DESIGN AND DEVELOPMENT OF CARGO BED OF TRUCK USING HONEYCOMB SANDWICH MATERIAL.

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Abstract – *Automobile chassis without the wheels and other engine parts is called frame. Automobile frames provide strength and flexibility to the automobile. The backbone of any automobile, it is the supporting frame to which the body of an engine, axle assemblies are affixed. Automotive chassis is a French word that was initially used to represent the basic structure. It is a skeletal frame on which various mechanical parts like engine, tires, axle assemblies, brakes, steering etc. are bolted. It gives strength and stability to the vehicle under different conditions. The Sandwich type materials are the materials which are used to decrease the weight f the system and are of high strength. By using this advantage of the sandwich type material we will use it for reduction of weight. In this project we are going to work on the weight reduction of the cargo bed by using the sandwich materials. The load carrying parts like vertical and horizontal supports and cargo area will be optimized.*

Key Words— *Chassis, Sandwich material, weight reduction.*

1. INTRODUCTION

Automotive industry is one of the biggest and most innovative in total industry area. The automobile market is one of the fastest growing market, which requires the light weight system. The chassis frame forms the backbone of a vehicle; its principle function is to safely carry the maximum load for all designed operating conditions. Automotive chassis is the main carriage system of a vehicle. The chassis serves as a skeleton upon which parts like gearbox and engine are mounted. Every vehicle has a body, which has to carry both the loads and its own weight. Vehicle body consists of two parts; chassis and bodywork or superstructure [1].

Automotive chassis is a French word that was initially used to represent the basic structure. It is a skeletal frame on which various mechanical parts like engine, tires, axle assemblies, brakes, steering etc. are bolted. It gives strength and stability to the vehicle under different conditions. [10]. Until recently, the average size and weight of vehicles sold worldwide had climbed steadily over the decades following the oil crisis of the 1970s. The vehicles themselves had proliferated and become heavier with all of the added entertainment, comfort and safety features, such as anti-lock brake systems, air bags and increasing safety body structure contributing to vehicle weight gain [11]. The truck industry has experienced a high demand in market as the economic growths are very significantly changed from time to time. There are many industrial sectors using this truck for their transportations such as the logistics, agricultures, factories and other industries. However, the development and production of truck industries are currently much relying on foreign technology and sometime not fulfil the market demand in term of costs, driving performances and transportations efficiency [12]. In this project we are going to work on the weight reduction of the cargo bed by using the sandwich materials. The load carrying parts like vertical and horizontal supports and cargo area will be optimized.

2. LITERATURE REVIEW

Cicek Karaoglu, N. Sefa Kuralay [1], In this study, stress analysis of a truck chassis with riveted joints was performed by using FEM. The commercial finite element package ANSYS version 5.3 was used for the solution of the problem. Determination of the stresses of a truck chassis before manufacturing is important due to the design improvement. In order to achieve a reduction in the magnitude of stress near the riveted joint of the chassis frame, side member thickness, connection plate thickness and connection plate length were varied. Numerical results showed that stresses on the side member can be reduced by increasing the side member thickness locally. If the thickness change is not possible, increasing the connection plate length may be a good alternative.

Karaoglu and Kuralay[2] investigated stress analysis of a truck chassis with riveted joints using FEM. Numerical results showed that stresses on the side member can be reduced by increasing the side member thickness locally. Fermer et al investigated the fatigue life of Volvo S80 Bi-Fuel using MSC Fatigue.

Teo Han Fui, RoslanAbd. Rahman [3], in December 2007, the authors works on the Statics and Dynamics, Structural Analysis of a 4.5 Ton Truck Chassis, he determined the dynamic characteristic, of the truck chassis, investigating the mounting locations of components on the truck chassis and observing the response of the truck chassis under static loading conditions. The maximum stress of the truck chassis is 490 MPa while the maximum translation is 33.6 mm. These values are acceptable as compared to the yield strength of the chassis material and the tolerance allowed for the chassis.

O Kurdi, R Abd- Rahman, M N Tamin [4], works on the Stress Analysis Of Heavy Duty Truck Chassis Using Finite Element Method, he mainly focus on the important steps in development of a new truck chassis is the prediction of fatigue life span and durability loading of the chassis frame. Fatigue study and life prediction on the chassis is necessary in order to verify the safety of this chassis during its operation. Stress analysis using Finite Element Method (FEM) can be used to locate the critical point which has the highest stress. This critical point is one of the factors that may cause the fatigue failure.

D.Mohankumar1, R. Sabarish1, Dr. M. PremJeya Kumar (2018) [5]this project discusses the stress and deformation developed in chassis during the different load cases and identifying the failure modes by the modal analysis. It starts from the benchmark study of different scooter frame in the aspect of material selection, mechanical properties and the sections used in it (usually circle section is preferred because of its easiness of manufacturing, even load distribution for different load Cases and some other geometrical reasons) Then Structural and modal analysis of frame under the various load consideration It involves 3d Modeling in Pro-E, analysis in ANSYS.

