Journal of Sound and Vibration (2002) **254**(4), 801–804
doi:10.1006/jsvi.2001.4105, available online at http://www.idealibrary.com on IDEAL®

LETTERS TO THE EDITOR

TRANSVERSE VIBRATIONS OF A CIRCULAR ANNULAR PLATE WITH A FREE INNER EDGE AND A SECANT SUPPORT

R. E. Rossi

Department of Engineering, Universidad Nacional del Sur, 8000—Bahía Blanca, Argentina

(*Received* 6 *September* 2001)

1. INTRODUCTION

The present study deals with the analysis of the structural system depicted in Figure 1 when executing transverse vibrations. The fundamental frequency is determined by means of a well-known finite element code [1].

No claim of originality is made but it is felt that the results may be of interest to designers in several fields of engineering in highly specialized applications. The isotropic case is considered but for the sake of generality, a particular case of an orthotropic material is also analyzed.

The case of a vibrating solid circular plate with a secant support has already been treated and numerical and analytical results have been obtained [2, 3].

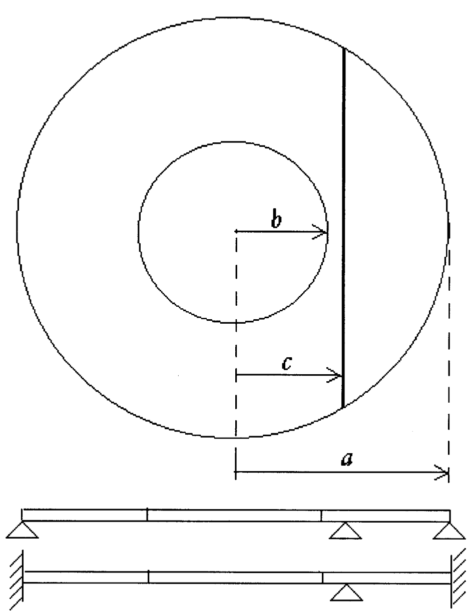

Figure 1. Structural systems under study.

0022-460X/02/$35.00

TABLE 1

Values of the frequency coefficient $\Omega_1 = \omega_1 a^2(\rho h/D)^{1/2}$ in the case of a simply supported outer boundary (Figure 1; isotropic case)

	c/a				
b/a	0·0	0·2	0·4	0·6	0·8
0·1	13·88	11·76	9·42	7·77	6·59
0·2	13·58	11·55	9·42	7·78	6·57
0·3	12·82	11·03	9·27	7·89	6·71
0·4	12·01	10·53	9·10	8·03	7·02
0·5	11·62	10·38	9·19	8·29	7·49
0·6	11·92	10·83	9·77	8·94	8·24
0·7	13·33	12·25	11·22	10·40	9·70
0·8	17·13	15·87	14·72	13·78	12·95

TABLE 2

Values of the frequency coefficient $\Omega_1 = \omega_1 a^2(\rho h/D_1)^{1/2}$ in the case of a simply supported outer boundary (Figure 1; orthotropic case)

	c/a				
b/a	0·0	0·2	0·4	0·6	0·8
0·1	13·47	11·38	9·07	7·41	6·21
0·2	13·08	11·10	9·03	7·43	6·20
0·3	12·13	10·46	8·79	7·48	6·32
0·4	11·14	9·83	8·54	7·52	6·56
0·5	10·63	9·58	8·54	7·70	6·91
0·6	10·81	9·91	9·01	8·24	7·51
0·7	12·01	11·15	10·29	9·51	8·57
0·8	15·34	14·37	13·40	12·48	11·58

2. APPLICATION OF THE FINITE ELEMENT METHOD AND NUMERICAL RESULTS

Using the well-known algorithmic procedure developed in reference [1], values of the fundamental frequency coefficient $\Omega_1 = \sqrt{\rho h/D}\,\omega_1 a^2$ (for the orthotropic case: $\Omega_1 = \sqrt{\rho h/D_1}\,\omega_1 a^2$) have been obtained for a convenient choice of the geometric parameters b/a and c/a; see Tables 1–4. The orthotropic case has been evaluated for $D_2/D_1 = \frac{1}{2}$, $D_k/D_1 = \frac{1}{3}$ and $\nu_2 = 0{\cdot}3$†. On the other hand, the dynamic determinations have been performed for the isotropic case making the Poisson ratio (ν) equal to 0·3. Half of the plate domain has been subdivided into 3730 elements for $b/a = 0{\cdot}8$ increasing to 10 028 for the case $b/a = 0{\cdot}1$ (see Figure 2). Tables 1 and 2 deal with the situation where the outer

†Lekhnitskii's classical notation is used [4].

