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FEASIBILITY STUDY ON REPLACEMENT OF STEEL REINFORCEMENT WITH BAMBOO REINFORCEMENT IN MULTISTORY BUILDING

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ABSTRACT

The current project demonstrates the great use of bamboo as a reinforcing material in concrete construction and its extensive use within the substitution with steel as reinforcement in concrete load bearing members. The report has been derived with the assistance of conclusions and results of the previous reports of varied conducted experiments for determining the mechanical properties of bamboo and its use as a material in construction. The use of bamboo in the place of steel as a whole as well as with steel is shown to ensure the reduction in weight, economic advantages with its strength compromised to a small and safe level. Various researches and study results are going to be used for the deduction of a way best suited for the replacement of bamboo as reinforcing material within the correct quantity and the right proportion and therefore the absolute best placement in situ of steel and or with steel. A method that might not compromise with the factor of safety of the structure has got to be shown within the report.

Keywords: Bamboo Reinforcement, Crack, Flexure Test, Tensile Test.

I. INTRODUCTION

Bamboo is a traditional building material throughout the world's tropical and sub-tropical regions. Bamboo is a renewable and versatile resource, with high strength and low weight. That's why it is widely used in different forms of construction, particularly for housing in rural areas. It can also be used to make traps, cages, tools, weapons, bridges, rafts, towers, fences, water wheels, irrigation pipe, and thousands of other items. Due to its low tensile strength, it is generally reinforced with materials which are strong in tension (Generally steel bars). But the price of steel is very high and also it cannot find in all the places. To overcome this problem, Architecture, Civil Engineers, Industrialist research and Scientist were searched for the new alternative eco-friendly & lowest cost material to reinforce with concrete. At last they all found one alternative material, i.e. bamboo, which is very used for replacements of reinforcing bar in concrete for eco-friendly & low cost constructions.

II. LITERATURE REVIEW

Francis E Brink et.al[(*1)](1966).It provides a set of instructions on how to properly construct a variety of structures and structural elements using Bamboo. This study suggested not to use green, unseasoned Bamboo for general construction, nor to use unwater proofed Bamboo in concrete. Concerning Bamboo reinforced concrete, it was found that the concrete mix designs may be the same as that used with steel, with a slump as low as workability will allow.

Suresh et.al[(*2)](2008).It has covered the analysis and the conceptual design of a typical bamboo based shed structure under various loads and their combinations. Wind loads have been considered as per IS 875 PART 3 and the structure analyzed in a simple fashion by considering the behavior of a typical frame in the transverse direction. The proposed structure aims to provide an alternative environmental friendly construction for a steel industrial shed, typically 10m in span and 5m in height. Not only is the structure light compared to conventional steel, it is at the same time several times cheaper and ecofriendly.

Agarwal A. et.al [(*3)](2011). The studied axial compression and bending test was performed on Plain, Steel & Bamboo reinforced members. As explained in there experimental program, For example, a total of 12 columns (150×150×1000 mm) were cast using design mix (M20) as per IS code. These columns included 3 columns of steel reinforcement, 3 columns of plain concrete, 3 columns of untreated bamboo reinforcement & 3 Columns of treated bamboo reinforcements (with varying percentage of reinforcement; i.e. 3, 5, & 8%). The load

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deformation curves displayed significant nonlinearity, indicating that the bamboo has the capacity to absorb energy. Failure of Columns predominately occurred in shear under compressive loading. Plain concrete and untreated bamboo columns showed brittle behavior in which, tiny cracks occurred at the surface of the column 7 at about 80% of maximum axial force. There were no visible signs of spoiled concrete covering to warn of impending failure.

III. AIM

To study the property of bamboo and use the same in analysis and designing of multistory building as replacement for steel reinforcement.

IV. OBJECTIVES

- To experimentally study the property of bamboo and select the relevant property of bamboo for analysis of the building
- To analyse the building by applying the property of the bamboo using ETABS software
- To compare the behaviour of multi-storey building by using bamboo as replacement for steel reinforcement.

