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ANALYSIS OF BAMBOO REINFORCED CONCRETE COLUMN

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Abstract: Bamboo being a grass and botanically belongs to family "*Poaceae*". It completes its growth within month's time and gets mature within 3 years. In Maharashtra it is commonly named as *"velu"*. Species of bamboo change as per topography and climatic conditions. It has good tensile and compression strength. As per review *dendrocalamus strictus, bambusa vulgaris schard* are species of bamboo which has highest value of tensile and compression strength. This paper represents 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 mm^3, 3 specimen of square column 150 x 150 x 750 mm^3 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. The specimens are tested in UTM.

Key words: 'poaceae','velu', topography and climatic condition, tensile and compression strength, bamboo reinforcement.

I. INTRODUCTION

The development of science & technology is a continuing quest for improvement in infrastructure of world around us. The structures in nature are great lessons for human study only the most eco- friendly structural forms have survived. The profound capacity respond to a variety of climatic and environmental forces, makes a natural form of tremendous exemplars to numerous fields of structural design.

A natural material which is available in bulk and ease of use in the rural areas in the developing countries is bamboo. Bamboos occur mostly in tropical and subtropical areas, from sea level to snowcapped mountain peaks, with a few species reaching into temperate areas.

After some years steel reinforcement may no longer be available. Then we will have to find an alternative to steel, as bamboo being a natural material and is abundantly available in most of the part of earth it can be a replacement for steel in reinforced concrete structure for green building and low cost housing purpose.

The major application of bamboo is for construction and housing. It is estimated that one billion people live in bamboo houses. For ages bamboo has been used in construction and currently they are used as props, foundations, framing, scaffolding flooring, walls, roofs and trusses. Bamboos are tied together to make grid reinforcement and placed in soft clay to solve deformation problems in embankments. In rural part of India mostly bamboo is use as reinforcement in mud walls as it has quit high strength.

In this paper for studying on various issues of bamboo reinforced concrete analysis and comparison of steel and bamboo reinforced column is made.

II. MATERIAL AND METHEDOLOGY

In order to conduct the compression tests, it was necessary to design the axially bamboo reinforced column varying from 2.5 % to 4 % at an increment of 0.5 % with 3 rectangular specimen of size 230 x 150 x 750 mm^3, 3 specimen of square column 150 x 150 x 750 mm^3 and 230 mm diameter and 750 mm length 3 circular specimens for each increment in percentage. The concrete used was of M 20 grade and steel used was Fe 500 MPa. The bamboo

used was of *Dendrocalamus strictus* species and its compression strength was carried out experimentally using IS 6874: 1973 was 66 MPa. The columns were designed as per IS 456: 2000.First, the bamboo samples were cut to the proper size and shape. The thickness, along with the width, differed between the samples because Bamboo is a natural material whose physical properties vary. For this reason a careful dimensioning of the sample was done before utilizing the bamboo. Split bamboo reinforcement should be reasonably straight. Its width should not exceed 20 to 25 mm. While placing, the basal and the distal ends of the reinforcement must be alternated, to obtain a uniform reinforcement area along the length of the member. The bamboo samples were treated with black Japan for water absorption. These bamboo reinforced columns were compared with axially reinforced steel concrete column which design for minimum reinforcement as per IS 456: 2000. These columns were tested under 100T capacity UTM.

III. RESULTS.

TABLE I
Results of bamboo reinforced concrete column.

Sr.No	Percentage Bamboo	Shape	B (mm)	D (mm)	L (mm)	Cross Sec. Area (mm^2)	Peak Comp. load (kN)	Displacement (mm)
1	2.50%	Square	150	150	750	22500	153.5	4.95
2		Square	150	150	750	22500	192.9	5.53
3		Square	150	150	750	22500	181.2	7.45
4		Rectangular	150	230	750	34500	317	12
5		Rectangular	150	230	750	34500	309	7.63
6		Rectangular	150	230	750	34500	177	8
7		Circular	-	230	750	41547.7	329	12.11
8		Circular	-	230	750	41547.7	268	10.55
9		Circular	-	230	750	41547.7	216	14.21
10	3%	Square	150	150	750	22500	142.8	7.83
11		Square	150	150	750	22500	125	6.84
12		Square	150	150	750	22500	170	9.49
13		Rectangular	150	230	750	34500	239.4	12.5
14		Rectangular	150	230	750	34500	208	9.96
15		Rectangular	150	230	750	34500	280	5.57
16		Circular	-	230	750	41547.7	366	9.28
17		Circular	-	230	750	41547.7	155.8	13.23
18		Circular	-	230	750	41547.7	221	8.85
19	3.50%	Square	150	150	750	22500	196.5	7.18
20		Square	150	150	750	22500	180.5	6.19
21		Square	150	150	750	22500	136.2	10.98

