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THE EXPERIMENTAL ON HARDENED CONCRETE M20 GRADE CONTAINS PET PLASTIC POWDER

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ABSTRACT

The usage of recycled material has been increased on buildings, things that bring the continuous or influence the use of material kind in construction industries. This experimental was conducted using a waste material as replacement or alternative for concrete mix design. Was casted lightweight concrete in M20 grade and the proportion of the partial replacement of concrete was 0%, 1.0%, 5.0%, 10.0%, 12.5%, 15.0%, and 20.0% by weight of sand. The experiment was conducted, using cubes specimens, were casted a compression, split tension and flexural strength test at third days, 7 and 28 days curing of concrete. The result of this experimental show that the properties of M20 grade using PET plastic powder as fine aggregate shows many advantages. Was found that amount of the PET plastic powder, generally can improves the properties up to 10.0% of mix proportions of replacement in concrete. And the strength in the concrete after 10.0% of mix proportion with PET plastic powder was decreasing. For this study, the optimal replacement was found in amount of 10.0% of mix proportion.

KEYWORDS: Concrete, fine Aggregate and PET plastic powder.

1. INTRODUCTION

The polyethylene terephthalate (PET) is a material that is present in every country in modern life,[1] and is the one of the plastic material most used or is one of the most abundant in the

urban waste in the world.[2,3] This waste material is being considered a non-biodegradable making it remaining in long time and being a big problem in the environment. The usage of PET plastic as an aggregate in concrete substituting sand can be considered when used properly.[3,4,5]

The waste PET can be considered or applied to modify concretes, the incorporation of PET bottle as reinforcement have indicated improvement in concrete and can be considered in civil construction industry.[6]

As recycled material, PET is widely and can contribute in construction material in concrete. The usage of plastic as an aggregate to substitute sand in the concrete is to improve the properties of concrete also to make or to save the environment in the earth. When used PET plastic as fine aggregate in concrete is not necessary to purify this recycled material, things that minimize costs of project[4] also PET have been seen as lightweight and also is easy to handle.[7]

The usage of PET in concrete as fine aggregate has shown a good results, where it seen in removing of wastes in the environment, preventing as well the pollution in the world and also the energy economized.[2]

The aims of this experimental is regarding on to finding the optimal replacement of PET plastic powder in concrete M20 grade according with IS 456 (2000), the study was conducted on the three tests of strength, following (Compressive strength, split tensile strength and flexural strength).

Was studied and found that the normal concrete can suddenly fail and the cubes can be broken easily although the concrete with plastic aggregate was not failed suddenly,[8] the study report that PET can increase the shrinkage when the treatment temperature is rising and its crystallinity decrease.[9]

Saikia N. and Brito Jorge (2013), reported that the incorporation of all type of PET aggregate in mix concrete was indicate a development of compressive strength which is similar to conventional concrete, they also found that, any type of PET aggregate incorporated in concrete, the compressive strength was significantly lower. Although when is incorporated the PET aggregate it can increase toughness behavior of concrete.[10]

Rao M. M and Ravula R. G (2018), reported that the compressive strength of concrete with PET aggregates was decreasing because increasing of PET plastic at 15% replacement level in concrete. And also was found that the split tensile strength was increasing than the concrete mix control. The flexural strength was found decreasing at 15% of replacement.[11]

Ramadevi K. and Manju R. (2012), studied the incorporation of PET bottle fibers in concrete, and they found that the split tensile casted in cylinder and compressive strength casted in cubes was increasing until 2% of replacement, and the flexural strength is increase up to 2% and at 4% of replacement start to decrease.[12]

1.1 Significance of experimental

The experimental was found relevant due to the usage of waste material, knowing that PET Plastic is non-biodegradable material, using this material making the world become cleaned step by step, also the usage of PET plastic powder as fine aggregate to make an improvement of concrete on its mechanical properties, being that the proportions in M20 grade.

2. THE EXPERIMENTAL AND PROCEDURES

2.1. Materials

2.1.1. Cement, Water and Aggregates

In this study, the Ordinary Portland cement was used and the grade of 43 using the IS 8112.1989,[13] with physical and chemical properties in the table 1 according to.[13,14,15] The water used in the mix design had a 6 - 8 of pH, specifically was used normal water for drink in IS 456 (2000).[14,15,16] The aggregate in this experiment fine aggregate and coarse aggregate was considered.

