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A general cohesive continuum mechanics framework for constitutive modeling of microdamage healing

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ABSTRACT

This study extends a recently developed [1, 2] general continuum damage mechanics-based framework to model the microdamage healing phenomenon in self-healing materials. The well-known nominal, healing and effective configurations of classical continuum damage mechanics are extended to self-healing materials. The theory of mixtures is used to estimate the elastic stiffness in the healed portions of the damaged material which is assumed to be different than the elastic stiffness of the intact material. Therefore, a new physically based state variable (i.e., healing variable) is defined based on the elastic stiffness to enrich the classical continuum damage mechanics theories in modeling the microdamage healing phenomenon. The well-known transformation hypotheses of the continuum damage mechanics (i.e., strain equivalence, elastic strain energy equivalence, and power equivalence hypotheses) are used to incorporate the effects of the microdamage healing in self-healing materials. Analytical relations are derived to relate elastic stiffness moduli in the nominal, healing and effective configurations for each postulated transformation hypothesis. The cohesive zone model presented in Ref. [3] is extended to incorporate the microdamage healing effects. The effects of heat and resting time on the healing behavior of the material are discussed. A general thermodynamic framework for constitutive modeling of damage and microdamage healing mechanisms is used to derive the evolution equations for the healing state variables. The ability of the proposed model to explain microdamage healing is demonstrated by presenting several examples and by comparing the model predictions and experimental data on a self-healing material.

REFERENCES

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