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Experimental Characterization of Flutter in a Straight Spar Using Modal Analysis and Wind Tunnel Testing

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[Karimi Mohd Sabri, Muhammad Aqil^a](#); [nor Zaidi, Muhammad Amirul Adli bin^a](#);
[Abdullah, Nur Azam^a](#) ; [Andan, Amelda Dianne^a](#); [Azami, Muhammad Hanafi^a](#); [+1 author](#)^a Department of Mechanical and Aerospace Engineering, Kulliyyah of Engineering, International Islamic University Malaysia, Jalan Gombak, Selangor, 53100, Malaysia[Show all information](#)

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Abstract

This study presents the experimental design and validation of a Straight Spar structure intended for aeroelastic flutter testing, particularly for fixed-wing UAV applications. The main objective is to develop a spar that exhibits flutter onset within a target velocity range of 20 - 25m / s. The research employs fully experimental methods, including vibration testing for modal analysis and wind tunnel testing to observe flutter behavior. Comparative analysis with simulation results was conducted for validation. The designed spar successfully demonstrated flutter at 20m / s, with only a 0.32m / s deviation from simulation predictions. Furthermore, both experimental and simulation methods identified the bending and torsion mode shapes at nearly identical frequencies, confirming strong agreement and model validity. These findings affirm the suitability of the proposed spar design for

UAVs operating within the specified flight speed range and lay the foundation for future studies on aeroelastic energy harvesting. © 2026, The Aeronautical and Astronautical Society of the Republic of China. All rights reserved.

Author keywords

Aeroelastic; Flutter; Modal Analysis; Wind Tunnel; Wing Spar

Indexed keywords

Engineering controlled terms

Aeroelasticity; Fixed wings; Unmanned aerial vehicles (UAV); Vibration analysis

Engineering uncontrolled terms

Aeroelastic; Aeroelastic flutter; Experimental characterization; Flutter; Flutter onset; Flutter testing; Target velocity; Velocity range; Wind-tunnel testing; Wing spar

Engineering main heading

Flutter (aerodynamics); Modal analysis; Wind tunnels

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Corresponding authors

Corresponding
author

N.A. Abdullah

Affiliation

Department of Mechanical and Aerospace Engineering, Kulliyyah of
Engineering, International Islamic University Malaysia, Jalan Gombak,
Selangor, 53100, Malaysia

Email address

azam@iium.edu.my

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