EJEMPLO No 4 == PLACA CON AGUJERO TP = ELEMENTOS 9 NODOS - v2018

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, 0, 0, 0, 0, 0}, {6}];
ElemNodes[[1]] = {1, 3, 17, 15, 2, 10, 16, 8, 9};
Do [ElemNodes[[e]] = ElemNodes[[e - 1]] + {2, 2, 2, 2, 2, 2, 2, 2, 2}, {e, 2, 3}];
ElemNodes[[4]] = ElemNodes[[3]] + {10, 10, 10, 10, 10, 10, 10, 10, 10};
Do [ElemNodes[[e]] = ElemNodes[[e - 1]] + {2, 2, 2, 2, 2, 2, 2, 2, 2}, {e, 5, 6}];
```

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

```
6
```

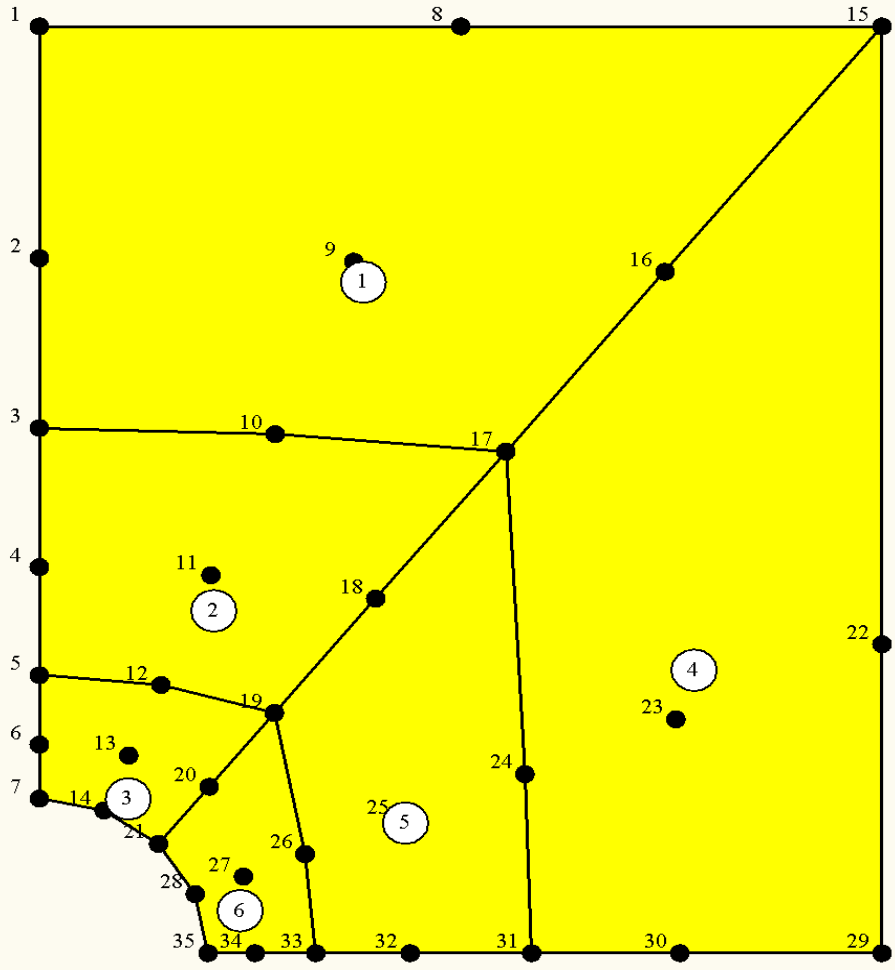
```
ElemTypes =    Table["Quad9", {numele}];
PrintPlaneStressElementTypeNodes[ElemTypes, ElemNodes, "", {}];
```

elem	type	node-list
1	Quad9	{1, 3, 17, 15, 2, 10, 16, 8, 9}
2	Quad9	{3, 5, 19, 17, 4, 12, 18, 10, 11}
3	Quad9	{5, 7, 21, 19, 6, 14, 20, 12, 13}
4	Quad9	{15, 17, 31, 29, 16, 24, 30, 22, 23}
5	Quad9	{17, 19, 33, 31, 18, 26, 32, 24, 25}
6	Quad9	{19, 21, 35, 33, 20, 28, 34, 26, 27}

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

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	0.0078	-10.5038	37.5000	2.0736	16.5947	-5.4255
2	0.0000	0.0056	5.6253	0.0000	0.6560	13.3107	-1.9606
3	0.0000	0.0044	-0.4823	0.0000	0.1015	8.4378	-0.9868
4	0.0000	0.0037	-0.7020	0.0000	0.6144	7.2829	-0.8608
5	0.0000	0.0033	-0.5749	0.0000	0.5391	3.4968	-1.2331
6	0.0000	0.0031	3.6583	0.0000	-0.6006	2.2331	-1.2764
7	0.0000	0.0031	2.9795	0.0000	-10.4859	-1.3762	-0.3997
8	-0.0006	0.0060	0.0000	75.0000	-0.9088	6.8627	-0.3385
9	-0.0005	0.0049	0.0000	0.0000	-0.1871	8.2056	-0.9225
10	-0.0003	0.0040	0.0000	0.0000	-0.0754	9.4921	-1.1264
