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# Experimental Study on Strength Behavior of Tire Fiber and Polyethylene Fiber for High Performance Concrete

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**Abstract**
Concrete is robust in compression but weak in tension and brittle additionally. Cracks also begin forming as quickly because the concrete is located. These three drawbacks don't allow the use ordinary concrete in pavements as they cause lack of ductility along with fracture and failure. These weaknesses in concrete may be mitigated by way of the usage of fibers as reinforcement in the concrete mix. Waste substances in the shape of polyethylene and tires purpose environmental pollution which leads to numerous fitness issues. Polyethylene and waste tires can be recycled and used efficiently in the concrete as reinforcement in the fiber form. Polyethylene is a synthetic hydrocarbon polymer that may improve the ductility, power, shrinkage traits and so on. This paper offers with the effects of addition of polyethylene fiber on the houses of concrete. Polyethylene and tire fibers have been cut into the dimensions of 30mm x 6mm and that they were used 1.5% every by using quantity. Grade of concrete used were M30, M35 and M40. IRC 44:2008 changed into observed for the layout of concrete blend. In this observe, the consequences of the Strength residences of Polyethylene fiber bolstered concrete had been supplied. 4 point bending take a look at and double shear test were accomplished in the laboratory for flexure and shear electricity determinations. There changed into visible an boom of 18% within the 28 day compressive power alongside an growth of 39% in flexure and 32% in shear power. 22% lower in 4 point bending check and 36% decrease in double shear test in deflection turned into found out from the experiments. Theoretical evaluation of deflection changed into performed by way of the assist of electricity strategies. Practical values were confirmed with the theoretical values inside the permissible limits. Finally it can be concluded that polyethylene and tire may be used successfully in strengthened cement concrete.

**Key words-** Compressive strength, Flexure strength, Slump value, polyethylene fiber, Tire Fiber, Deflection.

## Introduction

For a developing nation such as India, road networks play a crucial role in providing a durable and comfortable surface for vehicles. Pavements are mostly made using bitumen. However, in certain situations concrete pavements are also preferred. Many additives have been explored for beneficial use of concrete as a paving material. A recent research has shown that fiber reinforced concrete (FRC) can be used for the construction of pavements as it is found to be very good in strength and it also exhibits other desirable properties.

Plastics are very strong and non-biodegradable in nature. The chemical bonds in plastics make it extremely sturdy and impervious to ordinary common techniques of degradation. The daily use of plastics has increased very rapidly and it has become a common habit of people to just throw out the plastic and causing environmental pollution. Over 1 billion tons of plastic have been produced since 1950s, and the same is likely to remain as such for many years. These wastes get mixed with MSW or they are simply thrown causing nuisance to the society. There is a big need of recycling of the plastics as well waste tires because we don't have any other option of disposing them without securing environment from pollution. For example, there are two processes for the disposal of wastes: land filling and incineration. If the wastes are simply dumped, they cause soil and water pollution and if they are incinerated, they cause air pollution. Hence, there is a need to recycle the wastes into something useful which will not hamper the environment and the process in which it is used.

## 2. Objectives

The objectives of the research are outlined below:

- To achieve the desire strength in high performance concrete.
- To find out the dosage of the Waste polyethylene and tire fibers at which the concrete gain the higher strength.
- Determination of the compressive strength Concrete and flexural strength, shear strength of conventional concrete beams**,** Deflection of the concrete Beam.
- Waste polyethylene and tire fibers is also industrial waste by the use of it we can reduced the environmental degradation.

## 3. Literature Review

Works on waste materials are discussed in the subsequent headings comprehensively. Hasan,M.J.,Afroz,M.,andMahmud,H.M.I.(2018)"AnExperimentalInvestigationonMechanicalBehaviorofMacro Synthetic Fiber Reinforced Concrete," International Journal of Civil &Environmental Engineering, Vol. 11, Concrete is an indisputable material for the construction of various types of structures in the modern advancement of civil infrastructures. Concrete is strong in compression but weak in tension and shear. To eliminate those problems, the introduction of fiber was brought in as an alternative to developing concrete in view of enhancing its tensile and shears strength as well as improving its ductile property. Hence, the purpose of this study was to investigate the mechanical behavior of concrete reinforced with macro (structural) synthetic fibers. To determine these properties experimental work was carried out. Four batches of concrete were cast: one with no fibers and the remaining three with three different volume fractions fibers of 0.33, 0.42 and 0.51%, respectively. Concrete specimens (cubes, prisms and beams) were cast to determine the mechanical behavior such as compressive, tensile, shear strength and stress-strain relationships. Test results showed that macro synthetic fiber enhanced the compressive strength insignificantly. However, macro synthetic fibers at 0.33, 0.42 and 0.51% volume fractions improved the tensile strength by at least 10, 15 and 14%, respectively, compared to the control specimen. Similarly the ultimate shear strength was increased significantly by at least 15, 45 and 65% for macro synthetic fibers of 0.33, 0.42 and 0.51% volume fractions, respectively, compared to the control beams. The failure of plain concrete specimens was sudden (brittle) for both the tensile and shear strength tests. However, the concrete reinforced with macro synthetic fibers showed more ductile behavior compared to the plain concrete. Macro synthetic fibers improved the ultimate strain value by at least 50, 60 and 60% for macro fibers of 0.33, 0.42 and 0.51% volume fractions, respectively. Omanakuttan Athira, An Experimental study on Strength Behavior of Steel Fiber, Glass Fiber with Fly Ash and Rice Husk Ash(IJARIIT-2017) ISSN: 2454-132, Hybrid Fiber-reinforced concrete is a composite material consisting of mixtures of cement, fine aggregate, coarse aggregate, steel fiber and glass fiber. The hybrid fiber reinforced concrete exhibits better fatigue strength and increased static and dynamic tensile strength. In this project, the strength of fiber reinforced concrete was investigated with partial replacement of cement with rice husk ash and fly ash. Steel fiber and glass fiber was added in the order of 0.25%, 0.5% and 0.75% by volume of concrete and 0.25%, 0.5% and 0.75% by weight of cement. Rice Husk Ash was used to replace ordinary Portland cement by 20% and fly ash 20% by weight of cement proportion, Aswani Sabu, Thomas Paul, International Journal for Research in Applied Science & Engineering Technology (IJRASET)Volume 4 Issue IX, September 2016,Fibres are generally used as a common engineering material for crack resistance and strengthening of concrete. Their properties and characteristics greatly influence the properties of concrete which has been proved already in many previous researches. Accordingly it has been found that steel fibres give the maximum strength in comparison to glass and polypropylene fibres. In this experimental study, two types of steel fibers namely hooked end and crimped fibers are used. The volume fractions taken are 0.75%, 1.0% and 1.25% and M30 grade concrete is adopted. Cement has been replaced with 25% of Class F flyash. The primary focus is to compare the mechanical properties of concrete using both fibres.

