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Modelling and Structural Analysis of Drone Landing Gear for Forest Fire Sensing Applications

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A B S T R A C T :

Unmanned Aerial Vehicles (UAVs) are increasingly used for forest-fire sensing and monitoring due to their ability to access remote and hazardous locations. The landing gear is an important structural component of a drone, providing support during landing and ground contact. Its structural performance depends on material properties, applied loads, stiffness, strength, and weight. Therefore, selecting a suitable material is essential for developing structurally reliable and lightweight landing gear. The present project focuses on the modelling and structural analysis of drone landing gear for forest-fire sensing applications using Autodesk Fusion for both design and analysis.

The study considers three materials, namely Aluminium 6061, carbon-fibre-reinforced polymer (CFRP), and Titanium alloy (Ti-6Al-4V), under three loading conditions of 50 N, 100 N, and 150 N, resulting in nine analysis cases. The structural behaviour is evaluated in terms of factor of safety, von Mises stress, displacement, reaction force, The results reveal the influence of material selection and applied load on the structural response of the landing gear and provide a basis for identifying the most suitable material by considering stress, deformation, structural safety, and weight.

Keywords: Drone landing gear, forest-fire sensing, Autodesk Fusion, Aluminium 6061, CFRP, Ti-6Al-4V, structural analysis, material selection.

Introduction

Forest fires are a major environmental problem that can cause extensive damage to forests, wildlife, vegetation, and nearby human settlements. They also contribute to air pollution and the release of greenhouse gases into the atmosphere. Early detection of forest fires is essential for reducing their spread and supporting timely firefighting operations. Conventional forest-fire monitoring methods include ground patrols, watchtowers, satellite observations, and manned aerial surveillance. Although these methods are useful, they may have limitations in terms of accessibility, response time, observation frequency, and the ability to inspect remote forest regions.

Unmanned Aerial Vehicles (UAVs), commonly known as drones, have emerged as useful platforms for forest-fire monitoring and environmental surveillance. Drones can fly over difficult terrain, capture aerial images, monitor temperature variations, and carry sensors for detecting smoke, heat, and other indicators associated with fire. Their ability to operate at relatively low altitudes makes them suitable for inspecting areas that may be difficult to access using conventional methods.

A drone used for forest-fire sensing generally consists of a structural frame, propulsion system, electronic speed controllers, battery, flight controller, navigation system, sensing equipment, and landing gear. Each component contributes to the overall performance and reliability of the UAV. The landing gear is particularly important because it supports the drone during take-off preparation, landing, and ground operations. It also maintains the required clearance between the ground and sensitive components such as thermal cameras, infrared sensors, batteries, and other electronic equipment.

The landing gear must be sufficiently strong to withstand the loads generated during landing while maintaining low weight and adequate stability. In forest environments, landing surfaces may consist of soil, grass, small rocks, roots, and uneven ground. Therefore, the design must consider structural strength, deformation, stability, impact resistance, and material properties.

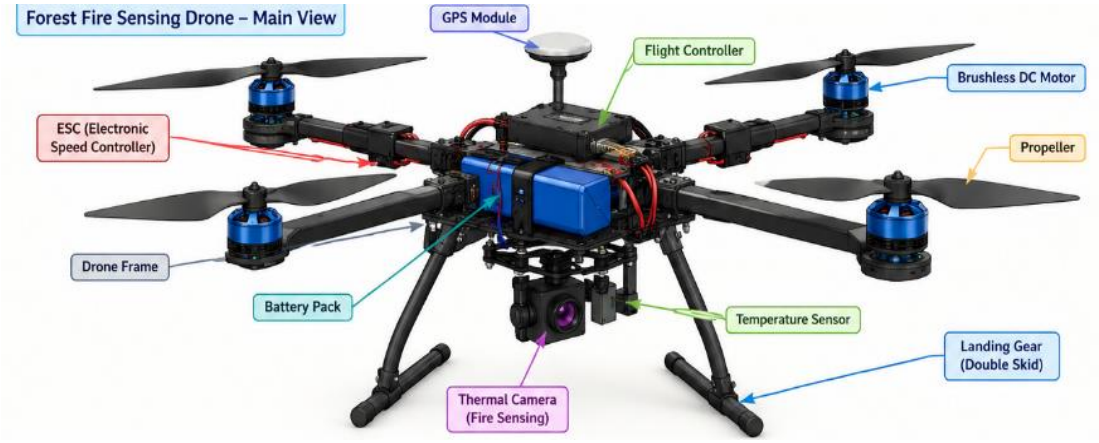


Figure 1.1: Drone for fire sensing operation

The present project focuses on the modelling and structural analysis of drone landing gear for forest-fire sensing applications. Three materials—Aluminium 6061, Carbon Fibre Reinforced Polymer (CFRP), and Titanium (TI-6AL-4V)—are considered for comparison. Autodesk Fusion is used to model the landing gear and evaluate its structural response under applied loads of 50 N, 100 N, and 150 N.

1.1 Forest-Fire Sensing by Drones

Forest-fire sensing involves the observation of forest regions to identify possible fire incidents, assess environmental conditions, and support emergency response. Drone-based monitoring can provide aerial views of locations where ground-based inspection is difficult or time-consuming.

Drones can carry different types of sensors depending on the intended application. RGB cameras capture visible-light images, while thermal and infrared cameras identify temperature patterns. Additional sensors may be used to monitor gases, smoke-related indicators, humidity, and other environmental parameters. GPS and navigation systems help record the location of observations.

The information collected by a drone can assist forest personnel in identifying suspicious heat sources, locating fire-affected regions, and monitoring the development of an incident. However, the effectiveness of a drone depends on its payload capacity, flight endurance, stability, structural integrity, and ability to operate reliably under field conditions.

The landing gear supports these requirements by providing a stable base during ground operations and protecting the lower portions of the drone. The landing-gear design should therefore be considered an important part of the overall UAV structure rather than merely an accessory.

1.2 Types of Drones for Forest-Fire Sensing

Drones can be classified according to their aerodynamic configuration and propulsion arrangement. This classification is different from the classification of landing gear.

1.2.1 Quadcopter

A quadcopter is a multirotor drone that uses four rotors to generate lift and control its movement. It can take off and land vertically, hover at a particular location, and manoeuvre at relatively low speeds.

Quadcopters are suitable for close-range forest inspection, thermal imaging, and monitoring of specific locations. Their vertical take-off and landing capability allows them to operate without a conventional runway.

1.2.2 Hexacopter

A hexacopter has six rotors. Compared with a quadcopter of similar design, it can offer greater lifting capability, depending on the motors, propellers, battery, and overall configuration. It may be selected when additional payload capacity is required for sensing equipment.

1.2.3 Octocopter

An octocopter has eight rotors and is generally considered for applications requiring higher lifting capacity or specialised propulsion redundancy. Its suitability depends on the complete system design, weight, and power requirements.

