Assignment 7

Samadrita Karmakar

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What kind of strategy (theory, elements, integration rule, boundary conditions, etc) will you use for solving the following problems:

Ans-a1

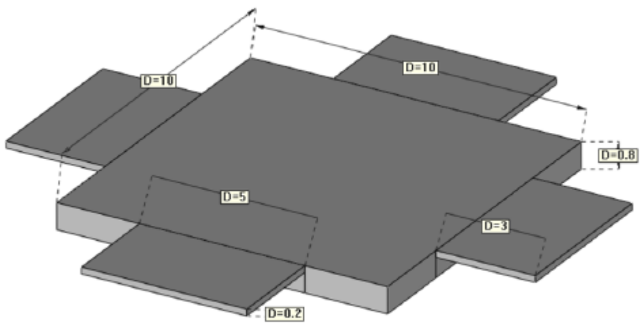


Figure 1: Problem a1

Theory:- Reissner Mindlin Plate Theory

For Problem a1, since the thin plates are attached on the top of the thicker plate, Reissner Mindlin plate theory is suggested to be used. This is due to the better ablity of Reissner Mindlin plate theory to capture the rotation about the mid-surface. It is will be better able to capture the movement of the top edge of the plate to which the thinner plates are attached.

Element:- 4 Node Quadrilateral Rectangular Element

4 Node Quadrilateral Rectangular Element with 5 degrees of freedom per node is to be used.

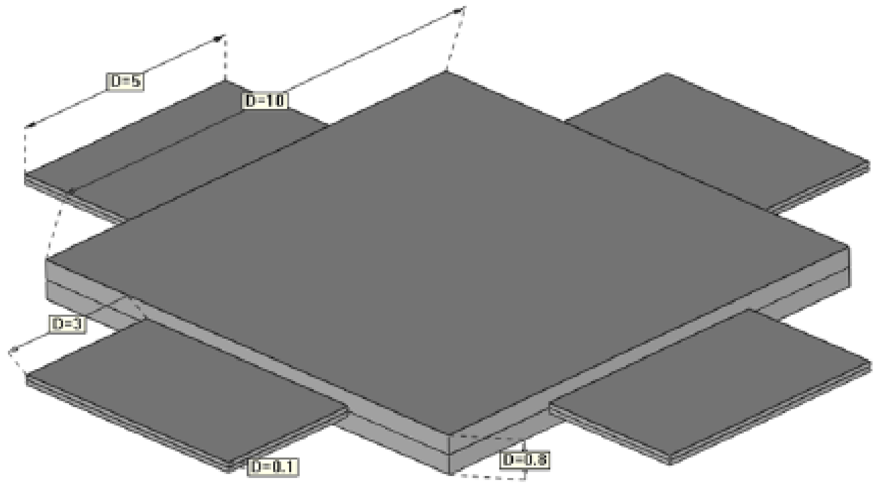
Integration:- Reduced Integration

Reduced Integration is suggested because the ratio between the Thickness and Characteristic Length is quite small. It is $\frac{8}{100}$. This will also ensure more accurate results for the thinner plates attached to the edges of the thicker plate.

Boundary Conditions

For Boundary Condition it may be assumed that the Force is applied at the middle of the thick plate and the plates are either clamped or simply supported at the outer edges of the thinner plates
if, clamped, the Boundary Conditions would be, $w = \theta_x = \theta_y = 0$
if, simply supported, the Boundary Conditions would be:
for strong support:$w = \theta_x = 0$ or $w = \theta_y = 0$
for weak support:$w = 0$

Ans-a2



Theory:- Kirchoff Plate Theory

For Problem a2, since the thin plates are attached to the middle of the thicker plate, Kirchoff plate theory is suggested to be used. This is because the thinner plates being fixed to the middle of the thicker plate will be less affected by the shear deformation of the plate edges about the mid-plane surface.

Element:- BFS Thin Element

BFS element has been chosen because of higher accuracy for Rectangular Shapes which would fit well with the kind of geometry given.

