AEROELASTIC ANALYSIS OF RAKED FOLDING WINGTIPS ON SWEPT WINGS

Francesco Sacchi*, Fintan Healy, Djamel Rezgui and Jonathan Cooper

*School of Civil, Aerospace and Design Engineering
University of Bristol,
Bristol, BS8 1TR,
United Kingdom

F.Sacchi@bristol.ac.uk

ABSTRACT

The application of Flared Folding Wingtips (FFWTs) on High Aspect Ratio Wings (HARWs) has been extensively reviewed as a solution to reducing in-flight loads, improving aerodynamic performance and meeting gate-width restrictions. However, these benefits are limited by the potential occurrence of aeroelastic instabilities, such as flutter, when the wingtips are free-floating in flight.

Previous literature has found that parameters such as hinge orientation, wingtip weight and wingtip size, can be useful design tools to augment the dynamic stability of the free-floating wingtip system without impacting its load alleviation characteristics [1]. Recent work [2] has considered the effect of wing sweep combined with FFWTs, and it is shown that whereas FFWTs help to increase the speed at which divergence occurs for forward swept wings, there is also the chance that FFWT- bending mode flutter may become the critical stability case.

In this paper, the inclusion of a novel FFWT design parameter, namely wingtip rake, is explored to investigate how this might be used to extend the flutter envelope of the free-floating wingtips system (Figure 1). The effects of FFWTs rake on the systems dynamic stability will be assessed via a parametric study of FFWT rake and wing sweep, highlighting the efficiency of rake as a means of increasing the flutter boundary across different wing sweeps. The analysis will be performed using MSC Nastran to calculate the stability of the system across different Mach numbers and Altitudes. To contextualise the impact of wingtip rake on the broader aeroelastic performance, gust load response and static manoeuvre loads will be presented for cases with wingtips locked and free. The baseline model for this analysis will be an A320-like sized aircraft with extended 45m wingspans to achieve an Aspect Ratio (AR) of 17.

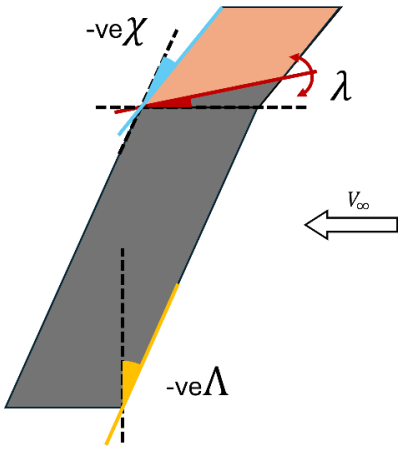

Figure 1. Illustration of 1.2m span wing with rake angle χ, flare angle λ, and sweep angle Λ.

Initial results for a reduced sized model with 1.34m wingspan, AR 17 and a 0.34m span FFWT (25% wing-span) with 10deg flare angle (λ), have shown that for a 10deg forward swept wing, the flutter speed can be increased by up to 37% when using FFWT rake without any weight penalties. In Figure 2, the effect of rake on the flutter speed for a single FFWT configuration (25% wing-span, $\lambda = 10$deg) is presented as a contour map against increasing forward sweep (40deg forward sweep → 0deg sweep).

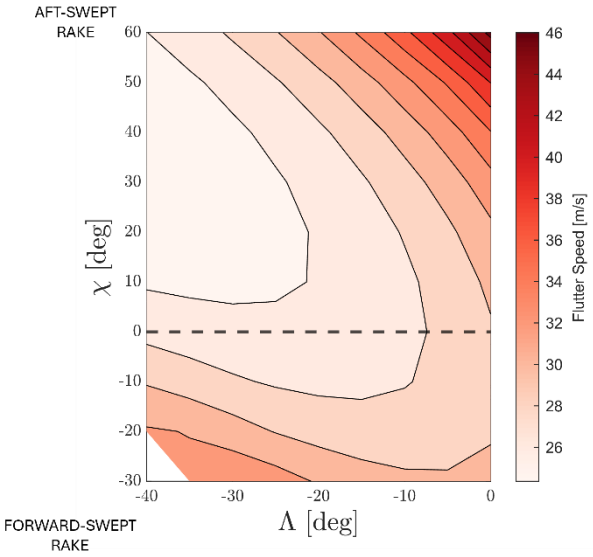

Figure 2. Onset flutter speed for the 1.34m span wing with free FFWTs as a function of wingtip rake and wing sweep.

The final version of the paper will also consider the effect of different FFWT length (<25% wing-span) and FFWT flare angle on the efficacy of using rake to increase the flutter speed.

[1] Castrichini, Andrea, et al. "Preliminary investigation of use of flexible folding wing tips for static and dynamic load alleviation." *The Aeronautical Journal* 121.1235 (2017): 73-94.

[2] Sacchi, Francesco, et al. "Aeroelastic Behavior of Forward-Swept Wings with Flared Folding Wingtips." *AIAA SCITECH 2026 Forum*. 2026.