iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH
IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 12 Issue: VI Month of publication: June 2024

DOI: https://doi.org/10.22214/ijraset.2024.63450

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 12 Issue VI June 2024- Available at www.ijraset.com

Effect of Stiffener Braces on Behaviour of Bamboo Bridge

Piyush Ghudawat[1], Dr. Umesh Pendharkar[2]
[1, 2]*Department of Civil Engineering, Ujjain Engineering College, Ujjain, (M.P.), India*

Abstract: This study aims to assess the structural, environmental, and economic implications of integrating bamboo into the design of deployable pedestrian bridges. The unique deployability requirement of such bridges, necessitating easy transportation, assembly, and disassembly, adds complexity but offers suitability for temporary or emergency use. The paper presents a comparative analysis of deployable pedestrian bridges constructed with different geometrical bamboo decks for six distinct cases abbreviated from Case BC1 to Case BC6. Objective is to study the effect of deck geometry on deflection of pedestrian deployable bamboo foot bridge. The study concludes with recommendations, noting that geometry plays an important role when using deployable bridge. Case BC6 is efficient in displacement but BC4 i.e. when using bamboo with triple longitudinal support observed to be most efficient when compared to other geometry cases for all parameters and should be recommended that the behaviour of bridge as per usage, always use bamboo with triple longitudinal support i.e. case BC4.
Keywords: Pedestrian loading, Bamboo Geometrical cases, Deployable bridge, Cross bracing support.

I. INTRODUCTION

Pedestrian bridges stand as essential elements in urban infrastructure, enabling safe passage over obstacles and fostering community connectivity. With a growing emphasis on sustainable construction practices, there's increasing interest in exploring alternative materials such as bamboo alongside conventional options like steel. This analysis delves into the feasibility and performance of deployable pedestrian bridges crafted from a fusion of steel and bamboo materials, with a focus on various geometric configurations of bamboo. While steel remains a cornerstone in bridge construction, prized for its strength, durability, and adaptability, concerns regarding environmental impact have spurred a quest for greener alternatives without compromising structural integrity. Bamboo, with its rapid growth, impressive strength-to-weight ratio, and renewable nature, emerges as a promising candidate. This analysis shifts its lens to examine the potential of different geometrical configurations of bamboo in deployable pedestrian bridge design. By exploring how variations in bamboo's geometric layout influence structural performance, environmental sustainability, and overall feasibility, this study aims to chart a path towards innovative and eco-conscious urban infrastructure solutions.

II. PERSPECTIVES ON DEPLOYABLE PEDESTRIAN BRIDGES

Deployable pedestrian bridges represent a pioneering frontier in modern civil engineering, presenting inventive resolutions to urban connectivity hurdles. Engineered for swift assembly, disassembly, and mobility, these bridges serve as critical conduits for pedestrian traffic over transient impediments like construction zones, water bodies, or event locales. Their emergence epitomizes a dynamic paradigm in infrastructure advancement, addressing the evolving requisites of contemporary cities. In contrast to conventional fixed structures, deployable pedestrian bridges offer adaptable, temporary remedies ideally suited for exigencies, special occasions, or short-term construction requirements.

Several key areas warrant focused attention when considering deployable pedestrian bridges:

Firstly, structural considerations are paramount. Evaluating the structural integrity, load-bearing capacity, and resilience of the bridge ensures its stability and safety during use. Secondly, deployment strategies play a crucial role. Exploring efficient and practical methods for assembling, disassembling, and deploying the bridge on-site is essential to its functionality and effectiveness.

Thirdly, transportation logistics must be carefully addressed. Planning for the compact packaging, easy transport, and logistical challenges associated with moving bridge components to various locations ensures smooth deployment and operational readiness. Ensuring safety and accessibility is another critical aspect. Incorporating features to mitigate risks, comply with safety standards, and accommodate pedestrians of all abilities promotes usability and reduces potential hazards.

Lastly, examining case studies and real-world applications provides valuable insights. Analysing existing deployments, successes, and challenges helps refine design principles, identify best practices, and inform future projects, fostering continuous improvement in deployable pedestrian bridge design and implementation.

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 12 Issue VI June 2024- Available at www.ijraset.com

III. PROCEDURE AND 3D MODELLING OF THE STRUCTURE

Comprehensive input data and its descriptions about the model given below. This input data used for creation of simulation of deployable pedestrian bridge made up of steel and bamboo material and using pedestrian loading under the guidance of IRC 6: 2017.

A. General Data Used

The bridge has a width of 1.5 meters, a span of 5 meters, and a height of 2 meters. It is designed as a deployable scissor type bridge. The bamboo type used is Awi Temen (Gigan Tochla Atler), with a modulus of elasticity of 17.20 GPa, Poisson's ratio of 0.15, density of 0.76 g/cm³ (equivalent to 74.556 kN/m³), damping of 0.63%, and tensile strength of 195.250 N/mm² (equivalent to 195250 kN/m²). The culm diameter is 8 cm (80 mm) with a wall thickness of 8 mm. The total height of the bamboo culm is 12 meters.

The bridge experiences a dead load consisting of its own self-weight and a live load of 5 kN/m, representing pedestrian traffic.

As per IRC 6:2017, the load combinations are as follows:

1) Load combination 1: Consists of the dead load (DL) and live load (LL).
2) Load combination 2: Comprises 1.35 times the dead load (1.35DL) plus the live load (LL).
3) Load combination 3: Involves 1.35 times the dead load (1.35DL) plus 1.5 times the live load (1.5LL).

Table 1: Model Description

Models framed for analysis	Abbreviation
Pedestrian bridge made up of Bamboo without longitudinal support-Case 1	**BC1**
Pedestrian bridge made up of Bamboo with single longitudinal support -Case 2	**BC2**
Pedestrian bridge made up of Bamboo with double longitudinal support -Case 3	**BC3**
Pedestrian bridge made up of Bamboo with triple longitudinal support -Case 4	**BC4**
Pedestrian bridge made up of Bamboo with cross bracing support -Case 5	**BC5**
Pedestrian bridge made up of Bamboo with single longitudinal support and cross bracing support -Case 6	**BC6**

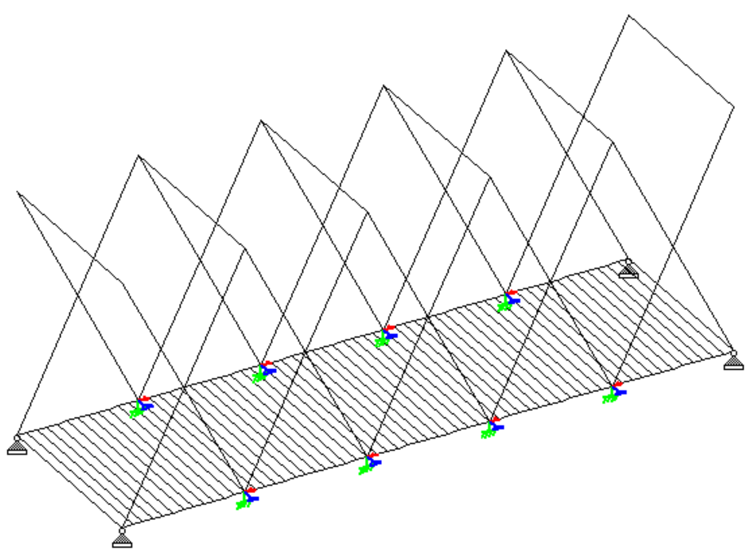

Fig. 1: Plan view of Pedestrian bridge made up of Bamboo without stiffener -Case 1 (BC1)

