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DESIGN AND MANUFACTURING OF MACHINE TO LIFT A LOAD ON STAIRCASES

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Abstract: *This project deals with the design and manufacture of a mechanism to carry load on staircase. Our project consist of a rover with a Rocker bogie mechanism on which load is transverse over stairs. Rocker bogie plays important function in rough and steep hills terrain. The primary mechanical feature of the rocker bogie design is its drive train simplicity and efficient high degree of mobility suspension system capable of traversing rough terrain, which is accomplished by using six motors for mobility. A series of mobility experiment in the land, rough roads, inclined, stairs and obstacle surface concluded that bogie can achieve some distance transverse field.*

Keywords: *Rocker Bogie, Mobility suspension system, rough and steep hills terrain**,** Lifting weight on staircase**.***

1. INTRODUCTION

There is need for mobile robots which are able to operate in unstructured environments with uneven steeped terrain. These robots are mainly used for tasks which humans cannot do efficiently and which are not safe. In order to perform these tasks mobile robot needs to be capable of climbing the stairs and have a suitable load lifting capacity. So, have to use a suspension system like rocker bogie which is capable to climb the stairs. The term “rocker” describes the rocking aspect of the larger links present each side of the suspension system and balance the bogie as these rockers are connected to each other and the vehicle chassis through a modified differential. In the system, “bogie” refers to the conjoining links that have a drive wheel attached at each end. Bogies were commonly used to bare loading as tracks of army tanks as idlers distributing the load over the terrain. Bogies were also quite commonly used on the trailers of semitrailer trucks as that very time the trucks will have to carry much heavier load. As accordance with the motion to maintain center of gravity of entire vehicle, when one rocker moves upward, the other goes down. The chassis plays vital role to maintain the average pitch angle of both rockers by allowing both rockers to move as per the situation. The physics of these rovers is quite complex. To design and control these analytical models of how the rover interacts with its environment are essential. Models are also needed for rover action planning. Simple mobility analysis of rocker-bogie vehicles has been developed and used for design evaluation in the available published works.

2. PROBLEM STATEMENT

This project is intended to design and manufacture a rover to lift a load on staircase. The main problem associated with current suspension systems installed in heavy loading vehicles rovers is their slow speed of motion which derails the rhythm to absorb the shocks generated by wheels, which could damage the vehicle or the goods it carries along with it. In order to pass over obstacles, the vehicle must be geared down significantly to allow for enough torque to raise the mass of the vehicle. Consequently, this reduces overall speed which cannot be tolerated in the case of heavy loading vehicles. Second, if the vehicle is travelling at a high speed and encounters an obstacle. Therefore, we are going to design rocker bogie which will help in traversing the heavy load over staircase.

3. METHODOLOGY

- Research survey on the problem statement
- Deciding the component required
- Drafting the 3D model of project in Catia software
- Finalizing the model with the actual dimensions required
- Calculation of the specification of component and material needed
- Performing Analysis with the help of Ansys software
- Defining the Result on the model
- Starting the actual Manufacturing of the model
- Testing the model on required parameters
- Concluding the result, calculation and testing of the model

4. CAD Model

Computer-aided design is the use of computer systems to aid in the creation, modification, analysis, or optimization of a design. CAD software is used to increase the productivity of the designer, improve the quality of design, improve communications through documentation, and to create a database for manufacturing. CAD output is often in the form of electronic files for print, machining, or other manufacturing operations. The term CADD (for Computer Aided Design and Drafting) is also used.

CAD is one part of the whole Digital Product Development (DPD) activity within the Product Lifecycle Management (PLM) processes, and as such is used together with other tools, which are either integrated modules or stand-alone products, such as:

Computer-aided engineering (CAE) and Finite element analysis (FEA)

- Computer-aided manufacturing (CAM) including instructions to Computer Numerical Control (CNC) machines
- Photorealistic rendering and Motion Simulation.
- Document management and revision control using Product Data Management (PDM).

