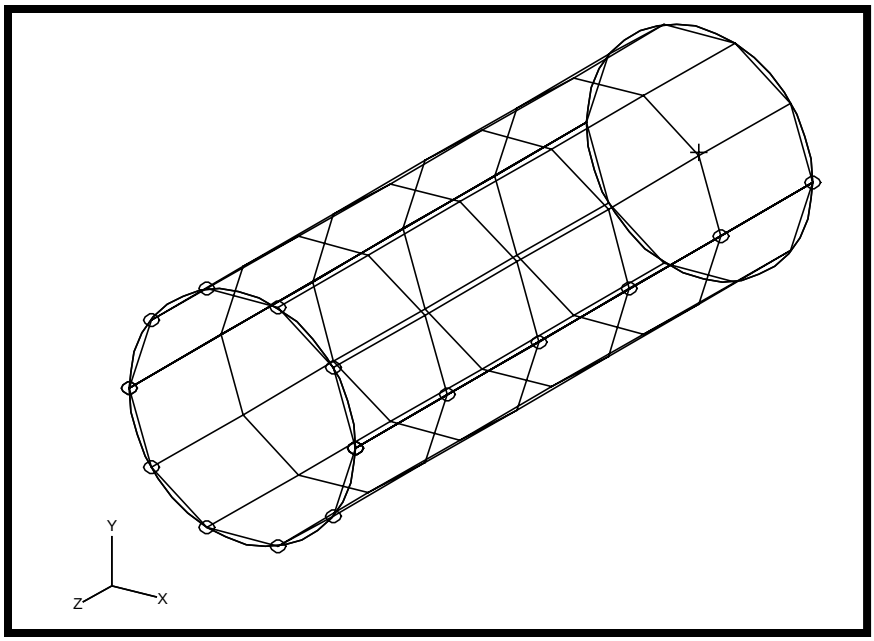
LESSON 17

Linear Static - Rigid Element Analysis with RBE2 and CONM2



Objectives:

- Create a geometric representation of a tube.
- Use the geometry model to define an analysis model comprised of plate elements.
- Idealize a rigid end using RBE2 elements.
- Define a concentrated mass, to represent the weight of the rigid enclosure (CONM2).
- Run an MSC/NASTRAN linear static analysis.
- Visualize analysis results.

Model Description:

The goal of the example is to maintain a circular cross section at the rigid end of the tube, (using RBE2 elements), while applying a gravitational force of 2.7g in the z-direction.

Additionally, a concentrated mass needs to be defined to represent the weight of the rigid enclosure. It is very important to account for all the weight contribution since inertia loading is used in this problem.

Below is a finite element representation of the tube. One end of the tube is considered rigid, and the other end is fixed in all translational and rotational degrees of freedom. Table 17.1 contains all the necessary parameters to construct the input file.

