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Influence Utilization Waste Plastic *Polyethylene Terephthalate* on the Flexural Strength of Concrete with Use East Kalimantan Aggregate

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ABSTRACT

Environmental pollution is still an issue that cannot be ignored. This type of waste causes environmental pollution due to its large and difficult to be recycled is Polyethylene Terephthalate (PET) plastic. So it is important to make an effort to utilize the plastic. On the other hand in the world of construction, the use of concrete increases every day causing the need for many new material sources in order to cover the needs of concrete mixtures. One of the abundant sources of aggregate is East Kalimantan aggregate but has not been used much. so combining East Kalimantan aggregate and PET plastic as a concrete constituent material becomes interesting to be analyzed, especially to determine the characteristics of the flexural strength of concrete. The flexural strength is based on SNI 03-4431-2011 method and tested at the age of 14 and 28 days. PET plastic chopped to a size of 5 cm long and 1-3 mm wide with variations 0.5%; 0.65%; and 0.8% of the weight of sand. The total number of samples is 24 blocks size of 15 × 15 × 60 cm. The results indicate that the flexural strength characteristics of concrete using local East Kalimantan aggregates and using PET plastic as a partial substitute for fine aggregate increased as the number of PET substitutions. Concrete without PET plastic has 3.187 MPa. In comparison with to normal concrete, 0.5% PET substitution increased by 3.07%, 0.65% PET variation increased by 3.63% and 0.8% PET variation increased by 4.32%.

Keywords: *Concrete; Flexural Strength; PET; East Kalimantan*

INTRODUCTION

The problem of environmental pollution is currently still an issue that cannot be ignored [1]. One type of waste that causes environmental pollution because the amount is very large and increasingly large is plastic waste. This huge amount of waste has a huge impact because the waste produced is not managed properly [2]. This type of plastic waste occupies the second position, namely 5.4 million tons per year, even Indonesia is also in second place in the world as one of the contributors of plastic waste to marine waters and reaches 187.2 million tons after China based on static data on Indonesia's domestic waste [3]. One of the largest types of waste comes from plastic packaging and containers such as plastic drinking bottles.

On the other hand, in the world of construction, construction is a complex job [4]. One thing that is very important and very dominant in building structures is the use of concrete [5]. The increasing use of concrete every day results in its depletion source Power natural [6]and the materials have also improved massively. Developments in the field construction develop with appearance some innovative ideas [7]. In this way, various kinds of research were carried out to create new innovations as mixtures for concrete that were easy to use and obtain. Replacing or adding used plastic or plastic bottles to the concrete mixture is one way that can be done to reduce the amount of plastic waste.

One of the important structural elements made of concrete and found in buildings is the beam and the structural element whose function is to withstand bending loads is the beam [8]. Therefore, researchers will conduct experiments when the concrete is 14 and 28 days old on flexural strength using PET plastic as a substitute or partial substitute for fine aggregate. The development of increasingly advanced construction technology as a means of support requires high quality and quality materials. So knowledge is needed regarding the classification and characteristics of the materials or construction materials that will be used, [9]therefore the fine aggregate used comes from Samboja district and the coarse aggregate Petangis comes from Tanah Grogot. Based on these several things, there is a problem formulation in this research, namely how the flexural strength characteristics of concrete use *Polyethylene Terephthalate* (PET) plastic as a substitute for fine aggregate. So this research aims to determine the flexural strength characteristics of concrete by utilizing *Polyethylene Terephthalate* (PET) plastic as a substitute for fine aggregate.

Previous research using PET plastic waste as a concrete mixture has been carried out, including research carried out in the city of Jimma, southwest Ethiopia regarding replacement materials for some of the fine aggregates in concrete mixtures with PET plastic waste. The research results state that the optimal value for flexural strength, compressive strength and splitting tensile strength is at a percentage of 3% [10]. Then research carried out using PET plastic as a partial replacement for sand and using marble dust as an additive stated that the values of flexural strength, compressive strength and split tensile strength increased with increasing PET plastic fibers up to a percentage variation of 8% [11]. One of the studies conducted in Nigeria was regarding the impact of using *Polyethylene Terephthalate* (PET) plastic waste on the flexural strength of concrete of the 0% variation; 5%; 10%; and 15% of the amount of fine aggregate carried out tests after concrete curing periods of 3, 7, 14, and 28 days. The test results stated that there was a progressive decrease in the flexural strength of concrete along with the addition of the percentage of PET plastic except for the 3 day concrete curing period, the percentage of 15% experienced an increase in the flexural strength value of 20.4% of normal concrete [12]. Previous research also used a percentage variation of 0%; 2%; 3%; 5% of the cement mass with the substitution of *Polyethylene Terephthalate (PET)* plastic waste as an additional material for the concrete mixture. The research was carried out at 7 and 28 days.

