Assignment-6

(CSMD)

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6.a)

We introduced the new Timoshenko 2 Nodes beam element with reduced integration for shear stiffness matrix in the code provided for Timoshenko full integration stiffness matrix

```
Timoshenko reduced integration matrix
K_shear= [   1   ,   len/2 ,   -1   ,  len/2 ;

         len/2 , len^2/4 , -len/2 , len^2/4 ;

         -1   ,  -len/2 ,    1   ,  -len/2 ;

         len/2 , len^2/4 , -len/2 ,  len^2/4 ];
```

Fig-1: Timoshenko reduced integration shear stiffness matrix

This code is simply a representation of the following Timoshenko reduced integration stiffness matrix-

$$\boldsymbol{K}_s^{(e)} = \left(\frac{GA^*}{L}\right)^{(e)} \begin{bmatrix} 1 & \frac{l^{(e)}}{2} & -1 & \frac{l^{(e)}}{2} \\ \ddots & \frac{(l^{(e)})^2}{4} & -\frac{l^{(e)}}{2} & \frac{(l^{(e)})^2}{4} \\ & \ddots & 1 & -\frac{l^{(e)}}{2} \\ Symm & & \ddots & \frac{(l^{(e)})^2}{4} \end{bmatrix}$$

6.b)

The next step is to solve a given beam profile with a 64 element mesh and compare maximum displacements, moments and shear for the 3 elements against the a/L relationship.

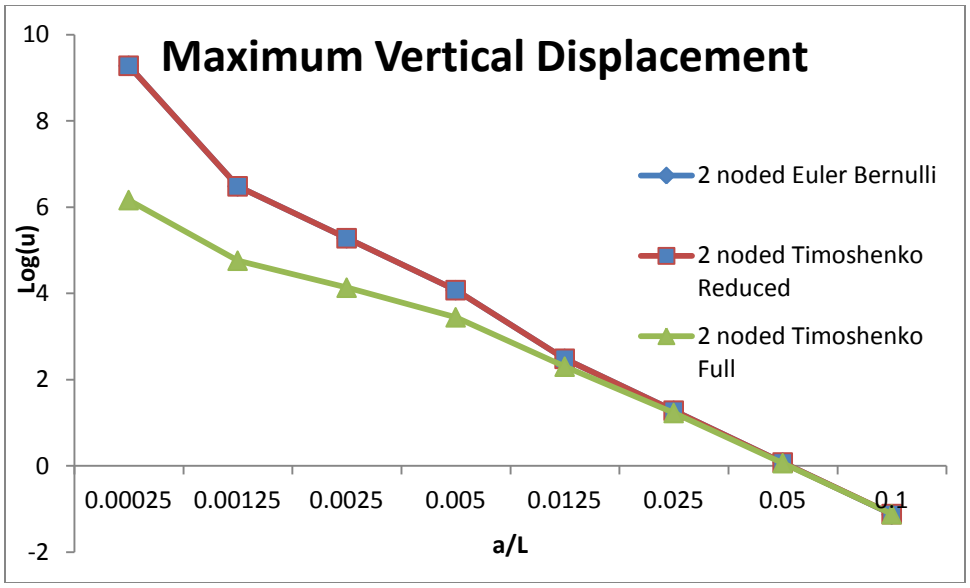

Fig-2: Log(Maximum Displacement) vs a/L ratio

As can be seen from the plot, the values for maximum displacements for 2 noded Euler-Bernoulli and 2 noded Timoshenko reduced integration are similar but differ from 2 noded Timoshenko full integration for lower values of area. As in the case of slender beams (very low transverse cross-sectional area) the effect of shear transverse deformation is negligible but as the area increases the results converge.

A similar profile is also obtained for maximum bending moment as Timoshenko full integration is unable to fully analyze the behaviour of slender beams.

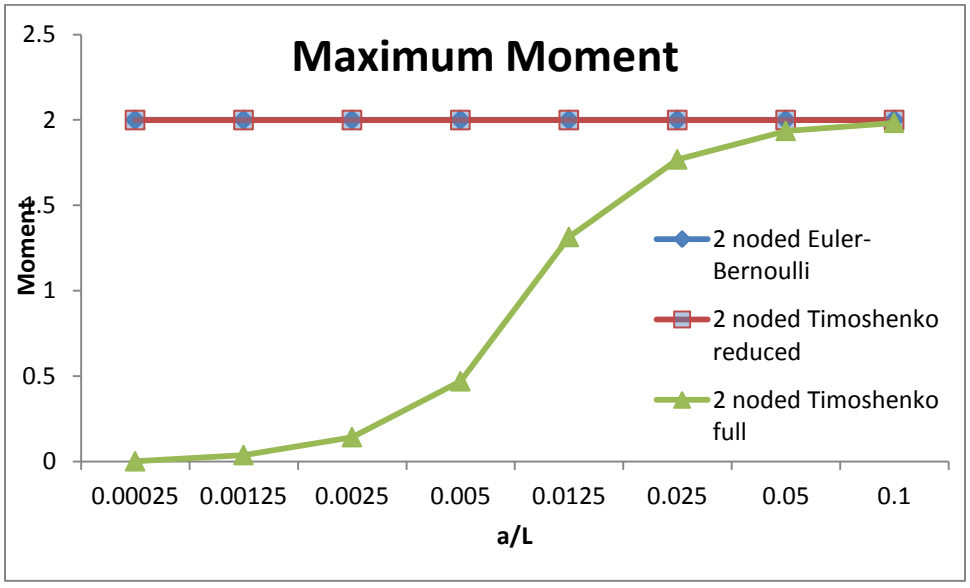

Fig-2: Maximum Bending Moment vs a/L ratio

Again the moments for Euler-Bernoulli and Timoshenko reduced integration show similar behaviour for slender beams which can be seen from the above profile.