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Design & Analysis of two wheeler chassis to reduce weight & cost by using Bamboo

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Abstract – ***The*** *two wheeler chassis consists of the frame, suspension, wheels and brakes. The chassis truly sets the overall style of the two wheeler. The main objective of the project is to model a frame using combination of steel and bamboo material to reduce the weight as well as cost of the chassis.*
The bamboo used in chassis where the stresses are within the permissible limit. The chassis use for the project is PULSAR 180 having weight 15.471 Kg without use of bamboo and by using bamboo reduction in weight up to 13.40 Kg is obtained. Reduction in weight is about 2.071 Kg.

1.INTRODUCTION

Automotive chassis is the main carriage systems of a vehicle. The frame serves as a skeleton upon which
Parts like gearbox and engine are mounted. It can be made of steel, aluminum or an alloy. It is essential that the frame should not buckle on uneven road surfaces and that any distortions which may occur should not be transmitted to the body. The reason of selection of bamboo as a Composite material is

1. Automobile industry is one of the most polluting industries of the world
2. Production of 1 ton of steel emits more than 2 ton of CO2 in the atmosphere
3. Eco friendly
4. Bamboo isolates up to 12 tons of carbon dioxide from the air per hectare
5. Low cost material
6. Light weight material as compared to steel

Bamboo is the fastest growing plants in the world having growth up to 60 cm or more in a day. Bamboo belongs to grass family and is columnar rather than tapering in nature. Bamboos have social, economic and cultural significance in East Asia and South East Asia and are used extensively for building materials, food source and as a highly versatile raw product. The bamboos have good bending strength and flexibility. The height of bamboo plant goes up to 40 m and it still withstands the wind pressure. Dendrocalmus Strictus occupies 53 per cent of total bamboo area in India. It is one of the predominant species of bamboo in Uttar Pradesh, Orissa, Madhya Pradesh and Western Ghats. Abundantly found in India in dry zone along plains and hilly regions up to an altitude of 1000 m. It is commonly cultivated throughout the plains and at
the foot of hills. It is widely adaptable to temperatures from -5^{0}C to 45^{0}C. This species is mainly found in drier forests. It grows in drained, poor, grained and stony soils. It occurs naturally in the regions of as low as 750 mm of rainfall And also in extensive in mixed forests. Bamboo is a kind of giant grass and an orthotropic material (i.e. it has particular mechanical properties in the three directions, longitudinal, radial and tangential.) Bamboo culms are cylindrical shells as shown in Figure, and are divided by nodes as solid transversal diaphragms. Non-uniformly distributed fibers in a parallel direction at culms, which consists of up to 70% longitudinal length, have high strength. Meanwhile, the fibers with perpendicular direction at culms have low strength. The strength distribution at the bottom of bamboo is more uniform than at the top or at the middle of it (Ghavam1995)

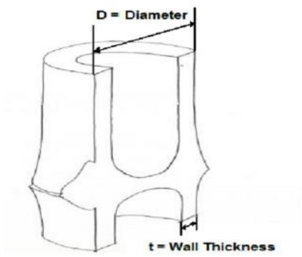

Figure1:- Longitudinal section of column

Bamboo is a composite material with long and parallel cellulose fibers in its structure. Also, it exhibits good flexibility and toughness characteristics. The most Surprising thing is its growing speed as most growth occurs during the first year and almost all growth ceaseby the fifth year (Amanda and Untao 2001). The strength of bamboo does increase with its age, but the maximum strength occurs at 3 4 years and then begins to decrease in strength (Amanda and Untao 2001). Bamboo nodes are spread along the giant grass and their function is to prevent buckling. In fact bamboo can bend as much as touching the ground without breaking.

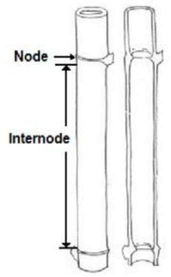

Figure 2:- Node and inter node regions

1.1 PROPERTIES OF BAMBOO

The properties of the column are determined by its anatomical structure. The column consists of internodes and nodes. At the internodes, the cells are axially oriented, whereas at the nodes, cells provide the transverse interconnections. No radial cell elements exist in the internodes. Within the nodes an intensive branching of the vessels occurs. These also bend radically inward and provide transverse conduction through the nodal diaphragms, so that all parts of the column are interwoven.