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 12 Issue VI June 2024- Available at www.ijraset.com

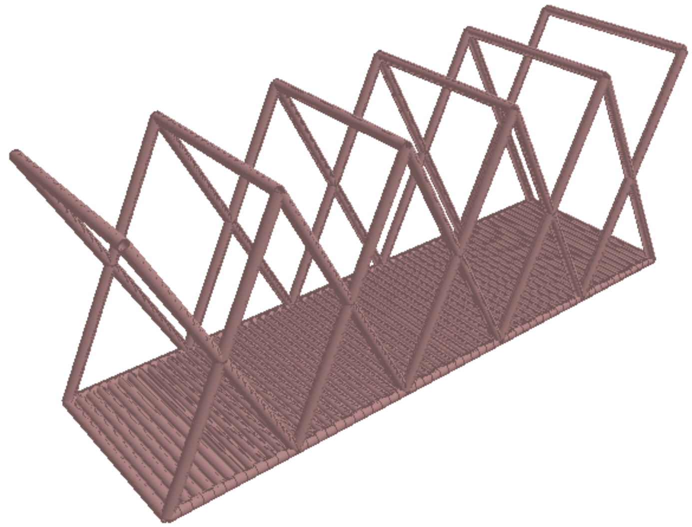

Fig. 2: 3D View of Pedestrian bridge made up of Bamboo without stiffener -Case 1 (BC1)

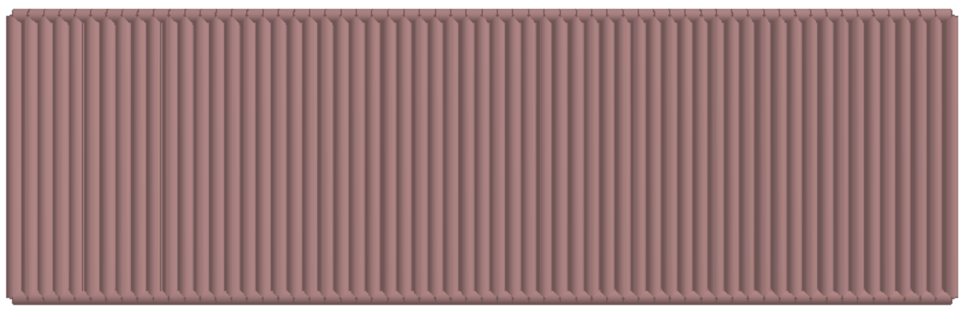

Fig. 3: Deck of Pedestrian bridge made up of Bamboo without stiffener -Case 1 (BC1)

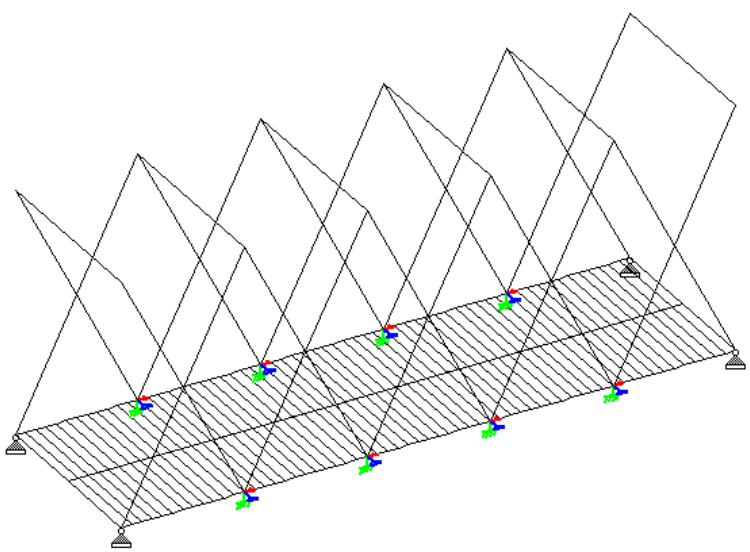

Fig. 4: Plan view of Pedestrian bridge made up of Bamboo with single stiffener -Case 2 (BC2)

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 12 Issue VI June 2024- Available at www.ijraset.com

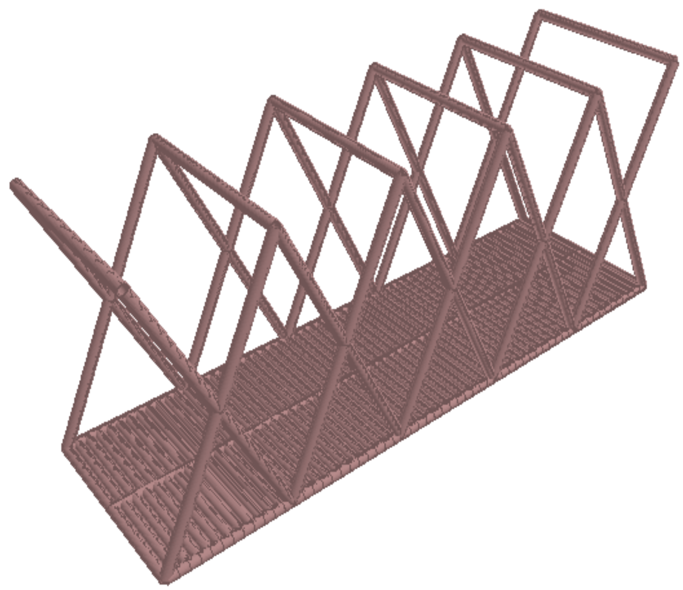

Fig. 5: 3D View of Pedestrian bridge made up of Bamboo with single stiffener -Case 2 (BC2)

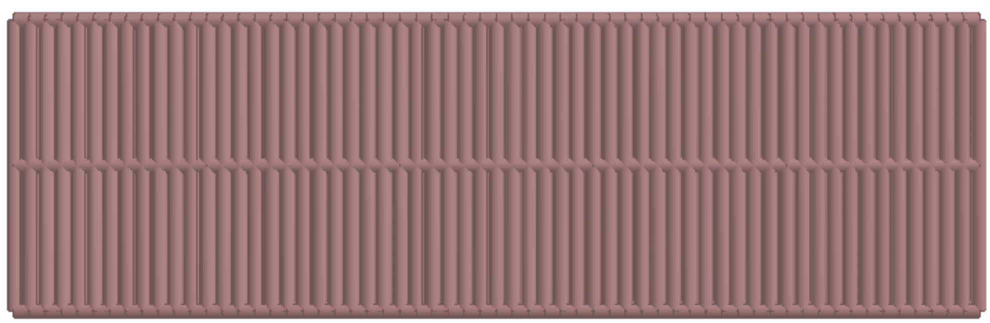

Fig. 6: Deck of Pedestrian bridge made up of Bamboo with single stiffener -Case 2 (BC2)

