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DESIGN OF (G+1) RESIDENTIAL BUILDING BY USING MUD CONCRETE & BAMBOO REINFORCEMENT

T. Venkata Naga Sai Ram[1], Dr. M Janardhan [2] M. Venkata Narasaiah [3],

[1]. Student, M. Tech, Chebrolu Engineering College, Chebrolu, Guntur (DT), A.P.

[2]Principal & Professor. Chebrolu Engineering College, Chebrolu, Guntur (DT), A.P

[3]Asst Professor. Chebrolu Engineering College, Chebrolu, Guntur (DT), A.P

Abstract:

Reinforced concrete is perhaps the most widely used building material in the world. However, the materials used for reinforcement of concrete i.e. steel is quite expensive and scarcely available in the developing world. As a result, bamboo is considered to be a cheaper replacement with high tensile strength. This research investigated the structural behaviour of bamboo-reinforced concrete slabs used for footplate foundation subjected to concentrated load. The intention of the research is, to evolve a design using Bamboo as one of the chief structural materials, for a safe and durable house, affordable by the urban poor. Planning of structure was done in AUTO CADD software and design of structure components like slab, beam, column, footing, staircase etc was done by Stadd Pro software. In this project we will work on to design manually (G+1) residential building by replacing steel reinforcement with bamboo reinforcement codes is the basic code for general construction in concrete structures, hence all the structural members are designed using limit state method in accordance with the IS 456:2000 code and design aids. The help of Microsoft Excel and Auto CAD we successfully found the estimated area of Plot area = 193.97 sq.m, Ground floor area = 105.02 sq.m, First floor area = 105.02 sq.m,F.S.I Permited = 1.0 Various researches and study results will be used for the deduction of a method most suitable for the replacement of bamboo as reinforcing material in the right amount and the right proportion and the best possible placement in place of steel and or with steel.

INTRODUCTION

The steel as a reinforcing material is a demand that is increasing day by day in most of the developing countries. There are situations when the production is not found enough to face the demand for steel. Hence it is essential to have an alternative that is worth compared to steel. Bamboo is a biodegradable, abundant renewable in nature. It is energy efficient as it is of natural origin and environmentally sustainable in nature. Even though existence of bamboo has been found from centuries, bamboo as reinforcement material is an innovation in the civil engineering construction field. It can become an ideal replacement for steel. Most of the population in India stays in Rural areas. Indiscriminate use of concrete and steel has led to the environmental issues in rural areas, which once were considered clean. Many researchers have used Bamboo as a replacement of reinforcing steel in concrete and found it very much effective. I intend to use bamboo as a replacement of reinforcing steel in mud concrete (concrete made by replacing cement with red mud, fly ash and lime).

Types of Non-engineered Houses:

The characteristics of non-engineered rural houses can be recognized by its roofs and walls. These are subjects to change with the variations of locations, climate and availability of local materials and technologies. The following types of rural houses are taken into considerations for this seismic assessment study.

Mud walled House:

In most of the rural areas of rural houses are characterized by mud walled. Sometimes walls are made of sun dried earthen blocks of one to two feet thickness. These mud walled houses are generally oblong in shape and covered with the roofs made with clay tiles, thatch or corrugated iron sheets. The application of these construction materials depends on their availability and the ability of the house owners. In these specific regions the lands are normally above flood level. Besides this, relatively less rainfall, dry climate and lateritic soil (which gets very hard when dry) are the main reasons behind the mud constructions. The houses with two or three levels are common in Chittagong region

Bamboo walled House:

In the piedmont alluvial plains, especially in Rangpur, Moribund delta area in Jessore and Haor Basins, flood plains of the Ganges, the Jamuna, the Brhamaputra, the Meghna, the Tista and in some areas in eastern and northern regions, the walls are generally made of bamboo and rooms are configured in rectangular shape. Bamboo is used for making posts and enclosing elements, which is called 'Bera'. Sometimes timber is used for the post and making an upper horizontal floor in the room.

Advantages of Bamboo:

- Bamboo is an extremely strong natural fiber, on par with standard hardwoods, when cultivated, harvested, prepared and stored properly. The strongest part of a bamboo stalk is its node, where branching occurs.
- Bamboo is an exceptionally versatile material. It is used in a myriad of ways for building, such as for scaffolding, roofing, flooring, concrete reinforcement, walls and piping. It may be used structurally and as a decorative element.
- Bamboo is extremely flexible. During its growth, it may be trained to grow in unconventional shapes. After harvest, it may be bent and utilized in archways and other curved areas. It has a great capacity for shock absorption, which makes it particularly useful in earthquake-prone areas.

Objectives:

The main objectives of this research are:

- To use bamboo as a possible replacement of reinforced steel in building construction
- Effectively utilizing the bamboo (instead of reinforcing steel) in construction of G and G+1 small buildings
- Use of bamboo reinforced and mud concrete can be a viable and environment friendly alternative.
- To use red mud and fly ash as a replacement of cement in rural building construction in order to reduce the cost of construction.

