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Focusing on in-service repair to composite laminates of different thicknesses via scarf-repaired method

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ABSTRACT

In terms of in-service components, sometimes it is difficult to undertake repairing with an autoclave due to the structure configurations and repair conditions. In order to conduct in-service soft patch repair, vacuum bagging process can be used. However, for composite materials manufactured in autoclaves, high porosity levels may be induced when cured using vacuum bagging, which harms the mechanical properties of composites. This article aims to use an alternative material which shows better performance than the original one when using vacuum bagging for the patch. Four groups of scarf repaired composites with various laminate thicknesses were fabricated and tested. Experimental results indicate that the failure strengths of different groups are similar and the dominated failure mode is cohesive failure of adhesive, accompanied by partial 45° and 90° matrix cracks of composite patch. In addition, a finite element model was established to predict the failure strength and explain the damage mechanism. The numerical results show good agreement with test results and indicate that matrix cracks of composites initiate before the adhesive failure. Based on the validated model, the effects of overlap patch and 3D defects on the ultimate strength were discussed.

Keyword: In-service repair; Scarf repair; CFRP; Laminate thickness; Vacuum bagging.

1. Introduction

In recent years, advanced composite materials especially those consist of fiber reinforcements (such as E-glass or carbon) encapsulated in a resin matrix (such as epoxy) have replaced traditional materials in aircraft structures extensively due to their high specific stiffness and specific strength **[1,2]**. Considering the high cost of composite materials and its relatively inferior ability to bear impact load, repair of composite structures is gradually attracting the attention of many researchers. Bonded repair can be regarded as a versatile cost-effective method without compromising structural integrity. Thus, the technique has been widely exploited and advanced forward considerably **[3–7]**. Advanced technologies like digital image correlation have been used to detect the damage of repaired composite structures **[8,9]**. Among these methods, scarf repair gets more uniform stress distribution and is often used for scenarios where smooth surface is needed to satisfy aerodynamic or stealth requirements **[10-13]**.

For the in-service components, it is not always convenient to undertake repairing with autoclave. Two major factors are (a) Structure configuration: If the component is large, it's difficult to be removed from the aircraft or disassembled to smaller parts for repair in autoclave. (b) Repair condition: Usually the aircraft, especially military aircraft, may be repaired in a situation that advanced facilities are unavailable. In addition, many industry repair sectors also do not have access to autoclave processing **[14,15]**. Vacuum bag cure is the most common technique for on-aircraft repairs. However, for the composite material manufactured in autoclave, vacuum processing is difficult to achieve low-void laminates of good quality **[16]**. High porosity levels may be induced when cured

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