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Influence of voids on the compressive failure behaviour of fibre-reinforced composites

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Abstract

The subject of this work is the micromechanical investigation of the influence of voids on the compressive failure behaviour of fibre-reinforced polymers (FRP). Although, the effect of void content on the mechanical properties was investigated in previous literature, a local examination of the failure mechanisms is essential to understand how the presence of voids reduces the compressive strength in FRP. Therefore, the complex three dimensional structure of a composite, including several voids, were analysed and a reduced mechanical model composite (focusing on one unique void) was derived. The experimental investigation of the model composite included the description of the stress- and strain behaviour of the matrix using photoelasticity. Additionally, a numerical examination of a parameterised model composite was conducted. From the experimental studies the failure initiation and propagation could be observed. Supported by the findings from numerical simulation, foundation and alignment of fibres as well as fibre-matrix bonding has the most impact on the failure initiation.

Keywords: B. Fibre/matrix bond, B. Porosity/Voids, C. Stress concentrations, Fractography

1. Introduction

During manufacturing of composite structures, the formation of voids cannot be avoided even after optimising the process parameters such as pressure and temperature during curing. Until now only a few publications could be found which deal with the investigation of the influence of voids on the mechanical behaviour under compression. In general, the compressive behaviour is a design limit for composite structures because only 50 %-60 % of their tensile strengths could be reached [19]. In addition to that, a number of studies indicate that with increasing of void content the compressive strength and modulus significantly decrease. A review about the first investigations in this topic was given by Schultheisz and Waas [17]. The assumption for the strong dependency of the compressive strength on void imperfections is due to the reduced interlaminar shear strength. But no evidence was succeeded either in an experimental or numerical way.

Furthermore Rubin and Jerina [21] investigated the influence of voids depending on the laminate thickness, while de Almeida and Neto [1] tried to build a link between the reduced ultrasonic signal

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