

ANEXO 4

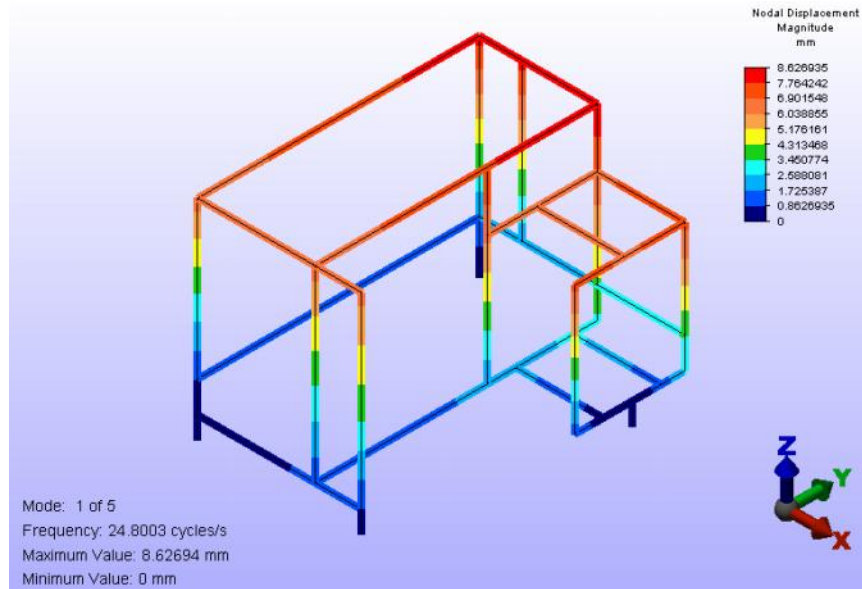


Fig. 8: Desplazamiento por la primera resonancia de la estructura.

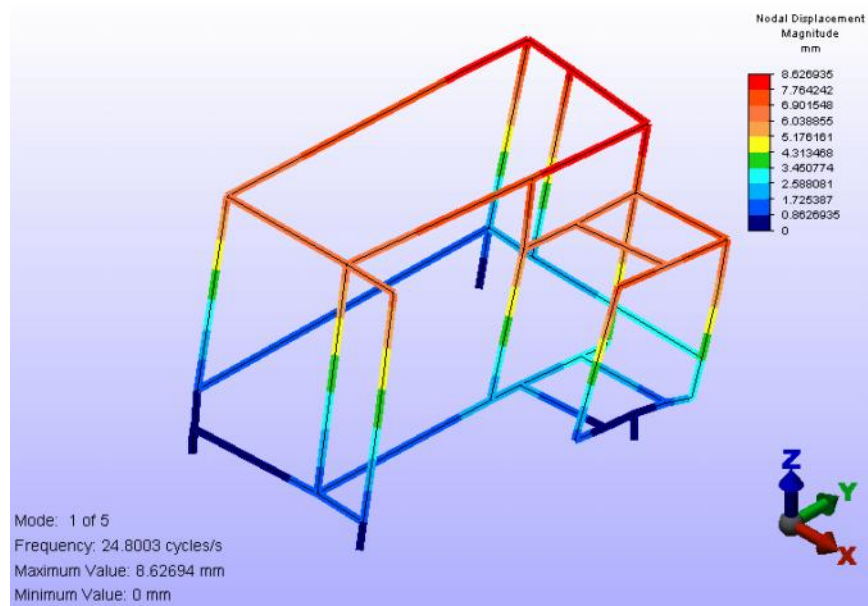


Fig. 9: Desplazamiento por la primera resonancia de la estructura a nueve veces su escala real.

