

## EXERCISE 1 - BRIDGE WITH TRAVELING LOAD - ANIMATION

### 1.- DATOS MALLA DE ELEMENTOS FINITOS

#### ■ GENERACION DE LOS NODOS

```

s = N[{1, 0.80, 0.60, 0.40, 0.20, 0.0}];
xytop = {{-60, 64}, {-50, 64}, {-40, 64}, {-30, 64}, {-20, 64},
  {-12, 64}, {-5, 64}, {0, 64}, {5, 64}, {12, 64}, {20, 64},
  {30, 64}, {40, 64}, {50, 64}, {60, 64}};
xybot = {{-60, 0}, {-50, 0}, {-40, 18}, {-30, 32}, {-20, 42},
  {-12, 47.12}, {-5, 49.5}, {0, 50}, {5, 49.5}, {12, 47.12}, {20, 42},
  {30, 32}, {40, 18}, {50, 0}, {60, 0}};
nx = Length[xytop]; ny = 6;
numnod = nx*ny; NodeCoordinates = Table[{0, 0}, {numnod}];
For[k = 1, k <= ny, k++,
  For[i = 1, i <= nx, i++, c = s[[k]]; NodeCoordinates[[nx*(k-1) + i]] =
    c*xytop[[i]] + (1 - c)*xybot[[i]]
  ];
]; NodeCoordinates = N[NodeCoordinates];
PrintPlaneStressNodeCoordinates[NodeCoordinates, "", {6, 4}];

```

node	x-coor	y-coor
1	-60.0000	64.0000
2	-50.0000	64.0000
3	-40.0000	64.0000
4	-30.0000	64.0000
5	-20.0000	64.0000
6	-12.0000	64.0000
7	-5.0000	64.0000
8	0.0000	64.0000
9	5.0000	64.0000
10	12.0000	64.0000
11	20.0000	64.0000
12	30.0000	64.0000
13	40.0000	64.0000
14	50.0000	64.0000
15	60.0000	64.0000
16	-60.0000	51.2000
17	-50.0000	51.2000
18	-40.0000	54.8000
19	-30.0000	57.6000
20	-20.0000	59.6000
21	-12.0000	60.6240
22	-5.0000	61.1000
23	0.0000	61.2000
24	5.0000	61.1000
25	12.0000	60.6240
26	20.0000	59.6000
27	30.0000	57.6000
28	40.0000	54.8000
29	50.0000	51.2000
30	60.0000	51.2000
31	-60.0000	38.4000
32	-50.0000	38.4000
33	-40.0000	45.6000
34	-30.0000	51.2000
35	-20.0000	55.2000
36	-12.0000	57.2480
37	-5.0000	58.2000
38	0.0000	58.4000
39	5.0000	58.2000
40	12.0000	57.2480
41	20.0000	55.2000
42	30.0000	51.2000
43	40.0000	45.6000
44	50.0000	38.4000

45	60.0000	38.4000
46	-60.0000	25.6000
47	-50.0000	25.6000
48	-40.0000	36.4000
49	-30.0000	44.8000
50	-20.0000	50.8000
51	-12.0000	53.8720
52	-5.0000	55.3000
53	0.0000	55.6000
54	5.0000	55.3000
55	12.0000	53.8720
56	20.0000	50.8000
57	30.0000	44.8000
58	40.0000	36.4000
59	50.0000	25.6000
60	60.0000	25.6000
61	-60.0000	12.8000
62	-50.0000	12.8000
63	-40.0000	27.2000
64	-30.0000	38.4000
65	-20.0000	46.4000
66	-12.0000	50.4960
67	-5.0000	52.4000
68	0.0000	52.8000
69	5.0000	52.4000
70	12.0000	50.4960
71	20.0000	46.4000
72	30.0000	38.4000
73	40.0000	27.2000
74	50.0000	12.8000
75	60.0000	12.8000
76	-60.0000	0.0000
77	-50.0000	0.0000
78	-40.0000	18.0000
79	-30.0000	32.0000
80	-20.0000	42.0000
81	-12.0000	47.1200
82	-5.0000	49.5000
83	0.0000	50.0000
84	5.0000	49.5000
85	12.0000	47.1200
86	20.0000	42.0000
87	30.0000	32.0000
88	40.0000	18.0000
89	50.0000	0.0000
90	60.0000	0.0000