Figure 17.1 - Grid Coordinates and Element Connectivites

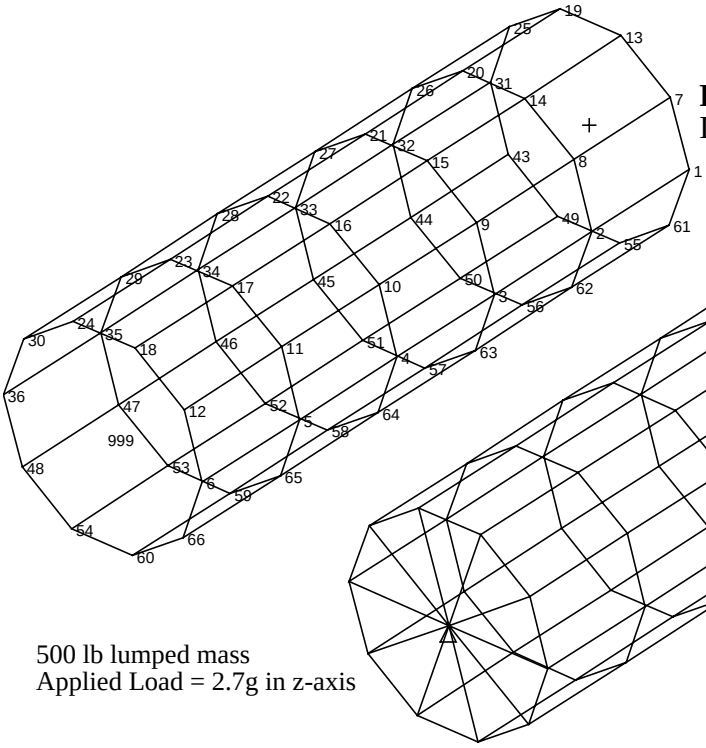


Figure 17.2 - Loads and Boundary Conditions

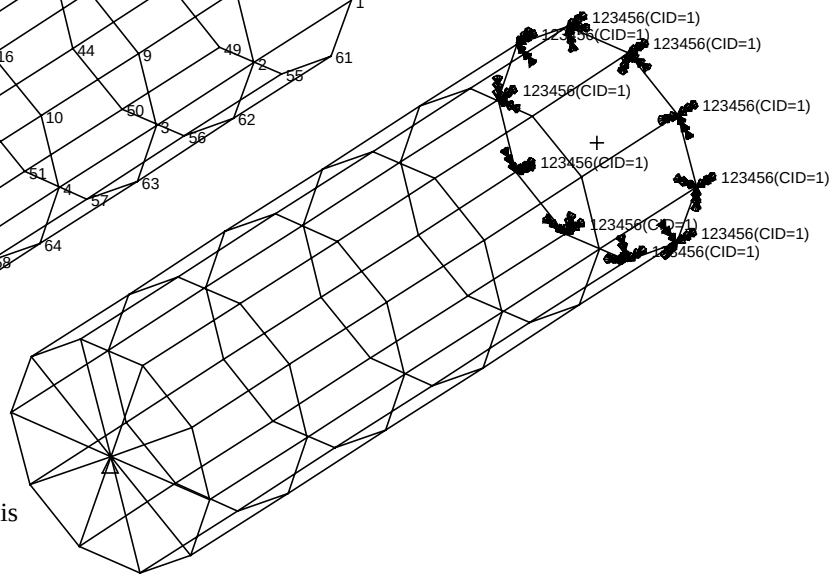


Table 17.1 - Properties

Radius:	**15 in**
Thickness:	**0.125 in**
Length:	**90 in**
Elastic Modulus:	**10E6 lb/in^2**
Density:	**0.101 lbs/in^3**
Poisson's Ratio:	**0.3**

Suggested Exercise Steps:

- Generate a finite element representation of the cylinder structure (i.e., The nodes (GRID) and element connectivities (CQUAD4) should be defined manually).
- Define material (MAT1) and element (PSHELL) properties.
- Create grid point 999 at the center of the rigid end. This point is to serve as the load application point, as well as the connection point for the rigid element.
- Idealize the rigid end with rigid elements (RBE2).
- Apply the fixed boundary constraints (SPC1).
- Apply a concentrated mass at the center of the top enclosure, Grid 999 (CONM2).
- Apply an inertial load to the entire structure (GRAV).
- Prepare the model for linear static analysis (SOL 101).
- Generate an input file and submit it to the MSC/NASTRAN solver for linear static analysis.
- Review the results, specifically the displacements along the free end.

ID SEMINAR, LESSON 17

CEND

BEGIN BULK

1	2	3	4	5	6	7	8	9	10

1	2	3	4	5	6	7	8	9	10

ENDDATA

Exercise Procedure:

1. Open database named **lesson16.db**.

   File/Open Database

   Existing Database Name: **lesson16**

   OK

2. Activate the entity labels by selecting the **Show Labels** icon on the tool-bar.

    **Show Labels**

3. Now you will create the inertial load.

   ◆ **Loads/BCs**

   Action: **Create**

   Object: **Inertial Load**

   Type: **Element Uniform**

   New Set Name: **Inertia**

   Input Data...