The results of the research showed that there was a decrease in the quality of the flexural strength of concrete along with adding PET plastic bottle waste to the concrete mixture [13]. The research results containing PET plastic used a variation of 0.5%; 1%; and 1.5% to the compressive strength and flexural strength increased to a PET percentage of 0.5% and the resulting flexural strength increased to a PET percentage of 1% [14]. Research on PET plastic as a partial substitute for fine aggregate and test results show that the greater the percentage of PET, the more it will influence the compressive strength and flexural strength values [15]. Tests on coarse aggregate as a substitute for PET plastic show that the higher the percentage of artificial aggregate made from PET plastic, the lower the compressive strength and flexural strength [16]. Then other research shows that the more PET plastic fibers are added, the more the flexural strength value increases [17]. Research on samboja fine aggregate had been carried out previously and the results showed that the compressive strength of mortar using samboja sand gave good values at 28 days [18]. And research conducted using Petangis coarse aggregate had the best average compressive strength compared to Hammer coarse aggregate

[19].

MATERIALS AND METHODS

The research method that will be used is an experimental method in which this research uses *Polyethylene Terephthalate* (PET) plastic as a partial replacement material for fine aggregate. The research was conducted at the Construction Materials Laboratory of Balikpapan University.

Data collection in this research was through testing in the laboratory and searching for journals or scientific articles related to this research so that issues could be developed and involved many perspectives and factors that had an influence on the research. The test data required for this research is shown in Table 1.

Table 1: Implementation Testing

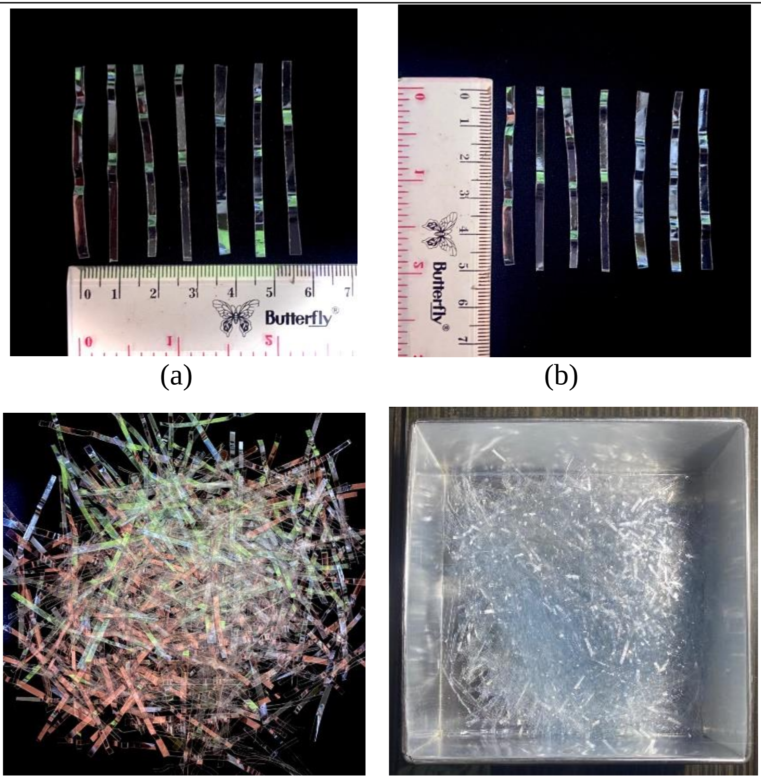
No	Test Type	Test Method
1.	Coarse aggregate sieve analysis	SNI 03-2834-2000
2.	Fine aggregate sieve analysis	SNI 03-2834-2000
3.	Specific gravity and water absorption of coarse aggregate	SNI 03-1969-1990
4.	Specific gravity and water absorption of fine aggregate	SNI 1970:2008
5.	Coarse aggregate moisture content	SNI 1971:2011
6.	Water content of fine aggregate	SNI 1971:2011
7.	Coarse aggregate sludge content	SNI ASTM C117:2012
8.	Fine aggregate sludge content	SNI ASTM C117:2012
9.	Volumetric weight of coarse aggregate	SNI 03-4804-1998
10.	Volumetric weight of fine aggregate	SNI 03-4804-1998
11.	Abrasion	SNI 2417:2008
12.	*Mix Design*	SNI 03-2834-2000
13.	Slump	SNI 1972:2008
14.	Concrete Treatment	SNI 2493:2011
15.	Flexible strong	SNI 4431:2011