#### ■ GENERACION DE LOS ELEMENTOS

```

numele = (nx - 1) * (ny - 1);
ElemNodes = Table[{0, 0, 0, 0}, {numele}];
ElemNodes[[1]] = {1, nx + 1, nx + 2, 2};
For[e = 2, e <= numele, e++,
  If[Mod[e - 1, nx - 1] == 0,
    ElemNodes[[e]] = ElemNodes[[e - nx + 1]] + {1, 1, 1, 1} * nx,
    ElemNodes[[e]] = ElemNodes[[e - 1]] + {1, 1, 1, 1}];

```

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

elem	type	node-list
1	Quad4	{1, 16, 17, 2}
2	Quad4	{2, 17, 18, 3}
3	Quad4	{3, 18, 19, 4}
4	Quad4	{4, 19, 20, 5}
5	Quad4	{5, 20, 21, 6}
6	Quad4	{6, 21, 22, 7}
7	Quad4	{7, 22, 23, 8}
8	Quad4	{8, 23, 24, 9}
9	Quad4	{9, 24, 25, 10}
10	Quad4	{10, 25, 26, 11}
11	Quad4	{11, 26, 27, 12}
12	Quad4	{12, 27, 28, 13}
13	Quad4	{13, 28, 29, 14}
14	Quad4	{14, 29, 30, 15}
15	Quad4	{16, 31, 32, 17}
16	Quad4	{17, 32, 33, 18}
17	Quad4	{18, 33, 34, 19}
18	Quad4	{19, 34, 35, 20}
19	Quad4	{20, 35, 36, 21}
20	Quad4	{21, 36, 37, 22}
21	Quad4	{22, 37, 38, 23}
22	Quad4	{23, 38, 39, 24}
23	Quad4	{24, 39, 40, 25}
24	Quad4	{25, 40, 41, 26}
25	Quad4	{26, 41, 42, 27}
26	Quad4	{27, 42, 43, 28}
27	Quad4	{28, 43, 44, 29}
28	Quad4	{29, 44, 45, 30}
29	Quad4	{31, 46, 47, 32}
30	Quad4	{32, 47, 48, 33}
31	Quad4	{33, 48, 49, 34}
32	Quad4	{34, 49, 50, 35}
33	Quad4	{35, 50, 51, 36}
34	Quad4	{36, 51, 52, 37}
35	Quad4	{37, 52, 53, 38}
36	Quad4	{38, 53, 54, 39}
37	Quad4	{39, 54, 55, 40}
38	Quad4	{40, 55, 56, 41}
39	Quad4	{41, 56, 57, 42}
40	Quad4	{42, 57, 58, 43}
41	Quad4	{43, 58, 59, 44}
42	Quad4	{44, 59, 60, 45}
43	Quad4	{46, 61, 62, 47}
44	Quad4	{47, 62, 63, 48}
45	Quad4	{48, 63, 64, 49}
46	Quad4	{49, 64, 65, 50}
47	Quad4	{50, 65, 66, 51}
48	Quad4	{51, 66, 67, 52}
49	Quad4	{52, 67, 68, 53}
50	Quad4	{53, 68, 69, 54}
51	Quad4	{54, 69, 70, 55}
52	Quad4	{55, 70, 71, 56}
53	Quad4	{56, 71, 72, 57}
54	Quad4	{57, 72, 73, 58}
55	Quad4	{58, 73, 74, 59}
56	Quad4	{59, 74, 75, 60}
57	Quad4	{61, 76, 77, 62}
58	Quad4	{62, 77, 78, 63}
59	Quad4	{63, 78, 79, 64}
60	Quad4	{64, 79, 80, 65}
61	Quad4	{65, 80, 81, 66}
62	Quad4	{66, 81, 82, 67}
63	Quad4	{67, 82, 83, 68}
64	Quad4	{68, 83, 84, 69}
65	Quad4	{69, 84, 85, 70}
66	Quad4	{70, 85, 86, 71}
67	Quad4	{71, 86, 87, 72}
68	Quad4	{72, 87, 88, 73}
69	Quad4	{73, 88, 89, 74}
70	Quad4	{74, 89, 90, 75}

