EJEMPLO No 3 == PLACA CON AGUJERO TP = ELEMENTOS 4 NODOS - v2018

Cell 13. Plate with circular hole, 4-node bilinear quad model

1.- DATOS MALLA DE ELEMENTOS FINITOS

- **NODOS**

```
s = {1, 0.70, 0.48, 0.30, 0.16, 0.07, 0.0};
xy1 = {0, 6}; xy7 = {0, 1}; xy8 = {2.5, 6}; xy14 = {Cos[3 * Pi / 8], Sin[3 * Pi / 8]};
xy8 = {2.5, 6}; xy21 = {Cos[Pi / 4], Sin[Pi / 4]}; xy15 = {5, 6};
xy22 = {5, 2}; xy28 = {Cos[Pi / 8], Sin[Pi / 8]}; xy29 = {5, 0}; xy35 = {1, 0};
NodeCoordinates = Table[{0, 0}, {35}];
Do[NodeCoordinates[[n]] = N[s[[n]]  * xy1 + (1 - s[[n]])  * xy7], {n, 1, 7}];
Do[NodeCoordinates[[n]] = N[s[[n - 7]] * xy8 + (1 - s[[n - 7]])  * xy14], {n, 8, 14}];
Do[NodeCoordinates[[n]] = N[s[[n - 14]] * xy15 + (1 - s[[n - 14]]) * xy21], {n, 15, 21}];
Do[NodeCoordinates[[n]] = N[s[[n - 21]] * xy22 + (1 - s[[n - 21]]) * xy28], {n, 22, 28}];
Do[NodeCoordinates[[n]] = N[s[[n - 28]] * xy29 + (1 - s[[n - 28]]) * xy35], {n, 29, 35}];
PrintPlaneStressNodeCoordinates[NodeCoordinates, "", {6, 4}];
```

node	x-coor	y-coor
1	0.0000	6.0000
2	0.0000	4.5000
3	0.0000	3.4000
4	0.0000	2.5000
5	0.0000	1.8000
6	0.0000	1.3500
7	0.0000	1.0000
8	2.5000	6.0000
9	1.8648	4.4772
10	1.3990	3.3604
11	1.0179	2.4467
12	0.7215	1.7361
13	0.5309	1.2792
14	0.3827	0.9239
15	5.0000	6.0000
16	3.7121	4.4121
17	2.7677	3.2477
18	1.9950	2.2950
19	1.3940	1.5540
20	1.0076	1.0776
21	0.7071	0.7071
22	5.0000	2.0000
23	3.7772	1.5148
24	2.8804	1.1590
25	2.1467	0.8679
26	1.5761	0.6415
27	1.2092	0.4959
28	0.9239	0.3827
29	5.0000	0.0000
30	3.8000	0.0000
31	2.9200	0.0000
32	2.2000	0.0000
33	1.6400	0.0000
34	1.2800	0.0000
35	1.0000	0.0000

```
numnod = Length[NodeCoordinates];
```

ELEMENTOS

```
ElemNodes = Table[{0, 0, 0, 0}, {24}];
ElemNodes[[1]] = {1, 2, 9, 8};
Do [ElemNodes[[e]] = ElemNodes[[e - 1]] + {1, 1, 1, 1}, {e, 2, 6}];
ElemNodes[[7]] = ElemNodes[[6]] + {2, 2, 2, 2};
Do [ElemNodes[[e]] = ElemNodes[[e - 1]] + {1, 1, 1, 1}, {e, 8, 12}];
ElemNodes[[13]] = ElemNodes[[12]] + {2, 2, 2, 2};
Do [ElemNodes[[e]] = ElemNodes[[e - 1]] + {1, 1, 1, 1}, {e, 14, 18}];
ElemNodes[[19]] = ElemNodes[[18]] + {2, 2, 2, 2};
Do [ElemNodes[[e]] = ElemNodes[[e - 1]] + {1, 1, 1, 1}, {e, 20, 24}];
```

```
numele = Length[ElemNodes];
```

