Study on Engineering Properties of Concrete Using PET Coated with Bagasse Fibres

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Abstract:- **The present paper is a study of engineering properties of concrete using Bagasse coated with PET synthetic fibres (POLYETHYLENE TEREPHTHALATE) to Investigate the effect of strength parameters on concrete which are coated with PET fibres in varying percentages thereby reducing plastic waste to the environment. PET fibres coated with bagasse ash are added partially to the concrete with replacement by weight of cement in varying percentages of 0%, 0.5, 1% , 1.5%,2%. The major study in this paper is to calculate the compressive strength, spilt tensile strength and Flexural strength of M 25 grade (1:1:2) concrete for 14 and 28days. Specimens are casted by varying the percentages of bagasse coated with PET fibres and are tested for engineering properties by tabulating the results. There is an increase in characteristic Strength of concrete mixed with bagasse ash coated with PET fibres when compared to the normal conventional concrete specimens & the testing of casted specimens is done by compressive testing machine and Flexural testing machine in the laboratory. The maximum strength gained is found to be in 1.5% replacement of fibre with weight of cement which also leads to increase in bonding strength of concrete & less amount of cracks in the concrete specimens.**

Keywords**: PET (plastic bottles) fibres, bagasse ash, compressive strength, spilt tensile strength , flexural strength**.

I. INTRODUCTION

In India Plastic wastes are foremost common and is generated in various abundance from plastic water bottles which is used as containers for drinking water. The plastic waste is non-biodegradable material which is creating bigger issues within the surroundings & environment, usage of plastic is increasing day by day so as there is increase in plastic industries in the society & with the less available land for plastic waste disposal it has become hazardous for the environment. With much population all over the country, it is also quiet difficult to manage the generation of plastic wastes so the recycling of PET fibres is important which can minimize pollution to the environment. PET bottles fibres are mixed in various proportions into the concrete which provides high plasticity and strength but the major drawback is reduction in workability as a result of PET fibres has really weak bond with cement paste.

The bagasse is a waste material which are generated in sugarcane mills & is used as a binder in the concrete mix which is made powdered & passing 150 micron sieve is taken for casting purposes which will increase the boding strength in concrete. 15 to 20% of bagasse in partial replacement with cement will tend to increase in the strength up to 10 to 20 % in compared with normal conventional concrete mix. Due to the increase in demand of construction leading to the increase in usage of cement raw materials there by production of more cement & cement industries will lead to impact on greenhouse gases such as CO_2. The replacement of cement with plastic fibre & Bagasse with known percentages will assist in cut back of the plastic waste & safer atmosphere. Use of replacement of cement with fibres give identical strength in concrete & also cut back in price with respect to production and can save the money.

Sika Plast - 600 I is a unique multipurpose super plasticizer that is particularly suitable for the production of ready mixed concrete & also additionally it provides high water reduction with improved fresh concrete characteristics.

With its outstanding cost / performance Sika Plast - 600 I is used for the following:

- A wide range of applications where excellent workability is requested.
- Concrete with high water reduction.
- High efficient concrete applications.
- Variable use in different concrete systems with different raw materials.

Permeability:

- Less sensitive against variations in aggregates and / or different cement types.
- High efficiency even at low dosage rates.
- Extended workability in conjunction with subsequent strength development.
- Superior plasticising effect, resulting in improved flow, placing and compaction Characteristics.
- Reduced shrinkage during curing and reduced creep when hardened.

0.5 % to 2.0 % will be the Optimum dosage that has to be finalized through site trials whereas Overdosing above 2.0 % may cause bleeding and settlement of concrete.

II. LITERATURE REVIEW

The incessant use of concrete has constrained many civil engineers to add some relevant constituents in proportion to the cement or any other ingredient in order to have some control over its depleting trend of concrete from universe. The

environmental degradation from various types of non-bio degradable wastes are not only making the environment hazardous but also are having a serious implications on the human lives In our investigations PET fibres were incorporated in the M20, M25 and M30 grades of concrete by the weight fraction of cement in 2%, 3%, 4% and 5% and the mechanical property viz. compressive strength of the concrete were compared with the conventional concrete for analysis [1].

