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An Investigation on Non-Destructive and Durability Properties of Nylon and HDPE Fibre Reinforced Concrete

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Abstract:- **As plastic waste is a severe global problem today a trial is made on the HDPE concrete and Nylon concrete at six variations 0%, 0.3%, 0.4%, 0.5%, 0.6% and 0.7% fibre was added to concrete on volume basis separately in M40 concrete with a w/c ratio of 0.45, comparing it with plain concrete. This paper deals with the durability, mechanical properties, and performance of recycled High density polyethylene and nylon fibres in the M40 concrete. The recycled nylon fibre was proven to be very good in the concrete. The recycled HDPE fibre has shown excellent post-cracking performance in concrete, bringing in significant ductility. In the M40 mix concrete the effectiveness of reinforcement of HDPE fibres depended on their tensile strength.**

Index Terms:- Bond strength; durability; HDPE fibre; Mechanical strength.

1. INTRODUCTION

Plastic is a non-biodegradable material and remains on landscape for several years. Polymer needs many hundreds of years to deteriorate in normal nature conditions [1].Plastic waste is dangerous as its pigment has many trace elements that are highly toxic [2]. Solid Plastic waste (SPW) is being manufactured on a large scale 348 million tonnes per year globally worldwide. In India for the past 70 years 8.3 billion tonnes of plastic is produced out of which 80% is discarded [3]. Plasticized PVC is used in manufacturing of shopping bags, garbage bags, toys, clothing, window framing, industrial products, packaging films, cables, floor coverings, wrapping materials, fluid containers, roofing sheets, pipes, household and building materials; so that it is discarded at a great rate [4]. Further, the recycling of a virgin plastic material can be done 2 to 3 times only, because, after every recycling, the strength of plastic material is reduced due to thermal degradation. Hence plastic should be removed by utilizing in concrete. Waste plastic can be used in cement roads, blacktop road of10km long laid 10 years back in ADB road in Surampalem, Andhra Pradesh, India which lead more durability without causing any repairs. Also SPW can be used for light weight structures as well as water tight structures or under water structures.

1.1. Literature Review

Ahmad and Jassim (2016), [5] investigated on the possibility to produce plastic cement using high density polyethylene waste and Portland cement in the range 15% 25% 30% 35% 40% and 60%, and 60%, 40%, respectively can produce plastic cement, also investigated on the effect of replacing sand in the range of 10% to 80% by volume by fine polyethylene waste packages include bottle and food crates as a short reinforcement. He achieved a density of 1.972gm-cm^{-3} and concluded that there is a 15% reduction of density comparing to traditional concrete. The moisture of plastic cement at 7 days and 28 days were in the range of 10.5% to 23.4%ver and 3.6% to 11.6% respectively. The percentage of moisture were 3.6 and 3.79% with 25% and 30% waste polyethylene, respectively. The compressive strengths 971, 915, and 945 N at 25%, 30%, and 35% polyethylene at 7days curing and at 28 days were 2352N 1271 N at 25% and 30% waste polyethylene respectively. A good workability were shown with 25% to 30% waste polyethylene. Nibudey et al. 2013, [6] utilised 0.0% to 3.0% PET plastic fibers of breadth (2mm) and long (25mm) with the aspect ratio 35, by weight of cement were added in M30 grade concrete. They reported that the workability decreases as fibres content increases. There was a loss of 52.3% in slump from 67mm (0.0%) to 32mm (3.0%). 11% loss in compaction factor 0.877 to 0.78. The compressive strength was increased from 41.19MPa (0.0%) to 42.96 MPa (1.0%) and there after it was reduced to 31.70 MPa (3.0%). The split tensile strength were increased from 3.48MPa (0.0%) to 3.87 MPa (1.0%) and finally it was 2.58 MPa (3.0%). Rao and Patro [7] found that the durability of concrete is increased with the addition of HDPE fibre.

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2. RESEARCH SIGNIFICANCE

Till date, a little investigated was carried out on use of HDPE or Nylon fibre in concrete. Possibility of utilization of HDPE fibre and Nylon fibre as an addition is here investigated. The main objectives of this investigation is to study the mechanical properties as well as durability properties HDPE fibre reinforced concrete (HFC) as well as Nylon fibre reinforced concrete (NFC).

