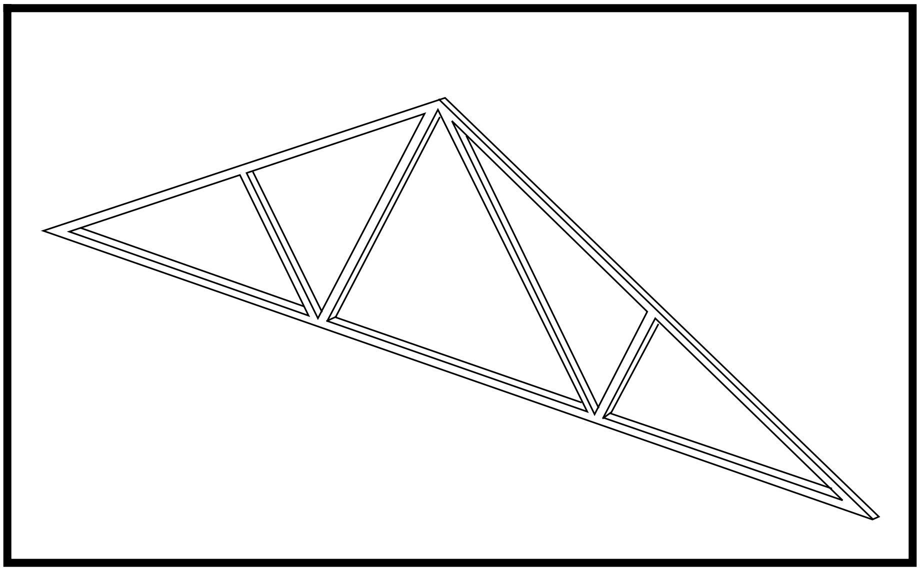
WORKSHOP PROBLEM 2

Linear Static Analysis of a Simply-Supported Truss



Objectives:

- Define a set of material properties using the beam library.
- Perform a static analysis of a truss under 3 separate loading conditions.
- Review results.

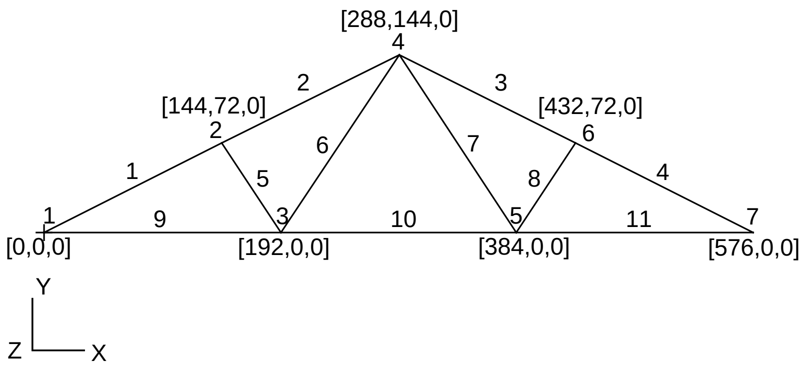
Model Description:

Below is a finite element representation of the truss structure shown on page 2-1. The nodal coordinates provided are defined in the Global Cartesian Coordinate System (MSC/NASTRAN Basic system).

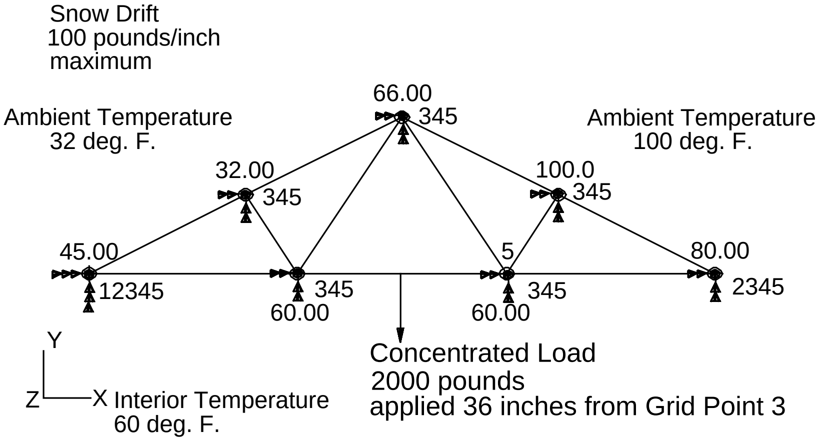
The roof frame shown in the attached figure consists of eleven wood and steel members. The wood members, have uniform cross section properties and act only as tension and compression members. (See page 2-5 for location.) The steel members, are bars that are capable of withstanding tension, compression, shear, and loads in the plane of the frame. (See page 2-5 for location.) The section properties for the steel members are supplied as problem data. All the steel members are welded end to end, however, the wood members are pinned end to end. The frame is supported by pinned connections in the horizontal and vertical directions at Grid Point 1 and in the vertical direction at Grid Point 7. In addition, all Grid Points have fixed out of plane translations and have constrained out of plane rotations.

Hint: DOF 345 for grid 1 thru 7 can be constrained by using the permanent single point constraint option in the GRID entry.

<u>Grid Coordinates and Element Connectivities</u>



Loads and Boundary Conditions



- Subcase One will be only the gravity load due to the weight of both the wood and steel members.
- Subcase Two will be the snow drift load and the concentrated load. The snow drift load is in the vertical direction and is given as a varying running load. The load increases linearly with distance along the beam, from 0 at Grid Point 4 to 100 lbs/in. at Grid Point 1.
- Subcase Three will be the temperature load which is calculated as the temperature averages and applied at the joints. The joint temperatures are supplied as problem data. The stress-free reference temperature is 72.0 degrees F.

Table 2.1

Description of Element Properties		
	material	element type and cross setion
Top members, elements 1, 2, 3, and 4	Steel	Beam, Cross Section B
Bottom members 9, 10 and 11	Steel	Beam, Cross Section A
Interior members 5, 6, 7, 8	Southen Pine	Rod, Area = 5.2 in2

Table 2.2

Material Properties		
Matieral	Steel	Southern Pine
Elastic Modulus	2.90E 7 psi	1.76E 6 psi
Poisson's Ratio	0.32	
Mass Density	7.349E -4 lbm/in4	5.435E -5 lbm/in4
Coefficient of Thermal Expansion	6.78E-6 in/deg. F	3.00e-6 in/deg. F
Reference Temperature	72 deg. F	72 deg. F
Allowable tension stress	24000 psi	1900 psi
Allowable compression stress	24000 psi	1900 psi
Allowable shear stress	24000 psi	
Gravitational Acceleration	386.4 in/sec2	386.4 in/sec2

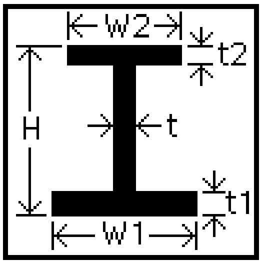


Table 2.3

Beam Dimensions		
	Cross Section A	**Cross Section B**
H	**8.0 in.**	**6.0 in.**
W1	**3.0 in.**	**3.0 in.**
W2	**3.0 in.**	**3.0 in.**
t	**0.5 in.**	**0.5 in.**
t1	**0.5 in.**	**0.5 in.**
t2	**0.5 in.**	**0.5 in.**

Table 2.4

Temperature Distribution	
Joint	**Values**
1	**45 deg. F.**
2	**32 deg. F.**
3	**60 deg. F.**
4	**66 deg. F.**
5	**60 deg. F.**
6	**100 deg. F.**
7	**80 deg. F.**

Suggested Exercise Steps:

- Generate a finite element representation of the truss structure using (GRID), (CROD), and (CBAR) elements.
  (**Hint:** Remember to use permanent constraints for DOF 345.)

