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Structural Analysis of Two Wheeler Suspension Frame

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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. 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 frame must therefore be torsion resistant.

The aim of the project is to model a frame using 3D modeling software Pro/Engineer. To validate the strength of a frame, Structural analysis is done by applying the wheel forces. In this analysis ultimate stress limit for the model is determined. Analysis is done for frame using four materials alloy steel, aluminum alloy A360, magnesium and carbon fiber reinforced polymer to verify the best material for frame. Model analysis is also done to determine different mode shapes for number of modes. Analysis is done in ANSYS software.

INTRODUCTION

Motorcycle Chasis

The motorcycle chassis consists of the frame, suspension, wheels and brakes. Each of these components is described briefly below.

Frame

Motorcycles have a frame made of steel, aluminum or an alloy. The frame consists mostly of hollow tubes and serves as a skeleton on which components like the gearbox and engine are mounted.

Suspension

The frame also serves as a support for the suspension system, a collection of springs and shock absorbers that helps keep the wheels in contact with the road and cushions the rider from bumps and jolts.

Wheels

Motorcycle wheels are generally aluminum or steel rims with spokes, although some models introduced since the 1970s offer cast wheels. Cast wheels allow the bikes to use tubeless tires, which, unlike traditional pneumatic tires, don't have an inner tube to hold the compressed air.

Brakes

The front and rear wheels on a motorcycle each have a brake. The rider activates the front brake with a hand lever on the right grip, the rear brake with the right foot pedal. Drum brakes were common until the 1970s, but most motorcycles today rely on the superior performance of disc brake.

SUSPENSION FRAMES

A Motorcycle suspension frame System consists of a spring coupled to a viscous damping element, a piston, in a cylinder filled with oil.

Categories of suspension frames

1. **Single cradle frame**. The single cradle is the simplest type of motorcycle frame, and looks similar to the first ever motorcycle frames.
2. **Double cradle frame**. Double cradle frames are descended from single cradle frames. They consist of two cradles that support the engine one either side.
3. **Backbone frame**. Far from the most desirable frame around, the backbone frame comprises a single, wide main beam from which the engine is suspended.

Fig: Back bone Frame

4. **Perimeter frame**. Motorcycle racing research has shown that major advantages are to be gained in terms of rigidity by joining the steering head to the swing arm in as short a distance as possible. Flexure and torsion are dramatically reduced. This is the concept behind the perimeter frame

Fig: Perimeter Frame

5. **Trellis frame**. The trellis frame rivals the aluminum perimeter frame for rigidity and weight. A favorite of Italian and European manufacturers it has proved a great success in racing and competition.

Fig: Trellis Frame

COMPUTER AIDED DESIGN (CAD)

Computer-aided design (**CAD**), also known as **computer-aided design and drafting** (**CADD**), is the use of computer technology for the process of design and design-documentation. Computer Aided Drafting describes the process of drafting with a computer. CADD software, or environments, provides the user

With input-tools for the purpose of streamlining design processes; drafting, documentation, and manufacturing processes.

CAD is mainly used for detailed engineering of 3D models and/or 2D drawings of physical components, but it is also used throughout the engineering process from conceptual design and layout of products, through strength and dynamic analysis of assemblies to definition of manufacturing methods of components. It can also be used to design objects.

PRO/ENGINEER:

Pro/ENGINEER Wildfire is the standard in 3D product design, featuring industry-leading productivity tools that promote best practices in design while ensuring compliance with your industry and company standards. Integrated Pro/ENGINEER CAD/CAM/CAE solutions allow you to design faster than ever, while maximizing innovation and quality to ultimately create exceptional products.