Intergration

Full Integration is suggested because the problem of a stiff stiffness matrix is not an issue for Kirchoff Plate Elements

Boundary Conditions

For Boundary Condition it may be assumed that the Force is applied at the middle of the thick plate and the plates are either clamped or simply supported at the outer edges of the thinner plates
if, clamped, the Boundary Conditions would be, $w = \theta_x = \theta_y = 0$
if, simply supported, the Boundary Conditions would be:
for strong support:$w = \theta_x = 0$ or $w = \theta_y = 0$
for weak support:$w = 0$

Ans-b: Patch Test Verification of MCZ Elements

The function in consideration is $w = \alpha_1 + \alpha_2 x + \alpha_3 y + \alpha_4 x^2 + \alpha_5 xy + \alpha_6 y^2 + \alpha_7 x^3 + \alpha_8 x^2 y + \alpha_9 xy^2 + \alpha_{10} y^3 + \alpha_{11} x^3 y + \alpha_1 2xy^3$

Value of α	Values
α_1	0.0001
α_2	0.00010204
α_3	0.000104122448646
α_4	0.000106248263557
α_5	0.000108418383602
α_6	0.000110633769457
α_7	0.00011289540417
α_8	0.000115204293743
α_9	0.000117561467735
$\alpha_1 0$	0.000119967979884
$\alpha_1 1$	0.000122424908747
$\alpha_1 2$	0.000124933358355

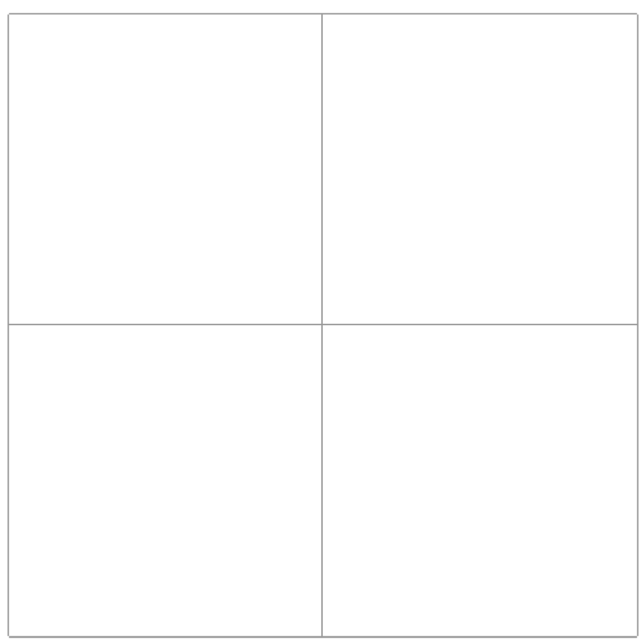


Figure 2: Mesh with 4 Elements and Disaplcements applied to the Nodes of the Left and Right Edges

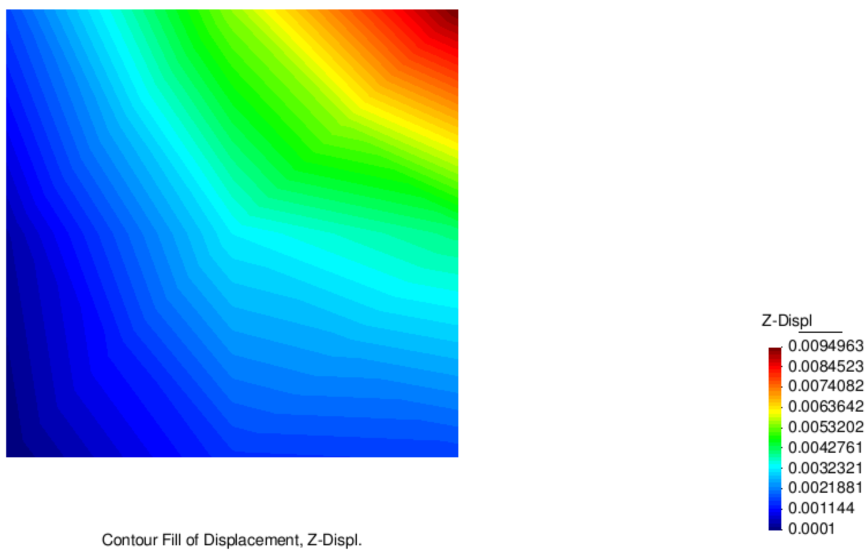


Figure 3: Results of Mesh with 4 Elements and Disaplcements applied to the Nodes of the Left and Right Edges

Values inserted in right side of the Geometry

x	y	x^2	y^2	x^3	y^3	Displacement (w)
2	0	4	0	8	0	0.001632236287589
2	1	4	1	8	1	0.004109003349906
2	2	4	4	8	8	0.009496292001644

Values inserted in left side of the Geometry

x	y	x^2	y^2	x^3	y^3	Displacement (w)
0	0	0	0	0	0	0.0001
0	1	0	1	0	1	0.000434724197988
0	2	0	4	0	8	0.001710523814197

Values obtained in Middle of the Geometry

x	y	x^2	y^2	x^3	y^3	Displacement (w)	FEM Approx	Error Percentage
1	0	1	0	1	0	0.000421183667727	0.0015403	2.65707437876907
1	1	1	1	1	1	0.001344450277896	0.0032872	1.44501418464022
1	2	1	4	1	8	0.004193515391886	0.0055477	0.322923485802401

