8

FEM Modeling: Mesh, Loads and BCs

Topics in Chapter 8

General Modeling Rules

Finite Element Mesh Layouts

Distributed Loads

Displacement BCs

- **suppressing rigid body motions**
- **taking advantage of symmetry and antisymmetry**

General FEM Modeling Rules

- **Use the simplest elements that will do the job**
- ***Never, never, never* use complicated or special elements unless you are absolutely sure of what you are doing**
- **Use the coarsest mesh that will capture the dominant behavior of the physical model, particularly in *design* situations**

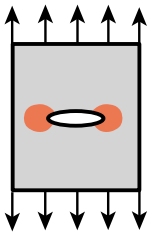
3 word summary: *Keep It Simple*

Another Justification for Simplicity

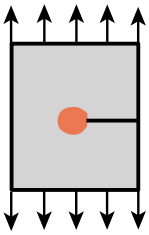
In product design situations
several FEM models of increasing refinement
will be set up as design evolves

Ergo, do not overkill at the beginning

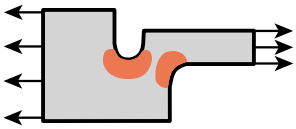
Where Finer Meshes Should be Used



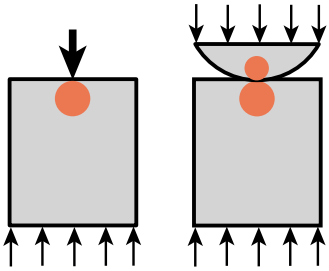
Cutouts



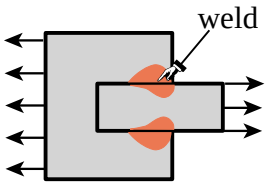
Cracks



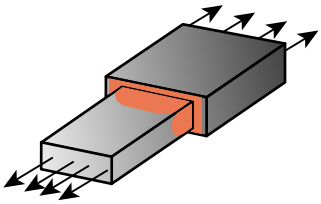
entrant corners



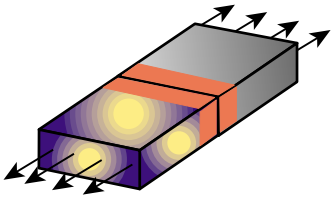
Vicinity of concentrated (point) loads, and sharp contact areas



Load transfer (bonded joints, welds, anchors, reinforcing bars, etc.)



