

**Summary of EC Superelement Results
for OH Inter-Module Connecting Forces**

Bob Wands, Kay Weber, Joe Zurawski

Introduction

The purpose of this report is to summarize the OH module connecting forces found as a result of the super-element modeling of the EC internal module structure. Although not presented here, this approach can also provide MH connecting forces and assembly deflections.

The Basic Superelement Approach

The EC calorimeter module assembly consists of three distinct module types as shown in Fig. 1. There are 16 OH modules which are assembled into a ring and supported at 56.25 degrees on either side of the centerline. The 16 MH modules are assembled concentrically within the OH assembly, and their weight is supported by OH along an arc from plus or minus 56.25 degrees about the centerline. The IH module is a single unit, and is supported within MH by bearing on MH at the 56.25 degree locations as indicated in the figure.

The closed-form calculation of the forces and moments between modules in such a structure is not trivial. Although it is possible to arrive at a solution by superimposing solutions for thin rings under various loadings, the thin ring approximations assume that the energy of the structure is well represented by the bending energy alone; that is, that membrane and shear deformations are not significant. A large error would be expected by applying this method to the analysis of the EC structure, since the module assemblies are not good approximations to thin rings, and their shear behaviour is difficult to characterize, since the rings are not continuous but in fact are stiff, discrete modules attached to adjacent modules at a finite number of points.

A numerical approach using finite element analysis was used instead to calculate the forces between modules. A well-developed technique known as substructuring (super-elements) was applied to permit economical analysis of intermediate assembly steps as well as primary stress evaluation of each module. This technique consists of three basic phases: 1)The "generation" phase breaks up the assembly into "super elements" (in this case, individual modules) which are then modeled in detail (many nodes and elements). The detailed model of each module is then mathematically condensed by the finite element program such that the only active degrees of freedom are those at the points of connection between the individual modules. 2)The "use" phase assembles the individual super-elements into the final structure, or any desired intermediate assembly of modules. This model can be run very economically due to the small size of the stiffness matrix. 3)The "stress pass" phase uses the displacements found in the use phase as input into the detailed super-element model of the module to extract stresses.

The Finite Element Model

OH Module Super-element

The OH module was modeled with the dimensions shown in Fig. 2. The model used only the outer skin and four internal steel plates to characterize the module stiffness. Super-elements representing both 1/16 in. and 1/32 in. skins were generated. The internal structural plates were 1.87 in. thick in both super-elements. Two load vectors were generated for each super-element. One of these was the module weight, which was applied as concentrated nodal loadings on the edges of the module. The other loading was thermal contraction, which allowed the possibility of assigning a uniform temperature to each module and thereby estimate cooldown stresses and their effect on connection forces. Eight super-elements were generated, and symmetry was exploited to account for the full arch assembly.

Each super-element was condensed from its detailed description down to an element containing 18 nodes, each with only three translational degrees of freedom. These "master" nodes are indicated in the Figure. Sixteen of these nodes were used to connect adjacent OH modules in the super-element use phase, and can be thought of as representing a connection scheme which uses four connectors on the inside radius and four connectors on the outside radius of each module. The remaining two nodes were used only on OH modules 1,2, and 3 to provide support points for the MH module assembly.

For clarity in presenting connection force results, the inner radius connectors at any interface of OH modules are numbered 1-4, with 1 being the backward-most (farthest from the collision center). The outer radius connectors are numbered with a similar convention.

MH Module Super-element

The MH module was modeled with the dimensions shown in Fig. 3. The model used only the outer skins and the endplates to characterize the module stiffness. Two load vectors, weight and thermal contraction, were generated with the super-element. Nine super-elements were generated, two of which were half modules, and symmetry was exploited to account for the full arch assembly.

Each super-element was condensed from its detailed description down to an element containing eight "master" nodes (one at the corner of each endplate) each with only three translational degrees of freedom. These nodes were used to connect adjacent MH modules, and can be thought of as representing a connection scheme which attaches the MH modules at the inner and outer radius of the endplates only. Some of these nodes also serve to provide contact with the inner radius of the OH arch for transferral of the MH weight.

IH Modeling

The effect of IH on the assembly was modeled by applying concentrated nodal loads to the MH arch at the location where IH will be supported in the final assembly. The loads were adjusted to account for the actual center of gravity of the IH module.

Boundary Conditions and Connection Modeling

The model represented only one-half of the EC assembly, with the effects of the other half accounted for by a symmetry boundary condition on the vertical plane containing the module assembly centerline. The weight of the modules was carried to ground through OH module 3, as shown in Fig. 4. This module was given a two inch thick steel plate along its underside where the supports are applied. The supports are allowed to translate freely in the horizontal direction, which requires that the arch assembly itself develop any horizontal reactions necessary for equilibrium. This should be conservative.

The MH arch was supported on the inner radius of the OH arch with "gap" elements, which allow two surfaces to maintain compressive contact only, or separate if necessary. They were used without friction, and so allowed relative sliding of the MH and OH arches at the contact points.

The simplest means of assembling super-elements is to generate them such that adjacent elements have identical node numbers at connecting interfaces. This will result in an "automatic" connection at this point. This method was used wherever total connection in all directions was desired between modules.

Some runs were made in which the connectors on the inner radius of OH were "disconnected" in the sense that only compressive surface contact was allowed. This was modeled by applying an offset to the node numbers in the super-elements, (which eliminated the automatic connecting), and then using "gap" elements at the four connectors on the inner radius of each module interface. Nodal coupling was then used to enforce full connection at the outer radius connectors. In some cases, it was desired to "reconnect" the inner radius connectors only at the bottom modules. This again was done by nodal coupling.

In some cases, it was desired to eliminate the ability of a given connector to sustain forces parallel to the module interface. This was done by constraining the two nodes at such a location to move with identical displacements perpendicular to the interface, but giving them freedom to displace relative to each other parallel to the interface.

Results

The connecting forces between OH modules were calculated for eight different models. These forces are presented in detail in the Appendices. A cover page to the Appendices shows the sign conventions and other details needed to interpret the results. The results will be summarized for each case in the text below.

In earlier work it was found that a 1/32 in. skin on OH 3 (the support module) resulted in unacceptable stresses. Therefore, in the following Models 1-6, all OH modules have 1/32 in skins except OH 3, which has a 1/8 in. skin.

Model 1.

Characteristics:

1. OH module skin thickness = 1/32 in. except OH 3 = 1/8 in.
2. OH modules fully connected at four locations on the inner radius and four locations on the outer radius of each module interface.
3. Loading is OH, MH, and IH module weight only.

The connecting forces for this case are given in detail in Appendix A. To summarize, the largest connecting force on OH is found at $\theta=67.5$ degrees at the second outer radius connector, and is 38000 lbs.

The forces which are transmitted to the inner radius of the OH arch from the weight of the MH arch and IH module for this case are shown in Fig. 4.

Model 2.

Characteristics: Same as for Model 1 except

1. Loading is OH, MH, and IH module weight plus a thermal gradient as shown in Fig. 5.

The connecting forces for this case are given in detail in Appendix B. To summarize, the largest connecting force is found at $\theta=67.5$ degrees, at the third outer radius connector, and is 67000 lbs.

Model 3.

Characteristics:

1. OH module skin thickness = $1/32$ in. except OH 3 = $1/8$ in.
2. OH modules completely connected only at four locations on the outer radius of each interface. The inner radius of each interface supports only compressive loading, and is free to separate if necessary.
3. Loading is OH, MH and IH weight only.

The connecting forces for this case are given in detail in Appendix C. To summarize, the largest connecting force is found at $\theta=45$ degrees, at the first outer radius connector, and is 63500 lbs. All but one of the inner radius compressive-only contact points separated at $\theta=0$, 22.5, and 45 degrees.

The forces transmitted to the inner radius of the OH arch from the weight of the MH arch and IH module for this case are shown in Fig. 6.

Model 4.

Characteristics: Same as for Model 3 except:

1. Loading is OH, MH and IH weight plus a thermal gradient as shown in Fig. 5.

The connecting forces for this case are given in detail in Appendix D. To summarize, the largest connecting force is found at $\theta=0$ degrees at the first outer radius connector, and is 73000 lbs. It can be seen that the inner radius compression-only connectors are more active in this cooldown scenario.

Model 5.

Characteristics:

1. OH module skin thickness= 1/32 in. except OH 3 = 1/8 in.
2. OH modules fully connected at only the first and fourth outer radius connectors at each interface. The second and third outer radius connectors can sustain no force parallel to the module interface (shear). The inner radius connectors at each interface support only compressive loading, and are free to separate if necessary.
3. Loading is OH, MH and IH weight only.

The connecting forces for this case are given in detail in Appendix E. To summarize, the largest connecting force is found at $\theta=45$ degrees at the first outer radius connector, and is 64000 lbs.

Model 6.

Characteristics: Same as for Model 5 except

1. Loading is OH, MH and IH weight only plus a thermal gradient as shown in Fig. 5.

The connecting forces for this case are given in detail in Appendix F. To summarize, the largest connecting force is found at $\theta=0$ degrees at the first outer radius connector, and is 73500 lbs.

Model 7.

Characteristics:

1. OH module skin thickness= 1/16 in on all OH modules
2. OH modules fully connected at only the first and fourth outer radius connectors at each interface. The second and third outer radius connectors cannot resist forces parallel to the module interface (shear). The inner radius connectors at each interface support only compressive loading and are free to separate if necessary.
3. Loading is OH, MH and IH module weight only.

The connecting forces for this case are given in detail in Appendix G. To summarize, the largest connecting forces occurs at $\theta=45$ degrees at the first outer radius connector, and is 66500 lbs. This force compares with 64000 lbs at the same location for Model 5, which is identical to Model 7 except for OH module skin thickness. This implies that the forces are not strong functions of skin thickness in the range being investigated.

The forces transmitted to the inner radius of the OH arch by the weight of the MH arch and IH module for this load case are shown in Fig. 7.

Model 8.

Characteristics:

1. OH module skin thickness = $1/16$ in on all OH modules.
2. OH modules fully connected at only the first and fourth outer radius connectors at each interface. The second and third outer radius connectors cannot resist forces parallel to the module interface (shear). The inner radius interfaces from $\theta=67.5$ to $\theta=180$ degrees can support compression only, and are free to separate if necessary. The inner radius connectors from $\theta=0$ to $\theta=45$ degrees can sustain both normal compression and tension, but cannot sustain any force parallel to the module interface.
3. Loading is OH, MH and IH module weight only.

The connecting forces for this case are given in detail in Appendix H. To summarize, the largest force occurs at $\theta=45$ degrees at the first connector on the outer radius and is 76500 lbs.

The forces transmitted to the inner radius of the OH arch by the weight of the MH arch and IH module are shown in Fig. 8.

Conclusion

This report includes only information on the OH connecting forces for various assumed connector schemes. The super-element machinery is in place to model other connector ideas, and provide information on overall deflections, MH connecting forces, and primary module stresses.

Interpreting the Appendices

A typical block of data is reproduced below:

16	THETA=		22.500							
17	NODE	11	FX =	25700.100	FY =	-10645.500	PHI =	90.000	RESF =	27817.633
18	NODE	12	FX =	17972.200	FY =	-7444.500	PHI =	90.000	RESF =	19423.033
19	NODE	13	FX =	15935.500	FY =	-6600.630	PHI =	90.000	RESF =	17248.911
20	NODE	14	FX =	-9345.450	FY =	3871.090	PHI =	-90.000	RESF =	10115.472
21	NODE	15	FX =	57715.900	FY =	-7225.970	PHI =	103.364	RESF =	58166.483
22	NODE	16	FX =	23953.800	FY =	-9922.210	PHI =	90.000	RESF =	25927.491
23	NODE	17	FX =	15169.500	FY =	-6283.560	PHI =	90.000	RESF =	16419.403
23	NODE	18	FX =	13584.500	FY =	-11212.600	PHI =	72.964	RESF =	17614.228
24	NORMAL FORCE = 169679.741 SHEAR = 10249.705 MOMENT = -730467.464									
25	FORCE ON INNER RADIUS = 54403.726 FORCE ON OUTER RADIUS = 115730.825									

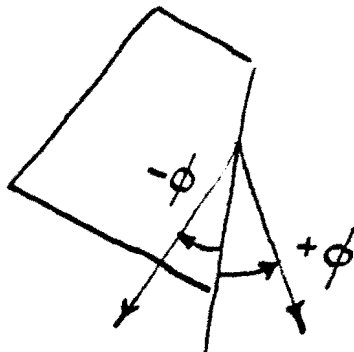
Explanation of terms:

Theta This is the angle of the OH module interface represented by the following data, and is measured in a clockwise direction beginning from the 6 o'clock position on the EC assembled structure. See Fig. 1.

Node This is the node number of the master node at which the connecting force RESF is found. It is of no real use to the reader, and was included only to check the program.

FX,FY These are the forces in the x and y coordinate directions at the master node, and are used to calculate RESF

Phi This is the angle which the force RESF makes with the module interface. It is always referenced to the module on the left and has the convention shown in the sketch below.



RESF This is the actual connecting force at the master node, acting on the interface at the angle ϕ . There are eight connecting points at each interface, and so eight RESF's. The first connecting point in each data group (node 11 in this example) is the inner radius connector farthest from the collision center, or inner connector 1, as shown in Fig. 2. The next connecting point (node 12 in this example) is inner connector 2, etc. The fifth connecting point (node 15 in this example) is the outer radius connector farthest from the collision center, or outer connector 1. The next connecting point (node 16 in this example) is outer connector 2, etc.

Normal Force

This is the total normal force (membrane force) between the two modules at the theta interface. The sign convention is that a positive normal force will tend to separate the modules (produce tension)

Shear This is the total force parallel to the interface of the modules. The sign convention is that a positive shear force tends to move the module to the right of the interface toward the center of the assembly.

Moment This is the total moment at the interface about the centroid of the section. The sign convention is that a positive moment tends to put the inner radius in tension.

Force on Inner Radius

This is the vector sum of the forces on the four connectors at the inner radius.

Force on Outer Radius

This is the vector sum of the forces on the four connectors at the outer radius.

