Subject: Finite Element Methods

Sub. Code: 15ME61

Topic: Axisymmetric Elements

Presented by: S A Goudadi

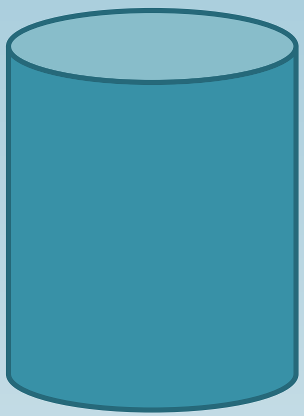
Class: VI A

Introduction

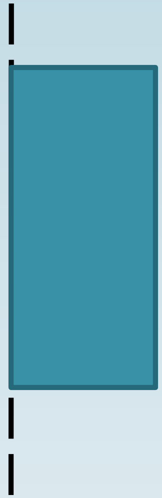
- Axisymmetric elements are 2-D elements that can be used to model axisymmetric geometries with axisymmetric loads
- These convert a 3-D problem to a 2-D problem
  - Smaller models
  - Faster execution
  - Easier postprocessing
- We only model the cross section, and ANSYS accounts for the fact that it is really a 3-D, axisymmetric structure (no need to change coord. Systems)

Modeling

- To model this:



- We just need this:



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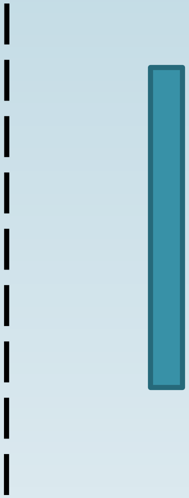

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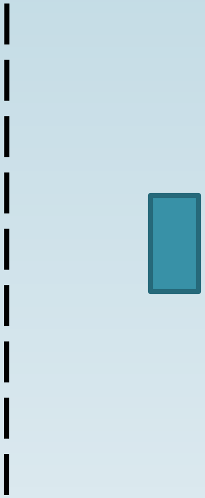

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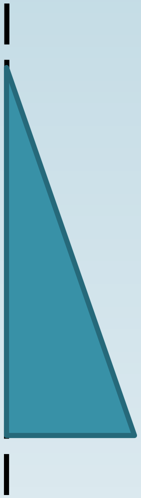

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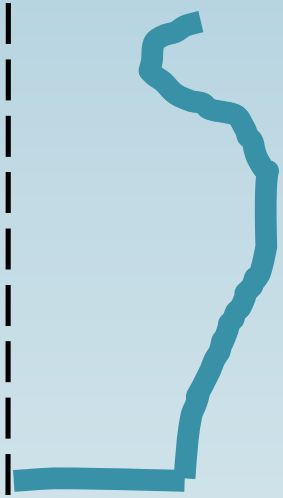

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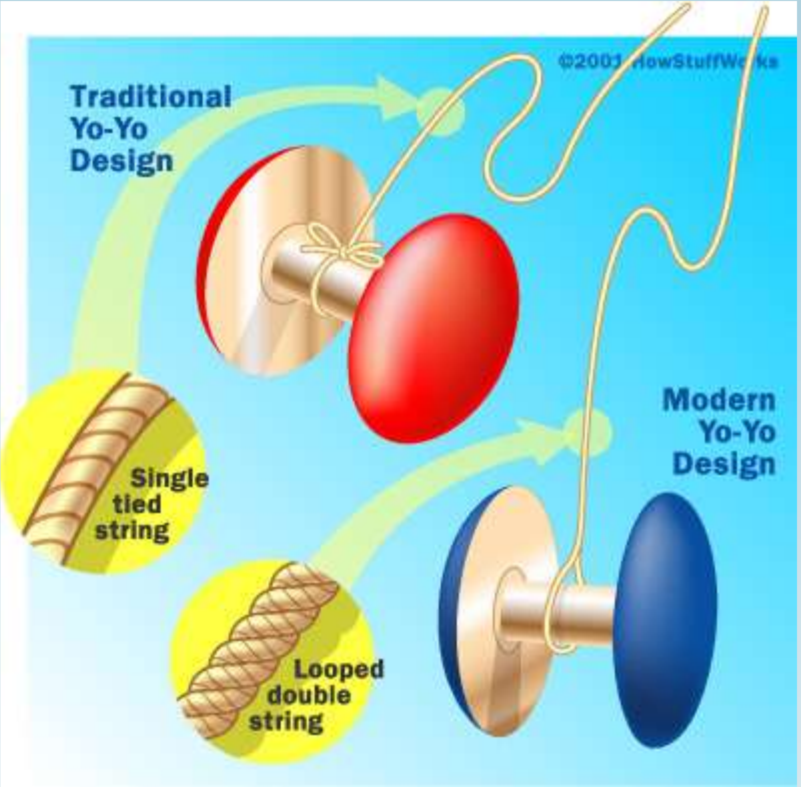