K. Venkatarao and J. Chandra Sekhar [6] have designed and analyzed the TATA 1109 EX2 vehicle chassis frame.In this paper the analysis is done with two different composite materials namely E-glass/Epoxy and S-glass/Epoxy subjected to the same pressure as that of a steel frame. The results are then compared with existing steel material. Author finally concluded that by employing a polymeric composite heavy vehicle chassis for the same load carrying capacity, there is a reduction in weight of 70% to 80%. Based on the results it is inferred that S-glass/Epoxy polymeric composite heavy vehicle chassis has superior strength, less deformation, less normal stress and less weight compared to steel, E-glass/Epoxy. From this work it is understood that that it is better to use S-glass/ Epoxy as a material for frames of heavy vehicle chassis. So that the fuel consumption decreases for the vehicles.

M. Ravi Chandra, S. Sreenivasulu, Syed AltafHussain[7] in this paper authorhave also designed and analyzed the vehicle chassis of a TATA 2515EX vehicle. In this work three different composite heavy vehicle chassis have been modeled by considering three different cross-sections namely C, I and Box type cross sections. For validation the design is done by applying the vertical loads acting on the horizontal different cross sections. Software is used in this work PRO – E 5.0 for modeling, ANSYS 12.0 for analysis.

V. VamsiKrishnamRaju, B. Durga Prasad, M. Balaramakrishna, Y. Srinivas[8] in his Modeling and Structural Analysis of Ladder Type Heavy Vehicle Frame have done analysis on heavy vehicle frame of a TATA 1109 EX2 vehicle. The analysis is done in this work with three different composite materials namely Carbon/Epoxy, E-glass/Epoxy and S-glass/Epoxy subjected to the same pressure as that of a steel frame.

Indu Gadagottu, M V Mallikarjun [9] this paper describes design and analysis of heavy vehicle chassis by using honeycomb structure. Weight reduction is now the main issue in automobile industries. Traditionally most common material for manufacturing vehicle chassis has been mild steel, in various forms. Over time, other materials have come into use, the majority of which have been is steel and Aluminium. In this paper traditional materials are replaced with composite materials [S-glass epoxy and E-glass epoxy]. Using reverse engineering method. Existing model, modified model, honey comb model are compared and studied. For validation the design is done by applying a single vertical loads acting on the chassis. And then Structural and, fatigue analysis will be carried out on three models to all materials and select the best material Impact analysis can also be done for the selection material in all models Software's used in this work solid works for modeling ANSYS 14.5 for analysis.

Findings from Literature review:

By studying all above paper, it is found that the work on the chassis for weight reduction was done. In previous literature the weight reduction was done by reducing the thickness of the chassis. Overall weight of truck was reduced by reducing the weight of the system. Some authors also used the composite materials for achieving the weight reduction. Very less study on Truck Cargo beds was found.

Scope:

Now a days the rates of petroleum fuels are increasing. The light weight vehicles are manufactured so that there should be less consumption of fuel. In my project I will work on the weight reduction of truck cargo bed using various materials. The Cargo Bed of the truck now a days is made of Wood, The wood can be a light weight solution but the weight increases when the wood becomes wet. This can increase the problems in fuel consumption of the Truck which increases the running cost. The Modeling of the truck cargo bed will be done by using SIEMENS NX and analysis will be done by using Ansys Software.

Problem defination:

The current design for belt conveyor is heavy weight that includes the critical parts like roller, belt, and roller shaft, supporting brackets, C channel base frame which directly affects on excess use of material with increase in costs, so that power consumption and also the maintenance is more due to heavy weight system. To overcome this problem redesign of existing system and analysis with optimization will be done.

Objectives of Project

1. To study the current system in detail with its specification and all required parameters of chassis and Cargo bed of Truck.

2. To design, optimize, the existing material for existing Cargo bed to minimize the overall weight of it, to save considerable amount of material, to save the fuel consumption of vehicle.
3. The modelling of new design with help of SIEMENS NX software.
4. Analysis of the redesigned new Cargo bed to study the stress on the system.

Proposed Work:

1. Data Collection of Cargo Bed:
   The specification and related data collection on existing cargo bed of truck is collected. The important data like material, quantity of components, measurements, etc. of components like horizontal vertical frames and supports etc. will be collected. The truck on which the survey is in process is of Model TATA 1614 system consist of following components.

