MEEN 673

Homework 4

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Problem 1: SS-3 square plate

$$P = \frac{q_0 a^4}{E_2 h^4}$$

$$\bar{\sigma}_{xx,\max} = \sigma_{xx,\max}\left(\frac{a^2}{E_2 h^2}\right),\quad \bar{\sigma}_{xy,\max} = \sigma_{xy,\max}\left(\frac{a^2}{E_2 h^2}\right)$$

Use 8×8L4 and 4×4Q9 elements to solve this problem.

(1) 8×8L4 mesh

Box 1.1. Input file of SS-3 square plate (8×8L4 mesh)

```
2    4    1    0   1   2    MODEL,NPE,MESH,NPRNT,IGRAD,NONLIN
2    1    1    1                     NIPL,NIPN,NITS,NSTR
8    8                               NX, NY
0.0   0.625   0.625   0.625   0.625   0.625   0.625   0.625   0.625    X0, (DX(I), I=1,NX)
0.0   0.625   0.625   0.625   0.625   0.625   0.625   0.625   0.625    Y0, (DY(I), I=1,NY)

85                                   NSPV and next lines ISPV, VSPV

1 1    1 2    1 4    1 5    2 2    2 5    3 2    3 5    4 2    4 5    5 2    5 5
6 2    6 5    7 2    7 5    8 2    8 5    9 1    9 2    9 3    9 5    10 1   10 4
19 1   19 4   28 1   28 4   37 1   37 4   46 1   46 4   55 1   55 4   64 1   64 4
18 1   18 2   18 3   27 1   27 2   27 3   36 1   36 2   36 3   45 1   45 2   45 3
54 1   54 2   54 3   63 1   63 2   63 3   72 1   72 2   72 3   73 1   73 2   73 3
73 4   74 1   74 2   74 3   75 1   75 2   75 3   76 1   76 2   76 3   77 1   77 2
77 3   78 1   78 2   78 3   79 1   79 2   79 3   80 1   80 2   80 3   81 1   81 2
81 3

0.0   0.0   0.0   0.0   0.0   0.0   0.0   0.0   0.0   0.0   0.0   0.0
0.0   0.0   0.0   0.0   0.0   0.0   0.0   0.0   0.0   0.0   0.0   0.0
0.0   0.0   0.0   0.0   0.0   0.0   0.0   0.0   0.0   0.0   0.0   0.0
0.0   0.0   0.0   0.0   0.0   0.0   0.0   0.0   0.0   0.0   0.0   0.0
0.0   0.0   0.0   0.0   0.0   0.0   0.0   0.0   0.0   0.0   0.0   0.0
0.0   0.0   0.0   0.0   0.0   0.0   0.0   0.0   0.0   0.0   0.0   0.0
0.0   0.0   0.0   0.0   0.0   0.0   0.0   0.0   0.0   0.0   0.0   0.0
0.0

0                                    NSSV
10.0   10.0   1.0                    XL,YL,THIKNS
7.80E6 2.60E6 1.30E6 1.30E6 1.30E6 0.25 0.8333       E1,E2,G12,G13,G23,ANU12,AKS
1300.0   0.0   0.0                   Q0,QX,QY
0                                    ICONV
32    20     0.001   0.0             NLS, ITMAX, EPS, GAMA
```

```
1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0
1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0
1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0
1.0  1.0                                        DP(I)
```

Table 1.1. Numerical results of SS-3 square plate (8×8L4 mesh)

