Feasibility checking of tipper unloading mechanism

Mr. Prakalp S. Moon[1], Dr. M. J. Sheikh[2], Dr. G. V. Thakre[3]

[1]*Department of Mechanical Engineering*
[2]*Prof. Department of Mechanical Engineering*
[3]*Prof. & Head. Department of Mechanical Engineering*
[1,2,3] *Bapurao Deshmukh College Of Engineering, Sevagram, Maharashtra, India*

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Abstract - *Tipper truck is damp truck which is used to transport sand, gravel, dirt, coals, etc. from one place to another place. Generally tipper truck is used in mines to transport heavy materials. But limitations of tipper truck to unload material only in one direction reduces its efficiency and effectiveness in today's era. Also to unload material in specific area, tipper has to be parked accordingly which ultimately time consuming process. Tipping requires safety consideration. If truck is not parked at relatively horizontal ground, overturning of tipper and slipping of tipper occurs. To overcome these problems it is necessary to study the existing unidirectional unloading technique. To overcome these problems design of tipper is suggested which uses three hydraulic cylinders instead of one , each situated on lateral side of tipper truck to unload the material in left or right side along with the existing rear side material unloading. This paper is focused on the modeling and feasibility checking of three way unloading mechanism of tipper. Existing tipper truck specifications are taken into consideration for geometric modeling of tipper. Same models has been used in ANSYS software for feasibility checking of the proposed system. The results generated are helpful for understanding the analysis of the system so as to overcome the limitations of the system to meet our desired goals.*

Key Words: **tipper, dump truck, hydraulic cylinder's,etc..**

1.INTRODUCTION

The tipper truck is highly popular in transportation of heavy materials such as sand, gravel, coals, etc.Tipper truck is the advanced version of conventional trucks. Conventioanal trucks can also transport heavy materials from one place to another but huge difference is that , in conventional truck man power is required to unload the material in the truck. While unloading the material, employees just open the side walls of the trolley and with the help of spade. This process is from last few decades. But this method is time consuming. Extra cost of man power is to be paid for unloading the material. Also the existing tipper can not perform in effective in small and congested area such as small roads, construction sites, mines,etc. It also consumes more time and more fuel which ultimately reduces efficiency of the sysyem.

To overcome these problems tipper truck was invented. This truck having hydraulic member in it which lifts the trolley upward to unload the material on rear side. The arrangment was, just backside of cabin head, the hydraulic cylinder is placed which provides the power to hydraulic member which is situated just below the top of the trolley and the chasis frame. With the help of hydraulic member , trolley get lifted upward at front ,which allows the material in truck to unload at the rear side. This kind of trucks are much popular uptill due to the unloading mehanism.

But it has also its own drawbacks. Truck has to be parked well according to site where material is to be unloaded. This consumes more time and cost of fuel which leads to reduction in efficiency. Also there are chance of sudden slipover or turning of trucks if is not parked properly in uneven sites such as coal mines,etc.

For safety consideration of life of human being and material safety these drawbacks are need to be resolve. So keeping these in mind, we are proposing three way unloading mechanism of tipper. In this mechanism, need to parked vehicle at right place will be resolve. We can easily parked vehicle and according to requirment, we will be able to unload the material , whether it is on right side or left side of the truck. We are suggeting instead of using one hydraulic cylinder use three, so as to give the trolley three way unloading mechanism. Which will increase effectiveness and efficiency of the system. Risk of life in overturning of vehicle will get reduced. Ultimately this new proposed design will change tipper truck working to provide better to performance.

But to devlope this three way unloading mechanism, we first have to go for studying the existing unloading mecahnism tipper and its full specifiactions. This will helps us to create 3D geometric modelling and for ANSYS software based analysis so as to complete understanding of the system.

2. Overview

This paper discussed about the modelling and analysis of multiside unloading mechanism of tipper truck.

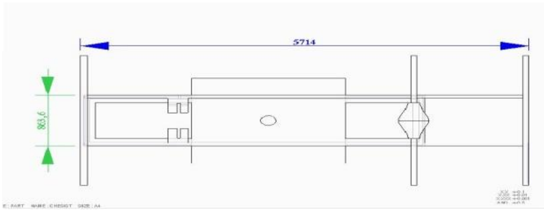
To understanding any system, modelling is the best way to show the importaint components of the system. This 3D modelling also helps to create analysis results of the system in software.

In This paper we will discuss, modelling and analysis of the existing mechanism along with the proposed multiside unloading mechanism. For modelling and analysis of the multiside unloading mechanism, its necessity components such as hydraulic cylinder, hydraulic motor, hinge and pin design, etc. are taken into consideration as major parts.

3. Specifications

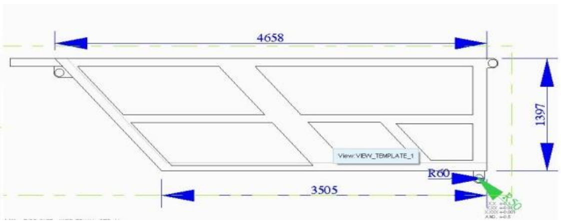
6 wheeler rigid tipper: Model: 1616
For Chasis

Total length	:	5714mm
Total width	:	863.6mm
Length from hydraulic Cylinder to chasis end	:	4658mm



For Trolley

Total height	:	1397mm
Total width	:	2489.2mm
Length(upper length L1)	:	4658mm
Length(lower length L2)	:	3505mm



Vehicle load specification

Max vehicle weight(fully loaded)	:	16.2 tons
Typical load capacity	:	8.5 tons
Total load to be delivered	:	10 tons
Total load to be delivered	:	98100 N

This specifications are used to create cad 3-D model with the help of creo parametric (PRO-E) software.

This cad generated model is converted into igs file and then it is imported to the analysis software named ANSYS

4. modeling and analysis for three way unloading mechanism

4.1 case of rear side unloading

In this unloading case, trolley is lifted upward from front end with the help of hydraulic cylinder and only rear side hinges are attached so as to material can get unload at rear side.

