

# The Effect of the Mixture of Plastic Waste as a Lightweight Concrete Material

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**Abstract :** Concrete has many functions, and is also an important role in maintaining building stability and strength. By using plastic fiber as a lightweight concrete mixture material, it is expected to increase the compressive strength of the lightweight concrete, and also to reduce the negative impact of waste plastic bottles. In this study also added differences in FAS for each specimen 0.5 and 0.6. With the difference in variation in each lightweight concrete specimen, it is expected to be able to know the performance of concrete from the different variations of PET and FAS. The use of PET and FAS mixtures in lightweight concrete produces the lightest Concrete at 9% PET mixture of fine aggregate weight. In full there are two results, FAS 0.5 = 11045 gr, and FAS 0.6 = 10981 gr. But for the maximum weight of test specimens it cannot be said to be structural lightweight concrete because it does not meet the minimum weight requirement of 1850 Kg / m<sup>3</sup>. The Slump test on the specimen shows that the highest Slump test is in FAS 0.6 with 9% PET mixture, with slump height reaching 135 mm or 13 cm, and 125 mm or 12.5 cm in FAS 0.5 9% PET mixture. Cylinder absorbance showed that the average maximum absorption of FAS specimens was 0.5 = 1,268% and FAS 0.6 = 1,212%. The value of the lightest concrete compressive strength is the most optimum in the variation of 3% PET specimens in FAS 0.5 and variation of 6% PET specimens in FAS 0.6. that is 25 Mpa and 19 Mpa. And for the SPSS test states that there is a significant difference in the differences in the variation of PET and FAS test objects.

**Keywords :** Lightweight Concrete; FAS; PET; Variations; Test Objects.

## I. Introduction

Nowadays there are many uses of lightweight concrete for the construction of high-rise buildings. Its own use is usually focused on making nonstructural walls or concrete parts. Lightweight concrete currently has many variations, such as concrete with ingredients added to fly-ash, coconut shells, coconut fiber, plastic fiber and much more even for general needs.

The use of lightweight concrete with additional plastic waste materials has been studied by many previous researchers. Using plastic waste as a lightweight concrete mixture material is expected to increase the compressive strength of the lightweight concrete, and also to reduce the negative impact of plastic bottle waste.

The use of plastic waste as a lightweight concrete mixture is one of the solutions to reduce the impact of increasing use of plastic waste. The nature of non-biodegradable plastics (difficult to decipher) is a problem that is still a solution to this. The use of plastic waste itself has been widely varied with other building materials, now one solution for the control of plastic waste is limited to being burned or recycled into the same material. Plastic waste combustion will cause various harmful substances that can damage health and natural conditions.

Nurmantian, Purnawan, Wibowo, (2014) the use of lightweight concrete is still intended for non-structural concrete only because generally lightweight concrete has a maximum compressive strength of 15 MPa. The solution to increase the lightweight concrete strength of foam is to add fiber to the mixture in the form of polypropylene fibers.

There are many types of polyethylene plastic. One of them is PET (polyethylene terephthalate), Polyethylene is produced from the polymerization process of ethylene gas molecules which together form a series of molecular lengths to form a plastic (polymer). This research uses plastic waste with the type of polyethylene or commonly abbreviated as PET.

In this study also added differences in FAS for each specimen 0.5 and 0.6. It is expected that the results of this study can be an alternative to progress in the field of construction as well as one of the remedies for PET type plastic waste.

## II. Review of Literatures

### Concrete

Concrete is a function of its constituent material consisting of hydraulic cement, coarse aggregates, fine aggregates, water, and added ingredients. To know and study the behavior of combined elements (concrete constituent materials) requires knowledge of the characteristics of each component. Concrete has a large compressive strength while the tensile strength is small. Therefore for building structures, concrete is always combined with steel reinforcement to obtain high performance. The main characteristic of concrete, which is very strong against compressive loads, is also brittle / easily broken or damaged against tensile loads. In calculating the structure, the tensile strength of this concrete is usually ignored.