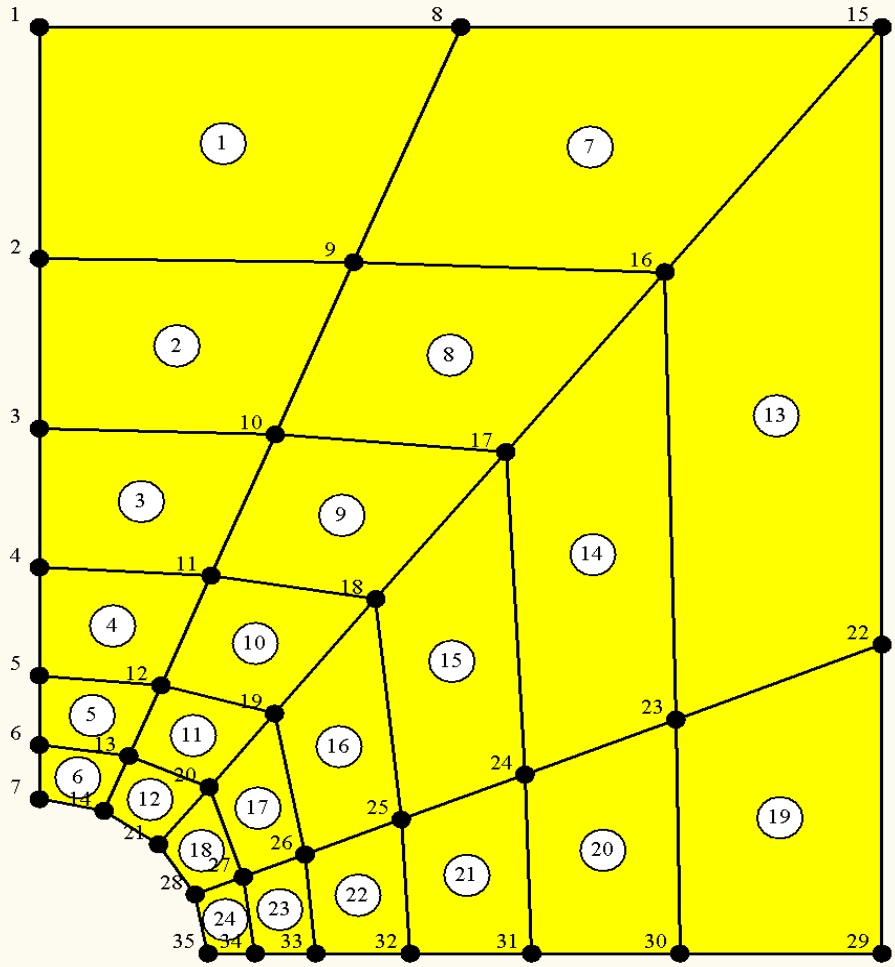
```
ElemTypes =    Table["Quad4", {numele}];
PrintPlaneStressElementTypeNodes[ElemTypes, ElemNodes, "", {}];
```

elem	type	node-list
1	Quad4	{1, 2, 9, 8}
2	Quad4	{2, 3, 10, 9}
3	Quad4	{3, 4, 11, 10}
4	Quad4	{4, 5, 12, 11}
5	Quad4	{5, 6, 13, 12}
6	Quad4	{6, 7, 14, 13}
7	Quad4	{8, 9, 16, 15}
8	Quad4	{9, 10, 17, 16}
9	Quad4	{10, 11, 18, 17}
10	Quad4	{11, 12, 19, 18}
11	Quad4	{12, 13, 20, 19}
12	Quad4	{13, 14, 21, 20}
13	Quad4	{15, 16, 23, 22}
14	Quad4	{16, 17, 24, 23}
15	Quad4	{17, 18, 25, 24}
16	Quad4	{18, 19, 26, 25}
17	Quad4	{19, 20, 27, 26}
18	Quad4	{20, 21, 28, 27}
19	Quad4	{22, 23, 30, 29}
20	Quad4	{23, 24, 31, 30}
21	Quad4	{24, 25, 32, 31}
22	Quad4	{25, 26, 33, 32}
23	Quad4	{26, 27, 34, 33}
24	Quad4	{27, 28, 35, 34}

■ VISUALIZACION DE LA MALLA DE ELEMENTOS FINITOS

```
aspect = 6 / 5;
ProcessOptions = {True};
Plot2DElementsAndNodes[NodeCoordinates, ElemNodes, aspect,
  "One element mesh - 4-node quad", True, True];
```

One element mesh – 4–node quad



2.- DATOS DEL PROBLEMA TENSION PLANA

■ MATERIAL

```
ClearAll[Em, v, th, Nsub];
Em = 10 000; v = .25;  Nsub = 4;
Emat = Em / (1 - v^2) * {{1, v, 0}, {v, 1, 0}, {0, 0, (1 - v) / 2}};
```

