Experimental Study on Mechanical Behaviour of Textile Reinforced Concrete

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***Abstract*:** This study is centered on evaluating the consequences of utilizing Textile Reinforced Concrete (TRC) in comparison to conventional standard concrete. In this research, we utilize M30 grade concrete for the nominal mix design. We employ high-strength and high-modulus polyester filament yarns to examine how they influence the Attributes of the textile-reinforced concrete (TRC) concrete mixtures and to determine their fundamental strength characteristics. In this research, curing is achieved by to avoid excessive moisture evaporation from... the concrete. This is done by either maintaining the with the formwork in position, the concrete is shielded by an impermeable membrane. once the formwork is removed, applying a suitable water-based chemical curing agent, or utilizing a combination of these methods. Curing is essential to minimize moisture loss from the exposed surface by continuously keeping it hydrated. The study involves testing layers 1, 2, and 3 of the textiles for their compressive, flexural, and split tensile strength properties. Based on the experimental findings, an observation revealed that incorporating 2 layers of textile into the specimens yielded the highest results in compression, flexural, and split tensile tests. However, the strengths in compression and flexure started to decline when 3 layers of textile were added.

Keywords- Compressive Strength, Flexural Strength, Tensile Strength, Membrane Curing, Textile Reinforced Concrete.

1. Introduction

Concrete stands out as one of the most versatile and predominant construction materials, capable of being molded to suit various structural forms. Though, Concrete is strong under compression but weakunder tension. Concrete offers several advantages, including its exceptional compressive strength, resistance to fire, excellent water resistance, low maintenance requirements, and a long service life. However, it also has its drawbacks, such as relatively poor tensile strength and the need for formwork during construction.

Textile-reinforced concrete (TRC) is a type of concrete that incorporates textile fibers. These fibers, whether woven or nonwoven, are utilized to strengthen materials that possess high tensile strength but limited elongation characteristics. Fabrics made from materials like jute, glass fiber, Kevlar, polypropylene, polyamides (nylon), and other high-tenacity fibers are used in the production of TRC. These fibers serve as a partial substitute for traditional reinforcing materials like HYSD bars.

2. Objectives

To examine the characteristics of Textile Reinforced Concrete (TRC).

To investigate the impact of incorporating Geo-textile on the compressive and flexural strength of concrete.

To minimize the reliance on traditional reinforcement in Reinforced Concrete (R.C.C.).

To find alternatives to the conventional water curing method for concrete.

To enhance the bending strength of concrete.

3. Materials & Methodology:

3.1 Cement

Cement is primarily employed within the building and construction sector as a crucial component in producing concrete, a robust construction material formed by blending cement and aggregates. Cement is a substance that has the capacity to set and harden and can effectively join various materials together. It plays a central role in creating mortar for masonry and concrete for construction purposes.

Table 1 Properties of Cement

Particulars	Test Results	Requirements of IS:1489-1991(Part1)	
CHEMICAL REQUIREMENTS			
1. Insoluble Material (%bymass)	22.80	X+(4.0(100-X))/100 (x = declaration% of fly ash)	Max
2. Magnesia (% by mass)	1.07	6.00	Max
3. Sulphuric Anhydride (% bymass)	2.38	3.00	Max
4. Loss on Ignition (% by mass)	1.72	5.00	Max
5. Total Chlorides (% by mass)	0.035	0.10	Max
PHYSICAL REQUIREMENTS			
1. Fineness (m^2/kg)	390	300	Min
2. Standard Consistency (%)	33.5		
3. Setting Time (minutes) a. Initial& Final	150 225	30 600	Min Max
4. Soundness a.Le-Chat Expansion (mm) b.Autoclave Expansion (%)	0.5 0.025	10.0 0.8	Max Max
5. Compressive Strength (MPa) a.72 +/- 1hr.(3 days) b.168 +/- 2 hr.(7 days)c.672 +/- 4 hr.(28 days)	28.6 38.6 58.0	16 22 33	Min Min Min
6. Drying Shrinkage (%)	UT	0.15	Max
7. % of Fly Ash addition	25.0	15.0 35.0	Min Max

3.2 Fine Aggregate:

High-quality riverbank sand should be free from any earthy or organic contaminants. Its particles should have a predominantly angular shape, capable of passing through a standard sieve with a 250-micron opening while being retained by a 150-micron sieve. Fine aggregate for the concrete mix was sourced locally from a nearby river and complies with the IS: 383:1970 standard. The characteristics of the fine aggregate can be found in the following table.