2.0 **LITERATURE REVIEW**

[1] Swapnil Dange, Smita (2017) In Bangladesh the majority percentage of people live in rural areas. Most of them are very poor. Due to financial problem most of the family built their dwelling house using low-cost local materials and technique. For low quality building materials and low-quality construction technique, the houses are not strong enough to resist the natural hazards. [2] Jayanetti L. and Follett P. (2004). In their found that this material has been used to carry out some of the building activities Finally the author thinks that if more information is found more can be done to put this material to use. the exploration of abundant, naturally occurring materials such as bamboo, coconut fibres, sisal and oil palm fibres which can be obtained locally at low cost and low levels of energy using local manpower and technology. [3] Prieto, S., et.al., (2002) The phrase intended to convey poverty, squalor and misery of those in need of aid including new housing. In much of the world architects' engineers and the government or authorities they served have assimilated the message and advocated building in permanent materials, especially unyielding concrete. [4] Prieto, S., et.al., (2002) The world timber demand is increasing at a rapid rate but the timber supply is depleting. It"s been found through research that bamboo can suitably replace timber and other materials in construction and other works. Industrially treated bamboo has shown great potential for production of composite materials and components which are cost effective and can be successfully utilized for structural and non-structural applications in construction. [5] Mahzuz et al. (2011) Reported that the shear strength of bamboo reinforcement in concrete reveals that concrete members reinforced with sections of bamboo culms, which had been split along their horizontal axes, developed considerably higher load capacities than unreinforced concrete beams of similar sections. [6] Terai and Minami (2012) Investigated that the tensile strength filled with cement paste cured w/c=80% and 100% significantly increase with aging time. The behavior of pull-out test with bamboo is almost the same as the plain steel bar; however, the bond strength with bamboo was higher than the one with plain steel bar. It can be expected that the bond strength covering with full treatment shows the high value 1.2-1.35 MPa. [8] Nayak et al. (2013) Concluded that this is a good idea for low-cost economic structure. Bamboo reinforcement technique is used for both main and distribution reinforcement as it was same earlier done for steel reinforcement. It is three times cheaper than steel reinforcement technique. It is clear from results that this bamboo

reinforcement technique is absolutely cheaper then steel reinforcement technique especially for single story structure.

3.0 METHODOLOGY

The proposed research studies the possibilities of using red mud and fly ash in different percentages to replace Ordinary Portland Cement (OPC) in producing a mud concrete of grade M20. Its strength and other properties is compared with conventional M20 Concrete.

In this designed Mud concrete i also propose to use bamboo as a replacement of conventional steel for building ecofriendly and sustainable houses (ground floor) in rural areas.

Steps would be followed:

- In the selected Mud Concrete, bamboo (seasoned and unseasoned) of suitable diameter would be introduced in the tensile zone in single and double layer of M20 strength is used.
- Bamboo (seasoned and unseasoned) would be tested for tensile strength.
- Beam (Prism) samples would be casted and tested in flexure strength for 3, 7 and 28 days.
- This will give an idea on the suitability of using bamboo as a replacement of steel reinforcement in mud concrete.
- Design of Footings, Columns, Beams, Slab using suitable methods. (Limit State Method). And applicable IS codes.
- Assuming suitable live loads. Dead load from the tests on mud concrete

Mud House:

In present days mainly low-income rural people are using this type of construction technique. The primary material used in this type of construction is mud. The mud used here is the mixture of clayey soil, straw, cow dung and coarse sand. From the experience of many past earthquakes occurs; it is proved that mud houses are more vulnerable to earthquake than any other type of traditional house, because of its brittle nature and lack of lateral force resisting system. For the improvement of mud house one can use wooden bracing at the corner location of the beams, metal straps at connection location. Also shifting of roof truss at proper location, blocking of excess opening, use of cement plaster over walls, insertion of new walls are some of important measure to improve a mud house.

Material Limitations:

Bamboo is a natural material and hence has certain limitations. Research energies, the world-over have been focusing on countering these limitations.

Steps need to elevate bamboo technically to a level for it to qualify as a sufficiently durable and structurally safe material for construction for the building sector and for bamboo buildings to become bankable assets.

Fire Rating: Susceptibility to fire is another limiting factor in the use of whole bamboo culms in buildings. Engineered bamboo is a solution to this problem, but it is unaffordable to the majority of clients. Hence fire rating of round bamboo and fire retarding treatment material and methodologies need to be developed for bamboo to be used in large-scale projects.

Jointing Systems: Owing to the round shape, jointing is very difficult and cumbersome in bamboo. The reduction of diameter along the length is another limiting factor. Various types of engineered and tested jointing systems with appropriate materials need to be developed for effective structural load distribution and transfer. Not many studies have been done relating suitability of joints and their mechanical behavior. Researchers need to include connection types with complete structural systems.