The aim of this study is to determine the reinforcing effect of a cheap Recycle Polyethylene Terephthalate (PET) fibre on asphalt concrete which was achieved by performing Resilient Modulus (MR) test in the laboratory on both unreinforced (i.e. neat asphalt mixture) and recycle PET fibre reinforced asphalt concrete mixtures. The percentage additions of recycle PET fibres are 0.3%, 0.5%, 0.7% and 1% of the total weight of the mixture & the results were analysed by means of Response Surface Methodology (RSM) using Design Expert 7.0 software and validated using analysis of variance (ANOVA). The results indicated that recycle PET fibres have significantly increased the mixture resilient modulus in lower temperature with improved fatigue resistance & increase in resilient modulus at higher temperatures, Recycled PET fibre have proved that the effective in strength improvement at 0.7% of total weight of asphalt concrete mixture [2].

Waste plastic bottles are major cause of solid waste disposal. Polyethylene Terephthalate (PET, PETE orpolyester) is commonly used for carbonated beverage and water bottles. This project deals with the possibility of using the waste PET bottles as the partial replacement of aggregate in Portland cement. Concrete with 1%, 2%, 4% and 6% PET bottle fibres for fine aggregate were produced and compared against control mix with no replacement. Cube specimens, cylinder specimens and prism specimens of 18 numbers each were cast, cured and tested for 7 day and 28 days strength. Compression test, splitting tensile test and flexural strength tests were done and the results were compared with control specimens. The findings revealed an increase in compression and tensile strength hence with the increasing demand for fine aggregate, PET bottle fibre replacements can be adopted [3].

Plastics waste has become a problem because of its non-degradable property which has larger portion of Polyethylene Terephthalate & is largely obtained from mineral water bottles. In the present study the use of PET bottle fibres obtained by just cutting the PET bottle without any separate recycling process in concrete matrix & is tested for different mechanical properties of concrete specimens like Compressive strength, Split tensile strength, Flexural strength, Young's modulus of concrete, stiffness, Ultimate load, maximum central deflection for different proportions of fibre are be reported. The specimens are reinforced with fibres made from waste Polyethylene Terephthalate (PET) bottles and added with superplasticizers & the dosage of the fibre are 0.25%, 0.5%, 0.75% by weight of cement and the dosage of the superplasticizers 0.8% by weight of cement [4].

On the other hand, urbanization growth will increase usage of plastic which are non-renewable ones where in eco friendly architectural principles are being incorporated but they are still out of reach of many people due to lack of knowledge and awareness. In this study is to explore the possibility of recycling a plastic bottles waste material for addressing this issue, the plastic fibres were added in various percentages in to the M25 grade concrete. An experimental work has been carried out by casting specimen's cubes in the laboratory and their behaviour under the test was observed. The plastic fibres were added from 0.0% to 3.0% & the compressive strengths of concrete were determined after 28 days of curing period with normal concrete [5].

The paper presents work on synthetic fibre Polyethene terephthalate (PET) as an alternate construction entity, since plastic is a non-biodegradable material & disposing it has become a problem. Recently, PET fibres were proposed to be used as either reinforcement in concretes or being casted as blocks, recent studies show that they can be accepted as successful building materials. Although PET fibre reinforced concrete offer less compression strength and flexural rigidity than conventional concrete but it offers high ductility thereby increasing deforming capability of the concrete. It also reduces density of the reinforced concrete thus aiding in light-weight materials production [6].

Modern activities in India leads to use of plastic bags in excess whereas plastic being non-biodegradable material, it takes years to decompose. Plastic bags have main constituent polymer poly-ethylene. The poly-ethylene material when combusted produces Carbon dioxide which leads to global warming so a major advantage of conducting this study is to know the efficiency of reusing plastic waste in concrete by comparing compressive strength of concrete whose fine aggregate is partially replaced by plastic (5%,10%,15%,25%) with control concrete of M20 grade [7].