There are two types of 3D Solid Modelling

1. Parametric modelling allows the operator to use what is referred to as "design intent". The objects and features created are modifiable. Any future modifications can be made by changing how the original part was created. If a feature was intended to be located from the center of the part, the operator should locate it from the center of the model. The feature could be located using any geometric object already available in the part, but this random placement would defeat the design intent. If the operator designs the part as it functions the parametric modeler is able to make changes to the part while maintaining geometric and functional relationships.
2. Direct or explicit modelling provide the ability to edit geometry without a history tree. With direct modelling, once a sketch is used to create geometry the sketch is incorporated into the new geometry and the designer just modifies the geometry without needing the original sketch. As with parametric modelling, direct modelling has the ability to include relationships between selected geometry (e.g., tangency, concentricity).

CATIA MODEL:

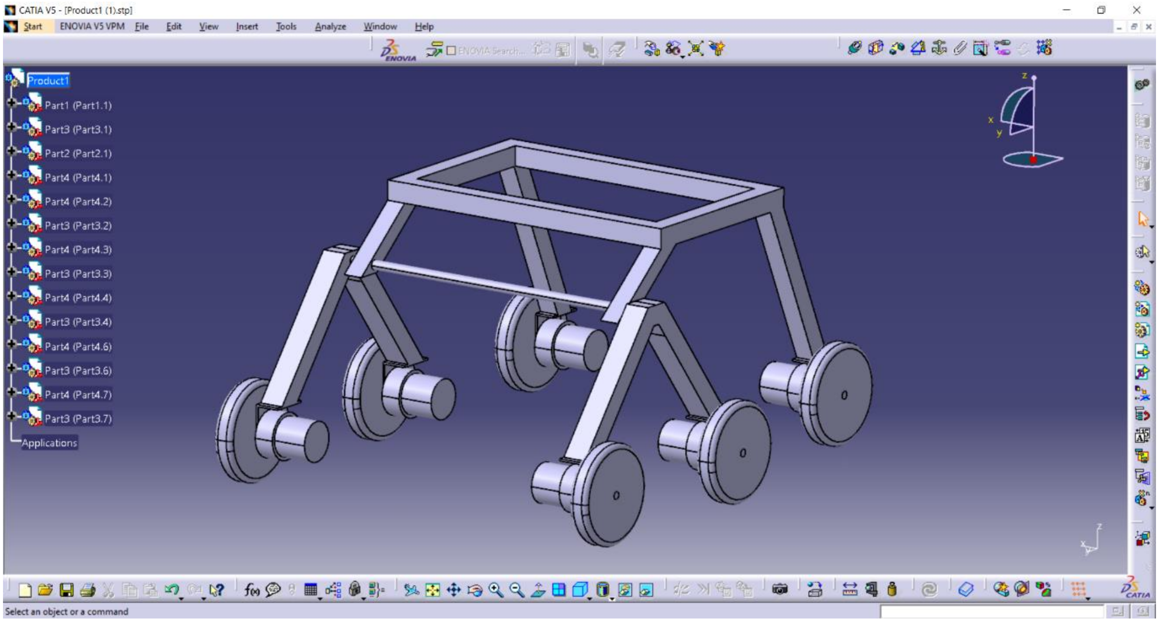


Fig.1: Isometric View

DRAFTING:

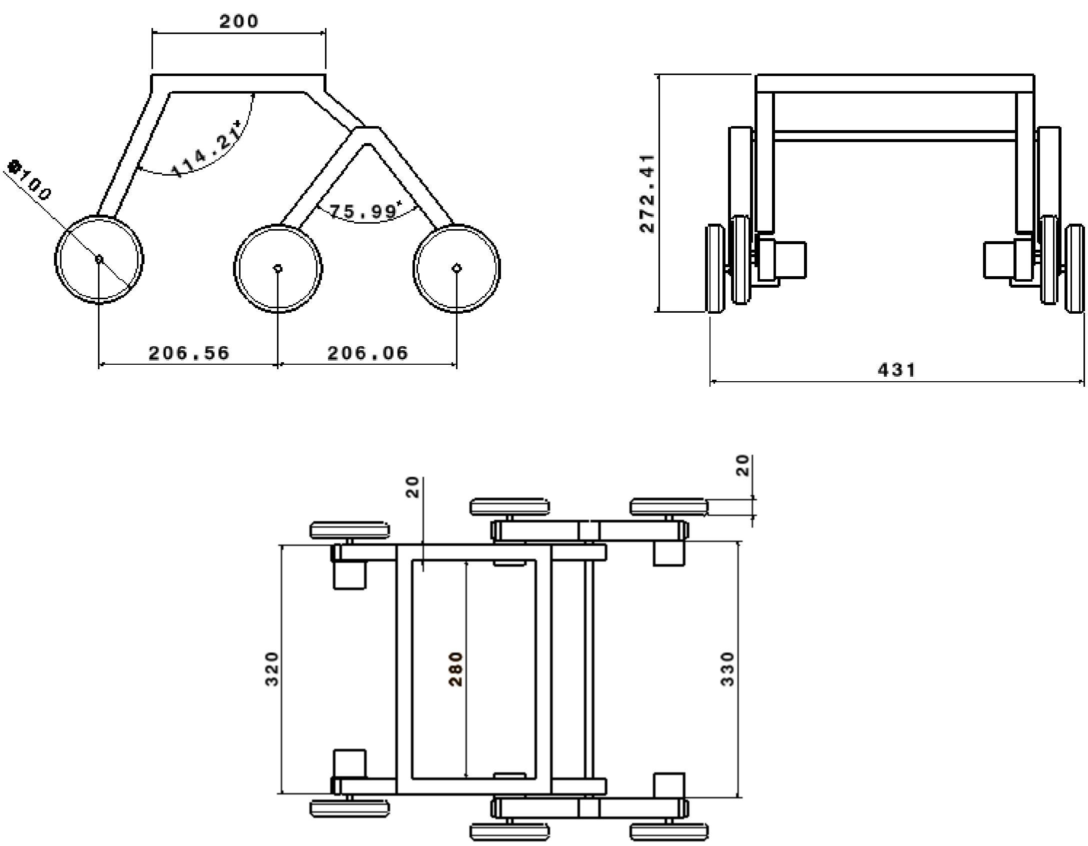


Fig.2: Drafting

5. CALCULATION

1. Frame design:

Material used – M.S. Pipe

Area= $Side^2$ – $Side^2$= 184 mm^2

Length of link =20 inch = 508 mm

Weight of project= 15 kg = 15*9.81 =147.15 N

Solution:

Bending stress is calculated using flexural formula

M/I = $\sigma b/y$

Y=12.5 mm

2. Moment of inertia

I = $BH^3/12$ – $BH^3/12$

I= 35552-16207

I= 19345 mm^4

Simply supported beam with point load

M= 37376 N/mm2

σb = 24.15 N/mm2

The yield strength of the material is 250 MPa and the calculated bending stress is 24 MPa then the design is safe.

3. Motor selection:

Consider the total mass of the rocker bogey=15 kg.

We are designing the rocker bogey with six (6) legs.

The total weight acting on the wheels= (Mass of vehicle) * (Acceleration due to gravity)

= (15*9.81)

W=147.15 N

This weight is distributed over the six wheels, so on each wheel 24.525 N force is acting.

For each wheel we are using one motor, hence the required torque is calculated as,

T= (vertical force) * (Radius of wheel)

T= (24.525*50)

T=1.226 N-m

Now for 12V motor generating 24 Watt,

For N=100

Torque supplied=2.29 N-m

Hence our design is safe.