11	-0.0002	0.0033	0.0000	0.0000	-0.4898	8.4400	-1.4615
12	-0.0001	0.0029	0.0000	0.0000	-1.2616	6.9810	-2.5251
13	-0.0001	0.0028	0.0000	0.0000	-1.9250	4.5168	-2.2702
14	-0.0004	0.0028	0.0000	0.0000	-4.4848	-0.9887	0.1468
15	-0.0013	0.0072	0.0000	37.5000	-0.9685	10.8489	3.0075
16	-0.0008	0.0047	0.0000	0.0000	0.0366	11.5619	0.6999
17	-0.0007	0.0036	0.0000	0.0000	-0.3764	9.6402	-0.8947
18	-0.0005	0.0028	0.0000	0.0000	-1.3508	11.5065	-0.9350
19	-0.0004	0.0022	0.0000	0.0000	-2.7235	12.6581	-1.6163
20	-0.0004	0.0020	0.0000	0.0000	-1.6434	11.7670	-2.9581
21	-0.0007	0.0022	0.0000	0.0000	3.3023	7.6260	-5.0933
22	-0.0014	0.0020	0.0000	0.0000	0.6283	12.1484	-0.3485
23	-0.0011	0.0016	0.0000	0.0000	0.4807	10.7834	0.1990
24	-0.0010	0.0013	0.0000	0.0000	0.9987	11.3734	0.4095
25	-0.0009	0.0010	0.0000	0.0000	0.9996	12.1613	0.2938
26	-0.0009	0.0009	0.0000	0.0000	1.9284	14.0993	0.2483
27	-0.0009	0.0009	0.0000	0.0000	2.2422	16.1899	-1.9907
28	-0.0009	0.0012	0.0000	0.0000	4.5370	21.9935	-7.9010
29	-0.0017	0.0000	0.0000	-12.6113	-1.8856	3.9853	2.0529
30	-0.0014	0.0000	0.0000	-43.8092	0.0304	10.6747	1.2085
31	-0.0012	0.0000	0.0000	-17.5735	1.0528	11.2188	0.5545
32	-0.0011	0.0000	0.0000	-31.1420	2.3254	12.0625	0.7103
33	-0.0011	0.0000	0.0000	-12.5066	4.0539	14.3413	0.9602
34	-0.0011	0.0000	0.0000	-24.9787	2.5873	19.3396	0.5401
35	-0.0010	0.0000	0.0000	-7.3787	0.7487	30.7560	-0.1362

4. - VISUALIZACION DE LOS DESPLAZAMIENTOS NODALES

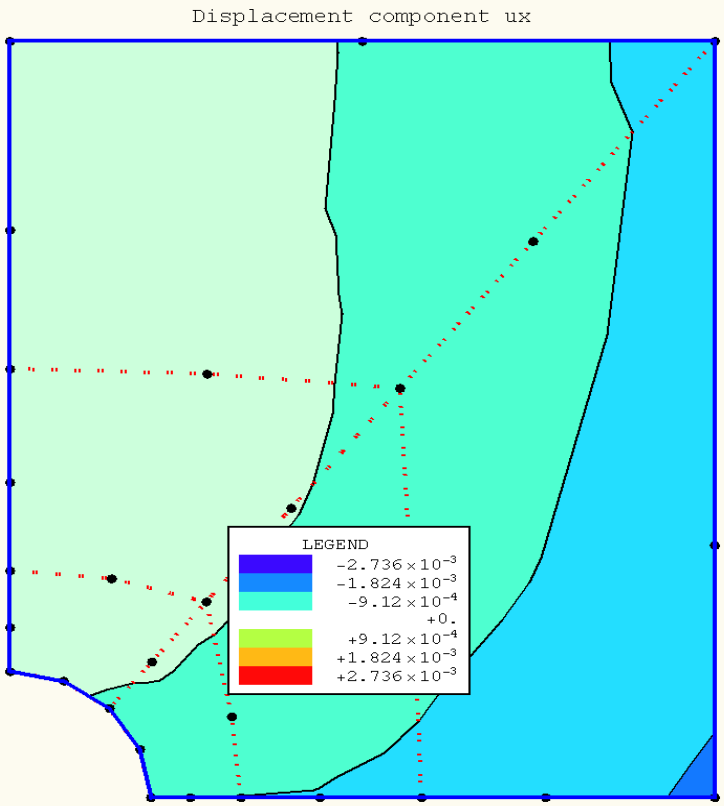
▫ CALCULO DE LOS VALORES MAXIMOS Y MINIMOS DE LOS DESPLAZAMIENTOS