4.1.1 Existing tipper modeling

Fig. rear side unloading

- This model shows the existing rear side unloading mechanism. In existing system , tipper can unload material only at rear side.
- In this process, maximum tipping angle is 45 degrees, so that the load can be easily dropped by gravity.
- Here only rear side hinges are attached to the trolley and the chasis and hydraulic member connected to the front end of the trolley gives the upward thrusts to lift up the trolley so that the material would unload from the rear end of the trolley.

4.1.2 Analysis of the existing unloading mechanism

This model of rear side unloading mechanism of tipper is used to create analytical results of the system with used of ANSYS software.

For this, chasis , hydraulic cylinder , hinge and pin assemble , trolley these components of the tipper are taken into consideration to generate analytica result.

In this analysis we will check the total deformation, shear stress, maximum shear stress and the von mises stresses for the hinge and pin assembly mainly so as to validate the theoretical results.

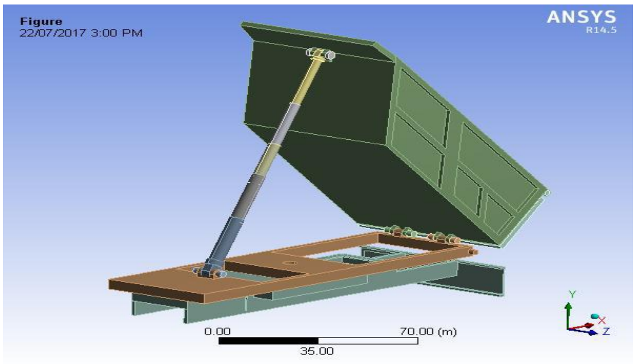


Fig.1.1 rear side unloading

Step 1: Mesh generation

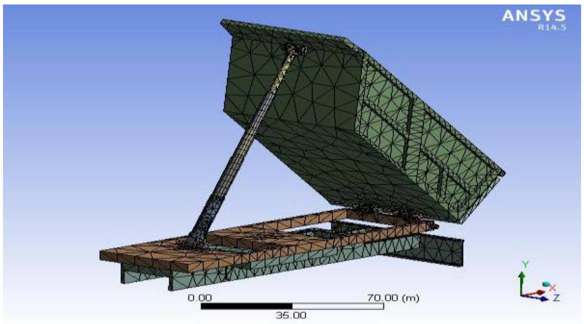


Fig. 1.2 mesh generation

Mesh generation is basic and most important step in generation of analytical result in software.
Mesh generation means creating very small nodes on all over the body on which we have to perform analysis.
Here, we have used triangular mesh generation system.
Above figure shows mesh generated in the body.

Step : 2 Applying boundry condition

Fixed supports plays an important role for analysis, on which all other parts having some degree of freedom are situated

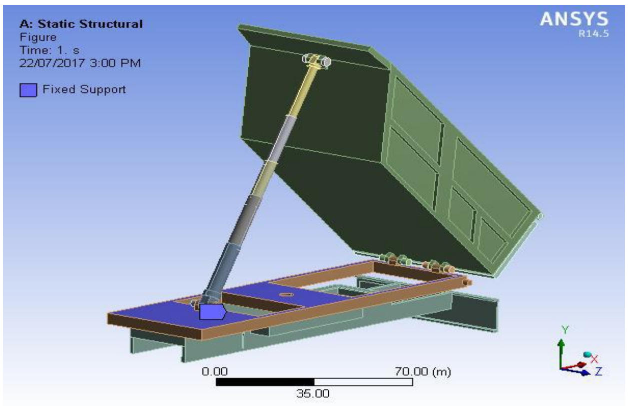


Fig. 1.3 fixed support

Here chasis is fixed.

Step 3: Applying force

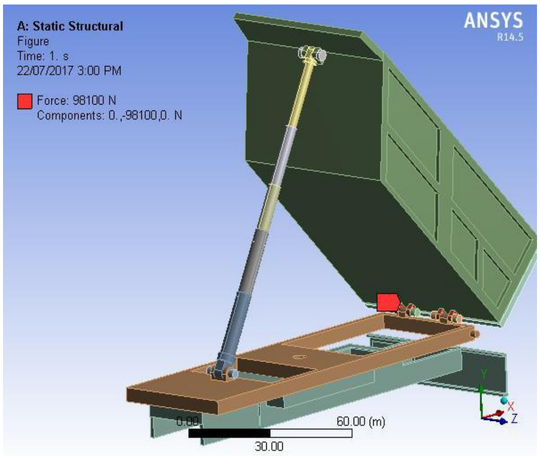


Fig.1.4 force diagram

A load of 10 ton is applied on the hinges (red portion shown in above fig.) which ultimately goes towards the hinge and pin assembly while unloading the material and distributed ain all over the body.

10 ton load is converted to 98100 N.

Results

TABLE 18
Model (A4) > Static Structural (A5) > Solution (A6) > Results

Object Name	*Total Deformation*	*Equivalent Stress*	*Maximum Shear Stress*	*Shear Stress*
State	Solved			
Scope				
Scoping Method	Geometry Selection			
Geometry	All Bodies			
Definition				
Type	Total Deformation	Equivalent (von-Mises) Stress	Maximum Shear Stress	Shear Stress
By	Time			
Display Time	Last			
Calculate Time History	Yes			
Identifier				
Suppressed	No			
Orientation				XY Plane
Coordinate System				Global Coordinate System
Results				
Minimum	0. m	0. Pa		-10084 Pa
Maximum	5.2086e-007 m	36615 Pa	19479 Pa	6053.3 Pa
Minimum Occurs On	Part 12	Part 13		Part 11
Maximum Occurs On	Part 4	Part 11		Part 12
Information				
Time	1. s			
Load Step	1			
Substep	1			
Iteration Number	1			
Integration Point Results				
Display Option		Averaged		