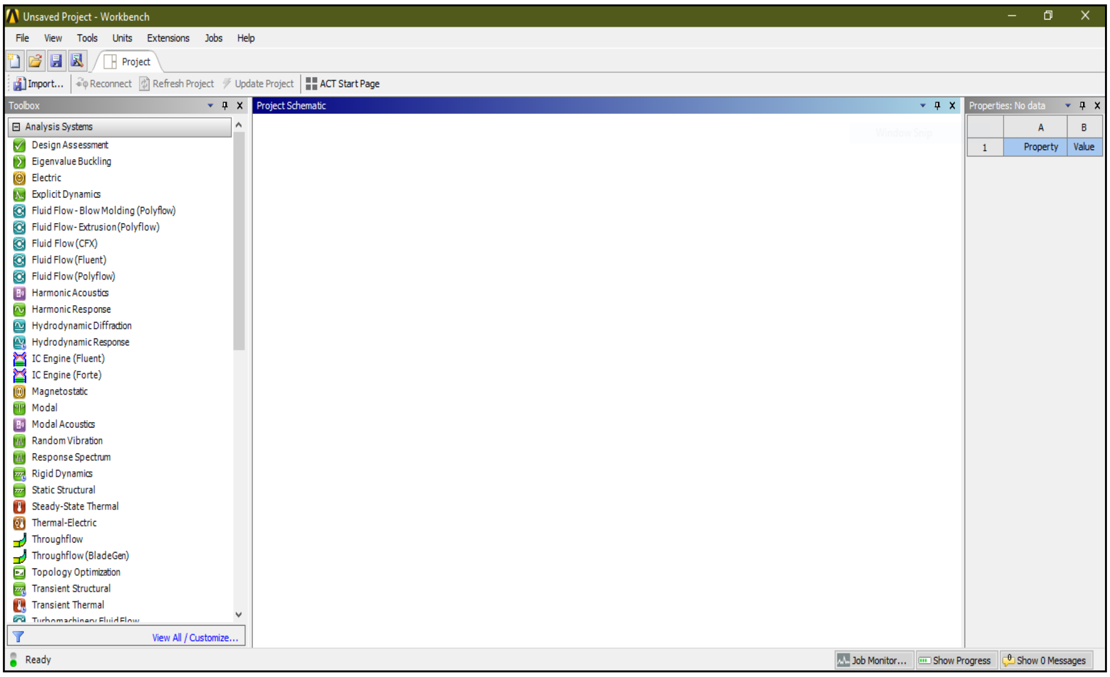
6. ANALYSIS

1. FEA (FINITE ELEMENT ANALYSIS)

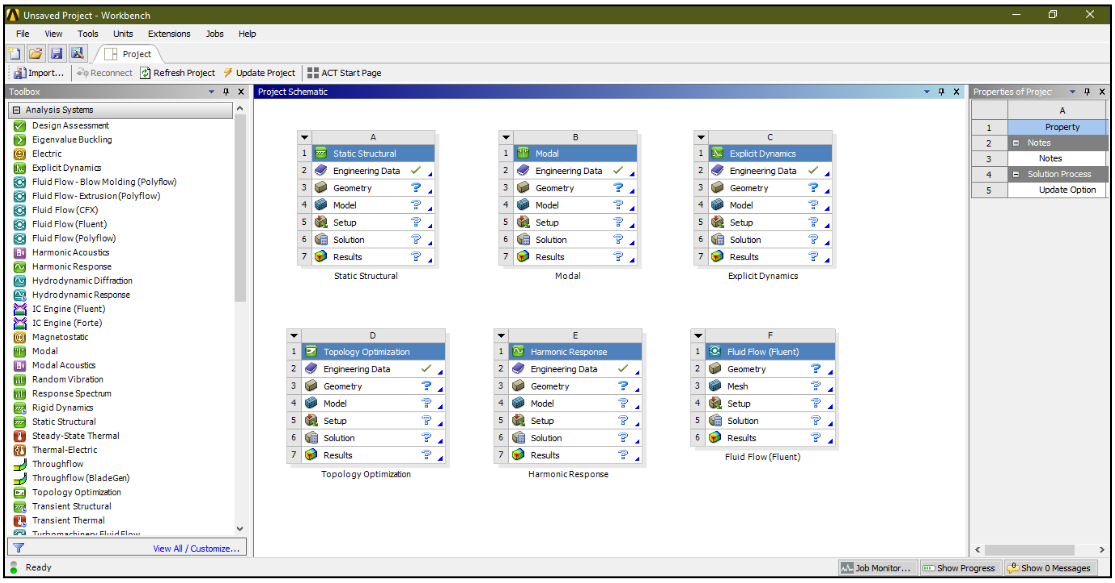
The finite element method (FEM), is a numerical method for solving problems of engineering and mathematical physics. Typical problem areas of interest include structural analysis, heat transfer, fluid flow, mass transport, and electromagnetic potential. The analytical solution of these problems generally require the solution to boundary value problems for partial differential equations. The finite element method formulation of the problem results in a system of algebraic equations. The method yields approximate values of the unknowns at discrete number of points over the domain. To solve the problem, it subdivides a large problem into smaller, simpler parts that are called finite elements.

