ME Seminar

MECHANICAL ENGINEERING
INDIAN INSTITUTE OF SCIENCE

Constitutive Modeling of Self-Healing Materials Using Continuum Damage-Healing Mechanics

Dr. Harini Subramanian, Indian Institute of Technology-Madras

ABSTRACT

The ability of self-healing materials to undergo automatic repair upon damage without external intervention has caused increased interest in academia and industries in the last few decades. The conventional and classical constitutive material models have yet to fully capture self-healing owing to the complexity of this phenomenon. Certain assumptions have been made in existing damage-healing models such that they cannot capture the complete failure of these materials. These models are based on the assumption that healed material does not undergo damage. A new variable called the secondary damage variable, capturing damage of healed material, is thus defined to address this drawback. The fundamentals of damage-healing theory are redefined. A three-dimensional (3-D) elasto-plastic damage-healing (EPDH) framework is developed for self-healing materials undergoing plastic deformation using continuum damage mechanics. Further, a 3-D viscoelastic damage-healing model is developed for materials like asphalt, which heal during unloading and rest periods.

This presentation will mainly focus on an elasto-plastic constitutive model for self-healing materials coupling continuum damage–healing mechanics (CDHM) framework with isotropic hardening. The necessity of the proposed secondary damage variable is successfully demonstrated by a four-spring material model. A novel pressure-dependent yield surface (qualitatively behaving like the Gurson model) is developed by damage-healing equivalent stress modifying von Mises yield surface. The physical interpretation of damage and healing energy release rates are presented to elucidate their impact on the energy dissipation within the system. The proposed formulation is finally numerically implemented by a return mapping approach employing the elastic strain equivalence hypothesis from CDHM. The secondary damage variable is finally found crucial while obtaining the physically realistic stress-strain response of self-healing materials leading to complete failure upon exhaustion of healing capabilities.

ABOUT THE SPEAKER

Dr. Harini is currently a project associate at the Indian Institute of Technology Madras. She has completed her PhD (MS + PhD) in Aerospace Engineering through the Prime Minister Research Fellowship scheme from IIT Madras. She was awarded the Institute Research Award by IIT Madras in recognition of her excellent PhD work. Before this, she has done her Bachelor's in Aeronautical Engineering at Madras Institute of Technology, Anna University. She has also worked as a modelling and simulation engineer at Schlumberger Technology India Pvt Ltd for a brief period. So far, her research has focused on modelling self-healing in materials, plasticity, viscoelasticity, homogenisation, and progressive failure analysis of laminated composites. She is currently working on viscoplastic damage modelling of particulate composites and a multi-scale damage-healing model for diffusion-based healing in materials. Her research interests include elasto-plastic material modelling, viscoelastic material modelling, homogenisation, progressive failure analysis, and continuum damage mechanics.

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