IJISET - International Journal of Innovative Science, Engineering & Technology, Vol.5 Issue 4, April 2018
ISSN (Online) 2348 – 7968
www.ijiset.com

Analysis of Hysteristis and Fatigue Response of Concrete Hybrid Beam Reinforced with Natural fibers and Steel Bars

Maria Eldho[1] and Anna M Thomas [2]

[1]Civil Engineering Department, APJ Abdul Kalam Technological University, Mar Baselios Institute of Technology and Science Nellimattom, Ernakulam, India

[2] Civil Engineering Department, APJ Abdul Kalam Technological University, Mar Baselios Institute of Technology and Science Nellimattom, Ernakulam, India

Abstract

Hybrid beam offers many structural benefits and widely used in civil engineering structures. Corrosion of the steel reinforcement is one of the main deteriorations from which steel reinforced concrete (SRC) structures suffer during their service life. Natural fibre–reinforced polymer (NFRP) bars are considered to be an alternative to steel bars due to their advantages such as lightweight, high strength, and noncorrosive in nature. To improve SRC and NFRP systems, a new design of concrete beams with a combination of NFRP and steel reinforcements was proposed. Corrosion-induced cracking in RC beams developed earlier at the corners than in the other parts due to bidirectional erosion at the corners. Therefore FRP bars are placed at the corners or near the outer surface and steel bars are placed at the inner levels of the tension zone. This paper aims to study the fatigue flexural performance of hybrid beam using ANSYS 17.0 (workbench), software.

Keywords: *Fatigue flexural performance, natural fibres, hybrid beam.*

1. Introduction

Structures that are subjected to repeated loads are susceptible to failure due to fatigue. Fatigue is a process of progressive permanent internal changes in the materials that occur under the actions of cyclic loadings. These changes can cause progressive growth of cracks present in the concrete system and eventual failure of structures when high levels of cyclic loads applied for short times or low levels of loads are applied for long times.

Many concrete structures such as highway pavements, highway bridges, railroad bridges, airport pavements and bridges, marine structure, etc. are subjected to dynamic loads. Fatigue strength data of concrete and other materials that are used in these structures are needed for obtaining their safe, effective, and economical design.

Numerous investigations have been directed toward evaluation of fatigue behavior of materials, including concrete. Although fatigue research began almost one hundred years ago, there is still a lack of understanding concerning the nature of fracture mechanism in cementitious composite materials due to fatigue. This is partly due to the 3 complex nature of structure of such materials and their properties are influenced greatly by a large number of parameters. Fatigue behavior of concrete is also influenced by several parameters such as type of loading, range of loading, rest period, material properties, environmental conditions, etc. However, initiation of fatigue cracks that can occur either in matrix or at the interfacial region would greatly depend on the size of dominant flaws present in these regions. Addition of fiber to concrete restrict crack formation and delays crack growth. Therefore, unstable cracks produced during loading is transformed into a slow and controlled growth.

2. Natural fibers

Fibre reinforcement is commonly used to provide toughness and ductility to brittle cementitious matrices. Reinforcement of concrete with a single type of fibre may improve the desired properties to a limited level. A composite is termed as hybrid, if two or more types of fibres are rationally combined to produce a composite that derives benefits from each of the individual fibres and exhibits a synergetic response. This study aims to characterize and quantify the mechanical properties of hybrid fibre reinforced concrete. Natural fibres are environmental friendly and present important attributes, such as low density, light weight, low cost, high tensile strength, as well as being water and fire resistant.

IJISET - International Journal of Innovative Science, Engineering & Technology, Vol.5 Issue 4, April 2018
ISSN (Online) 2348 – 7968
www.ijiset.com

3. Objectives and Methedology

The main objective of the present study is to investigate the fatigue response up to failure load of hybrid beam using ANSYS 16.0. This study will mainly be focused towards the static response. These include the distribution of stresses and deflections. The Main objectives of the study are;
1. To study the effectiveness of wrappings at various angles.
2. To study the flexural behavior of RC beams for various span with reference to fatigue failure.
3. To study the effect of hybrid reinforcement of steel and natural fibre composites on fatigue, hysteretic behavior on beams.

