SSC DETECTOR SOLENOID DESIGN NOTE #13

TITLE: 2-D Finite Element Examination of a Half-Meter Trussed Calorimeter Support

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Introduction

The purpose of this work is to continue the examination of a trussed calorimeter support structure. (see Design Note #7) The structure model has been recreated to incorporate an outside diameter of 9 meters. The Supertab module of I-DEAS was used to generate the model and the ANSYS finite element program was used to estimate the primary stresses.

Calorimetry Support Concept

The fundamental concept for supporting the SSC detector central calorimetry remains similar to that which is detailed in Design Note #7. However, the number of truss plates have been doubled and their thickness decreased to one inch. Also, the outside diameter was decreased to 9 meters. Because of this, the muon tracking chambers must be externally fastened to the support structure.

Finite Element Model

The finite element model of the support structure is shown in Fig. 2. The model is comprised of one inch thick 2-D elastic beam elements. Symmetry is assumed about the midplane. The calorimeter weight is shown as a vertical line load at 45° below horizontal (at Node 19).

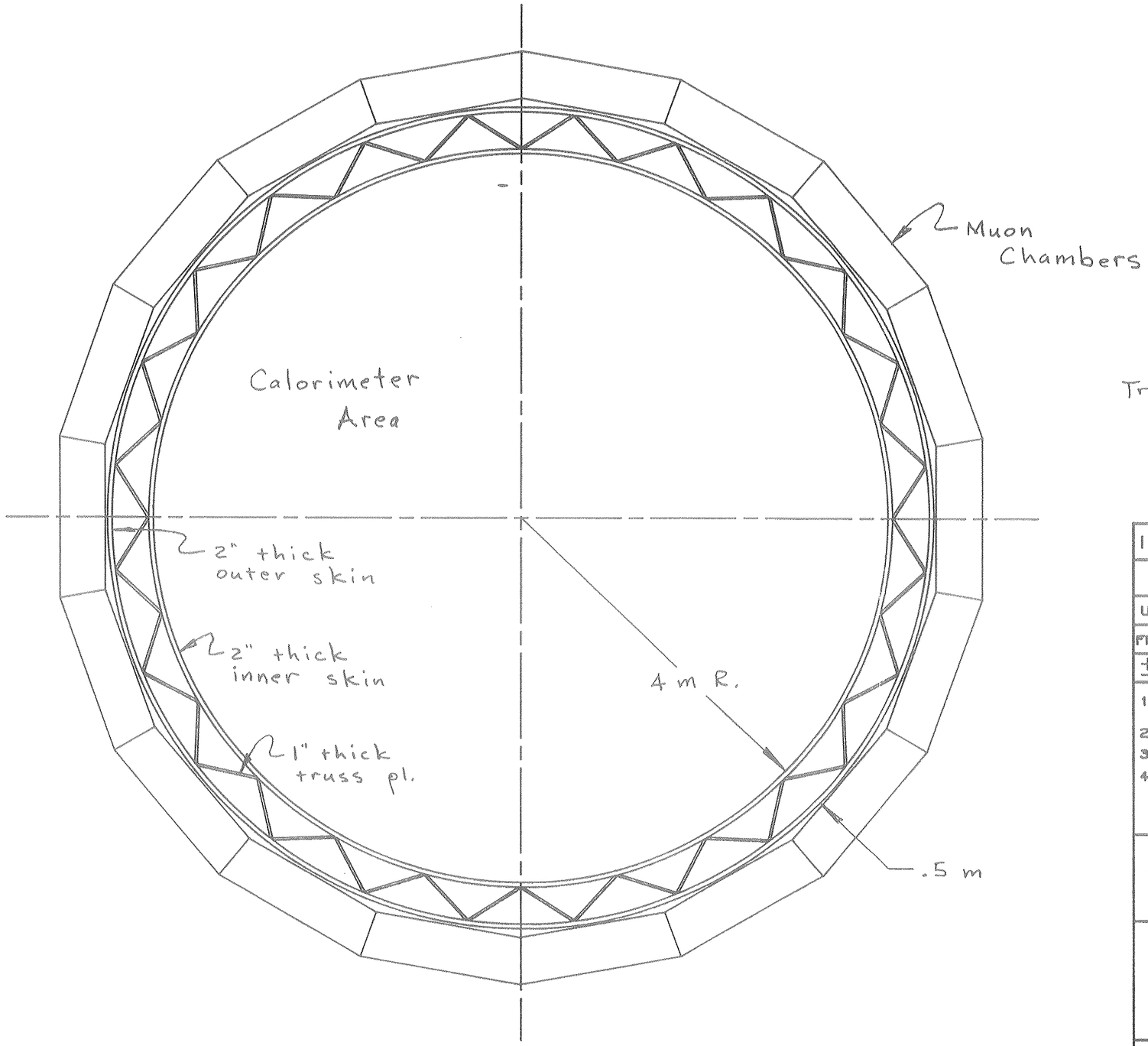
Results

The distorted shape of the support structure under load is shown in Figure 3. The maximum vertical deflection is .183 inches. The maximum stress occurs approximately halfway between the load and the horizontal axis. The magnitude is 16,900 PSI and appears to be highly localized. (see attached printout)

Conclusion

This support structure boasts several advantages over the earlier configuration. First, the external mounting of the muon tracking chambers eliminates

the necessity for multiple chamber designs. Second, this structure weighs 92 tons less per 8 meter long assembly. Furthermore, material costs for each assembly will decrease $275K. Also, the magnitudes of the stresses are far below the allowable stress for 304 stainless steel, thus indicating that the structure model is yet to be optimized.



Truss Est. Wt. = 242 tons

ITEM	PART NO.	DESCRIPTION OR SIZE	QTY.

PARTS LIST

UNLESS OTHERWISE SPECIFIED			ORIGINATOR		
FRACTIONS	DECIMALS	ANGLES	DRAWN		
±	±	±	CHECKED		
1. BREAK ALL SHARP EDGES 1/64 MAX.			APPROVED		
2. DO NOT SCALE DRAWING.			USED ON		
3. DIM. TO ANSI Y14.5					
4. MAX. ALL MACH. SURFACES √			MATERIAL		