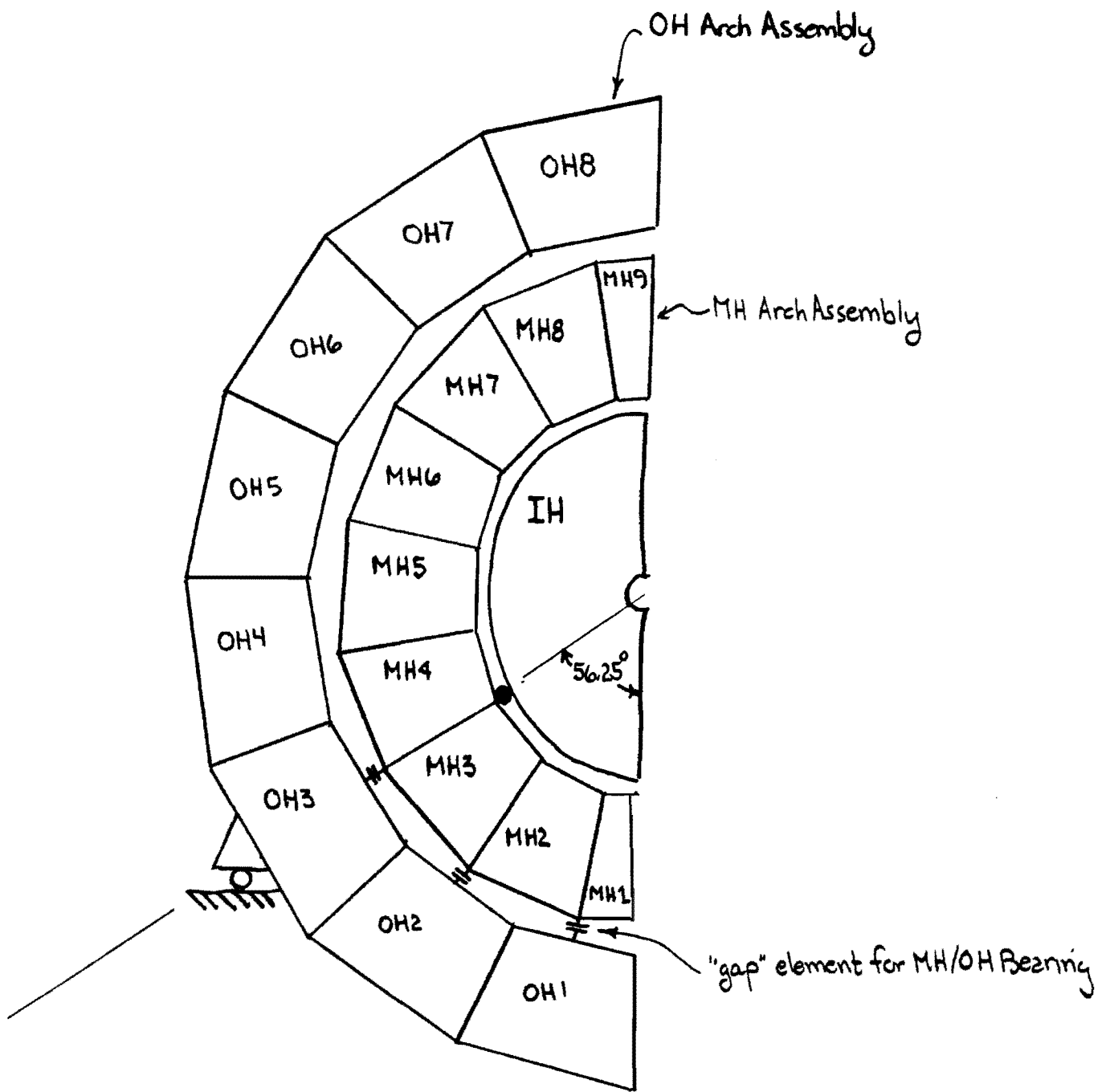


Fig1. View of EC Module Assembly looking toward collision center.

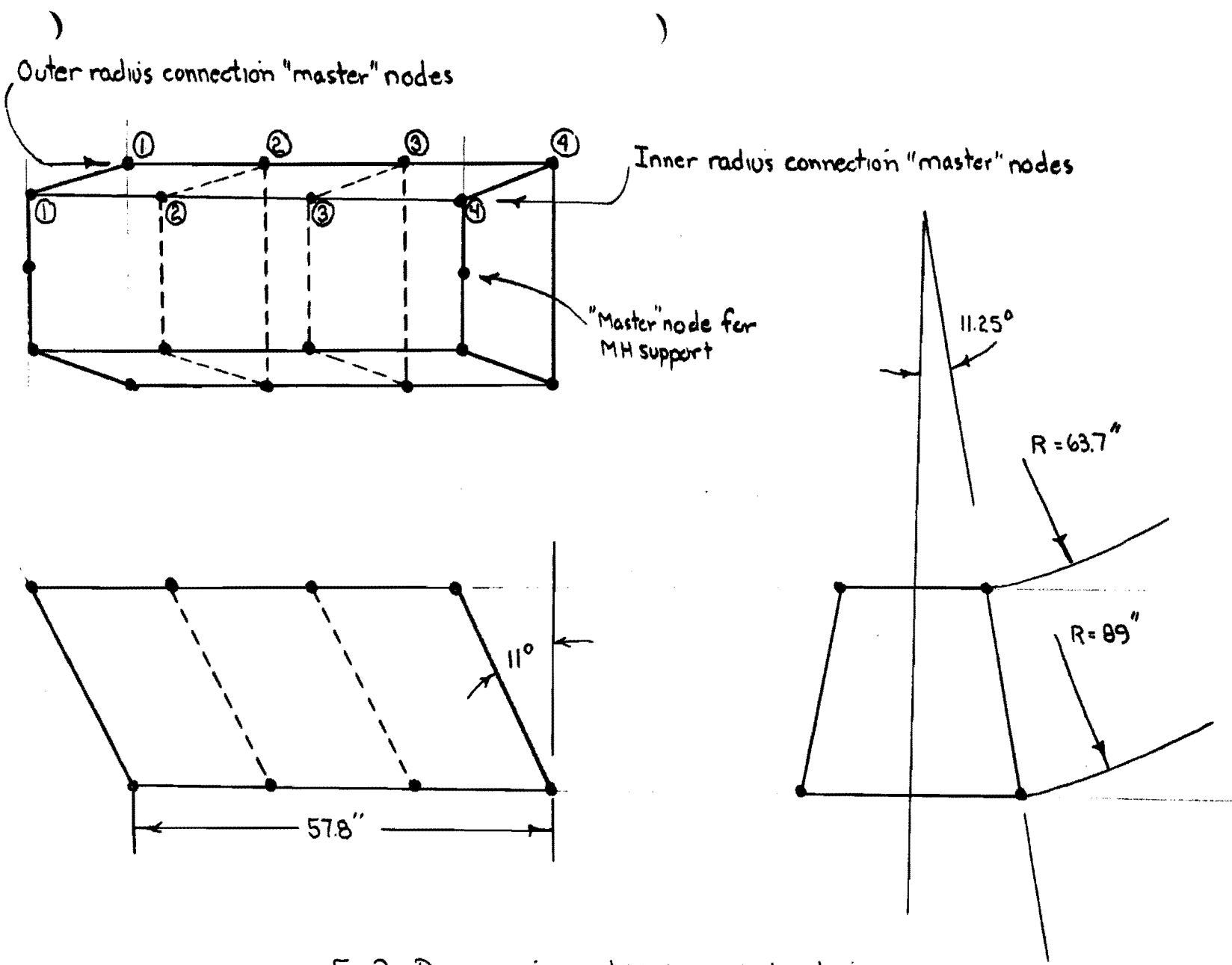
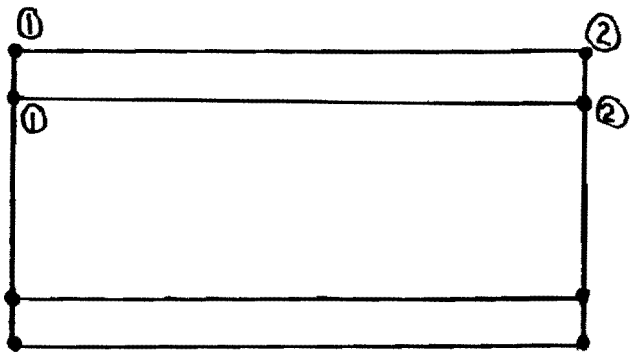


Fig 2. Dimensions and Master node locations on OH Super-element

Outer radius connection "master" nodes



Inner radius connection "master" nodes

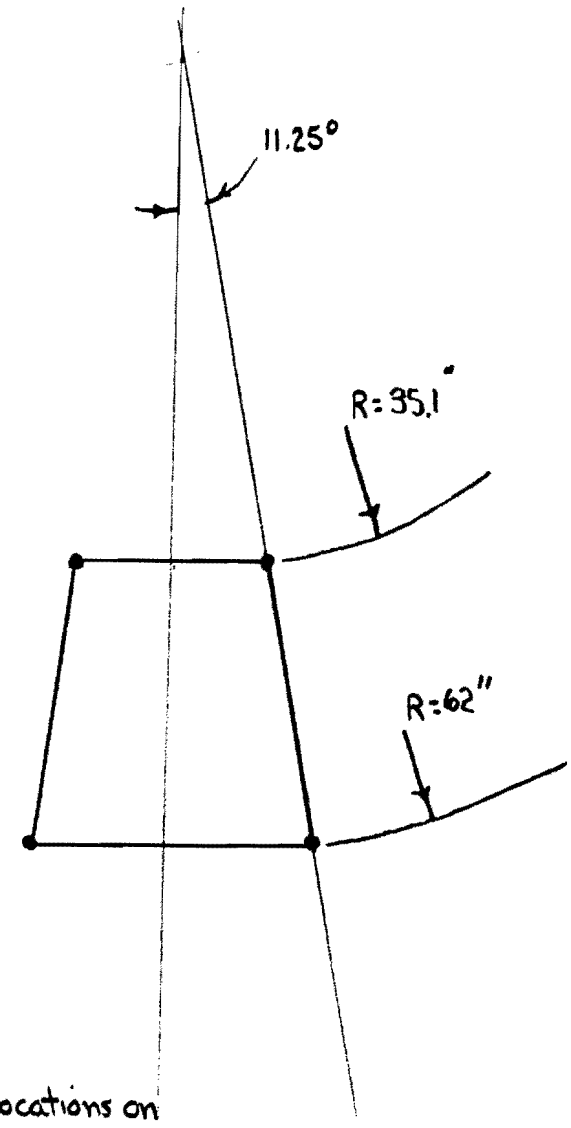
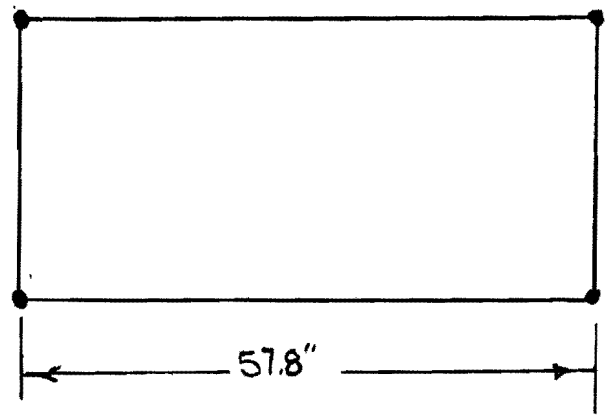