Planning of substitution as reinforcement:

The idea of substituting steel in concrete load bearing members is simple and goes hand in hand with the concept of reduction of self-weight, cost and be more eco-friendly for any small-scale project

Table 3.1: Mechanical properties of bamboo

Mechanical property	Symbol	Value [N/mm²]
Ultimate compressive strength		55.15806
Allowable compressive stress	Σ(c)	27.57
Ultimate tensile strength		124.1
Allowable tensile stress	Σ	27.57
Allowable bond stress	U	0.3447
Modulus of elasticity	E	1.7x10^4

These properties have been factored in while planning the design of columns and beam whether with sole bamboo reinforcements or substituted with steel. Methods that will be used are all theoretically analyzed and at most will be implemented on Stand.Pro, the only drawback of STAAD.PRO software is that the software won't factor in the shape and section of the bamboo, so it would be better to design the conventional steel reinforced concrete structure and then replace bamboo in the required places. An alternate method can be the compounding effect of yield stress, tensile strength and compressive strength of bamboo with steel and then designing by the conventional methods. Both the methods will be validated theoretically.

Selection of bamboo:

Selection of bamboo for reinforcement can be done based on these factors (a) Color and Age – Employ bamboo having an evident brown color. This shows the age of bamboo to be at least 3 years.

(b) Diameter – Use the one with long large culms

(c) Harvesting – Try to avoid those bamboos that are cut either during spring or summer seasons. (d) Species – Among 1500 species of bamboo, the best one must check, tested to satisfy the requirement as a reinforcing material.

- Specific gravity - 0.575 to 0.655
- Average weight - 0.625kg/m
- Modulus of rupture - 610 to 1600kg/cm2
- Modulus of Elasticity - 1.5 to 2.0 x105kg/cm2
- Ultimate compressive stress- 794 to 864kg/cm2
- Safe working stress in compression - 105kg/cm2

Safe working stress in tension It has also been found that bamboo acts very well in buckling but due to low stresses than compared to steel and due to it not being straight it may not be very good. Further, it has been established that in seismic zones the failure of bamboo is very less as the maximum absorption of the energy is at the joints. Cellulose is the main component present in bamboo which is the main source of mechanical properties of bamboo.

Some specific properties of Bamboo are as given below:

1. Specific gravity - 0.575 to 0.655
2. Average weight - 0.625kg/m
3. Modulus of rupture - 610 to 1600kg/cm2
4. Modulus of Elasticity - 1.5 to 2.0 x105kg/cm2
5. Ultimate compressive stress- 794 to 864kg/cm2
6. Safe working stress in compression - 105kg/cm2
7. Safe working stress in tension - 160 to 350 kg/cm2
8. Safe working stress in shear- 115 to 180 kg/cm2
9. Bond stress - 5.6kg/cm2

STAAD.PRO design and replacement method:

This is the most accurate design method out of all te methods depicted before and has huge theoretical and in the field applications. In this method the following design procedure can be followed for the determination of the amount of bamboo that can be replaced in a structure in beams and columns:-

a.) Design a G+1 structure on STAAD.PRO with normal data input-support, loads. And the test for the validity of the structure.

b.) Substitute the reinforcement properties into the members where the bamboo reinforcements are required and check for results. Ex-The yield stress can be changed from 415 KN/m2 to the average of compressive strength of steel and bamboo i.e. 260 KN/m2.

c.) Check for the validity of all the members and structures.

d.) If valid, then substitute bamboo with the main/secondary reinforcements as desired (only steel reinforced structure) and increase the bar diameter for the strength when bamboo will be replaced will reduce to an extent.

e.) The reinforcements with the structure that has been made with the values from the average of steel and bamboo have been taken can also be replaced with bamboo but the reduction of weight of the structure will not be obtained because of the software limitations

4.0 RESULTS AND DISCUSSIONS

In today's world, energy is extensively used for construction activities and is the major source of demand for energy. Alone construction sector has been accounted to consume 40% of total energy consumption directly or indirectly. The construction activities in urban development have exploited the conventional resources of the mother earth and now the trend is passing to the rural area too. From the beginning it was understood that many of the concepts applied to shelter and living conditions in urban communities are not always transferable or appropriate in a rural context. Compared to urban areas, rural areas suffer more from the concentration of deprivation. With incomes generally lower than the urban areas and seasonal unemployment, many households find it difficult to gain ownership of homes. This has implications for social sustainability of rural communities and is causing increased polarization as younger people migrate to the urban areas in search of jobs leaving behind their old folk and children resulting in negative impact on rural enterprise and economic viability The housing sector in rural India is growing rapidly but with increased cost due to materials like cement and steel, it is getting out of reach of people. Bamboo structures are one, which can replace steel structures, thus providing an ecofriendly and cost-effective option for rural construction industry

Growth of the Bamboo:

The growth pattern of the bamboos is a singular combination of grass, leaf-bearing tree and palm. Like the grasses they have tubular blades, lancet-shaped cover leaves and panicular flowers and from a subterranean rootstock branch extensively to form dense to loose bushes. The following characteristics distinguish bamboos from grasses: the longevity of their canes, their branching and the lignification. Like leaf bearing trees they increase their crown every year by throwing out new branches and also shed their leaves each year. Emerging with its definitive circumference from the soil without increasing in diameter later

Tensile Strength: Experimentally it has been found that the ultimate tensile strength of some species of bamboo is comparable to that of mild steel and it varies from 140N/mm2 - 280N/mm2 . Bamboo is able to resist more tension than compression. The fibers of bamboo run axial. In the outer zone are highly elastic vascular bundles that have a high tensile strength. The tensile strength of these fibers is higher than that of steel, but it's not possible to construct connections that can transfer this tensile strength.

Compressive Strength: Compared to the bigger tubes, slimmer ones have got, in relation to their cross-section, a higher compressive strength value. The slimmer tubes possess better material properties due to the fact that bigger tubes have got a minor part of the outer skin, which is very resistant in tension. The portion of lignin inside the culms affects compressive strength, whereas the high portion of cellulose influences the buckling and the tensile strength as it represents the building substance of the bamboo fibers

Elastic Modulus: The accumulation of highly strong fibers in the outer parts of the tube wall also work positive in connection with the elastic modulus like it does for the tension, shear and bending strength. The higher the elastic modulus, the higher is the quality of the bamboo. Enormous elasticity makes it a very useful building material in areas with very high risks of earthquakes.

Anisotropic Properties: Bamboo is an anisotropic material. Properties in the longitudinal direction are completely different from those in the transversal direction. There are cellulose fibers in the longitudinal direction, which is

strong and stiff and in the transverse direction there is lignin, which is soft and brittle. Shrinkage: Bamboo shrinks more than wood when it loses water. The canes can tear apart at the nodes. Bamboo shrinks in a cross section of 10-16 % and a wall thickness of 15-17 %. Therefore it is necessary to take necessary measures to prevent water loss when used as a building material.

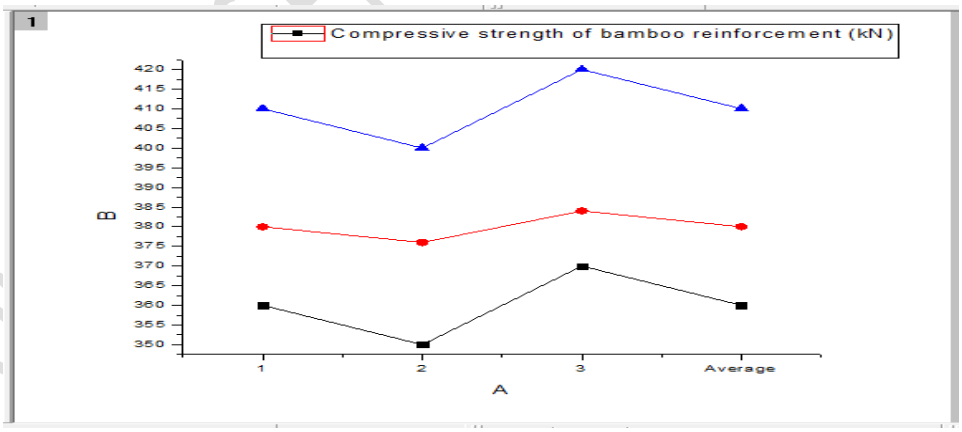
Fire Resistance: The fire resistance is very good because of the high content of silicate acid. Filled up with water, it can stand a temperature of 400° C while the water cooks inside.

Bamboo Use replacement of reinforced steel in building construction

As per the area, India is counted one of the largest countries in the world and a large area of the country is under developing stage. The primary need of the people living in rural areas is a shed to live in. Due to low availability of conventional materials (like steel) in remote areas and also because of high costs, it becomes difficult to use this material in construction, also the income of the people living in remote areas is not much and hike in prices of these materials is also a factor which affects their dream to live in good home. In this section, a comparative study has been demonstrated in terms of compressive, split tensile and flexure strength of PCC as well as bamboo reinforced concrete. Average compressive strength of bamboo reinforced concrete at 28 days, 14 days and 7 days were found as 23.21 N/mm2, 21.5 N/mm2 and 20.38 N/mm2 respectively. However, the average compressive strength for PCC at 28 days, 14 days and 7 days were obtained as 20.9 N/mm2, 19.7 N/mm2 and 18.5 N/mm2 respectively. The result shows a plunging rise in the compressive strength of approximately 10 to 15 % when the concrete is reinforced with bamboo This alarming emanation provided an approach to work towards making low cost and environment friendly construction building using bamboo reinforcement as well which may result into an enhanced strength parameters along with their reduced construction cost.