FERMI NATIONAL ACCELERATOR LABORATORY
UNITED STATES DEPARTMENT OF ENERGY

.5 meter Truss Assembly

SCALE	FILMED	DRAWING NUMBER	REV.
		Figure 1	

CREATED WITH CD/2000 VERSION 1.62

SDRC I-DEAS 3.9: Pre/Post Proce ing 19-FEB-8S 1 32:29

DATABASE:
VIEW:No stored VIEW
Task: Free Mesh Generation

UNITS = IN
DISPLAY:No stored OPTION

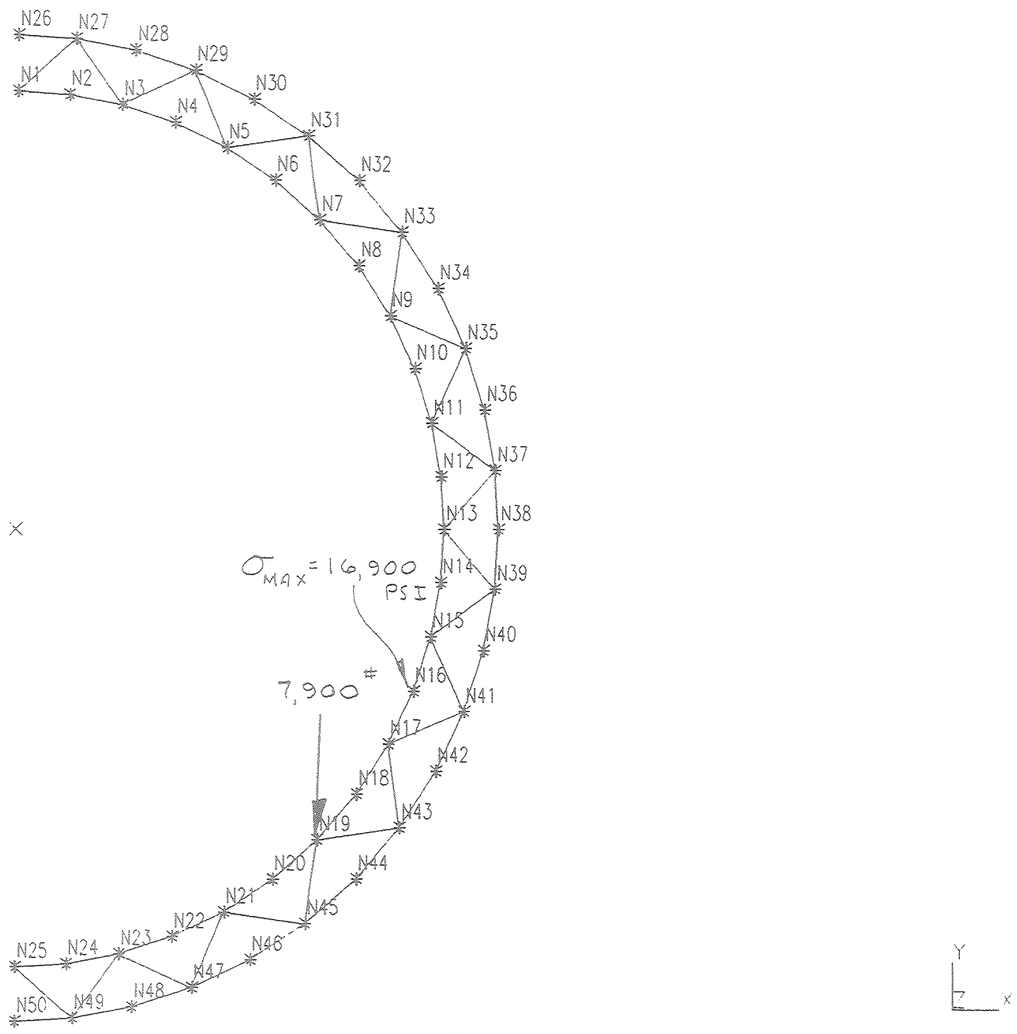


Figure 2

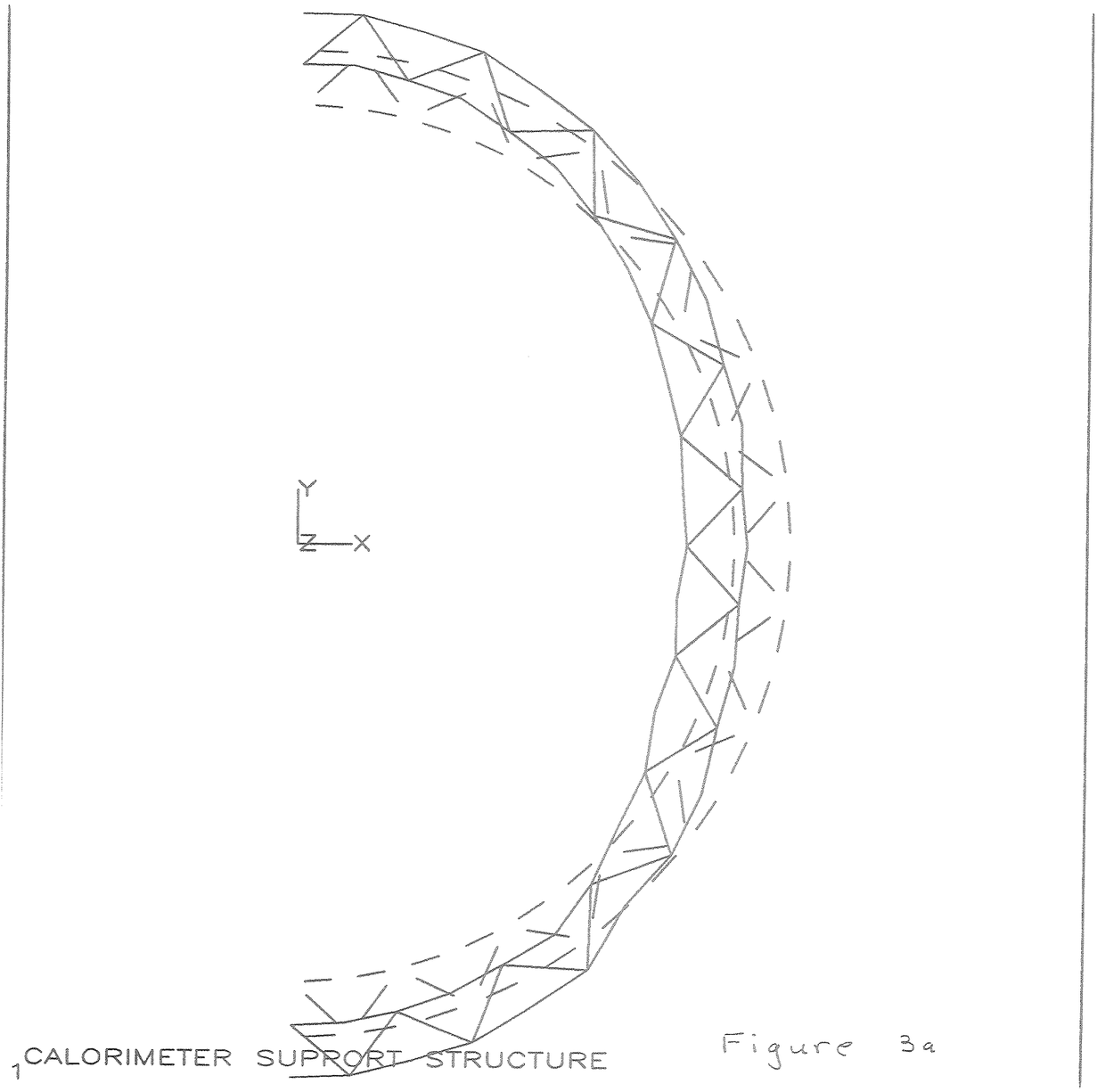

ANSYS +.3
MAR 2 1988
8:44:43
PLOT NO. 1
POST1 DISPL.
STEP=1
ITER=1
ORIG
ZV=1
DIST=195
XF=88.8
DMAX=.183
DSCA=106
Y
Z
X
1 CALORIMETER SUPPORT STRUCTURE