V. METHODOLGY

- The required properties of bamboo are selected
- Properties are used in ETABS software to create a new material, i.e. bamboo
- Analysis and Design for Multistory building has been carried out by applying the material property of conventional RCC.
- Analyze and Design for Multistory building has been carried out by applying the new material property of bamboo and comparing with the conventional RCC.
- Feasibility Study of Bamboo as Replacement for Steel

VI. RESULT

DESIGN OF A STEEL REINFORCED BEAM

- Design a steel reinforced concrete beam using **Limit State Method** for span 150 MM X 150 MM X 700 MM

RCC Beam Self Weight = 0.15 X 0.15 X 0.7 X 25 = 0.4 KN

Wall Load for 3m Height = 0.15 X 3 X 0.7 X 18 = 5.6 KN

TOTAL LOAD = 6.0 KN

- Bending Moment (M) $= \frac{Wl^2}{8} = \frac{4.2\ X 0.7^2}{8}$ = 0.26 KNm
- Factored Bending Moment (M_u) = 0.26 X 1.5 = 0.4 KNm
- From SP-16 $\frac{M_u}{b\ X\ d^2} = \frac{0.4\ X\ 10^6}{150\ X\ 150^2}$ = 0.118 ≈ 0.2

P_t = 0.07

$A_{st} = \frac{\text{Pt X b X d}}{100} = \frac{0.07\ X\ 150\ X\ 150}{100}$ = 15.75 mm^2

- Minimum Reinforcement in Beam (Main)

$A_{st\ min} = \frac{0.85\ \text{X b X d}}{f_y} = \frac{0.85\ X\ 150\ X\ 150}{500}$ = 38.25 mm^2

- Minimum Shear Reinforcement

$\frac{A_{SV}}{bS_v} = \frac{0.4}{0.87\ f_y}$ $\frac{2\ X\ \pi\ X\ (8^2/4)}{150\ X\ S_v} = \frac{0.4}{0.87\ X\ 500}$ = 728.77mm

∴ S_V = 728.77 mm

DESIGN OF A BAMBOO REINFORCED BEAM

1.Design a steel reinforced concrete beam using **Limit state method** of span 150 MM X 150 MM X 700 MM

RCC Beam Self Weight = 0.15 X 0.15 X 0.7 X 25 = 0.4 KN

Wall Load for 3m Height = 0.15 X 3 X 0.7 X 18 = <u>5.6 KN</u>

TOTAL LOAD = 6.0 KN

- Bending Moment (M) $= \frac{Wl^2}{8} = \frac{4.2\ X 0.7^2}{8} = 0.26$ KNm
- From SP-16 $\frac{M_u}{b\ X\ d^2} = \frac{0.26\ X\ 10^6}{150\ X\ 150^2} = 0.077$

$P_t = 0.07$

$A_{st} = \frac{\text{Pt X b X d}}{100} = \frac{0.07\ X\ 150\ X\ 150}{100} = 15.75\ \text{mm}^2$

- Minimum Reinforcement in Beam (Main)

$A_{st\ min} = \frac{0.85\text{ X b X d}}{f_y} = \frac{0.85\text{ X }150\text{ X }150}{15.5} = 1233.87\ \text{mm}^2$

- Minimum Shear Reinforcement

$\frac{A_{SV}}{bS_v} = \frac{0.4}{0.87\ f_y} \qquad \frac{2\ X\ \pi\ X\ (16^2/4)}{150\ X\ S_v} = \frac{0.4}{0.87\ X\ 15.5}$

⍰ S_V = 90.25 mm ≈ 100 mm

2.Design a steel reinforced concrete beam using **Working State method** of span 150 MM X 150 MM X 700 MM

RCC Beam Self Weight = 0.15 X 0.15 X 0.7 X 25 = 0.4 KN

Wall Load for 3m Height = 0.15 X 3 X 0.7 X 18 = <u>5.6 KN</u>

TOTAL LOAD = 6.0 KN

Here we use M25 Grade of concrete and Bamboo as reinforcement

- M25 → σ_{cbc} = 8.5 N/mm²
- Bamboo → σ_{st} = 15.5 N/mm²
- To identify the design Constants

b = 150 mm

$m = \frac{280}{3\ X\ \sigma cbc} = \frac{280}{3\ X\ 8.5} = 10.98$

- Neutral Axis

$k = \frac{m\ X\ \sigma cbc}{m\ X\ \sigma cbc + \sigma st} = \frac{10.98\ X\ 8.5}{10.98\ X\ 8.5 + 15.5} = \frac{93.33}{108.83} = 0.9$

