

Advanced Linear Analysis using MSC Nastran

NAS101B Workshops

March 2012



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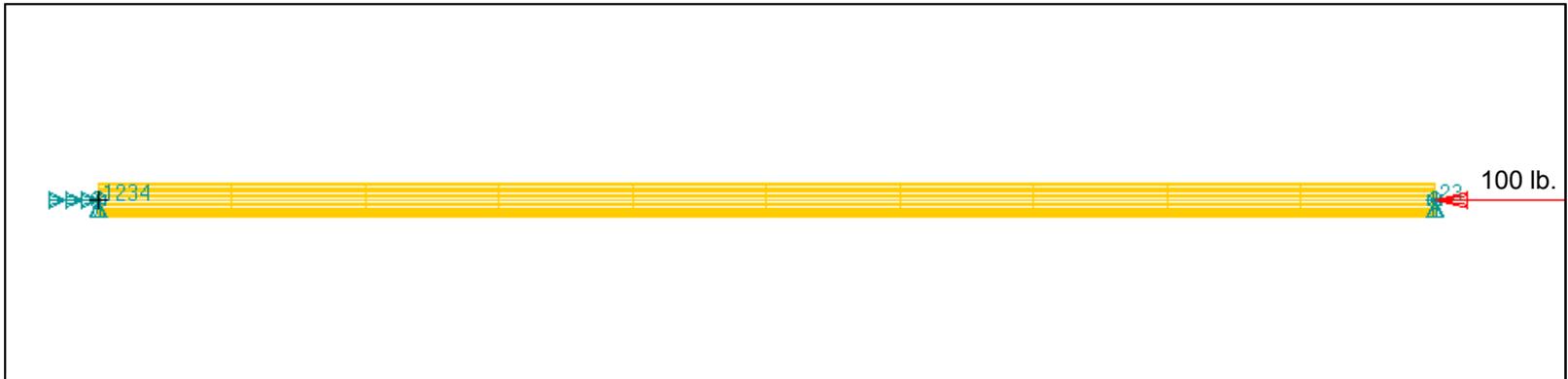
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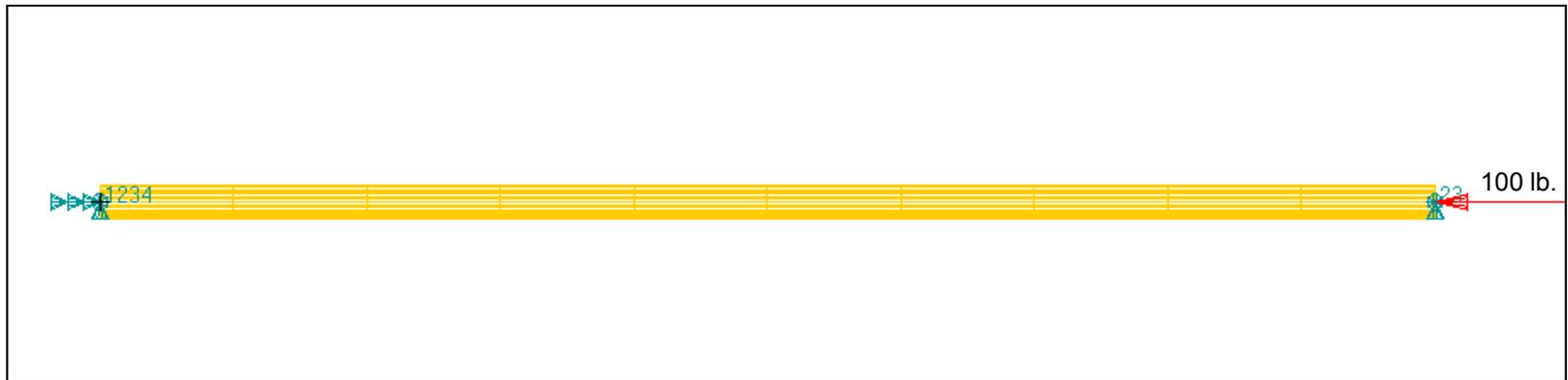
WORKSHOP 1

BUCKLING ANALYSIS OF A STEERING TIE ROD



WORKSHOP OBJECTIVE:

- Run a buckling analysis on a finite element model of a slender bar.
- **Software Version:**
 - MSC Nastran 2012.1
 - Patran 2012



SUGGESTED STEPS:

- 1. Input File: Create an MSC Nastran input file to perform a linear buckling (SOL 105) analysis.**
- 2. Case Control: Add method command.**
 - Create Executive Control and Case Control sections.
- 3. Bulk Data: Create EIGRL eigenvalue entry.**
- 4. Grids: Create GRID points every three inches along the x-axis from 0 to 30 in.**
- 5. Elements: Create ten CBAR elements connecting the GRID points.**
- 6. Properties: Create PBARL properties.**
 - The tie rod for the steering is made from aluminum tubing.
 - Outer Radius = 0.5 in.
 - Inner Radius = 0.25 in.

SUGGESTED STEPS:

- 7. Boundary Conditions:** Create a pin constraint at both rod ends (SPC1).
- 8. Load:** Apply a 100 lb. compression point load (FORCE entry) on the right end.
- 9. Analysis:** Solution Type = **Nastran Linear Buckling**, Solution Sequence = 105. Submit input file to MSC Nastran.
- 10. Examine Output Text File:** Examine the Nastran output F06 file
- 11. Analysis:** Access analysis results and model data by attaching the XDB file to a Patran database
- 12. Results:** Plot buckling results and determine critical buckling load.

1. Open Input File:

1. Open the MSC Nastran input file [wkshp1.bdf](#)

```
$
$ wkshp1.bdf
$
$ Add the Executive and Case Control Sections
$

BEGIN BULK
PARAM      POST      0
$
$
$ Add the eigenvalue entry

$ Create the GRID Points

$ Create the CBAR elements

$ Add the Element Properties

$ Material: Aluminum
MAT1      1          10.0E6          .3
$
$ Add the SPC1 entries to define the boundary condition

$ Add the Force entry

ENDDATA
```

2. Create Control Sections and EIGRL Card:

2. Create Executive Control and Case Control sections.
3. Bulk Data: Create EIGRL eigenvalue entry.

```
$
$ soln1.bdf
$
SOL 105
$
CEND
TITLE = Tie Rod Buckling Analysis
SPC = 1
SUBCASE 1
  LOAD = 1
  DISP = ALL
  SPCFORCE = ALL
SUBCASE 2
  METHOD = 1
  DISP = ALL
BEGIN BULK
PARAM      POST      0
$
$
$ Eigenvalue entry
$  1  <<  2  <<  3  <<  4  <<  5  <<  6  <<  7  <<  8  <<  9  <<  10  >
EIGRL      1                               5
```

4. Create GRID Points

4. **Grids: Create GRID points every three inches along the x-axis from 0 to 30 in.**

```
$ GRID Points
GRID 1      0.      0.      0.
GRID 2      3.      0.      0.
GRID 3      6.      0.      0.
GRID 4      9.      0.      0.
GRID 5     12.      0.      0.
GRID 6     15.      0.      0.
GRID 7     18.      0.      0.
GRID 8     21.      0.      0.
GRID 9     24.      0.      0.
GRID 10    27.      0.      0.
GRID 11    30.      0.      0.
```

5. Create CBAR and PBARL Cards:

5. Create ten CBAR elements connecting the GRID points.

```
$ CBAR elements
$ 1 >< 2 >< 3 >< 4 >< 5 >< 6 >< 7 >< 8 >< 9 >< 10 >
CBAR 1 1 1 2 0. 1. 0.
CBAR 2 2 1 2 3 0. 1. 0.
CBAR 3 3 1 3 4 0. 1. 0.
CBAR 4 4 1 4 5 0. 1. 0.
CBAR 5 5 1 5 6 0. 1. 0.
CBAR 6 6 1 6 7 0. 1. 0.
CBAR 7 7 1 7 8 0. 1. 0.
CBAR 8 8 1 8 9 0. 1. 0.
CBAR 9 9 1 9 10 0. 1. 0.
CBAR 10 10 1 10 11 0. 1. 0.
```

6. Create PBARL Tube properties

```
$ Element Properties
PBARL 1 1 TUBE
      .5 .25
```

7. Create Load and Boundary Conditions and Solve:

7. Apply SPC1 boundary conditions.

8. Apply FORCE load.

```
$ SPC1 entries
SPC1   1      1234   1
SPC1   1       23   11
$ Force entry
FORCE  1       11    0    100.  -1.   0.   0.
ENDDATA
```

9. Submit input file to MSC Nastran.

10. F06 OUTPUT FILE

```

MODEL SUMMARY BULK = 0
ENTRY NAME      NUMBER OF ENTRIES
-----
CBAR              10
EIGRL             1
FORCE            1
GRID            11
MAT1             1
PARAM           1
PBAR             1
SPC1            2

```

^^^
 >>> IFP OPERATIONS COMPLETE <<<
 ^^^

*** USER INFORMATION MESSAGE 4379 (IFP9A)
 THE USER SUPPLIED PBAR/PBSECT BULK DATA ENTRIES ARE REPLACED BY THE FOLLOWING PBAR ENTRIES.
 CONVERSION METHOD FOR PBAR/PBEAML - FINITE ELEMENT METHOD.

PBAR	1	1	5.8905E-01	4.6019E-02	4.6019E-02	9.2039E-02	0.0000E+00
	5.0000E-01	0.0000E+00	0.0000E+00	5.0000E-01	-5.0000E-01	0.0000E+00	0.0000E+00
	5.8856E-01	5.8856E-01	0.0000E+00				-5.0000E-01

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*** USER INFORMATION MESSAGE 7310 (VECPRN)
 ORIGIN OF SUPERELEMENT BASIC COORDINATE SYSTEM WILL BE USED AS REFERENCE LOCATION.
 RESULTANTS ABOUT ORIGIN OF SUPERELEMENT BASIC COORDINATE SYSTEM IN SUPERELEMENT BASIC SYSTEM COORDINATES.

SUBCASE/ DAREA ID	LOAD TYPE	OLOAD RESULTANT					
		T1	T2	T3	R1	R2	R3
0 1	FX	-1.000000E+02	----	----	----	0.000000E+00	0.000000E+00
	FY	----	0.000000E+00	----	0.000000E+00	----	0.000000E+00
	FZ	----	----	0.000000E+00	0.000000E+00	0.000000E+00	----
	MX	----	----	----	0.000000E+00	----	----
	MY	----	----	----	----	0.000000E+00	----
	MZ	----	----	----	----	----	0.000000E+00
	TOTALS		-1.000000E+02	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00

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SUBCASE/ DAREA ID	LOAD TYPE	OLOAD RESULTANT					
		T1	T2	T3	R1	R2	R3
0 2	FX	0.000000E+00	----	----	----	0.000000E+00	0.000000E+00
	FY	----	0.000000E+00	----	0.000000E+00	----	0.000000E+00
	FZ	----	----	0.000000E+00	0.000000E+00	0.000000E+00	----
	MX	----	----	----	0.000000E+00	----	----
	MY	----	----	----	----	0.000000E+00	----
	MZ	----	----	----	----	----	0.000000E+00
	TOTALS		0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00

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*** SYSTEM INFORMATION MESSAGE 4159 (DFMSA)
 THE DECOMPOSITION OF KLL YIELDS A MAXIMUM MATRIX-TO-FACTOR-DIAGONAL RATIO OF 4.437925E+01

10. F06 OUTPUT FILE (Cont.)

Lowest Buckling Load = λ_1 x applied load = 50.276 x 100 = 5027.6 lb.

MODE NO.	EXTRACTION ORDER	EIGENVALUE	REAL EIGENVALUES			GENERALIZED	
			RADIANS		CYCLES	MASS	STIFFNESS
1	1	5.027699E+01	7.090627E+00	1.128508E+00	1.644813E+01	8.269626E+02	
2	2	5.027700E+01	7.090628E+00	1.128508E+00	1.644813E+01	8.269627E+02	
3	3	1.989418E+02	1.410467E+01	2.244828E+00	7.265974E+01	1.445506E+04	
4	4	1.989418E+02	1.410467E+01	2.244828E+00	7.265974E+01	1.445506E+04	
5	5	4.401675E+02	2.098017E+01	3.339097E+00	1.472021E+02	6.479357E+04	

POINT ID.	TYPE	T1	T2	T3	R1	R2	R3
1	G	0.0	0.0	0.0	0.0	-1.043233E-01	-9.255992E-09
2	G	2.127844E-17	-2.741726E-08	3.090170E-01	2.153246E-16	-9.921733E-02	-8.802971E-09
3	G	-1.845540E-17	-5.215073E-08	5.877852E-01	7.599308E-17	-8.439931E-02	-7.488254E-09
4	G	7.948341E-18	-7.177933E-08	8.090170E-01	-1.302712E-16	-6.131969E-02	-5.440536E-09
5	G	2.607946E-17	-8.438165E-08	9.510565E-01	8.221203E-17	-3.223767E-02	-2.860259E-09
6	G	3.083569E-17	-8.872412E-08	1.000000E+00	2.162769E-16	1.403251E-15	4.469978E-16
7	G	-2.682393E-18	-8.438165E-08	9.510565E-01	-6.079723E-17	3.223767E-02	2.860259E-09
8	G	-1.958868E-17	-7.177933E-08	8.090170E-01	-1.944487E-16	6.131969E-02	5.440535E-09
9	G	-3.316310E-17	-5.215073E-08	5.877852E-01	1.361281E-16	8.439931E-02	7.488254E-09
10	G	-5.436896E-17	-2.741726E-08	3.090170E-01	-2.924974E-16	9.921733E-02	8.802971E-09
11	G	-8.540468E-17	0.0	0.0	1.946436E-16	1.043233E-01	9.255992E-09

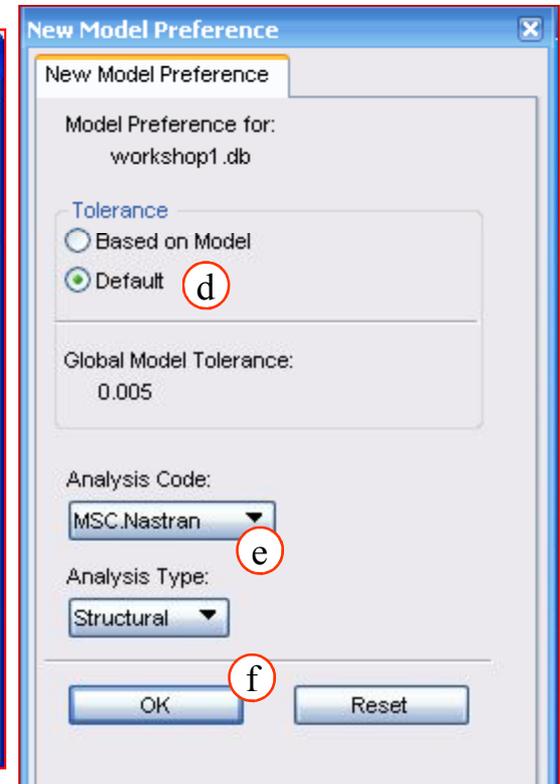
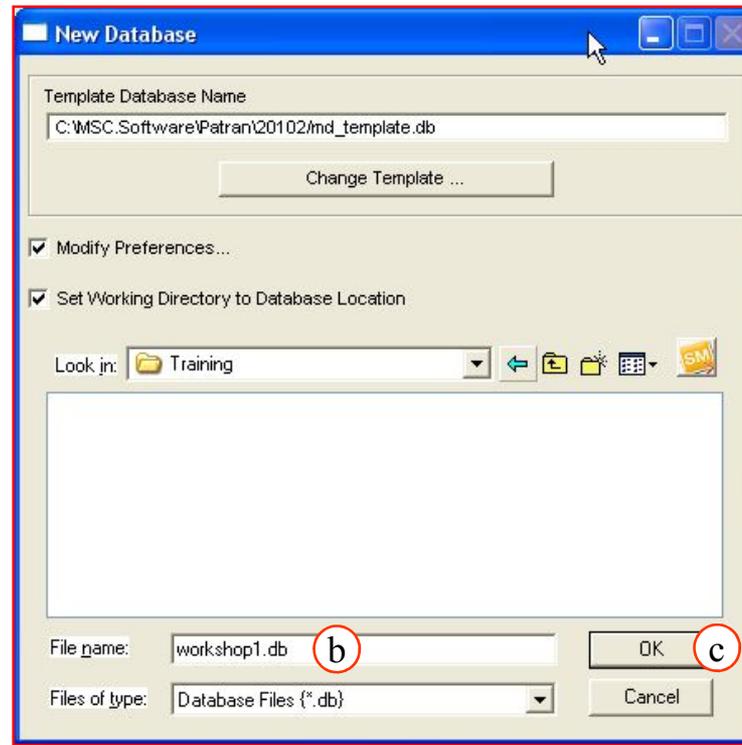
POINT ID.	TYPE	T1	T2	T3	R1	R2	R3
1	G	0.0	0.0	0.0	0.0	-9.255991E-09	1.043233E-01
2	G	3.798302E-17	3.090170E-01	2.741726E-08	5.642407E-17	-8.802971E-09	9.921733E-02
3	G	-5.289985E-18	5.877852E-01	5.215073E-08	2.505548E-17	-7.488254E-09	8.439931E-02
4	G	-1.935860E-17	8.090170E-01	7.177932E-08	1.288905E-16	-5.440534E-09	6.131968E-02
5	G	8.050066E-17	9.510565E-01	8.438165E-08	8.474543E-17	-2.860258E-09	3.223767E-02
6	G	1.204894E-16	1.000000E+00	8.872412E-08	-7.881538E-17	1.061818E-17	1.296137E-15
7	G	7.231704E-17	9.510565E-01	8.438165E-08	1.589264E-16	2.860259E-09	-3.223767E-02
8	G	-4.152661E-17	8.090170E-01	7.177932E-08	1.482724E-16	5.440535E-09	-6.131968E-02
9	G	2.080812E-17	5.877852E-01	5.215073E-08	-1.383783E-16	7.488254E-09	-8.439931E-02
10	G	3.703216E-18	3.090170E-01	2.741726E-08	1.659777E-16	8.802971E-09	-9.921733E-02
11	G	1.434584E-16	0.0	0.0	-5.134729E-17	9.255991E-09	-1.043233E-01

11. POST PROCESSING

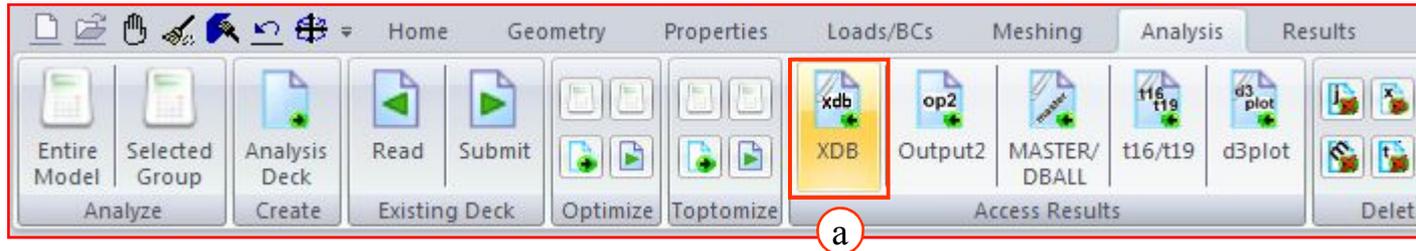


Create a new database

- a. File: New
- b. Enter **workshop1** as the File name
- c. Click **OK**.
- d. Select Default tolerances.
- e. Select **MSC Nastran** and **Structural** for the Analysis Code and Type.
- f. Click **OK**.



11. POST PROCESSING



Attach results file

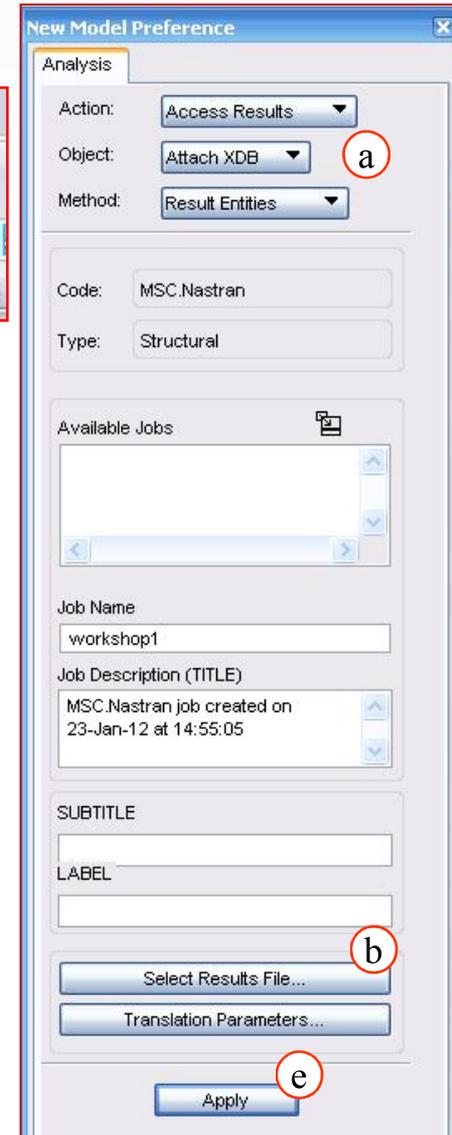
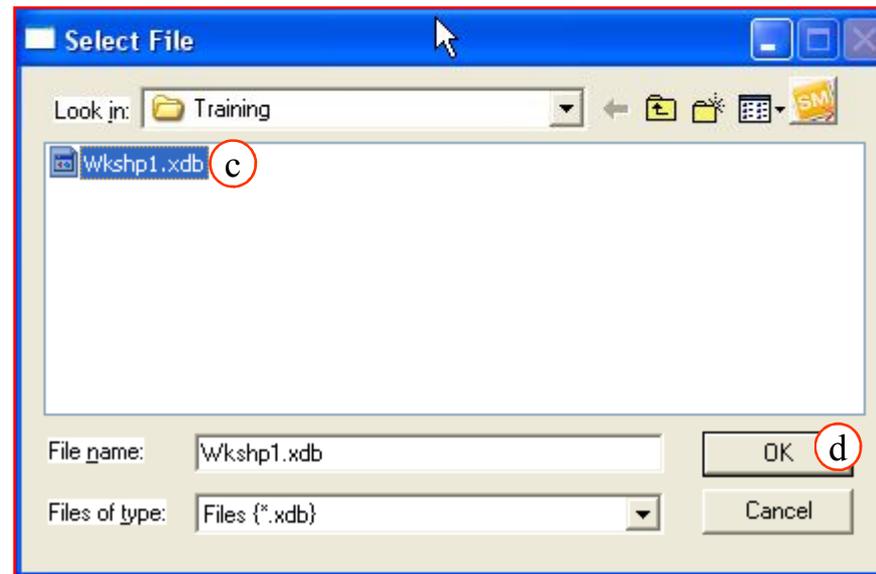
a. Analysis: Access Results / Attach XDB / Both

b. Click **Select Results File**.

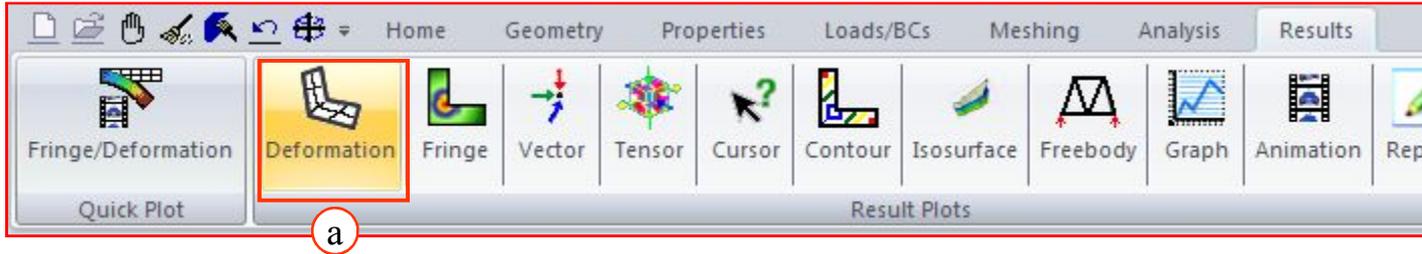
c. Select **wkshp1.xdb**.

d. Click **OK**.

e. Click **Apply**.

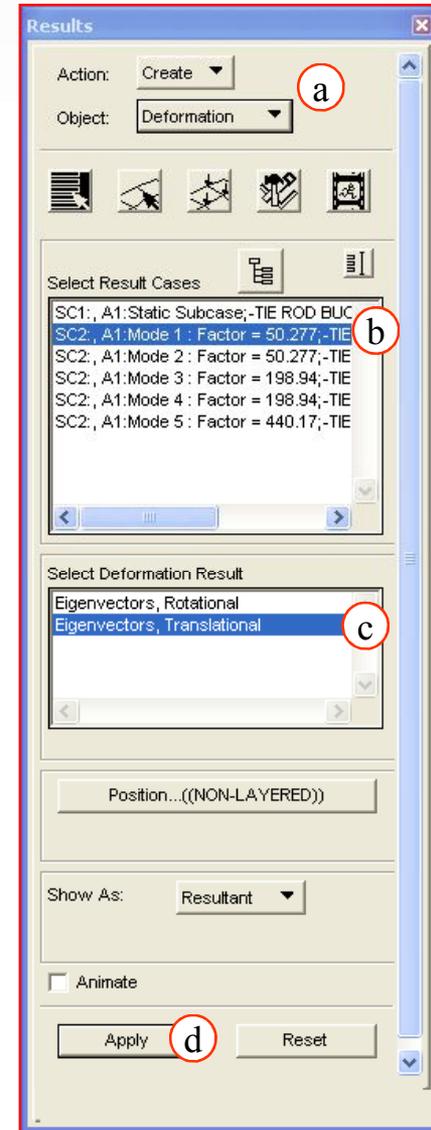
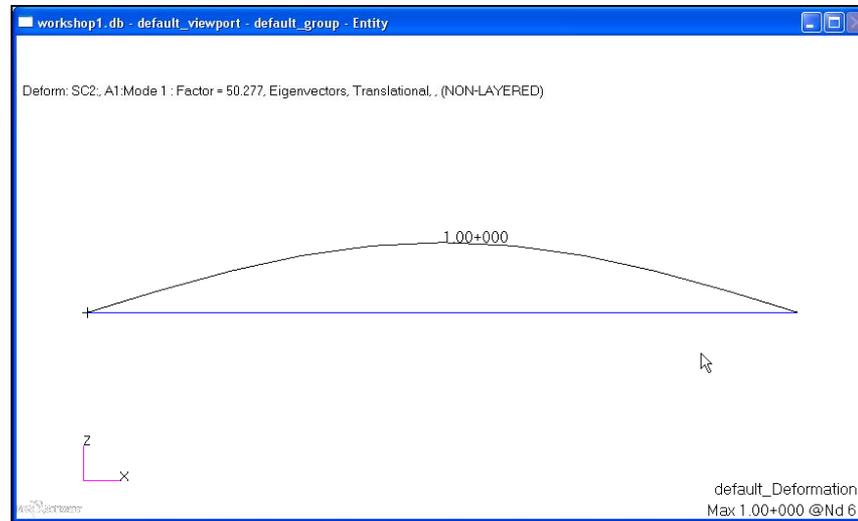


12. PLOT RESULTS



Plot the results

- a. **Results:** Create / Deformation
- b. Select the First Mode as shown.
- c. Select **Eigenvectors, Translational** as the Deformation Result.
- d. Click **Apply**.



SOLUTION FILE FOR WORKSHOP 1

```
$ soln1.bdf
SOL 105
CEND
TITLE = Tie Rod Buckling Analysis
SPC = 1
SUBCASE 1
  LOAD = 1
  DISP = ALL
  SPCFORCE = ALL
SUBCASE 2
  METHOD = 1
  DISP = ALL
BEGIN BULK
PARAM      POST      0
$
$ Eigenvalue entry
$  1 >>  2 >>  3 >>  4 >>  5 >>  6 >>  7 >>  8 >>  9 >> 10 >
EIGRL      1                5
$ GRID Points
GRID      1                0.      0.      0.
GRID      2                3.      0.      0.
GRID      3                6.      0.      0.
GRID      4                9.      0.      0.
GRID      5               12.      0.      0.
GRID      6               15.      0.      0.
GRID      7               18.      0.      0.
GRID      8               21.      0.      0.
GRID      9               24.      0.      0.
GRID     10               27.      0.      0.
GRID     11               30.      0.      0.
```

SOLUTION FILE FOR WORKSHOP 1 (Cont.)

```
$ CBAR elements
$  1  <>  2  <>  3  <>  4  <>  5  <>  6  <>  7  <>  8  <>  9  <> 10  >
CBAR   1      1      1      2      0.      1.      0.
CBAR   2      1      2      3      0.      1.      0.
CBAR   3      1      3      4      0.      1.      0.
CBAR   4      1      4      5      0.      1.      0.
CBAR   5      1      5      6      0.      1.      0.
CBAR   6      1      6      7      0.      1.      0.
CBAR   7      1      7      8      0.      1.      0.
CBAR   8      1      8      9      0.      1.      0.
CBAR   9      1      9     10      0.      1.      0.
CBAR  10      1     10     11      0.      1.      0.
$ Element Properties
PEARL  1      1      TUBE
      .5      .25
$ Material: Aluminum
MAT1   1      10.0E6      .3
$
$ SPC1 entries
SPC1   1      1234      1
SPC1   1      23      11
$ Force entry
FORCE  1      11      0      100.      -1.      0.      0.
ENDDATA
```

THEORETICAL SOLUTION FOR WORKSHOP 1

- **Critical Buckling Force:**

$$P_{cr} = \frac{\pi^2 EI}{L^2}$$

Where,

- $I = 0.04602 \text{ in.}^4$
- $E = 10e6 \text{ psi}$
- $L = 30 \text{ in.}$

$$P_{cr} = \frac{\pi^2 EI}{L^2} = \frac{\pi^2 \cdot 10e6 \cdot 0.04602}{30^2} = 5047lb$$

- The theoretical solution is slightly higher than the Nastran result. Can you explain this difference?

THEORETICAL SOLUTION FOR WORKSHOP 1

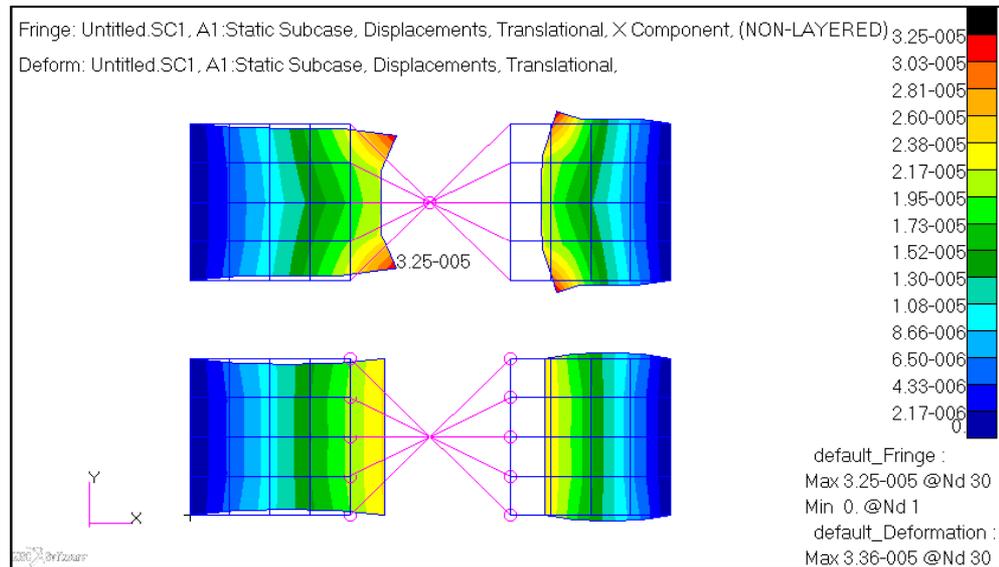
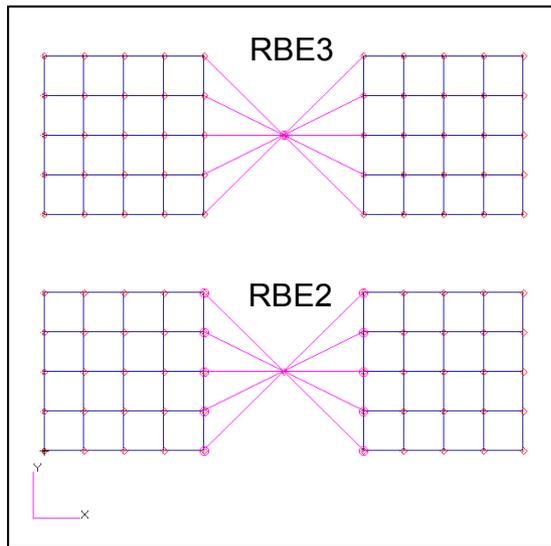
- **We used PBARL properties in this example, which incorporate shear flexibility.**
 - Shear flexibility is not accounted for in the theoretical Euler buckling equation.

$$P_{cr} = \frac{\pi^2 EI}{L^2}$$

- With shear flexibility, the critical force will be slightly lower.
- In order to match these results more closely in Nastran, you could set appropriate value of Area factor for shear K1 and K2 as follows; For PBAR, leave K1 and K2 blank. For PBEAM, set K1=K2 = 0.0 (For more details, see remarks under PBAR and PBEAM, in the Nastran Quick Reference Guide).

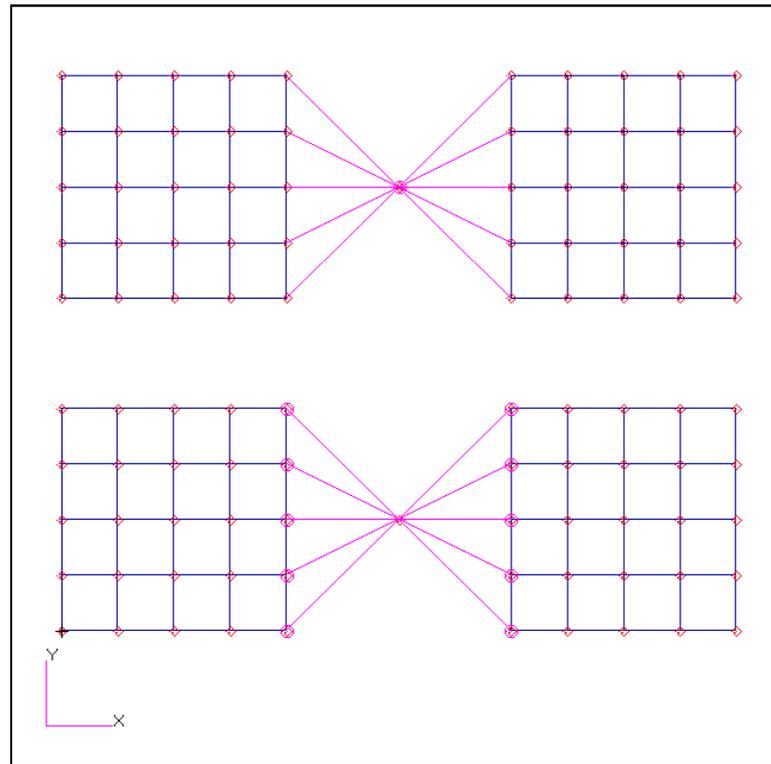
WORKSHOP 2

RBE2 v/s RBE3



WORKSHOP OBJECTIVE:

- Understand the difference between RBE2 and RBE3.
- **Software Version:**
 - MSC Nastran 2012.1
 - Patran 2012



SUGGESTED STEPS:

- 1. Input File: Edit the given MSC Nastran input file [wkshp2.bdf](#).**
The input file contains two models. Each model has two similar plates. There are two nodes created in between the two sets of plates. The two plates on the top are connected with **RBE3 element** and the bottom set of plates is connected with **RBE2 element**.
- 2. Create RBE2 and RBE3 entry.**
- 3. Analysis: Solution Type = Nastran Linear Static , Solution Sequence = 101. Submit input file to MSC Nastran.**
- 4. Examine Output File: Examine the Nastran output F06 file.**
- 5. Results: Plot displacements.**

1. Open Input File:

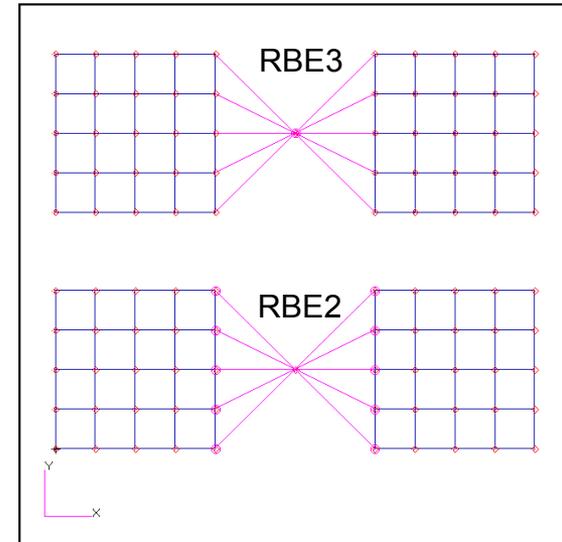
1. Input File: Edit the given MSC Nastran input file [wkshp2.bdf](#)

```
$
$wkshp1.bdf
SOL 101
CEND
TITLE = RBE2 VS. RBE3
SUBCASE 1
  SPC = 2
  LOAD = 2
  DISP=ALL
  SPCFORCE=ALL
  MPCFORCE=ALL
  STRESS=ALL
BEGIN BULK
PARAM      POST      0
PSHELL    1          1          .2          1          1
$
CQUAD4    1          1          1          2          7          6
CQUAD4    2          1          2          3          8          7
.
$
MAT1      1          1.+7          .33
$ Create RBE2 Element
$ Create RBE3 Element
$
GRID      1          0.          0.          0.
GRID      2          2.5         0.          0.
.
```


