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Investigation into the Mechanisms Underlying the Behavior of Textile Reinforced Concrete

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Abstract

Through experimentation, the performance of textile-reinforced concrete (TRC) and conventional concrete as reinforcing materials will be compared in this study. In this work, essential strength characteristics are determined, and the influence of the polyester filament yarns on concrete mixes is investigated by including them in M_{30}-grade concrete for nominal mix design. An essential component of optimizing concrete strength and durability is choosing the right curing time. The study's curing techniques focus on keeping the concrete from losing too much moisture. One of three approaches can be used to do this: either leave the form-work in place, cover the concrete with an impermeable membrane after the form-work is removed, use a water-based chemical curing agent, or combine these approaches. To reduce moisture loss, the exposed surface is continuously sprayed. Layers 1, 2, and 3 of the cloth must be organized in order to evaluate its split tensile, compressive, and flexural strengths. According to the experimental findings, the specimen that has two layers of textile in it achieves the best results in the split tensile, compression, and flexure tests. Nevertheless, the addition of three textile layers causes the strengths of compression and flexibility to diminish.

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Introduction

Concrete stands out as one of the most versatile and predominant building materials due to its ability to be molded to fit various structural shapes. It is easily accessible in urban areas and is cost-effective. While concrete exhibits considerable strength under compression, it is relatively weak under tension. Concrete has many benefits, including great compressive strength, remarkable water resistance, superior fire resistance, low maintenance needs, and an extended service life.

However, there are certain drawbacks associated with the use of concrete. Notably, it has poor tensile strength, making it susceptible to cracking or failure when subjected to tension forces. Additionally, the construction process often necessitates formwork, adding complexity and cost to the overall project. Despite these limitations, the overall benefits of concrete, especially its robust compressive strength and durability, make it a preferred choice in a wide range of construction applications.

Fig. 1: Fresh Concrete and Hardened Concrete

Concrete is inherently a relatively brittle material and lacks sufficient tensile strength. To enhance its tensile properties, reinforcement is incorporated into the concrete structure. The typical tensile strength of concrete hovers around 8% to 15% of its compressive strength. Over many decades, the challenge of concrete's weakness under tension has been addressed through the implementation of a system involving reinforcing bars. This system, known as reinforced concrete, ensures that concrete primarily withstands compressive stresses, while steel bars bear the brunt of tensile and shear stresses.

Fig. 2: Reinforced Concrete

Curing is controlling the temperature to control the cement's rate of hydration. Only the moisture content needs to be checked if the concrete's natural temperatures remain within an acceptable range during the curing process. Controlling the temperature of the concrete is necessary, though, if the ambient temperature rises above the allowable limit.

Objectives

- Analyzing the properties of textile-reinforced concrete.
- Investigating the impact of incorporating geotextile on the compressive and flexural strength of concrete.
- Minimizing the need for reinforcement in reinforced concrete (R.C.C.).
- Eliminating the reliance on water for the curing of concrete.
- Enhancing the flexural strength of concrete.

Concrete

Cement, fine and coarse aggregates, and water in the right amounts make up concrete, a composite material. The aggregates are bound together into a solid mass by the chemical reaction of cement and water. Because fresh concrete is pliable, it may be compacted to form a dense mass and molded into any desired shape in the molds.

Fig. 3: Materials used in Concrete

The transition of concrete from its pliable, plastic stage to a solid state is referred to as setting, and the subsequent development of strength after setting is termed hardening. Setting takes no more than 10 hours on average, and 90% of the hardening process is finished by the end of 28 days. The qualities of the components and the quality control procedures followed during the preparation and curing process have a major impact on the qualities of cement concrete as well as its overall attributes. As a result, it is crucial to carefully research the characteristics of each component of the concrete.

Fig. 4: Opc Cement

Cement

Cement plays a pivotal role in various construction applications, with its primary and crucial use being as a key component in the production of concrete. Concrete, formed by combining cement with aggregates, becomes a robust building material widely employed in construction projects. As a binder, cement is a substance utilized in construction that undergoes a process of setting and hardening, effectively binding and uniting other materials together to create durable structures.

