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Experimental Investigations on Plastic Reinforced Concrete

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Abstract— **Concrete is most widely used material for the construction of commercial and industrial infrastructure. Despite its high compressive strength, it has very low tensile strength, which is why it is reinforced with steel bar. However, steel reinforcement corrodes and expands over time, which impairs their functionality and affecting the durability of the concrete. Plastic waste is one of the challenges to dispose and manage as it is non-biodegradable material which is harmful to our environment. Our work mainly focuses on the reuse of plastic waste and thus helps to reduce the presence of plastic wastes in environment. This project mainly focuses on the evaluation of flexural strength, split tensile strength, compressive strength by the addition of plastic strips in the form of mesh in 3 layers. This work also includes a comparative study on the strength of plastic reinforced concrete and plain cement concrete.**

Keywords: Compressive strength, flexural strength, split tensile strength, plastic reinforcements, plastic strips.

I. INTRODUCTION

Plastic consumption has become an integral part of our lives today. The amount of plastic consumed annually is constantly increasing. There are several factors that contribute to the rapid growth of plastic consumption, such as low density, manufacturing capabilities, long life, light weight, and low production costs. Plastic is widely used in packaging, automotive and industrial applications, medical delivery systems, artificial implants, other healthcare applications, land/soil protection, water desalination, flood prevention, food preservation and distribution, housing, communication materials, security systems, and other uses. Large- scale applications of plastics in all parts of daily activities increase the volume of plastic waste. Plastics are bulky and break down very slowly, so they cause serious problems when landfilled, as they can restrict the movement of groundwater and also cause obstructions to tree roots. It should also be known that lead and cadmium are components of waste plastics that contain various toxic materials that can contaminate the earth's soil and water when mixed with rainwater. Therefore, to solve the negative impact of plastics on the environment, their recycling and reuse is considered one of the best solutions.

Concrete is the most widely used material for the construction of commercial and industrial infrastructure. Despite its high compressive strength, it has very low tensile strength, that is why it is reinforced with steel bars. Steel reinforcing bars transmit tensile stress and provide concrete structures with greater ductility and strength. However, steel reinforcements corrode and expand over time, which impairs their functionality and causes microcracks in the concrete affecting the durability of the concrete itself. Corrosion is thus a big problem in the construction industry. In addition, shrinkage cracks can propagate to the level of steel reinforcement and accelerate the corrosion of steel bars.

So, our work mainly focuses to replace steel reinforcement with plastics. This project mainly focuses on the evaluation of compressive strength, flexural strength and split tensile strength by the addition of plastic strips in the form of mesh in 3 layers. Normally when plastic added with concrete its strength

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decreases. Hence we are using plastic in the form and then conduct a comparative study on the strength of plastic reinforced concrete and plain cement concrete.

II. LITERATURE REVIEW

Weena Lokuge et al. (2021) *Mechanical properties of macro polypropelene fiber reinforced concrete.* presented research work mainly focused on the mechanical properties of macro polypropylene fiber reinforced concrete. In this work two different polypropylene dosages (4kg/m^3 and 6kg/m^3) are used. It is found that its workability slightly decreased, Compressive strength increased by 9.6% & 19.4% respectively and Split tensile strength increased by 28.7% & 41.9% respectively. This paper recommends the use of uniformly distributed fibers since it resists the internal tensile stresses as well as blocking the initiation of cracks.

Younis M Aishkane et al. (2021) *The possibility of using waste PET plastic strip to enhance the flexural capacity of concrete beams.* This presented paper deals with the study of using waste PET plastic strip to enhance the flexural capacity of concrete beams. Dimensions of PET fiber used were 12 mm wide and 0.8 mm thick. The load carrying capacity of beam can be enhanced by 225% if 3 strips are provided and by 280 % if 9 strips were provided. Deflection of beam increased by 190% if 3 strips are used andby more than 500% if 9 PET are used.

