Innovative Design and Analysis of Advanced Landing Gear Systems for Next-Generation Aerial Platforms

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***Abstract*—The landing gear is one of the most critical subsystems of an aircraft, responsible for supporting the entire weight of the vehicle during ground operations, take-off, and landing. This study focuses on the CAD design and static structural analysis of an aircraft landing gear system to ensure optimal strength, stability, and weight efficiency. A 3D model of the landing gear assembly was developed using Computer-Aided Design (CAD) software, incorporating key components such as the strut, wheel, axle, and shock absorber. The design process emphasized geometric accuracy, material selection, and manufacturability.**

The static structural analysis was conducted using Finite Element Analysis (FEA) tools to evaluate stress distribution, deformation, and factor of safety under various loading conditions such as landing impact and taxiing loads. The results indicate that the proposed design can withstand the expected operational stresses while maintaining structural integrity and minimizing material usage. The findings contribute to improved reliability and performance of aircraft landing systems and provide a framework for future optimization studies integrating fatigue and dynamic analyses.

***Index Terms*—Landing Gear, CAD Design, Static Structural Analysis, FEA, Aircraft Structure, Stress Distribution, Factor of Safety, Mesh Quality, Strain energy**

I. INTRODUCTION

The landing gear system is one of the most crucial structural components of an aircraft, responsible for supporting the entire weight of the aircraft during landing, taxiing, and takeoff operations. It must absorb and dissipate the kinetic energy generated during landing impact while maintaining structural integrity, stability, and reliability under various load conditions. The design of an efficient landing gear requires careful consideration of strength, material selection, weight optimization, and manufacturability to ensure both safety and performance.

In this study, a detailed CAD model of the aircraft landing gear was developed using SolidWorks to represent the geometric accuracy and assembly of all major components, including the shock absorber (oleo strut), link arms, axle, and wheel system. The model was designed considering operational constraints, load transmission paths, and ease of integration into the aircraft fuselage.

Following the design stage, a static structural analysis was performed using ANSYS 2025 R1 Student Edition to evaluate the strength and deformation characteristics of the landing gear under static loading conditions. The meshing process involved a fine tetrahedral element structure to ensure precise stress and strain distribution across critical regions. The analysis considered the material properties, boundary conditions, and loading representative of an aircraft's landing impact and taxiing loads.

II. OVERVIEW

The landing gear of an aircraft is a vital structural subsystem that enables safe ground operations, including takeoff, landing, and taxiing. It must support the entire aircraft weight during static and dynamic loading conditions while effectively absorbing and dissipating impact energy. This project focuses on the design, modeling, and static structural analysis of a main landing gear assembly using advanced CAD and CAE tools.

The CAD model of the landing gear was developed in SolidWorks, incorporating essential mechanical components such as the oleo-pneumatic shock absorber, supporting links, wheel, and axle system. The design aimed to achieve structural efficiency, optimal weight distribution, and ease of integration into the aircraft framework.

The Finite Element Analysis (FEA) was performed in ANSYS 2025 R1 Student Edition, where meshing and loading conditions were applied to simulate realistic landing loads. The structural analysis provided detailed results of stress distribution, total deformation, and critical load zones, highlighting the maximum von-Mises stress and displacement values.

III. METHODOLOGIES

The methodology adopted for this project involves a systematic approach to the design, modeling, and structural analysis of the aircraft landing gear assembly. The entire process is divided into multiple stages, as illustrated below:

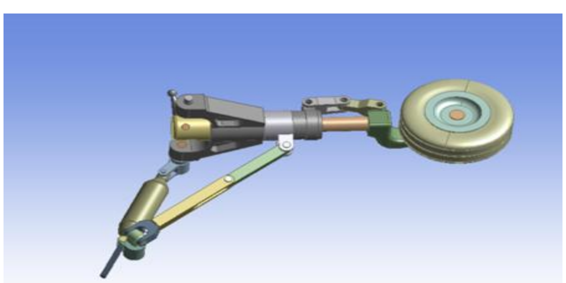
1. Conceptual Design and Literature Study

The initial phase involved reviewing existing landing gear configurations and mechanisms used in aircraft, including tricycle and conventional (tail-dragger) designs. The study helped in selecting a suitable configuration emphasizing structural strength, shock absorption, and weight optimization. Key design parameters such as load distribution, impact forces, and material selection criteria were identified based on standard aerospace practices.

2. CAD Modeling:

The 3D model of the landing gear was created using SolidWorks software.