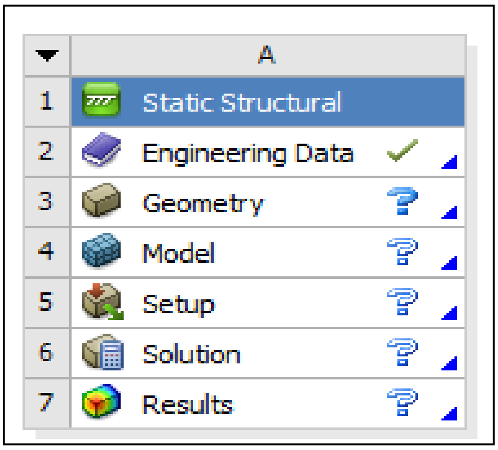
In present research for analysis ANSYS (Analysis System) software is used. Basically, its present FEM method to solve any problem. Following are steps in detail

1. Geometry
2. Discretization (Meshing)
3. Boundary condition
4. Solve (Solution)
5. Interpretation of results



Workbench contain analysis of different types namely static, modal, harmonic, explicit dynamics, CFD, ACP tool post, CFX, topology optimization etc. as per problem defined.





Step 1: Details of material namely copper, steel, grey cast iron, composite material, fluid domain material is defined in engineering data. i.e. ANSYS default material is structural steel.

Step 2: Import of geometry created in any CAD software namely CATIA, PRO E, SOLIDWORK, INVENTOR etc. in geometry section. If any correction is to be made it can be created in geometry section in Design modeler or space claim.

Step 3: In model section after import of component

- Material is assigned to component as per existing material
- Connection is checked in contact region i.e. bonded, frictionless, frictional, no separation etc. for multi body components.
- Meshing or discretization is performed i.e. to break components in small pieces (elements) as per size i.e. preferably tetra mesh and hexahedral mesh for 3D geometry and for 2 D quad or trial are generally preferred.

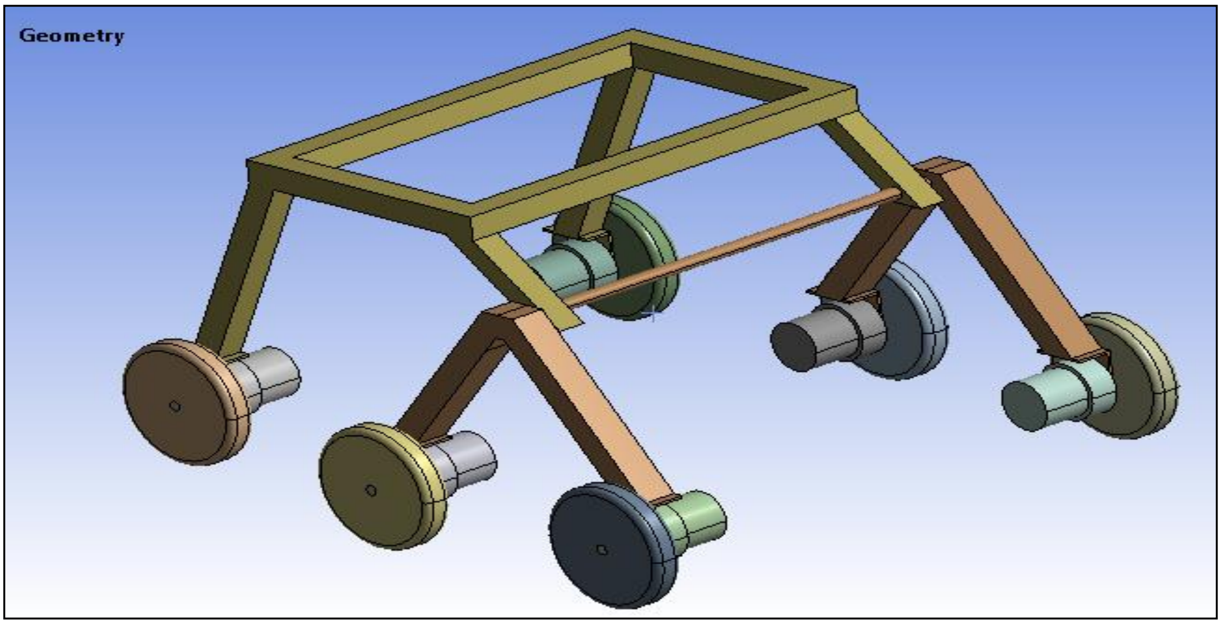
Step 4: Boundary condition are applied as per analysis namely in fixed support, pressure, force, displacement, velocity as per condition.

