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Utilization And Characterization Of One Time Used Waste Plastic As A Fiber In Concrete Base Course

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Abstract

The main purpose of this experimental work is to study and analyze how the one time used waste plastic will be effectively utilized in the construction of the Base layer of cement concrete pavement. In this investigation, we used Plastic Straws and Plastic cups. These onetime used plastics are cut into the dimension to make into a fiber after cutting into pieces it was added with a dry mix concrete with 0%, 0.2, 0.4%, 0.6%, and 0.8% by weight of concrete mould. The studies were carried out on an M15 Mix. For this experiment the test specimen are made in the form of a cube, cylinder, and beams. In this experimental work, two different dimensions of plastic fiber are used and investigate their effects on the mechanical properties of concrete. The use of smaller flattened end plastic fiber improves the strength and workability. The results showed that the addition of one time used plastic fiber in concrete increases the compressive strength, split tensile strength, and flexural strength. The results and mix design adopted in this project for base course is M15 grade concrete with DLC replacement.

Keywords: *Dry Lean Concrete (DLC), Environmental problems, M15 concrete base course, One time used plastic fiber, Properties of concrete and experimental study, Strength parameter*

1. Introduction

In modern days there is a serious issue regarding the disposal of one time used plastic or plastic waste throughout the world. This is creating serious environmental problems, so it became necessary to resolve those problems by effectively utilized plastic in civil engineering projects. The pavement is a multi-layer structure in which one layer is placed over another layer. An Individual layer of pavements is designed to bear the vehicular stress and load. The man aim of the experimental work is to increase strength and minimize the cost of the base layer in the rigid pavements there for alternative materials like (Plastic Straws, Plastic Water Bottles, and Coffee Cups, Plastic Bags, food packers and wrappers, take-away food containers) are used as a fiber in the construction of base layer of pavements. Many Investigations were already done by the earlier researcher for introducing new materials that can be added into the concrete to increase its strength parameter of concrete. The plastic fiber is one of them while using fiber we have to be concentrate on various types of fiber characteristics such as geometry and dimensions. Instead of disposing of this onetime used plastic directly, we can utilize it as a fiber in the construction of a base layer of rigid pavement, which helps to reduce the environmental pollution caused by plastic waste.

The main components of the pavement are:

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1.Foundation: The foundation comprises subgrade soil and sub-base. Foundation provides support for the above layers a pavement. Therefore it should withstand the loads to be transferred from the upper layer.
2. Base course: The base course of pavement is its main structural part which bears the vehicular load.
3. Surfacing: It is the topmost layer of pavement and has appropriate resistance to skidding and crack formation.
Dry Lean Concrete (DLC):
Dry lean concrete may be defined as a lean concrete with a low w/c ratio i.e. dry or most commonly known as roller compacted concrete.
Concrete pavement consists of three layers which are

- Sub-Grade
- Base Course (Dry Lean Concrete)
- Top Concrete Layer (Pavement Quality Concrete)

Base Layer for concrete pavement is generally made up of bonded materials such as Dry Lean Concrete. And higher grade of concrete is used for the construction of a top layer of rigid pavement. In this paper DLC is replaced completely with M15 concrete and all the results and studies are considered for M15 only.

Concrete is the main constituent which is composed of aggregate, sand, cement, and which get harden when adding with water. If that plastic is deposited in a land field or dumping in an open area without any alternate treatment process it may lead disaster to the environment and contamination of water bodies as well as soil. There are different types of waste are available among them plastic waste is non-biodegradable which takes hundreds of years to be decomposed. The plastic wastes become unmanageable if this plastic thrown directly to the ground and also create lots of environmental issues. So it became necessary to use those one-time use waste plastics as the construction of base course along with base course materials and its mechanical behavior is investigated.

Literature Review

Dora Foti, "Preliminary analysis of concrete reinforced with waste bottles PET fibers" [1]: In this paper the plastic waste used as a fiber to increase flexural strength of the mix and also performance of the mixes were compared.
Zainab Z. Enas A. AL-Hashmi, "Use of waste plastic in concrete mixture as an aggregate replacement [2]. In this paper replacement of plastic with aggregate were made and analyzed strength characteristics of the material.
Venu Malagavelli, Rao.P.N, "Effect of non-biodegradable waste in Concrete slabs"[3] In this paper plastic used for building concrete slab and analyses slab action due to varying percentage of plastic in the mix.