- All individual components such as the shock absorber (oleo strut), upper and lower link arms, axle, wheel, and mounting base were designed and assembled.
- Appropriate constraints and mating conditions were applied to ensure correct mechanical motion and alignment.
- The model was checked for dimensional accuracy, component interference, and weight balance before exporting it for analysis.



The final assembly accurately represents a retractable main landing gear mechanism suitable for light aircraft or UAV applications.

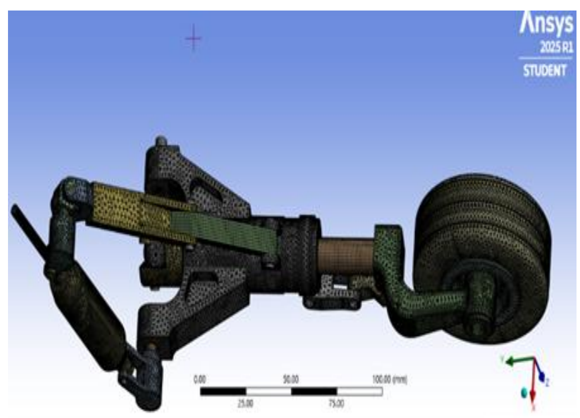
3. Material Selection:

Material selection was based on factors such as strength-to-weight ratio, fatigue resistance, impact absorption, and corrosion resistance. Typical aerospace-grade alloys such as Aluminum 7075-T6, Titanium alloy (Ti–6Al–4V), and high-strength steel (AISI 4340) were considered for comparison. For the analysis, Aluminum Alloy 7075-T6 was selected due to its high yield strength (503 MPa) and lightweight properties, making it ideal for aircraft structural components.

4. Meshing and Boundary Conditions

The finite element model was generated in ANSYS 2025 R1 Student Edition.

- A fine tetrahedral mesh was used to accurately capture stress concentrations around joints and curved surfaces.
- Mesh refinement was applied at critical zones like the axle, shock absorber junction, and linkage arms.



Boundary conditions were defined as follows:

- The base mounting was fixed to simulate attachment with the fuselage.
- A vertical load equivalent to the static aircraft weight acting on one wheel was applied to the wheel rim region.
- Gravity effects and contact interactions were considered where applicable.

5. Static Structural Analysis:
Static analysis was performed to evaluate the stress, strain, and deformation under applied loading.

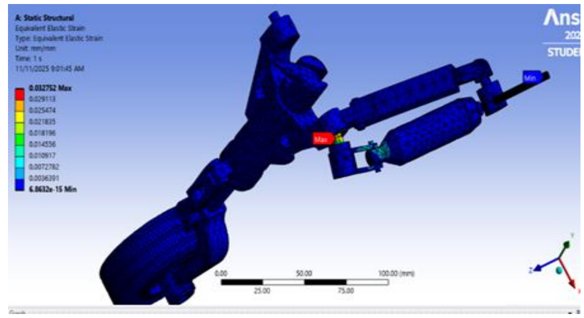
- Von-Misses stress distribution was used to identify high-stress regions and evaluate material yielding.
- Total deformation plots helped in determining displacement and deflection trends.
- The maximum stress (≈ 6351.9 MPa) and maximum deformation (≈ 1.98 mm) were recorded, indicating areas of critical loading.
- The Factor of Safety (FOS) was derived by comparing yield strength with maximum induced stress.

6. Result Interpretation and Validation:
The simulation results were analyzed to assess whether the structure can safely withstand the operational loads. Regions showing high stress were reviewed for potential geometric modifications or reinforcement in future design iterations. The analysis confirmed that the selected design and material combination provided an effective balance between strength, stiffness, and weight efficiency.

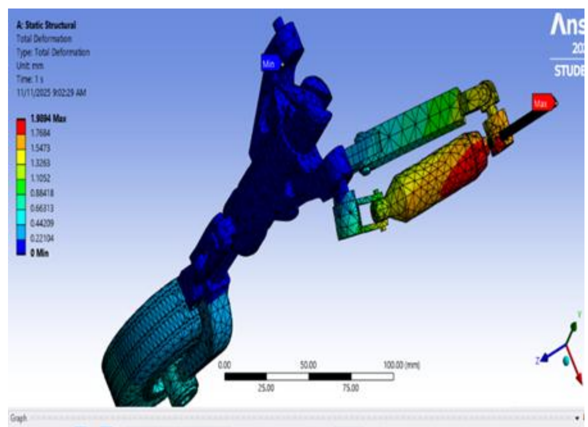
IV. FINAL RESULTS

The static structural analysis of the designed landing gear was carried out using ANSYS 2025 R1 (Student Version) to evaluate the performance of the structure under the applied loading conditions. The analysis focused on parameters such as equivalent (von-Mises) stress, total deformation, elastic strain, and strain energy distribution.