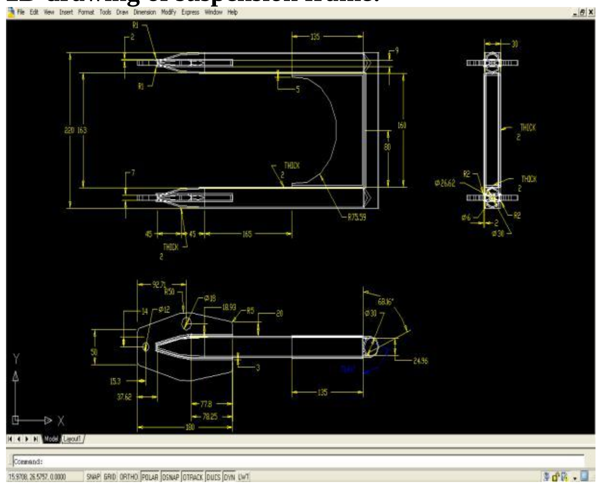
DIFFERENT MODULES IN PRO/ENGINEER

- Part design
- Assembly
- Drawing
- Sheetmetal
- Manufacturing

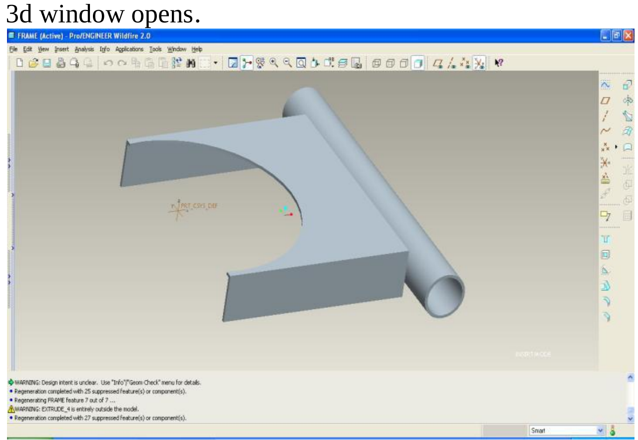
MODEL OF SUSPENSION FRAME:

2D PROCEDURE: open>pro/engineer>file>set working directory.
file>new file>sketch>toggle off >ok set units >mmns>ok>sketch>ok.

2D drawing of suspension frame:

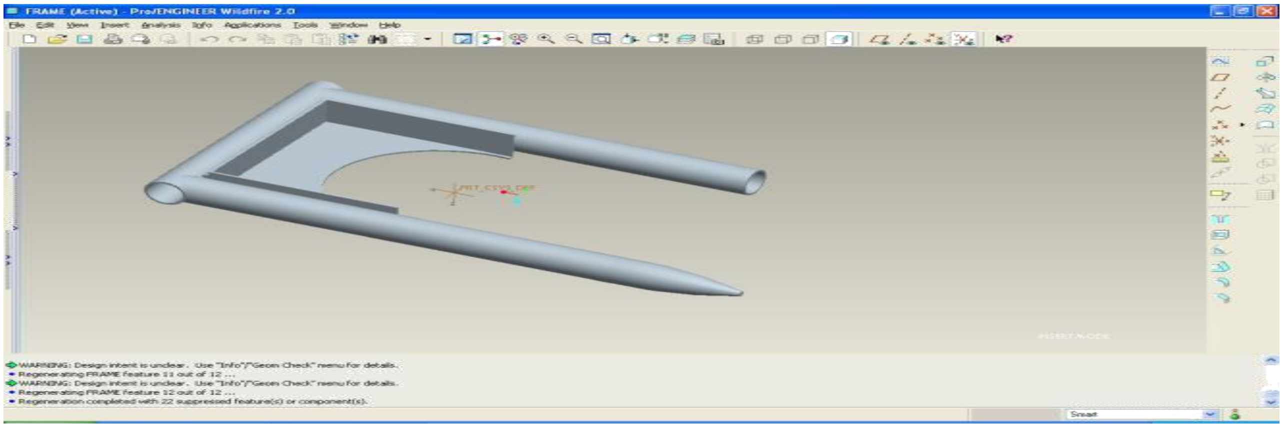


3DPROCEDURE: open>pro/engineer>set working directory.
file>new>part >toggle off >units>mmns>ok.
3d window opens.