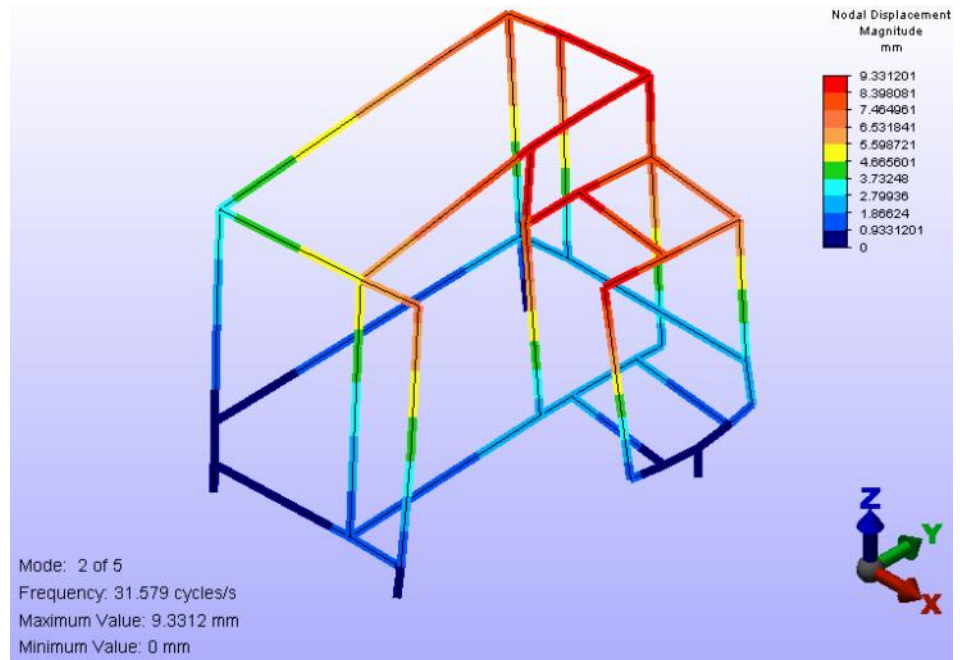


Fig. 10: Desplazamiento por la segundo resonancia de la estructura a nueve veces su escala real.

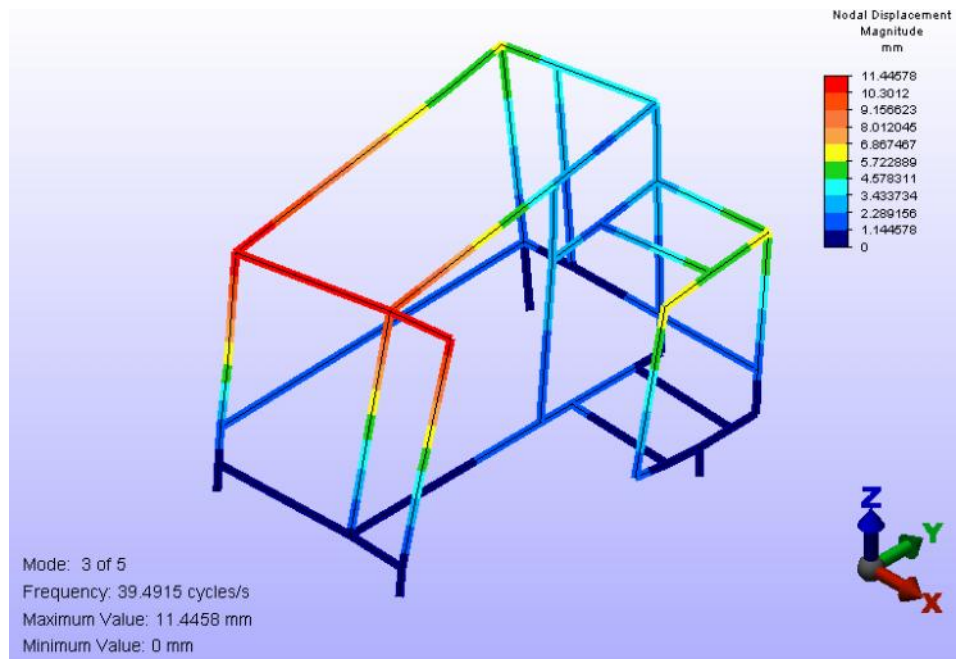


Fig. 11: Desplazamiento por la tercera resonancia de la estructura a nueve veces su escala real.