- Lever Axi $J = 1 - \frac{k}{3} = 1 - \frac{0.2}{3} = 0.69$

$Q = \frac{1}{2}\ X\ \sigma_{cbc}\ X\ j\ X\ k = \frac{1}{2}\ X\ 8.5\ X\ 0.69\ X\ 0.9$

$= 2.63\ \text{N/mm}^2$

- Total Load x Overall Depth of beam

W = 4.2 KN/m = 4200 N/m

Max B M = $\frac{Wl^2}{8} = \frac{4200 \text{ X} 0.7^2}{8}$ = 257.25 Nm = 257.25 X 10^3 Nmm

Area of steel required = $A_{st} = \frac{M}{\sigma st \text{ X } j \text{ X } d} = \frac{257.25 \text{ X} 10^3}{15.5 \text{ X } 0.69 \text{ X } 150}$

= 160.35 mm^2

18 mm Φ bars

- Minimum Shear Reinforcement $\frac{A_{SV}}{bS_v} = \frac{0.4}{0.87 f_y}$ $\frac{2 \text{ X } \pi \text{ X } (8^2/4)}{150 \text{ X } S_v} = \frac{0.4}{0.87 \text{ X } 500}$ = 728.77mm

∴ S_V = 728.77 mm

BAMBOO TREATMENT

The preservative used could also be a mix of boric acid and borax which end within the formation of disodium octaborate, which is definitely soluble in water. Boron salts are effective against borers, termites and fungi (except disease fungi). After treatment, the salt remains in the bamboo after water evaporates.

Table 1. Some specific properties of bamboo

Specific gravity	0.575 to 0.655
Modulus of elasticity	1.5 to 2.0 x 105 kg/cm2
Ultimate compressive stress	794 to 894 kg/cm2
Safe working stress in tension	160 to 350 kg/ cm2
Safe working stress in shear	115 to 180 kg/cm2
Safe working stress in compression	105 kg/ cm2
Bond stress	5.6 kg/cm2

TENSILE STRENGTH TEST ON BAMBOO SPECIMEN

Procedure

1. Measure the original length and diameter of the specimen.
2. Insert the test piece into the handle of the testing machine and attach the strain gauge to it
3. Start the application of load and note down the load versus elongation data.
4. Take measurements more often when yield strength is reached.
5. Measure elongation values with a Scale.
6. Continue the process till the specimen undergoes fracture
7. Join the broken pieces of the specimen and record the final length and diameter

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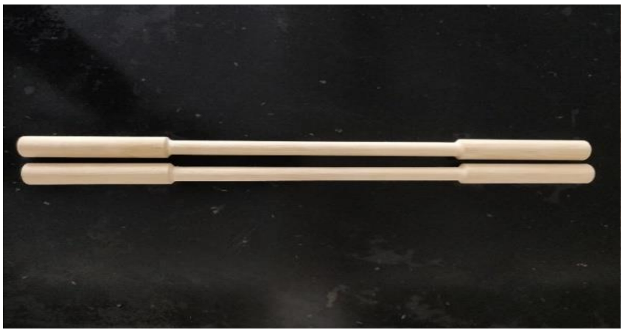

BEFORE TEST

AFTER TEST

Result : The Fracture occurs at 10KN load

DESIGN IN ETABS

ETABS is an engineering software product that can meet the analysis and design needs of multi-story buildings. Modeling tools and templates, code-based load regulations, analysis methods and solution techniques are coordinated with the unique grid-like geometry of this type of structure. You can use ETABS to evaluate basic or advanced systems under static or dynamic conditions.

Below is the design and analysis of Ten, Five and Two storey building using bamboo and steel as reinforcement.

