Experimental Study on Ground Granulated Blast Furnace Slag (GGBS) Based Polymer Concrete Using Polyethylene Terephthalate (PET) fibers as Fine Aggregate

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***Abstract*:- The present study investigates on polymer concrete with Ground granulated blast furnace slag (GGBS) and Polyethylene terephthalate (PET) bottle fibers. The polymer concrete is prepared with epoxy resin and aggregates. GGBS is added as cement replacement and aggregate is replaced in different percentages by PET bottle fibers (0%,5%,10% and15%). The compressive strength spilt tensile strength and flexural strength are experimentally evaluated. The influence of PET bottle fibers on workability, compressive strength, split tensile strength and flexural strength are discussed and compared with a conventional concrete.**

Keywords: Polymer concrete; GGBS; PET bottle fibers; Epoxy resin; Mechanical properties.

1.INTRODUCTION

Concrete is a composite material composed of fine and coarse aggregate bonded together with a fluid cement (cement paste) that hardens over a time compared to cement-based concrete, polymer concrete is more stronger and durable. For this reason, polymer concrete is used in many structures such as box culverts, hazardous waste containers, trench lines, floor drains, and in the repair and overlay of damaged cement concrete surfaces including pavement and bridges. Despite its advantages, however, polymer concrete is not used widely due to its relatively high material cost compared to cement-based concrete [1]. Polymer concrete increases the strength characteristics as well as resistance to environmental factors [2].

Enhancement of the properties of polymer composites is a complex problem, due to the different optimum condition for the setting of both co-binders such as cement hydration and hardening of the organic binder [3]. To utilise the wastes and to protect natural resources, aggregate can be replaced partially by silica fume, recycle glass, fly ash, GGBS, polystyrene granules, sawdust, PET particle, etc [4]. In this paper, we are presenting the experimental results obtained on polymer concrete with PET bottle fibers waste used as substitution of aggregates. The effects on workability, compressive strength, spilt tensile strength and flexural strength are investigated by testing different mixes in which dosages of cement by ground granulated blast furnace slag (GGBS) and fine aggregate replaced by PET bottle fibers.

2. LITERATURE SURVEY

- Semihaet et al. (2010) have investigated the utilization of shredded waste Poly-ethylene Terephthalate (PET) bottle granules as a lightweight aggregate in mortar. The water absorption values of the mortars produced in this investigation were within the limits of the lightweight concrete absorption value. The shrinkage values of the mortars containing PET aggregates were higher than the shrinkage values of the mortars containing PET and sand aggregates. The use of shredded waste PET granules and GBFS in mortar would be helpful for the environmental concern [5].
- K. Ramadevi et al. (2012) have discussed an environmental issue as waste plastic bottles are difficult to biodegrade and involves processes either to recycle or reuse that is way it used in the concrete field. The concrete with PET fibres reduced the weight of concrete and thus if mortar with plastic fibres can be made into light weight concrete based on unit weight [6].
- S. Arivalagan (2014) studied the concrete with GGBS as a Replacement material in cement with increasing demand and consumption of cement, researchers and scientist are in search of developing alternate binders that are eco-friendly and contributes towards waste management. Use of industrial waste products saves the environment and conserves natural resources. It is observed that GGBS-based concretes have achieved an increase in strength for 20% replacement of cement at the age of 28 days. Increasing strength is due to filler effect of GGBS [7].
- D.Faruq et al (2017) the Ground-granulated blast furnace slag is pozzolanic materials that can be utilized to produce highly durable concrete composites. Ground granulated blast furnace slag is known to produce a high strength concrete and is used in two different ways as a cement replacement, in order to reduce the cement content [8].

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3.MATERIALS PROPORTION RATIO AND MIXING PROCEDURE

An experimental program has been carried out for investigating the mechanical properties of polymer concrete [9]. The polymer is prepared by keeping 20% GGBS as replacement of cement and the requisite quantity of PET bottle fibers (viz; 0, 5, 10 and 15% as replacement of fine aggregate by mass). The tests performed in harden state are compressive strength, flexural strength and split tensile strength, also determining the influence of PET bottle fibers on workability of fresh prepared polymer concrete are studied.