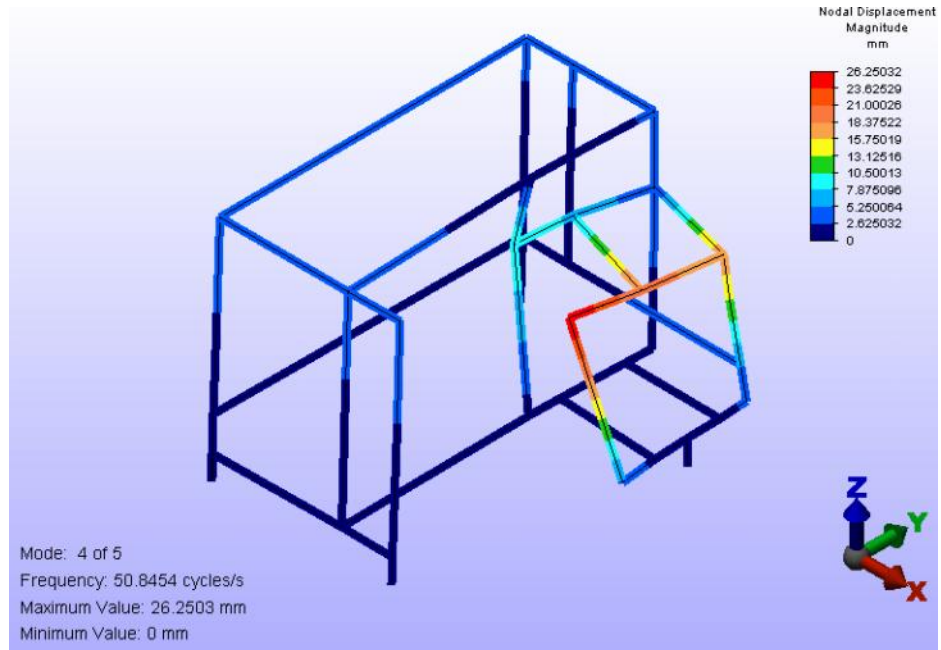


Fig. 12: Desplazamiento por la cuarta resonancia de la estructura a nueve veces su escala real.

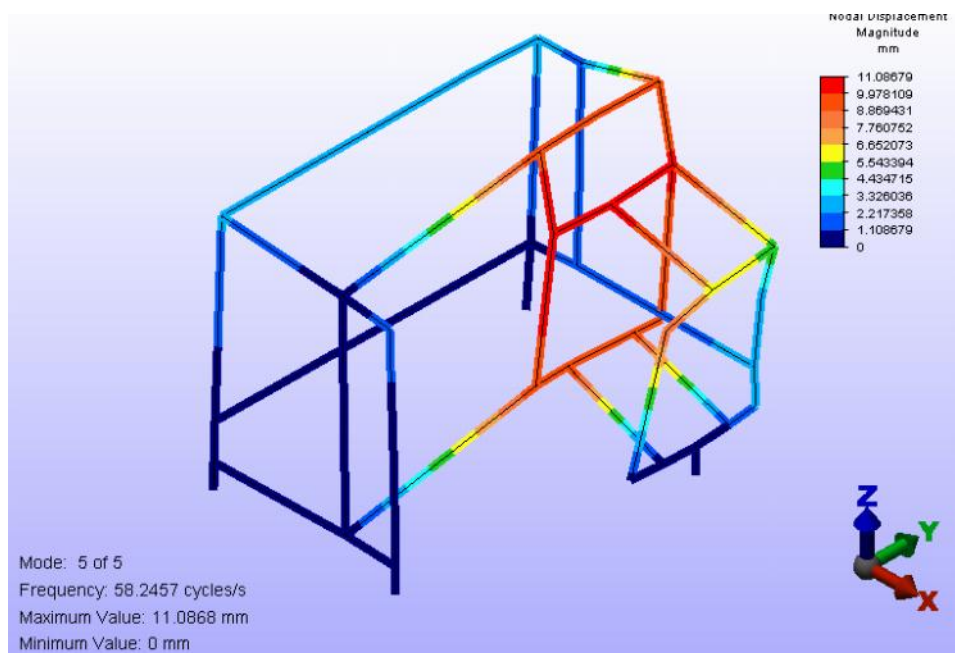
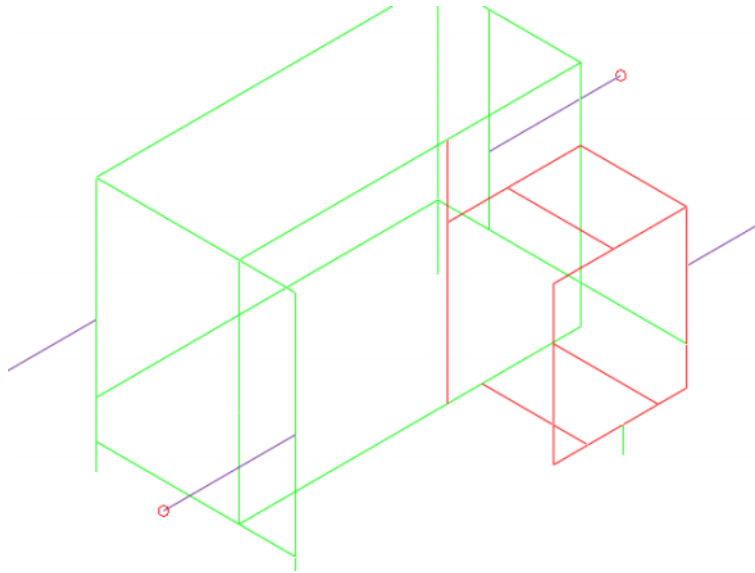


Fig. 13: Desplazamiento por la quinta resonancia de la estructura a nueve veces su escala real.

