ABSTRACT

The present work, deals with analysis of laminated composite materials behavior under static and dynamic loading, with different temperature conditions (room 30^{o}C, zero, and subzero -30^{o}C), which is realistic and exist within everyday life in winter. The analysis was done with experimental, theoretical and numerical procedures.

The laminated composite materials were manufactured by hand layup technique which is formulated by stacking different layers of fibers immersed in resin. Two types of polymer matrix (polyester and epoxy) and three types of fibers (E-glass mat chopped strand, E-glass woven roving and unidirectional carbon fibers) have been used to prepare eight types of laminated composites with different layers at a volume fraction of 30%.

The tensile properties were measured experimentally at room (30^{o}C), zero, and subzero (-30^{o}C) temperatures. They were also determined theoretically using Computer Aided Design Environment for Composite (CADEC 12) software program.

The Charpy impact test has been achieved at (room (30^{o}C), zero, and subzero (-30^{o}C)) temperatures to obtain the fracture toughness of the composite. The Charpy impact test has been modeled numerically in a 3D finite element technique using ANSYS workbench to calculate the fracture toughness and compare it with the experimental one.

The fatigue properties have been measured experimentally under constant stress ratio of R=-1 as a fully reversed load and performed at room temperature to determine S-N curves. A 3D finite element technique was used to model fatigue test numerically using ANSYS workbench program to find fatigue sensitivity and alternating stress resulting in the sample as a results of a specific moment which is applied as a cyclic load.

The dynamic response of laminated composite plate subjected to drop weight impact load was investigated experimentally and numerically. The effect of low temperature, weight and drop height of the falling body were taken into consideration. A special refrigerator device has been designed and manufactured to achieve the required test temperature. Finite element technique was used to model a dropped weight impact test using ANSYS LS-DYNA program.

Finally, the evaluation of the damping ratio was performed experimentally at room temperature on a beam fixed as a cantilever.

Results showed that the carbon reinforcement with epoxy has the highest mechanical properties; while E-glass mat chopped strand reinforcement with polyester have the lowest mechanical properties than other composite materials. The composite materials made from epoxy matrix have higher mechanical properties and fatigue strength than that made from polyester.

The increase of the laminated layers for the same type of composite will increase the mechanical properties. The modulus of elasticity and tensile strength of carbon fibers with epoxy matrix was increased by 76.03% and 83.58% respectively when the layers increased from 2 to 6 layers. The mechanical properties of the composite laminated plates improved with temperature decrease from room to zero to subzero, while the fracture toughness decreased. The modulus of elasticity and tensile strength of 6-layers of carbon/EP composite increased by 13.36% and 18.68% respectively as test done at (-30^{o}C) compared with that at room temperature, while the fatigue strength increased by 22.16% compared with that of 2-layers as test done at room temperature. The composite plate of the epoxy resin reinforcement with carbon fibers have a lower deflection when testing under dropped weight impact test; while the polyester resin reinforced with E-glass mat chopped strand have a higher deflection than others composite materials. The deflection of the laminated composite materials increased as the mass and the height of the dropped weight increased. While it decreased as the temperature decreased from room to zero to subzero. The deflection of 6-layers of carbon/EP composite decreases by 11.8% as test done at (-30^{o}C) compared with that at room temperature.

The effect of low temperature on the mechanical properties and the deflection due to the impact on the composite plate reinforcing with E-glass fibers is higher than that reinforcing with carbon fibers. Also, the results showed that the effect of low temperature on the mechanical properties and deflection due to dropped weight impact load on the composite plate made from epoxy is higher than that made from polyester with the same type of fibers. The numerical and theoretical results showed a good agreement with the experimental results.