P	**W/h**	$\bar{\sigma}_{xx,\max}$	$\bar{\sigma}_{xy,\max}$
5	0.16032	2.4625	0.76131
10	0.29023	4.7325	1.3932
15	0.39108	6.6571	1.901
20	0.47189	8.2996	2.3223
25	0.53912	9.7337	2.6844
30	0.59678	11.012	3.0042
35	0.64737	12.171	3.2922
40	0.69255	13.236	3.5557
45	0.73346	14.225	3.7994
50	0.77091	15.15	4.027
55	0.8055	16.022	4.2411
60	0.83769	16.849	4.4436
65	0.86782	17.636	4.6361
70	0.89618	18.389	4.82
75	0.923	19.111	4.9961
80	0.94845	19.807	5.1655
85	0.97269	20.478	5.3286
90	0.99585	21.127	5.4862
95	1.018	21.756	5.6387
100	1.0393	22.367	5.7867
105	1.0598	22.962	5.9304
110	1.0796	23.541	6.0701
115	1.0987	24.106	6.2063
120	1.1171	24.657	6.339
125	1.135	25.197	6.4687
130	1.1523	25.724	6.5954
135	1.1692	26.242	6.7193
140	1.1856	26.749	6.8407
145	1.2015	27.246	6.9596
150	1.2171	27.735	7.0762
155	1.2322	28.215	7.1907
160	1.247	28.687	7.3031

(2) 4×4Q9 mesh

Box 1.2. Input file modification of SS-3 square plate (4×4Q9 mesh)

```
2   9   1   0   1   2    MODEL,NPE,MESH,NPRNT,IGRAD,NONLIN
3   2   2   2                NIPL,NIPN,NITS,NSTR
4   4                      NX, NY
0.0  1.25  1.25  1.25  1.25          X0, (DX(I), I=1,NX)
0.0  1.25  1.25  1.25  1.25          Y0, (DY(I), I=1,NY)
```

Table 1.2. Numerical results of SS-3 square plate (4×4Q9 mesh)

P	**W/h**	$\bar{\sigma}_{xx,\max}$	$\bar{\sigma}_{xy,\max}$
5	0.16024	2.4741	0.81402
10	0.2897	4.7495	1.4888
15	0.38996	6.6739	2.0305
20	0.47021	8.3135	2.48
25	0.53694	9.7436	2.8665
30	0.59413	11.018	3.2078
35	0.64431	12.172	3.5155
40	0.68911	13.232	3.7969
45	0.72968	14.216	4.0573
50	0.76681	15.137	4.3006
55	0.80111	16.005	4.5294
60	0.83303	16.827	4.746
65	0.86291	17.61	4.9519
70	0.89103	18.359	5.1486
75	0.91762	19.078	5.337
80	0.94286	19.77	5.5182
85	0.9669	20.437	5.6928
90	0.98987	21.083	5.8616
95	1.0119	21.709	6.0249
100	1.033	22.317	6.1833
105	1.0533	22.908	6.3372
110	1.0729	23.484	6.4869
115	1.0918	24.046	6.6328
120	1.1101	24.595	6.7751
125	1.1279	25.132	6.914
130	1.1451	25.657	7.0498
135	1.1618	26.172	7.1827
140	1.1781	26.677	7.3129
145	1.1939	27.172	7.4404
150	1.2093	27.658	7.5655
155	1.2244	28.136	7.6883
160	1.239	28.607	7.8089

Problem 2: Clamped square plate

Use 8×8L4 and 4×4Q9 elements to solve this problem.