Table 1: Chemical composition of GGBS

Sl No.	Chemical requirements (%)	Observations
1.	Manganese oxide (MnO)	0.120
2.	Magnesium (MgO)	7.740
3.	Sulphide sulphur (S)	0.460
4.	Sulphate (as SO3)	0.290
5.	Insoluble Residue (I.R)	0.330
6.	Chloride content (C)	0.009
7.	Glass content	92.00

Table 2: Physical properties of GGBS

SL No.	Properties	Observations
1	Specific gravity	2.91
2	Fineness	379

Table 3: Physical properties of PET fibers

Sl. No.	Properties	Observations
1	Density	1.38 gm/cm^3
2	Thickness of fibers	200 microns

Table 4: Physical properties of 43-grade cement

Sl. No.	Properties	Observations
1	Specific gravity	3.04
2	Fineness of cement	2.67%
3	Normal consistency	29.0%
4	Initial setting time	130 minutes
5	Final setting time	270 minutes

Table 5: Physical properties of fine aggregates and coarse aggregates

Sl. No.	Properties	Observations according to IS: 2386-1963	
		Fine aggregate	Coarse aggregate
1	Particle shape	Spherical	Angular
3	Specific gravity	2.54	2.60
4	Fineness modulus	3.93	3.13
5	Water absorption (%)	1.0	2.85

In the present study, 4.75 mm down the size of river sand as fine aggregate and 20 mm downsize aggregate consider as coarse aggregate. The tests are conducted as per IS: 2386-1963

The moulds used for casting the specimens are selected as per IS: 516-1959. The cube moulds of size of 100 mm x 100 mm x 100 mm are used for the compressive strength test. Cylinder moulds of size 100 mm diameter and 200 mm height are used for Split tensile strength test. And beam moulds of size 100 mm x 100 mm x 500 mm are used for flexural strength test. For each concrete mix 6 cubes, 6 cylinders and 6 prisms have been cast and tested.

3.1 Materials Estimation

The mix design is carried out for M30 grade concrete according to IS: 10262-2019. In this study the GGBS is added as weight fraction of 20% by weight of cement (keeping 20% GGBS constant for all mixes) and PET fibers are added as Weight fractions of 0%,5%,10%,15% by weight of fine aggregate. The water-cement ratio is kept as 0.43 and epoxy resin used as 3% of weight of cement.

The mix proportions obtained are

- Cement = 392.9 kg/m^3
- GGBS = 98.23 kg/m^3
- Water = 192.0 kg/m^3
- Fine aggregate = 578.0 kg/m^3
- PET Fibers = 115.6 kg/m^3
- Coarse aggregate = 1161.76 kg/m^3
- Water-cement ratio = 0.48
- Epoxy resin = 11.78 kg/m^3

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Table 6: Mix proportions of Polymer concrete and identification of specimens

Specimens Type	Cement	GGBS	Fine aggregate	PET bottle fibers	Coarse aggregate	Epoxy resin	W/C ratio
M1	1 :	0.00 :	1.17 :	0.00 :	2.36 :	0.00 :	0.39
M2	1 :	0.25 :	1.47 :	0.00 :	2.95 :	0.03 :	0.48
M3	1 :	0.25 :	1.39 :	0.07 :	2.95 :	0.03 :	0.48
M4	1 :	0.25 :	1.32 :	0.14 :	2.95 :	0.03 :	0.48
M5	1 :	0.25 :	1.25 :	0.22 :	2.95 :	0.03 :	0.48


Fig.1 Polymer concrete mixing


Fig.2 Slump cone test


Fig.3 Casting of specimens

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3.2 Slump test

Concrete slump test is a measure of determining the workability of concrete mix prepared in the laboratory or at the construction site during the progress of construction work as shown Fig. 2. The slump test is carried out as per IS: 1199-1959. Slump values are given below in Table 7.

Table 7: Slump cone test values

S. No	Type of concrete mix	Slump values (mm)
1.	M1	66
2.	M2	69
3.	M3	65
4.	M4	60
5.	M5	63

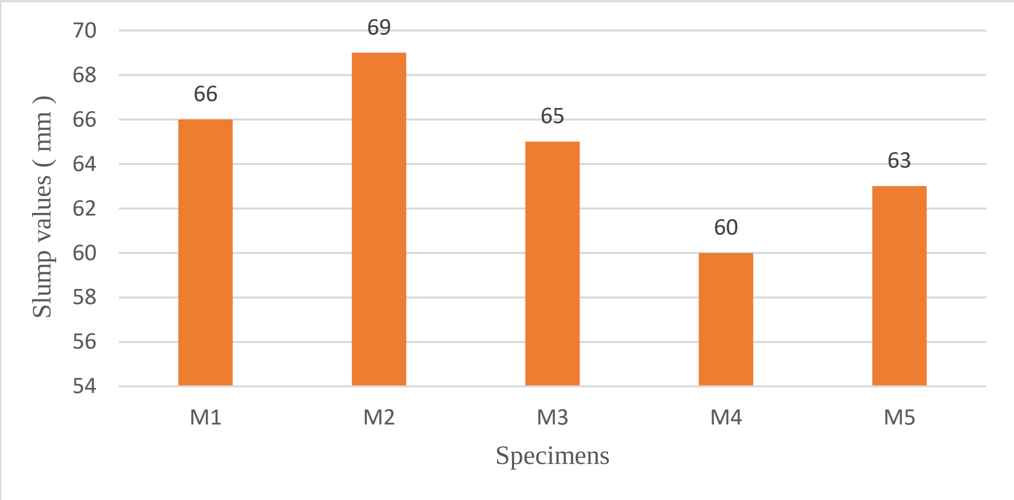

Fig.4 Slump value for different fibers quantity

4. RESULTS AND DISCUSSION

The results of experiment tests on the harden polymer concrete are presented here.