Table no. 1: List of components of truck

Sr No		Qty	Specifications	Materials
1	Vertical Column	20	100 × 100 mm L Channel Thickness = 3 inches	Mild Steel
2	Horizontal supporting columns	10	Length = 12 foot Width= 7 inches Thickness = 3 inches	Wood
3	Horizontal cargo area	144 Sq Ft	Length = 18 Foot Width = 8 foot Thickness = 3 inches	Wood
4	Vertical cargo area (Support	64 Sq.F	Length = 8 Foot Width = 4 foot Thickness = 3 inches	Wood

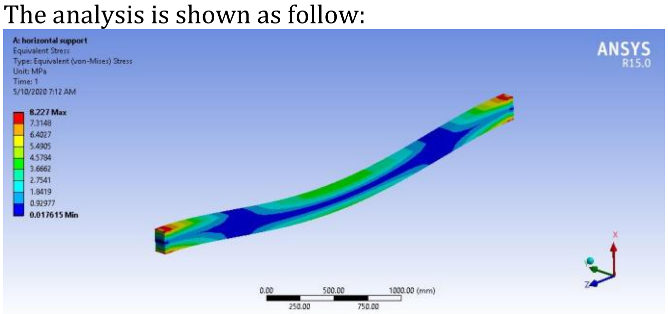
2. Calculations on existing system
   Calculation on existing system consist of its critical parts on which load is more, will be designed.
3. 2D and 3D modelling and analysis
   Modelling of the existing cargo bed will be by using SIEMENS NX software and after proper modelling the analysis of system will be done using ANSYS software.
4. Design of system for optimization
5. Modelling and analysis of optimized design

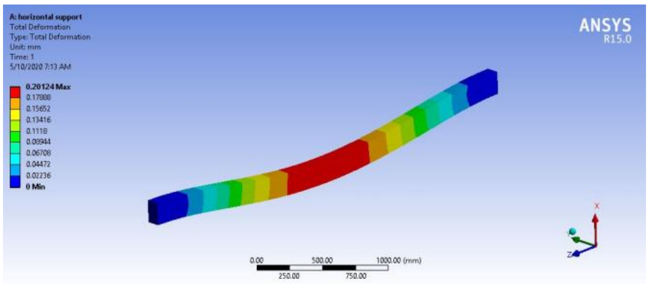
3. DESIGN OF EXISTING SYSTEM

1. Design of Existing Horizontal supporting columns:
Material - Wood
For given material we have to select standard properties of that material, such as
E= 7.2×105 Mpa
Syt= 200 Mpa
ρ= 740 kg/m3
Considering uniformly distributed load & FOS as 3
We have to calculate actual FOS for optimised roller.
Allowable Stress (σall) = Syt / Fs
= 66.6 Mpa.

The total weight exerted on vehicle is 15 tones, we will consider same weight on vertical columns, thus if we consider 10 vertical supports then weight exerted on each vertical column is 1500 Kg. Let us consider the load is uniformly distributed on the cantilever beam.

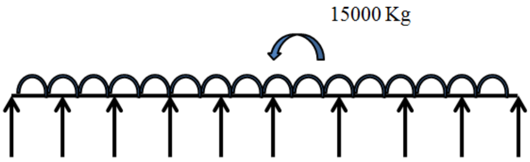
Maximum Stress Calculation for given condition
W= 1500 kg
Length= 3657
T= 76.2 mm
W= 177.8 mm
y = Distance from neutral axis = 177.8/2
= 88.9 mm
Considering Uniformly Distributed load
Maximum moment (Mmax) = W×L2 /8
= 24.599 kN-m.
Moment of Inertia (I) = 3.2117×10-4
Maximum Bending Stress
(σb) = Mmax x Y / I
σb = 6.81 Mpa.
Checking Factor of Safety for design.
FOS= (σall) / (σb)
FOS= 9.77
As calculated factor of safety (FOS) is greater than assume factor of safety,
So selected material can be considered as a safe.
Maximum deformation
(Ymax)= 5 x W x L3/384 x E x I
(Ymax) = 0.0405 mm.
Comparison with length 650 mm deformation obtained 0.0575 mm is very negligible. Hence selected material can be considered as safe for the same material.
Weight= Cross section area x width x mass density x numbers of rollers
= L×w×t x ρ x 10
= 366.64 Kg.
The weight of each column is 36.66 kg. Thus this weight should be reduced. The density shown above is at 12% moisture. Thus the density increases as the moisture contain increases into the wood. This moisture contain increases by 30% in wood after raining. Thus the weight of system increases in rainy seasons due to the moisture. Thus density increases by 30% i.e 962 Kg/m3. Thus the weight increases by
= L×w×t x ρ x 10
= 476.63 Kg.
The weight of each column becomes 47.6 Kg.
The analysis is shown as follow:



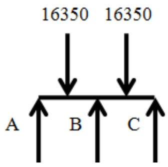


2. Design of Horizontal Cargo bed.

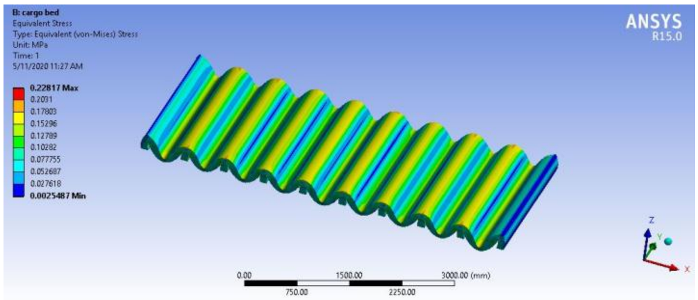
The cargo bed is made of wood. This wood increases its weight when moisture content increases. This also increases overall weight of vehicle and thus the power consumption of vehicle increases. The load exerted on cargo bed is 15000 Kg.

