ME M.Tech (Res) Thesis Defense

A Phenomenological One-Dimensional Model for Elastic Ribbons

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ABSTRACT

Ribbons exhibit fascinating buckling-dominated behavior under mechanical loading because of a unique combination of geometric dimensions. The recent interest in examining engineering applications of ribbon-like structures underscores the need for dedicated structural mechanics models to predict their complex behavior.

In this thesis, we are concerned with ribbons having flat unstressed configurations. Due to their physical appearance, such ribbons are typically modeled either as rods with highly anisotropic cross-sections or as narrow plates. We specifically examine the predictive capabilities of the geometrically exact 2-director Cosserat rod and geometrically exact 1-director Cosserat plate models. We compare ribbon shapes measured in various bending-dominated experiments with model predictions computed using detailed finite element simulations. We find the plate theory to be particularly useful under a broad range of loading conditions, mainly because it captures curvature distributions realized in material fibers oriented along the ribbon width. This feature, which is noticeably absent in rod models, which contributes to their poor predictive capabilities.

We then propose a phenomenological one-dimension ribbon model by dimensional reduction from the Cosserat plate theory. To this end, we impose kinematic assumptions on the displacement field's dependence in the direction of the width of a ribbon to permit non-trivial lateral surface curvatures observed in the Cosserat plate solutions. We specifically examine polynomial dependences for the displacement field on the coordinate along the width. In principle, we expect a quadratic dependence to suffice since it helps to reproduce non-zero curvatures along the width. However, we find that the resulting restricted kinematics is prone to membrane locking. Presuming a cubic dependence helps circumvent the issue. Alternately, resorting to selective reduced integration techniques during numerical approximation using finite element methods helps alleviate the issue.

ABOUT THE SPEAKER

Anindya is an M. Tech (Res) student in the Mechanical Engineering department at IISc. His topic of research is related understanding the mechanics of slender elastic structures. He has a bachelors degree in Mechanical Engineering from Jadavpur University. He is looking forward to working at Rolls Royce after graduation.

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