ME Seminar

Unraveling the intermittency of damage evolution for predicting the failure of quasi-brittle solids

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ABSTRACT

Failure of structural materials such as rocks, wood, mortar, etc., involves the accumulation and then the localization of a large number of micro-ruptures in interaction. At the macroscopic scale, these events manifest as bursts of dissipated energy (e.g., acoustic emission) and intensify on approaching failure. A better understanding of the intermittent damage evolution is, therefore, key to modelling the approach to failure and is of interest for applications of structural health monitoring. Yet standard damage models do not capture the intermittent nature of damage evolution. By considering damage growth at the scale of a representative volume element, the crucial role of material disorder is often missed. They also neglect the long-range interactions between the material elements constituting the specimen, a non-local effect resulting in damage evolution as cascades. Moreover, there are very few quantitative investigations examining the intermittency of the damage spreading process.
Our study intends to address this gap through experiments of compressive failure of 2D cellular solids. The bi-dimensionality of the system allows for tracking the complex spatio-temporal structure of damage cascades. We find that the characteristic features of the precursors - the size, the spatial extent and the duration are related to each other through distinct scaling relations. Further, their evolution on approaching failure is also described by power-laws. Interestingly, in stark contrast to the fixed (non-evolving) length scales considered in existing non-local damage models, we observe the damage cascades increase in length and reach specimen size at the onset of damage localization. To rationalize the experimental observations, we present a micro-mechanical model that considers both the elastic interactions within the specimen and the disordered failure properties of the material. Our results sort out a long-standing debate on the nature of the compressive failure point and the origin of the universal statistics of the precursors preceding it. They pave the way for a paradigm shift regarding the role of precursors to failure. Rather than causing the final failure, precursors are shown to be merely tracers of the stability of the damaged solid. As a direct application of this concept, we design a methodology showing how the precursors can be harnessed for quantitatively predicting the residual lifetime. Finally, as a perspective, we will discuss the application of our method to estimate remaining lifetime in case of complex materials/loading environment.

ABOUT THE SPEAKER

Dr. Ashwij Mayya is a postdoctoral researcher at Insitut Jean Le Rond d'Alembert, Sorbonne Université in Paris working towards deciphering the physics and the statistical aspects of fracture. He did his B.E. in Mechanical Engineering from Visvesvaraya Technological University and obtained his M.S. and Ph.D. degrees from IIT Madras. Ashwij is interested in the areas of mechanical behavior of biomaterials, fracture and damage mechanics of disordered materials with a focus on developing new tools for material design and qualification.

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