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RESEARCH ARTICLE

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EXPERIMENTAL INVESTIGATIONS ON DEFORMATIONS OF BAMBOO REINFORCED CONCRETE COLUMNS

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ABSTRACT

Bamboo is one of the oldest and most versatile building materials with many applications in the field of construction, particularly in developing countries. The diminishing wood resource and restrictions imposed on felling in natural forests, particularly in the tropics, have focused world attention on the need to identify a substitute material which should be renewable, environmentally friendly and widely available. In this paper, the work concentrates on the structural strength of concrete column reinforced with bamboo strips. Experimental work includes load capacity test, deflection and failure patterns observation of ten concrete columns. Bamboo strips of coated seasoned bamboo of variable cross-section, due varying thickness (4 to 6mm) and width of (8 to12mm) were used to reinforce the concrete columns in varying percentage (2% and 4%).The purpose was to study the feasibility of using bamboo as the reinforcing material in precast concrete column element. A comparison has been made between the steel reinforced and bamboo reinforced column. The investigation result reveals that the use of bamboo splints as reinforcement in concrete columns has improved the load carrying capacity of the column, not equal to steel and all columns failed in a similar pattern due to crushing of concrete.

Keywords: BRC, bamboo splints, axial and lateral deformations, epoxy resin

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1. INTRODUCTION

The haphazard infrastructural growth is leading to rapid environmental degradation. Steel, cement, synthetic polymers and metal alloys used for construction activities are energy demanding as well as cause environmental pollution during their entire life cycle.

Bamboo is one of the oldest materials used for the construction of houses and other structures. As an excellent building materials it is relatively cheap, easy to work with and readily available in most ofthe countries where bamboo grows. Of all the advantages of bamboo housing technology, the most important is its low cost that does not sacrifice quality, durability or space.Favourable mechanical properties, high flexibility, low weight and availability at reasonable cost bamboos rebuilding material with many opportunities. In India and China bamboo is used in construction of temporary suspension bridges. The strength of bamboo is greater than most timber products which are advantageous, but it is approximately half the tensile strength of steel.

Bamboo occurs in tropical, subtropical and temperate regions of the world, wherever suitable ecological factor exist. Accordingly it is found in the belt extending from India to Japan (including China and South East Asia), in Africa and Australia, and in the region extending from Southern United States to Argentina and Chile.

Bamboo is a composite material, consisting of long and parallel cellulose fibres embedded in a ligneous matrix. The density of the fibres in the cross-section of a bamboo shell varies along its thickness. Bamboo attains its greatest strength after three years, when it assumes a brownish colour.The bamboo average tensile strength is approximately 280 MPa in the specimens without node and 100 MPa with those with node. The maximum compressive strength and young modulus of one-In addition, the coefficient of thermal expansion of bamboo is as low as one-third that of concrete longitudinally and ten times diametrically year bamboo was 51 and 2834MPa respectively while that of three-year old are 86 and 5993MPa modulus of elasticity as ranging from 15833 to 22843 MPa.Bamboo is seismically resisting material and for sustainable environment development without harming our global environment since it absorbs a lot of nitrogen and carbon dioxide from the atmosphere during its growth. The applications of bamboo include earthquake resistant material, low cost housing and an alternative to steel in low rise structures.

Objectives of the work

The objectives were to:

1) Determine the load carrying capacity of BRC column.
2) Deflection of BRC column elements under axial load.

LITERATURE REVIEW

Prof. M. R. Wakchaure, Prof. U. R. Awari, Ajinkya Kaware investigated the design and testing of Bamboo reinforced concrete column to be casted with bamboo reinforcement varying from 2.5 % to 4 % at an increment of 0.5 with 3 rectangular specimen of size 230 X 150 X 750 mm3, 3 specimen of square column 150 X 150 X 750 mm3 and 230 mm diameter and 750 mm length 3 circular specimens for each increment in reinforcement. Above mentioned column are compared with steel reinforced concrete column of similar dimension, numbers and shape with minimum steel reinforcement as mentioned in IS 456: 2000.

Dr. Patel Pratima A., Maiwala Adit R., Gajera Vivek J., Patel Jaymin A., Magdallawala Sunny investigated the validation and justification of bamboo strips to confirm the application of bamboo as reinforcement element. Bamboo can be a substitute of steel in reinforcing of concrete structure. Various physical and mechanical properties like compressive strength, tensile strength, flexural test, bonding strength, water absorption, density etc. is determined in material testing laboratory.