2. Create RBE2 and RBE3 Elements

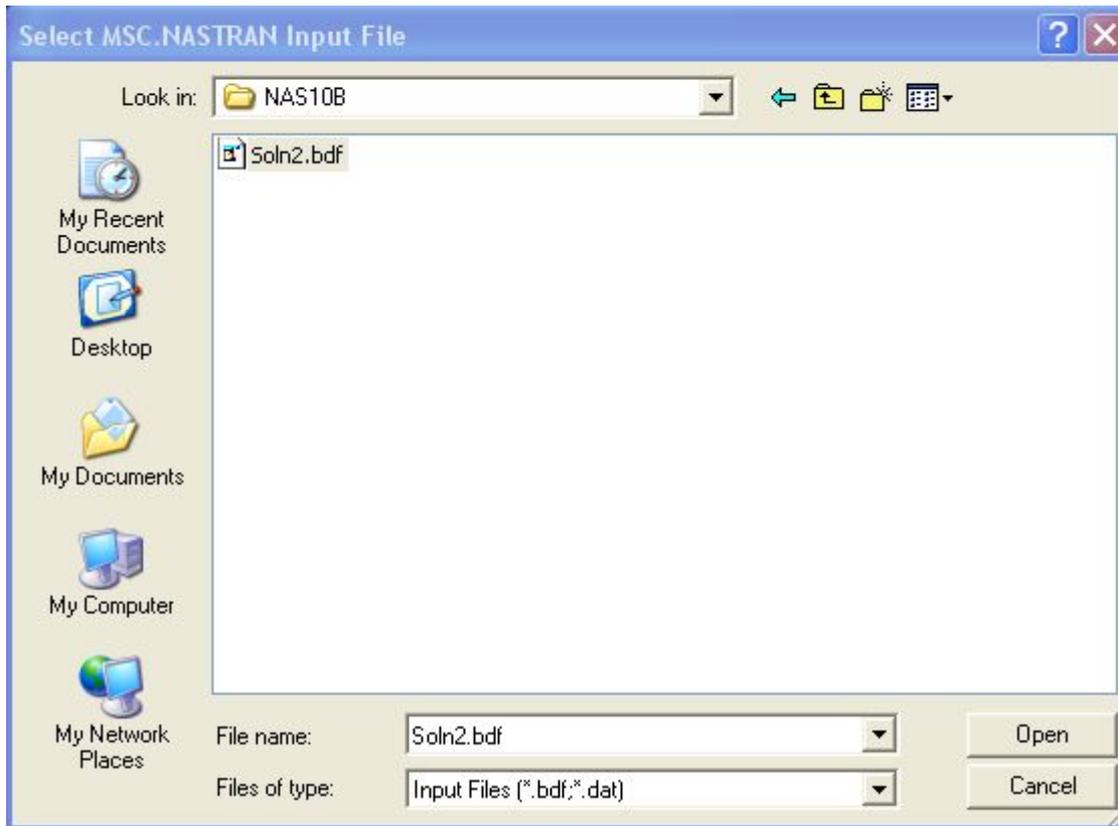
2. Create RBE2 and RBE3 entries

```
.  
.   
CQUAD4 62 1 92 93 98 97  
CQUAD4 63 1 93 94 99 98  
CQUAD4 64 1 94 95 100 99  
$  
MAT1 1 1.+7 .33  
$ Create RBE2 Element  
RBE2 1000 1000 123456 5 10 15 20 25  
51 56 61 66 71  
$ Create RBE3 Element  
RBE3 2000 2000 123456 1. 123 30 35  
40 45 50 76 81 86 91 96  
$  
GRID 1 0. 0. 0.  
GRID 2 2.5 0. 0.  
GRID 3 5. 0. 0.  
GRID 4 7.5 0. 0.
```



3. Submit Input file to MSC Nastran

3. Analysis: Solution Type = Nastran Linear Static , Solution Sequence = 101. Submit input file to MSC Nastran.



4. F06 Output File

DISPLACEMENT VECTOR									
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	6.565806E-06	3.511887E-06	0.0	0.0	0.0	5.942046E-07		
3	G	1.204811E-05	3.998799E-06	0.0	0.0	0.0	-3.169601E-21		
4	G	1.753042E-05	3.511887E-06	0.0	0.0	0.0	-5.942046E-07		
5	G	2.409623E-05	-4.009289E-20	0.0	0.0	0.0	-1.851701E-22		
6	G	0.0	0.0	0.0	0.0	0.0	0.0		
7	G	5.594183E-06	1.428110E-06	0.0	0.0	0.0	3.036926E-07		
8	G	1.204811E-05	2.153371E-06	0.0	0.0	0.0	-3.258264E-21		
9	G	1.850204E-05	1.428110E-06	0.0	0.0	0.0	-3.036926E-07		
10	G	2.409623E-05	-4.009289E-20	0.0	0.0	0.0	-1.851701E-22		
11	G	0.0	0.0	0.0	0.0	0.0	0.0		
12	G	5.682251E-06	-1.249389E-20	0.0	0.0	0.0	-2.771186E-21		
13	G	1.204811E-05	-2.538856E-20	0.0	0.0	0.0	-3.057424E-21		
14	G	1.841397E-05	-3.609862E-20	0.0	0.0	0.0	-1.807460E-21		
15	G	2.409623E-05	-4.009289E-20	0.0	0.0	0.0	-1.851701E-22		
16	G	0.0	0.0	0.0	0.0	0.0	0.0		
17	G	5.594183E-06	-1.428110E-06	0.0	0.0	0.0	-3.036926E-07		
18	G	1.204811E-05	-2.153371E-06	0.0	0.0	0.0	-3.470022E-21		
19	G	1.850204E-05	-1.428110E-06	0.0	0.0	0.0	3.036926E-07		
20	G	2.409623E-05	-4.009289E-20	0.0	0.0	0.0	-1.851701E-22		
21	G	0.0	0.0	0.0	0.0	0.0	0.0		
22	G	6.565806E-06	-3.511887E-06	0.0	0.0	0.0	-5.942046E-07		
23	G	1.204811E-05	-3.998799E-06	0.0	0.0	0.0	-4.539412E-21		
24	G	1.753042E-05	-3.511887E-06	0.0	0.0	0.0	5.942046E-07		
25	G	2.409623E-05	-4.009289E-20	0.0	0.0	0.0	-1.851701E-22		
26	G	0.0	0.0	0.0	0.0	0.0	0.0		
27	G	6.587659E-06	3.102031E-06	0.0	0.0	0.0	5.223362E-07		
28	G	1.285660E-05	3.265669E-06	0.0	0.0	0.0	2.027950E-07		
29	G	2.081188E-05	3.265133E-06	0.0	0.0	0.0	1.151112E-06		
30	G	3.248051E-05	8.644065E-06	0.0	0.0	0.0	3.147481E-06		
31	G	0.0	0.0	0.0	0.0	0.0	0.0		
32	G	5.608812E-06	1.094582E-06	0.0	0.0	0.0	2.397933E-07		
33	G	1.192417E-05	1.306161E-06	0.0	0.0	0.0	2.090700E-07		
34	G	1.774552E-05	1.303744E-06	0.0	0.0	0.0	8.023764E-07		
35	G	2.212203E-05	4.327805E-06	0.0	0.0	0.0	1.693299E-06		
36	G	0.0	0.0	0.0	0.0	0.0	0.0		
37	G	5.495887E-06	-1.058700E-20	0.0	0.0	0.0	-3.185034E-21		
38	G	1.097506E-05	-2.506589E-20	0.0	0.0	0.0	-4.202558E-21		
39	G	1.580976E-05	-3.897516E-20	0.0	0.0	0.0	-4.538000E-21		
40	G	2.159564E-05	-5.161149E-20	0.0	0.0	0.0	-4.981352E-21		
41	G	0.0	0.0	0.0	0.0	0.0	0.0		
42	G	5.608812E-06	-1.094582E-06	0.0	0.0	0.0	-2.397933E-07		
43	G	1.192417E-05	-1.306161E-06	0.0	0.0	0.0	-2.090700E-07		
44	G	1.774552E-05	-1.303744E-06	0.0	0.0	0.0	-8.023764E-07		
45	G	2.212203E-05	-4.327805E-06	0.0	0.0	0.0	-1.693299E-06		
46	G	0.0	0.0	0.0	0.0	0.0	0.0		
47	G	6.587659E-06	-3.102031E-06	0.0	0.0	0.0	-5.223362E-07		
48	G	1.285660E-05	-3.265669E-06	0.0	0.0	0.0	-2.027950E-07		
49	G	2.081188E-05	-3.265133E-06	0.0	0.0	0.0	-1.151112E-06		
50	G	3.248051E-05	-8.644065E-06	0.0	0.0	0.0	-3.147481E-06		

RBE2 VS. RBE3

FEBRUARY

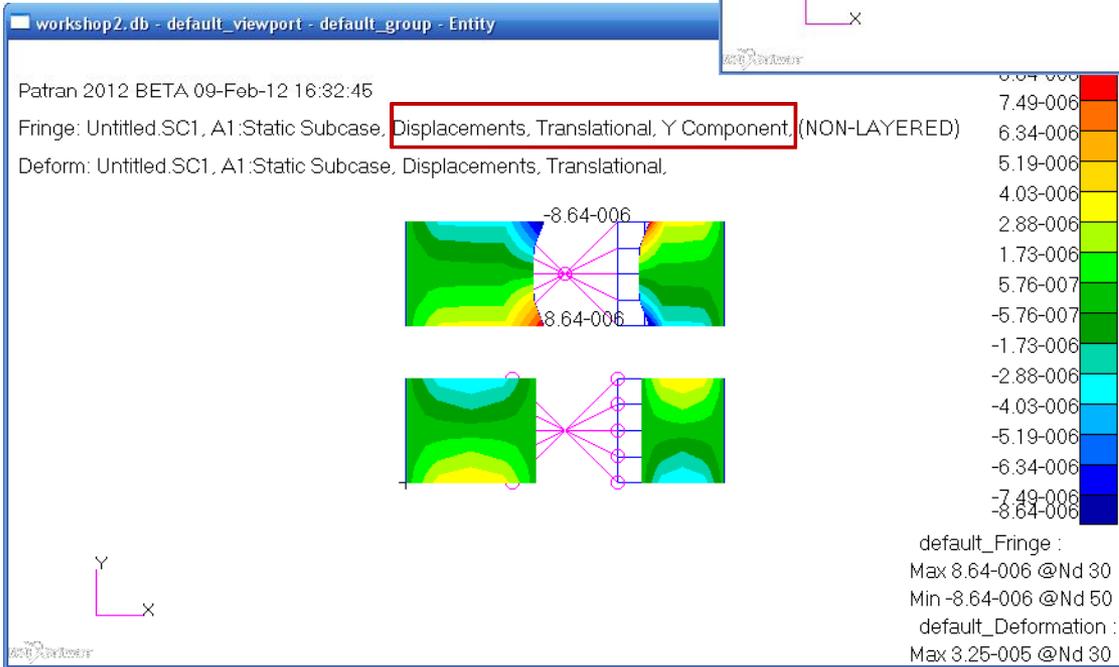
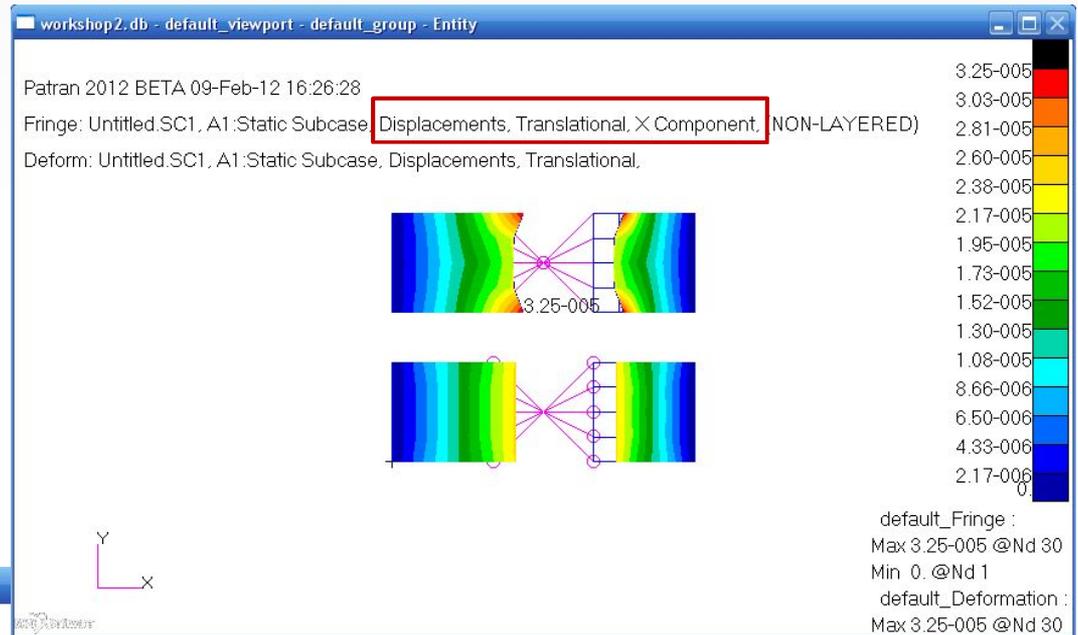
9, 2012

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5. Plot Displacements



Solution File for Workshop 2

```
$soln2.bdf
SOL 101
CEND
TITLE = RBE2 VS. RBE3
SUBCASE 1
  SPC = 2
  LOAD = 2
  DISP=ALL
  SPCFORCE=ALL
  MPCFORCE=ALL
  STRESS=ALL
BEGIN BULK
PARAM      POST      0
PSHELL    1          1      .2      1          1
$
CQUAD4    1          1      1      2          7          6
CQUAD4    2          1      2      3          8          7
.
MAT1      1          1.+7      .33
$ RBE2 Element
RBE2      1000      1000      123456  5          10          15          20          25
          51          56          61          66          71
$ RBE3 Element
RBE3      2000          2000      123456  1.          123          30          35
          40          45          50          76          81          86          91          96
$
GRID      1          0.          0.          0.
GRID      2          2.5          0.          0.
GRID      3          5.          0.          0.
```

Solution File for Workshop 2 (Cont.)

```
.  
.   
GRID      1000          15.    5.    0.   
GRID      2000          15.    20.   0.   
$   
SPCADD    2          1   
LOAD      2          1.    1.    1   
$   
  
SPC1      1          123456  1     6     11    16    21    26   
          31          36     41    46    55    60    65    70   
          75          80     85    90    95   100   
  
$   
FORCE     1          1000    0     100.  1.    0.    0.   
FORCE     1          2000    0     100.  1.    0.    0.   
$   
ENDDATA
```

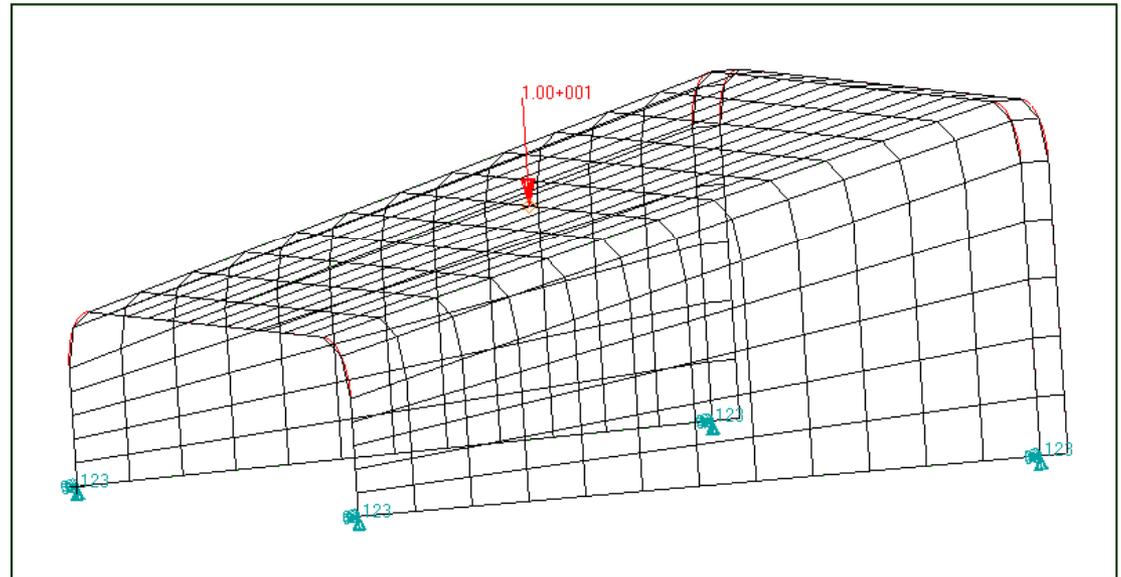
WORKSHOP 3

INSTRUMENT CONSOLE-COMPOSITES



WORKSHOP OBJECTIVES:

- **Create a composite shell model and material properties for a graphite-epoxy tape layup and perform a finite element analysis.**
- **Software Version:**
 - MSC Nastran 2012.1
 - Patran 2012



SUGGESTED STEPS:

- 1. Input File: Examine the existing MSC Nastran input file [wkshp3.bdf](#)**
 - The CQUAD4 elements have MCID set to coordinate 0. (So the material orientation will be aligned with the basic X axis.)
 - The load is already included in the file, and is a 10 lb. point load in the middle of the top face, representing someone pressing down on the console.
 - The model is constrained in all three translations at the lower edges.

SUGGESTED STEPS:

2. Materials: Create MAT8 composite material entry:

- Tape Properties (0.0054” thick):

E_1	E_2	ν_{12}	G_{12}	G_{23}	G_{13}	ρ	A_{11}	A_{22}
20e6	2e6	0.35	1e6	1e6	1e6	1.3e-4	-2.3e-7	4.5e-6

- Failure Criteria: Hill Theory

Component	Tension ₁₁	Tension ₂₂	Compression ₁₁	Compression ₂₂	Shear	Bonding Shear
Stress Limit	1.3e5	1.1e4	1.2e5	1.2e4	1.25e4	5000

- Composite Layup:

Ply	1	2	3	4	5	6	7	8
Orientation	0	45	-45	90	90	-45	45	0

SUGGESTED STEPS:

- 3. Properties: Create a PCOMP property to represent the laminate. The first two lines are shown below:**

PCOMP	PID	Z0	NSM	SB	FT	TREF	GE	LAM
	MID1	T1	THETA1	SOUT1	MID2	T2	THETA2	SOUT2
PCOMP	1			5000	HILL			
	1	.0054	0.	YES	1	.0054	45.	YES

- 4. Analysis: Solution Type = Nastran Linear Static, Solution Sequence = 101. Submit input file to MSC Nastran.**
- 5. Examine Output Text File: Examine the Nastran output F06 file**
- 6. Review the Nastran output F06 file for Displacement, Stress and Failure Indices output**
- 7. Results: Plot displacement results in Patran with OP2 file.**

1. Open Input File:

1. Open [wkshp3.bdf](#) with a text editor.

```
$
$ wkshp3.bdf
$
SOL 101
CEND
TITLE = Composite Console Analysis
ECHO = NONE
SUBCASE 1
  SPC = 1
  LOAD = 1
  DISP=ALL
  SPCFORCE=ALL
  STRESS(CORNER)=ALL
BEGIN BULK
PARAM  POST  -1
$
$ Enter composite properties (PCOMP)

$ Enter material properties (MAT8)

$ Elements:
CQUAD4 1 1 1 2 8 7 0
CQUAD4 2 1 2 3 9 8 0
CQUAD4 3 1 3 4 10 9 0
CQUAD4 4 1 4 5 11 10 0
CQUAD4 5 1 5 6 12 11 0
CQUAD4 6 1 7 8 14 13 0
CQUAD4 7 1 8 9 15 14 0
CQUAD4 8 1 9 10 16 15 0
CQUAD4 9 1 10 11 17 16 0
CQUAD4 10 1 11 12 18 17 0
```

2. Input Material Property and Solve:

2. Create MAT8 composite material entry:

```
$ Lamina Description:  
MAT8      1      2.+7      2.+6      .35      1.+6      1.+6      1.+6      1.3-4  
          -2.3-7 4.5-6          130000. 120000. 11000. 12000. 12500.
```

3. Create a PCOMP property to represent the laminate:

```
$ Composite Material Description:  
PCOMP     1          5000.      HILL  
          1      .0054      0.      YES      1      .0054      45.      YES  
          1      .0054     -45.     YES      1      .0054      90.      YES  
          1      .0054      90.      YES      1      .0054     -45.     YES  
          1      .0054      45.      YES      1      .0054      0.      YES
```

4. Submit input file to MSC Nastran.

5. Review F06 Output File:

```

0
*** USER INFORMATION MESSAGE 7310 (VECPRN)
ORIGIN OF SUPERELEMENT BASIC COORDINATE SYSTEM WILL BE USED AS REFERENCE LOCATION.
RESULTANTS ABOUT ORIGIN OF SUPERELEMENT BASIC COORDINATE SYSTEM IN SUPERELEMENT BASIC SYSTEM COORDINATES.
0
SUBCASE/      LOAD
DAREA ID     TYPE
0 1          FX      0.000000E+00
      FY      -1.000000E+01
      FZ      0.000000E+00
      MX      0.000000E+00
      MY      0.000000E+00
      MZ      0.000000E+00
      TOTALS  0.000000E+00 -1.000000E+01 0.000000E+00 3.000000E+01 0.000000E+00 -3.000000E+01
OLOAD        RESULTANT
R1           R2           R3
0.000000E+01 0.000000E+00 0.000000E+00
0.000000E+00 0.000000E+00 0.000000E+00
0.000000E+00 0.000000E+00 0.000000E+00
0.000000E+01 0.000000E+00 0.000000E+00
0.000000E+01 0.000000E+00 -3.000000E+01
0.000000E+01 0.000000E+00 -3.000000E+01
*** SYSTEM INFORMATION MESSAGE 4159 (DFMSA)
THE DECOMPOSITION OF KLL YIELDS A MAXIMUM MATRIX-TO-FACTOR-DIAGONAL RATIO OF 3.762013E+02
1 COMPOSITE CONSOLE ANALYSIS FEBRUARY 9, 2012 MSC.NASTRAN 11/25/11 PAGE 8
0
*** USER INFORMATION MESSAGE 5293 (SSG3A)
FOR DATA BLOCK KLL
LOAD SEQ. NO. 1 EPSILON 7.4723225E-13 EXTERNAL WORK 5.1977342E-01 EPSILONS LARGER THAN 0.001 ARE FLAGGED WITH ASTERISKS
1 COMPOSITE CONSOLE ANALYSIS FEBRUARY 9, 2012 MSC.NASTRAN 11/25/11 PAGE 9
SUBCASE 1

```

5. Review F06 Output File (Cont.):

0 SUBCASE 1

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	-1.173146E-03	9.637279E-05	1.355247E-02	-1.521598E-02	-6.544644E-03	-8.871543E-04
2	G	-1.505050E-03	5.607493E-05	1.835771E-02	-4.520245E-03	-5.357490E-03	-3.161216E-04
3	G	-1.501695E-03	1.776500E-05	1.831301E-02	4.175619E-03	-4.104503E-03	3.367080E-04
4	G	-1.188917E-03	-4.178903E-06	1.447496E-02	1.062390E-02	-2.915040E-03	8.611828E-04
5	G	-6.520884E-04	-1.297218E-05	7.943440E-03	1.490409E-02	-1.638246E-03	1.207903E-03
6	G	0.0	0.0	0.0	1.630455E-02	-3.803995E-04	1.321129E-03
7	G	-1.067962E-03	2.714421E-06	1.274365E-02	-1.265110E-02	-4.091262E-03	-1.041371E-03
8	G	-1.354246E-03	1.078218E-05	1.651755E-02	-3.559259E-03	-3.768490E-03	-2.497167E-04
9	G	-1.329132E-03	1.074290E-05	1.625712E-02	4.294426E-03	-2.907529E-03	3.634171E-04
10	G	-1.043089E-03	5.444645E-06	1.273136E-02	1.016809E-02	-2.015524E-03	8.333202E-04
11	G	-5.701677E-04	3.019532E-06	6.924652E-03	1.384681E-02	-1.087532E-03	1.136828E-03
12	G	0.0	0.0	0.0	1.486707E-02	7.588765E-05	1.231648E-03
13	G	-1.010090E-03	-3.267054E-06	1.223868E-02	-1.104231E-02	-3.741563E-03	-9.060681E-04
14	G	-1.250676E-03	-2.716689E-06	1.520437E-02	-2.502924E-03	-2.737517E-03	-1.961892E-04
15	G	-1.205900E-03	1.222540E-06	1.469369E-02	4.471809E-03	-2.065317E-03	3.775546E-04
16	G	-9.363572E-04	3.287090E-06	1.140050E-02	9.829626E-03	-1.343855E-03	8.150151E-04
17	G	-5.074327E-04	2.041207E-06	6.170063E-03	1.305269E-02	-6.265656E-04	1.081022E-03
18	G	0.0	0.0	0.0	1.399657E-02	-1.240751E-04	1.158869E-03
19	G	-9.670745E-04	-4.521040E-06	1.179654E-02	-9.736091E-03	-3.155699E-03	-8.376157E-04
20	G	-1.167479E-03	-3.238847E-06	1.417256E-02	-1.766365E-03	-2.261145E-03	-1.498585E-04
21	G	-1.110886E-03	-1.047694E-06	1.347598E-02	4.740516E-03	-1.470820E-03	3.936558E-04
22	G	-8.549221E-04	5.919663E-07	1.037120E-02	9.561963E-03	-8.808734E-04	7.942478E-04
23	G	-4.619031E-04	9.924635E-07	5.603996E-03	1.253952E-02	-4.201014E-04	1.040179E-03
24	G	0.0	0.0	0.0	1.348511E-02	-8.629733E-06	1.117809E-03
25	G	-9.361751E-04	-1.262275E-06	1.141650E-02	-8.563644E-03	-2.834791E-03	-7.333355E-04
26	G	-1.097346E-03	-1.126511E-06	1.329366E-02	-1.126345E-03	-1.845925E-03	-1.003547E-04
27	G	-1.031652E-03	-2.624857E-07	1.247503E-02	4.932106E-03	-1.122066E-03	4.071076E-04

5. Review F06 Output File (Cont.):

0												SUBCASE 1	
STRESSES IN LAYERED COMPOSITE ELEMENTS (QUAD4)													
ELEMENT ID	PLY ID	STRESSES IN FIBER AND MATRIX DIRECTIONS			INTER-LAMINAR STRESSES		PRINCIPAL STRESSES (ZERO SHEAR)			MAX			
		NORMAL-1	NORMAL-2	SHEAR-12	SHEAR XZ-MAT	SHEAR YZ-MAT	ANGLE	MAJOR	MINOR	SHEAR			
0	1	1	-1.39533E+03	7.86600E+02	1.78671E+01	1.50500E+01	2.16547E+00	89.53	7.86746E+02	-1.39548E+03	1.09111E+03		
0	1	2	2.59691E+03	3.31801E+02	3.71136E+02	1.87253E+01	7.45366E+00	9.07	2.65617E+03	2.72541E+02	1.19182E+03		
0	1	3	1.72657E+03	2.04533E+02	-2.41022E+02	2.09305E+01	1.06266E+01	-8.79	1.76383E+03	1.67278E+02	7.98275E+02		
0	1	4	1.76576E+03	1.60015E+01	2.49804E+01	2.11455E+01	1.37201E+01	0.82	1.76612E+03	1.56450E+01	8.75238E+02		
0	1	5	-4.45240E+02	-2.09623E+01	3.92629E+01	2.09305E+01	1.06266E+01	84.76	-1.73595E+01	-4.48843E+02	2.15742E+02		
0	1	6	-6.74318E+02	-1.91424E+02	1.49320E+02	1.87253E+01	7.45366E+00	74.13	-1.48982E+02	-7.16760E+02	2.83889E+02		
0	1	7	-2.79993E+03	-2.34140E+02	-2.79434E+02	1.50500E+01	2.16547E+00	-83.86	-2.04060E+02	-2.83001E+03	1.31297E+03		
0	1	8	9.24046E+02	-6.70869E+02	-8.21104E+01	0.0	8.93480E-16	-2.94	9.28262E+02	-6.75085E+02	8.01674E+02		
0	2	1	-6.24151E+02	7.00350E+02	3.45021E+01	6.66207E+00	2.35955E+00	88.51	7.01248E+02	-6.25049E+02	6.63149E+02		
0	2	2	2.62374E+03	3.17886E+02	2.99678E+02	8.28898E+00	8.12171E+00	7.29	2.66205E+03	2.79575E+02	1.19124E+03		
0	2	3	1.76402E+03	2.12100E+02	-1.94795E+02	9.26513E+00	1.15790E+01	-7.05	1.78810E+03	1.88023E+02	8.00038E+02		
0	2	4	1.72387E+03	5.11108E+01	3.12157E+01	9.36030E+00	1.49498E+01	1.07	1.72445E+03	5.05284E+01	8.36961E+02		
0	2	5	-1.28415E+02	1.21818E+01	5.31216E+01	9.26513E+00	1.15790E+01	71.46	2.99957E+01	-1.46229E+02	8.81121E+01		
0	2	6	-7.67533E+01	-1.54992E+02	1.19855E+02	8.28898E+00	8.12171E+00	35.96	1.02052E+01	-2.41951E+02	1.26078E+02		
0	2	7	-2.58436E+03	-1.49780E+02	-2.24739E+02	6.66207E+00	2.35955E+00	-84.77	-1.29208E+02	-2.60493E+03	1.23786E+03		
0	2	8	7.55341E+02	-5.38428E+02	-1.18839E+02	0.0	9.73560E-16	-5.20	7.66166E+02	-5.49253E+02	6.57710E+02		
0	3	1	-5.81520E+02	5.14788E+02	6.74019E+01	3.71820E+00	2.48597E+00	86.50	5.18916E+02	-5.85648E+02	5.52282E+02		
0	3	2	2.23525E+03	2.03565E+02	2.27344E+02	4.62621E+00	8.55682E+00	6.31	2.26038E+03	1.78437E+02	1.04097E+03		
0	3	3	9.44938E+02	1.68986E+02	-1.49032E+02	5.17101E+00	1.21993E+01	-10.51	9.72577E+02	1.41347E+02	4.15615E+02		
0	3	4	1.25283E+03	2.67550E+01	-1.79936E+00	5.22413E+00	1.57507E+01	-0.08	1.25284E+03	2.67524E+01	6.13042E+02		
0	3	5	-1.26483E+02	-1.82928E+00	2.00681E+01	5.17101E+00	1.21993E+01	81.08	1.32185E+00	-1.29634E+02	6.54781E+01		
0	3	6	-2.56863E+02	-1.14539E+02	8.59025E+01	4.62621E+00	8.55682E+00	64.82	-7.41515E+01	-2.97250E+02	1.11549E+02		
0	3	7	-1.90414E+03	-1.25074E+02	-1.64214E+02	3.71820E+00	2.48597E+00	-84.77	-1.10044E+02	-1.91917E+03	9.04561E+02		
0	3	8	4.74359E+02	-4.06776E+02	-8.56707E+01	0.0	1.02572E-15	-5.50	4.82611E+02	-4.15028E+02	4.48819E+02		
0	4	1	-3.49549E+02	3.20373E+02	9.03358E+01	3.82713E+00	2.66023E+00	82.45	3.32340E+02	-3.61516E+02	3.46928E+02		
1		COMPOSITE CONSOLE ANALYSIS					FEBRUARY		9, 2012 MSC.NASTRAN 11/25/11		PAGE 20		

5. Review F06 Output File (Cont.):

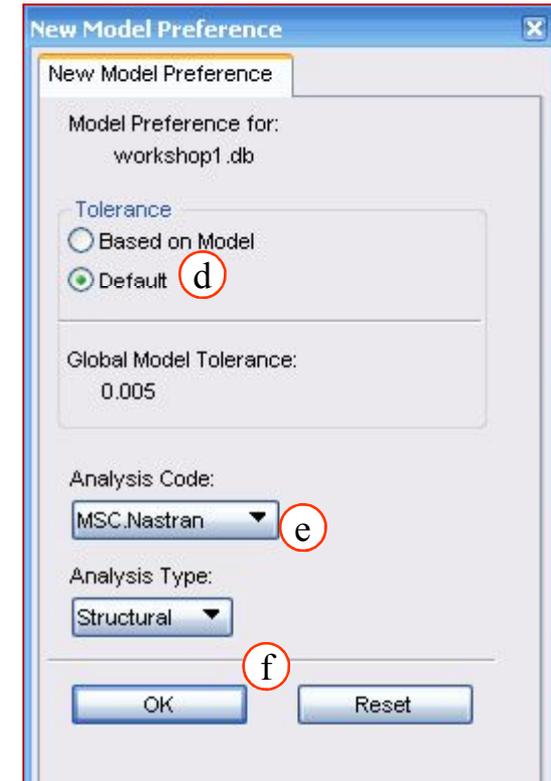
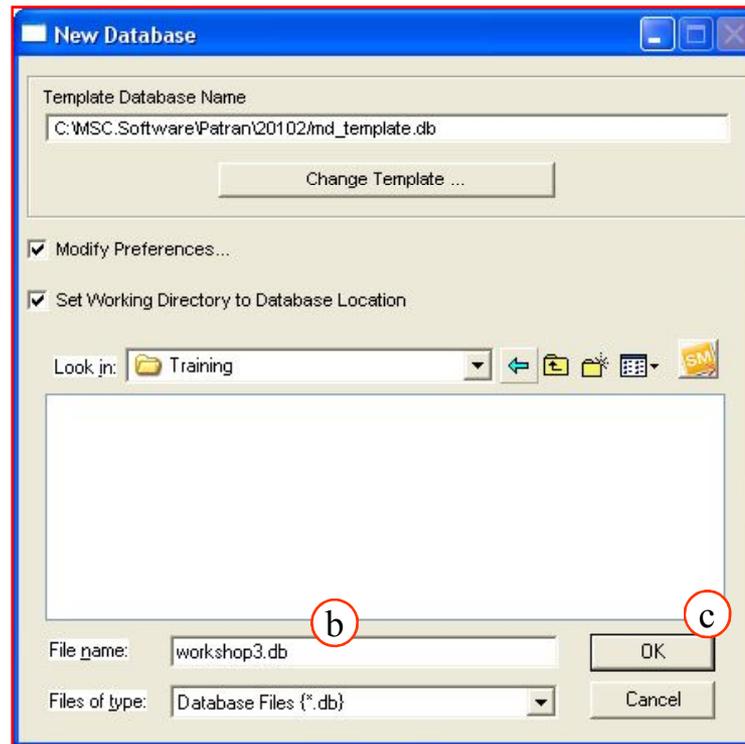
ELEMENT ID	FAILURE THEORY	PLY ID	INDICES FOR LAYERED COMPOSITE FP=FAILURE INDEX FOR PLY (DIRECT STRESSES/STRAINS)	FB=FAILURE INDEX FOR BONDING (INTER-LAMINAR STRESSES)	ELEMENTS (QUAD4) FAILURE INDEX FOR ELEMENT MAX OF FP,FB FOR ALL PLYS	FLAG
1	HILL	1	0.0053			
		2	0.0021	0.0030		
		3	0.0009	0.0037		
		4	0.0002	0.0042		
		5	0.0000	0.0042		
		6	0.0004	0.0042		
		7	0.0014	0.0037		
		8	0.0033	0.0030		
2	HILL	1	0.0041		0.0053	
		2	0.0018	0.0013		
		3	0.0008	0.0017		
		4	0.0002	0.0023		
		5	0.0000	0.0030		
		6	0.0003	0.0023		
		7	0.0009	0.0017		
		8	0.0022	0.0013		
3	HILL	1	0.0023		0.0041	
		2	0.0009	0.0007		
		3	0.0004	0.0017		
		4	0.0001	0.0024		
		5	0.0000	0.0032		
		6	0.0001	0.0024		
		7	0.0005	0.0017		
		8	0.0012	0.0007		
4	HILL	1	0.0009		0.0032	
				0.0008		

6. POST PROCESSING

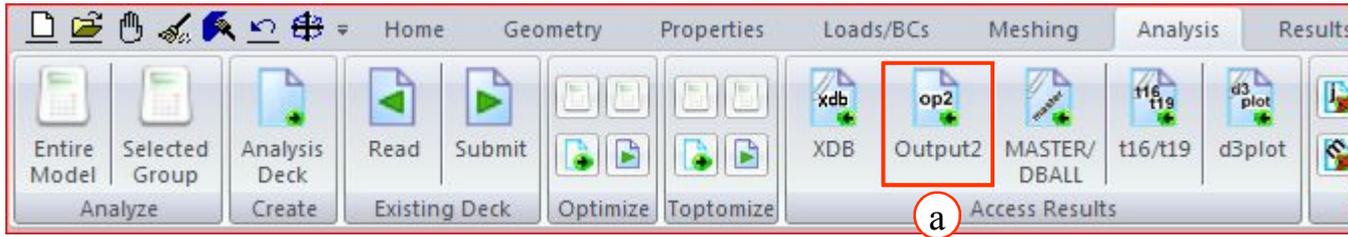


Create a new database

- a. File: **New**
- b. Enter **workshop3** as the File name
- c. Click **OK**.
- d. Select **Default** for Tolerance.
- e. Select **MSC Nastran** and **Structural** for the Analysis Code and Type.
- f. Click **OK**.

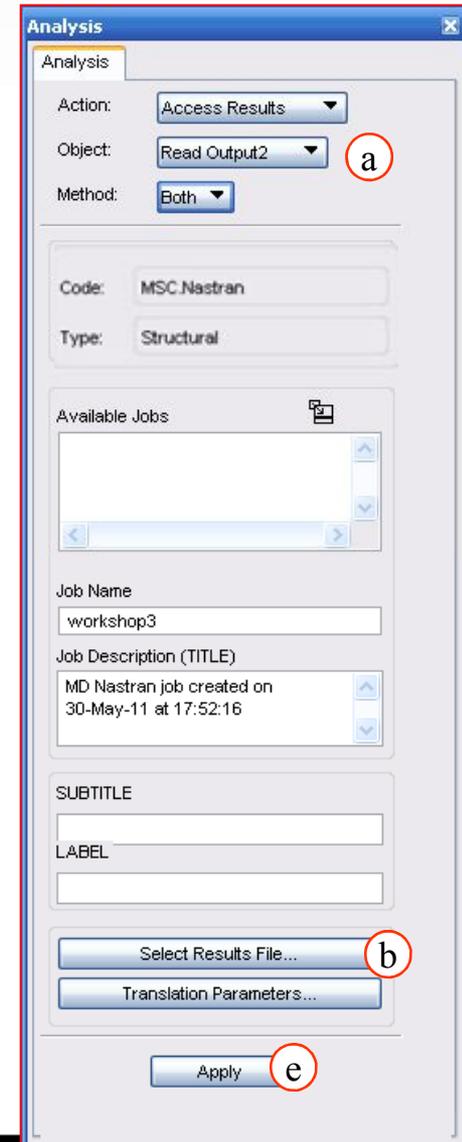
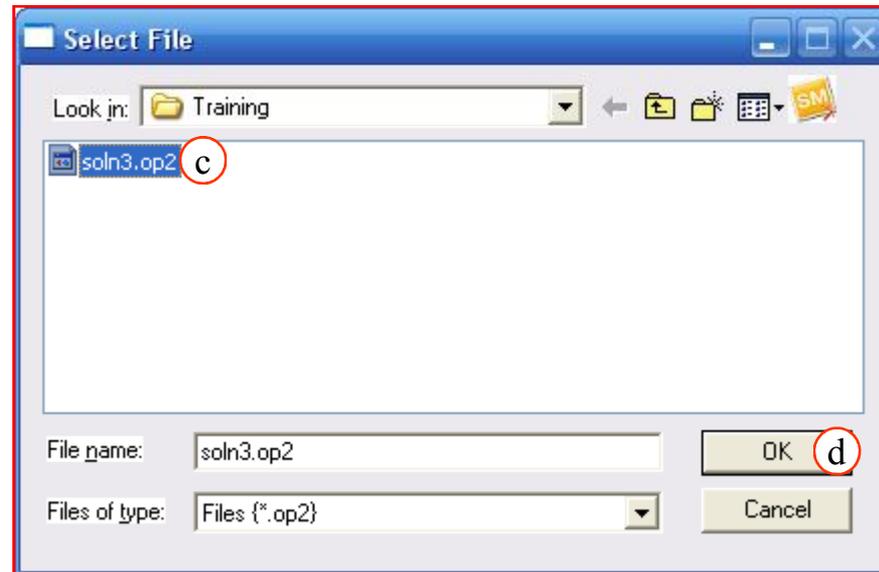


6. POST PROCESSING

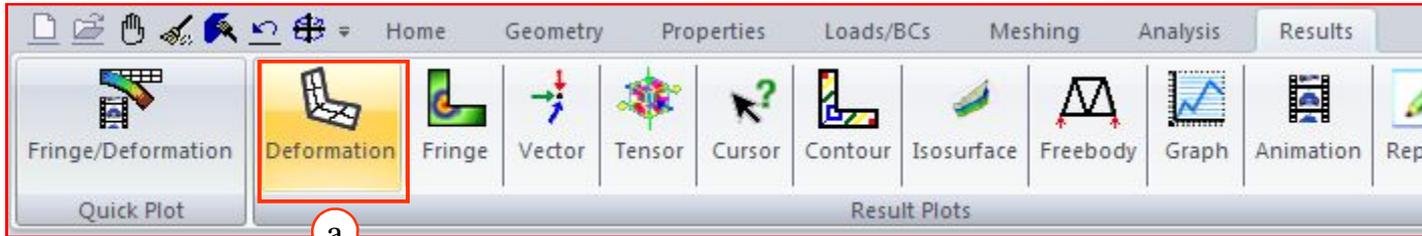


Attach results file

- a. Analysis: Access Results / Read Output2/ Both
- b. Click **Select Results File**.
- c. Select **wkshp3.op2**.
- d. Click **OK**.
- e. Click **Apply**.

