Published by :
http://www.ijert.org

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 14 Issue 05, May-2025

Experimental Investigation on the use of Fiber Reinforced Concrete in Rigid Pavement

Gokul Pt
Mtech Student, Department of Civil Engineering MIT

Priya Grace Itti Eipe
Professor, Department of Civil Engineering MIT

ABSTRACT

The project is a research experiment into the application of fiber reinforced concrete (FRC) to improve the performance of rigid pavement systems. Rigid pavements, made up normally of plain cement concrete, are susceptible to cracking and wear under heavy loading and exposure to the environment. To overcome such limitations, the use of discrete fibers like basalt, polypropylene, or glass fibers in concrete mixtures is examined. Fibers are likely to enhance mechanical characteristics like tensile strength, impact resistance, and post-cracking behavior. The experimental program emphasized the full-scale testing of slabs through a Universal Testing Machine (UTM), mimicking realistic load conditions comparable to those faced by real pavement systems. The slabs were cast and cured in controlled environments, followed by concentrated loading to evaluate load-carrying capacity.Flexural strength, compressive strength, and elastic modulus test is also conducted using appropriate specimens. The study points to the potential of fiber reinforced concrete as a good material for rigid pavement use, with the promise of longer service life and lower maintenance requirements. The research also offers suggestions for the best fiber types and dosages for use in the field in road infrastructure.

***Keywords*: Hybrid fiber reinforced concrete, Rigid pavement, Load test on slab**

1.INTRODUCTION

1.1 General Background

The increasing burden of traffic loads, environmental challenges and infrastructure constraints have made the need for resilient but durable pavement systems more urgent than ever before. The development of rigid pavements made of concrete material has a lifetime which far surpasses that of vehicle. However even these concrete pavements are prone to break and short lived because of their own characteristics and external factors like vibration, temperature fluctuations all those contribute to the degradation of its own solid structure. Hence a novel ideal of concrete with addition of fiber can lead to a material of better properties more suitable for pavements.

Fibre-reinforced concrete (FRC) has become a new and revolutionary material in constructing hard pavements, bringing about dramatic improvements in structural performance, longer service life and better resistance to fracturing. The materials of FRC have been modified with separate and uniformly distributed fibres. This improves tensile strength and flexural toughness, fatigue resistance and permits the concrete to mitigate the development of micro cracks which would eventually lead to premature pavement deterioration. The different variety of fibres commonly used where steel, polypropylene, glass, natural or synthetics also substantially increases the concrete’s continuation after cracking load.

Hybrid Fibre Reinforced Concrete (HFRC) is a milestone in modern concrete technology, say all the experts. It means for the first time that more than one kind of fibre can be placed one minute into a single concrete matric to form one uniform curtain of reinforcement. The reinforced material was named Mixed-fibre Reinforced Concrete. Unlike traditional reinforcement methods, which rely entirely on single types of fibre HFRC deliberately combines fibres with different sizes, materials and mechanical properties so as to suit performance criteria under varied stress regimes. This reinforcement method at different scales of size is better for bringing improvement in tensile-stress strength, crack resistance and resistance to impact cracking.

1.2 Scopeofthe study

The purpose of this study is to evaluate the effect of using different types of fibres on the mechanical properties of concrete and to compare the effect of using hybrid fibres (polypropylene – glass fibres, glass – basalt fibres and basalt – poly propylene fibres). The study also coducts the comparitive study of hybrid FRC with conventional concrete which could be benificial in concrete pavement.

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 14 Issue 05, May-2025

2. LITERATUREREVIEW

2.1.General

In normal concrete, micro-cracks form prior to the loading of structure due to drying shrinkage and other causes of change in volume. When the structure is under load, the micro cracks open and extend due to the formation of such micro-cracks, leads to inelastic deformation in concrete. In FRC, a quantity of short fibres are distributed and dispersed randomly in the concrete during mixing, and consequently enhance concrete properties in every direction. Rai and Joshi, (2014) performed a research on various types of fibers utilized in concrete like steel, glass, polymer, and natural fiber. They discovered that such fibres could be effectively employed in building with its high flexural-tensile strength, impact resistance, good permeability and frost resistance and also it possessed an effective method for enhancing toughness, shock resistance and plastic shrinkage cracking resistance of the mortar.

As per terminology coined by American Concrete Institute (ACI) Committee 544, four types of Fibre Reinforced Concrete are 1) SFRC (Steel Fibre Reinforced Concrete), 2) GFRC (Glass Fibre Reinforced concrete), 3) SNFRC (Synthetic Fibre Reinforced Concrete) and 4) NFRC (Natural Fibre Reinforced Concrete). It further gives information regarding different mechanical properties and design uses.

The application of fibres within a brittle matrix was first documented with the Egyptians, who applied animal hair and straw as reinforcement in mud walls and bricks of houses. This goes back to 1500 B.C. (Balaguruet al, 1992).

Fibre reinforcement has been found to be useful in numerous applications. Portland cement fibre reinforcement is intended to enhance the tensile and shear strengths of concrete, depending on the use. Fibres have been utilized to enhance the punching shear capacity of the column and slab interface by embedding the fibre in the concrete slab to span the failure surface (Keller, 2013; Khaleel, (2013).

The tensile strength value that fibre reinforcement adds has also been utilized to manage cracking in on grade slabs, plastic shrinkage and shrinkage cracking. The cracking reduction has been further enhanced to demonstrate that fibre reinforcement could supply the amount of increase in tensile strength to minimize the number of joints in slabs on grade (Bischoff, 2003; Collepardi, 2008). Fibre reinforcement of concrete does not eliminate the cracking of the concrete, but inhibits the crack growth by spanning across the crack (Banthia, 1994).

