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Study on Utilization of Waste Plastic as Fibres in Fibre Reinforced Concrete

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Abstract - *In the present decade, one of the environmental issues in most regions of world is the existence of large number of bottles made from poly-ethylene terephthalate (PET) and huge quantities of plastic wastes deposited in domestic wastes and landfills. These plastic wastes are adversely affecting the environment and is a topic of serious concern for various concerned authorities. In spite of all efforts made to limit the use of plastic based products, their utility is increasing day by day and thus the amount of plastic waste generated is also increasing day by day. Various attempts were made through experimentation to check the feasibility of plastic waste to be use partially in concrete with respect to various properties of strength, workability, durability and ductility of concrete. This paper is aiming to give an over view of various studies conducted on utility of waste plastic material used in the concrete. Waste plastics can also be used as fibres. The disposing of waste plastic is causing environmental pollution. The plastic is a non-biodegradable material, neither decays nor degenerate it either in water or in soil. In turn it pollutes the water and soil. The plastic if burnt releases many toxic gases, which are very dangerous for the health. Such plastic, which is non-biodegradable material, can be used in concrete in the form of fibres to improve some additional desirable qualities to the concrete.*

Key Words: Fibre Reinforced Concrete, Waste Plastic Fibre Reinforced Concrete, Waste Plastic Fibres, Compressive Strength, Split Tensile Strength, Concrete.

1. INTRODUCTION

Concrete is a multipurpose material for civil engineering construction. It has many beneficial properties such as good compressive strength, durability, specific gravity and fire resistance. The concrete consumption in India by various construction industries is around 370 million m^3 per year and it is expected to increase by 30 million m^3 every year. Concrete in its simplest form requires three basic components - cement (the binder), aggregates (ranging in size from fine to coarse) and water. Concrete's constituent materials are available naturally in all parts of the world but with the increasing requirement of concrete in various construction industries, these materials are getting scarce day by day. On the other hand the rapid urbanization and industrialization all over the world has resulted in huge deposition of plastic waste. Dumping of plastic waste in an environment is considered to be big hazard due to its very low biodegradability and presence in large quantities.

The world's annual usage of plastic materials was about 5 million tons in the 1950's which has now increased to 100 million tons in recent times, resulting in more amount of generation of plastic waste. Thus both the problems- disposal of plastic waste and absence of concrete's constituent materials can be effectively managed by using the plastic waste in concrete. Use of plastic waste materials not only helps in getting them utilized in cement concrete but also helps in reducing the cost of cement and concrete manufacturing. It has also numerous indirect benefits such as decrease in landfill cost, saving in energy, and protecting the environment from possible pollution effects. Various properties of concrete like ductility, durability and tensile strength can be improved by efficiently using plastic waste in concrete. Moreover using plastic waste in concrete decreases its weight also and thus buildings can be made more earthquake resistant by using plastic waste in concrete. It is manmade building material it can be mould into any shape. The fibres are dispersed and distributed randomly in the concrete during mixing and this improves certain properties like tensile strength, flexural strength etc. Fibre reinforced concrete can be defined as composite materials consist of cement based matrix containing an ordered or randomly distributed of fibres. The common fibres used in the concrete are steel, glass, asbestos, jute, polypropylene, nylon.

The usage of plastic fibres in the concrete improves the mechanical properties of concrete. Taking into account that concrete will continue to be the main construction material in the future, several research projects have showed that it was possible to use plastic waste in concrete. Thus it is highly efficient and justifiable to use plasti-fibres in concrete which in turn improves the mechanical properties and shear capacity of concrete.

Objectives of Study

- The main objective is to study the properties of fibre reinforced concrete by preparing fibres from different waste plastic materials and

adding them to the concrete in different percentages.

- To conduct laboratory test to check the properties of cement, sand and aggregates.
- To conduct laboratory test to check the strength of plastic waste fibre reinforced concrete.
- To compare the strength of the normal concrete to the plastic waste fibre reinforced concrete.

2. LITERATURE REVIEW

2.1 Venu Malagavell and Neelakanteswara Rao Patura,(2011), "Strength Characteristics of Concrete Using Solid Waste an Experimental Investigation"

They concluded concrete is a mixture of cement, fine aggregate, coarse aggregate and water. Concrete plays a vital role in the development of infrastructure, buildings, industrial structures, bridges and highways etc. leading to utilization of large quantity of concrete. Solid waste disposal i.e. water bottles, polythene bags, cement bags, cold drink bottles etc. was creating lot of environmental problems. An attempt has been made in this study by using solid waste (non-biodegradable) material in the concrete. Fibre Reinforced Concrete (FRC) is an emerging field in the area of Concrete Technology. This study mainly focused on the use of cement bags waste (High Density Polyethylene (HDPE)) in concrete. Concrete having compressive strength of 30 N/mm2 was used for this study. Cubes, cylinders and beams are casted with 0 to 6% of fibre with 0.5% increment. Samples were tested for the compressive strength, split tensile strength and Flexural strength and comparison analysis was made for the conventional concrete and modified concrete. It has been found that, increase in the compressive strength, split tensile strength and flexural strength of concrete by using the fibres up to some extent.

