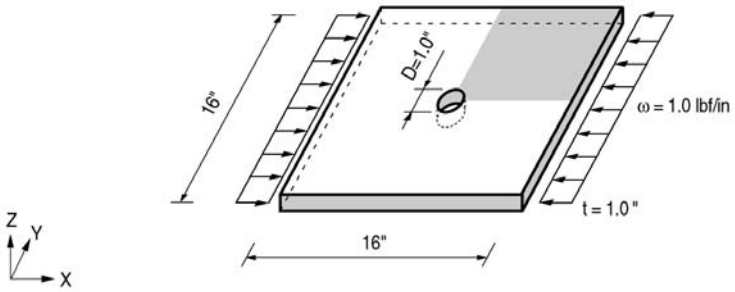
Static-18

Title

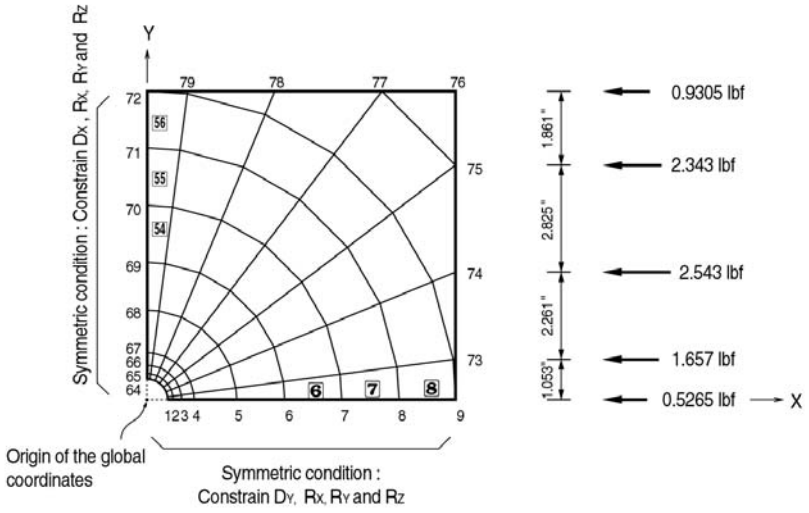
Stress concentration around a hole in a square plate

Description

Find the stress distribution in a square plate due to the effects of a circular hole at the center under an in-plane uniform line load.
Only a quarter model may be analyzed due to symmetry.



(a) Square plate with a hole



(b) Quarter model

Structural geometry and analysis model

Model

Analysis Type

2-D static analysis

Unit System

in, lbf

Dimension

Length 8.0 in Width 8.0 in

Thickness 1.0 in Radius of the hole 0.5 in

Element

Plate element (Thick type)

Material

Modulus of elasticity $E = 1.0$ psi

Poisson's ratio $\nu = 0.1$

Boundary Condition

Nodes 1 ~ 9 ; Constrain Dy, Rx, Ry and Rz (symmetric about X-axis)

Nodes 64 ~ 72 ; Constrain Dx, Rx, Ry and Rz (symmetric about Y-axis)

Load Case

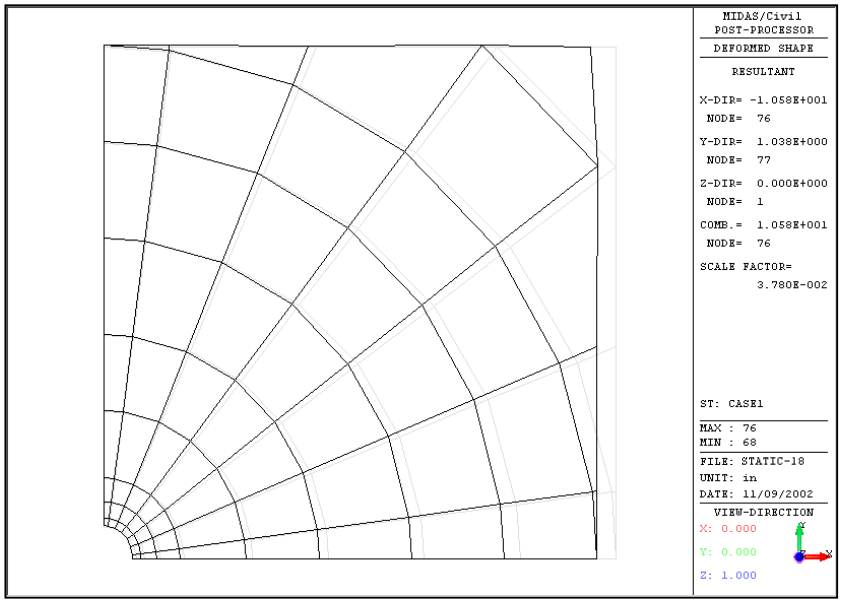
In-plane uniform compression in the X direction = 1.0 lbf/in

The line load is converted to equivalent nodal forces based on tributary length.