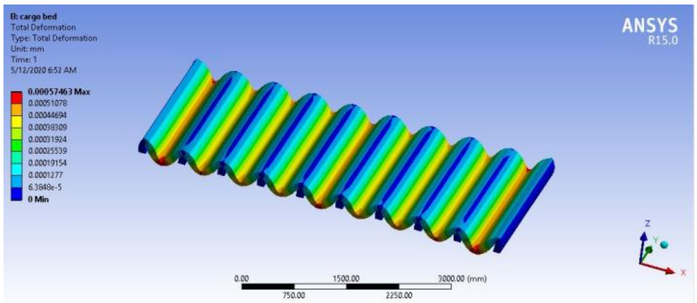


The Cargo bed is supported by ten fixed support, on which 15 ton load is uniformly distributed on it.
The 15 Ton is converted in N,
= 147150 N/mm
UDL on individual Segment = 147150/9
= 16350 N/mm
Consider each span separately and calculate their moment by three moment method.
Consider Span AB and BC



AB=BC= $WL^2/8$
= 615.09 N.m
Support Moment Calculations:
Apply MTM on AB and BC
$M_a l_1 + 2M_b (l_1 + l_2) + M_c l_2 = (6\, a_1 x_1 \times l_1) + (6\, a_2 x_2 \times l_2)$
Therefore,
$M_a = 0$, $l_1 = 0.5486$ m, $l_2 = 0.5486$ m, $M_b = 0$, $M_c = 0$
$a_1 x_1 = a_2 x_2 = 2/3 \times 0.5486 \times 615.09 \times (0.5486/2)$
= 61.70 m3
Therefore,
$2M_b(0.5486+0.5486)=(6\times61.70/0.5486)+(6\times61.70/0.5486)$
$2.1944\, M_b = 1349.61$
$M_b = 615.02$ N/m
As Same UDL is acting on overall span, as well as span is same for each section, hence same bending moment is acting on each section, Thus the bending moment acting on beam is
$M_{max} = M_b = 615.02$ N/m
The Specifications of the cargo bed is as follow,
L = 5486 mm
b = 2438 mm
t = 76.2 mm
I= Moment of inertia in mm^4
$= (b \times t_3) / 12$
$= 2.438 \times 0.07623/ 12$
$= 8.9891 \times 10^{-5}$ m^4
Ymax = 0.0762 / 2
= 0.0381 m
Now,
Bending stress = $(M_{max} / I) \times Y_{max}$
= 0.26 MPa
Maximum deformation
(Y_{max})= 5 x W x L^3/384 x E x I
(Ymax) = 0.429 mm.
Weight= Cross section area x width x mass density x numbers of rollers
= L×w×t x ρ x 10
= 754 Kg.
When moisture increased into the wood, the weight of it increases by 30 % and hence the weight of Cargo bed becomes 980 Kg



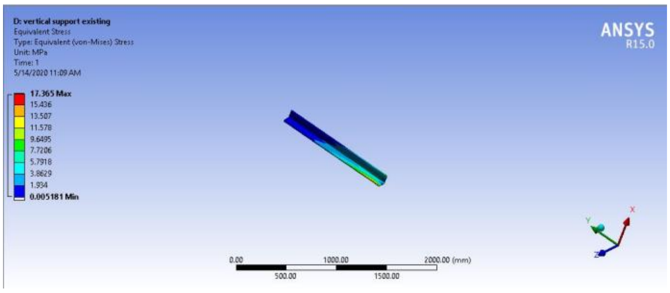


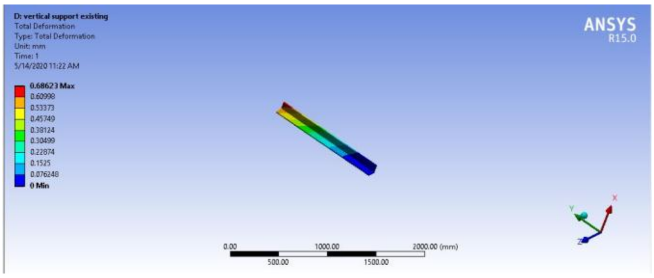
3. Design of Vertical Supports

Material – MS (L Channel)
For given material we have to select standard properties of that material, such as
E= 2.1×105 Mpa
Syt= 590 Mpa
ρ= 7860 kg/m3
Considering uniformly distributed load & FOS as 3
Allowable Stress (σall) = Syt / Fs
= 196.66 MPa
The Side supports are fixed at one end and free at other, this supports carry the vertical support plates (generally made of wood). Thus by considering the Cantilever beam with load acting uniformly distributed. The overall load on truck is 15000 Kg, the vertical supports are 20

on a cargo bed, thus 15 tons are distributed on 20 columns and this becomes 750 Kg.
Maximum moment is,
$M_{max} = WL^2/2$
$= 5471.86$ N.m
Section modulus (Z) = B × $H^2/6$
$= 1.219 \times 0.12 / 6$
$= 2.03 \times 10^{-4}$ m^3
Bending stress = Mmax / Z
$= 5471.86 / 2.03 \times 10^{-4}$
$= 26.95$ MPa
Weight= Cross section area x width x mass density x numbers of columes
$= 0.003429 \times 7860 \times 20$
$= 539$ Kg.