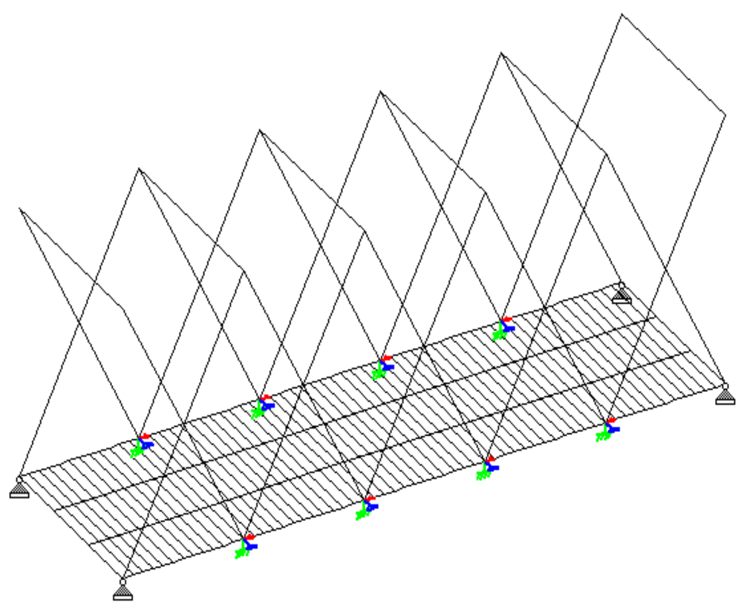

Fig. 7: Plan view of Pedestrian bridge made up of Bamboo with double stiffener -Case 3 (BC3)

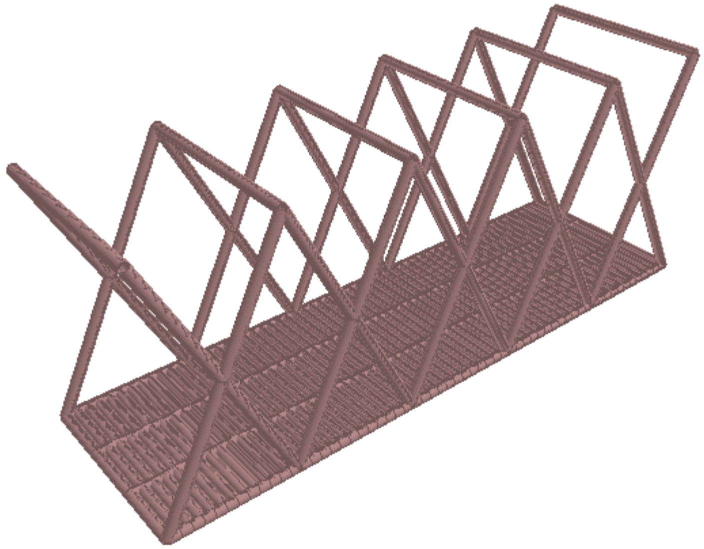

Fig. 8: 3D View of Pedestrian bridge made up of Bamboo with double stiffener -Case 3 (BC3)

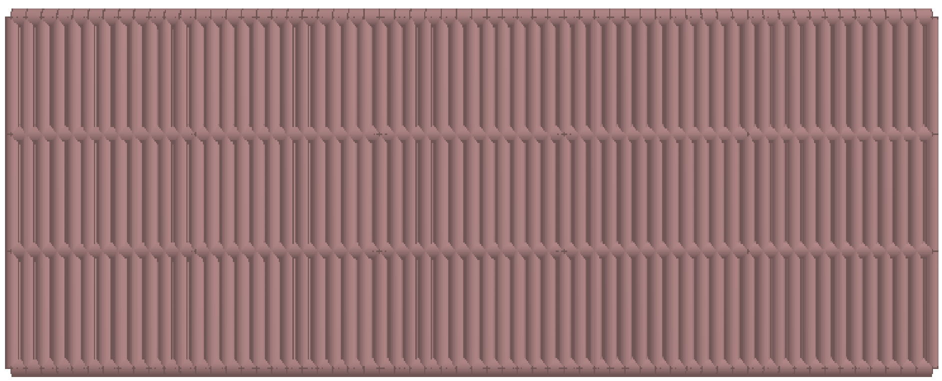

Fig. 9: Deck of Pedestrian bridge made up of Bamboo with double stiffener -Case 3 (BC3)

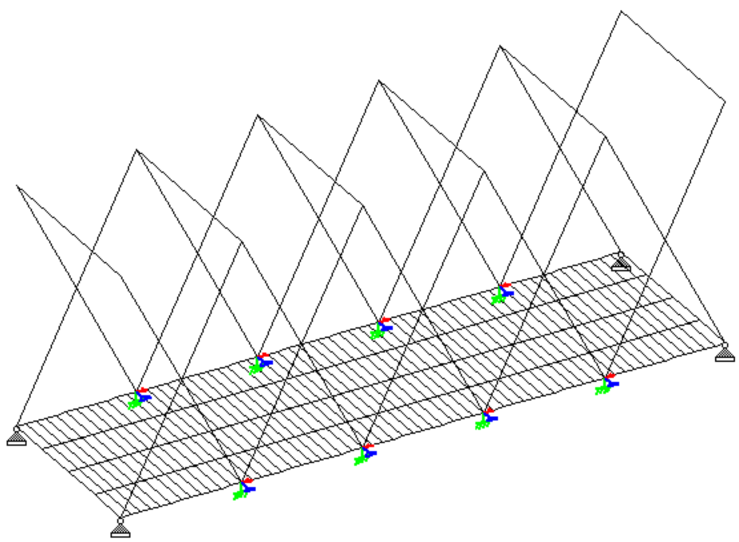

Fig. 10: Plan view of Pedestrian bridge made up of Bamboo with triple stiffener -Case 3 (BC3)

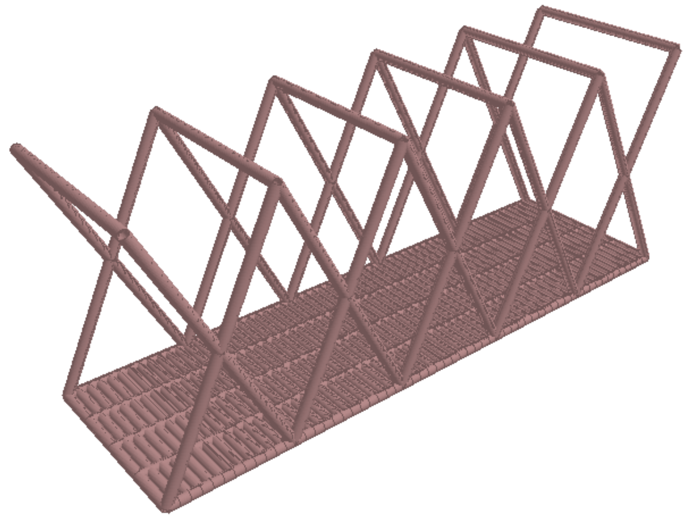

Fig. 11: 3D View of Pedestrian bridge made up of Bamboo with triple stiffener -Case 3 (BC3)

