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Retrofitting of RC Beams Using Natural FRP Wrapping (NSFRP)

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ABSTRACT

There is a pressing need to repair or upgrade the building and civil infrastructure in many parts of the world. For instance with the modernization of buildings, it is sometimes desirable to remove supporting walls or individual supports, leading to the need for local strengthening. The strengthening and enhancement of the performance of deficient structural elements or the structure as a whole is referred to as retrofitting. Retrofit aims to strengthen a building to satisfy the requirements of the current codes for seismic design. The building may not be damaged or deteriorated. The various retrofitting techniques include steel plate bonding, polymer injection followed by concrete jacketing, use of advanced composite materials like FRP, Ferro cement etc.

To meet up the requirements of advance infrastructure new innovative materials technologies in civil engineering industry has started to make its way. During the last decade there has been a renewed interest in the natural fibre as a substitute for conventional as glass fibres and carbon fibres, motivated by potential advantages of weight saving, lower raw material price and thermal recycling or the ecological advantages of using resources which are renewable, also natural fibres are sustainable materials.
Keywords : FRP Composites, Natural silk Fibers, Concrete, retrofitting.

I. INTRODUCTION

Concrete made with Portland cement is relatively strong in compression but weak in tension, it has little resistance to cracking and tends to be brittle. The weakness in tension can be overcome by man Performance Enhancement of Concrete Structures using Natural Fiber Composites.Conventional methods that are already available. Fibre Reinforced Polymers (FRP) are been extensively used as external wraps for the structural strengthening and rehabilitations of buildings. In particular its application is been in the area of masonry and concrete structures. Strengthening and retrofitting activity by using synthetic fibres such as glass/carbon/aramid is becoming popular all over the world. Extensive research across the world during the last 30 years are so as led to better understanding of the properties and behavior of FRPs under different conditions, and more extensive use of FRPs is likely to seen in the coming years. Synthetic fibres are non-made fibres resulting from research and development in the petrochemical and textile industries. The various synthetic fibres include - acrylic, aramid, carbon, glass, etc.., But using these synthetic fibres is as costlier and chances for applicability in rural areas are remote.

On other hand, Natural fibres have been used to reinforce materials for over many years. More recently they have been employed in combination with plastics. Many types of natural fibres have been investigated for use in plastics including flax, hemp, jute, straw, wood fibre, rice husks, wheat, barley, oats, rye, cane (sugar and bamboo), grass reeds, kenaf, ramie, oil palm empty fruit bunch, sisal, coir, pennywort, kapok, paper-mulberry, raphia, banana fibre, pineapple leaf fibre and papyrus. Natural fibres are increasingly used in automotive and packaging materials.

Here an experimental analysis is carried out in order to evaluate the performance of silk fibres by retrofitting a reinforced concrete beams.

Silk is a natural protein , some forms of which can be woven into textiles. The protein of silk is composed mainly of fibroin and produced by certain insect larvae to form cocoons, this jute is extracted from cocoon, FRNPs exhibit several improved properties, such as high strength, high stiffness-weight ratio, flexibility in design, non-corrosiveness, high fatigue strength, and ease of application. The Silk fibres are found commercially in several formats: fabric, strips, wire, rolls, etc.

II. METHODS AND MATERIAL

1. Material Investigation

The use of natural fibres such as jute, silk, Coir, banana, hemp, ramie, coir etc. as composites in structural up gradation is increasing tremendously. Wood flour and other fibres are primarily used as fillers in thermoplastic decking, building materials, furniture & automotive components. Long agricultural fibres such as flax, kenaf, bast, hemp & jute are used as structural reinforcements in thermoplastic/thermoset composites as a replacement of glass fibre. Natural fibre composites can easily be recycled than glass or carbon composites. The usage of natural fibre composites is higher in Europe than other countries. Advantages of Natural fibre composites components includes weight reduction of 10-30%, excellent acoustical absorption properties, good impact properties with convenience of forming complex shaped parts in a single moulding process.

1.1 Silk Fiber

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Figure 1. Silk Fiber

1.1.1 Mechanical properties of Silk fibers

- ✓ Specific gravity [g/cm3]: 1.32 to 1.33
- ✓ Water absorption [%] : 80
- ✓ Tensile strength [M Pa] : 130
- ✓ Modulus of elasticity [G Pa]: 9

Table 1. Properties of Resin & Hardener

Properties	unit	Araldite AW106	Hardener HV 953 IN
Visual appearance		opaque liquid	brownish yellow
Viscosity	mPas	25k-50k	20000-40000
Density	g/cc	1.2	0.95
Flash point	c	210	>100
Shelf life	years	2	2

2. Testing on Specimens

About experimental investigation on the specimen. Experimental investigation was carried out on

- Control Reinforced concrete beams
- Reinforced concrete beam retrofitted with Silk Reinforced polymer composite (SFRP)

2.1 Details of the Reinforced Concrete Model

Design work were carried out for Reinforced concrete beams as per IS:456-2000. Details of Reinforced Concrete Beam dimensions shown in figure below.