Table 1: Properties of Portland Pozzolana Cement (Fly Ash based)

Particulars		Test Results	Requirements ofIS:1489-1991(Part1)	
CHEMICAL REQUIREMENTS				
Sl.No	**Requirements**	**% in Mass**	**Limitations**	
1.	Insoluble Material	22.80	X+(4.0(100-X))/100 (x= declaration % of fly ash)	Max
2.	Magnesia	1.07	6.00	Max
3.	Sulphuric Anhydride	2.38	3.00	Max
4.	Loss on Ignition	1.72	5.00	Max
5.	Total Chlorides	0.035	0.10	Max
PHYSICAL REQUIREMENTS				
6.	Fineness(m2/kg)	390	300	Min
7.	Standard Consistency (%)	33.5		
8.	Setting Time(minutes)			
	a. Initial	150	30	Min
	b. Final	225	600	Max
9.	Soundness			
	a. Le-Chat Expansion (mm)	0.5	10.0	Max
	b. Autoclave Expansion (%)	0.025	0.8	Max
10.	Compressive Strength (MPa)			
	a. 72+/-1hr. (3days)	28.6	16	Min
	b. 168 +/- 2 hr. (7 days)	38.6	22	Min
	c. 672+/-4hr. (28days)	58.0	33	Min
11.	Drying Shrinkage (%)	UT	0.15	Max
12.	% of Fly Ash addition	25.0	15.0	Min
			35.0	Max

Sand

High-quality river bank sand is characterized by the absence of any earthy matter and organic content. The sand particles exhibit an almost angular shape, passing through a 250-micron standard sieve and retained on a 150-micron standard sieve. To ensure its purity, a sample is thoroughly washed in water to remove any earthy or organic impurities. Subsequently, the washed sample is dried over a 48-hour period in sunlight.

The desired properties of good river bank sand include being hard, durable, chemically inert, clean, and entirely free from organic matter. This ensures that the sand is suitable for various construction applications, contributing to the overall quality and performance of the materials used in building projects.

Coarse Aggregate

Crushed granite stone chips of maximum sizes 1” and 1⁄2” available in the local quarries were obtained. The aggregate of 1” size was sieved to separate the chips of size greater than 20mm. The remaining aggregate and aggregate of 1⁄2” size were mixed in the ratio of 20 : 80 respectively to get 20mm minimum size graded aggregate satisfying the specifications of IS : 383-1970

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	600microns	25.80	42.60	57.40
5	300microns	32.80	75.40	24.60
6	150microns	20.70	96.10	3.90

Table 3: Properties of Fine Aggregate

S.No	property	Result
1	Specific Gravity	2.6
2	Finesses modulus	2.8
3	Bulk Density	15.75kN/m3
4	Grading of sand	Zone-II

Fig. 5: Fine Aggregate

Geotextile

'Geotextile' can be separated into two terms, 'geo' and 'textile'. The word 'geo' comes from the Greek meaning 'earth', so geotextiles can be defined as the permeable textile materials that are used in combination with soil or any other civil engineering material. Geo textile is a branch of technical textiles. Geotextile is a special type of polymer fabric (polyester, polypropylene etc.) with very small holes that is used to improve the soil properties in civil construction projects. Geotextile is an ideal textile material for roads, ports, landfills, breakwater construction, drainage structures and other civil projects. According to The Textile Institute, "permeable textile material used for filtration, drainage, separation, reinforcement and stabilization purposes as an integral part of civil engineering structures of earth, rock or other constructional materials".

Table 4: Physical Properties Geotexitle

S.No	Properties	Geotextiles	Strong biaxial geogrid
1	Apertures Size (mm)	-	30x30
2	Ulitimate tensile strength (kN/m)	55.16	38.1
3	Yield strain(%)	38	16.7
4	Secant modulus at 2% strain (Kn/m)	151	588
5	Mass per unit area strain(kN/m)	230	530

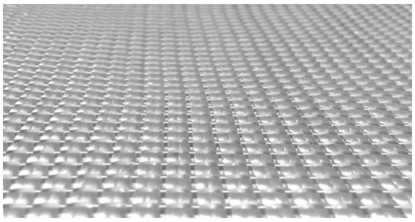


Fig. 6: Geotextile fiber

Membrane Curing

Membrane curing is an advanced and specialized curing method that involves the use of ROOFEX CURE WB. This particular approach is recommended in situations where a transparent coating is needed, providing an effective and specialized solution for curing processes. Curing membranes must be specified to cure concrete having a w/c greater than

0.42 made with either Portland cement or blended cement. When concrete is cast in dry and moderately windy conditions, usually the bleeding water that covers the finished concrete surface protects the concrete from plastic shrinkage long enough to have time to apply a curing membrane at a dosage (L/m2) recommended by admixture companies. It is only when air is particularly dry and/or particularly windy that fogging is recommended before applying curing membranes.