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22		Rectangular	150	230	750	34500	290	3.72
23		Rectangular	150	230	750	34500	205	7.32
24		Rectangular	150	230	750	34500	281	10.83
25		Circular	-	230	750	41547.7	360	6.91
26		Circular	-	230	750	41547.7	240	10.83
27		Circular	-	230	750	41547.7	245	7.2
28	4%	Square	150	150	750	22500	105.1	7.05
29		Square	150	150	750	22500	132	8.45
30		Square	150	150	750	22500	185	7.54
31		Rectangular	150	230	750	34500	200	9.78
32		Rectangular	150	230	750	34500	189	6.57
33		Rectangular	150	230	750	34500	285	7.72
34		Circular	-	230	750	41547.7	340	13.37
35		Circular	-	230	750	41547.7	204	9.87
36		Circular	-	230	750	41547.7	211	9.74

TABLE II
Results of steel reinforced concrete column.

Sr.No	Percentage Steel	Shape	B (mm)	D (mm)	L (mm)	C/S Area (mm^2)	Peak Comp. load (KN)	Displacement (mm)
37	2.0%	Square	150	150	750	22500	167.7	8.47
38		Square	150	150	750	22500	208.6	12.76
39		Square	150	150	750	22500	120.4	5.17
40	1.30%	Rectangular	150	230	750	34500	373	10.4
41		Rectangular	150	230	750	34500	174	12.33
42		Rectangular	150	230	750	34500	279	5.35
43	1.60%	Circular	-	230	750	41547.66	370	7.23
44		Circular	-	230	750	41547.66	329	11.41
45		Circular	-	230	750	41547.66	258	11.18

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Fig. 1 - Compression test on circular bamboo reinforce concrete column.

Fig. 2 - Failure of rectangular bamboo reinforce concrete column.

Fig. 3 - Failure of square bamboo reinforce concrete column

TABLE III

Comparison of Analytical and Experimental Values of Peak Load of Bamboo Reinforced Column

Analytical values are calculated as per the design of Bamboo reinforced concrete columns.

Sr.No	Percentage Bamboo	Shape	Peak Comp. load (kN)	Analytical Load (kN)	Area Bamboo (mm^2)
1	2.50%	Square	153.5	129.17	637.76
2		Square	192.9	132.70	682.16
3		Square	181.2	131.98	657.40
4		Rectangular	317	205.00	1055.17
5		Rectangular	309	204.40	1020.12
6		Rectangular	177	198.32	871.76
7		Circular	329	251.24	1063.68
8		Circular	268	251.04	1058.20
9		Circular	216	251.31	1066.42
10	3%	Square	142.8	132.69	682.88
11		Square	125	138.38	871.28
12		Square	170	133.78	720.16
13		Rectangular	239.4	203.72	1053.60
14		Rectangular	208	202.17	1001.40
15		Rectangular	280	203.70	1052.68
16		Circular	366	257.63	1269.77
17		Circular	155.8	257.38	1261.12
18		Circular	221	257.81	1275.64
19	3.50%	Square	196.5	136.19	798.68
20		Square	180.5	139.80	922.28
21		Square	136.2	149.11	1235.82
22		Rectangular	290	208.31	1208.92
23		Rectangular	205	208.71	1224.48
24		Rectangular	281	209.11	1235.28

25		Circular	360	263.82	1468.76
26		Circular	240	259.03	1314.10
27		Circular	245	264.10	1477.40
28	4%	Square	105.1	140.10	930.16
29		Square	132	141.85	996.88
30		Square	185	149.74	1256.60
31		Rectangular	200	213.16	1386.16
32		Rectangular	189	216.41	1485.52
33		Rectangular	285	215.09	1436.56
34		Circular	340	263.57	1460.80
35		Circular	204	265.19	1512.12
36		Circular	211	275.75	1851.02

TABLE IV

Comparison of Analytical and Experimental Values of Peak Load of Steel Reinforced Column

Analytical values are calculated as per the design of steel reinforced concrete columns.