a) total deformation

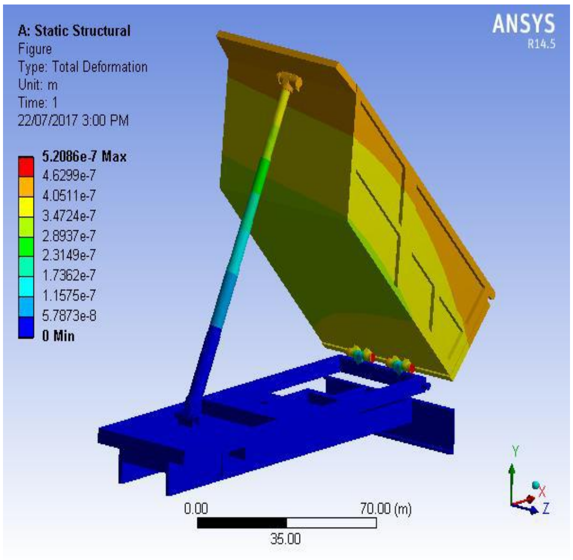


Fig.1.5 total deformation diagram

As shown in above table,

1. maximum deformation occurs is in hinge

5.2086e^-007=4.75*(10^-3) m

=4.75 mm

2. chasis is fully safe

3. as load is in trolley, so there is maximum deformation only upto 4.0511*e^-7=3.69*(10^-3)

=3.69mm

So, from above results, we can say that, other maximum deformation occurs in hinges.

b) equivalent(von- mises) stresses

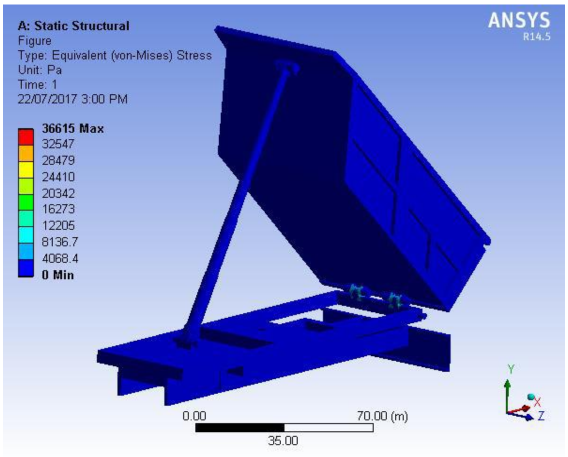


Fig.1.6 showing equivalent (von mises) stresses

As shown in figure, chais, trolley, hydraulic assembly is fully safe as von-mises stresses occurred there are negligible.

But in case of hinge and pin assembly, maximum shear stress occurred is 12205 pa i.e. 0.122 MPa

So, we can say that, our design for hinge and pin is safe.

c) maximum shear stress

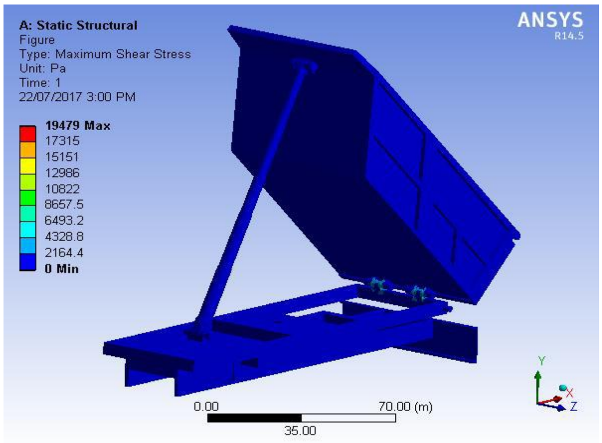


fig. 1.7 maximum shear stress

As shown in figure, the trolley, hydraulic cylinder, chasis are dark blue.

Means, the maximum shear stress occurred here is negligible.

So the design for trolley, hydraulic cylinder, chasis is fully safe.

The hinge and pin assembly is having maximum shear stress of 8657 Pa i.e. 0.08657 MPa

Hence, maximum shear stress is under limit, and hence, design is safe.

d) shear stress

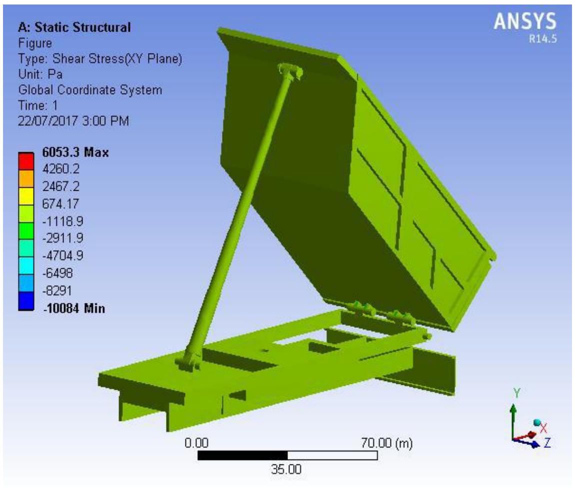


Fig.1.8 shear stress

As shown in figure, shear stress occurred in full assembly is constant nearly.
647.17 Pa i.e. 0.000674MPa

So we can say that, design is safe

4.2 case of left side unloading

In this unloading case, trolley is lifted upward from right side with the help of hydraulic cylinder and only left side side hinges are attached so as to material can get unload at left side.

4.2.1 Modeling of left side unloading mechanism

Fig. left side unloading

- This model shows the left side unloading mechanism system.
- Here , the hydraulic cylinder placed on right edge of chasis frame (looking from rear end) is giving neccessory thrust to lift the trolley.
- In this unloading mechanism, hinge and pin assembly on left edge of the chasis frame is engaged with the trolley.

