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Reinforcement of Hybrid Fibre Reinforced Concrete Beam using Steel and Polypropylene Fibre

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Abstract*: Most commonly the reinforced concrete structures fail by exhibiting the flexural and shear pattern of cracks. So in order to avoid this type of failure and to increase the life span of the structure, the strengthening of the structural members has to be studied. The concept of using fibres in the concrete has more advantage in increasing the concrete strength. However, in this investigation two different types of fibre which has higher (Steel hooked end fibre) and lesser moduli (Polypropelene fibre) which increases the modulus of elasticity of concrete. This Hybrid combination of fibres will reduce the chances of brittleness and small crack formation in the concrete. The use of computer software to model these elements is much faster, and extremely cost-effective. Hence, the Non-linear Finite Element Analysis (FEA) of a Hybrid fibre reinforced concrete beams has been modelled and analysed using the ANSYS software package. The flexure and shear pattern of arrangements in control beam and three Hybrid fibre Reinforced concrete beams of different proportions (1%, 1.5% and 2%) were modeled and analyzed for the results of ultimate load, deflection and stiffness ratio of the beams.

Keywords – Hybrid fibre reinforced concrete, steel hooked fibre, polypropylene fibre, ANSYS, FEA

I. INTRODUCTION

Fibre reinforced concrete is a composite material that is made of concrete and short fibres. The fibres can be considered as, more or less, uniformly distributed and their orientation is usually random. Fibre-reinforced concrete can also be combined with conventional reinforcement (steel bars) and post-tensioning or prestressing. Although fibre-reinforced concrete is a relatively young material, some cultures have used fibres as reinforcement in other materials in different ways. For example, old buildings were made of clay and straw fibres, and the builders made them without any significant technical knowledge[1]-[4].

Apart from the issue of the cost, there are many advantages in the use of FRC:

- Improved post-peak response in flexural, which means increased capacity to carry load. The post-peak response usually begins when elastic limit of the concrete in tension is reached

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- Improved tensile ductility.
- Possible to achieve a 3-D distribution of the fibres, which is favourable for triaxial loads.
- Excellent repair material, e.g. old structures
- Probably reduced cost of the execution of the work, moreover, the work techniques of manufacturing and distribute fibres are developing quite fast.
- Advantages in durability

There is, nevertheless, not so much information about the structural behaviour of the FRC structures and if it is possible that the conventional reinforcement can be avoided completely. Hence, there is a long path to travel until FRC is a commonly used material[5]-[8].

A. Application of FRC

Most of the actual applications of FRC are in non-structural or semi structural elements. This is mostly due to the fact that there is no completely developed code available or a systematic guide to design elements made of FRC. Examples of applications are: pavements, walls, beams, slabs, tunnel-linings, etc. The use of FRC in these applications also leads to improvements in their behaviour.

These depend on the type of load:

- Flexural members - Improves the post-peak response and increase the post-peak load.
- Shear loads - Increased shear capacity and post-cracking safety[9]-[13].
- Torsion loads - Increased torsional capacity and post-cracking safety.
- Uniaxial tension- members increased joint spacing and reduced crack widths.

New application areas may be discovered as more tests and investigations are conducted. For that reason, it is important to define a good and not too complicated code that is useful for all the designers who want to use FRC.

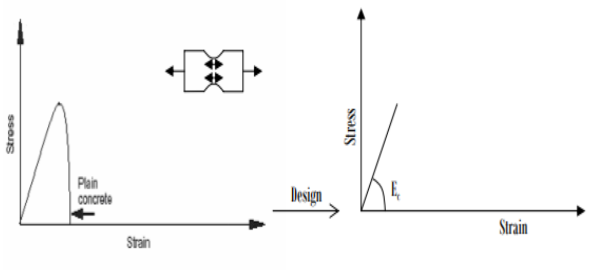

Figure 1 σ−ε relationship (Uniaxial tension tests) in plane reinforced concrete

Figure 2 Model used for the design of plane reinforced concrete elements. The post-peak resistance is neglected

