



Assessment of Durability Properties of Concrete with Polyethylene Fibers

KAVIPRIYA S¹, DHIVAKAR P², DIVAKARAN V³ and SIVA C⁴

¹ Professor and Head, Department of Civil Engineering, Kongunadu College of Engineering and Technology, Trichy, Tamilnadu

² UG Student, Department of Civil Engineering, Kongunadu College of Engineering and Technology, Trichy, Tamilnadu

Corresponding Author Email: kavipriyacivil2001@gmail.com

How to Cite this Article:

P, D., V, D. & C, S. (2026). Assessment of Durability Properties of Concrete with Polyethylene Fibers. International Journal of Creative and Open Research in Engineering and Management, <i>02</i>(04).
<https://doi.org/10.55041/ijcope.v2i4.042>

License:

This article is published under the terms of the Creative Commons Attribution 4.0 International License (CC BY 4.0), which permits unrestricted use, distribution, and reproduction in any medium, provided the original author(s) and the source are credited.

© The Author(s). Published by International Journal of Creative and Open Research in Engineering and Management.



<https://doi.org/10.55041/ijcope.v2i4.042>

Abstract—

This study investigates the durability properties of concrete reinforced with polyethylene (PE) fibers, and it notices the critical challenges in crack control, permeability, and long-term performance under environmental stresses. Conventional concrete exhibits brittleness, leading to micro-cracking that accelerates degradation via water ingress, chloride penetration, and freeze-thaw damage; PET fibers, including HDPE, UHMWPE, and recycled variants, bridge these cracks, reducing widths to 0.1-0.3 mm and enhancing matrix integrity. Experimental assessments involved M30-grade mixes with 0.5-1.5% fiber volume fractions (6-12 mm lengths), evaluating rapid chloride permeability (RCPT), sorptivity, carbonation depth, and freeze-thaw cycles per ASTM C1202 and RILEM standards. Results demonstrate 20- 25% lower chloride diffusion coefficients, 16-95% reduced permeability in cracked states, and up to 19% higher compressive strength (29-35 MPa) at optimal 1% dosage, attributed to fiber-matrix bonding and tortuous pore paths observed via SEM.

Keywords — Polyethylene fibers, Durability properties, Fiber- reinforced concrete, Permeability, Crack resistance.



I. INTRODUCTION

The durability of concrete remains a fundamental challenge to civil engineers, as the material's brittleness causes micro-cracks that undermine durability under environmental exposures such as moisture, chemicals, and thermal changes. Plain concrete, which has been historically used as a building material, has been shown to have high permeability, which allows for the penetration of chloride ions that accelerate steel rebar corrosion, freeze/thaw degradation, and carbon dioxide penetration, which causes degradation, thereby resulting in premature failures. The use of fibers has been shown to be an effective solution to these challenges, such as synthetic polymers such as polyethylene fibers, which include high-density polyethylene, ultra- high molecular weight polyethylene, and recycled polyethylene terephthalate, have been shown to be effective in crack control due to their tensile strengths up to 3 GPa, low density, and inert properties.

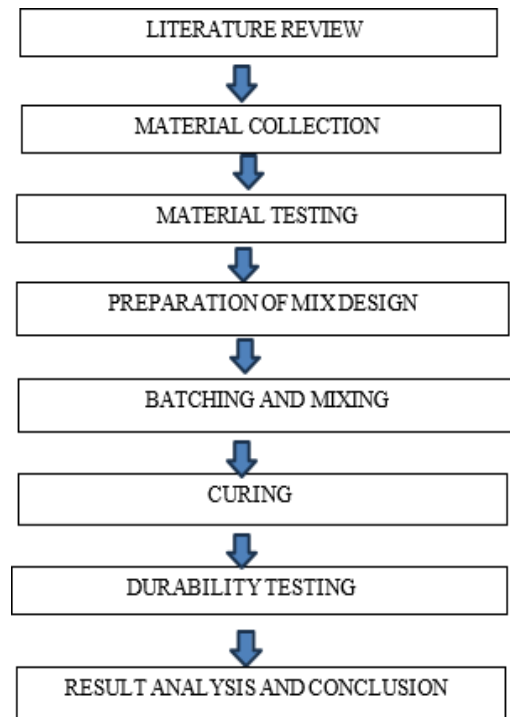
II. LITERATURE REVIEW

Kennedy C (2025) Focuses on machine learning techniques for predicting the tensile behavior of concrete. It covers mix design, aggregate characteristics, and curing aspects. The book also focuses on the use of recycled aggregates for sustainable development and their impact on tensile strength

Jianzhuang Xiao (2023) Focuses on the mechanical and durability characteristics of concrete using recycled aggregate concrete. The book covers aspects of strength, workability, and exposure to environmental influences. It also focuses on the problems faced during the use of recycled aggregate concrete. It also provides information on the benefits of using RAC for sustainable development.