Ibrahim Almeshal et.al (2020) *Eco friendly concrete containing recycled plastic as partial replacement for concrete*. This experimental work was conducted with six concrete mixtures containing PET. PET was used as a partial substitute for sand with substitution levels 0%, 10%, 20%, 30%, 40% and 50%. As the replacement ratio of PET increased, the splitting tensile and flexural strength decreased by 10.5%-85.5% and 2.4%-84.2% respectively.

Karthikeyan. M et.al (2019) *Utilization of waste plastic in concrete*. For this experimental work high strength concrete was prepared with 10% partial replacement of cement, fine aggregate and coarse aggregate with plastic. Based on the test results, the compressive strength for 7 days, and 28 days of 10% replacement is attained as 15 N/mm^2, 26 N/mm^2 respectively.

Adda Hadj Mostefa et al. (2019) *Study of concrete reinforced by plastic fibers based on local materials.* This presented work deals with the study of concrete reinforcement by plastic fibers based on local materials. Here wire fastener type plastic fibers having diameter 2mm and length 50 mm are used. Here plastic fibers were used to replace cement at 0.5%,1%,1.5%,2% and 2.5%. It was observed that the compressive strength, spilt tensile strength, flexural strength of concreteinitially increases and reaches a maximum value then it decreases. The optimum strength increase was found maximum at 1.5 % replacement.

Adewumi John Babafemi et.al (2018) *Properties of concrete with waste recycled plastic: a review*. In this work recycled plastics are used as a replacement for natural aggregates. Workability increases as the content of coarse recycled waste plastic aggregate increases, up to 50%. Increase in the content of plastic aggregates reduces the density of concrete. Upto 20% replacement an increase in the flexural / tensile properties can be achieved.

Balte Sanjaykumar et al. (2017) *Use of plastic fiber in the concrete.* This experimental study was conducted to evaluate the use of plastic fiber in concrete. PET fiber was used as a replacement of fine aggregate by 0.5% to 2%. Length of fiber was 35 mm and breadth were 1 mm.M20 grade of concrete were used. Compressive strength of Concrete increased by 4 to 5%. Split tensile strength increased by 8% and flexural strength increased by 59%.

Amani Alkalbani et.al (2016) *Use of recycled plastic water bottles in concrete blocks*. The purpose of this study is to examine the possibility of using plastic bottles in concrete block. The plastic bottles were used to create voids at equal distance between them in the masonry units. Concrete was placed around each bottle to encase it in the masonry units. The study utilized 500 mL plastic bottles placed inside concrete masonry units and analyzed the compressive strength. The proximity of compressive strength and density between cylinder, bottled concrete blocks and hollow concrete blocks are acceptable. In comparison to Omani hollow concrete blocks, the concrete blocks with plastic bottles shown 57% higher compressive strength.

III. METHODOLOGY

1. MATERIALS

Research materials are cement, natural fine aggregates, coarse aggregate, water, waste plastic bottles and adhesive material (combination of M-seal and wudfill).

Cement

Cement is a binding material on concrete. Here Ordinary Portland Cement of grade 53 is used. Testing of cement is done according to IS 431 (part IV)-1988. The properties of cement is shown below:

TABLE.1. PROPERTIES OF CEMENT

Sl. No	PROPERTY	VALUE
1	Fineness	7.9%
2	Standard Consistency	32%
3	Initial setting time	90 min

Fine Aggregate

Generally the size of aggregate which is passing through 4.75mm sieve size is called fine aggregates. Here we use Msand as fine aggregate. Properties of fine aggregate is shown below:

TABLE.2. PROPERTIES OF FINE AGGREGATE

SI.NO	PROPERTY	VALUE
1	Bulk Density	1.69kg/m^3
2	Void Ratio	0.564
3	Porosity	36.06%

Coarse Aggregate

The various properties of coarse aggregate is obtained by using IS 2386-1963 part-III. Properties of coarse aggregate is shown below:

TABLE.3. PROPERTIES OF COARSE AGGREGATE

SI.NO	PROPERTY	VALUE
1	Bulk Density	1.568kg/m^3
2	Void Ratio	0.712
3	Porosity	41.58%

Waste plastic bottles

Used plastic bottles are collected and cut into strip formats by making use of specially designed tool into equal width and length. Then they are placed in the form of a mesh as 3 layers inside the concrete with a minimum cover of 3cm.

