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Walled Tubes with rubberized coir Filled in axial Loading

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Abstract

The current challenge in transport industry is to increase the usage of lightweight materials and to fit them in vehicle designs in order to improve the fuel economy, efficiency and to reduce vehicle weight, without comprising other attributes such as the performance, comfort, and mainly safety. Major components of automobile such as bumper, frame etc., are constructed by means of the thin walled structures. Therefore, the major objective of this work is to improve the cross worthiness of the thin walled steel tubes whose inner surface is filled with the rubberized coir natural fiber mat. The circular shaped tubes are chosen for this research due to its high specific energy absorption. Fiber is filled stage by stage from 0%, 33%, 66% till 100% fill. Length to diameter ratio (L/d) of the prepared specimen is restricted to 2, which prevents the buckling effects. The specimen is tested for axial loading using quasi static testing. Experimental results shows that there is a gradual increase of energy absorption and compressive strength in the thin walled steel tubes during the stage by stage fiber filling. There is an improvement of 40% in energy absorption capacity, 92% in compressibility strength, 20% in mean absorbing load, while the initial force required to trigger the displacement in thin walled tube is found to have negligible impact.

Keywords: Thin walled tube, axial quasi static load, Natural fiber, rubberized coir, energy absorption capacity, compressibility strength.

1. Introduction

There is an increasing pressure on vehicle manufacturing internationally to increase the strength of vehicles without compromising its performance, emission ratings and it looks to survive in the urbanization markets. In response to that morbidity and mortality related to the vehicle crashes was demanding the new advancement in the materials of constructing the vehicles. This should result in the light weight solutions required to improve strength while minimizing structural mass. To avoid damage to the causalities, impact absorbers were installed on the vehicle structures. By concentrating on the frontal crashes alone results in the impact absorber i.e. Bumper ***(1-4).*** These bumper elements were often made in the concentric circulars due to its high specific energy absorbing nature of circular sections ***(5-6).*** Form filled thin walled members have recently gained attentions for their excellent energy absorption capacity. In past days aluminum ***(6-7)*** was used as form filling elements which also have adverse effect towards the weight to strength ratio until the entry of natural fibre ***(8-9)*** which is also environment, technical, economical and disposal advantages. The rubberized coir sheets which have naturally high impact absorbing character which induces its used in the comforting areas. To summarize, the objective of this research was to develop and propose a replaced composite bumper, which could satisfy following requirements:

1. Easy to manufacture by simplifying the shape. This was accomplished by removing strengthening ribs of bumper.
2. Being economical by utilizing low-cost composite materials.
3. Achieving reduced weight compared to the metallic bumpers.
4. Achieving improved or similar impact behavior compared to the current metallic structure.

2. Energy absorbers

Absorbing devices are based on the folding mechanism. However, tubes with various cross-sections can absorb a considerable proportion of the initial kinetic energy during the initial phase of axial compression. Thus reducing the energy, which remains to be absorbed by the folding mechanism. The initial axial compression phase becomes particularly important when the ratio between the striking mass and a shell is relatively small and the axial load is applied with a high initial velocity. This is the case for energy absorbing devices subjected to explosive loads when high axial velocities result from the impulsive load. From this viewpoint, it is important to analyze the influence of the loading parameters, the geometrical and material properties of various tubular elements on their energy absorbing characteristics such as the crushing distance, mean load and maximum load.

The aim of energy absorbing (longitudinal member) is to convert the kinetic energy to other form of energy when it deform. Another objective of the longitudinal members is to reduce the peak reaction force associated during impact since greater peak values can cause large deceleration values that probably cause irrecoverable brain damage. The energy absorption performance can be calculated from the load- displacement curve. Energy absorption EA is denoted as an integration of a load-displacement curve. **Coir fiber** is elastic enough to twist without breaking and it holds a curl as though permanently waved. Machine twisted fibre is produced by blending bristle and mattress fibres in varying ratios. They are then spun and curled into a thick single-ply rope. This is used in producing **Rubberized Coir sheets**

The spun natural fibres are shaped into a fleece and sprayed with latex as part of the production process. The latex binds the curled fibres which are then pressed and vulcanized in several layers into resilient coir fibre (coconut fibre) sheets. As in the case of the needling process, our factory has our own rubberizing plant.