Fig. 7: Membrane Curing

Features & Benefits

- Easy and Safe Spray Application: The product is non-toxic and non-flammable, allowing for a convenient and safe spray application process.
- Drying Time: Rapid drying, typically less than one hour, ensuring efficiency in the curing process.
- Acrylic Blended, White Pigmented Curing Membrane: Provides a white-pigmented curing membrane for new concrete, offering compatibility with many paints, adhesives, and resilient floor coverings.

Methodology

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

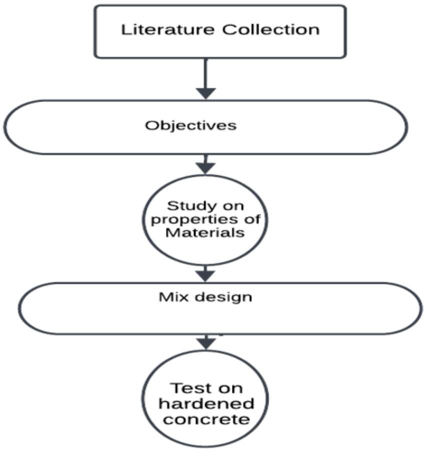


Fig. 8: Methodology flow chart

Literature Collection

Literature from different journals has been collected and research gap has found.

- Objective: Research gap has been identified and a objective has initiated which should be helpful for society.
- Study on material property: All the materials required for the project are procured and their basic properties are found.
- Mix Design: As per IS standards mix design is prepared for standard concrete.
- Tests on fresh concrete: Some of the tests for plastic concrete are done at Laboratory.
- Casting and Curing: Batching & mixing is done as per mix design and casted test specimen. After casting the specimen they are cured in water for 7 days, 14 days and 28 days.
- Tests on Hardened Concrete: Specimen is tested for Compressive Strength and Flexural strength on 7th ,14th and 28th day after casting

- Results Comparison and Conclusion: Testing results are been compared with each other and a brief analysis is made to give a conclusion

Timeline of the Project

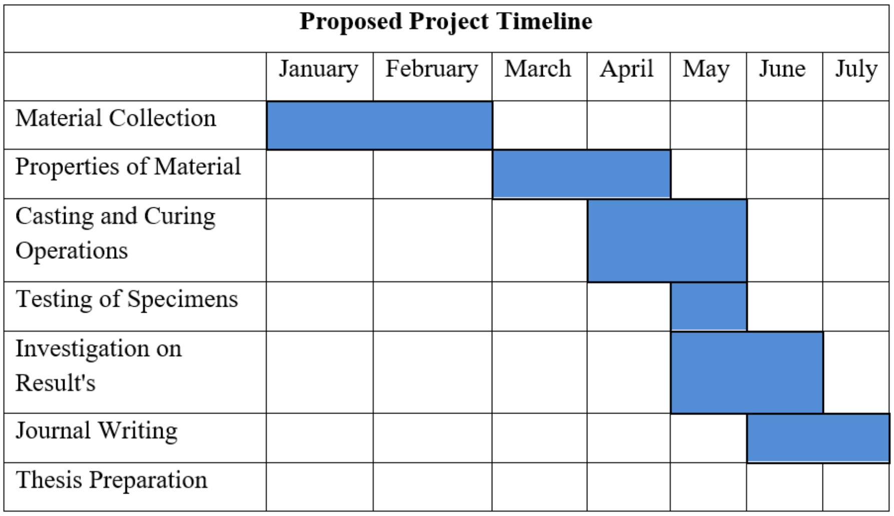


Fig. 9: Timeline Grant Chart

Mix Proportion

Table 5: Mix proportion for concrete

Material	Quantity (kg/m³)
Cement	350
Water	140
Chemical Admixture	7
Fine Aggregates	830.56
Coarse Aggregate	1215.43
W/C Ratio	0.4