Details of Reinforced Concrete Beam dimensions:

Length = 1800 mm, Width = 100 mm, Depth = 160 mm

Details of the Reinforcements:

Longitudinal Bars at top : 2 nos of 8mm dia each
Longitudinal Bars at bottom : 2 nos of 10mm dia eac

Stirrups : 8mm dia at 100 mm C/C.

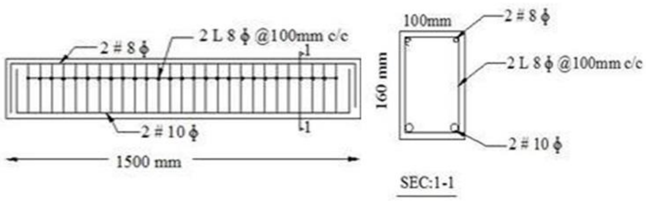

Figure 2. Reinforcement detailing

Figure 3. Loading Arrangement

2.1.1 Failure pattern of control beams

Figure 4. Failure pattern of CB-1

Figure 5. Failure pattern of CB-2

Figure 6. Failure pattern of CB-3

III. RESULTS OBTANED FROM EXPERIMENTAL INVESTIGATION

Type	Ultimate load (kN)	Average ultimate load (kN)	(%) of Strength Increase	Mode of Failure
CB-1	38.40	36.53	----------	Flexure&shear
CB-2	34.79			Shear
CB-3	36.42			Flexure&shear
NSPBW-1	49.440	51.06	39.77	Shear&Flexure
NSPBW-2	51.067			Shear
NSPBW-3	52.695			Shear
NSPFW-1	52.69	49.98	36.82	Shear
NSPFW-2	47.812			Flexure
NSPFW-3	49.44			Shear

3.1 Failure pattern of bottom wrap beams

Figure 7. Failure pattern of bottom wrap B1

Figure 8. Failure pattern of bottom wrap B2

Figure 9. Failure pattern of bottom wrap B3

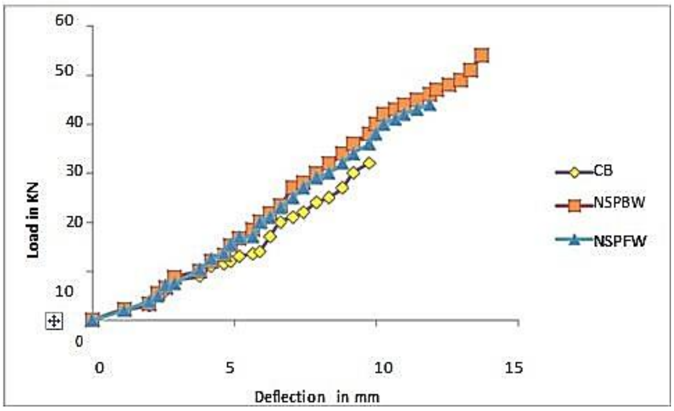

Figure 10. Load vs Deflection

3.2 Comparison Of Failure Load

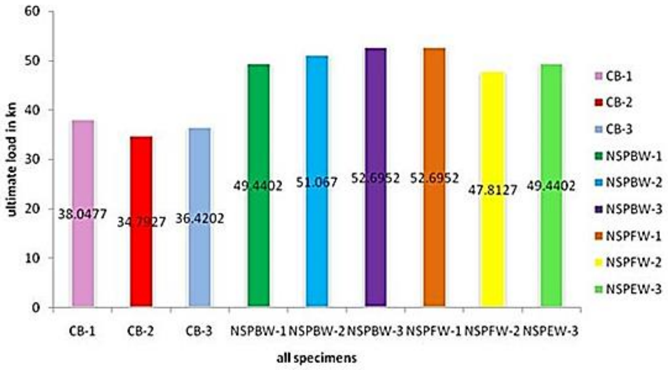

Figure 11. Ultimate loads of specimens

IV. CONCLUSION

From the experimental test results of nine beams and load v/s deflection curves including the bar charts the following conclusions have drawn.

- ✓ Strengthening by silk fibre composite at tension zone beams have carried more ultimate load by about 39.77% compared to that of control beam specimen.
- ✓ Strengthening by silk fibre composite at flexure zone beams have carried more ultimate load by about 36.82% compared to that of control beam specimen.
- ✓ The ultimate load carrying capacity was found to be high for beams retrofitted with NSFRP composites as compared to control beam.
- ✓ The flexural strengthening provided was high, which made the beams strong and stiff, because of which most of the beams could not fail by flexure so the failed by shear.

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