The numerical analysis investigations were to be performed with commercial software ANSYS. This software is a suite of powerful engineering simulation programs, based on finite element method, which can solve problems ranging from relatively simpler linear analyses to the most challenging non-linear simulations. The analysis of a structure with ANSYS is performed in three stages.
a) Pre-processing – defining the finite element model and environmental factors to be applied to it.
b) Analysis solver – solution of finite element model.
c) Post-processing of results like deformations contours for displacement, etc., using visualization tools.

4. Structural Model and Material Property

The specimens were simply supported with a total length of 2,200 mm and a span length of 1,800 mm. A four-point loading test was carried out and a steel plates were placed at the loading points and the supports to protect the concrete. Two longitudinal steel bars with a 10-mm diameter were placed at the top layer of the compression zone and four bars were placed at the bottom layer of the tension zone: two NFRP bars with an 8-mm diameter were placed at the corners and two steel bars with a 16-mm diameter in the middle. Steel stirrups with an 8-mm diameter were spaced at 100 mm between two loading points, 75 mm from the loading point to the support and 60 mm outside of the supports. The material properties are illustrated in table.1

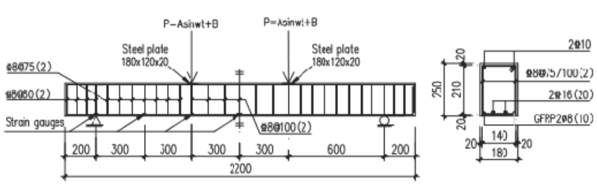

Fig 1. Specimen dimensions and reinforcement

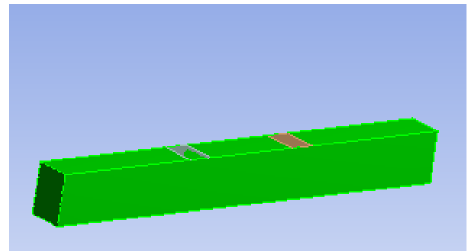
Fig 2. Geometry of the model

Table1. Material properties of Natural fibres

Properties	Values		
	Jute	Cotton	Flax
Density (kg/m^3)	1500	1550	1540
tensile strength (Pa)	8.5E8	4.52E8	1.5E9
Poisson's Ratio	0.38	0.32	0.3
Young's modulus (Pa)	3.1E10	1.26E10	7.5E10

4.1 Meshing

It is the most important part of an analysis and is done to discrete the structure. Mesh convergence is used to fix the size of the element. Here a mesh size of 15mm is provided for all the models. Fig 11 shows the meshing.

Fig 3. Meshed model

4.2 FEM Analysis

Depending on the type of physics involved (static structural, modal structural, harmonic, random vibration, response spectrum) provides several means to control the

IJISET - International Journal of Innovative Science, Engineering & Technology, Vol.5 Issue 4, April 2018
ISSN (Online) 2348 – 7968
www.ijiset.com

solution of the physics simulation. Deformation and stress is measured at mid-span of the beam from load-deformation diagrams by analytical results.

Static Structural analysis determines the displacements, stresses, strains, and forces and in-addition fatigue life and hysteretic response of hybrid beam can be calculated for a conventional beam and also the effectiveness of different natural fibres such as cotton, jute and flax.

.