Fibre distribution and orientation of FRC considerably influence FRC properties. According to this principle Soroushian and Lee (1990) had conducted some work by determining the number of fibres per unit cross sectional area of SNFRC specimen with different volume fractions of different fibres. Theoretical equations were obtained for the number of fibres per cross sectional area in fibre reinforced concrete in terms of volume fraction and length, with the assumption that the cross sectional boundaries were the only ones to account for the 3-D random orientation of fibres.

Naaman et al., (1993) conducted a thorough experimental study on high early strength fibre reinforced concrete (HESNFRC) in its fresh state and mechanical properties. Properties of fresh HESNFRC which have been tested include air content, workability, temperature and plastic unit weight and mechanical properties. Sixteen varying combinations of parameter were tested; the parameters varied were volume fraction of fibres (1% and 2%), fibre type (steel, polypropylene), fibrelength and aspect ratio, and introduction of latex or silica fume into the mix.

Wang et al., (1987) carried out an experimental program on the properties of various synthetic fibre reinforced cementitious composites and the properties of the reinforcing fibres. Acrylic, polyester, and aramid fibres were tested in uniaxial tension, both in their original condition and after ageing in cement. Samples of these fibres were found to lose differing amounts of strength with time, based on the ageing temperature. The tensile characteristics of the concrete reinforced with these fibres, whether in the form of random or uniaxial alignment, were analyzed through the application of three various tests: compact tension, flexural, and splitting tensile tests.

Orientation and distribution of fibres in FRC play a significant role in the properties of FRC. It is with this understanding that Soroushian and Cha-Don Lee (1990) have done some research, through determining the number of fibres per unit cross sectional area of SFRC specimen with different volume fractions of various fibres. Theoretical equations for number of fibres per cross sectional area in fibre reinforced concrete in terms of volume fraction and length were established, considering the cross sectional boundaries as being the sole parameters for distributing the 3-D random orientation of fibres. They compared the number of fibres per cross sectional area with reorientation fibres in concrete under the action of vibration.

Ganesan and Armani Murthy (1990) determined the stress – strain behaviour of short, confined, reinforced concrete column with and without steel fibres. The volume fraction of 1.5% with aspect ratio of 70 of steel fibres was utilized. The study variable was percentage reinforcement of lateral reinforcement. The peak load strain was enhanced to some extent.

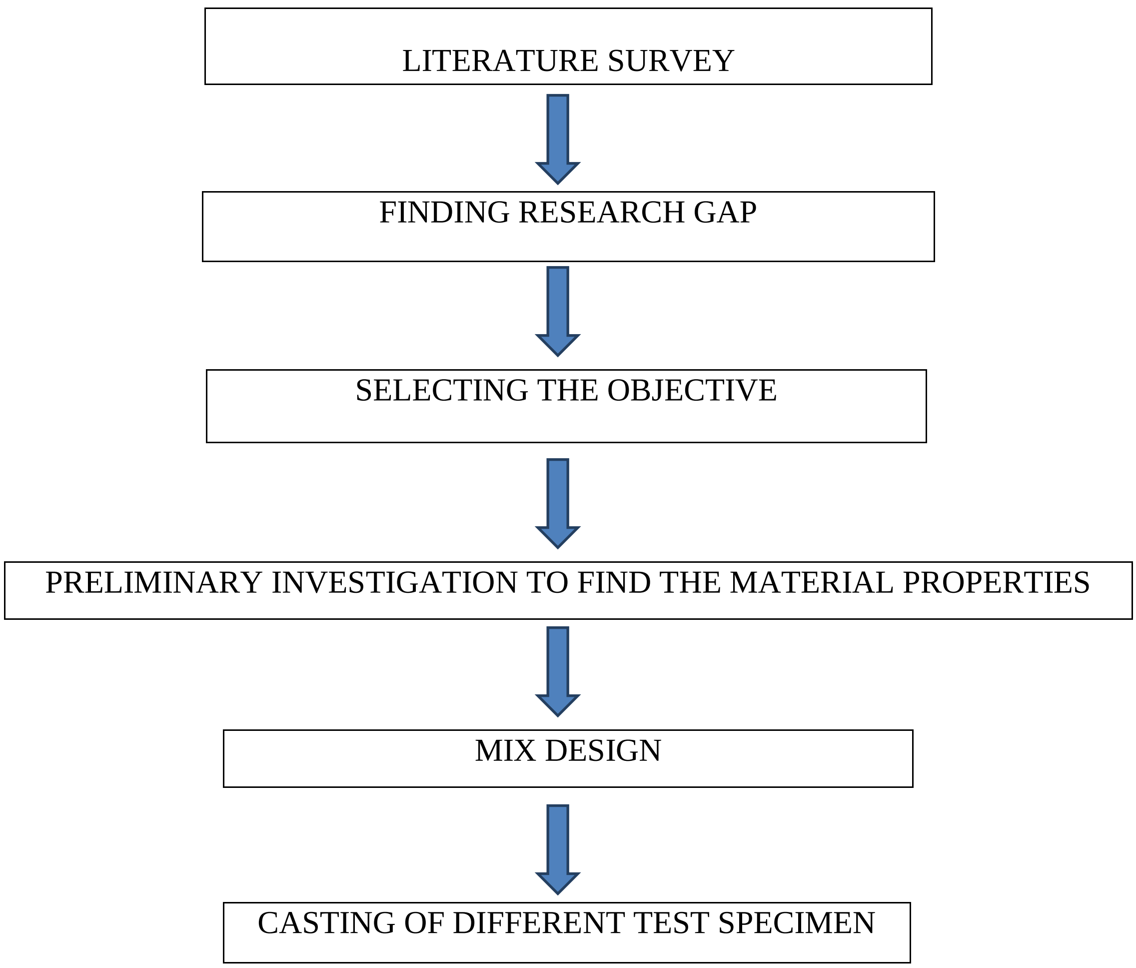
Several researches have identified the technical advantage of steel FRC pavements compared to traditional concrete pavements; yet, few investigations have been conducted on the environmental and cost effects of SFRC throughout the life cycle of the pavement (Achilleos et al., 2011). The life cycle analyses indicated that the type of steel fibre and dose can significantly affect the environmental and cost factors of the concrete pavement layer.