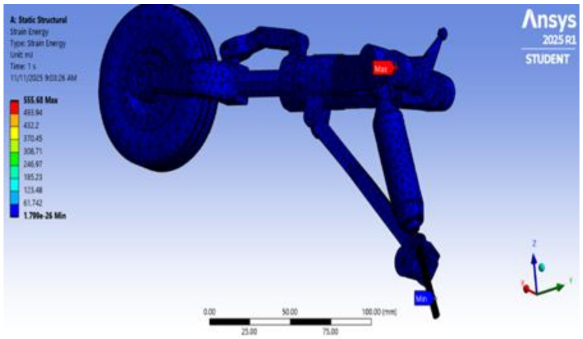
1. Equivalent Elastic Strain
The equivalent elastic strain contour plot indicates that the maximum strain occurs near the upper hinge joint where the shock absorber is connected to the main strut. The maximum strain value recorded was 0.03275 mm/mm, while the minimum strain approached zero in the wheel hub region. This suggests localized deformation under load, primarily due to stress concentration at the mechanical joint interfaces.



2. Total Deformation
The equivalent stress distribution showed a maximum value of 6351.9 MPa concentrated around the joint between the strut and actuator linkage. These regions experience the highest load transfer and bending moments during impact absorption. The minimum stress value was negligible across the lower wheel region. Although the peak stress value appears high, it is likely concentrated at mesh nodes or small contact areas.



4. Strain Energy
The strain energy plot highlighted energy absorption zones, with a maximum of 555.68 mJ concentrated near the shock absorber cylinder and upper link. These areas are critical for damping impact loads during touchdown. Efficient strain energy distribution indicates that the structure can absorb and dissipate landing impact without leading to permanent deformation or failure.



The analysis confirms that the landing gear design is structurally sound for static load conditions. The deformation pattern aligns with expected behavior, where the majority of the load is transferred through the strut and shock absorber assembly. Stress concentration at joint connections indicates the need for careful attention to fillet radii, material reinforcement, or load-bearing pin design in future optimization iterations.

The use of Aluminum 7075-T6 provides a favorable balance of high strength-to-weight ratio and adequate elastic recovery, making it suitable for aircraft landing gear applications. However, further dynamic and fatigue analysis would be beneficial to validate performance under real landing cycles.

V. IMPLEMENTATIONS OF THE SOLUTION

The overall implementation of the project involved the complete process of designing, analyzing, and validating the aircraft landing gear system using advanced Computer-Aided Design (CAD) and Finite Element Analysis (FEA) tools. The aim was to develop a structurally efficient, lightweight, and durable landing gear capable of withstanding the static and impact loads experienced during aircraft operations such as takeoff, landing, and taxiing.

The overall implementation successfully achieved the integration of CAD-based design and FEA-based structural validation of the aircraft landing gear system. The simulation results confirmed that the designed structure exhibits adequate strength, stiffness, and energy absorption capacity under static loading. This implementation demonstrates the effectiveness of computer-aided engineering tools in optimizing aerospace structural components before physical prototyping, leading to reduced design time, cost, and risk.

VI. ACKNOWLEDGMENT

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REFERENCES

[1] Aydın, G. and Ozkol, İ., 2022. Structural analysis of the nose landing gear of a fighter aircraft. Avrupa Bilim ve Teknoloji Dergisi, (43), pp.126-135.

[2] Huang, C. and Jia, Y., 2018, December. Optimal design of aircraft landing gear mechanism actuating force. In 2018 3rd Joint International Information Technology, Mechanical and Electronic Engineering Conference (JIMEC 2018) (pp. 287-292). Atlantis Press.

[3] Huang, M., Nie, H., Zhang, M., Wei, X. and Yue, S., 2016. Design of mission adaptive landing gear for near space travel lander. Journal of Vibroengineering, 18(8), pp.4949-4963.

[4] Parat, C., Li, Z.Y. and Zhao, J.S., 2019. Design and stiffness analysis of an overconstrained landing gear retraction mechanism with four side-stays. Proceedings of the Institution of Mechanical Engineers, Part G: Journal of Aerospace Engineering, 233(12), pp.4421-4435.