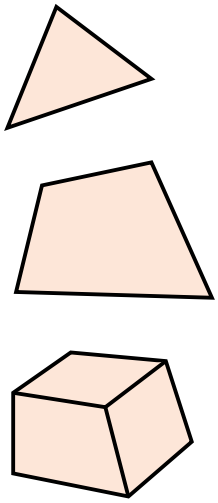
Abrupt thickness changes



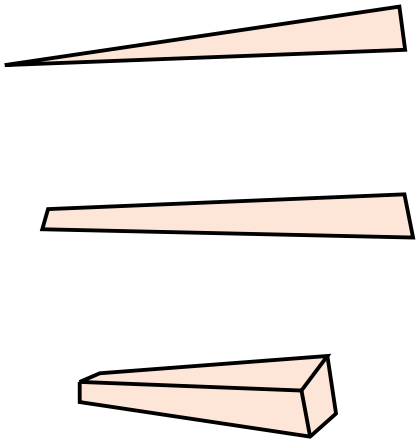
Material interfaces

Avoid 2D/3D Elements of Bad Aspect Ratio

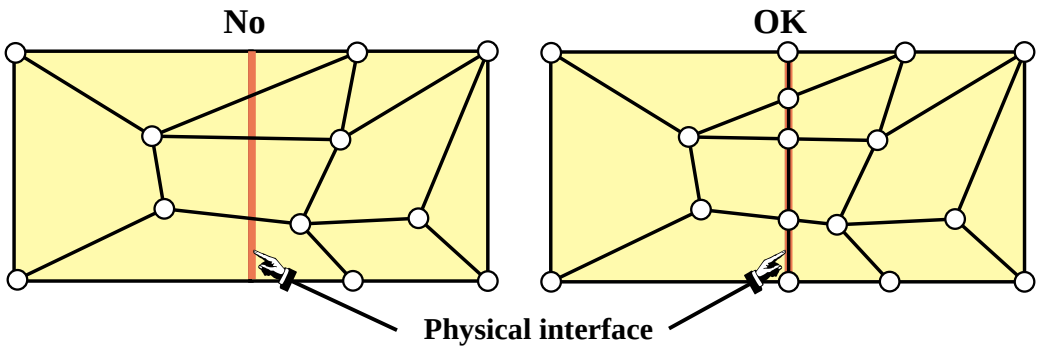
Good



Bad



Elements Must Not Cross Interfaces



Element Geometry Preferences

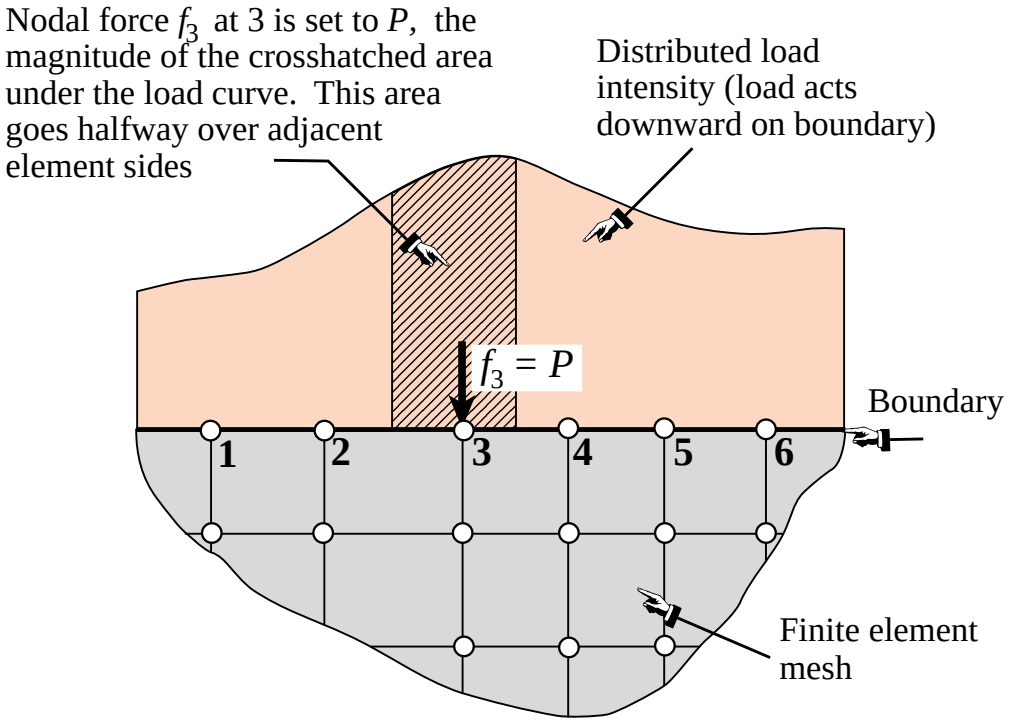
Other things being equal, prefer

in 2D: Quadrilaterals over Triangles