Table 4.1: Compressive strength of Bamboo reinforced concrete

	Compressive strength of bamboo reinforcement (kN)		
S. No.	**7 days**	**14 days**	**28 days**
1	360	380	410
2	350	376	400
3	370	384	420
Average	360	380	410

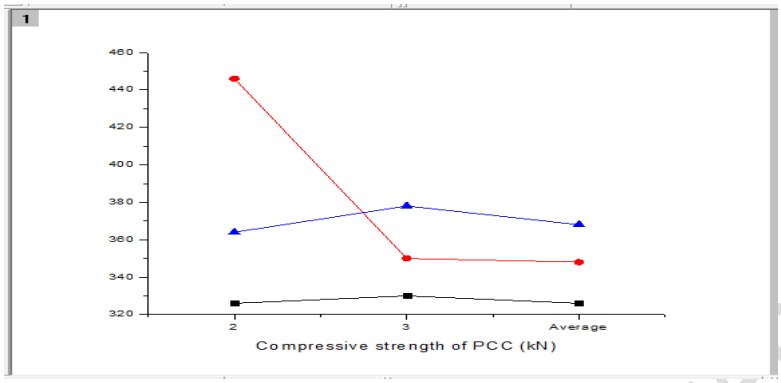


Graph 4.1: Compressive strength of bamboo reinforcement (kN)

Table 4.2: Compressive strength of PCC (kN)

	Compressive strength of PCC (kN)		
S. No.	**7 days**	**14 days**	**28 days**
1	322	348	360
2	326	446	364

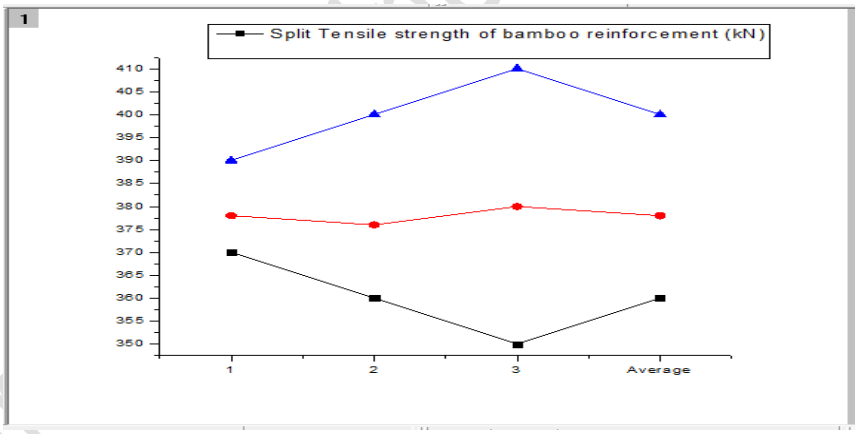
3	330	350	378
Average	326	348	368



Graph 4.2: Compressive strength of PCC (kN)

Table 4.3: Split Tensile strength of bamboo reinforcement (kN)

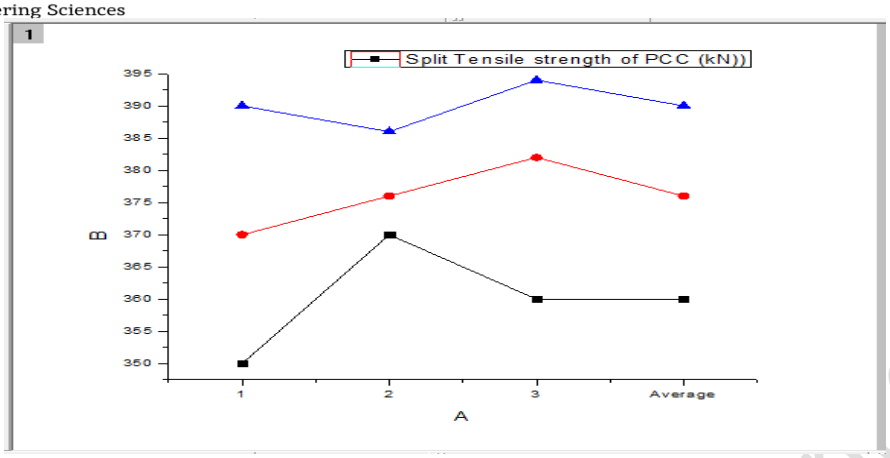
	Split Tensile strength of bamboo reinforcement (kN)		
S. No.	**7 days**	**14 days**	**28 days**
1	370	378	390
2	360	376	400
3	350	380	410
Average	360	378	400



Graph 4.3: Split Tensile strength of bamboo reinforcement (kN)

Table 4.4: Split Tensile strength of PCC (kN)

	Split Tensile strength of PCC (kN)		
S. No.	**7 days**	**14 days**	**28 days**
1	350	370	390
2	370	376	386
3	360	382	394
Average	360	376	390

