Dhaladhuli Pranavi

Thesis title : Nonlocal modelling of anisotropic fracture using phase field approach at small and finite strains.

Objectives: To model the anisotropic fracture in composites, polycrystalline materials, biological tissues at small and finite strains using phase field approach. To understand the interaction of interface with crack in composites at small strains using combined phase field and cohesive zone approach.

Summary of my work:

Fracture is one of the major failure modes in structures and computational modeling helps in understanding the crack initiation and propagation, which leads to the ultimate fracture of the materials at various material length scales ranging from atomic to macro scales. At lower length scales, inhomogeneities exist which affect the mechanical and fracture response of the material at higher scales. Therefore, the interaction and effect of various material points on a particular point must be considered. This can be achieved by using nonlocal theories. According to Eringen's nonlocal theory, the stress at a point not only depends on strain at that point, but also on its neighbourhood. Griffith's fracture criteria have been used, which states that the existing crack can propagate only when the energy release rate related to the extension of the crack reaches a critical value equal to the fracture toughness of the material. Of various computational models, phase field modeling (PFM) is one of the popular approaches to model fracture in cracking solids. The total energy is minimized with respect to the displacement field, which results in equilibrium equation, and the evolution equation is derived based on dissipation and thermodynamic principles. The two governing equations are solved simultaneously to obtain the displacement field and crack phase field at each loading step.

Composites have been widely applied in various industries, as they can be modeled according to the required purpose, and can also provide high strength and stiffness at low weight. Accordingly, the fibers are embedded in the matrix constituent at various directions, due to which, they become inherently inhomogeneous and anisotropic. There exists an interface between

the two constituents of the composite system. The overall response of such system depends on the properties of fiber, matrix, and fiber–matrix interface together with the stacking sequence and thickness of the laminate. Interaction of the crack with the fiber-matrix interface, and interfaces between different lamina in a laminate plays a key role in determining the overall strength of the system. Certain composites, rubber polymers, and elastomers are hyperelastic and anisotropic, and in general, subjected to mixed mode loading rather than pure modes. Soft biological tissues can also be considered as anisotropic hyperelastic material.

Nonlocal models have been developed for isotropic and anisotropic materials, which can capture weak or strong anisotropy, at small and finite strains. The crack-interface interaction at different material length scales is analyzed in fiber reinforced composites, polycrystalline materials, and can be applied to any material having interfaces. Practically, all the structural elements are subjected to mixed mode loading, therefore, a nonlocal model has been developed which can capture the mode-mixity.

Research Interest: cohesive zone approach, phase field model, interface mechanics, mechanics of composites, fracture modelling.

Publications:

Journals

1. D Pranavi, A Rajagopal, JN Reddy, Interaction of anisotropic crack phase field with interface cohesive zone model for fiber reinforced composites, Composite Structures 270 (2021), 114038.
2. P Dhaladhuli, R Amirtham, JN Reddy, Interaction between interfacial damage and crack propagation in quasi-brittle materials, Mechanics of Advanced Materials and Structures 29 (2022), 3187-3208.
3. D Pranavi, A Rajagopal, JN Reddy, A note on the applicability of Eringen's nonlocal model to functionally graded structures, Mechanics of Advanced Materials and Structures, 2022.

Book chapters

1. D Pranavi, A Rajagopal, Nonlocal Diffused Approach to Model Delamination in Composites, Advances in Structural Integrity (2022), 133-140.

2. D Pranavi, KSS Reddy, A Rajagopal, JN Reddy, Crack and interface interaction under quasi-static and dynamic loading, Modeling and Computation in Vibration Problems 1 (2021), 10-1.
3. D Pranavi, A Rajagopal, Modeling anisotropic fracture in a metal-fiber reinforced composite system, IOP Conference Series: Materials Science and Engineering 1166 (2021), 012023.

Conferences

1. Dhaladhuli Pranavi, Amirtham Rajagopal, Nonlocal diffused approach to model delamination in composites, 3rd Structural Integrity Conference and Exhibition (SICE 2020 e-Conference), India, 2020.
2. Dhaladhuli Pranavi, Amirtham Rajagopal, Modeling anisotropic fracture in a metal-fiber reinforced composite system, 3rd International conference on Materials Science and Manufacturing Technology (ICMSMT), India, 2021.
3. Dhaladhuli Pranavi, Amirtham Rajagopal, Constitutive relation for modelling anisotropic fracture in fiber reinforced composites at finite strain, 13^{th} international symposium on plasticity and impact mechanics, 2022.

Awards and recognition

• Secured University Gold Medal in JNTU for B.Tech, 2018.
• Secured MC Consulting Engineers Endowment Gold Medal for securing first rank in B.Tech, 2018.
• Secured Vellanki Rama Rao Memorial Endowment Gold Medal for securing first rank in B.Tech, 2018.