# CEE 2333 - Symmetrical Isoparametric Bilinear Element FEM

Homework 8b

Group 3

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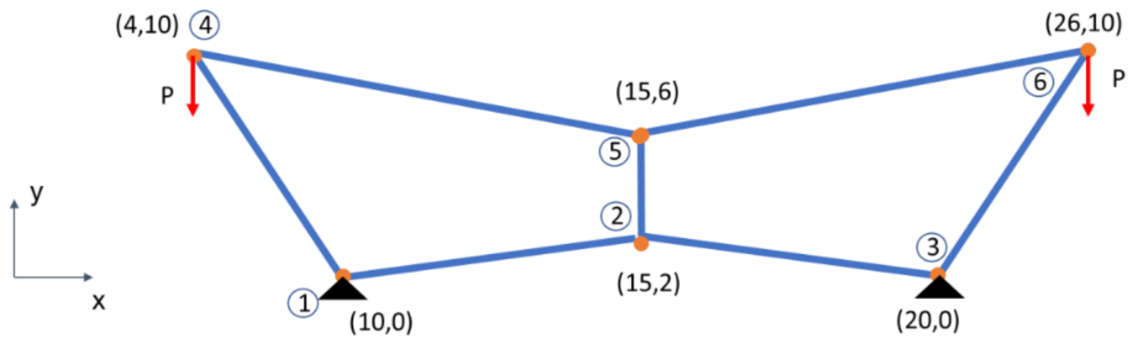
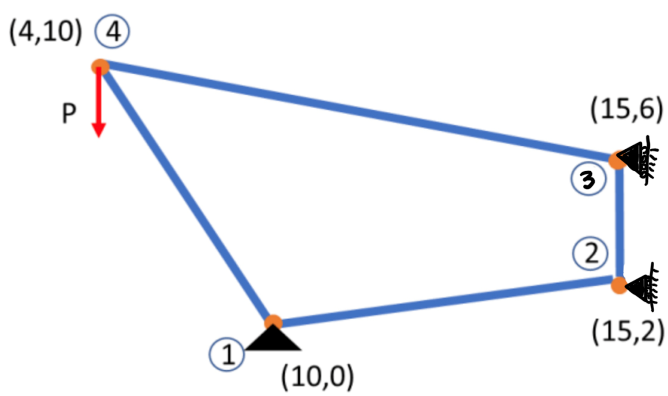
### *Problem Statement*

*Nodes 1 and 3 are fixed from displacements in both directions. Load P=10,000 lb. The modulus of elasticity and Poisson's ratio are 36,000 ksi and 0.25, respectively. Assuming that the out-of-plane thickness is 1 in and the plate is in plane stress condition. Use Gauss integration with nx=ny=2. Compute nodal displacements and stresses at Gauss points by taking advantage of the symmetry of the structure.*




*P = 10,000 lb = 10 kip*
*E = 36,000 ksi*
*v = 0.25*
*Out-of-plane thickness, t = 1 in*

### *Symmetrical Model*



## a. Global Stiffness Matrix [K]

K

8x8 double

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|---|
| 1 | 2.3193e+04 | 1.0670e+04 | -1.1569e+04 | -4.0544e+03 | -1.5046e+04 | -8.9654e+03 | 3.4212e+03 | 2.3501e+03 |
| 2 | 1.0670e+04 | 3.0230e+04 | -1.6544e+03 | -1.0501e+03 | -8.9654e+03 | -2.0675e+04 | -49.8671 | -8.5047e+03 |
| 3 | -1.1569e+04 | -1.6544e+03 | 2.1139e+04 | -693.6168 | -4.3560e+03 | -1.6767e+03 | -5.2142e+03 | 4.0247e+03 |
| 4 | -4.0544e+03 | -1.0501e+03 | -693.6168 | 2.2125e+04 | 723.3051 | -1.7625e+04 | 4.0247e+03 | -3.4499e+03 |
| 5 | -1.5046e+04 | -8.9654e+03 | -4.3560e+03 | 723.3051 | 2.6526e+04 | 1.1367e+04 | -7.1246e+03 | -3.1248e+03 |
| 6 | -8.9654e+03 | -2.0675e+04 | -1.6767e+03 | -1.7625e+04 | 1.1367e+04 | 3.4139e+04 | -724.8128 | 4.1616e+03 |
| 7 | 3.4212e+03 | -49.8671 | -5.2142e+03 | 4.0247e+03 | -7.1246e+03 | -724.8128 | 8.9176e+03 | -3.2501e+03 |
| 8 | 2.3501e+03 | -8.5047e+03 | 4.0247e+03 | -3.4499e+03 | -3.1248e+03 | 4.1616e+03 | -3.2501e+03 | 7.7930e+03 |

## b. Global Stiffness Matrix once Boundary Conditions are Applied [K]

K Kelim

4x4 double

| | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| 1 | 2.2125e+04 | -1.7625e+04 | 4.0247e+03 | -3.4499e+03 |
| 2 | -1.7625e+04 | 3.4139e+04 | -724.8128 | 4.1616e+03 |
| 3 | 4.0247e+03 | -724.8128 | 8.9176e+03 | -3.2501e+03 |
| 4 | -3.4499e+03 | 4.1616e+03 | -3.2501e+03 | 7.7930e+03 |

## c. Displacements (u,v)

| Displacements | | |
|---|---|---|
| Node | u | v |
| 1 | 0 | 0 |
| 2 | 0 | -1E-06 |
| 3 | 0 | 0.000185 |
| 4 | -0.00058 | -0.00162 |

## d. Stresses at each Gauss Point

| Stress | | | | | |
|---|---|---|---|---|---|
| Element | Gauss No | Global Nc | Stress-x | Stress-y | Stress-xy |
| 1 | 1 | 1 | -0.06399 | -3.70888 | 0.48694 |
| 1 | 2 | 2 | 0.615018 | -0.63796 | 0.655274 |
| 1 | 3 | 3 | 0.743063 | -2.47518 | 1.35672 |
| 1 | 4 | 4 | 1.634631 | 0.331405 | 1.91746 |

***Results and Explanation***

*It is noted that within the matrices, the displacements are in inches and the stresses are in ksi.*

This time we utilized symmetry to address the problem. This reduced the isoparametric elements from 2 to 1. This was done by redefining the nodes and using only the left element. The nodes were redefined counter clockwise as seen in the *symmetrical model*. We then placed restraints on nodes 2 and 3. These would prevent motion in the x direction. This is done to emulate the reactions of the full model. From then the same steps taken in HW 7b were taken with the difference of an 8x8 matrix as opposed to a 12x12. Producing displacements and stresses that are the same as 7b suggests that taking advantage of the symmetry is a successful alternative to solving 2 isoparametric elements.