Another notable study was conducted by Mohammadi and Kaushik (2003) on the influence of mixed aspect ratio of fibres on mechanical strength characteristics of concrete. Crimped type flat steel fibres 25 mm – 50 mm long were mixed in various ratios with concrete and tested for split tensile, compressive and static flexural strength. Compressive toughness and flexural toughness were derived from the test results. It is observed that 65% of long fibres and 35% of short fibres provided the best composite properties compared to other combinations. A significant point also was mentioned in that literature that utilization of mixed aspect ratio of fibres does not significantly influence the static modulus of elasticity.

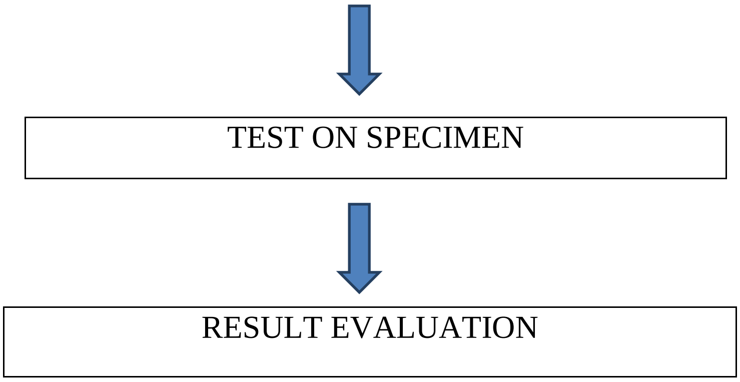
Katz (2004) had conducted a research on environmental load of fibre-reinforced polymer (FRP) pavement versus steel reinforced pavement. It was observed that the environmental load of FRP pavement was much smaller than that of steel reinforced pavement. This finding primarily indicated the reality that FRP pavement needed less maintenance, its cement proportion and concrete cover over the reinforcement can be minimized, and the reinforcement itself creates a less load.

3. Methodology

This section explains the mode of work involved, work methodology and varieties of work conduced.



International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 14 Issue 05, May-2025



IJERTV14IS050272

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 14 Issue 05, May-2025

3.1 Material Properties

The materials used are ordinary Portland cement (OPC), coarse aggregate, fine aggregate, water and super plasticizer. In addition to this, glass, polypropylene, and basalt fibres are also used. The properties of each of these materials were studied. Different tests were conducted for each material as specified by relevant Indian Standard codes.

3.1.1 Cement

Cement is the main binding agent used in concrete. It is the element that combines the aggregates, making it possible to achieve a solid structure. It usually consists of limestone and clay, among other materials, which are heated in a kiln to create clinker. This is then ground to powder and mixed with gypsum to form cement. When water is added, it undergoes a chemical reaction called hydration, creating cement paste which over time becomes solid and bonds with sand and coarse aggregates, turning into a strong durable material. This results to concrete's compressive strength, reason why it is one of the most used materials in construction of buildings, roads, bridges, and other infrastructures.
Standard consistency test was done to determine the amount of water essential to produce a cement paste. As per IS 4031 (part 5):1988, the initial setting time is not less than 30 minutes and the final setting time is not more than 600 minutes. Laboratory tests were conducted on cement to determine its specific gravity, standard consistency, fineness, initial setting time, final setting time and compressive strength.

Sl No.	**Test Conducted**	**Result**	**Standard Value**
1	Fineness of cement	3%	Less than 10%
2	Specific gravity of cement	3.04	3.04
3	Consistency of standard cement paste	35%	26% - 33%
4	Initial setting time	30mts	Greater than 30 min
5	Final setting time	600mts	Less than 600 min
6	3rd day Compressive Strength, N/mm^2	20	Greater than 10 N/mm^2
7	7th day Compressive Strength, N/mm^2	22.77	Greater than 17 N/mm^2

Table 3.1.1 Physical properties of Portland Pozzolana cement

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 14 Issue 05, May-2025

3.1.2 Fine Aggregate

Fine aggregate should be passed through I. S. Sieve 4.75mm. Locally available good quality Manufactured sand (M sand) was used in this investigation. Laboratory tests were conducted on fine aggregates to determine the different physical properties as per IS 383 (Part III)-1970. Fine aggregate used conforms to IS 383:1970 specification (Zone II).