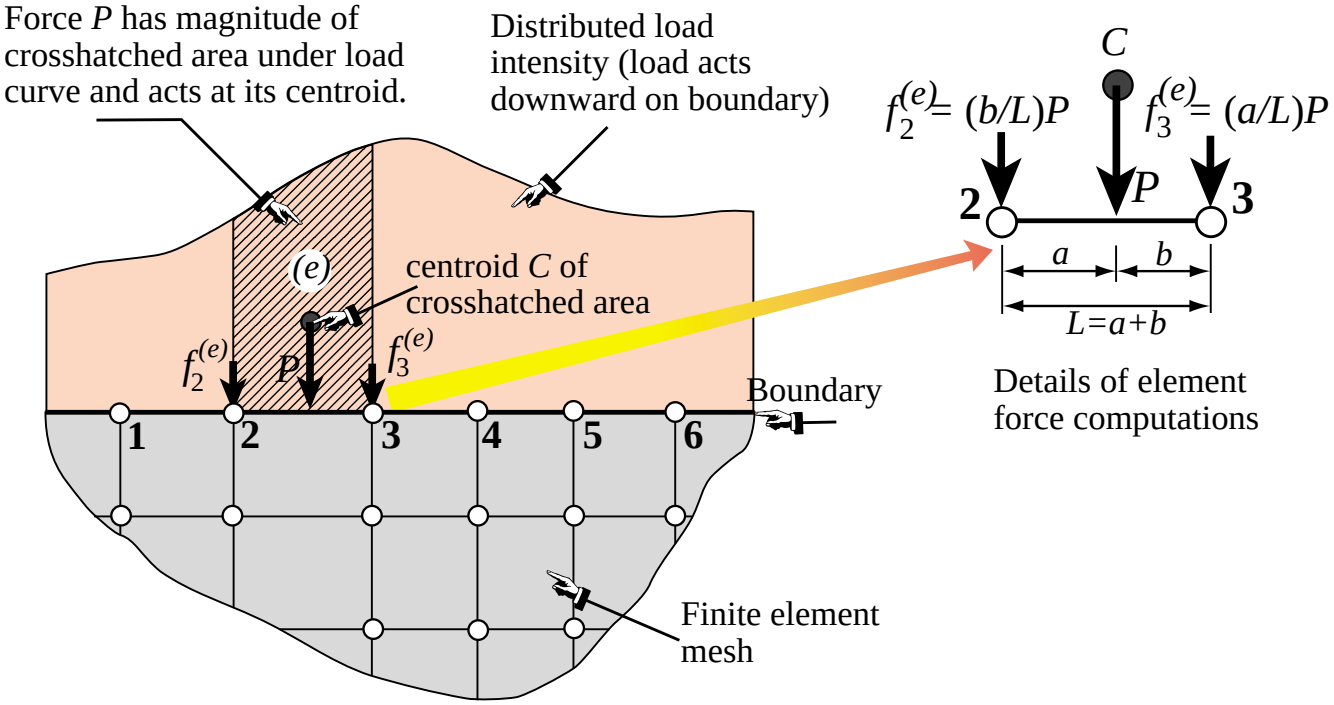
in 3D: Bricks over Wedges
Wedges over Tetrahedra

(Elements do not file discrimination suits)

Node by Node (NbN) Distributed Load Lumping



Element by Element (EbE) Distributed Load Lumping



Boundary Conditions (BCs)

The most difficult topic for FEM program users

Two types { **Essential**, **Natural**

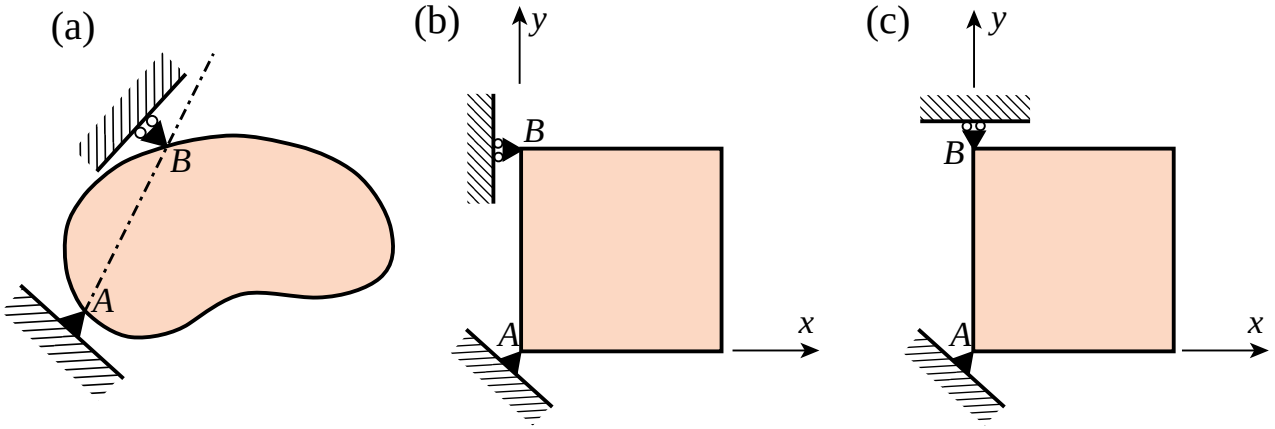
Boundary Conditions
Essential vs. Natural

