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DETERMINATION OF THE EFFECTS OF WIND-INDUCED VIBRATION ON CYLINDRICAL BEAMS

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ABSTRACT

When cylindrical beams are subjected to steady-state winds, an oscillation can occur causing excessive displacement and possible failure of the beam. This study determined which beams, identified by the length-to-diameter ratio (L/D_o), would be prone to this behavior. The beam sizes studied included standard sizes, 4 to 24 inches nominal pipe size, and thicknesses of American Society for Testing and Materials (ASTM) grade A and grade B or American Petroleum Institute (API) grade X42 steel supported by pinned, clamped (welded), or combination end connections and subjected to different loading conditions and maximum steady-state winds of 130 miles per hour.

The procedure included determining the cause of the wind-induced vibration, researching methods for reducing its effects, and deriving formulas for the wind-induced vibration frequency and natural frequency of cylindrical beams under axial, bending, shear, longitudinal, and torsional loads. The results were computed using a spreadsheet program and finite element analysis. The cut-off frequencies for individual beams were determined and trends were analyzed for single and combined loading situations.

It was found that the wind-induced vibration was caused by the formation of Karman vortices in the wake of the cylindrical beams, which displaced the beam transverse to and in-line with the flow when the Reynold's number of the beam was below 10^6. When the Reynold's number exceeds 10^6, the wake is turbulent, the vortex formation is irregular, and this analysis does not apply. As the wind velocity increases, the frequency of the induced vibration increases. Conversely, as the length of the beam increases, its natural frequency decreases. When the natural frequency of the beam lies in the range of the wind-induced vibration frequency, resonance occurs and the beam will vibrate. The data showed that welded end supports allowed the longest beam lengths before being affected by the wind-induced vibration, and that as axial and bending loads increased, the natural frequency of the beam decreased. In addition, almost all beams subjected to bending loads would be affected by the wind-induced vibration frequency. Individual longitudinal, torsional, and shear loads did not affect the transverse vibration natural frequency of the beams, but combinations of any of these loads will lower the natural frequency of the beam from 19 to 93 percent of that of an unloaded beam. Effective methods of reducing the wind-induced vibration include decreasing the L/D_o so as to avoid the range of resonance and adding vortex suppression devices, like strakes, to redirect the flow and keep vortices from forming in a regular pattern.

The conclusions drawn were that the greatest possible L/D_o is achieved using welded supports and limiting the maximum applied axial and bending loads to less than 50 percent. The effects of multiple loads must be analyzed for each particular load combination but not necessarily for individual applications of longitudinal, shear, and torsional loads. The effects of wind-induced vibration can be minimized using vortex suppression devices or reducing the L/D_o. It is recommended that only rigid, welded support connections be used; that the L/D_o be reduced, when possible, by increasing the beam diameter or decreasing the length by shortening the beam or adding a support along the length; or that helical strakes be added along the beam length.

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ABBREVIATIONS AND ACRONYMS

API	American Petroleum Institute
ASCE	American Society of Civil Engineers
ASTM	American Society for Testing and Materials
ft	feet
Hz	hertz; cycles per second
in	inches
$kips/in^2$	1000 pounds per square inch
KSC	John F. Kennedy Space Center
lb_f	pounds force
lb/ft^2	pounds per square feet
lb/in^2	pounds per square inch
lb_m	pounds mass
LETF	Launch Equipment Test Facility
mph	miles per hour
NASA	National Aeronautics and Space Administration
NPS	nominal pipe size
°F	degrees Fahrenheit