- Define material (MAT1) and element (PROD) and (PBARL) properties.

- Apply simply-supported boundary constraints (SPC1), inertial loads (GRAV), a temperature load (TEMP), and a distributed load (PLOAD1).

- Use the load and boundary condition sets to define loadcases (SUBCASE).

- Prepare the model for a linear static analysis (SOL 101).

- Submit it for a linear static analysis.

- Review results.

```
ID SEMINAR,PROB2
```

```
CEND
```

```
BEGIN BULK
```

1	2	3	4	5	6	7	8	9	10

1	2	3	4	5	6	7	8	9	10

ENDDATA

Exercise Procedure:

1. Users who are not utilitizing MSC/PATRAN for generating an input file should proceed to Step 20, otherwise, continue with step 2.

2. Create a new database called **prob2.db**.

File/New...

New Database Name: **prob2**

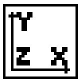
OK

In the New Model Preferences form set the following:

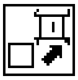
Tolerance:	◆ **Default**
Analysis Code:	**MSC/NASTRAN**
Analysis Type:	**Structural**

OK

3. Select a preset view by selecting the **Front View** icon on the toolbar.


Front View

4. Activate the entity labels by selecting the **Show Labels** icon on the toolbar.


Show Labels

5. Create the nodes by manually defining their respective coordinates:

◆ **Finite Elements**

Action:	**Create**
Object:	**Node**
Method:	**Edit**

❑ **Associate with Geometry**

Node Location List: **[0, 0, 0]**

Apply

Repeat the previous operation to create the remaining nodes. Refer to the figure on page 2-3 for the nodal coordinates.

Node Location List: **[144, 72, 0]**

Apply

Node Location List: **[192, 0, 0]**

Apply

Node Location List: **[288, 144, 0]**

Apply

Node Location List: **[384, 0, 0]**

Apply

Node Location List: **[432, 72, 0]**

Apply

Node Location List: **[576, 0, 0]**

Apply

Next, manually define the truss segment connectivites with BAR2 elements using our newly created nodes. Again, refer to page 2-3 for connectivity information.

◆ **Finite Elements**

Action:	**Create**
Object:	**Element**
Method:	**Edit**
Shape:	**Bar**
Topology:	**Bar2**

Node 1 =	**Node 1**
Node 2 =	**Node 2**

Apply

Repeat the previous operation until all the truss segments have been created.

Node 1 =	**Node 2**
Node 2 =	**Node 4**

Apply

Node 1 =	**Node 4**
Node 2 =	**Node 6**

Apply

Node 1 =	**Node 6**
Node 2 =	**Node 7**

Apply

Node 1 =	**Node 2**
Node 2 =	**Node 3**

Apply

Node 1 =	**Node 3**
Node 2 =	**Node 4**

Apply

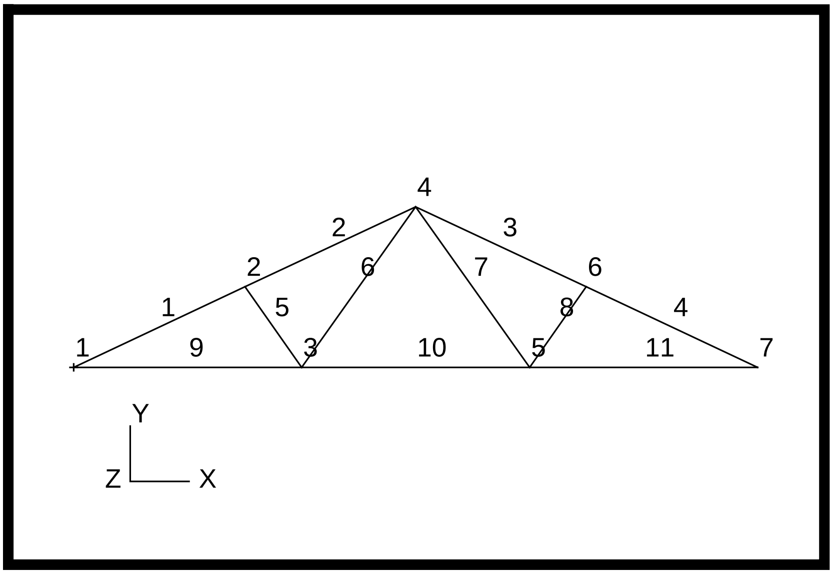
Node 1 =	**Node 4**
Node 2 =	**Node 5**

Apply

Node 1 =	**Node 5**
Node 2 =	**Node 6**

Apply	
Node 1 =	**Node 1**
Node 2 =	**Node 3**
Apply	
Node 1 =	**Node 3**
Node 2 =	**Node 5**
Apply	
Node 1 =	**Node 5**
Node 2 =	**Node 7**
Apply	

Figure 2.1 - Nodal and Element Locations



6. Next, define a material using the specified modulus of elasticity and allowable stresses.

◆ **Materials**

Action:	**Create**
Object:	**Isotropic**

Method:	**Manual Input**
Material Name:	**southern_pine**

Input Properties ...

Constitutive Model:	**Linear Elastic**
Elastic Modulus =	**1.76E6**
Density =	**5.435E-5**
Thermal Expan. Coeff =	**3.00E-6**
Reference Temperature =	**72.0**

Apply

Constitutive Model:	**Failure**
Tension Stress Limit =	**???** (Enter material limit)
Compression Stress Limit =	**???** (Enter material Limit)

Apply

In the *Current Constitutive Models* data box, you will see **Failure - [n/a,,,,] - [Active]** and **Linear Elastic - [,,,,] - [Active]** appear. Click on **Cancel** to close the form.

Cancel

7. Define another material for the model, steel.

◆ **Materials**

Action:	**Create**
Object:	**Isotropic**
Method:	**Manual Input**

Material Name: **steel**

Input Properties ...