Sr.No	Percentage Steel	Shape	Peak Comp. load (kN)	Analytical Load (kN)	Area Steel (mm^2)
1	2.0%	Square	167.7	196.12	452
2		Square	208.6	196.12	452
3		Square	120.4	196.12	452
4	1.3%	Rectangular	373	256.12	452
5		Rectangular	174	256.12	452
6		Rectangular	279	256.12	452
7	1.6%	Circular	370	349.82	678
8		Circular	329	349.82	678
9		Circular	258	349.82	678

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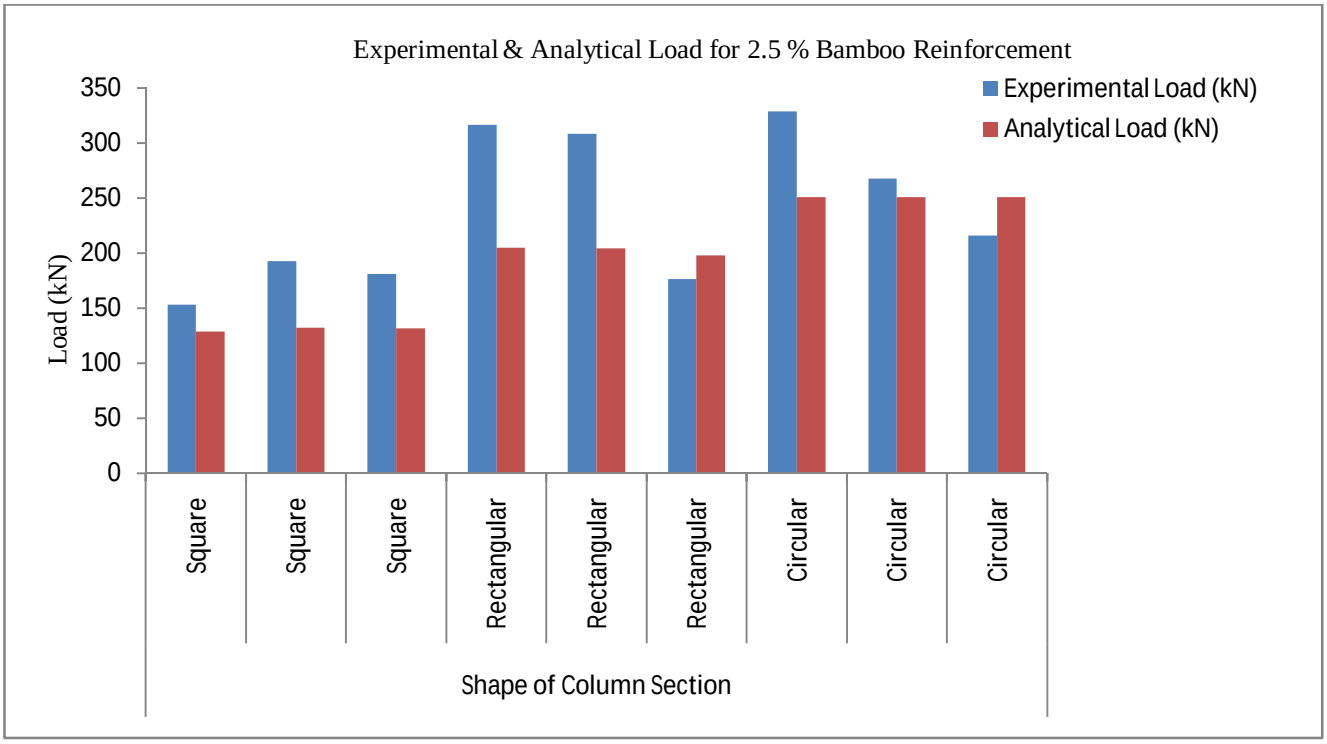
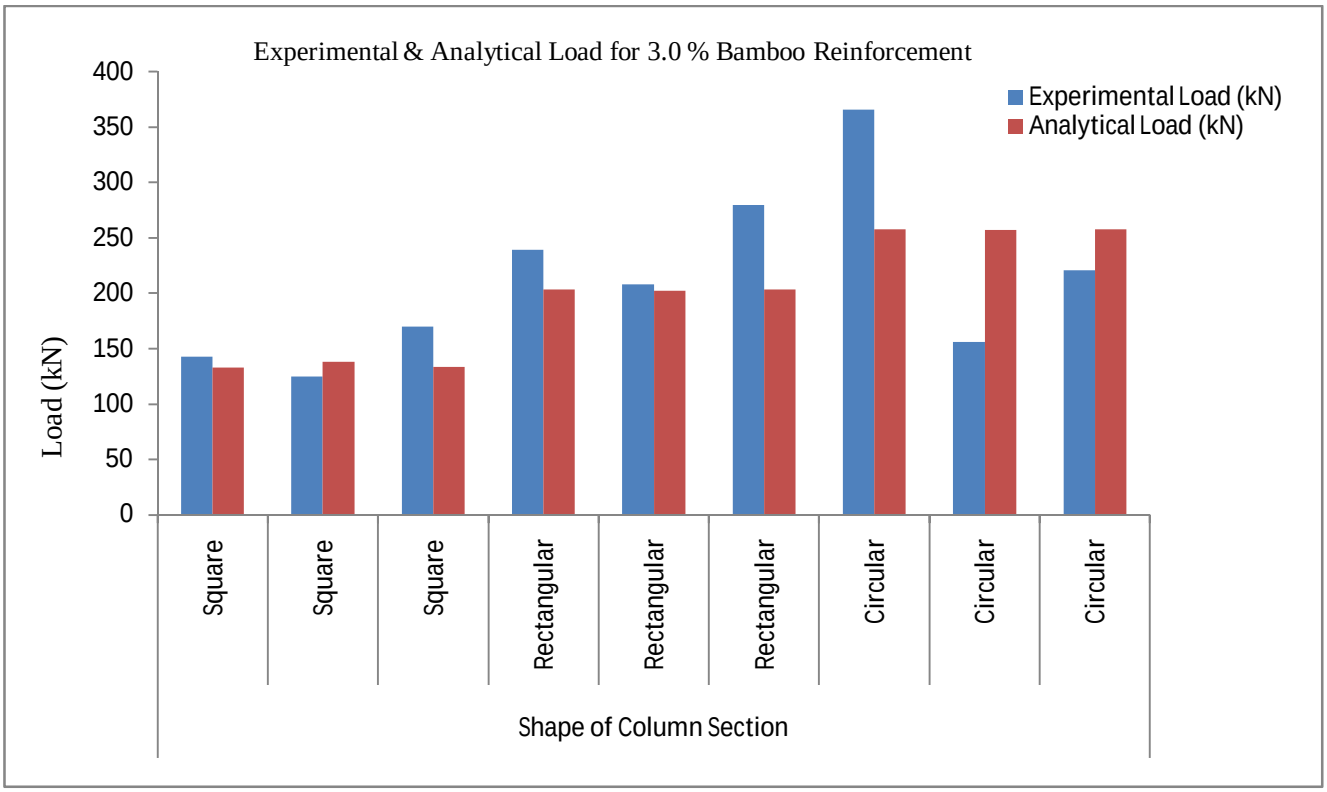