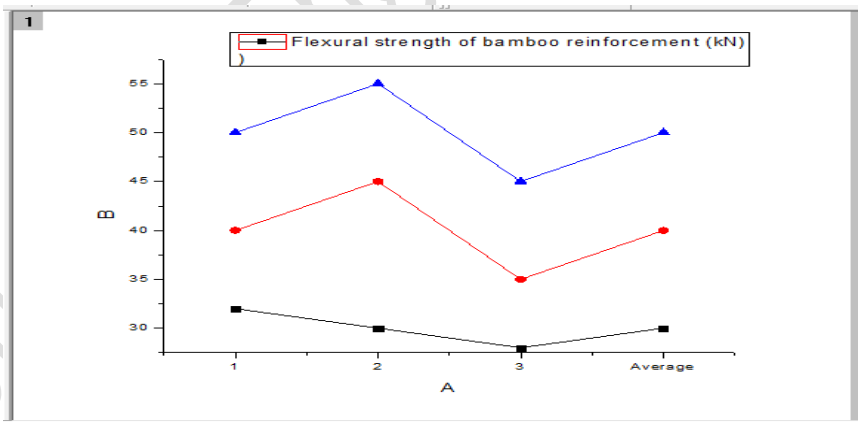


Graph 4.4: Split Tensile strength of PCC (kN)

Average Split Tensile strength at 28 days, 14 days and 7 days are 1.69 N/mm^2, 1.61 N/mm^2 and 1.53 N/mm^2 respectively for bamboo reinforcement. Average Split Tensile strength at 28 days, 14 days and 7 days are 1.67 N/mm^2, 1.59 N/mm^2 and 1.53 N/mm^2 respectively for PCC However the results of split tensile strength for both the cases are almost similar but are distinct in their magnitudes which clearly distinguish about the dominant effects of bamboo reinforcement in the concrete. To some extent the values have been magnified.

Table 4.5: Flexural strength for Bamboo reinforced concrete

	Flexural strength of bamboo reinforcement (kN)		
S. No.	**7 days**	**14 days**	**28 days**
1	32	40	50
2	30	45	55
3	28	35	45
Average	30	40	50



Graph 4.5: Flexural strength of bamboo reinforcement (kN)

These results show the significant enhancement in compressive strength and flexural strength of bamboo reinforced concrete as compared to plane cement concrete. The split tensile strength was slightly same in bamboo reinforced concrete and plane concrete, the reason for slightly same result due to failure is taking place in concrete others wise the tensile strength of the bamboo is also high.

STAAD.PRO results:

All the results obtained by the tests and simulations under different conditions which were applied on STAAD.PRO for the design of the whole structure reinforced with bamboo and steel together will be shown in this article. The members that were tested beforehand and the members substituted in the structure will also be elaborated for their design results and their respective properties assigned. All the loads that have been put on the

structure and the individual members which are responsible for the displacements, bending moments and shear reactions have all been shown before respectively in the article Now the results for the individual members and the steel reinforced and the steel and bamboo coupled structures would be depicted. Results for the steel and bamboo coupled reinforced concrete beam is shown as follows:

Height of the each floor = 3m
Total height of the building = 6m
Size of the beam = 400 mm x 230 mm
Diameter of the column = 300mm x300mm
Central column = 1500mm x150mm
Height of the parapet wall = 1.0m
Seismic zone: zone = III
Wind load = zone- 3
shows the Flooring layout.