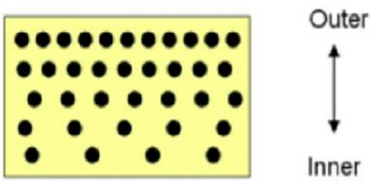

Figure 3:- Orientation of longitudinal cells

The outer part of the column is formed by two epidermal cell layers, the inner appearing thicker and highly lignified. The surface of outermost cells are covered by a cutinized layer with a wax coating. The inner parts of the column consist of numerous sclerenchyma cells. Any lateral movement of liquids is therefore much hindered. The gross anatomical structure of a transverse section of any column inter node is determined by the shape, size, arrangement and number of the vascular bundles. They are clearly contrasted by the darker colored sclerenchymatous tissue against the parenchymatous ground tissue. At the peripheral zone of the column the vascular bundles are smaller and more numerous, in the inner parts larger and fewer. Within the column wall the total number of vascular bundles decreases from bottom towards the top, while their density increases at the same time

PROPERTIES	BAMBOO	STEEL
1. Density	700 kg/m^3	7850 kg/m^3
2. Tensile strength	120 MPa	410 MPa (Sut)
3. Compressive strength	55 MPa	250 MPa (Syt)
4.Young's modulus	140 GPa	200 GPa
5. Poisson's ratio	0.38	0.305
6. Cost	Rs.10/ft	Rs.36/ft

(Source: Mechanical and Physico-Chemical Properties of Bamboos carried out by Aerospace Engineering Department, Indian Institute of Technology - Bombay by Prof. NK Naik)

1.2 PHYSICAL PROPERTIES

1. Moisture content

The moisture content varies within one column and is influenced by its age, the season of felling and the species. In the green stage greater differences exist within one column as well as in relation to age, season and species. Young, one year old shoots have a high relative moisture content of about 120 - 130% both at bottom and top. The nodes, however, show lower values than the internodes. These differences can amount to 25% of the water content and are larger at the base than at the top. In culms of 3-4 years the base has a higher moisture content than the top. The moisture content across the water content varies even in the same locality. This is mainly due to the variation in the amount of parenchyma cells, which corresponds to water holding capacity (Liese and Grover, 1961).

2. Seasoning

The cut bamboo should first be dried for at least four weeks preferably standing upright. Lying horizontally almost doubles the drying time Air seasoning under cover is preferred. Seasoning under controlled conditions can be performed in about two to three weeks but is considered to be uneconomical. The different seasoning behavior of bamboo species is chiefly due to the different column wall thickness which is the most important factor in controlling the rate of drying. The bottom part, there for takes much longer to season than the top portion. The rate of drying of immature culms is generally faster than that of mature ones but since the former have a higher moisture content they need longer.

1.3TESTS ON BAMBOO SPECIMEN

(A) Experimental tests

1. Tensile test

The tensile strength of the outer zone is two to three times higher than that of the inner zone. The tensile strength in the nodes is only moderate because the fibers there run disorderly. Nodes reduce the tensile strength of the column. Bamboo is able to resist more tensile than compression. Slim tubes are superior. Outer skin of bamboo find axial-parallel Extremely elastic fibers. The samples are 200 mm long and 20mm diameter with 50 mm grip portion on both side were prepared. The portion of bamboo at the grip is curved and crushes while testing, hence it is necessary to prepare proper grip for the testing

Figure 4 :- Test sample for tensile test

The cross sections of the test specimen at three sections in a gauge length were measured and the mean cross section was considered for each test. The sample was fixed in the Jaws of Universal Testing Machine. A load was applied at minimum range with constant rate of loading. The load and elongation reading were recorded.