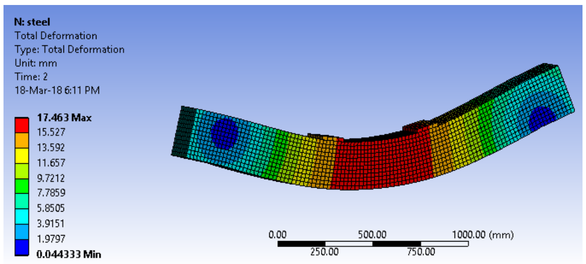

Fig 4. Total deformation of conventional beam

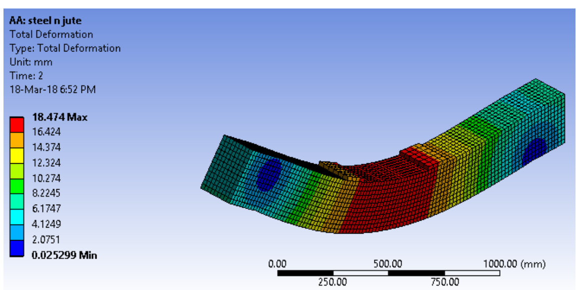

Fig 5. Total deformation of hybrid beam with jute fibres and steel bars

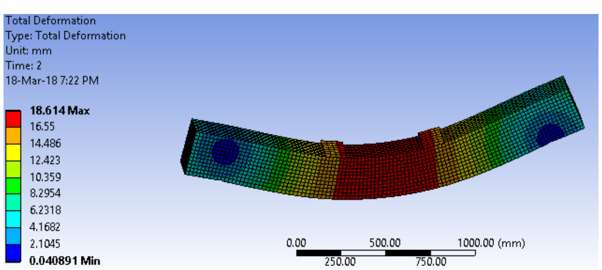

Fig 6. Total deformation of hybrid beam with cotton fibre and steel bars

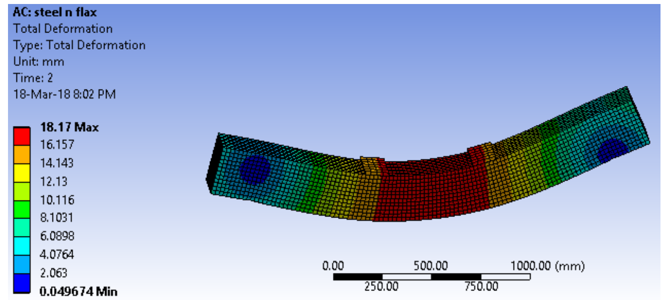

Fig 7. Total deformation of hybrid beam with flax fibre and steel bars

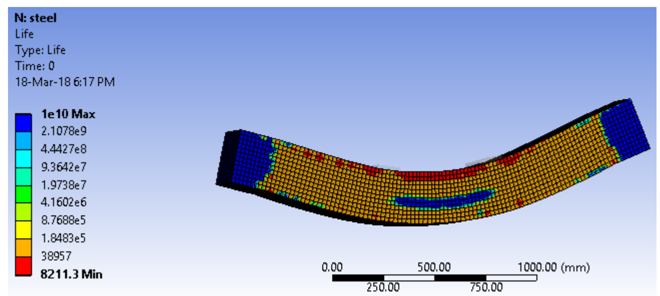

Fig 8. Fatigue life of conventional beam

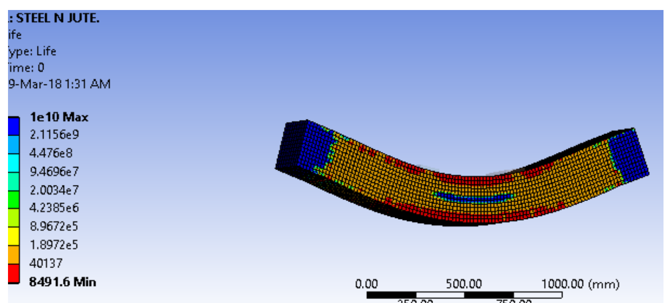

Fig 9. Fatigue life of hybrid beam with jute fibres and steel bars