1.2.4 Fixed-Wing UAV

A fixed-wing UAV generates lift through its wings and is generally suitable for covering larger areas efficiently. It is useful for wide-area forest mapping and surveillance. However, it normally requires a suitable launch and recovery arrangement, which may involve wheels, a launcher, a recovery system, or belly landing.

1.2.5 Hybrid VTOL UAV

A hybrid Vertical Take-Off and Landing (VTOL) UAV combines vertical take-off and landing capability with wing-borne forward flight. It can be useful when both local inspection and longer-range monitoring are required.

The above configurations describe the drone itself. A quadcopter, hexacopter, or octocopter may use different landing-gear designs according to its frame geometry, payload, operating terrain, and landing requirements.



Figure 1.2: Examples of UAV configurations: quadcopter, hexacopter, octocopter, fixed-wing UAV, and hybrid VTOL UAV.

1.3 Importance of Landing Gear in Forest-Fire Sensing Drones

Landing gear is the structural assembly that supports a UAV when it is on the ground. In a multirotor drone, it is generally attached to the main frame or lower structural members. Its configuration influences ground clearance, stability, weight distribution, landing behaviour, and protection of the payload.

In forest-fire sensing applications, landing gear has the following functions:

- **Ground support:** Supports the weight of the drone when it is stationary.
- **Landing load transfer:** Transfers loads from the landing contact points to the main frame.
- **Ground clearance:** Maintains sufficient distance between the ground and the drone body, battery, and sensors.
- **Stability:** Provides a support base that helps prevent the drone from tipping over.
- **Component protection:** Helps prevent direct contact between sensitive equipment and the ground.
- **Impact management:** Depending on the design, flexible members, rubber feet, or damping elements may reduce the loads transmitted during touchdown.
- **Field usability:** Supports safe ground operations on surfaces commonly encountered in forest environments.

Literature Review

[1] Yen-Chu Liang, Pei-Chieh Chin, Yun-Ping Sun, and Muh-Rong Wang (2021) published a research paper entitled “Design and Manufacture of Composite Landing Gear for a Light Unmanned Aerial Vehicle.” The study focused on designing and manufacturing lightweight composite landing gear for a light unmanned aerial vehicle (UAV). Carbon fibre-reinforced polymer (CFRP) was considered to achieve a suitable combination of structural strength and reduced weight. Different fibre orientations were investigated to understand their influence on the mechanical performance of the landing gear. Finite element analysis was performed using ANSYS to evaluate the structural response under the applied loading conditions. The proposed landing gear was manufactured, and experimental measurements were conducted to validate the numerical predictions. The results highlighted the importance of fibre orientation in controlling stress distribution and deformation. The study demonstrated the potential of CFRP composites for developing lightweight and structurally efficient UAV landing gear.

[2] Camil Lancea, Lucia-Antoneta Chicos, Sebastian-Marian Zaharia, Mihai-Alin Pop, Ionut Stelian Pascariu, George-Razvan Buican, and Valentin-Marian Stamate (2022) published a paper entitled “Simulation, Fabrication and Testing of UAV Composite Landing Gear.” The research investigated the structural performance of UAV landing gear manufactured using fused filament fabrication (FFF). Composite materials reinforced with short carbon fibres and glass fibres were examined for their suitability in landing gear applications. Finite element simulations were conducted to predict the mechanical behaviour of the developed components. Three-point bending tests were performed to evaluate their load-carrying capacity, while

microscopic observations were used to identify manufacturing defects. The numerical and experimental results showed a reported relative error of approximately 2%. Among the tested additively manufactured materials, PET reinforced with short carbon fibres achieved a bending strength of approximately 118 MPa. The study demonstrated the potential of fibre-reinforced additive manufacturing for producing lightweight UAV landing gear.

[3] Ibrahim Shamtaid and Batıkan Erdem Demir (2024) published a paper entitled "Development of a Deep Learning-Based Surveillance System for Forest Fire Detection and Monitoring Using UAV." The researchers developed a UAV-based surveillance system to detect and monitor forest fires using artificial intelligence techniques. A four-rotor UAV equipped with a camera was used to capture aerial images for fire identification. YOLOv5 and YOLOv8 models were evaluated for detecting fire in the captured images. CNN-RCNN-based classification was also investigated to distinguish fire images from non-fire images. An NVIDIA Jetson Nano embedded computing platform supported image processing, and a ground-station interface was developed for monitoring. The reported results included 96% classification accuracy and approximately 89% detection performance for selected models. The study demonstrated the usefulness of combining UAV technology and deep learning for forest fire surveillance and early detection.

[4] Montaser N. A. Ramadan, Tasnim Basmaji, Abdalla Gad, Hasan Hamdan, Bekir Tevfik Akgün, Mohammed A. H. Ali, Mohammad Alkhedher, and Mohammed Ghazal (2024) published a paper entitled "Towards Early Forest Fire Detection and Prevention Using AI-Powered Drones and the IoT." The study proposed an integrated forest fire detection system combining unmanned aerial vehicles, artificial intelligence, and the Internet of Things (IoT). Low-cost fire-sensing IoT nodes and LoRaWAN communication technology were considered for monitoring environmental conditions. An autonomous drone equipped with a visual camera was used to identify and track potential fire locations. Image classification techniques were applied to recognize fire, while a cloud-based backend supported data management and monitoring. The proposed approach combined sensor-based alerts with aerial observation to improve fire detection and response. The reported classification accuracy was 99.46%, with a mean average precision of 99.64%. The findings indicated that integrating UAVs, AI, and IoT can support timely forest fire detection and monitoring.

[5] Aryandi Marta, Fajar Ari Wandono, Abian Nurrohmad, Riki Ardiansyah, Ilham Bagus Wiranto, Iqbal Reza Alfikri, Aditya Rio Prabowo, and Gesang Nugroho (2025) published a paper entitled "Finite Element Analysis and Experimental Whiffletree Testing of a Small UAV Composite Wing." The researchers investigated the structural behaviour of a composite wing designed for a small unmanned aerial vehicle. Finite element analysis was combined with experimental whiffletree testing to evaluate the response of the wing under distributed loading. The experimental arrangement reproduced the loading conditions through multiple applied point loads. Numerical predictions of stress and deformation were compared with the measured experimental results. The maximum predicted deflection was approximately 122 mm, whereas the measured deflection was approximately 120 mm. The difference between the predicted and measured deflections was reported as 1.67%. The study demonstrated the value of validating finite element models experimentally when evaluating the structural performance and reliability of UAV components.