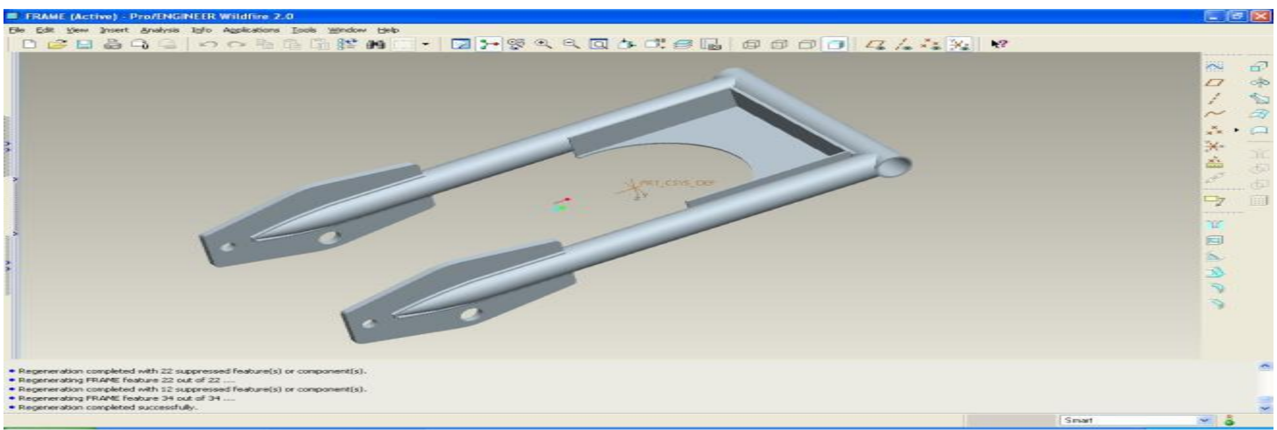
COMMANDS USED:

- Extrude
- Mirror
- Union



COMMANDS USED:

- Extrude (thin cut)
- Revolve
- Extrude up to end
- Mirror



COMMANDS USED:

- Extrude
- Mirror
- Union
- Extrude (thn cut)
- Round
- Chamfer

file>save>ok

file to iges: function to import model to ansys cae software.

file>save copy >iges>locate folder to save> ok.

FINITE ELEMENT ANALYSIS:

Finite Element Analysis (FEA) was first developed in 1943 by R. Courant, who utilized the Ritz method of numerical analysis and minimization of variation calculus to obtain approximate solutions to vibration systems.

SPECIFIC CAPABILITIES OF ANSYS:

STRUCTURAL ANALYSIS:

Structural analysis is probably the most common application of the finite element method as it implies bridges and buildings, naval, aeronautical, and mechanical structures such as ship hulls, aircraft bodies, and machine housings, as well as mechanical components such as pistons, machine parts, and tools.

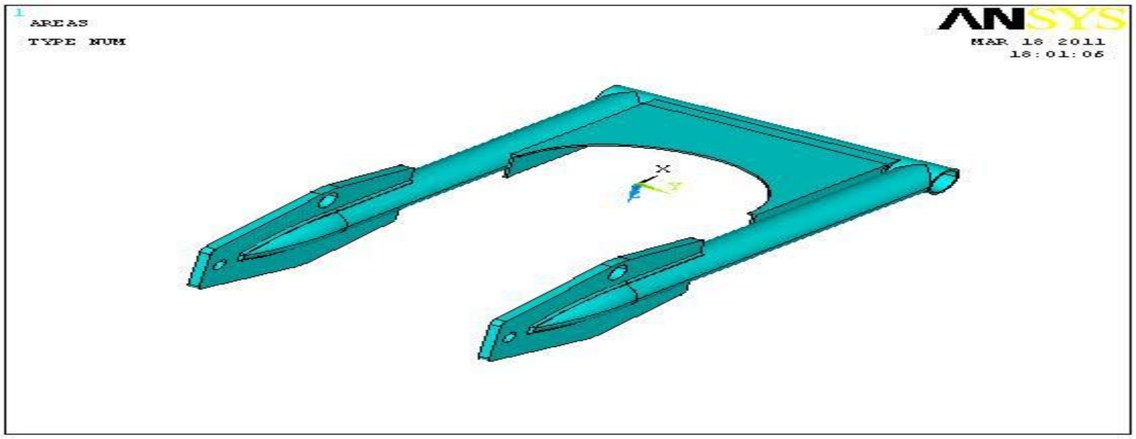
STRUCTURAL ANALYSIS OF SUSPENSION FRAME Using ALLOY STEEL

Material Properties: Young's Modulus (EX) : 205000
Poisson's Ratio (PRXY) : 0.29
Density : 0.00000785 kg/mm^3

STARTING OF ANSYS:

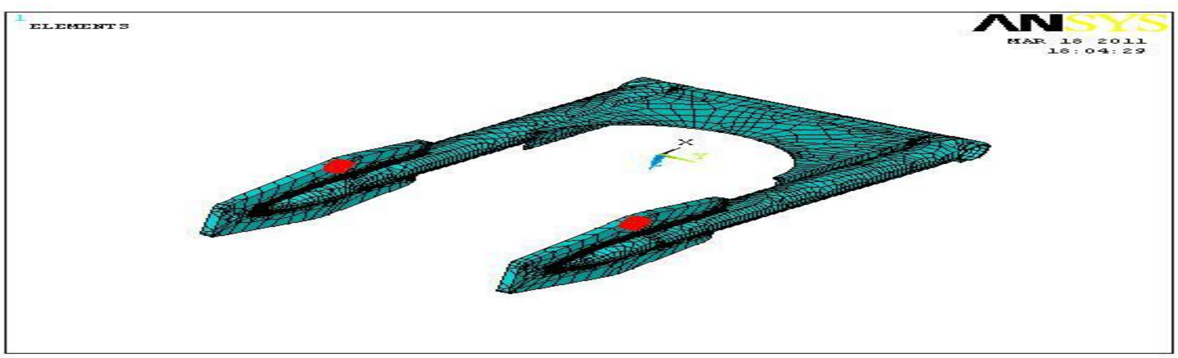
open>ansys software>file >change directory>select requird folder>ok.
units: command:/units,si,mm,kg,sec,k.

IMPORT MODEL FROM PRO/ENGNEER: file>import>iges>ok>select from iges option>select required file>ok



Loads:

Select>Loads>Define Loads>Apply Structural>Select Displacement On Areas>Select Area On Tube >Ok>Select All Dof>Ok.Select >Pressure >On Areas>Select Face Of Object>Ok>Enter Pressure Value>Ok **Pressure – 0.32N/mm^2**

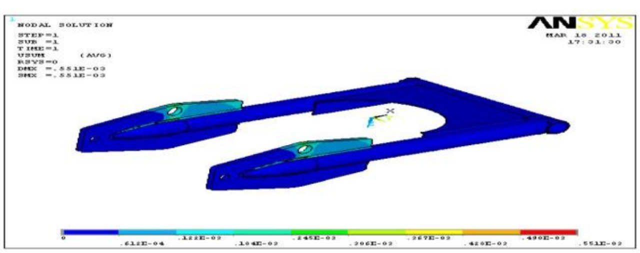


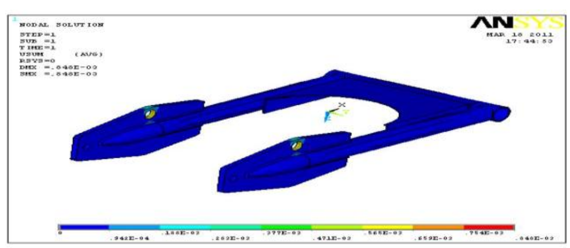
SOLUTION

Solution – Solve – Current LS – ok

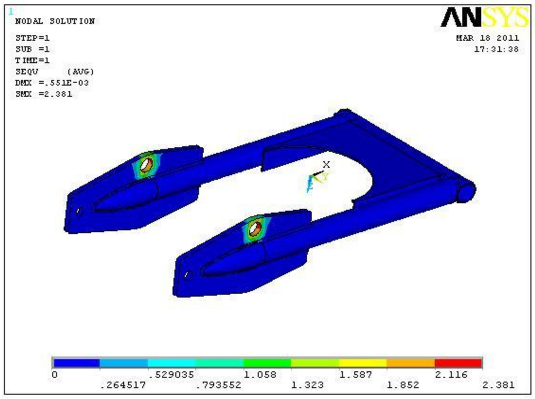
Post Processor

General Post Processor – Plot Results – Contour Plot - Nodal Solution – DOF Solution – Displacement Vector Sum





General Post Processor – Plot Results – Contour Plot – Nodal Solution – Stress – Von Mises Stress



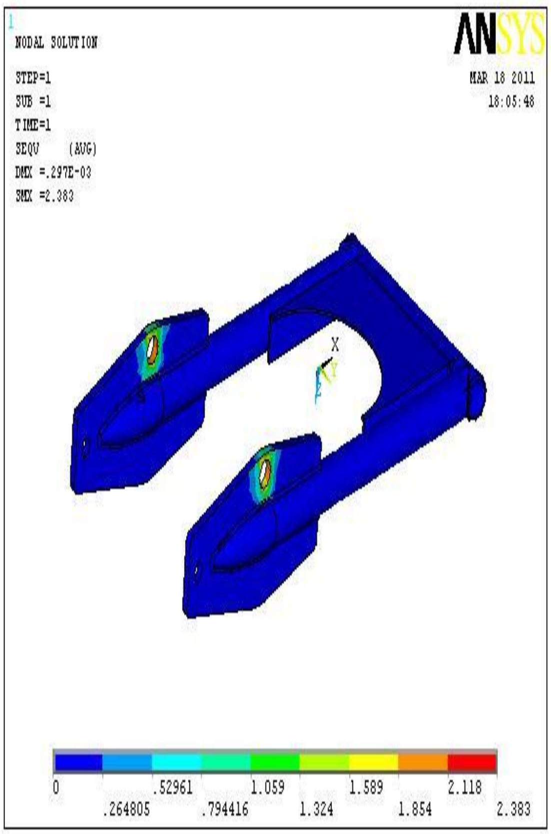
STRUCTURAL ANALYSIS OF SUSPENSION FRAME USING ALUMINIUM ALLOY A360:

Material Properties: Youngs Modulus (EX) : 8000

Poisson's Ratio (PRXY) : 0.33

Density : 0.0000026 kg/mm^3

General Post Processor – Plot Results – Contour Plot – Nodal Solution – Stress – Von Mises Stress.



Using magnesium

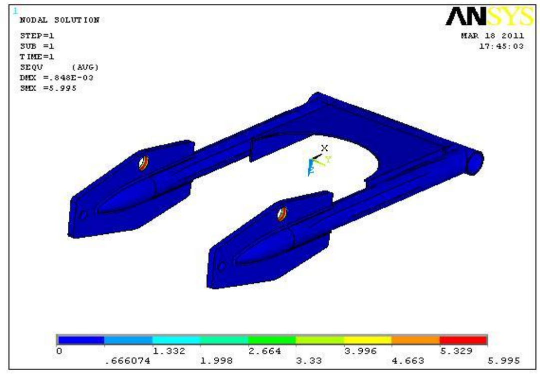
Material Properties: Youngs Modulus (EX) : 45000N/mm^2

Poisson's Ratio (PRXY) : 0.35

Density 0.00000185 kg/mm^3

General Post Processor – Plot Results – Contour Plot - Nodal Solution – DOF Solution – Displacement Vector Sum

General Post Processor – Plot Results – Contour Plot – Nodal Solution – Stress – Von Mises Stress



Using carbon fiber reinforced polymer

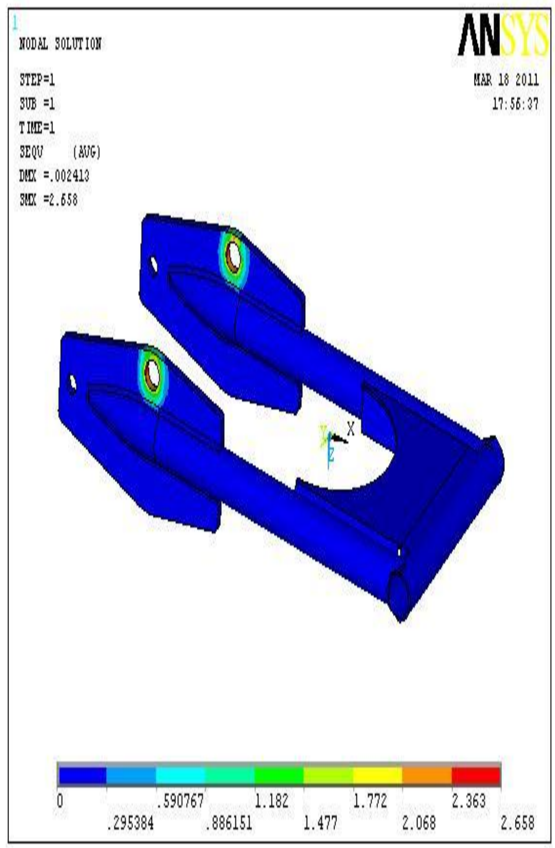
Material properties:

Youngs Modulus (EX) 750000N/mm^2

Poisson's Ratio (PRXY) : 0.30

Density : 0.00000125 kg/mm^3

General Post Processor – Plot Results – Contour Plot – Nodal Solution – Stress – Von Mises Stress



MODAL ANALYSIS

A modal analysis is typically used to determine the vibration characteristics (natural frequencies and mode shapes) of a structure or a machine component while it is being designed.

