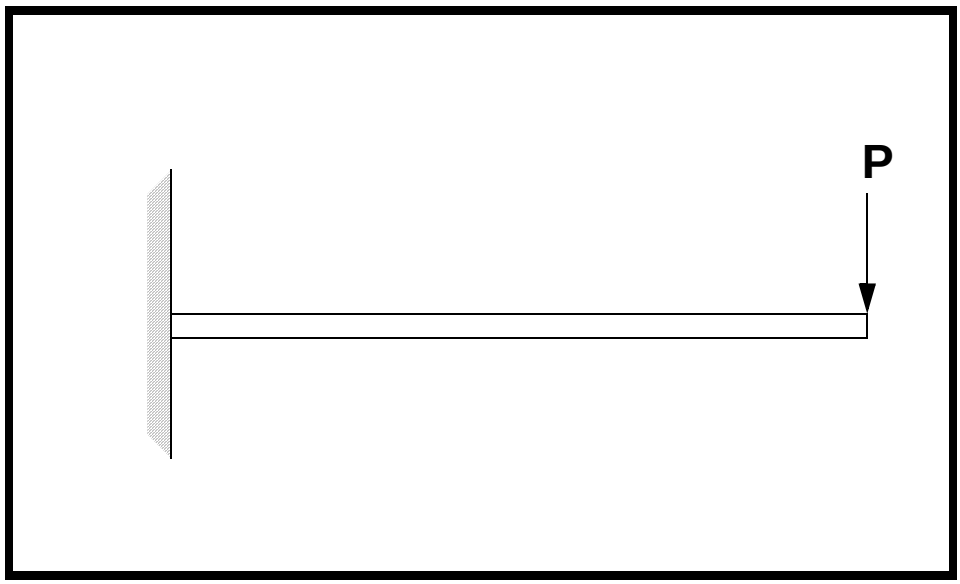
LESSON 7

# *Element Selection Study*




## Objectives:

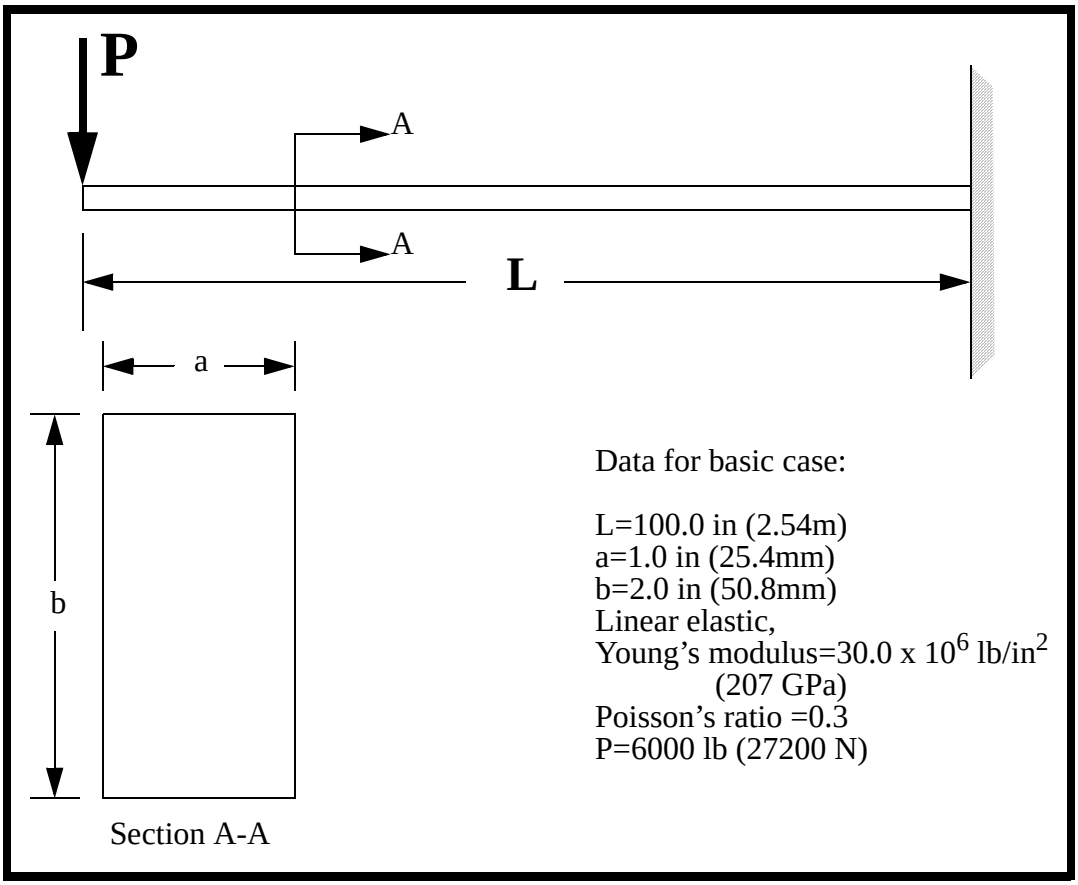
- Small/Large displacement analyses
- Compare performance of various element types
- Compare CPU time to solve the cantilever beam problem using a 1-D, 2-D and 3-D models