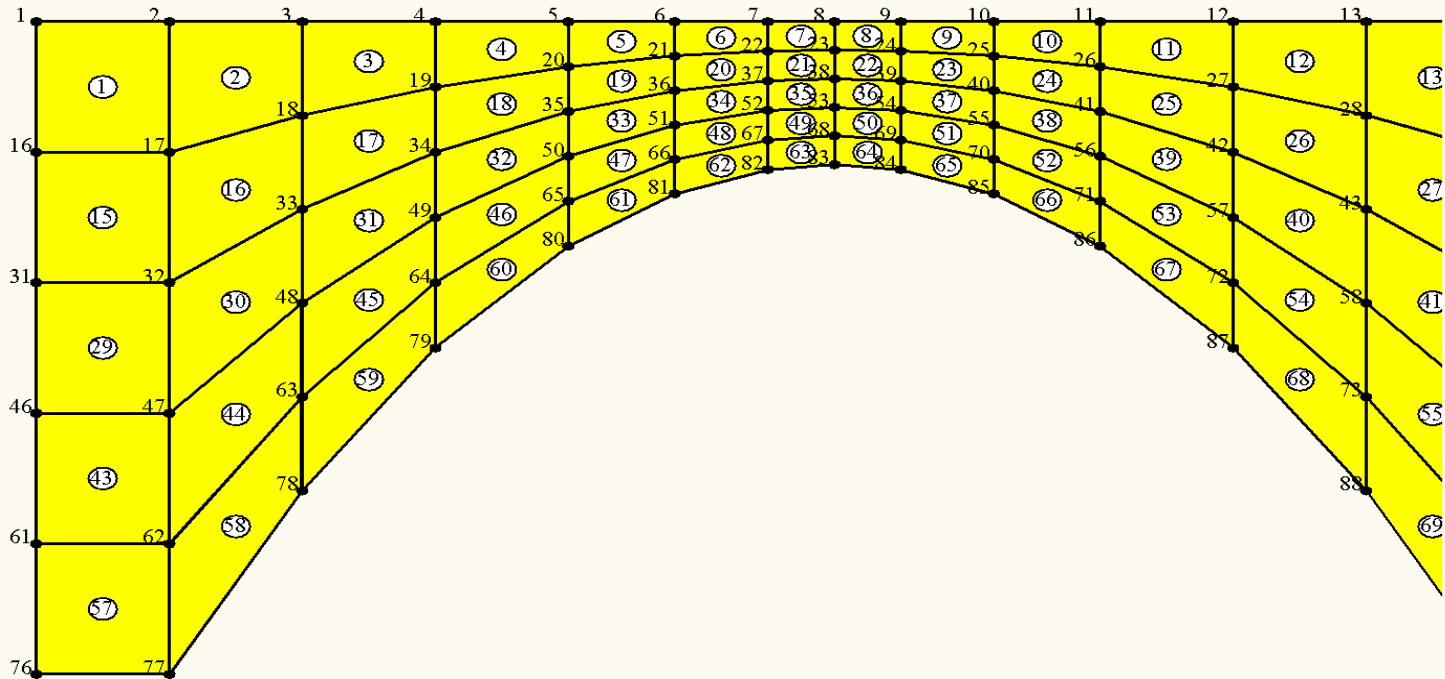
#### ■ VISUALIZACION DE LA MALLA DE ELEMENTOS FINITOS

```
ElemOptions = {True};
```

```
ProcessOptions = {True};
```

```
Plot2DElementsAndNodes[NodeCoordinates, ElemNodes, 1/2,
"Bridge Mesh", True, True];
```