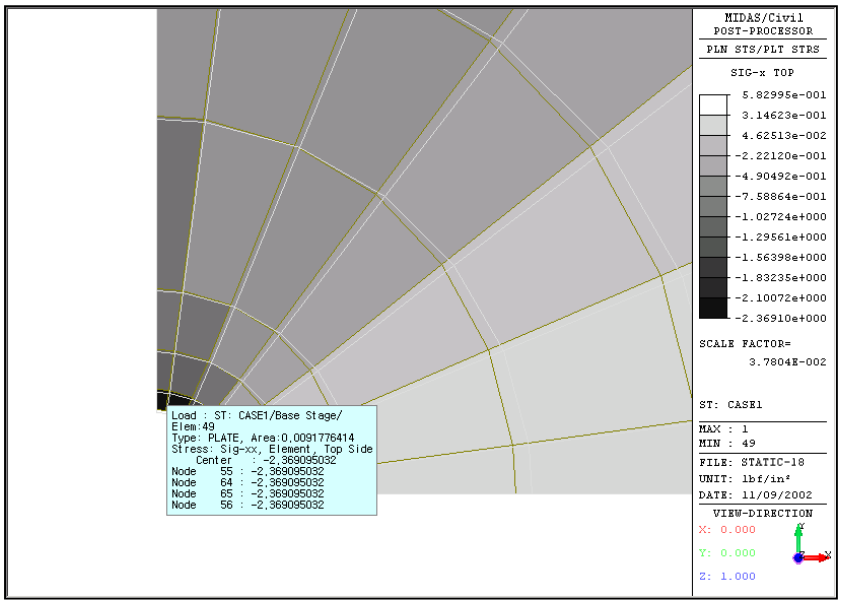
Refer to the figures shown above.

Equivalent loads : Node 9 ; 0.5265 lbf, Node 73 ; 1.657 lbf, Node 74 ; 2.543 lbf,
Node 75 ; 2.343 lbf, Node 76 ; 0.9305 lbf

Results



Deformed shape of the structure



x-stresses of the plate around the hole

Stresses around the hole

	Elem	Load	Node	Part	Sig-xx (lbf/in²)	Sig-yy (lbf/in²)	Sig-xy (lbf/in²)	Sig-Max (lbf/in²)	Sig-Min (lbf/in²)	Angle ([deg])	Sig-EFF (lbf/in²)
▶	49	CASE1	Cent	Top	-2,3691	-0,2063	0,0457	-0,2053	-2,3701	88,7909	2,2744
				Bot	-2,3691	-0,2063	0,0457	-0,2053	-2,3701	88,7909	2,2744
	50	CASE1	Cent	Top	-1,5487	-0,3467	0,0834	-0,3409	-1,5544	86,0506	1,4151
				Bot	-1,5487	-0,3467	0,0834	-0,3409	-1,5544	86,0506	1,4151
	51	CASE1	Cent	Top	-1,1909	-0,2539	0,0857	-0,2462	-1,1987	84,8154	1,0966
				Bot	-1,1909	-0,2539	0,0857	-0,2462	-1,1987	84,8154	1,0966
	52	CASE1	Cent	Top	-1,0569	-0,1147	0,0753	-0,1087	-1,0629	85,4583	1,0129
				Bot	-1,0569	-0,1147	0,0753	-0,1087	-1,0629	85,4583	1,0129
	53	CASE1	Cent	Top	-1,0162	-0,0448	0,0696	-0,0398	-1,0211	85,9227	1,0018
				Bot	-1,0162	-0,0448	0,0696	-0,0398	-1,0211	85,9227	1,0018
	54	CASE1	Cent	Top	-1,0025	-0,0240	0,0661	-0,0196	-1,0069	86,1516	0,9973
				Bot	-1,0025	-0,0240	0,0661	-0,0196	-1,0069	86,1516	0,9973
	55	CASE1	Cent	Top	-1,0002	-0,0136	0,0682	-0,0089	-1,0049	86,0623	1,0005
				Bot	-1,0002	-0,0136	0,0682	-0,0089	-1,0049	86,0623	1,0005
	56	CASE1	Cent	Top	-0,9927	-0,0053	0,0662	0,0000	-0,9971	86,1816	0,9967
				Bot	-0,9927	-0,0053	0,0662	0,0000	-0,9971	86,1816	0,9967

Comparison of Results

Unit :psi

Element	Average X stress		
	Theoretical	NISA II	MIDAS/Civil
49	2.3315	2.368	2.3691
50	1.5185	1.550	1.5487
51	1.1843	1.191	1.1909
52	1.0508	1.059	1.0569
53	1.0165	1.019	1.0162
54	1.0072	1.006	1.0025
55	1.0039	0.998	1.0002
56	1.0024	0.989	0.9927

References

Timoshenko, S. and Goodier, J. N., "*Theory of Elasticity*", McGraw-Hill, New York, 1951, pp 78-80.

"*NISA II, Verification Manual*", Version 91.0, Engineering Mechanics Research Corporation, 1991.