ASIGNACION DE MATERIAL Y ESPESOR A ELEMENTOS

```
th = 3;
```

```
ElemMaterials =  Table[Emat,  {numele}];
ElemFabrications = Table[th,   {numele}];
PrintPlaneStressElementMatFab[ElemMaterials, ElemFabrications, "", {}];
```

elem		material	fabrication
1	{{10666.7, 2666.67, 0.}, {2666.67, 10666.7, 0.}, {0., 0., 4000.}}		3
2	{{10666.7, 2666.67, 0.}, {2666.67, 10666.7, 0.}, {0., 0., 4000.}}		3
3	{{10666.7, 2666.67, 0.}, {2666.67, 10666.7, 0.}, {0., 0., 4000.}}		3
4	{{10666.7, 2666.67, 0.}, {2666.67, 10666.7, 0.}, {0., 0., 4000.}}		3
5	{{10666.7, 2666.67, 0.}, {2666.67, 10666.7, 0.}, {0., 0., 4000.}}		3
6	{{10666.7, 2666.67, 0.}, {2666.67, 10666.7, 0.}, {0., 0., 4000.}}		3
7	{{10666.7, 2666.67, 0.}, {2666.67, 10666.7, 0.}, {0., 0., 4000.}}		3
8	{{10666.7, 2666.67, 0.}, {2666.67, 10666.7, 0.}, {0., 0., 4000.}}		3
9	{{10666.7, 2666.67, 0.}, {2666.67, 10666.7, 0.}, {0., 0., 4000.}}		3
10	{{10666.7, 2666.67, 0.}, {2666.67, 10666.7, 0.}, {0., 0., 4000.}}		3
11	{{10666.7, 2666.67, 0.}, {2666.67, 10666.7, 0.}, {0., 0., 4000.}}		3
12	{{10666.7, 2666.67, 0.}, {2666.67, 10666.7, 0.}, {0., 0., 4000.}}		3
13	{{10666.7, 2666.67, 0.}, {2666.67, 10666.7, 0.}, {0., 0., 4000.}}		3
14	{{10666.7, 2666.67, 0.}, {2666.67, 10666.7, 0.}, {0., 0., 4000.}}		3
15	{{10666.7, 2666.67, 0.}, {2666.67, 10666.7, 0.}, {0., 0., 4000.}}		3
16	{{10666.7, 2666.67, 0.}, {2666.67, 10666.7, 0.}, {0., 0., 4000.}}		3
17	{{10666.7, 2666.67, 0.}, {2666.67, 10666.7, 0.}, {0., 0., 4000.}}		3
18	{{10666.7, 2666.67, 0.}, {2666.67, 10666.7, 0.}, {0., 0., 4000.}}		3
19	{{10666.7, 2666.67, 0.}, {2666.67, 10666.7, 0.}, {0., 0., 4000.}}		3
20	{{10666.7, 2666.67, 0.}, {2666.67, 10666.7, 0.}, {0., 0., 4000.}}		3
21	{{10666.7, 2666.67, 0.}, {2666.67, 10666.7, 0.}, {0., 0., 4000.}}		3
22	{{10666.7, 2666.67, 0.}, {2666.67, 10666.7, 0.}, {0., 0., 4000.}}		3
23	{{10666.7, 2666.67, 0.}, {2666.67, 10666.7, 0.}, {0., 0., 4000.}}		3
24	{{10666.7, 2666.67, 0.}, {2666.67, 10666.7, 0.}, {0., 0., 4000.}}		3

ASIGNACION DE CONDICIONES DE CONTORNO EN DESPLAZAMIENTOS

INICIALIZACION

```
NodeDOFValues = NodeDOFTags = Table[{0, 0}, {numnod}];
```

DEFINICION CONDICIONES DE CONTORNO EN DESPLAZAMIENTOS

```
NodeDOFValues[[1]] = NodeDOFValues[[15]] = {0, 37.5};
NodeDOFValues[[8]] = {0, 75}; (* nodal loads *)
Do[NodeDOFTags[[n]] = {1, 0}, {n, 1, 7}];  (* vroller @ nodes 1-7 *)
Do[NodeDOFTags[[n]] = {0, 1}, {n, 29, 35}]; (* hroller @ node 4 *)
```