Sl. No.	Test Conducted	Test Results
1	Specific gravity	2.54
2	Sand type	Medium
3	Grade	Zone II

Table 3.1.2 Physical properties of fine aggregate

3.1.3 Course Aggregate

Aggregates with particle size of 20mm were used for this investigation. Fineness modulus is only a numerical index of fineness, giving some idea of the mean size of the particles in the entire structure of aggregate. To a certain extent it is a method of standardization of the grading of the aggregate. It is obtained by adding the percentage weight of material keep hold on to in each of the standard sieves and dividing it by 100.

Sl No.	Test Conducted	Test Results
1	Specific gravity	2.5
2	Void ratio	0.73
3	Bulk density(kg/m^3)	1.58kg/m^3
4	Porosity (%)	0.422

Table 3.1.3 Physical properties of course aggregate

3.1.4 Water

Water is the most important and least expensive ingredient of concrete. Water used for mixing and curing shall be clean and free from injurious amounts of oils, acids, alkalis, salts, sugar, organic materials. Potable water is generally considered satisfactory for mixing concrete. Hence clean drinking water was used for casting as well as curing of the test specimens.

3.1.5 Super Plasticizers

The super plasticizer used were Cementon - Conflo, is a high-performance, next-generation product that acts as both a super plasticizer and a retarding admixture. It works by lowering the surface tension of water, making cement particles more hydrophilic. This leads to fantastic dispersion and helps control the setting time of

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 14 Issue 05, May-2025

concrete, depending on how much we use. As a result, the workability of the concrete improves significantly, allowing for better retention of that workability. With a lower water-cement ratio, we can eliminate the risk of bleeding, and the enhanced workability retention gives us more time to work with the mix. Plus, reducing the water-cement ratio cuts down on capillary porosity and boosts water tightness.

Sl No	Properties	Values
1	Supply form	Liquid
2	Colour	Black
3	Specific gravity	1.09
4	Dosage	0.3% to 0.4% by weight of cement
5	Chloride content	Nil

Table 3.1.5 Properties of super plasticizers

3.1.6 Fibers

The fibres used were polypropylene fibres, glass fibres and basalt fibres of both micro and macro fibres with different combinations according to the required integrations specified from the references.

3.2 Mix Proportion

The first step involved figuring out the right mix proportions for M30 grade concrete. We followed the guidelines set out in IRC: 44-2008 for designing cement concrete mixes for pavements that include fibres. We incorporated different fractions of steel, glass, and basalt fibres into the mix. Mix design is all about choosing the right ingredients for concrete and understanding their properties to create a product that achieves maximum strength and durability while being as cost-effective as possible. The goal of this design process is to meet the required minimum strength and durability while keeping the concrete economical. Here are the various steps we took:

- Calculate the target mean strength of the concrete
- Select the water-cement ratio
- Determine the water content
- Calculate the cement content
- Proportion the volume of coarse and fine aggregates
- Perform mix calculations
- Establish the mix proportions

Water	Cement	Fine Aggregate	Course Aggregate	Super Plasticizer
197.161litres	470 kg/m^3	685.8 kg/m^3	923.7 kg/m^3	0.3%

Table 3.2 Details of mix

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 14 Issue 05, May-2025

3.2.1 Preparation Of Test Specimen

Mixing took place in a rotating drum mixer. To prepare the concrete specimens, we started by mixing the measured amounts of aggregates and cement together. Once we achieved a good mix, the measured dosage of fibers are to be added then we added a small portion of water from the total measured amount. The mixing continued until we reached a uniform consistency. After that, we added the calculated amount of super plasticizers to ensure we got the desired flow and workability. And the concrete is being placed in to desired mould before thirty minitues of mixing the concrete. All the specimens were de-moulded after 24 hours. Control specimens were kept in a curing tank for water curing for the next 27 days.

Fig 3.2.1 Preparation of test specimen

3.2.2 Curing Of Specimen

Curing is the process of avoiding the moisture loss from concrete and keeping a satisfactory temperature. Casting was followed by keeping moulded specimens in the laboratory at room temperature for 24 hours from the time of water addition to dry materials. Upon completion of this duration, specimens were released from moulds, immediately put in clean and fresh water. 28, day curing were performed for various specimens

Fig 3.2.2 Curing of specimen

3.2.3 Details Of Test Specimen

Standard cube of size 15mm side, standard cylinder of diameter 150mm and height 300mm, standard beam of dimension 150mm x 150mm x 700mm and slab of dimension 600mm x 600mm x 60mm is being casted.

3.3 Workability Of Fresh Concrete

Fresh concrete, often referred to as plastic concrete, is a newly mixed material that can be shaped into just about anything. The specific proportions of cement, aggregate, mineral admixtures, chemical admixtures, and water that are combined play a crucial role in determining the properties of the concrete while it's still fresh. Workability is all about how easily the concrete can be compacted. It reflects the amount of effort needed to achieve full compaction. To assess the workability of a concrete mix, a slump test is typically performed. Additionally, the compacting factor test is conducted because it offers greater accuracy than the slump test, especially for concrete mixes with very low workability, which are often used when the concrete needs to be compacted through vibration.

3.3.1 Slump Test

The slump test is a practical way to assess how workable fresh concrete is. Essentially, it checks the consistency of a specific batch of concrete, which is all about how easily it flows. This consistency gives us an idea of how wet the mix is. Generally, wetter mixes are easier to work with than drier ones, but even concrete with the same consistency can differ in workability. To perform the test, you use a special vessel that looks like a frustum of a cone, open at both ends. The top diameter is 10 cm, the bottom is 20 cm, and the height is 30 cm. For tamping, a steel rod that's 16 mm in diameter and 60 cm long is used. It's worth noting that this aspect wasn't prioritized because the focus was on improving compaction during the casting process.