Fig 3, Dimensions and Master Node locations on MH Superelement

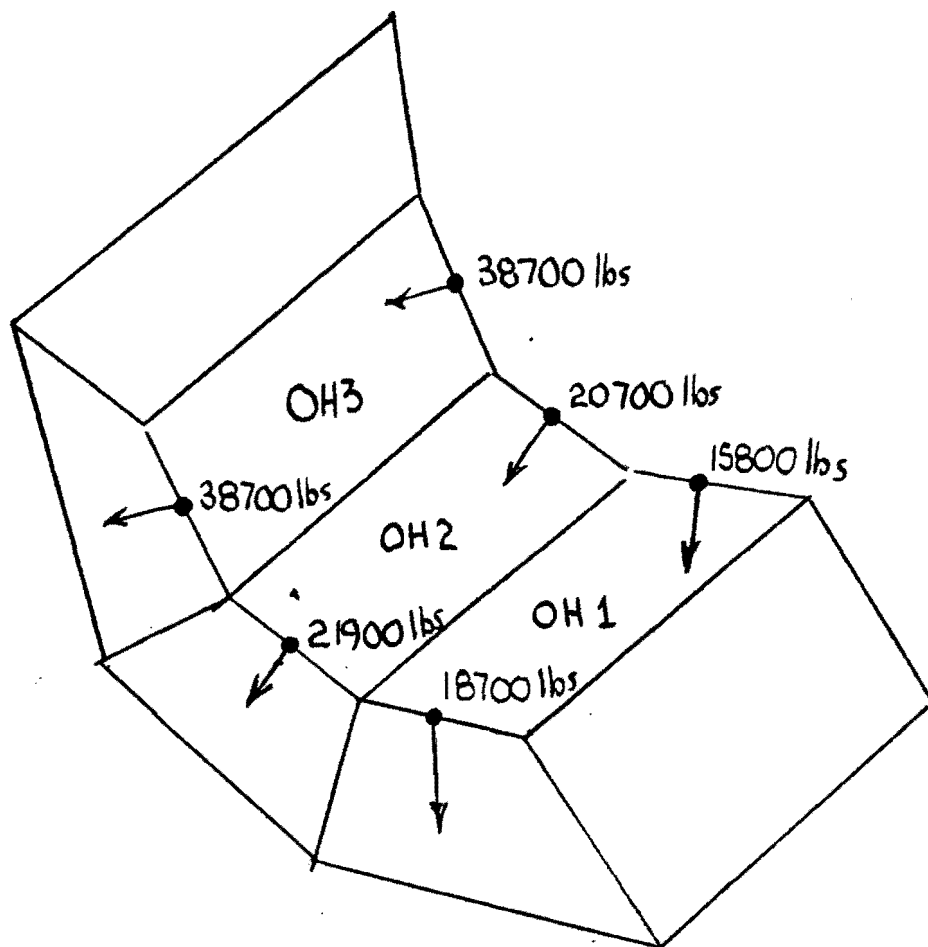


Fig 4. Forces applied by MH Arch to Inner Radius of OH Arch for Model 1

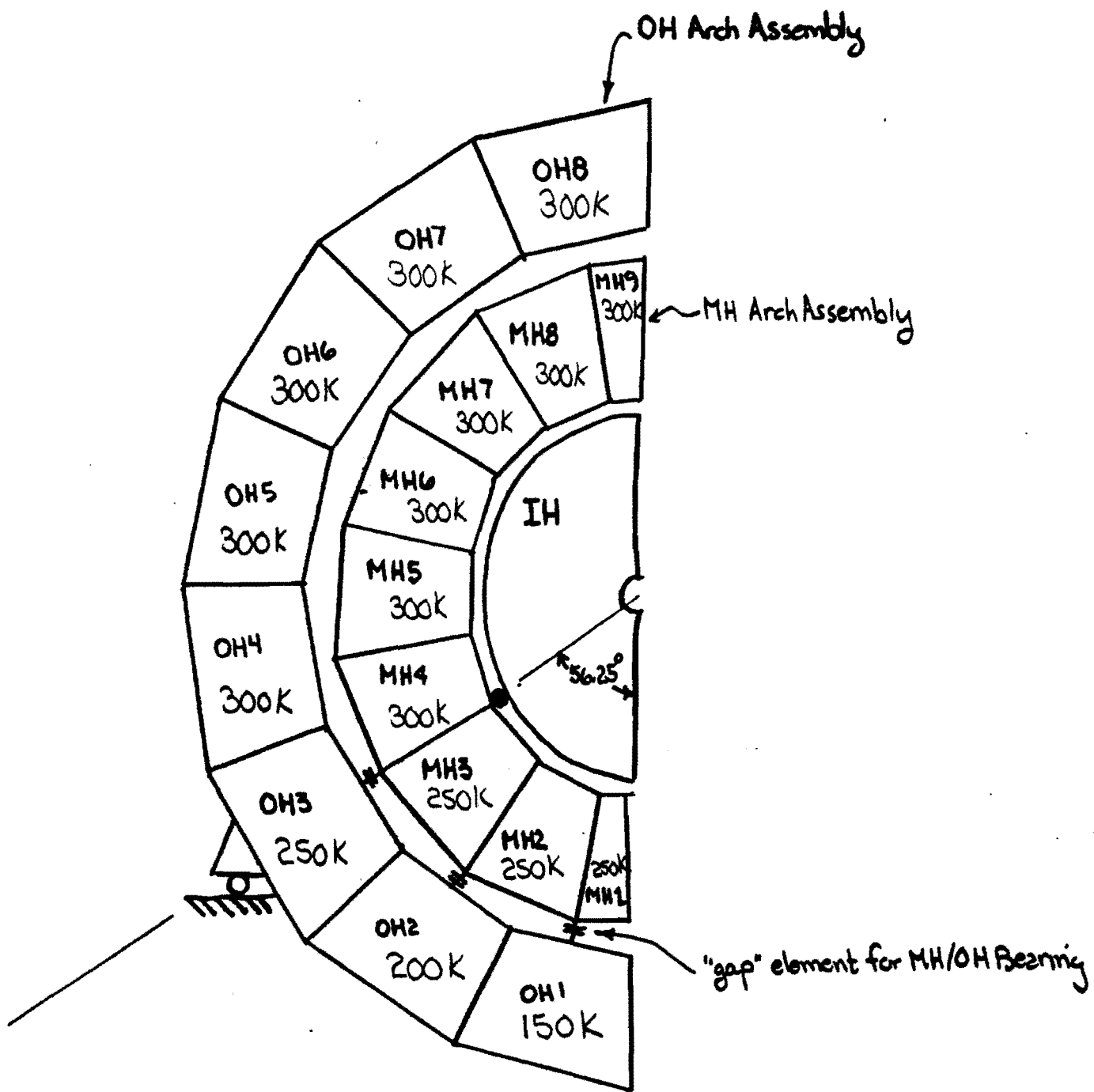


Fig 5. Module Temperatures for Thermal Loadings

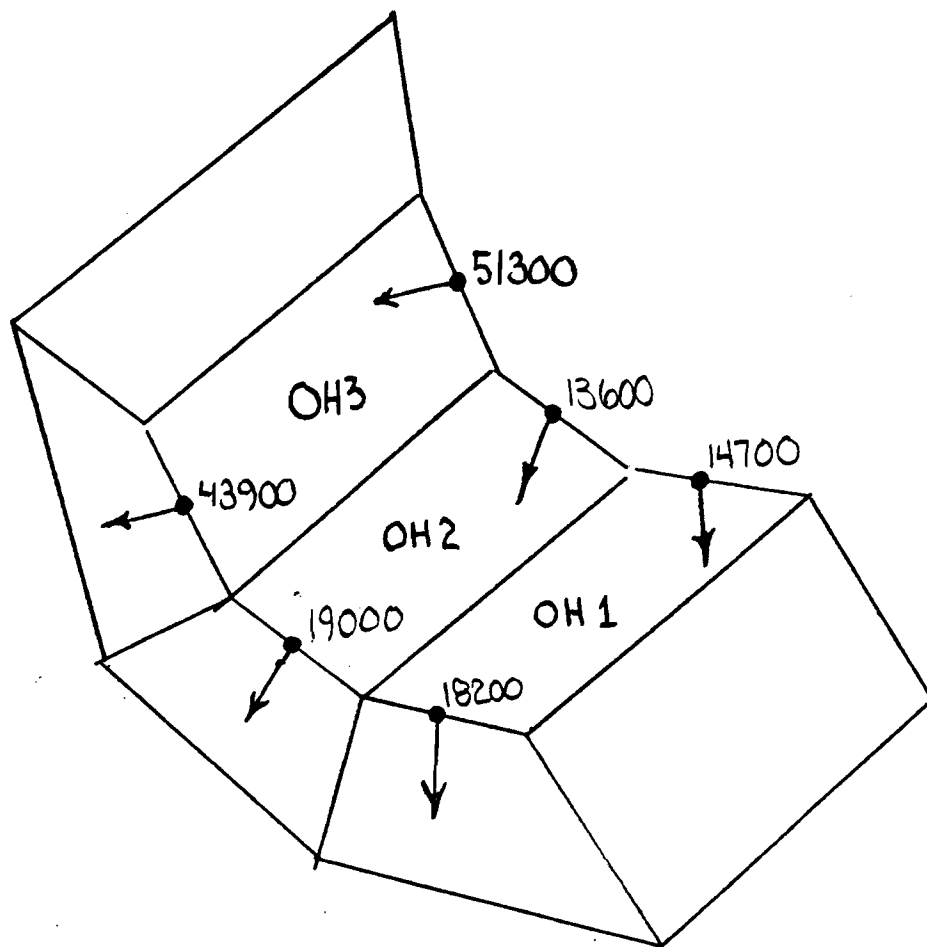


Fig 6. Forces applied by MH Arch to Inner Radius of OH Arch for Model 3

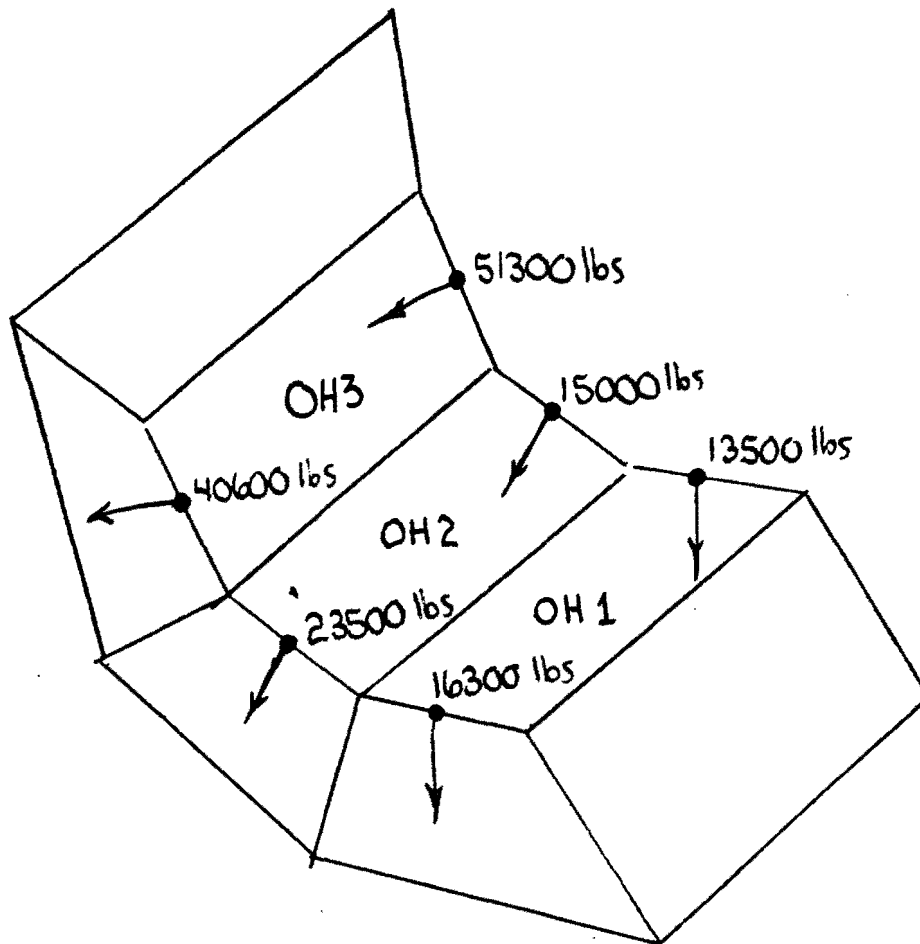


Fig 7. Forces applied by MH Arch on Inner Radius of OH Arch for Model 7

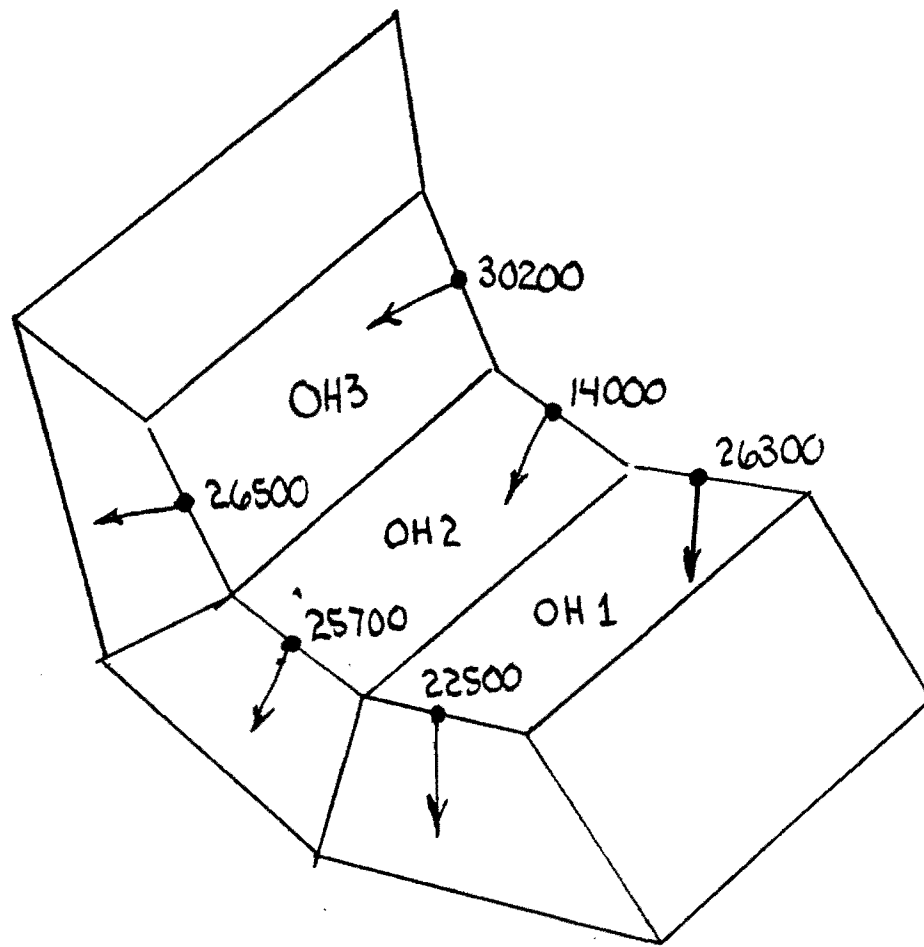


Fig B. Forces applied by MH Arch To Inner Radius of OH Arch for Model 8

***** FULLY ASSEMBLED EC STRUCTURE *****
 ***** SAME INPUT AS THERMAL LOADCASE E *****
 ***** NO THERMAL LOADING *****
 ***** 4/21/87 *****

Appendix A

THETA= 0.000

NODE	FX	FY	PHI	RES
1	36265.000	-.000	90.000	36265.000
2	-1507.800	-.000	-90.000	1507.800
3	1961.940	-.000	90.000	1961.940
4	15253.000	-.000	90.000	15253.000
5	22334.800	-.000	90.000	22334.800
6	12379.600	-.000	90.000	12379.600
7	11649.100	-.000	90.000	11649.100
8	14071.800	-.000	90.000	14071.800

NORMAL FORCE= 112407.440 SHEAR= -.000 MOMENT= -101557.920
 FORCE ON INNER RADIUS= 51972.140 FORCE ON OUTER RADIUS= 60435.200

THETA= 22.500

NODE	FX	FY	PHI	RES
11	32666.100	-11103.300	93.724	34502.200
12	-37.269	-3259.070	21.845	3259.283
13	3529.710	-2100.790	81.740	4107.575
14	14412.300	-4787.890	94.123	15186.780
15	22329.400	-7771.420	93.310	23643.119
16	8954.650	-6170.730	77.929	10874.910
17	9858.730	-4862.530	86.247	10992.666
18	13949.100	-5315.230	91.641	14927.460

NORMAL FORCE= 114983.105 SHEAR= -1483.815 MOMENT= -63287.940
 FORCE ON INNER RADIUS= 54855.283 FORCE ON OUTER RADIUS= 60140.546

