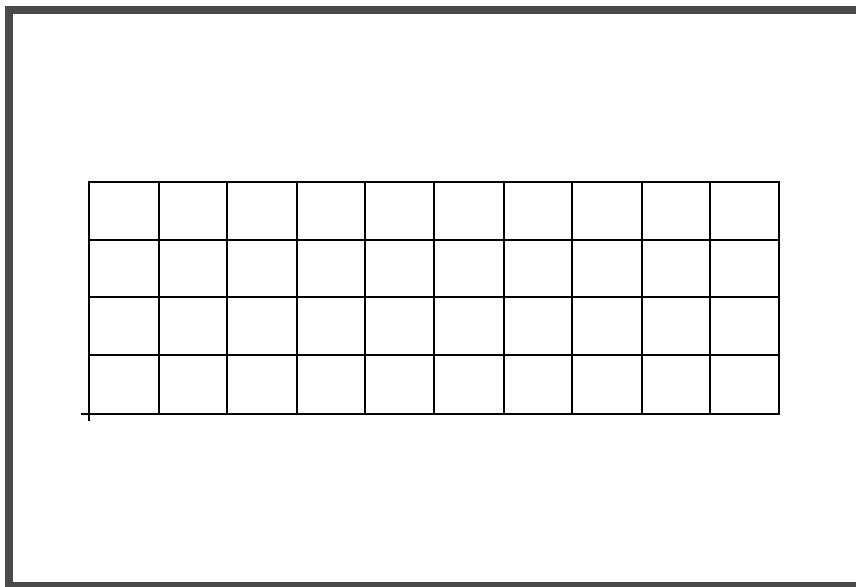

APPENDIX H

Elastic Stability of a Plate
(SI)



Objectives

- Produce a Nastran input file.
- Submit the file for analysis in MSC.Nastran.
- Find the first five natural modes of the plate.



Model Description:

For this example, find the unit critical compressive stress of a flat rectangular plate. This plate is under equal uniform compression of $6.89E+5$ Pa on two opposite edges. All edges are simply supported.

In addition, the applied edge compression shall be idealized as nodal forces for this example. See Page H-4 for helpful hints.

Below is a Finite Element representation of the flat plate. It also contains the geometric dimensions and the loads and boundary constraints. Table H.1 contains the necessary parameters to construct the input file