3. MATERIALS AND METHODS

3.1Materials

OPC (53 Grade) cement, fine aggregate and 12 mm coarse aggregate, recycled Waste HDPE Plastic and Nylon plastic fibre were utilised in this research work. Fine aggregate confirming to zone II was collected from river Godavari, Rajahmundry, Andhra Pradesh. Recycled Waste HDPE Plastic and Nylon plastic fibre were added in concrete in this investigation.

3.2 Mix proportions

M40 mix design with mix proportion of 1:1.41:2.05:0.45 containing cement (411.11kg), sand and 12mm granite aggregate with 0.45 water cement ratio was used. The High density polyethylene fibre reinforced concrete (HFC) was good enough in mixing but the mixing of Nylon fibre reinforced concrete (NFC) shown ball formation even though a great care is taken and also the mixture became stiffer since significant quantity of the water is adsorbed by the Nylon fibre.

Table 1. Chemical properties of ordinary Portland cement (OPC).

Compound (%)	Al2O3	SiO2	MgO	CaO	Fe2O3	Na2O+K2O	SO3
OPC	5.65	21.07	1.16	63.24	4.05	0.65	2.15

Investigating the effect of addition of HDPE plastic fibre as well as Nylon plastic fibre comprised six trials, with fibre 0%, 0.3%, 0.4%, 0.5%, 0.6%, 0.7% in concrete was done.

Table 2. Details of mix ingredients.

Ordinary Portland cement	Fine aggregate	Natural coarse aggregate	Water cement ratio
1	1.415	2.053	0.45

3.3 METHODOLOGY

Bond strength was determined by inserting a 16mm diameter HYSD reinforcing bar in to 150 mm x 150mm x150 mm cube perpendicularly to the surface of the specimen with some arrangement and cured in water. Pull out test was done as per the IS: 2770-1. The specimens of 7.07 cm cubes were casted for the water absorption test. The splitting tensile strength was determined as per IS: 5816 (1999) (Reaffirmed 2004).

4. RESULTS AND DISCUSSION

4.1 Slump

The slump values of the control concrete without fibre (0%) and control concrete with HDPE fibre (0.3%), Nylon Fibre (0.3%) were recorded at 100, 90 mm and 3mm respectively. On inclusion of various (0.3-0.7) % fibre either with HDPE or with Nylon further reduced the slump. Thus, workability decreased continuously with the addition of both the fibres but there was drastic reduction in slump while using the Nylon fibre as thickness was very minute, and also due to its more water absorption capacity. It is concluded that the workability is reduced for both HFC as well as NFC. HFC and NFC reduced workability 1% and 96.9 % respectively.

4.2 Rebound hammer test

Rebound hammer test is done as per IS 13311(2) 1992. HFC shown higher rebound value than N-FC. The values at 28 days curing are increased till 0.5% then decreased with further increase in fibre but it is higher than 0% controlled concrete. The NFC rebound value is increased till 0.5% then decreased. It is concluded that rebound compressive strength increased by 8.62% at 0.5% HFC as well as NFC respectively.