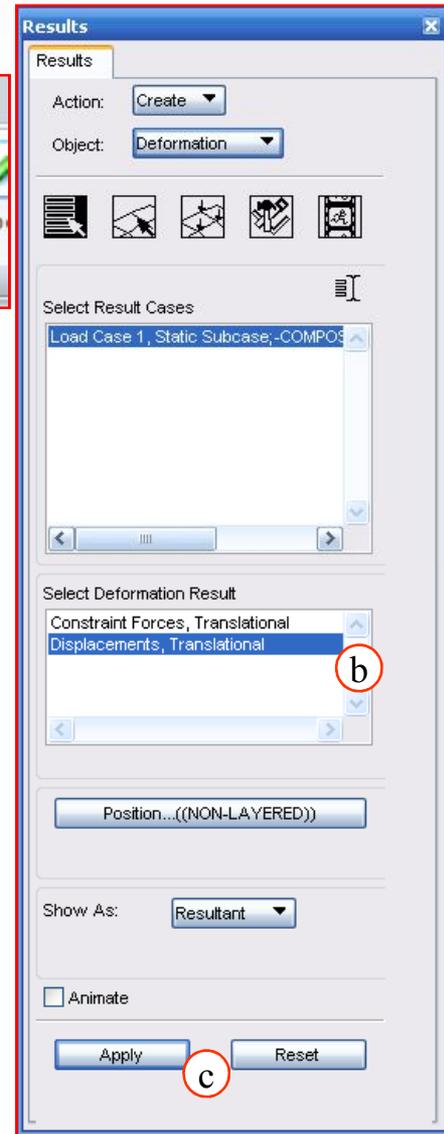
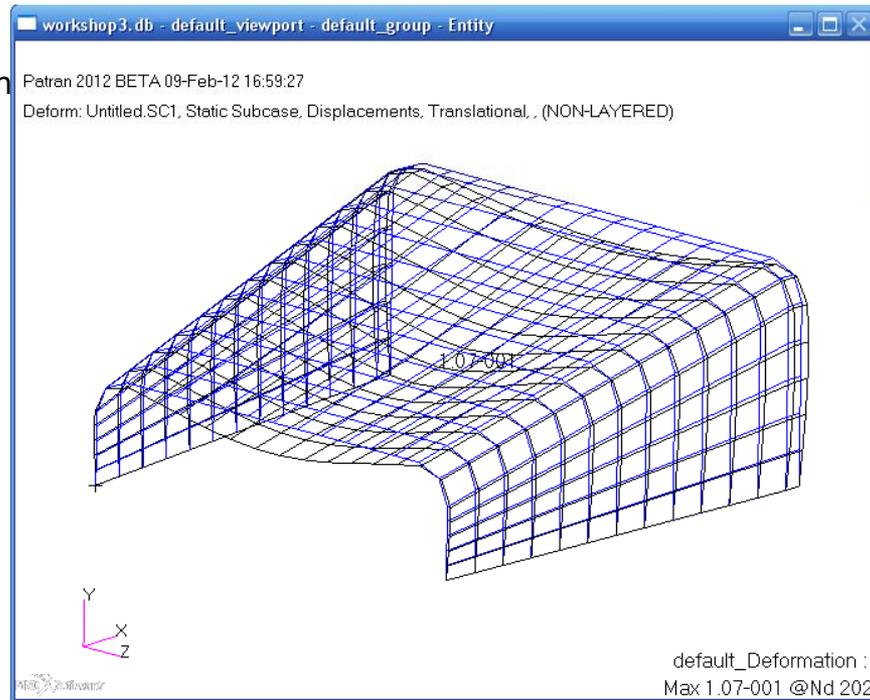


7. PLOT RESULTS



Plot the results

- a. Results: Create / Deformation
- b. Select **Displacements, Translational** as the Deformation Result.
- c. Click **Apply**.

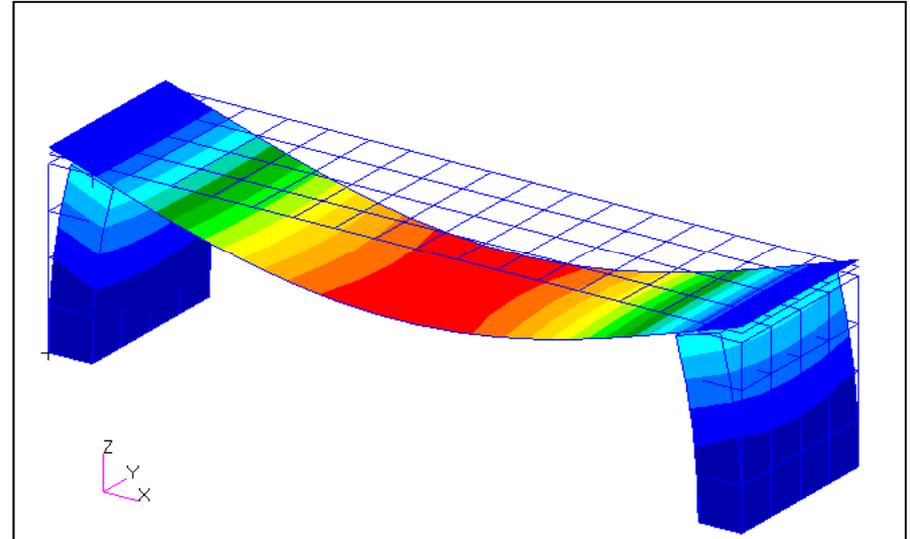
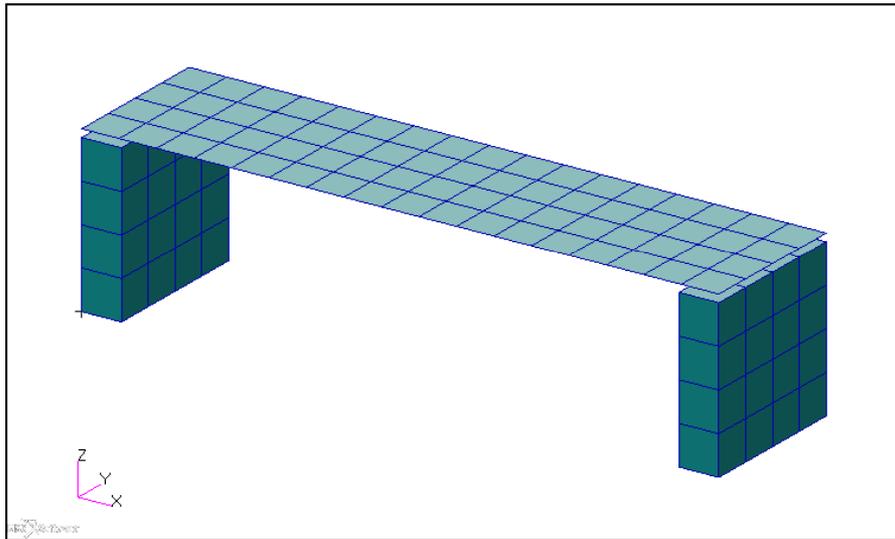


SOLUTION FILE FOR WORKSHOP 3

```
$ soln3.bdf
SOL 101
CEND
TITLE = Composite Console Analysis
ECHO = NONE
SUBCASE 1
  SPC = 1
  LOAD = 1
  DISP=ALL
  SPCFORCE=ALL
  STRESS (CORNER)=ALL
BEGIN BULK
PARAM      POST      -1
$ Composite Material Description:
PCOMP      1          5000.    HILL
           1          .0054    0.      YES    1          .0054    45.      YES
           1          .0054   -45.     YES    1          .0054    90.      YES
           1          .0054    90.     YES    1          .0054   -45.     YES
           1          .0054    45.     YES    1          .0054     0.      YES
$ Lamina Description:
MAT8       1          2.+7    2.+6    .35    1.+6    1.+6    1.+6    1.3-4
           -2.3-7  4.5-6      130000. 120000. 11000.  12000.  12500.
$ Elements:
CQUAD4     1          1          1          2          8          7          0
CQUAD4     2          1          2          3          9          8          0
CQUAD4     3          1          3          4          10         9          0
CQUAD4     4          1          4          5          11         10         0
CQUAD4     5          1          5          6          12         11         0
CQUAD4     6          1          7          8          14         13         0
CQUAD4     7          1          8          9          15         14         0
CQUAD4     8          1          9          10         16         15         0
```

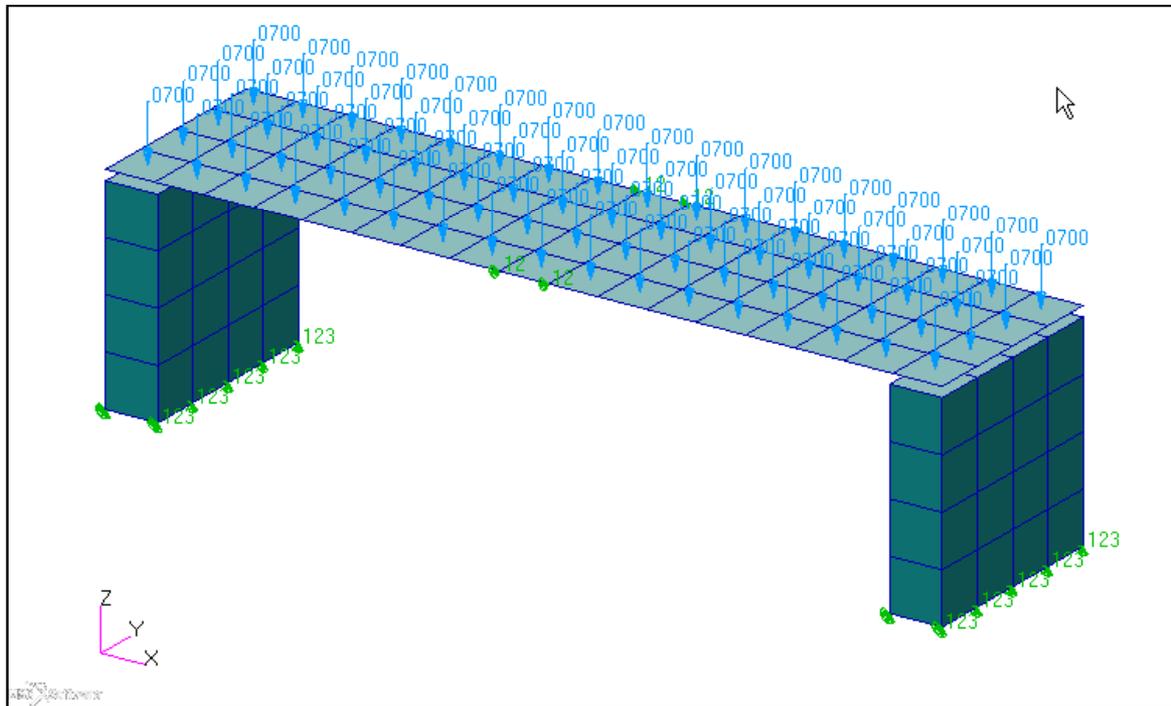
WORKSHOP 4

SOLID TO SHELL CONTACT



WORKSHOP OBJECTIVE:

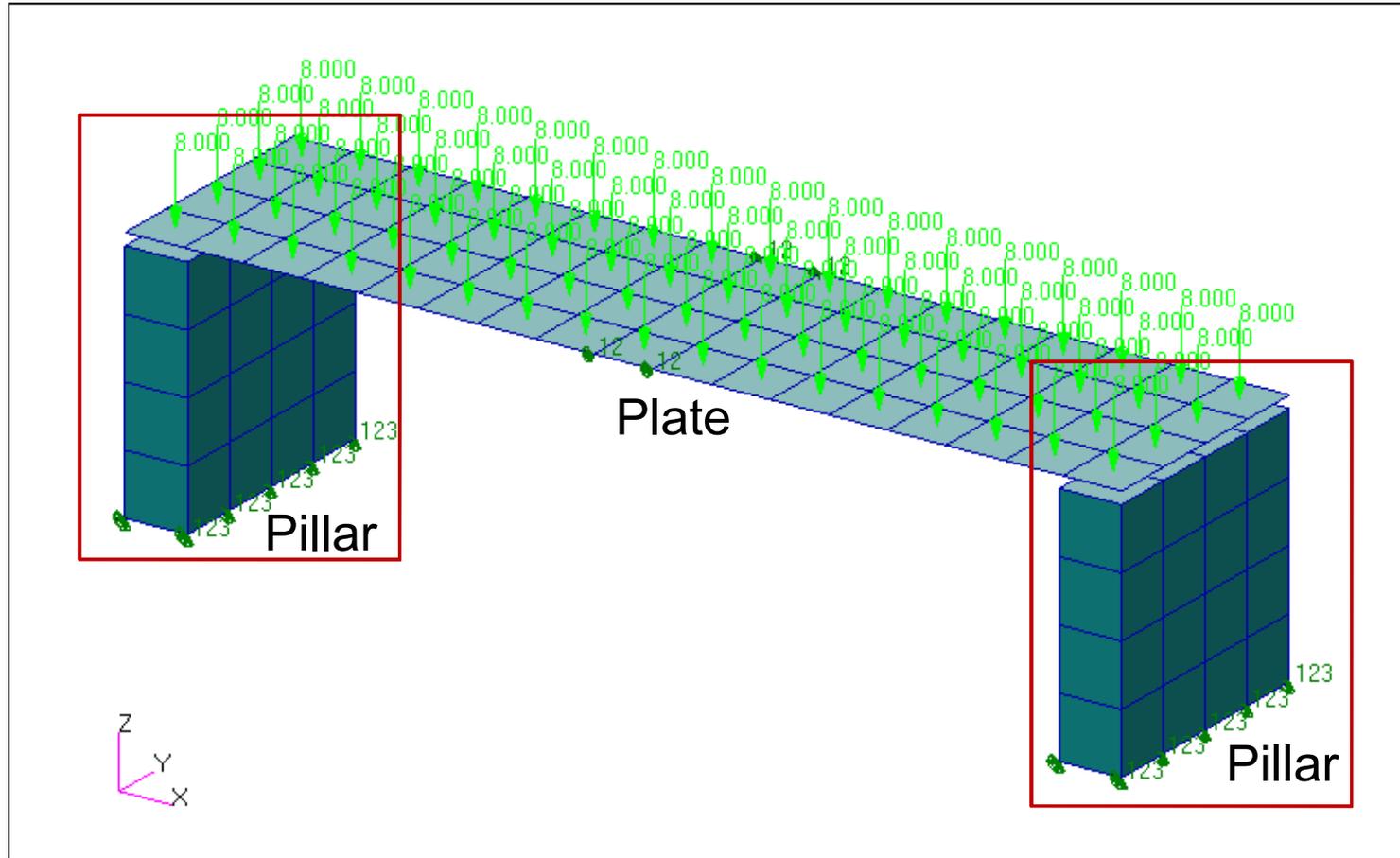
- To create and understand solid to shell contact.
- **Software Version:**
 - MSC Nastran 2012.1



MODEL DESCRIPTION:

- 1. The model contains a horizontal plate (meshed with Shells) resting on two vertical blocks (solid bodies with rectangular cross section) meshed with Hex elements. Hence this is a case of shells in contact with solids.**
- 2. The user will join the plate to pillars by solid to shell contact.**
- 3. Aluminum material is used for both the plate and the pillars.**
- 4. The bottom of the pillars are fixed and vertical sliding is applied to two rows of nodes, midway on the plate .**
- 5. A force of 2.5 psi is applied to each of the shell element in the model.**

MODEL DESCRIPTION (Cont.):



SUGGESTED STEPS:

- 1. Input File:** Edit the given MSC Nastran input file [wkshp4.bdf](#).
- 2. Create contact tables for the two solids** by creating entries for BCBODY, and BSURF .
- 3. Analysis:** Solution Type = Nastran Linear Static , Solution Sequence = 101. Submit input file to MSC Nastran.
- 4. Examine Output File:** Examine the Nastran output F06 file.
- 5. Results:** Plot displacements.

1. Open Input File:

1. Input File: Edit the given MSC Nastran input file wkshp4.bdf.

```
$wkshp4.bdf
NASTRAN SYSTEM(316)=19
SOL 101
CEND
TITLE = THIS IS A DEFAULT SUBCASE.
ECHO = NONE
SUBCASE 1
  TITLE=THIS IS A DEFAULT SUBCASE.
  BCONTACT = ALLBODY
  SPC = 2
  LOAD = 5
  DISPLACEMENT (SORT1,REAL)=ALL
  STRESS (SORT1,REAL,VONMISES,BILIN)=ALL
  BOUTPUT (SORT1,REAL)=ALL
$ Direct Text Input for this Subcase
BEGIN BULK
PARAM      POST      0
PARAM      PRTMAXIM YES
$ Elements and Element Properties for region : plate
PSHELL    1         1         .1         1         1
$ Pset: "plate" will be imported as: "pshell.1"
CQUAD4    100        1         217        218        236        235        0.         0.
CQUAD4    101        1         218        219        237        236        0.         0.
CQUAD4    102        1         219        220        238        237        0.         0.
CQUAD4    103        1         220        221        239        238        0.         0.
CQUAD4    104        1         221        222        240        239        0.         0.
.
.
.
```

1. Open Input File (Cont.):

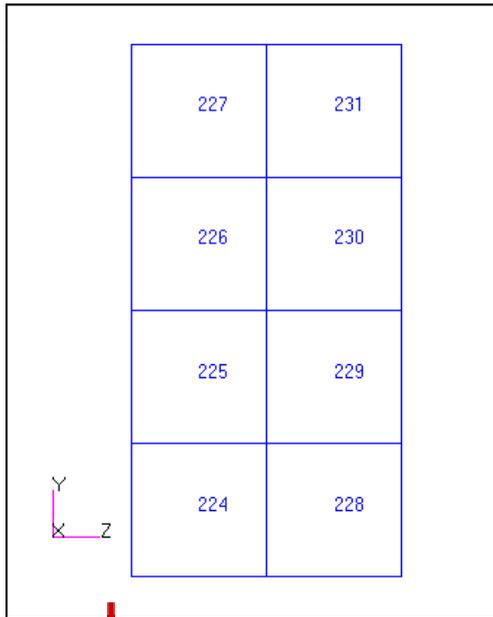
- Scroll down the input file:

```
.  
. .  
. .  
GRID      403          0.      .75      1.  
GRID      404          .25     .75      1.  
GRID      405          0.      1.      1.  
GRID      406          .25     1.      1.  
$ Loads for Load Case : Untitled.SC1  
SPCADD    2          1          3  
LOAD      5          1.      1.      1  
$ Displacement Constraints  
SPC1      1          12         225      226      297      298  
$ Displacement Constraints  
SPC1      3          123        307      THRU     316  
SPC1      3          123        357      THRU     366  
$ Deformable Body Contact LBC set of Hex Elements  
$  
$ Deformable Body Contact LBC set of Shell Elements  
$  
$ Pressures of Distributed Load Set  
PLOAD4    1          100      8.0          THRU     167  
          0.      0.      -1.  
  
ENDDATA
```

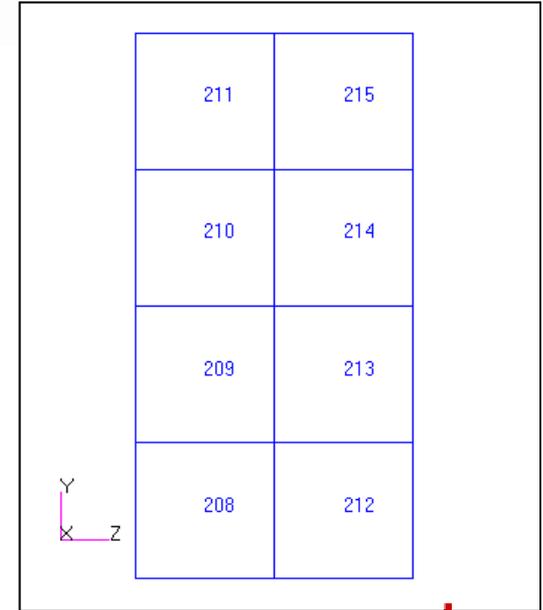
2. Create Contact Sets for Hex and Shell Elements

```
.
.
$ Displacement Constraints
SPC1 1 12 225 226 297 298
$ Displacement Constraints
SPC1 3 123 307 THRU 316
SPC1 3 123 357 THRU 366
$ Deformable Body Contact LBC set of Hex Elements
BCBODY 1 3D DEFORM 4 0
BSURF 4 200 208 209 210 211 212 213
214 215 224 225 226 227 228 229
231
$ Deformable Body Contact LBC set of Shell Elements
BCBODY 2 3D DEFORM 5 0
BSURF 5 100 117 134 151 101 118 135
152 115 132 149 166 116 133 150
167
$ Pressures of Distributed Load Set
PLOAD4 1 100 8.0 THRU 167
0. 0. -1.
ENDDATA
```

2. Create Contact Set for Hex Elements (Cont.)



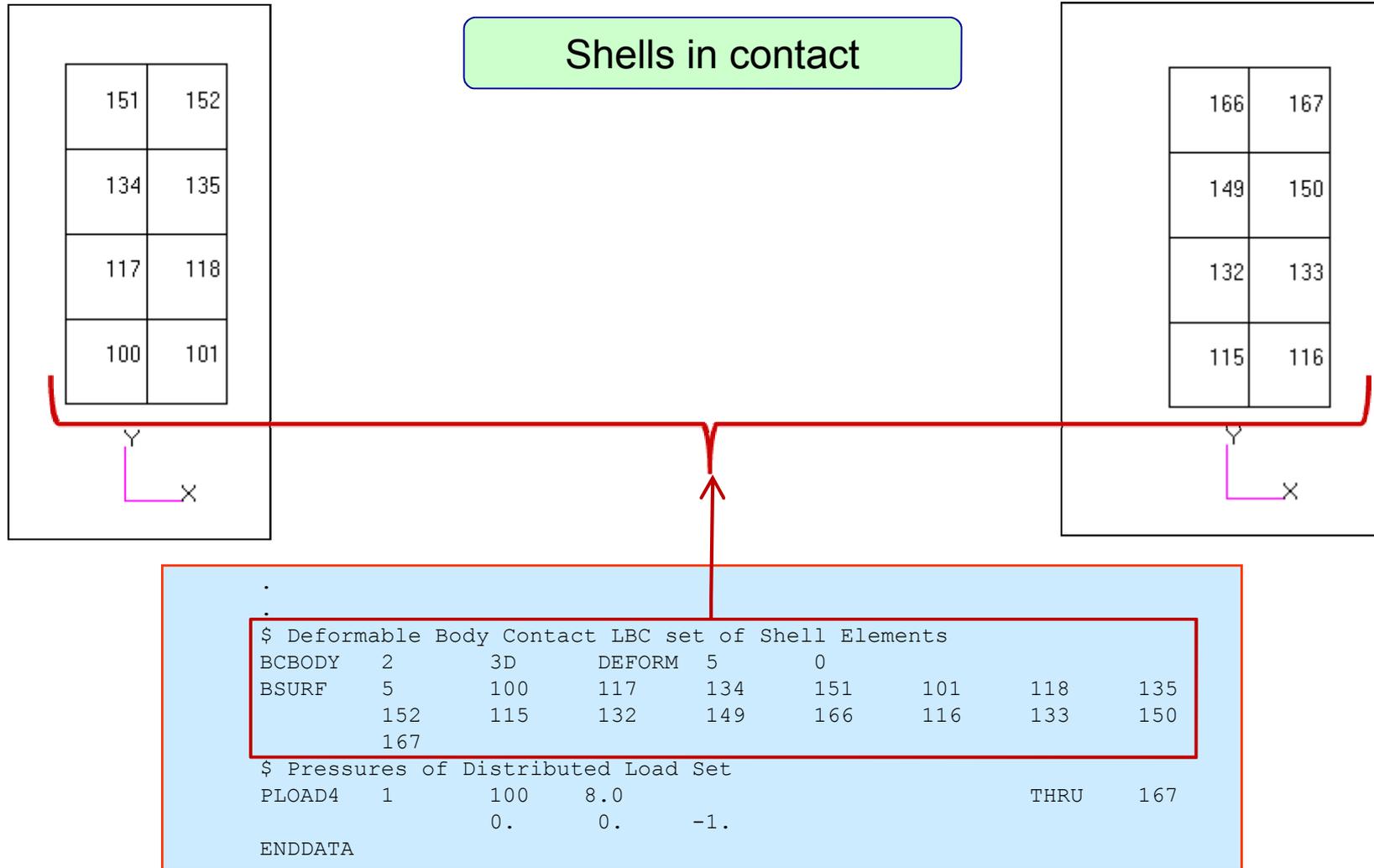
Hex elements in contact



```

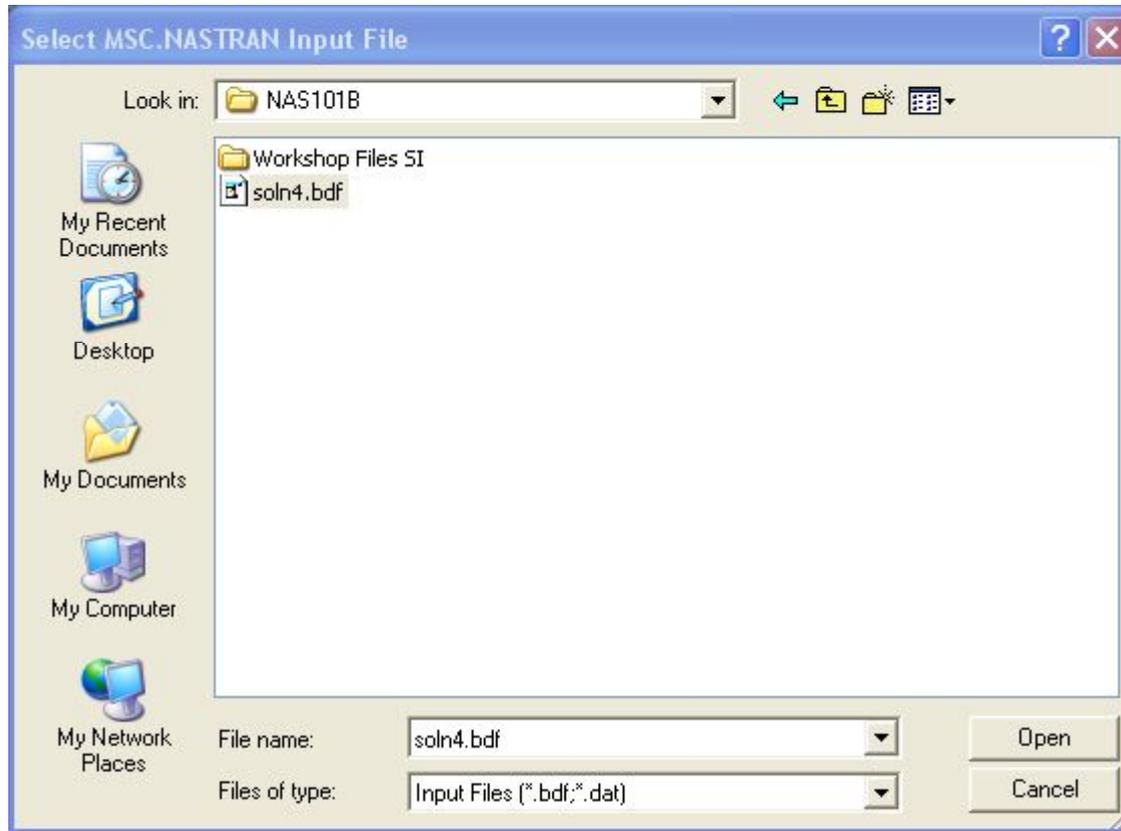
.
.
.
$ Displacement Constraints
SPC1      3      123      307      THRU      316
SPC1      3      123      357      THRU      366
$ Deformable Body Contact LBC set of Hex Elements
BCBODY    1      3D      DEFORM    4      0
BSURF     4      230      208      209      210      211      212
          213
          214      215      224      225      226      227      228
          229
          231
$ Deformable Body Contact LBC set of Shell Elements
.
    
```

2. Create Contact Set for Shell Elements (Cont.)



3. Submit Input File to MSC Nastran

3. Analysis: Solution Type = Nastran Linear Static , Solution Sequence = 101. Submit input file to MSC Nastran.



4. F06 Output File

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
217	G	4.377800E-07	-3.456810E-08	1.777553E-03	2.475120E-04	1.631454E-02	-4.848381E-08
218	G	4.399010E-07	-5.071809E-08	-2.066914E-03	3.465878E-04	1.636343E-02	-3.369467E-08
219	G	3.864696E-07	-6.214837E-08	-5.914032E-03	6.286511E-04	1.607201E-02	-1.259472E-08
220	G	3.278463E-07	-6.075057E-08	-9.602101E-03	1.004531E-03	1.499693E-02	1.087340E-08
221	G	2.678627E-07	-5.656547E-08	-1.295061E-02	1.366539E-03	1.321816E-02	1.861961E-08
222	G	2.071717E-07	-5.151321E-08	-1.580839E-02	1.679050E-03	1.086900E-02	2.499813E-08
223	G	1.464209E-07	-4.403188E-08	-1.805584E-02	1.923086E-03	8.077970E-03	3.285605E-08
224	G	8.310945E-08	-3.418430E-08	-1.960350E-02	2.089351E-03	4.972454E-03	6.035010E-08
225	G	0.0	0.0	-2.039214E-02	2.173381E-03	1.678460E-03	-2.396716E-08
226	G	0.0	0.0	-2.039214E-02	2.173381E-03	-1.678459E-03	2.396721E-08
227	G	-8.310947E-08	-3.418430E-08	-1.960350E-02	2.089350E-03	-4.972453E-03	-6.034953E-08
228	G	-1.464236E-07	-4.403228E-08	-1.805576E-02	1.923078E-03	-8.078095E-03	-3.285610E-08
229	G	-2.071718E-07	-5.151326E-08	-1.580840E-02	1.679050E-03	-1.086900E-02	-2.499817E-08
230	G	-2.678620E-07	-5.656549E-08	-1.295065E-02	1.366543E-03	-1.321813E-02	-1.861975E-08
231	G	-3.278469E-07	-6.075071E-08	-9.602072E-03	1.004530E-03	-1.499694E-02	-1.087339E-08
232	G	-3.864692E-07	-6.214840E-08	-5.914065E-03	6.286543E-04	-1.607200E-02	1.259443E-08
233	G	-4.399013E-07	-5.071817E-08	-2.066849E-03	3.465872E-04	-1.636344E-02	3.369380E-08
234	G	-4.377804E-07	-3.456862E-08	1.777554E-03	2.475137E-04	-1.631455E-02	4.848298E-08
235	G	4.448626E-07	-3.705285E-08	1.833693E-03	1.867295E-04	1.628415E-02	-9.740056E-09
236	G	4.420964E-07	-4.015303E-08	-1.991716E-03	2.355119E-04	1.625402E-02	-1.866315E-09
237	G	3.874372E-07	-4.145017E-08	-5.790678E-03	3.488344E-04	1.587380E-02	3.573519E-09
238	G	3.253755E-07	-3.951640E-08	-9.414132E-03	5.003188E-04	1.477567E-02	1.266621E-08
239	G	2.634602E-07	-3.486705E-08	-1.269758E-02	6.639865E-04	1.301276E-02	1.866522E-08
240	G	2.013310E-07	-2.976251E-08	-1.549822E-02	8.112896E-04	1.069824E-02	2.172730E-08
241	G	1.391988E-07	-2.378973E-08	-1.770062E-02	9.288868E-04	7.951606E-03	3.097282E-08
242	G	7.632674E-08	-1.091315E-08	-1.921744E-02	1.009899E-03	4.895216E-03	2.130069E-08
243	G	3.014392E-08	-6.272769E-09	-1.999047E-02	1.051063E-03	1.652508E-03	-1.891858E-08
244	G	-3.014394E-08	-6.272764E-09	-1.999047E-02	1.051063E-03	-1.652507E-03	1.891852E-08
245	G	-7.632676E-08	-1.091322E-08	-1.921744E-02	1.009899E-03	-4.895216E-03	-2.130068E-08
246	G	-1.392015E-07	-2.379010E-08	-1.770054E-02	9.288820E-04	-7.951729E-03	-3.097299E-08
247	G	-2.013311E-07	-2.976258E-08	-1.549822E-02	8.112899E-04	-1.069824E-02	-2.172733E-08
248	G	-2.634595E-07	-3.486707E-08	-1.269761E-02	6.639890E-04	-1.301273E-02	-1.866532E-08
249	G	-3.253761E-07	-3.951652E-08	-9.414103E-03	5.003172E-04	-1.477569E-02	-1.266637E-08
250	G	-3.874367E-07	-4.145031E-08	-5.790711E-03	3.488367E-04	-1.587379E-02	-3.573759E-09
251	G	-4.420965E-07	-4.015319E-08	-1.991651E-03	2.355109E-04	-1.625403E-02	1.865809E-09
252	G	-4.448626E-07	-3.705327E-08	1.833695E-03	1.867305E-04	-1.628415E-02	9.739254E-09
253	G	4.409322E-07	-3.335944E-08	1.857287E-03	-1.665211E-07	1.627002E-02	1.992159E-08
254	G	4.370952E-07	-2.868266E-08	-1.961689E-03	-1.256628E-07	1.620809E-02	2.087279E-08
255	G	3.835725E-07	-2.303267E-08	-5.746773E-03	-1.875280E-07	1.579900E-02	2.154889E-08
256	G	3.221746E-07	-1.753816E-08	-9.351569E-03	-2.192511E-07	1.468709E-02	2.036018E-08
257	G	2.595610E-07	-1.242026E-08	-1.261487E-02	-2.266230E-07	1.292764E-02	1.836256E-08
258	G	1.972139E-07	-7.863668E-09	-1.539723E-02	-2.273370E-07	1.062647E-02	1.558599E-08
259	G	1.354755E-07	-4.034434E-09	-1.758501E-02	-2.277117E-07	7.898082E-03	1.172407E-08
260	G	8.042086E-08	-1.374325E-09	-1.909174E-02	-2.277465E-07	4.862381E-03	7.055918E-09
261	G	2.384897E-08	6.804650E-11	-1.985964E-02	-2.277702E-07	1.641457E-03	2.841166E-09
262	G	-2.384898E-08	6.804306E-11	-1.985964E-02	-2.277703E-07	-1.641456E-03	-2.841204E-09
263	G	-8.042089E-08	-1.374335E-09	-1.909174E-02	-2.277467E-07	-4.862380E-03	-7.056027E-09
264	G	-1.354780E-07	-4.034605E-09	-1.758493E-02	-2.277121E-07	-7.898204E-03	-1.172425E-08
265	G	-1.972139E-07	-7.863728E-09	-1.539724E-02	-2.273375E-07	-1.062647E-02	-1.558614E-08
266	G	-2.595602E-07	-1.242029E-08	-1.261491E-02	-2.266238E-07	-1.292761E-02	-1.836268E-08

1 SOLID TO SHELL CONTACT IN SOL 101

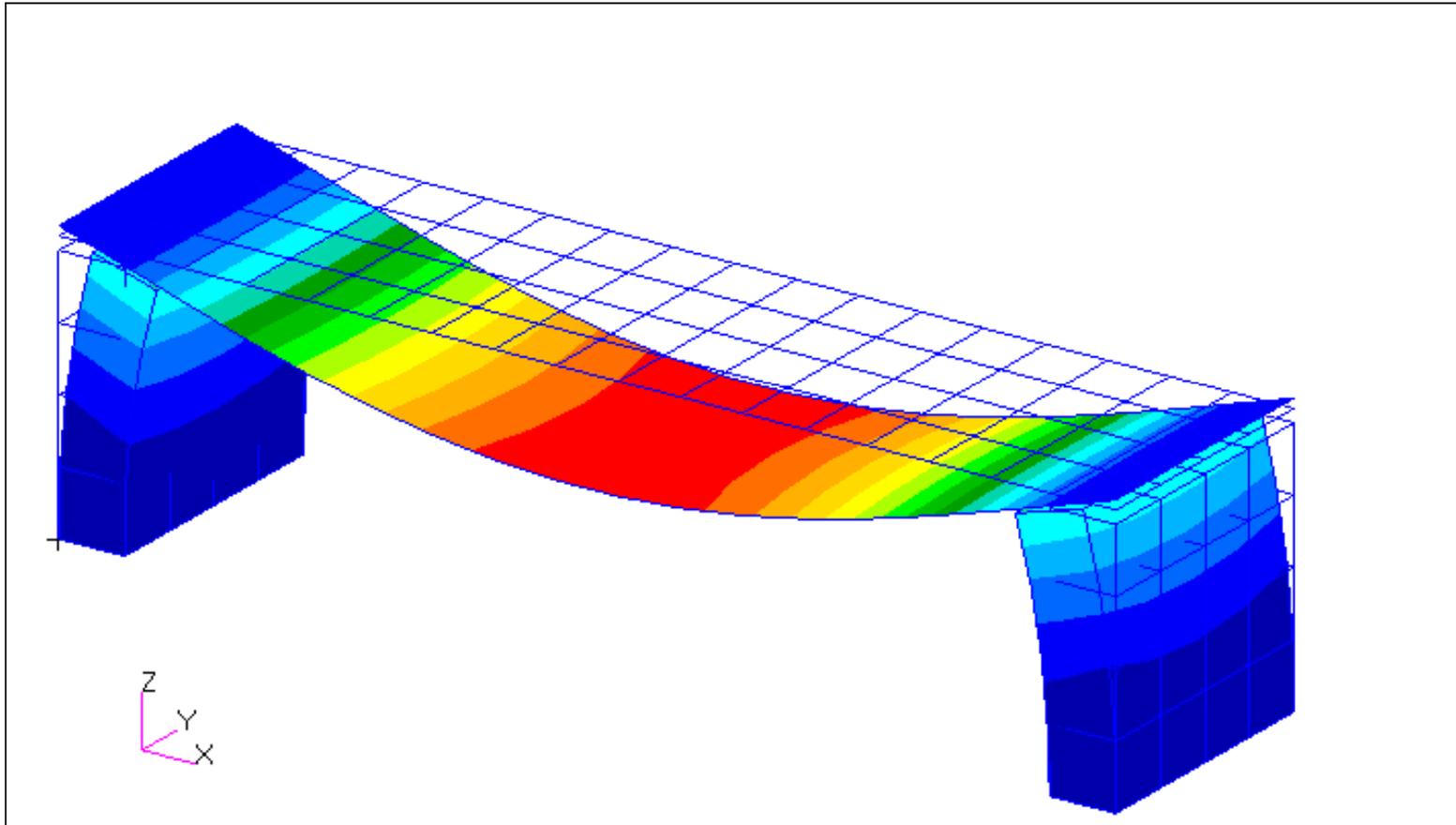
FEBRUARY

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5. Plot Displacements



Solution File For Workshop 4

```
$soln4
NASTRAN SYSTEM(316)=19
SOL 101
CEND
TITLE = THIS IS A DEFAULT SUBCASE.
ECHO = NONE
SUBCASE 1
  TITLE=THIS IS A DEFAULT SUBCASE.
  BCONTACT = ALLBODY
  SPC = 2
  LOAD = 5
  DISPLACEMENT (SORT1, REAL)=ALL
  STRESS (SORT1, REAL, VONMISES, BILIN)=ALL
  BOUTPUT (SORT1, REAL)=ALL
$
BEGIN BULK
PARAM      POST      0
PARAM      PRTMAXIM  YES
$ Elements and Element Properties for region for plate
PSHELL    1         1         .1         1         1
$
CQUAD4    100        1         217        218        236        235        0.         0.
CQUAD4    101        1         218        219        237        236        0.         0.
CQUAD4    102        1         219        220        238        237        0.         0.
CQUAD4    103        1         220        221        239        238        0.         0.
CQUAD4    104        1         221        222        240        239        0.         0.
CQUAD4    105        1         222        223        241        240        0.         0.
CQUAD4    106        1         223        224        242        241        0.         0.
CQUAD4    107        1         224        225        243        242        0.         0.
CQUAD4    108        1         225        226        244        243        0.         0.
CQUAD4    109        1         226        227        245        244        0.         0.
CQUAD4    110        1         227        228        246        245        0.         0.
```

Solution File For Workshop 4 (Cont.)

```
.  
. .  
. .  
. .  
GRID      401          0.      .5      1.  
GRID      402          .25     .5      1.  
GRID      403          0.      .75     1.  
GRID      404          .25     .75     1.  
GRID      405          0.      1.      1.  
GRID      406          .25     1.      1.  
$ Loads for Load Case  
SPCADD    2          1          3  
LOAD      5          1.      1.      1  
$ Displacement Constraints  
SPC1      1          12         225      226      297      298  
$ Displacement Constraints  
SPC1      3          123        307      THRU     316  
SPC1      3          123        357      THRU     366  
$ Deform Body Contact LBC set of Hex Elements  
BCBODY    1          3D         DEFORM   4          0  
BSURF     4          230        208      209      210      211      212      213  
          214        215        224      225      226      227      228      229  
          231  
$ Deform Body Contact LBC set of Shell Elements  
BCBODY    2          3D         DEFORM   5          0  
BSURF     5          100        117      134      151      101      118      135  
          152        115        132      149      166      116      133      150  
          167  
$ Pressures of Distributed Load Set  
PLOAD4    1          100        8.0          THRU     167  
          0.      0.      -1.  
ENDDATA
```

ADDITIONAL METHODS OF DEFORMABLE BODY

- Along with BSURF users also can try other deformable body methods for BSID in BCBODY: BCPROP

BCPROP

Defines a 3D contact region by element properties. All elements with the specified properties define a contact body used in SOL 101 and MSC Nastran SOLs 400 and 700 only.

