Universitat Politecnica De Catalunya, Barcelona
Master's in Computational Mechanics

Course
Computational Structural Mechanics and Dynamics

Assignment on 'Beam'

By

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Ques 1. Program in Matlab the Timoshenko 2 Nodes Beam element with reduce integration for the shear stiffness matrix

Solution:

Introduction: The fully implemented Matlab algorithm was given for Euler Bernoulli and Timoshenko. To overcome shear locking effect, the reduce shear stiffness matrix integration is implemented in Timoshenko algorithm. The changes in algorithm are as follow,

1. Function: To implement reduced stiffness.

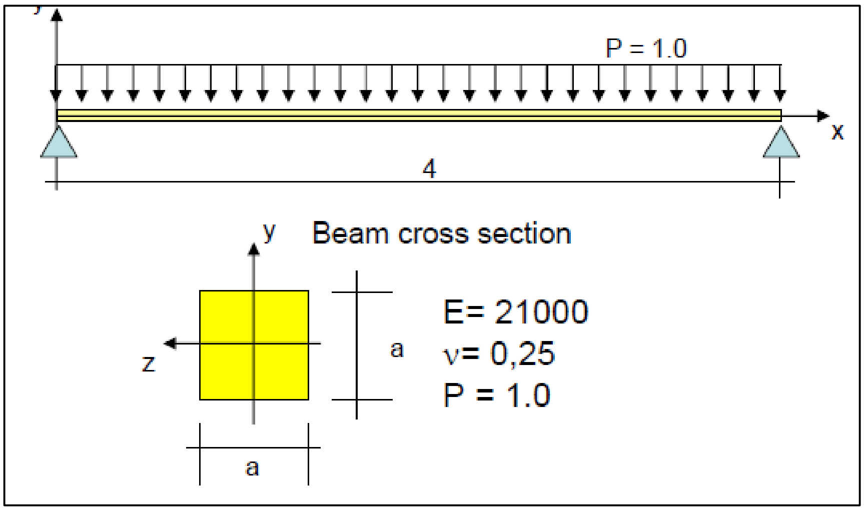
```
% Change to 1 to use reduced stiffness method
RdcdStiff=1;
```

2. Function: Changes in 'K' Matrix.

```
if RdcdStiff==0
  const = D_mats/len;

    K_s = [   1    ,    len/2 ,   -1    ,    len/2 ;
            len/2 , len^2/3 , -len/2 , len^2/6 ;
            -1    ,  -len/2 ,    1    ,  -len/2 ;
            len/2 , len^2/6 , -len/2 , len^2/3 ];

    K_s = K_s * const;
else
    const = D_matsRDCD/len;

    K_s = [   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 ];

    K_s = K_s * const;
```

From the above algorithm, we can use same algorithm for Timoshenko & Reduced Timoshenko, only we have mentioned by which method we want to solve the beam analysis.

Ques 2. Solve the following problem with a 64 element mesh with the
2 nodes Euler Bernoulli element
2 nodes Timoshenko Full Integrate element
2 nodes Timoshenko Reduce Integration element.
Compare maximum displacements, moments and shear for the 3 elements against the a/L relationship



Beam	1	2	3	4	5	6	7	8
a	0.001	0.005	0.01	0.02	0.05	0.1	0.2	0.4

Solution:

The Euler-Bernoulli theory is the classical approach to study the bending of slender plane beams while Timoshenko beam theory for the effect of transverse shear deformation as it takes into account the cross sections of the beam which do not necessarily remain orthogonal to the axis. Therefore, this theory applies for "thick" beams, $\lambda = \frac{L}{h} < 10$ where the transverse shear deformation plays a role and also for slender beams ($\lambda > 100$) where shear deformation is irrelevant.

Comparison of Maximum Displacement, Maximum Moment & Maximum Shear is done with a/L ratio separately.

In the figure 1, comparison is done between the maximum displacements of the beam and the displacements. As seen in the plot, the solution for the Timoshenko full integrate element differs from the one obtained for both Euler-Bernoulli and Reduced Timoshenko approaches when the ratio a=L is relatively low. These values correspond to the slender beams, $\lambda > 100$.