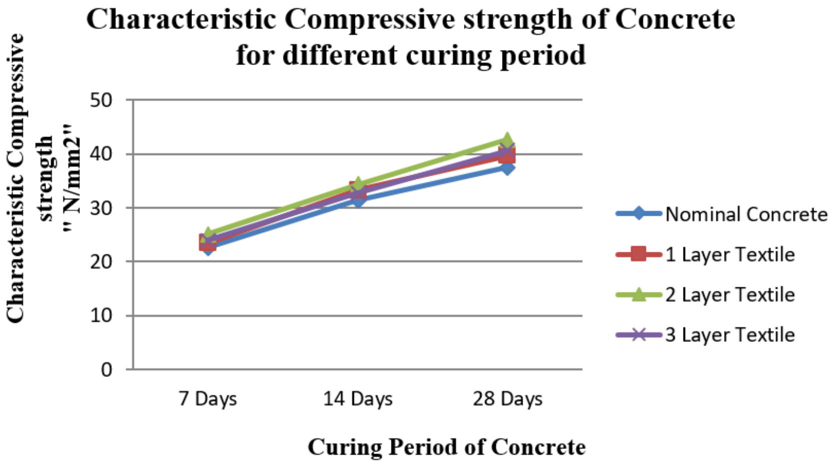
Results and Discussion

Compressive Test of Concrete

Table 6: Average of 3 cubes of Nominal concrete for 28 days

S. No.	Days	Load (KN)	Characteristic Compressive Strength (N/mm^2)	Cross sectional Area (mm^2)	Average Compressive Strength(N/mm^2)
1		826.2	36.72		
2	28	857.25	38.1	150*150mm	37.48 N/mm^2
3		846.45	37.62		

It appears from the above table that the average compressive strength of nominal concrete, as determined from three cubes tested at 28 days, is 37.48 N/mm^2.

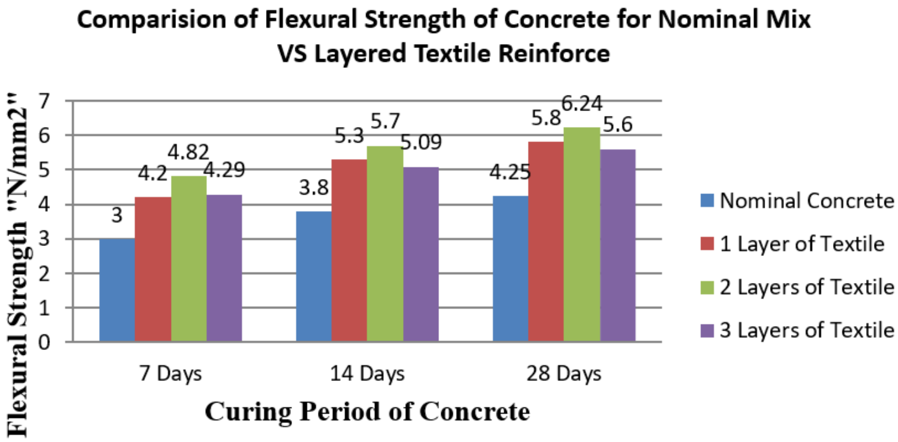


Graph 1: Variation of Compressive Strengths of Nominal Concrete vs Textile Reinforced Concrete

Table 7: Average of 3 Beams of two layers Textile Reinforced concrete for 28days

S. No.	Days	Load (KN)	Flexural Strength (N/mm^2)	Length (mm)	Cross sectional Area (mm^2)	Average Strength (N/mm^2)	flexural
1		11.72	5.86		100*100		
2	28	12.92	6.46	500mm	mm	6.24N/mm^2	
3		12.8	6.4				

It is observed from the above table that the average flexural strength of concrete with two layers of textile reinforcement, based on tests conducted on three beams at 28 days, is 6.24 N/mm^2.It is 42% greater than the conventional beam.



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

Conclusions

The previously described results were obtained after our theoretical ideas were put into practice. Based on the results the project was able to achieve, the following conclusions have been drawn:

- It was previously shown that adding two layers of geo textile—one on top and one at the bottom 42% increase the flexural strength of concrete beam compares to normal beam.
- It should be noted that the compressive strengths of the two types of concrete are identical.
- In addition, membrane curing has replaced conventional pond curing. In the end, the curing procedure required very little water—in fact, it used less water overall.
- In addition, the flexural strength variation shows that the flexural strength is approximately 48% greater than the nominal concrete.
- By incorporating a double layer at the top and a single layer at the bottom of the geotextile material into the concrete beam, we can partially lower the reinforcement material based on the results of the flexural strength test.
- When examining the split tensile strength variance, there is also an increase of around 46% in split tensile strength compared to the nominal concrete.

Author Contribution

Author SF is involved in data collection, experimental study and manuscript writing. Author LP and MS was involved in conceptualization, guidance and critical review of the manuscript.

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Conflicts of interest

No conflict of interest in this manuscript.

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