Chandra Sabnani, Madhuwanti Latkar and Utpal Sharma researched a design using bamboo as one of the chief structural materials, for a safe and durable house, affordable by the urban poor.The design thus evolved shall clearly indicate the cost reduction of the superstructure where steel reinforced concrete is replaced by bamboo reinforced concrete in key structural elements.

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Satish Pawar investigated theutilization of bamboo as a construction /structural element in various building components such as floor, roof, beam, wall-panels, columns etc. An engineered Bamboo can substitute steel in making tensile stresses of RCC members and also reduces the consumption of cement in building.

INVESTIGATIONS AND METHODOLOGY

A. Basic assumptions for columns

A.1. The maximum compressive strain in concrete in axial compression is taken as 0.002.

A.2. Strain in concrete and bamboo are equal.

A.3. Stress in bamboo is governed by characteristic stress –strain curve of bamboo in compression. The stress-strain curve of bamboo in compression is the same as in tension.

A.4. The column is short if Le/h ≤ 12

B. Reinforcement Preparation

Bamboo culm was cut into splints of cross sectional size of (8 to 12) mm and (4 to 6) mm, as longitudinal reinforcing bars required percentage of reinforcement. Splints are cut for 800 mm length for columns. Four splints are used along the length of column. Waterproof chemical material 'EPOXY RESIN coating was applied in a thin coat using a paintbrush. A thin coat is necessary to achieve good bond Spacing of lateral ties as per Indian standard, a distance of 120mm c/c with an extra tie at ends of column, placed 25 mm away from extreme ties. 3 test columns were namely steel column (150 X 230mm, 1.31% steel reinforcement of area = 452.7mm^2), BRC I (2.19% bamboo reinforcement of area = 755.5mm^2) and BRC II (4.18% bamboo reinforcement of area = 1442mm^2).

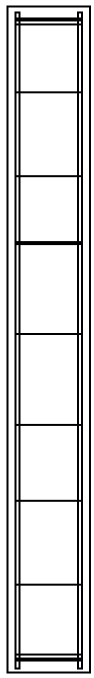


Fig.1 BRC (150X 230 mm C/S with 850 mm height)