In this process, maximum tipping angle is 20 degrees, so that the load can be easily dropped by gravity and risk of overturning of the vehicle at unloading process is minimized.

4.2.2 Analysis of left side unloading mechanism

This model of left side unloading mechanism of tipper is used to create analytical results of the system with used of ANSYS software.

For this, chasis , hydraulic cylinder , hinge and pin assemble , trolley these components of the tipper are taken into consideration to generate analytica result.

In this analysis we will check the total deformation, shear stress, maximum shear stress and the von mises stresses for the hinge and pin assembly mainly.

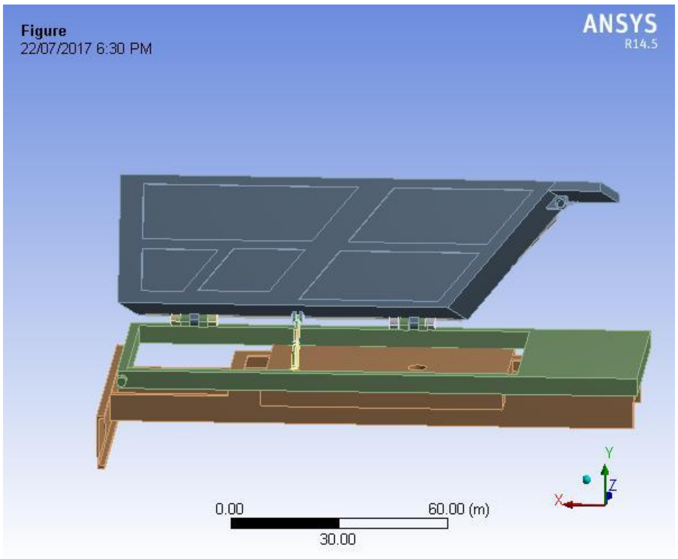


Fig. 2.1 left side unloading mechanism

STEP 1: Mesh generation

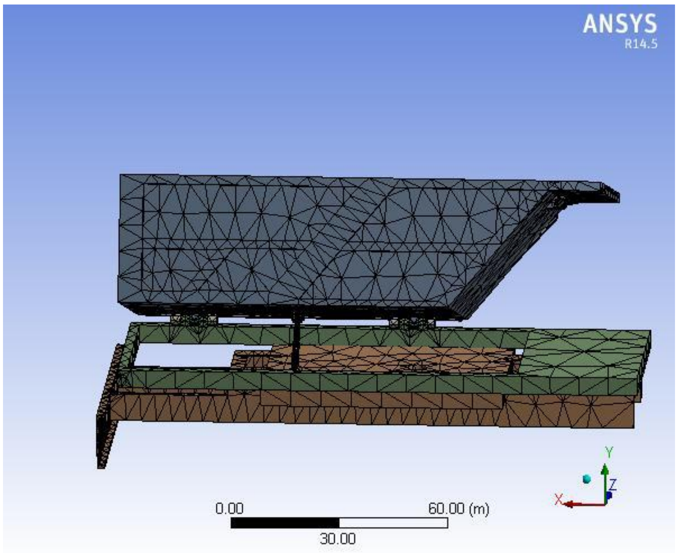


Fig. 2.2 mesh generation for left side unloading

Mesh generation is basic and most important step in generation of analytical result in software.

Mesh generation means creating very small nodes on all over the body on which we have to perform analysis.

Here, we have used triangular mesh generation system.
Above figure shows mesh generated in the body.

STEP : 2 Applying boundry condition

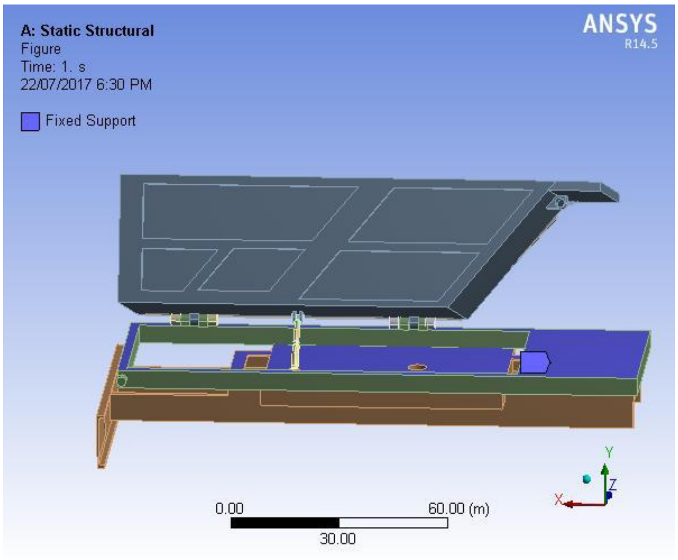


Fig. 2.3 static structural showing fixed support

Fixed supports plays an important role for analysis, on which all other parts having some degree of freedom are situated.

Here, as in previous case, chassis is fixed.

STEP 3: Applying force

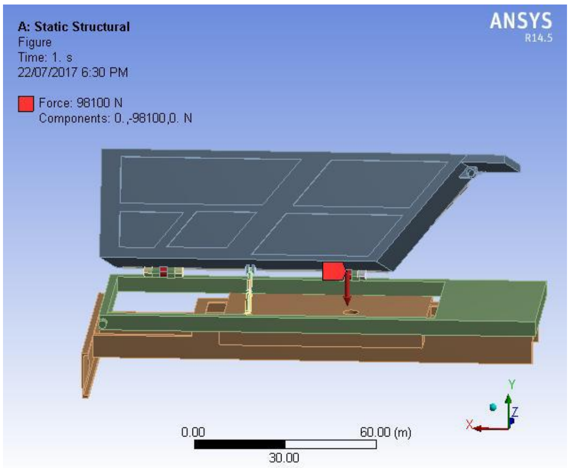


Fig.2.4 force diagram

A load of 10 ton is applied on the hinges (red portion shown in above fig.) which ultimately goes towards the hinge and pin assembly while unloading the material and distributed ain all over the body.