III. MATERIALS AND METHODOLOGY

.Materials

- Cement : Ordinary Portland cement 53 grade.
- Fine aggregate: < 4.75mm sieve.
- Coarse aggregate: Nominal maximum size of 20 mm.
- Super plasticizer : Sika Plast - 600 I High efficient superplasticizer (0.5 % by weight of cement).
- Water : Potable water.
- Plastic fibres : PET bottles fibres of size 50mm * 2mm.
- Coated fibres : Bagasse.

Methodology

Preliminary tests were conducted on the above materials as per IS standards & specifications, cubes & cylinders were

casted in the standard metallic moulds & vibrated to obtain the required sample size of specimen on both normal conventional concrete & specimens with bagasse & PET fibres mix. The moulds were cleaned initially and oiled on all the sides before concrete sample is poured in to it & thoroughly mixed concrete is poured into the moulds & vibrated. Testing is done for concrete grade of M25 (1:1:2) where in for a normal conventional concrete, replacement of cement is done for 0.5%, 1.0% 1.5% & 2.0% with PET fibres coated in bagasse by adding super plasticizer Sika Plast - 600 I of 0.5% by weight of cement for the mix.

Cubes are casted for Conventional concrete mix & the excess concrete is removed out of the mould using trowel and the top surface is finished smooth, the procedure is repeated for concrete mixed with PET fibres with bagasse, super plasticizers. After 24 hours the samples were demoulded and put in curing tank for the respective periods of 14 and 28 days of characteristic strength with a set of 5 samples were prepared in each stage for curing. The temperature of curing tank was maintained at 25 degrees during the analysis of compressive strength, split tensile & flexural strength of the casted specimens & the results are tabulated.

TABLE-1 Physical properties of cement

Property	Result obtained
Fineness	90µ
Consistency (%)	28%
Initial setting time	150 min
Final setting time	300 min
Specific gravity	3.15

TABLE-2 Properties of super plasticizer

Property	Sika Plast - 600 I
Approval Standard	EN 934 - 2
Appearance / Colour	Light brown hazy liquid
Chemical Base	Modified Polycarboxylate
Relative Density	~1.132 kg/l at 30°C
Storage Conditions / Shelf -Life	12 months from date of production if stored properly in undamaged unopened, original sealed packaging, in dry conditions at temperatures between +10°C and +40°C. Protect from direct sunlight and frost.

Tests conducted for coarse aggregates

1. Sieve analysis.
2. Specific gravity and Water absorption test.
3. Aggregate shape test.

The aggregate gradation was continuous with the maximum aggregate size of 20 mm sieve. The gradation & other tests were performed as per ASTM standards with 5 trials on each test & the below table represents the physical properties of aggregate materials.

TABLE-3 Test on coarse aggregates

Si no	Test	Method of test	Average Result	Permissible value
1	Sieve analysis	IS:2720-Pt-4	Fineness modulus = 2.90	2.3 to 3.1
2	Specific gravity **(20 mm)**	IS:2386-Pt-3	Bulk specific gravity = 2.70	2.5 to 3.2
			Apparent specific gravity = 2.5	
	Specific gravity **(10 mm)**	IS:2386-Pt-3	Bulk specific gravity = 2.80	2.5 to 3.2
			Apparent specific gravity = 2.67	
3	Water absorption	IS:2386-Pt-3	0.6	<2%
4	Aggregate shape test Flakiness index	IS:2386-Pt-1	12%	Max 30%
	Elongation index		14%	

TABLE-4 Test on fine aggregates

Si no	Test	Method of test	Average Result	Permissible value
1	Specific gravity	IS:2720-Pt-3	Bulk specific gravity = 2.60	2.53 to 2.67
			Apparent specific gravity = 2.48	
2	Water absorption	IS:2386-Pt-3	1.1	<2%

Fig -1 PET fibres

Fig -2 Bagasse fibres

Mix Design

The concrete mix design for M 25 grade is calculated using IS 10262 : 2009. The material required for mix design are as mentioned below,

Table - 5 Materials required as per design for M25 grade

Quantity of materials in kg/m^3					
Cement	FA	CA	Super Plasticizers	W/C Ratio	Mass of water
250	**822**	**1280**	**0.006**	**0.5**	**125**