Concrete is the result of a mixture obtained by mixing Portland cement, water and aggregate (additives that vary greatly from additional chemicals, fibers to chemical building materials with certain comparisons).

If you want to make good quality concrete, in the sense that it meets more stringent requirements because of higher demands, it must be carefully considered the ways to get a good mix of concrete (fresh concrete) and hardened concrete produced is also good.

### Lightweight Concrete

Lightweight concrete is basically divided into several types, namely those with different weight / weight, namely lightweight concrete, heavy concrete and normal concrete, usually concrete has density according to the needs of the concrete itself. Lightweight aggregates can form light-weight concrete. The terminology of ASTM C.125 defines that light aggregate is an aggregate that produces lightweight concrete, including pumice, scoria, clay burning, perlite, slag and so on.

### PET waste

PET plastic waste (polyethylene terephthalate) often known by another name polyester is a thermoplastic resin polymer from the polyester group. PET is widely used in manufacturing such as beverage bottles, resin plastic, and a mixed material for making glass. PET is one of the most important ingredients in the textile industry, around 60% of PET fiber is used in the form of synthetic fibers, and bottle production reaches 30% of world demand. Usually PET is called polyester. PET consists of polymerization of ethylene terephthalate monomer units with repetition of C<sub>10</sub>H<sub>8</sub>O<sub>4</sub> units. PET is generally recycled and given the number "1" which indicates the symbol can be recycled.

Bottles of packaging made with PET, if used too often and affected by high temperatures / heat, will cause the polymer layer to melt and release substances that are carcinogenic (toxic).

Polyethylene terephthalate, called PET, is a high polymer derived from dehydrated ethylene terephthalate condensation. Ethylene terephthalate originates from the esterification of terephthalic acid with ethylene glycol. PET is milky white or light yellow, the polymer is very crystalline, and the surface is smooth and shiny.

In a wide temperature range with excellent physical and mechanical properties, long-term use temperature of up to 120 °C, excellent electrical insulation, even at high temperatures and high frequencies, electrical performance is still good, but corona resistance is less, Creep resistance, fatigue. Resistance, abrasion resistance, good dimensional stability.

### Factor of Cement Water

The cement water factor (FAS) is the weight of water divided by the weight of the low cement causing the aggregate grains to be small and the grain spacing to be short. If the cement water factor is too high then the slump will drop, this causes a decrease in compressive strength.

The cement water factor (FAS) is a ratio between the amounts of water to the amount of cement in a concrete mixture, the function of the cement water factor, namely: To allow chemical reactions that cause binding and hardening to take place, and facilitate workability. The higher the value of cement water factor, the lower the quality of the concrete strength. However the value of the cement water factor which is getting lower does not always mean that the strength of the concrete is getting higher. The value of cement water factor given is at least 0.4 and a maximum of 0.6. (Muhammad, Srikirana, 2017).

## Testing

### Concrete Tensile Strength

Concrete compressive strength is the most important characteristic and one of the main performance of hard concrete, and is generally considered in planning concrete mixes. The concrete compressive strength is the concrete strength that holds the load in units of area.

Compressive strength is the ability of concrete to withstand how much force the force will be given in broad unity, but in the concrete still small drawings testing of concrete compressive strength can use compressive test equipment and cylindrical specimens measuring 150 mm x 300mm, by following SNI procedures or even ASTM C-39.

Several factors such as the size and shape of the aggregate, the amount of cement used, the amount of water usage, the proportion of the concrete mixture, the treatment of concrete (curing), the concrete age of the sample size and shape, can affect the compressive strength of the concrete.

The compressive strength of the concrete specimen is calculated by the formula:

$$f_c' = \frac{P}{A}$$

fc : Compressive strength (kg/cm<sup>2</sup>)

P : Press load (kg)

A : Surface area of the test object (cm<sup>2</sup>)

### III. Research Methods

The research method was carried out by experimental methods carried out in the laboratory.