Bridge Mesh



## 2.- DATOS DEL PROBLEMA TENSION PLANA

### ■ MATERIAL

```
ClearAll[Em, ν, th, aspect, Nsub];
Em = 10000; ν = .25; th = 3; aspect = 1/2; 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

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

```
PrintPlaneStressElementMatFab[ElemMaterials, ElemFabrications, "", {}];
```

## ■ ASIGNACION DE CONDICIONES DE CONTORNO EN DESPLAZAMIENTOS

### □ INICIALIZACION

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

### □ DEFINICION CONDICIONES DE CONTORNO EN DESPLAZAMIENTOS

```
Do[NodeDOFTags[[n]] = {1, 0}, {n, 1, numnod - nx + 1, nx}];
Do[NodeDOFTags[[n]] = {1, 0}, {n, nx, numnod, nx}];
NodeDOFTags[[numnod - nx + 1]] = NodeDOFTags[[numnod]] = {1, 1};
NodeDOFTags[[numnod - nx + 2]] = NodeDOFTags[[numnod - 1]] = {0, 1};
```

### □ LISTADO DE CONDICIONES DE CONTORNO

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

node	x-tag	y-tag	x-value	y-value
1	1	0	0.00	0.00
2	0	0	0.00	0.00
3	0	0	0.00	0.00
4	0	0	0.00	0.00
5	0	0	0.00	0.00
6	0	0	0.00	0.00
7	0	0	0.00	0.00
8	0	0	0.00	0.00
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	1	0	0.00	0.00
16	1	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	0	0.00	0.00
30	1	0	0.00	0.00
31	1	0	0.00	0.00
32	0	0	0.00	0.00
33	0	0	0.00	0.00
34	0	0	0.00	0.00
35	0	0	0.00	0.00
36	0	0	0.00	0.00
37	0	0	0.00	0.00
38	0	0	0.00	0.00
39	0	0	0.00	0.00
40	0	0	0.00	0.00
41	0	0	0.00	0.00
42	0	0	0.00	0.00
43	0	0	0.00	0.00
44	0	0	0.00	0.00
45	1	0	0.00	0.00
46	1	0	0.00	0.00
47	0	0	0.00	0.00
48	0	0	0.00	0.00
49	0	0	0.00	0.00
50	0	0	0.00	0.00
51	0	0	0.00	0.00
52	0	0	0.00	0.00
53	0	0	0.00	0.00
54	0	0	0.00	0.00
55	0	0	0.00	0.00
56	0	0	0.00	0.00
57	0	0	0.00	0.00

58	0	0	0.00	0.00
59	0	0	0.00	0.00
60	1	0	0.00	0.00
61	1	0	0.00	0.00
62	0	0	0.00	0.00
63	0	0	0.00	0.00
64	0	0	0.00	0.00
65	0	0	0.00	0.00
66	0	0	0.00	0.00
67	0	0	0.00	0.00
68	0	0	0.00	0.00
69	0	0	0.00	0.00
70	0	0	0.00	0.00
71	0	0	0.00	0.00
72	0	0	0.00	0.00
73	0	0	0.00	0.00
74	0	0	0.00	0.00
75	1	0	0.00	0.00
76	1	1	0.00	0.00
77	0	1	0.00	0.00
78	0	0	0.00	0.00
79	0	0	0.00	0.00
80	0	0	0.00	0.00
81	0	0	0.00	0.00
82	0	0	0.00	0.00
83	0	0	0.00	0.00
84	0	0	0.00	0.00
85	0	0	0.00	0.00
86	0	0	0.00	0.00
87	0	0	0.00	0.00
88	0	0	0.00	0.00
89	0	1	0.00	0.00
90	1	1	0.00	0.00

### 3.- SOLUCION DEL PROBLEMA Y VISUALIZACION DE RESULTADOS