Graph 1 - Experimental & Analytical Load for 2.5 % Bamboo Reinforcement



Graph 2 - Experimental & Analytical Load for 3 % Bamboo Reinforcement

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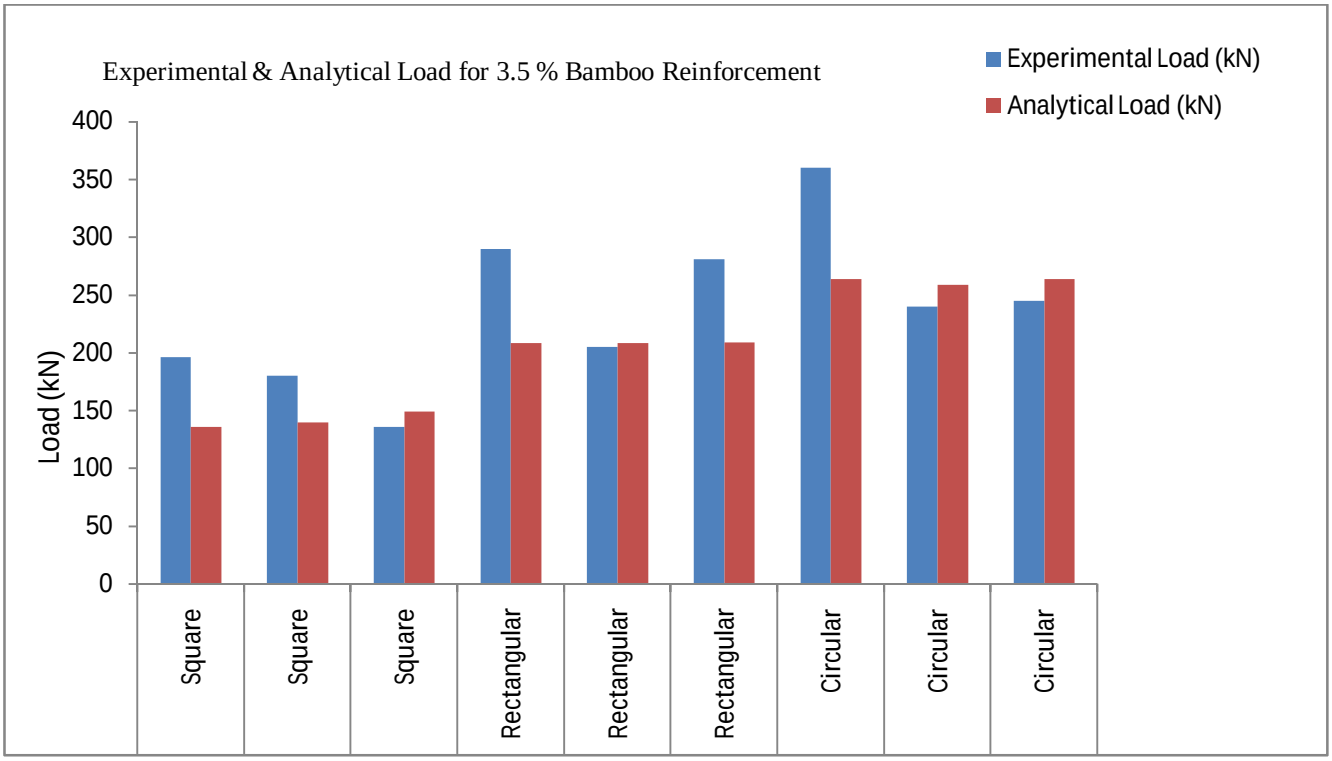
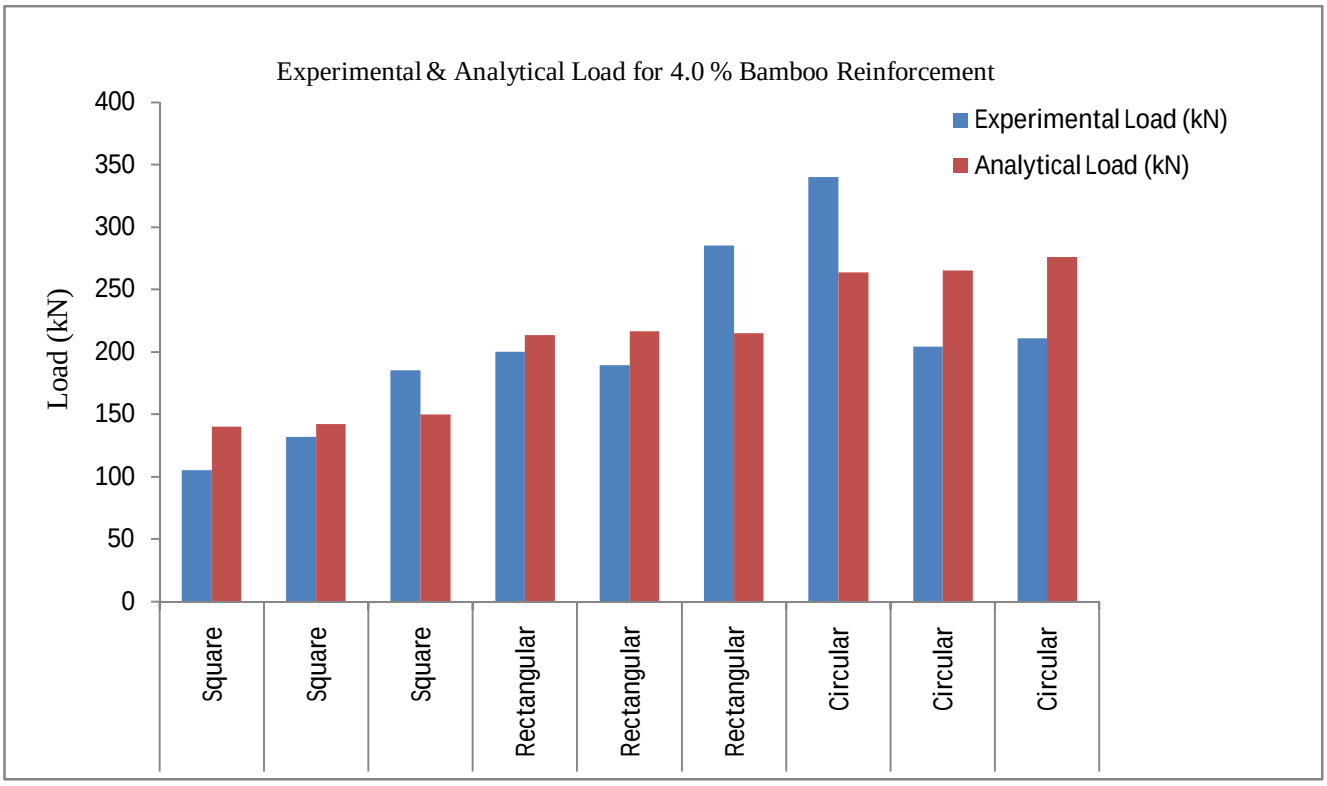