Recipe:

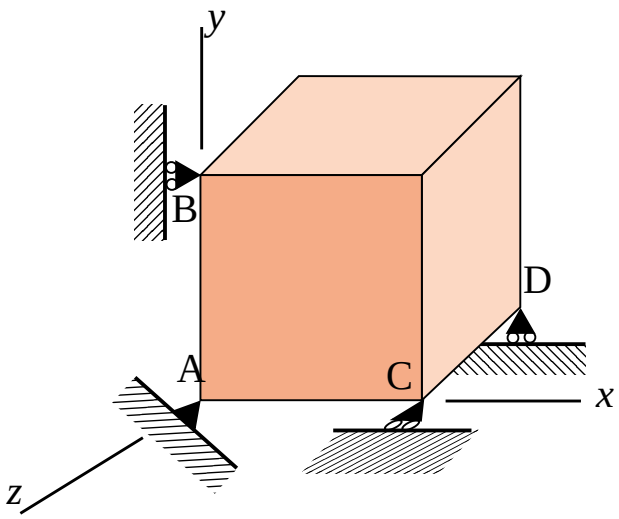
1. **If a BC involves one or more DOF in a *direct* way, it is *essential* and goes to the Left Hand Side (LHS) of Ku = f**

2. **Otherwise it is *natural* and goes to the Right Hand Side (RHS) of Ku = f**

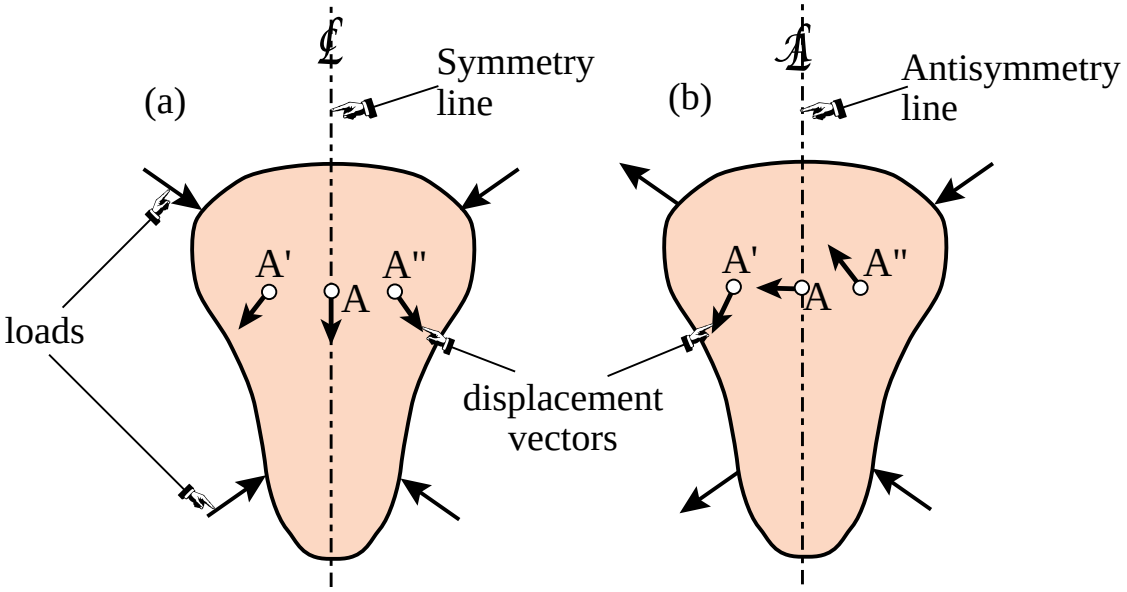
Minimum Support Conditions to Suppress Rigid Body Motions in 2D