The ongoing seismic tremors uncovered the significance of the plan of fortified cement (RC) structures with flexible conduct. Malleability can be portrayed as the capacity of fortified solid cross segments, components and structures to ingest the huge vitality discharged during seismic tremors without losing their quality under huge adequacy and reversible distortions[14]-[18]. This can be established by the potential use of two synthetic fibres like Steel and Polypropylene for improving the ductility as well as toughness of reinforced concrete members

II. ANALYTICAL STUDY

A. Finite element analysis of beams

Material specification

Table 1 Property of fibers

Properties	Steel	Polypropylene
Aspect ratio	50	48
Young's modulus(Gpa)	210	3.5
Tensile strength (Mpa)	1250-1550	300-400
Type	Hooked - end	Straight Fibrillated

The total fibre volume fraction used for casting is 1%, 1.5% and 2%. In this total fibre volume fraction the proportion of steel and polypropylene fibre fraction is as shown in table 2.

Table 2 Type of mix and its combinations

Type of mix	Combinations (Steel: Polypropylene)
CC	-
1% addition of hybrid fibers in the concrete	(30:70)
	(50:50)
	(70:30)
1.5% addition of hybrid fibers in the concrete	(30:70)
	(50:50)
	(70:30)
2% addition of hybrid fibers in the concrete	(30:70)
	(50:50)
	(70:30)

B. Experimental Results

The inputs required for the beam modeling in ANSYS software are experimentally found out. The compressive strength values are given in Table.

C. Compressive Strength

Compressive strength of M35 grade concrete for 1%, 1.5% and 2% dosage of HFRC is shown in table

Table 3 Compressive Strength of M35 grade concrete for 28 days

Percentage of fibre	28 days Compressive strength (N/mm^2)		
	Dosage of fibre		
	Steel-polypropylene (30-70)	Steel-polypropylene (50-50)	Steel-polypropylene (70-30)
1%	49.5	51.58	53.33
1.5%	48.76	49.82	51.88
2%	47.7	48.4	50.17

D. Energy Absorption Capacity

Vitality assimilation limit is characterized as the vitality retained in each cycle equivalent to the stir done in twisting the pillar up to the furthest reaches of avoidance[19]-[22]. It is determined utilizing the region under hysteresis circle for each cycle in load avoidance bend. The vitality retention limit is appeared in table 4 It can been seen that example containing half and half fiber has more vitality ingestion limit than customary cement.

Table 4 Energy absorption capacity

Cycle no	Energy absorption capacity (kN-mm)		Cumulative Energy absorption capacity (kN-mm)
	Conventional concrete	HFRC (70-30)	
1	0	0	0
2	0.5	0.75	0.75
3	0.7	1.2	1.95
4	0.85	1.4	3.35

E. Beam specimens

Beam of 150mm width, 200mm height and 1200mm span is used for making both conventional concrete and hybrid fibre specimen. In Meshing, discretization of masonry wall into finite element is done. The beam is constrained for two degree of freedom

F. Beam Modelling

Element type:

SOLID 65 is utilized for 3-D displaying of strong structures. It is characterized by eight hubs having three degrees of opportunity at every hub: interpretations in the nodal x, y and z bearings[23]-[25]. The component type has the versatility, hyper pliancy, stress hardening, creep, enormous redirection and huge strain abilities. It likewise has blended definition capacities for mimicking distortions of about in compressible elasto-plastic materials and completely incompressible hyper versatile materials.

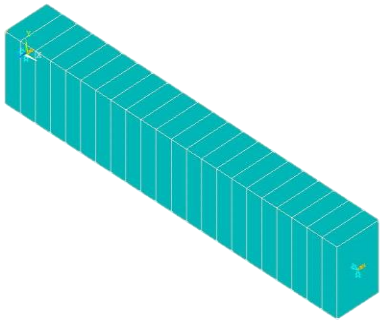

Figure - 3 Modeling of beam in ANSYS

The displacement obtained for the given set of cycle's after analysis as shown in Fig.4 and Fig 5

