ME - PhD Thesis Colloquium

Discrete particulate description of slender elastic structures undergoing geometrically nonlinear deformations and interacting dynamically with particles

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ABSTRACT

Particle simulation methods are traditionally used to describe granular matter and discontinuous phenomena in solids. In this thesis, a particulate approach based on the discrete element method (DEM) is used to describe slender linear elastic structures that undergo large displacements and have multiple, changing contacts. The emphasis is on scenarios where these structures coexist with particles and their mechanical responses are coupled together in a dynamic environment.

In the first part of the thesis, we model particulate beams and evaluate their geometrically nonlinear response under a variety of static, dynamic, and impact loading conditions. We also model particulate arches that show the presence of two force-free equilibrium states, namely bistability. The effect of asymmetry on bistability is assessed with respect to application of load, distribution of constituent particles, and positioning of connector (for double cosine arches). To illustrate the utility of these particulate models, we present a case study involving an array of oscillating cantilever beams in an environment of mobile particles. The interplay between particles and beams is simulated. Next, we demonstrate particle-arch interactions that result in particle gripping and trapping contingent on bistable characteristics of the arch. We draw insights on factors that regulate the governing dynamics in both cases.

The second part of the thesis deals with particulate thin films subjected to transverse loading along with initial in-plane tension or pre-stretch. Together, these loads yield transverse deflections that span linear and geometrically nonlinear regimes and cover both plate-like and membrane-like behaviors. Our simulations help identify threshold loads for the onset of nonlinearity depending on a combination of loading, geometric, and material parameters. Finally, we extend this particulate approach for films to provide a discrete perspective for the nucleus of a biological cell. The nuclear envelope, including the lamina, is modeled by a particulate shell. The interior, comprising the nucleoplasm and chromatin meshwork, is modeled with particles undergoing viscoelastic interactions. Such a compound particle framework allows for a realistic representation of the discreteness in nuclear structure and heterogeneity in material distribution. The proposed particle model is subjected to micropipette aspiration and its response is examined and validated with experimental data.

ABOUT THE SPEAKER

Prasenjit Ghosh is a PhD candidate in the Department of Mechanical Engineering at Indian Institute of Science (IISc), Bengaluru. He obtained his Bachelor's degree from BITS Pilani in 2012 and Master's degree from IISc in 2015. He briefly pursued an industrial stint at Ingersoll Rand and an academic stint at IIM Ahmedabad. His research focuses on discrete particle modeling and its applications in particle-structure interaction problems. He works with Prof. G.K. Ananthasuresh.