3. Specimen preparation

Here in this work only circular tubes were taken since it has more specific energy absorption the rubberized coir filled thin walled tube were tested under quasi static loading and the compressive strength, mean load, peak load and specific energy absorption were find out by means of the experiment and there were consistently increasing as the thickness, percentage filling of rubberized coir increases. The wall thickness of the specimens is measured and the variation in thickness relative to the average value was less than 5%. Tubes are subjected to axial compression loading. The thickness of all the tubes were 1.5 mm. Aspect ratio of 2 is maintained for all the cross sections. The dimensions and mass of each specimen are measured. The average length of the circular specimen is 120 mm and the mass was 0.136 kg.

4. Preparation of coir fill

The rubberised coir sheets were filled in the thin walled circular tubes to accommodate the percentage of mass in order to improve the strength of the tubes from inner side of the tube the sheets were processed in a condition to of flat surface as much as possible so when sticking to the surfaces nicely front side and bsck side of the sheet then to suport the mass of the tube.For 33% of coir fill in the inners side of the tube these actually required and it is directly made stick with the inner side of the tube after the resin is applied. For 66% of coir fill it required 2inch layer of rubberized coir sheet. But if available is of 1 inch sheet then the double layer is needed one layer is binded with the other by means of resin once they attached together then that sheet is rolled and made paste with the inner surface of the thin walled tube to support its strenght. And for 100% the whole inner surface has to be filled with the sheets and this can be done by roll of coir of combined sheet of three firstly made stick within themselves.These sheets may be often get unregularized when they were under the process. So after process is over the sheet may be regularized manually.

(a) (b)

Fig. 1 (a) Difference in coir filling (b) Machined specimen

Specific energy absorption the rubberized coir filled thin walled tube was tested under quasi static loading and the compressive strength, mean load, peak load. Load versus deflection curve graph showing the peak load obtained to trigger the deformation

4. RESULT AND DISCUSSION

The empty filled thin walled circular tube is examined quasi statically in axial loading on UTM machine. The three empty fill of same dimension 60mm diameter and 120mm length was tested load vs. deflection curve was obtained. The deflection between the dimension were neglected which is less than 5%. The area under the curve in the graph is obtained as mean load. The averages of the three specimens were drawn as a graph to obtain a mean load of deflection or the load the object can be absorbed. The load versus deflection curve was obtained using the quasi static loading which is connected with the software which generated the graph according to the real values. The load versus deflection curve was found out for the initial load required to actuate the thin walled cylinder to deform.

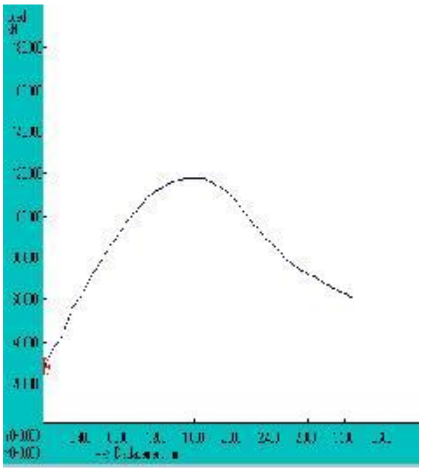
(a) (b)

Fig 2. (a) Initial compression (b) Final compression

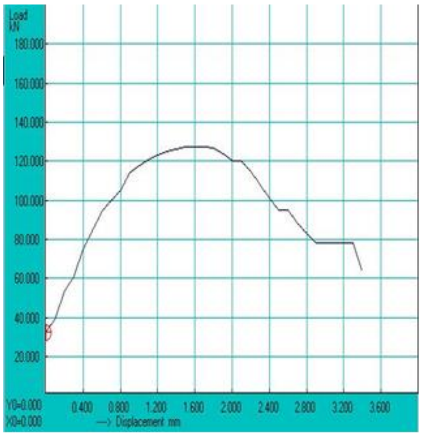
Initial load comparison between the different types of filling in the coir. This initial load actually causes the thin walled tube to trigger the folding formation and initiate the first folding. Initial compression load versus deflection curve for different filling of thin walled rubberized coir tubes were compared. The parameters which considered here were along with the initial load was working load these results in the energy absorption and specific energy absorption characteristics. As per the experiment the initial value to trigger the regular fold formation the average time required for that is approximately of 97 sec.