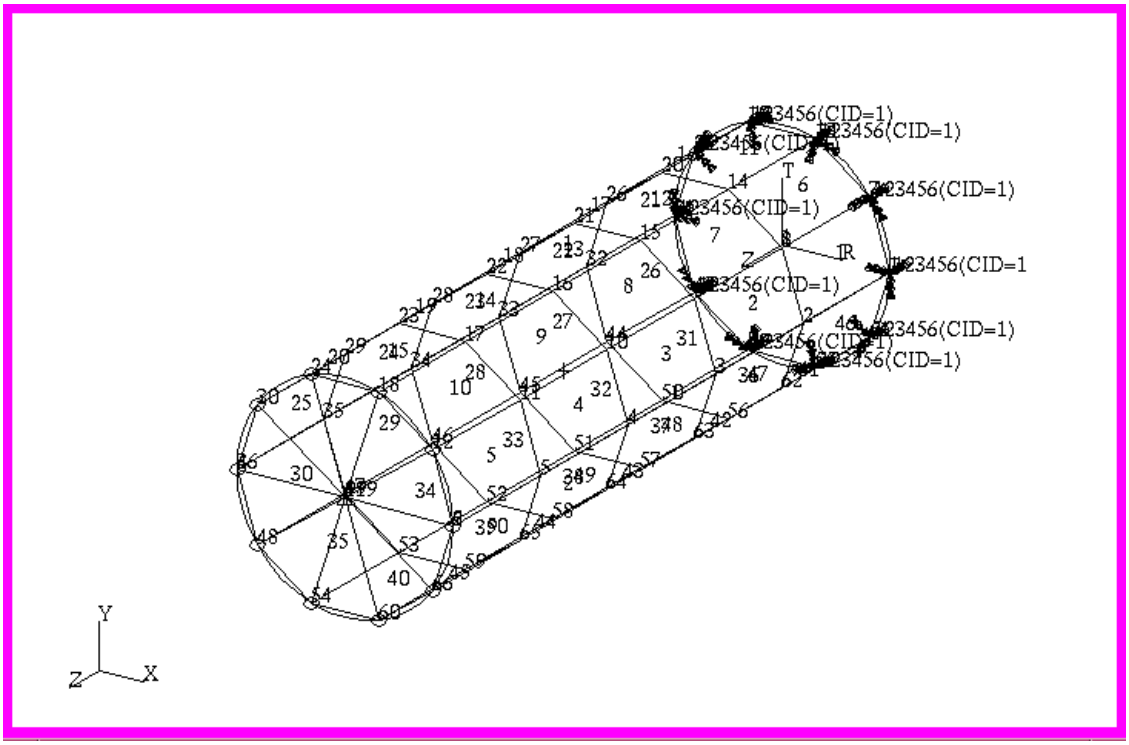
   Trans Accel <A1 A2 A3> **<0 0 1043.28>**

   Analysis Coordinate Frame: **Coord 0**

   OK

   Apply

Figure 17.3 - Model Showing All Labels With Interial Load



4. Now you are ready to run the analysis.

◆ **Analysis**

Action:	**Analyze**
Object:	**Entire Model**
Method:	**Analysis Deck**
Job Name:	**lesson17**

Solution Type...

Solution Type: ◆ **LINEAR STATIC**

Solution Parameters...

❒ **Automatic Contraints**

Wt. - Mass Conversion = **0.00259**

OK

OK

Apply

An MSC/NASTRAN input file called **lesson17.bdf** will be generated. This process of translating your model into an input file is called the Forward Translation. The Forward Translation is complete when the Heartbeat turns green.

Generating an input file for MSC/NASTRAN Users:

MSC/NASTRAN users can generate an input file using the data from Table 17.1. The result should be similar to the output below.