Fig 3.3.1 Slump test

3.4 Strength Properties On Hardened Concrete

3.4.1 Compressive Strength

Compression testing is perhaps the most basic and most common means of assessing the strength of concrete. In this test, a cube of concrete is loaded with a slowly applied compressive force until it fails or cracks. The highest load the specimen can withstand before failing is measured, and the compressive strength is obtained by dividing the load by the specimen cross-section area. This test is performed since concrete is engineered mainly to be resistive to compressive forces, and thus compressive strength is the most important property for structural use. Engineers use the results to ascertain if a given lot of concrete achieves the strength requirements for performance and safety. Compression testing also gives a quality control measure in that mix proportions, material quality, curing, and workmanship are all satisfactory. It is crucial in the construction and design of load-carrying structures such as foundations, walls, and columns, where the concrete will have to withstand huge compressive loads during its duration.

Compressive strength test is conducted using compressive testing machine with a capacity of 2000KN which is one of the easiest method to find the compressive strength of concrete. The test is conducted by preparing concrete cubes of dimension 150mm x 150mm x 150mm, and the load is applied with a rate of 14N/mm^2 per minute as per IS 516:1959 specification. The load in this experiment was first applied monotonically, meaning that there was no initial shock, and then increased at a rate of approximately 14 N/mm^2 per minute until the specimen's resistance to the applied increasing load was unable to be maintained. The specimen was held to record the maximal load after this was achieved. The specimen's compressive strength was determined by dividing the maximum load exerted on the specimen during the test by the cross-section area of the specimen which was cross-sectioned prior to the test.

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 14 Issue 05, May-2025

Fig 3.4.1 Compression test on cube

3.4.2 Modulus Of Elasticity Test

Elasticity modulus test was conducted by using compressive testing machine with a capacity of 2000KN. In this experiment the load on the specimen load in this experiment was first applied monotonically, meaning that there was no initial shock, and then increased at a rate of approximately 14 N/mm^2 per minute until the specimen's resistance to the applied increasing load was unable to be maintained. The specimen was held to record the maximal load after this was achieved. The specimen's modulus of elasticity was determined from the slope of the stress strain curve by dividing the maximum load exerted on the specimen during the test by the cross-section area of the specimen which was cross-sectioned prior to the test.

Modulus of elasticity test is performed on concrete to find out its capacity for elastic deformation (i.e., to come back to its original form) under applied stress, and it is one of the important properties in analyzing and designing concrete structures. Also referred to as the Elastic modulus or Young's modulus, this number is the concrete's stiffness, or the amount it will strain (deform) under a certain stress before permanent deformation or cracking happens. It is important to know the modulus of elasticity because it has a direct relationship with the way a structure will react when it is loaded, specifically with regard to deflection, cracking, and stress distribution. Both steel and concrete share loads in reinforced concrete design, and thus having knowledge about the stiffness of concrete enables engineers to correctly compute the amount of deformation each material will experience and contribute to the structural response. The test is particularly significant for tall structures, bridges, dams, and pavements because excessive deformation, even if the structure does not collapse, may cause serviceability issues. The test consists of applying an incrementally increasing compressive load to a cylindrical test specimen of concrete and measuring the created strain. The modulus of elasticity is determined by the slope of the stress-strain curve in the elastic region. The test assists in improving structural models, in guaranteeing serviceability, and in making proper mix designs or construction methods in accordance with the mechanical performance of the concrete under in-service conditions.

Fig 3.4.2 Elastic modulus test

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 14 Issue 05, May-2025

3.4.3 Flexural Strength Test

The flexural strength test is an important procedure in measuring the performance of concrete, especially in structures that will be subject to bending or tensile stress. It is also referred to as the modulus of rupture test and determines if a concrete beam or slab can withstand failure when in bending. In this test, a beam of concrete is loaded in a testing machine to a load at one or two points until it fails. The flexural strength is then determined from the maximum load supported by the specimen at the time of failure. This test is important since, while concrete is extremely strong in compression, it is comparatively weak in tension. Most concrete structures including pavements, beams, and slabs are loaded in bending in service and this imposes tensile stresses on the concrete. The flexural test ensures the ability of the concrete to resist such stresses without cracking and failing. It is particularly vital in highway and runway construction quality control where the flexural performance is a vital design consideration. Through this test, engineers are able to ensure that the curing process and the concrete mix have generated a material that will satisfy the necessary performance requirements for durability and structural safety.
Beams were tested after 28days. Flexural test was carried out by two point loading with pure bending at central zone of 50cm. A proving ring of class 500 KN was utilized to measure gauge load applied. Increment at each proving ring division increment on the loadable was applied at two marks. The resultant load was noted for the initial crack and the development of crack was marked on face for every 'load step' after that till the load incrementing stops. Noting cracks through a micrometre of degree 0.1mm was possible for all increment until the structure fails.

Fig 4.4.3 Flexural strength test on beam

3.4.4 Strength Test On Slab

Pavement slabs generally lies on ground with proper subgrade, hence the load is slightly distributed to the infinity earth beneath the pavement. Hence to achieve the right value an earth condition is being made by placing a steel plate of dimension 1000mm x 1000mm x 80mm filled with river sand and the specimen is placed above it and the load is applied. A slab test on a Universal Testing Machine (UTM) is performed to analyze the structural behavior and load-carrying capacity of a concrete slab under defined loading conditions. For this test, a concrete slab specimen usually a reduced scale model is set on supports within the UTM, and a load is gradually applied, at one point. Parameters like load, deflection, strain, and crack formation are monitored by sensors and data acquisition systems during the test on the slab. The test is repeated until the slab fails through cracking, crushing, or other types of structural failure.