#### Research Materials

1. 40 kg Portland Type-I cement, Semen Padang. With the condition that the cement is still tightly closed.
2. Smooth Aggregate in the form of River Sand from Binjai.
3. Aggregate Coarse Stone broken, from Tangkahan Patumbak with an average diameter of 20 mm.
4. Additional aggregates in the form of PET plastic fibers that have been processed into solid shapes and crushed to the size of sand.
5. Clean water free of organic content or water in the field PDAM.

#### Preparatory stages

1. Examination of fine aggregates (Sand), including: Test and analysis according to SNI SK namely filter analysis, water content, Saturated Surface Dry (SSD) water content, sludge content, specific gravity.
2. Coarse aggregate inspection, including: Test and analysis according to SK SNI, namely filter analysis, water content, sludge content, weight, density.
3. The PET aggregate examination includes: Test and analysis according to SNI SK namely filter analysis, water content, sludge content, fill weight, specific gravity.
4. Mix design with the SNI method after all data needed for the examination of the mixture material is obtained.

### IV. Results and Discussion

#### Test Result

The results of fine aggregate inspection can be seen in Table 1.

**Table 1.** Results of Fine Aggregate Examination

Examination	Result	Specifications / conditions
Sludge levels	2,6 %	< 5%
Sieve analysis	2,77	2,2 < 2,77 < 3,20
Content weight	1.232 kg/cm <sup>3</sup>	1.125 kg/m <sup>3</sup>
Absorption %	1,87 %	< 5%

Source: Research Results of 2018

The results of the rough aggregate examination can be seen in Table 2.

**Table 2.** Results of Rough Aggregate Examination

Examination	Result	Specifications / conditions
Sludge levels	0,60 %	< 5%
Sieve analysis	7,27	5,50 ~ 7,50

Content weight	1.679 kg/cm <sup>3</sup>	>1.125 kg/m <sup>3</sup>
Absorption %	1,72 %	< 5%

Source: Research Results of 2018

The results of PET aggregate inspection can be seen in Table 3.

**Table 3.** Results of PET Aggregate Examination

Examination	Result	Specifications / conditions
Sieve analysis	2,58	2,20 < 2,58 < 3,20
Content weight	873,67 kg/cm <sup>3</sup>	> 1.125 kg/m <sup>3</sup>
Absorption %	1,29 %	< 5%

Source: Research Results of 2018

The results of the mix mix of concrete mix designs can be seen as follows:

**Table 4.** Material requirements 5 specimens measuring 15x30 cm for fas 0.5

Variation	Cement (kg)	Sand (kg)	Gravel (kg)	PET (kg)	Water (Ltr)
0%	10,86	24,31	32,22	0	6,5
3%	10,86	23,58	32,22	0,729	6,5
6%	10,86	22,85	32,22	1,458	6,5
9%	10,86	22,12	32,22	2,18	6,5

Source: Research Results of 2018

**Table 5.** Material needs 5 specimens measuring 15x30 cm for fas 0.6:

Variation	Cement (kg)	Sand (kg)	Gravel (kg)	PET (kg)	Water (Ltr)
0%	9,05	26,2	32,11	0	6,5
3%	9,05	25,48	32,11	0,788	6,5
6%	9,05	24,69	32,11	1,576	6,5
9%	9,05	23,90	32,11	2,364	6,5

Source: Research Results of 2018

Test results

**Table 6.** Results of weight of the test specimen 0.5

No	Variation	Weight of the Test Object
1	0%	11448
2	0%	11397
3	0%	11455
4	0%	11389
5	0%	11323
1	3%	11360
2	3%	11308
3	3%	11315

4	3%	11327
5	3%	11303
1	6%	11166
2	6%	11254
3	6%	11247
4	6%	11245
5	6%	11251
1	9%	11102
2	9%	10986
3	9%	11017
4	9%	11039
5	9%	11082

