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Replacement of Fine Aggregates with Waste PET in Concrete having Marble Dust as Additive

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Abstract

Plastics are the awfully extensively used material, a standout amongst the most widely recognized plastic in urban waste is PET (Polyethylene Terephthalate) which are used as a crude material for sodas, pop jugs, mineral water bottles and other customer materials. It becomes waste after use and cause pollution to environment so needs solution for this. **Objective:** The goal of this paper is to study the impact of pulverized PET in concrete and quality change by using this waste as a substitute. **Method:** In this investigation concrete with 0%,4%,8%,12% and 16% PET supplanting with fine aggregates was done with 2% expansion of marble dust as an added substance to expand the quality of PET concrete. Scanning Electron Microscope (SEM) and X ray Diffraction (XRD) tests were performed on the specimens prepared to know about the shape and nature of PET molecules so that future modifications could be done with the prevailing results. **Findings:** Increase in strength by the addition of PET particles, also marble dust addition enhances the properties of PET concrete. SEM test shows magnifying image of particles present in PET concrete and XRD test shows the d spacing of particles and type of components in it. **Application:** Improves the concrete quality and utilization of waste product as PET waste and marble dust waste, protecting the environment.

Keywords: Concrete, PET,SEM, XRD

1. Introduction

Among all the wastes, plastic waste is very large in context to others[1]. PET waste are maximum in these plastic waste which are used as a crude material for packaging purpose of mineral water, soda and other shopper materials[2]. The PET transfer is exceptionally real issue and its debasement causes natural contamination along with other harmful effects to species living as when these wastes are burned forms toxic gases causing breathing problems to the living organisms[3]. Also as PET are discarded by burning and landfills causing air contamination and land contamination to the earth, so there is a need of use of this waste in a manner which will not cause any harm to the environment[4-7].

Concrete is the most generally utilized material in civil industry. It has the properties of high strength, low cost, structural stability & durability etc. The use of plastic in concrete improves the basic properties of concrete, so PET waste utilization in concrete is a strategy to take out the destructive impacts of PET to condition thus less ecological debasement happens[8]. Additionally marble dust builds the quality of concrete which is regularly not appeared with the option of pounded PET containers[9-11], after an estimation of 8% so it can similarly be used as a piece of PET concrete to improve the nature of concrete. In the accompanying investigation smashed PET replaces fine totals in concrete and comparison of this modified concrete with conventional concrete has been undertaken.

Compressive quality, Split Tensile Strength and Flexural Strengths has been seen in this examination on specimens following 7, 28 and 56 days of restoring or curing. Also SEM and XRD tests have been done for the

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samples of PET concrete with marble dust as additive. The SEM test gives the magnifying image of the sample elements inside the specimen and XRD gives the d-spacing of the molecules present in the specimens which gives the idea of arrangement of molecules of plastic and the bonding & spacing of elements inside the specimen.

2.Materials Used

- **Cement:** Cement utilized as a binder in concrete blend. Concrete utilized as a part of this is OPC cement of grade 43 affirming to IS 8112:1989 which should be free from lumps having specific gravity of 3.13, bulk density 1440kg/m^3, initial setting time as 35 min and final setting time as 450 min respectively.
- **Fine Aggregate:** Fine aggregates used are of river sand which is free from organic impurities and passed through 4.75mm size sieve of Zone II confirming to IS383-1970 having specific gravity 2.65 , fineness modulus 2.85, bulk density 1700 kg/m^3.
- **Coarse Aggregate:** The Coarse aggregates are obtained from an area quarry which can be of prolonged, irregular and angular shape. The coarse total is utilized with estimate somewhere in the range of 10mm and 20mm having a particular gravity 2.84, fineness modulus 7.3, bulk density 1800kg/m^3.
- **Crushed PET:** PET bottles are collected from the waste dump and clean properly then crushed by the pulveriser machine to the size less then 4.75mm most of them ranging between 150 microns and 1.18mm size having specific gravity as 1.06 , fineness modulus of 2.3, density of 1.3-1.4 g/cm^3.
- **Marble dust:** Marble dust taken from online store, Gravelart Marble Dust which is white in colour and of powdered form having specific gravity 2.67 was chosen.
- **Water:** Ordinary tap water used in all mix ratios of concrete mix.

3. Results

3.1 Compressive Strength Test

Compressive strength is deliberated as the proportion of load to the territory of cube specimen and is given by P/A N/mm2, where P speaks to the heap which is acting till the breakage of cube specimen and a stands for the area or territory of cube. Figure 1 represents the variety of compressive strengths at 7, 28 and 56 days of testing for distinctive level of expansion of PET particles to the concrete i.e 4, 8, 12 & 16% respectively.