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 14 Issue 05, May-2025

Fig 3.4.4 Load test on slab

4. RESULT

4.1 General

Strength studies were conducted on FRC using the experimental methods described in the previous chapter. In this chapter, the results from each of the tests conducted have been analysed and discussed. Every test result presented in the figures and tables is the average of the three specimens tested. The behaviour of slab specimens subjected to compression loading is also covered here.

4.2 Strength Study

4.2.1 Compression Test On Single Fiber Cube

Compression test was performed on single fiber reinforced cubes to check the influence of adding fibers on the compressive strength of concrete. In this test, normal concrete specimens with a single species of fiber were mixed and cured under standard conditions. Following the curing time, the specimens were tested for their compressive strength using a compression testing machine. The findings were contrasted with those of normal concrete for the determination of strength improvement. The fiber addition assists in postponing the propagation of cracks as well as improving the toughness of the concrete to ensure enhanced performance under compressive loading. This test was informative on the structural advantage of applying fiber reinforcement in concrete.

SL.NO	COMPRESSIVE STRENGTH OF CUBE		
1	PF	31.4 MPa	32.5MPa
		33.4 MPa	
		32.7MPa	
2	GF	35MPa	35.2MPa
		35.8MPa	
		34.9MPa	
3	BF	36 MPa	36MPa
		36.3MPa	
		35.7MPa	

Table 4.2.1 Compression test on single fibers

4.2.2 Compression Test On Hybrid Cubes

As compared to usual plain concrete, the fibre reinforced concrete showed desirable enhancement in compression strength. All in total, 9 150 mm sized cube specimens with casted and tested. There were casted 3 cubes per every mixture of fibre and calculated 28th day strength. Optimum volume fractions for three different fibres used. Outcomes on compression strength for the basis of mean of three test result values for every mix.

SL.NO	COMPRESSIVE STRENGTH OF CUBE		
1	GPHF	38.24 MPa	38.60 MPa
		38.36 MPa	
		39.22 MPa	
2	BPHF	41.6 MPa	42.20 MPa
		42.4 MPa	
		42.62 MPa	
3	BGHF	46.06 MPa	45.34 MPa
		45.14 MPa	
		44.83 MPa	

Table 4.2.2 Compression test vales on hybrid fibers cube

4.2.3 Modulus Of Elasticity

Modulus of elasticity is also named as Young's modulus is a quantification of a material's capacity to deform elastically under the application of a stress. It is merely a description of how stiff a material is how much it will stretch or be compressed under a specific load. For concrete, the modulus of elasticity is an important structural design parameter since it can determine the amount of deformation of a structure under working loads. Modulus of elasticity test in concrete is to find its stiffness as well as predict its behavior under service loads in real structures. By this, structures that are not only strong but also serviceable are designed such that deflection, vibration, and cracking are kept within acceptable limits throughout the life of the structure. It was determined from compression test on cylindrical specimens of diameter 150 mm and height 300 mm. Test was done at the age of 28 days. Specimens were loaded for 3 load cycles. Stress strain graphs were plotted from load-deformation data. Modulus of elasticity was determined from slope of stress-strain diagram.

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 14 Issue 05, May-2025

SL.NO	MODULUS OF ELASTICITY TEST ON CYLINDER		
1	GPHF	36.24GPa	34.60GPa
		34.36GPa	
		33.22GPa	
2	BPHF	39.6GPa	39.87GPa
		40.4GPa	
		39.62GPa	
3	BGHF	42.06GPa	42.67GPa
		42.14GPa	
		43.83GPa	

Table 4.2.3 Elastic modulus vales on cylinder

4.2.4 Flexural Strength

The flexural strength of different specimen with proper varieties of fibres is being tested and being found as per IS 516-1959 on beam specimens of size 100 x 100 x 700 mm. The flexural test for a concrete beam is done to establish the ability of the concrete to withstand bending or flexural stresses, which is very important in members such as beams, slabs, and pavements which are subjected to loads inducing bending. In this test, a normal concrete beam specimen is supported on two rollers in a flexural testing device, and a load is applied at two points on the upper surface until fracture occurs.

SL.NO	FLEXURAL STRENGTH TEST ON BEAM		
1	GPHF	3.9MPa	3.67MPa
		4.01MPa	
		3.09MPa	
2	BPHF	4.31MPa	4.37MPa
		4.44MPa	
		4.37MPa	
3	BGHF	4.87MPa	4.92MPa
		4.97MPa	
		4.92MPa	

Table 4.2.4 flexural strength test values on beam

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 14 Issue 05, May-2025

4.2.5 Load Test On Slab

The slab is being tested with different fibres combination with each consisting of a minimum of 3 specimen with each combination consist of 3 specimens. The specimen is being tested by preparing a subgrade which was created by a confined mould of size 1000mm x 1000mm x 80mm and river sand is being filled and the specimen is being placed above it. The 600 mm × 600 mm × 60 mm slab test is a laboratory test aimed at replicating and assessing the load performance of concrete pavement in a simulated environment, employing a Universal Testing Machine (UTM). This size of slab is usually selected in order to be a reduced scale replica of an actual pavement section, so that its ability to withstand loads can be researched, under test conditions. In this test, the slab is placed on an artificially prepared subgrade which consist of a steel mould support 1000mm x 1000mm x 800mm which is filled with river sand and placed within the UTM loading area. The point load is positioned on the surface of the slab, to simulate actual loading conditions like vehicular traffic or static load.