Souher Aldroubi (2023) The study focuses on the morphology, physical properties, and tensile behavior of flax fibers in various configurations. It provides information on how these parameters affect the interaction of flax fibers with the matrix of the composite materials. The study provides insights that can be applied to steel fibers for the development of stronger, durable, and sustainable concrete materials.

III. METHODOLOGY



IV. MATERIALS

A) PET FIBERS

The polyethylene fibers, including UHMWPE, HDPE, and recycled PET fibers, are used for micro-reinforcement of M30 concrete mixes at 0.5-1.5% volume fraction and 6-12mm lengths. UHMW PET fibers have excellent tensile strength of 2500-3000 MPa, elongation of 3.5%, and hydrophobicity with a density of 0.97g/cm³. They provide excellent bridging of cracks smaller than 0.3mm and permeability. HD PET fibers provide cost-effective water resistance, whereas PET fibers provide sustainability through waste bottles.

Table:1 Material Properties of PET Bottle Fiber

S. No	Property	PET Bottle Fiber
1	Material Type	Polyethylene Terephthalate (PET)
2	Density	1.34 – 1.39 g/cm ³
3	Tensile Strength	300 – 600 MPa
4	Length of Fiber	10 – 20 mm
5	Diameter	0.2 – 0.4 mm
6	Water Absorption	Negligible



B) COARSE AGGREGATE

The coarse aggregate of concrete is usually rounded shape, well graded, and smaller in size than that of conventional concrete and geopolymer concrete. The size of coarse aggregate used for concrete is between 10mm to 20mm. Rounded and smaller coarse aggregate helps to achieve better flowability and deformability of concrete. It also helps to avoid segregation of concrete. Graded aggregate is also important to cast concrete in highly congested reinforcement or formwork of smaller dimensions.

Table:2 Materials and Properties for Coarse Aggregate

s.no.	Property	Normal Coarse Aggregate
1	Specific gravity	2.17
2	Bulk Density Loose compacted	1857.33 kg/m ³
3	Flakiness index	3%
4	Elongation index	0%
5	Bulk Density after compaction	2047 kg/m ³

C) CEMENT

Ordinary Portland Cement (OPC-43 grade) will serve as a binding agent for the M20 concrete mixes, which will comply with the IS: 8112-2013 specifications. The Ordinary Portland Cement has a specific gravity of 3.15, a fineness of more than 320 m²/kg, an initial setting time of 180 minutes, and a 28-day compressive strength of 43 MPa.

Table:3 Material Properties of PET Bottle Fiber

S. No	Property	Cement (OPC)
1	Type	Ordinary Portland Cement (OPC 53 Grade)
2	Specific Gravity	3.15
3	Standard Consistency	30 – 35 %
4	Initial Setting Time	30 minutes (minimum)
5	Final Setting Time	600 minutes (maximum)
6	Fineness	225 – 300 m ² /kg

D) FINE AGGREGATE

Fine aggregate, which can be granular material or crushed stones, is a primary constituent of concrete. The quality of fine aggregate and density of fine aggregate have a significant influence on the properties of hardened concrete.

Table:3 Material Properties of PET Bottle Fiber

S. No	Property	Cement (OPC)
1	Type	Ordinary Portland Cement (OPC 53 Grade)
2	Specific Gravity	3.15
3	Standard Consistency	30 – 35 %
4	Initial Setting Time	30 minutes (minimum)
5	Final Setting Time	600 minutes (maximum)
6	Fineness	225 – 300 m ² /kg

E) WATER

Water has a very huge role in the concrete mix. The role of water in the concrete mix can be broken down as follows: as a main thing, bonding: water in the ingredient in the concrete mixes with cement, forming a binder.



