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Comparison of Deployable Bridges Having Similar Geometry but Different Material- Steel and Bamboo

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Abstract: This study aims to evaluate the structural, environmental, and economic implications of incorporating bamboo into the design of deployable pedestrian bridges.

Deployability adds another layer of complexity, requiring the bridge to be easily transportable, assembled, and disassembled as needed, making it suitable for temporary installations or emergency situations. In this paper to check the comparative analysis of deployable pedestrian bridge by using steel and bamboo materials 2 different cases made, the objectives has decided and the result have drawn. The recommendations have discussed after the conclusion that using steel material, the performance of the steel material is more as compared to bamboo material. As per weight and economic point of view, bamboo concluded as the lighter in weight, cost effective and eco-friendly material.

Keywords: Deployable bridge, Bamboo, hollow Steel tube, pedestrian loading.

I. INTRODUCTION

Pedestrian bridges serve as vital links in urban infrastructure, facilitating safe passage over obstacles and enhancing connectivity within communities. In recent years, there has been growing interest in sustainable construction practices, prompting exploration into alternative materials such as bamboo alongside traditional choices like steel. This analysis delves into the feasibility and performance of a deployable pedestrian bridge constructed with a combination of steel and bamboo materials. The utilization of steel in bridge construction is well-established, offering strength, durability, and versatility. However, concerns over environmental impact and sustainability have prompted researchers and engineers to seek alternatives that reduce carbon footprints without compromising structural integrity. Bamboo has emerged as a promising candidate due to its rapid growth, high strength-to-weight ratio, and renewability.

II. DEPLOYABLE PEDESTRIAN BRIDGE

Deployable pedestrian bridges stand at the forefront of contemporary civil engineering, offering innovative solutions to urban connectivity challenges. These bridges, designed for rapid assembly, disassembly, and transport, provide vital pedestrian access over temporary obstacles such as construction sites, rivers, or event venues. The emergence of deployable bridges reflects a dynamic approach to infrastructure development, catering to the fluctuating demands of modern cities. Unlike conventional permanent structures, deployable pedestrian bridges offer flexible, temporary solutions suitable for emergency situations, special events, or temporary construction needs.

Factors that are used for key areas to focus on:-

1) Structural Considerations
2) Deployment Strategies
3) Transportation Logistics
4) Safety and Accessibility
5) Case Studies and Applications

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.

Table 1: General data used

Constraint	Data used for both model cases
Width of bridge	1.5m
Span of bridge	5m
Height of bridge	2m
Usage type	Deployable scissor type
Steel tube properties	
Steel pipe section dimensions	Outside diameter – 0.08m Inside diameter – 0.064m
Type of steel section	Circular tube type
Bamboo properties	
Bamboo type	Awi temen type (Gigan tochla atler)
Modulus of elasticity	17.20 Gpa
Poisson's ratio	0.15
Density	0.76 gm/cc = 74.556 KN/ cu m
Damping	0.63%
Tensile strength	195.250 N/sq. mm = 195250 KN/sq. m
Clum diameter	8 cm =80mm
Thickness of clum wall	8 mm
Total height	12m

Table 2: Loading data used

Constraint	Data used for both model cases
Dead load	Self weight
Live load	5 KN/m pedestrian load
Load combinations (as per IRC 6:2017)	
Load combination 1	DL + LL
Load combination 2	1.35DL + LL
Load combination 3	1.35DL + 1.5 LL

Table 3: Model Description

Models framed for analysis	Abbreviation
Pedestrian bridge made up of Steel section	S1
Pedestrian bridge made up of Bamboo without stiffener-Case 1	BC1

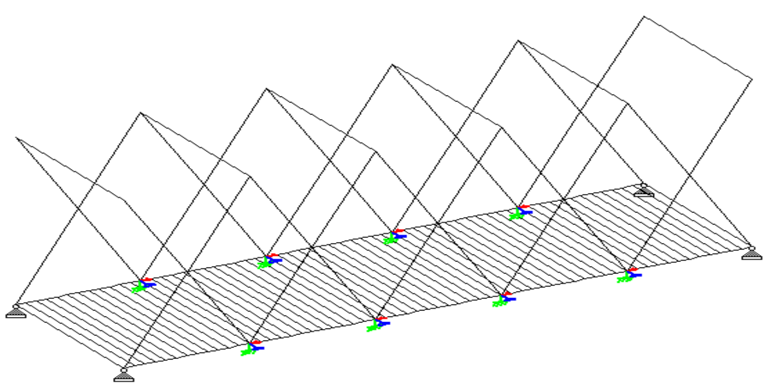

Fig. 1: Plan view of Pedestrian bridge made up of Steel section (S1)