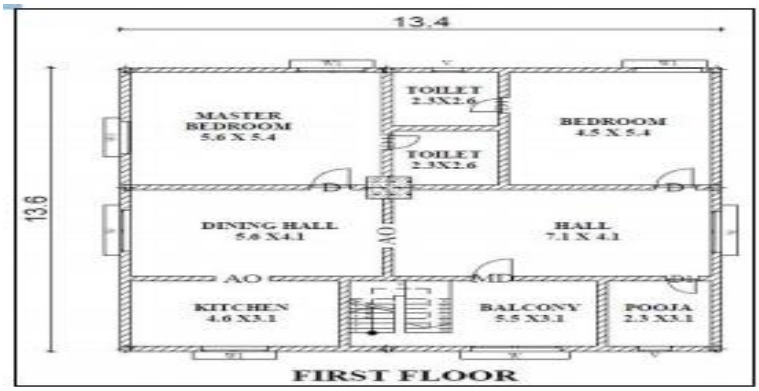


Figure 4.1: Flooring layout

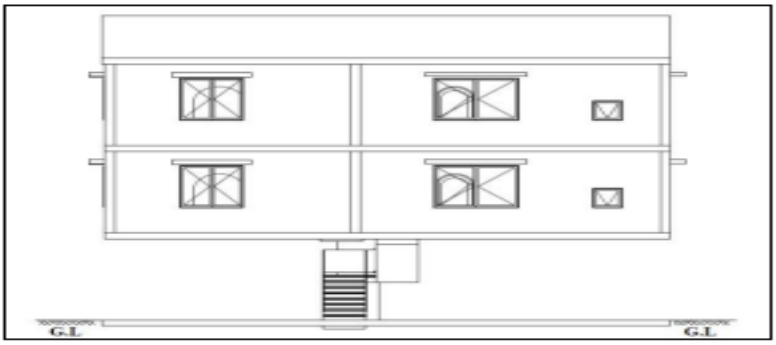


Figure 4.2: Elevation of the Building

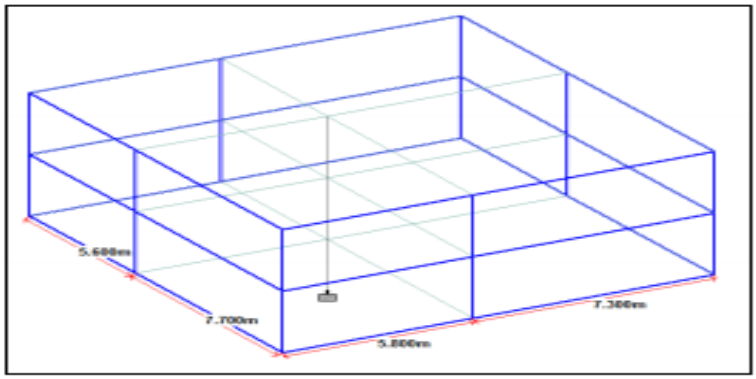


Figure 4.3: 2D Structure View

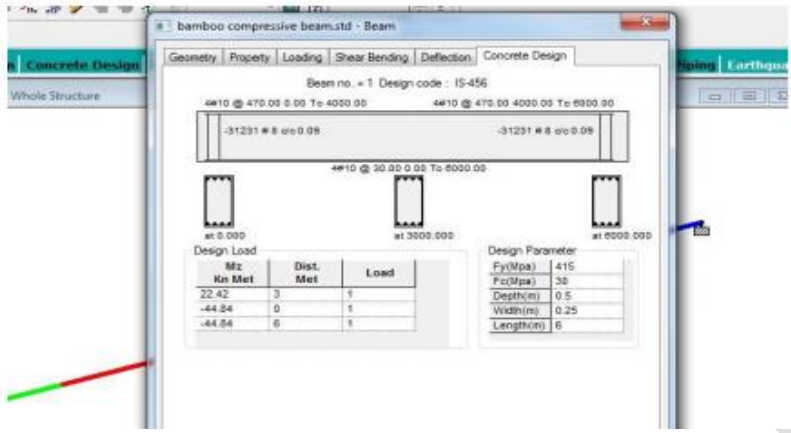


Figure 4.4 : Bamboo and steel coupled section of beam

Shown above is the valid design of a beam reinforced with the coupling of bamboo and steel in the compressive zone of the beam. The design diagram as shown by STAAD.PRO will depict the no. of bars that are used in the beam and the spacing that has to be put between the bars. Now, the results for the steel reinforced G+1 structure will be shown in the form of graphs for particular members.

In the following tables, it can clearly be seen that the volume of concrete is not changing even when the Percentage of steel has been increased. The bar die used in the structure fully reinforced with concrete has a dial ranging from 6mm-12mm, whereas in the structure in which the yield stress has been changed the die used is only 10mm and 12mm. This shows that the structure would remain safe and give the desired results with an increase in the percentage of steel.

Table 4.6: Steel reinforced structure result for reinforcement (STAAD.PRO)

TOTAL VOLUME OF CONCRETE = 15.9 CU.METER

BAR DIA (in mm)	WEIGHT (in New)
6	3266
8	2933
10	7499
12	8359
*** TOTAL=	22056

Table 4.7: Minimal yield stress for secondary reinforcement result (STAAD.PRO)

TOTAL VOLUME OF CONCRETE = 15.9 CU.METER

BAR DIA (in mm)	WEIGHT (in New)
10	7499
12	27879
*** TOTAL=	35378

when the yield stress of the secondary reinforcement is changed in the concrete design input, just the diameter of the reinforcement is increased but when bamboo will be substituted with steel in beams and columns in the real case scenarios, with the same strength that has been input, it will give even more strength as the value was just changed to 100kN which is just the compressive strength of bamboo but when it will be substituted with steel of larger die giving the anti-buckling effect the strength will instead increase the average of the compressive strengths of steel and bamboo will be acting.