LISTADO DE CONDICIONES DE CONTORNO

```
PrintPlaneStressFreedomActivity[NodeDOFTags, NodeDOFValues, "", {}];
```

node	x-tag	y-tag	x-value	y-value
1	1	0	0.00	37.50
2	1	0	0.00	0.00
3	1	0	0.00	0.00
4	1	0	0.00	0.00
5	1	0	0.00	0.00
6	1	0	0.00	0.00
7	1	0	0.00	0.00
8	0	0	0.00	75.00
9	0	0	0.00	0.00
10	0	0	0.00	0.00
11	0	0	0.00	0.00
12	0	0	0.00	0.00
13	0	0	0.00	0.00
14	0	0	0.00	0.00
15	0	0	0.00	37.50
16	0	0	0.00	0.00
17	0	0	0.00	0.00
18	0	0	0.00	0.00
19	0	0	0.00	0.00
20	0	0	0.00	0.00
21	0	0	0.00	0.00
22	0	0	0.00	0.00
23	0	0	0.00	0.00
24	0	0	0.00	0.00
25	0	0	0.00	0.00
26	0	0	0.00	0.00
27	0	0	0.00	0.00
28	0	0	0.00	0.00
29	0	1	0.00	0.00
30	0	1	0.00	0.00
31	0	1	0.00	0.00
32	0	1	0.00	0.00
33	0	1	0.00	0.00
34	0	1	0.00	0.00
35	0	1	0.00	0.00

3.- SOLUCION DEL PROBLEMA Y VISUALIZACION DE RESULTADOS

SOLUCION DEL PROBLEMA

```
{NodeDisplacements, NodeForces, NodePlateCounts, NodePlateStresses,
  ElemBarNumbers, ElemBarForces} = PlaneStressSolution[
  NodeCoordinates, ElemTypes, ElemNodes,
  ElemMaterials, ElemFabrications,
  NodeDOFTags, NodeDOFValues, ProcessOptions];
```

IMPRESION DE RESULTADOS

```
PrintPlaneStressSolution[NodeDisplacements, NodeForces, NodePlateCounts,
   NodePlateStresses, "Computed Solution:", {}];
```

Computed Solution:

node	x-displ	y-displ	x-force	y-force	sigma-xx	sigma-yy	sigma-xy
1	0.0000	0.0068	-3.6391	37.5000	1.2585	9.8731	-0.4873
2	0.0000	0.0054	-2.7945	0.0000	0.4050	9.3935	-0.5099
3	0.0000	0.0044	-1.1260	0.0000	-0.0033	8.4458	-0.6625
4	0.0000	0.0037	-0.5910	0.0000	-0.3640	6.7554	-1.0674
5	0.0000	0.0033	0.2452	0.0000	-0.8546	4.2540	-1.8444
6	0.0000	0.0031	3.0825	0.0000	-2.2196	2.1605	-2.6461
7	0.0000	0.0031	4.8229	0.0000	-9.9308	-0.1615	-2.5270
8	-0.0003	0.0065	0.0000	75.0000	0.7641	9.9804	-0.1998
9	-0.0004	0.0051	0.0000	0.0000	0.2857	9.8198	-0.3665
10	-0.0003	0.0041	0.0000	0.0000	-0.1979	9.4363	-0.7487
11	-0.0002	0.0034	0.0000	0.0000	-0.7317	8.6116	-1.2902
12	-0.0001	0.0029	0.0000	0.0000	-1.4644	7.1088	-2.1153
13	-0.0001	0.0028	0.0000	0.0000	-2.1263	4.9133	-2.1568
14	-0.0004	0.0028	0.0000	0.0000	-5.3628	2.7117	-1.0698
15	-0.0009	0.0060	0.0000	37.5000	0.1060	10.1883	-0.1601
16	-0.0008	0.0047	0.0000	0.0000	-0.0371	10.4361	-0.2913
17	-0.0007	0.0036	0.0000	0.0000	-0.6415	10.8367	-0.4821
18	-0.0006	0.0028	0.0000	0.0000	-1.4072	11.4247	-0.8604
19	-0.0005	0.0022	0.0000	0.0000	-2.1731	12.1470	-1.5842
20	-0.0005	0.0020	0.0000	0.0000	-1.6366	11.4725	-2.8260
21	-0.0007	0.0021	0.0000	0.0000	0.3263	11.6935	-4.3439
22	-0.0016	0.0019	0.0000	0.0000	-0.0913	9.9034	0.1309
23	-0.0013	0.0016	0.0000	0.0000	0.0384	10.5277	0.1585
24	-0.0012	0.0013	0.0000	0.0000	0.2133	11.1951	0.2870
25	-0.0010	0.0010	0.0000	0.0000	0.6184	12.1845	0.3171
26	-0.0010	0.0009	0.0000	0.0000	1.2966	13.8983	-0.0304
27	-0.0010	0.0009	0.0000	0.0000	1.6129	16.0498	-1.9466
28	-0.0010	0.0011	0.0000	0.0000	3.8942	23.5111	-5.2303
29	-0.0018	0.0000	0.0000	-17.0383	0.0773	9.6837	0.4312
30	-0.0015	0.0000	0.0000	-32.3323	0.4677	10.5940	0.4582
31	-0.0013	0.0000	0.0000	-26.5603	1.1280	11.3385	0.6107
32	-0.0012	0.0000	0.0000	-23.1720	2.0977	12.4323	0.9501
33	-0.0012	0.0000	0.0000	-19.6324	2.9528	14.5548	1.4487
34	-0.0012	0.0000	0.0000	-18.7140	2.0971	18.6807	1.5333
35	-0.0011	0.0000	0.0000	-12.5508	3.2638	30.6544	0.6186