Material

Materials used during the manufacturing process stir mixture concrete is Portland cement type I, aggregate rough origin _ from Petangis size item maximum 40 mm, aggregate fine from Sambodia size item maximum 4.75 mm, clean water , and PET plastic as substitution aggregate smooth .

PET Plastic Fiber

PET plastic in this study used used plastic drinking bottles that were cut or chopped. The chopping technique is carried out manually using scissors to obtain the appropriate size of PET plastic concrete. The size of the PET plastic in this study was 1-3 mm wide and 5 cm long, shown in Figure 1.



(a) (b) (c) (d)

Figure 1 (a) Size PET width 1-3 mm
(b) Size PET length 5 cm
(c), (d) Pieces PET plastic

The shredded PET plastic is then added to the concrete blocks as a mixture with varying percentages, namely 0.5%; 0.65%; and 0.8% of the amount of sand. The test specimens were made from 24 blocks. The total number of beam samples tested for flexural strength is shown in Table 2.

Table 2: Number of samples

Plastic Variations PET (%)	**Concrete Curing Period**		**Number of Test Samples**
	14 days	**28 Days**	
0	3	3	6
0.5	3	3	6
0.65	3	3	6
0.8	3	3	6
Total Number of Test Objects			24

The method for calculating *the mix design* for this research is based on SNI Standard 03-2834-2000 and the slump test value determined in this research is 10 ± 2 cm. The concrete mix planning is also calculated based on data from aggregate inspection results that have been carried out previously. The proportion of the PET plastic mixture is calculated using the weight of sand and a predetermined percentage. The calculation of the proportion of normal concrete and concrete with variations in PET substitution is shown in Table 3.

Table 3: Proportion *Mix Design* per 1m ^{3}

PET plastic variety (%)	Cement (kg)	Water (kg)	Coarse Aggregate (kg)	Fine Aggregate (kg)	PET plastic (kg)
0	373.75	185	1617.8	593.06	-
0.5	373.75	185	1617.8	590.1	2,965
0.65	373.75	185	1617.8	589.20	3,855
0.8	373.75	185	1617.8	588.32	4,745

After making the concrete mix, a slump test is then carried out to find out whether the concrete mix that has been made meets the specified slump value. After that, the test object is printed and opened 24 hours ± 8 hours after printing. After that, the concrete is soaked in a soaking tub for 14 and 28 days. After the test object reaches the specified *curing time , the concrete is lifted and dried before being tested.* The flexural strength test method used is based on SNI 03-4431-2011 with the *Universal Testing Machine test equipment* and two loading points using a beam measuring 15 × 15 × 60 cm as shown in Figure 2.

Figure 2Two Point Bending Test Equipment Loading

RESULTS AND DISCUSSION

Slump Test

The slump test is carried out to determine the level of workability of fresh concrete by measuring the difference between the height of the slump mold and the height of the concrete mix. The slump test results are shown in Figures 3 and 4 as well as Table 4.