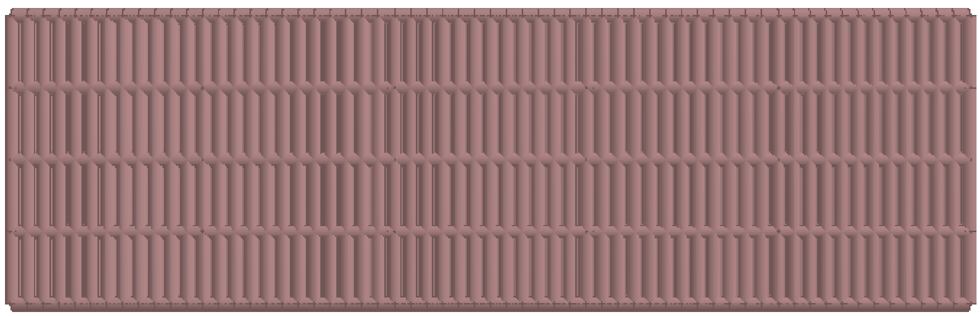

Fig. 12: Deck of Pedestrian bridge made up of Bamboo with triple stiffener -Case 3 (BC3)

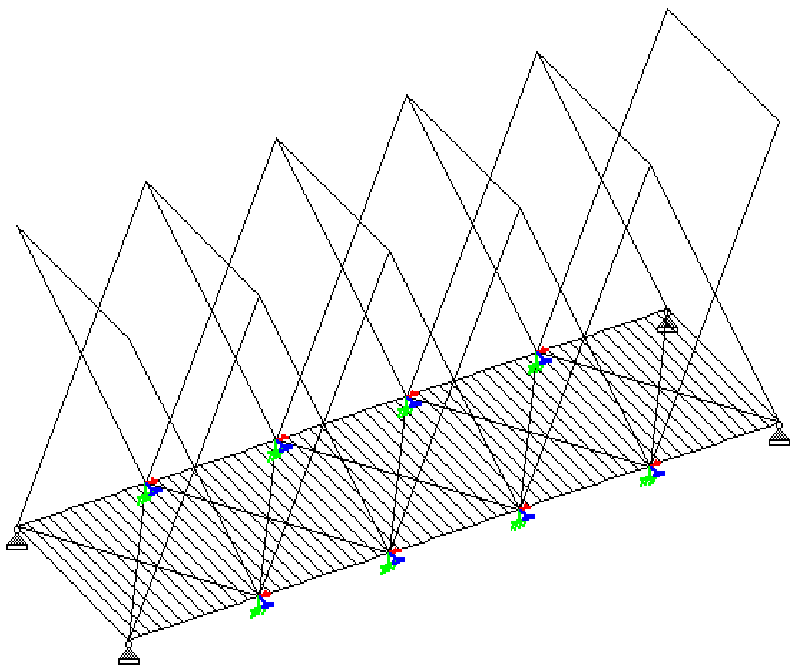

Fig. 13: Plan view of Pedestrian bridge made up of Bamboo with cross stiffener -Case 5 (BC5)

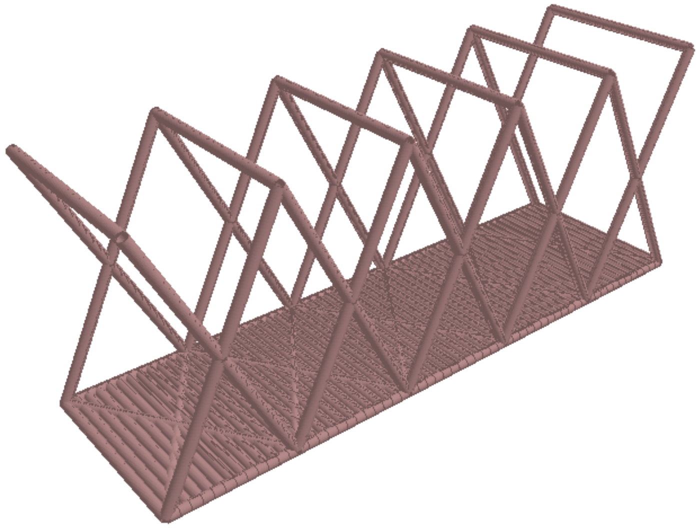

Fig. 14: 3D View of Pedestrian bridge made up of Bamboo with cross stiffener -Case 5 (BC5)

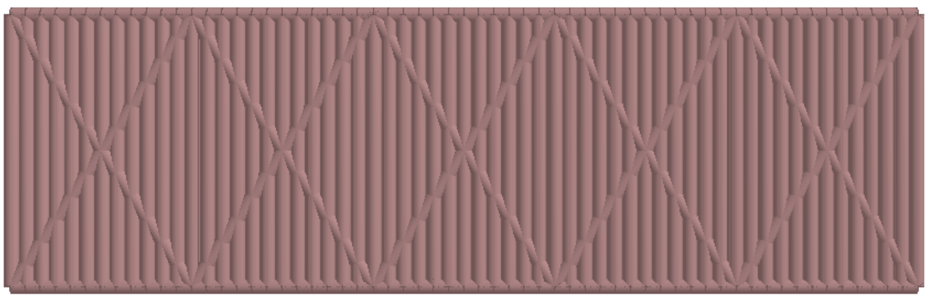

Fig. 15: Deck of Pedestrian bridge made up of Bamboo with cross stiffener -Case 5 (BC5)

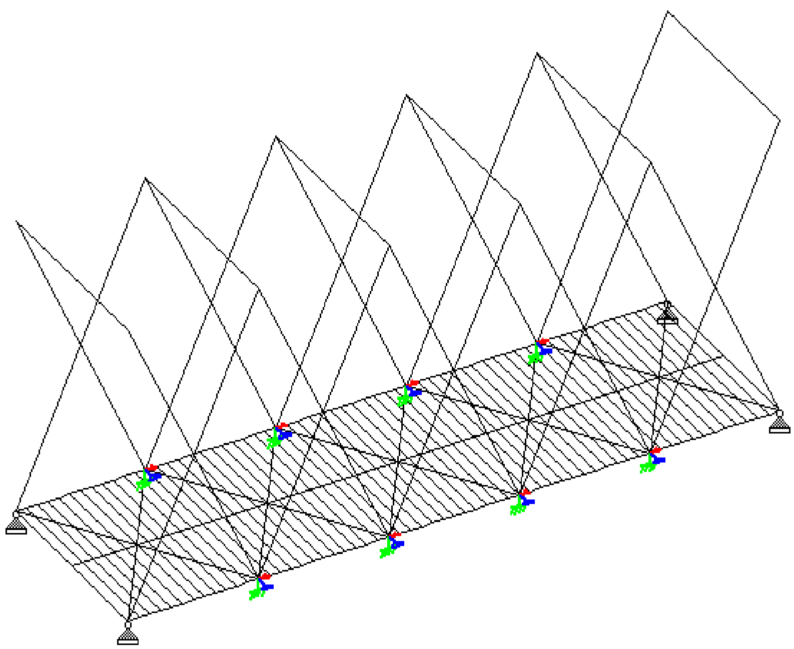

Fig. 16: Plan view of Pedestrian bridge made up of Bamboo with stiffener and cross stiffener - Case 6 (BC6)