RESUMEN DE INFORMACIÓN DEL PROCESO DE CÁLCULO EN EL SOFTWARE



Design Analysis



Project created on DateTime no válido..

Last updated on 24/11/2007.

Project checked on 24/11/2007.

Summary

Model Information

Analysis Type - Static Stress with Linear Material Models

Units - Custom - (N, mm, s, deg C, K, V, ohm, A, J)

Model location - D:\IVAN\ALGOR\CURSO 2007\tesis\Estructura\Estructura_Frec

Analysis Parameters Information

Load Case Multipliers

Static Stress with Linear Material Models may have multiple load cases. This allows a model to be analyzed with multiple loads while solving the equations a single time. The following is a list of load case multipliers that were analyzed with this model.

| Load Case | Pressure/Surface Forces | Acceleration/Gravity | Displaced Boundary | Thermal | Voltage |
|-----------|-------------------------|----------------------|--------------------|---------|---------|
| 1 | 0 | 1 | 0 | 0 | 0 |

Gravity Information

The following lists the values used if acceleration or gravity was included in the analysis. The Acceleration/Gravity direction multiplier is multiplied by the Acceleration Due To Body Force which is then multiplied by the Acceleration/Gravity load case multiplier.

Acceleration Due To Body Force = 9814.56 mm/s²

| Acceleration/Gravity X Multiplier | Acceleration/Gravity Y Multiplier | Acceleration/Gravity Z Multiplier |
|-----------------------------------|-----------------------------------|-----------------------------------|
| 0 | 0 | -1 |

Multiphysics Information

Default Nodal Temperature 0 °C
Source of Nodal Temperature None
Time step from Heat Transfer Analysis Last

Processor Information

Type of Solver Sparse
Disable Calculation and Output of Strains No
Calculate Reaction Forces No
Invoke Banded Solver Yes
Avoid Bandwidth Minimization No
Stop After Stiffness Calculations No
Displacement Data in Output File No
Stress Data in Output File No
Equation Numbers Data in Output File No
Element Input Data in Output File No
Nodal Input Data in Output File No
Centrifugal Load Data in Output File No

Part Information

| Part ID | Part Name | Element Type | Material Name |
|-------------------|-----------|--------------|----------------------------------|
| 1 | Part 1 | Beam | Steel (ASTM-A36) |
| 2 | Part 2 | Beam | Steel (ASTM-A36) |
| 3 | Part 3 | Beam | Steel (ASTM-A36) |

Element Properties used for:

- Part 1

| | |
|------------------|--------------|
| Element Type | Beam |
| Section 1 - Area | 339.99932 |
| Section 1 - SA2 | 0 |
| Section 1 - SA3 | 0 |
| Section 1 - J1 | 2913.6199792 |
| Section 1 - I2 | 45785.456816 |
| Section 1 - I3 | 45785.456816 |
| Section 1 - S2 | 1704.254656 |
| Section 1 - S3 | 1704.254656 |

Element Properties used for:

- Part 2

| | |
|------------------|--------------|
| Element Type | Beam |
| Section 1 - Area | 150.96744 |
| Section 1 - SA2 | 0 |
| Section 1 - SA3 | 0 |
| Section 1 - J1 | 416.2314256 |
| Section 1 - I2 | 9157.0913632 |
| Section 1 - I3 | 9157.0913632 |
| Section 1 - S2 | 507.998984 |
| Section 1 - S3 | 507.998984 |

Element Properties used for:

- Part 3

| | |
|------------------|-------|
| Element Type | Beam |
| Section 1 - Area | 157.5 |

Section 1 - SA2 0
 Section 1 - SA3 0
 Section 1 - J1 23700
 Section 1 - I2 11850
 Section 1 - I3 11850
 Section 1 - S2 894.3
 Section 1 - S3 894.3

Material Information

Steel (ASTM-A36)

Material Model Standard

Material Source Algor Material Library

Material Source File C:\ARCHIV~1\ALGOR\MatLibs\algor.mat.mlb

Date Last Updated 1999/06/02-11:03:56

Material Description Structural Steel Mechanics of Materials, 2nd Edition, F.P. Beer and E.R. Johnston, Jr. (mechanical)