Table - 6 M-25 CONCRETE MIX DESIGN As per IS 10262-2009 & MORTH

Stipulations for Proportioning	
Grade Designation	**M25**
Type of Cement	OPC 53 grade confirming to IS-12269-1987
Maximum Nominal Aggregate Size	20 mm
Minimum Cement Content (IS 456-2000)	240 kg/m^3
Maximum Water Cement Ratio (IS 456-2000)	0.6
Maximum Water content (10262-table-2)	186 Lit.
Workability (IS 456-2000)	25-75 mm (Slump)
Exposure Condition	Moderate
Degree of Supervision	Good
Type of Aggregate	Crushed Angular Aggregate
Chemical Admixture Type	Superplasticiser Confirming to IS - 9103

Table - 7 Materials calculation for 1 m^3

Cement Used	Coromandal King OPC 53 grade
Sp. Gravity of Cement	3.15
Chemical Admixture	Sika Plast - 600 I
Target Strength for Mix Proportioning	
Target Mean Strength	36N/mm^2
Characteristic Strength @ 28 days	25N/mm^2
Adopted Water Cement Ratio	0.5

Estimated Water content for 25 -75 mm Slump	125 Lit.
Superplasticiser used	0.5 % by wt. of cement
Cement Content	= (125/0.5) =250 kg/m^3, Which is greater than 240 kg/m^3
Vol. of C.A. as per table 3 of IS 10262	60 %
Adopted Vol. of Coarse Aggregate	60 %
Adopted Vol. of Fine Aggregate	= (1- 0.60) = 40 %
Volume of Concrete in m^3	1
Volume of Cement in m^3	(Mass of Cement) / {(Sp. Gravity of Cement) x 1000} = (250) / (3.15) x 1000 = 0.08
Volume of Water in m^3	(Mass of Water) / {(Sp. Gravity of Water) x 1000} (125) / (1) x 1000 = 0.125
Volume of Admixture @ 0.5% in m^3	0.00134
Volume of All in Aggregate in m^3	= [1 – {(0.08 + 0.125 + 0.00134)} = 0.79
Volume of Coarse Aggregate in m^3	= (0.79 *0.60) = 0.474
Volume of Fine Aggregate in m^3	= (0.79 *0.4) = 0.316
Mass of Cement in kg/m^3	**250**
Mass of Water in kg/m^3	**125**
Mass of Fine Aggregate in kg/m^3	**822**
Mass of Coarse Aggregate in kg/m^3	**1280**
Mass of Admixture in kg/m^3	**0.006**
Water Cement Ratio	**0.5**

Mix Proportion of Plastic fibres

The Mix proportion for replacement of cement with coated PET fibre in bagasse at varying percentages i.e,0%,0.5%,1%,1.5% and 2% is tabulated below:

Table -8 Material required for Mix proportion of Plastic bottles fibres in 1 kg/m^3

Coated Plastic Fibres (%)	0	0.5	1	1.5	2
Cement	250	248.7	247.5	246.2	245
Fine agg	822	822	822	822	822
Coarse.agg	1280	1280	1280	1280	1280
Sika Plast	0.006	0.006	0.006	0.006	0.006
Water	125	125	125	125	125

IV. RESULTS AND DISCUSSION

Cubes, Beams & Cylinders were casted for normal conventional concrete & also with the above said ratio by varying quantity of cement in concrete, the samples were demoulded & kept for curing in curing tank for 14 & 28days. Four sample specimens were casted for the varying proportions of cement with admixtures & tested for compressive strength, spilt tensile strength, flexural strength in compressive testing machine and flexural testing machine for engineering properties of concrete & the results are tabulated.

- *Compressive strength:*

Compressive strength is tested in the compressive testing machine .cubes specimens of 150mm*150mm*150mm.

