Scaling Laws for Damage Evolution in Quasi-Brittle Materials: An Application of Field Induced Percolation

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Field induced percolation is the phenomena in which mechanical, thermal, electrical and magnetic fields induce percolation or phase transition in the underlying system. In its simplest description, percolation theory deals with the random clustering of events approaching criticality in disordered systems. It provides a quantitative and conceptual model for understanding these phenomena and therefore presents a theoretical, statistical background to many physical and natural science disciplines dealing with randomness. Due to its broad scope of applicability, in the last two decades, it has received considerable attention from physicists, mathematicians, material scientists, and civil, mechanical, and chemical engineers.

This talk presents progressive damage evolution in brittle materials as an application of the stress induced percolation of the system. Damage evolution leading to material breakdown in disordered media under quasi-static loading can be described as a model system heading towards its critical point (macroscopic fracture). The theory that attempts to describe the system behavior close to its criticality is the scaling theory. Since the macroscopic response of a material system is defined only in the thermodynamic limit, scaling laws are essential for coupling the mesoscopic damage evolution with the continuum damage response and in determining the size effects on the constitutive response of the materials. This study presents the scaling laws based on renormalization group methodology for the critical fracture threshold and the mean fracture strength. This critical fracture threshold, below which macroscopic fracture of an infinite system does not occur, may be associated with the Griffith's crack driving force that is necessary for macroscopic crack propagation leading ultimately to the system failure.

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