5. MSC/NASTRAN input file: **lesson17.bdf**

```
SOL 101
TIME 600
CEND
TITLE = Linear Static w/RBE2
SUBCASE 1
   SUBTITLE=Default
   SPC = 2
   LOAD = 2
   DISPLACEMENT(SORT1,REAL)=ALL
   SPCFORCES(SORT1,REAL)=ALL
   STRESS(SORT1,REAL,VONMISES,BILIN)=ALL
BEGIN BULK
$ PARAMETERS
PARAM    POST    -1
PARAM    PATVER  3.
PARAM    AUTOSPC NO
PARAM    WTMASS  .00259
$ PROPERTIES
PSHELL   1       1       .125    1               1
$ ELEMENTS
CQUAD4   1       1       1       2       8       7
=        *1      =       *1      *1      *1      *1
=3
CQUAD4   6       1       7       8       14      13
=        *1      =       *1      *1      *1      *1
=3
CQUAD4   11      1       13      14      20      19
=        *1      =       *1      *1      *1      *1
=3
CQUAD4   16      1       19      20      26      25
=        *1      =       *1      *1      *1      *1
=3
CQUAD4   21      1       25      26      32      31
=        *1      =       *1      *1      *1      *1
=3
CQUAD4   26      1       31      32      44      43
=        *1      =       *1      *1      *1      *1
=3
CQUAD4   31      1       43      44      50      49
=        *1      =       *1      *1      *1      *1
=3
CQUAD4   36      1       49      50      56      55
=        *1      =       *1      *1      *1      *1
=3
CQUAD4   41      1       55      56      62      61
=        *1      =       *1      *1      *1      *1
=3
CQUAD4   46      1       61      62      2       1
```

```
=       *1      =       *1      *1      *1      *1
=3
$ CONCENTRATED MASS
CONM2   51      999             500.
$ MATERIALS
MAT1    1       1.+7            .3      .101
$ MPCS
RBE2    52      999     123     6       12      18      24      30      +       A
+       A 36    48      54      60      66
$ NODES
GRID    1       1       15.     0.      0.      1
=       *1      =       =       =       *18     =
=4
GRID    7       1       15.     36.     0.      1
=       *1      =       =       =       *18     =
=4
GRID    13      1       15.     72.     0.      1
=       *1      =       =       =       *18     =
=4
GRID    19      1       15.     108.    0.      1
=       *1      =       =       =       *18     =
=4
GRID    25      1       15.     144.    0.      1
=       *1      =       =       =       *18     =
=4
GRID    31      1       15.     180.    0.      1
=       *1      =       =       =       *18     =
=4
GRID    43      1       15.     216.    0.      1
=       *1      =       =       =       *18     =
=4
GRID    49      1       15.     252.    0.      1
=       *1      =       =       =       *18     =
=4
GRID    55      1       15.     288.    0.      1
=       *1      =       =       =       *18     =
=4
GRID    61      1       15.     324.    0.      1
=       *1      =       =       =       *18     =
=4
GRID    999     1       0.      0.      90.     1
$ LBCS
SPCADD  2       1
LOAD    2       1.      1.      1
SPC1    1       123456  1       7       13      19      25      31      +       B
+       B 43    49      55      61
GRAV    1       0       1043.28 0.      0.      1.
CORD2C  1               0.      0.      0.      0.      0.      1.      +       C
+       C 1.    0.      0.
ENDDATA
```

Submit the input file for analysis:

6. Submit the input file to MSC/NASTRAN for analysis.

   6a. To submit the MSC/PATRAN **.bdf** file for analysis, find an available UNIX shell window. At the command prompt enter: **nastran lesson17.bdf scr=yes**. Monitor the run using the UNIX **ps** command.

   6b. To submit the MSC/NASTRAN **.dat** file for analysis, find an available UNIX shell window. At the command prompt enter: **nastran lesson17 scr=yes**. Monitor the run using the UNIX **ps** command.

7. When the run is completed, edit the **lesson17.f06** file and search for the word **FATAL**. If no matches exist, search for the word **WARNING**. Determine whether existing WARNING messages indicate modeling errors.

8. While still editing **lesson17.f06**, search for the word:

D I S P L A C E M E N T (spaces are necessary)

What is the T3 displacement at Node 6, 12, 18, 24, 30, 36, 48, 54, 60, 66 and 999?

T3 Displacement = _____

Comparison of Results:

9. Compare the results obtained in the **.f06** file with the results on the following page:

D I S P L A C E M E N T V E C T O R

POINT ID.	TYPE	T1	T2	T3	R1	R2	R3
1	G	0.0	0.0	0.0	0.0	0.0	0.0
2	G	-7.674323E-05	1.372193E-19	2.409957E-04	-9.910285E-20	-2.822520E-06	6.485096E-20
3	G	-5.603609E-05	-5.136196E-19	4.840313E-04	-2.239343E-20	1.951360E-06	4.936085E-19
4	G	-5.465512E-05	-1.372193E-18	7.150446E-04	3.212372E-19	-1.302233E-06	5.378659E-19
5	G	-6.735860E-05	-2.507218E-18	9.400494E-04	2.028379E-19	1.370978E-06	6.966846E-20
6	G	8.463973E-18	-4.330222E-18	1.147170E-03	5.227781E-21	4.927580E-06	1.524659E-20
7	G	0.0	0.0	0.0	0.0	0.0	0.0
8	G	-7.674323E-05	-4.572545E-19	2.409957E-04	-1.247482E-19	-2.822520E-06	3.298314E-19
9	G	-5.603609E-05	-1.846203E-18	4.840313E-04	1.092950E-19	1.951360E-06	6.996232E-19
10	G	-5.465512E-05	-3.398586E-18	7.150446E-04	2.259813E-21	-1.302233E-06	5.738582E-19
11	G	-6.735860E-05	-5.434264E-18	9.400494E-04	2.411159E-19	1.370978E-06	4.078510E-19
12	G	3.668969E-18	-8.272454E-18	1.147170E-03	2.272510E-19	4.927580E-06	-6.196057E-20
13	G	0.0	0.0	0.0	0.0	0.0	0.0
14	G	-7.674323E-05	1.183147E-19	2.409957E-04	1.589047E-19	-2.822520E-06	-1.637485E-19
15	G	-5.603609E-05	-3.365452E-19	4.840313E-04	2.009416E-19	1.951360E-06	-7.818081E-19
16	G	-5.465512E-05	-2.110810E-18	7.150446E-04	1.300153E-19	-1.302233E-06	-6.505722E-19
17	G	-6.735860E-05	-5.039693E-18	9.400494E-04	-2.563982E-20	1.370978E-06	-1.736464E-19
18	G	-2.527457E-18	-8.643353E-18	1.147170E-03	2.881146E-19	4.927580E-06	2.503077E-19
19	G	0.0	0.0	0.0	0.0	0.0	0.0
20	G	-7.674323E-05	1.661288E-19	2.409957E-04	-8.324359E-20	-2.822520E-06	3.350880E-20
21	G	-5.603609E-05	-1.932965E-19	4.840313E-04	-2.151239E-19	1.951360E-06	5.835859E-19
22	G	-5.465512E-05	-1.436422E-18	7.150446E-04	4.760325E-19	-1.302233E-06	5.369031E-19
23	G	-6.735860E-05	-3.045354E-18	9.400494E-04	3.320337E-19	1.370978E-06	2.174347E-21
24	G	-7.758479E-18	-5.301250E-18	1.147170E-03	-1.730335E-19	4.927580E-06	-1.162047E-19
25	G	0.0	0.0	0.0	0.0	0.0	0.0
26	G	-7.674323E-05	2.402950E-19	2.409957E-04	7.276585E-20	-2.822520E-06	-3.738481E-20
27	G	-5.603609E-05	4.548139E-19	4.840313E-04	2.732623E-19	1.951360E-06	-5.728545E-19
28	G	-5.465512E-05	4.321157E-19	7.150446E-04	-3.996296E-19	-1.302233E-06	-3.922050E-19
29	G	-6.735860E-05	4.609046E-19	9.400494E-04	-8.551355E-20	1.370978E-06	2.382501E-19
30	G	-1.002603E-17	4.772865E-19	1.147170E-03	1.612288E-19	4.927580E-06	2.290300E-19
31	G	0.0	0.0	0.0	0.0	0.0	0.0
32	G	-7.674323E-05	1.368788E-19	2.409957E-04	-2.286989E-19	-2.822520E-06	2.288140E-19
33	G	-5.603609E-05	6.339022E-19	4.840313E-04	-2.863123E-19	1.951360E-06	9.099107E-19
34	G	-5.465512E-05	2.220775E-18	7.150446E-04	2.412985E-19	-1.302233E-06	7.099840E-19
35	G	-6.735860E-05	4.358738E-18	9.400494E-04	-1.118061E-19	1.370978E-06	4.230405E-20
36	G	-8.463973E-18	6.485052E-18	1.147170E-03	-1.170949E-19	4.927580E-06	-4.758133E-20
43	G	0.0	0.0	0.0	0.0	0.0	0.0
44	G	-7.674323E-05	8.666162E-19	2.409957E-04	4.084986E-20	-2.822520E-06	-9.233857E-20
45	G	-5.603609E-05	2.639956E-18	4.840313E-04	-1.547968E-19	1.951360E-06	-4.171795E-19
46	G	-5.465512E-05	4.775099E-18	7.150446E-04	2.031357E-19	-1.302233E-06	-4.034793E-19
47	G	-6.735860E-05	7.323148E-18	9.400494E-04	-3.976857E-19	1.370978E-06	-6.044355E-22
48	G	-3.668969E-18	1.042728E-17	1.147170E-03	-3.592464E-20	4.927580E-06	1.001111E-19
49	G	0.0	0.0	0.0	0.0	0.0	0.0
50	G	-7.674323E-05	1.019067E-18	2.409957E-04	4.912791E-20	-2.822520E-06	-1.997256E-19
51	G	-5.603609E-05	2.801852E-18	4.840313E-04	2.801002E-20	1.951360E-06	-5.377430E-19
52	G	-5.465512E-05	4.807018E-18	7.150446E-04	-6.522154E-19	-1.302233E-06	-2.478299E-19
53	G	-6.735860E-05	7.458112E-18	9.400494E-04	-1.949815E-19	1.370978E-06	9.724147E-20
54	G	2.527457E-18	1.079818E-17	1.147170E-03	-7.271527E-20	4.927580E-06	2.153954E-19
55	G	0.0	0.0	0.0	0.0	0.0	0.0
56	G	-7.674323E-05	4.905100E-19	2.409957E-04	-3.377130E-19	-2.822520E-06	4.420561E-19
57	G	-5.603609E-05	1.273528E-18	4.840313E-04	-1.606897E-19	1.951360E-06	1.420836E-18
58	G	-5.465512E-05	2.960104E-18	7.150446E-04	-2.164575E-19	-1.302233E-06	1.142265E-18
59	G	-6.735860E-05	5.243138E-18	9.400494E-04	3.361054E-19	1.370978E-06	2.099659E-19
60	G	7.758479E-18	7.456079E-18	1.147170E-03	-4.204996E-19	4.927580E-06	-2.340922E-19
61	G	0.0	0.0	0.0	0.0	0.0	0.0
62	G	-7.674323E-05	9.899912E-19	2.409957E-04	2.100642E-19	-2.822520E-06	-3.638672E-19
63	G	-5.603609E-05	2.111067E-18	4.840313E-04	1.487363E-19	1.951360E-06	-1.357386E-18
64	G	-5.465512E-05	2.506079E-18	7.150446E-04	-2.194874E-19	-1.302233E-06	-1.207542E-18
65	G	-6.735860E-05	2.099836E-18	9.400494E-04	-3.459763E-19	1.370978E-06	-1.851248E-19
66	G	1.002603E-17	1.677543E-18	1.147170E-03	1.963853E-19	4.927580E-06	3.597520E-19
999	G	8.463973E-18	-5.407637E-18	1.147170E-03	1.201928E-19	1.775074E-19	7.182766E-20

