ABSTRACT

The present work studied numerically and experimentally the fatigue behavior of carbon fiber reinforced polymer (CFRP) and glass fiber reinforced polymer (GFRP) with different numbers of layers under a biaxial loading of tension – tension. This work included the complete designing and manufacturing of mechanism that can perform biaxial loading. The numerical investigation included the simulation of the cruciform specimen under static loading using ANSYS APDL 14.5® and the fatigue simulation under the actual biaxial spectrum loading using nCode DesignLife 14.5®. The experimental and numerical results showed a good agreement regarding the fatigue behavior showing similar position, where the failure starts at different specimens geometries. The reduction in strength in uniaxially tested specimens of GFRP, under tension – tension of R = 0.2, showed an early reduction after 500 cycles only, while for biaxial specimens under similar loadings, the strength was not realized to reduce until 2000 cycles. The percentage reduction was 18.37% for GFRP16 after 500 cycles and between 13.46%-14.38% for the biaxial loaded specimens after 2000 cycles. The material behavior was investigated by assuming an isotropic and orthotropic behavior for CFRP and GFRP, the fatigue life was greatly affected by the material behavior. The orthotropic models gave the largest reduction in fatigue life. The percentage reduction in fatigue life for CFRP with reduced central section was (90.411%) between the isotropic and orthotropic material behavior.

Finally, the constructed biaxial mechanism (Biaxial3) is proven to compensate for the sophisticated biaxial testing machines with reasonable cost and possibilities. It can perform static and fatigue tests with multiple stretching ratios (1:1, 1:2, 1:3 and 1:4).