R. Madheswaran, S. Arun Singh, K.S. Sathyanarayanan International Journal of Civil Engineering and Technology (IJCIET)Volume 5, Issue 5, May (2014), pp. 114-122, Concrete is probably the most extensively used construction material in the world. The main ingredient in the conventional concrete is Portland cement. The amount of cement production emits approximately equal amount of carbon dioxide into the atmosphere. Cement production is consuming significant amount of natural resources. That has brought pressures to reduce cement consumption by the use of supplementary materials. Availability of mineral admixtures marked opening of a new era for designing concrete mix of higher and higher strength. Fly Ash and silica fume is a new mineral admixture, whose potential is not fully utilized. Moreover only limited studies have been carried out in India on the use of silica fume for the development of high strength concrete with addition of steel fibers. The study focuses on the compressive strength performance of the blended concrete containing different percentage of silica fume and Fly Ash and steel fiber as a partial replacement of OPC. The cement in concrete is replaced accordingly with Silica fume content was use from 0% to 10%in the interval of 2% in weight basis and also fly ash content was use from 10% in weight basis. So to improve the strength of concrete steel fibers were added 0.5%, 1%, 1.5%, 2% by weight of steel fiber. Concrete cubes are tested at the age of 3, 7, and 28 days of curing. Finally, the strength performance of Fly ash and silica fume blended fiber reinforced concrete is compared with the performance of conventional concrete. From the experimental investigations, it has been observed that, the optimum replacement Fly ash and silica fume to cement and steel fiber without changing much the compressive strength is 10% -8 % & 1.5 % respectively for M25 grade Concrete.

## 4. Base Materials

- **Basic materials**

The basic materials which compose concrete are:

1. Water
2. Cement
3. Fine aggregate
4. Coarse aggregate
5. Admixture (Plasticizer)

In case of polymer fiber reinforced concrete fibers are added. For this experiment 2 types of fiber are chosen. The fibers to be used in the concrete mixare:

1. Polyethylene fiber
2. Tire(Nylon) fiber

**A. Water**

Water is the most important material in concrete. It performs the following roles in concrete matrix:

a. It gives cement the adhering property. The quality, quantity, stability and rate of formation of the adhesive material that binds the aggregates depend on the quality and quantity of water added.

b. It also controls the workability of concrete. The more the water content (up to certain limit) the more is the workability.

c. The mechanical properties of hardened concrete as compressive, flexural strength and toughness also depend on hydration products of cement and there by depend on water content.

d. The plasticity of concrete depends on the water content.

e. Water is also needed for curing of hardened concrete to help concrete acquire its required strength.

**B. Ordinary Portland cement (OPC)**

It is a normal cement made by burning calcareous (Calcium carbonate) and argillaceous (Clay) together at a very high temperature and then grinding the resulting calcined product known as clinker with a minute amount of gypsum (for quicker hardening) into fine powder.

B. Fine Aggregate

Regular sand is generally used as the fine aggregate. In some cases quarry dust or dust from stone crushers are also used as fine aggregate. It contributes to a major portion of concrete matrix. Both natural and artificial sand can be used as fine aggregate.

C. Coarse Aggregate

It is generally comprises of crushed stones like granite. Sometimes gravel or broken bricks are also used as coarse aggregates. Coarse aggregate occupy the most part of the concrete matrix and contribute toward weight and strength of the hardened concrete.

D. Fibers

These are short discrete materials, may be metallic or polymeric, used as composing reinforcement for concrete structures. These are mixed with other components of concrete to form the matrix and add certain properties to it.

E. Preparation of fibers

The polythene used in milk packets is used as raw material for preparation of the fiber. These polythene packets are collected; they are washed and cleaned by putting them in hot water for 3- 4 hours. They are then dried. Similarly waste tires are collected. The steel wires inside them are striped out of the tires. They are washed in hot water and then dried.