10. Proceed with the Reverse Translation process, that is importing the **lesson17.op2** results file into MSC/PATRAN. To do this, return to the ***Analysis*** form and proceed as follows:

◆ **Analysis**

Action: **Read Output2**

Object: **Result Entities**

Method: **Translate**

Select Results File...

Select Results File: **lesson17.op2**

OK

Apply

11. When the translation is complete bring up the **Results** form.

Select **Fringe** to view different results with color spectrum analysis.

◆ **Results**

Action: **Create**

Object: **Fringe**

Select Result

Select Result Case(s): **Default, Static Subcase**

Select Fringe Result: **Stress Tensor**

Position...(AtZ1)

Positions: **At Z2**

Close

Quantity: **XY Component**

Target Entities

Target Entity:	**Materials**
Select Materials:	**mat_1**
Addtl. Display Control:	**Faces**

Display Attributes

Style:	**Continuous**
Element Shrink Factor:	**0.05**
Display:	**Element Edges**
Style:	▬▬▬

Label Style...

Label Format:	**Exponential**
Significant figures:	**5**

OK

Plot Options

Coordinate Transformation:	**CID**
Select Coordinate Frame:	**Coord 1**

Apply

Select **Deformation** to view physical changes of the model.

◆ **Results**

Action:	**Create**
Object:	**Deformation**

Select Result

Select Result Case(s):	**Default, Static Subcase**
Select Deformation Result:	**Displacements, Translational**
Show As:	**Component**

■ **XX** ■ **YY** ❑ **ZZ**

Display Attributes

Render Style:	**Shaded**

❑ **Show Undeformed**

❑ **Show Max/Min Label**

Plot Options

Coordinate Transformation:	**Projected CID**
Select Coordinate Frame Axis:	**Coord 1.1**

Apply

12. If you wish to reset your display graphics to the state it was in before you began post-processing your model, remember to select the **Reset Graphics** icon.

Reset Graphics

To view different results, after **Reset Graphics** repeat step 11 and change *Result Case(s)*, *Fringe Result*, and *Deformation Result*.

Quit MSC/PATRAN when you are finished with this exercise.