[6] Hassan Elahi, Muhammad Rizwan Mughal, Raja Wahab Akmal, Muhammad Rashid Ali Khan, Talha Ahmad Shaikh, and Muhammad Abdullah Khalid (2025) published a paper entitled "Design and Analysis of CFRP-Based Landing Gear for Unmanned Combat Aerial Vehicles." The study focused on developing a carbon fibre-reinforced polymer landing gear for an unmanned combat aerial vehicle. The proposed design aimed to reduce component weight while maintaining sufficient structural strength and impact resistance. Multiple landing gear configurations were investigated using numerical analysis. Static structural analysis was carried out in ANSYS to evaluate equivalent stress, strain, and principal stress. Dynamic impact analysis was also considered to study the response of the landing gear under impact loading. The factor of safety was used to assess the structural suitability of the proposed configurations. The study highlighted the potential of CFRP-based landing gear and the need for further optimization and experimental validation.

[7] Longhai Ye, Yanpeng Zhao, Haifeng Zhang, Yao Zhang, Jiming Lv, and Zonghan Yang (2025) published a paper entitled "Strength Analysis and Structural Optimization of UAV Airframe." The researchers investigated the structural strength and weight optimization of a quadrotor UAV airframe under hovering conditions. Finite element analysis was used to identify critical stress and deformation regions in the original structure. Two approaches, namely mass-constrained optimization and stiffener-based optimization, were investigated to improve structural performance. The first approach modified material distribution in critical and low-stress regions, while the second introduced reinforcing stiffeners in selected areas. The mass-constrained approach reduced the maximum von Mises stress by 38.8%. The stiffener-based approach achieved a 60.9% reduction in stress and a 5.2% reduction in structural mass, while maximum displacement decreased from 6.49 mm to 1.63 mm. The findings demonstrated that structural optimization can improve the strength-to-weight performance of UAV airframes.

Software tools and Methodology

Computer-aided design and computer-aided engineering play an important role in the design and development of mechanical components. These technologies enable engineers to develop three-dimensional models, examine geometrical features, evaluate material properties, and predict structural behaviour before manufacturing the physical component. The use of digital modelling and simulation can reduce the time and cost associated with repeated design modifications and experimental trials.

In the present research, the focus is on modelling and structural analysis of a drone landing gear intended for forest fire sensing applications. The landing gear is an important structural component because it supports the UAV during ground operations and transfers loads between the drone body and the ground. The component should provide adequate strength, stiffness, stability, and ground clearance while maintaining a suitable weight.

Autodesk Fusion is selected as the principal software platform for three-dimensional modelling and structural simulation. The software provides integrated tools for creating solid models, assigning materials, defining boundary conditions, generating finite element meshes, applying loads, and visualizing simulation outputs. This integrated environment helps maintain consistency between the design geometry and the analysis model.

The proposed study considers a U-shaped, two-frame landing gear configuration. Three candidate materials, namely Aluminium 6061, carbon fibre-reinforced polymer (CFRP), and Titanium (TI-6AL-4V), are considered for comparative evaluation. Three prescribed static load cases of 50 N, 100 N, and 150 N are used to investigate the influence of load magnitude and material properties on structural performance.

The principal outputs of interest include stress, deformation, strain, factor of safety where applicable, and support reaction forces. For composite materials, suitable failure criteria and directional material properties should be considered when the necessary material data and software capabilities are available. The results from these analyses will provide a basis for comparing the candidate materials and identifying a suitable option for the proposed landing gear.

3.1 Computer-Aided Design

Computer-aided design (CAD) refers to the use of computer software to create, modify, examine, and document the geometry of engineering components and systems. CAD tools are widely used in mechanical engineering for the development of parts, assemblies, machine components, tooling, and product prototypes.

Traditional manual drafting represents an engineering component using two-dimensional views and dimensions. Although engineering drawings remain essential for manufacturing, a three-dimensional CAD model provides a more complete representation of the component's geometry. The model can be rotated, sectioned, measured, and examined from different viewpoints.

CAD modelling also supports design modifications. Dimensions, cross-sections, mounting locations, and geometrical features can be adjusted without recreating the entire component. This capability is particularly useful when evaluating different design alternatives or preparing a component for structural simulation.

In the present project, CAD modelling is used to develop the landing gear geometry and define its important structural features. The model includes the skid members, connecting members, and mounting regions required to attach the landing gear to the drone body. The final geometry provides the basis for material assignment and finite element analysis.

3.1.1 Importance of CAD in mechanical engineering

CAD provides several advantages in the development of mechanical components:

- It improves the accuracy and consistency of geometrical modelling.
- It allows dimensional modifications to be made efficiently.
- It supports the generation of two-dimensional engineering drawings.
- It enables visualization of components from different orientations.
- It helps identify geometrical interference and assembly-related issues.
- It provides geometry that can be used in computer-aided engineering simulations.
- It supports documentation and communication of design information.

For the landing gear investigated in this project, CAD modelling helps establish a consistent geometry for comparing the structural behaviour of different materials under the selected loading conditions.

3.2 Overview of Autodesk Fusion

Autodesk Fusion is an integrated computer-aided design, manufacturing, and engineering software platform used for product development. It provides tools for solid modelling, surface modelling, assemblies, engineering drawings, manufacturing preparation, and engineering simulation. Its integrated

workflow allows a three-dimensional model to be developed and subsequently evaluated using supported simulation capabilities.

For the present research, Autodesk Fusion is used to develop the landing gear geometry and conduct the planned structural analysis. Using the same software environment for modelling and simulation helps maintain consistency between the original geometry and the model used for analysis.

3.2.1 Major capabilities of Autodesk Fusion

The principal capabilities relevant to this project are described below.

- Three-dimensional modelling: Sketching, extrusion, sweep, fillet, pattern, mirror, and other solid-modelling operations can be used to construct the required component geometry.
- Geometrical modification: Existing features and dimensions can be modified to investigate alternative geometrical configurations.
- Material assignment: Available material definitions can be assigned to the component. Additional material properties may be required when the default library does not contain the exact material or when a composite model requires directional properties.
- Engineering drawings: Two-dimensional drawings can be generated from the three-dimensional model to communicate the dimensions, shape, and manufacturing details.
- Simulation preparation: Supported simulation studies allow engineers to define loads, constraints, material properties, and analysis settings.
- Result visualization: Available result plots can be used to display displacement, stress, strain, and other output quantities supported by the selected study.
- Design integration: Since modelling and simulation are integrated into the software environment, design modifications can be incorporated into the analysis workflow.

The availability of particular simulation types and output quantities depends on the installed software version, licence, and study type.

4. Design and Analysis of Drone Landing Gear

The design and structural analysis of drone landing gear are important stages in the development of an unmanned aerial vehicle (UAV) for forest fire sensing applications. The landing gear supports the drone during ground operations and transfers the load between the main body and the ground. Its structural performance depends on the geometry, material properties, applied forces, mounting arrangement, and support conditions.