Figure 3a

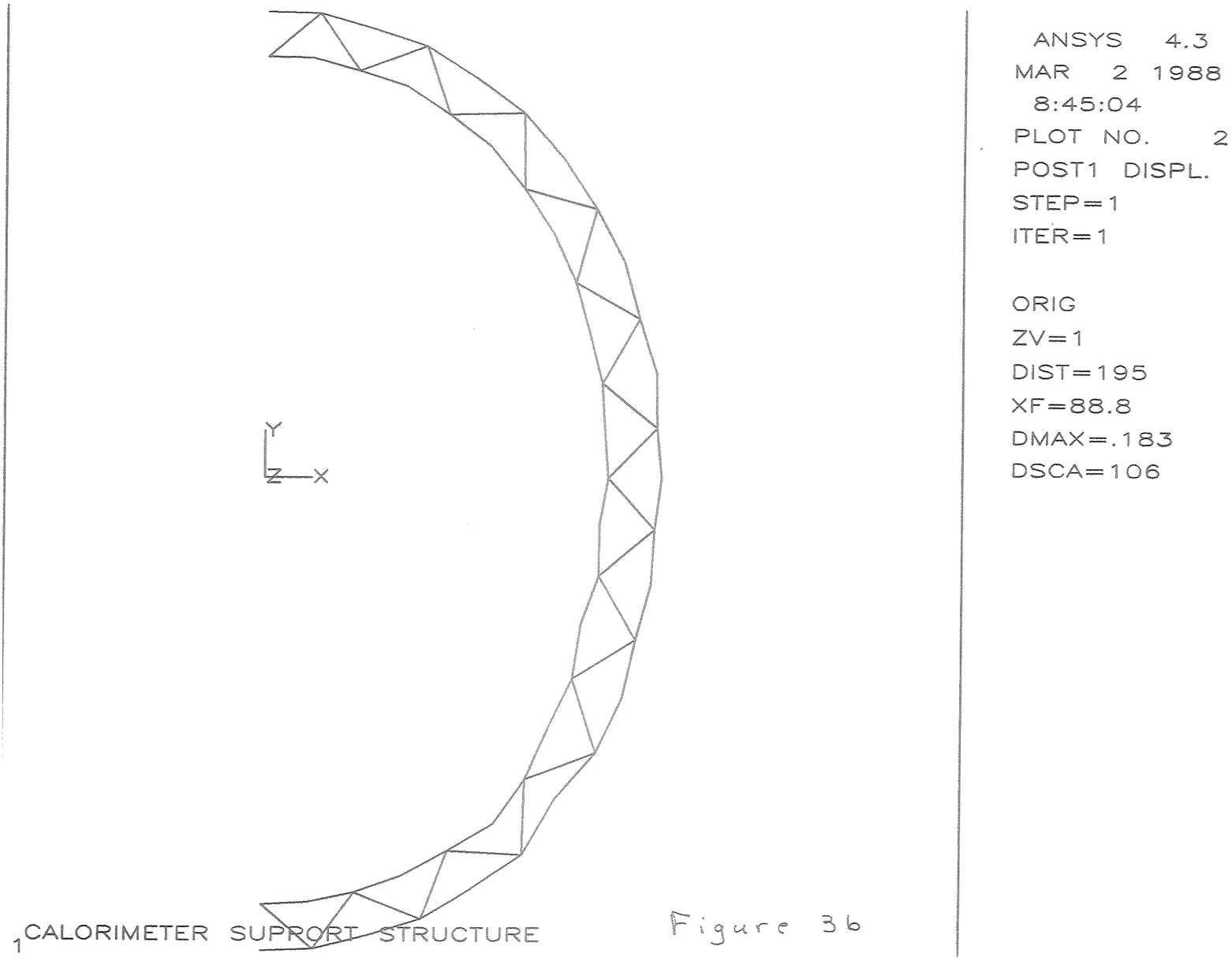

ANSYS 4.3
MAR 2 1988
8:45:04
PLOT NO. 2
POST1 DISPL.
STEP=1
ITER=1
ORIG
ZV=1
DIST=195
XF=88.8
DMAX=.183
DSCA=106
Y
Z
X
1 CALORIMETER SUPPORT STRUCTURE

Figure 3b

PRINT ELEMENT STRESS ITEMS PER ELEMENT

***** POST1 ELEMENT STRESS LISTING *****

LOAD STEP 1 ITERATION= 1 SECTION= 1
TIME= 0.00000E+00 LOAD CASE= 1

ELEM	SDPI	SDMI	SDPJ	SDMJ
1	1726.1537	-6871.5246	-7551.6123	2406.2414
2	-7552.1141	2405.7397	1644.5439	-6790.9182
3	2093.7387	-6371.1926	-7067.8195	2790.3656
4	-7068.7659	2789.4192	1441.8636	-5721.2104
5	2182.9812	-4738.3260	-4440.4836	1885.1388
6	-4442.5281	1883.0942	307.27480	-2866.7087
7	1350.7543	-1407.2464	-119.09463	62.602561
8	-121.91830	59.778882	-1315.1940	1253.0546
9	-61.284235	3032.8724	5031.1391	-2059.5510
10	5028.7788	-2061.9113	-2121.4794	5088.3469
11	-643.38201	6945.4039	9007.2588	-2705.2370