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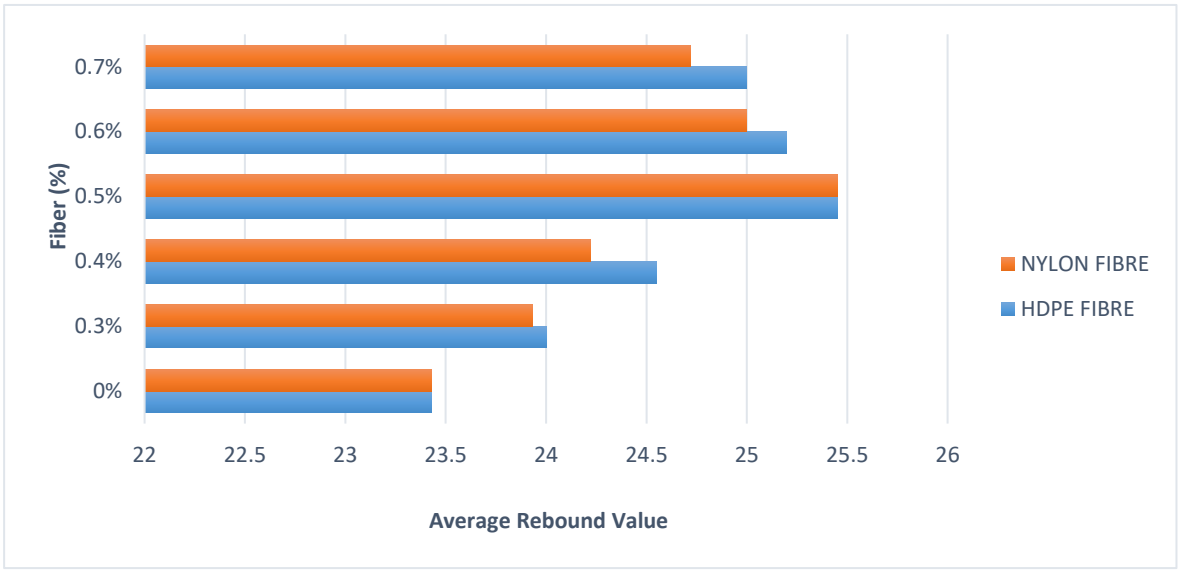

Fig-1 Rebound value of FRC

4.3 Compressive strength

The addition of HDPE and Nylon fibre in concrete compared to conventional concrete the compressive strength decreased. Comparing to Nylon and HDPE fibres, HFC shown higher value. Control concrete (0.7%) containing HDPE plastic has shown little higher strength than the control mix (0%), with 12mm aggregate examined at 28 days. The compressive strength of HFC increased than the NFC at all percentages. The maximum strength was occurred at 0.7%, whereas the same authors Rao and Patro (2018) shown maximum compressive strength at 0.4% with 25mm aggregate as coarse aggregate. The Compressive strength with HDPE fibre (0.7%) was increased, and was decreased by mixes containing Nylon fibre (0.7%) were 6.7%, 1.86% respectively. The compressive strength is gradually decreased as percentage of fibre increasing. The NFC shown lesser compressive strength comparing to HFC as well as no fibre concrete. The cube compressive strength is reducing by 14.81% and 25.08% with HFC as well as NFC respectively at 28 days curing where as the cylinder compressive strength is reducing by 15.51% and 35.81% with HFC as well as NFC respectively.

4.4 Pull out Strength

The pull out test was done using UTM, at the rate of 2.25kg/min until failure occurs after curing period of 28 days. NFC shown slightly higher bond strength at 0.3% comparing to 0% then after it is decreasing with increase in fibre in concrete. It is concluded that the bond strength is decreased continuously as there is increase in percentage of fibre. HFC showing a nominal increase in bond strength at 0.3% fibre.

