UNIVERSITI TEKNOLOGI MARA

EFFECT OF LAYER ARRANGEMENT ON POST IMPACT AND OPEN HOLE TENSILE PROPERTIES OF KENAF-GLASS HYBRID COMPOSITE LAMINATES

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AUTHOR'S DECLARATION

I declare that the work in this thesis was carried out in accordance with the regulations of Universiti Teknologi MARA. It is original and is the results of my own work, unless otherwise indicated or acknowledged as referenced work. This thesis has not been submitted to any other academic institution or non-academic institution for any degree or qualification.

I, hereby, acknowledge that I have been supplied with the Academic Rules and Regulations for Post Graduate, Universiti Teknologi MARA, regulating the conduct of my study and research.

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ABSTRACT

Kenaf fibre reinforced polymer (KFRP) composites attract researchers, scientists, academicians and also industry players because of their light weight properties, abundantly available and low cost compared to those of synthetic fibre composites. KFRP composites possess high potential to be used as primary and secondary structures for many applications, especially automotive, aerospace and building construction. Moreover, kenaf fibre plant is not harmful to human and has positive impact to environment. However, there are several limitations of kenaf fibre composites such as their low damage resistance and tolerance after subjected to low impact loading or presence of defect, open hole or notch. Thus, in this study, kenaf fibre plies have been hybridised with woven glass fibre mats in order to improve the post impact and open hole tensile properties. These hybrid composite materials were fabricated by hand lay-up and cold press techniques. Two different systems were fabricated based on specific fibre layer arrangements of kenaf-glass fibre reinforced polymer (KGFRP) hybrid composites, i.e. (i) Two layers of long kenaf fibre sandwiched two glass fibre mats, $[0°k/90°k/G]_s$ and (ii) One layer of glass fibre mat sandwiched four layers of long kenaf fibres, $[G/0°k/90°k]_s$. In this study, the tensile strength, modulus and strain to failure at maximum load for [G/0°k/90°k]s hybrid composites were 5%, 10% and 19% higher than those of [0°k/90°k/G]s hybrid composites, respectively. The effect of layer arrangement, for both KGFRP hybrid composites, on post impact and open hole condition was evaluated. The results of post impact tensile test revealed that the $[G/0°k/90°k]_s$. i.e woven glass fibre at the outer layer better strength than $[0°k/90°k/G]_s$ up to 10% higher as shown in Normalized Stress curve. The woven glass fibre at outer layer helps to sustain more impact load than having kenaf at outer layer. As a consequence, this hybrid composites exhibit more resistance to crack growth. However, the result obtained from open hole tensile test the hybrid composite $[0°k/90°k/G]_s$ having long kenaf fibre at the outer layer is less sensitive to holes size compared with the $[G/0°k/90°k]_s$. The tensile strength of the former laminate arrangements can be 15% higher than the latter with respect to larger hole sizes. The structure of long kenaf at outer layer influenced the strength of the hybrid composites as it holds higher loads before the load is transferred to the glass fibre at the inner layer. The damage mechanisms of KGFRP hybrid composite materials were then verified qualitatively with the surface texture scanning machine, optical microscope, digital DSLR camera and SEM. A closer examination on fracture surfaces for all specimens using SEM showed that matrix cracking, fibre fracture, fibre pull-out and delamination were the main failure mechanisms of KGFRP hybrid composite material. The damage area obtained from the post impact and open hole of hybrid composites tests was then correlated with the average stress criterion of Whitney-Nuismer equation with modifying factor (MF) via fracture mechanics concepts. This correlation equation could be used to predict the residual strength or strength degradation rate for both impact and open hole cases of composite materials.

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