Table 1: physical and Chemical properties of ordinary portland cement.

SI. no	Content	Requirement
1	**Physical properties**	
1.1	Minimum compressive strength	
1.1.1	3 – day	23
1.1.2	7 – day	33
1.1.3	28 – day	43
1.2	Fineness	
1.2.1	Minimum specific surface (m^2/kg)	225
1.3	Soundness, expansion	
1.3.1	Le Chatelier test (mm), Max	10.0
1.4	Setting time (min)	
1.4.1	Initial, min	30
1.4.2	Final, max	600

2	**Chemical Properties**	
2.1	Loss on ignition (%), max	5.0
2.2	Insoluble residue (%), max	2.0
2.3	Magnesio MgO (%), max	6.0
2.4	Total sulphuric anhydride (SO_3)	3.5

2.2. Concrete Mix

The PET aggregates was mixed with sand at the same amount and cement in the first of all, at second time, gravel and other remain sand was mixed together. After was added water to start to hydrate and saturate the particles. After was mixed the others existing materials eventually. The study was conducted for M20 grade of concrete mix design, with proportions of 1: 1.5: 3: considering that the water cement ratio was 0.5.

The mix proportions of PET plastic powder were added in the matrix of concrete in proportion of 0%, 1.0%, 5.0%, 10.0%, 12.5%, 15.0%, and 20.0% in volume.

2.3. Specimens and Performing tests in laboratory

The compressive strength test was casted, using a cubical specimen of 150mm x 150mm x 150mm as is written in IS: 516 –1959,[17] the cube specimens used in the were metal structure. For tensile strength test was used a specimen of size 150 mm and 300 mm according to IS: 5816 – 1999.[18] Also was performed flexural strength in the specimens with size of 150mm x 150mm x 700mm, according with IS: 516 –1959.[17]

2.4. Methods used in the experiment

For the study, to obtain the variation of the unit weights was found by measuring that weight of dry in comparison with the same weight of the reference specimen for all ages.

The issue in this experimental is to discover the hardness regarding to the compressive strength, tensile and flexural strength after dried the specimen for half hour at 3rd, 7 days and 28 days.

2.4.1. Compressive strength test

In this experimental the hardened concrete are tested for compressive strength, tensile strength and flexural strength as well till 28 days. Performing the tests, for compressive strength test, the concrete specimens were reached the ultimate strength by application of the axial compressive load. Was calculated the compressive strength dividing the load which is maximum to its cross section area, the proportions of aggregates can be shown in table 2.

Table 2: Concrete mix proportions for compressive strength test.

Component	0.0% PET	1.0% PET	5.0% PET	10.0% PET	12.5% PET	15.0% PET	20.0% PET
	w/c = 0.5						
	Content	Kg/m^3					
Cement	12.15	12.15	12.15	12.15	12.15	12.15	12.15
Fine Aggregate	18.23	18.05	17.32	16.41	15.95	15.50	14.58
PET Plastic Powder	0	0.18	0.91	1.82	2.28	2.73	3.65
Coarse Aggregate	36.45	36.45	36.45	36.45	36.45	36.45	36.45

2.4.2. Flexural strength test

Was determined the concrete mix control to find the flexural strength, and was found that the cement 56.7 kg/m^3 in the mix design concrete in proportions of 1: 1.5: 3: 0.5 according to the IS 456 (2000) for M20 grade concrete.[16] Plastic Powder was found in amount as illustrated in table 3

The flexural strength of the concrete on specimen in this study was made at 28 days. Was placed on two supports where is near of two ends and was applied the load until collapsed.

Table 3: Concrete mix proportions for flexural strength test.

Component	0.0% PET	1.0% PET	5.0% PET	10.0% PET	12.5% PET	15.0% PET	20.0% PET
	w/c = 0.5						
	Content	Kg/m^3					
Cement	56.70	56.70	56.70	56.70	56.70	56.70	56.70
Fine Aggregate	85.05	84.20	80.80	76.55	74.42	72.29	68.04
PET Plastic Powder	0	0.85	4.25	8.51	10.63	12.76	17.01
Coarse Aggregate	170.0	170.0	170.0	170.0	170.0	170.0	170.0

2.4.3. Splitting tensile strength test

To perform a tensile strength test, was considered concrete mix in proportions 1: 1.5: 3: 0.5 as is written IS 456 (2000) for M20 grade concrete,[13] Was found that for the concrete mix control was 19.09 kg, Plastic Powder to replace sand is shown in table 4.