Graph 3 - Experimental & Analytical Load for 3.5 % Bamboo Reinforcement



Graph 4 - Experimental & Analytical Load for 4 % Bamboo Reinforcement

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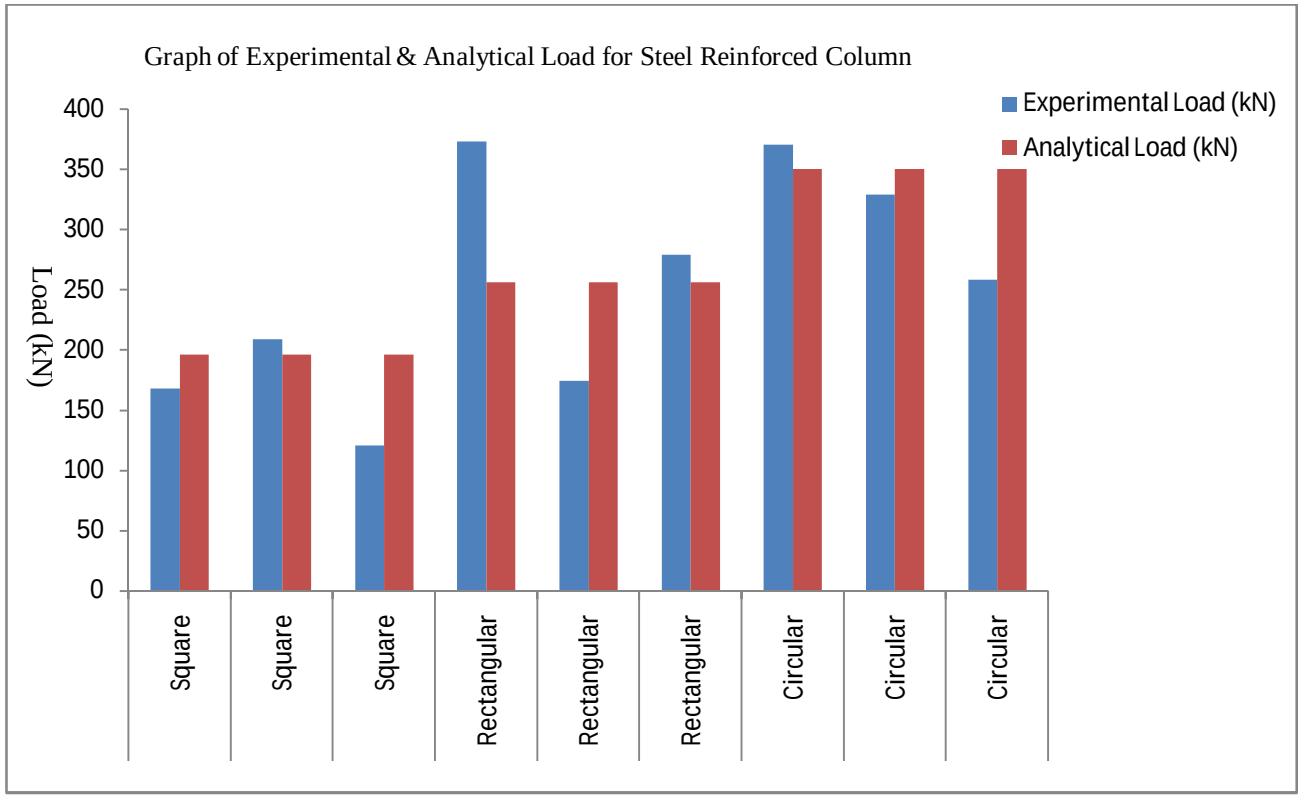