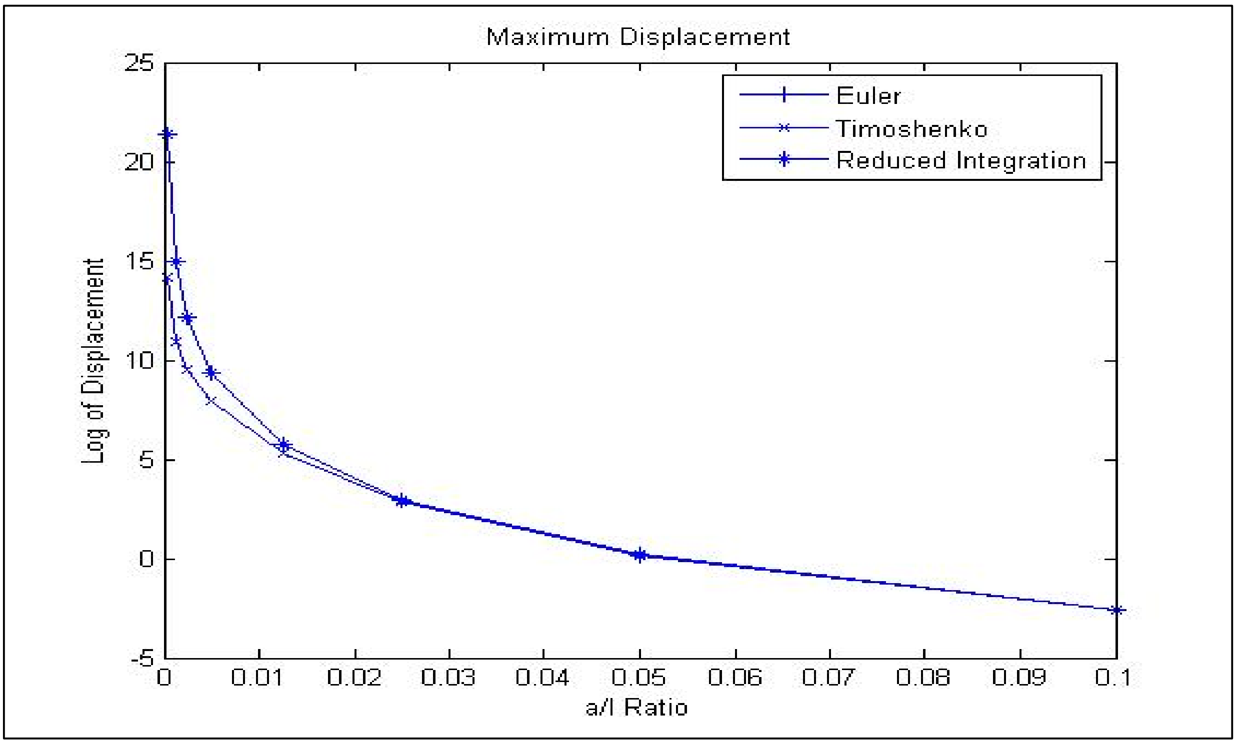


Fig 1: Max Displacement versus Log of Displacement

In the figure 2, comparison is done between the maximum moment of the beam and the moment. The Timoshenko full integrated element gives non-desirable results for slender beams, and Reduced Timoshenko element and Euler-Bernoulli gives the same results.

