International Journal For Technological Research In Engineering
Volume 3, Issue 8, April-2016 *ISSN (Online): 2347 - 4718*

INVESTIGATION ON RCC BEAM RETROFITTED WITH VARIOUS NATURAL FIBRE COMPOSITES

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Abstract: ***Reinforced concrete structures are used worldwide for construction applications. The major disadvantages they possess are that they get severely damaged during earthquakes in seismic zones and are affected by certain others factors like cracking, corrosion, lack of detailing and disposal. One strategy to overcome these demerits is retrofitting the RCC structures through external composite materials which possess high strength and ductility. These fibre materials enhance the properties like flexural, shear and axial loading capacity of the beam element. Natural fibre reinforcements are accepted over the synthetic ones as they exhibit excellent properties such as good fatigue, damping resistance, resistance to weathering and corrosion, high strength weight ratio and easily degradable. In this review literature we compared and analyzed standard RCC beam specimen retrofitted with different natural fibre composite namely jute, sisal and coir fibre.***

Index Terms: Natural fibre (jute, sisal, coir), Reinforced Cement Concrete, Retrofitting, Beam

I. INTRODUCTION

In India, conventionally concrete structures are being used but recent earthquakes in seismic zones have exposed a vulnerability to these reinforced concrete beams against seismic loading. The failure in this type of structures in such situation is a major concern from the safety stand point. Hence in such circumstances the RCC structure have to undergo modification to improve their credibility and performance. There are majorly two strategies to overcome this: replacement or retrofitting. Due to the high cost of material and labor and the inconvenience that would be caused during the interruption of functionof the structure, full structural replacement is not an economically viable choice. Therefore retrofitting is preferred over it. Fibre reinforced polymer plates are used for retrofitting and the same has enhanced the tensile strength, flexibility, fatigue and damping characteristics and corrosion resistance of RCC beam. They can also be formed on site into intricate shapes and easily be installed which makes it the best alternative in the field of retrofitting application. Compared to synthetic fibres like carbon and glass, natural fibres have lower strength but they are promising as they do not pollute the environment, easily recyclable, better strength to weight ratio and biodegradable. Environmental concerns and stricter government regulations on recycling materials pressed scientists to develop new materials mainly from renewable resources. Using natural fibres in biodegradable matrices can give numerous advantages with regard to fibres traditionally used in composites. The high cost, abundant availability in nature, light weight, high specific modulus as compared to synthetic fibres are few of the attractive features of natural fibres. Biodegradable composites are developed with a perspective of sustainability. The concept is to maximize the performance of the blend and deliver the optimal functional requirements. Natural fibre polymers composites are fabricated using traditional manufacturing techniques such as resin transfer moulding, vacuum infusion, hand layup, compression moulding, compounding, direct extrusion and injection moulding. Among the numerous natural fibres available in nature sisal, jute and coir fibre reinforced composite are chosen over the others as these have better impact strength, flexural properties, tensile strength, rigidity as compared, to other cellulosic fibres. Therefore these fibres are of prime interest for the purpose of structural retrofitting. Here we are conducting a study to find the best possible fibre material for structural retrofitting of RCC beamthat not only improves the structural stability but at the same time makes use of the abundant fibre effectively and economically for structural up-gradation.

II. REINFORCED CEMENT CONCRETE

Pure concrete cement has good compression strength but is weak in tensile strength and ductility. To overcome this, the concrete is reinforced with materials having higher tensile strength and ductility. This composite material, which is a combination of high tensile strength reinforcement and high compression strength matrix is known as reinforced concrete cement. Usually steel bars are used as the reinforcements, as shown in Fig 1. This composite has good corrosion resistance, high tolerance of tensile strain, thermal compatibility and resistance to bending and compression stresses.

Fig 1- Reinforced Cement Concrete beam
(www.archiexpo.com)

III. RETROFITTING

This is a technique for modifying the existing structures by encapsulating it with an additional component, in the form of plates/laminates around it, as shown in Fig 2. This improves the flexibility of the structure and holds good against failure of the structure during seismic activities like earthquakes, tornadoes, cyclones etc. Generally, Carbon or Glass fibre reinforced laminates are used but natural fibre reinforced polymeralso exhibits desirable characteristics for being used as a laminate in retrofitting.

Fig 2- Retrofitting of RCC beam using carbon fibre reinforced sheets. (www.rasonindia.in)

IV. MATERIAL INVESTIGATION

4.1 Sisal fibre

Sisal fibre is a natural hard fibre extracted from the leaves of sisal(Agave sisalana) plants. They are obtained by mechanically crushing the leaves, removing the inner pulp and then mechanically scraped to obtain the fibre stance from the outer leaf skin. Citing from the works conducted by Mrs. Tara Sen et Al, Sisal fibres have a diameter of 50 to 200mm, density of 1.45 gm/cc, elastic modulus of 9 to 16 GN/m2, an elongation percentage of 3 to 7 %, cellulose/Lignin content of 67/12 %, and micro fibrillar angle of 10 to 22 degrees.

Sisal fibre exhibit the following favorable characteristics which make them compatible as reinforcements in composite materials with polymer matrices:

- They are natural fibres withhigh cellulose content and hence can be easily recyclable and bio-degradable.
- They can be drawn into fine strands which makes it easy to manufacture mats of different weave patterns.
- They possess good minimal wear and tear, improving durability.
- High sound and impact absorbing properties.
- Good anti-static properties.

