A Multiaxial Fatigue Damage Model for Glass Fibre Reinforced Polymer in Seawater

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Abstract: It is anticipated that long-term durability of materials will be a key factor in the success of ocean energy devices. Glass-fibre reinforced polymers (GFRP) are candidate low cost materials for use in many areas of those devices due to their combination of corrosion resistance and fatigue resistance. However there is relatively little experience with highly stressed composite structures immersed in seawater and, therefore, the fatigue of quasi-isotropic laminates is investigated here as part of a larger research programme in the fatigue behaviour of immersed GFRP structures. A multiaxial fatigue damage model for glass fibre reinforced polymer materials is presented. The model combines fatigue-induced degradation for fibre strength, modulus and irrecoverable strain in the fibre direction with transverse and shear modulus degradation due to inter-fibre fatigue. The inter-fibre fatigue level is calculated using a fatigue-modified version of the Puck multiaxial failure criterion for static failure. The model is implemented in a user material finite element subroutine and calibrated using static and fatigue test data from unidirectional glass fibre epoxy. Validation is presented using a programme of uniaxial fatigue tests on quasi-isotropic glass fibre epoxy laminates. The model predictions are compared to both dry unaged tests and tests on coupons that have been immersion aged for 20 months in 30° water.

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