SL.NO	LOAD TEST ON SLAB		
1	GPHF	38.6KN	38.9KN
		39.4KN	
		38.7KN	
2	BPHF	42.8KN	44.06KN
		45.9KN	
		43.5KN	
3	BGHF	48.5KN	48.67KN
		49.5KN	
		48 KN	

Table 4.2.5 load test on slab

5. CONCLUSION

Experiment studies were conducted in the laboratory and conclusions were made.

The studies were conducted on M30 mix. The study aimed at exploring the influence of fibres on the properties of concrete employed in pavements. The workability, the 28-day cube compressive strength was studied to determine the most suitable combinations between the hybrid fibres. The blends were also examined for the mechanical properties. The conclusion of the current study is made on the basis of limited observations conducted during the research duration.

The best hybrid combination among the three combination obtained is Glass-Basalt fibre which shows the most impressive result in all the test conducted mainly in the strength test on slab, compression test on cube and flexural strength on beam.

It was seen that workability decreased as the fibre content was higher. Fresh properties of concrete were noted by using slump test where results indicate that workability decreases with an increasein fibre dosage.

Compressive strength was found to be rising with the rise in fibre dosage (until the optimum), which can be explained as when the fibre percentage rose, workability was compromised but the fibre content in the matrix was sufficient to bridge the micro cracks formed.

Flexural strength also improves owing to addition of fibres compared to the regular mix. This clearly proves that the incorporated fibre in the matrix behave as crack arresting mechanism and enhance the tensile strength of concrete.

The comparative analysis of mechanical behavior between conventional concrete and hybrid fiber reinforced concrete (HyFRC) illustrates that the use of more than one kind of fiber boosts the performance of concrete

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 14 Issue 05, May-2025

extensively. The findings indicated significant improvement in compressive strength, flexural strength, and load test on slab in HyFRC as compared to conventional concrete. The hybrid behavior of various fibers like polypropylene, glass and basalt exhibited enhanced crack bridging, load transfer, and energy absorption, resulting in improved ductility and toughness.

The compressive strength of HyFRC indicated moderate improvements with increased internal resistance and delayed crack growth, whereas flexural strength showed substantial improvements, reflecting the enhanced bending strength, which is a key requirement for pavement, slab, and beam applications. The tensile strength improved the most, which indicates the efficacy of hybrid fibers in mitigating brittleness and regulating microcracks. Furthermore, the incorporation of fibers minimized crack widening rate and enhanced post-cracking behavior, which leads to extended service life and enhanced structural integrity.

In conclusion, hybrid fiber reinforcement is a cost-saving yet performance-improving option for concrete in structural and non-structural applications, especially where greater toughness, ductility, and durability are needed. Further improvement can be achieved in fiber type, ratio, and orientation to achieve even better outcomes based on the particular application

6. FUTURE OF THE STUDY

The present study was focused on examining the strength and behavior of hybrid fiber reinforced concrete with polypropylene, glass and basalt fibres on pavement conditions. Some areas were future research required are:

1. Crack width study of hybrid fiber freinforced concrete in rigid pavement .
2. Finite element models in ANSYS software for load-deflection test.
3. A life-cycle cost evaluation of the benefits of adding fiber

