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Monotonic properties of unidirectional glass fiber (U)/random glass fiber (R)/epoxy hybrid composites

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ABSTRACT

The main objective of the present paper is to study the tensile and bending behaviors of unidirectional glass fiber (U)/random glass fiber (R)/epoxy hybrid composites with total fiber volume fraction (V_{fT}) = 37%. Six kinds of laminated composites of average thickness 5.5 mm were manufactured using hand lay-up technique; i.e. $[R]_5$, $[U/R/U/R/U]$, $[U/0.5R/U]_S$, $[0.5R/U/U]_S$, $[U/U/0.5R]_S$, and $[U]_5$. In bending test, notched and unnotched specimens were tested. For this purpose different circular notch sizes (D = 3, 6, 9 mm) were drilled at the specimen center. Tensile strength, tensile modulus, Poisson's ratio, bending strength and bending modulus were determined experimentally. The effect of stacking sequences, random fiber relative volume fraction (V_{fR}/V_{fT}), and notch diameter on the mechanical properties of the mentioned composite types were studied. Failure modes of all specimens were investigated.

1. Introduction

Laminated fiber reinforced polymer–matrix composite materials have been used successfully in many industries such as aerospace, automobile, marine, military and so on [1]. Composite laminates offer alternative material design solutions in terms of specific strength and stiffness allowing important weight savings. They also offer significant freedom to the designer by allowing, optimizing the strength and stiffness of a component or structure for a particular application [2].

The development of composites containing more than two elements (hybrid composites) has been motivated from industry because of the improved performance as well as reduced weight and cost that hybrid composites could provide. Consequently, the complete and accurate knowledge of mechanical properties of hybrid composites becomes important in approximating the design requirements or in developing new hybrid materials [3].

In general, the purpose of hybridization is to achieve a composite architecture which synergizes the properties of both materials and/or lowers the cost since one of the fibers could be too expensive. Structures of hybrid composites may be classified as interply hybrids, intraply hybrids, intimately mixed (intermingled) hybrids and super hybrid composites [4].

The mechanical characteristics of carbon fiber (CFRP)/non-woven carbon tissue (NWCT) hybrid composites were investigated under static tensile loading [5]. The results of hybrid composites have been compared with those of the CFRP composites. It is found that, the tensile properties of hybrid composites, the longitudinal Young's modulii and strengths of hybrid specimens are lower than those of the CFRP specimen.

Hybrid composites made from of polyethylene (PE) or polypropylene (PP) and AR glass or aramid fabrics were tested in tension [6]. It was found that hybrid composites made from PE and AR glass sustain strains better than 100% AR glass composites, and are stronger than a single PE fabric composite. Hybrid composites made with aramid and PP yarns performed better than a single aramid fabric composite relative to their reinforcing volume contents.

Li et al. [7] studied the flexural behavior of ultra-high-modulus polyethylene (UHMPE) fiber and carbon fiber hybrid composites The results show that the incorporation of a moderate amount of carbon fiber into a UHMPE–fiber composite greatly improves the flexural modulus and flexural strength while the addition of a small amount of UHMPE fiber into a carbon–fiber composite remarkably enhances the ductility.

Park and Jang [8] studied the mechanical performance of aramid/polyethylene/vinylester hybrid composites. The flexural strength and modulus increased with the volume fraction of aramid fiber. When the load was applied in the aramid direction, the highest flexural strength was obtained.

The mechanical properties of aramid/polyethylene/vinylester intraply hybrid composites have been investigated as functions

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