The influence of fibre cross section shape on critical fibre length and composite strength

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1.Introduction

The development of the micromechanical theories of composite materials has played an important role in studying and understanding the performance of fibre reinforced composites. Many of the concepts and equations developed to predict composite micromechanical performance were developed early in the history of the composite materials and are unquestioningly embedded in the collective psyche of the composites community. One such concept is the role of the fibre length to diameter ratio (L/D), which is often found in micromechanical discussions of composite performance parameters such as modulus, strength and impact resistance [1-3]. This leads on to the concept of critical fibre length (Lc), which is of particular use when considering the strength of composites [2]. Interestingly many of the considerations of composite micromechanics make use of the assumption, or approximation, that the fibres have a circular cross section. This is understandable since at the time of the development of these concepts most reinforcement fibres, such as glass fibres, often did have a circular cross section.

However, recently there have been a number of developments from glass fibre manufacturers in the production of non-circular cross section glass fibres [4-6]. Furthermore, it is well known that many of the carbon fibres on

the market do not have circular cross sections [7] and the more recent upsurge in interest in the use of natural fibres as a composite reinforcement also brings many different, and variable, fibre cross sections into the mix [8,9]. Hence, non-circular cross section fibres are now widely available and in use in many composite applications. This prompts the question whether all of the micromechanical analysis that we know and love is fully compatible with the reinforcement potential of these non-circular fibres. In a series of recent papers we noted how the commonly used assumption of circularity in determining the cross sectional area of natural fibres could lead to large errors in the values obtained for fibre strength [8,9]. In this paper we consider the effect of non-circularity on the micromechanical stress transfer capability of the fibre-matrix interface and its potential effects on composite performance.

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