Table 2. Input Value

Support condition	Fixed
Number of story	G+2, G+5, G+10
Grade of concrete	M25
Grade of steel	HYSD500 and BAMBOO
Size of plan	9m X 9m
Type of plan	Symmetrical
Floor to floor height	3m
Ground floor height	3.5m
Slab thickness	150mm

Table 3. Loading condition data

Design variable	Value
Live load on all foors	2KN/m^2
Super Dead load	0.8KN/m^2
Wall load on peripheral beams	10.8KN/m^2
Response reduction factor (R)	5
Zone factor (Z)	1
Importance factor (I)	1

Table 4. Column and Beam detail of structure

	Column	Beam
G+2	250X250	300X250
G+5	300X300	300X250
G+10	400X400	300X250

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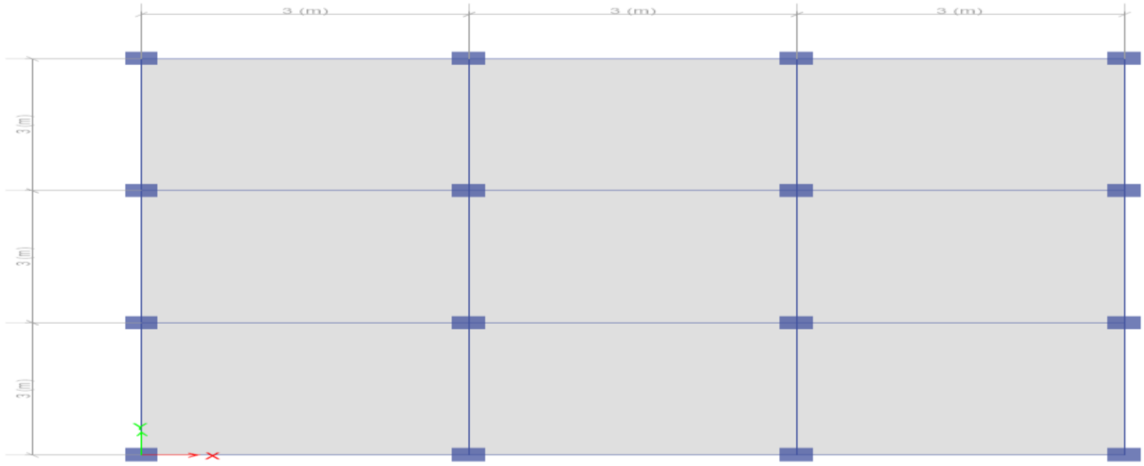
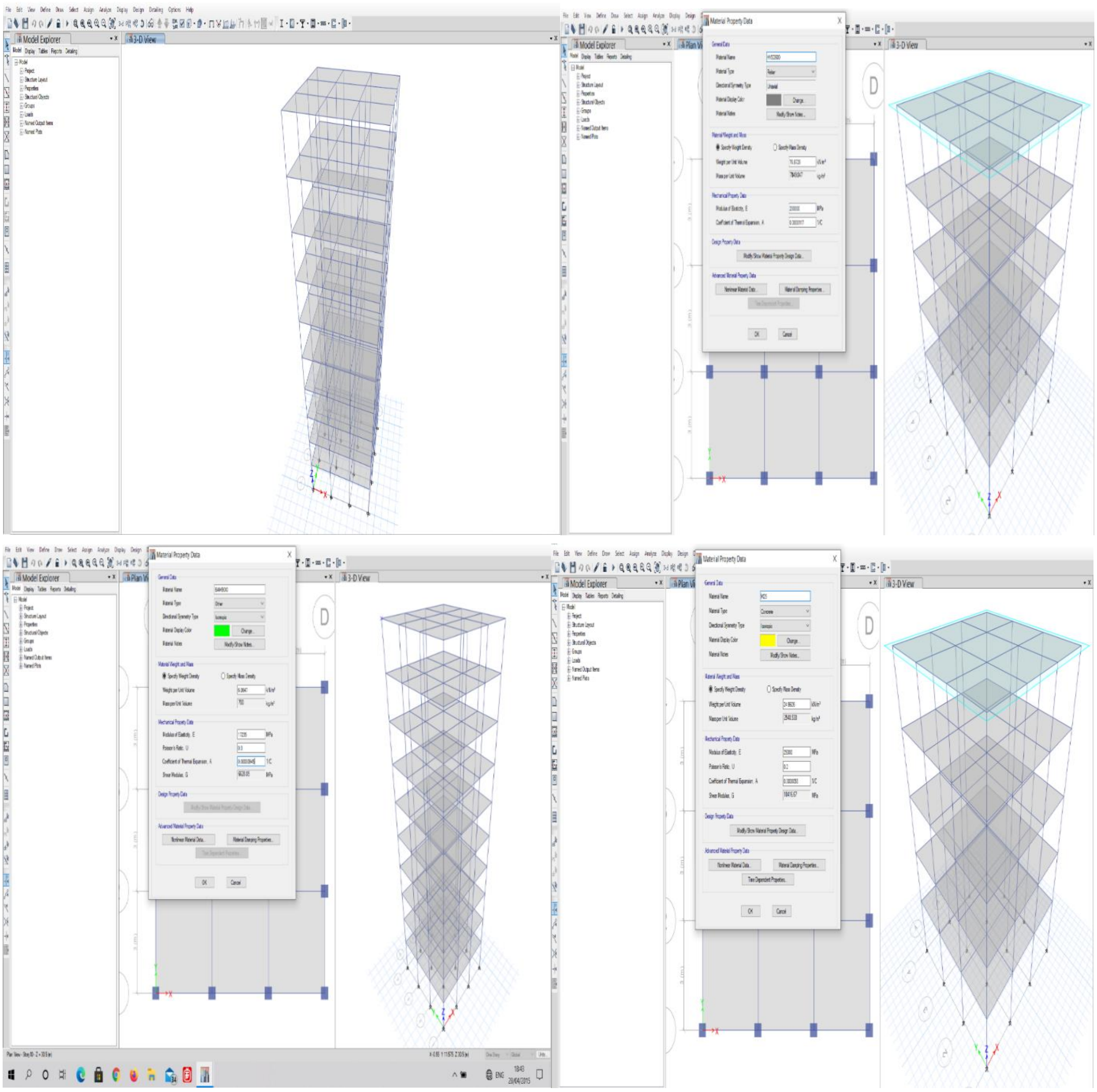