4.1 Compressive strength

- The highest value of compressive strength 41.28 MPa is obtained for mix M3, and the minimum value of compressive strength 32.62 MPa is obtained for M5.

Table 8: Compressive strength properties

S. No	Type of concrete mix	Age of concrete	Compressive strength (N/mm²)			
			Cube 1	Cube 2	Cube 3	Average
1.	M1	7 Days	27.34	24.97	20.52	24.27
		28 Days	37.89	38.95	39.20	38.68
2.	M2	7 Days	22.56	31.78	28.26	27.53
		28 Days	32.78	37.12	39.53	36.47
3.	M3	7 Days	30.60	25.70	28.37	28.22
		28 Days	37.63	40.86	45.37	41.28
4.	M4	7 Days	22.17	18.54	20.67	20.46
		28 Days	39.53	38.97	40.90	39.80
5.	M5	7 Days	19.98	20.20	19.87	20.01
		28 days	29.30	32.08	36.50	32.62

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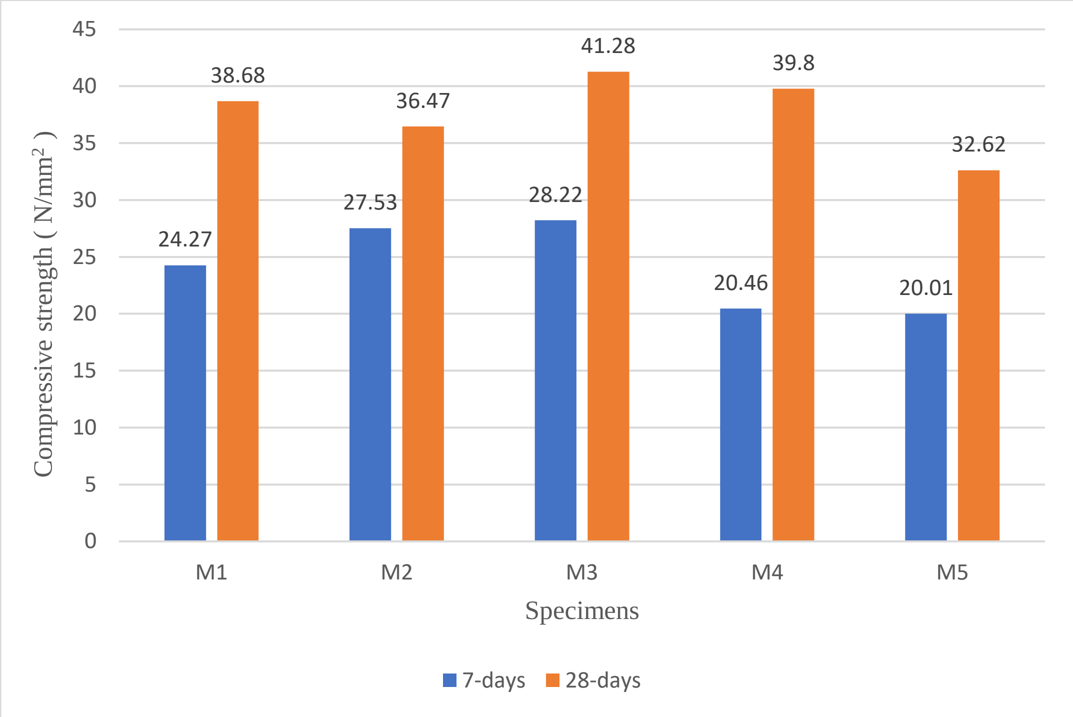

Fig.5 Compressive strength of concrete specimens for different fibers quantity

4.2 Spilt tensile strength

- The highest value of Spilt tensile strength 3.17 MPa is obtained for mix of M3, and the minimum value of compressive strength 3.65 MPa is obtained for M5.