Tensile strength test was performed and a cylindrical specimen was horizontally placed in a ring, and the was applied a force along the specimen vertical axis until happen an facture.

Table 4: Concrete mix proportions for splitting tensile strength test.

Component	0.0% PET	1.0% PET	5.0% PET	10.0% PET	12.5% PET	15.0% PET	20.0% PET
	w/c = 0.5						

	Content	Kg/m^3					
Cement	19.09	19.09	19.09	19.09	19.09	19.09	19.09
Fine Aggregate	28.63	28.34	27.20	25.78	25.05	24.34	22.90
PET Plastic Powder	0	0.29	1.43	2.86	3.58	4.29	5.73
Coarse Aggregate	57.26	57.26	57.26	57.26	57.26	57.26	57.26

3. RESULTS AND DISCUSSIONS

3.1. Compressive strength

First of all, is very good to know that, the specimen was cured at the room temperature, for measure the compressive strength, was used the average of three specimen for each proportion in 0%, 1.0%, 5.0%, 10.0%, 12.5%, 15.0%, and 20.0%, the code proportion used is in the table 5

Table 5: Code proportion used.

Mix code	**M0**	**M1**	**M5**	**M10**	**M12.5**	**M15**	**M20**
Mix proportion	0%	1%	5%	10%	12.50%	15%	20%

The results show that, using PET plastic powder can be improved the compressive strength, but is there an attention taken in consideration. The amount of PET aggregates influence the compressive strength in concrete.

In order to find the influence of PET plastic powder in concrete was found that with increasing of PET plastic powder the figure 1 shows that, incorporation of PET increase until 10%, after this, the compressive strength starts to decrease.

The compressive strength of concrete contains PET plastic powder, at 5% of replacement by sand, increase regarding of the shape of plastic aggregates, the percentage of the efficient incorporation, it reach up to 10%. After this it starts to decrease, because of lake of cohesion between matrixes with the PET plastic aggregates. The effect of PET plastic powder aggregates on compressive strength test in concrete is shown in the figure 1.

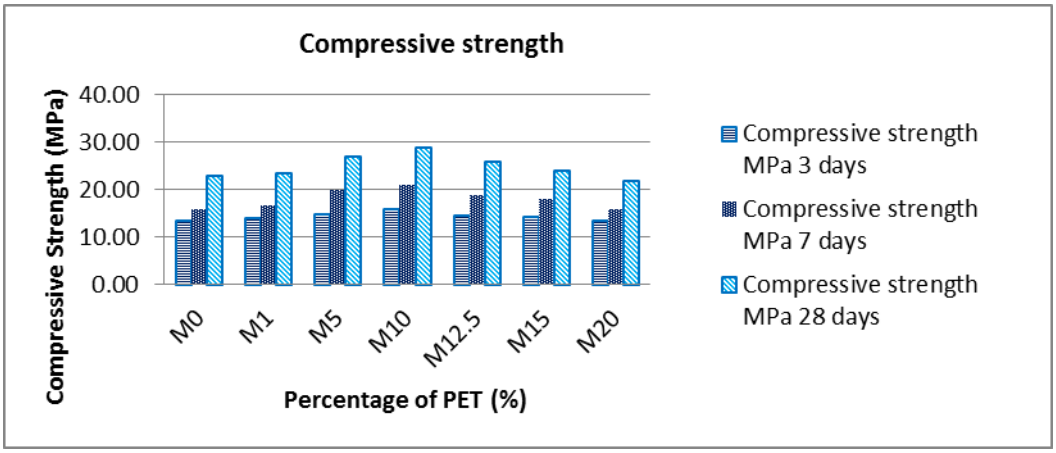

Figure 1: Effect of PET plastic powder aggregates on compressive strength in concrete.

