Assessment of Dimensional Finite Element Models for Free Vibration and Aeroelastic Flutter Analysis of Straight Spar Wing Structure

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Abstract Vibration and aeroelastic analyses are vital for ensuring the structural integrity of aircraft and UAV components. This study experimentally and numerically investigates a rib-and-spar wing box using Ground Vibration Testing and wind tunnel flutter tests to determine natural frequencies, mode shapes, and flutter speed for different modelling fidelities. In modal analysis, the 2D shell model was most accurate across the first four modes, followed by the 3D solid model, with the 1D beam showing larger deviations. In flutter prediction, the 1D beam model performed the best with 6.75% flutter speed error, followed by 3D solid (15.50%) and 2D shell (18.40%) models. While 2D excelled in modal analysis, it was less effective for flutter analysis. The 3D solid model, though theoretically has the highest fidelity, delivered moderate accuracy in both and may be considered a practical compromise when both structural and aeroelastic predictions are needed.

Keywords **Author Keywords:** FEM; Modal Analysis; Element Fidelity; Flutter Analysis

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