Source: Research Results of 2018

**Table 7.** Results of weight of fas test object 0.6

No	Variation	Weight of the Test Object
1	0%	11313
2	0%	11165
3	0%	11379
4	0%	11439
5	0%	11511
1	3%	11371
2	3%	11283
3	3%	11307
4	3%	11129
5	3%	11245
1	6%	11275
2	6%	11218
3	6%	11045
4	6%	11011
5	6%	11178
1	9%	10960
2	9%	10934
3	9%	11072
4	9%	10980
5	9%	10959

Source: Research Results of 2018

Based on the test results in the table above it can be seen that the addition of PET fibers tends to reduce the weight of lightweight concrete. The maximum reduction in the weight of lightweight concrete is found at 9% PET mixture of fine aggregate weight. In full there are two results, FAS 0.5 = 11045, gr, and FAS 0.6 = 10981 gr

The results of the slump test specimens can be seen in the following table:

**Table 8.** results of 0.5 slump test results

No	Variation	Slump
1	0%	
2	0%	
3	0%	110
4	0%	
5	0%	
1	3%	
2	3%	
3	3%	110
4	3%	
5	3%	
1	6%	
2	6%	
3	6%	120
4	6%	
5	6%	
1	9%	
2	9%	
3	9%	125
4	9%	
5	9%	

Source: Research Results of 2018

**Tabel 9.** Slump Results test fas 0,6

No	Variation	Slump
1	0%	
2	0%	
3	0%	120
4	0%	
5	0%	
1	3%	
2	3%	
3	3%	120
4	3%	
5	3%	
1	6%	
2	6%	
3	6%	130
4	6%	
5	6%	
1	9%	
2	9%	
3	9%	135
4	9%	
5	9%	

Slump testing shows workability in lightweight concrete when mixing. With the results of these tests, it can be seen that the highest Slump test is in FAS 0.6 with a 9% PET mixture, ie with slump heights reaching 135 mm or 13 cm, and 125 mm or 12.5 cm on FAS 0.5 with variations of PET 9 mixture % on lightweight concrete.

The results of the absorption of specimens can be seen in the following table:

**Table 10.** Results of absorption of fas test specimens 0.5

No	Variation	Dry test weight	Heavy wet object	Absorption %
1	0%	11448	11554	0,93
2	0%	11397	11524	1,11
3	0%	11455	11543	0,77
4	0%	11389	11557	1,48
5	0%	11323	11535	1,87
1	3%	11360	11446	0,76
2	3%	11308	11435	1,12
3	3%	11315	11453	1,22
4	3%	11327	11420	0,82
5	3%	11303	11448	1,28
1	6%	11166	11321	1,39
2	6%	11254	11310	0,50
3	6%	11247	11329	0,73
4	6%	11245	11301	0,50
5	6%	11251	11334	0,74
1	9%	11102	11106	0,04
2	9%	10986	11108	1,11
3	9%	11017	11097	0,73
4	9%	11039	11085	0,42
5	9%	11082	11102	0,18

Source: Research Results of 2018

**Table 11.** Results of absorption of fas test material 0.6

No	Variation	Dry test weight	Heavy wet object	Absorption %
1	0%	11313	11529	1,91
2	0%	11165	11510	3,09
3	0%	11379	11521	1,25
4	0%	11439	11506	0,59
5	0%	11511	11515	0,03
1	3%	11371	11410	0,34
2	3%	11283	11398	1,02
3	3%	11307	11387	0,71
4	3%	11129	11387	2,32
5	3%	11245	11401	1,39
1	6%	11275	11282	0,06
2	6%	11218	11264	0,41



3	6%	11045	11298	2,29
4	6%	11011	11256	2,23
5	6%	11178	11280	0,91
1	9%	10960	11101	1,29
2	9%	10934	11086	1,39
3	9%	11072	11081	0,08
4	9%	10980	11070	0,82
5	9%	10959	11095	1,24

Source: Research Results of 2018

Concrete absorption according to 03-0349-1989, maximum water absorption is 10%. The highest average absorption of FAS specimens was 0.5 = 1.268% and FAS was 0.6 = 1.212%, so the cylinder test material absorption met the requirements.