2. Materials and Properties of Materials

Materials:
1**.** Material collection
Cement
Fine Aggregate
Coarse Aggregate
Water
One Time Used Plastic Fibers
2**.** Evaluation of material properties
(a) On Cement:
(b) On Sand:
(c) On Coarse aggregate:
[1] Cement: It is the most important component in the field of construction and it acts as a binder material and it helps to binds the particles together and it is available in different grades. Based on the types of construction the suitable grade of cement is adopted. Mainly it is available in three grades

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which are 33 grade 43 grade and 53 grade. In this experiment, we used 43 grade of ordinary portland cement. The cement used was fresh and free from lumps. Physical Properties of cement

Table 1: Cement properties

S.N	Test Carried out	Obtained Value	Standard value
1	Specific gravity	3.13	3.0-3.15
2	Normal Consistency	30%	Not less than 30%
3	Initial Setting Time	110 (Minutes)	Not less than 30min
4	Final Setting Time	340 (Minutes)	Not more than 600min

[2] Aggregate: Aggregate is defined as mineral constituents usually comprising both coarse and fine fraction. It is mainly obtained from crushed stone, rock sand natural gravels. it occupies the most volume of a concrete. It is classified into two major types:

- Coarse aggregate
- Fine aggregate

(a) Fine Aggregate (Sand): Fine aggregate plays an important role in the concrete component, it helps to fill up the open pores between the two aggregate. it is mainly recognized by its size and its texture. Sand is also available in two-state one is river sand and another is M sand. In this experiment, we used M sand as a fine aggregate.

Table 2: Properties of Fine Aggregate (Sand)

S.N	Test	Obtained Result	Standard value
1	Sieve Analysis (Fineness modulus)	2.44	FS-2.2-2.6 MS-2.6-2.9 CS-2.9-3.2
2	Specific Gravity	2.62	2.5-2.9
3	Water Absorption	1.02%	0.3-2.5%

(b) Coarse Aggregate: Aggregate in concrete is a structural filler, Aggregate occupies most of the volume of the concrete. To achieve a good strength we have to use a hard and clean aggregate. In this experimental work, we used two sizes of coarse aggregate which are 20mm and 12.5mm aggregate. The properties of the Coarse aggregate are listed below.

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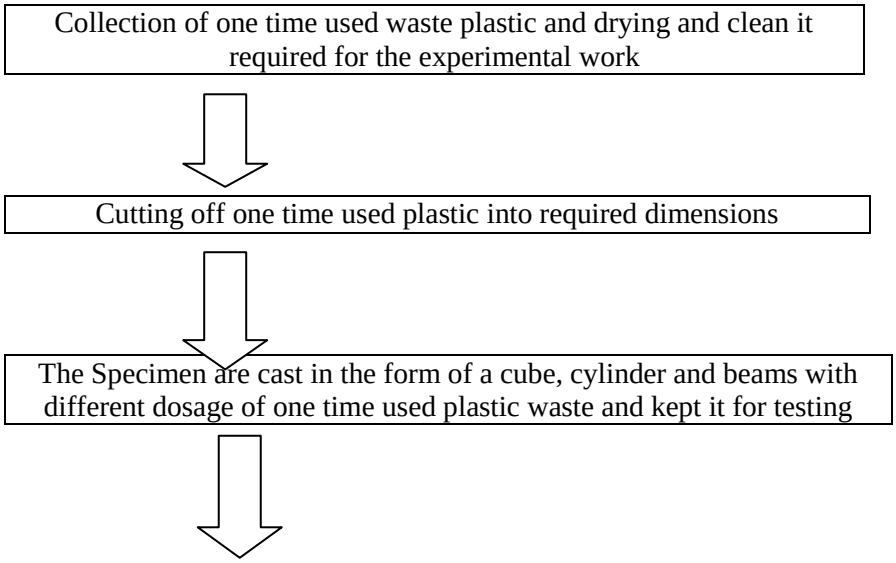
Table 3: Aggregate Properties

S.N	Test	Obtained Result	Standard value
1	Sieve Analysis (finess)	3.61	
2	Specific Gravity	2.78	2.5-3.1
3	Water Absorption	0.72%	<2%
4	Impact	18%	30%
5	Crushing	22%	30%