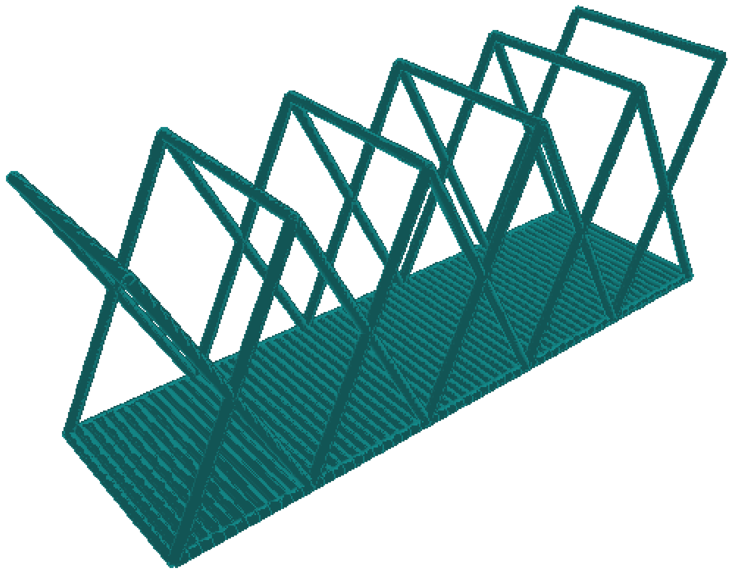

Fig. 2: 3D View of Pedestrian bridge made up of Steel section (S1)

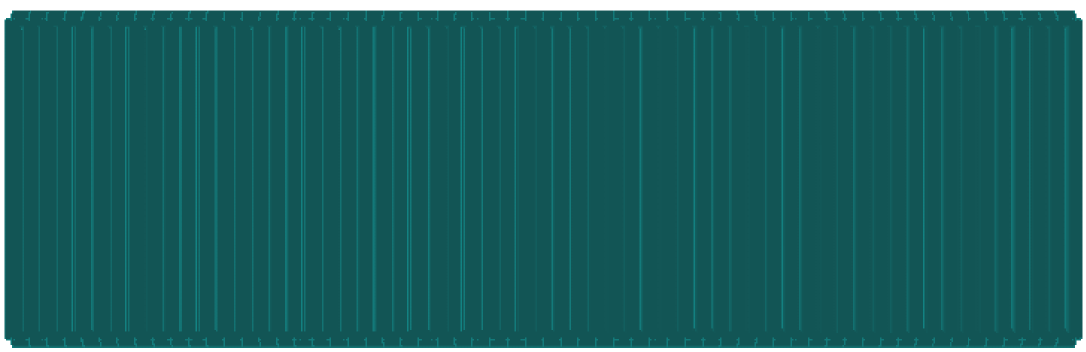

Fig. 3: Deck of Pedestrian bridge made up of Steel section (S1)