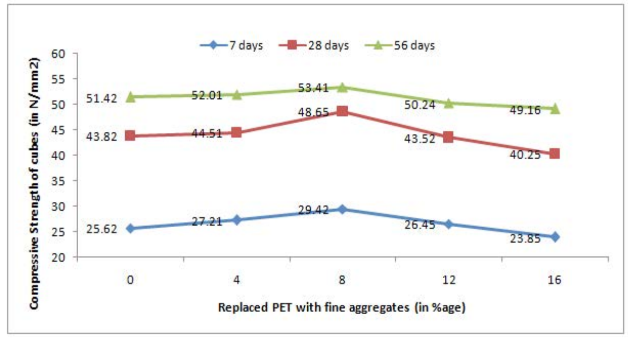

Figure 1. Compressive Strength of M40 grade PET concrete with 2% marble dust.

The Figure 1 shows that the maximum strength achieved till 8 % replacement with fine aggregates after 7, 28 and 56 days testing and then diminishing step by step on further addition. Thus addition of PET up to 8% is considered to be sensible.

3.2 Flexural Strength Test

Flexural strength for 10 cm specimen is calculated as given below

$f_b = pl/bd^2$ for $a > 13.3$cm

$f_b = 3pa/bd^2$ for $a < 13.3$cm

Where p = load, l = supported length, b = specimen width, d = specimen depth,

a = distance between the line of crack and nearer support

Figure 2 reveals the assortment of flexural quality accomplished at 7, 28 and 56 days testing result.

From the Figure 2 it is clear that the maximum growth for flexural strength achieved at 8 % in case of PET concrete and beyond that it starts decreasing step by step. So the scope of addition is 8 % or less than that.

3.3 Split Tensile Strength

As concrete is weak in tensile strength due to its brittle nature so it is vital to think about its part rigidity where concrete tends to shape breaks. Split tensile strength is computed as given below

$T_{sp} = 2P/\pi\ d\ l$ where P is the maximum load at which crack appears, d is specimen diameter and l is specimen length.

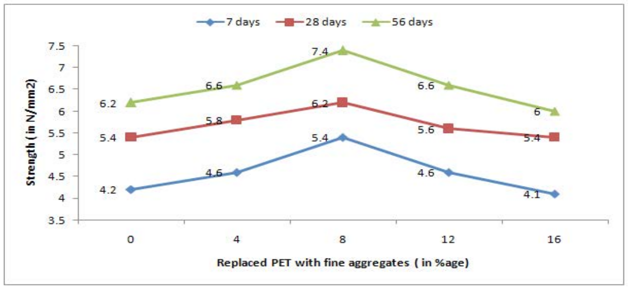

Figure 2. Flexural Strength of M40 grade PET concrete with 2% marble dust.

Figure 3 represents split rigidity by PET expansion at 7, 28 and 56 days substitution.

Split elasticity for PET concrete of M40 grade shows the maximum growth at 8 % replacement of concrete, so possibility of increment in rigidity by expansion of PET with 2% marble dust as added substance is till 8% or not as much as that.

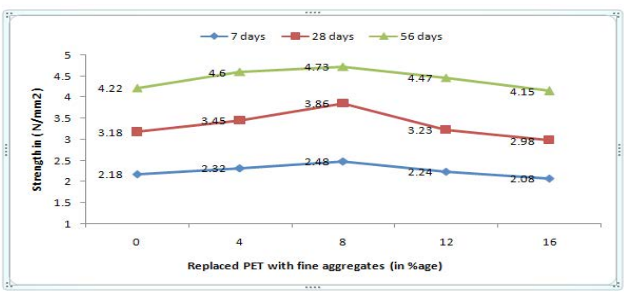

Figure 3. Split Tensile Strength of PET concrete of M40 grade with 2% marble dust.

3.4 SEM and XRD Tests

The test outcome reveals that the compressive, flexural and split elasticity for M40 grade concrete is maximum at 8 % and decrease thereafter in every addition of PET. It might be due to low bonding nature of plastic components, so it was necessary to know about the nature and spacing of molecules of PET; therefore SEM and XRD tests are done for that.

3.5 SEM

SEM (Scanning Electron Microscope) test results for the PET concrete are given in Figure 4(a) for magnified image of PET concrete and 4(b) for magnified image of PET molecule.