In the present study, a U-shaped, two-frame landing gear is modelled using Autodesk Fusion. The design is investigated using three candidate materials: Aluminium 6061, carbon fibre-reinforced polymer (CFRP), and Titanium (TI-6AL-4V). The material configurations are evaluated under three prescribed static load conditions of 50 N, 100 N, and 150 N.The final design should also be checked for mounting compatibility, propeller clearance, ground clearance, and potential interference with the UAV body. These checks are part of the design assessment and are not replaced by the static structural simulation.

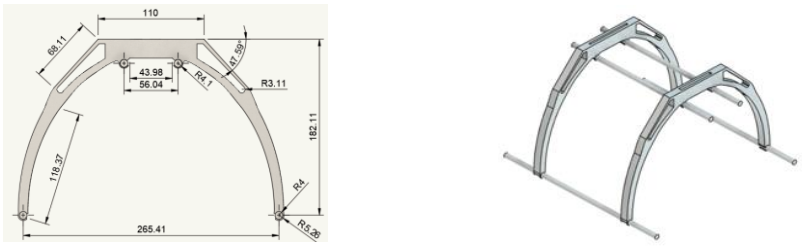


Figure 4.1: U-shaped, two-frame landing gear for a forest fire sensing UAV.

4.1 Selection of Materials

Three materials are considered in the present study to investigate the influence of material properties on the structural performance of the landing gear.

4.1.1 Aluminium 6061

Aluminium 6061 is a widely used aluminium alloy that provides a combination of strength, corrosion resistance, machinability, and availability. Its relatively low density compared with many structural metals makes it attractive for lightweight mechanical components.

For this investigation, Aluminium 6061 serves as the metallic reference material. The precise properties depend on the alloy temper and product form. Therefore, the selected material should be specified as, for example, Aluminium 6061-T6, if that is the actual material definition used in Autodesk Fusion.

Published property data for 6061-T6 commonly report a density near 2700 kg/m³, an elastic modulus near 68.9 GPa, a Poisson's ratio near 0.33, and a tensile yield strength around 276 MPa for typical material data. Actual values vary with product form, thickness, temper, and source.

4.1.2 Carbon fibre-reinforced polymer

CFRP consists of carbon fibres embedded in a polymer matrix. It is widely used in lightweight structures because it can provide high stiffness and

strength relative to its mass.

The mechanical response of CFRP depends on the fibre orientation, laminate stacking sequence, resin system, fibre volume fraction, and manufacturing quality. A CFRP laminate is generally direction-dependent and should preferably be represented using suitable orthotropic material properties.

For the landing gear, CFRP is investigated as a candidate for reducing component mass while maintaining appropriate structural performance. A valid assessment requires material data corresponding to the actual CFRP material or laminate represented in the model.

4.1.3 Titanium alloy (Ti-6Al-4V)

Ti-6Al-4V is a titanium alloy containing aluminium and vanadium as the principal alloying elements. It is widely used in aerospace and structural applications that require a high strength-to-weight ratio, good corrosion resistance, and excellent mechanical performance.

Its strength, stiffness, and deformation behaviour depend on the alloy composition, heat treatment, manufacturing process, and loading conditions. Ti-6Al-4V offers high specific strength and good resistance to fatigue, making it a suitable candidate for lightweight structural components subjected to mechanical loads.

Ti-6Al-4V is included to evaluate whether its structural response, deformation characteristics, and mass provide a suitable balance for the proposed drone landing gear used in forest fire sensing applications.

4.2 Simulation conditions

Table 4.1: Simulation matrix for the nine analysis cases.

Case	Material	Load
1	Aluminium 6061	50 N
2	Aluminium 6061	100 N
3	Aluminium 6061	150 N
4	CFRP	50 N
5	CFRP	100 N
6	CFRP	150 N
7	TI-6AL-4V	50 N
8	TI-6AL-4V	100 N
9	TI-6AL-4V	150 N

4.3 Output Parameters and Data Collection

The outputs from each simulation are recorded in a consolidated table. The parameters selected for recording should reflect the actual quantities available in Autodesk Fusion and the material model used.

The principal outputs are:

- Maximum relevant stress measure.
- Minimum stress, if useful and consistently reported.
- Maximum total deformation.
- Relevant strain measure.
- Factor of safety, where the material model and failure criterion support a valid assessment.
- Reaction force at the supports.
- Contact pressure and contact force, if a suitable contact interaction is explicitly included.

Component mass calculated from the assigned material and geometry.

4.3.1 Consolidated table for all nine conditions

Table 4.2: Consolidated simulation results for different material and load conditions.

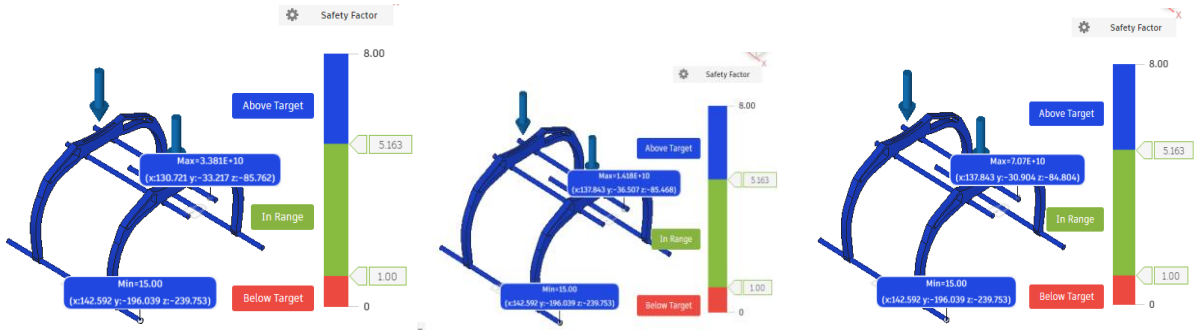
Case	Material	Load (N)	FoS. (Target is 1)	Von Mises Stress (MPa)	Displacement (mm)	Reaction force (N)
1	Al 6061	50	3.38 E10	1.037	0.004	10.741
2	Al 6061	100	1.68 E10	2.074	0.008	21.481
3	Al 6061	150	1.12 E10	3.111	0.012	32.221

4	CFRP	50	1.41 E10	1.005	0.002	10.874
5	CFRP	100	7.05 E9	2.009	0.004	21.747
6	CFRP	150	4.69 E9	3.014	0.006	32.621
7	TI-6AL-4V	50	7.07 E10	1.028	0.003	10.784
8	TI-6AL-4V	100	3.46 E10	2.055	0.005	21.569
9	TI-6AL-4V	150	2.34 E10	3.083	0.007	32.353