Constitutive Model:	**Linear Elastic**
Elastic Modulus =	**2.90E7**
Poisson Ratio =	**0.32**
Density =	**7.349E-4**
Thermal Expan. Coeff =	**6.78E-6**
Reference Temperature =	**72.0**

Apply

Constitutive Model:	**Failure**
Tension Stress Limit =	**???** (Enter material limit)
Compression Stress Limit =	**???** (Enter material Limit)
Shear Stress Limit =	**???** (Enter material Limit)

Apply

In the *Current Constitutive Models* data box, you will see **Failure - [n/a,,,,] - [Active]** and **Linear Elastic - [,,,,] - [Active]** appear. Click on **Cancel** to close the form.

Cancel

8. Next, reference the material that was created in the previous step. Define the properties of the truss segments using the specified cross-sectional data.

◆ **Properties**

Action: **Create**

Dimension:	**1 D**
Type:	**Rod**
Property Set Name:	**rod**
Input Properties ...	
Material Name:	**m:southern_pine**
Area:	**???** (Enter cross-sectional area)
OK	
Select Members:	**Elm 5:8**
Add	
Apply	

9. Enter the properties for the steel members using bar elements with the beam library.

◆ **Properties**

Action:	**Create**
Dimension:	**1 D**
Type:	**Beam**
Property Set Name:	**steel_member_a**
Input Properties ...	
Material Name	**m:steel**
Bar Orientation	**<0, 1, 0>**

■ **Associate Beam Section**

Click the beam library icon:

Action:	**Create**
Type:	**Standard Shape**
New Section Name:	**section_a**
H	**8**
W1	**3**
W2	**3**
t	**0.5**
t1	**0.5**
t2	**0.5**

OK

OK

Select Members:	**Elm 9:11**

Add

Apply

10. Repeat the procedure for the remaining sections of the truss.

◆ **Properties**

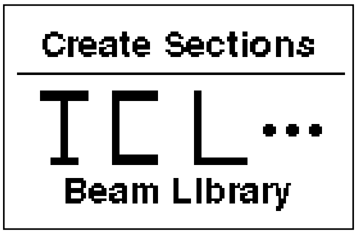
Action:	**Create**
Dimension:	**1 D**
Type:	**Beam**
Property Set Name:	**steel_member_b**

Input Properties ...

Material Name	**m:steel**
Bar Orientation	**<0, 1, 0>**

■ **Associate Beam Section**

Click the beam library icon:



Action:	**Create**
Type:	**Standard Shape**
New Section Name:	**section_b**
H	**6**
W1	**3**
W2	**3**
t	**0.5**
t1	**0.5**
t2	**0.5**

OK

OK

Select Members:	**Elm 1:4**

Add

Apply

11. Shrink the elements by 10% for clarity; this allows us to easily assess the element connectivities. Use the **Display/Finite Elements...** option.

Display/Finite Elements...

FEM Shrink:	**0.10**

Apply

Cancel

12. Create three nodal constraints and apply them to the analysis model. These boundary conditions represent the simply-supported ends of the truss, the fixed out of plane translations, and the contrained rotations..

12a. The left-hand support is defined as follows:

◆ **Loads/BCs**

Action:	**Create**
Object:	**Displacement**
Type:	**Nodal**
New Set Name:	**pin**
Input Data...	
Translations < T1 T2 T3 >	**<0, 0, >**
OK	
Select Application Region...	
Geometry Filter:	◆ **FEM**
Select Nodes:	**Node 1**
Add	
OK	
Apply	

12b. The right-hand support is located at the opposite end of the truss.

◆ **Loads/BCs**

Action:	**Create**
Object:	**Displacement**
Type:	**Nodal**
New Set Name:	**roller**
Input Data...	
Translations < T1 T2 T3 >	**< , 0, >**
OK	

Select Application Region...

Geometry Filter: ◆ **FEM**

Select Nodes: **Node 7**

Add

OK

Apply

12c. The out of plane translations and out of plane rotations can be constrained as follows:

◆ **Loads/BCs**

Action: **Create**

Object: **Displacement**

Type: **Nodal**

New Set Name: **out_of_plane**

Input Data...

Translations < T1 T2 T3 > **< , ,0>**

Rotations < R1 R2 R3 > **<0, 0, >**

OK

Select Application Region...

Geometry Filter: ◆ **FEM**

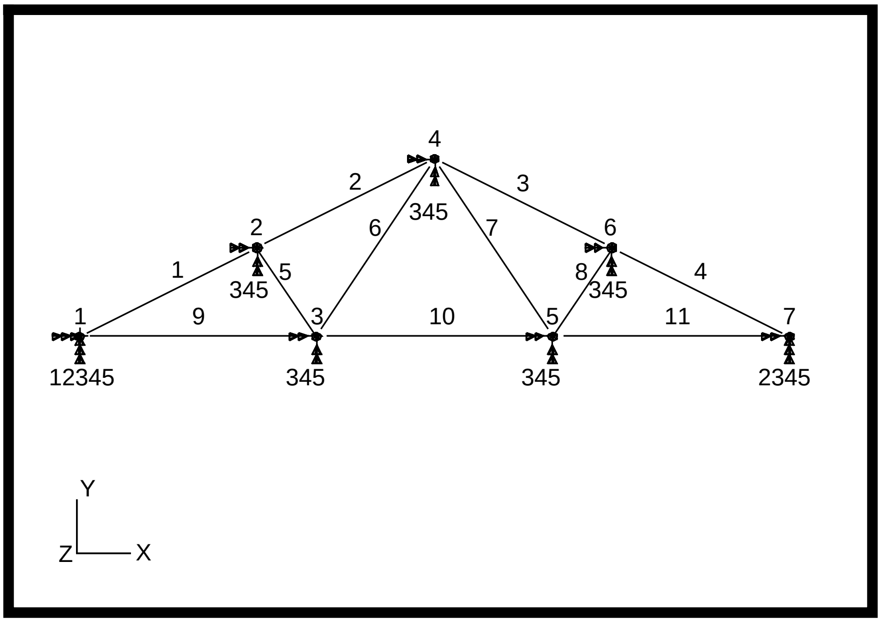
Select Nodes: **Node 1:7**

Add

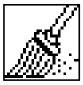
OK

Apply

Figure 2.2 - Displacement Constraints

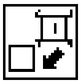


12d. Reset the display by selecting the **Reset Graphics** icon on the **Top Menu Bar**.



Reset Graphics

13. Deactivate the entity labels by selecting the **Hide Labels** icon on the toolbar.



Hide Labels

14. Create the gravity load..

◆ **Loads/BCs**

Action:	**Create**
Object:	**Inertial Load**
Type:	**Element Uniform**
New Set Name:	**gravity_load**
Input Data...	
Load/BC Set Scale Factor:	**386.4**
Trans Accel < A1 A2 A3 >	**<0, -1, 0>**

OK

Since the gravity load acts uniformly on the body, the application region is automatically set as the entire model.

Apply

15. Next, define the temperature load using fields.

◆ **Fields**

Action:	**Create**
Object:	**Spatial**
Method:	**FEM**
Field Name:	**temp_profile**

Input Data ...

Enter the data into the table as shown below.

