GRADUATE STUDENT RESEARCH SEMINAR SERIES (2020)

# ASYMPTOTIC HOMOGENIZATION AND WAVE ANALYSIS OF PANTOGRAPHIC LATTICES WITH VARIABLE ORDER ROTATIONAL RESISTANCE AT PIVOTS

## SPEAKER: SAI KOSARAJU

In this research work, different asymptotic orders of torsional resistance at the pivots for linear orthogonal, skew, triangular and 3D orthogonal pantographic lattices, scaled with the bending stiffness of the beam fibers, are introduced within an asymptotic homogenization of the discrete micro-beam model associated with the summation of internal forces and moments at the pivots, in order to systematically identify corresponding continuum field equations and associated homogenized material properties. There is one rotational spring between two intersecting beams at the pivot for 2D orthogonal and skewed lattice structures. The 2D triangular and 3D orthogonal lattices have three torsional springs connecting the rotations of three intersecting beams at the pivot. The equations for the continuum models generated at the leading order, together with their homogenized material properties, arise naturally and directly from the equations modeling the physical behavior of the underlying beam lattice with the different asymptotic orders in the dimensionless torsional resistance at the pivots. The homogenized shear modulus within these equations is defined in terms of different asymptotic orders of torsional resistance at the pivots, together with the beam fiber bending stiffness between pivots. By increasing torsional stiffness to high orders, the continuum field equations and homogenized shear modulus is obtained for the limiting case of rigid connections.

The discrete model using frame elements is developed to verify the validity of homogenized model. Constraint equations are used to apply displacement compatibility condition at the pivots. The rotations of frame elements at the pivots are connected using torsional spring with different asymptotic orders of rotational resistance. Numerical results from the discrete model are compared with continuum model results for standard elongation bias tests with varying torsional resistance at pivots.

The study of periodic lattice structures is extended to consider the dynamics of wave propagation. Bloch wave analysis for the unit cell of a periodic lattice structure is performed by generalizing the reduction matrices to include constraint equations at the pivot and torsional springs. The reduction matrices are substituted in dynamic eigen value problem which is solved for different mode frequencies in the irreducible Brillouin zone. The frequency vs wave number dispersion curves are compared by varying torsional resistance at the pivot.

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