Table 4.8: Check Results (steel reinforced structure)

L/C		Fx kN	Fy kN	Fz kN	Mx kNm	My kNm	Mz kNm
1	Loads	0.000	-590.000	0.000	1770.000	0.000	-2360.000
	Reactions	0.000	590.000	0.000	-1770.000	0.000	2360.000
	Difference	0.000	0.000	0.000	-0.000	0.000	-0.000
2	Loads	0.000	-648.000	0.000	1944.000	0.000	-2592.000
	Reactions	-0.000	648.000	0.000	-1944.000	-0.000	2592.000
	Difference	-0.000	0.000	0.000	-0.000	-0.000	-0.000

Table 4.9: Check results (steel + Bamboo reinforced)

L/C		Fx kN	Fy kN	Fz kN	Mx kNm	My kNm	Mz kNm
1	Loads	0.000	-590.000	0.000	1770.000	0.000	-2360.000
	Reactions	-0.000	590.000	-0.000	-1770.000	0.000	2360.000
	Difference	-0.000	0.000	-0.000	-0.000	0.000	-0.000
2	Loads	0.000	-624.000	0.000	1872.000	0.000	-2496.000
	Reactions	0.000	624.000	-0.000	-1872.000	0.000	2496.000
	Difference	0.000	0.000	-0.000	-0.000	0.000	-0.000

A very slight and tolerable difference can be spotted in the stats of the check results of the two structures that have been tested on STAAD.PRO. There is no change in the reactions 74 in all the dimensions of the 1st load case that includes the self-weight and the uniform floor load of -1kN/m2. Whereas a slight change in the reactions and loadings can be seen under the 2nd load case that includes the varying floor loads as shown in fig below are the STAAD.PRO results for the maximum forces by section result for the whole structures respectively:

Table 4.10: Max. Forces by section (steel reinforced)

		Axial	Shear		Torsion	Bending	
Section		Max Fx kN	Max Fy kN	Max Fz kN	Max Mx kNm	Max My kNm	Max Mz kNm
Rect 0.	Max +ve	53.912	0.624	0.626	0.000	1.069	1.067
	Max -ve		-0.624	-0.626	-0.000	-1.069	-1.067
Rect 0.	Max +ve	0.595	5.013	0.001	0.007	0.001	2.087
	Max -ve	-0.191	-5.013	-0.001	-0.007	-0.001	-1.273

Table 4.11: Max. Forces by section (steel & bamboo reinforced)

		Axial	Shear		Torsion	Bending	
Section		Max Fx kN	Max Fy kN	Max Fz kN	Max Mx kNm	Max My kNm	Max Mz kNm
Rect 0.	Max +ve	51.915	0.610	0.612	0.000	1.038	1.035
	Max -ve		-0.610	-0.612	-0.000	-1.038	-1.035
Rect 0.	Max +ve	0.538	4.761	0.001	0.007	0.001	1.983
	Max -ve	-0.194	-4.761	-0.001	-0.007	-0.001	-1.210

There are differences in all the dimensions at all the sections but are very minute differences so it can be stated that the structure is successful.

CONCLUSION:

Bamboo has been used for several years since the ancient times as a building material but has gained much attention in the spotlight since the Clemson study. However, there is no such method that can be relied upon for the proper construction of any structure that is reinforced with bamboo. The property of bamboo is the reason for which it was selected as the material for reinforcing beams and columns. It is a sure inevitability that the structural member that has been reinforced with bamboo will lose its strength up to a significant limit, so this project report has focused on providing a method by which steel and bamboo can be used together so that the strength of the member and thus the structure is not compromised with sighting a reduction in self-weight and making the structure economical. In this report, STAAD.PRO has been used as the simulator which was used to confirm that the structure can be safe and all the members of the structure will pass with a change in the material that is being used in the reinforcement. In the

past years architects have been using bamboo in different ways in their designs. From interior finishes to bamboo constructions the application of bamboo in design is still developing and there are more new applications to be expected. Materials that are used in green design are always assessed for their environmental impact. Bamboo can replace concrete, steel or wood, depending on the situation and the application, although more built examples and dissemination is needed. Bamboo has been proved to be a versatile material because of its high strength-to-weight ratio, easy workability and availability. The positive attributes of Bamboo are its environment-friendly nature. But there are some negative attributes of Bamboo which has also been identified in the past researches, focusing on its tendency to absorb water. Of those, the bonding between the Bamboo and concrete is considered.

Future work:

Bamboo is a versatile material because of its high strength-to-weight ratio, easy workability and availability. The Analysis of the replacement of steel with bamboo as reinforcement shows that reinforcement with bamboo is quite cheaper than that of steel reinforcement. The positive attributes of Bamboo are listed, supporting its environment friendly nature. But there are some negative attributes of Bamboo were also given, focusing on its tendency to absorb water. Of those, the bonding between the Bamboo and concrete is considered the biggest problem due to absorption of water and smooth wall of the Bamboo Culm. Also, there is a need for the development of a simple design code for the application of Bamboo as a Construction material. Several Researches are ongoing to overcome these problems. Many new techniques are being developed which may make bamboo the best constructional material in future. It has wide scope in Low-Cost Constructions. biggest problem due to absorption of water and smooth wall of the Bamboo Culm. This aspect can be a source of future research and there is a need for the development of a simple design code for the application of Bamboo as a Construction material.

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