1	2	3	4	5	6	7	8	9	10
BCPROP	ID	IP1	IP2	IP3	IP4	IP5	IP6	IP7	
	IP8	IP9	etc.						

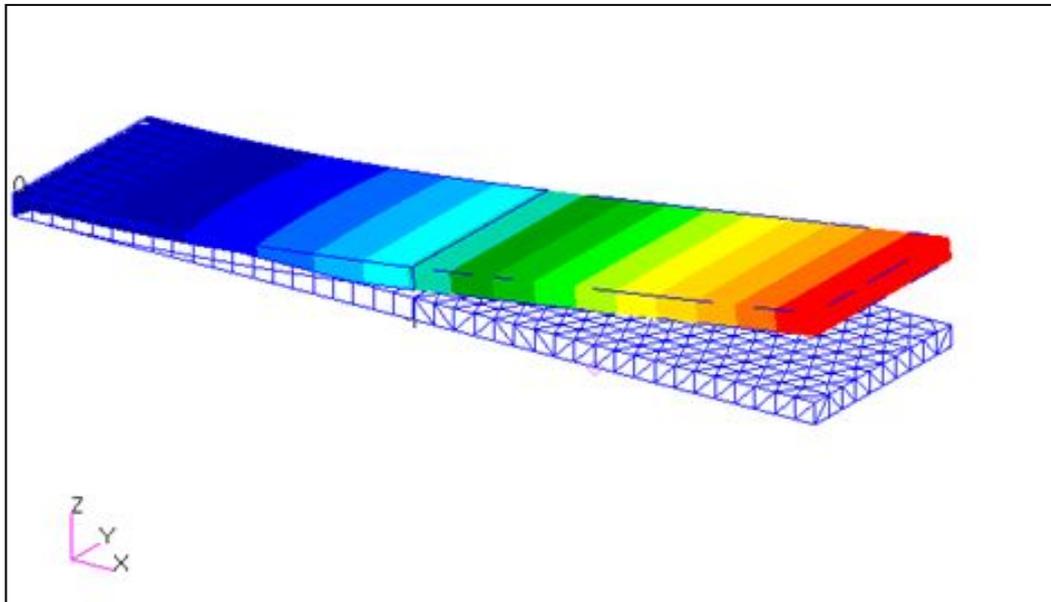
Field

Contents

- ID Identification of a deformable surface corresponding to a BSID value on the BCBODY entry. All elements corresponding to the property IDs specified that may potentially come into contact. Do not specify mixed property types (use all shell, all solid or all beam properties only). (Integer > 0)
- IPi Property ID. A minimum of one entry is required. (Integer; no Default)

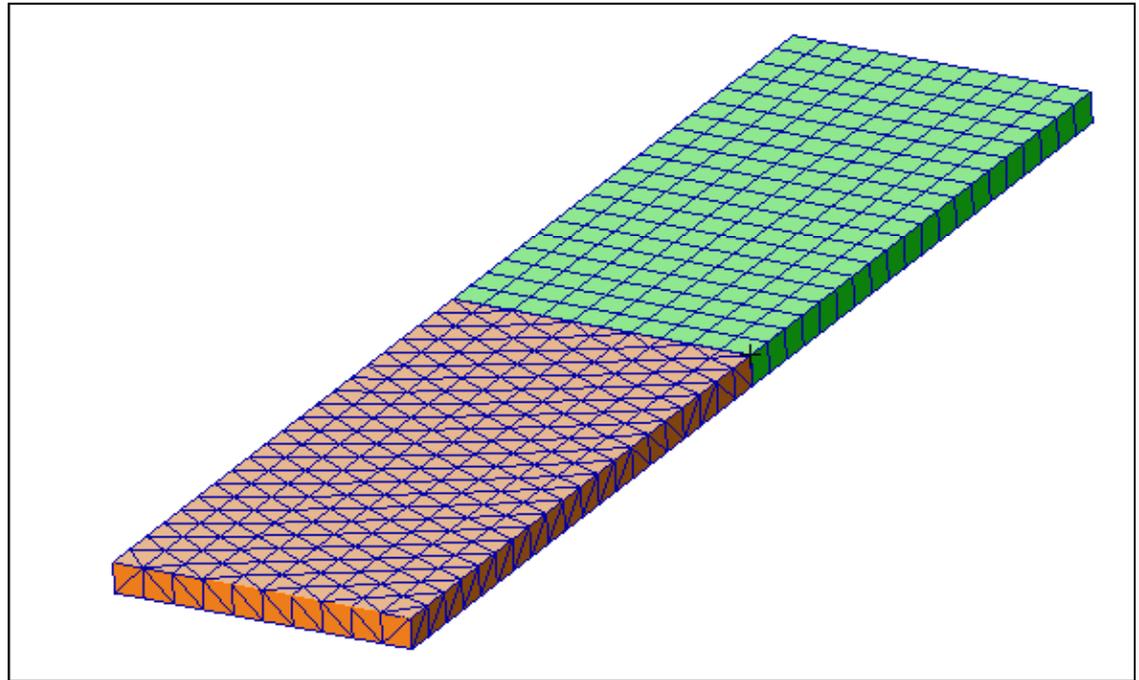
WORKSHOP 5

SOLID GLUE CONTACT



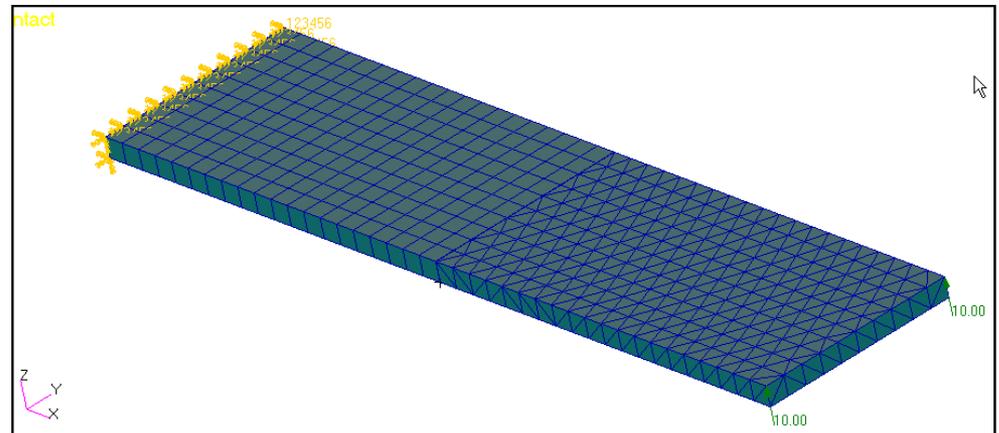
WORKSHOP OBJECTIVE:

- To create and understand solid face-to-face glue contact.
- **Software Version:**
 - MSC Nastran 2012.1

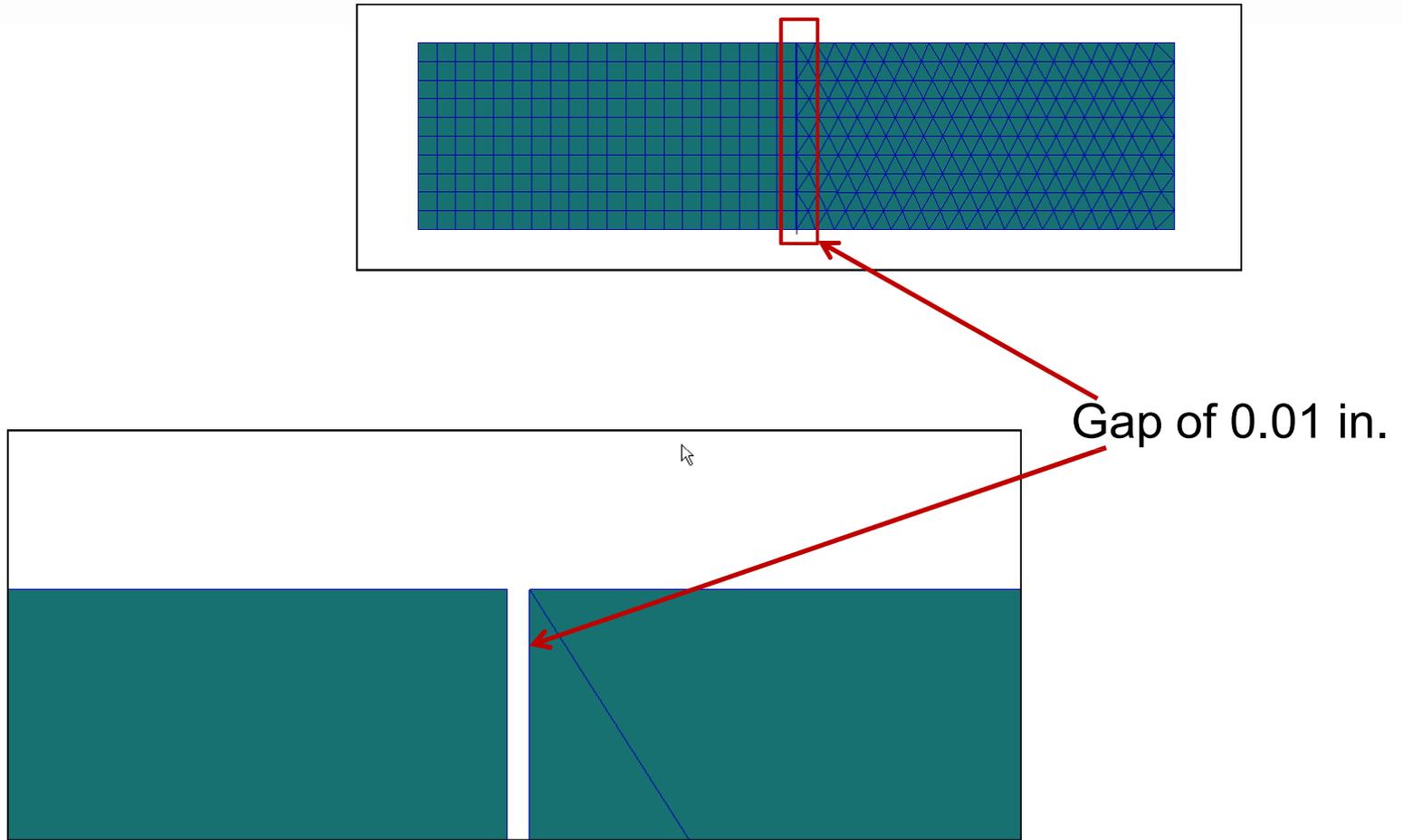


MODEL DESCRIPTION:

1. The model contains two solid bodies and are meshed with Solid elements.
2. The first body is meshed with CHEXA elements and the second body with CTETRA elements and hence they have dissimilar mesh.
3. Both these bodies are separated by a gap of 0.01 inches between them.
4. The user will join the two solids by means of glue contact.
5. Aluminium material is used for both the solid bodies.
6. The free end of the solid with hex mesh is fixed in all directions.
7. A force of 10 psi is applied to the two corner nodes of the solid meshed with Tet mesh.



MODEL DESCRIPTION (CONT.):



Gap of 0.01 in.

Suggested Steps:

- 1. Input File: Edit the given MSC Nastran input file [wkshp5.bdf](#).**
- 2. Create contact tables for the two solids by creating entries for BCBODY, BSURF and BCTABLE.**
- 3. Analysis: Solution Type = Nastran Linear Static , Solution Sequence = 101. Submit input file to MSC Nastran.**
- 4. Examine Output File: Examine the Nastran output F06 file.**
- 5. Results: Plot displacements.**

1. Open Input File:

1. Input File: Edit the given MSC Nastran input file wkshp5.bdf.

```
$wkshp5.bdf
NASTRAN SYSTEM(316)=19
SOL 101
CEND
ECHO = NONE
SUBCASE 1
  TITLE=This is a default subcase.
  BCONTACT = 1
  SPC = 2
  LOAD = 2
  DISPLACEMENT (SORT1,REAL)=ALL
  STRESS (SORT1,REAL,VONMISES,BILIN)=ALL
  NLOPRM MPCPCH=BEGN
BEGIN BULK
$
PARAM      POST      0
PARAM      PRTMAXIM  YES
$
$ Elements and Element Properties for Hex Elements
PSOLID    1          1          0
$
CHEXA     1          1          7293    7294    7315    7314    7524    7525
          7546    7545
CHEXA     2          1          7294    7295    7316    7315    7525    7526
          7547    7546
.
.
.
```

1. Open Input File (Cont.):

- Scroll down the input file:

```
.  
. .  
. .  
GRID      8244          9.5004  5.      0.  
GRID      8245          10.     5.      0.  
$ Loads for Load Case  
SPCADD    2           1  
LOAD      2           1.      1.      1  
$ Displacement Constraints of Load Set  
SPC1      1           123456  7313   7334   7355   7376   7397   7418  
          7439   7460   7481   7502   7523   7544   7565   7586  
          7607   7628   7649   7670   7691   7712   7733   7754  
$ Create Contact Tables  
$  
$ Create Deformable Body Contact LBC set for Hex Elements  
$  
$ Create Deformable Body Contact LBC set for Tet Elements  
$  
$  
$ Nodal Forces Applied in the Z Direction  
FORCE     1           8017   0      10.    0.     0.     1.  
FORCE     1           8225   0      10.    0.     0.     1.  
$  
ENDDATA
```

2. Create Contact Set for Hex Elements

Format:

1	2	3	4	5	6	7	8	9	10
BCBODY	BID	DIM	BEHAV	BSID	ISTYP	FRIC	IDSPL	CONTROL	
	NLOAD	ANGVEL	DCOS1	DCOS2	DCOS3	VELRB1	VELRB2	VELRB3	
	"ADVANCE"	SANGLE	COPTB	USER					
	"CTVDEF"	ICMALL	ITVDF	ITVDF	DEFALT	ALCDIST			

1	2	3	4	5	6	7	8	9	10
BSURF	ID	ELID1	ELID2	ELID3	ELID4	ELID5	ELID6	ELID7	
	ELID8	ELID9	etc.						

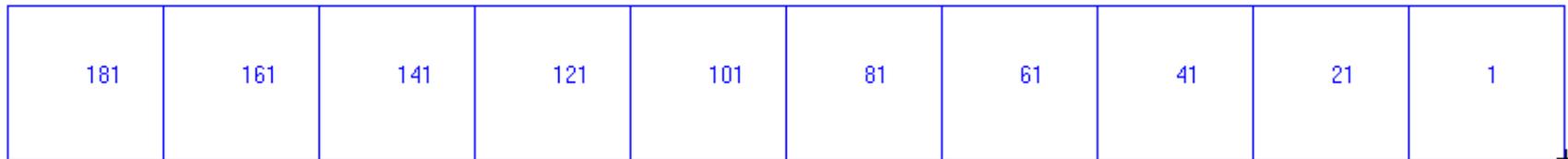
```

.
.
.
$ Create Contact Tables
$
$ Create Deformable Body Contact LBC set for Hex Elements
BCBODY 1 3D DEFORM 1 0
$
BSURF 1 1 21 41 61 81 101 121
141 161 181
$ Create Deformable Body Contact LBC set for Tet Elements
$
.
.
.

```

2. Create Contact Set for Hex Elements (Cont.)

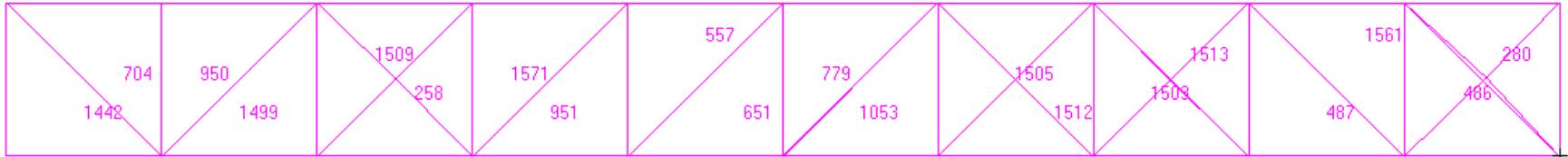
Hex elements in contact



```
.  
. .  
$ Create Contact Tables  
$  
$ Create Deformable Body Contact LBC set for Hex Elements  
BCBODY 1 3D DEFORM 1 0  
$  
BSURF 1 1 21 41 61 81 101 121  
141 161 181  
$ Create Deformable Body Contact LBC set for Tet Elements  
$  
. .  
.
```

2. Create Contact Set for Tet Elements

Tet elements in contact



```

.
.
.
$ Create Contact Tables
$
$ Create Deformable Body Contact LBC set for Hex Elements
BCBODY 1 3D DEFORM 1 0
$
BSURF 1 1 21 41 61 81 101 121
      141 161 181
$ Create Deformable Body Contact LBC set for Tet Elements
BCBODY 2 3D DEFORM 2 0
$
BSURF 2 704 950 258 951 557 651 779
      487 486 280 1513 1561 1505 1512 1503
      1442 1499 1509 1571 1053
.
.

```

3. Create Contact Tables

Format: (SOLs 101, 103, 105, 107, 108, 109, 110, 111, 112, 200 and 400 only)

1	2	3	4	5	6	7	8	9	10
BCTABLE	ID			NGROUP	COPTS	COPTM			
	"SLAVE"	IDSLA1	ERROR			CINTERF	IGLUE		
		ISEARCH	ICOORD						
	"FBSH"			BIAS			COPTS1	COPTM1	
	"MASTERS"	IDMA1	IDMA2	IDMA3	IDMA4	IDMA5	IDMA6	IDMA7	
		IDMA8	IDMA9	...					

```

.
.
$ Create Contact Tables
BCTABLE 0
      SLAVE 2      0.015
          0      0      0
      MASTERS 1

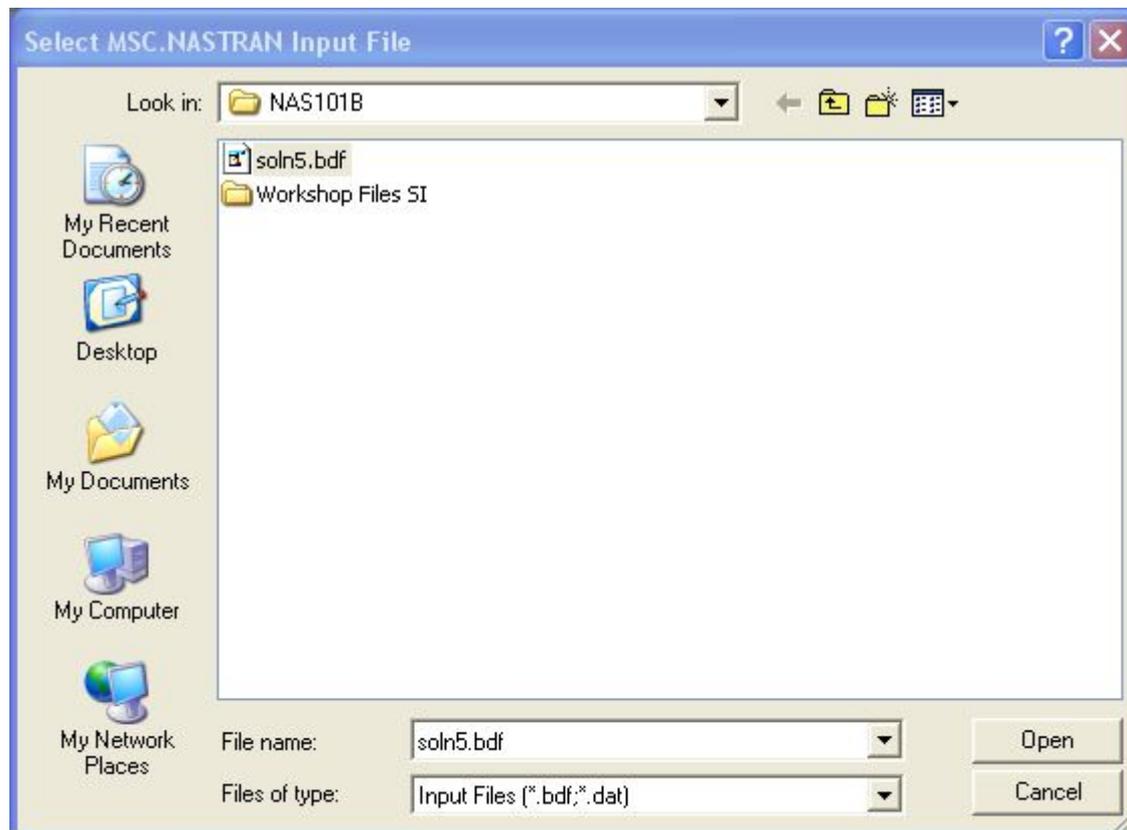
$
BCTABLE 1
      SLAVE 2      0.015
          0      0      0
      MASTERS 1

$ Create Deformable Body Contact LBC set for Hex Elements
BCBODY 1      3D      DEFORM 1      0
$
BSURF 1      1      21      41      61      81      101      121
      141      161      181
$ Create Deformable Body Contact LBC set for Tet Elements
.
.

```

3. Submit Input File to MSC Nastran

3. Analysis: Solution Type = Nastran Linear Static , Solution Sequence = 101. Submit input file to MSC Nastran.



4. F06 Output File

```

0
      M O D E L   S U M M A R Y           BULK = 0
      ENTRY NAME   NUMBER OF ENTRIES
      -----
      BCBODY                2
      BCTABLE              2
      BSURF                 2
      CHEXA                200
      CTETRA              1378
      FORCE                 2
      GRID                 953
      LOAD                  1
      MAT1                 1
      PARAM                 2
      PSOLID                2
-----
      SPC1                  1
-----
      SPCADD                1
-----

^^^
^^^ >>> IFP OPERATIONS COMPLETE <<<
^^^

1
                                         FEBRUARY  9, 2012  MSC.NASTRAN 11/25/11  PAGE  5

0
*** USER INFORMATION MESSAGE 7310 (VECPRN)
    ORIGIN OF SUPERELEMENT BASIC COORDINATE SYSTEM WILL BE USED AS REFERENCE LOCATION.
    RESULTANTS ABOUT ORIGIN OF SUPERELEMENT BASIC COORDINATE SYSTEM IN SUPERELEMENT BASIC SYSTEM COORDINATES.
0
      SUBCASE/   LOAD
      DAREA ID   TYPE
      1          FX   0.000000E+00   T1   T2   T3   R1   R2   R3
      FY   -----   0.000000E+00   -----   -----   0.000000E+00   0.000000E+00
      FZ   -----   -----   2.000000E+01   5.000000E+01   -2.000000E+02   0.000000E+00
      MX   -----   -----   -----   0.000000E+00   -----   -----
      MY   -----   -----   -----   -----   0.000000E+00   -----
      MZ   -----   -----   -----   -----   -----   0.000000E+00
      TOTALS 0.000000E+00 0.000000E+00 2.000000E+01 5.000000E+01 -2.000000E+02 0.000000E+00
1
                                         FEBRUARY  9, 2012  MSC.NASTRAN 11/25/11  PAGE  6

0
                                         SUBCASE 1

*** SYSTEM INFORMATION MESSAGE 4159 (DFMSA)
    THE DECOMPOSITION OF KLL YIELDS A MAXIMUM MATRIX-TO-FACTOR-DIAGONAL RATIO OF 1.755084E+04
*** USER INFORMATION MESSAGE 5293 (SSG3A)
    FOR DATA BLOCK KLL
    LOAD SEQ. NO.      EPSILON      EXTERNAL WORK      EPSILONS LARGER THAN 0.001 ARE FLAGGED WITH ASTERISKS
1
      1                7.7663403E-11  8.9695323E-01
                                         FEBRUARY  9, 2012  MSC.NASTRAN 11/25/11  PAGE  7

```

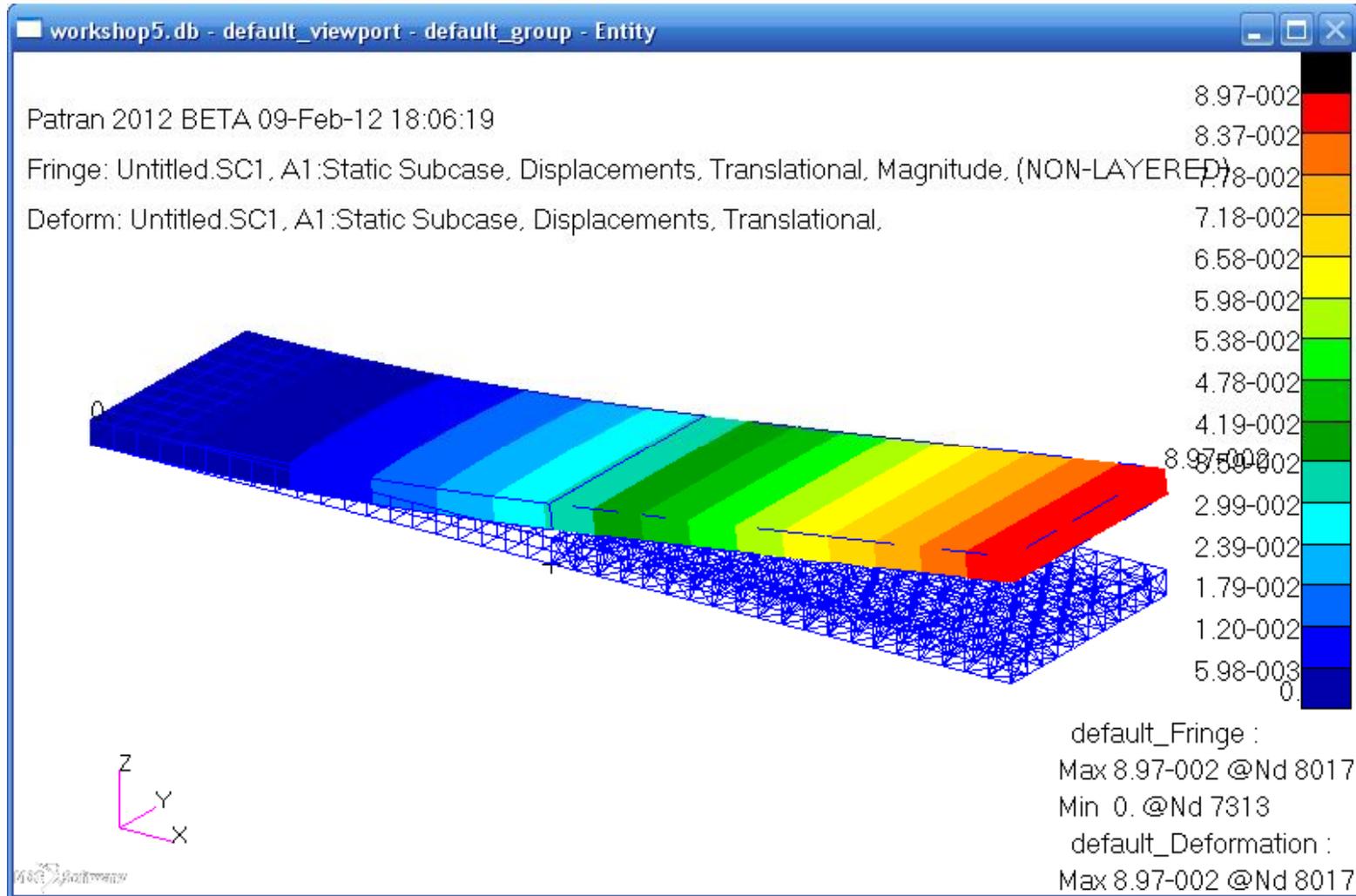
DISPLACEMENT OUTPUT IN F06

DISPLACEMENT VECTOR									
POINT ID.	TYPE	T1	T2	T3	R1	R2	R3		
7293	G	-1.395732E-03	-2.445344E-05	3.061841E-02	0.0	0.0	0.0		
7294	G	-1.358234E-03	-4.539832E-05	2.784805E-02	0.0	0.0	0.0		
7295	G	-1.309198E-03	-5.708948E-05	2.516660E-02	0.0	0.0	0.0		
7296	G	-1.255733E-03	-6.770774E-05	2.259159E-02	0.0	0.0	0.0		
7297	G	-1.199169E-03	-7.630802E-05	2.012816E-02	0.0	0.0	0.0		
7298	G	-1.139869E-03	-8.360048E-05	1.778208E-02	0.0	0.0	0.0		
7299	G	-1.078048E-03	-8.976454E-05	1.555819E-02	0.0	0.0	0.0		
7300	G	-1.013794E-03	-9.496573E-05	1.346124E-02	0.0	0.0	0.0		
7301	G	-9.471177E-04	-9.928053E-05	1.149597E-02	0.0	0.0	0.0		
7302	G	-8.780032E-04	-1.027285E-04	9.667214E-03	0.0	0.0	0.0		
7303	G	-8.064168E-04	-1.052665E-04	7.979885E-03	0.0	0.0	0.0		
7304	G	-7.323152E-04	-1.067871E-04	6.439051E-03	0.0	0.0	0.0		
7305	G	-6.556492E-04	-1.071109E-04	5.049935E-03	0.0	0.0	0.0		
7306	G	-5.763703E-04	-1.059773E-04	3.817924E-03	0.0	0.0	0.0		
7307	G	-4.944486E-04	-1.030293E-04	2.748572E-03	0.0	0.0	0.0		
7308	G	-4.099112E-04	-9.780350E-05	1.847544E-03	0.0	0.0	0.0		
7309	G	-3.229388E-04	-8.968120E-05	1.120446E-03	0.0	0.0	0.0		
7310	G	-2.341482E-04	-7.798376E-05	5.723610E-04	0.0	0.0	0.0		
7311	G	-1.447274E-04	-6.119454E-05	2.067382E-04	0.0	0.0	0.0		
7312	G	-6.013352E-05	-4.046844E-05	2.282065E-05	0.0	0.0	0.0		
7313	G	0.0	0.0	0.0	0.0	0.0	0.0		
7314	G	-1.392757E-03	-2.170066E-05	3.066905E-02	0.0	0.0	0.0		
7315	G	-1.351919E-03	-3.170102E-05	2.792154E-02	0.0	0.0	0.0		
7316	G	-1.303977E-03	-4.158918E-05	2.526520E-02	0.0	0.0	0.0		
7317	G	-1.251386E-03	-5.044036E-05	2.270900E-02	0.0	0.0	0.0		
7318	G	-1.195404E-03	-5.794904E-05	2.026184E-02	0.0	0.0	0.0		
7319	G	-1.136657E-03	-6.424716E-05	1.792942E-02	0.0	0.0	0.0		
7320	G	-1.075351E-03	-6.952383E-05	1.571706E-02	0.0	0.0	0.0		
7321	G	-1.011573E-03	-7.387998E-05	1.362974E-02	0.0	0.0	0.0		
7322	G	-9.453601E-04	-7.738403E-05	1.167234E-02	0.0	0.0	0.0		
7323	G	-8.767190E-04	-8.004696E-05	9.849715E-03	0.0	0.0	0.0		
7324	G	-8.056469E-04	-8.182489E-05	8.166697E-03	0.0	0.0	0.0		
7325	G	-7.321354E-04	-8.261224E-05	6.628142E-03	0.0	0.0	0.0		
7326	G	-6.561749E-04	-8.223553E-05	5.238916E-03	0.0	0.0	0.0		
7327	G	-5.777621E-04	-8.044448E-05	4.003893E-03	0.0	0.0	0.0		
7328	G	-4.969155E-04	-7.690633E-05	2.927929E-03	0.0	0.0	0.0		
7329	G	-4.137131E-04	-7.119466E-05	2.015788E-03	0.0	0.0	0.0		
7330	G	-3.283908E-04	-6.283271E-05	1.271940E-03	0.0	0.0	0.0		
7331	G	-2.414706E-04	-5.122121E-05	7.001180E-04	0.0	0.0	0.0		
7332	G	-1.546135E-04	-3.601130E-05	3.021642E-04	0.0	0.0	0.0		
7333	G	-7.152755E-05	-1.866115E-05	7.464606E-05	0.0	0.0	0.0		
7334	G	0.0	0.0	0.0	0.0	0.0	0.0		
7335	G	-1.390520E-03	-1.611531E-05	3.070452E-02	0.0	0.0	0.0		
7336	G	-1.343527E-03	-2.237936E-05	2.797469E-02	0.0	0.0	0.0		
7337	G	-1.295589E-03	-2.881877E-05	2.533404E-02	0.0	0.0	0.0		
7338	G	-1.243968E-03	-3.541786E-05	2.279401E-02	0.0	0.0	0.0		
7339	G	-1.188995E-03	-4.133584E-05	2.036035E-02	0.0	0.0	0.0		
7340	G	-1.131222E-03	-4.638240E-05	1.803946E-02	0.0	0.0	0.0		
7341	G	-1.070812E-03	-5.057344E-05	1.583669E-02	0.0	0.0	0.0		
7342	G	-1.007875E-03	-5.398093E-05	1.375722E-02	0.0	0.0	0.0		

SOLID GLUED CONTACT IN SOL 101.

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5. Plot Displacements



Solution File For Workshop 5

```
$soln5.bdf
NASTRAN SYSTEM(316)=19
SOL 101
CEND
ECHO = NONE
SUBCASE 1
  TITLE=This is a default subcase.
  BCONTACT = 1
  SPC = 2
  LOAD = 2
  DISPLACEMENT (SORT1, REAL)=ALL
  STRESS (SORT1, REAL, VONMISES, BILIN)=ALL
  NLOPRM MPCPCH=BEGN
BEGIN BULK
$
PARAM      POST      0
PARAM      PRTMAXIM YES
$
$ Elements and Element Properties for Hex Elements
PSOLID    1          1          0
$
CHEXA     1          1          7293    7294    7315    7314    7524    7525
          7546    7545
CHEXA     2          1          7294    7295    7316    7315    7525    7526
          7547    7546
CHEXA     3          1          7295    7296    7317    7316    7526    7527
          7548    7547
CHEXA     4          1          7296    7297    7318    7317    7527    7528
          7549    7548
CHEXA     5          1          7297    7298    7319    7318    7528    7529
          7550    7549
```

Solution File For Workshop 5 (Cont.)

```
.
.
.
GRID      8243          9.0003  5.      0.
GRID      8244          9.5004  5.      0.
GRID      8245          10.      5.      0.
$ Loads for Load Case
SPCADD    2          1
LOAD      2          1.      1.      1
$ Displacement Constraints of Load Set
SPC1      1          123456  7313    7334    7355    7376    7397    7418
          7439    7460    7481    7502    7523    7544    7565    7586
          7607    7628    7649    7670    7691    7712    7733    7754
$ Create Contact Tables
BCTABLE   0
          SLAVE    2          0.015          2
          0          0          0
          MASTERS 1
$
BCTABLE   1
          SLAVE    2          0.015          2
          0          0          0
          MASTERS 1
$ Create Deformable Body Contact LBC set for Hex Elements
BCBODY    1          3D          DEFORM  1          0
$
BSURF     1          1          21      41      61      81      101     121
          141     161     181
$
.
```

Solution File For Workshop 5 (Cont.)

```
.  
.   
.$  
$ Create Deformable Body Contact LBC set for Tet Elements  
BCBODY 2 3D DEFORM 2 0  
.$  
BSURF 2 704 950 258 951 557 651 779  
487 486 280 1513 1561 1505 1512 1503  
1442 1499 1509 1571 1053  
  
$ Nodal Forces Applied in the Z Direction  
FORCE 1 8017 0 10. 0. 0. 1.  
FORCE 1 8225 0 10. 0. 0. 1.  
.$  
ENDDATA
```

ADDITIONAL METHODS OF DEFORMABLE BODY

- Along with BSURF users also can try other deformable body methods for BSID in BCBODY: BCPROP

BCPROP

Defines a 3D contact region by element properties. All elements with the specified properties define a contact body used in SOL 101 and MSC Nastran SOLs 400 and 700 only.

1	2	3	4	5	6	7	8	9	10
BCPROP	ID	IP1	IP2	IP3	IP4	IP5	IP6	IP7	
	IP8	IP9	etc.						