```

Print["Frames for animation:"]; nloads = nx;
For[load = 1, load <= nloads, load++,
  NodeDOFValues = Table[{0, 0}, {numnod}]; NodeDOFValues[[load]] = {0, -1000};
{NodeDisplacements, NodeForces, NodePlateCounts, NodePlateStresses,
  ElemBarNumbers, ElemBarForces} = PlaneStressSolution[
  NodeCoordinates, ElemTypes, ElemNodes,
  ElemMaterials, ElemFabrications,
  NodeDOFTags, NodeDOFValues, ProcessOptions];

(* Plot Stresses Distribution *)

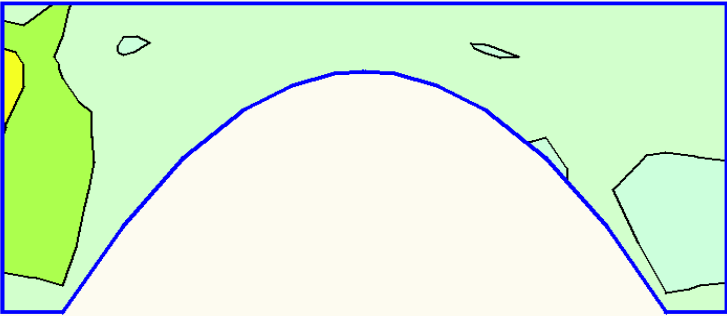
sVM = sig1 = sig2 = tmax = Table[0, {numnod}];
For[n = 1, n <= numnod, n++,
  {sigxx, sigyy, sigxy} = NodePlateStresses[[n]]; s0 = (sigxx + sigyy) / 2;
  R = N[Sqrt[(sigxx - sigyy)^2 + sigxy^2]];
  sig1[[n]] = s0 + R; sig2[[n]] = s0 - R; tmax[[n]] = R;
  sVM[[n]] = N[Sqrt[3 * (sigxx^2 + sigyy^2 + sigxy^2) / 2]];
sVMmax = sg1max = sg2max = 0;
For[n = 1, n <= numnod, n++, sg1max = Max[Abs[sig1[[n]]], sg1max];
  sg2max = Max[Abs[sig2[[n]]], sg2max];
  sVMmax = Max[Abs[sVM[[n]]], sVMmax];];

(*Print["Max sig1,sig2,sigVM =",{sg1max,sg2max,sVMmax}];*)
sg1max = 40; sg1min = -sg1max; sg1inc = (sg1max - sg1min) / 10;
ContourBandPlotNodeFuncOver2DMesh[NodeCoordinates, ElemNodes, sig1, {sg1min, sg1max, sg1inc},
{True, False, False, False, True, True}, {}, aspect, "Principal stress sig1"];
];