4. - VISUALIZACION DE LOS DESPLAZAMIENTOS NODALES

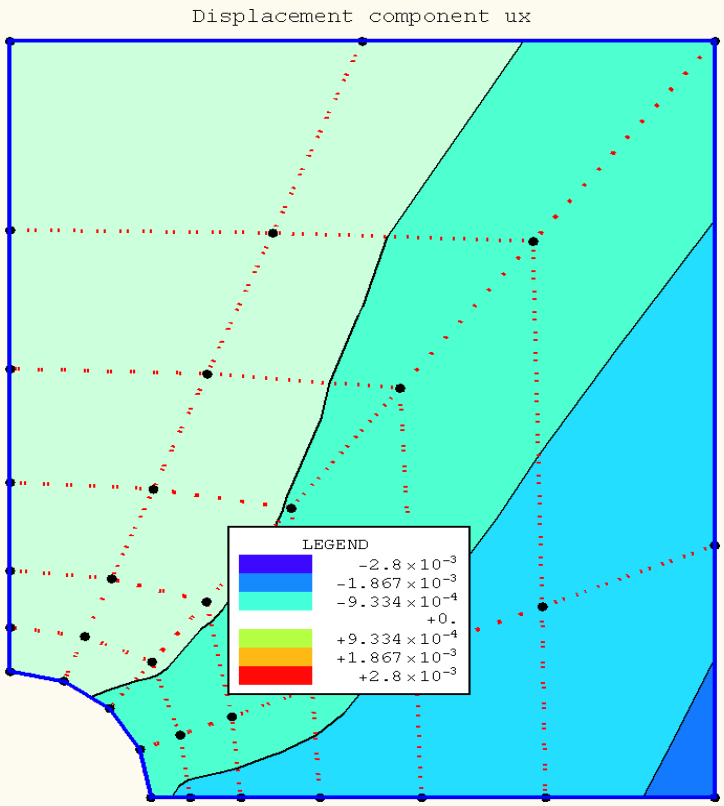
CALCULO DE LOS VALORES MAXIMOS Y MINIMOS DE LOS DESPLAZAMIENTOS

```
ueps = 10.^(-3); nbands = 10;
ux = Table[NodeDisplacements[[n, 1]], {n, numnod}];
uy = Table[NodeDisplacements[[n, 2]], {n, numnod}];
{uxmax, uymax} = Abs[{Max[ux], Max[uy]}] + ueps;
{uxmin, uymin} = Abs[{Min[ux], Min[uy]}] + ueps;
uxmax = Max[uxmax, uxmin];  uxmin = -uxmax;
uymax = Max[uymax, uymin];  uymin = -uymax;
{uxinc, uyinc} = {uxmax - uxmin, uymax - uymin} / nbands;
```

VISUALIZACION DESPLAZAMIENTOS NODALES - X e Y

```
Print["uxmin,uxmax,uxinc=", {uxmin, uxmax, uxinc}];
ContourBandPlotNodeFuncOver2DMesh[NodeCoordinates, ElemNodes, ux, {uxmin, uxmax, uxinc},
 {True, True, True, False, True, True}, {2, 2}, aspect, "Displacement component ux"];
```