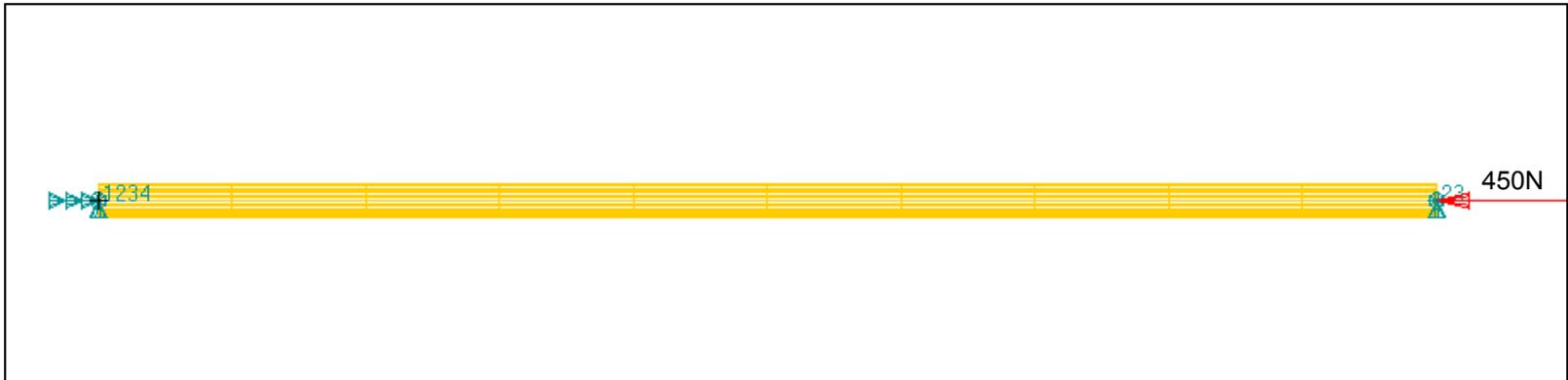
Field

Contents

- ID Identification of a deformable surface corresponding to a BSID value on the BCBODY entry. All elements corresponding to the property IDs specified that may potentially come into contact. Do not specify mixed property types (use all shell, all solid or all beam properties only). (Integer > 0)
- IP_i Property ID. A minimum of one entry is required. (Integer; no Default)

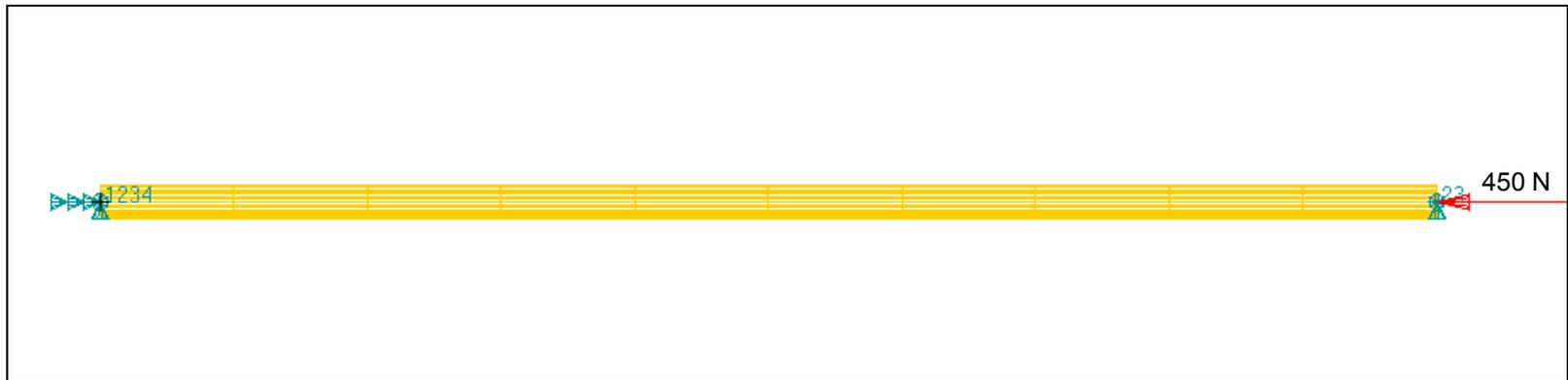
WORKSHOP 1

BUCKLING ANALYSIS OF A STEERING TIE ROD



WORKSHOP OBJECTIVE:

- Run a buckling analysis on a finite element model of a slender bar.
- **Software Version:**
 - MSC Nastran 2012.1
 - Patran 2012



SUGGESTED STEPS:

- 1. Input File: Create an MSC Nastran input file to perform a linear buckling (SOL 105) analysis.**
- 2. Case Control: Add method command.**
 - Create Executive Control and Case Control sections.
- 3. Bulk Data: Create EIGRL eigenvalue entry.**
- 4. Grids: Create GRID points every three inches along the x-axis from 0 to 750 mm**
- 5. Elements: Create ten CBAR elements connecting the GRID points.**
- 6. Properties: Create PBARL properties.**
 - The tie rod for the steering is made from aluminum tubing.
 - Outer Radius = 13 mm.
 - Inner Radius = 6.5 mm.

SUGGESTED STEPS:

- 7. Boundary Conditions:** Create a pin constraint at both rod ends (SPC1).
- 8. Load:** Apply a 450 N compression point load (FORCE entry) on the right end.
- 9. Analysis:** Solution Type = **Nastran Linear Buckling**, Solution Sequence = 105. Submit input file to MSC Nastran.
- 10. Examine Output Text File:** Examine the Nastran output F06 file
- 11. Analysis:** Access analysis results and model data by attaching the XDB file to a Patran database
- 12. Results:** Plot buckling results and determine critical buckling load.

1. Open Input File:

1. Open the MSC Nastran input file [wkshp1.bdf](#)

```
$
$ wkshp1.bdf
$
$ Add the Executive and Case Control Sections
$

BEGIN BULK
PARAM      POST      0
$
$
$ Add the eigenvalue entry

$ Create the GRID Points

$ Create the CBAR elements

$ Add the Element Properties

$ Material: Aluminum
MAT1      1          68.9E3          .3
$
$ Add the SPC1 entries to define the boundary condition

$ Add the Force entry

ENDDATA
```

2. Create Control Sections and EIGRL Card:

2. Create Executive Control and Case Control sections.
3. Bulk Data: Create EIGRL eigenvalue entry.

```
$
$ soln1.bdf
$
SOL 105
$
CEND
TITLE = Tie Rod Buckling Analysis
SPC = 1
SUBCASE 1
  LOAD = 1
  DISP = ALL
  SPCFORCE = ALL
SUBCASE 2
  METHOD = 1
  DISP = ALL
BEGIN BULK
PARAM      POST      0
$
$
$ Eigenvalue entry
$  1  <<  2  <<  3  <<  4  <<  5  <<  6  <<  7  <<  8  <<  9  <<  10  >
EIGRL      1                               5
```

4. Create GRID Points

4. Grids: Create GRID points every three inches along the x-axis from 0 to 750mm

```
$ GRID Points
GRID 1      0.  0.  0.
GRID 2     75.  0.  0.
GRID 3    150.  0.  0.
GRID 4    225.  0.  0.
GRID 5    300.  0.  0.
GRID 6    375.  0.  0.
GRID 7    450.  0.  0.
GRID 8    525.  0.  0.
GRID 9    600.  0.  0.
GRID 10   675.  0.  0.
GRID 11   750.  0.  0.
```

5. Create CBAR and PBARL Cards:

5. Create ten CBAR elements connecting the GRID points.

```
$ CBAR elements
$ 1 >< 2 >< 3 >< 4 >< 5 >< 6 >< 7 >< 8 >< 9 >< 10 >
CBAR 1 1 1 2 0. 1. 0.
CBAR 2 2 1 2 3 0. 1. 0.
CBAR 3 3 1 3 4 0. 1. 0.
CBAR 4 4 1 4 5 0. 1. 0.
CBAR 5 5 1 5 6 0. 1. 0.
CBAR 6 6 1 6 7 0. 1. 0.
CBAR 7 7 1 7 8 0. 1. 0.
CBAR 8 8 1 8 9 0. 1. 0.
CBAR 9 9 1 9 10 0. 1. 0.
CBAR 10 10 1 10 11 0. 1. 0.
```

6. Create PBARL Tube properties

```
$ Element Properties
PBARL 1 1 TUBE
      13.0 6.5
```

7. Create Load and Boundary Conditions and Solve:

7. Apply SPC1 boundary conditions.

8. Apply FORCE load.

```
$ SPC1 entries
SPC1 1 1234 1
SPC1 1 23 11
$ Force entry
FORCE 1 11 0 450. -1. 0. 0.
ENDDATA
```

9. Submit input file to MSC Nastran.

10. F06 OUTPUT FILE

```

          M O D E L   S U M M A R Y           BULK = 0
    ENTRY NAME      NUMBER OF ENTRIES
    -----
          CBAR                      10
          EIGRL                       1
          FORCE                        1
          GRID                       11
          MAT1                         1
          PARAM                        1
          PBAR                         1
          SPC1                         2

^^^
^^^ >>> IFP OPERATIONS COMPLETE <<<
^^^
*** USER INFORMATION MESSAGE 4379 (IFP9A)
    THE USER SUPPLIED PBAR/PBRSECT BULK DATA ENTRIES ARE REPLACED BY THE FOLLOWING PBAR ENTRIES.
    CONVERSION METHOD FOR PBAR/PBEAML - FINITE ELEMENT METHOD.
    PBAR
          1 3.000E+01 0.0000E+00 0.0000E+00 1.3000E+01 -1.3000E+01 0.0000E+00 0.0000E+00 -1.3000E+01
          5.8855E-01 5.8856E-01 0.0000E+00
1  TIE ROD BUCKLING ANALYSIS                                     MARCH 5, 2012 MSC.NASTRAN 11/25/11 PAGE 6
0
*** USER INFORMATION MESSAGE 7310 (VECPRN)
    ORIGIN OF SUPERELEMENT BASIC COORDINATE SYSTEM WILL BE USED AS REFERENCE LOCATION.
    RESULTANTS ABOUT ORIGIN OF SUPERELEMENT BASIC COORDINATE SYSTEM IN SUPERELEMENT BASIC SYSTEM COORDINATES.
0
    SUBCASE/   LOAD
    DAREA ID   TYPE      T1          T2          T3          R1          R2          R3
0          1   FX   -4.500000E+02  -----  -----  -----  0.000000E+00  0.000000E+00
          FY   -----  0.000000E+00  -----  0.000000E+00  0.000000E+00  0.000000E+00
          FZ   -----  -----  0.000000E+00  0.000000E+00  0.000000E+00  0.000000E+00
          MX   -----  -----  -----  0.000000E+00  0.000000E+00  0.000000E+00
          MY   -----  -----  -----  0.000000E+00  0.000000E+00  0.000000E+00
          MZ   -----  -----  -----  0.000000E+00  0.000000E+00  0.000000E+00
          TOTALS -4.500000E+02  0.000000E+00  0.000000E+00  0.000000E+00  0.000000E+00  0.000000E+00
1  TIE ROD BUCKLING ANALYSIS                                     MARCH 5, 2012 MSC.NASTRAN 11/25/11 PAGE 7
0
*** USER INFORMATION MESSAGE 7310 (VECPRN)
    ORIGIN OF SUPERELEMENT BASIC COORDINATE SYSTEM WILL BE USED AS REFERENCE LOCATION.
    RESULTANTS ABOUT ORIGIN OF SUPERELEMENT BASIC COORDINATE SYSTEM IN SUPERELEMENT BASIC SYSTEM COORDINATES.
0
    SUBCASE/   LOAD
    DAREA ID   TYPE      T1          T2          T3          R1          R2          R3
0          2   FX   0.000000E+00  -----  -----  -----  0.000000E+00  0.000000E+00
          FY   -----  0.000000E+00  -----  0.000000E+00  0.000000E+00  0.000000E+00
          FZ   -----  -----  0.000000E+00  0.000000E+00  0.000000E+00  0.000000E+00
          MX   -----  -----  -----  0.000000E+00  0.000000E+00  0.000000E+00
          MY   -----  -----  -----  0.000000E+00  0.000000E+00  0.000000E+00
          MZ   -----  -----  -----  0.000000E+00  0.000000E+00  0.000000E+00
          TOTALS 0.000000E+00  0.000000E+00  0.000000E+00  0.000000E+00  0.000000E+00  0.000000E+00

```

10. F06 OUTPUT FILE (Cont.)

Lowest Buckling Load = λ_1 x applied load = 56.3 x 100 = 25335 N

MODE NO.	EXTRACTION ORDER	EIGENVALUE	REAL EIGENVALUES			GENERALIZED MASS	GENERALIZED STIFFNESS
			RADIANS	CYCLES			
1	1	5.630815E+01	7.503876E+00	1.194279E+00	2.960653E+00	1.667089E+02	
2	2	5.630816E+01	7.503876E+00	1.194279E+00	2.960653E+00	1.667089E+02	
3	3	2.226072E+02	1.492003E+01	2.374596E+00	1.307804E+01	2.911266E+03	
4	4	2.226072E+02	1.492003E+01	2.374596E+00	1.307804E+01	2.911266E+03	
5	5	4.918294E+02	2.217723E+01	3.529615E+00	2.648946E+01	1.302829E+04	

1 TIE ROD BUCKLING ANALYSIS MARCH 5, 2012 MSC.NASTRAN 11/25/11 PAGE 14

0 SUBCASE 2

EIGENVALUE = 5.630815E+01

POINT ID.	TYPE	REAL EIGENVECTOR NO. 1					
		T1	T2	T3	R1	R2	R3
1	G	0.0	0.0	0.0	0.0	-2.338928E-10	4.171641E-03
2	G	-5.613876E-17	3.090170E-01	1.732576E-08	-1.160062E-18	-2.224453E-10	3.967466E-03
3	G	-2.386250E-18	5.877852E-01	3.295555E-08	-1.893076E-18	-1.892232E-10	3.374929E-03
4	G	1.273202E-17	8.090170E-01	4.535942E-08	6.630044E-18	-1.374787E-10	2.452029E-03
5	G	-4.768336E-17	9.510565E-01	5.332320E-08	-3.000617E-18	-7.227683E-11	1.289108E-03
6	G	-1.742306E-17	1.000000E+00	5.606733E-08	-1.007134E-17	1.176742E-17	-5.393898E-17
7	G	-2.355597E-17	9.510565E-01	5.332319E-08	7.671368E-19	7.227685E-11	-1.289108E-03
8	G	-2.265262E-17	8.090170E-01	4.535942E-08	1.087170E-17	1.374787E-10	-2.452029E-03
9	G	1.036038E-17	5.877852E-01	3.295555E-08	-1.396621E-17	1.892232E-10	-3.374929E-03
10	G	2.393368E-17	3.090170E-01	1.732576E-08	2.091782E-18	2.224452E-10	-3.967466E-03
11	G	7.487618E-17	0.0	0.0	1.144068E-18	2.338928E-10	-4.171641E-03

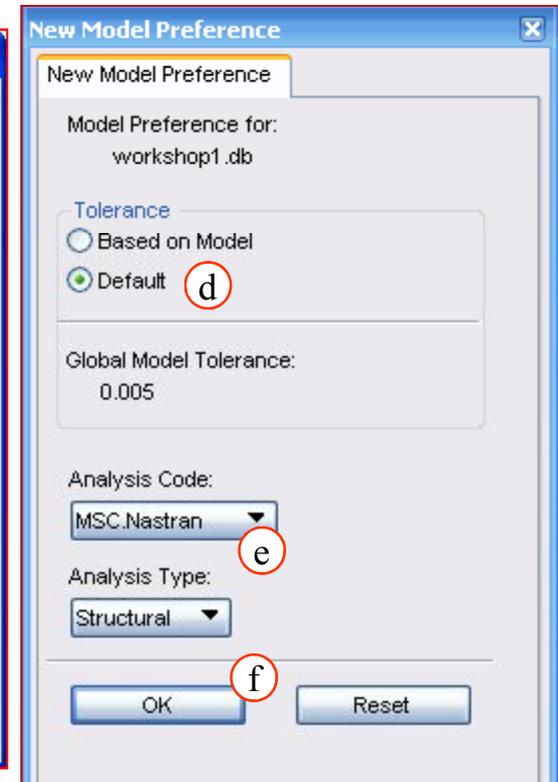
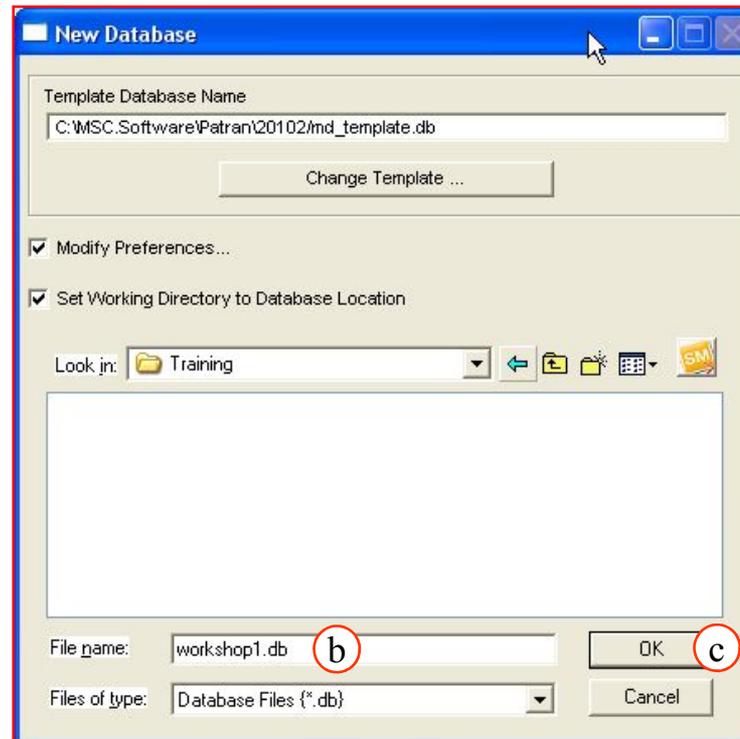
1 TIE ROD BUCKLING ANALYSIS MARCH 5, 2012 MSC.NASTRAN 11/25/11 PAGE 15

11. POST PROCESSING

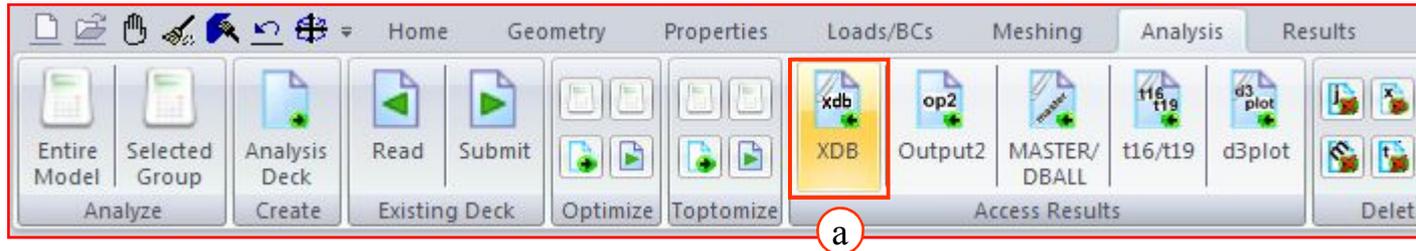


Create a new database

- a. File: New
- b. Enter **workshop1** as the File name
- c. Click **OK**.
- d. Select Default tolerances.
- e. Select **MSC Nastran** and **Structural** for the Analysis Code and Type.
- f. Click **OK**.



11. POST PROCESSING



Attach results file

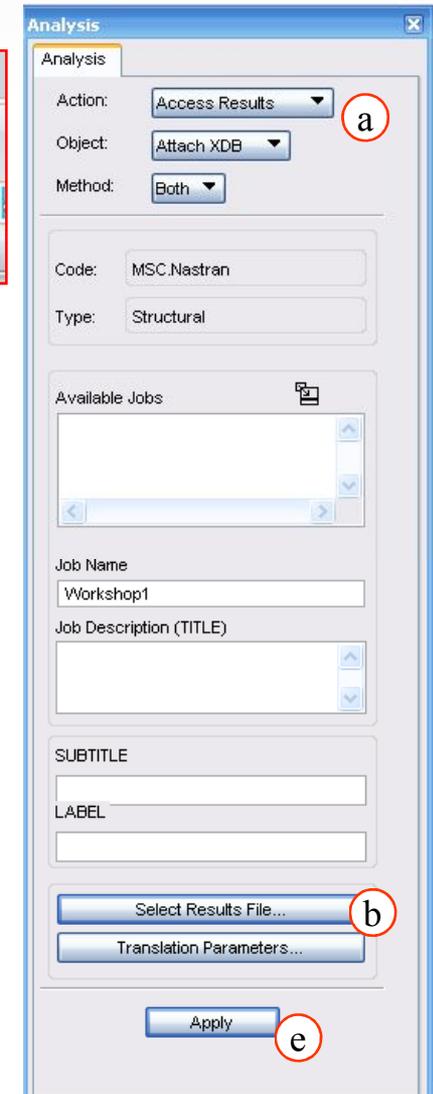
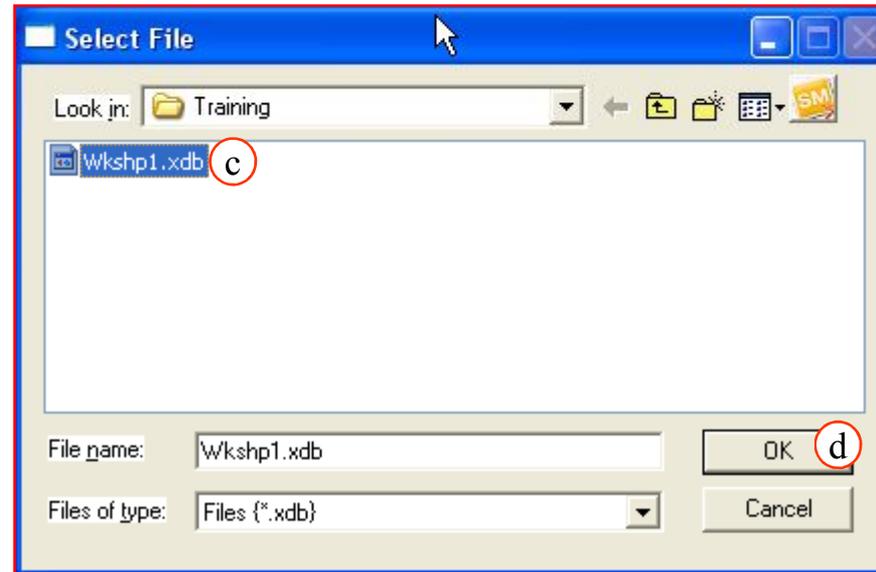
a. Analysis: Access Results / Attach XDB / Both

b. Click Select Results File.

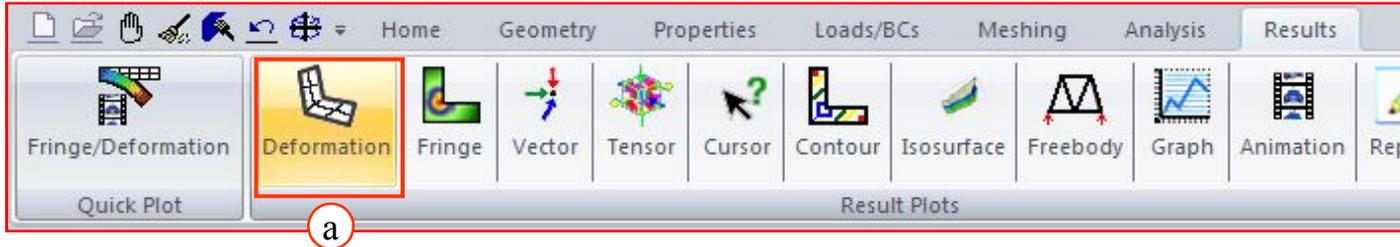
c. Select wkshp1.xdb.

d. Click OK.

e. Click Apply.



12. PLOT RESULTS



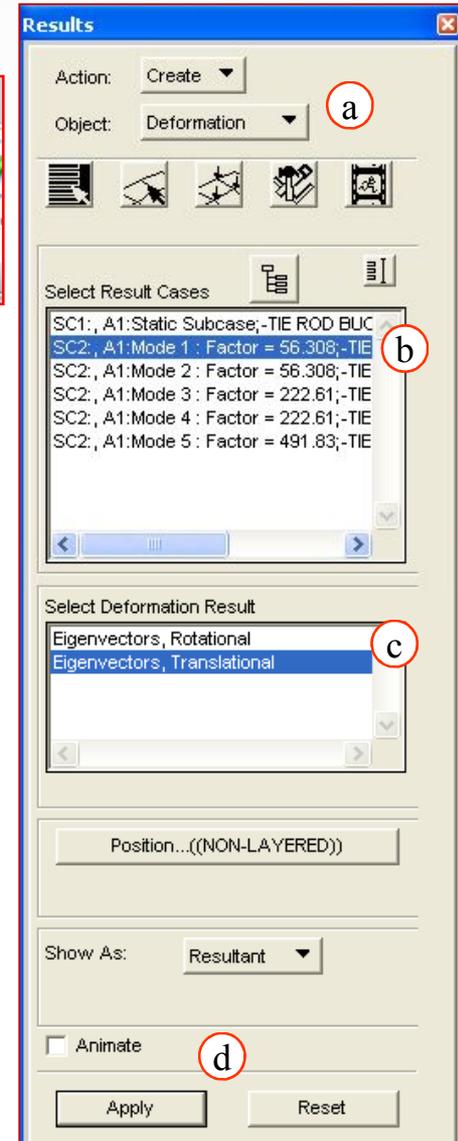
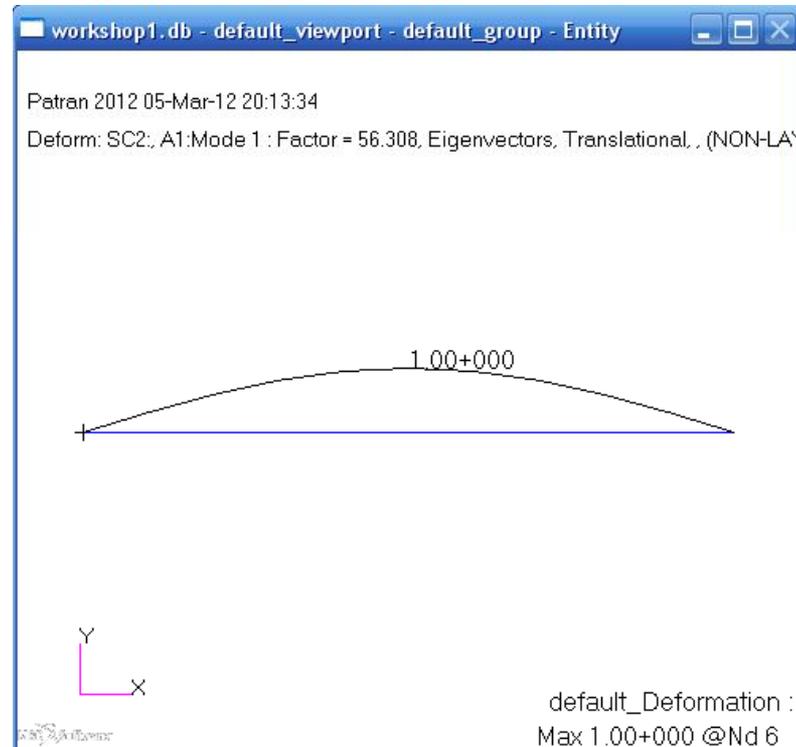
Plot the results

a. Results: Create / Deformation

b. Select the **First Mode** as shown.

c. Select **Eigenvectors, Translational** as the Deformation Result.

d. Click **Apply**.



SOLUTION FILE FOR WORKSHOP 1

```
SOL 105
$
CEND
TITLE = Tie Rod Buckling Analysis
SPC = 1
SUBCASE 1
  LOAD = 1
  DISP = ALL
  SPCFORCE = ALL
SUBCASE 2
  METHOD = 1
  DISP = ALL
BEGIN BULK
PARAM  POST  0
$
$ Eigenvalue entry
$ 1 >< 2 >< 3 >< 4 >< 5 >< 6 >< 7 >< 8 >< 9 >< 10 >
EIGRL 1          5
$ GRID Points
GRID 1          0.  0.  0.
GRID 2          75. 0.  0.
GRID 3          150. 0.  0.
GRID 4          225. 0.  0.
GRID 5          300. 0.  0.
GRID 6          375. 0.  0.
GRID 7          450. 0.  0.
GRID 8          525. 0.  0.
GRID 9          600. 0.  0.
GRID 10         675. 0.  0.
GRID 11         750. 0.  0.
```

SOLUTION FILE FOR WORKSHOP 1 (Cont.)

```
$ CBAR elements
$ 1 >< 2 >< 3 >< 4 >< 5 >< 6 >< 7 >< 8 >< 9 >< 10 >
CBAR 1 1 1 2 0. 1. 0.
CBAR 2 1 2 3 0. 1. 0.
CBAR 3 1 3 4 0. 1. 0.
CBAR 4 1 4 5 0. 1. 0.
CBAR 5 1 5 6 0. 1. 0.
CBAR 6 1 6 7 0. 1. 0.
CBAR 7 1 7 8 0. 1. 0.
CBAR 8 1 8 9 0. 1. 0.
CBAR 9 1 9 10 0. 1. 0.
CBAR 10 1 10 11 0. 1. 0.
$ Element Properties
PBARL 1 1 TUBE
13. 6.5
$ Material: Aluminum
MAT1 1 68.95E3 .3
$
$ SPC1 entries
SPC1 1 1234 1
SPC1 1 23 11
$ Force entry
FORCE 1 11 0 450. -1. 0. 0.
ENDDATA
```

THEORETICAL SOLUTION FOR WORKSHOP 1

- **Critical Buckling Force:**

$$P_{cr} = \frac{\pi^2 EI}{L^2}$$

Where,

- $I = 21029.77 \text{ mm}^4$
- $E = 68.95 \text{E}3 \text{ N/mm}^2$
- $L = 750 \text{ mm}$.

$$P_{cr} = \frac{\pi^2 EI}{L^2} = \frac{\pi^2 \times 68.95 \text{e}3 \times 21029.7}{750^2} = 25442 \text{ N}$$

- The theoretical solution is slightly higher than the MSC Nastran result. Can you explain this difference?

THEORETICAL SOLUTION FOR WORKSHOP 1

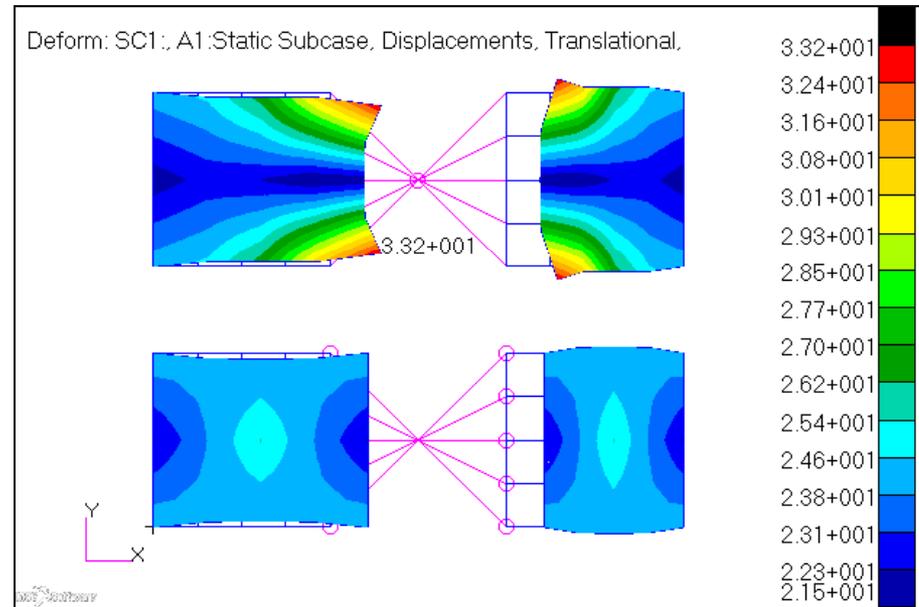
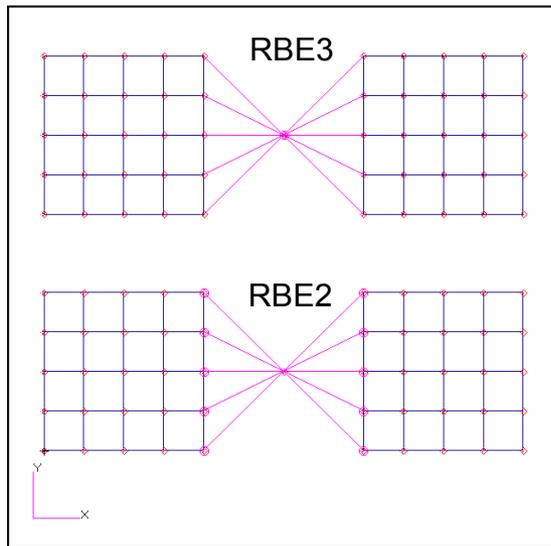
- **We used PBARL properties in this example, which incorporates shear flexibility.**
 - Shear flexibility is not accounted for in the theoretical Euler buckling equation.

$$P_{cr} = \frac{\pi^2 EI}{L^2}$$

- With shear flexibility, the critical force will be slightly lower.
- In order to match these results more closely in Nastran, you could set appropriate value of Area factor for shear K1 and K2 as follows; For PBAR, leave K1 and K2 blank. For PBEAM, set K1=K2 = 0.0 (For more details, see remarks under PBAR and PBEAM, in the Nastran Quick Reference Guide).

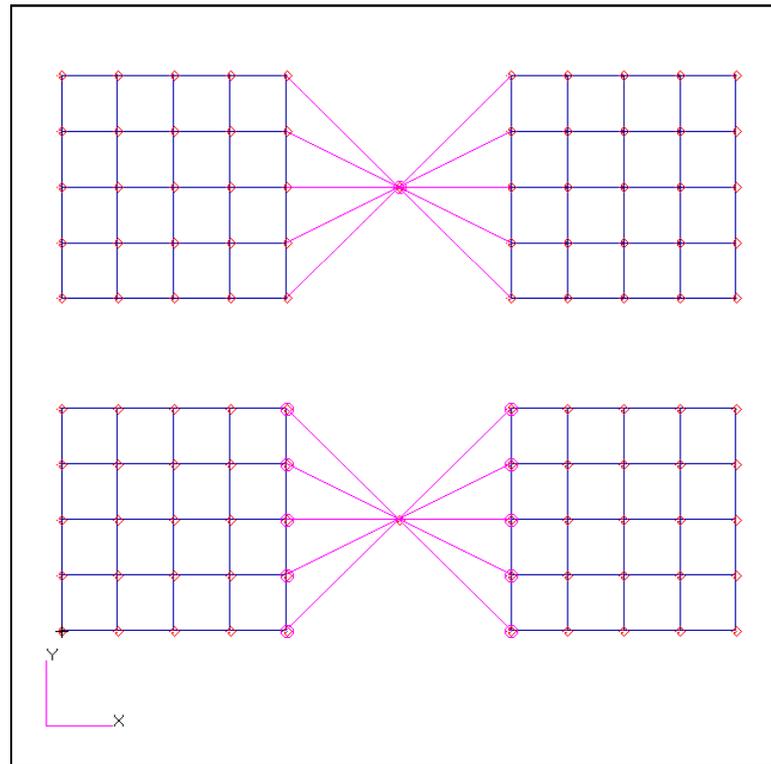
WORKSHOP 2

RBE2 v/s RBE3



WORKSHOP OBJECTIVE:

- Understand the difference between RBE2 and RBE3.
- **Software Version:**
 - MSC Nastran 2012.1
 - Patran 2012



SUGGESTED STEPS:

- 1. Input File: Edit the given MSC Nastran input file [wkshp2.bdf](#).**
The input file contains two models. Each model has two similar plates. There are two nodes created in between the two sets of plates. The two plates on the top are connected with **RBE3 element** and the bottom set of plates is connected with **RBE2 element**.
- 2. Create RBE2 and RBE3 entry.**
- 3. Analysis: Solution Type = Nastran Linear Static , Solution Sequence = 101. Submit input file to MSC Nastran.**
- 4. Examine Output File: Examine the Nastran output F06 file.**
- 5. Results: Plot displacements.**

1. Open Input File:

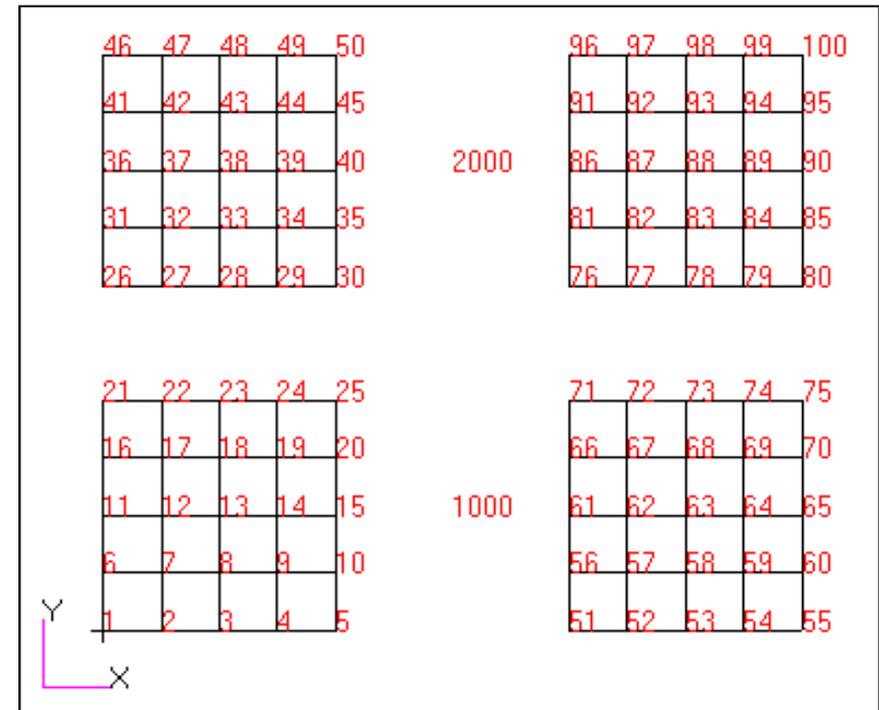
1. Input File: Edit the given MSC Nastran input file [wkshp2.bdf](#)

```
$
$wkshp1.bdf
SOL 101
CEND
TITLE = RBE2 VS. RBE3
SUBCASE 1
  SPC = 2
  LOAD = 2
  DISP=ALL
  SPCFORCE=ALL
  MPCFORCE=ALL
  STRESS=ALL
BEGIN BULK
PARAM      POST      0
PSHELL    1          1          .2          1          1
$
CQUAD4    1          1          1          2          7          6
CQUAD4    2          1          2          3          8          7
.
$
MAT1      1          1.+7          .33
$ Create RBE2 Element
$ Create RBE3 Element
$
GRID      1          0.          0.          0.
.
```

1. Open Input File: (Cont.)

- **Scroll down to the end of the Grid list to see the two nodes to create RBE elements.**

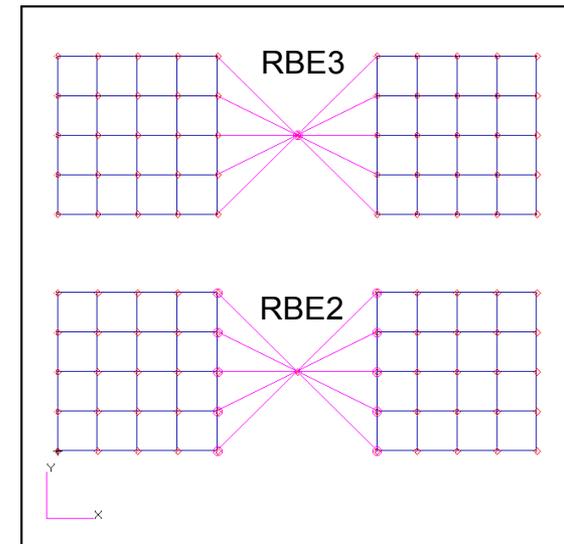
```
.  
. .  
. .  
GRID      98      635.    635.    0.  
GRID      99      698.5   635.    0.  
GRID     100      762.    635.    0.  
$  
$Create two independent nodes  
GRID     1000     381.    127.    0.    1  
GRID     2000     381.    508.    0.    1  
$  
SPCADD    2        1  
LOAD      3        1.    1.    1  
$  
. .  
. .
```