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 12 Issue VI June 2024- Available at www.ijraset.com

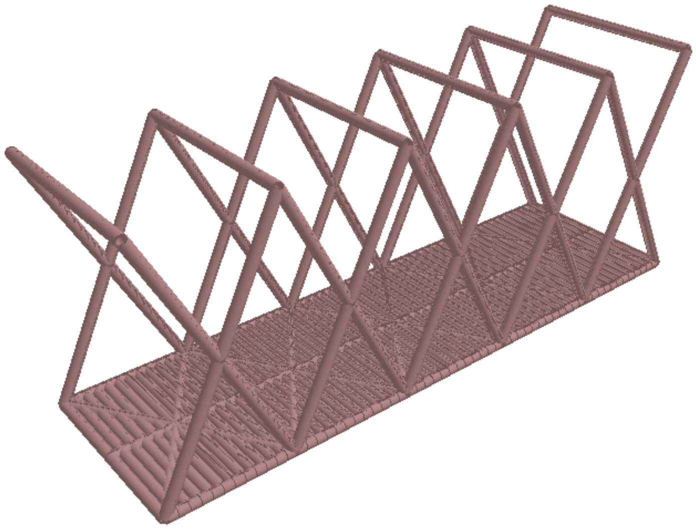

Fig. 17: 3D View of Pedestrian bridge made up of Bamboo with stiffener and cross stiffener - Case 6 (BC6)

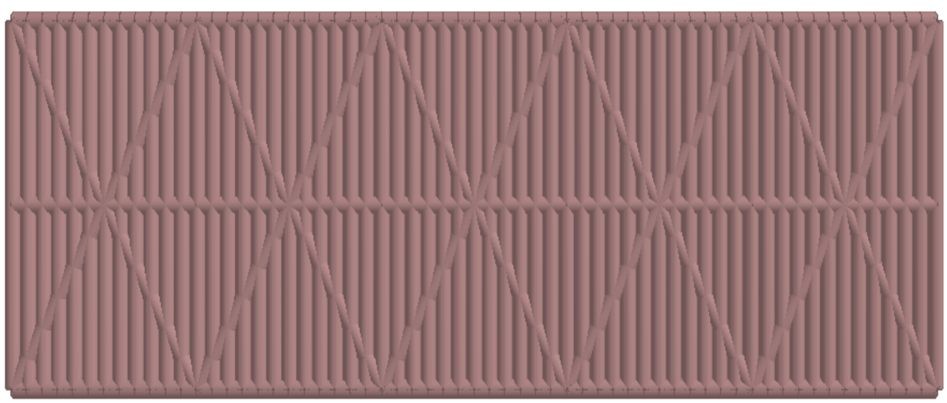

Fig. 18: Deck of Pedestrian bridge made up of Bamboo with stiffener and cross stiffener -Case 6 (BC6)

IV. RESEARCH OBJECTIVES

On keeping in mind the problem statement outlined for comparative analysis of deployable pedestrian bridge for different geometrical configurations of bamboo materials are given below :-

1) To check behavior in the analysis, it is recommended to compare the behavior analysis of geometrical configurations of bamboo material.
2) To determine and compare maximum displacement in X, Y and Z direction for all geometrical bamboo cases.
3) To study the variation in Maximum Axial forces for all geometrical bamboo cases.
4) To determine and relate Maximum Shear forces for all geometrical bamboo cases.
5) To evaluate Maximum Bending moment for all geometrical bamboo cases.
6) To compare Maximum Torsional moment for all geometrical bamboo cases.
7) To determine Maximum Axial Stresses for all geometrical bamboo cases.
8) To evaluate Maximum Shear stresses for all geometrical bamboo cases.
9) To compare Maximum Bending stresses for all geometrical bamboo cases.
10) To provide the recommendations that will made a feasible construction reference.

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 12 Issue VI June 2024- Available at www.ijraset.com

V. RESULTS ANALYSIS

A comparison of results below for different bamboo bridges for various parameters is shown in the form of figures below from fig. 19 to fig. 26 :-

