# Design and Linear Static Analysis of Landing Gear

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***Abstract*—Landing is one of the most maneuvering occurring in aircraft. Landing gear is considered as a nonlinear structure due to its complicate behavior. During landing period large amount of impact forces are transferred into nose gear and main landing gear. The main objective of this paper is to present prototype of aircraft landing gear using CATIA V5 software to study the behavior of landing gear as per actual working condition. Static loads are applied over the landing gear and internal forces are extracted from critical landing gear components like torque arm is separately analysed for the internal forces obtained from the generalized modal the components were modelled with CATIA V5 and imported to MSC Patran. MSC Nastran is used as a solver. From the obtained limit stresses, linear static analysis was carried out to find the stress of the main landing gear with different conditions.**

***Keywords*— Main landing gear, linear static, CATIA V5, MSC Patran, nastran**

## I. INTRODUCTION

Aircraft landing gear supports the entire weight of an aircraft during landing and ground operations. Aircraft landing gear supports the entire weight of an aircraft during landing and ground operations. They are attached to primary structural members of the aircraft. The type of gear depends on the aircraft design and its intended use. Most landing gears have wheels to facilitate operation to and from hard surfaces, such as airport runways. Other gear feature skids for this purpose, such as those found on helicopters, balloon gondolas, and in the tail area of some tail dragger aircraft. Aircraft that operate to and from frozen lakes and snowy areas may be equipped with landing gear that have skis. Aircraft that operate to and from the surface of water have pontoon-type landing gear. Regardless of the type of landing gear utilized, shock absorbing equipment, brakes, retraction mechanisms, controls, warning devices, cowling, fairings, and structural members necessary to attach the gear to the aircraft are considered part of the landing gear system.

Landing gear is one of the most important airplane components to be used for aircraft take off, landing, taxiing, parking and steering on ground. In order to verify the structural design loads and the structural strength, it is necessary to measure landing gear loads in flight tests. Generally, ground load calibration test is to remove the landing gear from the test aircraft, then fix it in specially designed test rig and apply loads to the landing gear. In this way, the connection stiffness between landing gear and rig cannot be fully simulated as the real connection stiffness with the aircraft. This will affect the accuracy of the result of loads measurement

Numerous configurations of landing gear types can be found. Additionally, combinations of two types of gear are common. Amphibious aircraft are designed with gear that allows landings to be made on water or dry land. The gear features pontoons for water landing with extendable wheels for landing on hard surface. A similar system is used to allow the use of skis and wheels on aircraft that operate on both slippery, frozen surfaces and dry runways. Typically, the skis are retractable to allow use of the wheels when needed.

The material included within the submissions include an overview of the various types of shock absorbers and the general equations pertinent to these designs, an in depth technical investigation of the oleo-pneumatic shock absorber, an analysis of multiple case studies, in addition to a discussion of future innovations.

## II. LANDING GEAR CONFIGURATION

The first job of an aircraft designer in the landing gear design process is to select the landing gear configuration. Landing gear functions may be performed through the application of various landing gear types and configurations. Landing gear design requirements are parts of the aircraft general design requirements including cost, aircraft performance, aircraft stability, aircraft control, maintainability, product ability and operational considerations.

In general, there are some configurations for a landing gear as follows:

a. Conventional gear
b. Single main wheel
c. Bicycle gear
d. Tricycle gear
e. Quadricycle gear
f. Multi-bogey gear

### *a. Conventional Gear*

A conventional landing gear consists of two main wheels located at both sides underneath the nose and one small tail wheel. The configuration is often used in small piston-engine aircraft. The tail wheel causes less drag and the construction is relatively light.

*b. Single Main Wheel*

This configuration consists of a main gear and a small tail wheel. Both gears are located at the centerline. This landing gear configuration often has outriggers underneath the wings to stabilize the aircraft. For some aircraft, the outriggers have to be installed by the airport crew before taxiing. The single main wheel configuration is used for light aircraft like gliders and sailplanes.

*c. Bicycle Gear*

A bicycle gear consists of two main gears that are situated on the centerline of the aircraft. One gear is situated underneath the nose and the second gear is situated at the back, behind the center of gravity. Outriggers under the wings prevent the aircraft from overturning. This configuration is useful for aircraft with long and small fuselages. The bicycle gear is light and the lock up compartment is small. This gear configuration is relatively unstable and the pilot prevents the outriggers from touching the ground. The bicycle gear is often used for bomber aircraft with a wide wing span.