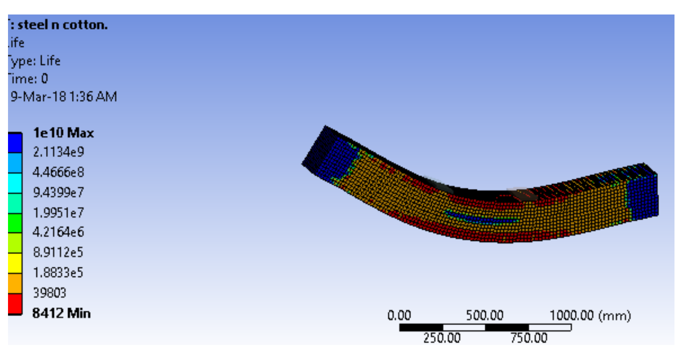

Fig 10. Fatigue life of hybrid beam with cotton fibre and steel bars

IJISET - International Journal of Innovative Science, Engineering & Technology, Vol.5 Issue 4, April 2018
ISSN (Online) 2348 – 7968
www.ijiset.com

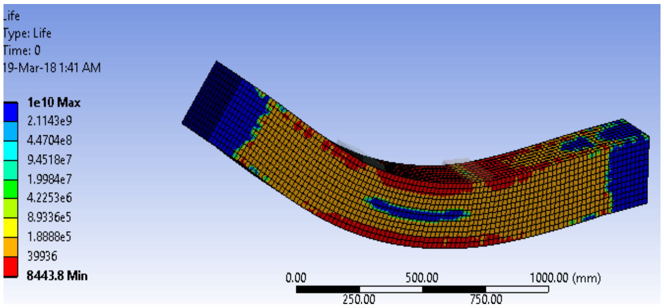

Fig 11. Fatigue life of hybrid beam with flax fibre and steel bars

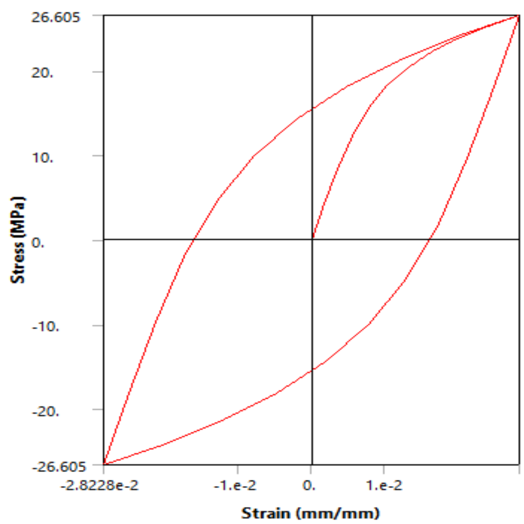

Fig 12. Hysteresis curve of stress and strain of conventional beam

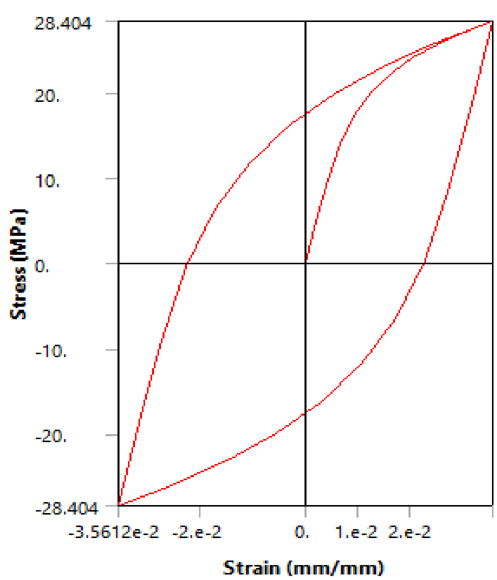

Fig13. Hysteresis curve of stress and strain of hybrid beam with jute fibres and steel bars