Figure H.1 - Loads and Boundary Constraints

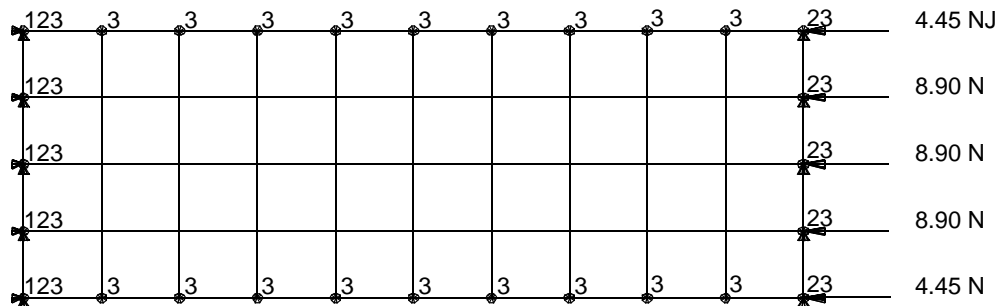


Figure H.2 - Grid Coordinates and Element Connectivities

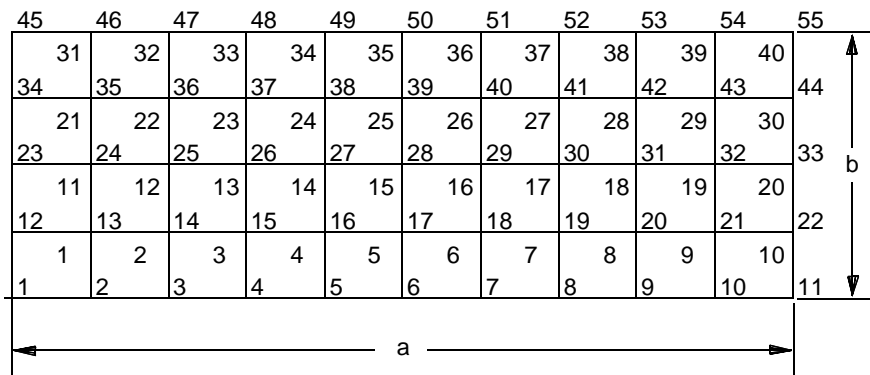


Table H.1 - Model Properties

Elastic Modulus:	200 GPa
Poisson Ratio:	0.3
Plate Thickness:	0.254 mm
Length (a):	508 mm
Height (b):	203.2 mm

Suggested Exercise Steps:

- Generate a finite element representation of the plate structure i.e., the nodes (GRID) and element connectivity (CQUAD4).
- Define material (MAT1) and element (PSHELL) properties.
- Apply the simply-supported boundary constraints (SPC1).
- Apply a force load to the model (FORCE).
- Specify real eigenvalue extraction data for Lanczos method (EIGRL).
- Prepare the model for a buckling analysis (SOL 105 and PARAMs).
 - PARAM, COUPMASS, 1
- Generate an Input file and submit it to the MSC.Nastran solver for buckling analysis.
- Review the results, specifically the eigenvalues.

HINT: Conversion of edge pressure to nodal force:

$$(6.89\text{e}+5 \text{ Pa})(203.2 \text{ mm})(0.254 \text{ mm}) = 35.6 \text{ N}$$

thus,

$$\text{for 3 middle grids, } F = 8.90 \text{ N}$$

$$\text{for 2 outer grids, } F = 4.45 \text{ N}$$

Generating an Input File for MSC.Nastran Users:

MSC.Nastran users can generate an input file using the data from Table H.1. The result should be similar to the output below.

1. MSC.Nastran Input File: **ex07plate.dat**

```

ID EXERCISE,CATIAFEM
SOL      105
$ TOPAZMODIFIED FOR TOPAZ POST-PROCESSING
CEND
$.
$-----
$.
$.
$.          CASE CONTROL DECK
$.
SPCFORCES=ALL
TITLE = EXERCISE 7 ELASTIC STABILITY OF A PLATE
DISPL   =      ALL
METHOD  =      1
MPC     =      1
$.
SUBCASE =      1
$ CATIA RESTRAINT SET NAME :
$ RESTRAINT1
   SPC =      1
$ CATIA LOAD SET NAME :
$ LOAD1
   LOAD =      1
$.
$-----
$.
$.
$.          BULK DATA CARDS
$.
BEGIN BULK
EIGRL,1,,5
PARAM  POST      1
PARAM  AUTOSPC YES
$.
$-----
$.
$.
$.          RESTRAINTS
$.
$ NASTRAN ID =      1 / RESTRAINT SET NAME :
$ RESTRAINT1
SPC1   1      123      25      26      27
SPC1   1      23      11      12      13
SPC1   1      3       1       2       3       4       5       6       1
+      17      8       9      15      16      17      18      19       2
+      220     21      22      23
SPC1   1      23      10      14

```


GRID	25	0.	152.4	0.
GRID	26	0.	101.6	0.
GRID	27	0.	50.8	0.
GRID	28	0.	0.	0.
GRID	29	457.2	50.8	0.
GRID	30	406.4	50.8	0.
GRID	31	355.6	50.8	0.
GRID	32	304.8	50.8	0.
GRID	33	254.	50.8	0.
GRID	34	203.2	50.8	0.
GRID	35	152.4	50.8	0.
GRID	36	101.6	50.8	0.
GRID	37	50.8	50.8	0.
GRID	38	457.2	101.6	0.
GRID	39	406.4	101.6	0.
GRID	40	355.6	101.6	0.
GRID	41	304.8	101.6	0.
GRID	42	254.	101.6	0.
GRID	43	203.2	101.6	0.
GRID	44	152.4	101.6	0.
GRID	45	101.6	101.6	0.
GRID	46	50.8	101.6	0.
GRID	47	457.2	152.4	0.
GRID	48	406.4	152.4	0.
GRID	49	355.6	152.4	0.
GRID	50	304.8	152.4	0.
GRID	51	254.	152.4	0.
GRID	52	203.2	152.4	0.
GRID	53	152.4	152.4	0.
GRID	54	101.6	152.4	0.
GRID	55	50.8	152.4	0.