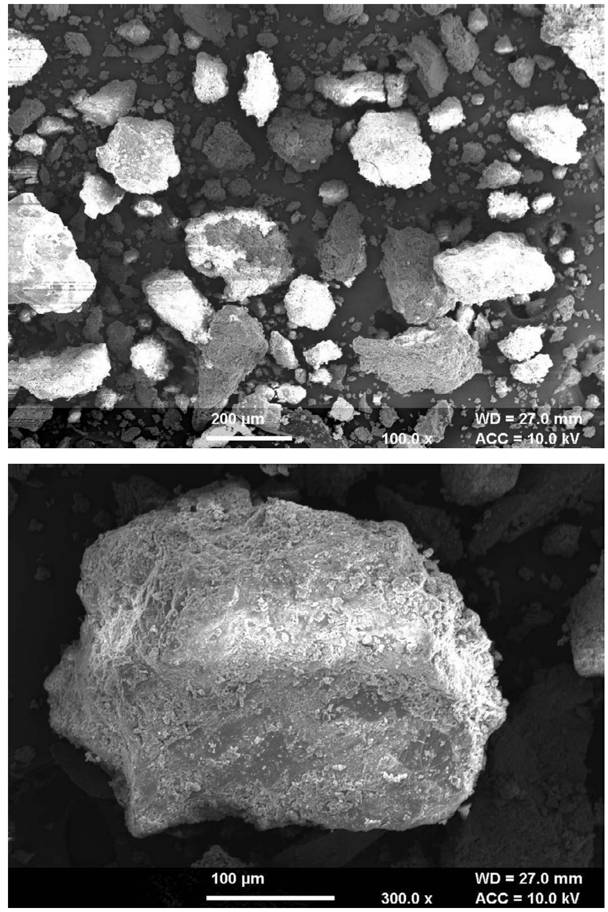

Figure 4(a) Magnified image for PET concrete
4(b) Magnified image of PET molecule

Figures 4a-b exhibit the shape and placement of PET molecules present in the concrete sample. (i) Figure 4a shows the different particles in the PET concrete, as in this the voids are filled by small particles of marble dust powder which are very little particles in the image and white coloured molecules are of crushed PET bottles mixed with cement and the other particles are of mix proportion of all the ingredients of concrete with PET and marble dust. (ii) Figure 4b shows the magnified image of white coloured molecules which is crushed PET molecule showing the shape of molecule.

3.6 XRD

In XRD (X-ray Diffraction) method, an x ray having specific wavelength falls on the sample and then diffracts to give the d-spacing of the molecule. The specific wavelengths are characteristics of target material. Copper is the most common target material for single crystal diffraction. A cathode ray tube is used to strike the X-ray on to the sample, diffracts after striking on the sample to give the definite number of counts to the detector screen satisfying the Bragg's equation as $n\lambda=2d\sin\theta$ where n is for number of counts and λ stands for wavelength and θ is the angle with which x ray falls and thus helps to determine d-spacing which is the spacing between the two molecules of the sample.

In XRD the X-ray falls with an angle of 2θ getting the diffraction pattern at different positions for different number of counts for XRD and thereby results in getting different d spacing at different positions. As each mineral has a unique d-spacing so by comparing this with standard diffraction patterns we conclude about the minerals present in the sample. For PET concrete sample the figure shows the diffraction pattern which gives different d-spacing values at different positions.

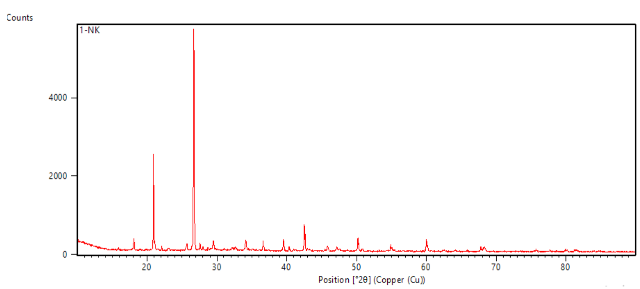

Figure 5. XRD test result for PET concrete sample showing no of counts at different positions.

Figure 5 shows the peak change at positions between 20 to 30 due to copper target which strikes the sample giving higher value of intensity and so shows higher peak value giving larger number of counts which is then converted to d-spacing. It shows particle to particle spacing which reveals low bonding nature of PET molecules.

4. Conclusion

1. There is an expansion in quality with supplanting of fine totals with crushed PET particles in ordinary concrete.
2. Marble residue expansions increment the quality of PET concrete.
3. The most extraordinary augmentation for compressive, split elastic and flexural quality tests is finished up at 8 % supplanting with 2% expansion of marble dust as added substance to each sample.
4. Marble dust expansion likewise constitute as a space covering material in with the mix as it fills the voids of PET cement by which increment in strength happens as appeared in SEM test.
5. There is a possibility of replacement of PET flakes till 8% or less percentage of PET to concrete which is sensible for the enhancement in strength of concrete along with addition of suitable additive such as marble dust.
6. By SEM test, shape and nature of molecules present in concrete can be determined.
7. XRD shows the d spacing of PET flakes with concrete which concludes that low bonding nature of PET with concrete may be the reason for decrease in strength by further addition of PET flakes.

5. Future Scope

- Additive addition percentage can be increased to get better strength values at further addition also.
- Other kind of admixtures can be used for the improvement of strength in concrete.
- By XRD, molecule type can be determined introduction of which would result in better bonding of PET molecules with concrete.
- Additional type of molecule to be added can conclude for better strength results by comparing d-spacing with standard diffraction pattern.

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