From empty fill to the complete filling the initial load required to initiate the displacement of the rubberized coir fill thin walled tubes were consistently increasing. Experiment result Graphs are as follows.

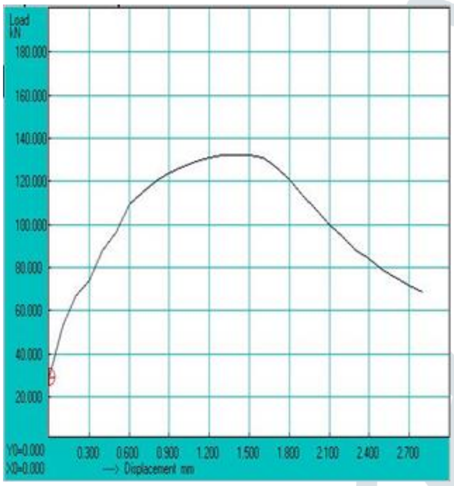
Graph 1. Curve for empty fill



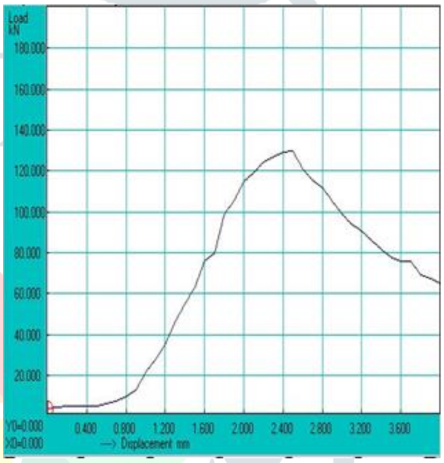
Graph 2. Curve for 33%filling



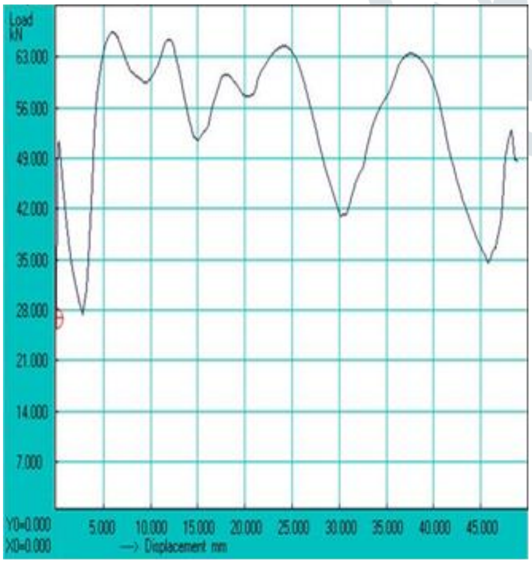
Graph 3 Curve for 33%filling



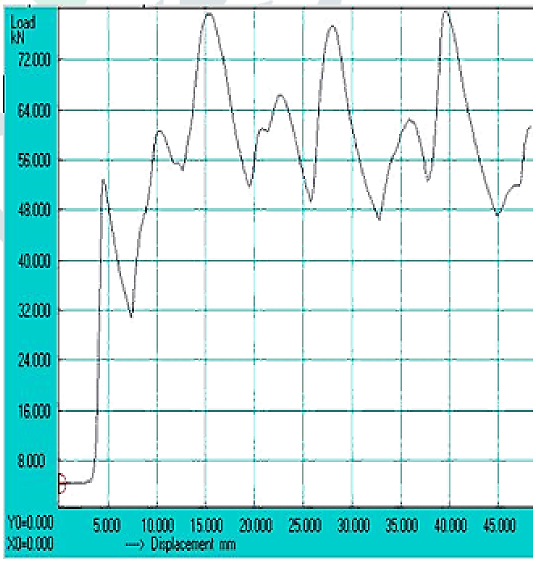
Graph 4. Curve for 33%filling



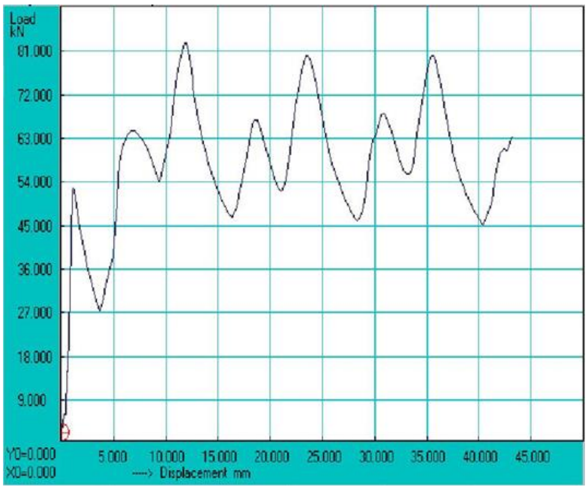
Graph 1. Load vs. deflection for empty fill



Graph 3. Load vs. deflection for 66% filling



Graph 2. Load vs. deflection for 33% filling



Graph 4. Load vs. deflection for full fill

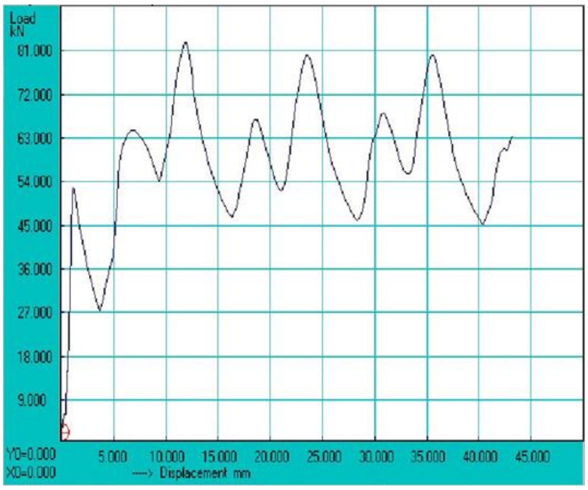


Fig 4.3. Different fill final compression

Here in this work only circular tubes were taken since it has more specific energy absorption the rubberized coir filled thin walled tube were tested under quasi static loading and the compressive strength, mean load, peak load and specific energy absorption were find out by means of the experiment and there were consistently increasing as the thickness, percentage filling of rubberized coir increases. The results were tabulated below. So the inclusion of rubberized coir of different percentage results in improvement of the specific energy absorption characteristics. Even though the there is a considerable energy absorption the initial force actually required to trigger the displacement was not too far from the empty filled tube. Hence the inclusions of the rubberized coir in the thin walled tubes were improving the specific energy absorption and cross worthiness of the specimen.

Table 4.1 quasi static test results of empty filled circular thin walled tube

Filling	Crush length (mm)	Energy Absorbed (J)	Peak load (kN)	Mean load (kN)	Compressive strength (kN/mm2)	Specific energy absorbed (kJ/kg)