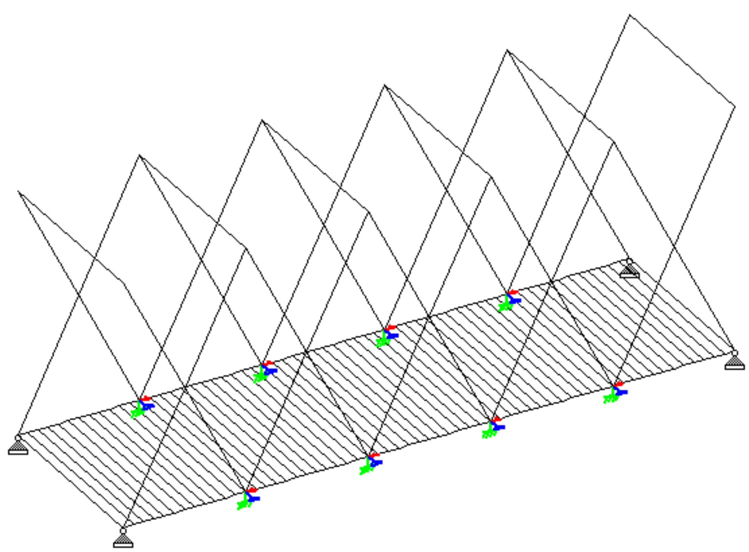

Fig. 4: Plan view of Pedestrian bridge made up of Bamboo without stiffener -Case 1 (BC1)

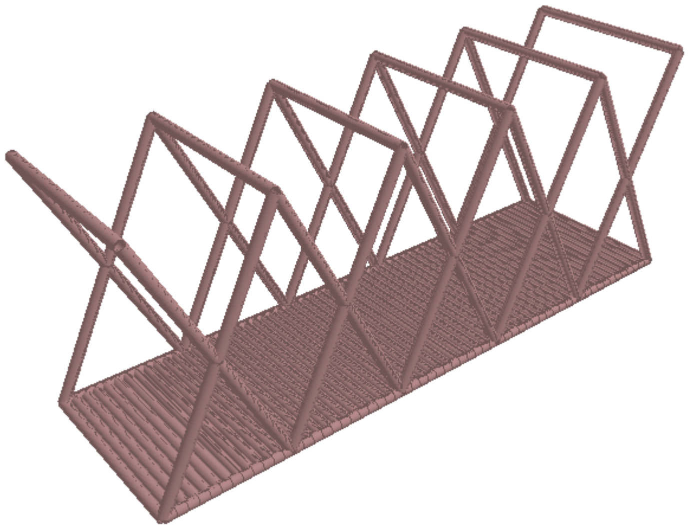

Fig. 5: 3D View of Pedestrian bridge made up of Bamboo without stiffener -Case 1 (BC1)

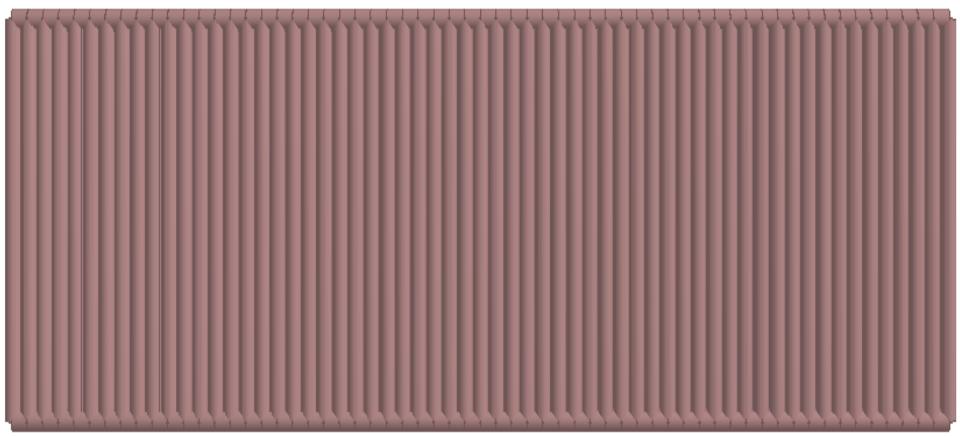

Fig. 6: Deck of Pedestrian bridge made up of Bamboo without stiffener -Case 1 (BC1)

IV. RESEARCH OBJECTIVES

On keeping in mind the problem statement outlined for comparative analysis of deployable pedestrian bridge by using steel and bamboo materials are given below :-

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

V. RESULTS ANALYSIS

A comparison of results below for steel bridge and bamboo bridge for various parameters is shown in the form of figures below from fig. 7 to fig. 14 :-