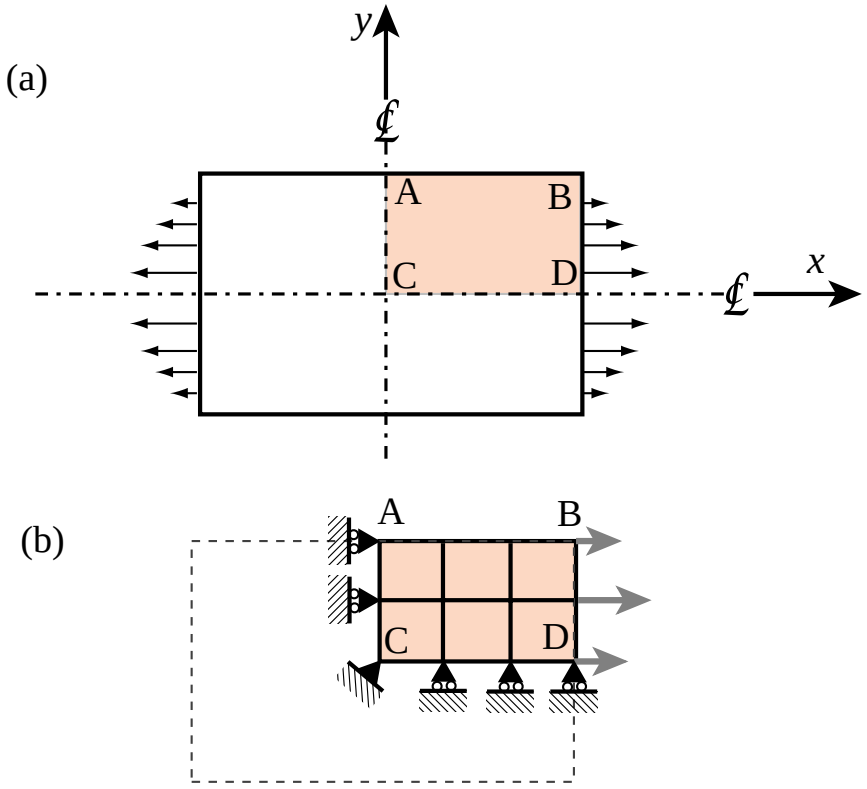
Minimum Support Conditions to Supress Rigid Body Motions in 3D



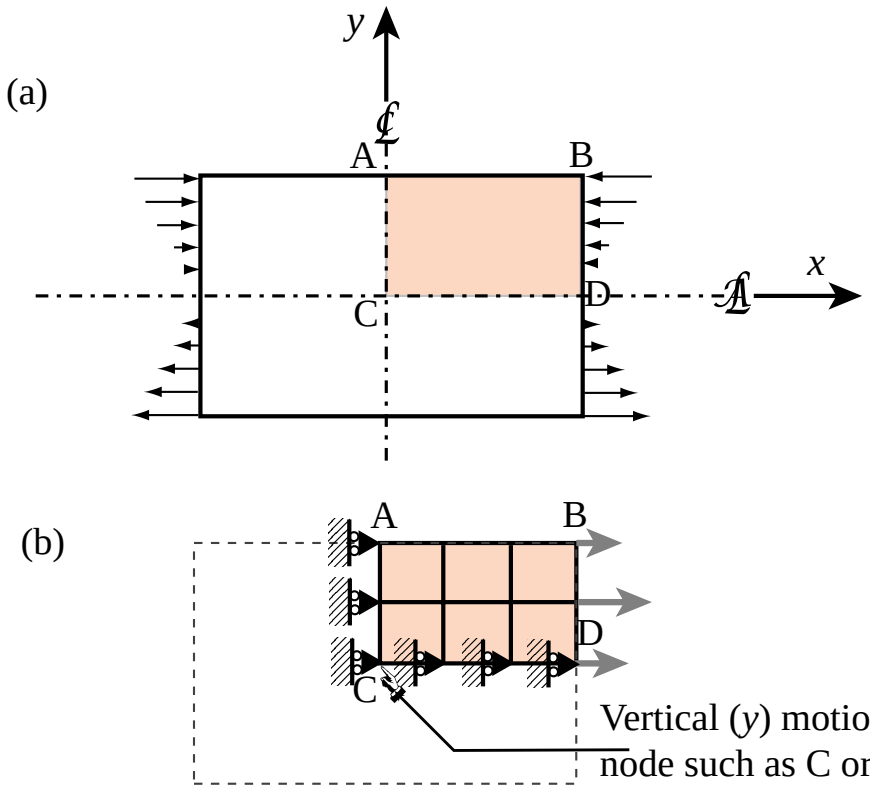
Visualizing Symmetry and Antisymmetry Conditions in 2D