SYMBOLS AND NOTATION

A	cross-sectional area of beam (in^2)
a, b	distance of applied load from end supports, where $(a + b) = L$ (ft)
C_D	drag coefficient (dimensionless)
C_K	Karman-force coefficient (dimensionless)
D_i	diameter, inside (in)
D_o	diameter, outside (in)
E	Modulus of Elasticity (lb_f/in^2)
f_1	fundamental natural frequency (Hz)
f_D	frequency of vibration in line with flow (Hz)
F_D	drag force per unit length (lb_f/ft)
f_L	frequency of vibration transverse to flow (Hz)
F_K	Karman force (lb_f/ft)
f_n	natural frequency (Hz) at mode n, where n=1, 2, 3, ...
f_p	frequency of vibration of a beam subjected to axial loads (Hz)
$f_{p=0}$	frequency of vibration of a beam not subjected to axial loads (Hz)
G	Shear Modulus (lb_f/in^2)
h	height (in)
I	area moment of inertia (in^4)
k	spring constant (lb_f/in)
K	shear coefficient (dimensionless)
L	length of beam (ft)
L/D_o	length-to-diameter ratio (dimensionless)
m	mass applied to beam (lb_m)
m_b	mass of beam (lb_m)
n	mode number (dimensionless)
P	applied load (lb_f)
P_b	buckling load (lb_f)
r_o	radius, outside (in)
R	Reynold's number (dimensionless)
S	Strouhal number (dimensionless)
T	temperature (degrees Fahrenheit)
t	wall thickness of cylindrical beam (in)
V	wind velocity (mph)
W	weight per unit length of beam (lb_f/ft)
α	integral of fundamental mode shape
α_p, β_p	parameters, function of applied load position on beam
β	parameter, function of beam length, radius, and λ (dimensionless)
λ	frequency parameter, function of the beam's boundary conditions (dimensionless)
μ	mass density of steel (lb_m/ft^3); coefficient of viscosity (lb_m/ft-sec) in R
ν, ν	Poisson's ratio (dimensionless)
π	pi
ρ, ϱ	density of air (lb_m/ft^3)
ς	damping factor (dimensionless)
ω_n, ω_n	circular frequency (radians/sec)
%	percent
∞	infinity
$^\circ$	degree

1. INTRODUCTION

This document discusses the causes and methods of reducting the effects of wind-induced vibration on cylindrical beams, focusing on determining if a particular beam may be subject to the resultant oscillations. Section 1 defines the purpose of the analysis detailing the physical constraints (dimensions and boundary conditions) of the beams studied, applied loads, and atmospheric conditions at John F. Kennedy Space Center (KSC). Section 2 reviews the methods, procedures, and formulas used to perform the research and analysis, in addition to the causes of wind-induced vibration. Section 3 discusses factors influencing the natural frequency of beams, such as resonance, combined loading, and structural arrays. This section also explains several methods of reducing the effects of wind-induced vibration and compares various vortex suppression devices. Section 4 provides a summary of the results, and Section 5 states conclusions and recommendations. Appendix A furnishes a graph of the modulus of elasticity of steel versus temperature. Appendices B and C provide formulas for computing the wind-induced vibration frequency and natural frequencies of beams under various loads, respectively; appendices C and D are composed of tables of data produced during the analysis; and appendix E contains a list of references.

1.1 PURPOSE

Many of the facilities at KSC are constructed of cylindrical beams, like the Rotating and Fixed Service Structures at the pads, and the Launch Equipment Test Facility (LETF). Cylindrical beams are often used in these facilities because they are less susceptible to corrosion and carry loads and stresses effectively. The following analysis provides a method for determining which beams, identified by the length-to-diameter ratio, would be affected by wind-induced vibration.

1.2 STRUCTURAL CONSIDERATIONS

1.2.1 GEOMETRY. The analysis considered single, hollow, steel cylindrical beams (shells and tubes) ranging from 4 to 12 in NPS in standard thicknesses of ASTM grade A and grade B steel, and 4 to 24 in NPS in standard thicknesses of API grade X42 steel. The sizes and grades of steel studied were considered because of their utilization at KSC.

1.2.2 SUPPORT CONNECTIONS. This analysis considered clamped, pinned, and clamped-pinned support conditions (figure 1). Pinned connections are considered to be secured with one bolt allowing some rotation at the support. Clamped supports are rigid and do not allow rotation at the joint. They are usually welded, although a connection made with many bolts preventing rotation would be equivalent to the welded connection. For this document, a clamped support condition is referred to as "welded."