12	9003.3116	-2709.1842	-3890.3331	10184.460
13	-2136.5311	13251.153	16570.670	-5456.0483
14	16568.875	-5457.8436	-4678.2225	15789.254

***** POST1 ELEMENT STRESS LISTING *****

LOAD STEP 1 ITERATION= 1 SECTION= 1
TIME= 0.00000E+00 LOAD CASE= 1

ELEM	SDPI	SDMI	SDPJ	SDMJ
15	-5312.7287	15486.484	16892.070	-6718.3146
16	16895.208	-6715.1763	-2924.8434	13104.876
17	-5351.0527	10064.472	8081.1570	-3367.7381
18	8087.5061	-3361.3890	541.39196	4184.7251
19	-2523.4564	-1372.7328	-8561.4909	4665.3017
20	-8555.8722	4670.9204	2697.1402	-6582.0920
21	2989.3518	-5331.0689	-3359.1124	1017.3953
22	-3362.1185	1014.3893	19.827065	-2367.5562
23	445.91135	-1976.5159	-2285.4736	754.86904
24	-2285.3165	755.02619	477.67774	-2007.9680
25	5825.2001	-1567.3604	-2430.8814	6688.7212
26	-2693.4667	6582.1240	5974.3514	-2085.6941
27	5974.9434	-2085.1021	-2363.9513	6253.7926
28	-2956.6354	5580.2316	4394.8446	-1771.2484

