4.2.35. STUDY OF THE EFFECTS OF ENVIRONMENTAL PARAMETERS AND IMPACT IN THE COMPRESSIVE STRENGTH OF LAMINATE COMPOSITES

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Abstract. The aim of this work is to study the influence of the effects of water absorption and temperature in compressive strength of carbon-fibre-reinforced epoxy laminates before and after low velocity impacts. These kinds of composites are used in components to sustain large stress like in structural parts exposed to aqueous medium involving submarine structures. The degradation of the carbon-epoxy laminates can occur when exposed to the environment such as wet conditions. The absorbed water can influence not only physical features but also the compressive strength, before and after low velocity impacts. According Kishore and Kumar [1] the absorption into epoxy resin occurs in two ways: (i) absorption by the free volume of polymer depending on the cross-link density and (ii) hydrogen bonding of water molecule into hydrophilic sites present in the polymer network. To evaluate the effects of water absorption, the samples should be tested in dry and immersion conditions, with different temperatures. Carbon epoxy laminates were prepared in the laboratory from high strength unidirectional carbon pre-preg (Texipreg HS 160 REM from SEAL^{TM}, Legnano, Italy) and processed in agreement with the manufacturer recommendations, using the autoclave/vacuum-bag moulding process. The laminates were manufactured with sixteen unidirectional carbon layers with two stacking sequences $[0,90,0,90]_{2s}$ and $[0,90]_8$. Low velocity impact tests were made using a drop weight-testing machine IMATEK-IM10. The impacts were produced on samples of 75×125 mm with rectangular shape using an impactor of 20 mm. The impact energy used for whole tests was 3 J, which corresponds to an impact velocity of 1.72 ms^{-1}. The compression after impact test was carried out using the compression test fixture according to the ASTMD3410 standards. In this work, the samples have been sunk for 50 hours and 100 hours taking the following conditions: (a) samples immersed in plain water at room temperature, and samples sunk in plain water at 80°C. It is expected the compressive strength presents lower values for samples immersed 50 hours in plain water compared to the unexposed case, at room temperature. Also, its value should be higher when compared with samples sunk for 100 hours. That behaviour is due to the higher energy absorption characteristics presented by immersed samples compared with the dry samples. At 80°C due to matrix resin property degradation and the development of fissures in the interface matrix/fibre the compressive strength will decrease. After low velocity impact, the samples present some defects like delamination, being expected the compressive strength shows lower values when compared to the samples without defects. That can be explained by the fact that samples absorbing more energy originate higher damaged areas and consequently a decreasing in the compressive strength value.

To prove the behaviour of the compressive strength for the above mentioned environmental situations (temperature and sinking) and structural alteration by impact, two approaches based on Lamb waves have been used for the considered laminate composites, namely: (1) Calculation of the Lamb wave symmetric mode (S_0) velocity (see fig. 1) in order to

order to establish some correlations with transverse compressive strength for composites subjected

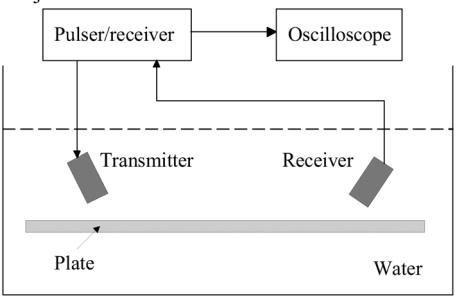

Fig. 1. Experimental setup for Lamb wave evaluation

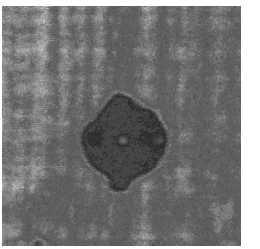

Fig. 2. C-Scan of a damaged composite sample with stacking sequence $[0,90,0,90]_{2s}$

to heating, immersion, and impacts. (2) Evaluation of the Lamb wave symmetric mode (S_0) amplitude (attenuation) versus the characteristics of delaminations, namely size and depth [2]. It is observable that the amplitude is strongly dependent on the depth of the delaminations. Finally, ultrasonic C-scan images of the tested specimens were also produced to evaluate the extension of the damages originated by impacts necessary to check the transverse compressive strength behaviour (see fig. 2).

References:

1. **Kishore and Kumar N. L. R.** An evaluation of the effects of type and temperature of aqueous media on the compressive strength of glass-epoxy composites, Journal of Reinforced Plastics and Composites, Vol. 23, No. 16, 2004.

2. **Tan K.S., Guo N., Wong B.S. and Tui C.G.** Comparison of Lamb waves and pulse echo in detection of near-surface defects in laminate plates, NDT & International, Vol. 28, No. 4, 215 – 223, 1995.