Figure 5:- Test setup for tensile test

No. of tests conducted:- 3
Tensile strength of test specimen - 46.24 MPa
Actual tensile strength of bamboo specimen:- 120 MPa

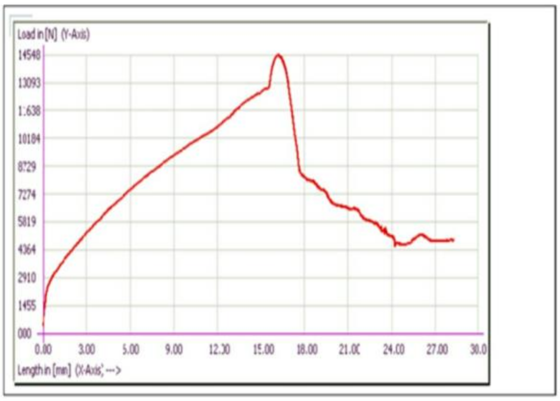

Figure 6:- Test results for tensile test

2. Compression test

Bamboo has relatively high axial compression strength, but this is often offset by a lack of straightness resulting in buckling long before the crushing load is reached. The equipment used for this experiment was the Uni axial Compression Machine. In this direct compression test, the compressive strength of the bamboo is determined by dividing the load (P) at failure, by the cross-sectional area (A) of the column. The cross-sectional area of the column is determined by averaging the diameter and wall thickness at four locations at both the top and bottom of the specimen. These measurements yield the diameter of the column, which is in turn used to calculate the area of the cross-section and the subsequent failure stress. The samples are 200 mm long and 25 mm diameter were prepared. The portion of bamboo at the center is buckle at the time of load. The Compression test is carried out at a room temperature. The equipment used is the Uni axial Compression Machine with a maximum capacity of 1500 KN. The stopwatch is then engage to record the time of failure of crushing. The load of failure is read from the dial indicator of the Uni axial Compression machine. Figure shows a bamboo specimen subjected to compressive loading condition

Figure 7:- Compression test setup

Maximum load apply :-25KN
No. of sample tested: - 3

(B) Computation tests

CAD model is created in CATIA. The dimensions required for this are measured from actual model manually. CATIA model is imported in the hypermesh model for meshing. Initially the complete model is meshed considering steel component. Load conditions are applied on the model in hypermesh the load distribution is given in the table below-

- Engine load- 300 N
- Total Weight- 1200 N
- Fuel Tank- 150 N
- Driver – 750 N
- Pillion- 750 N

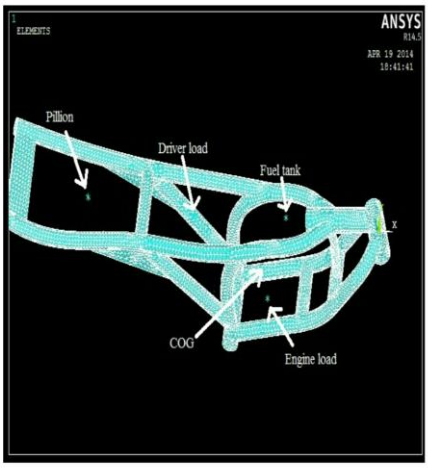

Figure 8:- Load Distribution

1.4 ANALYSIS OF CHASSIS

The analysis using steel as material has been done in ANSYS Multi physics . The analysis was done on two wheeler chassis in the static condition. Constraints are applied on the front end and also on the rear where suspension are mounted. This two ends are assumed to be fixed. The deflection of the chassis is calculated by the software along with the stresses induced in the system by applying loads. Using the deflection and the stresses induced, the low stress area are determined which is then replaced by bamboo.

