Introduction

Composite vertical tail ribs are integral parts of modern aircraft architecture, designed to endure significant aerodynamic forces during flight. Traditionally, these ribs were constructed from metallic materials; however, the industry has progressively transitioned to advanced composite materials, particularly carbon fiber reinforced polymers (CFRP). These materials are favored for their superior strength-to-weight ratio, corrosion resistance, and adaptable mechanical properties. Despite these advantages, ensuring the stability and load-bearing capacity of composite vertical tail ribs continues to be a challenge, necessitating ongoing research and development.

The current design of vertical tail ribs involves utilizing composite laminates in conjunction with structural reinforcements to manage the complex stress distributions encountered during flight operations. While these components offer substantial benefits, they remain susceptible to buckling under specific loading conditions, which can compromise the structural integrity of the aircraft. Buckling, a critical failure mode, is influenced by material properties, dimensions, and the applied loads.

Given these limitations, there is a pressing need for innovative approaches to enhance the stability and load-bearing capacity of composite vertical tail ribs. Optimizing reinforcement techniques can enhance buckling resistance and reduce weight, improving overall aircraft efficiency. Moreover, enhancing the structural integrity of vertical tail ribs directly impacts the safety and reliability of the aircraft, reducing the risk of in-flight failures.

This research proposes an experimental framework based on the work of Handbuch Struktur Berechnung (HSB) on the buckling of rectangular orthotropic plates under in-plane shear loading. The primary aim is to develop and validate innovative reinforcement techniques for composite vertical tail ribs. This study will employ a surrogate material for preliminary testing, allowing for cost-effective and scalable experiments. The experimental framework involves designing and fabricating models of vertical tail ribs with varying reinforcement configurations, subjecting these models to in-plane shear loading to induce buckling, and recording the critical load at which buckling occurs. The results will be analyzed and compared with theoretical predictions and computational models to evaluate the effectiveness of the reinforcement techniques. If the models demonstrate reliable buckling behavior, the findings will be extrapolated to composite materials, and optimized reinforcement methods for composite vertical tail ribs will be proposed.

The objectives of this research are to assemble models of composite vertical tail ribs with different reinforcement configurations, implement and test the effectiveness of these reinforcements through experimental and computational analysis, and optimize the reinforcement methods to enhance the buckling resistance of the ribs. By achieving these objectives, the study aims to significantly contribute to the field of aerospace engineering by providing practical solutions for improving the stability and performance of composite vertical tail ribs.