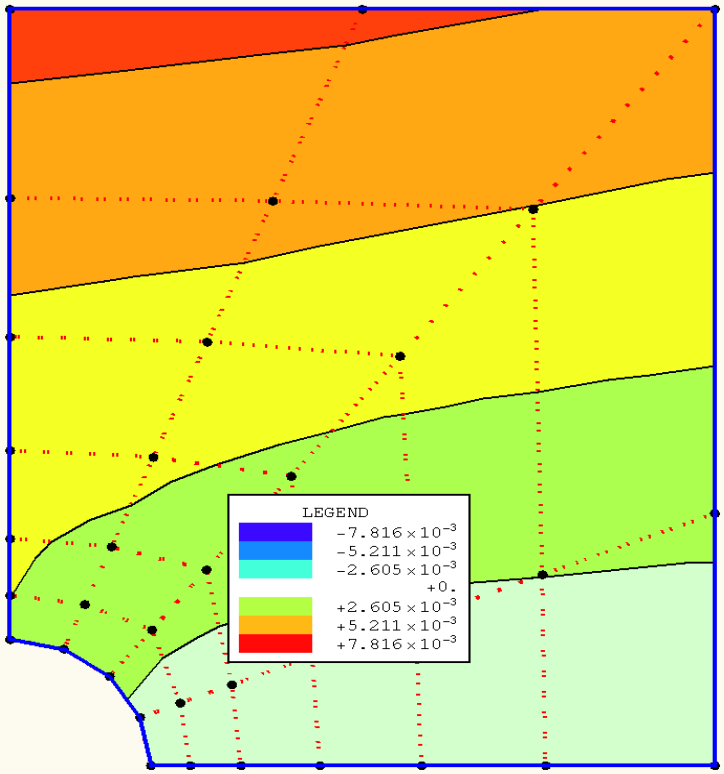
```
uxmin,uxmax,uxinc={-0.00280024, 0.00280024, 0.000560049}
```




```
Print["uymin,uymax,uyinc=", {uymin, uymax, uyinc}];
ContourBandPlotNodeFuncOver2DMesh[NodeCoordinates, ElemNodes, uy, {uymin, uymax, uyinc},
 {True, True, True, False, True, True}, {2, 2}, aspect, "Displacement component uy"];
```

```
uymin,uymax,uyinc={-0.00781581, 0.00781581, 0.00156316}
```

Displacement component uy



5. - VISUALIZACION DE LAS TENSIONES - NODALES - NORMALES Y TANGENCIALES

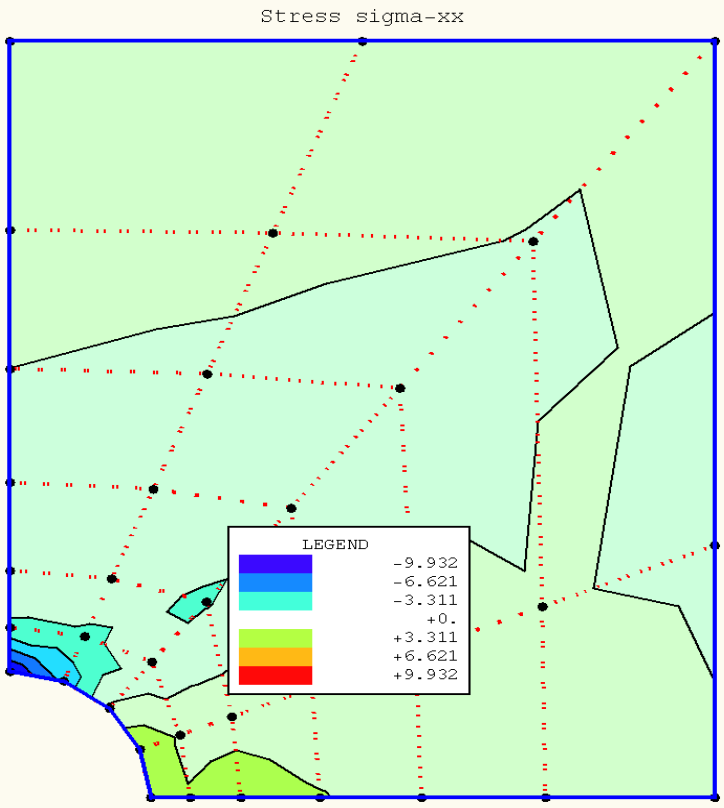
CALCULO DE LOS VALORES MAXIMOS Y MINIMOS DE LAS TENSIONES NORMALES Y TANGENCIALES

```
sigeps = 10.^(-3); nbands = 10;
sxx = Table[NodePlateStresses[[n, 1]], {n, numnod}];
syy = Table[NodePlateStresses[[n, 2]], {n, numnod}];
sxy = Table[NodePlateStresses[[n, 3]], {n, numnod}];
{sxxmax, syymax, sxymax} = Abs[{Max[sxx], Max[syy], Max[sxy]}] + sigeps;
{sxxmin, syymin, sxymin} = Abs[{Min[sxx], Min[syy], Min[sxy]}] + sigeps;
sxxmax = Max[sxxmax, sxxmin];  sxxmin = -sxxmax;
syymax = Max[syymax, syymin];  syymin = -syymax;
sxymax = Max[sxymax, sxymin];  sxymin = -sxymax;
{sxxinc, syyinc, sxyinc} = {sxxmax - sxxmin, syymax - syymin, sxymax - sxymin} / nbands;
```