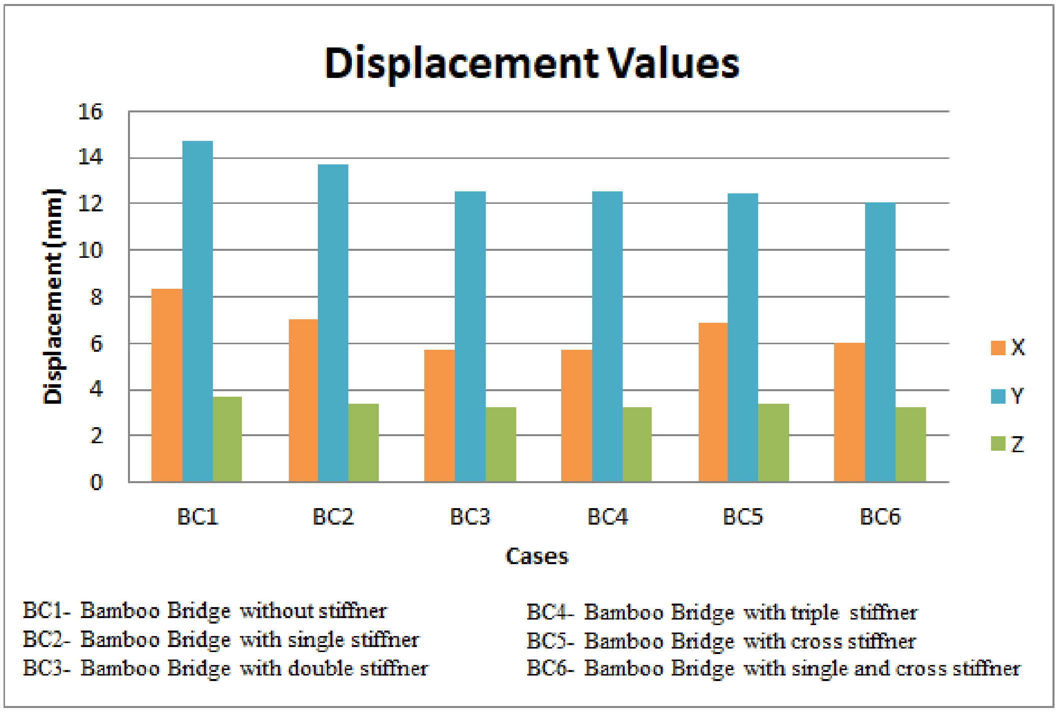

Fig. 19: Maximum Displacement for all bamboo bridge cases

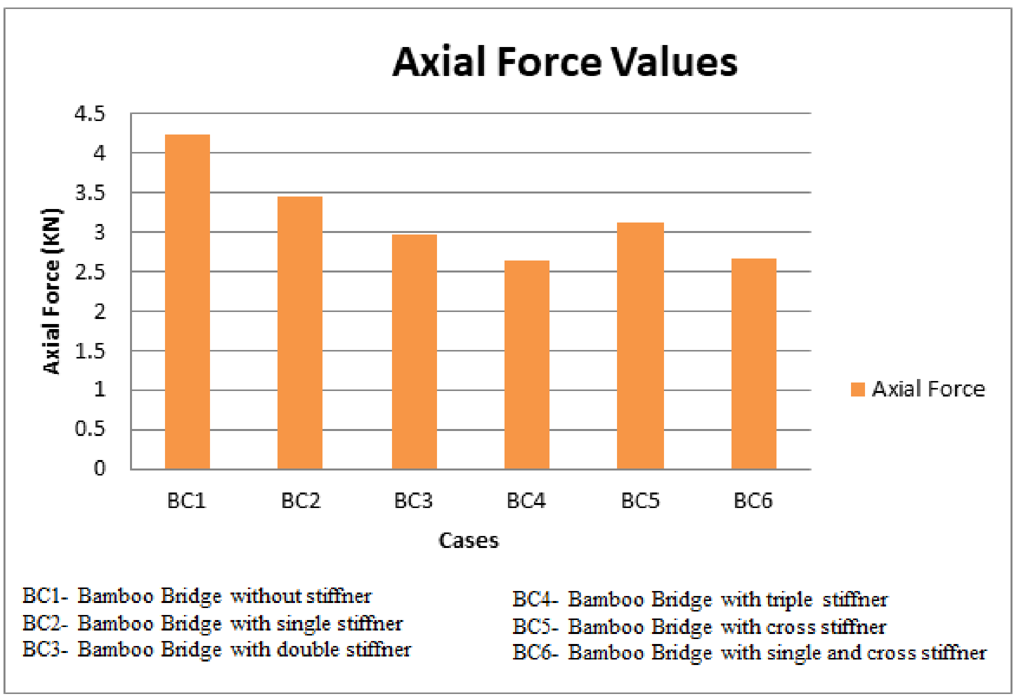

Fig. 20: Maximum Axial forces for all bamboo bridge cases

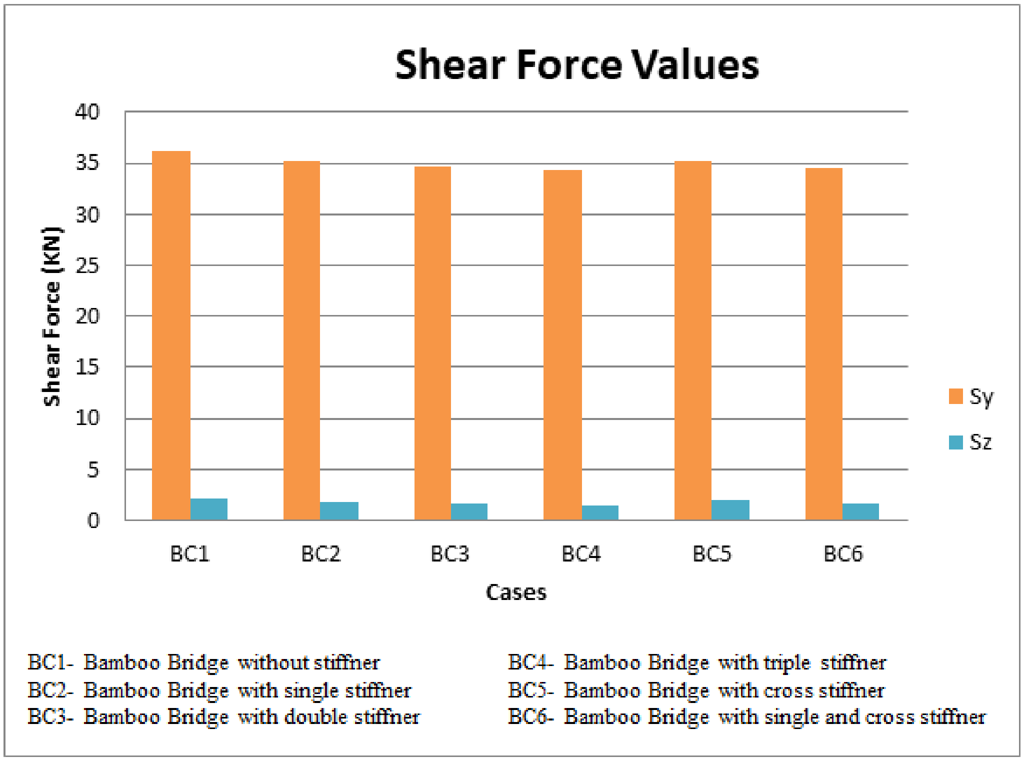

Fig. 21: Maximum Shear forces for all bamboo bridge cases

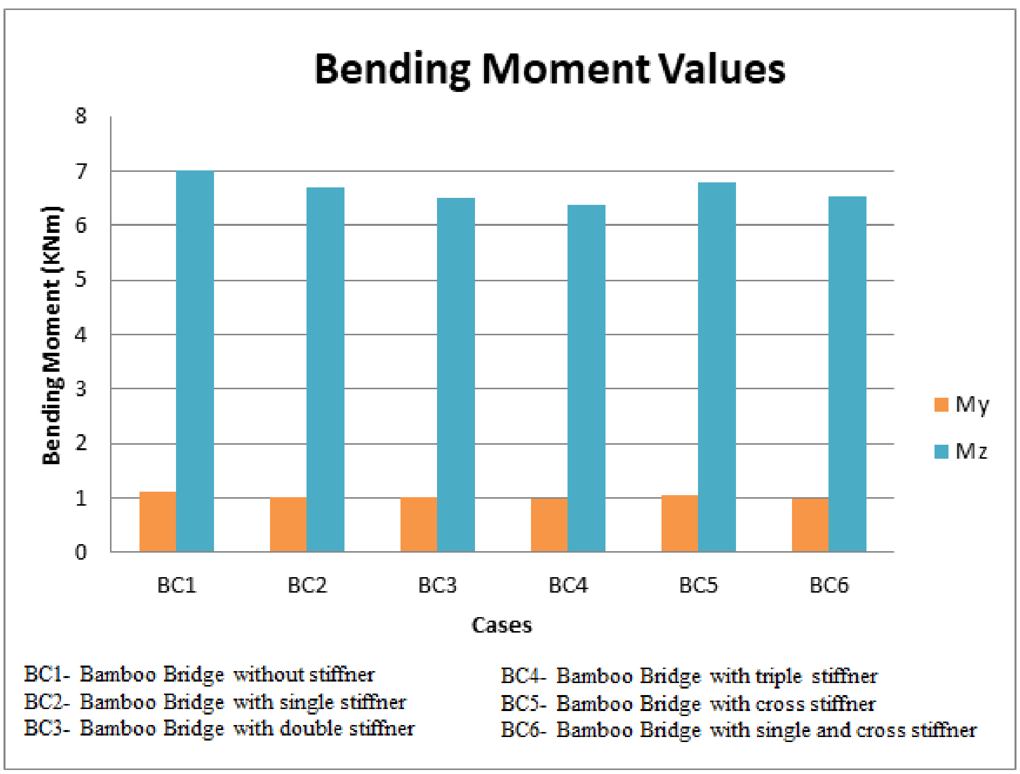

Fig. 22: Maximum Bending moment for all bamboo bridge cases

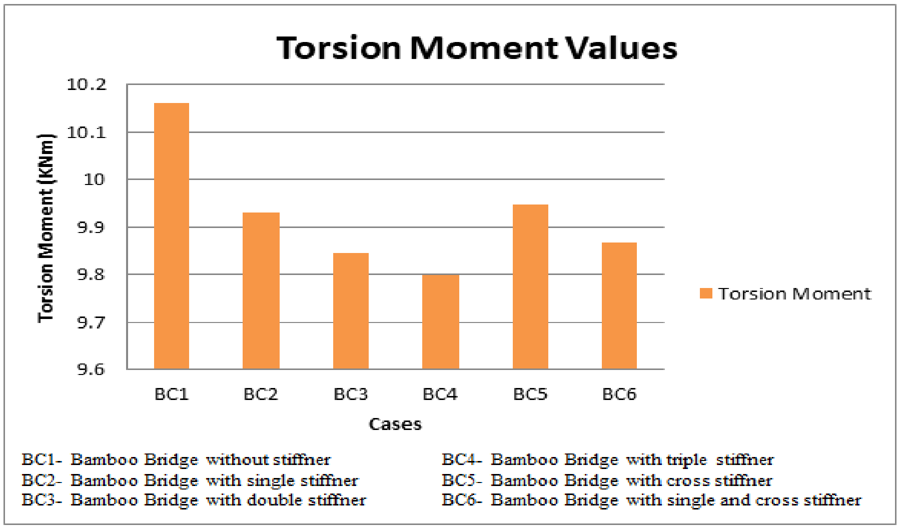