Water

Water should be fresh, colourless, odourless and tasteless potable water which is free from organic matter of any type.

M-Seal and wud fill

- M-seal is resistant to moisture, heat, mild acids and alkali.

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- Fevicol wudfill is a cyano acralyate adhesive that bonds extremely fast when compared to other superglues

Fig.1.M-seal and wudfill

2. MIX DESIGN CALCULATION

Mix design is the process of selecting appropriate ingredients of concrete and determining their qualified amounts with the objective of producing a concrete of the required compressive strength, durability, workability as economical as possible.

Design of M20 grade concrete

Concrete mix design for M20 (1:1.5:3) grade concrete is prepared with w/c ratio 0.5. The total quantities of each material required for the preparation of 3 cubes, 3 beams and 3 cylinders are given below:

1) Water content – 10.465 l
2) Cement content – 20.931 kg
3) Fine aggregate – 31.3965 kg
4) Coarse aggregate -62.793 kg

3. MOLDING PROCESS

- Concrete is mixed thoroughly and placed in moulds. It was compacted by using tamping rod to remove all air voids in them.
- 3 Beams of size 50×10×10cm, 3 cylinders of diameter 15cm, length 30cm and 3 cubes of size 15cm are prepared.
- For plastic reinforced concrete, plastic reinforcement is placed as 3 layers inside the concrete with a minimum cover of 3cm.


Fig.2. Preparation of moulds

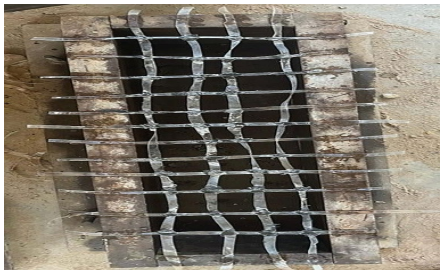
Fig.3. Preparation of plastic reinforcement


Fig.4. Placing of plastic reinforcement


Fig.5. Casting

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4. DEMOLDING

- After 24 hours, molds were removed.
- After demolding, legible identification marks were given on the top or bottom of cubes, beams and cylinders using a waterproof marker.

Fig.6. Demolding

5. CURING PROCESS

- Cubes, beams and cylinders were cured in fresh water for 28 days at room temperature.
- Curing plays an important role in gaining strength of concrete. If curing is not done properly, concrete will not gain enough strength.

Fig.7. Curing

6. TESTING PROCESS

- Testing of plain cement concrete as well as plastic reinforced concrete were done after 14 and 28 days of curing.
- Tests conducted on hardened concrete are compression strength test, flexural and split tensile strength test.

