

STUDY OF BUCKLING COLLAPSE OF HETEROGENEOUS TUBES

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PROBLEM DESCRIPTION

- Heterogeneous tubes such as biological tubes (e. g. blood vessels, renal tubes etc.) are subjected to external pressure caused by surrounding muscles or fluid.
- Axisymmetric deformation is observed at the initial stages of loading.
- Bifurcation leading to buckling of the tubes occurs at some critical pressure.
- The buckled mode shapes obstruct normal fluid flow inside the tubes.

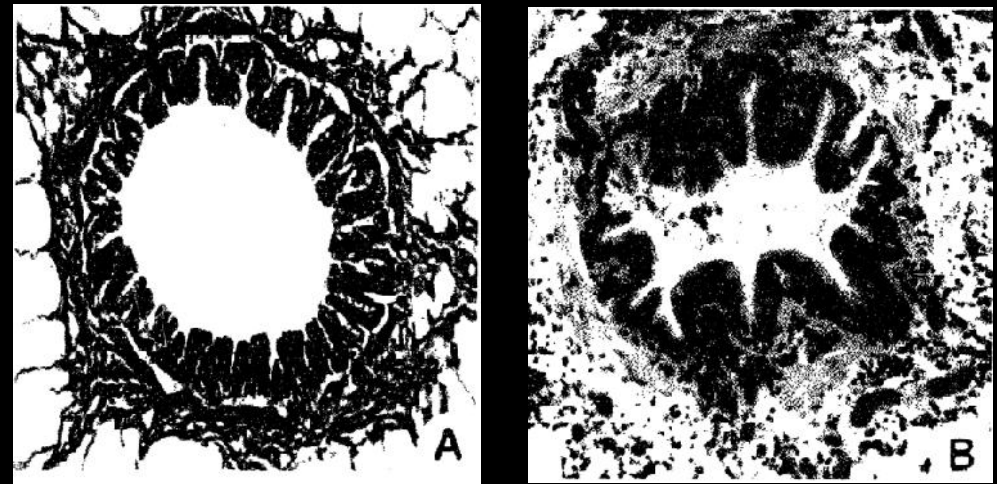


Fig. 1: (A) Normal shape of airway
(B) Buckled shape (blocking airway passage).
[University of British Columbia Pulmonary research laboratory]

MODELLING

- Experimental observations have led to modelling of the heterogeneous tubes as two layered tubes: a thin inner layer (stiffer) surrounded by a thicker outer layer.
- The buckled mode shape is determined by the thickness ratio and the ratio of the elastic moduli.
- For the same stiffness ratio, a relatively thicker inner layer buckles in a mode shape having a relatively lower number of folds.
- Lower number of folds leads to bigger blockage in the central lumen area when two consecutive folds come in contact.

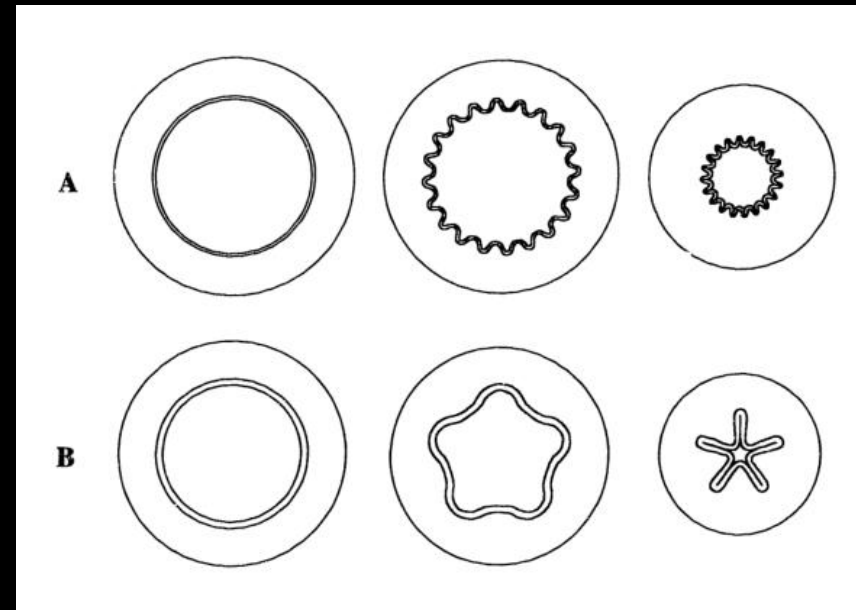


Fig. 2: Buckled mode shapes: (A) thin inner layer,
(B) thick inner layer.
[Hrousis PhD dissertation, 1998]

NON-LINEAR FEM

- Non-linear FEM is applied using energy (variation) method considering Lagrangian strain (Non-linear).
- This approach is used to predict deformations for uniaxial elongation (Fig. 3) and axiradial contraction (Fig. 4).

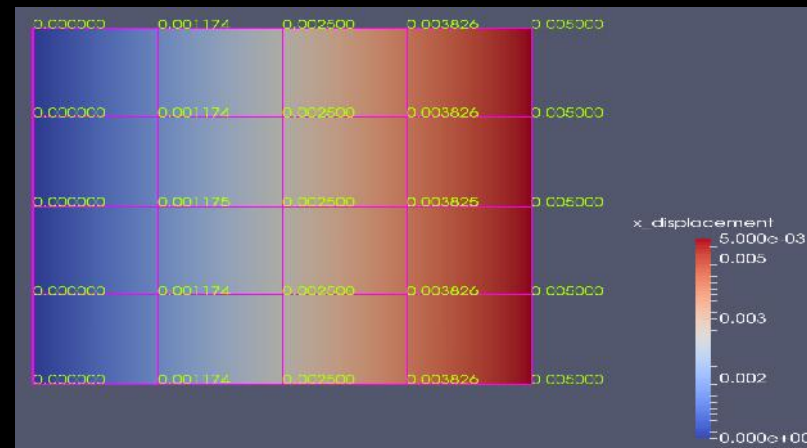


Fig. 3: Uniaxial elongation (non-linear).

FURTHER WORK

- To obtain a proportional loading curve from the uniaxial elongation results for observation of non-linearity of the response.
- To obtain non-axisymmetric response for radial contraction (may need to use geometric perturbation).
- Detailed information about stiffness matrix for checking of numerical derivatives.

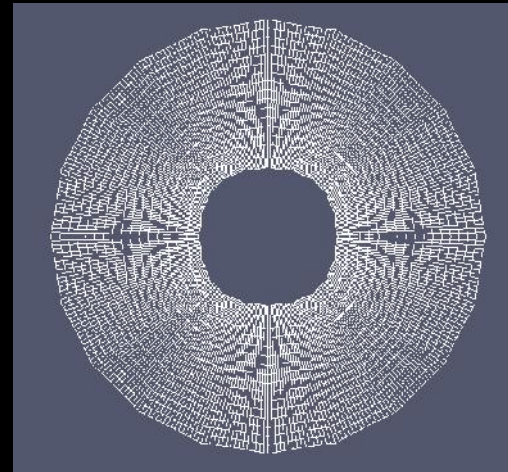


Fig. 4: Axisymmetric radial contraction (non-linear) of annular heterogeneous tube.