## Model Description:

In this problem, you will re-run the cantilever beam you analyzed in Lesson 1 with different Finite Elements. You will study the effectiveness of various1-D, 2-D and 3-D elements in linear as well as non-linear analysis.

## Suggested Exercise Steps:

- Re-run the cantilever model in Lesson 1 with various elements.
- Use the mesh density suggested in Table 1.



# Exercise Procedure:

1. Repeat exercise 1 and try different elements for Linear and Nonlinear analysis and use the elements suggested in the tables below.

Note: Use the following linear elastic material properties in all models:

E = 30.0E+06 psi
Poisson's Ratio = 0.3

Define the Tip_Load to sum to 6000 lbs in all cases.

2. Fill out the tables for deflection and total cpu time.

**Note:** 50x2 mesh means 50 elements long and 2 elements deep.

**Note:** CPU time for each run can be obtained from the end of the ".msg" file.

3. There are questions at the end of this exercise. Read them over and be prepared to discuss them in class.

**Table 1: Linear Analysis for Maximum Y-Displacement**

| | Finite Elements | | Element Properties | | | | | |
|---|---|---|---|---|---|---|---|---|
| ABAQUS ELEMENT | Element Type | Mesh | Dimension | Type | Option 1 | Option 2 | Tip Displacement | CPU Time |
| B23 | BAR2 | 5x1 | 1D | Beam in XY Plane | Rectangular Section | Cubic Interpolation | | |
| CPS4 | QUAD4 | 50x2 | 2D | 2D Solid | Plane Stress | Standard Formulation | | |
| CPS4 | QUAD4 | 50x4 | 2D | 2D Solid | Plane Stress | Standard Formulation | | |
| CPS4R | QUAD4 | 50x2 | 2D | 2D Solid | Plane Stress | Reduced Integration | | |
| CPS4R | QUAD4 | 50x4 | 2D | 2D Solid | Plane Stress | Reduced Integration | | |
| CPS4I | QUAD4 | 50x1 | 2D | 2D Solid | Plane Stress | Incompatible Modes | | |
| CPS8R | QUAD8 | 50x1 | 2D | 2D Solid | Plane Stress | Reduced Integration | | |
| C3D8 | HEX8 | 50x2x1 | 3D | Solid | Standard Formulation | ---------- | | |
| C3D20 | HEX20 | 50x1x1 | 3D | Solid | Standard Formulation | ---------- | | |
| C3D4 | TET4 | 1.0 | 3D | Solid | Standard Formulation | ---------- | | |
| C3D10 | TET10 | 1.0 | 3D | Solid | Standard Formulation. | ---------- | | |

Note: Mesh the models using Tet4 and Tet10 elements with the isomesher and a global edge length of 1.0.