\$..

\$..

\$..

ELEMENTS

\$..

CQUAD4	1	1	10	11	29	9
CQUAD4	2	1	11	12	38	29
CQUAD4	3	1	12	13	47	38
CQUAD4	4	1	13	14	15	47
CQUAD4	5	1	9	29	30	8
CQUAD4	6	1	29	38	39	30
CQUAD4	7	1	38	47	48	39
CQUAD4	8	1	47	15	16	48
CQUAD4	9	1	8	30	31	7
CQUAD4	10	1	30	39	40	31
CQUAD4	11	1	39	48	49	40
CQUAD4	12	1	48	16	17	49
CQUAD4	13	1	7	31	32	6
CQUAD4	14	1	31	40	41	32
CQUAD4	15	1	40	49	50	41
CQUAD4	16	1	49	17	18	50

CQUAD4	17	1	6	32	33	5
CQUAD4	18	1	32	41	42	33
CQUAD4	19	1	41	50	51	42
CQUAD4	20	1	50	18	19	51
CQUAD4	21	1	5	33	34	4
CQUAD4	22	1	33	42	43	34
CQUAD4	23	1	42	51	52	43
CQUAD4	24	1	51	19	20	52
CQUAD4	25	1	4	34	35	3
CQUAD4	26	1	34	43	44	35
CQUAD4	27	1	43	52	53	44
CQUAD4	28	1	52	20	21	53
CQUAD4	29	1	3	35	36	2
CQUAD4	30	1	35	44	45	36
CQUAD4	31	1	44	53	54	45
CQUAD4	32	1	53	21	22	54
CQUAD4	33	1	2	36	37	1
CQUAD4	34	1	36	45	46	37
CQUAD4	35	1	45	54	55	46
CQUAD4	36	1	54	22	23	55
CQUAD4	37	1	1	37	27	28
CQUAD4	38	1	37	46	26	27
CQUAD4	39	1	46	55	25	26
CQUAD4	40	1	55	23	24	25

\$. .

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\$. .

\$. .

PROPERTIES

\$. .

PSHELL	1	1	.254	1	1.	1	.83333
--------	---	---	------	---	----	---	--------

\$. .

ENDDATA

Submitting the Input File for Analysis:

2. When the run is completed, edit the **ex07plate.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.
3. While still editing **ex07plate.f06**, search for the word:

E I G E N (spaces are necessary)

Eigenvalue (1st Extraction) = _____

Comparison of Results:

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

MODE NO.	EXTRACTION ORDER	EIGENVALUE	RADIANS	CYCLES	GENERALIZED MASS	GENERALIZED STIFFNESS
1	1	1.721790E+00	1.312170E+00	2.088383E-01	1.084010E+00	1.866438E+00
2	2	1.759176E+00	1.326339E+00	2.110934E-01	5.771757E-01	1.015354E+00
3	3	2.150048E+00	1.466304E+00	2.333696E-01	1.883777E+00	4.050212E+00
4	4	2.918777E+00	1.708443E+00	2.719071E-01	2.346175E+00	6.847962E+00
5	5	3.732858E+00	1.932060E+00	3.074970E-01	1.529502E-01	5.709413E-01

Since the applied pressure = $35.6 \text{ N} / [(203.2 \text{ mm})(0.254 \text{ mm})] = 6.89\text{E}+5 \text{ Pa}$
 $\sigma_{cr} = 1.722 (6.89\text{E}+5 \text{ Pa}) = 1.186 \text{ MPa}$

Theoretical Value:

$$\sigma_{cr} = K \frac{E}{1 - \nu^2} \left(\frac{t}{b} \right)^2$$

Here K depends on the a/b value.

$$a/b = 508/203.2 = 2.5, \quad K = 3.373$$

$$\sigma_{cr} = 3.373 \frac{200E9}{1 - (0.3)^2} \left(\frac{0.254}{203.2} \right)^2 = 1.158 MPa$$