C. Test Set-Up and Instrumentation for column:

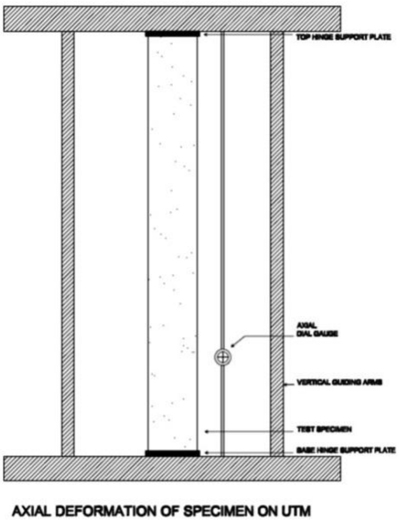


Fig.2 Axial Dial Gauge and Support Attachment

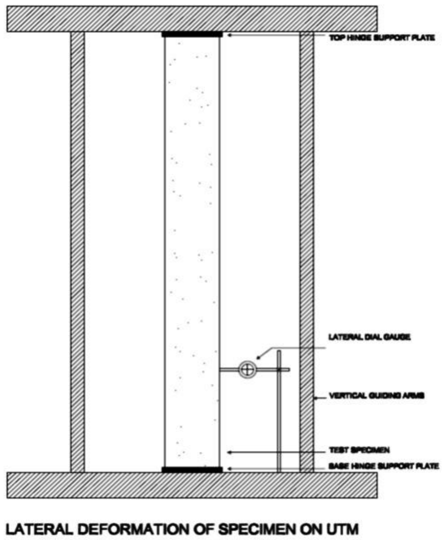


Fig.3 Lateral Dial Gauge and Support Attachment

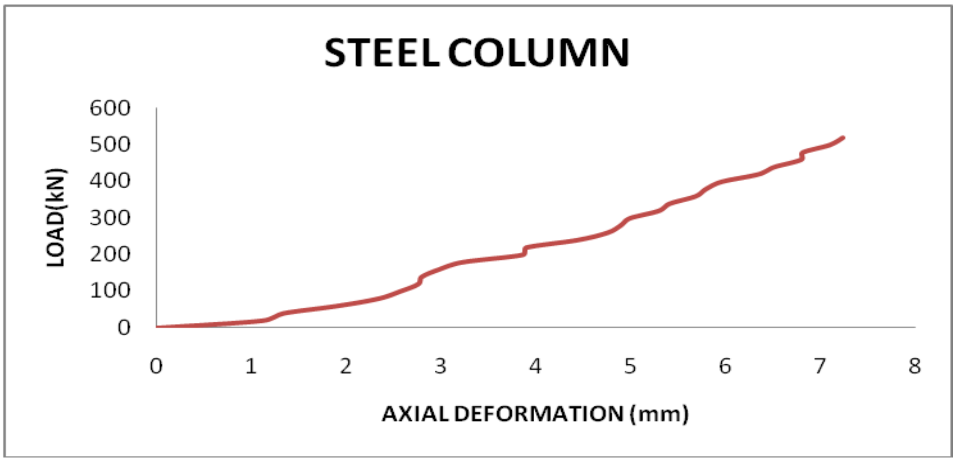
RESULTS AND DISCUSSIONS

Table 1: Compressive Strength Results for Steel Column

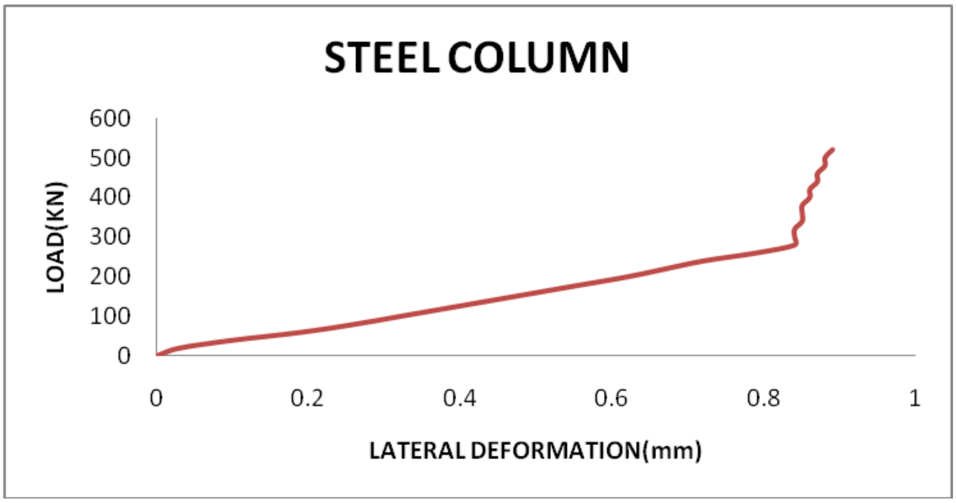
Sr. No	Load(kN)	Axial deformation (mm)	Lateral deformation (mm)
1.	0	0	0
2.	50	1.62	0.14
3.	100	2.57	0.32
4.	150	2.89	0.47
5.	200	3.86	0.62
6.	250	4.59	0.75
7.	300	4.99	0.84
8.	350	5.54	0.85
9.	400	5.96	0.86
10.	450	6.65	0.87
11.	500	7.09	0.88
12.	550	7.45	0.92