5. Results and Discussions

Factor of Safety Analysis

5.1.1: Aluminium, CFRP, Ti-6Al-4V at 50N condition

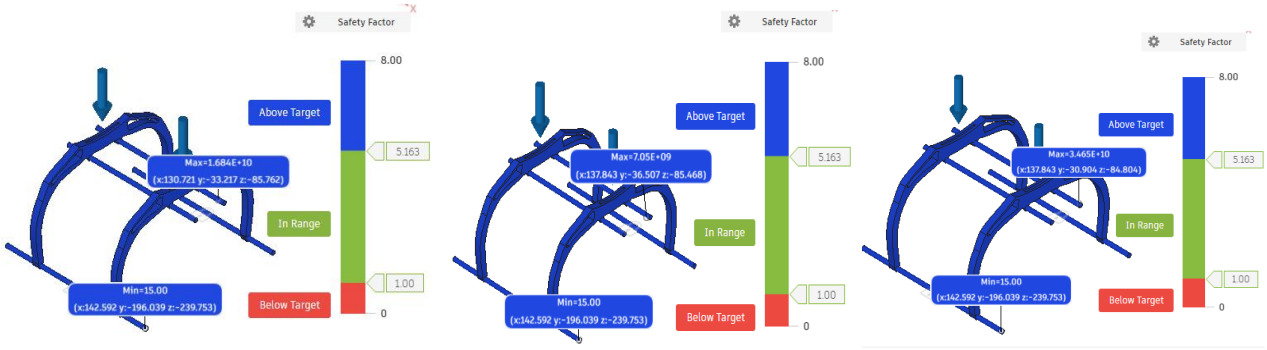


(a) **(b)** **(c)**

Figure 5.1: FOS of Aluminium, CFRP, TI-6AL-4V at 50N loading condition

The recorded Factor of Safety values at 50 N are 3.38 × 10^{10} for Aluminium 6061, 1.41 × 10^{10} for CFRP, and 7.07 × 10^{10} for Ti-6Al-4V. These values are extremely large for a conventional structural FoS and should be checked against the Fusion result panels and material strength definitions. If these values are confirmed, all are numerically above 1; however, their magnitude should not be interpreted as proof of practical landing safety without validating the material model and failure criterion.

5.1.2: Aluminium, CFRP, TI-6AL-4V at 100N condition

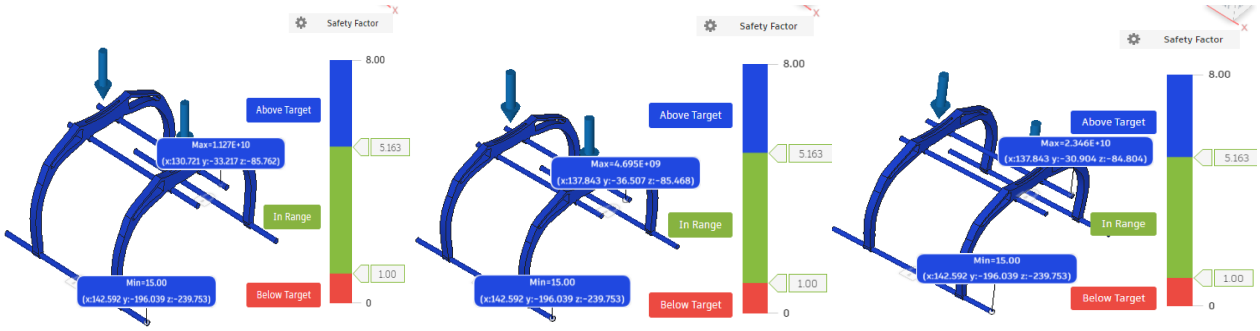


(a) **(b)** **(c)**

Figure 5.2: FOS of Aluminium, CFRP, TI-6AL-4V at 100N loading condition

At 100 N, the reported Factor of Safety values are 1.68 × 10^{10} for Aluminium 6061, 7.05 × 10^{9} for CFRP, and 3.46 × 10^{10} for Ti-6Al-4V. The reported values decrease compared with the corresponding 50 N cases, which is consistent with a lower safety margin as loading increases. Their very large magnitude makes verification of units, output field, and material strength data essential.

5.1.3: Aluminium, CFRP, TI-6AL-4V at 150N condition



(a) **(b)** **(c)**

Figure 5.3: FOS of Aluminium, CFRP, TI-6AL-4V at 150N loading condition

At 150 N, the reported Factor of Safety values are 1.12×10^{10} for Aluminium 6061, 4.69×10^{9} for CFRP, and 2.34×10^{10} for Ti-6Al-4V. Each reported value is lower than the corresponding value at 100 N, following the expected direction as load increases. Because the values remain unusually large, they should be validated in Autodesk Fusion before being used as a quantitative safety claim.

5.2 Von Mises stress analysis

5.2.1: Aluminium, CFRP, TI-6AL-4V at 50N condition

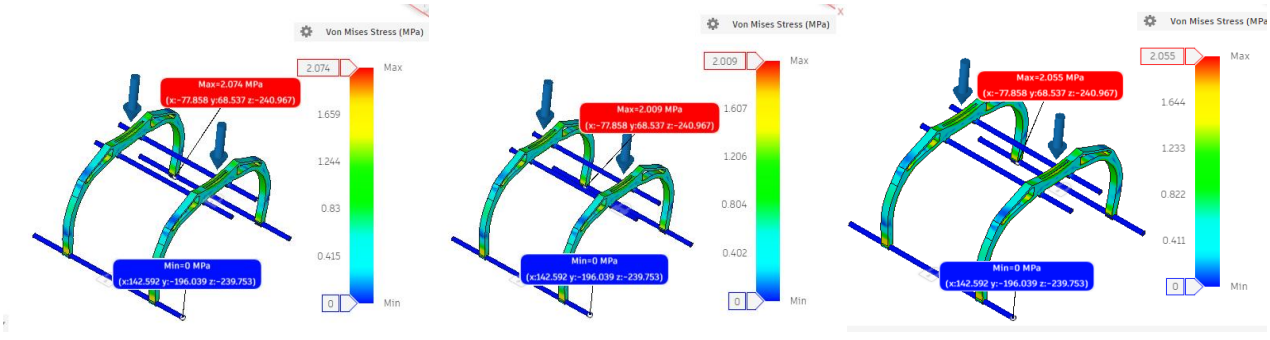


(a) **(b)** **(c)**

Figure 5.4: Von Mises stress analysis of Aluminium, CFRP, TI-6AL-4V at 50N loading condition

At 50 N, the recorded von Mises stresses are 1.037 MPa for Aluminium 6061, 1.005 MPa for CFRP, and 1.028 MPa for Ti-6Al-4V. The values are close, with CFRP showing the lowest recorded stress and Aluminium 6061 the highest. Similar stress levels may result when the geometry and load application are similar; small differences arise from the material-dependent stiffness and numerical response. For CFRP, von Mises stress should be treated cautiously because composite failure is directional and is better assessed with an appropriate composite failure criterion.