Step 5: Now problem is well defined and solve option is selected to obtain the solution in the form of equivalent stress, strain, energy, reaction force etc.

STATIC ANALYSIS OF ROCKER BOOGIE

Properties of Outline Row 3: Structural Steel

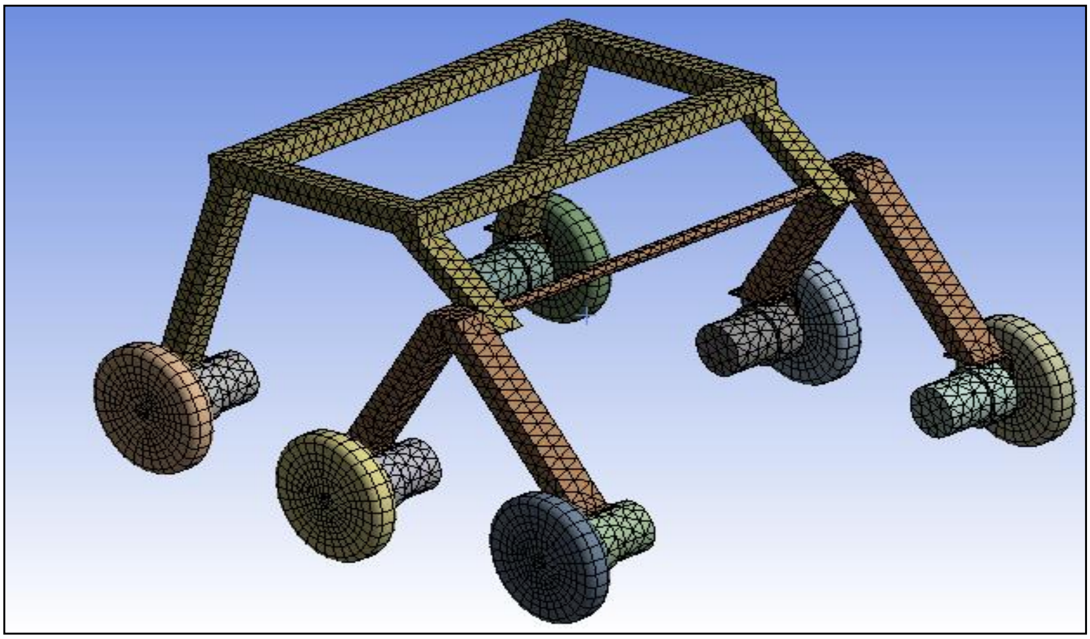
	A	B	C
1	Property	Value	Unit
2	Material Field Variables	Table	
3	Density	7850	kg m^-3
4	Isotropic Secant Coefficient of Thermal Expansion		
6	Isotropic Elasticity		
7	Derive from	Young's Modul...	
8	Young's Modulus	2E+11	Pa
9	Poisson's Ratio	0.3	
10	Bulk Modulus	1.6667E+11	Pa
11	Shear Modulus	7.6923E+10	Pa