THETA= 45.000

NODE	FX	FY	PHI	RES
21	20441.800	-20526.900	89.881	28464.308
22	2938.170	-14504.900	56.451	14799.492
23	4164.120	-7212.190	75.001	8328.000
24	8820.920	-14590.400	76.136	17049.587
25	23311.200	-15278.100	101.750	27871.713
26	-1336.710	-5681.150	31.760	5836.288
27	9558.300	-9396.090	105.553	10976.287
28	14072.500	-9106.720	102.092	16762.088

NORMAL FORCE= 123225.196 SHEAR= -7301.772 MOMENT= 102943.686
 FORCE ON INNER RADIUS= 67472.675 FORCE ON OUTER RADIUS= 57770.236

THETA= 67.500

NODE	FX	FY	PHI	RES
31	1303.680	-12289.700	73.555	12358.653
32	15291.200	-782.149	160.868	13314.194
33	4373.090	-443.978	151.677	4395.772
34	3633.600	-8954.560	89.586	9663.705
35	-2396.790	16051.100	-104.007	16229.061
36	1379.740	37703.500	-114.596	37728.737
37	-1678.530	20241.400	-107.739	20310.877
38	-2290.930	4237.900	-84.105	4817.484

NORMAL FORCE= -46221.114 SHEAR= 38211.878 MOMENT= 1225832.918
 FORCE ON INNER RADIUS= 30789.270 FORCE ON OUTER RADIUS= 78392.655

THETA= 90.000

NODE	FX	FY	PHI	RESF
41	1532.930	-10084.600	754	10203.467
42	5777.220	10635.200	-118.312	12103.047
43	2605.090	4700.470	-118.996	5374.096
44	919.016	-1624.170	119.503	1866.131
45	904.608	10002.100	-95.168	10042.924
46	3213.120	14257.000	-102.701	14614.588
47	1461.160	10614.100	-97.838	10714.201
48	1181.930	7360.500	-99.122	7454.792

NORMAL FORCE= -45860.577 SHEAR= 17615.135 MOMENT= 463281.665
 FORCE ON INNER RADIUS= 11444.181 FORCE ON OUTER RADIUS= 42771.417

THETA= 112.500

NODE	FX	FY	PHI	RESF
51	169.450	-5730.200	114.194	5732.705
52	4122.870	8596.140	-93.123	9534.713
53	2166.000	4766.520	-91.936	5235.577
54	761.193	1736.240	-91.173	1895.770
55	3244.310	4424.610	-103.750	5486.595
56	2396.290	7430.290	-85.375	7807.139
57	2230.610	6658.710	-86.020	7022.396
58	2524.370	6513.050	-88.686	6985.146

NORMAL FORCE= -38518.168 SHEAR= 3111.753 MOMENT= 188178.025
 FORCE ON INNER RADIUS= 11827.675 FORCE ON OUTER RADIUS= 27099.844

THETA= 135.000

NODE	FX	FY	PHI	RESF
61	-353.317	-1589.300	122.466	1628.099
62	4456.750	1003.270	-122.313	4568.279
63	2915.720	-221.857	-139.351	2924.148
64	2899.660	-1024.990	-154.468	3075.469
65	2018.600	3068.390	-78.340	3072.841
66	982.778	8643.960	-51.486	8699.649
67	1639.450	8143.180	-56.383	8306.574
68	3055.440	4907.910	-76.904	5781.288

NORMAL FORCE= -28670.107 SHEAR= -3758.556 MOMENT= 206818.800
 FORCE ON INNER RADIUS= 10086.738 FORCE ON OUTER RADIUS= 25931.843

THETA= 157.500

NODE	FX	FY	PHI	RESF
71	152.052	1685.700	-27.654	1692.544
72	-1786.020	6081.330	-6.133	6338.173
73	-2431.800	5950.190	-.270	6427.940
74	-3986.650	5361.290	14.135	6681.078
75	7639.850	-2676.360	-131.806	8095.073
76	7614.350	-2192.680	-128.565	7923.773
77	6802.100	-2136.040	-129.934	7129.602
78	3611.210	-608.150	-122.059	3662.060

NORMAL FORCE= -20661.805 SHEAR= -3851.486 MOMENT= 251262.929
 FORCE ON INNER RADIUS= 20708.235 FORCE ON OUTER RADIUS= 26772.791

THETA= 180.000

NODE	FX	FY	PHI	RESF
81	2028.130	.000	-90.000	2028.130
82	-415.443	.000	90.000	415.443
83	-1566.760	.000	90.000	1566.760
84	-2280.570	.000	90.000	2280.570

NODE 85	FX =	4421.000	FY =	-.000	PHI =	-90.000	RESF =	4421.000
NODE 96	FX =	6299.610	FY =	-.000	PHI =	-90.000	RESF =	6299.610
NODE 1	FX =	5885.920	FY =	-.000	PHI =	-90.000	RESF =	5885.920
NODE 2	FX =	4832.190	FY =	.000	PHI =	-90.000	RESF =	4832.190

NORMAL FORCE = -17615.077 SHEAR = .047 MOMENT = 303148.356
 FORCE ON INNER RADIUS = 3823.643 FORCE ON OUTER RADIUS = 21438.720

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42

***** FULLY ASSEMBLED EC STRUCTURE *****
 ***** THERMAL LOADING CORRECTED FOR 2 IN. *****
 ***** OH 1 AT 150K *****
 ***** OH 2 AT 200K *****
 ***** OH 3 AT 250K *****
 ***** MH 1 AT 250K *****
 ***** MH 2 AT 250K *****
 ***** MH 3 AT 250K *****

Appendix B

***** 4/20/87 *****

THETA= 0.000

NODE 1	FX = 35983.400	FY = .000	PHI = 90.000	RES F = 35983.400
NODE 2	FX = 18829.400	FY = .000	PHI = 90.000	RES F = 18829.400
NODE 3	FX = 33286.300	FY = .000	PHI = 90.000	RES F = 33286.300
NODE 4	FX = 52198.700	FY = .000	PHI = 90.000	RES F = 52198.700
NODE 5	FX = 7271.230	FY = .000	PHI = 90.000	RES F = 7271.230
NODE 6	FX = -326.307	FY = .000	PHI = -90.000	RES F = 326.307
NODE 7	FX = -2532.000	FY = .000	PHI = -90.000	RES F = 2532.000
NODE 8	FX = -2870.910	FY = -.000	PHI = -90.000	RES F = 2870.910

NORMAL FORCE= 141839.813 SHEAR= .000 MOMENT= 1665069.444
 FORCE ON INNER RADIUS= 140297.800 FORCE ON OUTER RADIUS= 1542.013

THETA= 22.500

NODE 11	FX = 22438.600	FY = -44502.600	PHI = 49.258	RES F = 49839.464
NODE 12	FX = 1963.520	FY = -41180.000	PHI = 25.230	RES F = 41226.785
NODE 13	FX = 13862.400	FY = -41910.800	PHI = 40.802	RES F = 44143.870
NODE 14	FX = 30886.900	FY = -44372.000	PHI = 57.341	RES F = 54063.620
NODE 15	FX = 23493.500	FY = 30301.400	PHI = 164.710	RES F = 38343.361
NODE 16	FX = 12525.800	FY = 33647.300	PHI = -177.919	RES F = 35903.154
NODE 17	FX = 13711.500	FY = 35678.200	PHI = -178.522	RES F = 38222.234
NODE 18	FX = 17802.800	FY = 34969.500	PHI = 175.520	RES F = 39240.357

NORMAL FORCE= 140582.843 SHEAR= 17783.357 MOMENT= 1425706.214
 FORCE ON INNER RADIUS= 185348.368 FORCE ON OUTER RADIUS= 130589.668

THETA= 45.000

NODE 21	FX = 5110.540	FY = -47312.500	PHI = 51.165	RES F = 47587.711
NODE 22	FX = -17772.600	FY = -44699.100	PHI = 23.317	RES F = 48102.753
NODE 23	FX = -13934.200	FY = -37494.200	PHI = 24.613	RES F = 39999.712
NODE 24	FX = -3695.360	FY = -44670.400	PHI = 40.271	RES F = 44822.989
NODE 25	FX = 48474.000	FY = 16319.800	PHI = 153.607	RES F = 51147.478
NODE 26	FX = 18435.900	FY = 30602.500	PHI = -166.066	RES F = 35726.677
NODE 27	FX = 33741.100	FY = 29510.600	PHI = 176.174	RES F = 44825.633
NODE 28	FX = 47653.200	FY = 20960.400	PHI = 158.742	RES F = 52059.253

NORMAL FORCE= 137741.224 SHEAR= 29153.695 MOMENT= 788905.301
 FORCE ON INNER RADIUS= 176790.641 FORCE ON OUTER RADIUS= 177424.887

THETA= 67.500

NODE 31	FX = -30775.700	FY = -26137.700	PHI = 17.841	RES F = 40377.259
NODE 32	FX = -21099.600	FY = -15788.900	PHI = 14.308	RES F = 26353.036
NODE 33	FX = -30648.100	FY = -15404.100	PHI = 4.185	RES F = 34301.492
NODE 34	FX = -32241.500	FY = -22676.700	PHI = 12.620	RES F = 39417.598
NODE 35	FX = 33398.700	FY = 36929.500	PHI = -154.626	RES F = 49792.179
NODE 36	FX = 40820.900	FY = 52986.700	PHI = -150.111	RES F = 66887.490
NODE 37	FX = 37110.400	FY = 33318.400	PHI = -160.582	RES F = 49872.814

NODE 38 FX= 33874.300 FY= 14098.600 PHI= -179.903 RESF= 36691.126

NORMAL FORCE= -41313.429 SHEAR= 50060.014 MOMENT= 1215723.653
FORCE ON INNER RADIUS= 139900.559 FORCE ON OUTER RADIUS= 199861.694

THETA= 90.000

NODE 41	FX=	4215.900	FY=	-10222.200	PHI=	112.412	RESF=	11057.449
NODE 42	FX=	8201.440	FY=	15658.000	PHI=	-117.645	RESF=	17675.876
NODE 43	FX=	5012.240	FY=	11757.300	PHI=	-113.089	RESF=	12781.109
NODE 44	FX=	2575.900	FY=	1669.200	PHI=	-147.056	RESF=	3069.444
NODE 45	FX=	1598.920	FY=	9007.950	PHI=	-100.065	RESF=	9148.754
NODE 46	FX=	4213.380	FY=	11689.600	PHI=	-109.821	RESF=	12425.752
NODE 47	FX=	2614.610	FY=	6427.970	PHI=	-112.134	RESF=	6939.379
NODE 48	FX=	2007.070	FY=	-127.239	PHI=	176.373	RESF=	2011.099

NORMAL FORCE= -45860.541 SHEAR= 30439.521 MOMENT= 97631.924
FORCE ON INNER RADIUS= 27493.556 FORCE ON OUTER RADIUS= 28944.365

THETA= 112.500

NODE 51	FX=	2985.930	FY=	-3240.740	PHI=	155.157	RESF=	4406.606
NODE 52	FX=	8737.660	FY=	15911.000	PHI=	-96.274	RESF=	18152.317
NODE 53	FX=	7535.820	FY=	14098.100	PHI=	-95.626	RESF=	15985.775
NODE 54	FX=	6450.720	FY=	10128.200	PHI=	-99.993	RESF=	12008.007
NODE 55	FX=	2032.170	FY=	-1256.330	PHI=	170.775	RESF=	23389.159
NODE 56	FX=	974.164	FY=	1180.430	PHI=	-107.032	RESF=	1530.494
NODE 57	FX=	392.274	FY=	-694.959	PHI=	141.943	RESF=	798.027
NODE 58	FX=	1330.720	FY=	-1730.350	PHI=	150.062	RESF=	2182.871

NORMAL FORCE= -43425.812 SHEAR= 14959.933 MOMENT= -533133.487
FORCE ON INNER RADIUS= 44970.734 FORCE ON OUTER RADIUS= 5350.008

THETA= 135.000

NODE 61	FX=	5017.470	FY=	1347.790	PHI=	-119.964	RESF=	5195.339
NODE 62	FX=	13517.400	FY=	7747.750	PHI=	-105.180	RESF=	13580.364
NODE 63	FX=	13650.800	FY=	7795.620	PHI=	-103.270	RESF=	15719.925
NODE 64	FX=	17731.500	FY=	7960.560	PHI=	-110.822	RESF=	19436.476
NODE 65	FX=	-3680.460	FY=	-5067.820	PHI=	99.011	RESF=	6263.273
NODE 66	FX=	-5418.140	FY=	1786.730	PHI=	26.749	RESF=	5705.142
NODE 67	FX=	-2752.680	FY=	1163.780	PHI=	33.563	RESF=	5869.217
NODE 68	FX=	-4626.500	FY=	196.154	PHI=	42.572	RESF=	4630.656

NORMAL FORCE= -37738.246 SHEAR= 5309.617 MOMENT= -816010.343
FORCE ON INNER RADIUS= 55761.383 FORCE ON OUTER RADIUS= 19572.296

THETA= 157.500

NODE 71	FX=	6416.970	FY=	66.900	PHI=	-111.903	RESF=	6417.319
NODE 72	FX=	3365.190	FY=	5285.390	PHI=	-54.985	RESF=	6265.768
NODE 73	FX=	2688.630	FY=	5646.130	PHI=	-47.963	RESF=	6253.600
NODE 74	FX=	843.460	FY=	5467.200	PHI=	-31.270	RESF=	5531.880
NODE 75	FX=	4960.790	FY=	-2024.660	PHI=	-134.702	RESF=	5358.049
NODE 76	FX=	5270.790	FY=	-1665.120	PHI=	-130.032	RESF=	5527.554
NODE 77	FX=	4912.480	FY=	-1489.910	PHI=	-129.372	RESF=	5133.448
NODE 78	FX=	1981.140	FY=	179.349	PHI=	-107.327	RESF=	1989.242

NORMAL FORCE= -32509.955 SHEAR= 1056.212 MOMENT= -56326.302
FORCE ON INNER RADIUS= 21175.125 FORCE ON OUTER RADIUS= 17840.288