## 5. Methodology

To study the various parameters of polymeric fiber reinforce concrete that affect the service life of a pavement with minimal maintenance, the following experiments are needed to be carried out:

1. Test of aggregates
a. Abrasion resistance of aggregates
b. Impact resistance of aggregates
c. Crushing resistance of aggregates
2. Test of concrete
a. Physical inspection of concrete
b. 28 day compressive strength test
c. Flexural strength test
d. Shear strength test

The flexural strength test to be conducted is 2-point load test (4-point bend test) and the shear strength test to be conducted is double shear test.

a. Casting and curing

Standard sized cubes (150mm x 150mm x 150mm) are casted for compression test of concrete. The beams casted are however different than standard size. The beams are casted with dimension 500mm x 100mm x 75mm.

b. Samples casted:

**A. Cubes**

I. 3 numbers of M30 conventional concrete
II. 3 numbers of M35 conventional concrete
III. 3 numbers of M40 conventional concrete
IV. 3 numbers of M30 fiber introduced concrete
V. 3 numbers of M35 fiber introduced concrete
VI. 3 numbers of M40 fiber introduced concrete

**B. Beams**

I. 6 numbers of M30 conventional concrete
II. 6 numbers of M35 conventional concrete
III. 6 numbers of M40 conventional concrete
IV. 6 numbers of M30 fiber introduced concrete
V. 6 numbers of M35 fiber introduced concrete
VI. 6 numbers of M40 fiber introduced concrete

Total 18 numbers of cubes and 36 numbers of beams are casted. They are allowed to stay in the mould for 24 hours. Then they are immersed in water for curing. After 28 days they are taken out from water, dried and then tested.

## 6. Experimental Work

### A. Compressive Strength Test

The compressive strength test is the most important test done on the concrete as it determines the characteristic strength of the concrete which represents the resistance of concrete against crushing load. The casted cubes are tested for compressive strength in the compression testing machine.

**Table 1:** Compressive strength of conventional concrete cubes.

| Grade of Concrete | Specimen no | Failure Load (tons) | Compressive Strength (N/mm2) | Mean Compressive Strength (N/mm$^2$) |
|---|---|---|---|---|
| M30 | 1 | 83 | 36.88 | 37.18 |
| | 2 | 84 | 37.33 | |
| | 3 | 84 | 37.33 | |
| M35 | 1 | 95 | 42.22 | 42.66 |
| | 2 | 97 | 43.11 | |
| | 3 | 96 | 42.66 | |
| M40 | 1 | 104 | 46.22 | 46.96 |
| | 2 | 108 | 48 | |
| | 3 | 105 | 46.66 | |

**Table 2:** Compressive strength of fiber introduced concrete cubes.

| Grade of Concrete | Specimen No. | Failure Load (tons) | Compressive Strength (N/mm$^2$) | Mean Compressive Strength | Strength Gain (%) |
|---|---|---|---|---|---|
| M30 | 4 | 99 | 44 | 43.85 | 17.93 |
| | 5 | 99 | 44 | | |
| | 6 | 98 | 42.56 | | |
| M35 | 4 | 111 | 49.33 | 49.48 | 15.98 |
| | 5 | 112 | 49.78 | | |
| | 6 | 112 | 49.78 | | |
| M40 | 4 | 124 | 55.11 | 54.57 | 16.1 |
| | 5 | 122 | 54.22 | | |
| | 6 | 122 | 54.22 | | |

**Table 3:** Load and deflection of conventional concrete and fiber introduced concrete beams (M30).

| Conventional concrete | | Fiber introduced concrete | |
|---|---|---|---|
| **Load(KN)** | **Deflection(mm)** | **Load(KN)** | **Deflection(mm)** |
| 0 | 0 | 0 | 0 |
| 1 | 0.006 | 1 | 0.004 |
| 2 | 0.018 | 2 | 0.013 |
| 3 | 0.034 | 3 | 0.024 |
| 4 | 0.056 | 4 | 0.036 |
| 5 | 0.072 | 5 | 0.042 |
| 5.47 | 0.088 | 6 | 0.051 |
| | | 7 | 0.062 |
| | | 7.53 | 0.071 |

**Table 4:** Load and deflection of conventional concrete and fiber introduced concrete beams (M35).

| Conventional concrete | | Fiber introduced concrete | |
|---|---|---|---|
| **Load(KN)** | **Deflection(mm)** | **Load(KN)** | **Deflection(mm)** |
| 0 | 0 | 0 | 0 |
| 1 | 0.018 | 1 | 0.008 |
| 2 | 0.032 | 2 | 0.017 |
| 3 | 0.044 | 3 | 0.026 |
| 4 | 0.061 | 4 | 0.031 |
| 5 | 0.078 | 5 | 0.037 |
| 5.66 | 0.086 | 6 | 0.044 |
| | | 7 | 0.052 |
| | | 7.92 | 0.065 |

**Table 5:** Load and deflection of conventional concrete and fiber introduced concrete beams (M40).

| Conventional concrete | | Fiber introduced concrete | |
|---|---|---|---|
| **Load(KN)** | **Deflection(mm)** | **Load(KN)** | **Deflection(mm)** |
| 0 | 0 | 0 | 0 |
| 1 | 0.011 | 1 | 0.007 |
| 2 | 0.018 | 2 | 0.013 |
| 3 | 0.031 | 3 | 0.024 |
| 4 | 0.048 | 4 | 0.031 |
| 5 | 0.063 | 5 | 0.038 |
| 5.91 | 0.079 | 6 | 0.046 |
| | | 7 | 0.052 |
| | | 8 | 0.061 |
| | | 8.07 | 0.061 |