```
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

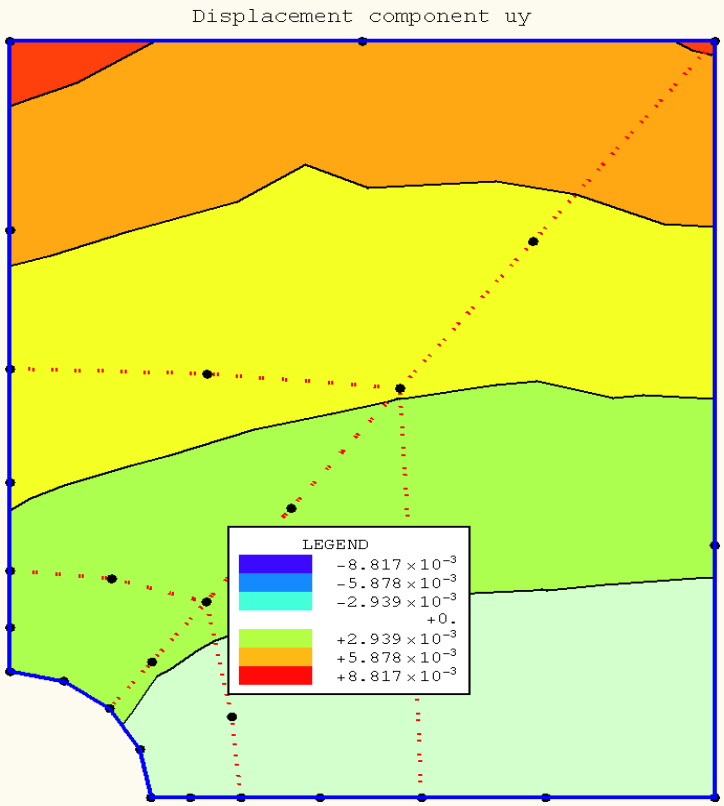
```
Print["uxmin,uxmax,uxinc=", {uxmin, uxmax, uxinc}];
ContourBandPlotNodeFuncOver2DMesh[NodeCoordinates, ElemNodes, ux, {uxmin, uxmax, uxinc},
 {True, True, True, False, True, True}, {2, 2}, aspect, "Displacement component ux"];
```

```
uxmin,uxmax,uxinc={-0.00273615, 0.00273615, 0.000547229}
```




```
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={-0.00881662, 0.00881662, 0.00176332}
```