MODAL ANALYSIS OF SUSPENSION FRAME USING STEEL :

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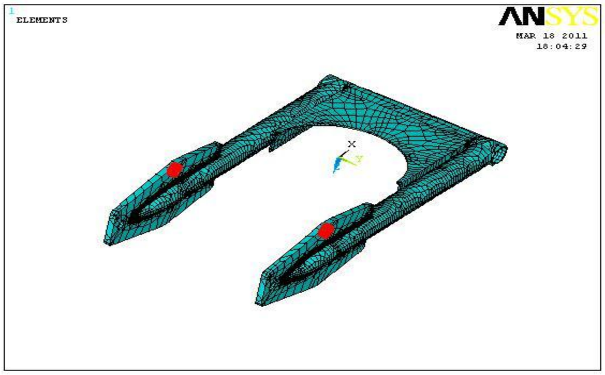
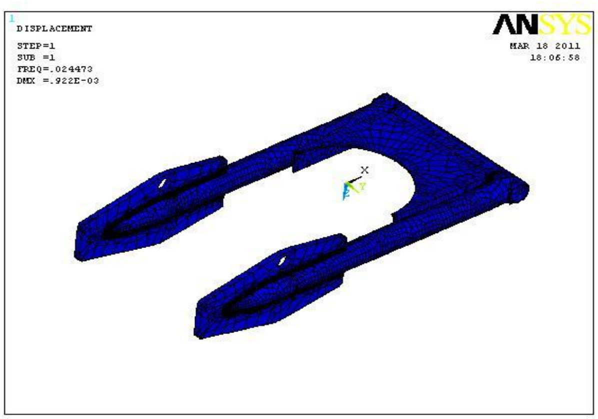
Element Type: solid 20 nodes 95
Material Properties: Young's Modulus (EX) : 205000N/mm^2
Poisson's Ratio (PRXY) : 0.29
Density : 0.00000785 kg/mm^3
Loads Pressure – 0.32N/mm^2



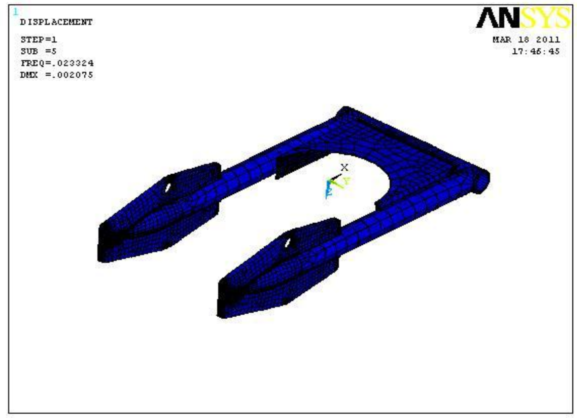
main menu>preprocessor>loads>analysis type> new analysis> select modal> click> ok
main menu>preprocessor>loads>analysis type> analysis options>
no. of modes to extract: 5
click> ok
main menu>solution>solve>current ls>ok

results
main menu>general postproc>read results> first set plot result>deformed shape> def+ undeform > click> ok

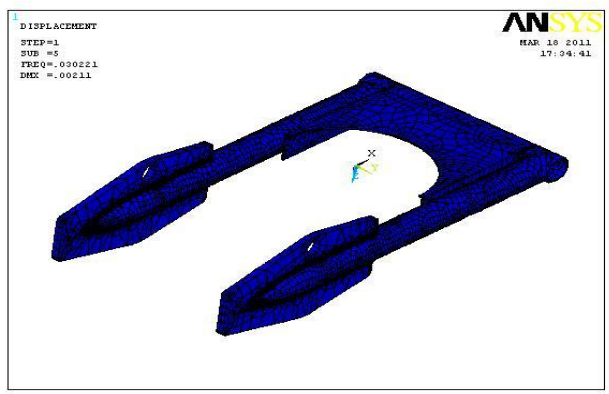


: 45000n/mm^2

MODAL ANALYSIS OF SUSPENSION FRAME USING MAGNESIUM ALLOY
element type: solid 20 nodes 95
material properties: youngs modulus (ex)
poisson's ratio (prxy) : 0.35
density : 0.00000185 kg/mm^3
main menu>general postproc>read results> next set plot result>deformed shape> def+ undeform > click> ok