An analytical study on multi-story building of G+2, G+5 and G+10 stores were carried for steel reinforcement and bamboo reinforcement. The structural responses on base reaction, joint displacement, and axial load are analyzed using Static Analysis method. Concrete, steel and bamboo quantities required for the frame structure is calculated and are represented below.

BASE REACTION Fz (KN)

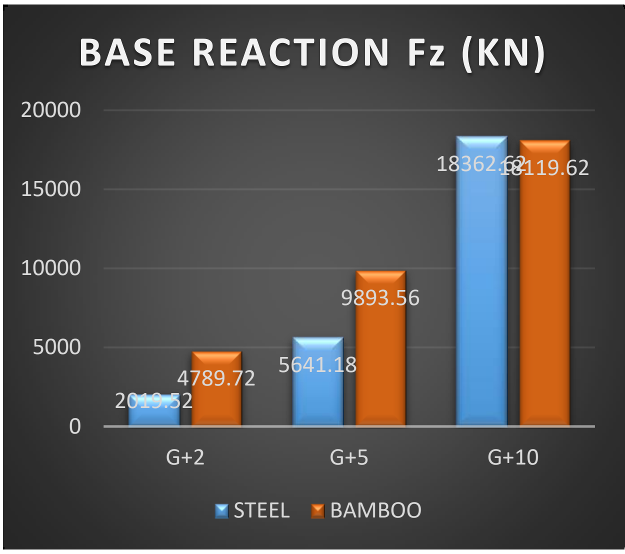
Base Reaction is an estimate of the maximum expected lateral force on the base of the structure.