Table 2. Sieve Analysis Results

S.No	Sieve size(mm)	Percent Retained	Cumulative % retained	Percentage Passing
1	4.75	5.20	5.20	94.80
2	2.36	3.00	8.20	91.80
3	1.18	8.60	16.80	83.20
4	600 microns	25.80	42.60	57.40
5	300 microns	32.80	75.40	24.60
6	150 microns	20.70	96.10	3.90

Table 3 Properties of Fine Aggregate

S. No	Property	Result
1	Specific Gravity	2.600
2	Fineness Modulus	2.8
3	Bulk Density	15.75 kN/m^3
4	Grading Of Sand	Zone-III

3.3 Coarse Aggregate:

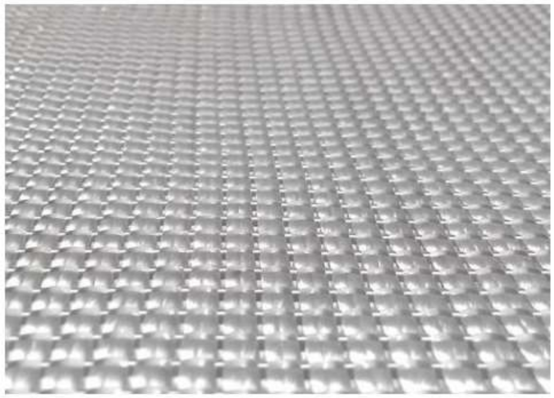
Coarse aggregate, often referred to as material retained on the IS: 4.75mm sieve and passing through the IS: 20mm sieve, is a crucial component that contributes to the concrete's strength and overall stability. The coarse aggregate utilized in this project was sourced from the Miyapur Quarry, and it exhibits a Specific Gravity ranging from 2.4 to 2.6.

Table 4. Properties of Coarse Aggregate

S. No	Property	Result
1	Specific Gravity	2.600
2	Bulk Density (Loose)	14.150 kN/m3
3	Water Absorption	0.50%
4	Fineness Modulus	7.20

3.4 Geo textile:

Advanced production facilities are used to weave high-strength, high-modulus polyester filament yarns into geotextile fabric, providing resistance against common soil chemicals and microorganisms. This geotextile fabric is employed in reinforced constructions, such as mechanically stable earth barriers, soft foundation enhancements, and improving soil shear strength. It also serves fundamental geotextile functions like filtration and separation. Geotextiles are porous materials that, when combined with soil, can perform functions such as separation, filtration, reinforcement, protection, or drainage. Woven geotextiles are created through the interweaving of two sets of strands, positioned at right angles to each other. A specialized heavy-duty fabric, denoted as HTSF-Q-W-3020-A, meets the AASHTO M-288-96 Class I requirements for reinforcement in erosion control along highway embankments. It offers a cost-effective alternative to multilayer aggregates and serves as a filtering medium. Additionally, HTSF-Q-W-6398 complies with the AASHTO M-288-96 Class I & II criteria for separation in embankment slope protection.



(Fig 1: Geo textile)

Table 5 Properties of Geo Textile (woven):

Material		Cutting-edge manufacturing facilities are employed to weave high-strength, high-modulus polyester filament yarns into geo-textile fabric. This fabric is designed to withstand the challenges posed by chemicals and microorganisms commonly present in soil. It finds application in reinforced structures such as mechanically stabilized earth walls and soft foundation enhancements, contributing to improved soil shear strength. Additionally, the geo-textile fabric fulfills essential geo-textile functions like filtration and separation.		
PROPERTIES		**TEST METHOD**	**UNIT**	**VALUE**
Mass Per UnitArea		ASTM D 5261	g/m^2	≥440
TensileStrength	MD	ASTM D 4595	kN/m	≥200
	CD			≥60
Elongat@ Designated Tensile Strength	MD	ASTM D 4595	%	≤15
	CD			≤15
CBR Puncture Strength		ASTM D 6241	KN	≥10.0
Apparent opening size		ASTM D 4751	mm	≤0.250
Water Permeability		ASTM D 4491	$L/m^2/s$	≥4

Primary Applications

Road pavements, Dams, Embankments, Drains, Silt fencing for the purpose of soil reinforcement and stabilization. Sedimentation and erosion control, Drainage and support. Slabs, Beams etc.

Packaging:

These are available in sheet rolls of 100,150,200,250 square meters of GSM200,400,440,500.

Curing Compound:

WB is a concrete curing solution that consists of a blend of acrylics and is water-based. It exhibits strong bonding adhesion when applied to the treated surface. Roofexcure WB remains unaffected by the effects of natural weathering over time.

Roofexcure Tac:

An acrylic, transparent, water-based concrete curing compound, possessing identical characteristics to ROOFEXCURE WB, should be selected whenever a transparent seal is needed.

Appearance:

ROOFEXCURE WB is an acrylic mix with a white pigment. After application and drying, Roofexcure WB has a highly bonded white appearance.

Coverage:

Textured Concrete: 4.0 -6.0 Sq.mt.

Smooth Concrete: 5.0 -7.0 Sq.mt

Surface Preparation:

The surface of the concrete must be clean and clear of standing water. I Remove any sealant or other substance that may inhibit ROOFEXCURE WB absorption.