10 ton load is converted to 98100 N.

Results

TABLE 19
Model (A4) > Static Structural (A5) > Solution (A6) > Results

Object Name	*Equivalent Stress*	*Maximum Shear Stress*	*Shear Stress*	*Total Deformation*
State	Solved			
Scope				
Scoping Method	Geometry Selection			
Geometry	All Bodies			
Definition				
Type	Equivalent (von-Mises) Stress	Maximum Shear Stress	Shear Stress	Total Deformation
By	Time			
Display Time	Last			
Calculate Time History	Yes			
Identifier				
Suppressed	No			
Orientation			XY Plane	
Coordinate System			Global Coordinate System	
Integration Point Results				
Display Option	Averaged			
Results				
Minimum	1.0282e-010 Pa	5.6733e-011 Pa	-5944.2 Pa	0. m
Maximum	19323 Pa	9896.8 Pa	6472.6 Pa	3.7793e-007 m
Minimum Occurs On	Part 11		Part 10	Part 11
Maximum Occurs On	Part 10			

a) equivalent(von- mises) stresses

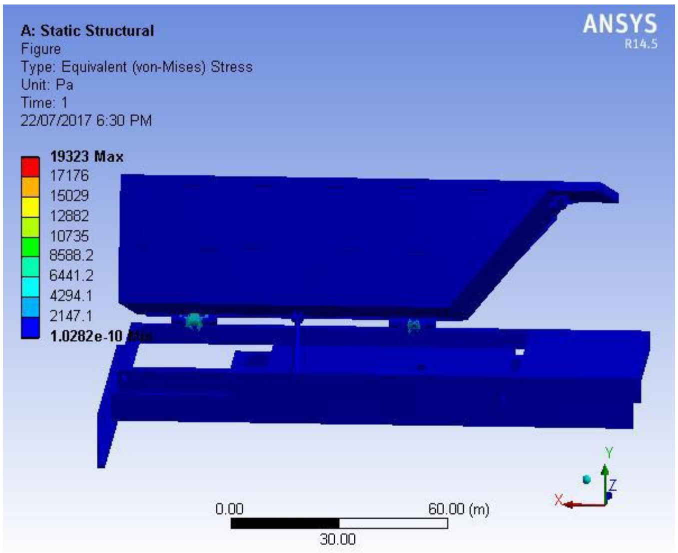


Fig. 2.5 equivalent(von- mises) stresses

As shown in figure,
The chasis frame, hydraulic cylinder, and the trolley is safe and having minimum von mises stresses developed which is 1.0282*(e^-10)= 4.66 *(10^-5) Pa i.e. 4.66*(10^-11)
So we can conclude that the design is fully safe.

In case of , hinge and pin, von mises stresses developed are 6441.2 Pa i.e. 0.0064412 MPa
So design is safe.

b) maximum shear stress

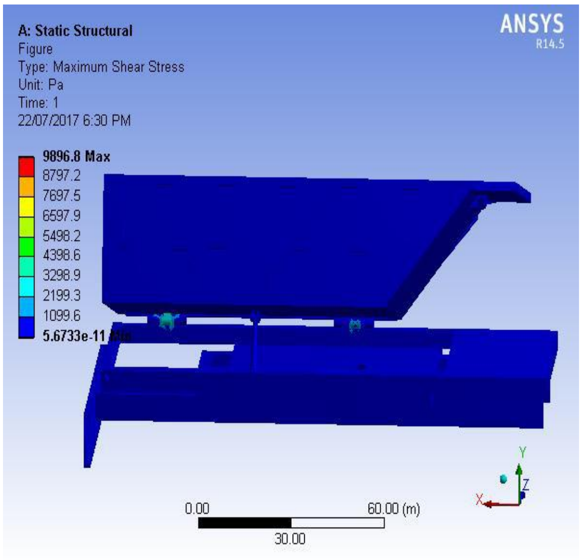


Fig. 2.6 maximum shear stress

As shown in above figure,
Maximum shear stress occurred in hinge and pin assembly. The value of maximum shear stress is 3298.96 Pa i.e. 0.003298 MPa
Which is under limit so we can conlude that, design of hinge and pin for maximum shear stress is safe.

The dark blue portion of trolley, hydraulic cylinder, and chais shows that, the design is fully safe.

c) shear stress

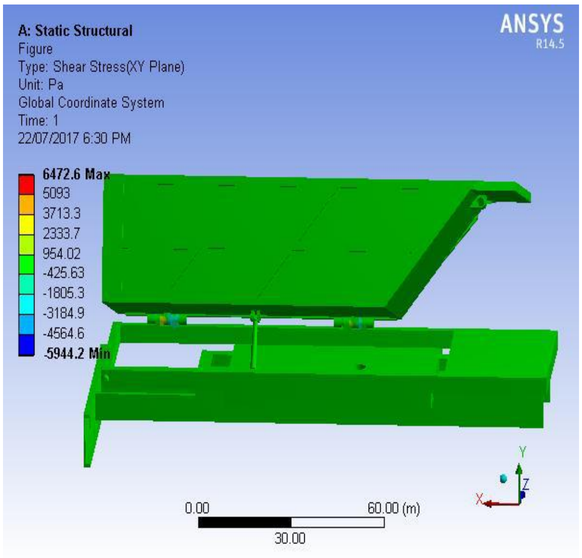


Fig.2.7 shear stress

As shown in above figure, shear stress occurred in trolley, chasis, and hydraulic cylinder shown in green color is -425.63 Pa i.e. 0.425*(10^-3) MPa
So we can say that, the design is safe

In case of, hinge and pin assembly, yellow portion shows the shear stresses developed there. The value of it is 2333.7 Pa i.e. 0.002333MPa
So we can say that the design is safe.