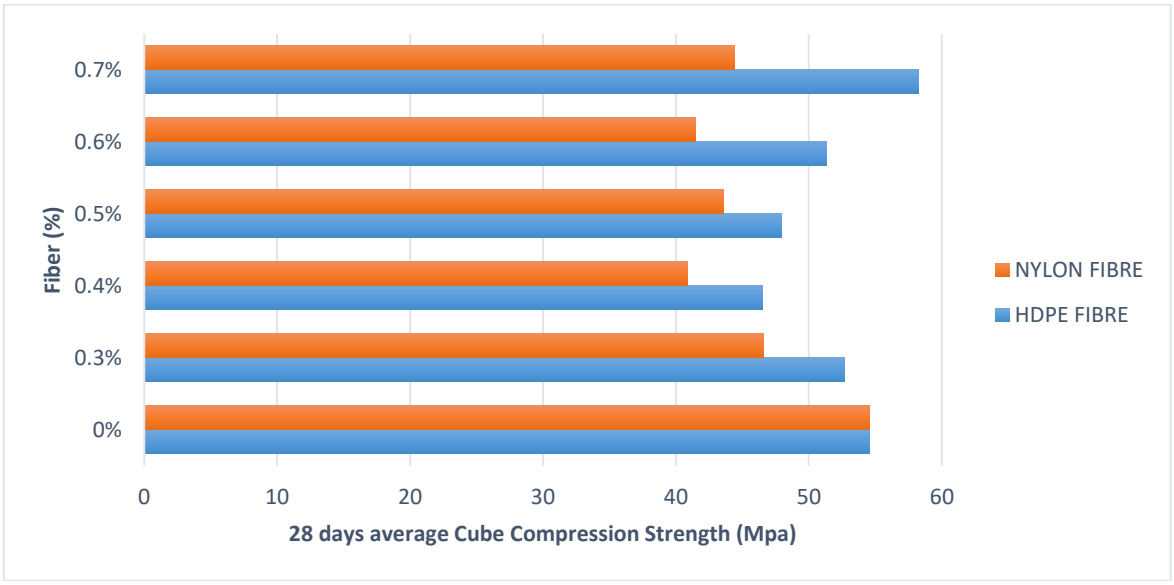

Fig-2 Compressive strength of FRC

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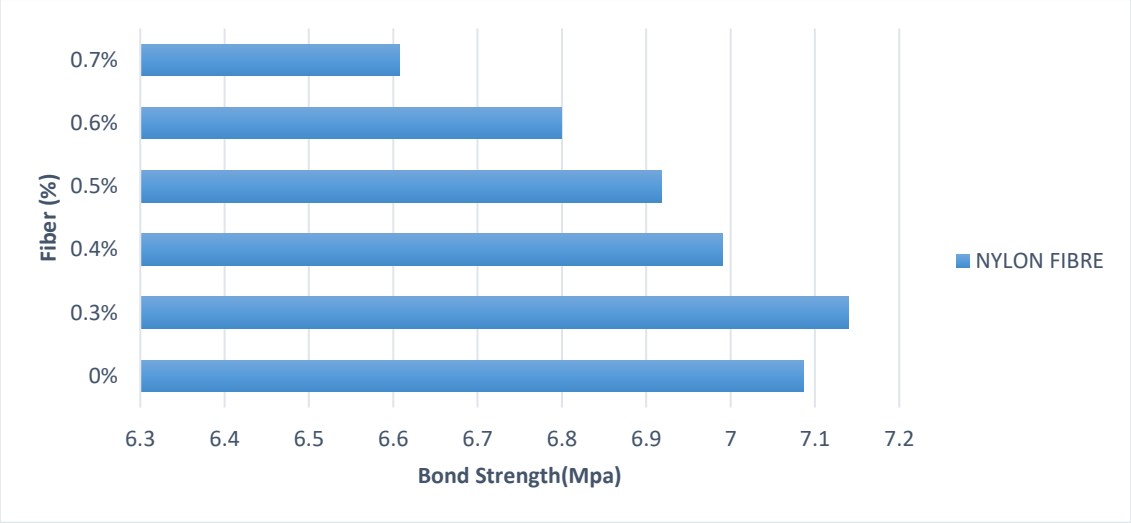