TABLE 3

Values of the frequency coefficient $\Omega_1 = \omega_1 a^2 (\rho h/D)^{1/2}$ in the case of an outer clamped boundary (Figure 1; isotropic case)

	c/a				
b/a	0·0	0·2	0·4	0·6	0·8
0·1	21·20	17·85	14·41	12·13	10·76
0·2	20·56	17·54	14·68	12·49	11·05
0·3	19·90	17·32	15·23	13·61	12·18
0·4	19·59	17·99	16·63	15·63	14·51
0·5	22·01	20·93	20·01	19·36	18·69
0·6	28·74	28·01	27·39	26·94	26·56
0·7	45·29	44·80	44·39	44·08	42·82
0·8	94·50	94·24	93·97	93·75	93·56

TABLE 4

Values of the frequency coefficient $\Omega_1 = \omega_1 a^2 (\rho h/D_1)^{1/2}$ in the case of an outer clamped boundary (Figure 1; orthotropic case)

	c/a				
b/a	0·0	0·2	0·4	0·6	0·8
0·1	20·20	16·92	13·51	11·19	9·74
0·2	19·38	16·47	13·68	11·50	10·00
0·3	19·13	16·04	14·03	12·44	11·00
0·4	17·95	16·51	15·19	14·14	13·02
0·5	20·15	19·16	18·20	17·40	16·61
0·6	26·43	25·65	24·83	24·05	23·34
0·7	41·67	40·85	39·74	38·52	37·57
0·8	85·83	83·39	79·82	77·17	76·09

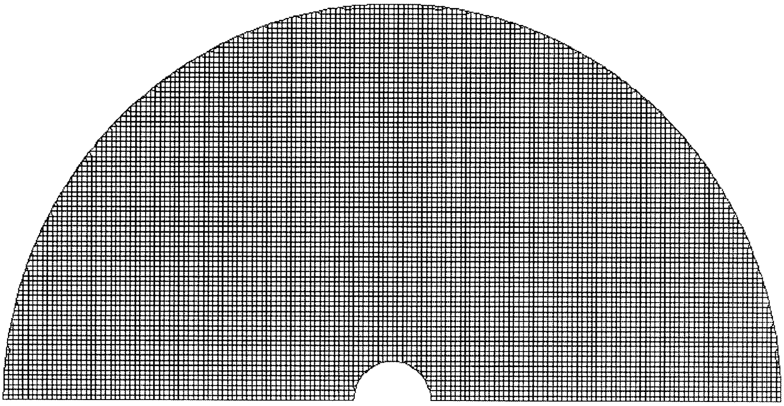

Figure 2. Finite element mesh corresponding to half of the plate in the case $b/a = 0·1$.

boundary is simply supported, for isotropic and orthotropic configuration, respectively, while Tables 3 and 4 correspond to the clamped outer boundary structural systems.

It is important to point out that when $c/a = 0$, the fundamental frequency coefficient of the structure shown in Figure 1 is the exact value corresponding to the first natural antisymetric frequency for the isotropic case [5]. On the other hand and for this geometric configuration, one notices the dynamic stiffening effect for $b/a = 0{\cdot}8$ in the case of Tables 1 and 2 and for $b/a > 0{\cdot}5$ when considering the plates with clamped outer boundary, Tables 3 and 4.

ACKNOWLEDGMENTS

The present study has been sponsored by CONICET Research and Development Program and by Secretaría General de Ciencia y Tecnología of Universidad Nacional del Sur.

REFERENCES

1. ALGOR Professional Mech VE 1999 Linear Stress and Dynamics Reference Division. Part Number 6000.501, Revision 5.00, Pittsburgh, Pennsylvania.
2. P. A. A. LAURA, R. H. GUTIERREZ, V. H. CORTINEZ and J. C. UTJES 1987 *Journal of Sound and Vibration* **113**, 81–86. Transverse vibrations of circular plates and membranes with intermediate supports.
3. P. A. A. LAURA, R. H. GUTIERREZ and R. E. ROSSI 2001 Publication IMA No. 2001–14. *Department of Engineering, Universidad Nacional del Sur*. Fundamental frequency of transverse vibration of a circular plate of rectangular orthotropy with a secant support.
4. S. G. LEKHNITSKII 1968 *Anisotropic Plates*. New York: Gordon and Breach (translated from the second Russian edition).
5. A. W. LEISSA 1969 *Vibration of Plates*. NASA SP 160.