Mass Density 0.0000000078548 N*s²/mm/mm³

Modulus of Elasticity 199950 N/mm²

Poisson's Ratio 0.29

Load and Constraint Information

Constraints

Constraint Set 1: Unnamed

Nodal Boundary Conditions

| ID | Description | Node ID | Tx | Ty | Tz | Rx | Ry | Rz |
|----|-------------|---------|----|-----|-----|----|----|----|
| 9 | Unnamed | 38 | No | Yes | Yes | No | No | No |
| 10 | Unnamed | 39 | No | Yes | Yes | No | No | No |
| 11 | Unnamed | 41 | No | Yes | Yes | No | No | No |

Processor Output

Processor Summary

ALGOR (R) Static Stress with Linear Material Models
Version 12.32-WIN 27-JUN-2003
Copyright (c) 1984-2003 ALGOR, Inc. All rights reserved.

DATE: NOVEMBER 24,2007
TIME: 11:44 AM
INPUT MODEL: D:\IVAN\ALGOR\CURSO
2007\tesis\Estructura\Estructura_Frec
ALG.DLL VERSION:13240000

Structural

1**** CONTROL INFORMATION

| | | | |
|-----------------------------|----------|---|------------|
| number of node points | (NUMNP) | = | 51 |
| number of element types | (NELTYP) | = | 3 |
| number of load cases | (LL) | = | 1 |
| number of frequencies | (NF) | = | 0 |
| analysis type code | (NDYN) | = | 0 |
| equations per block | (KEQB) | = | 0 |
| bandwidth minimization flag | (MINBND) | = | 0 |
| gravitational constant | (GRAV) | = | 9.8146E+03 |

**** PRINT OF NODAL DATA SUPPRESSED
**** PRINT OF EQUATION NUMBERS SUPPRESSED
**** PRINT OF TYPE-2 ELEMENT DATA SUPPRESSED
**** PRINT OF TYPE-2 ELEMENT DATA SUPPRESSED
**** PRINT OF TYPE-2 ELEMENT DATA SUPPRESSED
**** Hard disk file size information for processor:

Available hard disk space on current drive = 17682.762
megabytes

1**** ELEMENT LOAD MULTIPLIERS

| load case | case A | case B | case C | case D |
|-----------|-----------|-----------|-----------|-----------|
| case E | | | | |
| ----- | ----- | ----- | ----- | ----- |
| 1 | 0.000E+00 | 1.000E+00 | 0.000E+00 | 0.000E+00 |
| 0.000E+00 | | | | |

**** Invoking Sparse Solver ...

**** Symbolic Assembling Using the Row-Hits Matrix Profile ...

**** Assembled in One Block.
 **** Real Sparse Matrix Assembly ...

1**** STIFFNESS MATRIX PARAMETERS

minimum non-zero diagonal element = 3.1202E+02
 maximum diagonal element = 1.3316E+09
 maximum/minimum = 4.2677E+06
 average diagonal element = 1.1188E+08

in the upper off-diagonal matrix:
 number of entries in the profile = 3678
 number of symbolic nonzero entries= 2643
 number of real nonzero entries = 724

**** Sparse Matrix Assembled in One Block
 **** Load case 1
 **** Sparse Matrix Factorization ...
 Completing in-core sparse solution
 **** Sparse Matrix Solving ...
 **** End Sparse Matrix Solution

Reaction Sums and Maxima for Load Case 1

Sum of applied forces
 X-Force Y-Force Z-Force X-Moment Y-Moment
 Z-Moment
 0.0000E+00 0.0000E+00 -4.0025E+02 0.0000E+00 0.0000E+00
 0.0000E+00

Sum of reactions
 X-Force Y-Force Z-Force X-Moment Y-Moment
 Z-Moment
 1.0658E-14 8.8818E-15 -5.3291E-15 -1.6984E-09 -1.7974E-09 -
 9.2712E-11

Sum of residuals
 X-Force Y-Force Z-Force X-Moment Y-Moment
 Z-Moment
 1.0658E-14 8.8818E-15 -4.0025E+02 -1.6984E-09 -1.7974E-09 -
 9.2712E-11

Sum of unfixed direction residuals
 X-Force Y-Force Z-Force X-Moment Y-Moment
 Z-Moment
 1.0658E-14 3.4016E-11 -1.2012E-09 -1.6984E-09 -1.7974E-09 -
 9.2712E-11