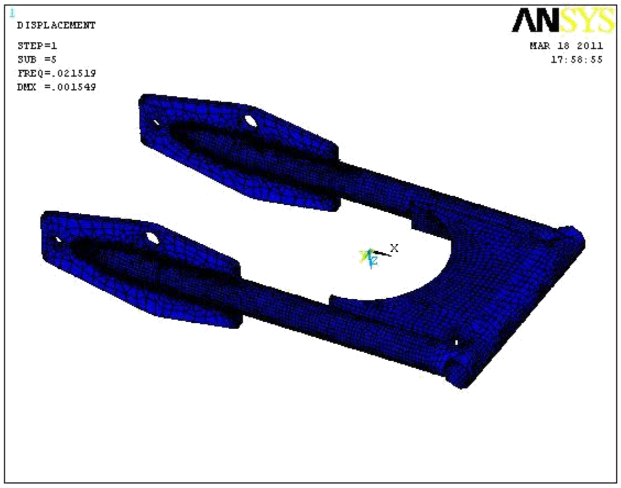


MODAL ANALYSIS OF SUSPENSION FRAME USING ALUMINUM ALLOY A360 : 80000n/mm^2
element type: solid 20 nodes 95
material properties: youngs modulus (ex)
poisson's ratio (prxy) : 0.33
density : 0.0000026kg/mm^3
pressure – 0.32n/mm^2
main menu>general postproc>read results> next set plot result>deformed shape> def+ undeform > click>ok.



MODAL ANALYSIS OF SUSPENSION FRAME USING CARBON FIBER REINFORCED POLYMER : 75000n/mm^2

element type: solid 20 nodes 95
material properties: youngs modulus (ex)
poisson ratio (prxy) : 0.30
density : 0.00000125 kg/mm^3
main menu>general postproc>read results> next set plot result>deformed shape> def+ undeform > click> ok



RESULTS:

Von Misses Stress - The Von Misses criteria is a formula for combining these 3 stresses into an equivalent stress, which is then compared to the tensile stress of the material.

For Alloy Steel:

	Results	Permissable
Displacement	0.297e^{-3}	
Vonmises stress	2.383	325
	Frequency	Displacement
Mode 01	0.024473	0.922 e^{-3}
Mode 02	0.025756	.001876
Mode 03	0.026079	0.001991
Mode 04	0.02613	0.925 e^{-3}
Mode 05	0.032796	0.004175

For Magnesium alloy:

	Results	Permissable
Displacement	0.848 e^{-3}	
Vonmises stress	5.995	165
	Frequency	Displacement
Mode 01	0.04726	0.00167
Mode 02	0.014729	0.00167
Mode 03	0.021785	0.001547
Mode 04	0.021795	0.001547
Mode 05	0.023324	0.002075

For Aluminum Alloy A360:

	Results	Permissable
Displacement	0.551 e^{-3}	
Vonmises stress	2.381	520
	Frequency	Displacement
Mode 01	0.023455	0.001676
Mode 02	0.02448	0.001906
Mode 03	0.02958	0.001593
Mode 04	0.02967	0.001768
Mode 05	0.030221	0.00211

For Carbon fiber reinforced polymer:

	Results	Permissable
Displacement	0.002413	
Vonmises stress	2.658	83
	Frequency	Displacement
Mode 01	0.01383	0.001667
Mode 02	0.014074	0.001666
Mode 03	0.014399	0.002029
Mode 04	0.014559	0.002031
Mode 05	0.021519	0.001549

CONCLUSION:

In our project we have modelled a suspension frame used in two-wheeler. Modelling is done in Pro/Engineer.

- We have done structural and modal analysis on suspension frame using four materials Steel, Aluminium Alloy A360, Magnesium and carbon fiber reinforced polymer to validate our design.
- By observing the results, for all the materials the stress values are less than their respective permissible yield stress values. So our design is safe.
- By comparing the results for four materials, stress obtained is same and displacement is less for carbon fiber reinforced polymer than other three materials.
- So we conclude that for our design, **CFRP** is better material for suspension frame.

Future scope:

By using the carbon fiber reinforced polymer we can suitably prepare the model.

As the material has less density compared to the another materials used for manufacturing of chassis and frame, this is the best suited for our process of manufacturing, and can with stand very high loads

Using carbon fiber reinforced polymer frequently in the up coming days we can reduce the cost of manufacturing of frame.

Carbon fiber-reinforced polymers (CFRPs) have an almost infinite service lifetime when protected from the sun, and, unlike steel alloys, have no endurance limit when exposed to cyclic loading.

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- Auto mobile engineering – B.Gupta. **Understanding materials science: Rolf E. Hummel** . http://motorcyclist.automotive.com