(c) One Time Used Plastic Fiber: The one-time-use plastic fiber used in this experimental work was prepared by hand cutting of various dimensions. In this work, we used two types of one time use plastic fiber i.e. Plastic Straw having the dimensions of 50mm length and 5mm thickness and Plastic cup having dimensions of 60mm length and 5mm thickness. One time used plastic fiber that has been used in this experimental work are

3.Methodology: The Flow Diagram of Methodology of the projects shown below



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Comparison of results of conventional concrete with plastic fiber concrete

(a) Mix Design and Workability test: After collecting all the properties of the materials the mix design for Dry Lean Concrete was to be designed as per the MORTH Specification for conventional concrete (0%) for the same Mix design the various percentage of one time used plastic fiber was added

(b) Casting Procedure

- The Freshly mixed concrete was placed in a cube of 150mm*150mm*150mm, Cylinder of 300mm height and 150mm diameter, and a beam of 100mm*100mm*500mm dimensions.
- The inner surface of the mold should be cleaned completely and oiled.
- Concrete is compacted with the help of a tamping rod which is made of steel having radius 8cm and 61cm height.
- The excess concrete was trimmed off.

(c) Curing

- All the cubes, cylinders, and beams are kept for a curing period of 7, 14, and 28 days.
- In this work, the specimen was cured under gunny bags.

(d) Testing

- After curing, the specimen is tested for 7, 14, and 28 days with a respective machine.

4. Experimental Procedure: In this division, the test conducted during dissertation work explained briefly Such as

- ❖ Compression Test
- ❖ Split Tensile Test
- ❖ Flexural Strength Test

(a) Compression Strength Test: Compressive strength is the capacity of a material to withstand load tending to reduce the size, as opposide to tensile strength. The specimens were tested for compressive strength at 7days 14days and 28 days. It is obtained by dividing the failure load by a cross-sectional area. Three samples are tested to obtain the average compressive strength. A cube having a dimension of 150mm*150mm*150mm was cast. Samples are kept for curing for 7days, 14days, and 28days after completion of the curing period of individual cubes the samples are kept for testing under the Compression testing machine, and the fracture load was noted of an individual cube and finally, the average value was calculated.

$$\text{Compressive Strength (Mpa):} \quad \frac{\text{Failure Load}}{\text{C/S Area}}$$

(b) Split Tensile Strength Test: The tensile strength of concrete helps to determine the important properties of concrete. Split tensile strength of a concrete is determined when the samples fail to withstand the load. cylindrical samples were cast to determine the split tensile strength, the mould is having the dimension of 150mm diameter and 300mm length. after 24 hours of casting the specimen were remolded ad keep it for 7days, 14days, and 28 days curing.and then take out the cylinder from the curing and tested under CTM by applying gradually load along the length of the cylinder and the corresponding load is noted. for every percentage of one time used plastic fiber, three cylinders were tested and their average value noted. It is calculated by using the below formula.

$$\text{Split Tensile Strength (Mpa)} = \frac{2P}{\Pi * D * L}$$

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Where,
P= Load Failure in KN
D= Cylinder Diameter in mm
L= Length of a cylinder in mm

(c) Flexural Strength Test: It is defined as the ability of materials to resist the deformation for applied load, flexural strength is also known as modulus of rapture. This can be done by either two-point loading or by center loading. In a two-point loading load is applied at 1/3 rd of a span, for center loading load is applied at the center of the span. Beam specimen of dimension 100mm x100mm x500mm was cast for the flexural strength test. after 24 hours of casting the specimen was remold ad keep it for 7days, 14days, and 28days for curing, and the specimen is tested on a testing machine. Load and corresponding deflection reading were noted down up to beam shows the crack (Failure Point) and the average value is reported. The flexural strength is calculated by using the following formula.

$$\text{Flexural Strength (Mpa)} = \frac{PL}{BD^2}$$

Where,
P= Load Failure in KN
L= Distance between two support in mm
B= Width of a specimen in mm
D= Depth of specimen in mm

Replacement of DLC with M15 concrete

In this experiment gradation of DLC as per IRC-SP-49-1998 is followed with increase in cement content in the mix as per the code provision and the minimum limit. The adopted cement content up to 7.5 % that is 180 kg/m^3 that is more than the minimum cement content 6% that is 150Kg/m^3. Increase in cement content and strength parameters of the mix to produce stable rigid base course layer for higher loads and to cutoff infiltration of water through base course.