2.2 R.Kandasamy and R.Murugesan(2011), "Fibre Reinforced Concrete Using Domestic Waste Plastics as Fibres"

Fibre Reinforced Concrete (FRC) is a composite material consisting of cement based matrix with an ordered or chance division of fibre which can be Steel, Nylon, Polythene and etc. The addition of steel fibre increases the properties of concrete, viz., flexural strength, impact strength and shrinkage properties to name a few. A number of papers have previously been published on the use of steel fibres in concrete and a considerable amount of research has been directed towards study the various properties of concrete as well as reinforced concrete due to the addition of steel fibres. Hence, an attempt has been complete in the present investigations to study the influence of addition of polythene fibres (domestic waste plastics) at a dosage of 0.5% by weight of cement. The properties studied include compressive strength and flexural strength. The study were conducted on a M20 mix and tests have been carried out as per recommended procedures of pertinent codes.

2.3 ZainabZ Ismail and EnasaAl-Hashmi (2011), "Validation of Using Mixed Iron and Plastic Wastes in Concrete"

The reason of this paper is to evaluate the possibility of using mixed iron filings and granulated plastic waste materials simultaneously to partially alternative the fine aggregate in concrete composites. Type I Portland cement was mixed with the aggregates to create the concrete composites. Three weight fractions (30, 40, and 50%) of iron filings waste aggregate were used along with 5% of granulated plastic waste. The slump, compressive and flexural strengths as well as the fresh and hard density of the concrete mixture were determined. The results of the mechanical properties were analysed in comparison to the control specimens. The main findings of this investigation revealed that the mixture of iron filings and plastic waste materials could be used successfully as partial substitutes of sand in concrete composites. Raising the granulated plastic waste in the mixed aggregate waste materials up to 10% did not seriously hinder the strength properties of the waste-concrete specimens.

2.4 Rajat Saxenaa, Abhishek Jaina and Yash Agrawala (2016), "Utilization of Waste Plastic in Concrete Towards Sustainable Development: A Review"

This review paper has presented aspects on plastic waste and its usage in concrete, which could be summarized and concluded as:

- According to prior test studies, it refers that plastic waste can be utilized in concrete up to certain limit without much effecting the properties of concrete.
- Plastic waste has control on the workability property of concrete. Slump value and the compaction factor decreased with the increase in amount of plastic waste in concrete.
- Different studies demonstrates that strength of concrete containing plastic waste were comparable to that of reference concrete up to certain limits.
- Use of plastic waste in concrete mix proved exceptionally helpful to produce green sustainable concrete.

2.5 A. Ananthi, A. Jay Tamil Eniyan, S. Venkatesh (2017), "Utilization of Waste Plastics as a Fiber in Concrete"

Based on the test result, the following conclusions are made.

- The compressive strength and split tensile strength increases to maximum when 0.9% of plastic fibres are added to conventional concrete.
- The compressive strength increases to 40.3% than conventional concrete at 7 days.
- The compressive strength increases to 28.5% than conventional concrete at 28 days.
- The split tensile strength increases to 54.8% than conventional concrete at 7 days.

The split tensile strength increases to 54.4% than conventional concrete at 28 days.

3. METHODOLOGY

i. Literature review.
ii. Preparation of materials.
iii. Tests on materials.
iv. Mix design.
v. Preparation of test specimens and moulds.
vi. Mixing of wet concrete.
vii. Casting.
viii. Curing.
ix. Testing (Compressive and Split Tensile Strength etc.)
x. Result, Comparison and analysis.
xi. Conclusion.

3.1 Materials Used and their Properties

The composition of the plastic fibre reinforced concrete consists of two components. The concrete matrix component consisting of cements, aggregate, water and fibre constituent consisting of waste plastic fibres added to the concrete mix in different proportion.

A. Cement

Ordinary Portland cement of 53 grades available in local market is used in the investigation. The cement used has been tested for various proportions as per IS: 4031-1988 and found to be conforming to various specifications of IS: 12269-1987. The specific gravity was 3.21, normal consistency is 33%, initial setting time is 85 minutes and final setting time is 374 minutes. The fineness of cement is 1%.

B. Coarse Aggregate

Locally available coarse aggregate conforming IS 383-1970 with a maximum size of 20mm and minimum size of 12mm are used; specific gravity is 2.84 and water absorption 0.40%. Aggregate impact value is 23.66%

C. Fine Aggregate

Fine aggregate can be natural or crushed stone dust. Locally available river sand passing through 4.75 mm IS sieve is used and it conforms to zone III (As per IS 383 – 1970). The specific gravity and fineness was found to be 2.593, water absorption is 0.401%

D. Plastic Fibres

Plastic fibres are obtained from domestic waste plastics by cutting them in form of fibres. The length of fibres varies between 20mm to 50mm with thickness varying 0.125mm to 0.85mm and width ranging 2mm to 5mm.

