National Institute of Technology Rourkela

Defence Seminar

Seminar Title	: Nonlinear Thermomechanical Characteristics of Damaged Smart (Bonded with Shape Memory Alloy Fibre) Layered Composite Structural Panel Theoretical Analysis and Experimental Verification
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Venue	: Seminar Hall (Ground Floor, ME-001), Mechanical Engineering Science Building
Date and Time	: 23 Jul 2024 (3.00PM)
Abstract	: A novel nonlinear mathematical framework has been developed to compute damaged layered structural responses under combined loading (thermal and mechanical) conditions. The physical composite structural model is derived using higher-order kinematics, including the full-scale geometrical distortion via Green&rsquos strain in the Lagrangian frame. Further, the model uses the marching technique to numerically introduce shape memory alloy (SMA) fibre properties to enhance structural stiffness due to damage and elevated environment. The system responses are obtained numerically using an in-house customized computer code (MATLAB platform) utilizing the mathematical model associated with isoparametric finite element steps, including the solution techniques, i.e., the direct iterative method (nonlinear solution) and Newmark&rsquos integration technique. Initially, the numerical solution consistency and accuracies are verified with the published benchmark solutions (numerical/analytical/experimental) and a few experimental data obtained from the lab-scale experimentation (static, frequency, and dynamic values for damaged layered structure with and without SMA). The numerical prediction efficacies are also verified through a machine-learning model to show the independence of the proposed model variables and the corresponding assumptions. Using the currently derived MATLAB code, the linear and nonlinear static deflection, eigenvalue, dynamic responses, and buckling and/or post-buckling cases. The influence of volume fractions, pre-strain values, and thermal environments on smart material alloy fibre properties is assessed using the numerical model, demonstrating substantial enhancements in composite performance. The study indicates that incorporating SMAs in laminated composites significantly enhances static and dynamic responses, and the improvements range from 40 to 65% and 15 to 58%, respectively. The SMA volume fraction increases from (Vf = 0% to 24%). Similarly, natural frequency values also show an improvement of 4% to 8% when SMA volume fractions increase (Vf =10% to 20%). In damaged laminated plates, SMAs mitigate losses, resulting in notable enhancements of up to 5% to 18% across static, dynamic, and frequency characteristics. It highlights SMAs effectiveness in restoring and reinforcing damaged structures. Finally, the study explores influential input parameters affecting structural stiffness and design aspects, offering recommendations for future functional materials and composite structure applications.