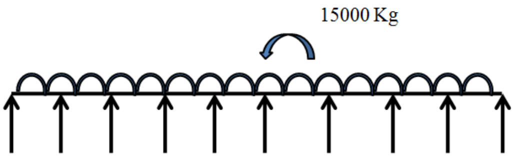
The Model and analysis is shown in below Diagrams,



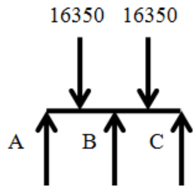


4. Design of Vertical Cargo bed.

The cargo bed is made of wood. This wood increases its weight when moisture content increases. This also increases overall weight of vehicle and thus the power consumption of vehicle increases. The load exerted on cargo bed is 15000 Kg.

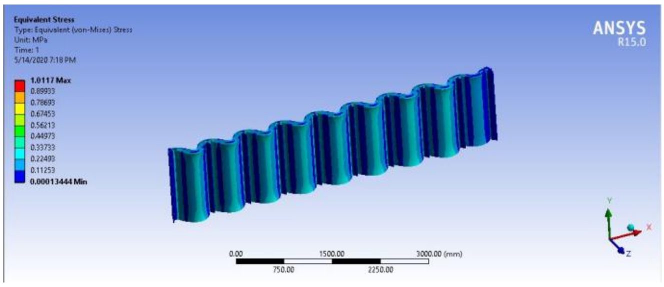


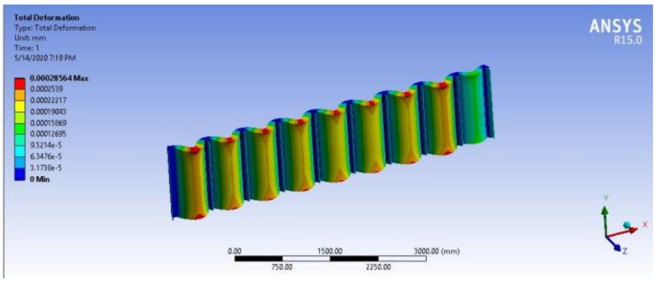
The Cargo bed is supported by ten fixed support, on which 15 ton load is uniformly distributed on it.
The 15 Ton is Converted in N = 147150 N/mm
UDL on individual Segment = 147150/9
= 16350 N/mm
Consider each span separately and calculate their moment by three moment method.
Consider Span AB and BC



$AB = BC = WL^2/8$
$= 615.09$ N.m
Support Moment Calculations:
Apply MTM on AB and BC
$M_a l_1 + 2M_b (l_1 + l_2) + M_c l_2 = (6\, a_1 x_1 \times l_1) + (6\, a_2 x_2 \times l_2)$
Therefore,
$M_a = 0$, $l_1 = 0.5486$ m, $l_2 = 0.5486$ m, $M_b = 0$, $M_c = 0$
$a_1 x_1 = a_2 x_2 = 2/3 \times 0.5486 \times 615.09 \times (0.5486/2)$
$= 61.70$ m3
Therefore,
$2M_b(0.5486+0.5486)=(6\times61.70/0.5486)+(6\times61.70/0.5486)$
$M_b = 615.02$ N/m
As Same UDL is acting on overall span, as well as span is same for each section, hence same bending moment is acting on each section, Thus the bending moment asting on beam is
$M_{max} = M_b = 615.02$ N/m
The Specifications of the cargo bed is as follow,
L = 5486 mm
b = 1219 mm
t = 76.2 mm
I= Moment of inertia in mm^4
$= (b \times t^3) / 12$
$= 1.219 \times 0.0762^3 / 12$
$= 4.49456 \times 10\text{-}5$ m^4
Ymax = 0.0762 / 2
= 0.0381 m
Now,
Bending stress = $(M_{max} / I) \times Y_{max}$
= 0.52134 MPa
Maximum deformation
(Ymax)= 5 x W x L^3/384 x E x I
(Ymax) = 0.0722 mm.

Weight= Cross section area x width x mass density x numbers of rollers
= L×w×t x ρ x 10
= 754 Kg.
When moisture increased into the wood, the weight of it increases by 30 % and hence the weight of Cargo bed becomes 980 Kg
The Modelling and Analysis of Vertical Cargo is shown below,





4. DESIGN OF OPTIMISATION

1. Design of Optimised Horizontal supporting columns:

Material - Wood

For given material we have to select standard properties of that material, such as

E= 7.2×105 Mpa

Syt= 200 Mpa

ρ= 740 kg/m3

Considering uniformly distributed load & FOS as 3

We have to calculate actual FOS for optimised roller.