Compressive strength = P/A N/mm^2

Fig - 3 compression testing machine

Table – 9 Results of tested specimen for compressive strength in N/mm^2

Si no		Compressive strength in N/mm^2		Coated fibre ratio (%)	Compressive strength in N/mm^2	
		14days	28days		14days	28days
1	Conventional concrete	22.2	24.7	0.5	21.2	22.3
2		22.4	25	1	21.6	23.0
3		22.1	23.9	1.5	22.6	25.1
4		22.5	25	2	21.1	22.5

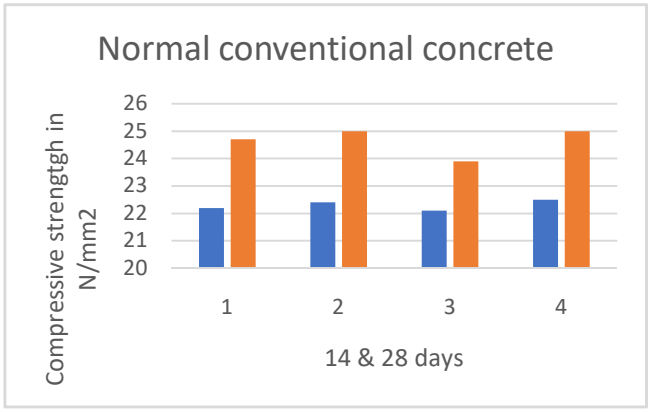

Fig - 4 Compressive strength of conventional concrete

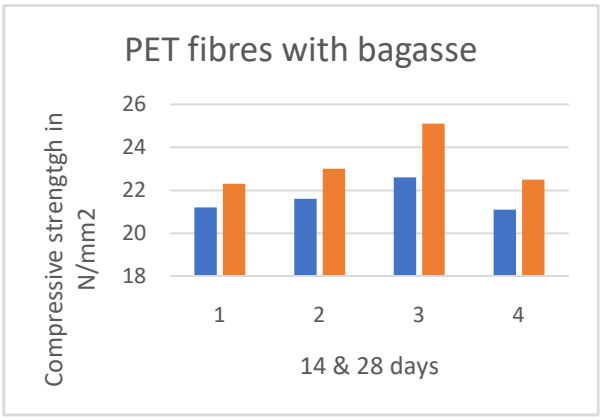

Fig - 5 Compressive strength of PET fibres with bagasse (%)

- *Spilt tensile strength:*

Spilt tensile strength = 2P / 3.14 LD N/mm^2

Spilt tensile strength is tested in compressive testing machine for a cylinder specimen of size 300mm*150mm.

Fig - 6 Spilt tensile set up

Table – 10 Results of tested specimen for Spilt tensile strength in N/mm^2

Si no		Spilt tensile strength N/mm^2		Coated fibre ratio %	Spilt tensile strength N/mm^2	
		14 days	28days		14 days	28days
1	Conventional concrete	3.67	4.36	0.5	3.32	4.59
2		3.85	4.43	1	3.51	4.1
3		3.90	4.8	1.5	3.95	5.0
4		3.86	4.67	2	3.68	4.3

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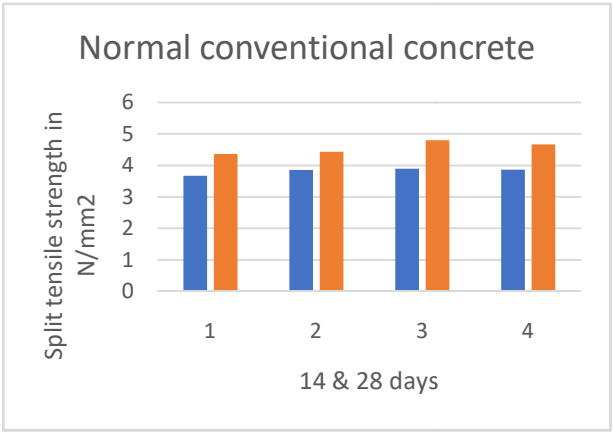