Example of Application of Symmetry BCs

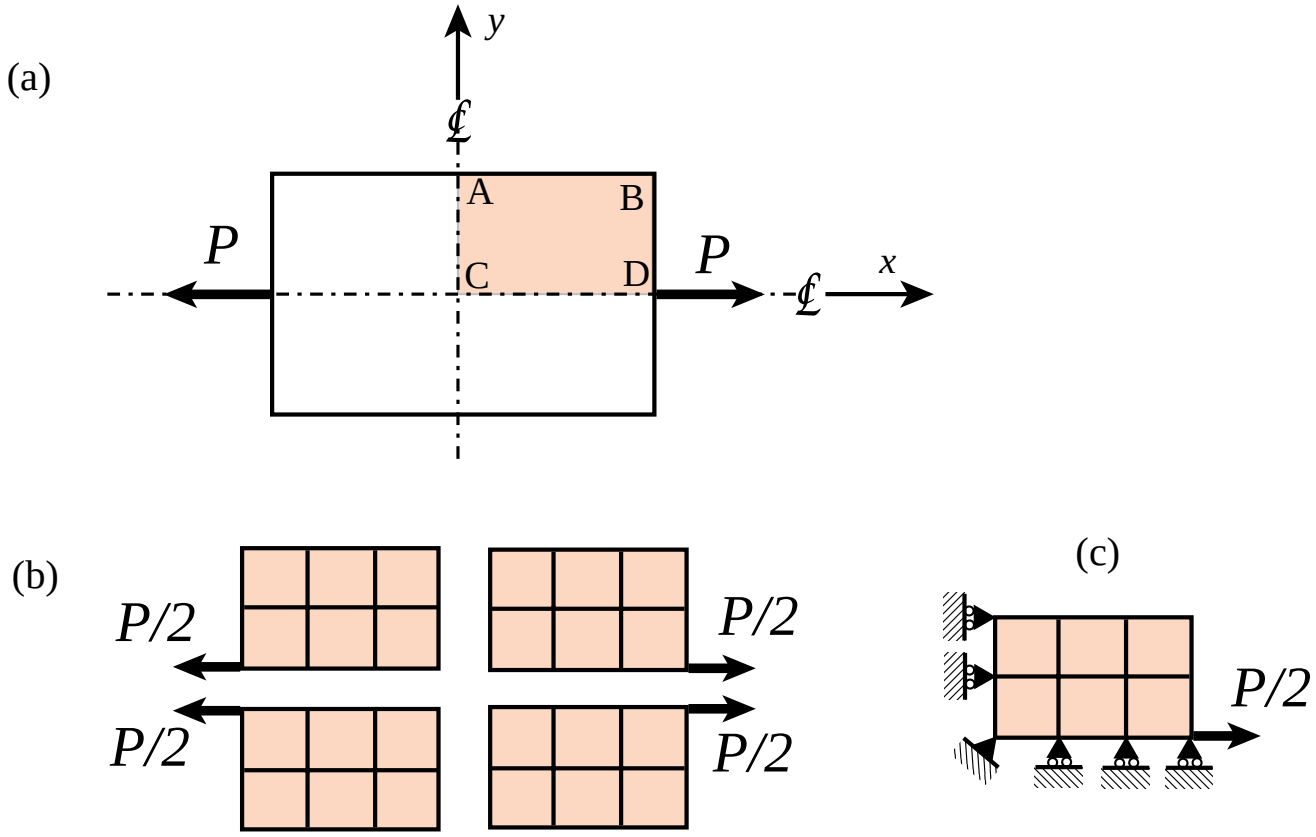


Example of Application of Antisymmetry BCs



Vertical (y) motion of one node such as C or D may be constrained to suppress y-RBM

"Breaking Up" Point Loads at Symmetry BCs



"Breaking Up" Point Loads at Antisymmetry BCs

(A trickier problem)