	Entity	Values
1	Node 1	45
2	Node 2	32
3	Node 3	60
4	Node 4	66
5	Node 5	60
6	Node 6	100
7	Node 7	80

OK

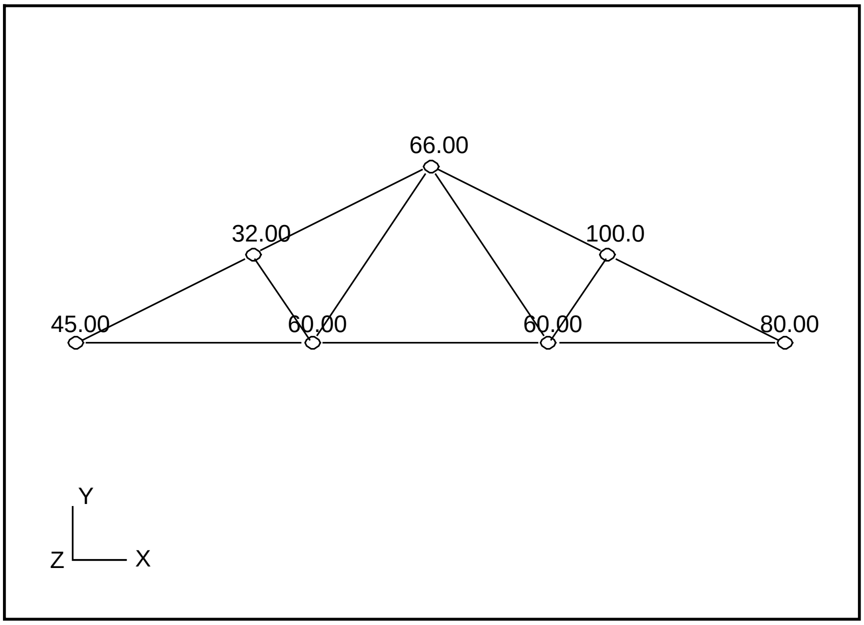
Apply

◆ **Loads/BCs**

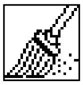
Action:	**Create**
Object:	**Temperature**

Type:	**Nodal**
New Set Name:	**temperature_load**
Input Data...	
Spatial Fields:	**temp_profile** (Click on this to select.)
OK	
Select Application Region...	
Geometry Filter:	◆ **FEM**
Select Nodes:	**Node 1:7**
Add	
OK	
Apply	

Figure 2.3 - Temperature Loads



15a. Reset the display by selecting the **Reset Graphics** icon on the **Top Menu Bar**.

 **Reset Graphics**

16. Create a load case that references the inertial load and the boundary conditions that have already been defined.

◆ **Load Cases**

Action:	**Create**
Load Case Name:	**gravity_load**
Load Case Type:	**Static**

Assign/Prioritize Loads/BCs

Select all the Load/BC sets in the *Select Loads/BCs to Add to Spreadsheet* box by clicking on all of them.

Highlight Loads/BCs to Add to Spreadsheet	**Displ_out_of_plane** **Displ_pin** **Displ_roller** **Inert_gravity_load**

* **REMINDER**: Make sure that the LBC Scale Factor column shows the proper value for each entry.

OK

Apply

17. Create a second load case that references the temperature load, and the boundary conditions that have already been defined.

◆ **Load Cases**

Action:	**Create**
Load Case Name:	**temperature_load**
Load Case Type:	**Static**

Assign/Prioritize Loads/BCs

Select all the Load/BC sets in the *Select Loads/BCs to Add to Spreadsheet* box by clicking on all of them.

Highlight Loads/BCs to Add to Spreadsheet

Displ_out_of_plane
Displ_pin
Displ_roller
Tempe_temperature_load

If the inertial gravity load is in the spreadsheet, it can be removed as follows:

Click the inertial gravity load in the spreadsheet.

Remove Selected Rows

17a. Close the form.

OK

Apply

18. Now you are ready to generate an input file for analysis.

Click on the **Analysis** radio button on the **Top Menu Bar** and complete the entries as shown here.

◆ **Analysis**

Action:	**Analyze**
Object:	**Entire Model**
Method:	**Analysis Deck**
Job Name:	**prob2**

Translation Parameters...

OUTPUT2 Format:	**Binary**
MSC/NASTRAN Version:	**???** Set accordingly, here it is 70.

OK

Solution Type...	
Solution Type:	◆ **Linear Static**
Solution Parameters...	
■ **Database Run**	
■ **Automatic Constraints**	
Data Deck Echo:	**Sorted**
OK	
OK	
Subcase Select...	
Subcases For Solution Sequence:	**gravity_load** **temperature_load** (Click on these to select.)
Subcases Selected:	**Default** (Click on this to deselect.)
OK	
Apply	

An MSC/NASTRAN input file called **prob2.bdf** will be generated. This process of translating your model into an input file is called the Forward Translation. The Forward Translation is complete when the Heartbeat turns green.

19. Modify prob2a.bdf to include a third subcase for the snow-drift load.

Open the file **prob2.bdf** with a text editor. The text below defines a third subcase. Enter this text on the line before **BEGIN BULK**.

```
SUBCASE 3
$ Subcase name : snow_&_concentrated_load
   SUBTITLE=snow & concentrated load
   spc = 2
   load = 5
   disp = all
   spcforce = all
   force = all
```

This text describes the snow drift load for the third subcase, entire this text on the line before **ENDDATA**, which is at the very end of the file.

```
PLOAD1,5,1,FY,FRPR,0.0,-100.,1.0,-50.
PLOAD1,5,2,FY,FRPR,0.0,-50.,1.0,0.0
PLOAD1,5,10,FY,LE,36.,-2000.
```

MSC/PATRAN Users should proceed to step 21.

Generating an input file for MSC/NASTRAN Users:

MSC/NASTRAN users can generate an input file using the data from the **Model Description** section at the beginning of the exercise. The result should be similar to the output below.