Fig- 7 Spilt tensile strength of conventional concrete

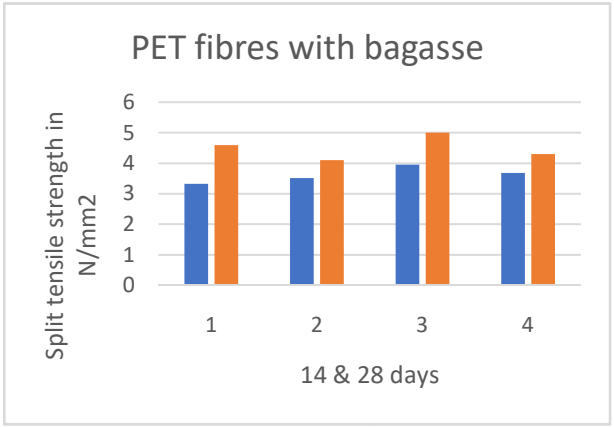

Fig- 8 Spilt tensile strength of PET fibres with bagasse ash (%)

- *Flexural strength test:*

Flexural strength is tested in flexural testing machine .Beam specimen is 500*100*100.

The flexural strength when a >13.3 cm for 10 cm beam,

F_b(flexural strength) =Pa/bd^2 N/mm^2

The flexural strength when a < 13.3cm for 10 cm beam,

F_b= 3Pa/bd^2 N/mm^2

Figure - 9 flexural testing test set up

Table – 11 Result of tested specimen for Flexural strength in N/mm^2

Si no		Flexural Strength N/mm^2		Coated fibre ratio (%)	Flexural Strength N/mm^2	
		14days	28days		14days	28days
1	Conventional concrete	3.1	4.9	0.5	3.3	4.29
2		3.3	4.3	1	3.4	4.3
3		3.7	4.5	1.5	3.7	4.62
4		3.4	4.38	0.2	3.3	4.35

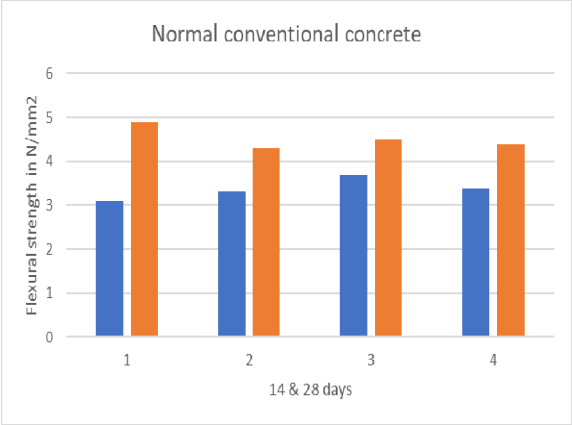

Fig - 10 Flexural strength of conventional concrete

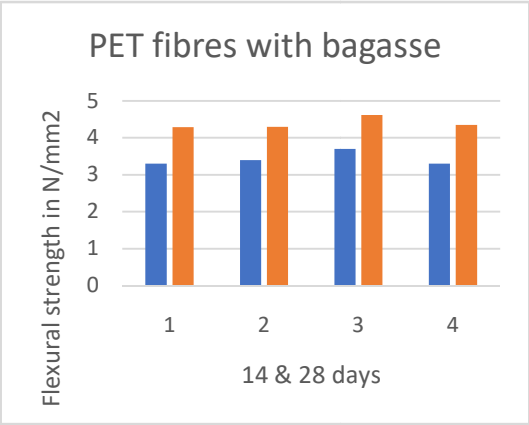

Fig - 11 Flexural strength of PET fibres with bagasse ash (%)

V. CONCLUSION

- The concrete specimens mixed with PET fibres will show an increase in engineering properties at a percentage of 1.5% when compared to other replacements & is tested for 14 & 28 days.
- From the experimental analysis it has been found that there is an increase of compressive strength for the casted specimens of PET fibres of up to16% when compared to normal conventional concrete specimens.
- It has also been found that an increase of 12% & 15% for the concrete specimens which are mixed with 1.5% variations of cement mix with respect to split tensile & flexural strength characteristics.
- Using of PET fibres with bagasse in the cement mix is economical & eco-friendly which will also contribute in reduction of plastic waste to the environment.

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