Cement for concrete which is very resistant to sulphate.

### 2.7. *Coarse aggregates and fine aggregates*

The coarse aggregates used in SCC are limited to only 50% of the total volume of concrete. This is done so that the blocks that occur when the concrete flow through the steel reinforcement can be minimized. These blocks occur because of the high viscosity of fresh concrete so that coarse aggregates intersect. As a result of the mutual contact between coarse aggregates, the concrete flow is very slow so the concrete will be collected in one place thereby reducing the workability of the concrete. Limitation of the amount of coarse aggregate is done so that the ability of the concrete flow to pass through reinforcement is more maximal. The same is true for fine aggregates so that the fine aggregate in mortar is limited to approximately 40% of the total volume of mortar.

### 3. Methodology



**Figure 1.** Flow chart methodology.

Examination of concrete compressive strength is conducted at 28 days. To get the compressive strength in the concrete equation is used:

$$\text{Concrete Compressive Strength} = \frac{P}{A} \text{ (kg/cm}^2\text{)} \quad (1)$$

where: P = Maximum load (kg)  
A = Cross-sectional area of the test object (cm<sup>2</sup>)

#### 4. Results and discussion

The following is a table of test results obtained from research conducted by ready mix company:

**Table 1.** Test result data.

No.	Type of Testing	Unit	Total Sample	Testing		Specification
				Results	Method	
1.	Coarse&fine aggregate filter analysis		4	Attached	SNI ASTM C136:2012	SK SNI S-04-1984
2.	Water content local fine aggregate	%	2	6.048	SNI 03-1971-2011	
3.	Water Content of fine aggregate palu	%	2	10.153	SNI 03-1971-2011	
4.	Water content of coarse aggregate palu 1/2	%	2	0.596		
5.	Water content of coarse aggregate palu 2/3	%	2	1.517		
6.	Local fine aggregate slurry content	%	2	2.061	SNI 03-4142-1996	< 5%
7.	Palu fine aggregate slurry content	%	2	0.887	SNI 03-4142-1996	< 5%
8.	Coarse palu aggregate slurry 1/2	%	2	0.487		< 1%
9.	Coarse palu aggregate slurry 2/3	%	2	0.573		
10.	Local fine aggregate specific gravity	gr/cc	2	2.672	SNI 03-1970-2008	
11.	Fine palu aggregate specific gravity	gr/cc	2	2.603		
12.	Coarse palu aggregate specific gravity 1/2	gr/cc	2	2.660		
13.	Coarse palu aggregate specific gravity 2/3	gr/cc	2	2.646		
14.	Absorption of local fine aggregates	%	2	1.172		
15.	Absorption of fine palu aggregates	%	2	1.217	SNI 03-1970-2008	
16.	Absorption of	%	2	0.963		



17.	palu coarse aggregates ½ Absorption of Palu coarse aggregates 2/3	%	2	0.871	
18.	Local fine aggregate content weight	gr/cm <sup>3</sup>	2	1.474	
19.	Palu fine aggregate content weight	gr/cm <sup>3</sup>	2	1.343	SNI 03-4808-1998
20.	Palu coarse Aggregate content weight ½	gr/cm <sup>3</sup>	2	1.353	
21.	Aggregate content weight 2/3	gr/cm <sup>3</sup>	2	1.359	
22.	The weight of fresh concrete contents	gr/cm <sup>3</sup>	1	2.420	
23.	Local sand organic matter		1	Good	SNI 03-1969-1990
24.	Sand hammer organic matter		1	Good	SNI 03-1969-1990
25.	Abrasion	%	1	18.70	SNI 03-1969-1990
26.	Concrete mixture design		1	Attached	SNI 03-2834-1992
27.	Check results of Concrete compressive strength		1	Attached	SNI 03-1974-2011

#### 4.1. Determining concrete samples <sup>2</sup>

The mould used for this study was a cylinder with a diameter of 150 mm and a height of 300 mm.