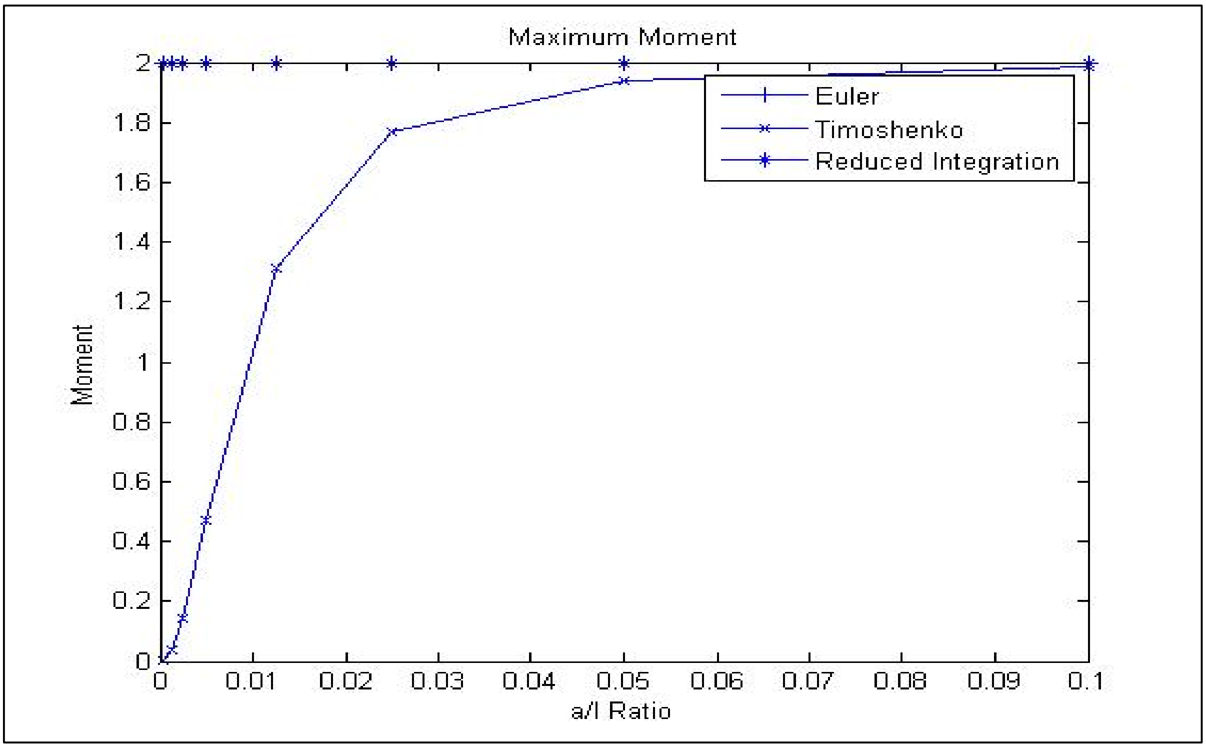


Fig 2: Max Moment versus Moment

In the figure 3, comparison is done between the maximum shear of the beam and the shear. The effect of transverse shear deformation is not considered for Euler-Bernoulli theory, but are considered in Timoshenko & Reduced Timoshenko theory. The plot shows that Timoshenko element is corrupted, while Reduced Timoshenko is constant.

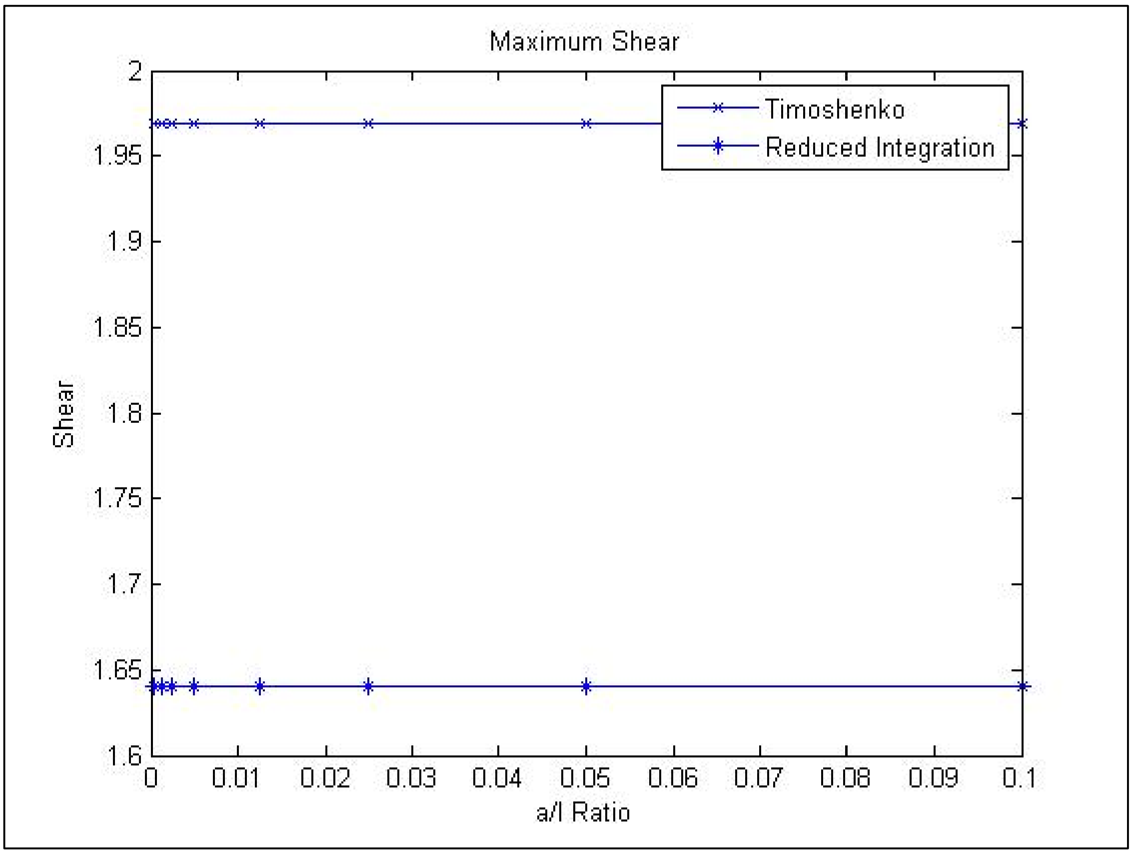


Fig 3: Max Shear versus Shear

------x-----x-----x------