There are various methods of fastening beams, some using plates or gussets. These fasteners would fall into a category between the welded and pinned conditions and would, therefore, be covered in this study. For completeness, formulas for other types of support conditions are listed in the appendix B.

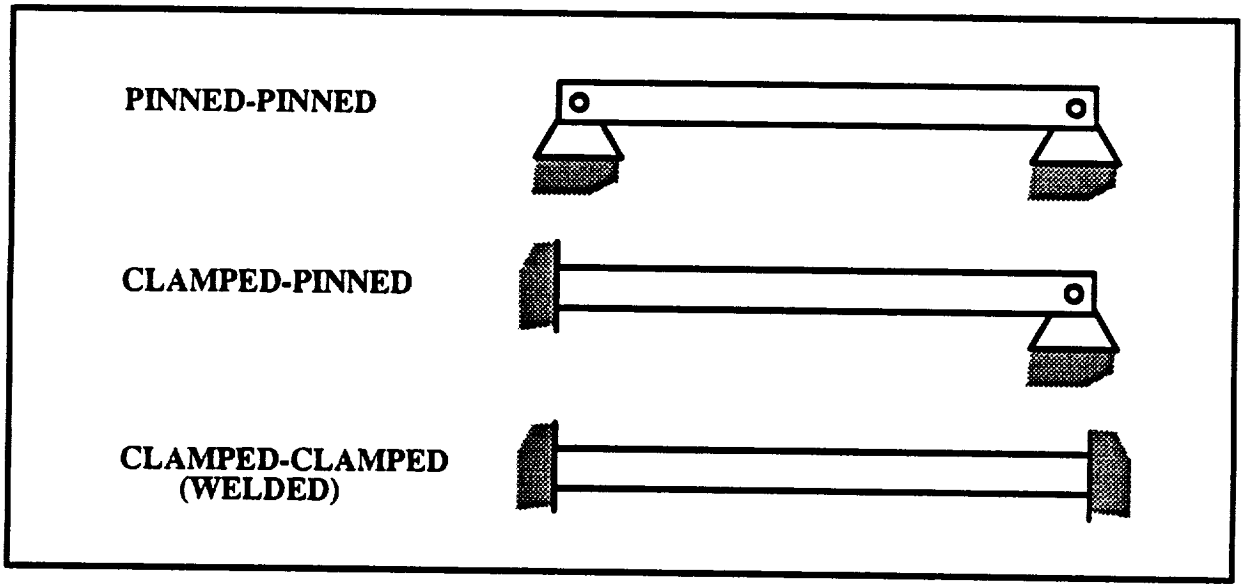


Figure 1. End Support Connections

1.2.3 APPLIED LOADS. The analysis first considered beams with no applied loads, then with applied axial, bending, shear, longitudinal, and torsional loads. Combinations of these loads were analyzed for trends in the natural frequency behavior.

1.3 ATMOSPHERIC AND FLOW CONDITIONS

The primary constraint of this study was that the Reynold's number (R) of the flow must be less than 10^6. R increases when wind velocity and cylinder diameter increases. When R exceeds 10^6, the wake behind the cylinder becomes turbulent, the vortex formation is unpredictable, and this analysis is not applicable. R is determined using equation 1 at standard atmospheric conditions.

$$R = \frac{\varrho VL}{\mu} = 780V(mph)D_o(in) \tag{1}$$

The wind velocities considered ranged from 0 to 200 miles per hour (mph), with 130 mph being the maximum steady-state velocity as the criteria for determining the cut-off point of the beam natural frequencies. This velocity was chosen based on the maximum recorded, steady-state hurricane winds over the past 55 years.

The temperature range at KSC was assumed to be 20 to 105 degrees Fahrenheit, with the higher temperature being the constraint. Since temperature affects the modulus of elasticity (E) of steel (appendix A) where E decreases when temperature increases, the higher temperature reduces E, thus reducing the beam natural frequency. The atmospheric pressure and density were assumed to be standard.