20. MSC/NASTRAN Input File: prob2a.dat

```
ID SEMINAR,PROB2
TIME 5
SOL 101
CEND
TITLE = GARAGE ROOF FRAME
SUBTITLE = WOOD AND STEEL MEMBERS
   SPC = 20
   DISP = ALL
   FORCE = ALL
   STRESS = ALL
   SPCFORCE = ALL
SUBCASE 1
   LABEL = GRAVITY LOAD
   LOAD = 1
SUBCASE 2
   LABEL = TEMPERATURE LOAD
   TEMP(LOAD) = 2
SUBCASE 3
   LABEL = SNOW AND CONCENTRATED LOAD
   LOAD = 3
BEGIN BULK
GRID,1,,0.0,0.0,0.0,,345
GRID,2,,144.0,72.0,0.0,,345
GRID,3,,192.0,0.0,0.0,,345
GRID,4,,288.0,144.0,0.0,,345
GRID,5,,384.0,0.0,0.0,,345
GRID,6,,432.0,72.0,0.0,,345
GRID,7,,576.0,0.0,0.0,,345
CBAR,1,200,1,2,0.,1.,0.
CBAR,2,200,2,4,0.,1.,0.
CBAR,3,200,4,6,0.,1.,0.
CBAR,4,200,6,7,0.,1.,0.
CBAR,9,300,1,3,0.,1.,0.
CBAR,10,300,3,5,0.,1.,0.
CBAR,11,300,5,7,0.,1.,0.
CROD,5,100,2,3
CROD,6,100,3,4
CROD,7,100,4,5
CROD,8,100,5,6
PROD,100,10,5.2
PBARL    200     20              I
         6.      3.      3.      .5      .5      .5
PBARL    300     20              I
         8.      3.      3.      .5      .5      .5
MAT1,10,1.76+6,,,5.435-5,3.0-6,72.
 ,1900.,1900.
MAT1,20,2.9+7,,.32,7.349-4,6.78-6,72.
 ,24000.,24000.,24000.
GRAV,1,,386.4,0.0,-1.0,0.0
PLOAD1,3,1,FY,FRPR,0.0,-100.,1.0,-50.
```

```
PLOAD1,3,2,FY,FRPR,0.0,-50.,1.0,0.0
PLOAD1,3,10,FY,LE,36.,-2000.
TEMP,2,1,45.
TEMP,2,2,32.
TEMP,2,3,60.
TEMP,2,4,66.
TEMP,2,5,60.
TEMP,2,6,100.
TEMP,2,7,80.
SPC,20,1,12,0.0
SPC,20,7,2,0.0
ENDDATA
```

SUBMITTING THE INPUT FILE FOR MSC/NASTRAN and MSC/PATRAN USERS:

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

    21a. To submit the MSC/PATRAN **.bdf** file for analysis, find an available UNIX shell window. At the command prompt enter: **nastran prob2.bdf scr=yes**. Monitor the run using the UNIX **ps** command.

    21b. To submit the MSC/NASTRAN **.dat** file for analysis, find an available UNIX shell window. At the command prompt enter: **nastran prob2 scr=yes**. Monitor the run using the UNIX **ps** command.

22. When the run is completed, edit the **prob2.f06** file and search for the word **FATAL**. If no matches exist, search for the word **WARNING**. Determine whether existing **WARNING** messages indicate modeling errors.

    22a. While still editing **prob2.f06**, search for the word:

    D I S P L A C E (spaces are necessary).

    What are the components of the displacement vector for GRID 3 and 5 (translation only)?

Gravity Load Case		Temperature Load Case		Snow Drift Load Case	
Grid 3		Grid 3		Grid 3	
Disp. X =	______	Disp. X =	______	Disp. X =	______
Disp. Y =	______	Disp. Y =	______	Disp. Y =	______
Disp. Z =	______	Disp. Z =	______	Disp. Z =	______
Grid 5		Grid 5		Grid 5	
Disp. X =	______	Disp. X =	______	Disp. X =	______
Disp. Y =	______	Disp. Y =	______	Disp. Y =	______
Disp. Z =	______	Disp. Z =	______	Disp. Z =	______

Search for the word:

S I N G L E (spaces are necessary).

What are the components of the reaction force at GRID 1 and GRID 7?

Gravity Load Case		**Temperature Load Case**		**Snow Drift Load Case**	
GRID 1		GRID 1		GRID 1	
T1 =	________	T1 =	________	T1 =	________
T2 =	________	T2 =	________	T2 =	________
T3 =	________	T3 =	________	T3 =	________
GRID 7		GRID 7		GRID 7	
T1 =	________	T1 =	________	T1 =	________
T2 =	________	T2 =	________	T2 =	________
T3 =	________	T3 =	________	T3 =	________

Search for the word:

F O R C E D I S T (spaces are necessary).

What is the axial force in the BAR elements (CBAR) for each element case?

Gravity Load Case		**Temperature Load Case**		**Snow Drift Load Case**	
Element 4		Element 4		Element 4	
PCT 1.000	________	PCT 1.000	________	PCT 1.000	________
PCT 0.000	________	PCT 0.000	________	PCT 0.000	________
Element 11		Element 11		Element 11	
PCT 1.000	________	PCT 1.000	________	PCT 1.000	________
PCT 0.000	________	PCT 0.000	________	PCT 0.000	________

What is the axial force in CROD elements 7 and 8?

Gravity Load Case		**Temperature Load Case**		**Snow Drift Load Case**	
Element 7	________	Element 7	________	Element 7	________
Element 8	________	Element 8	________	Element 8	________

Search for the word:

S T R E S S (spaces are necessary).

What is the margin of safety for elements 6 and 11?

Gravity Load Case		**Temperature Load Case**		**Snow Drift Load Case**	
Element 6		Element 6		Element 6	
PCT 1.000		PCT 1.000		PCT 1.000	
PCT 0.000		PCT 0.000		PCT 0.000	
Element 11		Element 11		Element 11	
PCT 1.000		PCT 1.000		PCT 1.000	
PCT 0.000		PCT 0.000		PCT 0.000	

What is the Axial Stress for all elements 6 and 11?

Gravity Load Case		**Temperature Load Case**		**Snow Drift Load Case**	
Element 6		Element 6		Element 6	
PCT 1.000		PCT 1.000		PCT 1.000	
PCT 0.000		PCT 0.000		PCT 0.000	
Element 11		Element 11		Element 11	
PCT 1.000		PCT 1.000		PCT 1.000	
PCT 0.000		PCT 0.000		PCT 0.000	

Comparison of Results:

23. Compare the results obtained in the **.f06** file with the results on the next page.

GRAVITY LOAD

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

POINT ID.	TYPE	T1	T2	T3	R1	R2	R3
1	G	0.0	0.0	0.0	0.0	0.0	-1.810154E-04
2	G	9.097225E-03	-2.192763E-02	0.0	0.0	0.0	-5.905244E-06
3	G	1.497809E-03	-2.494602E-02	0.0	0.0	0.0	-6.952493E-05
4	G	2.020590E-03	-1.119851E-02	0.0	0.0	0.0	-1.510895E-19
5	G	2.543371E-03	-2.494602E-02	0.0	0.0	0.0	6.952493E-05
6	G	-5.056045E-03	-2.192763E-02	0.0	0.0	0.0	5.905244E-06
7	G	4.041180E-03	0.0	0.0	0.0	0.0	1.810154E-04

TEMPERATURE LOAD

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

POINT ID.	TYPE	T1	T2	T3	R1	R2	R3
1	G	0.0	0.0	0.0	0.0	0.0	-1.640538E-04
2	G	-2.911754E-02	-2.330577E-02	0.0	0.0	0.0	1.430237E-04
3	G	-2.548194E-02	-1.314894E-02	0.0	0.0	0.0	1.492482E-04
4	G	-7.371972E-02	9.976783E-03	0.0	0.0	0.0	3.720360E-04
5	G	-4.109691E-02	3.371104E-02	0.0	0.0	0.0	9.121846E-05
6	G	-4.592643E-02	3.897398E-02	0.0	0.0	0.0	6.057345E-06
7	G	-4.358151E-02	0.0	0.0	0.0	0.0	-3.110594E-04