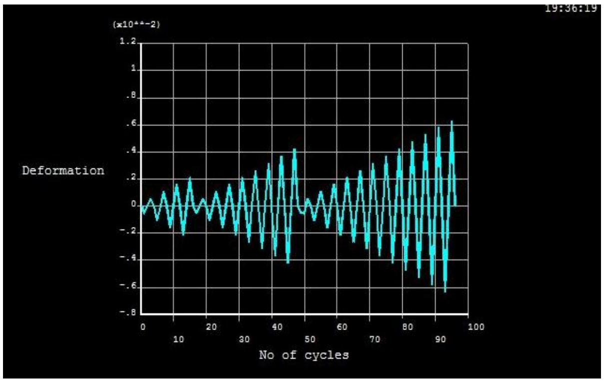

Fig 4 Time history analysis of conventional concrete beam

III. RESULTS AND DISCUSSIONS

A. Cyclic Loading Using Ansys Stiffness Ratio

The stiffness ratio values computed using experimental results and analytical results have difference less than or nearly equal to 1. The stiffness ratio for forward cycle and reverse cycle of conventional concrete is shown in table 5[26]-[30]

Table 5: Stiffness ratio for conventional concrete beam

CYCLE NO	STIFFNESS RATIO
FORWARD CYCLE	
1	2.55
2	1.99
3	1.55
REVERSE CYCLE	
1	1.65
2	1.44
3	1.20

CYCLE NO	STIFFNESS RATIO
FORWARD CYCLE	
1	1.4
2	1.11
3	0.97
REVERSE CYCLE	
1	0.97
2	0.87
3	1.01

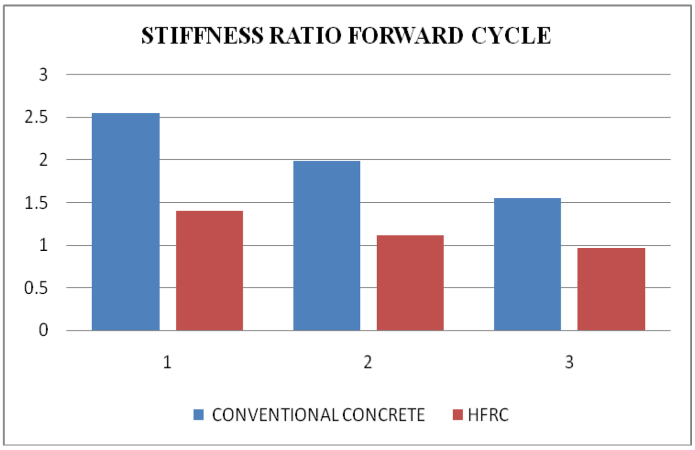

Figure - 5 Stiffness ratio forward cycle for CC and HFRC

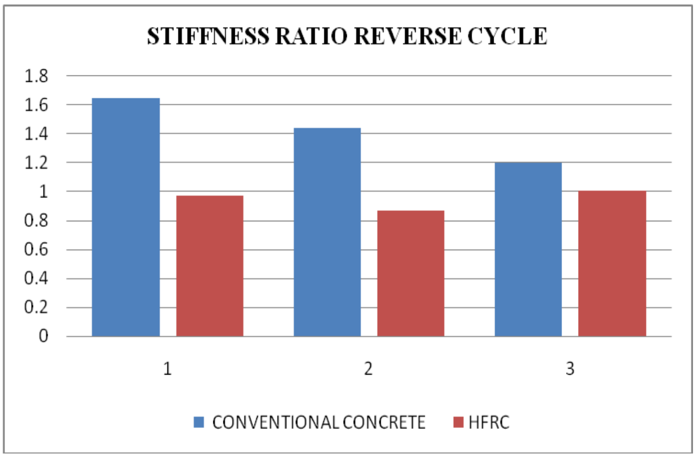

Figure - 6 Stiffness ratio forward cycle for CC and HFRC

IV. CONCLUSION

conclusions:

- The addition of 1% hybrid fibers (70:30, Steel: polypropylene) considerably increases the compressive strength compare to the conventional concrete and as well the other two proposed combinations.
- The prominent compressive strength at 1% addition of hybrid fibers is 53.33 N/mm2[31]-[34]
- Energy absorption capacity of HFRC beam has been increased in 1.65 times the conventional concrete beam
- The stiffnes ratio of experimental displacement value to analytical displacement value using ANSYS nearly equal to ≈ 1.0

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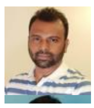

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