



INDIAN INSTITUTE OF TECHNOLOGY GUWAHATI  
SHORT ABSTRACT OF THESIS

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Thesis Title: **Studies on Strain Softening Materials using Nonlocal Finite Element and Element-Free Galerkin Methods**  
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**SHORT ABSTRACT**

The present work simulates the failure phenomenon of various materials in nonlocal finite element (FEM) and element-free Galerkin (EFG) methods. It commences by examining the constraints inherent in conventional FEM, especially in its application to adhesive bonded joints. Subsequently, it introduces the nonlocal integral theories to accurately capture numerically converged structural responses in complex mode-I and mixed-mode problems within a thermodynamic framework, selecting strain as the regularized variable. Building on the limitations of the nonlocal strain approach, including its tendency to underestimate peak loads and high computational time, the study proposes a strain difference-based method to enhance the prediction of failure behaviour and damage/crack propagation in quasi-brittle materials within a thermodynamic framework. The study then delves into ductile materials exploring the concepts of continuum damage mechanics (CDM) to propose a new nonlocal equivalent plastic strain based ductile damage model which is relatively simpler, reduces the number of material parameters, and enhances the understanding of ductile damage behaviour. A nonlocal equivalent plastic strain is integrated with the proposed damage model to address the challenges associated with strain localization.

The work further explores the EFG method's superior performance in describing continuous fields compared to FEM. Its effectiveness in capturing the strain softening phenomenon, with a particular emphasis on addressing challenges related to both strong (sharp cracks) and weak (sudden change in the area) discontinuities are presented. In the context of strong discontinuities, this work investigates the crack propagation in mode I and mode II problems using CZM concept within the proposed modified EFG framework. Furthermore, it also highlights the stability of GDCM in dealing with various material nonlinearity conditions and improving computational efficiency. Regarding the weak discontinuities, it introduces the application of nonlocal integral theories within the EFG framework and presents a comparative study of convergence over FEM. Lastly, the flexibility of EFG method in dealing with large deformation problems associated with hyperelastic materials are explored.