Areas of applications:

Interior and exterior concrete/tarmac as soon as it is freshly poured.

Storage & shelf life:

ROOFEXCURE WB has a shelf life of two years when stored within the temperature range of 5°C to 35°C. To prevent surface evaporation, it is essential to keep the containers securely sealed.

Packing

1.0, 5.0, 10.0, 20.0, 30.0 & 210.0 Litres Pack.

(Fig 2: Roofexcure-WB)

3.5 MIX DESIGN

Mix Design Followed as per IS 10262-2009

MIX PROPORTION

- Cement = 350.0kg/m^3
- Water = 140.0 kg/m^3
- Chemical Admixture = 7.0 kg/m^3
- Fine aggregates = 830.560 kg/m^3
- Coarse aggregate = 1215.430 kg/m^3
- W/c = 0.40

3.6 Methodology

The below is the flow chart of Research Methodology adopted for this project.

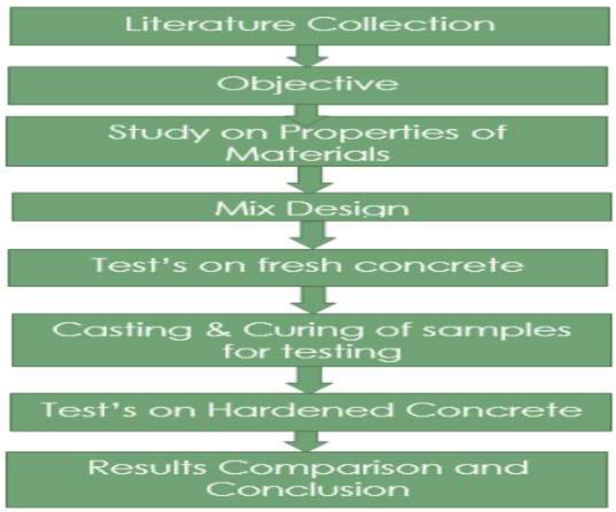


Fig 3 Methodology flow chart

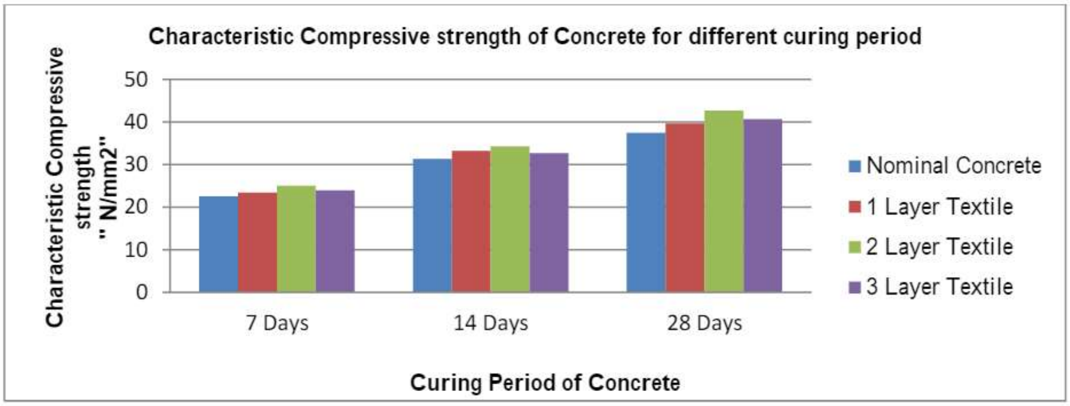
4. Results & Discussion

4.1 Compressive Test of Concrete:

Table 6. Compressive Strength Test Results

S. No	Type of Concrete	Average Compressive Strength (N/mm2)		
		7 Days	14 days	28 Days
1	Nominal Concrete	22.56	31.36	37.48
2	One layer textile Reinforced concrete	23.46	33.25	39.67
3	Two-layer textile Reinforced concrete	25.05	34.33	42.7
4	Three-layer textile Reinforced concrete	23.97	32.72	40.67

Graph: 1 Variation of Compressive Strengths of NominalConcrete vs Textile Reinforced Concrete



Discussion:

In Nominal Concrete, the compressive strength of nominal concrete is the least among all variations. In One Layer Textile Reinforced Concrete, this concrete type displays superior compressive strength compared to nominal concrete but falls short of the strength exhibited by two and three layers. In Two Layers Textile Reinforced Concrete, two-layer textile-reinforced concrete demonstrates the highest compressive strength among all variants, making it the most robust. In Three Layers Textile Reinforced Concrete, the compressive strength of three-layer textile-reinforced concrete falls between that of nominal concrete and one or two layers. It is noteworthy that the maximum compressive strength is achieved with two layers of textile-reinforced concrete, making it a suitable choice for applications requiring high compressive strength.