FIGURE:1 Materials



MIX DESIGN

- Grade Designation = M30
- Type Of Cement: Opc 53 Grade
- Max Nominal Size of Aggregate: 20mm
- Workability: 100-120mm Slump
- Exposure Condition: Moderate
- Types Of Aggregate: Crushed Angular Aggregates
- Max Water Cement Ratio: 0.45
- Max Cement Content: 360 kg /m³
- Addition of Polyethylene Fibers

I. TEST DATA FOR MATERIALS

- cement used: opc 53 grade
- specific gravity of cement: 3.15
- specific gravity of
 - coarse aggregate 20mm : 2.67
 - fine aggregate : 2.65
- sieve analysis
 - coarse aggregate = 3.26
 - fine aggregate = 4.41

II. TEST DATA FOR MATERIALS

The largest mean compressive strength of 28 days given by

$$f_{ck}' = f_{ck} + 1.65 s$$

from IS10262:2000

$$S = 5 \text{ N / mm}^2$$

$$f_{ck}' = 30 + (1.65 \times 5)$$

$$= 38.25 \text{ mpa}$$

$$f_{ck}' = 38.25 \text{ N / mm}^2$$

III. SELECTION OF WATER CEMENT RATIO

Adopted max water amount ratio

$$= 0.44$$

IV. SELECTION OF WATER CONTENT

Max water content for 20mm aggregate

$$= 186 \text{ litre (for 25 to 50 mm slump range)}$$

Estimate water content for 100 mm slump

$$= 186 (6/186)$$

$$= 197 \text{ litres}$$

V. CALCULATION OF CEMENT CONTENT

$$\text{Adopted w/c ratio} = 0.44$$

$$\text{Cement content} = 158/0.44$$

$$= 359 \text{ kg / m}^3 > 340 \text{ kg / m}^3 \text{ hence ok.}$$

VI. PROPORTION OF VOLUME OF COARSE AGGREGATE AND FINE AGGREGATE

From table 3 of (IS 1062:2009)

Volume of Coarse aggregate corresponding to 20 mm Size aggregate and fine aggregate (zone 11) for water cement ratio of 0.50

$$= 0.62$$

$$\text{Volume of Coarse aggregate} = 0.64 \times 0.9$$

$$= 0.57$$

$$\text{Volume of fine aggregate} = 1 - 0.546$$

$$= 0.424$$

MIX CALCULATION

The mix calculation per unit volume of concrete shall be as follows

$$\text{a) Volume of concrete} = 1 \text{ m}^3$$

$$\text{b) Volume of cement} = \frac{\text{mass of cement}}{\text{specific gravity of cement} \times 1000}$$

$$= 359 / 3.15 \times 1000$$

$$= 0.114 \text{ m}^3$$

$$= 0.114 \text{ m}^3$$

$$\text{c) volume of water} = \text{mass of water} / (\text{specific gravity of water} \times 1000)$$

$$= 158 / (1 \times 1000)$$

$$= 0.158 \text{ m}^3$$

$$= 0.158 \text{ m}^3$$

$$\text{d) mass of Coarse aggregate}$$

$$= e \times \text{volume of Coarse aggregate} \times \text{Coarse aggregate of specific gravity} \times 1000$$

$$= 0.724 \times 0.576 \times 2.67 \times 1000$$

$$= 1113 \text{ kg / m}^3$$

$$= 1113 \text{ kg / m}^3$$

$$\text{e) mass of fine aggregate}$$

$$= e \times \text{volume of fine aggregate} \times \text{specific gravity of fine aggregate} \times 1000$$

$$= 0.724 \times 0.424 \times 2.60 \times 1000$$

$$= 798 \text{ kg / m}^3$$

$$= 798 \text{ kg / m}^3$$

$$\text{f) Addition of PET fibers}$$

$$\text{fiber} = 0.00236 \text{ kg / m}^3$$

$$0.5\% = (0.5/100) \times 0.00236 \times 1.4$$

$$0.5\% = 0.0214 \text{ kg / m}^3$$

$$1\% = 0.024 \text{ kg / m}^3$$

$$1.5\% = 0.0322 \text{ kg / m}^3$$

MIX PROPORTION

$$\text{Cement} = 340 \text{ kg / m}^3$$

$$\text{Water} = 158 \text{ L / m}^3$$

$$\text{Coarse aggregate} = 1113 \text{ kg / m}^3$$

$$\text{Fine aggregate} = 798 \text{ kg / m}^3$$

$$\text{Fiber (0.5\%)} = 0.0107 \text{ Kg / m}^3$$



TEST ON FRESH CONCRETE

A) Slump Cone Test

The Slump Cone Test was conducted to find out the workability of the fresh concrete mixes. In this test, a concrete mix is filled into a cone-shaped mold, which is then raised vertically. The test was conducted according to ASTM C-143 and IS-1199 norms, which gave valuable insights into the workability of the concrete mixes with the inclusion of recycled aggregate, and PET fibers

The test was conducted according to ASTM C- 143 and IS-1199 nor



B) Compaction Factor Test

The compacting factor test is intended mainly for laboratory use, although it may be employed in the field. It is more accurate and sensitive than the slump test.