**Table 2: Nonlinear Analysis for Maximum Y-Displacement**

| | Finite Elements | | Element Properties | | | | | |
|---|---|---|---|---|---|---|---|---|
| ABAQUS ELEMENT | Element Type | Mesh | Dimension | Type | Option 1 | Option 2 | Tip Displacement | CPU Time |
| B23 | BAR2 | 5x1 | 1D | Beam in XY Plane | Rectangular Section | Cubic Interpolation | | |
| CPS4 | QUAD4 | 50x2 | 2D | 2D Solid | Plane Stress | Standard Formulation | | |
| CPS4 | QUAD4 | 50x4 | 2D | 2D Solid | Plane Stress | Standard Formulation | | |
| CPS4R | QUAD4 | 50x2 | 2D | 2D Solid | Plane Stress | Reduced Integration | | |
| CPS4R | QUAD4 | 50x4 | 2D | 2D Solid | Plane Stress | Reduced Integration | | |
| CPS4I | QUAD4 | 50x1 | 2D | 2D Solid | Plane Stress | Incompatible Modes | | |
| CPS8R | QUAD8 | 50x1 | 2D | 2D Solid | Plane Stress | Reduced Integration | | |
| C3D8 | HEX8 | 50x2x1 | 3D | Solid | Standard Formulation | ---------- | | |
| C3D20 | HEX20 | 50x1x1 | 3D | Solid | Standard Formulation | ---------- | | |
| C3D4 | TET4 | 1.0 | 3D | Solid | Standard Formulation | ---------- | | |
| C3D10 | TET10 | 1.0 | 3D | Solid | Standard Formulation | ---------- | | |

Note: Mesh the models using Tet4 and Tet10 elements with the isomesher and a global edge length of 1.0.

**Table 3: Linear/Nonlinear Analysis for Maximum Y-Displacements (Answers)**

| | | Linear Analysis | | Nonlinear Analysis | |
|---|---|---|---|---|---|
| ABAQUS ELEMENT | Mesh | Tip Displacement | CPU Time | Tip Displacement | CPU Time |
| B23 | 5x1 | -100 | 0.07 | -60.33 | 1.37 |
| CPS4 | 50x2 | -70.91 | 1.19 | -51.38 | 17.07 |
| CPS4 | 50x4 | -71.84 | 2.19 | -51.59 | 35.89 |
| CPS4R | 50x2 | -121.09 | 0.66 | -67.46 | 10.93 |
| CPS4R | 50x4 | -100.09 | 1.09 | -62.31 | 20.51 |
| CPS4I | 50x1 | -100.02 | 0.69 | -60.72 | 10.35 |
| CPS8R | 50x1 | -98.37 | 0.73 | -59.87 | 15.46 |
| C3D8 | 50x2x1 | -76.54 | 2.67 | -53.55 | 72.26 |
| C3D20 | 50x1x1 | -99.70 | 9.00 | -60.64 | 346.73 |
| C3D4 | 1.0 | -68.72 | 6.18 | -50.47 | 117.16 |
| C3D10 | 1.0 | -99.85 | 23.71 | -62.97 | 1675.5 |

Notes:

1. CPU Time is based on a HP 710 running HPUX 9.0.1. CPU time will vary depending platform analysis is performed on.

2. Tetrahedron Mesh Information:
   C3D4 Mesh had 1000 elements, 606 nodes
   C3D10 Mesh had 1000 elements, 2815 nodes

**Figure 3.1 - Deflection Results and Times for Linear Solution**

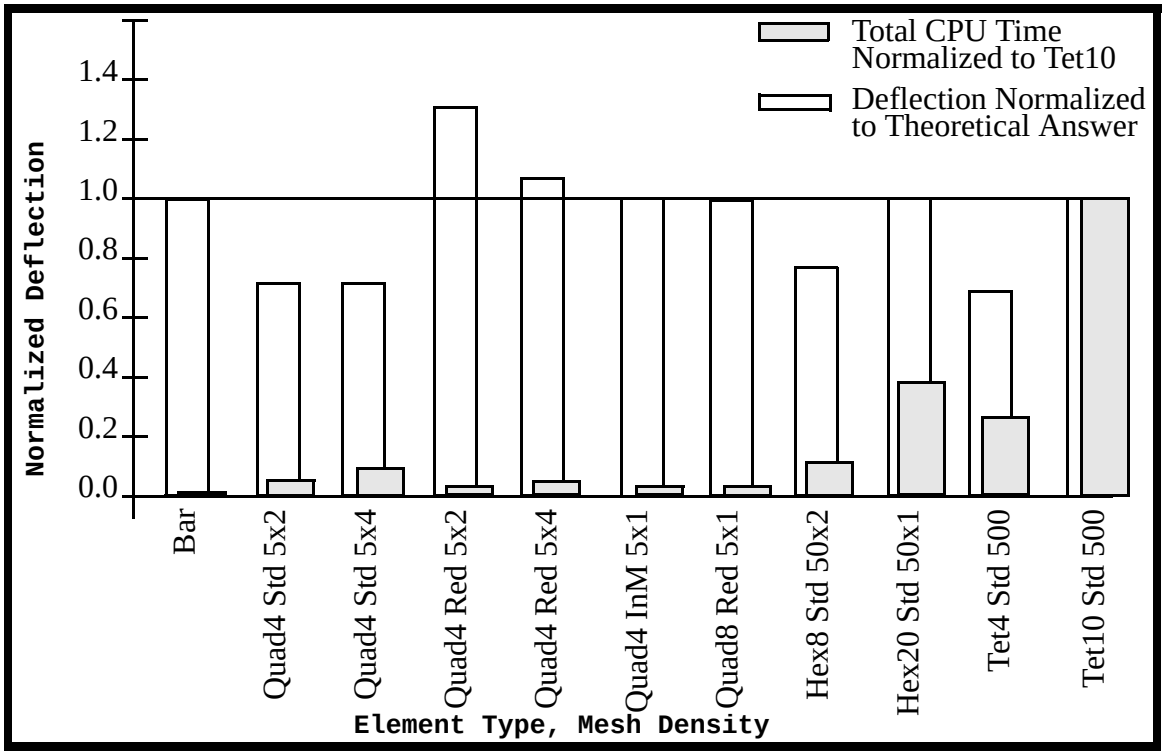
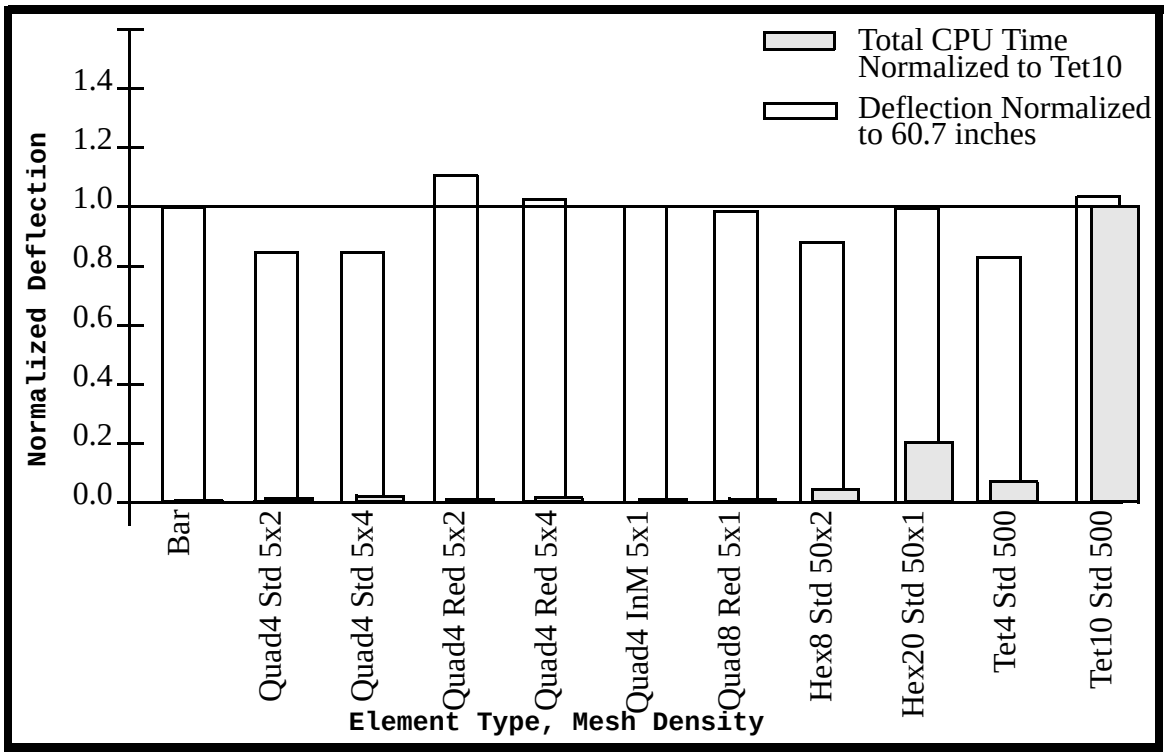



**Figure 3.2 - Deflection Results and Times for NonLinear Solution**



**Question: For Linear Elastic analysis using continuum elements, which one of the elements seem to be appropriate for bending application? Keep in mind that you may have distorted elements.**

(class discussion)

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**Question: For non-linear analysis, which continuum element would you choose?**

(class discussion)

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**Question: When is it appropriate to use 1-D, 2-D or 3-D elements?**

(class discussion)

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