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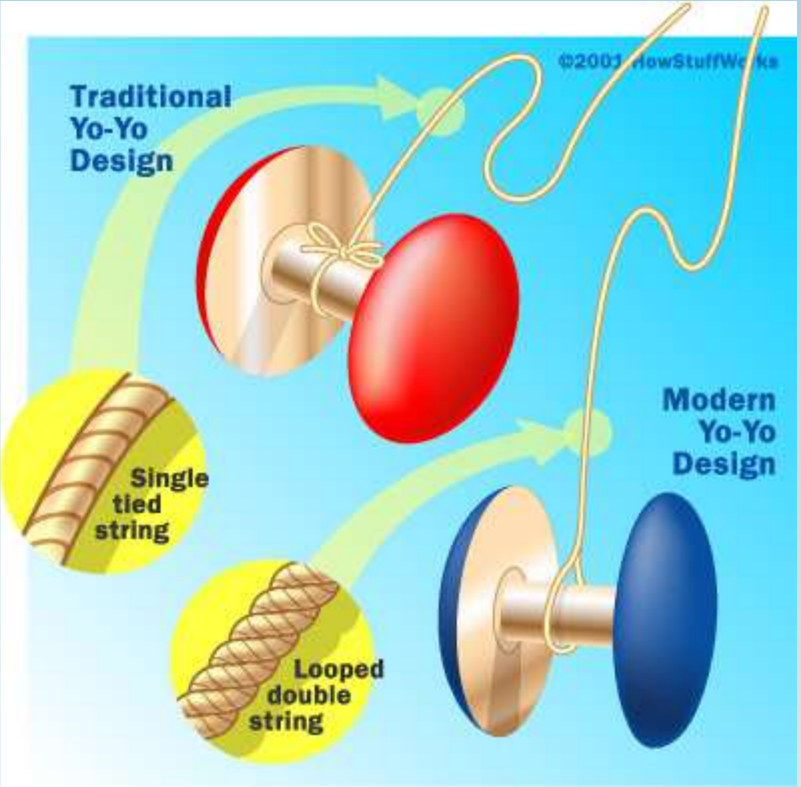

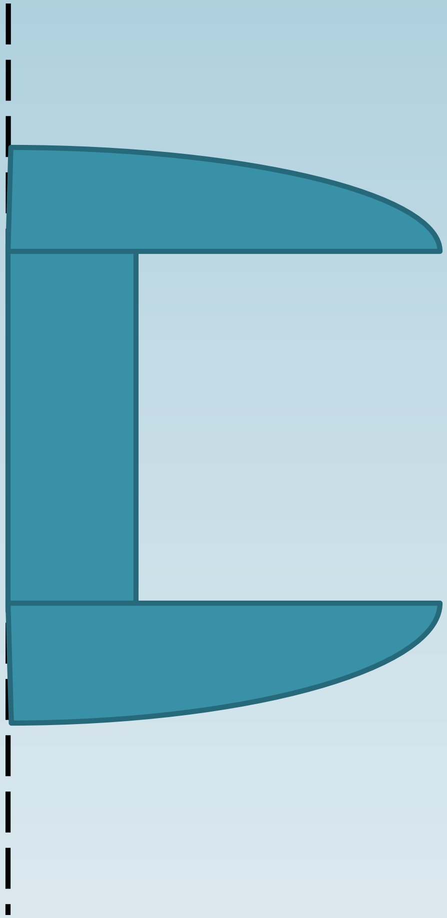

Note

- In ANSYS, axisymmetric models must be drawn in the x-y plane.
- The x-direction is the radial direction.
- The 2-D model will be rotated about the y-axis (and always about x=0)
- Nothing in your model should be in the region x<0
- In postprocessing, σ_x will be the radial stress, σ_y will be the axial stress, and σ_z will be the "hoop" stress