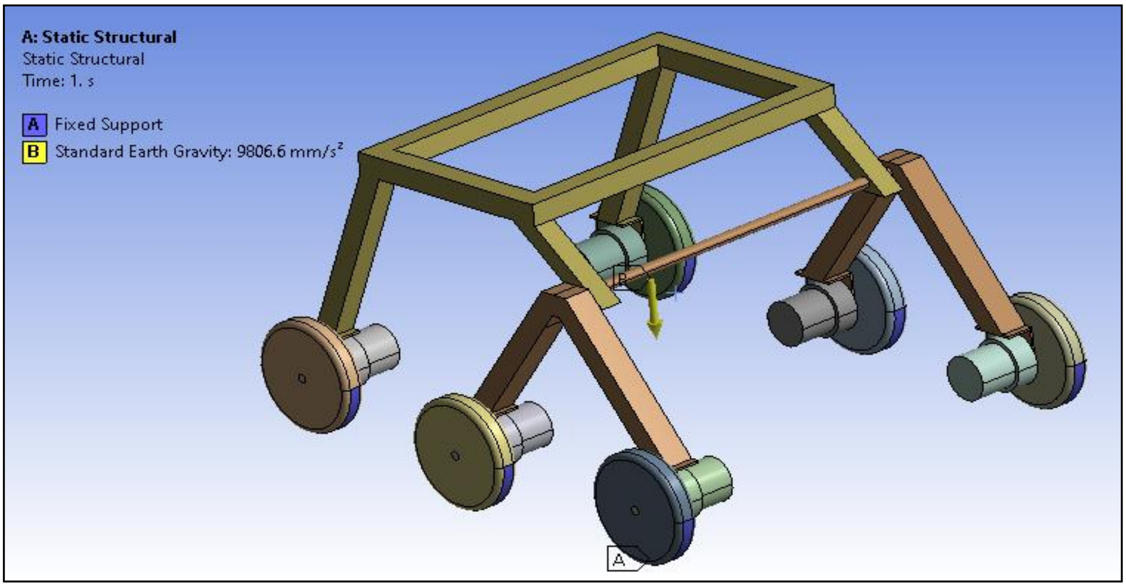
MESH

ANSYS Meshing is a general-purpose, intelligent, automated high-performance product. It produces the most appropriate mesh for accurate, efficient Multiphysics solutions. A mesh well suited for a specific analysis can be generated with a single mouse click for all parts in a model. Full controls over the options used to generate the mesh are available for the expert user who wants to fine-tune it. The power of parallel processing is automatically used to reduce the time you have to wait for mesh generation.

Creating the most appropriate mesh is the foundation of engineering simulations. ANSYS Meshing is aware of the type of solutions that will be used in the project and has the appropriate criteria to create the best suited mesh. ANSYS Meshing is automatically integrated with each solver within the ANSYS Workbench environment. For a quick analysis or for the new and infrequent user, a usable mesh can be created with one click of the mouse. ANSYS Meshing chooses the most appropriate options based on the analysis type and the geometry of the model. Especially convenient is the ability of ANSYS Meshing to automatically take advantage of the available cores in the computer to use parallel processing and thus significantly reduce the time to create a mesh. Parallel meshing is available without any additional cost or license requirements.