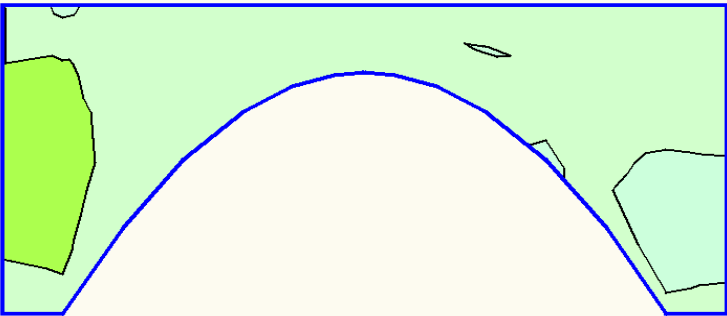
```

Frames for animation:

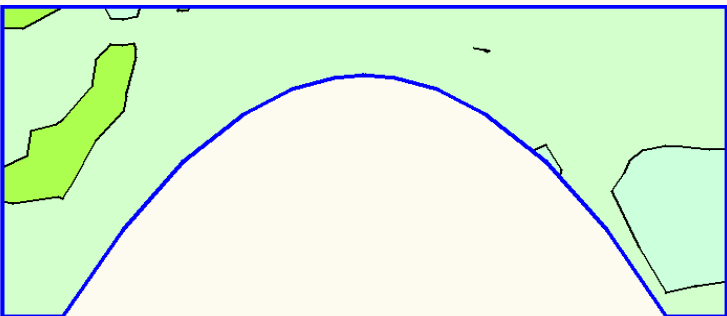
Principal stress sig1



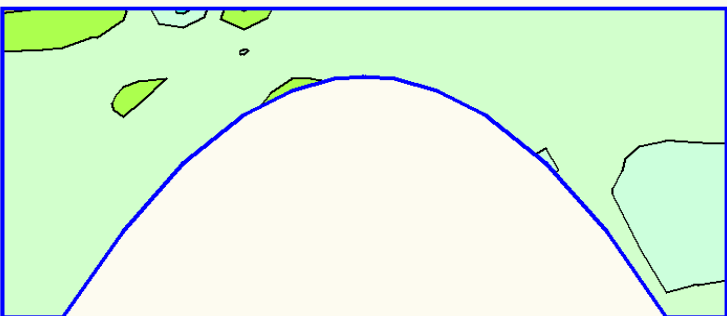
Principal stress sig1



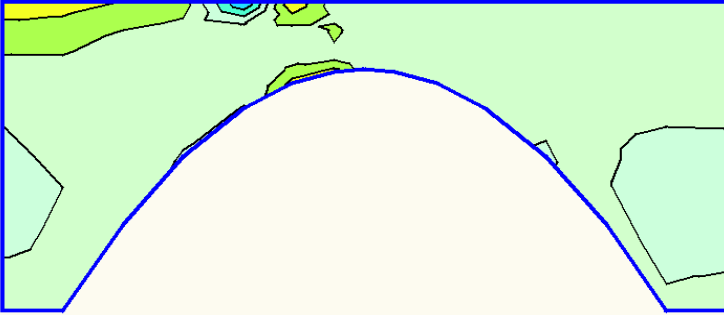
Principal stress sig1



Principal stress sig1



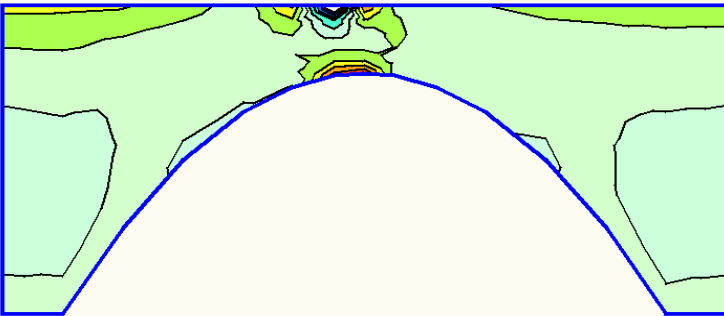
Principal stress sig1



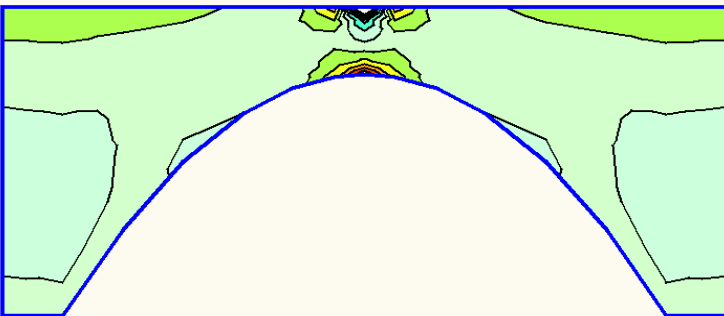
Principal stress sig1