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(a) (b)

Figure 3: Normal Concrete Slump Test
(a), (b) Slump Test

Table 4: Slump Test Results

Concrete With PET Substitution (%)			
Normal Concrete	**0.5**	**0.65**	**0.8**
10 cm	10 cm	9 cm	8 cm

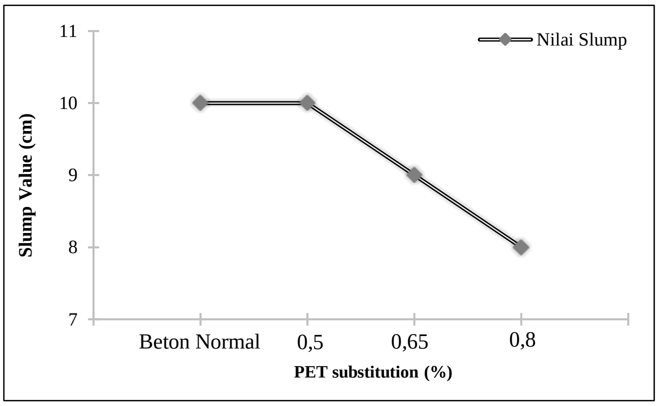

Figure 4: Graph of the Relationship Between PET Substitution and Slump Value

The research results in Table 4 and Figure 4 show that the slump value of the concrete mixture decreases in each variation. The research results show that normal concrete without the addition of PET fiber has the highest level *of workability , namely with a value of 10 cm, while the concrete mixture containing 0.8% PET plastic with a value of 8 cm* shows the lowest *workability compared to other PET proportions. Workability* in question is the level of ease of mixing concrete, mixing and pouring the concrete mixture into the mold. By adding PET plastic fibers measuring 1-3 mm wide and 5 cm long, it can lock and hold the concrete mixture so that the *workability level* is reduced. These results are in accordance with various previous studies which have been carried out as follows.

Previous research concluded that this factor is related to the physical properties of the PET fiber used and consists of rectangular fibers which influence the distribution of particles in the concrete mixture. Therefore, the interlocking of fibers that resist the flow of fresh concrete affects *the workability* of the concrete. Even though *the workability of* concrete decreases as the PET proportion increases, the slump value for all mix proportions is still proven to have a moderate level of [14]*workability* . The more total plastic fibers mixed into the concrete mixture will inhibit *fiber dispersion* and reduce *workability* as indicated by a smaller slump result [20].

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The results of this slump test research are similar to the results obtained where it was found that increasing PET fibers resulted in reduced *workability* of fresh concrete but still resulted in good *workability* . [21].

Flexible Strength

The analysis results of the flexural strength test of concrete containing PET plastic and normal concrete at the age of 14 days are shown in Figures 5 and 6 as well as the average flexural strength test results of 3 samples in Table 5.

(a) (b) (c)

Figure 5: 14 Day Flexural Strength Test Reading (kN)
(a), (b), (c) Test Objects

Table 5: 14 Day Flexural Strength Analysis Results

No	% Plastic	Concrete Age (Days)	Bending Test Equipment Readings		Flexural Strength (MPa)	Increase in Flexural Strength of PET Concrete compared to Normal Concrete (%)
			kN	kg		
1	0%	14 days	22.82	2327.30	3,043	-
2	0.5%	14 days	23.57	2403.09	3,142	3.26
3	0.65%	14 days	23.70	2416.69	3,160	3.84
4	0.8%	14 days	23.87	2433.68	3,182	4.57

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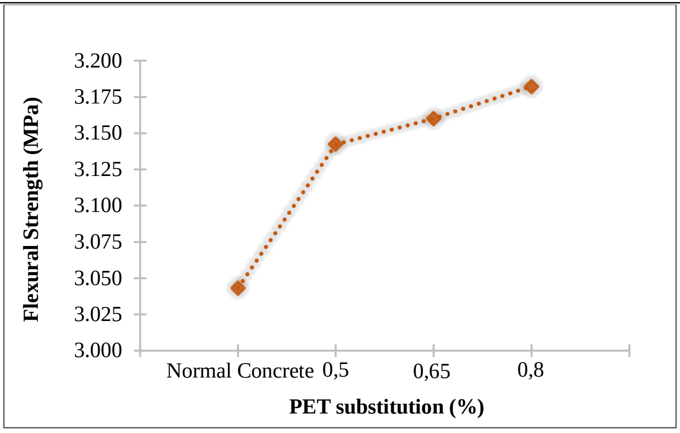