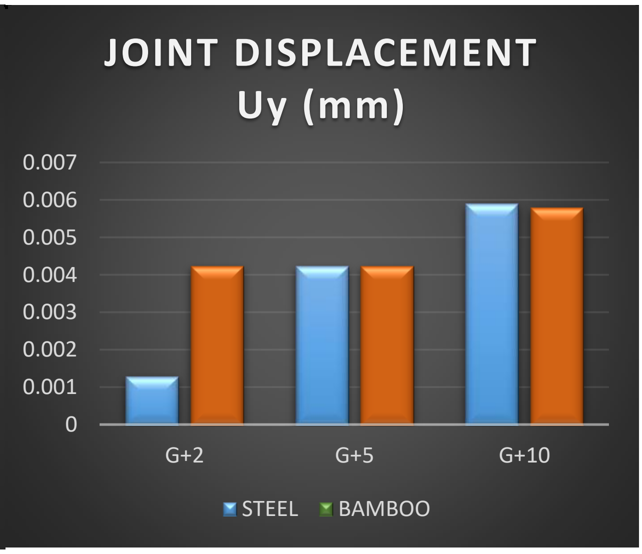
Table 5. Base Reaction For Steel

BASE REACTION FOR STEEL F_z (KN)		
G+2	2019.52	1.5(D.L+L.L)
G+5	5641.18	1.5(D.L+L.L)
G+10	9559.57	1.5(D.L+L.L)

Table 6. Base Reaction For Bamboo

BASE REACTION FOR BAMBOO F_z (KN)		
G+2	4789.72	1.5(D.L+L.L)
G+5	9893.56	1.5(D.L+L.L)
G+10	18119.62	1.5(D.L+L.L)





JOINT DISPLACEMNTS UY (mm)

Joint Displacement is the distance from which one node or element moved from its original location

Table 7. Joint Displacement For Steel

JOINT DISPLACEMENT FOR STEEL Uy (mm)		
G+2	0.00129	1.5(D.L+L.L)
G+5	0.004232	1.5(D.L+L.L)
G+10	0.005904	1.5(D.L+L.L)

Table 8. Joint Displacement For Bamboo

JOINT DISPLACEMENT FOR BAMBOO Uy (mm)		
G+2	0.004237	1.5(D.L+L.L)
G+5	0.004232	1.5(D.L+L.L)
G+10	0.005996	1.5(D.L+L.L)

AXIAL LOAD

Axial load is outlined as applying a force on structure directly on associate degree axis of the structure. Here Column 1 is Center column, Column 2 is Corner Column and Column 3 is Edge Column

Table 9. Axial Load For Steel

AXIAL LOAD FOR STEEL			
	C1	C2	C3
G+2	201.0915	71.163	116.3139
G+5	499.2197	229.1861	340.9458
G+10	1215.998	990.2943	1192.183

Table 10. Axial Load For Bamboo

AXIAL LOAD FOR BAMBOO			
	C1	C2	C2
G+2	319.3033	239.1891	312.4699
G+5	569.3429	429.7687	557.9429
G+10	1191.358	982.1938	1178.177