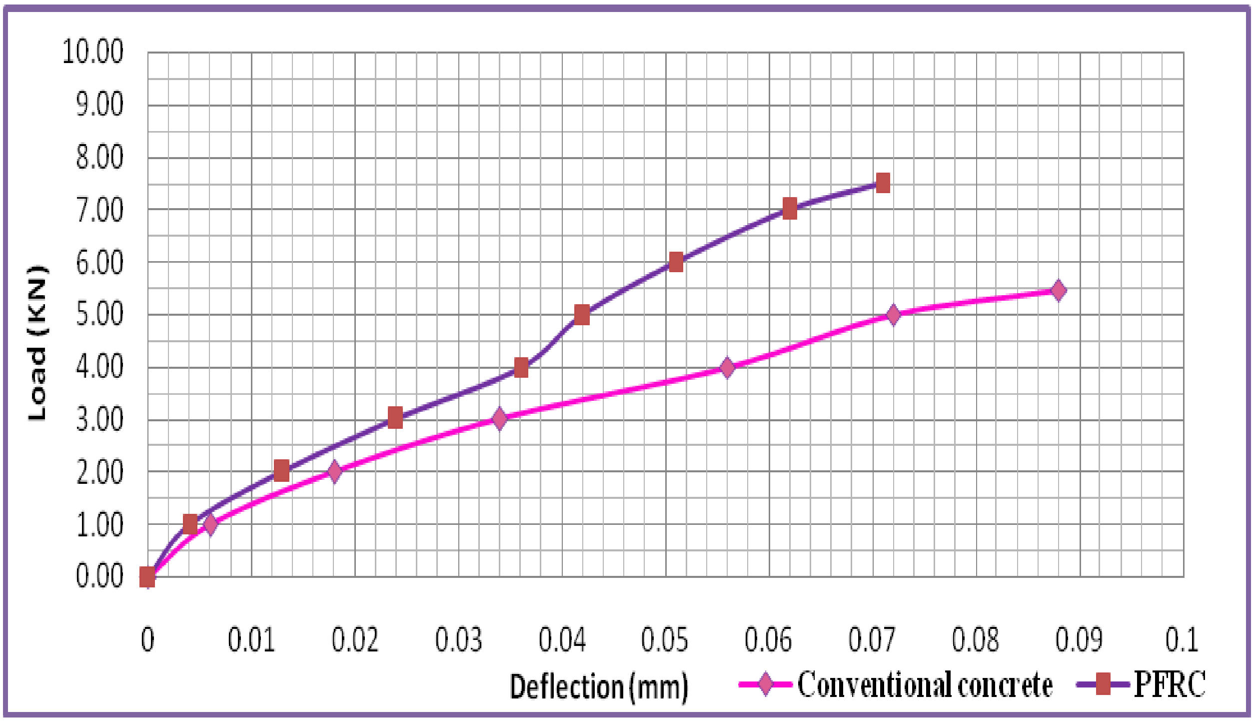



**Fig-1:** 4 Point bend test Load vs Deflection for M30concrete.

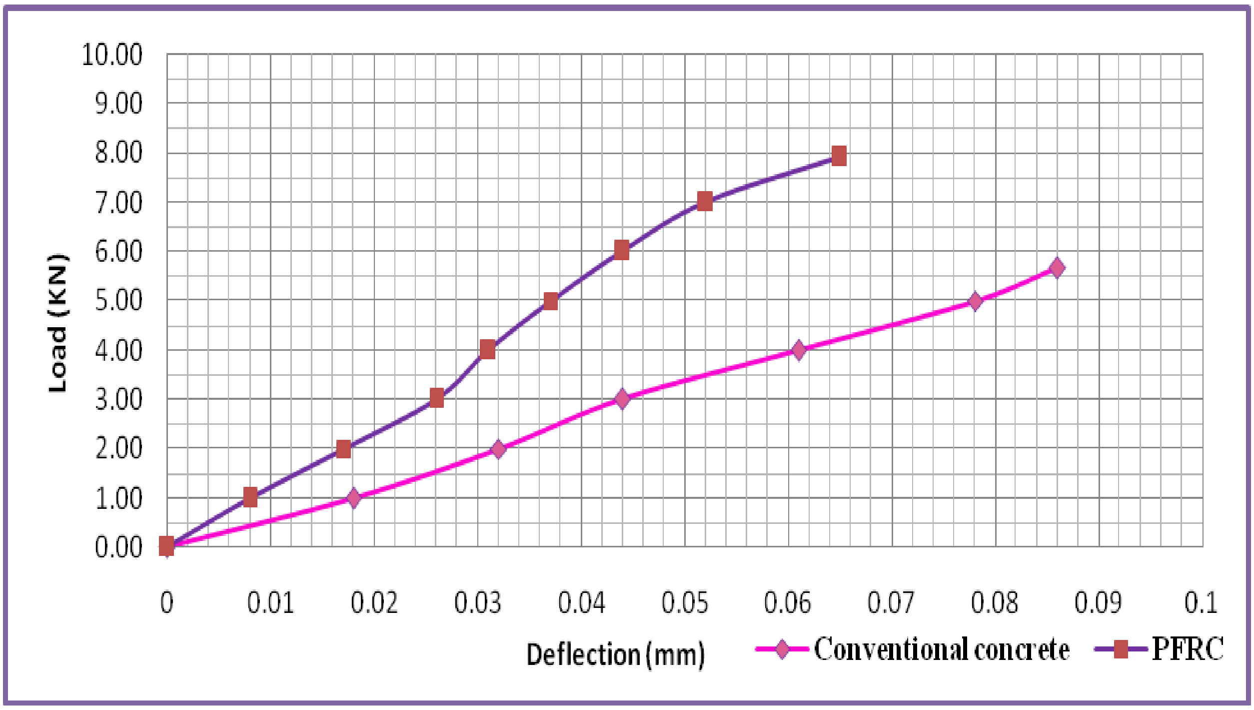



**Fig-2:** Point bend test Load vs Deflection for M35concrete.

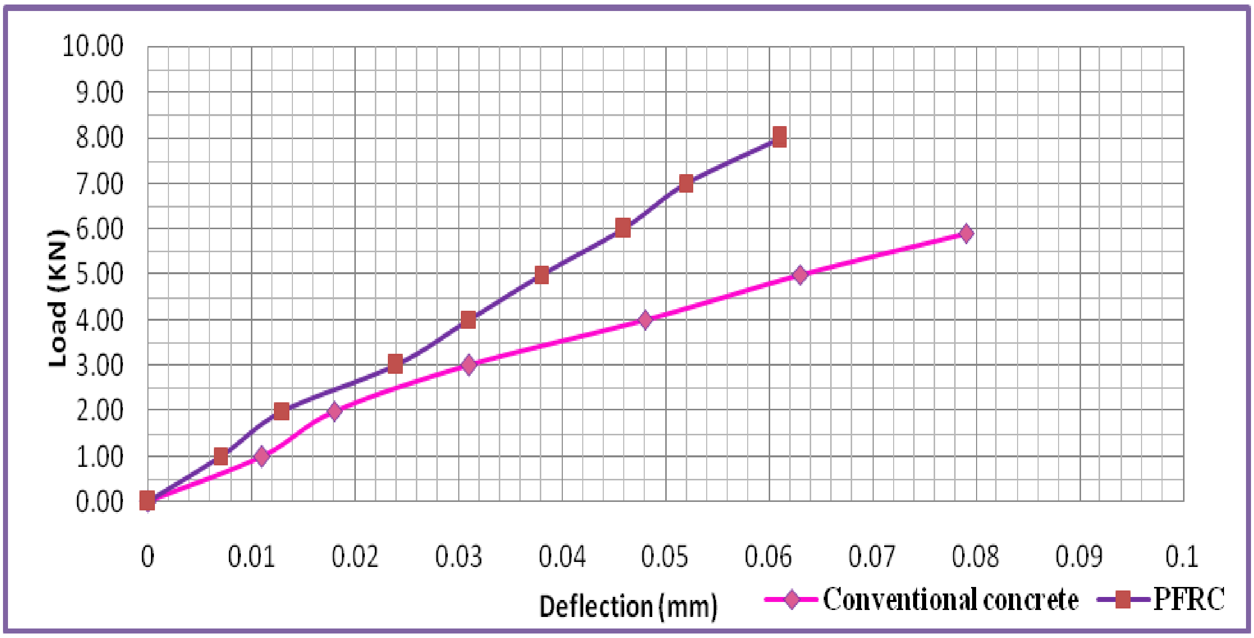



**Fig-3:** 4 Point bend test Load vs Deflection for M40concrete.

### 7. Double shear test

The shear strength is one of the most important characteristic of concrete. The shear strength of concrete represents the resistance offered by concrete towards shear force applied to it. The casted beams are tested for shear strength in compression test machine with certain arrangements.

**Table 6:** Shear strength gain and deflection reduction in fiber introduced concrete beams.

| Grade of concrete | Mean shear strength ($N/mm^2$) | Gain in shear strength (%) | Mean deflection(mm) | Reduction in deflection (%) |
|---|---|---|---|---|
| **M30** | **11.26** | **31.33** | **0.44** | **38.69** |
| **M35** | **11.42** | **32.56** | **0.44** | **36.23** |
| **M40** | **11.52** | **32.72** | **0.43** | **33.75** |