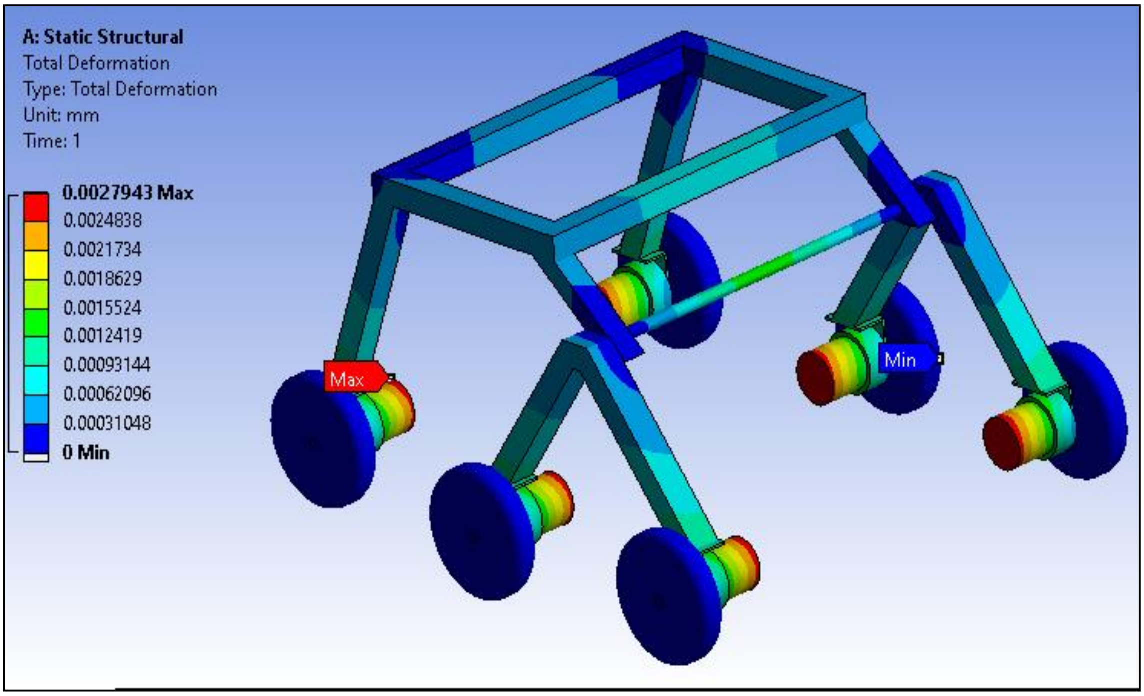


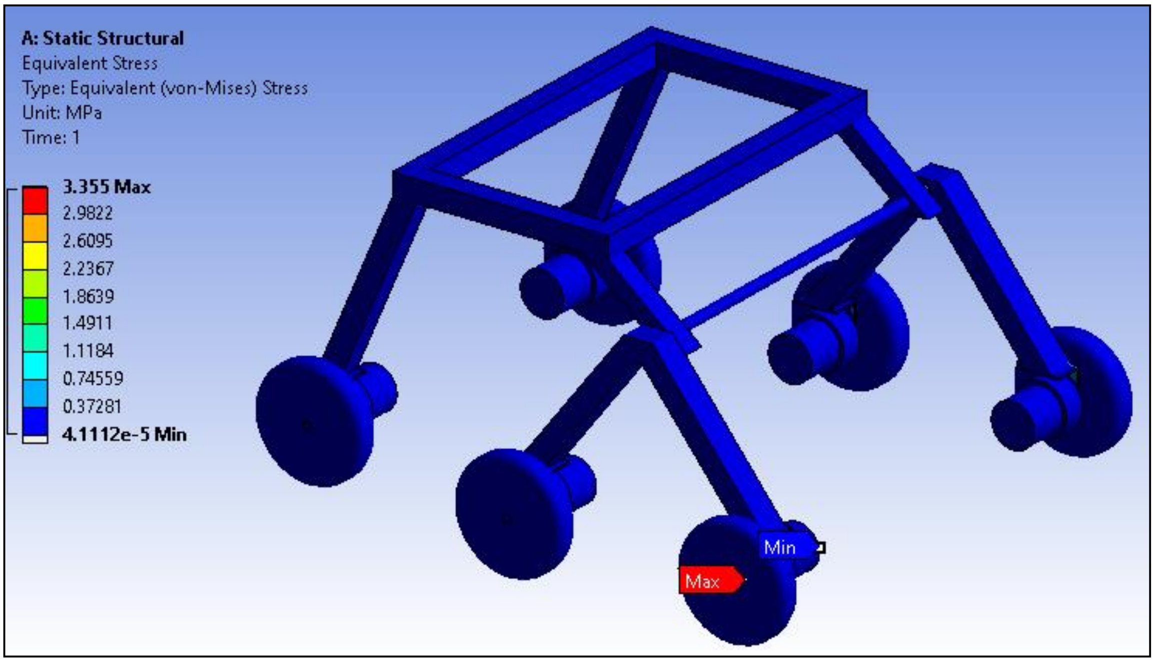
BOUNDARY CONDITION



7. RESULTS

Total deformation





8. FUTURE SCOPE

- Its future application will be to assist astronauts during space operations and it will act as a path finder too.
- This rover has larger wheel as compared to obstacles, it can easily operate over most of the pits and hills on the track.

- It is also used in coal mines, act as a spy robot
- The rover can help in study geo survey
- The rover can be used for the military and defense application, e.g.- Bomb detector, Metal detector.
- Industrial Application, e.g.- Load Carriers

9. CONCLUSION

We conclude that with the help of this design we are able to solve the problem statement to lift the load on staircase.

The 3D model and simulation of rocker-bogie mechanism in CATIA V5 R20 software. The analysis of design which is done in ANSYS software result shows that the model is capable to lift the load on staircase

Also, we successfully manufactured the model and performed experimental testing and plotted out result. In future, this system can find many applications in the industry like in heavy vehicles, conventional off-road vehicles and Geosurvey rovers.

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