Table 2: Results of Behaviour pattern under compression of Steel Column

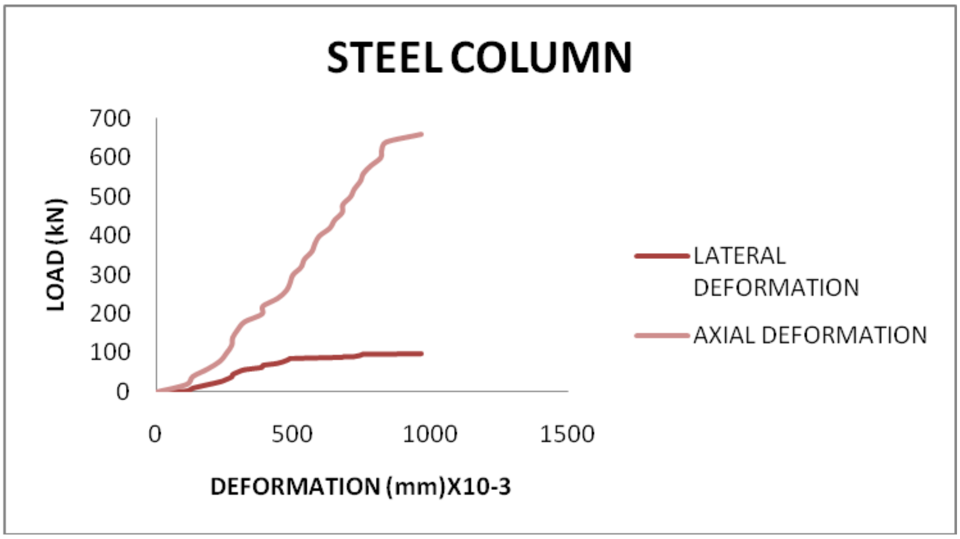
First crack load at (kN)	Followed by another crack(kN)	Position of crack	Vertical crack load(kN)	Widening of crack load in (kN)	Maximum failure load in (kN)
400	450	End supports	500	500	550



Graph 1:Load Vs Axial Deformation for Steel Column



Graph 2: Load Vs Lateral Deformation for Steel Column



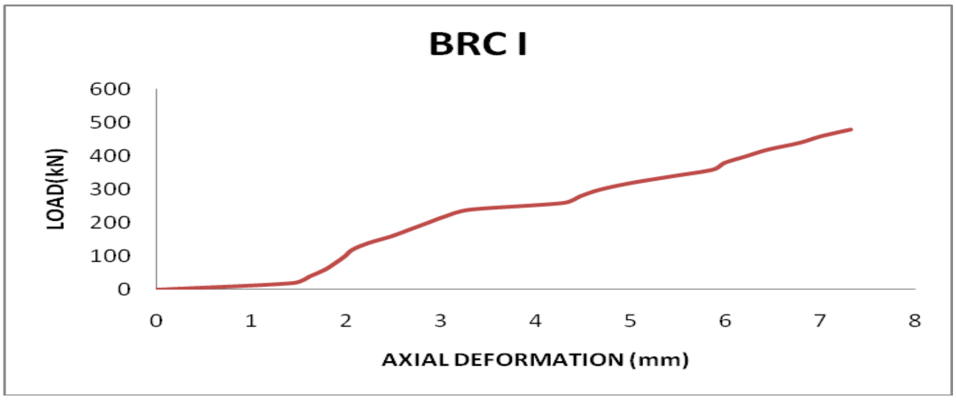
Graph 3: Comparison of Axial and Lateral Deformation w.r.t. Load for Steel Column

Table 3: Compressive Strength Results for BRC I Column

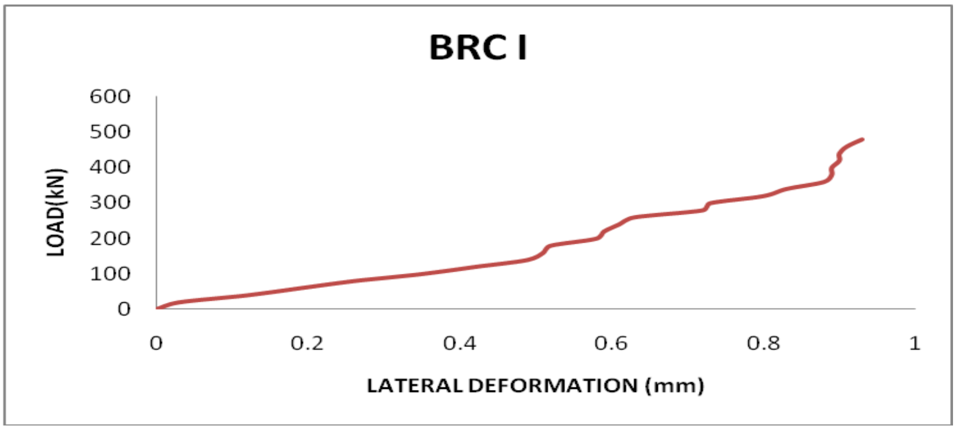
Sr. No	Load(KN)	Axial deformation (mm)	Lateral deformation (mm)
1.	0	0	0
2.	50	1.70	0.16
3.	100	1.99	0.35
4.	150	2.36	0.50
5.	200	2.86	0.58
6.	250	3.80	0.62
7.	300	4.68	0.73
8.	350	5.95	0.82
9.	400	7.27	0.91
10.	450	8.61	0.95
11.	500	8.78	0.96