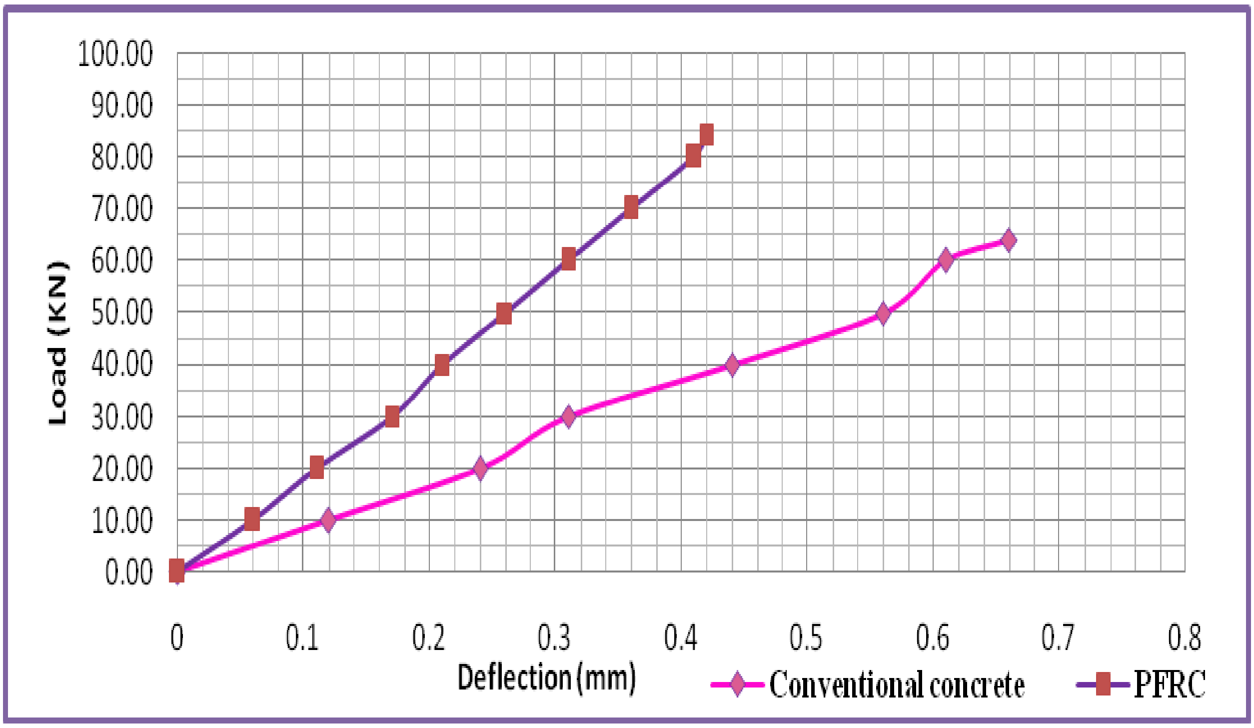



**Fig-4:** Double shear test Load vs Deflection for M30concrete.

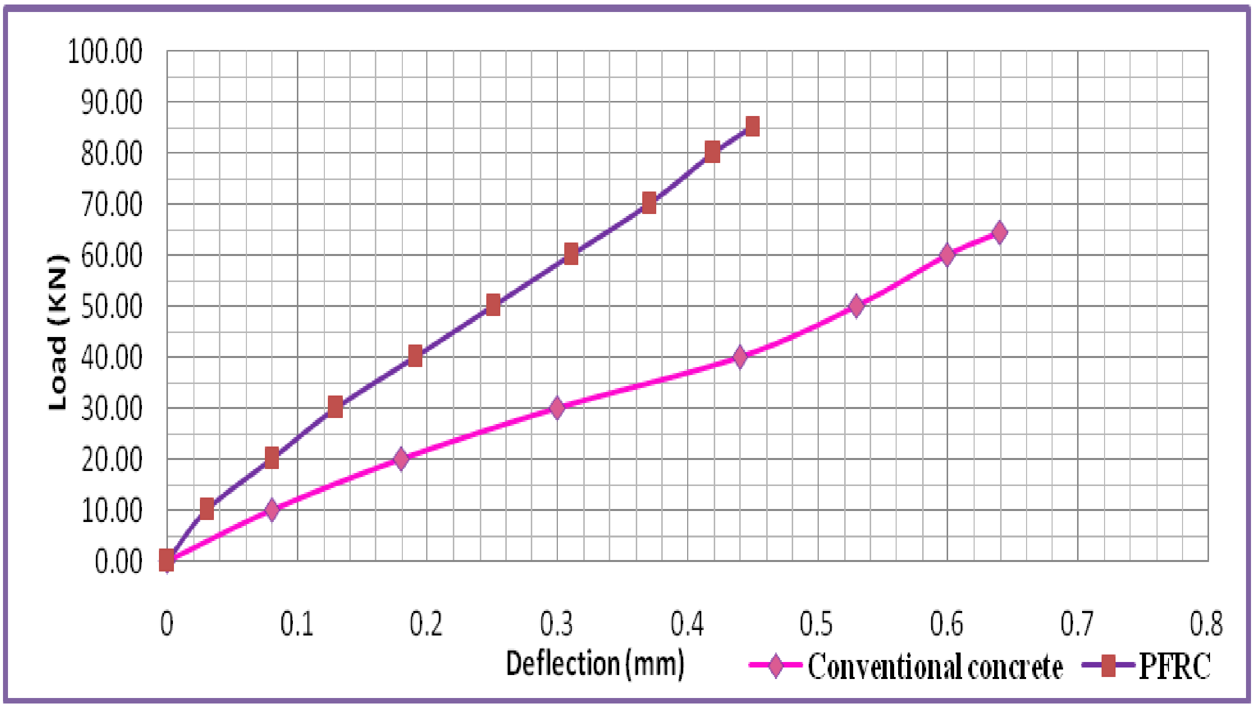



**Fig-5:** Double shear test Load vs Deflection for M35concrete.

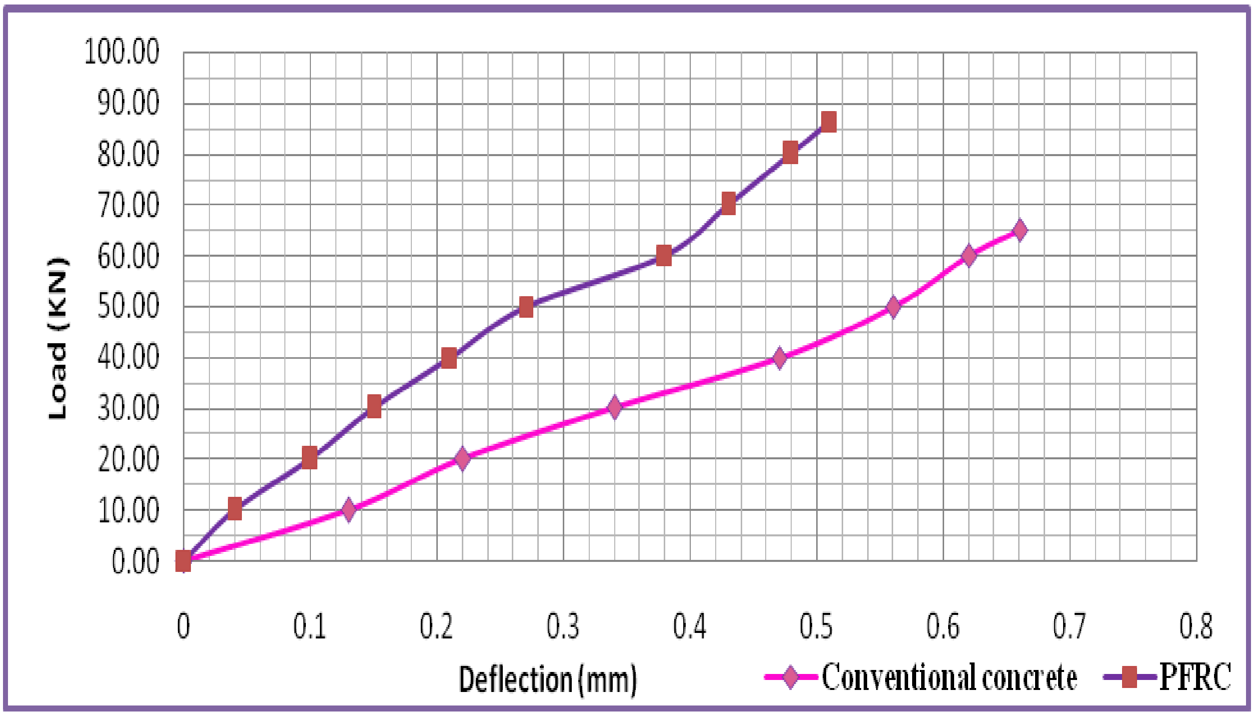



**Fig-6:** Double shear test Load vs Deflection for M40 concrete.

**Table 7:** Comparison of theoretical and experimental deflection.

| Type of Concrete | Grade of Concrete | Mean Theoretical Deflection (mm) | Mean Experimental Deflection (mm) | Percentage of Variation |
|---|---|---|---|---|
| **Conventional concrete** | **M30** | **0.0945** | **0.09** | **4.76** |
| | **M35** | **0.091** | **0.085** | **6.59** |
| | **M40** | **0.088** | **0.077** | **12.5** |
| **Fiber Introduced concrete** | **M30** | **0.0796** | **0.07** | **13.7** |
| | **M35** | **0.0786** | **0.065** | **17.3** |
| | **M40** | **0.0756** | **0.061** | **19.31** |

