MICROMECHANISMS OF COMPRESSIVE FAILURE OF FIBRE REINFORCED POLYMERS

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Fibre reinforced polymers benefit from high flexural strength, corrosion resistance and low density. These qualities make them a candidate to substitute the conventional rigid steel pipelines for subsea transport of oil and gas. However, deep water pipelines are subject to high external hydrostatic compressive stresses alongside variable internal fluid pressure that can result in high compressive hoop, radial and axial stress. For aligned fibre reinforced composites, compressive strength is generally lower than the tensile strength and a design limiting factor. Therefore, failure mechanisms and conditions need to be well understood in order to design safe and cost-effective structures.

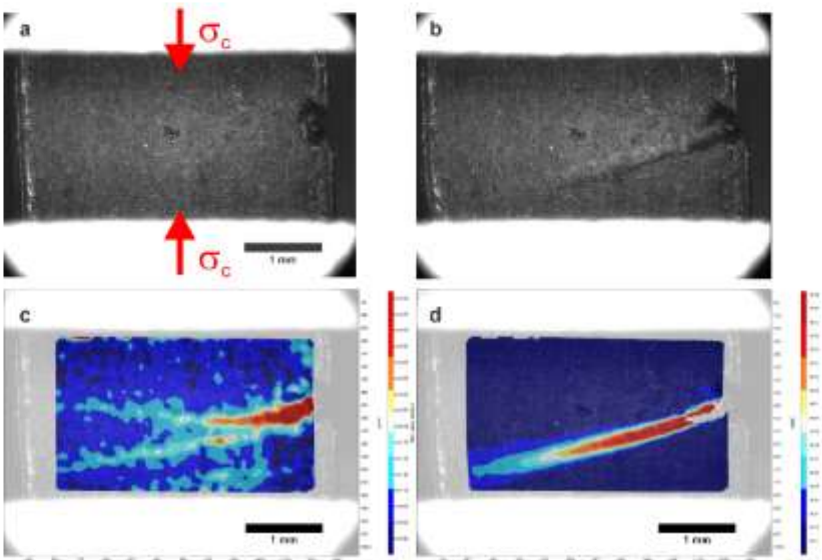

Figure 1 –A sequence of frames extracted from the video recorded during one of the in situ tests. a) Frame recorded right before and b) after the failure initiation and kink band formation and propagation. c,d) Maximum shear strain mapped through DIC showing shear bands formation and convergence towards the final angle at which the kink band propagates

Different failure modes have been observed in literature, but a common trait is that initiation usually occurs at the level of the composite constituents. The vast majority of the current literature bases their models of failure on post-mortem observations of tested samples. Techniques able to measure the strength of a lamina and observe the failure as it occurs are, however, crucial to understand the mechanisms of failure initiation and propagation. Therefore, we have developed a testing setup that enables observation of microbuckling formation and kink band propagation (see Figure 1). Measurements of strain and fibre rotation developed during the test was performed through image analysis, i.e. using digital image correlation (DIC). The effect of pre-existing fibre misalignment and environmental degradation were also investigated. Combining these observations with knowledge of matrix degradation and fibre-matrix interfacial properties obtained from push-out tests could yield a more accurate model of failure.