Table 9: Split tensile strength properties

S. No	Type of concrete mix	Age of concrete	Split tensile strength (N/mm²)			
			Cylinder 1	Cylinder 2	Cylinder 3	Average
1.	M1	7 Days	2.40	2.70	2.72	2.60
		28 Days	3.11	2.77	2.87	2.91
2.	M2	7 Days	2.27	2.15	2.04	2.15
		28 Days	3.20	3.01	2.52	2.91
3.	M3	7 Days	2.10	2.27	2.41	2.26
		28 Days	3.08	3.13	3.31	3.17
4.	M4	7 Days	2.13	2.01	2.20	2.11
		28 Days	3.02	2.69	2.81	2.84
5.	M5	7 Days	2.15	2.05	2.09	2.09
		28 days	2.52	2.72	2.71	2.65

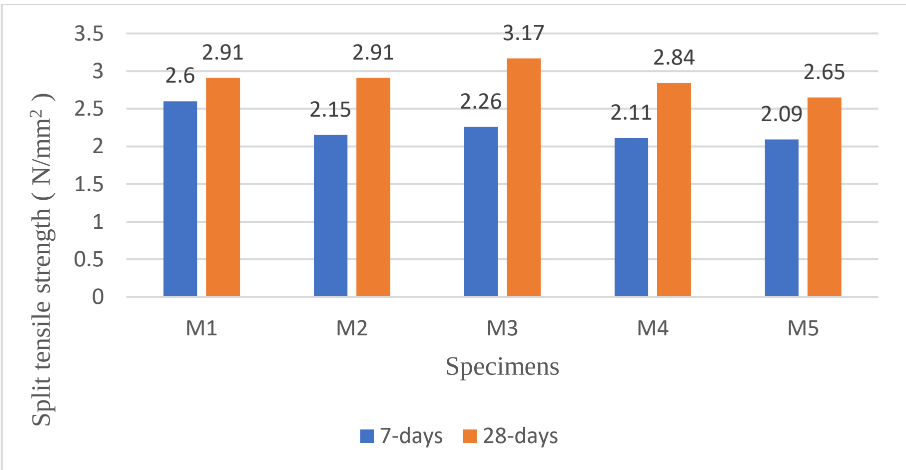

Fig.6 Split tensile strength of concrete specimens for different fibers quantity

4.3 Flexural strength

- The highest value of Flexural strength 11.32 MPa was obtained for mix of M3, and the minimum value of compressive strength 10.15 MPa is obtained for M5.

Table 10: Flexural strength properties

S. No	Type of concrete mix	Age of concrete	Flexural strength (N/mm²)			
			Prism 1	Prism 2	Prism 3	Average
1.	M1	28 Days	4.30	4.36	4.38	4.34
2.	M2	28 Days	11.25	10.80	10.53	10.86
3.	M3	28 Days	11.53	11.95	10.50	11.32
4.	M4	28 Days	10.11	10.59	10.75	10.48
5.	M5	28 Days	10.10	9.85	10.51	10.15

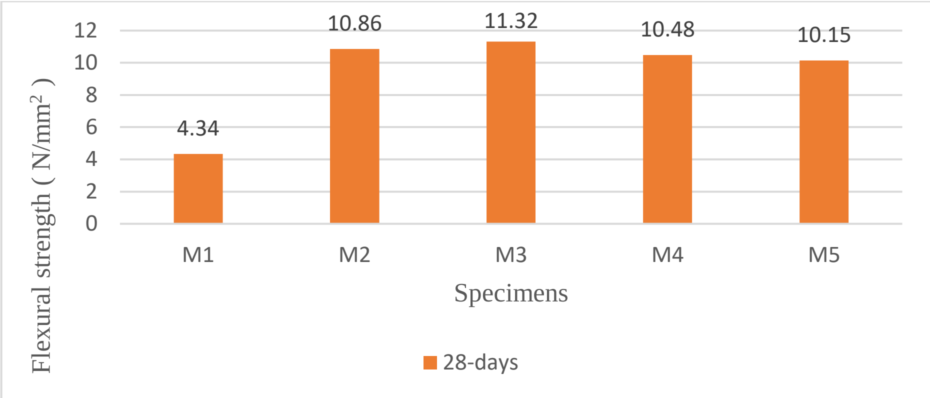

Fig.7 Flexural strength of concrete specimens for different fibers quantity

Where, M1=Conventional concrete, M2 =20%GGBS+0%PET Fibers+3%Resin, M3=20%GGBS+5% PET Fibers+3%Resin, M4=20%GGBS+10%PET Fibers+3%Resin, M5=20%GGBS+15%PET Fibers+3%Resin.

5.CONCLUSIONS

The results of experimental study on ground granulated blast furnace slag-based polymer concrete using polyethylene terephthalate bottle fibers as fine aggregate have been discussed. This investigation contains an experimental observation in which the comparison between conventional concrete and polymer-based concrete has made. In the present study, it is observed that the strength properties such as compression, spilt tensile and flexural strength are increasing upto 5% PET Fibers replacement for M3 type of mix polymer concrete.

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