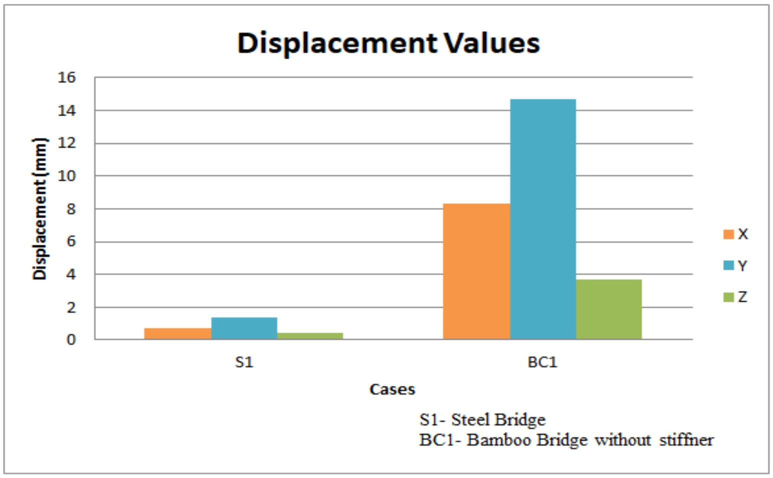

Fig. 7: Maximum Displacement for steel bridge and bamboo bridge

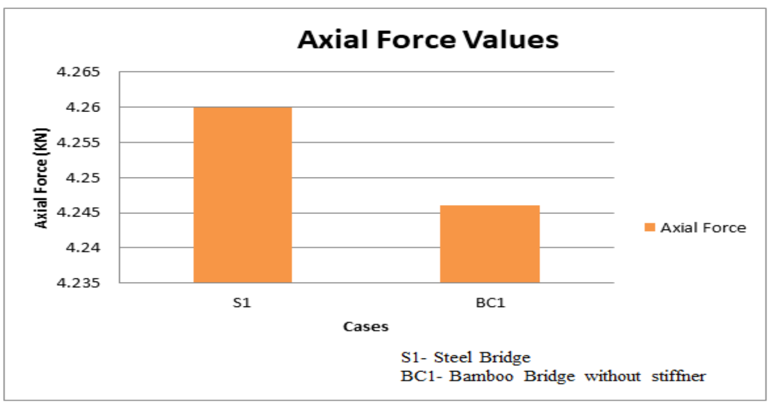

Fig. 8: Maximum Axial forces for steel bridge and bamboo bridge

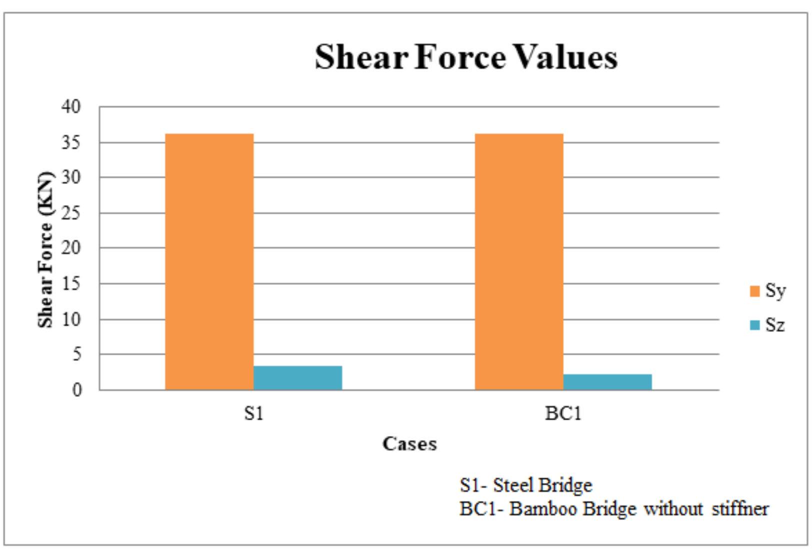

Fig. 9: Maximum Shear forces for steel bridge and bamboo bridge

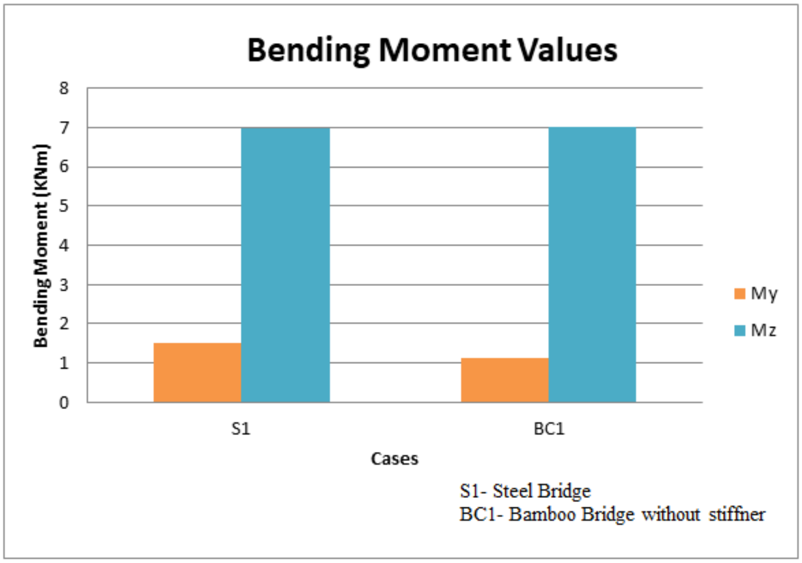

Fig. 10: Maximum Bending moment for steel bridge and bamboo bridge

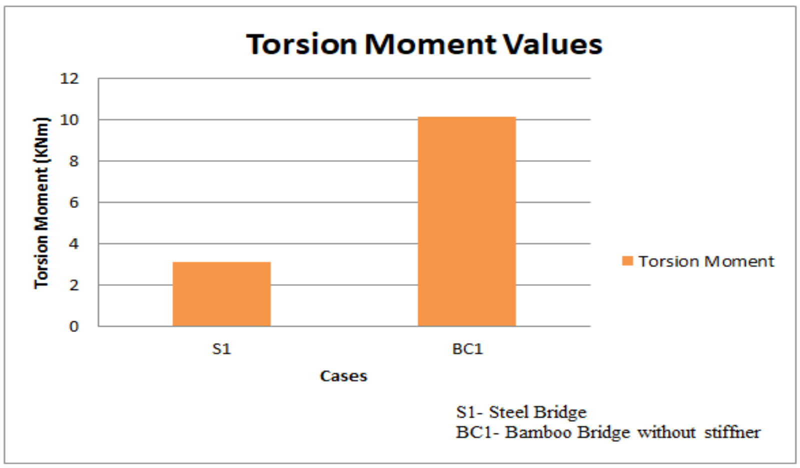

Fig. 11: Maximum Torsional moment for steel bridge and bamboo bridge

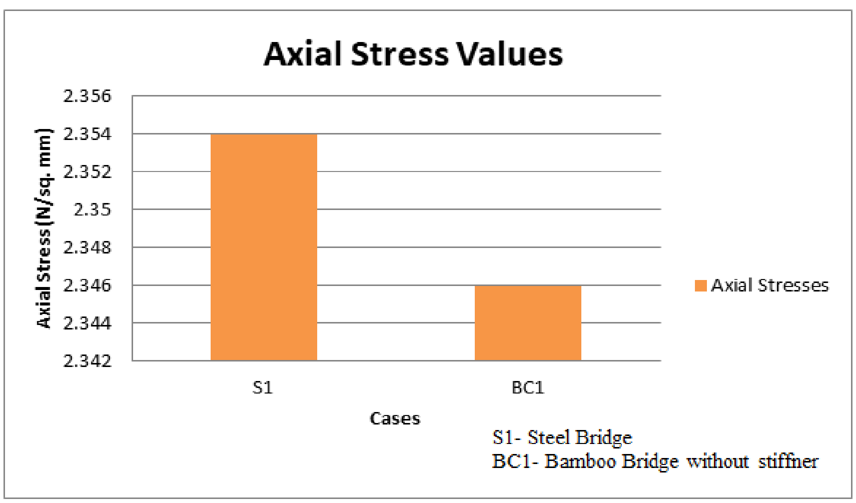

Fig. 12: Maximum Axial Stresses for steel bridge and bamboo bridge

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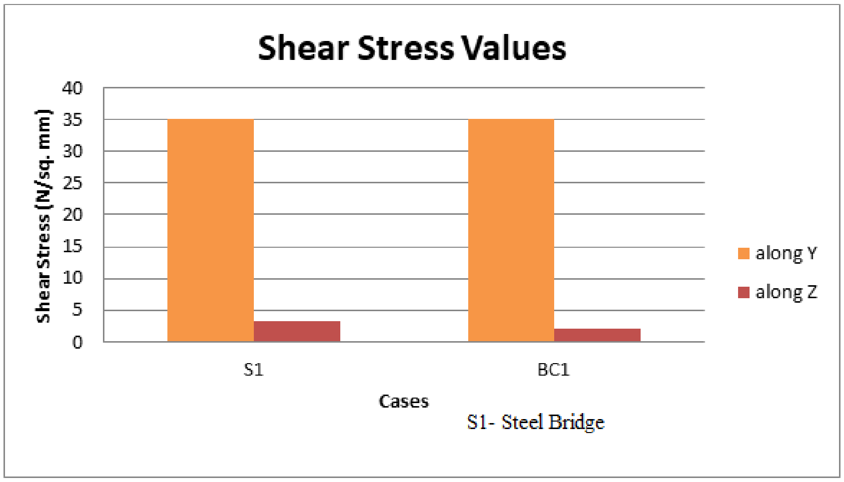

Fig. 13: Maximum Shear stresses for steel bridge and bamboo bridge