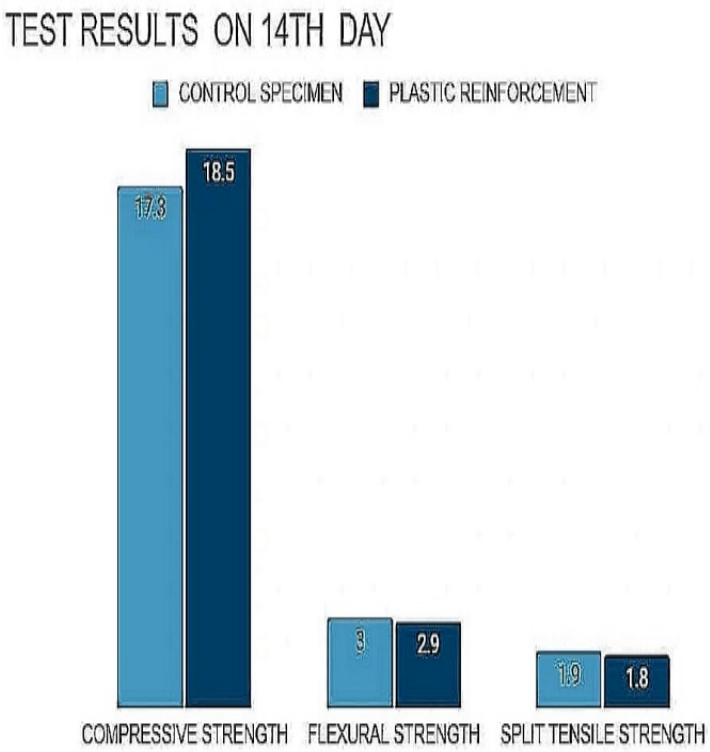
IV. RESULTS

TEST RESULT ON 14TH DAY

TABLE.4. TEST RESULT ON 14TH DAY

	Compressive strength (N/mm^2)	Flexural strength (N/mm^2)	Split tensile strength (N/mm^2)
Control specimen	17.3	3	1.9
Plastic Reinforced concrete	18.5	2.9	1.8

GRAPH.1. TEST RESULTS ON 14TH DAY



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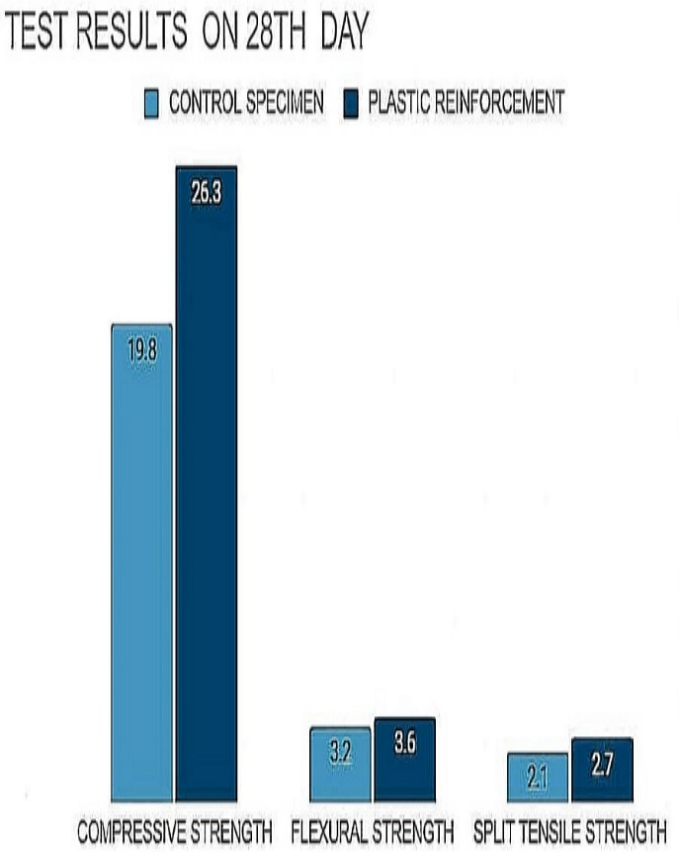
TEST RESULT ON 28TH DAY

TABLE.5. TEST RESULT ON 28TH DAY

	Compressive strength (N/mm^2)	Flexural strength (N/mm^2)	Split tensile strength (N/mm^2)
Control specimen	19.8	3.2	2.1
Plastic Reinforced concrete	26.3	3.6	2.7

GRAPH.2. TEST RESULTS ON 28TH DAY



V. ADVANTAGES & DISADVANTAGES

The following are the advantages and disadvantages of using plastic reinforced concrete:

ADVANTAGES

- It is cost effective.
- It improves strength over time.
- Since plastics are inert to salts, it can be used in saline environments.
- It can be used in construction of compound walls.
- It can be used for manufacturing of precast building materials such as partition walls etc.

DISADVANTAGES

- It can't be used in the construction of high load bearing structures.
- Only certain shaped plastic bottles can be used for making meshes.
- Melting point of plastic is very low. Hence it melts easily when exposed to high temperature.

VI. CONCLUSIONS

The following are the conclusions of the comparative study:

- The compressive strength of concrete is improved by 11.1% than plain cement concrete.
- Flexural and split tensile strengths are lower plain cement concrete on 14th day but on 28th day test both strengths are improved by 2.7% and 1.5%

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