2. Create RBE2 and RBE3 Elements

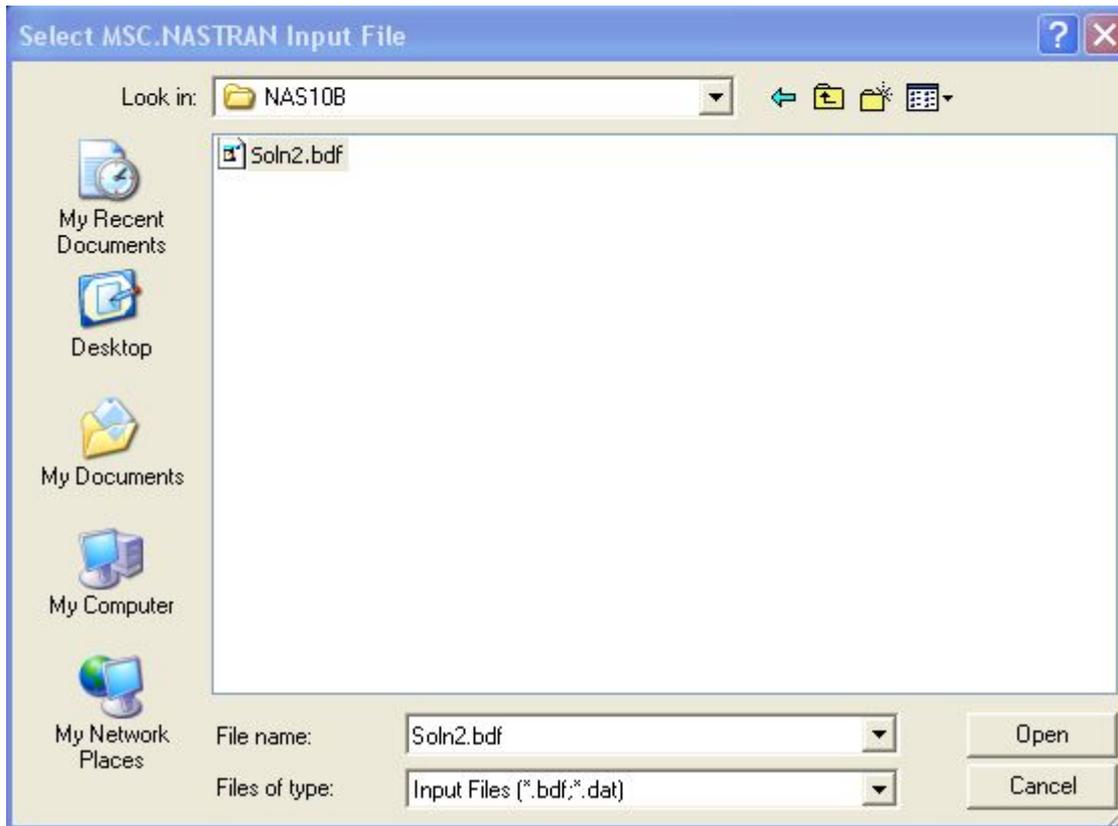
2. Create RBE2 and RBE3 entries

```
.  
.   
CQUAD4 62 1 92 93 98 97  
CQUAD4 63 1 93 94 99 98  
CQUAD4 64 1 94 95 100 99  
$  
MAT1 1 68000. 2500. .33  
$ Create RBE2 Element  
RBE2 1000 1000 123456 5 10 15 20 25  
51 56 61 66 71  
$ Create RBE3 Element  
RBE3 2000 2000 123456 1. 123 30 35  
40 45 50 76 81 86 91 96  
$  
GRID 1 0. 0. 0.  
GRID 2 63.5 0. 0.  
GRID 3 127. 0. 0.  
GRID 4 190.5 0. 0.
```



3. Submit Input file to MSC Nastran

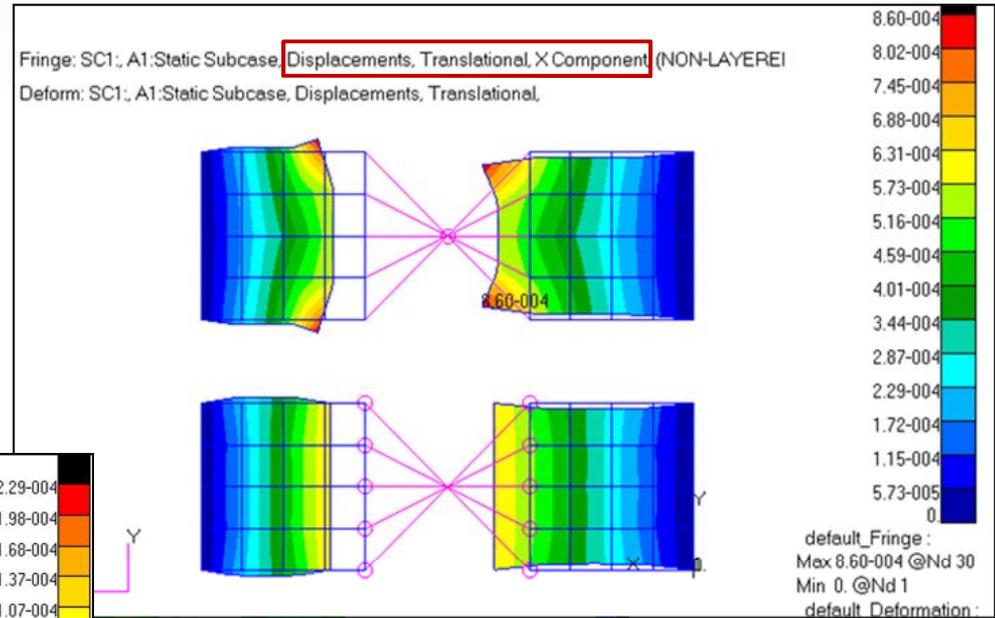
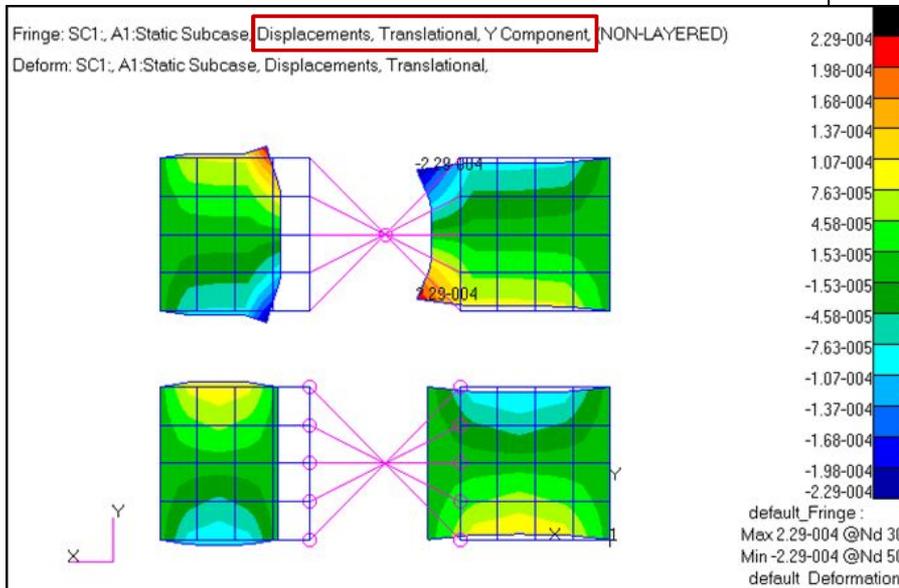
3. Analysis: Solution Type = Nastran Linear Static , Solution Sequence = 101. Submit input file to MSC Nastran.



4. F06 Output File

DISPLACEMENT VECTOR									
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	1.738007E-04	9.296171E-05	0.0	0.0	0.0	6.192498E-07		
3	G	3.189206E-04	1.058506E-04	0.0	0.0	0.0	2.250631E-21		
4	G	4.640405E-04	9.296171E-05	0.0	0.0	0.0	-6.192498E-07		
5	G	6.378412E-04	5.209580E-19	0.0	0.0	0.0	-3.875961E-22		
6	G	0.0	0.0	0.0	0.0	0.0	0.0		
7	G	1.480813E-04	3.780291E-05	0.0	0.0	0.0	3.164929E-07		
8	G	3.189206E-04	5.700098E-05	0.0	0.0	0.0	8.963438E-22		
9	G	4.897599E-04	3.780291E-05	0.0	0.0	0.0	-3.164929E-07		
10	G	6.378412E-04	5.209580E-19	0.0	0.0	0.0	-3.875961E-22		
11	G	0.0	0.0	0.0	0.0	0.0	0.0		
12	G	1.504125E-04	1.633426E-19	0.0	0.0	0.0	1.554870E-21		
13	G	3.189206E-04	3.606874E-19	0.0	0.0	0.0	1.490767E-21		
14	G	4.874287E-04	4.996473E-19	0.0	0.0	0.0	6.534628E-22		
15	G	6.378412E-04	5.209580E-19	0.0	0.0	0.0	-3.875961E-22		
16	G	0.0	0.0	0.0	0.0	0.0	0.0		
17	G	1.480813E-04	-3.780291E-05	0.0	0.0	0.0	-3.164929E-07		
18	G	3.189206E-04	-5.700098E-05	0.0	0.0	0.0	2.378652E-21		
19	G	4.897599E-04	-3.780291E-05	0.0	0.0	0.0	3.164929E-07		
20	G	6.378412E-04	5.209580E-19	0.0	0.0	0.0	-3.875961E-22		
21	G	0.0	0.0	0.0	0.0	0.0	0.0		
22	G	1.738007E-04	-9.296171E-05	0.0	0.0	0.0	-6.192498E-07		
23	G	3.189206E-04	-1.058506E-04	0.0	0.0	0.0	1.952846E-21		
24	G	4.640405E-04	-9.296171E-05	0.0	0.0	0.0	6.192498E-07		
25	G	6.378412E-04	5.209580E-19	0.0	0.0	0.0	-3.875961E-22		
26	G	0.0	0.0	0.0	0.0	0.0	0.0		
27	G	1.743792E-04	8.211259E-05	0.0	0.0	0.0	5.443522E-07		
28	G	3.403217E-04	8.644417E-05	0.0	0.0	0.0	2.113426E-07		
29	G	5.509027E-04	8.642998E-05	0.0	0.0	0.0	1.199630E-06		
30	G	8.597781E-04	2.288135E-04	0.0	0.0	0.0	3.280145E-06		
31	G	0.0	0.0	0.0	0.0	0.0	0.0		
32	G	1.484686E-04	2.897422E-05	0.0	0.0	0.0	2.499004E-07		
33	G	3.156399E-04	3.457485E-05	0.0	0.0	0.0	2.178821E-07		
34	G	4.697343E-04	3.451086E-05	0.0	0.0	0.0	8.361959E-07		
35	G	5.855832E-04	1.145595E-04	0.0	0.0	0.0	1.764670E-06		
36	G	0.0	0.0	0.0	0.0	0.0	0.0		
37	G	1.454794E-04	1.931433E-19	0.0	0.0	0.0	2.489938E-21		
38	G	2.905163E-04	4.794707E-19	0.0	0.0	0.0	3.846422E-21		
39	G	4.184936E-04	8.328048E-19	0.0	0.0	0.0	3.992933E-21		
40	G	5.716493E-04	1.140165E-18	0.0	0.0	0.0	3.772802E-21		
41	G	0.0	0.0	0.0	0.0	0.0	0.0		
42	G	1.484686E-04	-2.897422E-05	0.0	0.0	0.0	-2.499004E-07		
43	G	3.156399E-04	-3.457485E-05	0.0	0.0	0.0	-2.178821E-07		
44	G	4.697343E-04	-3.451086E-05	0.0	0.0	0.0	-8.361959E-07		
45	G	5.855832E-04	-1.145595E-04	0.0	0.0	0.0	-1.764670E-06		
46	G	0.0	0.0	0.0	0.0	0.0	0.0		
47	G	1.743792E-04	8.211259E-05	0.0	0.0	0.0	5.443522E-07		

5. Plot Displacements



Solution File for Workshop 2

```
$
$soln2.bdf
SOL 101
CEND
TITLE = RBE2 VS. RBE3
SUBCASE 1
  SPC = 2
  LOAD = 2
  DISP=ALL
  SPCFORCE=ALL
  MPCFORCE=ALL
  STRESS=ALL
BEGIN BULK
PARAM      POST      0
PSHELL    1          1      5.      1          1
$
CQUAD4    1          1      1        2        7        6
CQUAD4    2          1      2        3        8        7
.
MAT1      1          68000.  2500.  .33
$ RBE2 Element
RBE2      1000      1000      123456  5          10          15          20          25
          51          56          61          66          71
$ RBE3 Element
RBE3      2000          2000      123456  1.          123          30          35
          40          45          50          76          81          86          91          96
GRID      1          0.          0.          0.
GRID      2          63.5       0.          0.
GRID      3          127.        0.          0.
```

Solution File for Workshop 2 (Cont.)

```
.  
.br/>GRID      1000          381.   127.    0.    1  
GRID      2000          381.   508.    0.    1  
$ Loads for Load Case : Untitled.SC1  
SPCADD    2          1  
LOAD      3          1.    1.    1  
$ Displacement Constraints of Load Set : spc1.1  
SPC1      1          123456  1      6      11      16      21      26  
          31          36      41      46      55      60      65      70  
          75          80      85      90      95      100  
$ Nodal Forces of Load Set : force.1  
FORCE     1          1000    1      450.   1.      0.      0.  
FORCE     1          2000    1      450.   1.      0.      0.  
$  
ENDDATA
```

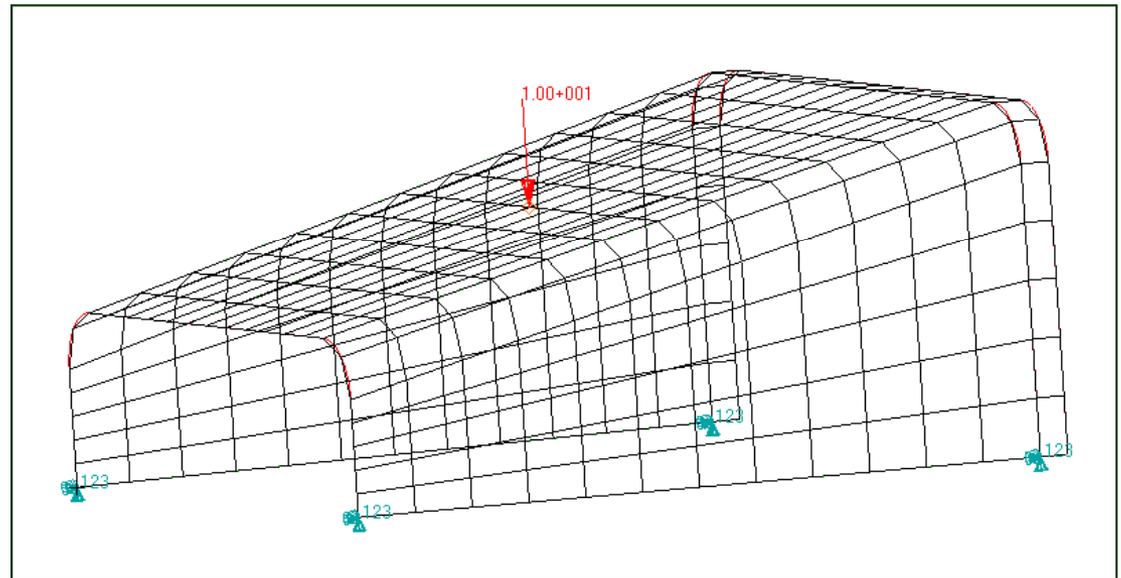
WORKSHOP 3

INSTRUMENT CONSOLE-COMPOSITES



WORKSHOP OBJECTIVES:

- Create a composite shell model and material properties for a graphite-epoxy tape layup and perform a finite element analysis.
- Software Version:
 - MSC Nastran 2012.1
 - Patran 2012



SUGGESTED STEPS:

- 1. Input File: Examine the existing MSC Nastran input file [wkshp3.bdf](#)**
 - The CQUAD4 elements have MCID set to coordinate 0. (So the material orientation will be aligned with the basic X axis.)
 - The load is already included in the file, and is a 10 lb. point load in the middle of the top face, representing someone pressing down on the console.
 - The model is constrained in all three translations at the lower edges.

SUGGESTED STEPS:

2. Materials: Create MAT8 composite material entry:

- Tape Properties (0.14 mm thick):

E_1	E_2	ν_{12}	G_{12}	G_{23}	G_{13}	ρ	A_{11}	A_{22}
13.8E4	13.8E3	0.35	6.89E3	6.89E3	6.89E3	3.6E-9	-4.14e-7	8.1e-6

- Failure Criteria: Hill Theory

Component	Tension ₁₁	Tension ₂₂	Compression ₁₁	Compression ₂₂	Shear	Bonding Shear
Stress Limit	6.17	0.52	827.3	82.7	86.18	34.47

- Composite Layup:

Ply	1	2	3	4	5	6	7	8
Orientation	0	45	-45	90	90	-45	45	0

SUGGESTED STEPS:

- 3. Properties: Create a PCOMP property to represent the laminate. The first two lines are shown below:**

PCOMP	PID	Z0	NSM	SB	FT	TREF	GE	LAM
	MID1	T1	THETA1	SOUT1	MID2	T2	THETA2	SOUT2
PCOMP	1			34.47	HILL			
	1	0.137	0.	YES	1	0.137	45.	YES

- 4. Analysis: Solution Type = Nastran Linear Static, Solution Sequence = 101. Submit input file to MSC Nastran.**
- 3. Examine Output Text File: Examine the Nastran output F06 file**
- 4. Review the Nastran output F06 file for Displacement, Stress and Failure Indices output**
- 5. Results: Plot displacement results in Patran with OP2 file.**

1. Open Input File:

1. Open [wkshp3.bdf](#) with a text editor.

```
$
$ wkshp3.bdf
$
SOL 101
CEND
TITLE = Composite Console Analysis
ECHO = NONE
SUBCASE 1
  SPC = 1
  LOAD = 1
  DISP=ALL
  SPCFORCE=ALL
  STRESS(CORNER)=ALL
BEGIN BULK
PARAM  POST  -1
$
$ Enter composite properties (PCOMP)

$ Enter material properties (MAT8)

$ Elements:
CQUAD4 1 1 1 2 8 7 0
CQUAD4 2 1 2 3 9 8 0
CQUAD4 3 1 3 4 10 9 0
CQUAD4 4 1 4 5 11 10 0
CQUAD4 5 1 5 6 12 11 0
CQUAD4 6 1 7 8 14 13 0
CQUAD4 7 1 8 9 15 14 0
CQUAD4 8 1 9 10 16 15 0
CQUAD4 9 1 10 11 17 16 0
CQUAD4 10 1 11 12 18 17 0
```

2. Input Material Property and Solve:

2. Create MAT8 composite material entry:

\$ Lamina Description:

```
MAT8      1      138000. 13800.  .35      6890.  6890.  6890.  3.6e-9
          -2.3-7  4.5-6          6.17    827.3  .52    82.7   86.8
```

3. Create a PCOMP property to represent the laminate:

```
PCOMP     1          34.47  HILL
          1      .14      0.      YES    1      .14      45.      YES
          1      .14     -45.     YES    1      .14      90.      YES
          1      .14      90.     YES    1      .14     -45.     YES
          1      .14      45.     YES    1      .14      0.       YES
```

4. Submit input file to MSC Nastran.

5. Review F06 Output File:

```

*** USER INFORMATION MESSAGE 7310 (VECPRN)
ORIGIN OF SUPERELEMENT BASIC COORDINATE SYSTEM WILL BE USED AS REFERENCE LOCATION.
RESULTANTS ABOUT ORIGIN OF SUPERELEMENT BASIC COORDINATE SYSTEM IN SUPERELEMENT BASIC SYSTEM COORDINATES.
0
SUBCASE/   LOAD
DAREA ID  TYPE      T1          T2          T3          R1          R2          R3
0          1      FX      0.000000E+00  -----  -----  -----  -----  0.000000E+00  0.000000E+00
          FY      -----  -4.500000E+01  -----  3.429000E+03  -----  -3.429000E+03
          FZ      -----  -----  0.000000E+00  0.000000E+00  0.000000E+00  -----
          MX      -----  -----  -----  0.000000E+00  -----  -----
          MY      -----  -----  -----  -----  0.000000E+00  -----
          MZ      -----  -----  -----  -----  -----  0.000000E+00
          TOTALS  0.000000E+00 -4.500000E+01  0.000000E+00  3.429000E+03  0.000000E+00 -3.429000E+03
1  COMPOSITE CONSOLE ANALYSIS          MARCH 5, 2012 MSC.NASTRAN 11/25/11 PAGE 7
0
SUBCASE 1
*** SYSTEM INFORMATION MESSAGE 4159 (DFMSA)
THE DECOMPOSITION OF KLL YIELDS A MAXIMUM MATRIX-TO-FACTOR-DIAGONAL RATIO OF 3.679505E+02
*** USER INFORMATION MESSAGE 5293 (SSG3A)
FOR DATA BLOCK KLL
LOAD SEQ. NO. EPSILON EXTERNAL WORK EPSILONS LARGER THAN 0.001 ARE FLAGGED WITH ASTERISKS
1 1 2.6129785E-13 5.6652290E+01
1  COMPOSITE CONSOLE ANALYSIS          MARCH 5, 2012 MSC.NASTRAN 11/25/11 PAGE 8

```

5. Review F06 Output File (Cont.):

0

SUBCASE 1

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	-2.849216E-02	2.336342E-03	3.294381E-01	-1.458551E-02	-6.266951E-03	-8.524970E-04
2	G	-3.660502E-02	1.355142E-03	4.466627E-01	-4.362814E-03	-5.142789E-03	-3.056534E-04
3	G	-3.655222E-02	4.257419E-04	4.458716E-01	3.982171E-03	-3.953998E-03	3.208881E-04
4	G	-2.895310E-02	-1.065361E-04	3.525710E-01	1.017724E-02	-2.812908E-03	8.247802E-04
5	G	-1.588448E-02	-3.183142E-04	1.935480E-01	1.428966E-02	-1.583882E-03	1.157986E-03
6	G	0.0	0.0	0.0	1.564317E-02	-3.703762E-04	1.266999E-03
7	G	-2.593575E-02	6.324003E-05	3.097068E-01	-1.213111E-02	-3.930615E-03	-9.982515E-04
8	G	-3.292646E-02	2.588738E-04	4.017496E-01	-3.427860E-03	-3.626366E-03	-2.411225E-04
9	G	-3.233496E-02	2.557641E-04	3.955935E-01	4.102292E-03	-2.804767E-03	3.469254E-04
10	G	-2.538481E-02	1.259738E-04	3.098872E-01	9.738266E-03	-1.949149E-03	7.979086E-04
11	G	-1.387888E-02	6.804049E-05	1.685752E-01	1.327039E-02	-1.054005E-03	1.089418E-03
12	G	0.0	0.0	0.0	1.424785E-02	7.258959E-05	1.180410E-03
13	G	-2.452408E-02	-8.592900E-05	2.973600E-01	-1.058643E-02	-3.588507E-03	-8.697758E-04
14	G	-3.039322E-02	-6.975765E-05	3.696447E-01	-2.409275E-03	-2.638266E-03	-1.891462E-04
15	G	-2.931812E-02	2.925072E-05	3.573403E-01	4.274878E-03	-1.995678E-03	3.607206E-04
16	G	-2.277027E-02	8.218904E-05	2.772949E-01	9.410547E-03	-1.302686E-03	7.800799E-04
17	G	-1.234122E-02	5.293293E-05	1.500804E-01	1.250033E-02	-6.092328E-04	1.035170E-03
18	G	0.0	0.0	0.0	1.340214E-02	-1.198121E-04	1.109696E-03
19	G	-2.347440E-02	-1.113863E-04	2.865106E-01	-9.330143E-03	-3.032421E-03	-8.026437E-04
20	G	-2.835934E-02	-7.988367E-05	3.443825E-01	-1.699497E-03	-2.178553E-03	-1.443849E-04
21	G	-2.699338E-02	-2.598270E-05	3.275242E-01	4.531891E-03	-1.424000E-03	3.761379E-04
22	G	-2.077615E-02	1.426908E-05	2.520799E-01	9.150283E-03	-8.566226E-04	7.599185E-04
23	G	-1.122428E-02	2.406144E-05	1.362053E-01	1.199934E-02	-4.099693E-04	9.952134E-04
24	G	0.0	0.0	0.0	1.290255E-02	-9.155961E-06	1.069196E-03
25	G	-2.271754E-02	-3.016065E-05	2.771573E-01	-8.204283E-03	-2.721156E-03	-7.032930E-04
26	G	-2.664476E-02	-2.747192E-05	3.228613E-01	-1.084207E-03	-1.780101E-03	-9.673936E-05
27	G	-2.505406E-02	-8.000467E-06	3.030116E-01	4.715899E-03	-1.087897E-03	3.891454E-04
28	G	-1.916571E-02	9.247113E-06	2.316865E-01	9.036588E-03	-5.822997E-04	7.498679E-04
29	G	-1.032588E-02	1.303702E-05	1.248249E-01	1.169686E-02	-2.448995E-04	9.713594E-04
30	G	0.0	0.0	0.0	1.255961E-02	-5.418378E-05	1.042969E-03
31	G	-2.209277E-02	1.176386E-05	2.683563E-01	-7.228509E-03	-2.413292E-03	-6.252875E-04
32	G	-2.516455E-02	2.241084E-05	3.040048E-01	-5.298234E-04	-1.523462E-03	-4.952886E-05
33	G	-2.337003E-02	2.936453E-05	2.818243E-01	4.921928E-03	-8.471824E-04	4.067717E-04
34	G	-1.777616E-02	3.070938E-05	2.142455E-01	8.991704E-03	-4.108038E-04	7.468027E-04
35	G	-9.559021E-03	2.225881E-05	1.151858E-01	1.151651E-02	-1.655813E-04	9.575200E-04
36	G	0.0	0.0	0.0	1.236368E-02	-2.553069E-05	1.028300E-03
37	G	-2.154078E-02	2.990697E-05	2.597903E-01	-6.308832E-03	-2.196231E-03	-5.401428E-04
38	G	-2.383176E-02	4.367979E-05	2.867500E-01	-1.495358E-05	-1.314723E-03	-3.082705E-06

5. Review F06 Output File (Cont.):

0											SUBCASE 1	
STRESSES IN LAYERED COMPOSITE ELEMENTS (QUAD4)												
ELEMENT ID	PLY ID	STRESSES IN FIBER AND MATRIX DIRECTIONS			INTER-LAMINAR STRESSES			PRINCIPAL STRESSES (ZERO SHEAR)			MAX SHEAR	
		NORMAL-1	NORMAL-2	SHEAR-12	SHEAR XZ-MAT	SHEAR YZ-MAT	ANGLE	MAJOR	MINOR			
0	1	1	-9.33339E+00	5.29340E+00	1.15951E-01	1.01506E-01	1.46586E-02	89.55	5.29432E+00	-9.33431E+00	7.31431E+00	
0	1	2	1.74559E+01	2.23593E+00	2.48964E+00	1.26289E-01	5.04483E-02	9.06	1.78528E+01	1.83903E+00	8.00690E+00	
0	1	3	1.16346E+01	1.37503E+00	-1.61482E+00	1.41159E-01	7.19221E-02	-8.74	1.18827E+01	1.12687E+00	5.37793E+00	
0	1	4	1.18191E+01	1.09594E-01	1.68446E-01	1.42609E-01	9.28630E-02	0.82	1.18216E+01	1.07171E-01	5.85720E+00	
0	1	5	-3.07491E+00	-1.40187E-01	2.63245E-01	1.41159E-01	7.19221E-02	84.91	-1.16761E-01	-3.09833E+00	1.49079E+00	
0	1	6	-4.58782E+00	-1.29129E+00	1.00963E+00	1.26289E-01	5.04483E-02	74.26	-1.00665E+00	-4.87246E+00	1.93291E+00	
0	1	7	-1.88564E+01	-1.58320E+00	-1.88445E+00	1.01506E-01	1.46586E-02	-83.85	-1.38000E+00	-1.90596E+01	8.83979E+00	
0	1	8	6.23545E+00	-4.52633E+00	-5.47643E-01	0.0	3.47758E-18	-2.91	6.26325E+00	-4.55413E+00	5.40869E+00	
0	2	1	-4.21433E+00	4.71974E+00	2.33421E-01	4.45666E-02	1.62941E-02	88.50	4.72583E+00	-4.22043E+00	4.47313E+00	
0	2	2	1.76859E+01	2.13840E+00	2.01557E+00	5.54477E-02	5.60767E-02	7.27	1.79430E+01	1.88136E+00	8.03081E+00	
0	2	3	1.18220E+01	1.42720E+00	-1.30815E+00	6.19764E-02	7.99463E-02	-7.06	1.19841E+01	1.26510E+00	5.35947E+00	
0	2	4	1.15265E+01	3.40921E-01	2.05688E-01	6.26130E-02	1.03224E-01	1.05	1.15303E+01	3.37140E-01	5.59657E+00	
0	2	5	-9.87391E-01	7.76412E-02	3.52057E-01	6.19764E-02	7.99463E-02	73.27	1.83496E-01	-1.09325E+00	6.38371E-01	
0	2	6	-6.59831E-01	-1.05061E+00	8.14086E-01	5.54477E-02	5.60767E-02	38.25	-1.80134E-02	-1.69242E+00	8.37205E-01	
0	2	7	-1.74376E+01	-1.02668E+00	-1.52150E+00	4.45666E-02	1.62941E-02	-84.75	-8.86810E-01	-1.75775E+01	8.34534E+00	
0	2	8	5.08569E+00	-3.64998E+00	-7.91166E-01	0.0	3.86557E-18	-5.13	5.15676E+00	-3.72105E+00	4.43891E+00	
0	3	1	-3.91930E+00	3.47265E+00	4.55060E-01	2.47943E-02	1.71701E-02	86.49	3.50055E+00	-3.94721E+00	3.72388E+00	
0	3	2	1.50788E+01	1.37144E+00	1.52985E+00	3.08480E-02	5.90918E-02	6.29	1.52474E+01	1.20277E+00	7.02234E+00	
0	3	3	6.34744E+00	1.13802E+00	-1.00104E+00	3.44802E-02	8.42447E-02	-10.51	6.53318E+00	9.52282E-01	2.79045E+00	
0	3	4	8.38195E+00	1.79440E-01	-1.28311E-02	3.48344E-02	1.08774E-01	-0.09	8.38197E+00	1.79420E-01	4.10127E+00	
0	3	5	-9.45392E-01	-1.38354E-02	1.34578E-01	3.44802E-02	8.42447E-02	81.94	5.21700E-03	-9.64444E-01	4.84831E-01	
0	3	6	-1.78653E+00	-7.78720E-01	5.85380E-01	3.08480E-02	5.90918E-02	65.36	-5.10232E-01	-2.05501E+00	7.72390E-01	
0	3	7	-1.29002E+01	-8.51674E-01	-1.11419E+00	2.47943E-02	1.71701E-02	-84.76	-7.49506E-01	-1.30023E+01	6.12642E+00	
0	3	8	3.22226E+00	-2.75918E+00	-5.76807E-01	0.0	4.07341E-18	-5.46	3.27738E+00	-2.81430E+00	3.04584E+00	
0	4	1	-2.35528E+00	2.16217E+00	6.10746E-01	2.57417E-02	1.83510E-02	82.43	2.24329E+00	-2.43640E+00	2.33984E+00	
0	4	2	1.18893E+01	6.79252E-01	9.30741E-01	3.20266E-02	6.31558E-02	4.71	1.19660E+01	6.02500E-01	5.68175E+00	
0	4	3	1.99956E+00	8.21955E-01	-5.85428E-01	3.57976E-02	9.00387E-02	-22.42	2.24106E+00	5.80447E-01	8.30308E-01	
0	4	4	4.53941E+00	1.27433E-01	-1.29583E-01	3.61653E-02	1.16255E-01	-1.68	4.54322E+00	1.23630E-01	2.20979E+00	
0	4	5	-1.48551E+00	9.81344E-03	3.08047E-02	3.57976E-02	9.00387E-02	88.82	1.04478E-02	-1.48614E+00	7.48294E-01	
0	4	6	-1.23210E+00	-5.30699E-01	4.50510E-01	3.20266E-02	6.31558E-02	63.95	-3.10478E-01	-1.45232E+00	5.70920E-01	
0	4	7	-9.18893E+00	-5.18189E-01	-7.95823E-01	2.57417E-02	1.83510E-02	-84.80	-4.45752E-01	-9.26137E+00	4.40781E+00	
0	4	8	2.76915E+00	-1.84710E+00	-5.11968E-01	0.0	4.35356E-18	-6.25	2.82525E+00	-1.90320E+00	2.36422E+00	
0	5	1	-1.92270E+00	4.32251E-01	6.38269E-01	6.23754E-02	1.70257E-02	75.77	5.94117E-01	-2.08456E+00	1.33934E+00	

5. Review F06 Output File (Cont.):

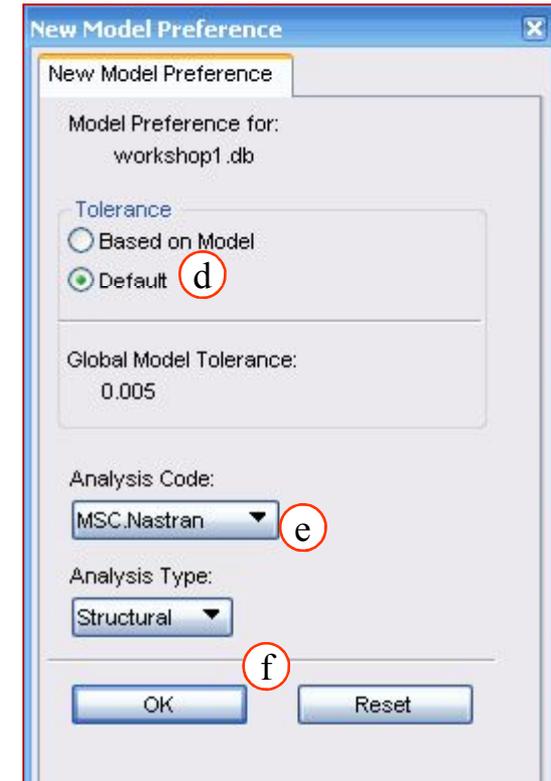
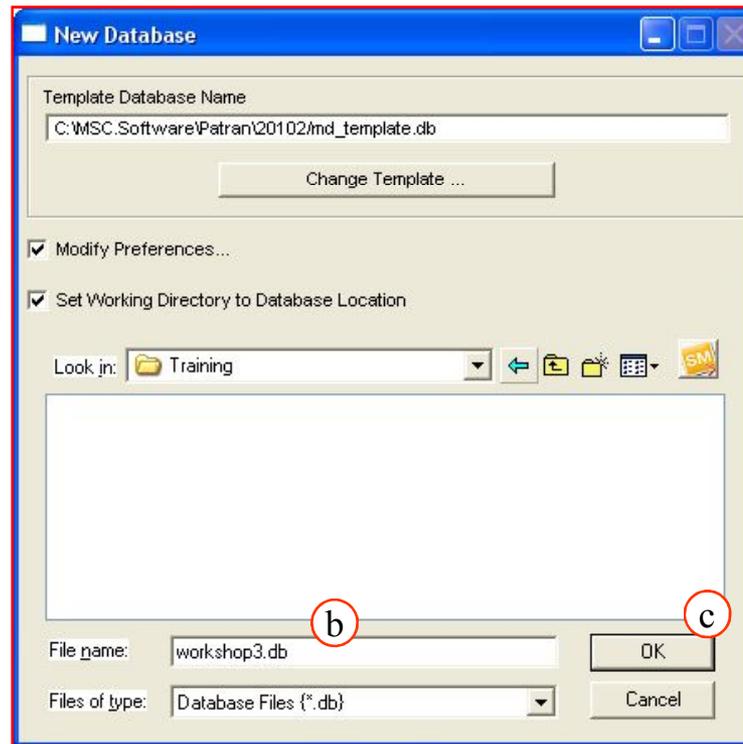
							SUBCASE 1
0							
FAILURE INDICES FOR LAYERED COMPOSITE ELEMENTS (QUAD4)							
ELEMENT ID	FAILURE THEORY	PLY ID	FP=FAILURE INDEX FOR PLY (DIRECT STRESSES/STRAINS)	FB=FAILURE INDEX FOR BONDING (INTER-LAMINAR STRESSES)	FAILURE INDEX FOR ELEMENT MAX OF FP,FB FOR ALL PLYS	FLAG	
1	HILL	1	103.6247				
		2	25.4685	0.0029			
		3	10.1281	0.0037			
		4	3.6799	0.0041			
		5	-0.0113	0.0041			
		6	-0.1552	0.0041			
		7	-0.7828	0.0037			
		8	1.0244	0.0029			
2	HILL	1	82.3814		103.6247	***	
		2	24.1347	0.0013			
		3	10.7612	0.0016			
		4	3.8166	0.0023			
		5	0.0223	0.0030			
		6	-0.0180	0.0023			
		7	-0.4694	0.0016			
		8	0.6815	0.0013			
3	HILL	1	44.5980		82.3814	***	
		2	12.3855	0.0007			
		3	5.6583	0.0017			
		4	1.9251	0.0024			
		5	-0.0003	0.0032			
		6	-0.0364	0.0024			
		7	-0.2881	0.0017			
		8	0.2739	0.0007			
4	HILL	1	17.2892		44.5980	***	
				0.0007			

6. POST PROCESSING

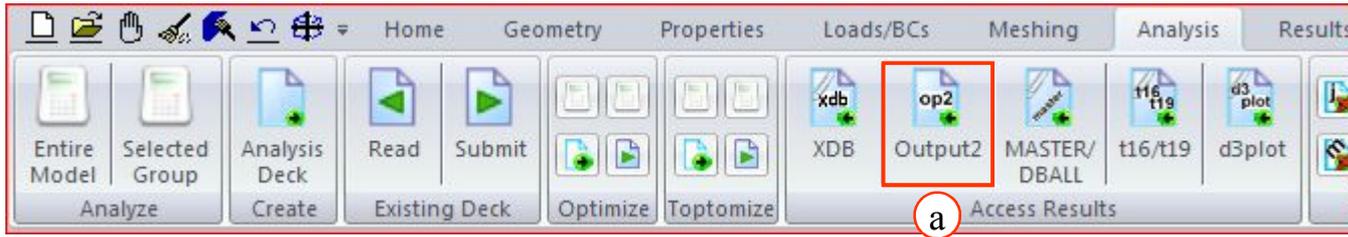


Create a new database

- a. File: **New**
- b. Enter **workshop3** as the File name
- c. Click **OK**.
- d. Select **Default** for Tolerance.
- e. Select **MSC Nastran** and **Structural** for the Analysis Code and Type.
- f. Click **OK**.