*d. Tricycle Gear*

The most used landing gear configuration consists of one nose gear and two main gears which are located just behind the center of gravity. The tricycle gear is a stable design and easy to steer. It provides better visibility over the nose and the aircraft loading is much easier. The disadvantage of this configuration is the larger weight and the increase of drag. When loading the aircraft, the load must be distributed over the aircraft to prevent tail tipping. This configuration is used for many commercial aircraft, for example the Boeing 737-800 NG.

*e. Quadricycle Gear*

The quadricycle gear is almost similar to the bicycle gear, but the quadricycle consists of two nose gears and two main gears that have an equal design. The gear turns in other directions during crosswind landings. Cargo aircraft often use the configuration, because the quadricycle aircraft are close to the ground. The quadricycle generates more drag then the bicycle gear and weighs more.

*f. Multi-bogey Gear*

In a multi-bogey gear configuration, multiple wheels are fastened on one beam, a bogey. The nose gear consists of two legs with two wheels each. The main gear consists of bogeys with multiple wheels. The advantage of the multi-bogey gears for larger aircraft is the pressure spreading over the ground: the forces on each tire are minimal.

## III. METHODOLOGY

a. Literature review
b. CAD modeling of nose landing gear using CATIA V5
c. Stress and fatigue analysis of different components using MSC NASTRAN and MSC PATRON
d. Fatigue life estimation of critical components
e. Conclusion

## IV. CONCEPTUAL MODEL

Conceptual model of nose landing gear for trainer aircraft is shown above in Figure

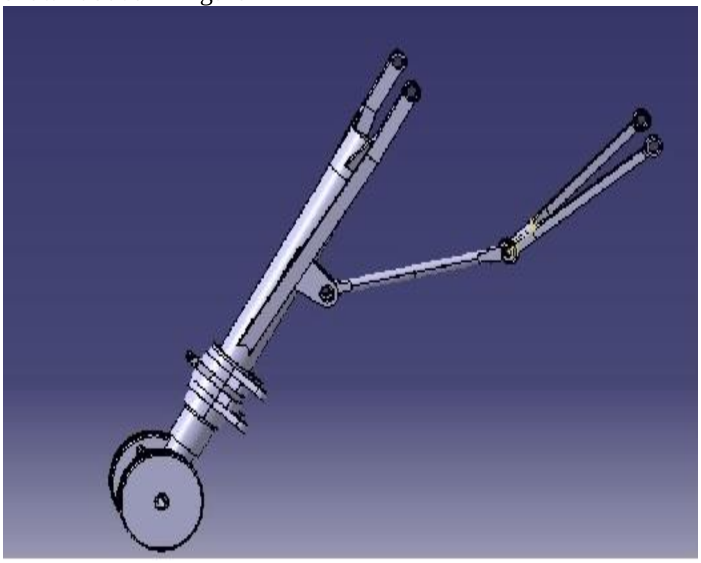

Fig.1 Main Landing Gear Conceptual Model.

## V. MATERIAL

The material selection is the most important factor while designing a component. It offers a major role in assigning the strength to the part

*a. Aluminum 2014-T6*

Ultimate tensile strength 483 MPa
Modulus of elasticity 73.1 GPa
Poisson’s ratio 0.33
Fatigue strength 124 MPa

*b. NCM Steel*

Ultimate tensile strength 1230 MPa
Poisson’s ratio 0.33
Fatigue strength 124 MPa

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## VI. LANDING GEAR LOADS

Loads acting on landing gear on three different axes :

a. Drag load – load in X direction
b. Vertical load – load in Y direction
c. Side load – load in Z direction

Landing gear experiences landing and ground manoeuvring load cases . The different static and critical loads that act on under carriage are as follows:

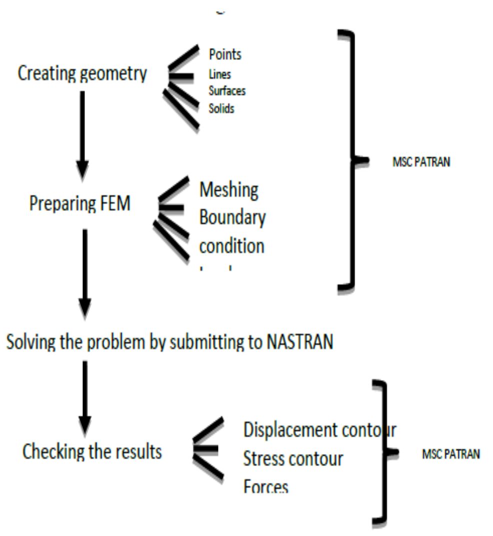
a. Three-point landing spin-up load
b. Three-point landing spring back load
c. Three-point landing –impact load
d. Taxing load
e. Pivoting load
f. Turning load
g. Towing load
h. Three point braked roll load
i. Unsymmetrical braking load

*a. Vertical load*

$$R_{(M.L.G)} = \frac{Ml * Vv^2}{4 * \eta m * \delta m}$$

$R_{(M.L.G)}$ - Reaction load on main landing gear
Ml – Landing weight of aircraft
Vv – Vertical velocity for civil a/c- 3.05m/s
$\eta_m$- is the overall lyre and shock absorber efficiency
$\delta_m$- is the corresponding overall vertical deflection.
$\eta_{m*}\ \delta_m = (0.47\ \delta_{mt} + \eta_{ms}\delta_{ms})$ where suffixes *'MT'* and *'MS'* refer to the main-wheel tire and shock absorber.

## VII. FINITE ELEMENT ANALYSIS




The finite element method (FEM) is a numerical technique for solving engineering problem this method can solve complex geometry, shape, material properties, load and boundary condition. In this method given problem is divided in to small elements these elements are connected each other by nodes. Nodes are the points where the properties of elements determined. For static linear problem a system of the linear algebraic equation should be solved. The software used for the analysis of the wing fuselage attachment bracket of a fighter aircraft airframe structure is MSC.Patran & MSC.Nastran.

## VIII. FEM CONCEPT

The finite element method is based on the idea of building a complicated objects with simple blocks, or dividing a complicated object into small or manageable pieces. Application of this can be found in everyday life as well as in engineering.

Ex. Buildings, kid's play(lego)

FEM method is most widely applied computer simulation in engineering.

Procedure for structural analysis

**a.** Divide structure into pieces(element with nodes)
**b.** Describe the behavior of the physical quantities on each element
**c.** Assemble the elements at the nodes to form an approximate system of equations for the whole structure.
**d.** Solve the system of equations involving unknown quantities(displacements)
**e.** Calculate the desired quantities (strains, stresses)at selected elements.

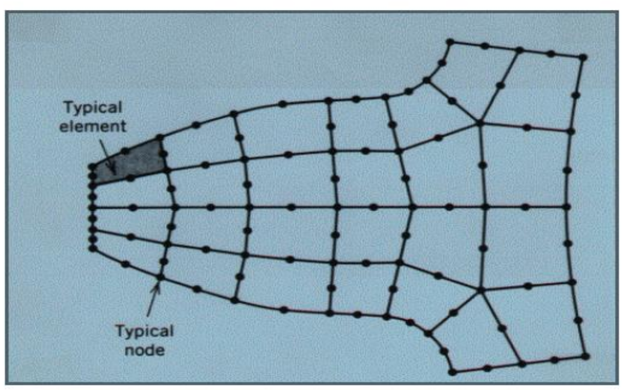



Fig.2 structure analysisl.

Meshing is the process of dividing the structure into domains so that the complicated parts can be easily analyzed.

By dividing the structure the stress concentration and stress sensitivity spots can be easily determined.

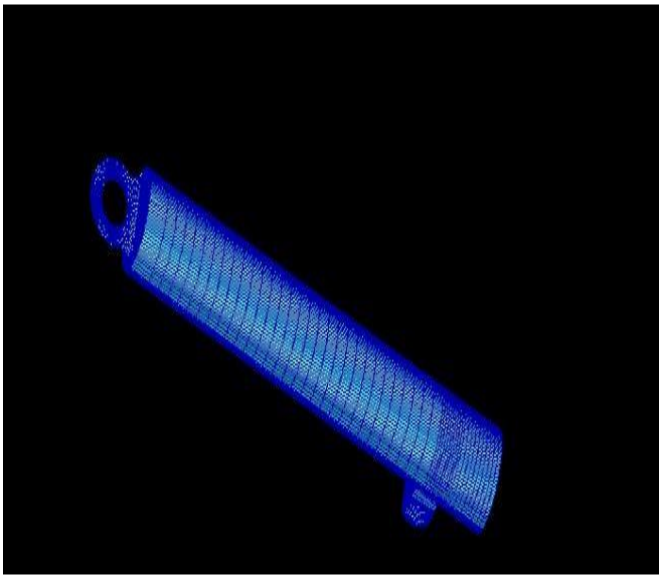


Fig.3 FE model of sock strut.