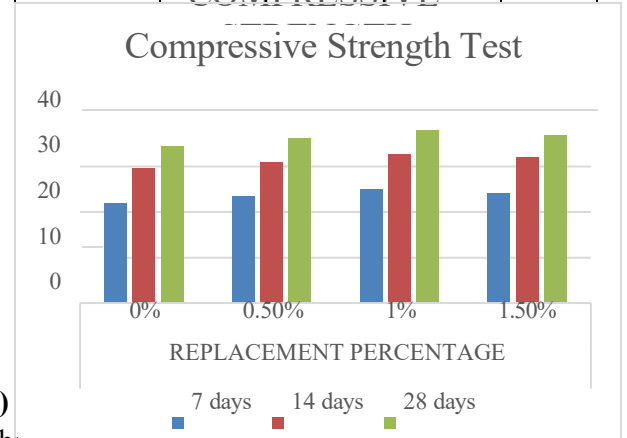
TEST ON HARDENED CONCRETE

For testing concrete in the hardened state, it is necessary to prepare different molds like cubes, cylinders, and beams. It is cured 24 hours after the required time.

A) Compressive Strength

The results of the mechanical properties (according to IS: 516) obtained based on the samples tested according to Indian standard testing procedures are discussed.

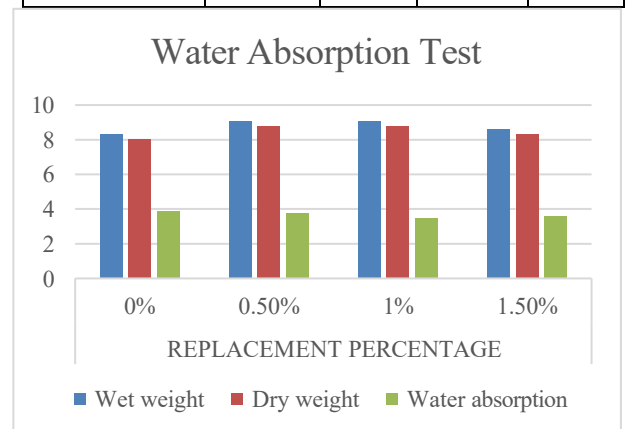
COMPRES SIVE STRENG TH N/mm ²	REPLACEMENT PERCENTAGE			
	0%	0.5%	1%	1.5%
7 days	22.00	23.50	25.00	24.20
14 days	29.50	31.00	32.00	32.00
28 days	34.50	36.20	38.00	36.80



B)

The determine the amount of water absorbed by concrete specimens, which indicates their porosity and durability.

Water Absorption Test	REPLACEMENT PERCENTAGE			
	0%	0.5%	1%	1.5%
Wet weight	8.33	9.11	9.08	8.64
Dry weight	8.02	8.78	8.77	8.34
Water absorption	3.87	3.75	3.46	3.59

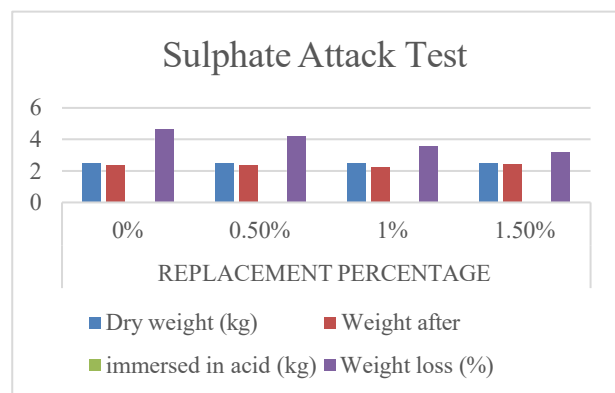
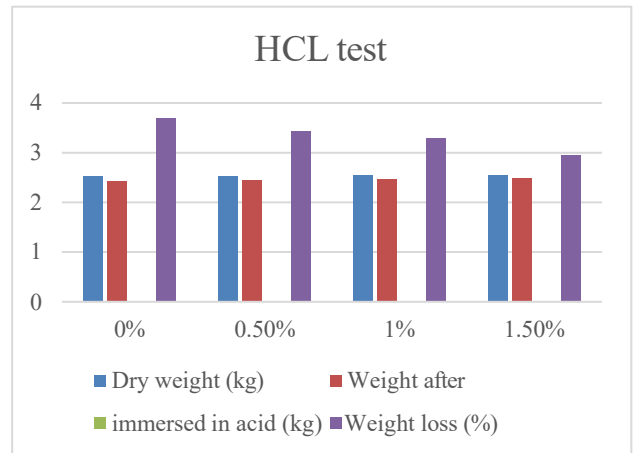