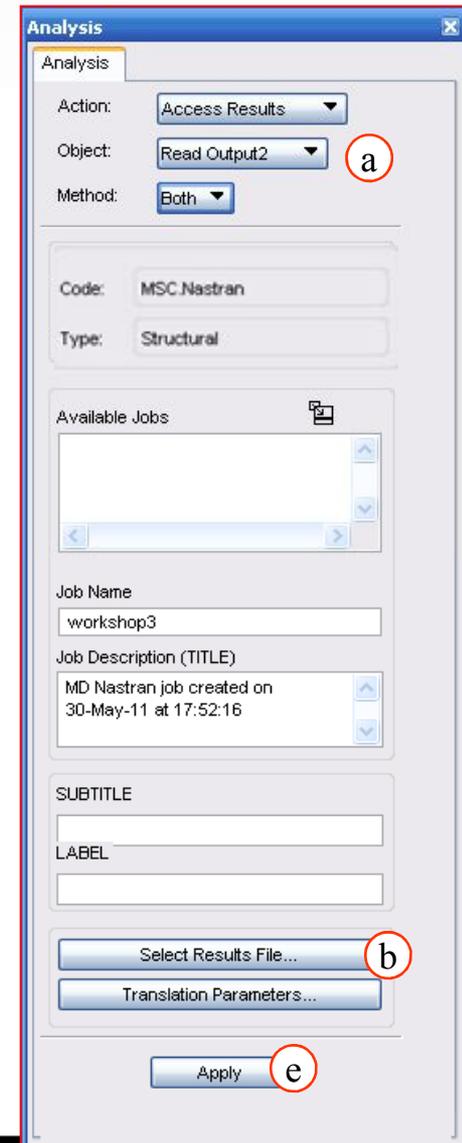
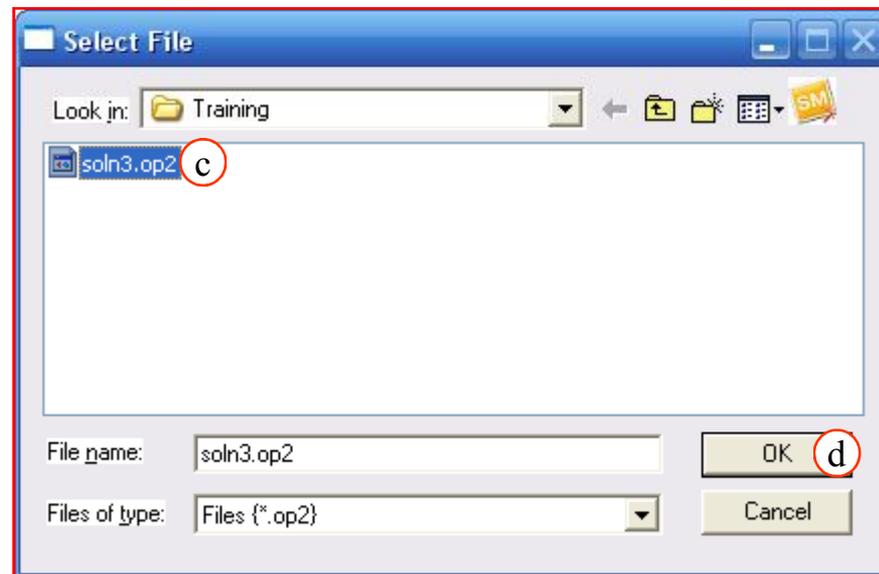


6. POST PROCESSING

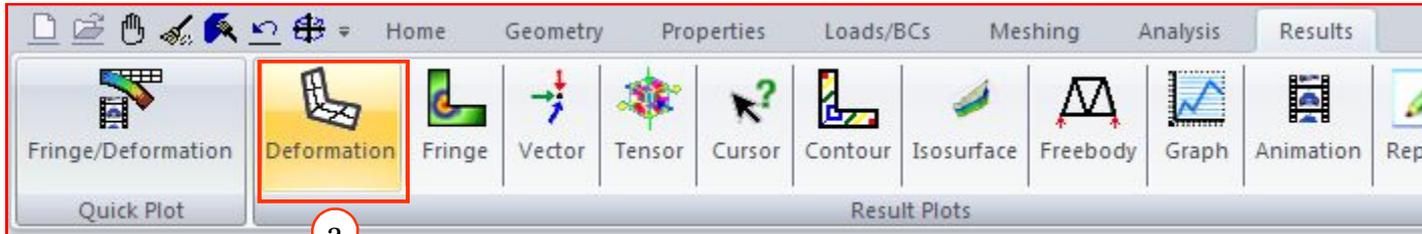


Attach results file

- a. Analysis: **Access Results / Read Output2/ Both**
- b. Click **Select Results File**.
- c. Select **wkshp3.op2**.
- d. Click **OK**.
- e. Click **Apply**.

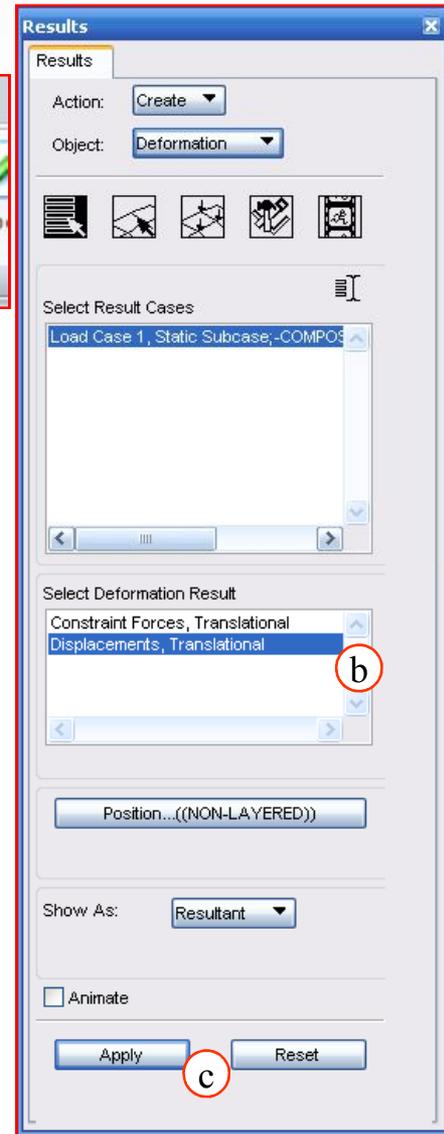
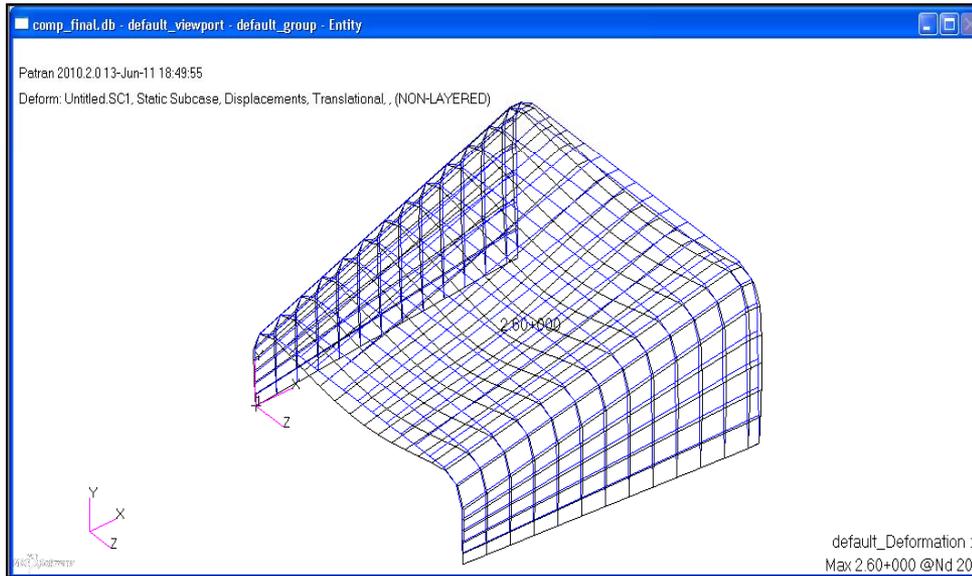


7. PLOT RESULTS



Plot the results

- a. Results: Create / Deformation
- b. Select **Displacements, Translational** as the Deformation Result.
- c. Click **Apply**.

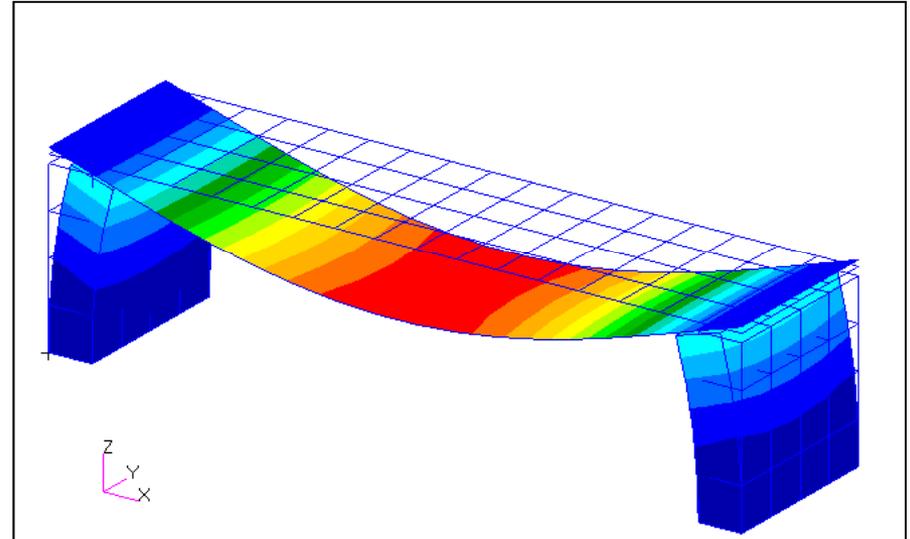
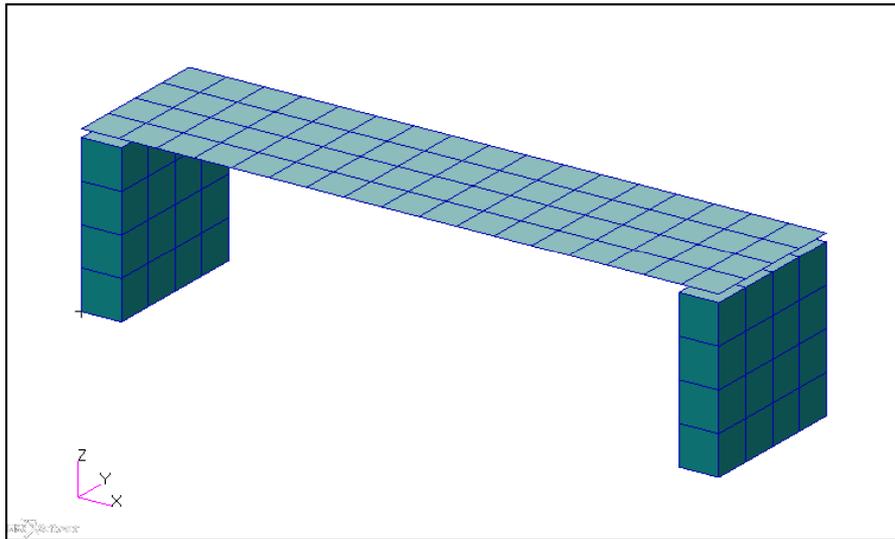


SOLUTION FILE FOR WORKSHOP 3

```
$ soln3.bdf
SOL 101
CEND
TITLE = COMPOSITE CONSOLE ANALYSIS
ECHO = NONE
SUBCASE 1
  TITLE=COMPOSITE CONSOLE ANALYSIS
  SPC = 2
  LOAD = 3
  DISPLACEMENT (SORT1, REAL) =ALL
  SPCFORCES (SORT1, REAL) =ALL
  STRESS (SORT1, REAL, VONMISES, BILIN) =ALL
BEGIN BULK
PARAM      POST      -1
PCOMP      1          34.47  HILL
           1          .14      0.      YES      1          .14      45.      YES
           1          .14     -45.     YES      1          .14      90.      YES
           1          .14      90.     YES      1          .14     -45.     YES
           1          .14      45.     YES      1          .14      0.       YES
$ Lamina Description:
MAT8      1          138000. 13800.  .35      6890.    6890.    6890.    3.6e-9
          -2.3-7  4.5-6          6.17    827.3    .52      82.7    86.8
$ Elements:
CQUAD4    1          1          1          2          8          7          1          0.
CQUAD4    2          1          2          3          9          8          1          0.
CQUAD4    3          1          3          4          10         9          1          0.
CQUAD4    4          1          4          5          11         10         1          0.
CQUAD4    5          1          5          6          12         11         1          0.
CQUAD4    6          1          7          8          14         13         1          0.
CQUAD4    7          1          8          9          15         14         1          0.
CQUAD4    8          1          9          10         16         15         1          0.
CQUAD4    9          1          10         11         17         16         1          0.
```

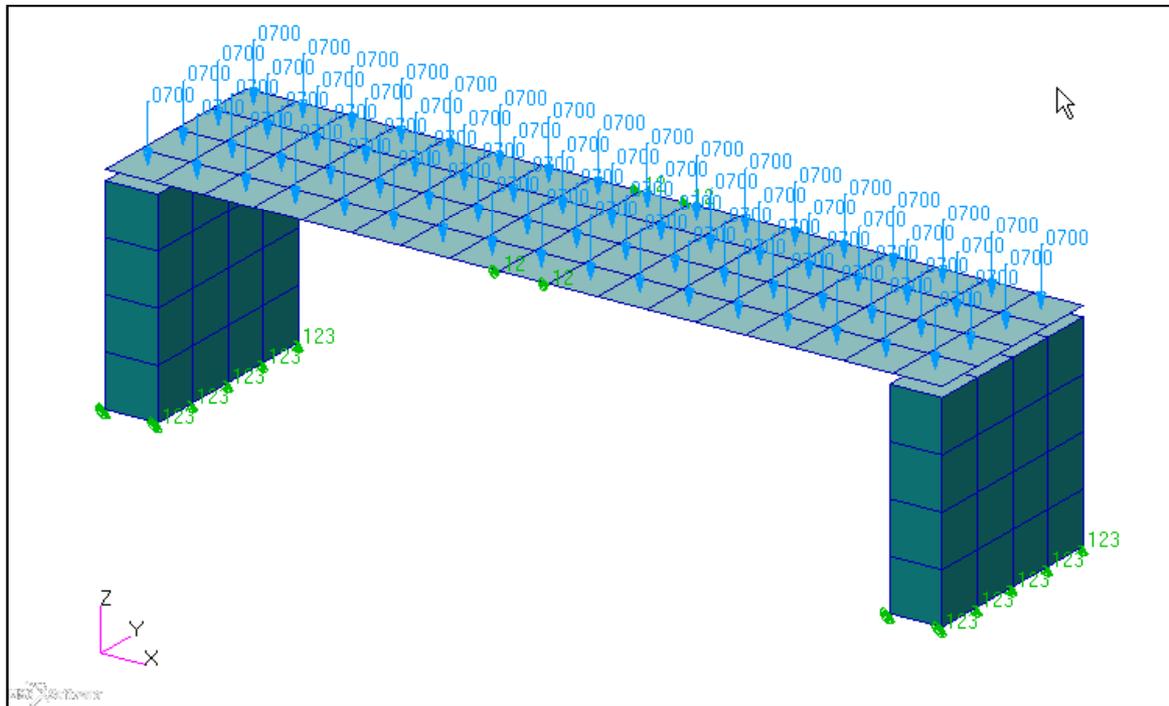
WORKSHOP 4

SOLID TO SHELL CONTACT



WORKSHOP OBJECTIVE:

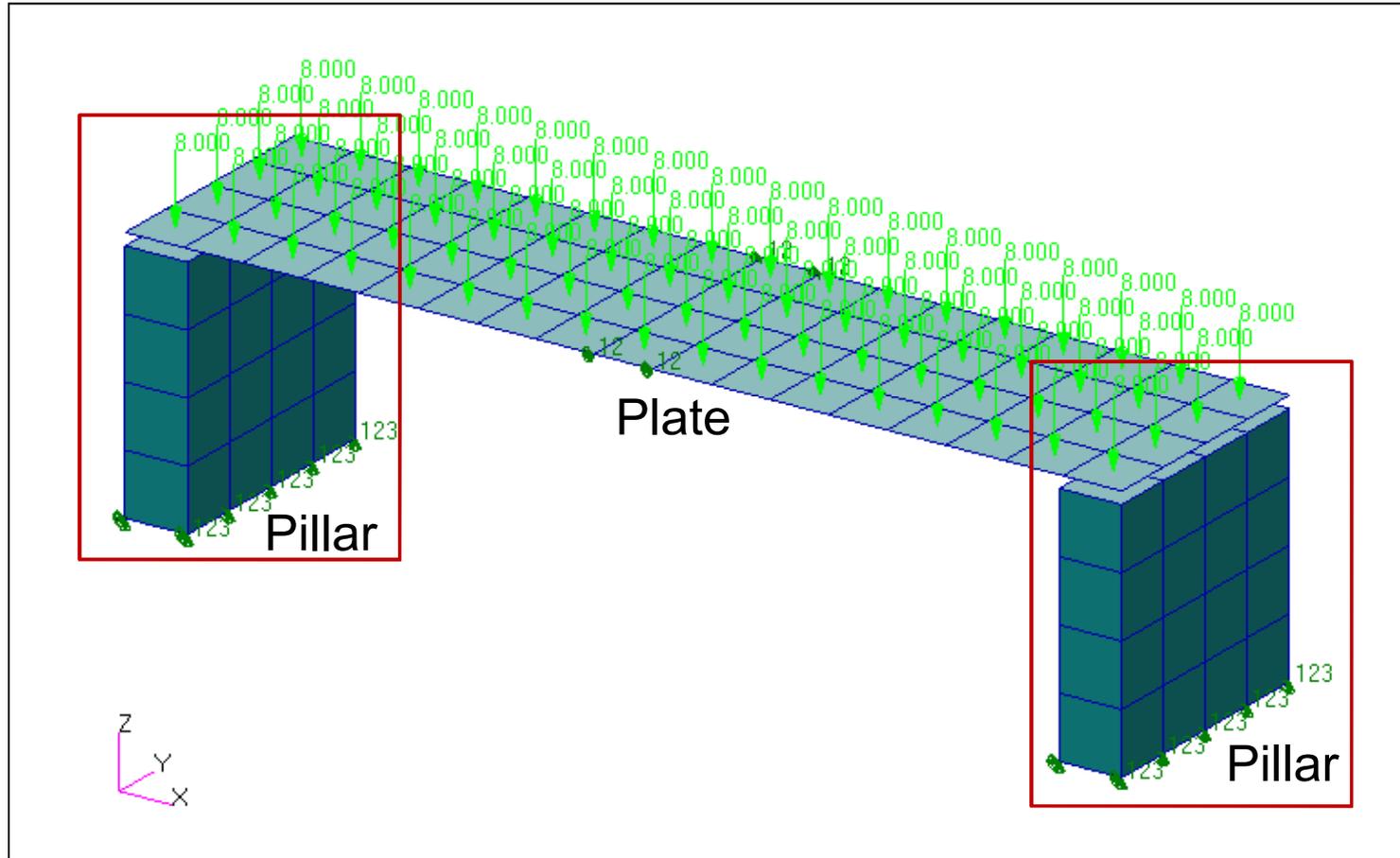
- To create and understand solid to shell contact.
- **Software Version:**
 - MSC Nastran 2012.1



MODEL DESCRIPTION:

- 1. The model contains a horizontal plate (meshed with Shells) resting on two vertical blocks (solid bodies with rectangular cross section) meshed with Hex elements. Hence this is a case of shells in contact with solids.**
- 2. The user will join the plate to pillars by solid to shell contact.**
- 3. Aluminum material is used for both the plate and the pillars.**
- 4. The bottom of the pillars are fixed and vertical sliding is applied to two rows of nodes, midway on the plate .**
- 5. A force of 100Pa is applied to each of the shell element in the model.**

MODEL DESCRIPTION (Cont.):



SUGGESTED STEPS:

- 1. Input File: Edit the given MSC Nastran input file [wkshp4.bdf](#).**
- 2. Create contact tables for the two solids by creating entries for BCBODY, and BSURF .**
- 3. Analysis: Solution Type = Nastran Linear Static , Solution Sequence = 101. Submit input file to MSC Nastran.**
- 4. Examine Output File: Examine the Nastran output F06 file.**
- 5. Results: Plot displacements.**

1. Open Input File:

1. Input File: Edit the given MSC Nastran input file wkshp4.bdf.

```
$soln4 (in SI units)
NASTRAN SYSTEM(316)=19
SOL 101
CEND
TITLE = THIS IS A DEFAULT SUBCASE.
ECHO = NONE
SUBCASE 1
  TITLE=THIS IS A DEFAULT SUBCASE.
  BCONTACT = ALLBODY
  SPC = 2
  LOAD = 5
  DISPLACEMENT (SORT1, REAL) =ALL
  STRESS (SORT1, REAL, VONMISES, BILIN) =ALL
  BOUTPUT (SORT1, REAL) =ALL
BEGIN BULK
PARAM      POST      0
PARAM      PRTMAXIM  YES
include 'Model_Include_SI.bdf'
$ Loads for Load Case
.
.
.
```

The 'include' card calls the model bulk data from file 'Model_Include_SI.bdf'

1. Open Input File (Cont.):

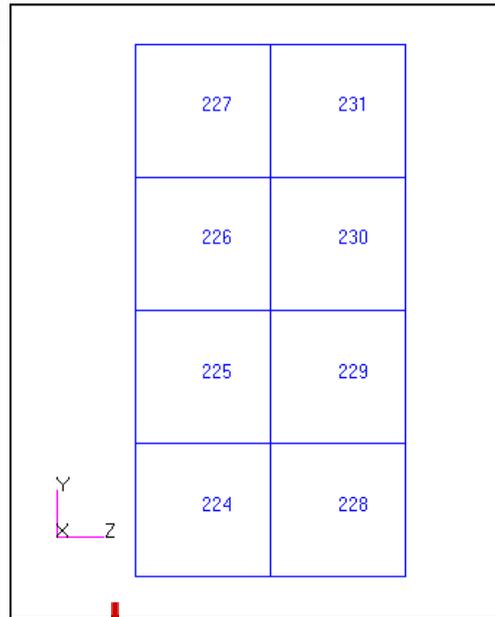
- Scroll down the input file:

```
.  
. .  
$ Loads for Load Case  
SPCADD 2 1 3  
LOAD 5 1. 1. 1  
$ Displacement Constraints of Load Set  
SPC1 1 12 225 226 297 298  
$ Displacement Constraints of Load Set  
SPC1 3 123 307 THRU 316  
SPC1 3 123 357 THRU 366  
$ Deform Body Contact LBC set of Hex Elements  
$  
$ Deform Body Contact LBC set of Shell Elements  
$  
$ Pressures of Distributed Load Set  
PLOAD4 1 100 0.07 THRU 167  
0. 0. -1.  
ENDDATA
```

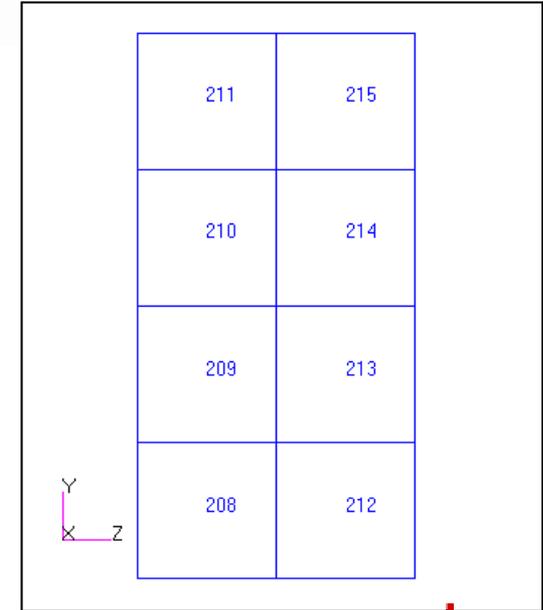
2. Create Contact Sets for Hex and Shell Elements

```
.  
. .  
$ Displacement Constraints of Load Set  
SPC1 3 123 307 THRU 316  
SPC1 3 123 357 THRU 366  
$ Deform Body Contact LBC set of Hex Elements  
BCBODY 1 3D DEFORM 4 0  
BSURF 4 230 208 209 210 211 212 213  
214 215 224 225 226 227 228 229  
231  
$ Deform Body Contact LBC set of Shell Elements  
BCBODY 2 3D DEFORM 5 0  
BSURF 5 100 117 134 151 101 118 135  
152 115 132 149 166 116 133 150  
167  
$ Pressures of Distributed Load Set  
PLOAD4 1 100 0.07 THRU 167  
0. 0. -1.  
ENDDATA
```

2. Create Contact Set for Hex Elements (Cont.)



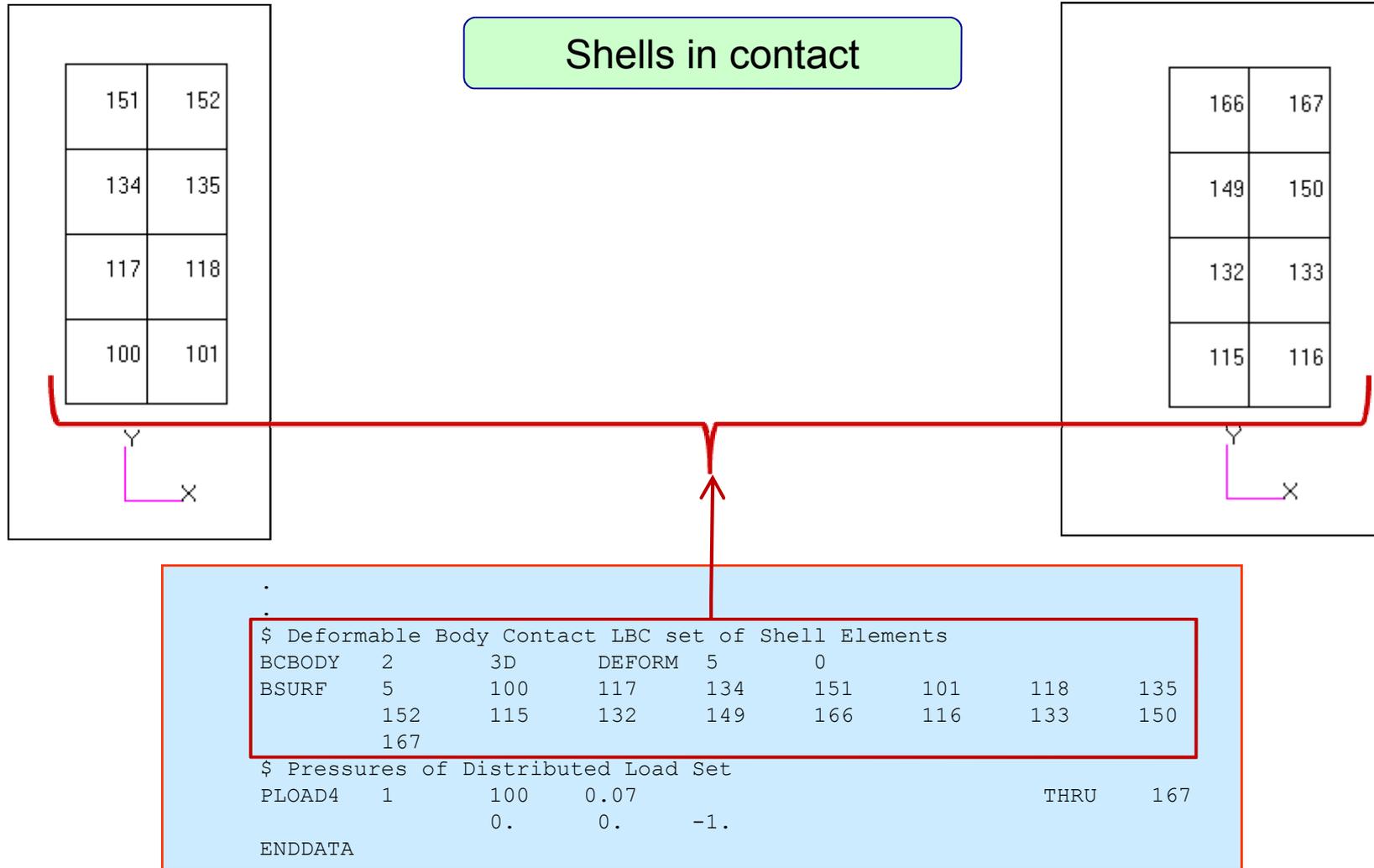
Hex elements in contact



```

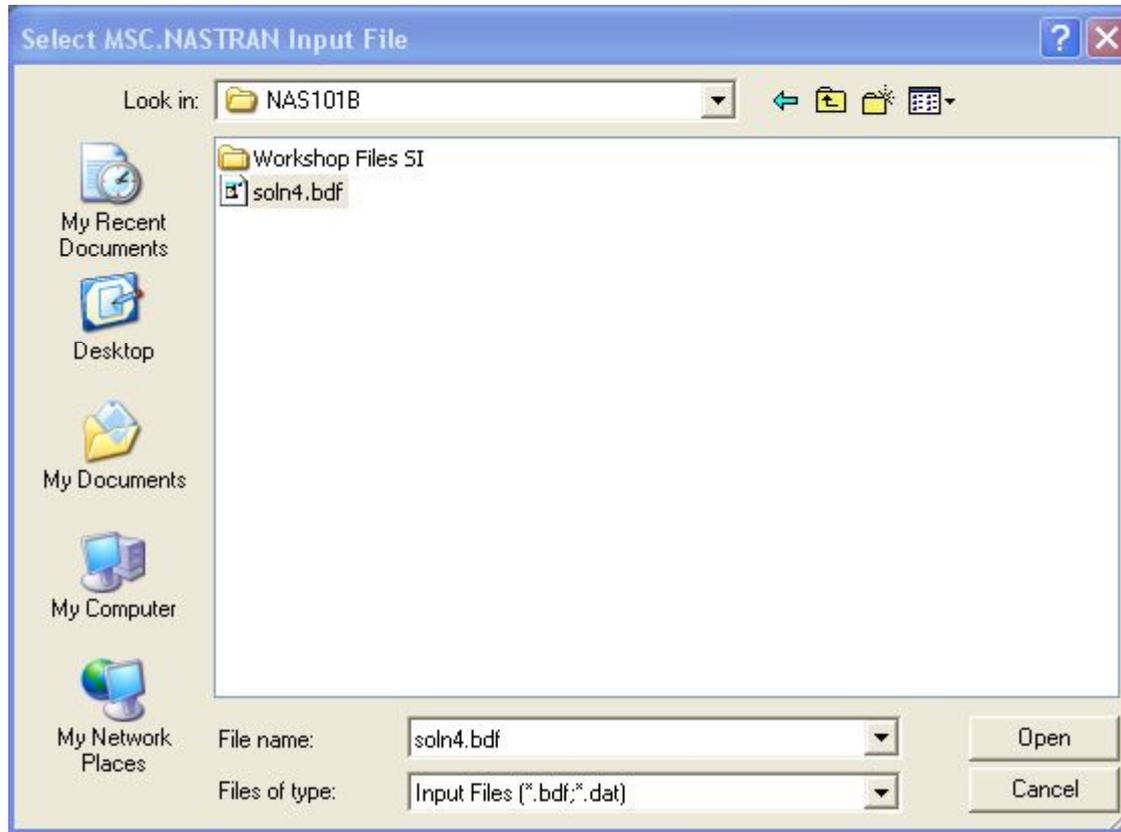
.
.
.
$ Displacement Constraints
SPC1 3 123 307 THRU 316
SPC1 3 123 357 THRU 366
$ Deformable Body Contact LBC set of Hex Elements
BCBODY 1 3D DEFORM 4 0
BSURF 4 230 208 209 210 211 212 213
      214 215 224 225 226 227 228 229
      231
$ Deformable Body Contact LBC set of Shell Elements
.
    
```

2. Create Contact Set for Shell Elements (Cont.)



3. Submit Input File to MSC Nastran

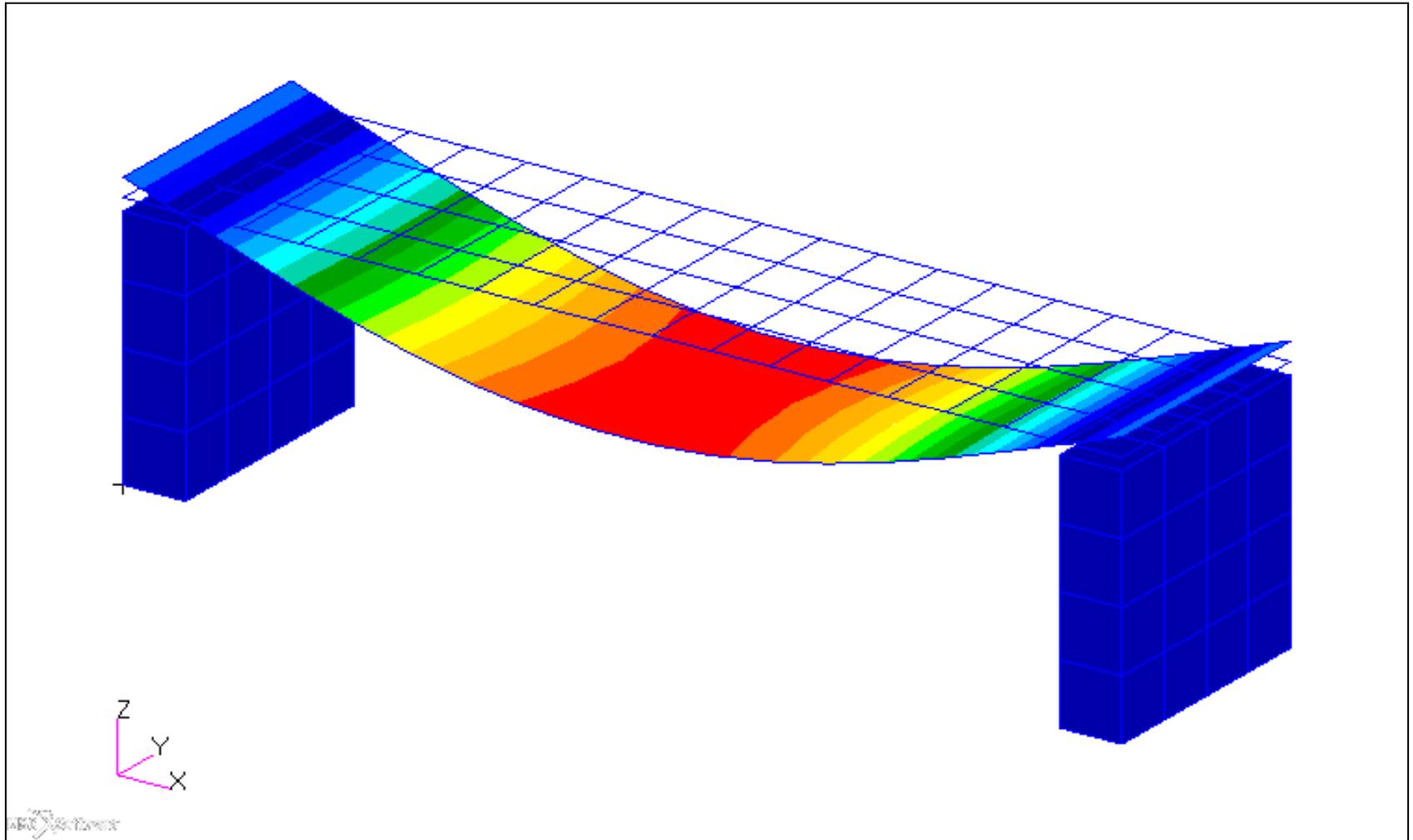
3. Analysis: Solution Type = Nastran Linear Static , Solution Sequence = 101. Submit input file to MSC Nastran.