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 14 Issue 05, May-2025

7. REFERENCES

1. Rai, A., & Joshi. (2014). Applications and Properties of Fibre Reinforced Concrete. International Journal of Engineering Research and Applications, 4(5).
2. Al-Oraimi, S. K., &Seibi, A. C. (1995). Mechanical characterisation and impact behaviour of concrete reinforced with natural fibres. Composite Structures, 3, 165-171.
3. ACI Committee 544 (1996). "State-of-the-art report on fibre reinforced concrete." ACI 544.IR-96, American Concrete Institute, Detroit, Michigan.
4. Balaguru, P. N., & Shah, S. P. (1992). Fiber-reinforced cement composites.5, 500-511.
5. Rossi, P. (1997). 'High Performance Multimodal Fibre Reinforced Cement Composites (HPM-FRCC): the LCPC Experience". ACIMaterials Journal, 94 PP 478–483.
6. Khaleel, G. I., Shaaban, I. G., Elsayedand, K. M., &Makhlouf, M. H. (2013). Strengthening of Reinforced Concrete Slab-Column Connection Subjected to Punching Shear with FRP Systems. International Journal of Engineering and Technology. 5, 657.
7. Collepardi, M., Troli, R., Bressan, M., Liberatore, F.,& Sforza, G. (2008) Crack-Free Concrete for Outside Industrial Floors in the Absence of Wet Curing and Contraction Joints. Cement and Concrete Composites. 30, 887-891.
8. Soroushian, P., & Lee, C. D. (1990). Distribution and orientation of fibers in steel fiber reinforced concrete. Materials Journal, 87, 433-439.
9. Naaman, A. E., Al-khairi, F. M., and Hammoud, H. (1993). "Mechanical Behavior of High Performance Concretes, Volume 6: High Early Strength Fibre Reinforced Concrete (HESNFRC)". Strategic Highway Research Program, National Research Council, Washington, D. C.
10. Rossi, P. (1997). 'High Performance Multimodal Fibre Reinforced Cement Composites (HPM-FRCC): the LCPC Experience". ACIMaterials Journal, 94 PP 478–483.
11. Kukreja, C. B., Kaushik, S. K., Kanchi, M. B., & Jain, O. P. (1980). Tensile strength of steel fibre reinforced concrete.5, 312-321.
12. Ganesan, N., & Murthy, J. R. (1990). Strength and behavior of confined steel fiber reinforced concrete columns. Materials Journal, 87, 221-227.
13. Achilleos, C., Hadjimitsis, D., Neocleous, K., Pilakoutas, P., Neophytou, P.O., and Kallis, S. (2011). "Proportioning of Steel Fibre Reinforced Concrete Mixes for Pavement Construction and Their Impact on Environment and Cost". Sustainability, http://www.mdpi.com/journal/sustainability.
14. Mohammadi, Y., &Kaushik, S. K. (2003). Investigation of mechanical properties of steel fibre reinforced concrete with mixed aspect ratio of fibres. Journal of ferrocement, 33, 1-14.
15. Katz, A. (2004). "Environmental Impact of Steel and Fibre–Reinforced Polymer Reinforced Pavements". Journal of Composites for Construction, ASCE.
16. Lee, S. (2003). "A Probabilistic Model for Joint-movements in Jointed Concrete Pavement". KSCE Journal of Civil Engineering .7, 141-146.
17. Krishna, K. V., Rao, J. V. (2014). "Effect of Glass Fibres in Rigid Pavement". International Journal of Scientific Research and Education, 2(9), PP1797- 1804.
18. Kumar, R., Goel, P., &Mathur, R. (2013). Suitability of Concrete Reinforced with Synthetic Fibre for the Construction of Pavements. Third International Conference on Sustainable Construction Material and Technologies, http://www.claisse.info/proceedings.hmt.
19. S P Shah, V K Rangan, Effect of Fiber Addition on Concrete Strength , Indian Concrete Journal, 5, 13-21, 1994.
20. IRC 44-2008, Recommended guidelines for Cement Concrete Mix Design for Pavements with fibres, Indian Road Congress, New Delhi.
21. IS 12269 – 1987 – Specification for 53 grade Ordinary Portland Cement,Bureau of Indian Standards, New Delhi.
22. IS 383-1970 – Specification for coarse aggregate and fine aggregate from natural sources for concrete, Bureau of Indian Standards, New Delhi.
23. IS 456 – 2000, Plain and Reinforced Concrete - Code of practice, Bureau of Indian Standards, New Delhi.
24. IS: 516 (1959). "Methods of tests for strength of concrete." BIS, Bureau of Indian Standard, New Delhi, India.
25. IS: 516 (1959). "Methods of tests for strength of concrete." BIS, Bureau of Indian Standard, New Delhi, India.
26. Shakor, P. N., Pimplikar, S. S. (2011). Glass Fibre Reinforced Concrete Use in Construction. International Journal of Technology and Engineering System, 2, 56-64.
27. Pour-Ghaz, M. (2011). "Detecting Damage in Concrete using Electrical Methods and Assessing Moisture Movement in Cracked Concrete". Japan Association for Earthquake Engineering.
28. Thomas, J., &Ramaswamy, A. (2007). Mechanical properties of steel fiber-reinforced concrete. Journal of materials in civil engineering, 19, 385-392.
29. Chon, B. J., & Woo Lee, S. (2007). Effects of Uncracked Joints in Jointed Concrete Pavements. KSCE Journal of Civil Engineering. 11, 141-144.
30. Aziz, A., & Na, T. Y. (1984). Perturbation methods in heat transfer. Washington, DC, Hemisphere Publishing Corp., 121-130.
31. Al-Oraimi, S. K., &Seibi, A. C. (1995). Mechanical characterisation and impact behaviour of concrete reinforced with natural fibres. Composite Structures, 3, 165-171.
32. Ramakrishna, G., &Sundararajan, T. (2005). Impact strength of a few natural fibre reinforced cement mortar slabs: a comparative study. Cement and concrete composites, 27, 547-553.
33. Coutts, R. S. (2005). A review of Australian research into natural fibre cement composites. Cement and Concrete Composites, 27, 518-526.
34. Agopyan, V., Savastano, H., John, V. M., &Cincotto, M. A. (2005). Developments on vegetable fibre–cement based materials in São Paulo, Brazil: an overview. Cement and Concrete Composites, 27, 527-536.
35. Khan, N. U., Khan, B., & Badshah, N. (2012). "Performance Of Polymeric Concrete With Synthetic Fibre Reinforcement Against Reflective Cracking in Rigid Pavement Overlay". Sci., Tech. and Dev., 31 (3): PP 260-270
36. Sinha, D., Mishra, C. B., Solanki, R. V. (2014). "Comparison of Normal Concrete Pavement with Steel Fibre Reinforced Concrete Pavement". Indian Journal of Applied Research, 4(8).
37. Song, P.S., and Hwang, S. (2005). "Strength Properties Of Nylon And Polypropylene- Fibre – Reinforced Concretes". Cement and ConcreteResearch 35(8), PP 1546-1550.
38. Yazıcı, S., Inan, G., &Tabak, V. (2007). Effect of aspect ratio and volume fraction of steel fiber on the mechanical properties of SFRC. Construction and Building Materials, 21, 1250-1253.
39. Zollo, R. F. (1997). Fiber-reinforced concrete: an overview after 30 years of development. Cement and Concrete Composites, 19, 107-122.