Table 4: Results of Behaviour pattern under compression of BRC I Column

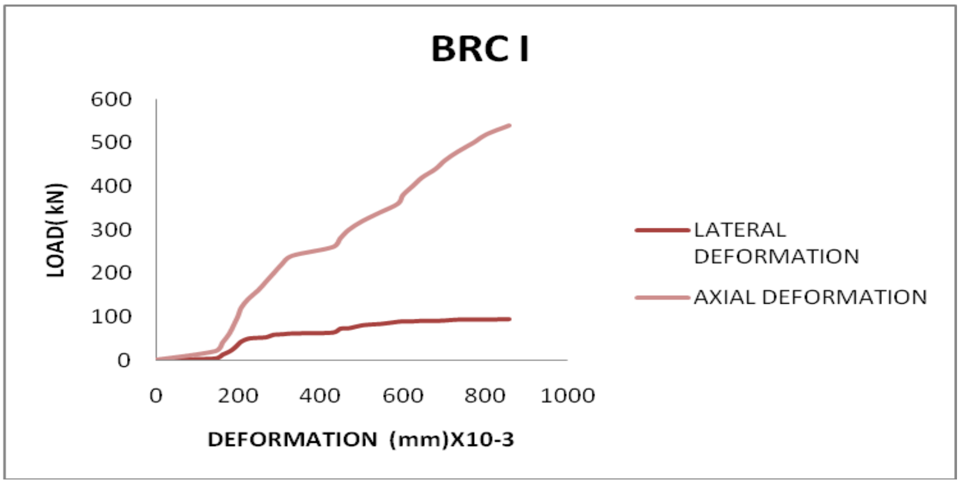
First crack load at (kN)	Followed by another crack(kN)	Position of crack	Vertical crack load(kN)	Widening of crack load in (kN)	Maximum failure load in (kN)
250	400	End supports	400	450	500



Graph 4: Load Vs Axial Deformation for BRC I Column



Graph 5: Load Vs Lateral Deformation for BRC I Column



Graph 6: Comparison of Axial and Lateral Deformation w.r.t. Load for BRC I Column

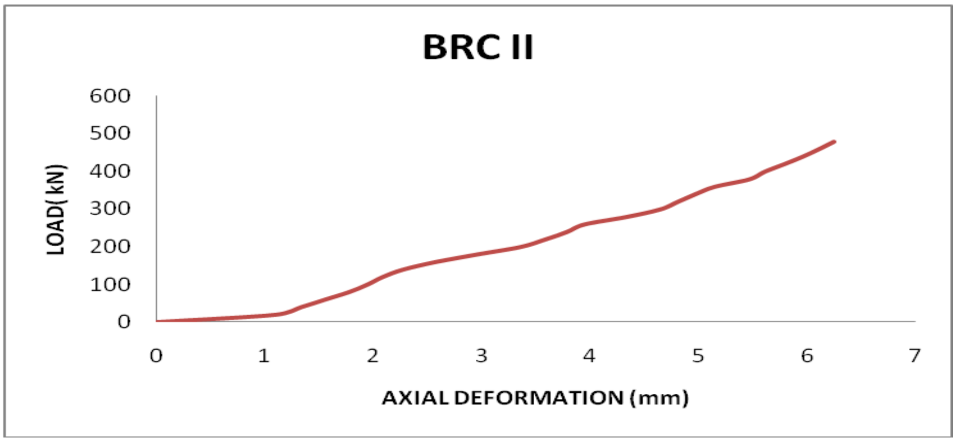
Table 5 Compressive Strength Results for BRC II Column

Sr. No	Load(KN)	Axial deformation (mm)	Lateral deformation (mm)
1.	0	0	0
2.	50	1.45	0.12
3.	100	1.95	0.29
4.	150	2.43	0.48
5.	200	3.36	0.67
6.	250	3.87	0.84
7.	300	4.65	0.89