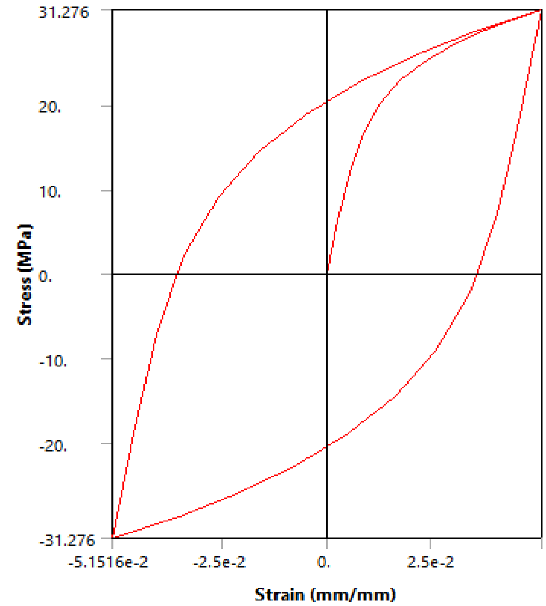

Fig 14. Hysteresis curve of stress and strain of hybrid beam with cotton fibre and steel bars

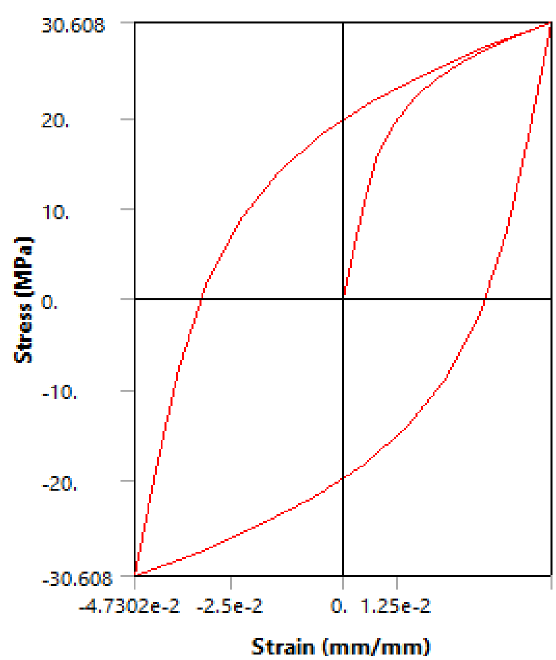

Fig 15. Hysteresis curve of stress and strain of hybrid beam with flax fibre and steel bars

A modal analysis determines the fatigue and hysteristic response (fatigue life and stress strain curve) of a structural component.

The results of total deformation and fatigue life conventional beam and the natural fibres (jute, cotton & flax) are shown below.

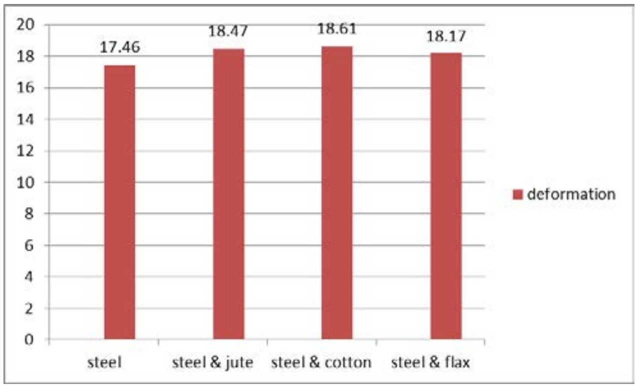

Fig 16. comparison of results of deformation of conventional beam and hybrid fibres