Fig 3- Extracted Sisal Fibre (www.globaltextiles.com)

Table 1. Variation of tensile properties of sisal fiber with test length (diameter of fiber: 200μm), (Mukherjee & Satyanarayana, 1984)

Test Length (mm)	Initial Modulus (GNm-2)	Tensile Strength (MNm-2)	Elongation at Break (%)	Average Modulus (GNm-2)
15	14.15	793.8	8.15	9.74
25	17.26	757.1	5.7	13.28
35	19.71	728.1	4.65	15.64
50	22.52	630.1	3.98	15.83
65	25.36	620.81	3.5	17.87

4.2 Jute fibre

Jute fibre is a cellulosic vegetable fibre extracted from the jute (Corchorus) plant. Citing from the works conducted by Tara Sen et Al,jute fibres have a diameter of 40 to 100 mm, density of 1.46 gm/cc, elastic modulus of 28.43 GN/m2, an elongation percentage of 1 to 1.8 %, cellulose/Lignin content of 67/12 %, and micro fibrillar angle of 7 to 9 degrees.

The desirable properties of jute fibre which is advantageous over other fibres are:

- They are 100% bio-degradable.
- They have good sound and heat insulation property with low thermal conductivity.
- Good anti-static property.
- Readily available at low cost.
- High tenacity and bulkiness.

Fig 4- Extracted Jute Fibre (www.yarnsandfibres.com)

4.3 Coir fibre

This is a natural fibre extracted from the husk of coconut plant. Citing from the works conducted by Mrs. Tara Sen et Al Coir fibres have adiameter of 100 to 450mm, density of 1.15 gm/cc, elastic modulus of 4 to 6 GN/m2, an elongation percentage of 15 to 40 %, cellulose/Lignin content of 43/45 %, and micro fibrillar angle of 30 to 49 degrees.

Desirable properties of coir are:

- It absorbs energy effectively.
- It has good water retaining ability.
- Due to its easy extraction and low capital cost they are widely used as reinforcement fibres in composite materials.

Fig 5- Extracted Coir Fibre (www.cocopalm.in)

Table 2: Mechanical Properties of Composites with Different Coir Fibers Volume (Rao and Rao, 2007)

Fiber Content (% vol)	Tensile Strength (MPa)	Failure Strain (%)	Young's Modulus (GPa)
5	25.2	3.4	630
7.5	23.1	3.8	544.2
10	21.4	4.6	460.6
12.5	20.8	5.8	379.2
15	19.7	6.2	315.3

V. EXPERIMENTAL INVESTIGATION

From the experiments carried out by Mrs. Tara Sen et Al and A.S.Jeyabharathy et Al, a standard specimen was designed according Indian code of practice IS 456: 1958. Fourdifferent specimens are designed and analyzed. In the first specimen (S1) the concrete beam is retrofitted with the sisal fibre composite plates of 5mm thickness. In specimen (S2) the concrete beam is retrofitted with jute fibre composite plates of 5mm thickness and in specimen (S3) the concrete beam is retrofitted with coir fibre plates of the same thickness and last specimen (S4) plain reinforced concrete beam.

The retrofitted RCC beams specimen are horizontally fixed in simply supported manner, as shown in fig 6 and the extreme ends are hinged. Uniformly distributed load is gradually applied along the length of the beam till the first appearance of crack and subsequent failure for specimen S1, S3 and S4 (as conducted by Tara Sen et Al). For specimen S3 point load is applied gradually till failure (as conducted by A.S.Jeyabharathy et Al).

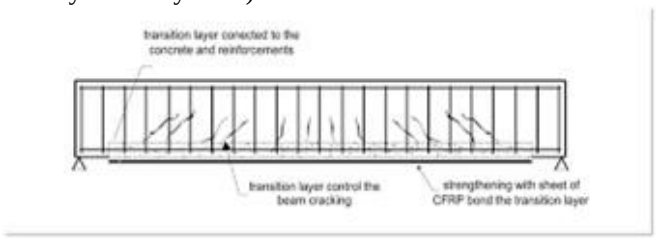

Fig 6- RCC beam in Simple supported manner (www.scielo.br)

VI. RESULT AND ANALYSIS

From the loading test carried out on the RCC retrofitted specimen beams, S1, S2, S3 and S4 the following results were obtained.

Table 3: Comparison between the concrete model and the Concrete model retrofitted by different fibre around all four sides (cited from by Mrs. Tara Sen et Al and A.S.Jeyabharathy et Al)

Specimen	Max. deflection (mm)	Failure Load (ken/m)
S1	0.025144	11
S2	2.53	9
S3	0.024842	10.75
S4	0.191395	6

Table 4: Comparison of Deflection between Retrofitted Specimens

Specimen	Percentage reduction in deflection
S1	83.33
S2	69
S3	79.12

VII. CONCLUSION

On the basis of experimental investigations and review carried out on the control and retrofitted beam specimens and obtained results, the following conclusions were drawn:

- The RCC beam retrofitted with sisal fibre composite showed maximum reduction in deflection of 83.33% as compared to concrete beams retrofitted with jute and coir fibre.
- Also it was seen that concrete beams which were retrofitted with fibre reinforced polymers exhibited higher load carrying capacity as compared to plain concrete beam.
- Sisal fibre is the most suitable natural fibre for retrofitting and with increase in percentage of sisal fibre in the composite laminate will provide better mechanical properties and will increase the life of the beam.

So it can be concluded that RCC beams retrofitted with natural fibres (sisal) can be used for providing enhanced resistance to seismic loading and will enhance the tensile

strength, flexibility, fatigue and corrosion resistance of RCC beam. This proves to be the best strategy to overcome failure of structures located in the seismic zones with minimal cost, as these natural fibres are readily available in nature.

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