Cylinder Volume = Area x Height

Cylinder Area (A) =  $\frac{1}{4} \times \pi \times D^2$

$$= 0.25 \times 3.14 \times (150 \times 150)$$

$$= 17671.45 \text{ mm}^2$$

Cylinder Volume (V) = L x H = 17671.45 mm<sup>2</sup> x 300 mm = 0.0053 mm<sup>3</sup>

Calculation of the volume of cylindrical molds used for 3 sample specimens = 0.0053 x 3 samples = 0.0159 mm<sup>3</sup>. The volume of actual needs if the concrete is shrinking, and in this study, normal concrete and concrete made from plastic are both increased by 30% because when stirring, a lot of material is stuck in molen 0.0159 + (30% x 0.0159) = 0.02067

Composition for three samples with 0% mixture (Normal Concrete) that is =

1. Rough Aggregate of Hammer 1/2 = 572 x 0.02067 = 11.82 kg

2. Rough Aggregate of Hammer 2/3 = 771 x 0.02067 = 15.94 kg

3. Mahakam Local Fine Aggregate = 201 x 0.02067 = 4.15 kg

4. Smooth Aggregate Palu = 417 x 0.02067 = 8.62 kg

5. Cement = 300 x 0.02067 = 6.201 kg

6. Water = 146 x 0.02067 = 3.01782 = 3 kg

Composition for three samples with 5% HDPE plastic mixture namely =

1. Rough Aggregate of Hammer 1/2 =  $572 \times 0.02067 = 11.82$  kg
2. Rough Aggregate of Hammer 2/3 =  $771 \times 0.02067 = 15.94$  kg
3. Mahakam Local Fine Aggregate =  $201 \times 0.02067 = 4.15$  kg
4. Smooth Aggregate Palu =  $417 \times 0.02067 = 8.62$  kg
5. Cement =  $300 \times 0.02067 = 6.201$  kg
6. Water =  $146 \times 0.02067 = 3.01782 = 3$ kg
7. Pieces of HDPE plastic 5% =  $0.05 \times 6,201 = 0.31005\text{gr} = 310.05$  kg

Furthermore, for 3 concrete samples with plastic mixtures, they are only differentiated based on the shape or size of the plastic pieces divided into 3 sizes: 1x1cm, 2x1 / 2cm, and 1 / 4x4cm with the same mixture composition and the same size of plastic pieces.

#### 4.2. Testing of concrete press strength

The following are the results of compressive strength tests that have been obtained:

#### 4.3. Normal concrete press strength

Based on the results of testing the concrete compressive strength carried out in the laboratory of PT. Samarinda Ready Mix can be seen in table 2 below:

**Table 2.** 28 Day normal concrete press strength test.

No.	Creation Date	Test Date	Shape	Age (Days)	Cylinder Compressive Strength (kg/cm <sup>2</sup> )	Cylinder Compressive Strength (MPa)	Test Slump (cm)
1.	21/11/2018	19/12/2018	Cylinder	28	237.575	23.758	14
2.	21/11/2018	19/12/2018	Cylinder	28	173.091	17.309	14
3.	21/11/2018	19/12/2018	Cylinder	28	167.321	16.732	14

From the table data the results of compressive strength tests that have been done for normal concrete with N test code, and then from the graph of normal concrete compressive strength above can be seen that at 28 days, normal concrete specimens without the addition of HDPE plastic pieces reach compressive strength 12.87 MPa and has achieved the planned characteristic compressive strength of 10 MPa.

#### 4.4. Concrete compressive strength with addition of HDPE plastic pieces size 1x1cm on 28 days old

Based on the results of testing the concrete compressive strength carried out in ready mix laboratory can be seen in table 3 below:

**Table 3.** 28 days concrete compressive strength test on concrete material mixture add pieces HDPE plastic size 1x1cm.

No	Creation Date	Test Date	Shape	Age (Days)	Cylinder Compressive Strength (kg/cm <sup>2</sup> )	Cylinder Compressive Strength (MPa)	Test Slump (cm)
1	21/11/2018	19/12/2018	Cylinder	28	169,697	16,979	12
2	21/11/2018	19/12/2018	Cylinder	28	150,012	15,001	12
3	21/11/2018	19/12/2018	Cylinder	28	190,400	19,040	12

From the table of the results of the above compressive strength testing for concrete with K test code, the results of the compressive strength of concrete with the addition of 5% HDPE plastic pieces of 1x1 cm reach a compressive strength of 136.915 kg / cm<sup>2</sup> or 13.691 MPa and have achieved the planned compressive strength of 10 MPa . In addition, this type of concrete is a type of concrete with the test results which has the lowest quality compared to other HDPE plastic mix sizes.

#### 4.4.1. Concrete compressive strength with addition of HDPE plastic pieces size 1/2x2cm on 28 days old

Based on the results of testing the concrete compressive strength carried out in the laboratory of PT. Samarinda Ready Mix can be seen in table 4 below:

**Table 4.** 28 days concrete compressive strength test on concrete material mixture add pieces HDPE plastic size 0.5x2cm.