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

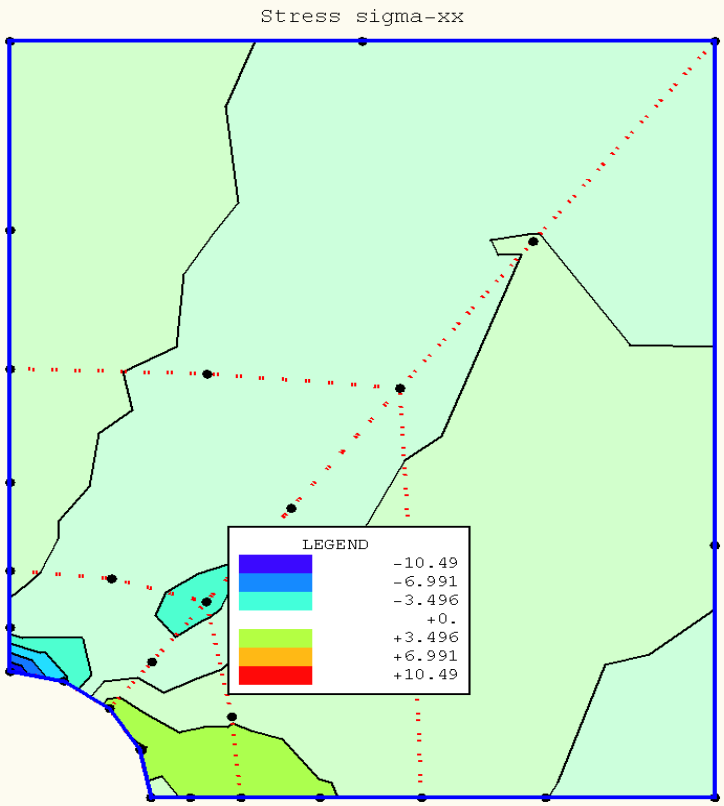
CALCULO DE LOS VALORES MAXIMOS Y MINIMOS DE LAS TENSIONES NORMALES Y TANGENCIALES

```
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

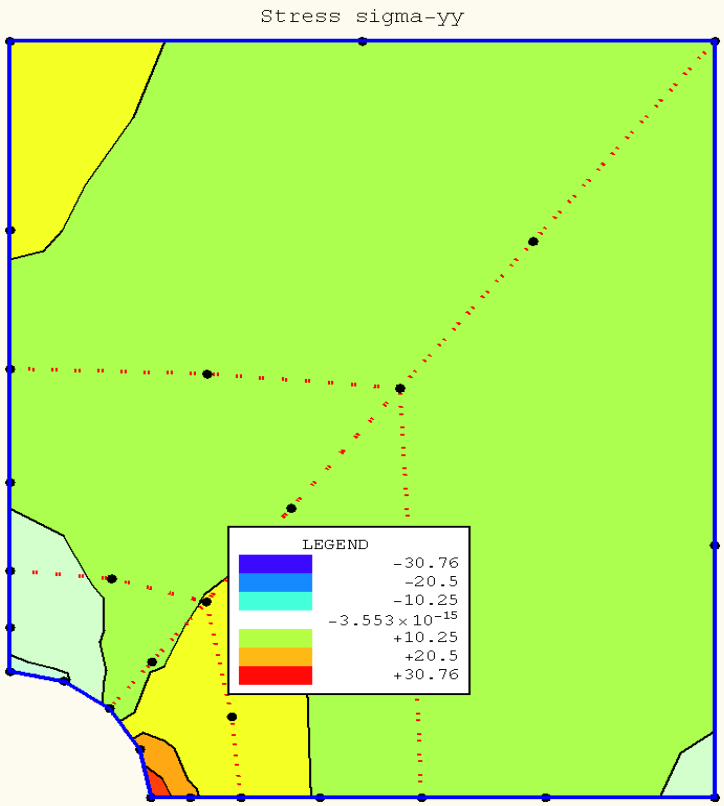
```
Print["sxxmin,sxxmax,sxxinc=", {sxxmin, sxxmax, sxxinc}];
ContourBandPlotNodeFuncOver2DMesh[NodeCoordinates, ElemNodes, sxx, {sxxmin, sxxmax, sxxinc},
 {True, True, True, False, True, True}, {2, 2}, aspect, "Stress sigma-xx"];
```

```
sxxmin,sxxmax,sxxinc={-10.4869, 10.4869, 2.09739}
```




```
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={-30.757, 30.757, 6.15141}
```




```
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={-7.90196, 7.90196, 1.58039}