4. F06 Output File

DISPLACEMENT VECTOR							SUBCASE 1
POINT ID.	TYPE	T1	T2	T3	R1	R2	R3
217	G	2.144549E-05	-2.012929E-06	1.203412E-01	-8.287240E-05	2.204931E-02	2.010084E-07
218	G	2.207081E-05	-1.184280E-06	-1.197474E-02	3.047064E-05	2.227826E-02	2.551305E-07
219	G	1.786217E-05	-1.283400E-06	-1.456521E-01	5.773910E-04	2.200291E-02	3.694406E-08
220	G	1.453582E-05	-1.609443E-06	-2.738615E-01	1.230788E-03	2.049025E-02	-2.346038E-08
221	G	1.171426E-05	-1.868351E-06	-3.900130E-01	1.793682E-03	1.803298E-02	-1.870672E-08
222	G	9.034575E-06	-1.940668E-06	-4.890027E-01	2.253907E-03	1.481465E-02	6.604181E-09
223	G	6.384838E-06	-1.793397E-06	-5.667877E-01	2.602131E-03	1.100434E-02	3.363659E-08
224	G	3.627112E-06	-1.467243E-06	-6.203252E-01	2.835581E-03	6.771651E-03	9.273398E-08
225	G	0.0	0.0	-6.475999E-01	2.952619E-03	2.285426E-03	-4.396612E-08
226	G	0.0	0.0	-6.475999E-01	2.952620E-03	-2.285426E-03	4.396606E-08
227	G	-3.627111E-06	-1.467242E-06	-6.203252E-01	2.835580E-03	-6.771651E-03	-9.273253E-08
228	G	-6.384972E-06	-1.793409E-06	-5.667844E-01	2.602117E-03	-1.100454E-02	-3.363613E-08
229	G	-9.034573E-06	-1.940667E-06	-4.890027E-01	2.253906E-03	-1.481465E-02	-6.603844E-09
230	G	-1.171421E-05	-1.868352E-06	-3.900148E-01	1.793689E-03	-1.803293E-02	1.870680E-08
231	G	-1.453588E-05	-1.609435E-06	-2.738595E-01	1.230779E-03	-2.049029E-02	-2.345991E-08
232	G	-1.786212E-05	-1.283394E-06	-1.456544E-01	5.773981E-04	-2.200290E-02	-3.694394E-08
233	G	-2.207083E-05	-1.184287E-06	-1.197318E-02	3.046650E-05	-2.227826E-02	-2.551340E-07
234	G	-2.144552E-05	-2.012959E-06	1.203412E-01	-8.287524E-05	-2.204932E-02	-2.010144E-07
235	G	1.977312E-05	-1.722262E-06	1.198857E-01	-3.164303E-05	2.207008E-02	2.131472E-07
236	G	1.921821E-05	-5.441684E-07	-1.195316E-02	2.911317E-05	2.207160E-02	2.162000E-07
237	G	1.716711E-05	-3.146128E-07	-1.430168E-01	2.774432E-04	2.158308E-02	4.832877E-08
238	G	1.452302E-05	-7.051651E-07	-2.681676E-01	5.749208E-04	2.010979E-02	-1.831656E-08
239	G	1.177587E-05	-9.280573E-07	-3.816525E-01	8.530215E-04	1.771297E-02	-1.290518E-08
240	G	8.990520E-06	-9.851346E-07	-4.784644E-01	1.079724E-03	1.456227E-02	4.030070E-09
241	G	6.209160E-06	-8.997257E-07	-5.545973E-01	1.252329E-03	1.082246E-02	3.173526E-08
242	G	3.402153E-06	-4.413758E-07	-6.070261E-01	1.368283E-03	6.662017E-03	2.483986E-08
243	G	1.337839E-06	-2.835253E-07	-6.337447E-01	1.426502E-03	2.248806E-03	-3.600041E-08
244	G	-1.337837E-06	-2.835252E-07	-6.337447E-01	1.426502E-03	-2.248806E-03	3.600041E-08
245	G	-3.402151E-06	-4.413789E-07	-6.070261E-01	1.368283E-03	-6.662016E-03	-2.483959E-08
246	G	-6.209299E-06	-8.997359E-07	-5.545940E-01	1.252320E-03	-1.082266E-02	-3.173515E-08
247	G	-8.990518E-06	-9.851344E-07	-4.784644E-01	1.079724E-03	-1.456227E-02	-4.029713E-09
248	G	-1.177582E-05	-9.280574E-07	-3.816543E-01	8.530262E-04	-1.771293E-02	1.290531E-08
249	G	-1.452306E-05	-7.051583E-07	-2.681656E-01	5.749137E-04	-2.010982E-02	1.831588E-08
250	G	-1.716707E-05	-3.146110E-07	-1.430190E-01	2.774485E-04	-2.158306E-02	-4.832872E-08
251	G	-1.921820E-05	-5.441732E-07	-1.195162E-02	2.910934E-05	-2.207160E-02	-2.162015E-07
252	G	-1.977311E-05	-1.722280E-06	1.198857E-01	-3.164538E-05	-2.207008E-02	-2.131515E-07
253	G	1.853500E-05	-8.431892E-08	1.196765E-01	1.051942E-11	2.205297E-02	2.066893E-09
254	G	1.807496E-05	-7.179015E-08	-1.196409E-02	1.535088E-10	2.198764E-02	2.119679E-09
255	G	1.646356E-05	-5.782912E-08	-1.422003E-01	-6.691166E-11	2.141881E-02	2.136723E-09
256	G	1.434928E-05	-4.395057E-08	-2.663611E-01	-1.712341E-10	1.994612E-02	2.026123E-09
257	G	1.174458E-05	-3.106826E-08	-3.789594E-01	-1.936764E-10	1.757876E-02	1.822828E-09
258	G	8.962313E-06	-1.961952E-08	-4.750533E-01	-1.955255E-10	1.445571E-02	1.543634E-09
259	G	6.156504E-06	-1.002847E-08	-5.506388E-01	-1.967895E-10	1.074559E-02	1.158466E-09
260	G	3.650906E-06	-3.384079E-09	-6.026998E-01	-1.968497E-10	6.615627E-03	6.962431E-10
261	G	1.082131E-06	2.114162E-10	-6.292336E-01	-1.969305E-10	2.233307E-03	2.802789E-10
262	G	-1.082129E-06	2.114041E-10	-6.292336E-01	-1.969306E-10	-2.233306E-03	-2.802844E-10

5. Plot Displacements



Solution File For Workshop 4

```
$soln4 (in SI units)
NASTRAN SYSTEM(316)=19
SOL 101
CEND
TITLE = THIS IS A DEFAULT SUBCASE.
ECHO = NONE
SUBCASE 1
  TITLE=THIS IS A DEFAULT SUBCASE.
  BCONTACT = ALLBODY
  SPC = 2
  LOAD = 5
  DISPLACEMENT (SORT1,REAL)=ALL
  STRESS (SORT1,REAL,VONMISES,BILIN)=ALL
  BOUTPUT (SORT1,REAL)=ALL
BEGIN BULK
PARAM      POST      0
PARAM      PRTMAXIM YES
include 'Model_Include_SI.bdf'
$ Loads for Load Case
SPCADD      2          1          3
LOAD        5          1.          1.          1
$ Displacement Constraints of Load Set
SPC1        1          12          225          226          297          298
.
.
.
```

Solution File For Workshop 4 (Cont.)

```
.  
. .  
$ Displacement Constraints of Load Set  
SPC1 3 123 307 THRU 316  
SPC1 3 123 357 THRU 366  
$ Deform Body Contact LBC set of Hex Elements  
BCBODY 1 3D DEFORM 4 0  
BSURF 4 230 208 209 210 211 212 213  
214 215 224 225 226 227 228 229  
231  
$ Deform Body Contact LBC set of Shell Elements  
BCBODY 2 3D DEFORM 5 0  
BSURF 5 100 117 134 151 101 118 135  
152 115 132 149 166 116 133 150  
167  
$ Pressures of Distributed Load Set  
PLOAD4 1 100 0.07 THRU 167  
0. 0. -1.  
ENDDATA
```

Do not forget to 'include' the file 'Model_Include_SI.bdf' in the same directory as your 'soln4.bdf' file.

ADDITIONAL METHODS OF DEFORMABLE BODY

- Along with BSURF users also can try other deformable body methods for BSID in BCBODY: BCPROP

BCPROP

Defines a 3D contact region by element properties. All elements with the specified properties define a contact body used in SOL 101 and MSC Nastran SOLs 400 and 700 only.

1	2	3	4	5	6	7	8	9	10
BCPROP	ID	IP1	IP2	IP3	IP4	IP5	IP6	IP7	
	IP8	IP9	etc.						

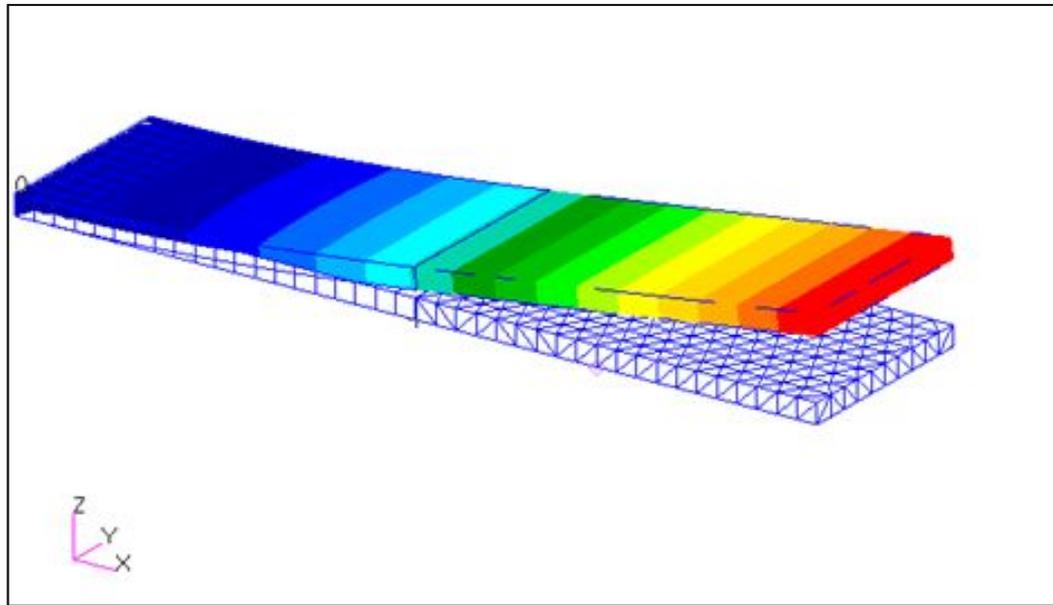
Field

Contents

- ID Identification of a deformable surface corresponding to a BSID value on the BCBODY entry. All elements corresponding to the property IDs specified that may potentially come into contact. Do not specify mixed property types (use all shell, all solid or all beam properties only). (Integer > 0)
- IPi Property ID. A minimum of one entry is required. (Integer; no Default)

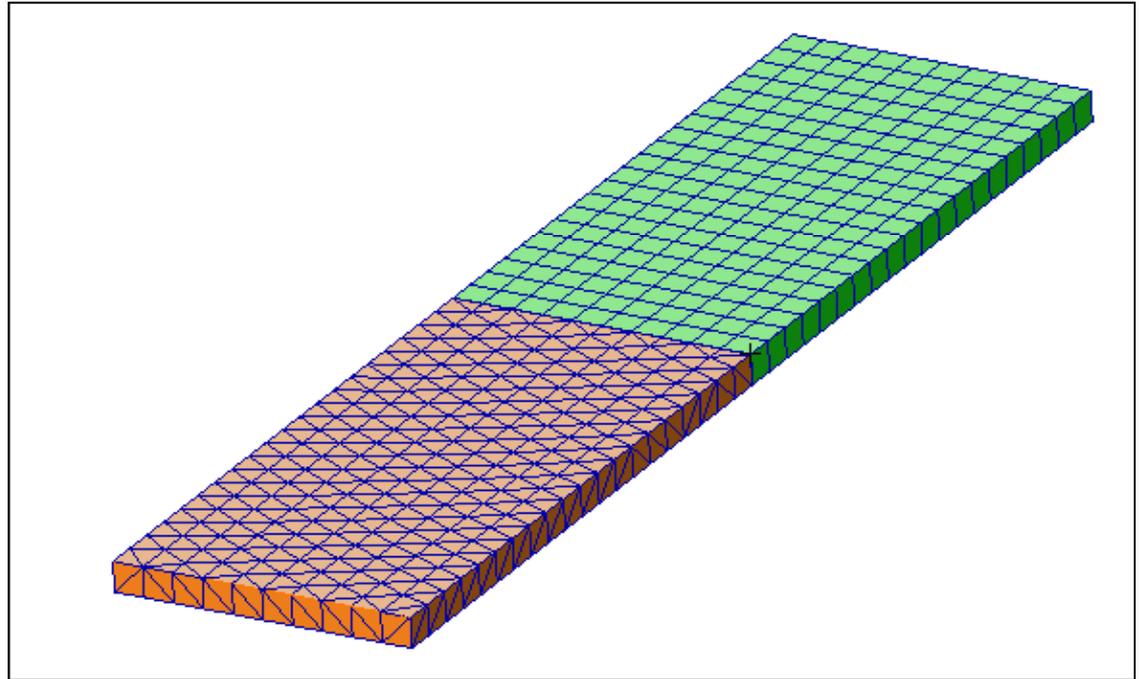
WORKSHOP 5

SOLID GLUE CONTACT



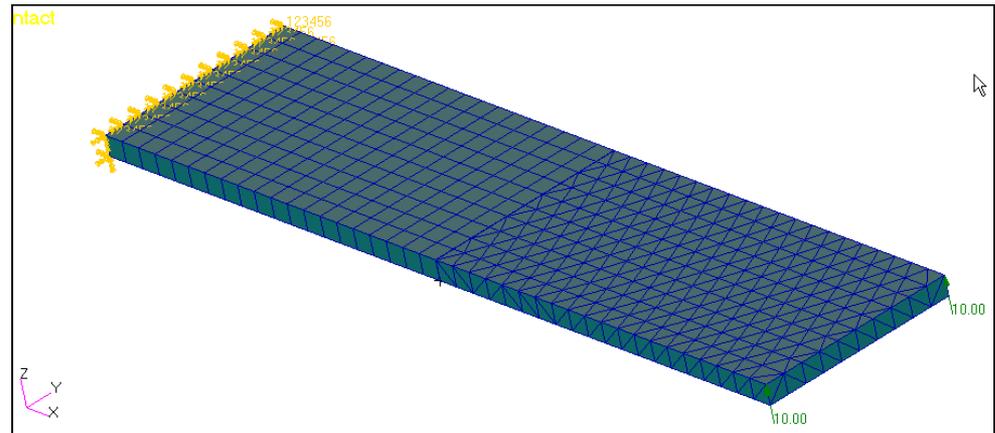
WORKSHOP OBJECTIVE:

- To create and understand solid face-to-face glue contact.
- **Software Version:**
 - MSC Nastran 2012.1

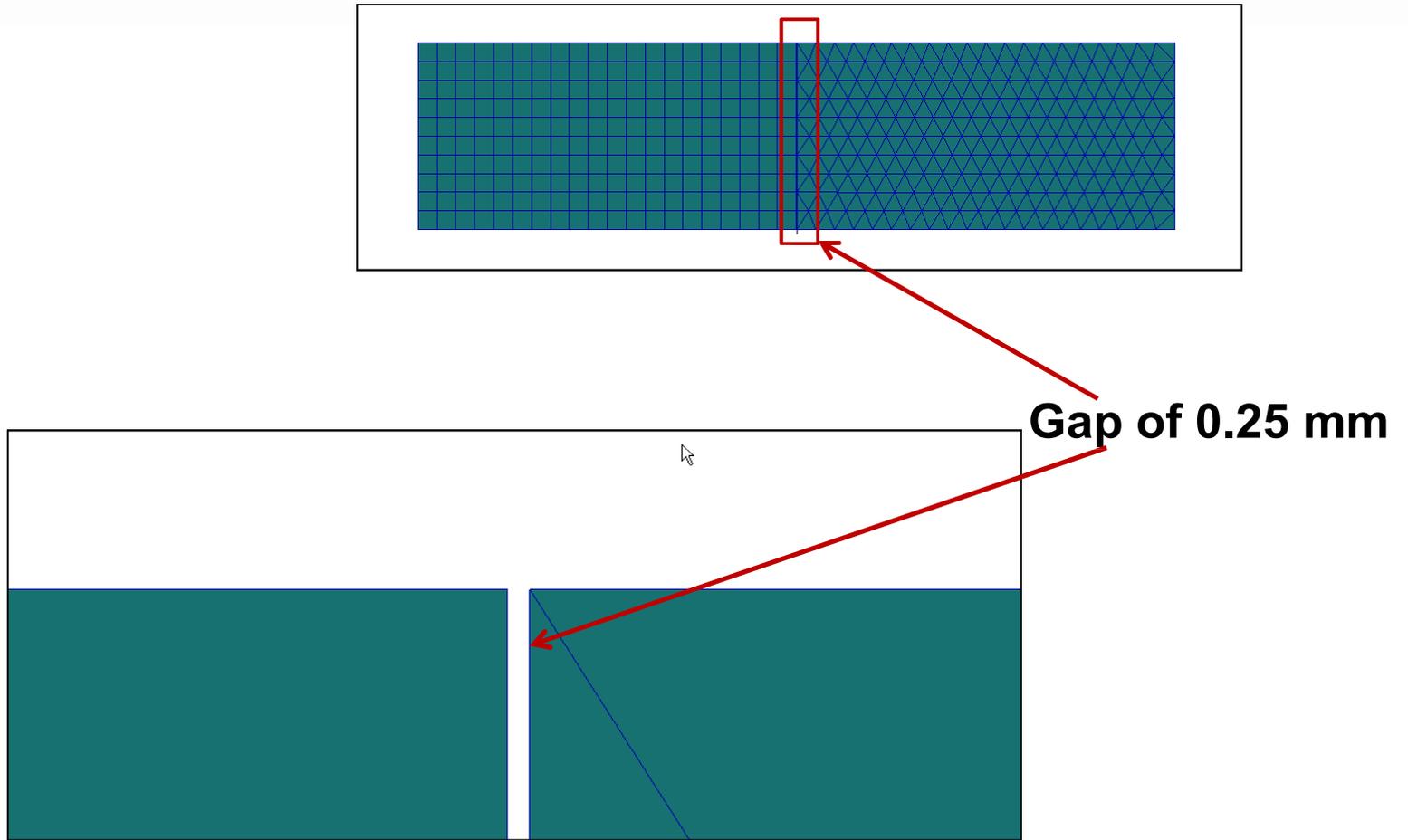


MODEL DESCRIPTION:

1. The model contains two solid bodies and are meshed with Solid elements.
2. The first body is meshed with CHEXA elements and the second body with CTETRA elements and hence they have dissimilar mesh.
3. Both these bodies are separated by a gap of 0.25 mm between them.
4. The user will join the two solids by means of glue contact.
5. Aluminium material is used for both the solid bodies.
6. The free end of the solid with hex mesh is fixed in all directions.
7. A force of 45 N is applied to the two corner nodes of the solid meshed with Tet mesh.



MODEL DESCRIPTION (CONT.):



Suggested Steps:

- 1. Input File: Edit the given MSC Nastran input file [wkshp5.bdf](#).**
- 2. Create contact tables for the two solids by creating entries for BCBODY, BSURF and BCTABLE.**
- 3. Analysis: Solution Type = Nastran Linear Static , Solution Sequence = 101. Submit input file to MSC Nastran.**
- 4. Examine Output File: Examine the Nastran output F06 file.**
- 5. Results: Plot displacements.**

1. Open Input File:

1. Input File: Edit the given MSC Nastran input file wkshp5.bdf.

```
$wkshp5.bdf
NASTRAN SYSTEM(316)=19
SOL 101
CEND
ECHO = NONE
SUBCASE 1
  TITLE=This is a default subcase.
  BCONTACT = 1
  SPC = 2
  LOAD = 2
  DISPLACEMENT (SORT1, REAL)=ALL
  STRESS (SORT1, REAL, VONMISES, BILIN)=ALL
  NLOPRM MPCPCH=BEGN
BEGIN BULK
$
PARAM      POST      0
PARAM      PRTMAXIM  YES
$
$ Elements and Element Properties for Hex Elements
PSOLID     1         1         0
$
CHEXA      1         1         7293      7294      7315      7314      7524      7525
           7546      7545
CHEXA      2         1         7294      7295      7316      7315      7525      7526
           7547      7546
.
.
.
```

1. Open Input File (Cont.):

- Scroll down the input file:

```
.  
. .  
GRID      8244          241.31  127.    0.  
GRID      8245          254.    127.    0.  
$ Referenced Coordinate Frames  
CORD2R    1            0.      0.      0.      0.      0.      1.  
          1.          0.      0.  
  
$ Loads for Load Case  
SPCADD    2            1  
LOAD      2            1.      1.      1  
$ Displacement Constraints of Load Set  
SPC1      1            123456  7313    7334    7355    7376    7397    7418  
          7439    7460    7481    7502    7523    7544    7565    7586  
          7607    7628    7649    7670    7691    7712    7733    7754  
  
$ Create Contact Tables  
$  
$ Create Deformable Body Contact LBC set for Hex Elements  
$  
$ Create Deformable Body Contact LBC set for Tet Elements  
$  
$ Nodal Forces Applied in the Z Direction  
FORCE     1            8017    0      45.    0.      0.      1.  
FORCE     1            8225    0      45.    0.      0.      1.  
$  
ENDDATA
```

2. Create Contact Set for Hex Elements

Format:

1	2	3	4	5	6	7	8	9	10
BCBODY	BID	DIM	BEHAV	BSID	ISTYP	FRIC	IDSPL	CONTROL	
	NLOAD	ANGVEL	DCOS1	DCOS2	DCOS3	VELRB1	VELRB2	VELRB3	
	"ADVANCE"	SANGLE	COPTB	USER					
	"CTVDEF"	ICMALL	ITVDF	ITVDF	DEFALT	ALCDIST			

1	2	3	4	5	6	7	8	9	10
BSURF	ID	ELID1	ELID2	ELID3	ELID4	ELID5	ELID6	ELID7	
	ELID8	ELID9	etc.						

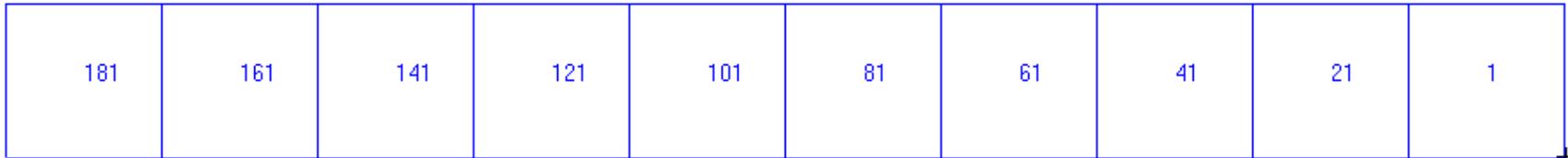
```

.
.
.
$ Create Contact Tables
$
$ Create Deformable Body Contact LBC set for Hex Elements
BCBODY 1 3D DEFORM 1 0
$
BSURF 1 1 21 41 61 81 101 121
141 161 181
$ Create Deformable Body Contact LBC set for Tet Elements
$
.
.
.

```

2. Create Contact Set for Hex Elements (Cont.)

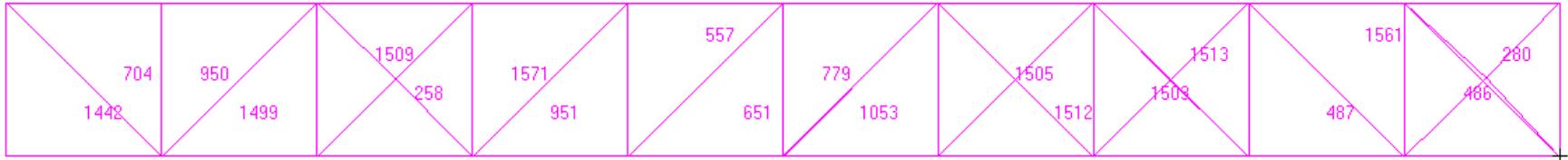
Hex elements in contact



```
.  
. .  
$ Create Contact Tables  
$  
$ Create Deformable Body Contact LBC set for Hex Elements  
BCBODY 1 3D DEFORM 1 0  
$  
BSURF 1 1 21 41 61 81 101 121  
141 161 181  
$ Create Deformable Body Contact LBC set for Tet Elements  
$  
. .  
.
```

2. Create Contact Set for Tet Elements

Tet elements in contact



```

.
.
.
$ Create Contact Tables
$
$ Create Deformable Body Contact LBC set for Hex Elements
BCBODY 1 3D DEFORM 1 0
$
BSURF 1 1 21 41 61 81 101 121
      141 161 181
$ Create Deformable Body Contact LBC set for Tet Elements
BCBODY 2 3D DEFORM 2 0
$
BSURF 2 704 950 258 951 557 651 779
      487 486 280 1513 1561 1505 1512 1503
      1442 1499 1509 1571 1053
.
.

```

3. Create Contact Tables

Format: (SOLs 101, 103, 105, 107, 108, 109, 110, 111, 112, 200 and 400 only)

1	2	3	4	5	6	7	8	9	10
BCTABLE	ID			NGROUP	COPTS	COPTM			
	"SLAVE"	IDSLA1	ERROR			CINTERF	IGLUE		
		ISEARCH	ICOORD						
		"FBSH"		BIAS			COPTS1	COPTM1	
	"MASTERS"	IDMA1	IDMA2	IDMA3	IDMA4	IDMA5	IDMA6	IDMA7	
		IDMA8	IDMA9	...					

```

$ Create Contact Tables
BCTABLE 0
      SLAVE 2      0.4
          0      0      0
      MASTERS 1

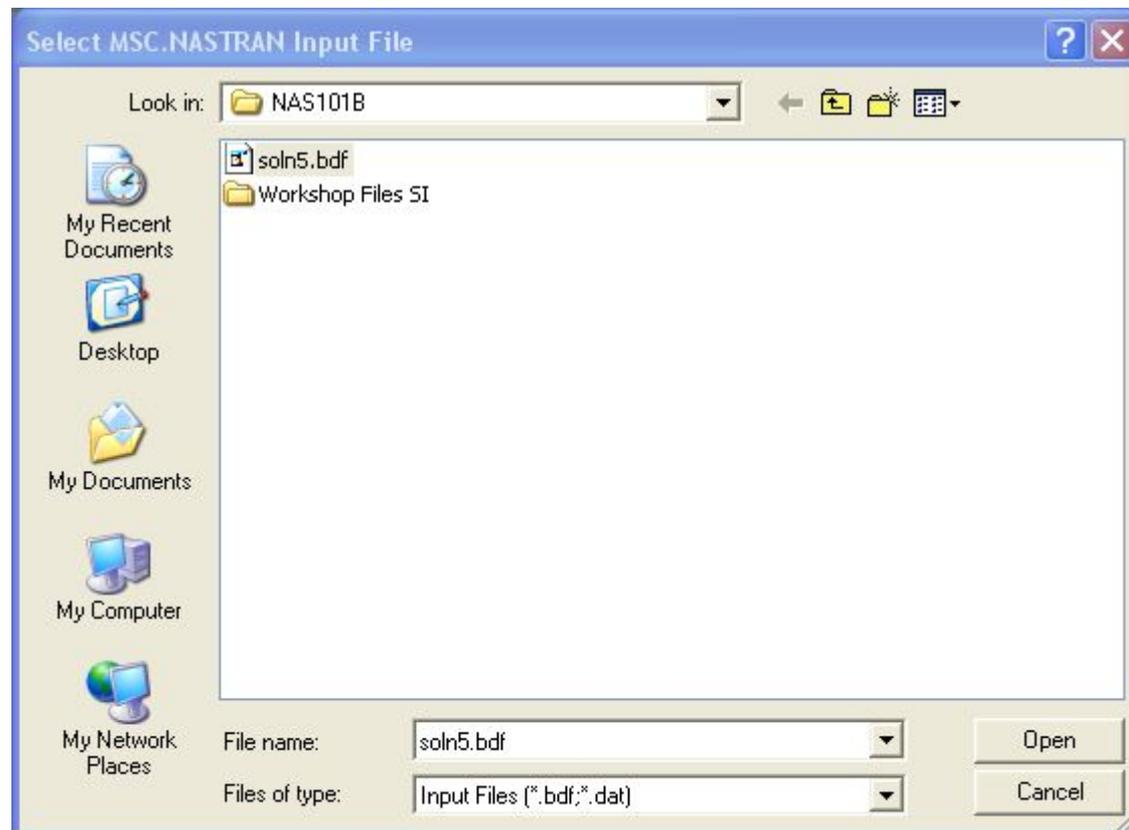
$
BCTABLE 1
      SLAVE 2      0.4
          0      0      0
      MASTERS 1

$ Create Deformable Body Contact LBC set for Hex Elements
BCBODY 1      3D      DEFORM 1      0
$
BSURF 1      1      21      41      61      81      101      121
      141      161      181

$ Create Deformable Body Contact LBC set for Tet Elements
BCBODY 2      3D      DEFORM 2      0
$
  
```

3. Submit Input File to MSC Nastran

3. Analysis: Solution Type = Nastran Linear Static , Solution Sequence = 101. Submit input file to MSC Nastran.



4. F06 Output File

```

0
      M O D E L   S U M M A R Y           BULK = 0
      ENTRY NAME   NUMBER OF ENTRIES
      -----
      BCBODY                2
      BCTABLE                2
      BSURF                  2
      CHEXA                  200
      CORD2R                  1
      CTETRA                 1378
      FORCE                   2
      GRID                   953
      LOAD                   1
      MAT1                    1
      PARAM                  2
      PSOLID                  2
      SPC1                    1
      SPCADD                  1

^^^
^^^ >>> IFP OPERATIONS COMPLETE <<<
^^^

1                                     MARCH   5, 2012  MSC.NASTRAN 11/25/11  PAGE   5
0
*** USER INFORMATION MESSAGE 7310 (VECPRN)
    ORIGIN OF SUPERELEMENT BASIC COORDINATE SYSTEM WILL BE USED AS REFERENCE LOCATION.
    RESULTANTS ABOUT ORIGIN OF SUPERELEMENT BASIC COORDINATE SYSTEM IN SUPERELEMENT BASIC SYSTEM COORDINATES.
0
      OLOAD   RESULTANT
      SUBCASE/  LOAD
      DAREA ID  TYPE      T1          T2          T3          R1          R2          R3
0      1      FX      0.000000E+00  -----  -----  -----  0.000000E+00  0.000000E+00  0.000000E+00
      FY      -----  0.000000E+00  -----  0.000000E+00  -----  -----  0.000000E+00
      FZ      -----  -----  9.000000E+01  5.715000E+03  -2.286000E+04  -----
      MX      -----  -----  -----  0.000000E+00  -----  -----
      MY      -----  -----  -----  -----  0.000000E+00  -----
      MZ      -----  -----  -----  -----  -----  0.000000E+00
      TOTALS  0.000000E+00  0.000000E+00  9.000000E+01  5.715000E+03  -2.286000E+04  0.000000E+00
1                                     MARCH   5, 2012  MSC.NASTRAN 11/25/11  PAGE   6
0
                                                                                   SUBCASE 1
*** SYSTEM INFORMATION MESSAGE 4159 (DFMSA)
    THE DECOMPOSITION OF KLL   YIELDS A MAXIMUM MATRIX-TO-FACTOR-DIAGONAL RATIO OF   1.755070E+04
*** USER INFORMATION MESSAGE 5293 (SSG3A)
    FOR DATA BLOCK KLL
    LOAD SEQ. NO.      EPSILON      EXTERNAL WORK      EPSILONS LARGER THAN 0.001 ARE FLAGGED WITH ASTERISKS
1      1              -1.0624235E-10      1.0516039E+02
1                                     MARCH   5, 2012  MSC.NASTRAN 11/25/11  PAGE   7

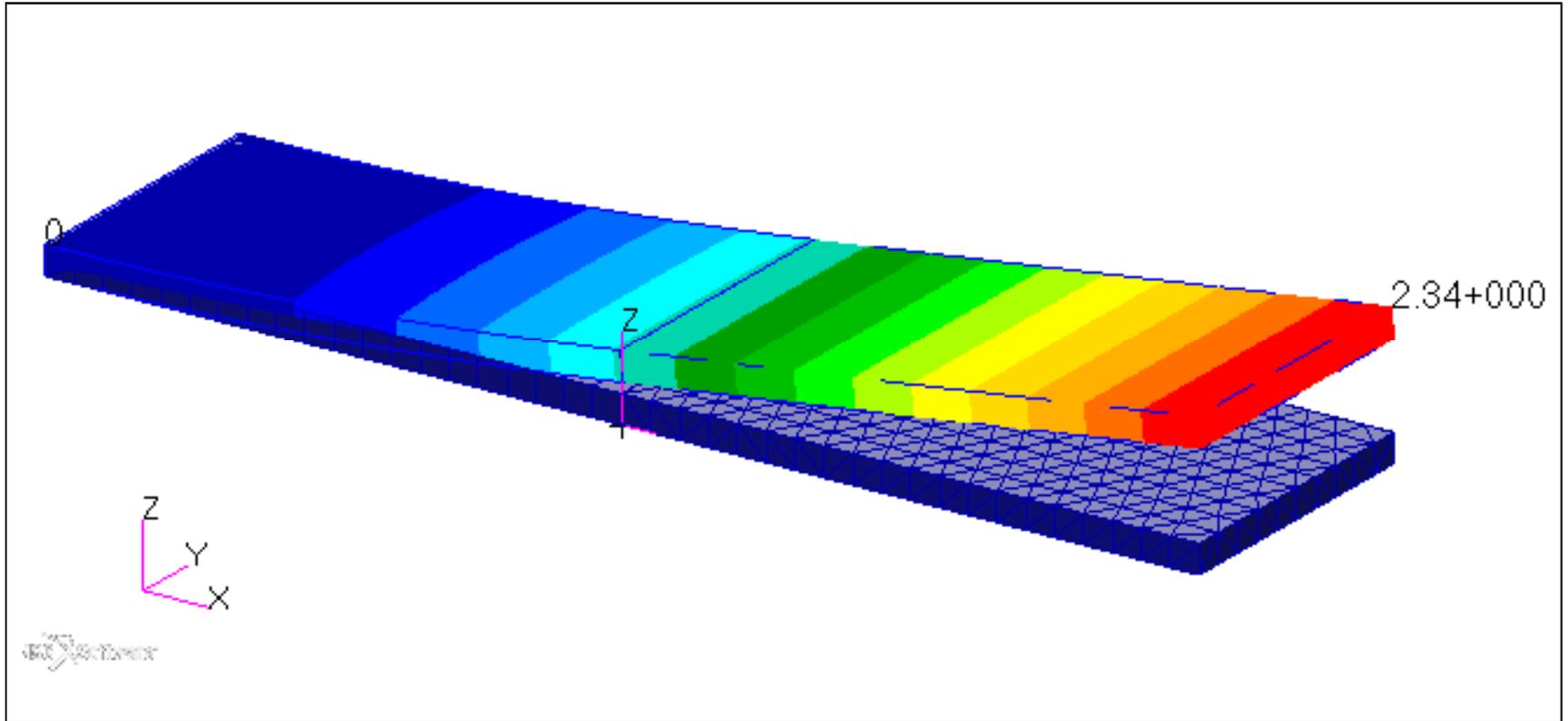
```

DISPLACEMENT OUTPUT IN F06

DISPLACEMENT VECTOR									
POINT ID.	TYPE	T1	T2	T3	R1	R2	R3		
7293	G	-3.636403E-02	-6.371031E-04	7.977238E-01	0.0	0.0	0.0		
7294	G	-3.538705E-02	-1.182795E-03	7.255455E-01	0.0	0.0	0.0		
7295	G	-3.410950E-02	-1.487394E-03	6.556838E-01	0.0	0.0	0.0		
7296	G	-3.271653E-02	-1.764039E-03	5.885950E-01	0.0	0.0	0.0		
7297	G	-3.124283E-02	-1.988108E-03	5.244136E-01	0.0	0.0	0.0		
7298	G	-2.969782E-02	-2.178104E-03	4.632895E-01	0.0	0.0	0.0		
7299	G	-2.808718E-02	-2.338701E-03	4.053487E-01	0.0	0.0	0.0		
7300	G	-2.641312E-02	-2.474211E-03	3.507154E-01	0.0	0.0	0.0		
7301	G	-2.467595E-02	-2.586628E-03	2.995130E-01	0.0	0.0	0.0		
7302	G	-2.287525E-02	-2.676461E-03	2.518670E-01	0.0	0.0	0.0		
7303	G	-2.101016E-02	-2.742585E-03	2.079057E-01	0.0	0.0	0.0		
7304	G	-1.907954E-02	-2.782201E-03	1.677613E-01	0.0	0.0	0.0		
7305	G	-1.708210E-02	-2.790638E-03	1.315696E-01	0.0	0.0	0.0		
7306	G	-1.501659E-02	-2.761105E-03	9.947114E-02	0.0	0.0	0.0		
7307	G	-1.288223E-02	-2.684296E-03	7.161055E-02	0.0	0.0	0.0		
7308	G	-1.067971E-02	-2.548146E-03	4.813541E-02	0.0	0.0	0.0		
7309	G	-8.413758E-03	-2.336529E-03	2.919180E-02	0.0	0.0	0.0		
7310	G	-6.100434E-03	-2.031768E-03	1.491214E-02	0.0	0.0	0.0		
7311	G	-3.770689E-03	-1.594346E-03	5.386302E-03	0.0	0.0	0.0		
7312	G	-1.566702E-03	-1.054354E-03	5.945630E-04	0.0	0.0	0.0		
7313	G	0.0	0.0	0.0	0.0	0.0	0.0		
7314	G	-3.628652E-02	-5.653827E-04	7.990431E-01	0.0	0.0	0.0		
7315	G	-3.522252E-02	-8.259295E-04	7.274601E-01	0.0	0.0	0.0		
7316	G	-3.397347E-02	-1.083553E-03	6.582527E-01	0.0	0.0	0.0		
7317	G	-3.260327E-02	-1.314159E-03	5.916541E-01	0.0	0.0	0.0		
7318	G	-3.114472E-02	-1.509788E-03	5.278965E-01	0.0	0.0	0.0		
7319	G	-2.961415E-02	-1.673878E-03	4.671282E-01	0.0	0.0	0.0		
7320	G	-2.801690E-02	-1.811355E-03	4.094881E-01	0.0	0.0	0.0		
7321	G	-2.635526E-02	-1.924849E-03	3.551055E-01	0.0	0.0	0.0		
7322	G	-2.463015E-02	-2.016142E-03	3.041081E-01	0.0	0.0	0.0		
7323	G	-2.284180E-02	-2.085522E-03	2.566218E-01	0.0	0.0	0.0		
7324	G	-2.099011E-02	-2.131843E-03	2.127729E-01	0.0	0.0	0.0		
7325	G	-1.907486E-02	-2.152357E-03	1.726878E-01	0.0	0.0	0.0		
7326	G	-1.709580E-02	-2.142542E-03	1.364933E-01	0.0	0.0	0.0		
7327	G	-1.505286E-02	-2.095878E-03	1.043163E-01	0.0	0.0	0.0		
7328	G	-1.294650E-02	-2.003697E-03	7.628347E-02	0.0	0.0	0.0		
7329	G	-1.077877E-02	-1.854886E-03	5.251879E-02	0.0	0.0	0.0		
7330	G	-8.555803E-03	-1.637026E-03	3.313878E-02	0.0	0.0	0.0		
7331	G	-6.291209E-03	-1.334503E-03	1.824068E-02	0.0	0.0	0.0		
7332	G	-4.028259E-03	-9.382285E-04	7.872503E-03	0.0	0.0	0.0		
7333	G	-1.863559E-03	-4.861926E-04	1.944808E-03	0.0	0.0	0.0		
7334	G	0.0	0.0	0.0	0.0	0.0	0.0		
7335	G	-3.622824E-02	-4.198634E-04	7.999672E-01	0.0	0.0	0.0		
7336	G	-3.500388E-02	-5.830656E-04	7.288449E-01	0.0	0.0	0.0		
7337	G	-3.375491E-02	-7.508361E-04	6.600462E-01	0.0	0.0	0.0		
7338	G	-3.241000E-02	-9.227672E-04	5.938690E-01	0.0	0.0	0.0		
7339	G	-3.097776E-02	-1.076953E-03	5.304631E-01	0.0	0.0	0.0		
7340	G	-2.947256E-02	-1.208434E-03	4.699952E-01	0.0	0.0	0.0		

SUBCASE 1

5. Plot Displacements



Solution File For Workshop 5

```
.
.
.
GRID      8243          9.0003  5.      0.
GRID      8244          9.5004  5.      0.
GRID      8245          10.      5.      0.
$ Loads for Load Case
SPCADD    2      1
LOAD      2      1.      1.      1
$ Displacement Constraints of Load Set
SPC1      1      123456  7313    7334    7355    7376    7397    7418
          7439    7460    7481    7502    7523    7544    7565    7586
          7607    7628    7649    7670    7691    7712    7733    7754
$ Create Contact Tables
BCTABLE   0          1
          SLAVE    2      0.4          2
          0      0      0
          MASTERS  1
$
BCTABLE   1          1
          SLAVE    2      0.4          2
          0      0      0
          MASTERS  1
$ Create Deformable Body Contact LBC set for Hex Elements
BCBODY    1      3D      DEFORM  1      0
$
BSURF     1      1      21      41      61      81      101     121
          141     161     181
$
.
.
```

Solution File For Workshop 5 (Cont.)

```
.  
. .  
$  
$ Create Deformable Body Contact LBC set for Tet Elements  
BCBODY 2 3D DEFORM 2 0  
$  
BSURF 2 704 950 258 951 557 651 779  
487 486 280 1513 1561 1505 1512 1503  
1442 1499 1509 1571 1053  
$  
$ Nodal Forces Applied in the Z Direction  
FORCE 1 8017 0 45. 0. 0. 1.  
FORCE 1 8225 0 45. 0. 0. 1.  
$  
ENDDATA
```

ADDITIONAL METHODS OF DEFORMABLE BODY

- Along with BSURF users also can try other deformable body methods for BSID in BCBODY: BCPROP

BCPROP

Defines a 3D contact region by element properties. All elements with the specified properties define a contact body used in SOL 101 and MSC Nastran SOLs 400 and 700 only.

1	2	3	4	5	6	7	8	9	10
BCPROP	ID	IP1	IP2	IP3	IP4	IP5	IP6	IP7	
	IP8	IP9	etc.						

Field

Contents

- ID Identification of a deformable surface corresponding to a BSID value on the BCBODY entry. All elements corresponding to the property IDs specified that may potentially come into contact. Do not specify mixed property types (use all shell, all solid or all beam properties only). (Integer > 0)
- IP_i Property ID. A minimum of one entry is required. (Integer; no Default)