5.2.2: Aluminium, CFRP, TI-6AL-4V at 100N condition

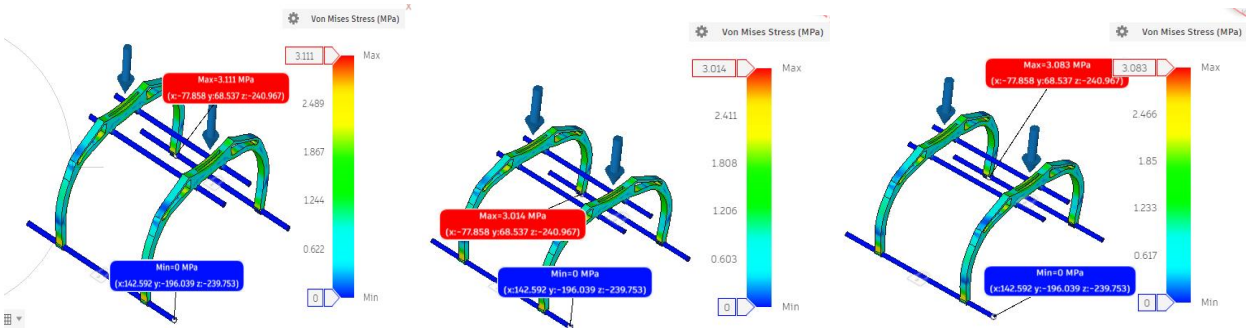


(a) **(b)** **(c)**

Figure 5.5: Von Mises stress analysis of Aluminium, CFRP, TI-6AL-4V at 100N loading condition

At 100 N, the reported stresses are 2.074 MPa for Aluminium 6061, 2.009 MPa for CFRP, and 2.055 MPa for Ti-6Al-4V. The stress is approximately twice the 50 N value in each case, indicating an almost proportional stress response to the increased load. This behaviour is typical of a linear static analysis when geometry, constraints, and material response remain unchanged.

5.2.3 Aluminium, CFRP, TI-6AL-4V at 150N condition



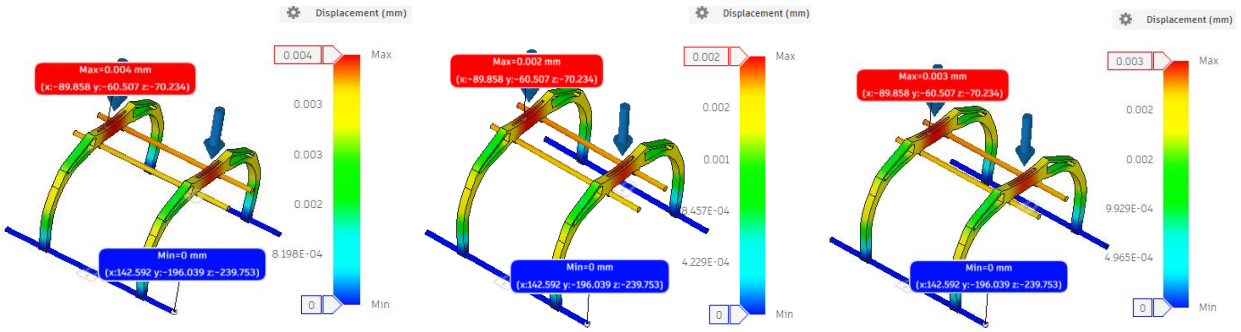
(a) **(b)** **(c)**

Figure 5.6: Von Mises stress analysis of Aluminium, CFRP, TI-6AL-4V at 150N loading condition

At 150 N, the recorded stresses are 3.111 MPa for Aluminium 6061, 3.014 MPa for CFRP, and 3.083 MPa for Ti-6Al-4V. These values are approximately three times the corresponding 50 N results. This trend is consistent with a linear-elastic static response, where stress generally increases in proportion to the applied load. The location of the peak stress in each contour should also be examined to identify geometric transitions or constrained regions that may concentrate stress.

5.3 Displacement analysis

5.3.1: Aluminium, CFRP, TI-6AL-4V at 50N condition

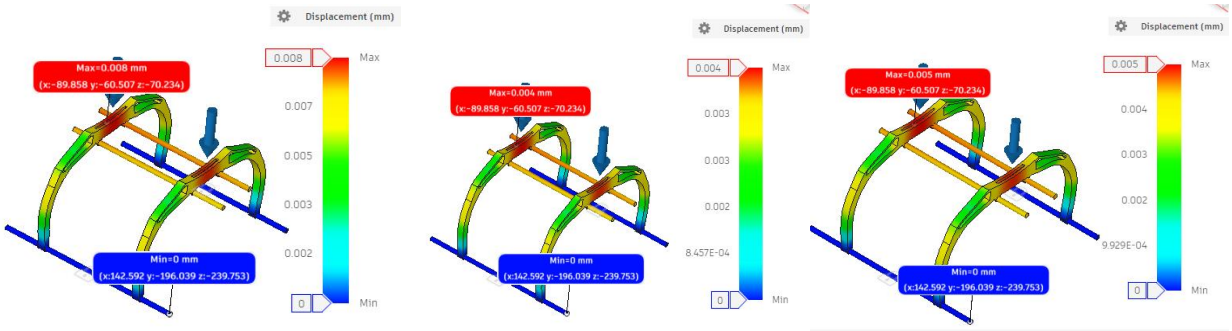


(a) **(b)** **(c)**

Figure 5.7: Displacement analysis of Aluminium, CFRP, TI-6AL-4V at 50N loading condition

At 50 N, the recorded displacements are 0.004 mm for Aluminium 6061, 0.002 mm for CFRP, and 0.003 mm for Ti-6Al-4V. CFRP shows the lowest displacement in the supplied results. Displacement depends on stiffness, geometry, load path, and boundary conditions; the lower CFRP value may reflect the assigned laminate properties and orientations in the model. These properties should be confirmed because CFRP is anisotropic.

5.3.2: Aluminium, CFRP, TI-6AL-4V at 100N condition

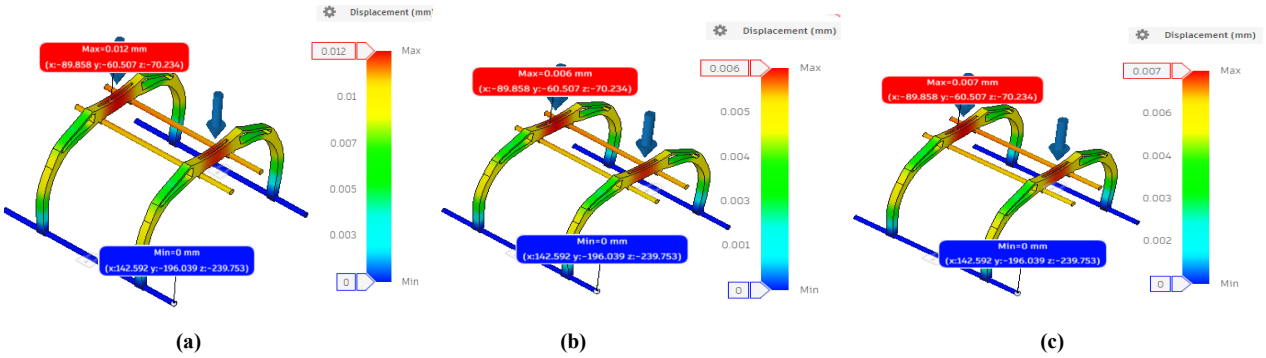


(a) **(b)** **(c)**

Figure 5.8: Displacement analysis of Aluminium, CFRP, TI-6AL-4V at 100N loading condition

At 100 N, the reported displacements are 0.008 mm for Aluminium 6061, 0.004 mm for CFRP, and 0.005 mm for Ti-6Al-4V. Compared with the 50 N case, the displacement increases for each material. The increase is broadly consistent with a linear response to the applied load. CFRP remains the lowest-displacement case in the recorded results, followed by Ti-6Al-4V and Aluminium 6061 only as ranked by the reported values.