VISUALIZACION TENSIONES NODALES - NORMALES Y TANGENCIALES

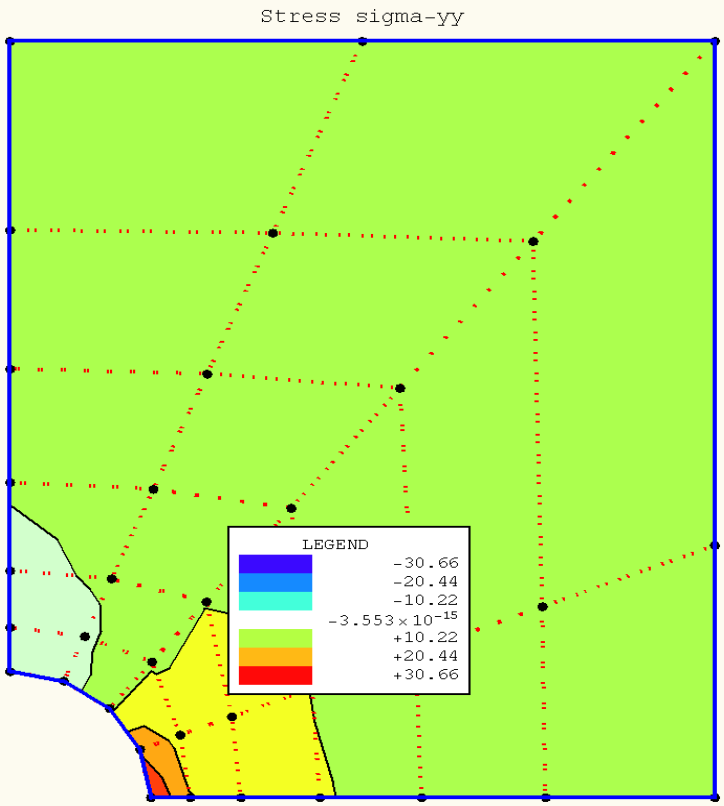
```
Print["sxxmin,sxxmax,sxxinc=", {sxxmin, sxxmax, sxxinc}];
ContourBandPlotNodeFuncOver2DMesh[NodeCoordinates, ElemNodes, sxx, {sxxmin, sxxmax, sxxinc},
 {True, True, True, False, True, True}, {2, 2}, aspect, "Stress sigma-xx"];
```

```
sxxmin,sxxmax,sxxinc={-9.93177, 9.93177, 1.98635}
```




```
Print["syymin,syymax,syyinc=", {syymin, syymax, syyinc}];
ContourBandPlotNodeFuncOver2DMesh[NodeCoordinates, ElemNodes, syy, {syymin, syymax, syyinc},
 {True, True, True, False, True, True}, {2, 2}, aspect, "Stress sigma-yy"];
```

```
syymin,syymax,syyinc={-30.6554, 30.6554, 6.13108}
```




```
Print["sxymin,sxymax,sxyinc=", {sxymin, sxymax, sxyinc}];
ContourBandPlotNodeFuncOver2DMesh[NodeCoordinates, ElemNodes, sxy, {sxymin, sxymax, sxyinc},
 {True, True, True, False, True, True}, {2, 2}, aspect, "Stress sigma-xy"];
```

```
sxymin,sxymax,sxyinc={-5.23127, 5.23127, 1.04625}
```

Stress sigma-xy