SNOW AND CONCENTRATED LOAD

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

POINT ID.	TYPE	T1	T2	T3	R1	R2	R3
1	G	0.0	0.0	0.0	0.0	0.0	-5.570779E-03
2	G	1.271998E-01	-2.928742E-01	0.0	0.0	0.0	2.406997E-03
3	G	1.541444E-02	-2.935280E-01	0.0	0.0	0.0	7.510522E-05
4	G	5.572549E-03	-7.900714E-02	0.0	0.0	0.0	1.498581E-03
5	G	2.198621E-02	-7.672425E-02	0.0	0.0	0.0	1.233808E-03
6	G	5.831808E-03	-6.193648E-02	0.0	0.0	0.0	-5.114951E-05
7	G	2.857348E-02	0.0	0.0	0.0	0.0	2.269690E-04

GRAVITY LOAD

F O R C E S   O F   S I N G L E - P O I N T   C O N S T R A I N T

POINT ID.	TYPE	T1	T2	T3	R1	R2	R3
1	G	-9.094947E-13	1.062826E+03	0.0	0.0	0.0	0.0
7	G	0.0	1.062826E+03	0.0	0.0	0.0	0.0

TEMPERATURE LOAD

F O R C E S   O F   S I N G L E - P O I N T   C O N S T R A I N T

POINT ID.	TYPE	T1	T2	T3	R1	R2	R3
1	G	2.910383E-11	-1.818989E-12	0.0	0.0	0.0	0.0
7	G	0.0	-1.818989E-12	0.0	0.0	0.0	0.0

SNOW AND CONCENTRATED LOAD

F O R C E S   O F   S I N G L E - P O I N T   C O N S T R A I N T

POINT ID.	TYPE	T1	T2	T3	R1	R2	R3
1	G	1.164999E-04	1.320833E+04	0.0	0.0	0.0	0.0
7	G	0.0	3.191667E+03	0.0	0.0	0.0	0.0

GRAVITY LOAD

F O R C E   D I S T R I B U T I O N   I N   B A R   E L E M E N T S   (C B A R)

ELEMENT ID.	STATION (PCT)	BEND-MOMENT PLANE 1	BEND-MOMENT PLANE 2	SHEAR FORCE PLANE 1	SHEAR FORCE PLANE 2	AXIAL FORCE	TORQUE
1	0.000	-7.167844E+02	0.0	-1.985941E+01	0.0	-1.654005E+03	0.0
1	1.000	2.480519E+03	0.0	-1.985941E+01	0.0	-1.654005E+03	0.0
2	0.000	2.480519E+03	0.0	3.044506E+01	0.0	-1.517089E+03	0.0
2	1.000	-2.421041E+03	0.0	3.044506E+01	0.0	-1.517089E+03	0.0
3	0.000	-2.421041E+03	0.0	-3.044506E+01	0.0	-1.517089E+03	0.0
3	1.000	2.480519E+03	0.0	-3.044506E+01	0.0	-1.517089E+03	0.0
4	0.000	2.480519E+03	0.0	1.985941E+01	0.0	-1.654005E+03	0.0
4	1.000	-7.167843E+02	0.0	1.985941E+01	0.0	-1.654005E+03	0.0
9	0.000	7.167844E+02	0.0	-2.451677E+00	0.0	1.470505E+03	0.0
9	1.000	1.187506E+03	0.0	-2.451677E+00	0.0	1.470505E+03	0.0
10	0.000	1.187506E+03	0.0	-2.842171E-14	0.0	1.026502E+03	0.0
10	1.000	1.187506E+03	0.0	-2.842171E-14	0.0	1.026502E+03	0.0
11	0.000	1.187506E+03	0.0	2.451677E+00	0.0	1.470505E+03	0.0
11	1.000	7.167844E+02	0.0	2.451677E+00	0.0	1.470505E+03	0.0

F O R C E S   I N   R O D   E L E M E N T S   (C R O D)

ELEMENT ID.	AXIAL FORCE	TORQUE	ELEMENT ID.	AXIAL FORCE	TORQUE
5	-1.802138E+02	0.0	6	6.202254E+02	0.0
7	6.202254E+02	0.0	8	-1.802138E+02	0.0

TEMPERATURE LOAD

F O R C E   D I S T R I B U T I O N   I N   B A R   E L E M E N T S   (C B A R)

ELEMENT ID.	STATION (PCT)	BEND-MOMENT PLANE 1	BEND-MOMENT PLANE 2	SHEAR FORCE PLANE 1	SHEAR FORCE PLANE 2	AXIAL FORCE	TORQUE
1	0.000	4.113555E+02	0.0	-1.410100E+01	0.0	1.001056E+02	0.0
1	1.000	2.681573E+03	0.0	-1.410100E+01	0.0	1.001056E+02	0.0
2	0.000	2.681573E+03	0.0	1.898485E+01	0.0	9.596985E+01	0.0
2	1.000	-3.749292E+02	0.0	1.898485E+01	0.0	9.596985E+01	0.0
3	0.000	-3.749293E+02	0.0	1.823842E+01	0.0	-1.149399E+02	0.0
3	1.000	-3.311259E+03	0.0	1.823842E+01	0.0	-1.149399E+02	0.0
4	0.000	-3.311259E+03	0.0	-2.129528E+01	0.0	-1.198816E+02	0.0
4	1.000	1.172143E+02	0.0	-2.129528E+01	0.0	-1.198816E+02	0.0
9	0.000	-4.113555E+02	0.0	-3.215626E+01	0.0	-9.584331E+01	0.0
9	1.000	5.762646E+03	0.0	-3.215626E+01	0.0	-9.584331E+01	0.0
10	0.000	5.762646E+03	0.0	6.518988E+01	0.0	6.045220E+00	0.0
10	1.000	-6.753811E+03	0.0	6.518988E+01	0.0	6.045220E+00	0.0
11	0.000	-6.753811E+03	0.0	-3.456561E+01	0.0	1.167489E+02	0.0
11	1.000	-1.172141E+02	0.0	-3.456561E+01	0.0	1.167489E+02	0.0

F O R C E S   I N   R O D   E L E M E N T S   (C R O D)

ELEMENT ID.	AXIAL FORCE	TORQUE	ELEMENT ID.	AXIAL FORCE	TORQUE
5	3.334333E+01	0.0	6	-1.503388E+02	0.0
7	1.597325E+02	0.0	8	-3.984136E+01	0.0

SNOW AND CONCENTRATED LOAD

F O R C E   D I S T R I B U T I O N   I N   B A R   E L E M E N T S   (C B A R)