d) total deformation

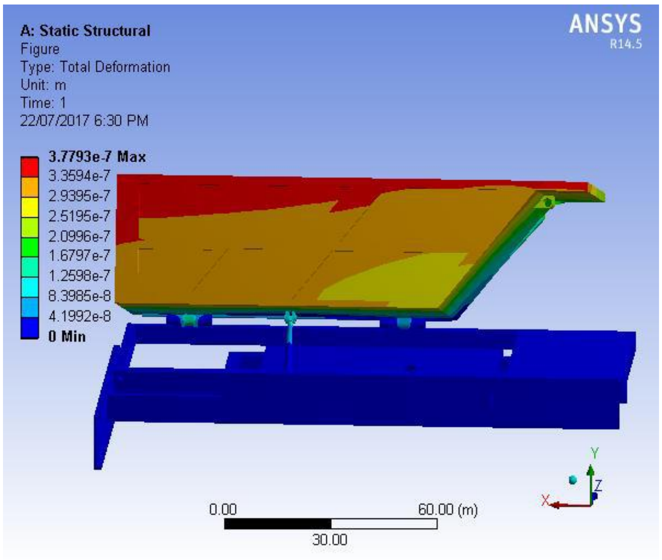


Fig.2.8 total deformation

As shown in above figure the chasis, and pin is shown in blue portion, which means the deformation occurs here is zero i.e. minimum.
But in case of hydraulic, some deformation occurs in minimum value 8.3985*(e^-8)m = 2.81*(10^-3) m
=2.81 mm
In case of hinge,
the deformation occurred is
1.2598*(e^-7)m=1.148*10^-3m
=10148 mm
So we can say that, deformation is under control and design is safe.

4.3 case of right side unloading

In this unloading case, trolley is lifted upward from left side with the help of hydraulic cylinder and only right side side hinges are attached so as to material can get unload at right side

4.3.1 Modeling of right side unloading mechanism

- This model shows the right side unloading mechanism system.

- Here , the hydraulic cylinder placed on left edge of chasis frame (looking from rear end) is giving neccessory thrust to lift the trolley.

Fig. right side unloading

- In this unloading mechanism, hinge and pin assembly on right edge of the chasis frame is engaged with the trolley.

- In this process, maximum tipping angle is 20 degrees, so that the load can be easily dropped by gravity and risk of overturning of the vehicle at unloading process is minimized.

4.3.2 Analysis of right side unloading mechanism

This model of right side unloading mechanism of tipper is used to create analytical results of the system with used of ANSYS software.

For this, chasis , hydraulic cylinder , hinge and pin assemble , trolley these components of the tipper are taken into consideration to generate analytica result.

In this analysis we will check the total deformation, shear stress, maximum shear stress and the von mises stresses for the hinge and pin assembly mainly.

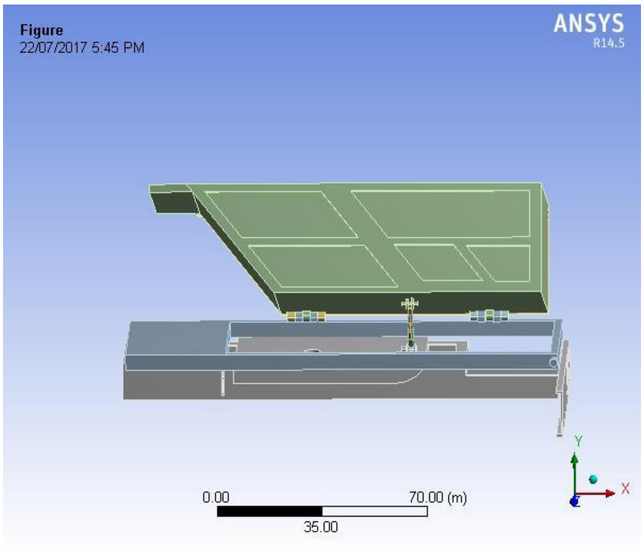


Fig.3.1 right side unloading mechanism

STEP 1: Mesh generation

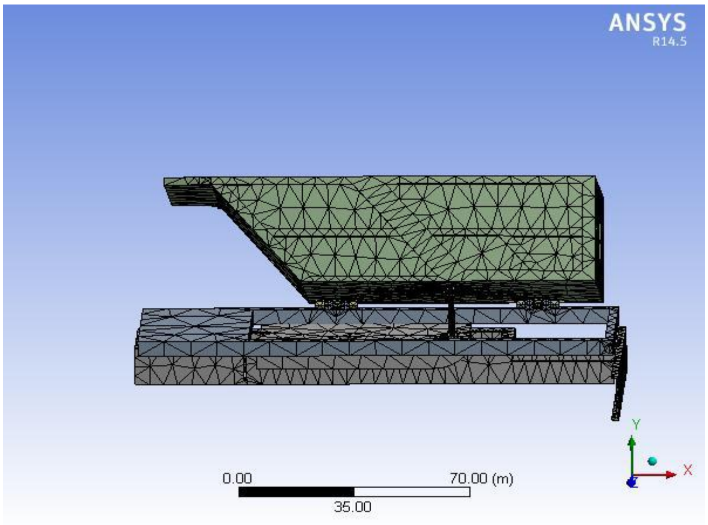


Fig. 3.2 mesh generation for right side unloading mechanism

Mesh generation is basic and most important step in generation of analytical result in software.

Mesh generation means creating very small nodes on all over the body on which we have to perform analysis.

Here, we have used triangular mesh generation system.

Above figure shows mesh generated in the body.