According to Patel Deep and Jamani Abbas (2018), they reported also that the result of incorporation of PET in concrete is approximately found in this experiment.[19] In mortars the incorporation of PET plastic powder can decrease the compressive, because there some existence of week bond.[20]

Siddique Rafat (2008) reported that the compressive strength result using a length of fiber 19 mm of polypropylene was found without any effect on the compressive strength, and also studied a length of 12.7 of fiber in concrete where found that the compressive strength was improved with 0.5% of proportions in volume.[21]

The other study of influence of plastic on hardens concrete show that the incorporation of plastic decreases the compressive strength.[22] Also the results of this experiment show an approximation of, with the results of Rahmani E. et al (2013) when they found that the compressive strength increase up to 10%, and with 15% of incorporation is decreasing.[2]

Ismail, Z. Z., & AL-Hashmi, E. A. (2008), reported that using waste plastic in concrete the compressive strength was found decreasing compared with the values of the concrete control mix, attributing a decrease of adhesive strength between the cement paste and surface of waste plastic.[23]

3.2. Split tensile strength

To determine the tensile strength of this experimental study was followed the IS 5816 – 1999. The standard size of 300 mm and 150 mm a cylindrical specimen was used for the test.

The results in figure 2 shows that when the PET plastic powder aggregates is increased, the split tensile strength increase up to 10% of incorporation in concrete, the increasing of amount of PET decrease from 12.5% in this experimental because the highlight of PET plastic and also is smoother than sand in comparison, from this incorporation the surface or interface between aggregates in the concrete is weakened. The effect of PET plastic powder aggregates on split tensile strength test in concrete is shown in the figure 2.

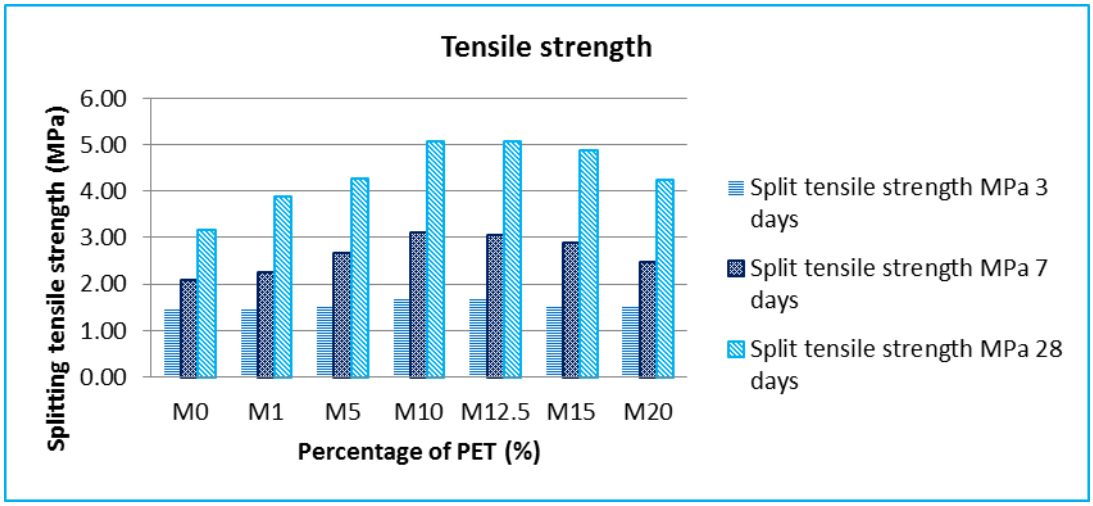

Figure 2: Effect of PET plastic powder aggregates on split tensile strength in concrete.

According to Yang Shutong et al (2015) says that the splitting tensile strength at the replacement level of 15% are improved at maximum, and as the substitution increases the strengths decrease because of weakened interface between aggregates, that's why the many plastic aggregates pulled out from the paste.[24]

When the incorporation is being made by plastic bag waste fibers in concrete, the tensile strength is higher than the concrete without plastic, and was found that the variation or the different results is due to the amount of plastic.[25]

Mastan Vali N and SS. Asadi (2017), reported that the split tensile strength was found increasing until 10% of replacement in concrete,[26] and their results regarding to split tensile is near of the results of this experimental.