Figure 6: Graph of the Relationship Between PET Substitution and 14 Day Flexural Strength

From the test results in Table 5 and Figure 6 , when the concrete was 14 days old, the flexural strength of the concrete increased. It can be seen that concrete containing PET plastic fibers has a higher value than normal concrete. The highest flexural strength value was achieved by PET flexural strength with a percentage variation of 0.8% with a value of 3.182 MPa [22]. Stated that the factor that influences this is that the plastic fibers in the concrete mix are able to withstand the load so that direct collapse or total fracture does not occur due to the load so that adding plastic fibers to the concrete mix can increase the flexural strength value of the concrete. The tensile properties of PET fiber particles which are able to withstand tensile forces cause an increase in the flexural strength value of concrete [11].

The analysis results of the flexural strength test of normal concrete and concrete containing PET plastic when aged 28 days are shown in Figures 7 and 8 and the average Flexural strength results for 3 samples in Table 6.

(a) (b) (c)

Figure 7: 14 Day Flexural Strength Test Reading (kN)
(a), (b), (c) Test Objects

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Table 6: Results of 28 Day Flexural Strength Analysis

No	% Plastic	Concrete Age (Days)	Bending Test Equipment Readings		Flexural Strength (MPa)	Increase in Flexural Strength of PET Concrete compared to Normal Concrete (%)
			kN	kg		
1	0%	28 Days	23.90	2437.08	3,187	-
2	0.5%	28 Days	24.63	2511.86	3,285	3.07
3	0.65%	28 Days	24.77	2525.46	3,302	3.63
4	0.8%	28 Days	24.93	2542.45	3,325	4.32

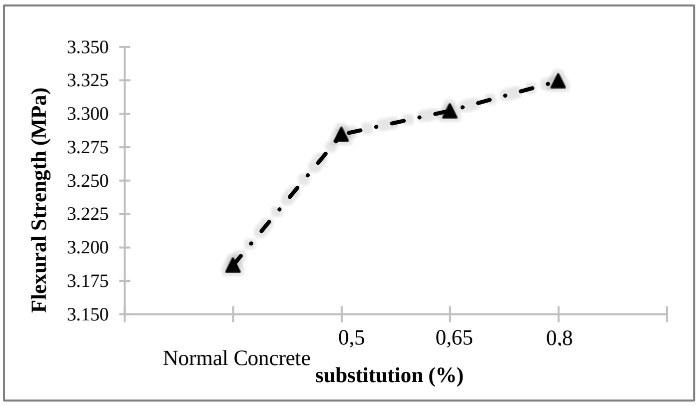

Figure 8: Graph of the Relationship Between PET Substitution and Flexural Strength at 28 Days

Based on the test results in Table 6 and Figure 8 , when the concrete is 28 days old, the flexural strength value increases along with the increase in PET plastic. The highest flexural strength value was achieved by PET flexural strength with a percentage variation of 0.8% with a value of 3.325 MPa. By increasing the percentage of PET plastic waste content in concrete, it can result in a gradual increase in its flexural strength [14].

The nature of the fiber is very influential and is able to increase the flexural strength value of the beam along with the addition of fiber at each percentage variation [23]. Based on the data that has been obtained, replacing some of the fine aggregate with PET plastic can increase the flexural strength value. This is in accordance with the results of several previous researchers that the interlocking nature of microcracks from PET fibers provides strength to the beam specimen to absorb stress [24]. The role of PET fiber as reinforcement in preventing fine micro cracks that form in the early stages of loading from propagating. PET fibers do not react chemically but act as bridging reinforcement to resist microcracks in the beam specimen. The low increase in strain shows that PET plastic fibers are able to resist cracks in the beam [15].

CONCLUSION

Based on the test results in this research, it can be concluded that the flexural strength characteristics of concrete using *Polyethylene Terephthalate* (PET) plastic as a substitute for fine aggregate have increased along with the increase in the number of PET percentage variations. When compared with normal concrete , concrete with 0.5% PET has a value of 3.285 Mpa and increases as big as 3.07% , PET variation 0.65% has a value of 3.302 MPa increase 3.63% and the 0.8% PET variation has a value of 3.325 Mpa increased 4.32%.

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