5.3.2: Aluminium, CFRP, TI-6AL-4V at 150N condition



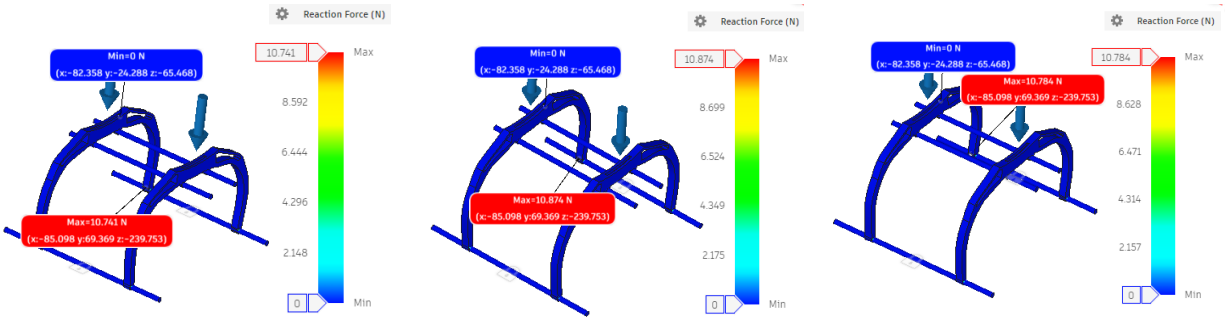
(a) **(b)** **(c)**

Figure 5.9: Displacement analysis of Aluminium, CFRP, TI-6AL-4V at 150N loading condition

At 150 N, the recorded displacements are 0.012 mm for Aluminium 6061, 0.006 mm for CFRP, and 0.007 mm for Ti-6Al-4V. Displacement increases as the load rises, as expected for a structure deforming under greater applied force. CFRP records the lowest displacement in this dataset. A final material decision should also consider density, manufacturing practicality, cost, and appropriate composite strength checks rather than displacement alone.

5.4 Reaction force analysis

5.4.1: Aluminium, CFRP, TI-6AL-4V at 50N condition

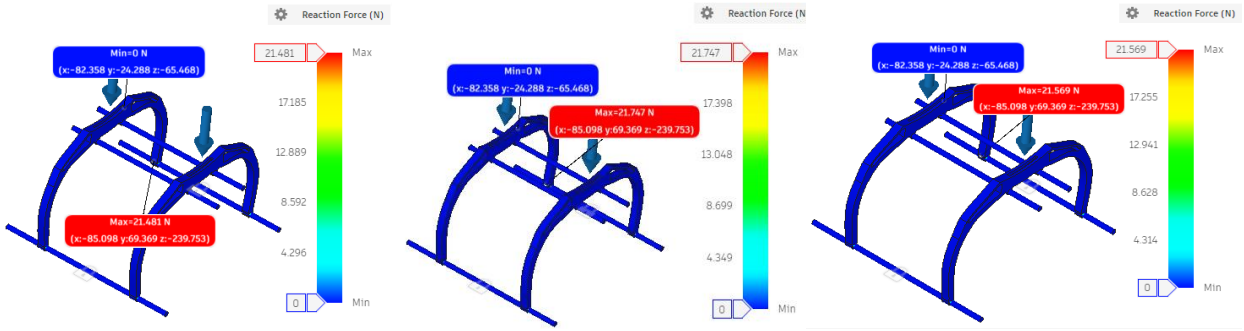


(a) **(b)** **(c)**

Figure 5.10: Reaction force analysis of Aluminium, CFRP, TI-6AL-4V at 50N loading condition

At 50 N, the recorded reaction forces are 10.741 N for Aluminium 6061, 10.874 N for CFRP, and 10.784 N for Ti-6Al-4V. The values are close, which may indicate similar overall support response across the material cases. However, these reported values are lower than the applied 50 N load. The sum of reaction-force components at all supports must be checked; a single reaction component or one support reaction may not equal the full applied load.

5.4.2: Aluminium, CFRP, TI-6AL-4V at 100N condition

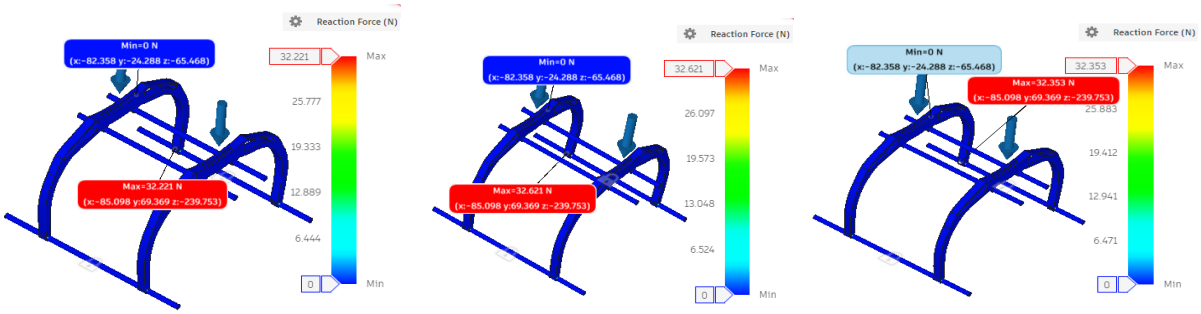


(a) **(b)** **(c)**

Figure 5.11: Reaction force analysis of Aluminium, CFRP, TI-6AL-4V at 100N loading condition

At 100 N, the recorded reaction forces are 21.481 N for Aluminium 6061, 21.747 N for CFRP, and 21.569 N for Ti-6Al-4V. The values increase relative to the 50 N cases and remain close to one another. Because the values are lower than the applied load, they should not be treated as total support reactions until the complete reaction vector at all constrained regions has been summed and checked for static equilibrium.