C) Sulphate Attack Test

The Sulphate Attack Test is performed to evaluate the resistance of concrete to deterioration caused by sulphate exposure.

Sulphate Attack Test	REPLACEMENT PERCENTAGE			
	0%	0.5%	1%	1.5%
Dry weight (kg)	2.480	2.495	2.510	2.525
Weight after immersed in acid (kg)	2.365	2.390	2.240	2.445
Weight loss (%)	4.637	4.208	3.585	3.168



D) HCL test

The HCl (Hydrochloric Acid) Test is conducted to assess the resistance of concrete to acid attack.

V.

HCL test	REPLACEMENT PERCENTAGE			
	0%	0.5%	1%	1.5%
Dry weight (kg)	2.522	2.539	2.549	2.553
Weight after immersed in acid (kg)	2.429	2.449	2.465	2.478
Weight loss (%)	3.69	3.43	3.29	2.94

CONCLUSION

The experiments carried out on polyethylene (PET) fiber reinforced on conventional concrete have produced positive results, which confirm that polymer fibers can be used for reinforcing concrete to improve durability properties. Concrete mixed with ordinary Portland cement, fine aggregate, coarse aggregate, and polyethylene fibers exhibit good durability properties. Durability tests on concrete include water absorption, permeability, chemical resistance, and freeze-thaw tests. Adding polyethylene fibers to concrete shows that it is beneficial in enhancing concrete durability.

REFERENCES

1. N. Pesic "Effect of Fibers on Durability of Concrete: A Practical Review," *Materials*, vol. 13, no. 20, p. 4564, Oct. 2020.
2. K. Asagai "Effect of Polyethylene Terephthalate (PET) Fibers on Concrete Properties," *Int. J. Res. Rev.*, vol. 12, no. 9, pp. 89-96, Sep. 2025.
3. M. Saya and O. Eren, "Physical and Durability Properties of Recycled PET Fibre Reinforced Concrete," *Semantic Scholar*, 2022
4. Thivya, J., Iyappan, G., & Vijayaraghavan, J. (2024). Enhanced structural performance of reinforced cement concrete beams using lightweight foam bricks with deep learning prediction. *European Journal of Environmental and Civil Engineering*, 29(8), 1491–1511. <https://doi.org/10.1080/19648189.2024.2445543>
5. G., Iyappan, G., Subramani, N., Thivya, J., Vijayaraghavan, J., & Ahsan, M. S. (2025). Experimental investigation of fly ash-based foam bricks: Sustainable mix design and its performance.



Advances in Civil Engineering, 2025, 3856191.

<https://doi.org/10.1155/adce/3856191>

6. Kavipriya, S., C. G. Deepanraj, S. Dinesh, N. Prakash, N. Lingeswaran, and S. Ramkumar. 2021. "Flexural Strength of Lightweight Geopolymer Concrete Using Sisal Fibres." *Materials Today: Proceedings* 47: 5503–7.

<https://doi.org/10.1016/j.matpr.2021.08.135>.

7. Kavipriya, S., G. Ramesh Kumar, M. Aravindhraj, S. Gowtham, N. Lingeswaran,

and T. Soundharya. 2023. "Absorption Capacity and Porosity Percentage of Geopolymer Concrete with Varying Percentage of Source Material and Alkalinity Ratio." *Materials Today: Proceedings* 72: 3144–48.

<https://doi.org/10.1016/j.matpr.2022.10.071>.

8. Karthikeyan, M.K.V., Kamaraj, L., Kavipriya, S. *et al.* Investigation and chemical processing effect of sisal fiber epoxy composite characteristic enhancement with nano-SiC via injection mold. *Int J Adv Manuf Technol* **132**, 2209–2216 (2024). <https://doi.org/10.1007/s00170-024-13516-9>