THETA= 180.000

NODE 81)	=	7901.530	FY=	.000	PHI=	-90.000	REST=	7901.530
NODE 82)	=	5256.640	FY=	.000	PHI=	-90.000	REST=	5256.640
NODE 83	FX=	=	3920.040	FY=	.000	PHI=	-90.000	REST=	3920.040
NODE 84	FX=	=	1274.540	FY=	-.000	PHI=	-90.000	REST=	1274.540
NODE 85	FX=	=	898.609	FY=	-.000	PHI=	-90.000	REST=	898.609
NODE 86	FX=	=	3776.110	FY=	-.000	PHI=	-90.000	REST=	3776.110
NODE 87	FX=	=	3964.670	FY=	-.000	PHI=	-90.000	REST=	3964.670
NODE 88	FX=	=	3447.310	FY=	.000	PHI=	-90.000	REST=	3447.310

NORMAL FORCE= -30439.449 SHEAR= .081 MOMENT= -75192.612
FORCE ON INNER RADIUS= 18352.750 FORCE ON OUTER RADIUS= 12086.699

7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40

***** FULLY ASSEMBLED EC STRUCTURE *****
 ***** DISCONNECTED AT INNER RADIUS OF ARCH *****
 ***** CORRECTED FOR 2 INCH PLATE *****
 ***** CORRECTED GAP ORIENTATIONS *****
 ***** 4/22/87 *****

Appendix C

THETA= 0.000

NODE	FX	FY	PHI	RESF
1	0.000	0.000	0.000	0.000
2	0.000	0.000	0.000	0.000
3	0.000	0.000	0.000	0.000
4	0.000	0.000	0.000	0.000
5	58686.600	0.000	90.000	58686.600
6	28431.000	0.000	90.000	28431.000
7	18359.700	0.000	90.000	18359.700
8	13587.700	0.000	90.000	13587.700

NORMAL FORCE= 119065.000 SHEAR= 0.000 MOMENT= 0.000
 FORCE ON INNER RADIUS= 0.000 FORCE ON OUTER RADIUS= 119065.000

THETA= 22.500

NODE	FX	FY	PHI	RESF
11	0.000	0.000	0.000	0.000
12	0.000	0.000	0.000	0.000
13	0.000	0.000	0.000	0.000
14	0.000	0.000	0.000	0.000
15	55242.200	-22215.200	90.593	59541.715
16	26153.700	-11194.900	89.327	26448.933
17	17827.000	-6395.240	92.765	18939.404
18	13409.700	-3998.070	95.898	13993.020

NORMAL FORCE= 120821.794 SHEAR= 2633.516 MOMENT= 0.000
 FORCE ON INNER RADIUS= 0.000 FORCE ON OUTER RADIUS= 120850.492

THETA= 45.000

NODE	FX	FY	PHI	RESF
21	0.000	0.000	0.000	0.000
22	0.000	0.000	0.000	0.000
23	0.000	0.000	0.000	0.000
24	-1876.870	1876.870	-90.000	2654.295
25	47141.200	-42563.400	92.921	63513.272
26	15986.500	-22171.100	90.793	27333.603
27	18291.500	-11896.000	101.962	21819.574
28	14731.400	-7991.210	106.522	16759.283

NORMAL FORCE= 125171.037 SHEAR= 8152.073 MOMENT= -1565755.520
 FORCE ON INNER RADIUS= 2654.295 FORCE ON OUTER RADIUS= 128085.017

THETA= 67.500

NODE	FX	FY	PHI	RESF
31	-2027.260	4894.250	-90.000	5297.496
32	-6101.510	14730.400	-90.000	15944.062
33	-6031.960	14362.500	-90.000	15762.327
34	-5019.710	12118.700	-90.000	13117.179
35	3502.910	-12938.300	82.649	13404.103
36	20179.800	-23230.600	-153.480	30771.498
37	10278.700	-8509.180	-162.880	13343.831
38	842.227	-7781.510	73.677	7826.956

NORMAL FORCE= -46983.377 SHEAR= 36371.640 MOMENT= -639105.005
 FORCE ON INNER RADIUS= 50121.064 FORCE ON OUTER RADIUS= 36506.614

THETA= 90.000

NODE 41	FX=	0.000	FY=	3355.340	PHI=	-90.000	RESF=	3355.340
NODE 42	FX=	0.000	FY=	29733.300	PHI=	-90.000	RESF=	29733.300
NODE 43	FX=	0.000	FY=	25417.400	PHI=	-90.000	RESF=	25417.400
NODE 44	FX=	0.000	FY=	20524.100	PHI=	-90.000	RESF=	20524.100
NODE 45	FX=	710.373	FY=	-15696.700	PHI=	92.591	RESF=	15712.766
NODE 46	FX=	7579.050	FY=	-5719.310	PHI=	142.961	RESF=	9494.867
NODE 47	FX=	5290.320	FY=	-6625.160	PHI=	128.608	RESF=	8478.221
NODE 48	FX=	2043.440	FY=	-5128.380	PHI=	111.725	RESF=	5520.501

NORMAL FORCE= -45860.569 SHEAR= 15623.244 MOMENT= -1346396.529
FORCE ON INNER RADIUS= 79030.140 FORCE ON OUTER RADIUS= 36664.736

THETA= 112.500

NODE 51	FX=	1413.100	FY=	3411.530	PHI=	-90.000	RESF=	3692.613
NODE 52	FX=	10311.200	FY=	24893.500	PHI=	-90.000	RESF=	26944.521
NODE 53	FX=	10266.900	FY=	24786.500	PHI=	-90.000	RESF=	26828.713
NODE 54	FX=	10207.100	FY=	24642.100	PHI=	-90.000	RESF=	26672.420
NODE 55	FX=	-7353.550	FY=	-14958.100	PHI=	86.321	RESF=	16667.917
NODE 56	FX=	-5304.180	FY=	-10189.600	PHI=	85.001	RESF=	11487.483
NODE 57	FX=	-3802.860	FY=	-10782.000	PHI=	93.072	RESF=	11432.990
NODE 58	FX=	-114.549	FY=	-7408.590	PHI=	111.614	RESF=	7409.476

NORMAL FORCE= -37755.873 SHEAR= 1271.455 MOMENT= -1566247.896
FORCE ON INNER RADIUS= 84138.266 FORCE ON OUTER RADIUS= 46399.813

THETA= 135.000

NODE 61	FX=	1934.180	FY=	1934.180	PHI=	-90.000	RESF=	2735.344
NODE 62	FX=	14043.100	FY=	14043.100	PHI=	-90.000	RESF=	19859.942
NODE 63	FX=	16919.400	FY=	16919.400	PHI=	-90.000	RESF=	23927.645
NODE 64	FX=	20958.600	FY=	20958.600	PHI=	-90.000	RESF=	29639.936
NODE 65	FX=	-12011.600	FY=	-7840.810	PHI=	76.135	RESF=	14344.227
NODE 66	FX=	-10963.300	FY=	-7010.940	PHI=	77.598	RESF=	13013.348
NODE 67	FX=	-10280.700	FY=	-9582.340	PHI=	87.986	RESF=	14053.969
NODE 68	FX=	-4976.500	FY=	-6490.620	PHI=	97.522	RESF=	8178.857

NORMAL FORCE= -27261.628 SHEAR= -5167.051 MOMENT= -1500769.277
FORCE ON INNER RADIUS= 76162.867 FORCE ON OUTER RADIUS= 49173.480

THETA= 157.500

NODE 71	FX=	2923.470	FY=	1210.940	PHI=	-90.000	RESF=	3164.341
NODE 72	FX=	973.613	FY=	403.283	PHI=	-90.000	RESF=	1053.831
NODE 73	FX=	0.000	FY=	0.000	PHI=	0.000	RESF=	0.000
NODE 74	FX=	0.000	FY=	0.000	PHI=	0.000	RESF=	0.000
NODE 75	FX=	-908.228	FY=	3067.800	PHI=	-6.008	RESF=	3199.418
NODE 76	FX=	3050.090	FY=	3515.420	PHI=	-63.446	RESF=	4654.162
NODE 77	FX=	5590.930	FY=	2915.510	PHI=	-84.959	RESF=	6305.450
NODE 78	FX=	3993.290	FY=	352.336	PHI=	-107.458	RESF=	4008.804

NORMAL FORCE= -18821.509 SHEAR= -4613.776 MOMENT= 124621.992
FORCE ON INNER RADIUS= 4218.172 FORCE ON OUTER RADIUS= 15314.846

THETA= 180.000

NODE 81	FX=	0.000	FY=	0.000	PHI=	0.000	RESF=	0.000
NODE 82	FX=	0.000	FY=	0.000	PHI=	0.000	RESF=	0.000

NODE 84	FX=	0.000	FY=	0.000	PHI=	0.000	RESFX=	0.000
NODE 85	FX=	2736.000	FY=	0.000	PHI=	-90.000	RESFX=	2736.000
NODE 86	FX=	4372.800	FY=	0.000	PHI=	-90.000	RESFX=	4372.800
NODE 87	FX=	5625.960	FY=	0.000	PHI=	-90.000	RESFX=	5625.960
NODE 88	FX=	2888.420	FY=	0.000	PHI=	-90.000	RESFX=	2888.420

NORMAL FORCE = -15623.180 SHEAR = .041 MOMENT = 0.000
 FORCE ON INNER RADIUS = 0.000 FORCE ON OUTER RADIUS = 15623.180

***** FULLY ASSEMBLED EC STRUCTURE *****
 ***** DISCONNECTED AT INNER RADIUS OF OH ARCH *****
 ***** ALL OH CONNECTORS ON OUTER RADIUS R1 *****
 ***** SHEAR. THERMAL GRADIENT OH1=150K, OH2=200K *****
 ***** OH3=250K *****
 ***** MH1=250K, MH2=250K *****
 ***** MH3=250K *****

Appendix D

5/5/87

 THETA= 0.000

NODE 1	FX=	-8988.310	FY=	-3.928	PHI=	-89.975	RESF=	8988.311
NODE 2	FX=	0.000	FY=	0.000	PHI=	0.000	RESF=	0.000
NODE 3	FX=	0.000	FY=	0.000	PHI=	0.000	RESF=	0.000
NODE 4	FX=	0.000	FY=	0.000	PHI=	0.000	RESF=	0.000
NODE 5	FX=	72656.100	FY=	0.000	PHI=	90.000	RESF=	72656.100
NODE 6	FX=	23825.300	FY=	0.000	PHI=	90.000	RESF=	23825.300
NODE 7	FX=	12949.900	FY=	0.000	PHI=	90.000	RESF=	12949.900
NODE 8	FX=	18438.600	FY=	0.000	PHI=	90.000	RESF=	18438.600

NORMAL FORCE= 118881.590 SHEAR= -3.928 MOMENT= -1642298.520
 FORCE ON INNER RADIUS= 8988.311 FORCE ON OUTER RADIUS= 127869.900

THETA= 22.500

NODE 11	FX=	0.000	FY=	0.000	PHI=	0.000	RESF=	0.000
NODE 12	FX=	-1416.000	FY=	586.528	PHI=	-90.000	RESF=	1532.668
NODE 13	FX=	-8013.270	FY=	3319.200	PHI=	-90.000	RESF=	8673.499
NODE 14	FX=	-5474.470	FY=	2267.600	PHI=	-90.000	RESF=	5925.524
NODE 15	FX=	62288.900	FY=	-26386.400	PHI=	89.542	RESF=	67647.241
NODE 16	FX=	23607.100	FY=	-10658.400	PHI=	88.201	RESF=	25901.673
NODE 17	FX=	17308.700	FY=	-4218.310	PHI=	98.803	RESF=	17815.309
NODE 18	FX=	26193.200	FY=	1564.040	PHI=	115.917	RESF=	26239.854

NORMAL FORCE= 118608.561 SHEAR= 12841.232 MOMENT= -1810463.312
 FORCE ON INNER RADIUS= 16131.691 FORCE ON OUTER RADIUS= 135350.776

THETA= 45.000

NODE 21	FX=	0.000	FY=	0.000	PHI=	0.000	RESF=	0.000
NODE 22	FX=	0.000	FY=	0.000	PHI=	0.000	RESF=	0.000
NODE 23	FX=	-4507.720	FY=	4507.720	PHI=	-90.000	RESF=	6374.879
NODE 24	FX=	-16242.400	FY=	16242.400	PHI=	-90.000	RESF=	22970.222
NODE 25	FX=	50712.000	FY=	-43216.500	PHI=	94.563	RESF=	66628.619
NODE 26	FX=	17095.800	FY=	-25594.800	PHI=	78.741	RESF=	30779.216
NODE 27	FX=	21699.500	FY=	-15520.500	PHI=	99.426	RESF=	26678.722
NODE 28	FX=	25277.500	FY=	-12029.400	PHI=	109.551	RESF=	27993.901

NORMAL FORCE= 119957.676 SHEAR= 13027.373 MOMENT= -2143774.538
 FORCE ON INNER RADIUS= 29345.101 FORCE ON OUTER RADIUS= 149870.048

THETA= 67.500

NODE 31	FX=	-2158.350	FY=	5210.730	PHI=	-90.000	RESF=	5640.052
NODE 32	FX=	-6104.060	FY=	14736.500	PHI=	-90.000	RESF=	15950.673
NODE 33	FX=	-8927.190	FY=	21552.200	PHI=	-90.000	RESF=	23327.924
NODE 34	FX=	-10808.100	FY=	26093.100	PHI=	-90.000	RESF=	28242.962
NODE 35	FX=	-1630.310	FY=	-23659.000	PHI=	63.358	RESF=	23715.105
NODE 36	FX=	24454.800	FY=	26623.100	PHI=	-155.069	RESF=	36150.058
NODE 37	FX=	15632.200	FY=	10119.400	PHI=	-169.583	RESF=	18621.706

NODE 38 FX = -5757.220 FY = -23350.200 PHI = 53.549 RESF = 24049.479

NORMAL FORCE = -51162.845 SHEAR = 26281.565 MOMENT = 1141924.518
FORCE ON INNER RADIUS = 73161.611 FORCE ON OUTER RADIUS = 34273.320