No	Creation Date	Test Date	Shape	Age (Days)	Cylinder Compressive Strength (kg/cm <sup>2</sup> )	Cylinder Compressive Strength (MPa)	Test Slump (cm)
1	21/11/2018	19/12/2018	Cylinder	28	203,636	20,364	8
2	21/11/2018	19/12/2018	Cylinder	28	152,897	15,290	8
3	21/11/2018	19/12/2018	Cylinder	28	184,630	18,463	8

From the table the results of the above compressive strength testing for concrete with a test code 2, the results of the compressive strength of concrete with the addition of 5% HDPE plastic pieces size 1 / 2x2 cm reached 138.34 kg / cm<sup>2</sup> or 13.835 MPa compressive strength and reached the planned compressive strength 10 MPa. In addition, for this type of concrete, it is a type of concrete with the results of testing which has the highest quality compared to other HDPE plastic mix sizes.

#### 4.4.2. Concrete compressive strength with the addition of HDPE plastic pieces size 1/4x4cm on 28 days old

Based on the results of testing the concrete compressive strength carried out in the laboratory of PT. Samarinda Ready Mix can be seen in table 3.5 below:

**Table 5.** 28 days concrete compressive strength test on concrete material mixture add pieces HDPE plastic size 1x1cm.

No	Creation Date	Test Date	Shape	Age (Days)	Cylinder Compressive Strength (kg/cm <sup>2</sup> )	Cylinder Compressive Strength (MPa)	Test Slump (cm)
1	21/11/2018	19/12/2018	Cylinder	28	147,070	14,707	12
2	21/11/2018	19/12/2018	Cylinder	28	167,321	16,732	12
3	21/11/2018	19/12/2018	Cylinder	28	178,860	17,886	12

From the table of the above compressive strength test results for concrete with test code 4, the results of the concrete compressive strength with the addition of 5% of 1 / 4x4 cm HDPE plastic pieces reached a compressive strength of 138.025 kg / cm<sup>2</sup> or 13.803 MPa and reached the planned compressive strength 10 MPa. In addition, for this type of concrete it is a type of concrete with the results of testing which is of little quality below the results of concrete quality testing on concrete with HDPE 1 / 2x2 cm plastic mixture size.

#### 4.4.3. Crack pattern and collapse on concrete

Based on the test results above, it is known that for normal concrete experiencing shear cracks on the beam (Web Shear Crack), concrete made from HDPE plastic in the form of cubes measuring 1x1cm has cracked Voids and Honeycomb, concrete made of rectangular-shaped 0.5x2cm cracked Honeycomb and 0.25x4cm long stick-shaped concrete with cracks experienced a crack of Concrete Cracking and Honeycomb. While the collapse obtained on each concrete has the same results, namely the collapse occurs between the joints or the gap between the coral and cement paste, but in the material added plastic pieces are not damaged or broken.

### 5. Conclusions

Based on the results of the research and discussion described in the previous chapter, conclusions can be drawn as follows:

1. From the research results, it can be concluded that the differences in the shape and size of pieces of HDPE plastic the concrete mixture has an effect on the value of slump, collapse, adhesion between plastic pieces, coral, and other concrete building materials, as well as added plastic pieces of material that also functions as fiber in concrete.
2. From the results of the research that has been done, the value of compressive strength is higher than the compressive strength normal plans and concrete that have been made. The following is the result of the concrete compressive strength obtained that is, in concrete with a plastic add material that is 1x1cm with K code is 136,915 kg/cm<sup>2</sup> or 13,691 MPa. Then on the concrete with the material added 1 / 2x2cm plastic pieces with code 2 is 138,347 kg / cm<sup>2</sup> or 13.835 MPa. And the last is the value of concrete compressive strength the size of 1 / 4x4cm plastic pieces with code 4 is 138.025 kg / cm<sup>2</sup> or 13.803 MPa.
3. From the results of the research that has been done, it is known that the shape and size of the piece of plastic is right used in concrete mixes are rectangular plastic pieces measuring 1 / 2x2 cm.
4. From the results of the study also found a pattern of cracks and collapses that occur in concrete. Type of crack pattern obtained, namely, shear cracks in the beam section (Web Shear Crack) for normal concrete. Then crack Voids and Honeycomb for concrete with added cube-sized plastic pieces 1x1cm. Next crack Honeycomb for concrete with the added plastic shaped material rectangle measuring 1 / 2x2cm, and cracking Concrete Cracking and Honeycomb for concrete with material added plastic pieces in the form of long sticks measuring 1 / 4x4cm. While collapse on Concrete occurs between the connections between the coral and the concrete mixture, and for the material add plastic pieces not damaged or broken.

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