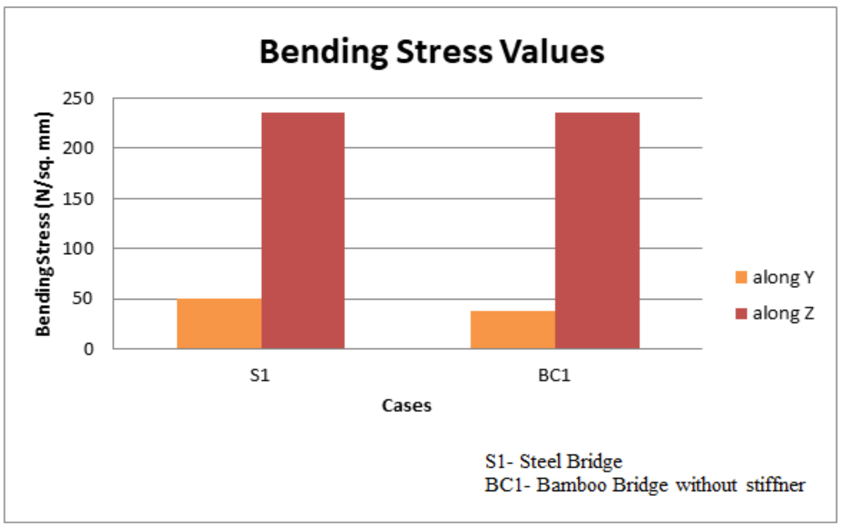

Fig. 14: Maximum Bending stresses for steel bridge and bamboo bridge

VI. CONCLUSIONS

Conclusions for comparison of deployable bridge made up of steel and bamboo material are as follows:-

1) On comparing maximum displacement values, bamboo deployable bridge generates more displacement as compared to steel bridge with a value of 8.342 mm, 14.682 mm and 3.663 mm for x, y and z direction respectively.
2) Observing the axial force values, it is decreasing by 0.33% as compared to steel material used.
3) Comparing the shear forces in members, shear increases along y by 0.38% but shear decreases along z by 34.74% when using bamboo material.
4) Comparing the bending moment in members, moment decreases along y by 25.8% but moment increases along z by only 0.43% when using bamboo material.
5) Torsional moment seems to be more when using the bamboo material with a value of 10.162 KNm.
6) When comparing the stresses values, the axial stresses decreases by 0.34% when using the bamboo material, the shear stresses in members increases along y by 0.04% but stresses decreases along z by 34.74% when using bamboo material. Finally the bending stresses in members, stresses decreases along y by 25.8% but moment increases along z by only 0.44% when using bamboo material.

This part of the project concluded that when using steel material, the performance of the steel material is more as compared to bamboo material. On contrasting to the weight and economic point of view, bamboo concluded as the lighter in weight, cost effective and eco-friendly material.

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