THETA = 90.000

NODE 41	FX = 0.000	FY = 0.000	PHI = 0.000	RESF = 0.000
NODE 42	FX = 0.000	FY = 30698.500	PHI = -90.000	RESF = 30698.500
NODE 43	FX = 0.000	FY = 34874.400	PHI = -90.000	RESF = 34874.400
NODE 44	FX = 0.000	FY = 21788.400	PHI = -90.000	RESF = 21788.400
NODE 45	FX = -3706.720	FY = -18874.700	PHI = 78.889	RESF = 19235.230
NODE 46	FX = 8719.310	FY = -4244.490	PHI = 154.044	RESF = 9697.529
NODE 47	FX = 4920.290	FY = -7551.880	PHI = 123.085	RESF = 9013.332
NODE 48	FX = -5231.090	FY = -10829.500	PHI = 64.217	RESF = 12026.736

NORMAL FORCE = -45860.724 SHEAR = 4701.851 MOMENT = -1546342.515
FORCE ON INNER RADIUS = 87361.300 FORCE ON OUTER RADIUS = 41766.064

THETA = 112.500

NODE 51	FX = 138.711	FY = 334.878	PHI = -90.000	RESF = 362.469
NODE 52	FX = 10398.700	FY = 25104.600	PHI = -90.000	RESF = 27173.036
NODE 53	FX = 11378.600	FY = 27470.400	PHI = -90.000	RESF = 29733.742
NODE 54	FX = 7841.300	FY = 18930.800	PHI = -90.000	RESF = 20490.549
NODE 55	FX = -8278.780	FY = -13419.600	PHI = 80.829	RESF = 15767.811
NODE 56	FX = -5855.490	FY = -8309.920	PHI = 77.330	RESF = 10165.704
NODE 57	FX = -6915.180	FY = -8654.910	PHI = 73.875	RESF = 11078.230
NODE 58	FX = -4006.140	FY = -7060.980	PHI = 82.931	RESF = 8118.288

NORMAL FORCE = -33576.404 SHEAR = -8818.537 MOMENT = -1463318.266
FORCE ON INNER RADIUS = 77759.796 FORCE ON OUTER RADIUS = 45054.870

THETA = 135.000

NODE 61	FX = 1126.300	FY = 1126.300	PHI = -90.000	RESF = 1592.629
NODE 62	FX = 11945.200	FY = 11945.200	PHI = -90.000	RESF = 16893.064
NODE 63	FX = 13916.900	FY = 13916.900	PHI = -90.000	RESF = 19681.469
NODE 64	FX = 13538.900	FY = 13538.900	PHI = -90.000	RESF = 19146.896
NODE 65	FX = -9710.250	FY = -5752.000	PHI = 75.641	RESF = 11286.029
NODE 66	FX = -10265.800	FY = -3135.390	PHI = 61.984	RESF = 10733.933
NODE 67	FX = -10396.100	FY = -4075.560	PHI = 66.406	RESF = 11166.427
NODE 68	FX = -5453.330	FY = -4633.760	PHI = 85.355	RESF = 7156.154

NORMAL FORCE = -19539.090 SHEAR = -12889.648 MOMENT = -1141073.094
FORCE ON INNER RADIUS = 57314.257 FORCE ON OUTER RADIUS = 39913.772

THETA = 157.500

NODE 71	FX = 2396.840	FY = 992.804	PHI = -90.000	RESF = 2594.321
NODE 72	FX = 1888.720	FY = 782.334	PHI = -90.000	RESF = 2044.336
NODE 73	FX = 1970.000	FY = 615.598	PHI = -90.000	RESF = 2132.312
NODE 74	FX = 344.713	FY = 142.784	PHI = -90.000	RESF = 373.114
NODE 75	FX = -2702.200	FY = 2836.870	PHI = 21.107	RESF = 3917.871
NODE 76	FX = 364.468	FY = 3128.850	PHI = -29.144	RESF = 3150.006
NODE 77	FX = 774.559	FY = 2029.820	PHI = -38.911	RESF = 2741.513
NODE 78	FX = -335.317	FY = 135.823	PHI = 45.449	RESF = 361.781

NORMAL FORCE = -8731.475 SHEAR = -8793.226 MOMENT = -66680.288
FORCE ON INNER RADIUS = 7144.083 FORCE ON OUTER RADIUS = 8935.377

THETA= 180.000

NODE	FX	FY	PHI	RESF
81	0.000	0.000	0.000	0.000
82	0.000	0.000	0.000	0.000
83	0.000	0.000	0.000	0.000
84	0.000	0.000	0.000	0.000
85	1510.670	0.000	-90.000	1510.670
86	2278.930	0.000	-90.000	2278.930
87	2148.880	0.000	-90.000	2148.880
88	-1236.690	0.000	90.000	1236.690

NORMAL FORCE= -4701.790 SHEAR= .012 MOMENT= 0.000
FORCE ON INNER RADIUS= 0.000 FORCE ON OUTER RADIUS= 4701.790

89				
90				
91				
92				
93				
94				
95				
96				
97				
98				
99				
100				
101				
102				
103				
104				
105				
106				
107				
108				
109				
110				
111				
112				
113				
114				
115				
116				
117				
118				
119				
120				
121				
122				
123				
124				
125				
126				
127				
128				
129				
130				
131				
132				
133				
134				
135				
136				
137				
138				
139				
140				
141				
142				
143				
144				
145				
146				
147				
148				
149				
150				

3/32 skins on all OH
except OH3 = 1/8

Appendix E

***** OH DISCONNECTED ON INNER RADIUS *****
***** CENTER CONNECTORS ON OUTSIDE RADIUS *****
***** RESIST ONLY FORCES NORMAL TO M YLE *****
***** INTERFACE *****
***** GAPS CORRECTED *****
***** 4/24/87 *****

THETA= 0.000

NODE	FX	FY	PHI	RES
1	0.000	0.000	0.000	0.000
2	0.000	0.000	0.000	0.000
3	0.000	0.000	0.000	0.000
4	0.000	0.000	0.000	0.000
5	58627.100	0.000	90.000	58627.100
6	28790.500	0.000	90.000	28790.500
7	17749.200	0.000	90.000	17749.200
8	14321.000	0.000	90.000	14321.000

NORMAL FORCE= 119487.800 SHEAR= 0.000 MOMENT= 0.000
FORCE ON INNER RADIUS= 0.000 FORCE ON OUTER RADIUS= 119487.800

THETA= 22.500

NODE	FX	FY	PHI	RES
11	0.000	0.000	0.000	0.000
12	0.000	0.000	0.000	0.000
13	-899.938	372.766	-90.000	974.086
14	0.000	0.000	0.000	0.000
15	35701.700	-21599.800	91.305	59743.039
16	26823.600	-11110.900	90.000	29033.732
17	17007.600	-7044.940	90.000	18408.955
18	14666.900	-3190.880	100.226	15009.986

NORMAL FORCE= 120967.695 SHEAR= 4024.920 MOMENT= -1474990.398
FORCE ON INNER RADIUS= 974.086 FORCE ON OUTER RADIUS= 122008.188

THETA= 45.000

NODE	FX	FY	PHI	RES
21	0.000	0.000	0.000	0.000
22	0.000	0.000	0.000	0.000
23	-1747.450	1747.450	-90.000	2471.267
24	-2718.720	2718.720	-90.000	3844.851
25	47011.100	-43156.800	92.448	63816.557
26	20583.800	-20583.800	90.000	29109.889
27	14072.800	-14072.800	90.000	19901.945
28	18366.200	-7229.760	113.513	19737.952

NORMAL FORCE= 124553.133 SHEAR= 10599.971 MOMENT= -1646224.433
FORCE ON INNER RADIUS= 6316.118 FORCE ON OUTER RADIUS= 131297.830

THETA= 67.500

NODE	FX	FY	PHI	RES
31	-1589.870	3838.290	-90.000	4154.534
32	-7565.980	18265.900	-90.000	19770.866
33	-6861.010	16564.000	-90.000	17928.735
34	-4738.000	11438.600	-90.000	12381.043
35	19380.700	-5060.380	172.134	20030.502
36	903.122	-2180.280	90.000	2359.926
37	1406.020	-3396.360	90.000	3674.040
38	12738.100	7733.100	-171.239	14901.679

THETA= 90.000

NODE 41	FX=	0.000	FY=	13000.000	PHI=	-90.000	RESF=	13000.000
NODE 42	FX=	0.000	FY=	19724.900	PHI=	-90.000	RESF=	19724.900
NODE 43	FX=	0.000	FY=	19271.300	PHI=	-90.000	RESF=	19271.300
NODE 44	FX=	0.000	FY=	28521.600	PHI=	-90.000	RESF=	28521.600
NODE 45	FX=	6390.420	FY=	-15005.100	PHI=	113.068	RESF=	16309.215
NODE 46	FX=	0.000	FY=	-7921.750	PHI=	90.000	RESF=	7921.750
NODE 47	FX=	0.000	FY=	-8171.310	PHI=	90.000	RESF=	8171.310
NODE 48	FX=	7282.610	FY=	-3559.010	PHI=	153.955	RESF=	8105.736

NORMAL FORCE= -45860.612 SHEAR= 13673.091 MOMENT= -1382099.858
 FORCE ON INNER RADIUS= 80317.800 FORCE ON OUTER RADIUS= 37256.827

THETA= 112.500

NODE 51	FX=	4277.910	FY=	10327.800	PHI=	-90.000	RESF=	11178.728
NODE 52	FX=	7230.220	FY=	17455.300	PHI=	-90.000	RESF=	18893.480
NODE 53	FX=	7799.130	FY=	18828.800	PHI=	-90.000	RESF=	20380.141
NODE 54	FX=	12455.200	FY=	30069.500	PHI=	-90.000	RESF=	32546.994
NODE 55	FX=	-8887.690	FY=	-14709.200	PHI=	81.358	RESF=	17185.796
NODE 56	FX=	-4303.780	FY=	-10390.000	PHI=	89.999	RESF=	11246.094
NODE 57	FX=	-4250.320	FY=	-10261.000	PHI=	90.000	RESF=	11106.455
NODE 58	FX=	-647.627	FY=	-6925.920	PHI=	107.158	RESF=	6956.133

NORMAL FORCE= -37009.543 SHEAR= -530.198 MOMENT= -1547869.719
 FORCE ON INNER RADIUS= 82999.343 FORCE ON OUTER RADIUS= 45992.858

THETA= 135.000

NODE 61	FX=	3291.190	FY=	3291.190	PHI=	-90.000	RESF=	4654.446
NODE 62	FX=	12293.000	FY=	12293.000	PHI=	-90.000	RESF=	17384.927
NODE 63	FX=	14434.800	FY=	14434.800	PHI=	-90.000	RESF=	20413.890
NODE 64	FX=	21456.400	FY=	21456.400	PHI=	-90.000	RESF=	30343.932
NODE 65	FX=	-13432.400	FY=	-5257.860	PHI=	66.377	RESF=	14424.786
NODE 66	FX=	-9198.360	FY=	-9198.360	PHI=	90.000	RESF=	13008.445
NODE 67	FX=	-9274.410	FY=	-9274.410	PHI=	90.000	RESF=	13119.996
NODE 68	FX=	-5897.200	FY=	-4814.220	PHI=	84.227	RESF=	7612.732

NORMAL FORCE= -25882.639 SHEAR= -6546.004 MOMENT= -1436541.010
 FORCE ON INNER RADIUS= 72797.195 FORCE ON OUTER RADIUS= 47369.058

THETA= 157.500

NODE 71	FX=	3354.060	FY=	1389.300	PHI=	-90.000	RESF=	3630.409
NODE 72	FX=	954.223	FY=	395.252	PHI=	-90.000	RESF=	1032.843
NODE 73	FX=	71.485	FY=	29.610	PHI=	-90.000	RESF=	77.375
NODE 74	FX=	0.000	FY=	0.000	PHI=	0.000	RESF=	0.000
NODE 75	FX=	-2917.820	FY=	4407.180	PHI=	11.007	RESF=	5285.538
NODE 76	FX=	3779.040	FY=	1565.360	PHI=	-90.000	RESF=	4090.415
NODE 77	FX=	5070.450	FY=	2100.290	PHI=	-90.000	RESF=	5488.231
NODE 78	FX=	3361.600	FY=	1578.280	PHI=	-87.350	RESF=	3713.667

NORMAL FORCE= -17019.822 SHEAR= -5360.046 MOMENT= 90462.798
 FORCE ON INNER RADIUS= 4740.628 FORCE ON OUTER RADIUS= 13398.089

THETA= 180.000

NODE 83	FX=	0.000	FY=	0.000	PHI=	0.000	RESF=	0.000
NODE 84	FX=	0.000	FY=	0.000	PHI=	0.000	RESF=	0.000
NODE 85	FX=	2105.900	FY=	0.000	PHI=	-90.000	RESF=	2105.900
NODE 86	FX=	3942.080	FY=	0.000	PHI=	-90.000	RESF=	3942.080
NODE 87	FX=	4969.420	FY=	0.000	PHI=	-90.000	RESF=	4969.420
NODE 88	FX=	2655.640	FY=	0.000	PHI=	-90.000	RESF=	2655.640

NORMAL FORCE= -13673.040 SHEAR= .036 MOMENT= 0.000
 FORCE ON INNER RADIUS= 0.000 FORCE ON OUTER RADIUS= 13673.040

1
 2
 3
 4
 5
 6
 7
 8
 9
 10
 11
 12
 13
 14
 15
 16
 17
 18
 19
 20
 21
 22
 23
 24
 25
 26
 27
 28
 29
 30
 31
 32
 33
 34
 35
 36
 37
 38
 39
 40
 41
 42

***** FULLY ASSEMBLED EC STRUCTURE
 ***** DISCONNECTED AT INNER RADIUS OF OH ARCH
 ***** MIDDLE CONNECTORS AT OUTER RADIUS OF O ARCH
 ***** CANNOT RESIST SHEAR
 ***** THERMAL GRADIENT OH1=150K, OH2=200K, OH3=250K
 ***** NH1=250K NH2=250K NH3=250K