Fig-3 Bond strength of NFC

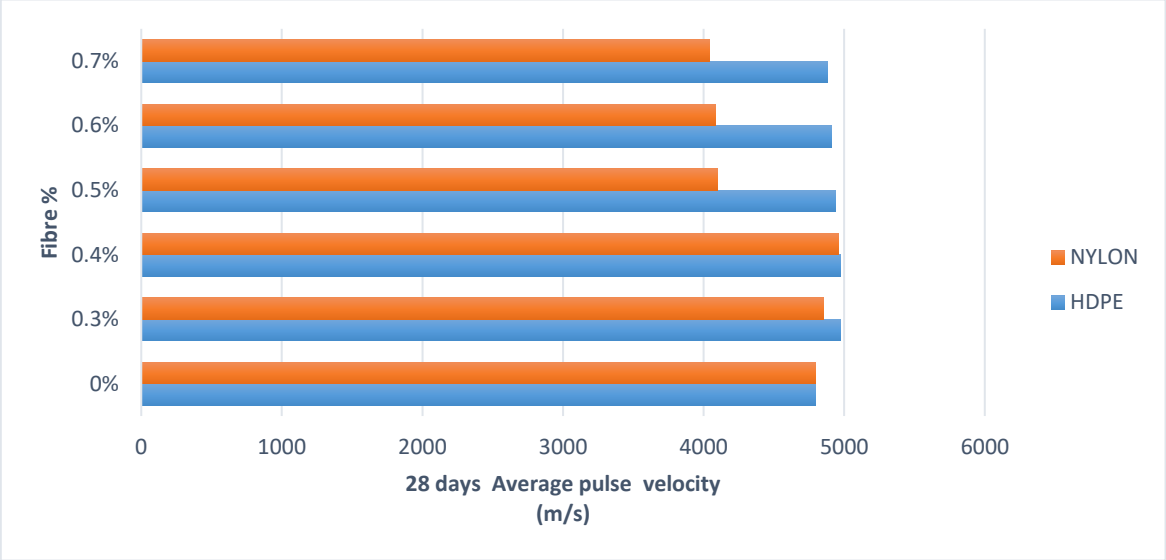

Fig-4 Pulse velocity FRC

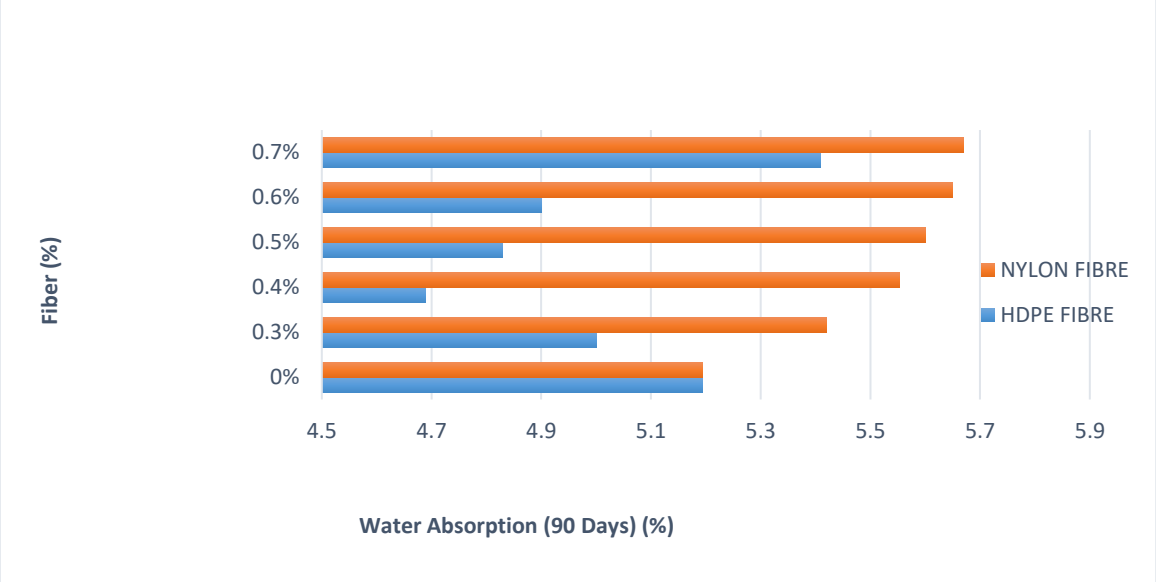

Fig-5 Water absorption FRC

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4.5 Water absorption

Water absorption test is done as per the IS code ASTM C642-06. In this test 100 x 100 x 30 mm cube were casted and allowed for 28 days water curing and after surface dry condition weight of specimen is note and then shifted to oven under temperature of 110 ^{o}C. The specimens were kept in oven until its loss of weight is less than 0.5%, then the weight of the specimens is noted and water absorption is calculated. The results shown that the HFC absorbed less water than the FC. HFC and NFC absorbed higher water at 0.3% then decreased the water absorption. It is concluded that the water absorption isoccured at 0.4% HFC where as there is a continuous increment in NFC

5. CONCLUSIONS

The following are the key conclusions derived from the investigation.

The workability is reduced by adding the plastic fibres but there is a drastic reduction in workability with the NFC.

The rebound value is increased by both HFC as well as NFC at 0.5% fibre, cube compressive strength also increased with both the FRC but NFC given higher increase compare with HFC.

The bond strength is decreased continuously as there is increase in percentage of fibre. NFC showing a nominal increase in bond strength at 0.3% fibre.

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