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Fluid-Structure Interaction Benchmarking using Solids4Foam

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Synopsis

This study presents a fluid-structure interaction (FSI) analysis of a flexible beam subjected to cross-flow using the solids4foam toolbox. An elastic plate attached to the bottom of a rectangular channel is investigated, with incompressible viscous fluid entering under a parabolic velocity profile (Re = 40).The fluid domain follows the incompressible Navier-Stokes equations, while the solid beam employs a neo-Hookean hyperelastic model for finite strains. A strongly-coupled partitioned approach with Aitken relaxation ensures convergence at the fluid-solid interface.Two configurations are examined: a baseline case with a peak inlet velocity of 0.2 m/s and a Young's modulus of 1.4 MPa, and a modified case with a peak inlet velocity of 0.3 m/s and a Young's modulus of 10 kPa to induce larger structural deformations. Results show steady-state displacements of 0.1 mm and 13.4 mm respectively, with drag coefficients of 1.224 and 1.235. Grid convergence and validation against benchmark solutions confirm numerical accuracy.This work demonstrates solids4foam's capability for external flow FSI problems and provides insights into coupled flexible structure responses under varying flow and material conditions.

Keywords: Fluid-Structure Interaction, solids4foam, OpenFOAM, beam in cross-flow, hyperelasticity, partitioned solver