3.3. Flexural strength

The modulus of rupture was determined using three specimens at 3, 7 and 28 days. The specimen was found subjected to bending tests, there was a concentrated load applied to the

concrete specimen to discover their properties, the tests was being made following the instructions according to IS: 516 –1959.

The results show that the incorporation of PET plastic powder in concrete is higher than the concrete without plastic powder from the 0% up to 10% of incorporation of PET plastic aggregate. The decreasing start after 10%, this means that the flexural strength of the concrete with plastic aggregates is better in comparison with the results found in the concrete without plastic aggregates, as illustrated in graphic 3. The effect of PET plastic powder aggregates on flexural strength test in concrete is shown in the figure 3.

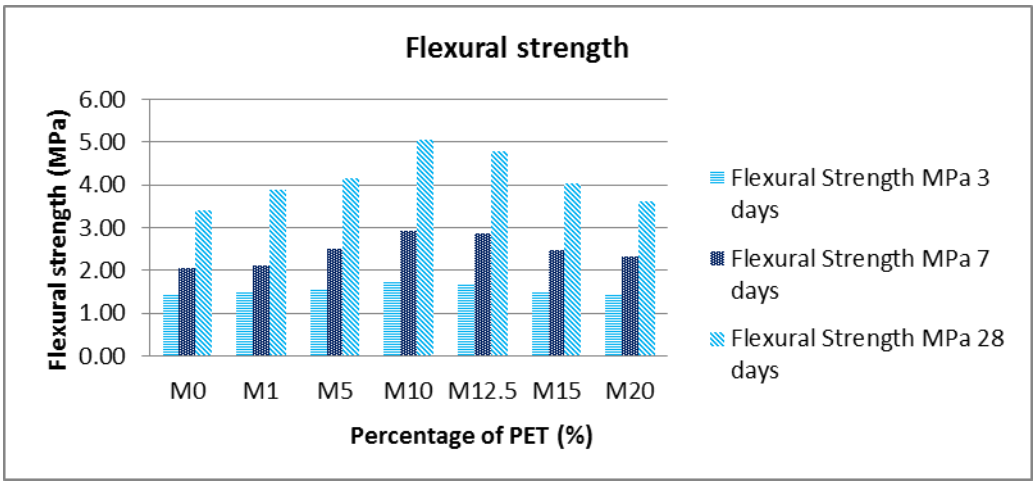

Figure 3: Effect of PET plastic powder aggregates on flexural strength test in concrete.

Ghernouti Youcef et al (2015), they found also results that are near of the results of this experiment. They say that the result of flexural strength of all reinforced concrete was higher than the control concrete. For them, concluded that there some improvements that's come from or depends on the type, length and amount of fibers. They incorporate 2 cm, 4 cm and 6 cm and were found that is improved with length of 4 cm and 6 cm because the shape of this recycled material was occurring in vertical and oblique way protecting the micro cracks. This means that the bond between the fibers and the matrix was strong. Was found also that the specimen without fibers get a cracks early than the concrete with fibers.[25] For Jibrael M. A. and Peter Farah (2016), found that when there is an increasing of ratios of plastic the modulus of rupture is decrease.[27] And The results found in this experimental is near of the results found in report of Mastan Vali N and SS. Asadi (2017), they found that also the flexural was expanded until 10%.[26]

Ismail, Z. Z., & AL-Hashmi, E. A. (2008), they found that the flexural strength of concrete containing waste plastic ten to decrease compared with the concrete without waste plastic fiber, was found concrete with 20% of replacement lower at 28 days curing age.[23]

4. CONCLUSION

The use of PET plastic powder in concrete as fine aggregate shows many advantages in its application on concrete.

Was found that amount of the PET plastic powder, generally can improves the properties up to 10% of mix proportions of replacement in concrete.

When increasing the plastic powder with 1%, 5% and 10% of mix proportion the strength of the concrete was increasing.

The strength was found decreasing in the concrete after 10% of mix proportion with PET plastic powder because of the weakened bond and the highlight of the plastic aggregates.

Using plastic powder in concrete as fine aggregate the split tensile strength after 10% of mix proportion shows a decreasing gradually when it compared with compressive and flexural strength in this experimental.

For this experiment, the optimal replacement was found in amount of 10% of mix proportion.

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