***** POST1 ELEMENT STRESS LISTING *****

LOAD STEP 1 ITERATION= 1 SECTION= 1
TIME= 0.00000E+00 LOAD CASE= 1

ELEM	SDPI	SDMI	SDPJ	SDMJ
29	4396.7612	-1769.3318	-1037.5923	3665.0217
30	-1957.8841	2382.8315	733.95460	-309.00716
31	736.98237	-305.97939	1261.6843	-830.68133
32	24.759050	-2508.8474	-4090.5372	1606.4488
33	-4086.8268	1610.1592	3858.0927	-6334.7604
34	2513.6049	-8217.5715	-9103.0607	3399.0941
35	-9101.0668	3401.0881	4194.5199	-9894.4985
36	2186.0255	-11014.251	-9573.1445	744.91856
37	-6670.7607	3647.3024	4550.8527	-7574.3109

38	3629.9155	-7869.0747	-6121.5936	1882.4344
39	-6122.8160	1881.2120	2656.9378	-6898.5419
40	4341.5973	-5401.1603	-2535.6512	1476.0882
41	-2543.8172	1467.9222	-4294.4959	3218.6009
42	-1691.3879	8773.2520	13652.608	-6570.7440

***** POST1 ELEMENT STRESS LISTING *****

LOAD STEP 1 ITERATION= 1 SECTION= 1
TIME= 0.00000E+00 LOAD CASE= 1

ELEM	SDPI	SDMI	SDPJ	SDMJ
43	13647.763	-6575.5889	-6843.3719	13915.546
44	-6660.9487	11739.187	7954.2452	-2876.0069
45	7958.1748	-2872.0773	-2250.9060	7337.0035
46	-2975.2462	6689.2707	5729.6183	-2015.5938
47	5730.4212	-2014.7908	-1834.3646	5549.9951
48	-1900.0032	5210.2802	4518.7253	-1208.4483
49	-1086.2989	-843.46481	-1168.8683	-760.89545
50	-296.04527	-514.56230	-678.49821	-132.10936
51	-1843.3825	-1178.6377	-1356.2368	-1665.7834
52	299.85566	315.13204	-221.41073	836.39843
53	-1893.0987	-1806.2887	-1447.6607	-2251.7266
54	924.21606	1573.6298	761.45096	1736.3949
55	-1516.8373	-2212.5906	-1432.9598	-2296.4680
56	1780.2594	2688.8913	1878.6533	2590.4973

***** POST1 ELEMENT STRESS LISTING *****

LOAD STEP 1 ITERATION= 1 SECTION= 1
TIME= 0.00000E+00 LOAD CASE= 1

ELEM	SDPI	SDMI	SDPJ	SDMJ
57	-867.15925	-2267.5013	-1196.7670	-1937.8936
58	2348.0236	3768.9459	3373.9262	2743.0433
59	-139.62973	-2292.5148	-1937.6274	-494.51714
60	4480.0669	2353.7559	2315.4010	4518.4218
61	1392.0469	-1677.8476	-755.94818	470.14746
62	2269.6698	980.88746	1430.9927	1819.5646
63	3279.7864	2336.0157	2857.3246	2758.4775
64	-2068.9966	-1415.6862	-117.28803	-3367.3948
65	5500.6164	4717.2780	2254.9863	7962.9081
66	-3306.4516	-9452.7090	-6314.3469	-6444.8136
67	-7607.3114	2273.2027	983.04079	-6317.1495
68	-917.86882	1255.4368	-716.69616	1054.2642
69	-720.38437	-2800.2650	-2088.0974	-1432.5520
70	8.4345058	356.30403	-8.5436915	373.28223

***** POST1 ELEMENT STRESS LISTING *****

LOAD STEP 1 ITERATION= 1 SECTION= 1
TIME= 0.00000E+00 LOAD CASE= 1

ELEM	SDPI	SDMI	SDPJ	SDMJ
71	-1138.4810	-615.90899	-557.12816	-1197.2618
72	-518.64840	-58.018873	-318.61982	-258.04745

PRINT ELEMENT LISTING

***** POST1 ELEMENT LISTING *****

ELEM	TYPE	STIF	MAT	NODES	
1	1	3	1	1	2
2	1	3	1	2	3
3	1	3	1	3	4
4	1	3	1	4	5
5	1	3	1	5	6
6	1	3	1	6	7
7	1	3	1	7	8
8	1	3	1	8	9
9	1	3	1	9	10
10	1	3	1	10	11
11	1	3	1	11	12
12	1	3	1	12	13
13	1	3	1	13	14
14	1	3	1	14	15
15	1	3	1	15	16