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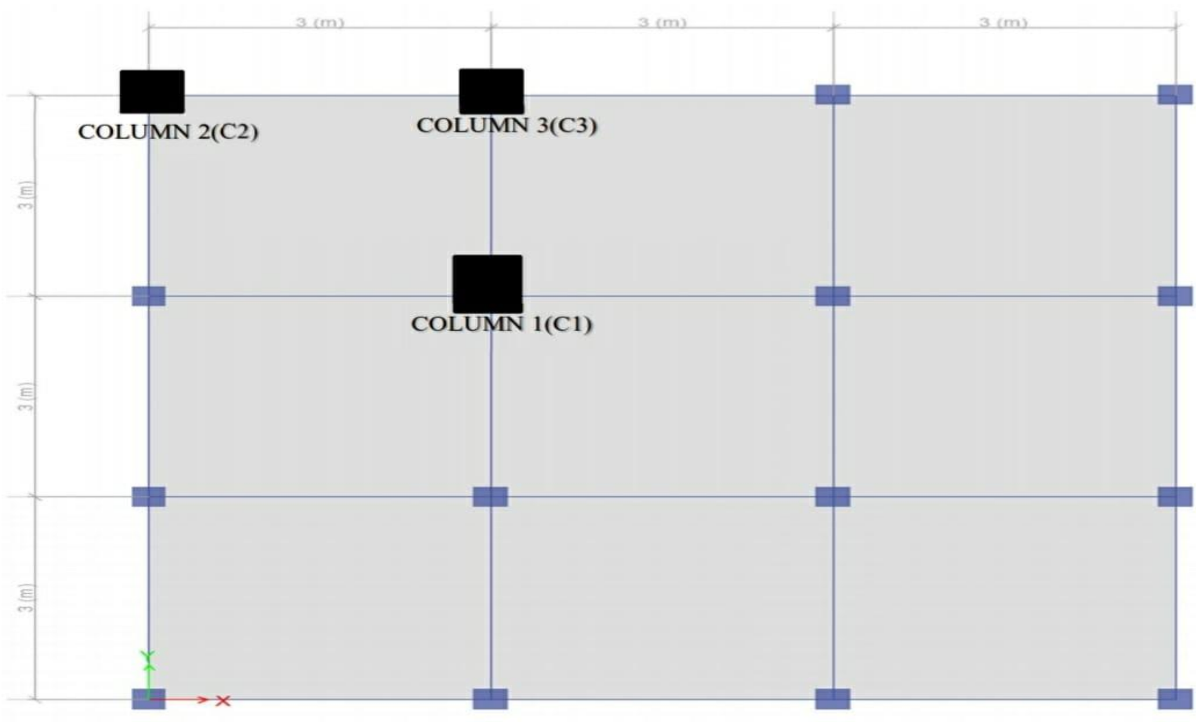
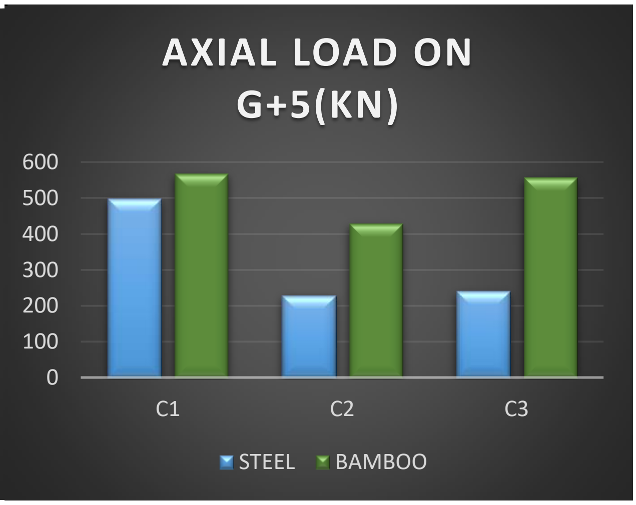
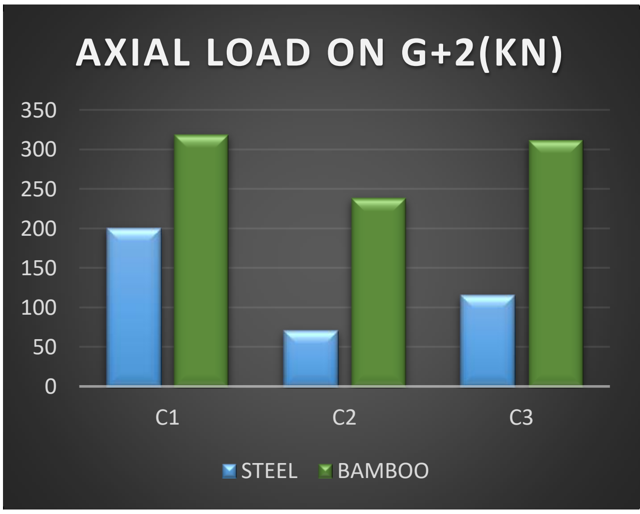