Largest applied forces and moments
 Node Node Node Node Node
 X-Force Y-Force Z-Force X-Moment Y-Moment
 Z-Moment
 0 0 6 0 0
 0
 0.0000E+00 0.0000E+00 -2.8989E+01 0.0000E+00 0.0000E+00
 0.0000E+00

Largest nodal reactions
 Node Node Node Node Node
 Node

| | X-Force | Y-Force | Z-Force | X-Moment | Y-Moment |
|----------|------------|-------------|-------------|------------|-------------|
| Z-Moment | | | | | |
| 14 | 4 | 41 | 41 | 14 | 4 |
| | 3.7322E-11 | -2.3547E+01 | -1.2902E+02 | 1.5116E-09 | -3.1199E-10 |
| | 1.2142E-10 | | | | |

Largest nodal residuals

| Node | Node | Node | Node | Node | Node |
|----------|------------|-------------|-------------|------------|-------------|
| | | | | | |
| X-Force | Y-Force | Z-Force | X-Moment | Y-Moment | |
| Z-Moment | | | | | |
| 14 | 4 | 41 | 41 | 14 | 4 |
| | 3.7322E-11 | -2.3547E+01 | -1.3175E+02 | 1.5116E-09 | -3.1199E-10 |
| | 1.2142E-10 | | | | |

Largest unfixed direction residuals

| Node | Node | Node | Node | Node | Node |
|----------|------------|------------|-------------|------------|-------------|
| | | | | | |
| X-Force | Y-Force | Z-Force | X-Moment | Y-Moment | |
| Z-Moment | | | | | |
| 14 | 4 | 24 | 36 | 14 | 4 |
| | 3.7322E-11 | 5.6048E-11 | -5.4037E-10 | 1.5116E-09 | -3.1199E-10 |
| | 1.2142E-10 | | | | |

1**** TEMPORARY FILE STORAGE (MEGABYTES)

```

-----
UNIT NO. 7 : 0.002
UNIT NO. 8 : 0.002
UNIT NO. 9 : 0.000
UNIT NO. 10 : 0.000
UNIT NO. 11 : 0.004
UNIT NO. 12 : 0.002
UNIT NO. 13 : 0.002
UNIT NO. 14 : 0.000
UNIT NO. 15 : 0.000
UNIT NO. 17 : 0.000
UNIT NO. 51 : 0.004
UNIT NO. 52 : 0.060
UNIT NO. 54 : 0.001
UNIT NO. 55 : 0.003
UNIT NO. 56 : 0.006
UNIT NO. 58 : 0.002

TOTAL : 0.088 Megabytes

```

Processor Log

ALGOR (R) Static Stress with Linear Material Models
Version 12.32-WIN 27-JUN-2003
Copyright (c) 1984-2003 ALGOR, Inc. All rights reserved.

Structural

```
51 3 1 0 0 0
**** Linear stress analysis
**** Memory Dynamically Allocated = 261528 KB
```

Options executed are:

```
NOMIN
STRAIN
SPARSE
SUPCNF
SUPELM
SUPNOD
REAC
ENOR
```

processing ...

```
**** OPENING TEMPORARY FILES
NDYN = 0
```

```
DATE: NOVEMBER 24,2007
TIME: 11:44 AM
INPUT MODEL: D:\IVAN\ALGOR\CURSO
2007\tesis\Estructura\Estructura_Frec
ALG.DLL VERSION:13240000
```

```
**** BEGIN NODAL DATA INPUT
51 NODES
**** END NODAL DATA INPUT
**** BEGIN TYPE-2 DATA INPUT
35 ELEMENTS
**** END TYPE-2 DATA INPUT
**** BEGIN TYPE-2 DATA INPUT
18 ELEMENTS
**** END TYPE-2 DATA INPUT
**** BEGIN TYPE-2 DATA INPUT
4 ELEMENTS
**** END TYPE-2 DATA INPUT
**** Hard disk file size information for processor:
```

