

Failure of ETFE Film Membrane

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ABSTRACT

The failure of foil cushions made of Ethylene tetrafluoroethylene (ETFE) is investigated. The chosen film is 250 μm thick Novoflon ET 6235Z, widely used for ETFE cushions on buildings. The visco-elastic behaviour of film is extensively studied by [1][2]. However, few models capture the transition from visco-elastoplastic behaviour to fracture [3]. Presumably, a cushion fails from a defect, before it reaches its ultimate strain level, involves that understanding the fracture behaviour is important.

Unidirectional tension tests on 50mm wide, 200mm long strips of Novoflon ET 6235Z have shown that extensive plastic deformation occurs at operating temperatures. If a pinhole defect is present in the film, failure begins when crazing reaches the defect; the hole stretches plastically until ductile fracture tears through the specimen. Rigotti et al. [3] carried out essential work of fracture tests on double-edge notched ETFE film specimens and gave a method for evaluation of the plastic shape factor (β) which is necessary for calculating J-integral. Our next step was determining a failure criterion based on the J-integral calculated around the tip of a crack for ETFE thin foils. The critical level of J-integral (J_c) with the corresponding β has been determined when the crack starts to propagate. According to visco-elastic fracture mechanics [4] the J-integral must contain only the stored deformation energy. The change of J_c was inversely proportional to the decrease of the strain rate and the pinhole length on the specimen, while it was proportional to the temperature level, even at small temperature level differences. The effect of possible orthotropicity showed no significant change in the J_c .

It is shown that realistic estimates of failure of ETFE membrane structures can be obtained from visco-elastic simulations based on the non-linear visco-elastic model of polymers by Cabello [5], supplemented with a fracture resistance criterion derived from the experimentally-based J-integral.

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