Allowable Stress (σall) = Syt / Fs

= 66.6 Mpa.

The total weight exerted on vehicle is 15 tones, we will consider same weight on vertical columns, thus if we consider 10 vertical supports then weight exerted on each vertical column is 1500 Kg. Let us consider the load is uniformly distributed on the cantilever beam.

Maximum Stress Calculation for given condition

W= 1500 kg

Length= 3657

T= 76.2 mm

W= 177.8 mm

y = Distance from neutral axis = 177.8/2

= 88.9 mm

Considering Uniformly Distributed load

Maximum moment (Mmax) = W×L2 /8

= 24.599 kN-m.

Moment of Inertia (I) = 3.2117×10-4

Maximum Bending Stress

(σb) = Mmax x Y / I

= 24599 x 0.0889 / (3.2117×10-4)

σb = 6.81 Mpa.

Checking Factor of Safety for design.

FOS= (σall) / (σb)

= 66.6 / 6.81

FOS= 9.77

As calculated factor of safety (FOS) is greater than assume factor of safety,

So selected material can be considered as a safe.

Maximum deformation

(Ymax)= 5 x W x L3/384 x E x I

(Ymax) = 0.0405 mm.

Comparison with length 0.0405 mm is very negligible.

Hence selected material can be considered as safe for the same material.

Weight of Columes = Cross section area x width x mass density x numbers of Columes

= L×w×t x ρ x 10

= 366.64 Kg.

The weight of each column is 36.66 kg. Thus this weight should be reduced. The density shown above is at 12% moisture. Thus the density increases as the moisture contain increases into the wood. This moisture contain increases by 30% in wood after raining. Thus the weight of system increases in rainy seasons due to the moisture. Thus density increases by 30% i.e 962 Kg/m3. Thus the weight increases by

= L×w×t x ρ x 10

= 476.63 Kg.

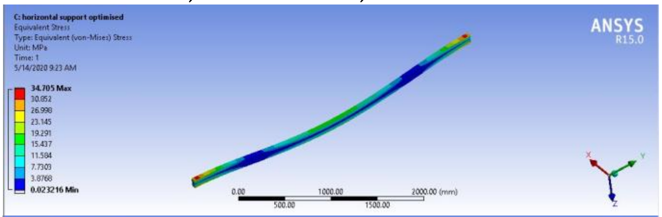
The weight of each column becomes 47.6 Kg.

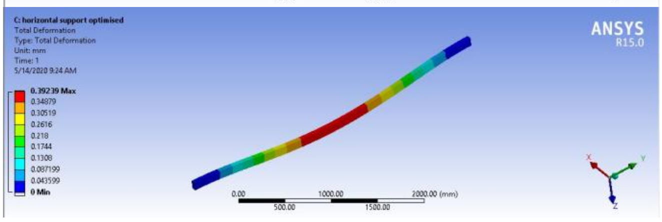
Same like above Following Iterations are carried out, here the length of the system will remain constant, only the width and thickness will change.

Sr. No	L (m)	W (m)	T (m)	Bending Stress (Mpa)	Weight after Moisture Content (Kg)	Weight per Columes (Kg)	Weight reduction (Kg)
1	3.657	0.1778	0.0762	6.81	476.6	47.7	0
2	3.657	0.1524	0.0762	9.27	408.5	40.9	68
3	3.657	0.127	0.0762	13.35	340.5	34.0	136
4	3.657	0.1016	0.0762	20.85	272.4	27.2	204
5	3.657	0.0762	0.0762	37.07	204.3	20.4	272
6	3.657	0.1778	0.0635	6.81	397.2	39.7	79
7	3.657	0.1524	0.0635	9.27	340.5	34.0	136
8	3.657	0.127	0.0635	13.35	283.7	28.4	193
9	3.657	0.1016	0.0635	20.85	227.0	22.7	250
10	3.657	0.0762	0.0635	37.07	170.2	17.0	306
11	3.657	0.1778	0.0508	6.81	317.8	31.8	159
12	3.657	0.1524	0.0508	9.27	272.4	27.2	204
13	3.657	0.127	0.0508	13.35	227.0	22.7	250
14	3.65	0.1016	0.0508	20.85	181.6	18.2	295

	7						
15	3.657	0.0762	0.0508	37.07	136.2	13.6	340
16	3.657	0.1778	0.0381	6.81	238.3	23.8	238
17	3.657	0.1524	0.0381	9.27	204.3	20.4	272
18	3.657	0.127	0.0381	13.35	170.2	17.0	306
19	3.657	0.1016	0.0381	20.85	136.2	13.6	340
20	3.657	0.0762	0.0381	37.07	102.1	10.2	374

