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Corresponding author: HAIDER Zawar
e-mail of corresponding author: 100057743@ku.ac.ae
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## Title

# Load alleviation using polymorphing wings: The effect of the morphing rate.


## Authors

*Zawar HAIDER [1]*, Rafic M. Ajaj [2], Lakmal Seneviratne [3]*

** Corresponding author*
*[1] Ph.D. Candidate, Department of Aerospace Engineering, Khalifa University, 122778 Abu Dhabi, UAE, 100057743@ku.ac.ae*
*[2]Associate Professor, Department of Aerospace Engineering, Khalifa University, 122778 Abu Dhabi, UAE, rafic.ajaj@ku.ac.ae*
*[3]Professor, Khalifa University Robotics Institute, Khalifa University, 122778 Abu Dhabi, UAE, lakmal.seneviratne@ku.ac.ae*



## Abstract

The role of morphing wing technologies to enable the design of multi-mission capable aircraft has gained momentum over the years, with research being conducted in order to ascertain the advantages offered by several morphing schemes in terms of structural, aerodynamic, and flight performance-related metrics [1]–[4]. An emerging field of research concerning morphing wing technologies focuses on the application of two-or-more morphing mechanisms into a single aircraft wing, in order to optimize performance for a greater flight envelope and enable superior aero-structural properties by employing real-time changes for various situation-dependent dynamic changes. While several aspects of morphing wing technologies have been receiving substantial interest, including their mechanical, structural, aerodynamic, and aeroelastic effects, the role of the span morphing rate has been largely ignored. Moreover, the concept of dynamic utilization of span morphing as a means of load alleviation in the case of gust has not been studied. This paper is concerned with examining the utility of span morphing rate as a means of load alleviation mechanism for a polymorphing wing, capable of active span and passive twist morphing [5], [6]. The wing is modeled as an Euler-Bernoulli beam by application of the variable domain size beam finite element model incorporating wing twist, developed by the authors [7]. The inclusion of an explicit morphing rate term introduces a structural damping term in the system, which is otherwise absent in static analysis, and requires investigation in order to ascertain its effects on the overall stability of the system. Theodorsen's unsteady model [8] is used to model the aerodynamic forces on the system. The effect of various morphing rates is analyzed for sharp-edged gusts and the dynamic changes in root shear force and root bending moments of the wing are examined before, during, and after the completion of the morphing process dynamically. The morphing rate for each analysis is selected such that the morphing process commences after the manifestation of the gust load and finishes before the load reaches its peak value. Kussner function is used to incorporate the unsteady effect on the system due to the sharp-edged gust. Lastly, the role of cubic nonlinearities is analyzed by replacing the linear spring connecting the inboard and the outboard wing section in the system with a cubic hardening and softening spring, and the effect of morphing rate is investigated in delaying the onset of flutter instability in the system.


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