Aerospace Engineering Thesis Defense

Aerodynamic Nuances on Wings Subjected to Ground Effect

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Abstract

This thesis aims to determine how finite wing aerodynamic loads change in proximity to the ground. In this study, the primary design tool is an inviscid panel method code, VORLAX. The validation tool is a commercial volume grid CFD package, ANSYS FLUENT. I use VORLAX to simulate wings with different incidences and aspect ratios to look at how ground effect impacts spanwise loading and incipient flow separation. Then the results were compared to widely published equations such as McCormick, Torenbeek, and Hoerner & Borst. Because I found that these “famous” equations function best only for specific conditions, I propose a new empirical equation to estimate ground effect lift as a function of aspect ratio and incidence. Using Stratford’s method to predict signs of flow separation in the inviscid solutions, I found that variations in the height-above-the-ground were not significant enough to change the stall angle of low aspect ratio wings. I did find early signs of flow separation with increasing aspect ratio. I observe significant changes in spanwise loading when in ground effect; as I narrow the gap, the transverse loading builds higher near the center of the wing. These effects were more apparent in wings with smaller aspect ratio; higher aspect ratio wings experience a higher loading gradient near the tips in proximity to the ground. I found that high aspect ratio wings have a smaller stall angle compared to that of lower aspect ratio wings; these trends are consistent between the potential flow solution and the volume grid CFD viscous solution.

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