5.4.3: Aluminium, CFRP, TI-6AL-4V at 150N condition



(a) **(b)** **(c)**

Figure 5.12: Reaction force analysis of Aluminium, CFRP, TI-6AL-4V at 150N loading condition

At 150 N, the recorded reaction forces are 32.221 N for Aluminium 6061, 32.621 N for CFRP, and 32.353 N for Ti-6Al-4V. Reaction force increases with the applied load, and the three reported values are similar. A static model in equilibrium should have total support reactions that balance the applied force and moments; therefore, the full reaction output should be reviewed before finalizing the discussion.

5.5 Comparative Discussion of Simulation Results

The comparative graphs summarize the numerical results for all three materials across the 50 N, 100 N, and 150 N loading conditions. The stress and displacement trends increase with load, which is expected for a predominantly linear-static response. The FoS values reported in the supplied table are exceptionally large and are plotted on a logarithmic vertical axis so that the differences among materials remain readable. They must be verified in Autodesk Fusion before being used as definitive safety factors.

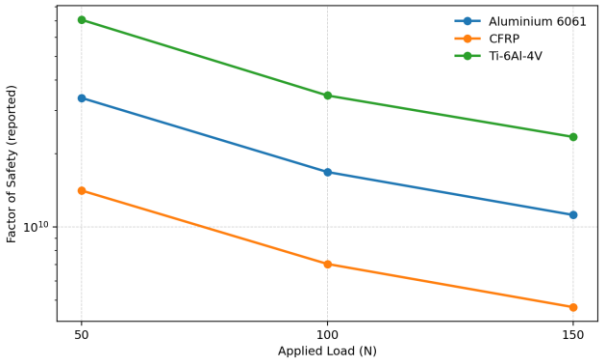


Figure 5.13: Comparison of reported factor of safety for the three materials.

The reported FoS decreases as the applied load increases for all three materials. Ti-6Al-4V has the highest reported FoS in each load case, followed by Aluminium 6061 and CFRP. The absolute values are unusually high; confirm that the column represents FoS rather than another Fusion output or a unit/formatting error.

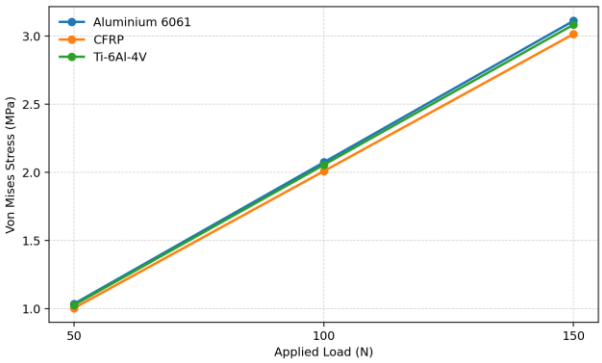


Figure 5.14: Comparison of von Mises stress for the three materials.

Von Mises stress increases nearly in direct proportion to applied load. Aluminium 6061 records the highest stress values, while CFRP records the lowest. For CFRP, a directional composite failure criterion should supplement or replace a metal-oriented von Mises interpretation.

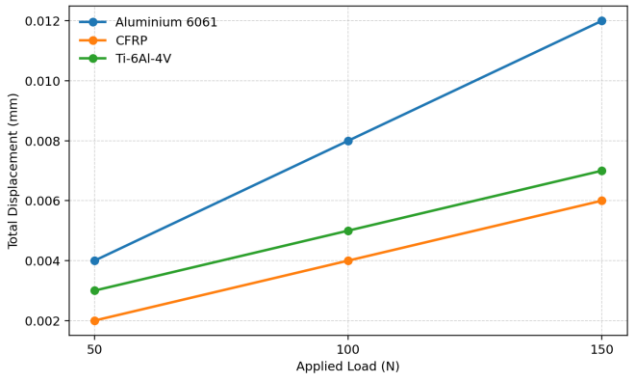


Figure 5.15: Comparison of total displacement for the three materials.

Displacement increases with load for each material. CFRP has the lowest recorded displacement, followed by Ti-6Al-4V and Aluminium 6061 in this dataset. This ranking depends on the material properties and orientations assigned in the model and should be checked against the simulation setup.

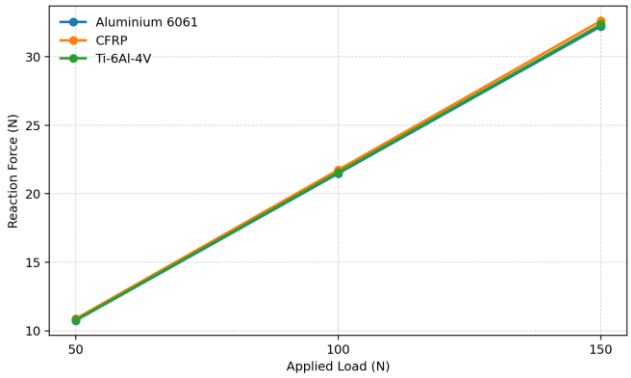


Figure 5.16: Comparison of recorded reaction force for the three materials.

The recorded reaction force increases with applied load and is similar for the three material cases. The values are below the applied loads, so the total reactions at all supports should be checked as vectors before drawing an equilibrium conclusion.

The present chapter discussed the structural analysis of drone landing gear using Aluminium 6061, CFRP, and Ti-6Al-4V under different loading conditions. The simulation results were compared in terms of Factor of Safety, von Mises stress, displacement, and reaction force. Among the three materials, CFRP exhibited the lowest stress and displacement, particularly at the maximum applied load of 150 N, indicating favourable structural performance under the specified conditions. Therefore, CFRP is considered the preliminary preferred material for the proposed drone landing gear. However, the reported Factor of Safety and reaction force values require further verification before confirming the structural safety of the design. The conclusions drawn from this analysis provide a basis for material selection and further validation of the landing gear for forest fire sensing drone applications.

6. Conclusions

Based on the structural analysis results obtained for the three materials under different loading conditions, the major conclusions of the present study are summarized as follows.

- The structural analysis of drone landing gear was performed using Autodesk Fusion for Aluminium 6061, CFRP, and Ti-6Al-4V under applied loads of 50 N, 100 N, and 150 N.
- The von Mises stress and displacement increased with an increase in the applied load for all three materials.
- Among the three materials, CFRP exhibited the lowest von Mises stress and displacement under all investigated loading conditions.
- At 150 N, CFRP recorded a von Mises stress of 3.014 MPa and a displacement of 0.006 mm, making it the best-performing material based on these results.
- Based on the reported Factor of Safety values, Ti-6Al-4V at 50 N recorded the highest FoS of 7.07 $X10^{10}$. However, this unusually high value must be verified against the material properties, failure criteria, and simulation settings before drawing conclusions about structural safety.

- Based on the combined stress and displacement results, CFRP is identified as the preliminary preferred material for the proposed drone landing gear, while the FoS results require further validation.

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