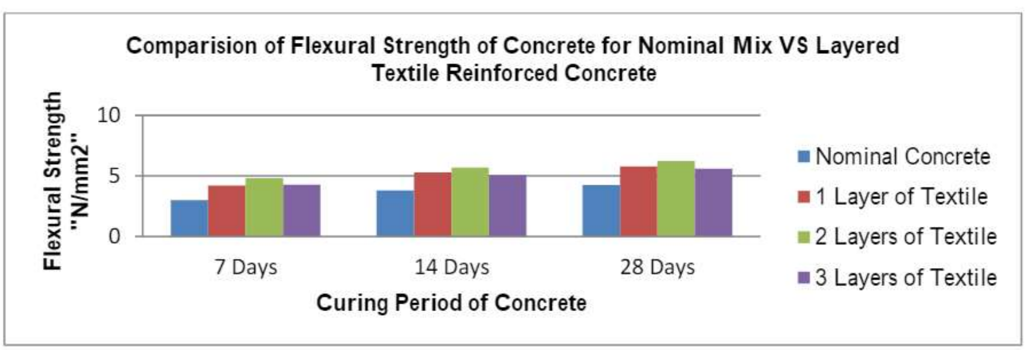
4.2 Flexural Strength Test

Table 7. Flexural Strength Test Results

S. No	Type of Concrete	Flexural Strength (N/mm^2)		
		7 Days	14 days	28 Days
1	Nominal Concrete	3	3.8	4.25
2	One layer textile Reinforced concrete	4.2	5.3	5.8
3	Two-layer textile Reinforced concrete	4.82	5.7	6.24
4	Three-layer textile Reinforced concrete	4.29	5.09	5.6

It is worth highlighting that the optimum flexural strength is achieved with two layers of textile-reinforced concrete, making it a favorable choice for a wide range of applications.

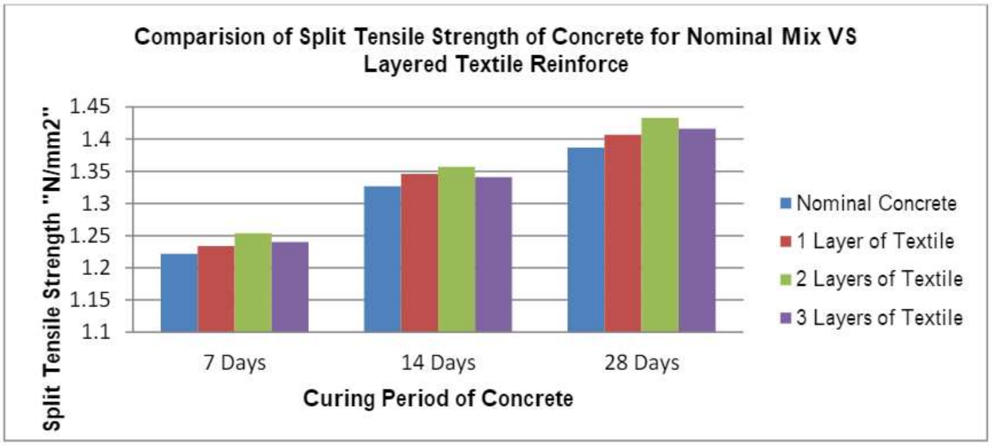
Graph: 2 Flexural Strengths of Nominal Concrete vs Textile Reinforced Concrete



5.3 Split Tensile Test:

Table 8. Split Tensile Test Results

S. No	Type of Concrete	Split Tensile Strength (N/mm^2)		
		7 Days	14 days	28 Days
1	Nominal Concrete	1.222	1.327	1.387
2	one layer textile Reinforced concrete	1.234	1.346	1.407
3	Two-layer textile Reinforced concrete	1.254	1.357	1.433
4	Three-layer textile Reinforced concrete	1.24	1.341	1.416



Graph: 3 Split Tensile Strengths of Nominal Concrete vs TextileReinforced Concrete

6. Conclusions

Based on the practical implementation of our theoretical hypotheses, we have derived the following conclusions from the results of our project:

i) Incorporating geotextile material in two layers, both at the top and bottom, has proven to enhance the ultimate flexural strength of concrete.

ii) There is no significant disparity in compressive strength between the two concrete types.

iii) Traditional pond curing has been effectively replaced with membrane curing, eliminating the necessity for water during the curing process.

iv) Analysis of flexural variance reveals an approximate 48% boost in flexural strength compared to nominal concrete.

v) The results of the flexural strength test suggest that the quantity of reinforcing material in concrete can be reduced by introducing geotextile material.

vi) Split tensile strength demonstrates a roughly 46% increase compared to nominal concrete.

These findings underscore the potential advantages and enhancements achieved by incorporating geotextile material in concrete applications.

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