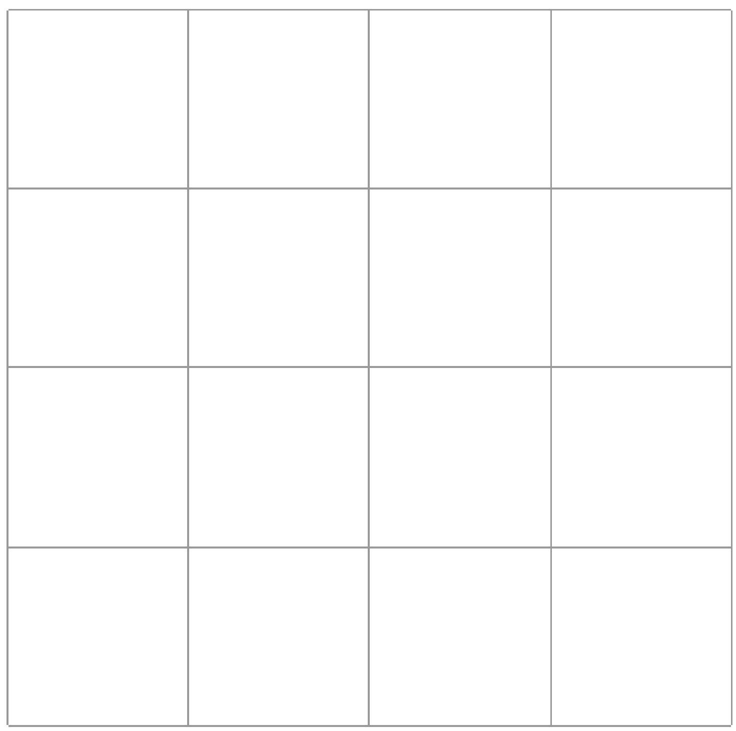


Figure 4: Mesh with 16 Elements and Disaplcements applied to the Nodes of the Left and Right Edges

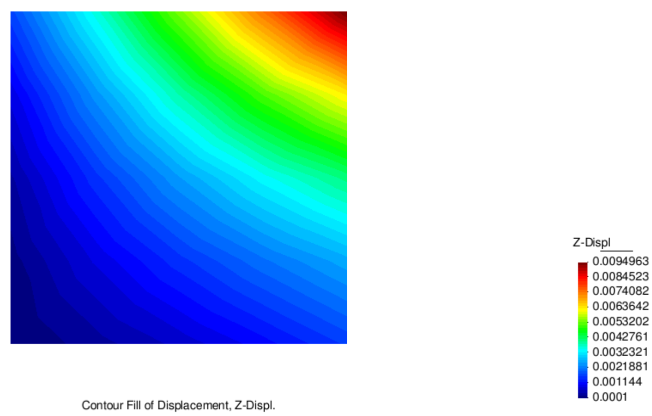


Figure 5: Result of Mesh with 16 Elements and Disaplcements applied to the Nodes of the Left and Right Edges

Values inserted in right side of the Geometry

x	y	x^2	y^2	x^3	y^3	Displacement (w)
2	0	4	0	8	0	0.001632236287589
2	0.5	4	0.25	8	0.125	0.002645492631293
2	1	4	1	8	1	0.004109003349906
2	1.5	4	2.25	8	3.375	0.006300144465875
2	2	4	4	8	8	0.009496292001644

Values inserted in left side of the Geometry

x	y	x^2	y^2	x^3	y^3	Displacement (w)
0	0	0	0	0	0	0.0001
0	0.5	0	0.25	0	0.125	0.000194715664173
0	1	0	1	0	1	0.000434724197988
0	1.5	0	2.25	0	3.375	0.000910001586359
0	2	0	4	0	8	0.001710523814197

Values obtained in Middle of the Geometry

x	y	x^2	y^2	x^3	y^3	Displacement (w)	FEM Approx	Error Percentage
1	0	1	0	1	0	0.000421183667727	0.00071349	0.694011555221675
1	0.5	1	0.25	1	0.125	0.000733930161674	0.0015129	1.06136779628961
1	1	1	1	1	1	0.001344450277896	0.0025127	0.868942304011159
1	1.5	1	2.25	1	3.375	0.002436420020074	0.0038435	0.57751946229836
1	2	1	4	1	8	0.004193515391886	0.0054305	0.294975573598057

Conclusion

Hence if we compare the Error Percentage from the Coordinates (1,0), (1,1), and (1,2) for 16 elements against the Error Percentage of the same the Coordinates for 4 elements we see a drop in the error precentage hence the values are converging and hence the MCZ elements pass the patch test.