(1) 8×8L4 mesh

Box 2.1. Input file of clamped square plate (8×8L4 mesh)

```
2    4    1    0   1   2     MODEL,NPE,MESH,NPRNT,IGRAD,NONLIN
2    1    1    1                        NIPL,NIPN,NITS,NSTR
8    8                                  NX, NY
0.0   0.625   0.625   0.625   0.625   0.625   0.625   0.625   0.625              X0, (DX(I), I=1,NX)
0.0   0.625   0.625   0.625   0.625   0.625   0.625   0.625   0.625              Y0, (DY(I), I=1,NY)

117                                     NSPV and next lines ISPV, VSPV
1 1    1 2    1 4    1 5    2 2    2 5    3 2    3 5    4 2    4 5    5 2    5 5
6 2    6 5    7 2    7 5    8 2    8 5    9 1    9 2    9 3    9 4    9 5    10 1
10 4   19 1   19 4   28 1   28 4   37 1   37 4   46 1   46 4   55 1   55 4   64 1
64 4   18 1   18 2   18 3   18 4   18 5   27 1   27 2   27 3   27 4   27 5   36 1
36 2   36 3   36 4   36 5   45 1   45 2   45 3   45 4   45 5   54 1   54 2   54 3
54 4   54 5   63 1   63 2   63 3   63 4   63 5   72 1   72 2   72 3   72 4   72 5
73 1   73 2   73 3   73 4   73 5   74 1   74 2   74 3   74 4   74 5   75 1   75 2
75 3   75 4   75 5   76 1   76 2   76 3   76 4   76 5   77 1   77 2   77 3   77 4
77 5   78 1   78 2   78 3   78 4   78 5   79 1   79 2   79 3   79 4   79 5   80 1
80 2   80 3   80 4   80 5   81 1   81 2   81 3   81 4   81 5

0.0   0.0   0.0   0.0   0.0   0.0   0.0   0.0   0.0   0.0   0.0   0.0
0.0   0.0   0.0   0.0   0.0   0.0   0.0   0.0   0.0   0.0   0.0   0.0
0.0   0.0   0.0   0.0   0.0   0.0   0.0   0.0   0.0   0.0   0.0   0.0
0.0   0.0   0.0   0.0   0.0   0.0   0.0   0.0   0.0   0.0   0.0   0.0
0.0   0.0   0.0   0.0   0.0   0.0   0.0   0.0   0.0   0.0   0.0   0.0
0.0   0.0   0.0   0.0   0.0   0.0   0.0   0.0   0.0   0.0   0.0   0.0
0.0   0.0   0.0   0.0   0.0   0.0   0.0   0.0   0.0   0.0   0.0   0.0
0.0   0.0   0.0   0.0   0.0   0.0   0.0   0.0   0.0   0.0   0.0   0.0
0.0   0.0   0.0   0.0   0.0   0.0   0.0   0.0   0.0   0.0   0.0   0.0
0.0   0.0   0.0   0.0   0.0   0.0   0.0   0.0   0.0

0                                       NSSV
10.0   10.0   1.0                       XL,YL,THIKNS
7.80E6 2.60E6 1.30E6 1.30E6 1.30E6 0.25 0.8333     E1,E2,G12,G13,G23,ANU12,AKS
1300.0   0.0   0.0                      Q0,QX,QY
0                                       ICONV
32    20     0.001   0.0                NLS, ITMAX, EPS, GAMA
1.0   1.0   1.0   1.0   1.0   1.0   1.0   1.0   1.0   1.0
1.0   1.0   1.0   1.0   1.0   1.0   1.0   1.0   1.0   1.0
1.0   1.0   1.0   1.0   1.0   1.0   1.0   1.0   1.0   1.0
1.0   1.0                                              DP(I)
```

Table 2.1. Numerical results of clamped square plate (8×8L4 mesh)

P	**W/h**	$\bar{\sigma}_{xx,\max}$	$\bar{\sigma}_{xy,\max}$
5	0.051359	1.6429	0.17851
10	0.10223	3.308	0.35731
15	0.15216	4.9818	0.53484
20	0.20078	6.6522	0.70975
25	0.24782	8.3087	0.88091
30	0.2931	9.9429	1.0475
35	0.33653	11.549	1.2089
40	0.37809	13.122	1.3649
45	0.41779	14.66	1.5153
50	0.45571	16.162	1.6601
55	0.49192	17.627	1.7994
60	0.52651	19.056	1.9334
65	0.5596	20.449	2.0623
70	0.59127	21.808	2.1863
75	0.62162	23.134	2.3084
80	0.65074	24.428	2.4273
85	0.67872	25.692	2.5423
90	0.70563	26.926	2.6537
95	0.73156	28.134	2.7617
100	0.75656	29.315	2.8663
105	0.78071	30.471	2.9679
110	0.80405	31.603	3.0665
115	0.82663	32.713	3.1622
120	0.84852	33.801	3.2553
125	0.86974	34.869	3.3458
130	0.89034	35.917	3.4339
135	0.91036	36.947	3.5197
140	0.92983	37.958	3.6033
145	0.94878	38.952	3.6848
150	0.96724	39.93	3.7642
155	0.98523	40.892	3.8417
160	1.0028	41.84	3.9173

