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# A physically based fatigue damage model for fibre-reinforced plastics under plane loading

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Abstract

The subject of the present article is a new layer-based fatigue damage model (FDM) for laminated multidirectional laminates exposed to general states of plane stress, which allows for simulating the stiffness and the strength degradation by means of a FEM analysis. The essential of the new model is its use of an energy approach which makes the fatigue life prediction of composites more physical and therewith its characterization much less extensive. Since the failure analysis bases on an interacting failure criterion, the material degradation depends also on the failure mode and is layer-based. (Typical fatigue phenomena as stress redistributions and sequence effects can be analyzed with the new model and due to its efficiency it is also applicable to larger structures.)

The paper presents a partial validation of the model based on experimental results from the literature and different application examples. These are a shell with a hole and a rotor blade of a wind energy converter demonstrating the analysis of stress redistribution, sequence effects and the applicability of the model to large structures respectively. .

Keywords

Fibre-reinforced plastics, fatigue, degradation, damage model, layer-based

**Nomenclature**

| | |
|---|---|
| A: | area |
| b: | ratio of plastic to inelastic strain |
| CDS: | characteristic damage state |
| ***C***: | elasticity tensor |
| *E:* | elasticity modulus |
| FRP: | fibre-reinforced plastic |
| g: | volume specific energy |
| l: | length |
| n: | number of load cycles |
| N: | number of cycles to failure |