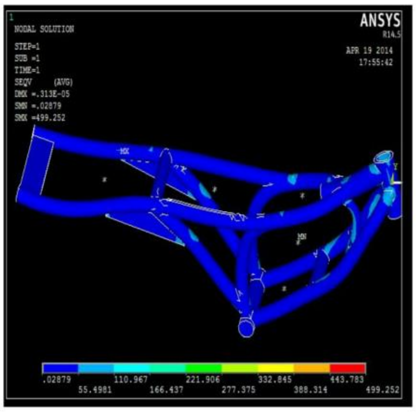

Figure 9:- Stresses and Deformation in steel two wheeler chassis

The low stressed area in steel chassis is replaced by the bamboo material and the analysis is carried out with the same loading conditions and the results are compared with that of steel chassis, Which are included further in report In this analysis two combinations are considered.

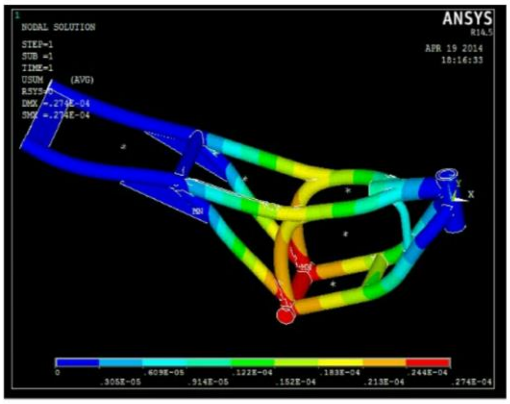

Figure 10:- deformation in bamboo metal matrix chassis

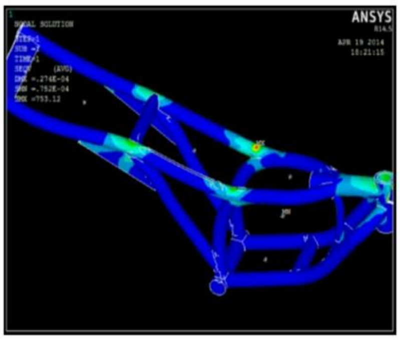

Figure 11:- stresses in bamboo metal matrix chassis

CHASSIS	MAXIMUM VONMISES STRESS (MPa)	MAXIMUM DEFORMATION (mm)
ONLY STEEL	499.252	0.00313
BAMBOO + STEEL	1530.21	1.337

1.5 PREPARATION OF ACTUAL FRAME

Figure 12:-Chassis frame with steel Structure

Figure 13:-Chassis frame with use of bamboo and steel

The frame is prepared by using bamboo and steel. Initially weight the frame which is around 15.471 Kg. By analyzing computationally we found less concentration areas in the chassis frame. We cut the bamboo sections at those points and replace it with bamboo material. While fixing, care should be taken such that the cross section of bamboo column should be greater than steel material. Bamboo material is inside the steel tube so, while fixing the bamboo material in the steel interference fit should be so that press fitting is obtained by applying external force by hammer. When the external force is applied by hammer the care must be taken that it should not break the bamboo specimen. Bamboo is fitted inside the steel by using resin such as Araldite solution so that join will sustain. For complete socking of Araldite solution, it will take about 24 Hrs. At the joints, combination of resin and wood powder is used so that gripping is better

1.6 CONCLUSIONS

After fitment of bamboo columns, the weight of chassis is 13.40 Kg Hence, reduction in weight is about 2.071 Kg so, by using bamboo specimen in the frame we can reduce the cost as well as weight of the overall structure. For protection from water a layer of liquid cement is applied so that water should not react with bamboo specimen.

Experimentally cost and weight reduction is-

Total prize of steel frame –Rs. 5500/-

5500/15.471=Rs. 355 (approximate) /Kg

Reduction in weight= 2.071 Kg

Total prize of bamboo + Steel chassis = {Cost of 12.95 Kg of steel+ Cost of .45 kg of bamboo}

= {12.95*355 + Rs.100}

= Rs. 4697 /-

Cost Reduction = 14.6 %

Weight Reduction = 13.4 %

1.7 FUTURE SCOPE

Bamboo material has high strength for lesser density. This property enables systems to be lighter and stronger at the same time. This report deals with use of bamboo for two wheeler chassis systems. Due to their light weight, they'll help to reduce overall weight of the vehicle. Future work includes- Dynamic analysis of bamboo metal matrix chassis