Available hard disk space on current drive = 17682.762 megabytes

```
**** BEGIN LOAD INPUT
Load factor = 1.00E+00 in the 2nd basket in load case 1
**** END LOAD INPUT
```

```
**** Invoking Sparse Solver ...
```

```
**** Symbolic Assembling Using the Row-Hits Matrix Profile ...
**** Assembled in One Block.
**** Real Sparse Matrix Assembly ...
in the upper off-diagonal matrix:
number of entries in the profile = 3678
number of symbolic nonzero entries= 2643
number of real nonzero entries = 724
**** Sparse Matrix Assembled in One Block
**** Load case 1
**** Sparse Matrix Factorization ...
```

```

**** Sparse Matrix Solving ...
**** End Sparse Matrix Solution

**** BEGIN DISPLACEMENT OUTPUT
**** PRINT OF DISPLACEMENT OUTPUT SUPPRESSED
**** END DISPLACEMENT OUTPUT
**** BEGINNING REACTION COMPUTATIONS
**** LOADCASES REMAINING      1
**** BLOCKS REMAINING        1
**** GROUPS REMAINING        3
**** GROUP USED--ELEMENT/GLOBAL CONTRIBUTIONS
    35 ELEMENTS
    35 ELEMENTS REMAINING
    30 ELEMENTS REMAINING
    20 ELEMENTS REMAINING
    10 ELEMENTS REMAINING
**** GROUPS REMAINING        2
**** GROUP USED--ELEMENT/GLOBAL CONTRIBUTIONS
    18 ELEMENTS
    18 ELEMENTS REMAINING
    10 ELEMENTS REMAINING
**** GROUPS REMAINING        1
**** GROUP USED--ELEMENT/GLOBAL CONTRIBUTIONS
    4 ELEMENTS
    4 ELEMENTS REMAINING
**** ENDING REACTION COMPUTATIONS

Estructura_Frec.t7      =      2.055 kilobytes
Estructura_Frec.t8      =      2.480 kilobytes
Estructura_Frec.t9      =      0.000 kilobytes
Estructura_Frec.t10     =      0.000 kilobytes
Estructura_Frec.t11     =      3.750 kilobytes
Estructura_Frec.t12     =      2.047 kilobytes
Estructura_Frec.t13     =      2.055 kilobytes
Estructura_Frec.t14     =      0.000 kilobytes
Estructura_Frec.t15     =      0.000 kilobytes
Estructura_Frec.t17     =      0.000 kilobytes
Estructura_Frec.t51     =      4.453 kilobytes
Estructura_Frec.t52     =     61.898 kilobytes
Estructura_Frec.t54     =      1.047 kilobytes
Estructura_Frec.t55     =      2.828 kilobytes
Estructura_Frec.t56     =      5.656 kilobytes
Estructura_Frec.t58     =      2.047 kilobytes

total temporary disk storage (megabytes) = .08820

Estructura_Frec.l       =      5.769 kilobytes
Estructura_Frec.do      =      2.438 kilobytes

**** BEGIN DELETING TEMPORARY FILES
Processing completed for model:
[D:\IVAN\ALGOR\CURSO 2007\tesis\Estructura\Estructura_Frec]
**** TEMPORARY FILES DELETED
**** END OF SUCCESSFUL EXECUTION

Total actual hard disk space used      =      0.096 megabytes
Sub-total elapsed time                  =      0.012 minutes

```

ALGOR (R) Stress Calculation Utility
Version 12.16-WIN 25-APR-2003
Copyright (c) 1989-2003 ALGOR, Inc. All rights reserved.

```
**** Memory Dynamically Allocated =      261528 KB
      Percent capacity: .005828

      DATE: NOVEMBER 24,2007
      TIME: 11:44 AM
      INPUT.....D:\IVAN\ALGOR\CURSO
2007\tesis\Estructura\Estructura_Frec
      Percent capacity: .005831
      Percent capacity: .005831
**** BEGIN TYPE-2 DATA INPUT
      35 ELEMENTS
      Percent capacity: .006178
      0 elements remaining
**** END TYPE-2 DATA INPUT
**** BEGIN TYPE-2 DATA INPUT
      18 ELEMENTS
      Percent capacity: .006178
      0 elements remaining
**** END TYPE-2 DATA INPUT
**** BEGIN TYPE-2 DATA INPUT
      4 ELEMENTS
      Percent capacity: .006178
      0 elements remaining
**** END TYPE-2 DATA INPUT
      Percent capacity: .005837
**** Writing stress and strain output files ...
      0 load cases remaining
**** Hard disk file size information for postprocessor:
      Estructura_Frec.son   =      10.098 kilobytes
      Estructura_Frec.nso   =       4.531 kilobytes
      Estructura_Frec.sto   =       4.531 kilobytes

      Total MKNSO disk space used      =      0.01871 megabytes
**** End of successful execution
**** MKNSO elapsed time                =      0.001 minutes
**** The TOTAL elapsed time           =      0.013 minutes
```

Stress Analysis

The stress analysis output file (D:\IVAN\ALGOR\CURSO
2007\tesis\Estructura\Estructura_Frec.S) was not found.