Principal stress sig1



Principal stress sig1

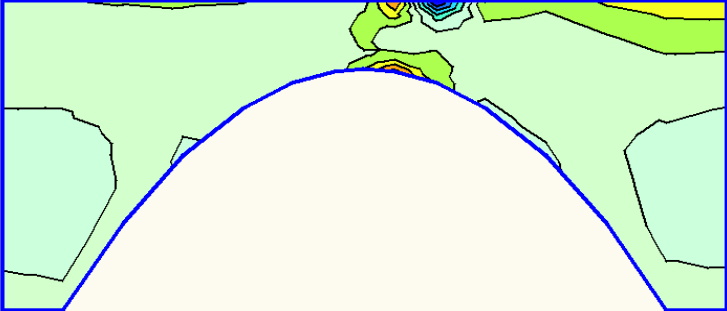




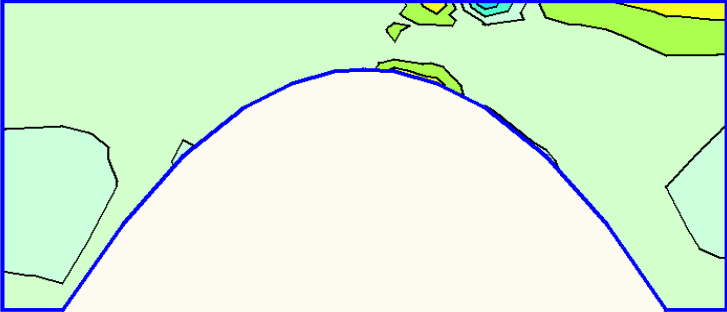
Principal stress sig1



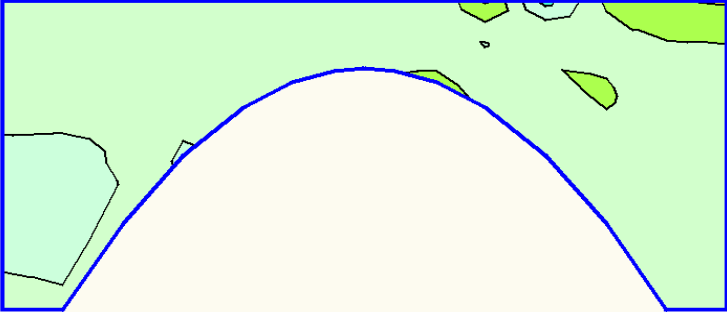
Principal stress sig1



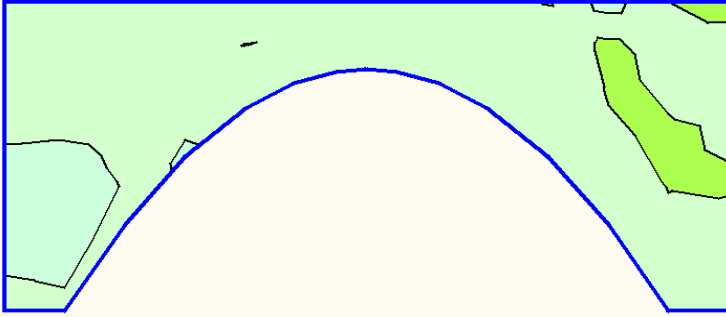
Principal stress sig1



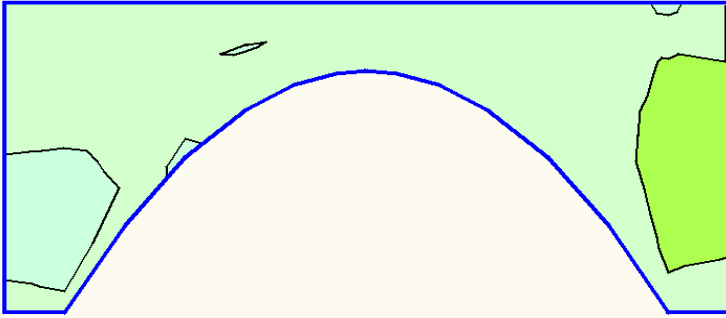
Principal stress sig1



Principal stress sig1



Principal stress sig1



Principal stress sig1