Table 4: Aggregate Gradation for Dry Lean Concrete

Sieve Designation (mm)	**Percentage passing the sieve by weight**	**Adopted gradation**
26.50 mm	**100**	**100**
19.00 mm	**80-100**	**90**
9.50 mm	**55-75**	**65**
4.75 mm	**35-60**	**47.5**
600 micron	**10-35**	**22.5**
75 micron	**0-8**	**4**

5. Results and Discussion

In this experimental work, the various percentage of one time used plastic fiber i.e (0% 0.2%,0.4%, 0.6%,0.8%) were added by the weight of the concrete which are used to check different mechanical and durability properties of concrete.

Table

(a) Compressive Strength: The Compressive strength of cube having a dimension of 150mm x 150mm x 150mm samples was cast to find out the compressive strength after 7days, 14days, and 28days of curing. The below table shows the compressive strength of the concrete cube specimen with various percentages of one time used plastic fiber. And cubes are tested under CTM
Compressive Strength results for 7 days, 14days, and 28days of curing are shown below.

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(b) **Split Tensile Test:** For the Split tensile test cylinder having a dimension of 150mm diameter and 300mm length specimen with various percentage of one-time-use plastic fiber is cast to obtain the split tensile strength after7days, 14days, and 28days of curing. The below table shows the split tensile strength of concrete cylinder specimens with various percentages of one time used plastic fiber. and the cylinder is tested under CTM.

(c) Flexural Strength: Flexural strength test of a beam having a dimension of 700mm x 150mm x 150mm specimen cast to determine the flexural strength after the 7, 14, and 28 days of curing. The below table shows the flexural strength of the concrete beam specimen with various percentages of one time used plastic fiber. And beams were tested under UTM.

Table 5: The result of Compressive Strength, Split Tensile Strength, and Flexural strength test of 7 days, 14 days, and 28 days are shown in the below table.

SI.No	Plastic Fiber (%)	Compressive Strength (N/mm^2)			Split Tensile Strength (N/mm^2)			Flexural Strength (N/mm^2)		
		7 Days	14 Days	28 Days	7 Days	14 Days	28 Days	7 Days	14 Days	28 Days
1	0%	10	13.55	14.97	1.53	2.33	2.73	1.78	2.39	2.83
2	0.2%	10.57	13.73	15.67	1.69	2.65	2.86	1.89	2.57	2.96
3	0.4%	11.55	14.03	16.82	1.98	2.95	3.15	2.03	2.71	3.07
4	0.6%	10.67	13.82	15.75	1.75	2.55	2.86	1.94	2.62	2.97
5	0.8%	10.32	13.69	15.24	1.62	2.41	2.76	1.83	2.53	2.85

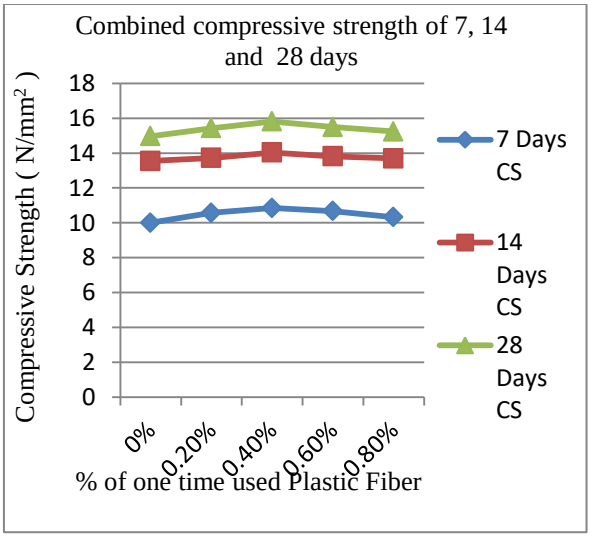

Figure 1: Line chart of combined compressive strength of 7days, 14days, and 28days

From the above-obtained result, it is concluded that the addition of one time used plastic with concrete increases the compressive strength. The compressive strength is increased from 0% to 0.4% and after 0.4% the strength was decreased