The optimised solution seleceted is having below specifications:
Material= Wood.
L= 3657 mm, W= 101.6 mm, T= 50.8 mm

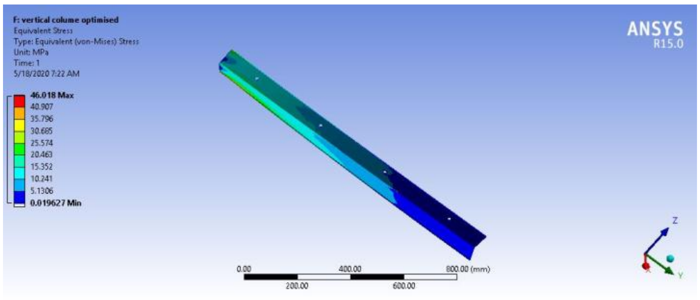




2. **Design of Vertical Colume:**
The Esisting Colume is of Mild Steel and L Channel, it can be optimised. For this we have to reduce the thickness of the C/S.
Material – MS (L Channel)
For given material we have to select standard properties of that material, such as
E= 2.1×105 Mpa
Syt= 590 Mpa
ρ= 7860 kg/m3
The calculations of this colume is done and tabulated below:

L	w	T	BENDING STRESS (MPa)	FOS	ACTUAL WEIGHT (Kg)	WEIGHT PER Support (Kg)
0.1	0.1	0.015	26.93	7.30	531.8	26.6
0.1	0.1	0.01	26.93	7.30	364.1	18.2
0.1	0.1	0.005	26.93	7.30	186.8	9.3
0.075	0.075	0.015	47.88	4.11	388.0	19.4
0.075	0.075	0.01	47.88	4.11	268.3	13.4
0.075	0.075	0.005	47.88	4.11	138.9	6.9
0.05	0.05	0.015	107.73	1.83	244.3	12.2
0.05	0.05	0.01	107.73	1.83	172.5	8.6
0.05	0.05	0.005	107.73	1.83	91.0	4.6

The Best Solution selected from above solutions is as follow:
Material : Mild Steel, C Channel 75×75×5 and length of 1219 mm.
The Modelling and Analysis is shown in following figure.



3. Design of Horizontal and Vertical Cargo Support

A5052-H111 is an Aluminium-Magnesium wrought alloy in the H111 tamper/category. To achieve this category, the metal is strained to a reduced strength than is permitted for H111. Compared to the other 5052 aluminium type, it has the second largest ductility.
The following iteration was carried out to check the critical loading on the plate:
Core height of 25 mm and face sheets of 1 mm thickness each, the specimen taken for experiment is having following specifications:
Length= 200 mm, width = 100 mm, thickness of honeycomb = 25 mm, face sheets = 1mm.

a) Mass of facing material

mf =2(a×b) ρf * tf

Where,
a =200mm
b =100mm
ρf =8 gm/cm³ =0.008gm/mm³
tf =1mm
mf= 2(200x100)x0.008x1
= 320 gm

b) Average density of honeycomb core

$$\rho_{ca} = \frac{8}{3\sqrt{3}} \times \frac{tc}{d} \times \rho c$$

tc= thickness of core cell = 0.3 mm
d = length of side hexagon = 5 mm
ρc= 2.7 g/cm³
= 0.8985 gm/cm³
= 898.5 kg/m³

c) Mass of honeycomb core (mc)

mc= a× b×hc×ρca
mc= 200x100x25x898.5x10-6
=449.25 gm
Mass of honeycomb test specimen
(mc+mf) = (320+449.25)
= 769.25 gm

d) Critical Load

$$P_o = \frac{cbh^2\sigma cf}{2a} \times \left\{1 - \left(\frac{hc}{h}\right)^2\right\}$$

Where,

$$C=\frac{c1}{c1+c2}$$

$$c1=\frac{a^3}{(48\times Ef\times If)}$$

$$I_f=\frac{b(h^3-hc^3)}{12}$$

= 3.381x104 mm4

c1 = 8.9329x10-6

$$c2=\frac{a}{4\times Ac\times Gca}$$

$$Ac=b\times hc$$

= 2500mm2

$$Gca=\frac{Gcw+Gcl}{2}$$

= 315 Mpa

$$c2=\frac{100}{4\times 2500\times 315}$$

= 3.174x10-6

$$c=\frac{c1}{c1+c2}$$

$$=\frac{8.9329x10-6}{8.9329x10-6+3.174x10-6}$$

= 1.5

Critical load (p0):

$$P_0=\frac{cbh^2\sigma cf}{2a}\times\left\{1-\left(\frac{hc}{h}\right)^2\right\}$$

P0=11.31 KN

The specimen taken for experiemnet is of 200 × 100 mm. We are calculating the stress on cargo bed of 15 Ton capacity. Thus the critical load on 200 × 100 mm plate is 11 KN it means 1100 Kg, which is safe. Thus The stress on the plate is calculated as follows, The plate is subjected to a uniformly distributed load and it is simply supported,