Empty fill	63.6	3716.4	127.650	66.59	0.071	17.50
33% coir fill	71.6	4056.3	129.660	74.480	0.111	22.05
66% coir fill	72.9	4568.8	131.460	79.780	0.513	26.65
100% coir fill	76.4	4989.7	132.260	82.820	0.914	29.59

5. CONCLUSION

The predictability of the deformation pattern is another characteristic, which is not only important for estimation of the energy absorbing efficiency but also for the prediction of the magnitude of the transmitted forces to the main structure. While an introduction of a trigger for the buckling initiation is sufficient for structures which are subjected to quasi-static axial loads. Here in this work only circular tubes were taken since it has more specific energy absorption. The rubberized coir was filled in thin walled tube which is tested under quasi static loading and results obtained for the compressive strength, mean load, peak load and specific energy absorption by means of the experiment and there were consistently increasing as the thickness, percentage filling of rubberized coir increases. The results were tabulated below. So the inclusion of rubberized coir of different percentage results in improvement of the specific energy absorption characteristics. Even though the there is a considerable energy absorption the initial force actually required to trigger the displacement was not too far from the empty tube.

Form the experimental values obtained it shows that there is an increase in the specific energy absorption characteristic of thin walled tubes by the inclusion of rubberized coir fill in it. There is an improvement in Specific energy absorption of 12kN when compared with non-filling tubes with completely filled and the compressive strength of specimen showing about 92% improvement in its characteristic.

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