CONCRETE QUANTITY

Table 11. Concrete Quantity of Steel Reinforced Structure

Concrete Quantity for Bamboo RC(m3)	
G+2	17.05
G+5	48.94
G+10	125.19

Table 12. Concrete Quantity of Bamboo Reinforced Structure

Concrete Quantity for Steel RC(m3)	
G+2	17.25
G+5	49.57
G+10	126

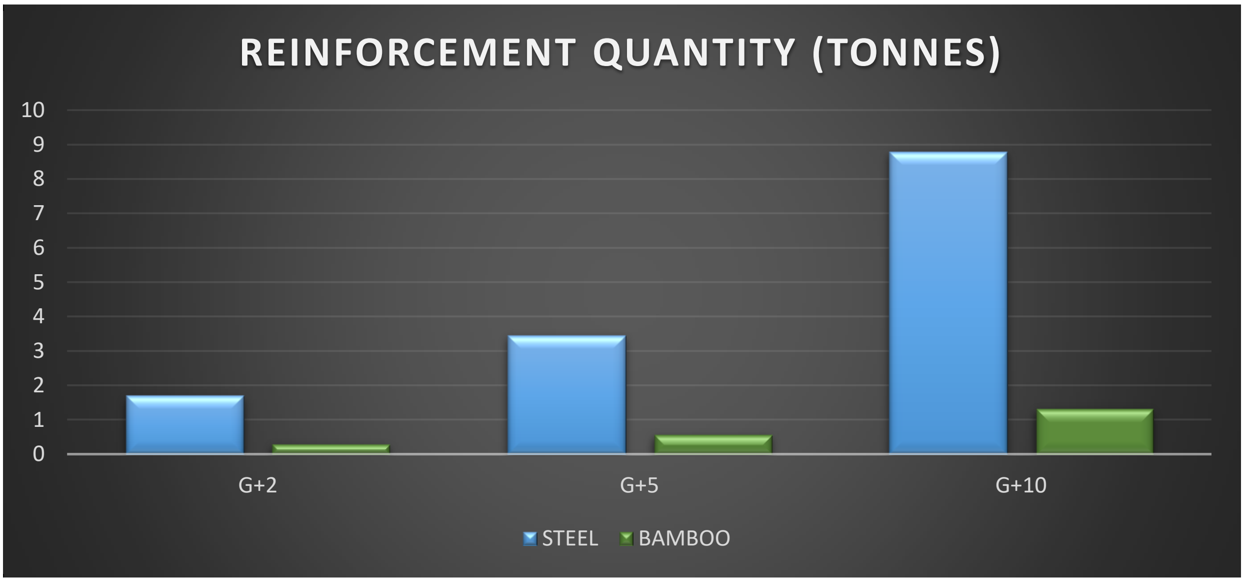
STEEL QUANTITY, BAMBOO QUANTITY

Table 13. Steel Quantity

STEEL QUANTITY(Tonnes)	
G+2	1.705
G+5	3.453
G+10	8.979

Table 14. Bamboo Quantity

BAMBOO QUANTITY(Tonnes)	
G+2	0.2931
G+5	0.5693
G+10	1.311



VII. CONCLUSION

From the analysis of different models of G+2, G+5 and G+10 building the following points can be concluded.

- Base reaction increases by 57.83% for G+2, 42.98% for G+5, 47.42% for G+10, with respect to Bamboo reinforcement with RCC.
- Joint Displacement increases by 69.55% for G+2, 0% for G+5, 1.53% for G+10, with respect to Bamboo reinforcement with RCC.
- Axial Load increases by 37.02% for Column 1, 70.25% for Column 2, 62.77% for Column 3, with respect to Bamboo reinforcement with RCC for G+2.
- Axial Load increases by 12.31% for Column 1, 46.67% for Column 2, 38.89% for Column 3, with respect to Bamboo reinforcement with RCC for G+5.
- Axial Load increases by 2.02% for Column 1, 0.817% for Column 2, 1.175% for Column 3, with respect to

RCC with Bamboo reinforcement for G+10.

- Concrete quantity increases by 1.15% for G+2, 1.27% for G+5, 0.64% for G+10, with respect to RCC with Bamboo reinforcement.

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