***** POST1 ELEMENT LISTING *****

ELEM	TYPE	STIF	MAT	NODES	
16	1	3	1	16	17
17	1	3	1	17	18
18	1	3	1	18	19
19	1	3	1	19	20
20	1	3	1	20	21
21	1	3	1	21	22
22	1	3	1	22	23
23	1	3	1	23	24
24	1	3	1	24	25
25	1	3	1	26	27
26	1	3	1	27	28
27	1	3	1	28	29
28	1	3	1	29	30
29	1	3	1	30	31
30	1	3	1	31	32

***** POST1 ELEMENT LISTING *****

ELEM	TYPE	STIF	MAT	NODES	
31	1	3	1	32	33
32	1	3	1	33	34
33	1	3	1	34	35
34	1	3	1	35	36
35	1	3	1	36	37
36	1	3	1	37	38
37	1	3	1	38	39
38	1	3	1	39	40
39	1	3	1	40	41
40	1	3	1	41	42
41	1	3	1	42	43
42	1	3	1	43	44

43	1	3	1	44	45
44	1	3	1	45	46
45	1	3	1	46	47

***** POST1 ELEMENT LISTING *****

ELEM	TYPE	STIF	MAT	NODES	
46	1	3	1	47	48
47	1	3	1	48	49
48	1	3	1	49	50
49	1	3	1	1	27
50	1	3	1	27	3
51	1	3	1	3	29
52	1	3	1	29	5
53	1	3	1	5	31
54	1	3	1	31	7
55	1	3	1	7	33
56	1	3	1	33	9
57	1	3	1	9	35
58	1	3	1	35	11
59	1	3	1	11	37
60	1	3	1	37	13

***** POST1 ELEMENT LISTING *****

ELEM	TYPE	STIF	MAT	NODES	
61	1	3	1	13	39
62	1	3	1	39	15
63	1	3	1	15	41
64	1	3	1	41	17
65	1	3	1	17	43
66	1	3	1	43	19
67	1	3	1	19	45
68	1	3	1	45	21
69	1	3	1	21	47
70	1	3	1	47	23
71	1	3	1	23	49
72	1	3	1	49	25

DISPLAY COORDINATE SYSTEM SET TO 1 (CYLINDRICAL)

PRINT NODE LISTING

***** POST1 NODE LISTING *****

THE FOLLOWING X,Y,Z COORDINATES ARE IN SYSTEM 1

NODE	X	Y	Z	THXY	THYZ	T
1	157.50000	90.000000	0.00000000E+00	0.00000000E+00	0.00000000E+00	0.00
2	157.49999	83.087090	0.00000000E+00	0.00000000E+00	0.00000000E+00	0.00
3	157.49997	75.874166	0.00000000E+00	0.00000000E+00	0.00000000E+00	0.00
4	157.50004	68.401844	0.00000000E+00	0.00000000E+00	0.00000000E+00	0.00

5	157.49999	60.722382	0.00000000E+00	0.00000000E+00	0.00000000E+00	0.00
6	157.50003	52.898378	0.00000000E+00	0.00000000E+00	0.00000000E+00	0.00
7	157.49997	45.000000	0.00000000E+00	0.00000000E+00	0.00000000E+00	0.00
8	157.50003	37.101622	0.00000000E+00	0.00000000E+00	0.00000000E+00	0.00
9	157.49998	29.277612	0.00000000E+00	0.00000000E+00	0.00000000E+00	0.00
10	157.50004	21.598156	0.00000000E+00	0.00000000E+00	0.00000000E+00	0.00
11	157.49997	14.125834	0.00000000E+00	0.00000000E+00	0.00000000E+00	0.00
12	157.49998	6.9129060	0.00000000E+00	0.00000000E+00	0.00000000E+00	0.00
13	157.50000	0.00000000E+00	0.00000000E+00	0.00000000E+00	0.00000000E+00	0.00