Therefore,

Maximum moment (Mmax) = W×L2 /8

= (11310× 2002) / 8

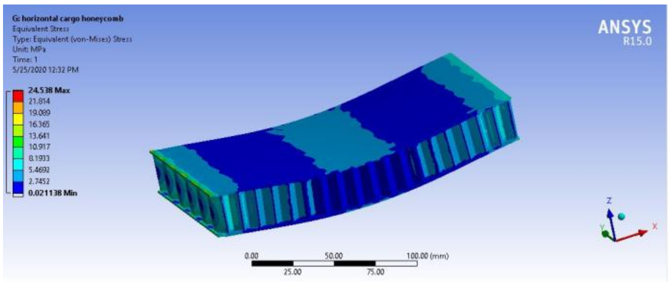
= 56.55 kN-mm.

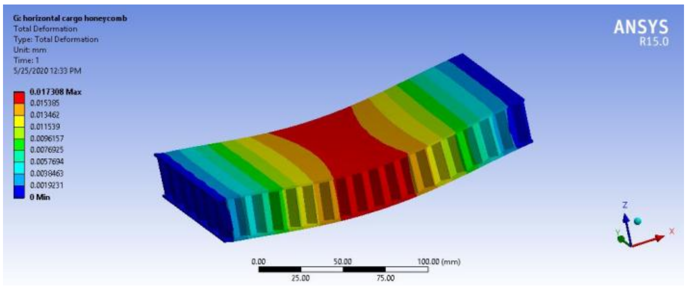
Moment of Inertia (I)= 3.125×10-6 m4

Bending stress = (Mmax /I) × Ymax

= (56550/3.125 × 10-5) × 0.0135

= 24.4296 MPa





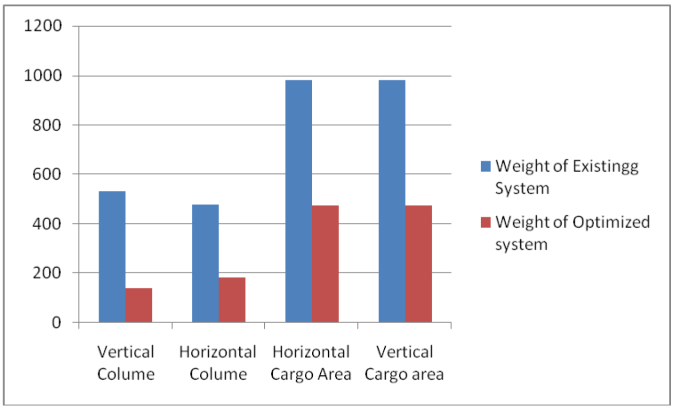
Thus the total weight of this plate is 0.769 Kg and same weight of this plate of wood is 1.49 Kg, thus we have achieved the weight reduction of 0.721 Kg for the sample plate. It means we will achieve the weight reduction of 51.61%

5. RESULT AND DISCUSSION

The weight reduction achieved in total system is tabulated below:

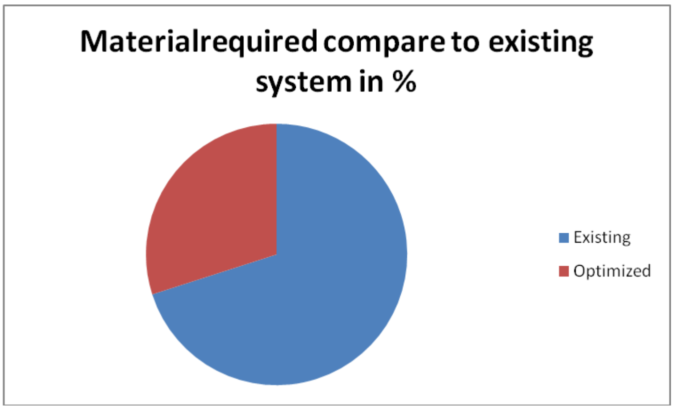
Sr. No.	Component	Weight of Existingg System	Weight of Optimized system
1.	Vertical Colume	531	138.9
2.	Horizontal Colume	476.6	181.6
3.	Horizontal Cargo Area	980	474
4.	Vertical Cargo area	980	474
TOTAL WEIGHT		**2967.6 Kg**	**1268.5 Kg**

Here we have achieved the total weight reduction of 1699 Kg, which is good. Here we have achieved 51.61% of weight reduction due to the use of Honeycomb structured Sandwich panels.



The saving of material is shown in table below:

Design of system	Materialrequired compare to existing system in %	Material save compare to existing system in %
Existing	100	-
Optimized	42.74	57.26 %



6. CONCLUSIONS:

- The material saving of overall system is achieved upto 57.26 %.
- Material saved in system is of 1677 Kg.
- The use of honeycomb structure material decreases the weigth of the cargo bed upto 51.61 %.
- As the dead weight of the cargo bed decreases, the fuel consumption of the truck will decrease.

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