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NUMERICAL MODELING OF NANOPARTICLE-REINFORCED ADHESIVELY BONDED JOINTS

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The single-lap shear (SLS) behavior of joints composed of epoxy plates bonded with nanoparticle-reinforced adhesives was modeled using a two stage modeling approach. In the first stage, the fracture toughness, tensile and shear strengths of the nano-reinforced adhesive were derived using a multi-scale modeling approach. In the second stage, the SLS behavior of the bonded joints was modeled using a cohesive zone model implemented by means of a FE model developed in the LS-DYNA FE code. In the cohesive zone model, the mechanical properties of the nanoparticle-reinforced adhesive, derived from the first stage, were used.

In parallel to the modeling work, an experimental work was also conducted. The adherents and the adhesive were manufactured from the epoxy material T20BD. The adhesive was reinforced using two different nanoparticles, applied independently in different weight ratios, namely graphene and carbon nanofillers. SLS tests were conducted to characterize the shear behavior of the bonded joints.The experimental results show that the addition of 1.3%wt of carbon nanofibers enhanced significantly the SLS behavior of the bonded joints. On the contrary, the addition of 3.7%wt exfoliated graphene and 5%wt carbon nanofibers degraded the SLS behavior of the bonded joints, possibly due to the poor dispersion of the nanoparticles in the adhesive which led to agglomerations that served as defects.

The model predicted successfully the enhancement in the SLS behavior of the bonded joints due to the addition of the 1.3%wt of carbon nanofibers. In addition, by taking into account the effects of poor dispersion and agglomeration at the nano/micro scale, the model was capable to predict the degradation in the SLS behavior of the bonded joints for the cases of addition of 3.7%wt exfoliated graphene and 5%wt carbon nanofibers.

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