Graph 5 - Experimental & Analytical Load for Steel Reinforced Column

IV. DISCUSSION

The maximum load carried by square, rectangular & circular column for 2.5% bamboo reinforcement 192.9 kN, 317 kN, 329 kN, for 3% bamboo reinforcement 170 kN, 280 kN, 366 kN, for 3.5% bamboo reinforcement 196.5 kN, 290 kN, 360 kN & for 4% bamboo reinforcement 185 kN, 285 kN, 340 kN respectively. These test result suggest that with increase in reinforcement with similar lateral dimension there is relative difference in strengths. The increase in reinforcement resulted in lower cracking load and further caused decrease in ultimate strength of column. The maximum loads carried by square, rectangular and circular column for minimum steel reinforcement were 208.6 kN, 373 kN & 370 kN respectively.

The lateral dimension of bamboo reinforced column should be increased in comparison to steel reinforced column for attaining desired strength. The test results prove that bamboo can be used as reinforcement in low rise & low cost structures as it has good load carrying capacity.

The bamboo reinforced column showed typical load- deformation and compression stress-strain as of steel reinforced column. Failure pattern of bamboo reinforced column were of similar pattern with fissures at edges and cracks along the length. The failure confinement acted in two different parts i.e. bamboo reinforcement and concrete form two different failure confinements for 150 mm square column. For using bamboo reinforced concrete column minimum dimension should be greater than 150 mm to avoid confinement problems. Bamboo reinforced column attained the desire strength as compare with steel column. Proper casting should be done under skilled supervision and by skilled labors to avoid specimen damages.

V. CONCLUSION

- Split bamboo reinforcement should be reasonably straight. Its width should not exceed 2 to 2.5 cm. While placing, the basal and the distal ends of the reinforcement must be alternated, to obtain a uniform reinforcement area along the length of the member.
- Bamboo reinforced concrete column achieved desired strength. Failure occur in compression are of similar pattern. Fissures at the edges and cracks along the length of column.
- Minimum width or depth of column should be 230 mm as for 150 mm the bamboo splits does not create unique confinement for reinforcement.
- Proper workmanship and skilled supervision helps in getting desire strength. Compaction of concrete should be adequate or else honey combed structure are created.
- Bamboo reinforcement should be coated with black Japan as it has good water repellent and bond quality.
- Bamboo should season for at least 6 months before using it as reinforcement.
- Bamboo reinforcement should not be exposed to environment as it created defects like swelling and decay.
- For lateral dimension less than 230 mm two different confinements of bamboo reinforcement and concrete cover occur. As it does not maintain uniqueness in design we find two different failure patterns of reinforcement and outer cover.
- Load displacement and stress strain curves in bamboo reinforce column show typical pattern as in steel reinforce column.
- For low cost housing projects bamboo reinforce structure is feasible and gives desired strength.
- Steel formwork should be used for good quality and for achieving desired strength.
- Based on the limited number of testing conducted, it was concluded that Bamboo can potentially be used as substitute for steel reinforcement. However, for regions of the world that availability of steel is limited and plain concrete members are commonly being used, the use of reinforced bamboo concrete is highly recommended.

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