Appendix F

5/5/87

THETA= 0.000

NODE 1	FX=	-9912.000	FY=	-17.301	PHI=	-89.900	RESF=	9912.015
NODE 2	FX=	0.000	FY=	0.000	PHI=	0.000	RESF=	0.000
NODE 3	FX=	0.000	FY=	0.000	PHI=	0.000	RESF=	0.000
NODE 4	FX=	0.000	FY=	0.000	PHI=	0.000	RESF=	0.000
NODE 5	FX=	73306.900	FY=	0.000	PHI=	90.000	RESF=	73306.900
NODE 6	FX=	25279.000	FY=	0.000	PHI=	90.000	RESF=	25279.000
NODE 7	FX=	11850.800	FY=	0.000	PHI=	90.000	RESF=	11850.800
NODE 8	FX=	18423.300	FY=	0.000	PHI=	90.000	RESF=	18423.300

NORMAL FORCE= 118948.000 SHEAR= -17.301 MOMENT= -1665264.000
 FORCE ON INNER RADIUS= 9912.015 FORCE ON OUTER RADIUS= 128860.000

THETA= 22.500

NODE 11	FX=	0.000	FY=	0.000	PHI=	0.000	RESF=	0.000
NODE 12	FX=	-2354.320	FY=	975.192	PHI=	-90.000	RESF=	2548.298
NODE 13	FX=	-9986.130	FY=	4136.390	PHI=	-90.000	RESF=	10808.909
NODE 14	FX=	-3804.220	FY=	1575.760	PHI=	-90.000	RESF=	4117.658
NODE 15	FX=	63248.000	FY=	-25038.100	PHI=	90.903	RESF=	68023.643
NODE 16	FX=	25877.100	FY=	-10718.900	PHI=	90.000	RESF=	28009.268
NODE 17	FX=	15695.800	FY=	-6501.550	PHI=	90.000	RESF=	16989.064
NODE 18	FX=	26003.700	FY=	2631.490	PHI=	118.278	RESF=	26136.510

NORMAL FORCE= 118555.929 SHEAR= 13453.739 MOMENT= -1842067.911
 FORCE ON INNER RADIUS= 17474.865 FORCE ON OUTER RADIUS= 136694.476

THETA= 45.000

NODE 21	FX=	0.000	FY=	0.000	PHI=	0.000	RESF=	0.000
NODE 22	FX=	-1859.300	FY=	1859.300	PHI=	-90.000	RESF=	2629.447
NODE 23	FX=	-7119.690	FY=	7119.690	PHI=	-90.000	RESF=	10068.762
NODE 24	FX=	-13827.200	FY=	13827.200	PHI=	-90.000	RESF=	19554.614
NODE 25	FX=	50472.000	FY=	-45620.500	PHI=	92.890	RESF=	68034.203
NODE 26	FX=	23654.200	FY=	-23654.200	PHI=	90.000	RESF=	33452.090
NODE 27	FX=	17487.500	FY=	-17487.500	PHI=	90.000	RESF=	24731.060
NODE 28	FX=	26022.600	FY=	-10156.300	PHI=	113.680	RESF=	27934.318

NORMAL FORCE= 119460.341 SHEAR= 14649.618 MOMENT= -2207591.843
 FORCE ON INNER RADIUS= 32252.823 FORCE ON OUTER RADIUS= 152418.814

THETA= 67.500

NODE 31	FX=	-948.407	FY=	2289.880	PHI=	-90.000	RESF=	2478.547
NODE 32	FX=	-8864.580	FY=	21401.000	PHI=	-90.000	RESF=	23164.274
NODE 33	FX=	-9129.970	FY=	22041.700	PHI=	-90.000	RESF=	23857.764
NODE 34	FX=	-10239.400	FY=	24720.100	PHI=	-90.000	RESF=	26756.843
NODE 35	FX=	17816.900	FY=	-4228.698	PHI=	156.122	RESF=	17632.057
NODE 36	FX=	1389.940	FY=	-3355.350	PHI=	90.000	RESF=	3632.031
NODE 37	FX=	2814.800	FY=	-6795.380	PHI=	90.000	RESF=	7355.290
NODE 38	FX=	10395.100	FY=	-2547.290	PHI=	143.731	RESF=	10702.653

FORCE ON INNER RADIUS = 76257.428 FORCE ON OUTER RADIUS = 34973.719

THETA = 90.000

NODE 41	FX = 0.000	FY = 9334.840	PHI = -90.000	RESF = 9334.840
NODE 42	FX = 0.000	FY = 22122.900	PHI = -90.000	RESF = 22122.900
NODE 43	FX = 0.000	FY = 23898.100	PHI = -90.000	RESF = 23898.100
NODE 44	FX = 0.000	FY = 33124.800	PHI = -90.000	RESF = 33124.800
NODE 45	FX = 2552.900	FY = -16326.300	PHI = 98.887	RESF = 16524.690
NODE 46	FX = 0.000	FY = -7585.740	PHI = 90.000	RESF = 7585.740
NODE 47	FX = 0.000	FY = -9223.310	PHI = 90.000	RESF = 9223.310
NODE 48	FX = 681.435	FY = -9484.630	PHI = 94.109	RESF = 9509.078

NORMAL FORCE = -45860.656 SHEAR = 3234.396 MOMENT = -1573207.491
FORCE ON INNER RADIUS = 88480.640 FORCE ON OUTER RADIUS = 42742.527

THETA = 112.500

NODE 51	FX = 3254.530	FY = 7857.130	PHI = -90.000	RESF = 8504.496
NODE 52	FX = 7042.110	FY = 17001.200	PHI = -90.000	RESF = 18401.960
NODE 53	FX = 7999.920	FY = 19313.500	PHI = -90.000	RESF = 20904.784
NODE 54	FX = 11132.800	FY = 26877.100	PHI = -90.000	RESF = 29091.541
NODE 55	FX = -11446.300	FY = -11621.700	PHI = 67.936	RESF = 18312.011
NODE 56	FX = -3821.110	FY = -9224.790	PHI = 89.999	RESF = 9984.870
NODE 57	FX = -4073.250	FY = -9833.490	PHI = 89.999	RESF = 10643.725
NODE 58	FX = -6854.350	FY = -5973.610	PHI = 63.572	RESF = 9092.092

NORMAL FORCE = -33014.900 SHEAR = -10174.322 MOMENT = -1449487.941
FORCE ON INNER RADIUS = 76902.781 FORCE ON OUTER RADIUS = 45051.795

THETA = 135.000

NODE 61	FX = 1560.590	FY = 1560.590	PHI = -90.000	RESF = 2207.008
NODE 62	FX = 10420.100	FY = 10420.100	PHI = -90.000	RESF = 14736.257
NODE 63	FX = 12703.900	FY = 12703.900	PHI = -90.000	RESF = 17966.028
NODE 64	FX = 14051.900	FY = 14051.900	PHI = -90.000	RESF = 19872.388
NODE 65	FX = -12105.600	FY = -93.555	PHI = 45.443	RESF = 12105.962
NODE 66	FX = -7617.490	FY = -7617.490	PHI = 90.000	RESF = 10772.758
NODE 67	FX = -7795.850	FY = -7795.850	PHI = 90.000	RESF = 11024.997
NODE 68	FX = -7983.180	FY = -299.013	PHI = 47.145	RESF = 7988.778

NORMAL FORCE = -18501.443 SHEAR = -13927.288 MOMENT = -1092742.756
FORCE ON INNER RADIUS = 54781.670 FORCE ON OUTER RADIUS = 38861.642

THETA = 157.500

NODE 71	FX = 2950.240	FY = 1222.030	PHI = -90.000	RESF = 3193.317
NODE 72	FX = 1529.030	FY = 633.344	PHI = -90.000	RESF = 1655.010
NODE 73	FX = 1491.490	FY = 617.879	PHI = -90.000	RESF = 1614.594
NODE 74	FX = 992.527	FY = 411.118	PHI = -90.000	RESF = 1074.303
NODE 75	FX = -3941.760	FY = 4744.200	PHI = 28.894	RESF = 7603.417
NODE 76	FX = 2197.550	FY = 910.278	PHI = -90.000	RESF = 2378.619
NODE 77	FX = 2814.850	FY = 1041.620	PHI = -90.000	RESF = 2721.854
NODE 78	FX = -2499.600	FY = 1864.810	PHI = 30.482	RESF = 3130.576

NORMAL FORCE = -7375.722 SHEAR = -9354.794 MOMENT = -92384.717
FORCE ON INNER RADIUS = 7537.224 FORCE ON OUTER RADIUS = 9356.206

THETA = 180.000

88	NODE	88	V	0.000	FY	0.000	PHI	0.000	RESF	0.000
87	NODE	87	V	0.000	FY	0.000	PHI	0.000	RESF	0.000
86	NODE	86	V	0.000	FY	0.000	PHI	0.000	RESF	0.000
85	NODE	85	V	0.000	FY	0.000	PHI	0.000	RESF	0.000
84	NODE	84	V	0.000	FY	0.000	PHI	0.000	RESF	0.000
83	NODE	83	V	-68.061	FY	0.000	PHI	90.000	RESF	68.061
82	NODE	82	V	2526.160	FY	0.000	PHI	-90.000	RESF	2526.160
81	NODE	81	V	2810.370	FY	0.000	PHI	-90.000	RESF	2810.370
80	NODE	80	V	-2034.340	FY	0.000	PHI	90.000	RESF	2034.340

NORMAL FORCE = 3234.329 SHEAR = .009 MOMENT = 0.000
 FORCE ON INNER RADIUS = 0.000 FORCE ON OUTER RADIUS = 3234.329



***** FULLY ASSEMBLED EC STRUCTURE *****
 ***** 1/16 IN. SKINS ON ALL MODULES *****
 ***** OH ARCH DISCONNECTED AT INNER RADIUS *****
 ***** MIDDLE CONNECTORS ON OUTSIDE RADIUS OF OCH *****
 ***** ARCH CANNOT RESIST SHEAR *****
 ***** 5/8/87 *****

Appendix G

THETA= 0.000

NODE	FX	FY	PHI	RES
1	0.000	0.000	0.000	0.000
2	0.000	0.000	0.000	0.000
3	0.000	0.000	0.000	0.000
4	0.000	0.000	0.000	0.000
5	59520.700	0.000	90.000	59520.700
6	27045.100	0.000	90.000	27045.100
7	17017.300	0.000	90.000	17017.300
8	15523.700	0.000	90.000	15523.700

NORMAL FORCE= 119106.800 SHEAR= 0.000 MOMENT= 0.000
 FORCE ON INNER RADIUS= 0.000 FORCE ON OUTER RADIUS= 119106.800

THETA= 22.500

NODE	FX	FY	PHI	RES
11	0.000	0.000	0.000	0.000
12	-60.443	23.036	-90.000	6.423
13	-1944.890	803.597	-90.000	2103.133
14	0.000	0.000	0.000	0.000
15	57582.200	-20504.200	92.900	61123.907
16	24958.700	-10338.900	89.999	27013.203
17	16692.100	-6914.230	90.000	18067.451
18	16060.200	-3792.740	99.213	16501.967

NORMAL FORCE= 120246.844 SHEAR= 5733.863 MOMENT= -1495055.467
 FORCE ON INNER RADIUS= 2170.556 FORCE ON OUTER RADIUS= 122551.610

THETA= 45.000

NODE	FX	FY	PHI	RES
21	0.000	0.000	0.000	0.000
22	0.000	0.000	0.000	0.000
23	-2391.440	2391.440	-90.000	3382.007
24	-1207.870	1207.870	-90.000	1708.186
25	45598.600	-48346.000	88.323	66457.263
26	17823.000	-17823.000	90.000	23203.328
27	13347.200	-13347.200	90.000	18875.791
28	18719.900	-8292.230	111.108	20474.270

NORMAL FORCE= 124520.454 SHEAR= 5430.688 MOMENT= -1616410.083
 FORCE ON INNER RADIUS= 5090.193 FORCE ON OUTER RADIUS= 129724.370

THETA= 67.500

NODE	FX	FY	PHI	RES
31	-1360.730	3285.100	-90.000	3535.763
32	-7434.440	17996.600	-90.000	19479.381
33	-6215.200	15004.800	-90.000	16241.082
34	-4305.510	10394.400	-90.000	11230.821
35	21221.100	3405.750	166.618	21492.653
36	-1011.530	2441.990	-89.999	2643.200
37	568.261	-1371.870	90.000	1484.907
38	13988.700	6168.910	-178.703	15288.531

NORMAL FORCE= -47056.932 SHEAR= 36193.697 MOMENT= -647965.993

THETA= 90.000

NODE 41	FX=	0.000	FY=	12754.400	PHI=	-90.000	RESF=	12754.400
NODE 42	FX=	0.000	FY=	19799.800	PHI=	-90.000	RESF=	19799.800
NODE 43	FX=	0.000	FY=	18594.500	PHI=	-90.000	RESF=	18594.500
NODE 44	FX=	0.000	FY=	18068.400	PHI=	-90.000	RESF=	18068.400
NODE 45	FX=	7545.310	FY=	-16164.000	PHI=	115.023	RESF=	17838.346
NODE 46	FX=	0.000	FY=	-5602.650	PHI=	90.000	RESF=	5602.650
NODE 47	FX=	0.000	FY=	-7032.750	PHI=	90.000	RESF=	7032.750
NODE 48	FX=	7885.330	FY=	-4516.970	PHI=	150.195	RESF=	9087.433

NORMAL FORCE= -45860.710 SHEAR= 15430.701 MOMENT= -1349921.886
 FORCE ON INNER RADIUS= 79177.100 FORCE ON OUTER RADIUS= 36716.279

THETA= 112.500

NODE 51	FX=	4393.460	FY=	10606.800	PHI=	-90.000	RESF=	11480.710
NODE 52	FX=	7374.530	FY=	17803.700	PHI=	-90.000	RESF=	19270.584
NODE 53	FX=	7772.050	FY=	18763.400	PHI=	-90.000	RESF=	20309.356
NODE 54	FX=	12615.200	FY=	30453.900	PHI=	-90.000	RESF=	32965.211
NODE 55	FX=	-8296.020	FY=	-16068.900	PHI=	85.194	RESF=	18084.067
NODE 56	FX=	-3982.840	FY=	-9615.230	PHI=	89.999	RESF=	10407.481
NODE 57	FX=	-4102.620	FY=	-9904.390	PHI=	89.999	RESF=	10720.468
NODE 58	FX=	-343.153	FY=	-7645.940	PHI=	109.930	RESF=	7653.637