(2) 4×4Q9 mesh

Box 2.2. Input file modification of clamped square plate (4×4Q9 mesh)

```
2   9   1   0   1   2     MODEL,NPE,MESH,NPRNT,IGRAD,NONLIN
3   2   2   2                NIPL,NIPN,NITS,NSTR
4   4                        NX, NY
0.0  1.25  1.25  1.25  1.25        X0, (DX(I), I=1,NX)
0.0  1.25  1.25  1.25  1.25        Y0, (DY(I), I=1,NY)
```

Table 2.2. Numerical results of clamped square plate ($4\times4Q9$ mesh)

P	**W/h**	$\bar{\sigma}_{xx,\max}$	$\bar{\sigma}_{xy,\max}$
5	0.051456	1.6964	0.18199
10	0.1024	3.4152	0.36407
15	0.15237	5.1421	0.54461
20	0.20099	6.864	0.72241
25	0.24797	8.57	0.89692
30	0.29314	10.251	1.0671
35	0.33642	11.902	1.2323
40	0.37778	13.517	1.3924
45	0.41726	15.095	1.5472
50	0.45493	16.634	1.6967
55	0.49087	18.134	1.841
60	0.52519	19.596	1.9803
65	0.55799	21.02	2.1147
70	0.58937	22.409	2.2444
75	0.61943	23.763	2.3697
80	0.64826	25.084	2.4909
85	0.67595	26.373	2.608
90	0.70258	27.632	2.7213
95	0.72823	28.863	2.8311
100	0.75296	30.066	2.9375
105	0.77684	31.244	3.0406
110	0.79992	32.397	3.1406
115	0.82225	33.527	3.2377
120	0.84389	34.634	3.3321
125	0.86487	35.72	3.4238
130	0.88524	36.786	3.513
135	0.90503	37.833	3.5998
140	0.92427	38.861	3.6844
145	0.94301	39.872	3.7667
150	0.96126	40.866	3.8469
155	0.97904	41.843	3.9252
160	0.9964	42.806	4.0015