The results of the compressive strength test specimens can be seen in the following table:

**Table 12.** Results of absorption of fas test specimens 0.5

No	Variation	Maximum load (KN)	Maximum load (Mpa)
1	0%	380	21,5
2	0%	380	21,5
3	0%	360	20,37
4	0%	370	20,93
5	0%	380	21,5
1	3%	450	25,46
2	3%	470	26,59
3	3%	450	25,46
4	3%	460	26,03
5	3%	450	25,46
1	6%	380	21,5
2	6%	440	24,89
3	6%	390	22,06
4	6%	400	22,63
5	6%	410	23,20
1	9%	300	16,97
2	9%	280	15,84
3	9%	310	17,52
4	9%	290	16,41
5	9%	310	17,52

Source: Research Results of 2018

**Table 13.** Results of absorption of fas test material 0.6

No	Variation	Maximum load (KN)	Maximum load (Mpa)
1	0%	350	19,80
2	0%	360	20,37

3	0%	350	19,80
4	0%	350	19,80
5	0%	350	19,80
1	3%	340	20,37
2	3%	330	18,10
3	3%	340	19,24
4	3%	340	19,80
5	3%	330	20,37
1	6%	360	19,24
2	6%	320	18,67
3	6%	340	19,24
4	6%	350	19,24
5	6%	360	18,67
1	9%	280	15,84
2	9%	260	14,71
3	9%	260	14,71
4	9%	250	14,14
5	9%	260	14,71

Source: Research Results of 2018

The results show the most optimum compressive strength of cylindrical specimens in the variation of 3% PET specimens in FAS 0.5 and variations in the 0% PET test specimen in FAS 0.6 which is 25 Mpa and 19.9 Mpa.

## V. Conclusion

From the results of research and discussion that has been done on cylindrical lightweight concrete specimens. Then the results are as follows:

1. The lightest weight of the concrete cylinder is found at 9% PET mixture of fine aggregate weight. In full there are two results, FAS 0.5 = 11041.40 gr, and FAS 0.6 = 10824.4 gr. It can be said that the fine PET aggregate reduces the weight of the concrete itself.
2. The test results of the Slump test on specimens show that the highest Slump test is in FAS 0.6 with a 9% PET mixture, i.e. with slump heights reaching 135 mm or 13 cm, and 125 mm or 12.5 cm in FAS 0.5 with a variation of 9% PET mixture on concrete. Then it can be concluded that the addition of the cement water factor in the concrete can increase the amount of water or the mortar has high (dilute) friction.
3. The results of the absorption of cylindrical specimens show that the average absorption of the highest FAS specimens is 0.5 = 1.268% and FAS 0.6 = 1.212%, whereas according to the maximum absorption requirements is 10%, the cylinder test specimens meet the requirements.
4. The value of compressive strength of lightweight concrete with PET mixture as a substitute for fine aggregate shows the most optimum compressive strength of cylindrical specimens in variation of PET test material 3% in FAS 0.5 and variation of 0% PET test material in FAS 0.6 which is 25 Mpa and 19.9 Mpa. It can be concluded that the effect of adding PET tends to increase the compressive strength of the concrete and the effect of the addition of FAS tends to reduce the value of the compressive strength of the concrete.

## Suggestion

From the results of the research that has been done, the suggestions that can be conveyed for this research and subsequent research are. In making mix designs the results of mixing are done more carefully so that the mixture on the mortar can be more evenly distributed. For the use of gravel or broken stones should be reduced or replaced with lighter materials, because it affects the specific gravity of the concrete.

The PET or plastic fiber material used should use plastic seeds from the manufacturer or workmanship with a special plastic crusher machine so that the aggregate size and weight of each aggregate can be equated to facilitate workmanship.

For the development of further research can use a number of variations that are more or the same but without using broken stones as coarse aggregates. The waste plastic used can be varied to replace the cement water factor so that the best plastic material can be seen.

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