STEP : 2 Applying boundry condition

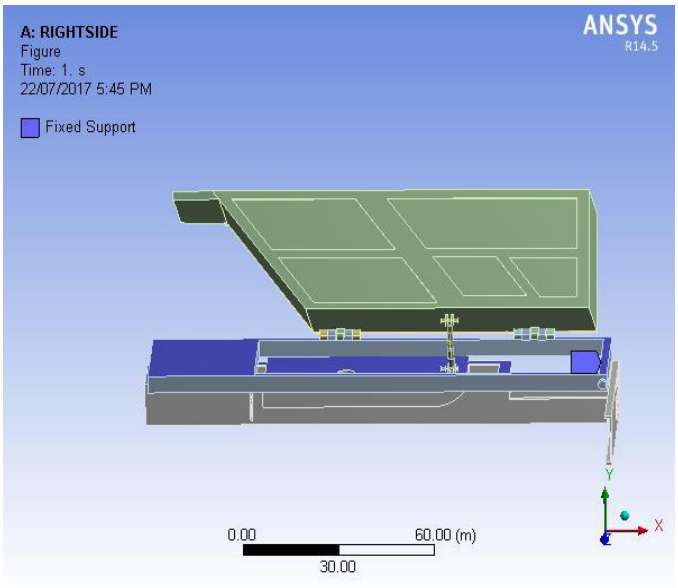


Fig.3.3 fixed support

Fixed supports plays an important role for analysis, on which all other parts having some degree of freedom are situated. Here, as in previus case, chasis is fixed

STEP 3: Applying force

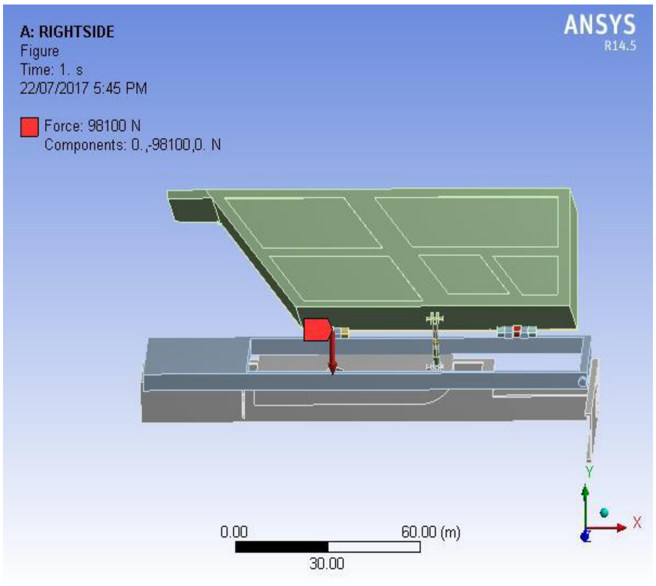


Fig. 3.4 force diagram

A load of 10 ton is applied on the hinges (red portion shown in above fig.) which ultimately goes towards the hinge and pin assembly while unloading the material and distributed ain all over the body.

10 ton load is converted to 98100 N.

Results

TABLE 19
Model (A4) > Static Structural (A5) > Solution (A6) > Results

Object Name	*Total Deformation*	*Equivalent Stress*	*Maximum Shear Stress*	*Shear Stress*
State	Solved			
Scope				
Scoping Method	Geometry Selection			
Geometry	All Bodies			
Definition				
Type	Total Deformation	Equivalent (von-Mises) Stress	Maximum Shear Stress	Shear Stress
By	Time			
Display Time	Last			
Calculate Time History	Yes			
Identifier				
Suppressed	No			
Orientation				XY Plane
Coordinate System				Global Coordinate System
Results				
Minimum	0. m	5.3226e-011 Pa	3.0686e-011 Pa	-4101.6 Pa
Maximum	1.6047e-007 m	16067 Pa	8892.2 Pa	5021.6 Pa
Minimum Occurs On	Part 5	Part 6		
Maximum Occurs On	Part 7			
Information				
Time	1. s			
Load Step	1			
Substep	1			
Iteration Number	1			
Integration Point Results				
Display Option		Averaged		

a) equivalent(von- mises) stresses

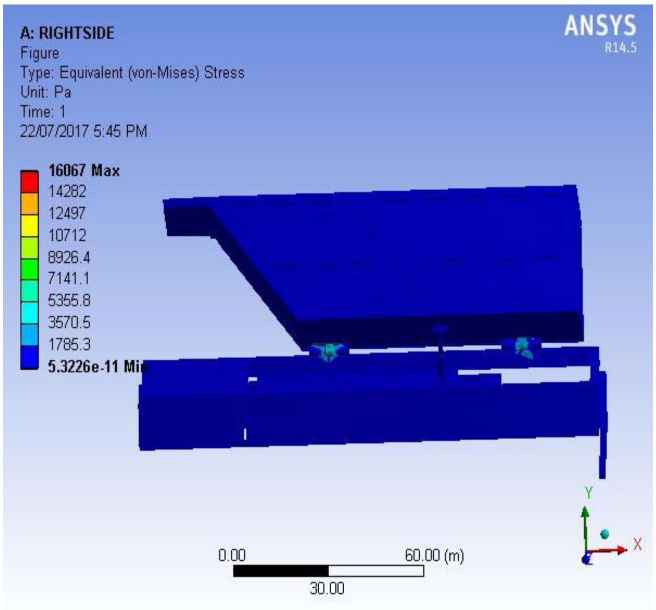


Fig. 3.5 equivalent (von- mises) stresses

As shown in above figure, chasis frame, hydraulic cylinder and trolley are having minimum von mises stresses having value of 5.3226*(e^-11) Pa = 8.89*10^-5 Pa
= 8.89*(10^-11) MPa

So we can say that the value is so minimum i.e. negligible. So design is safe.