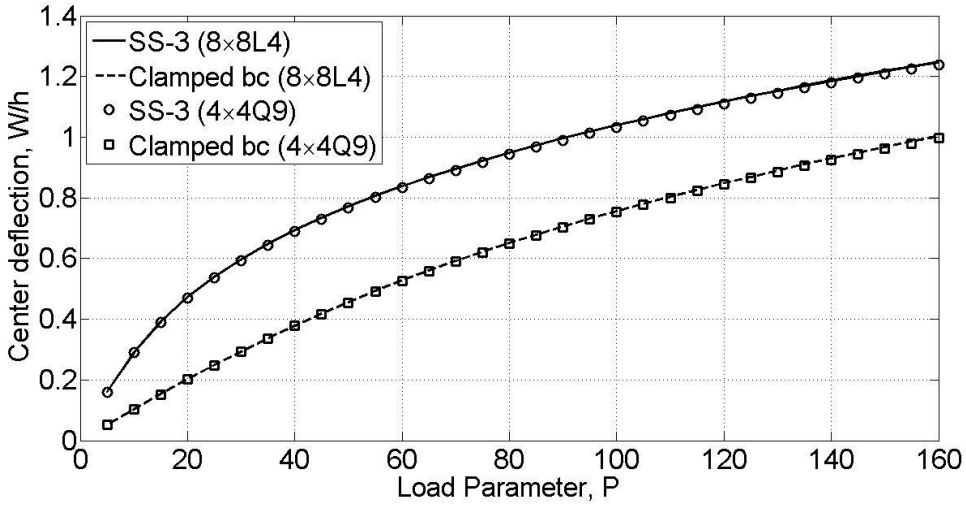

Fig 1. Load vs center deflection of the SS-3 and clamped boundary condition

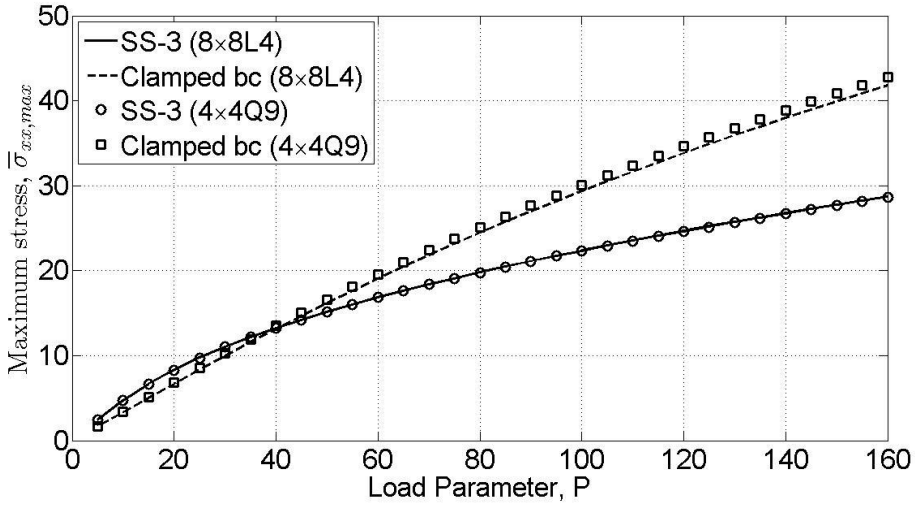

Fig 2. Load vs maximum stress ($\bar{\sigma}_{xx,\max}$) of the SS-3 and clamped boundary condition

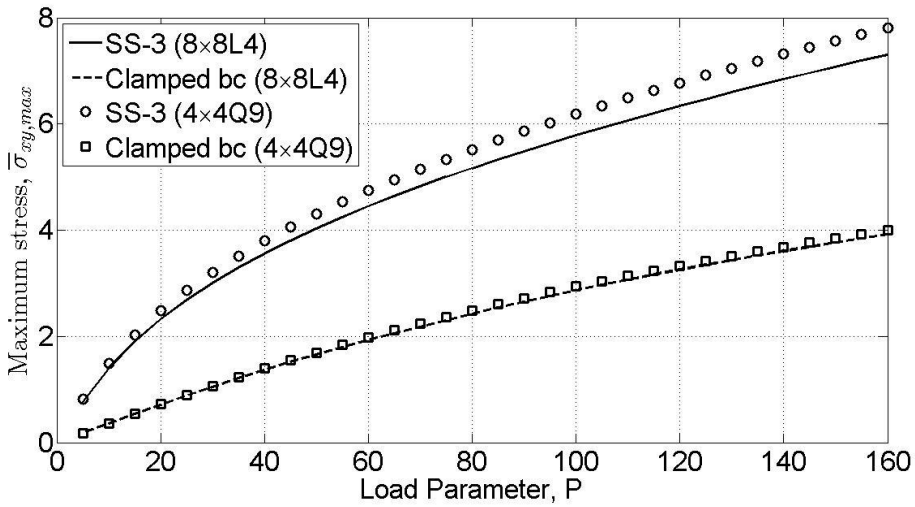

Fig 3. Load vs maximum stress ($\bar{\sigma}_{xy,\max}$) of the SS-3 and clamped boundary condition