Fig. 23: Maximum Torsional moment for all bamboo bridge cases

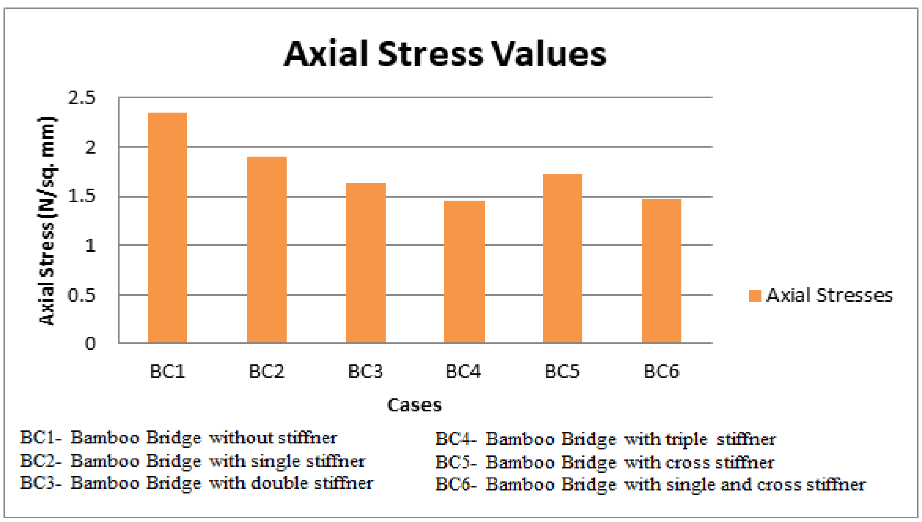

Fig. 24: Maximum Axial Stresses for all bamboo bridge cases

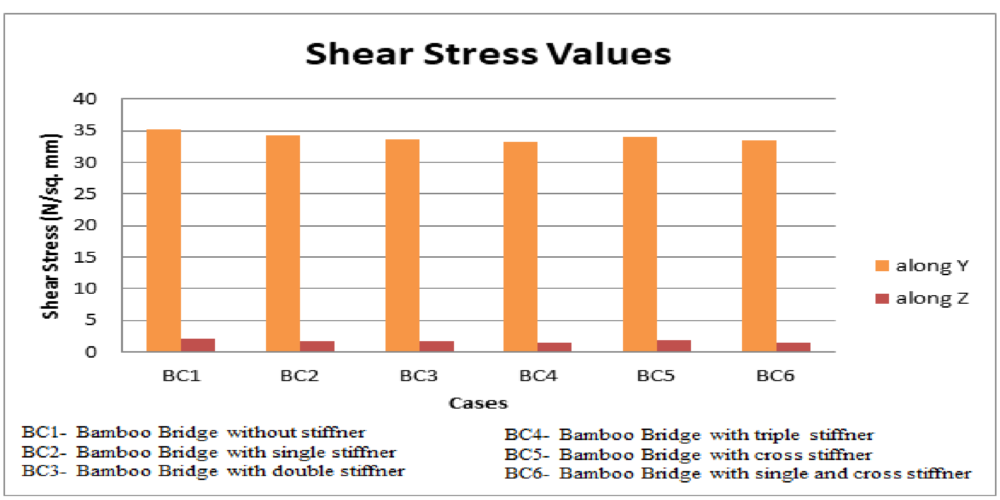

Fig. 25: Maximum Shear stresses for all bamboo bridge cases

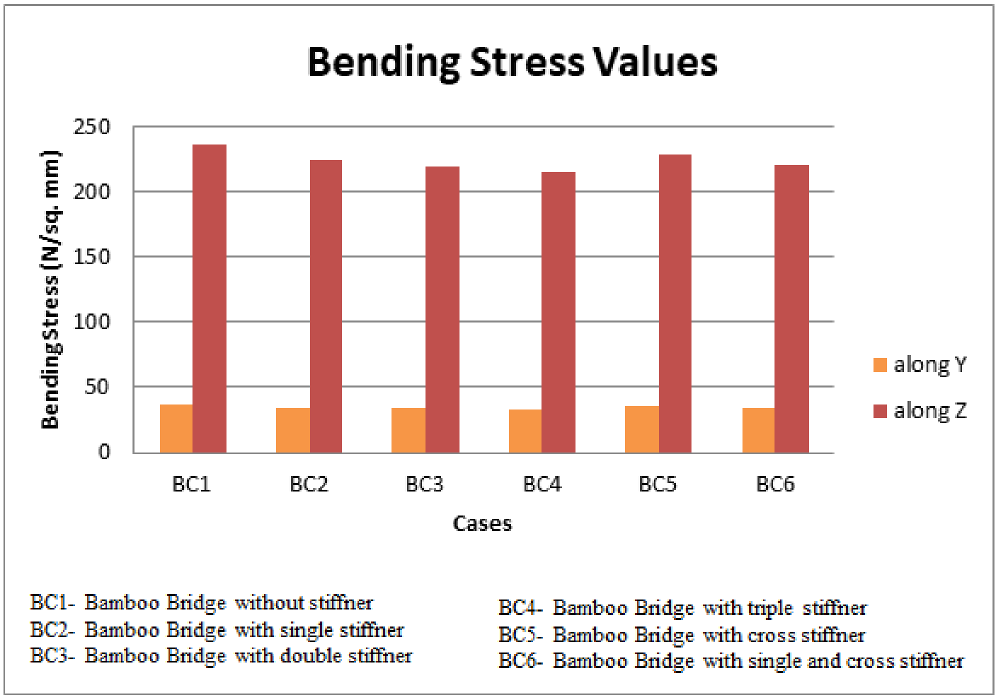

Fig. 26: Maximum Bending stresses for all bamboo bridge cases

VI. CONCLUSIONS

Conclusions for effect of geometry on behaviour of bamboo bridge are as follows:-