Subject: Finite Element Methods
Sub. Code: 15ME61
Topic: Fluid flow through porous media
Presented by: S A Goudadi
Class : VI A

GeneralStepstobefollowedwhilesolvingaproblemonFluidflowthroughporousmediabyusingFEM:

1.Discretize and select the element type

2.Choose a potential function

3.Define the gradient / potential and velocity / gradient relationship

4.Derive the element stiffness matrix and equations

5.Assemble the element equations to obtain the global equations and introduce boundary conditions

6.Solve for the nodal potential

7.Solve for the element velocities and volumetric flow rates

Points to be remembered:

- 1. This is similar to one dimensional heat conduction problem
- 2. The temperature function T is to be replaced by fluid velocity potential Φ
- 3.The nodal temperature vector should be replaced by vector of nodal potential denoted by
- 4. Fluid velocity v replaces heat flux q and permeability coefficient K for flow through porous medium replaces the conduction coefficient K
- 5. If fluid flow through a pipe or around a solid body is considered, then K is taken as unity

- Navier-Stokes equations:

$$\frac{\partial v}{\partial t} + v\nabla v = -\frac{1}{\rho}\nabla p + \nu\Delta v + f$$

- Darcy law:

$$q = -\frac{K}{\mu}\nabla p$$

- K is the matrix of permeability: porous media characteristic

- Poiseuille flow in a tube:

  single-phase, horizontal flow steady and laminar   no entrance and exit effects

$$v = -\frac{\pi R^2}{8\mu}\frac{\Delta p}{L}$$

v mean velocity

R radius

L length

Δp pressure gradient

- Defining the porosity as $\phi=\Delta Vf/\Delta V\phi=\Delta Vf/\Delta V$, where ΔV is the volume of the representative elementary volume and $\Delta Vf\Delta Vf$ is the volume of fluid in the representative elementary volume, the flux of fluid per unit area (the "Darcy velocity") is given by the volume av

General Description of the finite element method

Application of the finite element method to a structural problem demands the subdivision of the structure into a number of discrete elements. Each of these elements must satisfy three conditions

1. Equilibrium of forces;
2. Compatibility of strains; and The force displacement relationship specified by the geometric and elastic properties of the discrete element

An equivalent set of conditions for a pipe network exist; hence, the ability to draw the analogy:

- The algebraic sum of the flows at any joint or node must be zero.
- The value of the piezometric head at a joint or node is the same for all pipes connected to that joint; and
- The flow-head relationship {such as Darcy-Weisbach or Hazen-Williams} must be satisfied for each element or pipe.

For Direct application of the finite element method involving a matrix solution, a linear relationship is required to define the element or pipe.

Hence there is a relationship of the form:

q = c h (1)

In which q = flow; h = head loss and c = the hydraulic properties of the pipe (to be assumed).

The solution technique can be subdivided into three steps:

1. An initial value of the pipe coefficient. c, is selected for each pipe and is then combined to yield the system matrix coefficient {C}. The system matrix is then solved for the value of piezometric head at each joint.
2. The individual pipe flows, q, are computed by means of Eq. (1) using the difference between the determined piezometric heads. These flows are then substituted in the Darcy-Weisbach equation to calculate the pipe head losses. If the pipe head losses obtained from Q the Darcy-Weisbach equation correspond to those obtained from the matrix solution, then the unique solution, satisfying both the Darcy-Weisbach equation and the linear equation (1) has been found.
3. If there is a difference between the values of head loss calculated by the two methods, the values of c are changed to cause the problem to converge to a solution.