ELEMENT ID.	STATION (PCT)	BEND-MOMENT PLANE 1	BEND-MOMENT PLANE 2	SHEAR FORCE PLANE 1	SHEAR FORCE PLANE 2	AXIAL FORCE	TORQUE
1	0.000	-1.098263E+05	0.0	-5.620021E+03	0.0	-1.972972E+04	0.0
1	1.000	-6.902036E+04	0.0	4.039792E+03	0.0	-1.489982E+04	0.0
2	0.000	-6.902037E+04	0.0	-2.410550E+03	0.0	-1.409352E+04	0.0
2	1.000	-2.652932E+04	0.0	8.093880E+02	0.0	-1.248356E+04	0.0
3	0.000	-2.652932E+04	0.0	-2.326103E+02	0.0	-7.333517E+03	0.0
3	1.000	1.092021E+04	0.0	-2.326103E+02	0.0	-7.333517E+03	0.0
4	0.000	1.092021E+04	0.0	1.182581E+02	0.0	-7.289658E+03	0.0
4	1.000	-8.118965E+03	0.0	1.182581E+02	0.0	-7.289658E+03	0.0
9	0.000	1.098263E+05	0.0	6.417671E+02	0.0	1.513345E+04	0.0
9	1.000	-1.339296E+04	0.0	6.417671E+02	0.0	1.513345E+04	0.0
10	0.000	-1.339295E+04	0.0	-1.562901E+03	0.0	6.451971E+03	0.0
10	1.000	-2.531606E+04	0.0	4.370995E+02	0.0	6.451971E+03	0.0
11	0.000	-2.531606E+04	0.0	-1.741408E+02	0.0	6.467182E+03	0.0
11	1.000	8.118966E+03	0.0	-1.741408E+02	0.0	6.467182E+03	0.0

F O R C E S   I N   R O D   E L E M E N T S   (C R O D)

ELEMENT ID.	AXIAL FORCE	TORQUE	ELEMENT ID.	AXIAL FORCE	TORQUE
5	-6.500541E+03	0.0	6	9.150221E+03	0.0
7	3.810205E+02	0.0	8	3.535989E+02	0.0

GRAVITY LOAD

S T R E S S   D I S T R I B U T I O N   I N   B A R   E L E M E N T S   (C B A R)

ELEMENT ID.	STATION (PCT)	SXC	SXD	SXE	SXF	AXIAL	S-MAX	S-MIN	M.S.-T M.S.-C
1	0.000	7.691278E+01	-7.691278E+01	-7.691278E+01	7.691278E+01	-3.007281E+02	-2.238154E+02	-3.776409E+02	6.3E+01
1	1.000	-2.661660E+02	2.661660E+02	2.661660E+02	-2.661660E+02	-3.007281E+02	-3.456216E+01	-5.668942E+02	4.1E+01
2	0.000	-2.661660E+02	2.661660E+02	2.661660E+02	-2.661660E+02	-2.758343E+02	-9.668304E+00	-5.420002E+02	4.3E+01
2	1.000	2.597838E+02	-2.597838E+02	-2.597838E+02	2.597838E+02	-2.758343E+02	-1.605054E+01	-5.356180E+02	4.4E+01
3	0.000	2.597838E+02	-2.597838E+02	-2.597838E+02	2.597838E+02	-2.758343E+02	-1.605054E+01	-5.356181E+02	
3	1.000	-2.661660E+02	2.661660E+02	2.661660E+02	-2.661660E+02	-2.758343E+02	-9.668335E+00	-5.420003E+02	4.3E+01
4	0.000	-2.661660E+02	2.661660E+02	2.661660E+02	-2.661660E+02	-3.007281E+02	-3.456216E+01	-5.668942E+02	
4	1.000	7.691277E+01	-7.691277E+01	-7.691277E+01	7.691277E+01	-3.007281E+02	-2.238154E+02	-3.776409E+02	4.1E+01
9	0.000	-5.070840E+01	5.070840E+01	5.070840E+01	-5.070840E+01	2.262316E+02	2.769400E+02	1.755232E+02	7.6E+01
9	1.000	-8.400930E+01	8.400930E+01	8.400930E+01	-8.400930E+01	2.262316E+02	3.102409E+02	1.422223E+02	
10	0.000	-8.400930E+01	8.400930E+01	8.400930E+01	-8.400930E+01	1.579233E+02	2.419326E+02	7.391402E+01	9.8E+01
10	1.000	-8.400930E+01	8.400930E+01	8.400930E+01	-8.400930E+01	1.579233E+02	2.419326E+02	7.391402E+01	9.8E+01
11	0.000	-8.400930E+01	8.400930E+01	8.400930E+01	-8.400930E+01	2.262316E+02	3.102409E+02	1.422223E+02	7.6E+01
11	1.000	-5.070840E+01	5.070840E+01	5.070840E+01	-5.070840E+01	2.262316E+02	2.769400E+02	1.755232E+02	

S T R E S S E S   I N   R O D   E L E M E N T S   (C R O D)

ELEMENT ID.	AXIAL STRESS	SAFETY MARGIN	TORSIONAL STRESS	SAFETY MARGIN	ELEMENT ID.	AXIAL STRESS	SAFETY MARGIN	TORSIONAL STRESS	SAFETY MARGIN
5	-3.440148E+01	5.4E+01	0.0		6	1.182449E+02	1.5E+01	0.0	
7	1.182449E+02	1.5E+01	0.0		8	-3.440148E+01	5.4E+01	0.0	

TEMPERATURE LOAD

S T R E S S   D I S T R I B U T I O N   I N   B A R   E L E M E N T S   (C B A R)

ELEMENT ID.	STATION (PCT)	SXC	SXD	SXE	SXF	AXIAL	S-MAX	S-MIN	M.S.-T M.S.-C
1	0.000	-4.413949E+01	4.413949E+01	4.413949E+01	-4.413949E+01	1.820101E+01	6.234050E+01	-2.593847E+01	3.8E+02
1	1.000	-2.877395E+02	2.877395E+02	2.877395E+02	-2.877395E+02	1.820101E+01	3.059406E+02	-2.695385E+02	7.7E+01
2	0.000	-2.877395E+02	2.877395E+02	2.877395E+02	-2.877395E+02	1.744906E+01	3.051886E+02	-2.702905E+02	7.8E+01
2	1.000	4.023085E+01	-4.023085E+01	-4.023085E+01	4.023085E+01	1.744906E+01	5.767992E+01	-2.278179E+01	4.2E+02
3	0.000	4.023086E+01	-4.023086E+01	-4.023086E+01	4.023086E+01	-2.089816E+01	1.933270E+01	-6.112902E+01	7.1E+01
3	1.000	3.553065E+02	-3.553065E+02	-3.553065E+02	3.553065E+02	-2.089816E+01	3.344083E+02	-3.762047E+02	6.3E+01
4	0.000	3.553065E+02	-3.553065E+02	-3.553065E+02	3.553065E+02	-2.179665E+01	3.335098E+02	-3.771031E+02	7.1E+01
4	1.000	-1.257740E+01	1.257740E+01	1.257740E+01	-1.257740E+01	-2.179665E+01	-9.219258E+00	-3.437405E+01	6.3E+01
9	0.000	2.910105E+01	-2.910105E+01	-2.910105E+01	2.910105E+01	-1.474512E+01	1.435593E+01	-4.384618E+01	6.0E+01
9	1.000	-4.076743E+02	4.076743E+02	4.076743E+02	-4.076743E+02	-1.474512E+01	3.929292E+02	-4.224194E+02	5.6E+01
10	0.000	-4.076743E+02	4.076743E+02	4.076743E+02	-4.076743E+02	9.300338E-01	4.086043E+02	-4.067443E+02	5.8E+01
10	1.000	4.777935E+02	-4.777935E+02	-4.777935E+02	4.777935E+02	9.300338E-01	4.787236E+02	-4.768635E+02	4.9E+01
11	0.000	4.777935E+02	-4.777935E+02	-4.777935E+02	4.777935E+02	1.796137E+01	4.957549E+02	-4.598322E+02	4.7E+01
11	1.000	8.292229E+00	-8.292229E+00	-8.292229E+00	8.292229E+00	1.796137E+01	2.625360E+01	9.669140E+00	5.1E+01