Weight and Center of Gravity Analysis

The weight and center of gravity analysis output file (D:\IVAN\ALGOR\CURSO
2007\tesis\Estructura\Estructura_Frec.WCG) was not found.

ALGOR (R) Natural Frequency (Modal)
Version 12.32-WIN 27-JUN-2003
Copyright (c) 1984-2003 ALGOR, Inc. All rights reserved.

DATE: DECEMBER 6,2007
TIME: 08:50 AM
INPUT MODEL: D:\IVAN\ALGOR\CURSO
2007\tesis\Estructura\Estructura_Frec
ALG.DLL VERSION:13240000

Structural

1**** CONTROL INFORMATION

| | | | |
|-------------------------|----------|---|------------|
| number of node points | (NUMNP) | = | 47 |
| number of element types | (NELTYP) | = | 2 |
| number of load cases | (LL) | = | 1 |
| number of frequencies | (NF) | = | 5 |
| analysis type code | (NDYN) | = | 1 |
| equations per block | (KEQB) | = | 0 |
| gravitational constant | (GRAV) | = | 9.8146E+03 |

**** PRINT OF NODAL DATA SUPPRESSED
**** PRINT OF EQUATION NUMBERS SUPPRESSED
**** PRINT OF TYPE-2 ELEMENT DATA SUPPRESSED
**** PRINT OF TYPE-2 ELEMENT DATA SUPPRESSED

**** EQUATION PARAMETERS

| | | |
|--------------------------------|---|--------|
| total number of equations | = | 228 |
| bandwidth | = | 222 |
| number of equations in a block | = | 114 |
| number of blocks | = | 2 |
| blocking memory (kilobytes) | = | 267804 |
| available memory (kilobytes) | = | 267804 |

**** Hard disk file size information for processor:

Available hard disk space on current drive = 15683.715
megabytes

**** Invoking Sparse Eigensolver ...

**** Symbolic Assembling Using the Row-Hits Matrix Profile ...
**** Assembled in One Block.
**** Real Sparse Matrix Assembly ...

1**** STIFFNESS MATRIX PARAMETERS

| | | |
|-----------------------------------|---|------------|
| minimum non-zero diagonal element | = | 2.6938E+03 |
| maximum diagonal element | = | 1.3316E+09 |
| maximum/minimum | = | 4.9432E+05 |
| average diagonal element | = | 1.1830E+08 |

in the upper off-diagonal matrix:
number of entries in the profile = 3285
number of symbolic nonzero entries= 2325
number of real nonzero entries = 636

**** Sparse Matrix Assembled in One Block

**** SOLUTION SOUGHT FOR FOLLOWING EIGENPROBLEM

| | | |
|--------------------------------|---|-----|
| number of equations | = | 228 |
| number of eigenvalues required | = | 5 |
| rigid body modes (0 for none) | = | 0 |

**** Sparse Matrix Solving ...

**** End Sparse Matrix Solution

1**** PRINT OF NATURAL FREQUENCIES

| mode number | circular frequency (rad/sec) | frequency (Hertz) | period (sec) |
|----------------|------------------------------------|----------------------|-----------------|
| 1 | 1.5582E+02 | 2.4800E+01 | 4.0322E-02 |
| 2 | 1.9842E+02 | 3.1579E+01 | 3.1667E-02 |
| 3 | 2.4813E+02 | 3.9492E+01 | 2.5322E-02 |
| 4 | 3.1947E+02 | 5.0845E+01 | 1.9667E-02 |
| 5 | 3.6597E+02 | 5.8246E+01 | 1.7169E-02 |

1**** TEMPORARY FILE STORAGE (MEGABYTES)

| | |
|---------------|-----------------|
| UNIT NO. 7 : | 0.009 |
| UNIT NO. 8 : | 0.002 |
| UNIT NO. 9 : | 0.002 |
| UNIT NO. 10 : | 0.000 |
| UNIT NO. 11 : | 0.003 |
| UNIT NO. 12 : | 0.000 |
| UNIT NO. 13 : | 0.002 |
| UNIT NO. 14 : | 0.000 |
| UNIT NO. 15 : | 0.000 |
| UNIT NO. 54 : | 0.001 |
| UNIT NO. 55 : | 0.002 |
| UNIT NO. 56 : | 0.005 |
| UNIT NO. 58 : | 0.002 |
| TOTAL : | 0.028 Megabytes |