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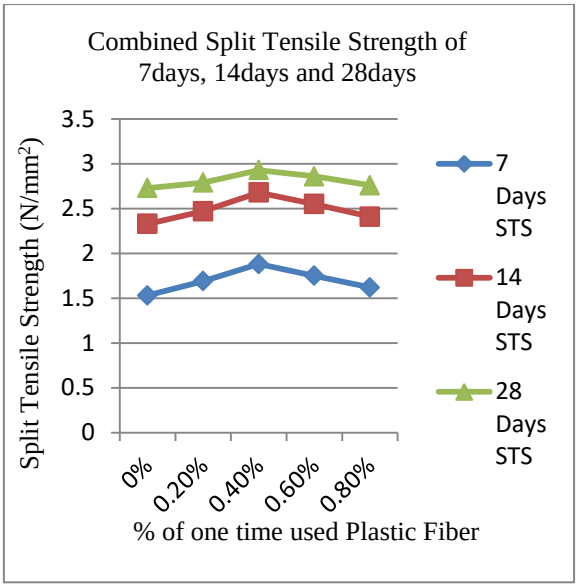

Figure 3: Line chart of combined Split Tensile strength of 7, 14 and 28 days

From the above result, it is concluded that the split tensile strength of concrete was increased till 0.4% and after the addition of one time used plastic fiber the split tensile strength was decreased.

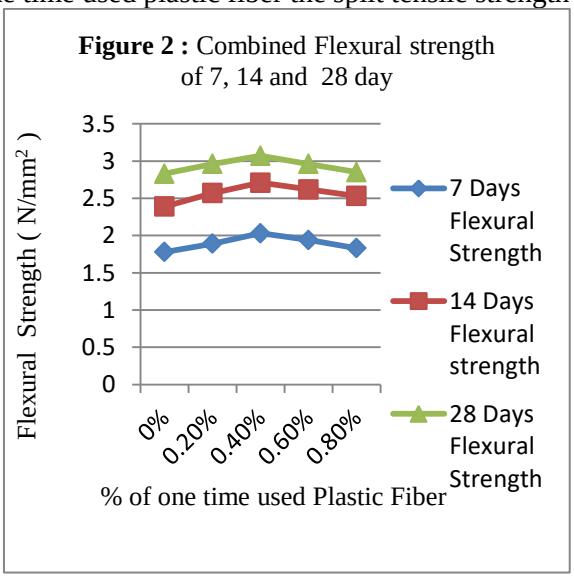

Figure 2 : Combined Flexural strength of 7, 14 and 28 day

CONCLUSION

Based on the laboratory work the following results were made.
1) In this experimental work, the onetime used plastic fiber has been added to concrete to determine the strength parameter and improving the structural performance of the base layer of concrete pavement. On the other hand, the effective utilization of one time used plastic which is difficult to re-cycle completely.
2) In this work the fibers used are obtained by simply cutting by scissor in various dimensions without any processing, the test result shown that the addition of a small amount of plastic fiber can have a large influence on a concrete element.
3) In this work, we used the different ratios of plastic fiber such as (0%, 0.2%, 0.4%, 0.6%, and 0.8%), and the optimum strength was observed at 0.4% of fiber content for all types of strength. and helps to increase the ductility of concrete.

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4) Compressive strength of concrete is increased up to 10% of the addition of one time used plastic fiber and over 0.4% it goes on decreasing.
5) The Split tensile strength of concrete shows the improvement up to 0.4% of the addition of one time used plastic fiber after that added strength of concrete is decreased with an increase in plastic fiber.
6) It was observed that the flexural strength of concrete shows that improvement up to 0.4% addition of one time used plastic fiber after that added strength of concrete is decreased with an increase in plastic fiber.
7) From the above results, we can conclude that the use of one time used plastic fiber can be useful for improving the properties of concrete as well as helps to minimize the problems created by plastic.
8) Increase in cement content reduces voids in the mix and behavior of the layer is completely rigid in character. Also infiltrated water does not percolate through this layer.

Future Scope Of Work

1) Grinding of one time used plastic may be followed to obtain fiber in large quantities.
2) To improve the bonding of fibers admixture may be used.
3) To improve the strength of concrete, fiber can be used along with steel fiber.
4) Permeability properties of the base course to be studied to adopt on site and performance of the mix to be verified,

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