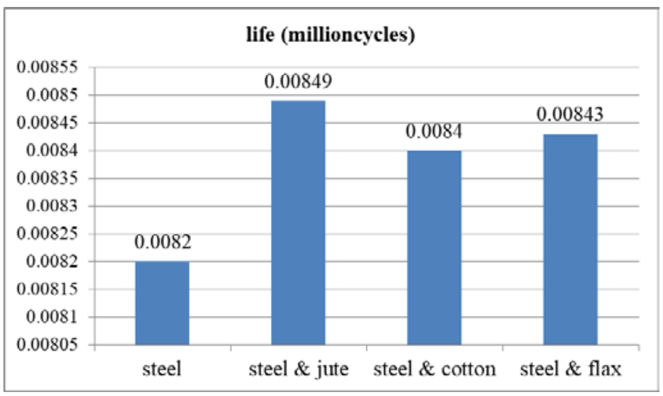

Fig17. comparison of results of fatigue life of conventional beam and hybrid beams

5. Conclusions

Concrete beams reinforced with a combination of steel and natural fiber-reinforced polymer (jute, cotton and flax) bars exhibit promising strength, serviceability, and durability. The results show that the stress of conventional beam is slightly smaller than that of natural fibres. In case of deformations, the conventional beam and hybrid beam (natural fibres and steel) showing the similar results. But in the case of fatigue life, life of natural fibres are giving the better results as compared with the conventional beams. The result shows that hybrid fibres improves the fatigue life marginally as compared to mono-fibres. Whereas the addition of natural fibres improves the strength and exhibit a synergetic response.

Acknowledgments

I express my deepest sense of gratitude to Ms. Anna M Thomas, Asst. Professor, MBITS, Nellimattom, my esteemed guide and my cordial thanks for her warm encouragement, thoughtful guidance, insightful decision, critical comments and correction of the thesis. I also express my sincere thanks to all the faculty members and students of the Civil Engineering Department of Mar Baselios Institute of Technology and Science for their co-operation and support.

References

[1] Peng Zhu; Jiajing Xu (2017), “Experimental Study of Fatigue Flexural Performance of Concrete Beams Reinforced with Hybrid GFRP and Steel Bars”, Journal of Composites for Construction, © ASCE, ISSN 1090-0268.

[2] Amr El-Ragaby(2007),” Fatigue Life Evaluation of Concrete Bridge Deck Slabs Reinforced with Glass FRP Composite Bars”, journal of composites for construction © asce / may/june

[3] Weiping Zhang(2015).” Fatigue behavior of corroded prestressed concrete beams”, Construction and Building Materials Department of Structural Engineering, Tongji University.

[4] J.Karthick(2014),” Cyclic Load Behaviour of RC T - Beams internally Reinforced with GFRP Reinforcements”, International Journal of Advanced Research in Education Technology (IJARET)

[5] Moneeb Genedy(2015),” Improving Fatigue Performance of GFRP Composite Using Carbon Nanotubes”, journal of composites for construction © asce

[6] Mariappan Mahalingam(2013),” Ductility behavior fiber reinforced concrete beams strengthened with externally bonded glass fiber reinforced polymer laminates”, American Journal of Applied Sciences, 10 (1): 107-111, 2013

[7] Harry G.(2008),” Ductile hybrid FRP reinforcing bar for concrete structures, Journal of composites for construction

[8] Dat Duthinh Monica Starnes(2011),” Strength and Ductility of Concrete Beams Reinforced with Carbon FRP and Steel”, Journal of composites for construction

[9] Lei Pang(2015),” Design Propositions for Hybrid FRP-Steel Reinforced Concrete Beams”, Journal of Composites for Construction, © ASCE, ISSN 1090-0268.

[10] Thong M. Pham(2016),” Impact Behavior of FRP-Strengthened RC Beams without Stirrups”, Journal of Composites for Construction, © ASCE, ISSN 1090-0268.

[11] J. E. Femandez,” Flax fiber reinforced concrete-a natura1 fiber biocomposite for sustainable building material”, High Performance Structures and Composites.

[12]Ramkumar(2016)”fabrication and mechanical testing of natural (jute) fibre composite material”, international journal for innovate research in science & technology.