E. Water

Portable water free from impurities and salt used for casting and curing the concrete blocks as per IS – 456-2000.

3.2 Mix Design

The experimental investigation was carried out to study the properties of M25 grade concrete. The mix was designed as per IS 10262-2009. To study the effect of waste plastic fibres on the strength of concrete the % of plastic fibres is varied from 0.5% to 2.0% by total weight of cement. No chemical admixtures are used in this study.

Quantity of materials required for M25 Concrete with w/c = 0.5

Ingredient	Quantity Kg/m³	Ratio
Cement	425.7	1
Fine Aggregate	727.2	1.708
Coarse Aggregate	1119	2.628
Water	191.58	0.45

Materials Properties:

Physical Properties	Obtained Result
Specific gravity of Cement	3.21
Fineness of Cement	1%
Normal Consistency of Cement	33%
Initial Setting Time of Cement	85 min
Final Setting Time of Cement	374 min

Compressive Strength of Cement(MPa) at 28	53.6
Sp. Gravity of Fine Aggregates	2.593
Sp. Gravity of Coarse Aggregates	2.83
FM of Fine Aggregates	2.65
FM of Coarse Aggregate	7.29
Aggregate Impact Value	23.66%
Water Absorption of Fine Aggregate	0.401%
Water Absorption of Coarse Aggregate	0.40%

3.3 Test Specimen

In this study a total of 60 specimens were casted of which, 30 cubes of size 150mm x 150mm x150mm for compression test and 30 cylinders of size 150mm X 300mm for split tensile strength test. The specimens without fibres are considered as control specimens & with fibres are considered as plastic fibre reinforced concrete (PFRC). All the specimens were cured and tested after 7 & 28 days.

3.4 Test Procedure

Compressive strength test

Compressive strength of concrete is one of the most significant and useful properties of concrete. In most structural applications concrete is used mainly to resist compressive stress. The compression test was conducted on cube specimens cured for 14 & 28 days. The test cubes were removed from the moist storage 24 hours before testing. The top and bottom bearing plates of the compression testing machine were wiped and cleaned in before the placement of the specimen. After ensuring the connection between, the cube specimen was placed on the lower bearing plate keeping the centre alignment by the screwed guides on the bearing plate.

Fig 1. Compressive strength test

Split tensile strength

The splitting tests are well known indirect tests used for determining the tensile strength of concrete sometimes referred to as split tensile strength of concrete. The test specimens shall consist of concrete cylinder of 150mm diameter and 300mm long. It consists of applying a compressive line load along a concrete cylinder placed with its axis horizontal between the compressive plates using compression testing machine. This test is conducted on specimens cured for 14 and 28 days.

Fig 2. Split tensile strength test

4. RESULT AND DISCUSSION

Workability In the present study the workability tests were performed using standard sizes of Slump moulds as per IS: 1199 -1999 to find out the workability of the plastic fibre reinforced concrete. It was noticed that mix was slightly stiff with slum ranging from 60mm to 42mm. For PFRC fibres are mixed in percentages of 0.5% to 2.0% by weight of cement, the workability is determined by slump value. Higher percentages of plastic fibres give less slump values.

Table 1.Effect of plastic fibres on compressive strength of concrete

Mix	Compressive Strength in N/mm2 when W/C ratio is 0.5		Workability of mix (w/c = 0.5)
M 25	7 Days Mean	28 Days Mean	Slump Value (mm)
PFRC 0.0%	29.4	33.38	66
PFRC 0.5%	28.65	33.61	52
PFRC 1.0%	26.98	35.04	46
PFRC 1.5%	27.22	37.01	41
PFRC 2.0%	26.81	36.38	32

Table 2.Effect of plastic fibres on split tensile strength of concrete

Mix	Split Tensile Strength in N/mm2 when W/C ratio is 0.5		Workability of mix (w/c = 0.5)
M 25	7 Days Mean	28 Days Mean	Compaction factor
PFRC 0.0%	2.33	2.75	0.90
PFRC 0.5%	2.38	2.78	0.89
PFRC 1.0%	2.61	3.32	0.87
PFRC 1.5%	2.83	3.44	0.85
PFRC 2.0%	2.85	3.49	0.83

5. CONCLUSION

From this study it can be concluded that the use of unmanaged or non-decomposable plastics in concrete mixtures as fibres can not only pave ways for its safe disposal method but also it has enhanced the mechanical properties of concrete. Plastic waste can be utilized in concrete up to certain limit without much affecting the properties of concrete. Slump value and the compaction factor decreases with the increase in amount of plastic waste in concrete. It is desirable to use plasticizers to increase the slump value and compaction factor for making it more workable. This study establishes that strength of concrete containing plastic waste fibres were comparable to that of reference concrete up to certain limits. The compressive strength is maximum at 0.5% PFRC for 7 days strength and PFRC 1.5% gives maximum value at 28 days strength. On the other hand PFRC 2% gives maximum result at 7 days and 28 days for split tensile strength. Use of plastic waste in concrete mix can be remarkably helpful to produce green sustainable concrete.

6. REFERENCES

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