1) On comparing maximum displacement values in different geometry cases of bamboo deployable bridge generates less displacement with a value of 5.744 mm in case BC4, 12.098 mm in case BC6 and 3.202 mm in case BC6 for x, y and z direction respectively.
2) Observing the axial force values in different geometry cases of bamboo deployable bridge, the minimum value observed with a value of 2.639 KN when using bamboo with triple longitudinal support i.e. case BC4.
3) Comparing the shear forces values in different geometry cases of bamboo deployable bridge, the minimum value observed with a value of 34.339 KN along y and 1.519 KN along z when using bamboo with triple longitudinal support i.e. case BC4.
4) Comparing the bending moment values in different geometry cases of bamboo deployable bridge, the minimum value observed with a value of 0.987 KNm along y and 6.384 KNm along z when using bamboo with triple longitudinal support i.e. case BC4.
5) Torsional moment values in different geometry cases of bamboo deployable bridge, the minimum value observed with a value of 9.800 KNm when using bamboo with triple longitudinal support i.e. case BC4.
6) When comparing the stresses values, the axial stresses has a minimum value of 1.459 N/sq. mm in case BC 4. The shear stresses along y has a minimum value of 33.292 N/sq. mm and along z has a minimum value of 1.473 N/sq. mm respectively. The bending stresses observed a minimum value of 33.257 N/sq. mm along y and 215.125 N/sq. mm along z. For all the stresses, best possible case observed when using bamboo with triple longitudinal support i.e. case BC4.

This part of the project concluded that when using bamboo material, the performance of the different types of geometry plays an important role when using deployable bridge. Case BC6 is efficient in displacement but BC4 i.e. when using bamboo with triple longitudinal support observed to be most efficient when compared to other geometry cases for all parameters and should be recommended that the behaviour of bridge as per usage, always use bamboo with triple longitudinal support i.e. case BC4.

VII. ACKNOWLEDGEMENT

I, Piyush Ghudawat, M. Tech. Student, would like to thank ***Dr. Umesh Pendharkar,*** Professor, Department of Civil Engineering, Ujjain Engineering College, Ujjain, (M.P.), India for his valuable guidance from the commencement of the work up to the completion of the work along with his encouraging thoughts.

REFERENCES

[1] Bapat Himanshu Yogesh, Dr. Siddharth G. Shah, "Analysis and Design of Deployable Bridge Based on Origami Skill", Conference paper, pp. 1-6.

[2] Xiaoming Yu, Yinghua Yang, Yanxia Ji, and Lin Li, (2021), "Experimental Study on Static Performance of Deployable Bridge Based on Cable-Strengthened Scissor Structures", Hindawi-Advances in Civil Engineering, Vol. 2021, Article ID 4373486, 11 pages.

[3] Mohamad Nabil Aklif Biro and Noor Zafirah Abu Bakar, (2018), "Design and Analysis of Collapsible Scissor Bridge", Eureca 2017, MATEC Web of Conferences 152, 02013.

[4] Bing Wang, Juncheng Zhu, Shuncong Zhong, Wei Liang, Chenglong Guan, (2023), "Space deployable mechanics: A review of structures and smart driving", Materials & Design, pp. 1-19.

[5] Yenal Akgüna, Feray Madena, Erinc, (2020), "Weight and Material Optimization of Scissor-hinge Linkages According to Given Span Length", 1st International Conference on Optimization-Driven Architectural Design (OPTARCH 2019), ISSN 2351-9789, Procedia Manufacturing 44, pp. 387–393.

[6] J. Pérez-Valcárcel, M. Muñoz-Vidal, M. J. Freire-Tellado, Isaac R. López-César, F. Suárez-Riestra, (2020), "Expandable covers of skew modules for emergency buildings", International Journal of Innovation Engineering and Science Research, ISSN: 2581-4591, Volume 4, Issue 5, pp. 38-52.

[7] Choy Hau Yan and Tan Aik Aik, (2020), "Design and Analysis of Emergency Deployable Bridge", International Journal of Mechanical Engineering and Robotics Research Vol. 9, No. 10, pp. 1393-1399.

[8] Fernando del Ama, Mariano Molina, M. Isabel Castilla, Dolores Gomez, Pulido , Covadonga Lorenzo, Juan Garcia Millan, Juan C. Sancho, (2020), "A Methodology for Optimal Design and Simulation of Deployable Structures", IOP Conf. Series: Materials Science and Engineering, Issue 960, pp. 1-10.

[9] Niki Georgiou and Marios C. Phocas, (2020), "Kinematics analysis of deployable and reconfigurable bar-linkage structures", The 2020 Structures Congress (Structures20) 25-28, GECE, Seoul, Korea, pp. 1-12.

[10] Rahula and Kaushik Kumar, (2014), "Design and Optimization of Portable Foot Bridge", 12th Global Congress On Manufacturing And Management, GCMM, Procedia Engineering 97, ISSN 1877-7058, pp.1041 – 1048.

[11] Li qiyu, Yuan jiehong, Sun haitao, Zhou shiming and Peng yuxing, (2020), "Design of a New Type of Deployable Bridge", IOP Conf. Series: Materials Science and Engineering 926 (ATDMAE 2020) 012026.

[12] Gökhan Kiper et. al., (2020), "Loop Based Design and Classification of planner scissor linkages", Research square, pp. 1-28.

[13] Manuel J Freire-Tellado et. al., (2022), "Bias deployable grids with horizontal compound scissor-like elements: A geometric study of the folding/ deployment process", International Journal of Space Structures, vol. 37, Issue 1, pp. 22-36.

[14] A.P. Thrall et. al., (2012), "Linkage-based movable bridges: Design methodology and three novel forms", Engineering Structures, ISSN: 0141-0296, Vol. 37, pp. 214–223.

[15] Brittani R. Russell et. al., (2023), "Portable and Rapidly Deployable Bridges: Historical Perspective and Recent Technology Developments", ISSN: 1943-5592, Journal of Bridge Engineering, Vol. 18, Issue 10, pp. 1074-1085.

[16] Pengyuan Zhao et. al., (2020), "Novel Surface Design of Deployable Reflector Antenna Based on Polar Scissor Structures", Chinese Journal of Mechanical Engineering, Vol. 33, Issue 68, pp. 1-15.

[17] A.M.B.B.S. Athauda et. al. (2010), FEASIBILITY OF USING BAMBOO AS A POTENTIAL REINFORCEMENT IN CONCRETE ELEMENT, Conference paper, pp. 1-9.

[18] Xiaoyi Chen et. al., (2021), "Measuring the Damping Performance of Gradient-Structured Bamboo Using the Resonance Method", Forests, Vol. 12, Paper no. 1654, pp. 1-12.

[19] A H D Abdullah et. al. (2017), "Physical and mechanical properties of five Indonesian bamboos", 1st International Symposium on Green Technology for Value Chains 2016, IOP Conf. series: Earth and Environmental Science, Vol. 60, paper 012014, pp. 1-6.