S T R E S S E S   I N   R O D   E L E M E N T S   (C R O D)

ELEMENT ID.	AXIAL STRESS	SAFETY MARGIN	TORSIONAL STRESS	SAFETY MARGIN	ELEMENT ID.	AXIAL STRESS	SAFETY MARGIN	TORSIONAL STRESS	SAFETY MARGIN
5	6.412179E+00	3.0E+02	0.0		6	-2.891131E+01	6.5E+01	0.0	
7	3.071780E+01	6.1E+01	0.0		8	-7.661800E+00	2.5E+02	0.0	

SNOW AND CONCENTRATED LOAD

S T R E S S   D I S T R I B U T I O N   I N   B A R   E L E M E N T S   (C B A R)

ELEMENT ID.	STATION (PCT)	SXC	SXD	SXE	SXF	AXIAL	S-MAX	S-MIN	M.S.-T M.S.-C
1	0.000	1.178464E+04	-1.178464E+04	-1.178464E+04	1.178464E+04	-3.587222E+03	8.197420E+03	-1.537187E+04	5.6E-01
1	1.000	7.406060E+03	-7.406060E+03	-7.406060E+03	7.406060E+03	-2.709058E+03	4.697002E+03	-1.011512E+04	1.4E+00
2	0.000	7.406061E+03	-7.406061E+03	-7.406061E+03	7.406061E+03	-2.562459E+03	4.843602E+03	-9.968520E+03	1.4E+00
2	1.000	2.846663E+03	-2.846663E+03	-2.846663E+03	2.846663E+03	-2.269737E+03	5.769253E+02	-5.116400E+03	3.7E+00
3	0.000	2.846663E+03	-2.846663E+03	-2.846663E+03	2.846663E+03	-1.333367E+03	1.513296E+03	-4.180030E+03	1.5E+01
3	1.000	-1.171767E+03	1.171767E+03	1.171767E+03	-1.171767E+03	-1.333367E+03	-1.616001E+02	-2.505133E+03	4.7E+00
4	0.000	-1.171767E+03	1.171767E+03	1.171767E+03	-1.171767E+03	-1.325392E+03	-1.536259E+02	-2.497159E+03	
4	1.000	8.711855E+02	-8.711855E+02	-8.711855E+02	8.711855E+02	-1.325392E+03	-4.542069E+02	-2.196578E+03	8.6E+00
9	0.000	-7.769585E+03	7.769585E+03	7.769585E+03	-7.769585E+03	2.328223E+03	1.009781E+04	-5.441362E+03	1.4E+00
9	1.000	9.474753E+02	-9.474753E+02	-9.474753E+02	9.474753E+02	2.328223E+03	3.275699E+03	1.380748E+03	3.4E+00
10	0.000	9.474749E+02	-9.474749E+02	-9.474749E+02	9.474749E+02	9.926110E+02	1.940086E+03	4.513605E+01	1.1E+01
10	1.000	1.790967E+03	-1.790967E+03	-1.790967E+03	1.790967E+03	9.926110E+02	2.783578E+03	-7.983558E+02	7.6E+00
11	0.000	1.790967E+03	-1.790967E+03	-1.790967E+03	1.790967E+03	9.949510E+02	2.785918E+03	-7.960159E+02	7.6E+00
11	1.000	-5.743705E+02	5.743705E+02	5.743705E+02	-5.743705E+02	9.949510E+02	1.569322E+03	4.205806E+02	2.9E+01

S T R E S S E S   I N   R O D   E L E M E N T S   (C R O D)

ELEMENT ID.	AXIAL STRESS	SAFETY MARGIN	TORSIONAL STRESS	SAFETY MARGIN	ELEMENT ID.	AXIAL STRESS	SAFETY MARGIN	TORSIONAL STRESS	SAFETY MARGIN
5	-1.250104E+03	5.2E-01	0.0		6	1.759658E+03	8.0E-02	0.0	
7	7.327319E+01	2.5E+01	0.0		8	6.799979E+01	2.7E+01	0.0	

24. MSC/NASTRAN Users have finished this exercise. MSC/PATRAN Users should proceed to the next step.

25. Proceed with the Reverse Translation process, that is, importing the **prob2.op2** results file into MSC/PATRAN. To do this, return to the **Analysis** form and proceed as follows:

◆ **Analysis**

Action:	**Read Output 2**
Object:	**Result Entities**
Method:	**Translate**

Select Results File...

Filter

Available Files:	**prob2.op2**

OK

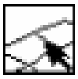
Apply

26. When the translation is complete and the Heartbeat turns green, bring up the **Results** form.

◆ **Results**

Action:	**Create**
Object:	**Fringe**
Select Results Case(s):	**temperature_load, Static Subcase**
Select Fringe Result:	**Displacements, Translational**
Quantity:	**Magnitude**

To change the target entites of the plot, click on the **Target Entities** icon.

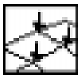


Target Entites

Target Entity: **Materials**

Select Materials: **southern_pine**
steel

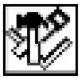
To change the display attributes of the plot, click on the **Display Attributes** icon.



Display Attributes

Style: **Discrete/Smooth**

To change the plot options, click on the **Plot Options** icon.



Plot Options

Coordinate Transformation: **None**

Apply

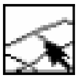
26a. Next, add the deformation options to the plot.

◆ **Results**

Action: **Create**

Object: **Deformation**

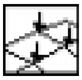
To change the target entites of the plot, click on the **Target Entites** icon.



Target Entities

Target Entity:	**Materials**
Select Materials:	**southern_pine** **steel**

To change the properties of the plot, click on the **Display Attributes** icon.



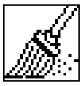
Display Attributes

■ **Show Undeformed**

Line Style:	- - - - -

Apply

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



Reset Graphics

You can go back and select any *Results Case, Fringe Results or Deformation Results* you are interested in.

Quit MSC/PATRAN when you have completed this exercise.