***** POST1 NODE LISTING *****

THE FOLLOWING X,Y,Z COORDINATES ARE IN SYSTEM 1

NODE	X	Y	Z	THXY	THYZ	T
14	157.49999	-6.9129132	0.00000000E+00	0.00000000E+00	0.00000000E+00	0.00
15	157.49997	-14.125831	0.00000000E+00	0.00000000E+00	0.00000000E+00	0.00
16	157.50004	-21.598156	0.00000000E+00	0.00000000E+00	0.00000000E+00	0.00
17	157.49999	-29.277621	0.00000000E+00	0.00000000E+00	0.00000000E+00	0.00
18	157.50003	-37.101622	0.00000000E+00	0.00000000E+00	0.00000000E+00	0.00
19	157.49997	-45.000000	0.00000000E+00	0.00000000E+00	0.00000000E+00	0.00
20	157.50003	-52.898378	0.00000000E+00	0.00000000E+00	0.00000000E+00	0.00
21	157.49999	-60.722382	0.00000000E+00	0.00000000E+00	0.00000000E+00	0.00
22	157.50004	-68.401844	0.00000000E+00	0.00000000E+00	0.00000000E+00	0.00
23	157.49997	-75.874173	0.00000000E+00	0.00000000E+00	0.00000000E+00	0.00
24	157.49999	-83.087087	0.00000000E+00	0.00000000E+00	0.00000000E+00	0.00
25	157.50000	-90.000000	0.00000000E+00	0.00000000E+00	0.00000000E+00	0.00
26	177.50000	90.000000	0.00000000E+00	0.00000000E+00	0.00000000E+00	0.00

***** POST1 NODE LISTING *****

THE FOLLOWING X,Y,Z COORDINATES ARE IN SYSTEM 1

NODE	X	Y	Z	THXY	THYZ	T
27	177.49998	83.087090	0.00000000E+00	0.00000000E+00	0.00000000E+00	0.00
28	177.50003	75.874172	0.00000000E+00	0.00000000E+00	0.00000000E+00	0.00
29	177.49997	68.401840	0.00000000E+00	0.00000000E+00	0.00000000E+00	0.00
30	177.49998	60.722382	0.00000000E+00	0.00000000E+00	0.00000000E+00	0.00
31	177.49995	52.898336	0.00000000E+00	0.00000000E+00	0.00000000E+00	0.00
32	177.50007	45.000000	0.00000000E+00	0.00000000E+00	0.00000000E+00	0.00
33	177.49995	37.101664	0.00000000E+00	0.00000000E+00	0.00000000E+00	0.00
34	177.49998	29.277615	0.00000000E+00	0.00000000E+00	0.00000000E+00	0.00
35	177.49997	21.598160	0.00000000E+00	0.00000000E+00	0.00000000E+00	0.00
36	177.50003	14.125831	0.00000000E+00	0.00000000E+00	0.00000000E+00	0.00
37	177.49998	6.9129065	0.00000000E+00	0.00000000E+00	0.00000000E+00	0.00
38	177.50000	0.00000000E+00	0.00000000E+00	0.00000000E+00	0.00000000E+00	0.00
39	177.49998	-6.9129129	0.00000000E+00	0.00000000E+00	0.00000000E+00	0.00

***** POST1 NODE LISTING *****

THE FOLLOWING X,Y,Z COORDINATES ARE IN SYSTEM 1

NODE	X	Y	Z	THXY	THYZ	T
40	177.50003	-14.125828	0.00000000E+00	0.00000000E+00	0.00000000E+00	0.00
41	177.49998	-21.598166	0.00000000E+00	0.00000000E+00	0.00000000E+00	0.00
42	177.49998	-29.277618	0.00000000E+00	0.00000000E+00	0.00000000E+00	0.00
43	177.49995	-37.101664	0.00000000E+00	0.00000000E+00	0.00000000E+00	0.00
44	177.50007	-45.000000	0.00000000E+00	0.00000000E+00	0.00000000E+00	0.00
45	177.50003	-52.898356	0.00000000E+00	0.00000000E+00	0.00000000E+00	0.00
46	177.49998	-60.722382	0.00000000E+00	0.00000000E+00	0.00000000E+00	0.00
47	177.49997	-68.401840	0.00000000E+00	0.00000000E+00	0.00000000E+00	0.00
48	177.50003	-75.874172	0.00000000E+00	0.00000000E+00	0.00000000E+00	0.00
49	177.49998	-83.087087	0.00000000E+00	0.00000000E+00	0.00000000E+00	0.00
50	177.50000	-90.000000	0.00000000E+00	0.00000000E+00	0.00000000E+00	0.00