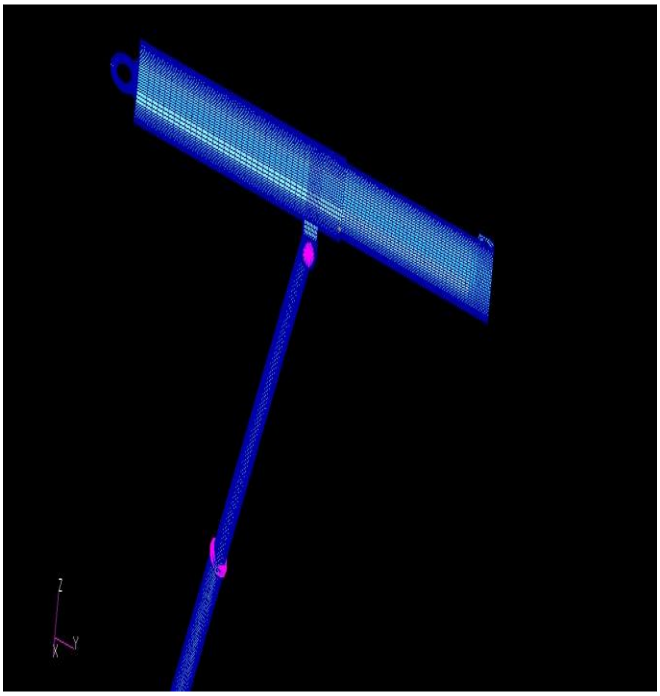


Fig.4 FE model of landing gear

## IX. RESULTS AND DISCUSSION

The optimization of design variables using NASTRAN PATRAN

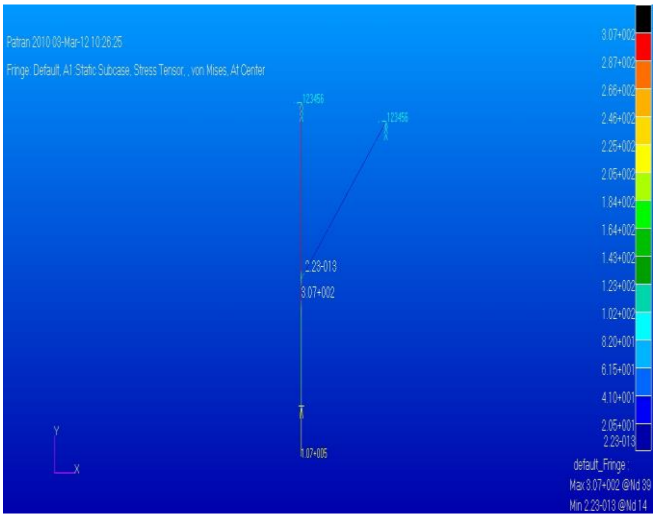



Fig.5 one dimensional stress analysis

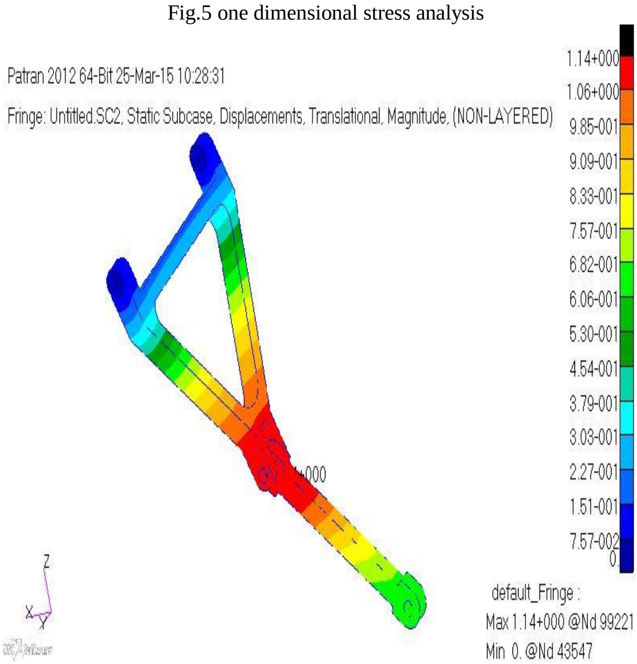



Fig.6 displacement,translation ,magnitude

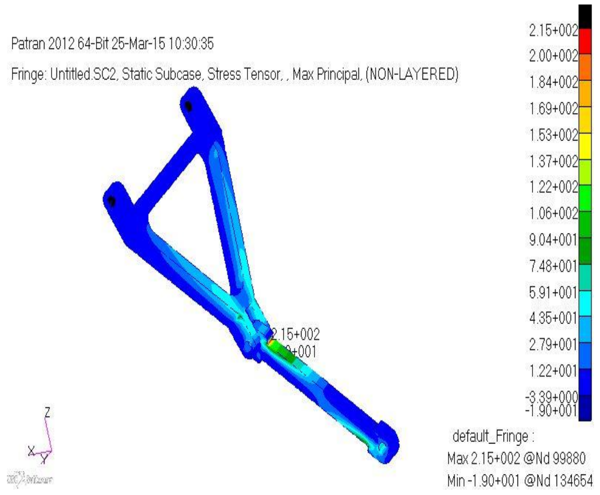



Fig.7 stress tenser

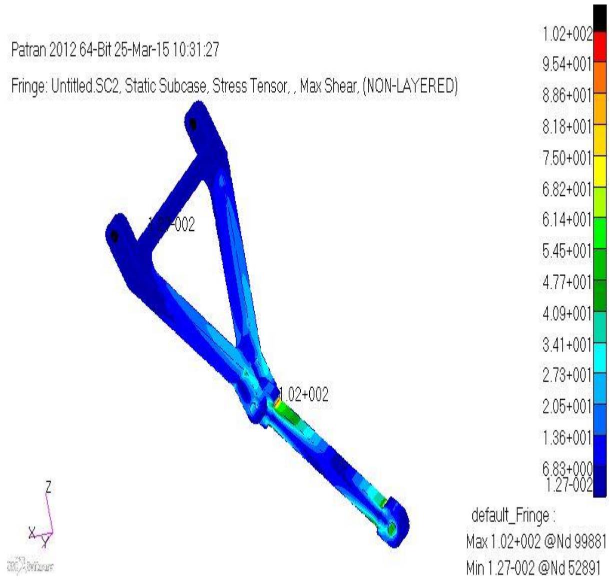



Fig.7 Max. shear stress

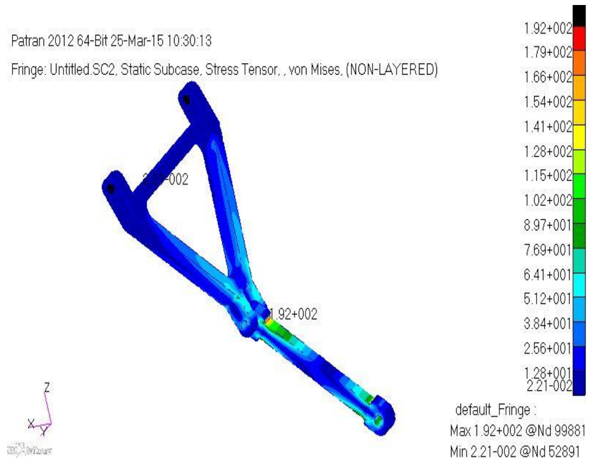



Fig8 Von mises stress

## X .CONCLUSION

This design is an attempt to the study and preliminary initial layout of the Landing gear.Study of software packages like MSC NASTRAN/PATRAN, CATIA V5 are carried out in order to design and analyze the static strength requirement of landing gearl.The geometric modeling of landing gear is done using CATIA V5 R19 software package. A thorough study of finite element analysis is carried out in order to produce a finite element model of modeled landing gear using finite element software package MSC PATRAN

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