In case of, hinge and pin assembly, the von mises stresses occurred are 5355.8 Pa = 0.005355MPa which is under limit So deign is safe

b) maximum shear stress

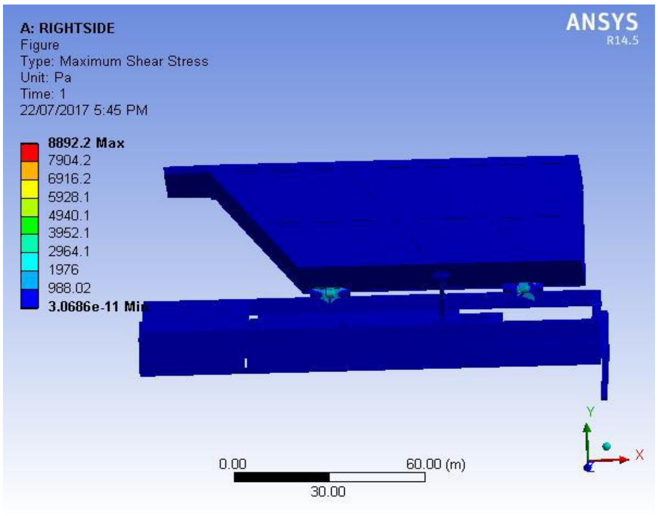


Fig. 3.6 maximum shear stress

As shown in above figure,
Maximum shear stress occurred in hinge and pin assembly. The value of maximum shear stress is 2964.1Pa i.e. 0.002964.1 MPa
Which is under limit so we can conlude that, design of hinge and pin for maximum shear stress is safe.

The dark blue portion of trolley, hydraulic cylinder, and chais shows that, they have minimum value of maximum shear stress of 3.0686*(e^-11) Pa i.e. 5.13*(10^-11) MPa
Which is negligible

So the design is fully safe.

c) shear stress

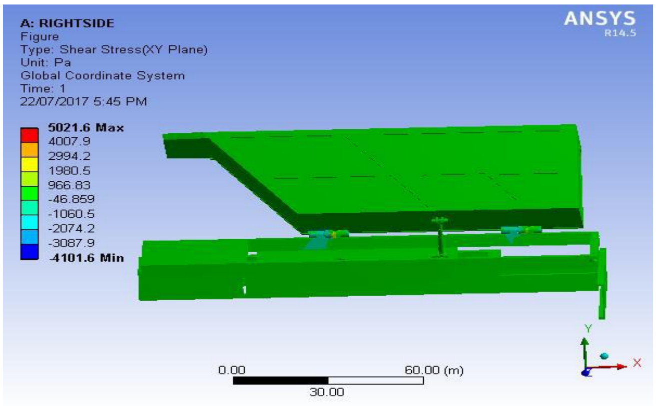


Fig.3.7 shear stress

As shown in above figure, shear stress occurred in trolley, chasis, and hydraulic cylinder shown in green color is -46.859 Pa i.e. -0.468*(10^-3) MPa
So we can say that, the design is safe.

In case of, hinge and pin assembly, yellow sky blue portion shows the shear stresses developed there. The value of it is -1060.5 Pa i.e. -0.001060MPa which is under limit
So we can say that the design is safe.

Another half portion of hinge and pin assembly is showing yellow color having value of 1980.5 Pa i.e. 0.001980MPa Which is under limit, so we can say that the design is safe.

d) total deformation

As shown in figure the chasis is shown in blue portion, which means the deformation occurs here is zero i.e. minimum.

But in case of hydraulic, some deformation occurs in minimum value 3.5661*(e^-8)m=1.20*(10^-3)m
=1.20mm
So we can say that, deformation is under control and design is safe.

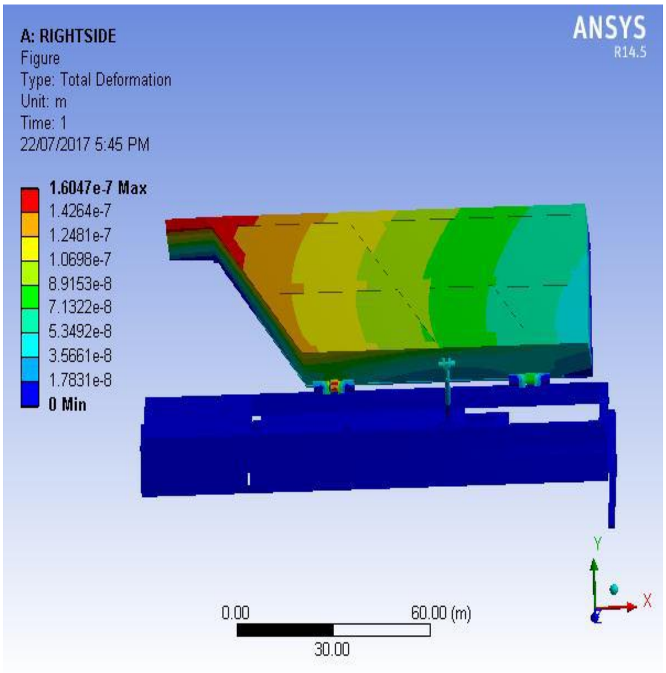


Fig. 3.8 total deformation

In case of hinge, the deformation occurred is maximum as shown in red color

1.6074*(10^-7)m=1.46*(10^-3)m
=1.46mm

So we can say that, deformation occurs, to overcome this deformation, we can select higher diameter of hinge and pin assembly.

4. Conclusion

We have obtained the motivating and encouraging results from this study. From studying modeling and analysis of all the three cases of unloading mechanism of tipper, we conclude that the whole design and functioning of mechanism is safe.

Every aspect such as chasis, trolley, hydraulic cylinder, hinge and pin are safe while system is working and can provide us the desired output.

5. Future scope

We can go for application of this proposed three way unloading mechanism of tipper in actual working prototype model so that we can check that our system will work properly or not.

Automation of tipping i.e. unloading in all three direction will be possible by using a power pack with plc control (device provides automated working system) or some similar kind of automation devices.

Engage and disengagement of hinges at the time of side tilting can be possible with automation according to requirement.

Engagement/disengagement of main hydraulic cylinder with trolley during side unloading can be operating through automation.

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