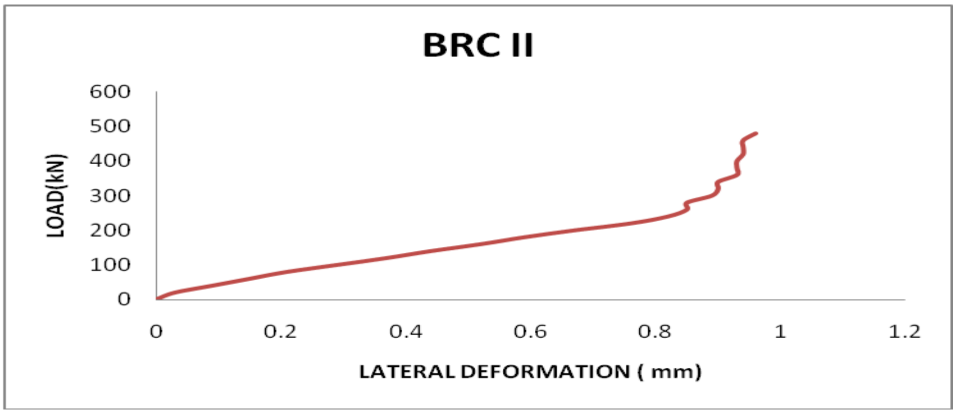
8.	350	5.07	0.91
9.	400	5.61	0.93
10.	450	6.03	0.94
11.	500	6.25	0.96

Table 6: Results of Behaviour pattern under compression of BRCII Column

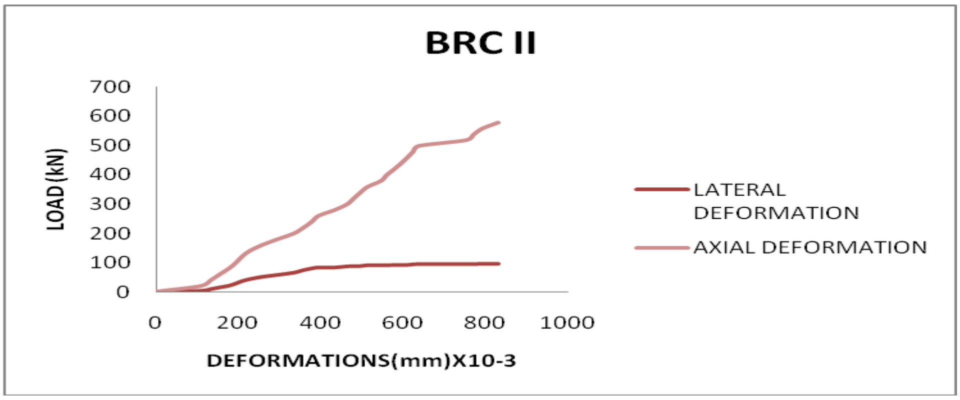
First crack load at (kN)	Followed by another crack(kN)	Position of crack	Vertical crack load(kN)	Widening of crack load in (kN)	Maximum failure load in (kN)
350	450	End supports	450	450	500



Graph 7: Load Vs Axial Deformation for R2B4 I Column



Graph8: Load Vs Lateral Deformation for BRCII Column



Graph9: Comparison of Axial and Lateral Deformation w.r.t. Load for BRCII Column

CONCLUSION

Based on the experiments done on BRC columns, the following conclusions can be drawn:

I. The use of bamboo splints as reinforcement in concrete columns has proved the load carrying capacity of the column, with improved the post cracking ability of the concrete but not equal to steel reinforced column. Increase in the percentage of bamboo do not increase strength but enhances the ductility of the section.

II. Failure mode is independent of the materials used. There is a need in improvement in the bond between concrete and reinforcing bamboo.

III. The bamboo reinforced columns are recommended for light use and low rise structure construction.

IV. The bamboo reinforced columns not suitable in water retaining structures due to large deflections and penetration of moisture through cracks leading to failure.

V. Optimum percentage of bamboo reinforcement should not be more than 4% to avoid the cracks due to swelling and shrinking of bamboo and to maintain clear cover requirements.

FUTURE SCOPE

a) The development of finite element models for each type of Bamboo. This would assist identification of bamboo behaviour with different geometric variables.

b) Low frequency fully cyclic experimental tests should be conducted to identify the behaviour of Bamboo reinforced concrete in earthquake induced ground acceleration.

c) Long term studies investigating the durability of Bamboo reinforced concrete.

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