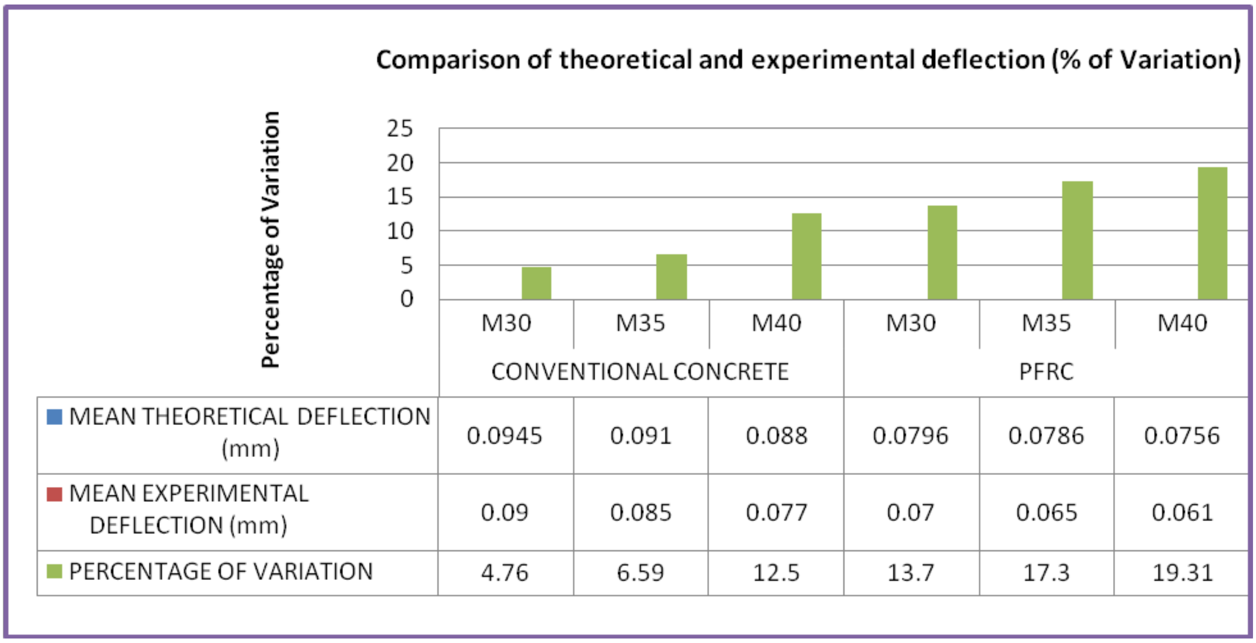
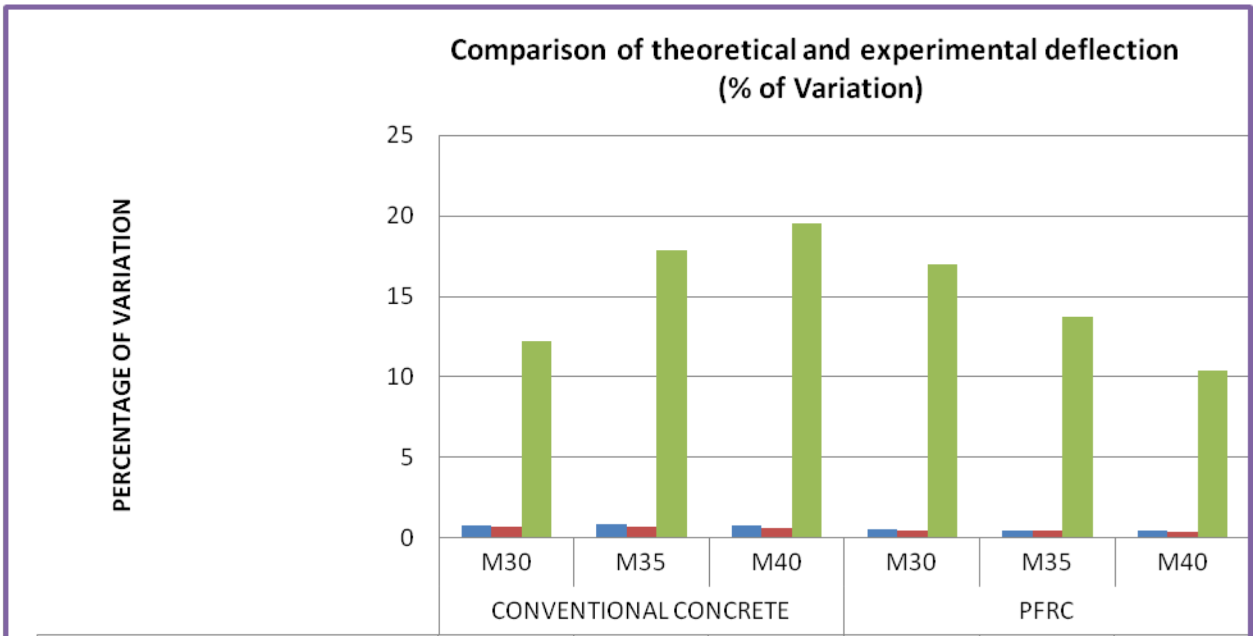



**Fig-7:** Comparison of theoretical and experimental deflection for 4-point bend test.

**Table 8:** Comparison of theoretical and experimental deflection.

| Type of Concrete | Grade of Concrete | Mean Theoretical Deflection (mm) | Mean Experimental Deflection (mm) | Percentage of Variation |
|---|---|---|---|---|
| **Conventional Concrete** | **M30** | **0.82** | **0.72** | **12.19** |
| | **M35** | **0.84** | **0.69** | **17.86** |
| | **M40** | **0.82** | **0.66** | **19.5** |
| **Fiber Introduced Concrete** | **M30** | **0.53** | **0.44** | **16.98** |
| | **M35** | **0.51** | **0.44** | **13.72** |
| | **M40** | **0.48** | **0.43** | **10.41** |




| | M30 | M35 | M40 | M30 | M35 | M40 |
|---|---|---|---|---|---|---|
| MEAN THEORETICAL DEFLECTION (mm) | 0.82 | 0.84 | 0.82 | 0.53 | 0.51 | 0.48 |
| MEAN EXPERIMENTAL DEFLECTION (mm) | 0.72 | 0.69 | 0.66 | 0.44 | 0.44 | 0.43 |
| PERCENTAGE OF VARIATION | 12.19 | 17.86 | 19.5 | 16.98 | 13.72 | 10.41 |

**Fig-8:** Comparison of theoretical and experimental deflection for double shear test.

## 8. Conclusions

The following inferences have been drawn from the experiments done on concrete with polyethylene and tire fibers:

- There is a gain of 17.93%, 15.98% and 16.1% in compressive strength of M30, M35 and M40 grade concrete respectively.
- Gain in flexural strength were found to be 37.34%, 39.70% and 39.66% for M30, M35, and M40 respectively. And respective reduction in deflection were 22.22%, 23.53% and 20.78%.
- There is a significant amount of gain found in shear strength. Gain in shear strength were found to be 31.33%, 32.56% and 32.72% for M30, M35, and M40 respectively. And respective reduction in deflection were 38.69%, 36.23% and 33.75%.
- The percentage of variation of deflection in conventional concrete is found to be 4.76%, 6.59% and 12.5% for M30, M35 and M40 respectively and for fiber introduced concrete it is found to be13.7%, 17.3% and 19.31%.
- The percentage of variation of deflection in conventional concrete is found to be 12.19%, 17.86% and 19.5% for M30, M35 and M40 respectively and for fiber introduced concrete it is found to be 16.98%, 13.72% and 10.41%.

From the above mentioned findings it can be concluded that the wasted polyethylene and tire fibers can be used effectively to positively influence the mechanical properties of the fiber reinforced concrete.

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