NORMAL FORCE= -37682.186 SHEAR= 1093.558 MOMENT= -1564434.425
 FORCE ON INNER RADIUS= 84025.861 FORCE ON OUTER RADIUS= 46356.573

THETA= 135.000

NODE 61	FX=	3851.910	FY=	3851.910	PHI=	-90.000	RESF=	5447.423
NODE 62	FX=	12740.100	FY=	12740.100	PHI=	-90.000	RESF=	18017.222
NODE 63	FX=	14703.600	FY=	14703.600	PHI=	-90.000	RESF=	20794.031
NODE 64	FX=	22324.700	FY=	22324.700	PHI=	-90.000	RESF=	31571.894
NODE 65	FX=	-13722.300	FY=	-6702.650	PHI=	71.033	RESF=	15271.772
NODE 66	FX=	-9205.750	FY=	-9205.750	PHI=	90.000	RESF=	13018.897
NODE 67	FX=	-9364.160	FY=	-9364.160	PHI=	90.000	RESF=	13242.922
NODE 68	FX=	-5897.460	FY=	-5417.190	PHI=	87.569	RESF=	8007.870

NORMAL FORCE= -27125.475 SHEAR= -5303.190 MOMENT= -1494427.968
 FORCE ON INNER RADIUS= 75830.570 FORCE ON OUTER RADIUS= 48992.976

THETA= 157.500

NODE 71	FX=	3355.930	FY=	1390.070	PHI=	-90.000	RESF=	3632.432
NODE 72	FX=	588.813	FY=	243.894	PHI=	-90.000	RESF=	637.326
NODE 73	FX=	0.000	FY=	0.000	PHI=	0.000	RESF=	0.000
NODE 74	FX=	0.000	FY=	0.000	PHI=	0.000	RESF=	0.000
NODE 75	FX=	-1848.900	FY=	4371.570	PHI=	90.425	RESF=	4746.478
NODE 76	FX=	4341.140	FY=	1798.200	PHI=	-90.000	RESF=	4698.832
NODE 77	FX=	3324.080	FY=	2205.350	PHI=	-90.000	RESF=	3762.759
NODE 78	FX=	3669.580	FY=	1456.200	PHI=	-90.855	RESF=	3947.953

NORMAL FORCE= -18643.640 SHEAR= -4687.447 MOMENT= 121249.486
 FORCE ON INNER RADIUS= 4269.758 FORCE ON OUTER RADIUS= 15118.887

THETA= 180.000

NODE 81 FX= 0.000 FY= 0.000 PHI= 0.000 RESF= 0.000

NO00	99	11	00	00	00	11	00	00	11	00	00
NO00	88	10	00	00	00	00	00	00	00	00	00
NO00	77	09	00	00	00	00	00	00	00	00	00
NO00	66	08	00	00	00	00	00	00	00	00	00
NO00	55	07	00	00	00	00	00	00	00	00	00
NO00	44	06	00	00	00	00	00	00	00	00	00
NO00	33	05	00	00	00	00	00	00	00	00	00
NO00	22	04	00	00	00	00	00	00	00	00	00
NO00	11	03	00	00	00	00	00	00	00	00	00
NO00	00	02	00	00	00	00	00	00	00	00	00

1	NORMAL FORCE = -15430.650	SHEAR = 0.000	MOMENT = 0.000
2	FORCE ON INNER RADIUS = 0.000	FORCE ON OUTER RADIUS = 15430.650	

- 1
- 2
- 3
- 4
- 5
- 6
- 7
- 8
- 9
- 10
- 11
- 12
- 13
- 14
- 15
- 16
- 17
- 18
- 19
- 20
- 21
- 22
- 23
- 24
- 25
- 26
- 27
- 28
- 29
- 30
- 31
- 32
- 33
- 34
- 35
- 36
- 37
- 38
- 39
- 40
- 41
- 42

***** ASSEMBLED EC STRUCTURE *****
 ***** DISCONNECTED AT INNER RADIUS OF OH ARCH EXCEPT *****
 ***** FOR THE INTERFACE OF THE LOWER SIX MODULES *****
 ***** THE INTERFACE OF THE LOWER SIX MODULES CANNOT *****
 ***** SUSTAIN SHEAR *****
 ***** THE MIDDLE CONNECTORS ON THE OUTER RADIUS OF OH ARCH *****
 ***** CANNOT SUSTAIN SHEAR *****
 ***** WEIGHT ONLY *****
 ***** 5/8/87 *****

Appendix H

THETA= 0.000

NODE	1	FX=	39366.900	FY=	0.000	PHI=	90.000	RESF=	39366.900
NODE	2	FX=	17804.200	FY=	0.000	PHI=	90.000	RESF=	17804.200
NODE	3	FX=	13508.100	FY=	0.000	PHI=	90.000	RESF=	13508.100
NODE	4	FX=	3785.580	FY=	0.000	PHI=	90.000	RESF=	3785.580
NODE	5	FX=	47143.900	FY=	0.000	PHI=	90.000	RESF=	47143.900
NODE	6	FX=	25786.600	FY=	0.000	PHI=	90.000	RESF=	25786.600
NODE	7	FX=	17044.800	FY=	0.000	PHI=	90.000	RESF=	17044.800
NODE	8	FX=	18984.700	FY=	0.000	PHI=	90.000	RESF=	18984.700

NORMAL FORCE= 183424.780 SHEAR= 0.000 MOMENT= -413942.640
 FORCE ON INNER RADIUS= 74464.780 FORCE ON OUTER RADIUS= 108960.000

THETA= 22.500

NODE	11	FX=	25700.100	FY=	-10645.500	PHI=	90.000	RESF=	27817.653
NODE	12	FX=	17972.200	FY=	-7444.500	PHI=	90.000	RESF=	19453.035
NODE	13	FX=	15935.500	FY=	-6600.830	PHI=	90.000	RESF=	17248.511
NODE	14	FX=	-9345.430	FY=	3871.090	PHI=	-90.000	RESF=	10115.472
NODE	15	FX=	57715.900	FY=	-7225.970	PHI=	105.364	RESF=	58166.483
NODE	16	FX=	23953.800	FY=	-9922.210	PHI=	90.000	RESF=	23927.491
NODE	17	FX=	15169.500	FY=	-6283.560	PHI=	90.000	RESF=	16419.405
NODE	18	FX=	13584.500	FY=	-11212.600	PHI=	72.964	RESF=	17614.228

NORMAL FORCE= 169679.741 SHEAR= 10249.705 MOMENT= -730467.464
 FORCE ON INNER RADIUS= 54405.726 FORCE ON OUTER RADIUS= 115730.825

THETA= 45.000

NODE	21	FX=	-10972.100	FY=	10972.100	PHI=	-90.000	RESF=	13316.893
NODE	22	FX=	-22637.000	FY=	22637.000	PHI=	-90.000	RESF=	32015.552
NODE	23	FX=	-15648.000	FY=	15648.000	PHI=	-90.000	RESF=	22129.614
NODE	24	FX=	2620.760	FY=	-2620.760	PHI=	90.000	RESF=	51706.314
NODE	25	FX=	52394.600	FY=	-52394.600	PHI=	88.321	RESF=	76367.001
NODE	26	FX=	21468.000	FY=	-21468.000	PHI=	90.000	RESF=	30360.337
NODE	27	FX=	14683.100	FY=	-14683.100	PHI=	90.000	RESF=	20765.039
NODE	28	FX=	3442.830	FY=	-8237.240	PHI=	67.683	RESF=	8927.777

NORMAL FORCE= 69764.912 SHEAR= -5627.280 MOMENT= -2420068.813
 FORCE ON INNER RADIUS= 65953.745 FORCE ON OUTER RADIUS= 135835.270

THETA= 67.500

NODE	31	FX=	-6951.090	FY=	16781.400	PHI=	-90.000	RESF=	18164.059
NODE	32	FX=	-11915.300	FY=	28766.100	PHI=	-90.000	RESF=	31136.199
NODE	33	FX=	-8800.240	FY=	21245.700	PHI=	-90.000	RESF=	22996.173
NODE	34	FX=	3548.240	FY=	-13395.700	PHI=	-90.000	RESF=	14498.309
NODE	35	FX=	18154.600	FY=	-19154.700	PHI=	110.964	RESF=	26301.136
NODE	36	FX=	3456.060	FY=	-8343.490	PHI=	90.000	RESF=	9030.957
NODE	37	FX=	2188.460	FY=	-5283.290	PHI=	90.000	RESF=	5718.611

NODE 3H FX= 7655.320 FY= 9919.390 PHI= -150.159 RESF= 12529.893

NORMA FORCE ORCE= -53635.810 SHEAR= 20311.266 MOMM -1439444.044
FORCE INNER RADIUS= 86794.740 FORCE ON OUTER DIUS= 38885.177

THETA= 90.000

NODE	41	FX=	0.000	FY=	19373.900	PHI=	-90.000	RR	RESF	19373.900
NODE	42	FX=	0.000	FY=	25034.600	PHI=	-90.000	RR	RESF	25034.600
NODE	43	FX=	0.000	FY=	20921.600	PHI=	-90.000	RR	RESF	20921.600
NODE	44	FX=	0.000	FY=	26960.700	PHI=	-90.000	RR	RESF	26960.700
NODE	45	FX=	-4865.900	FY=	-25718.100	PHI=	79.286	RR	RESF	26174.370
NODE	46	FX=	0.000	FY=	-11788.000	PHI=	90.000	RR	RESF	11788.000
NODE	47	FX=	0.000	FY=	-8438.090	PHI=	90.000	RR	RESF	8438.090
NODE	48	FX=	3105.480	FY=	-485.888	PHI=	171.108	RR	RESF	3143.262

NORMAL FORCE= -45860.724 SHEAR= -1760.359 MOMENT= -1664650.508
FORCE ON INNER RADIUS= 92290.800 FORCE ON OUTER RADIUS= 46463.440

THETA= 112.500

NODE	51	FX=	4268.950	FY=	18306.200	PHI=	-90.000	RR	RESF	11115.344
NODE	52	FX=	6986.050	FY=	16865.800	PHI=	-90.000	RR	RESF	18233.413
NODE	53	FX=	7083.860	FY=	17102.000	PHI=	-90.000	RR	RESF	18511.064
NODE	54	FX=	9974.200	FY=	24879.900	PHI=	-90.000	RR	RESF	26063.888
NODE	55	FX=	-19034.100	FY=	-12029.500	PHI=	54.793	RR	RESF	122516.790
NODE	56	FX=	-4401.230	FY=	-10625.300	PHI=	90.000	RR	RESF	11500.775
NODE	57	FX=	-3591.950	FY=	-8671.550	PHI=	89.999	RR	RESF	9386.047
NODE	58	FX=	-3046.230	FY=	-2632.160	PHI=	63.329	RR	RESF	4023.889

NORMAL FORCE= -31103.526 SHEAR= -14788.938 MOMENT= -1402414.680
FORCE ON INNER RADIUS= 73985.708 FORCE ON OUTER RADIUS= 45360.736

THETA= 135.000

NODE	61	FX=	0.000	FY=	0.000	PHI=	0.000	RR	RESF	0.000
NODE	62	FX=	7972.890	FY=	7972.890	PHI=	-90.000	RR	RESF	11275.369
NODE	63	FX=	11060.300	FY=	11060.300	PHI=	-90.000	RR	RESF	15641.626
NODE	64	FX=	13607.900	FY=	13607.900	PHI=	-90.000	RR	RESF	19244.477
NODE	65	FX=	-14981.400	FY=	-4449.450	PHI=	28.439	RR	RESF	15628.178
NODE	66	FX=	-7047.410	FY=	-7047.410	PHI=	90.000	RR	RESF	9966.543
NODE	67	FX=	-6816.470	FY=	-6816.470	PHI=	90.000	RR	RESF	9639.944
NODE	68	FX=	-5556.210	FY=	-296.096	PHI=	48.050	RR	RESF	5564.094

NORMAL FORCE= -14969.601 SHEAR= -17459.118 MOMENT= -928240.117
FORCE ON INNER RADIUS= 46161.472 FORCE ON OUTER RADIUS= 35745.725

THETA= 157.500

NODE	71	FX=	3809.550	FY=	1577.970	PHI=	-90.000	RR	RESF	4123.428
NODE	72	FX=	2213.800	FY=	917.019	PHI=	-90.000	RR	RESF	2396.286
NODE	73	FX=	1510.910	FY=	625.839	PHI=	-90.000	RR	RESF	1635.397
NODE	74	FX=	665.410	FY=	275.622	PHI=	-90.000	RR	RESF	720.295
NODE	75	FX=	-13631.300	FY=	4632.050	PHI=	48.732	RR	RESF	14396.813
NODE	76	FX=	130.371	FY=	54.003	PHI=	-89.999	RR	RESF	141.113
NODE	77	FX=	2575.970	FY=	1067.020	PHI=	-90.000	RR	RESF	2788.217
NODE	78	FX=	964.825	FY=	2315.760	PHI=	-45.118	RR	RESF	2508.711

NORMAL FORCE= -2761.217 SHEAR= -11266.204 MOMENT= -179873.705
FORCE ON INNER RADIUS= 8875.346 FORCE ON OUTER RADIUS= 12818.359

NODE	88	FX	0.000	FY	0.000	PHI	0.000	R	0.000
NODE	88	FX	0.000	FY	0.000	PHI	0.000	R	0.000
NODE	88	FX	0.000	FY	0.000	PHI	0.000	R	0.000
NODE	88	FX	0.000	FY	0.000	PHI	0.000	R	0.000
NODE	88	FX	0.000	FY	0.000	PHI	0.000	R	0.000
NODE	88	FX	0.000	FY	0.000	PHI	0.000	R	0.000
NODE	88	FX	-624.320	FY	0.000	PHI	0.000	R	624.320
NODE	88	FX	540.771	FY	0.000	PHI	0.000	R	540.771
NODE	88	FX	3053.710	FY	0.000	PHI	0.000	R	3053.710
NODE	88	FX	889.418	FY	0.000	PHI	0.000	R	889.418

NORMAL FORCE= 1760.421 SHEAR= -.005 MOMENT= 0.000
 FORCE ON INNER RADIUS= 0.000 FORCE ON OUTER RADIUS= 1760.421

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42