1.4 OTHER ASSUMPTIONS

This study is concerned with the lowest beam natural frequency (f_n) that may coincide with the wind-induced vibration frequency. The lowest f_n corresponds to the fundamental frequency, or the first mode (n=1). Since only the lowest f_n is analyzed, the effects of rotary inertia and shear deformation can be neglected. These effects, though, should be considered when analyzing all other modes.

1.5 DEFINITIONS

a. Amplitude. The maximum displacement from the equilibrium position that a body travels during oscillation.

b. Clamped Support Connection. A rigid connection, usually welded, that allows no rotation at the joint.

c. Damping. The diminishing of the vibration amplitude that a body exhibits as the vibrational energy gradually converts to heat by way of such occurrences as friction, sound, and fluid resistance.

d. Frequency. The number of cycles of motion per unit of time.

e. Karman Vortices. The clockwise and counterclockwise vortices shed in a regular and alternating pattern resulting from the force of a flow over a cylindrical body.

f. Natural Frequency. The frequency at which a body vibrates following a disturbance to that body.

g. Pinned Support Connection. A semirigid connection, usually bolted, that allows some rotation at the joint.

h. Resonance. The situation when the forced vibration frequency equals that of the natural frequency of the body or system. This condition causes a significant increase in the amplitude of the displacement causing greater stresses and possible failure of the system.

i. Shell. A tube whose wall is considered to be thin; $t < 0.1r_o$.

j. Torsional Motion. Rotational and twisting motion, measured in radians or degrees.

k. Tube. A hollow, cylindrical beam or pipe.

2. ANALYSIS

2.1 PROBLEM STATEMENT

The objective of the analysis was to determine a critical length-to-diameter ratio (L/D_o) of a hollow, cylindrical beam subjected to wind-induced vibration. The sizes of beams ranged from 4 to 24 inches (in), inclusive of all standard thicknesses, and were composed of American Society for Testing and Materials (ASTM) grade A and grade B [4 to 12 in nominal pipe size (NPS)] and American Petroleum Institute (API) grade X42 (4 to 24 in NPS). Calculations used maximum steady-state wind speeds of 130 mph associated with hurricane conditions possible at KSC. This study examined the effect that different end support and load conditions have on the f_n of the beams. Finally, methods of changing the frequency of the wind-induced vibration were examined.

2.2 METHODS AND PROCEDURES

The procedures followed in this study included researching the behavior of wind around cylinders, material properties of steel, and the f_n of beams.

2.2.1 RESEARCH. The research involved determining how the wind causes vibration in cylinders, how to reduce the effects of wind-induced vibration, and how the beam oscillation changes with increased wind velocity.

At this point, the constraints were defined for the air flow, material properties of steel, and beam support and loading configurations. Next, the formulas for f_n were obtained for beams (tubes and shells) subjected to axial, bending, shear, torsional, and longitudinal loads. The air flow constraints to be determined were the maximum R, the range of possible ambient temperatures (T), maximum wind velocity (V), and density of air (ρ). The material properties included defining the modulus of elasticity (E) and Poisson's ratio (ν) for steel. Beam properties required were the diameter and thickness for each grade of steel and the end support conditions.

2.2.2 COMPUTATIONS. Computations, using a spreadsheet program, were first performed to determine each cylinder's R for wind velocities ranging from 0 to 200 mph in 5-mph increments. R must be less than 10^6 for this study (see 1.3). Also computed at these wind velocities were the frequencies of the wind-induced vibration for each diameter cylinder.

The natural frequencies of the cylindrical beams were computed for each loading and end support condition for each L/D_o from 1 to 25. Once the natural frequencies were known, the cutoff resonance frequency ranges were computed and the corresponding L/D_o determined. From this data, trends in the L/D_o were analyzed for each beam size, load type, and end support condition. The combined load analysis, performed using finite element analysis, simulated the effects of multiple loads in all possible combinations of bending, axial and torsional forces and moments.

2.3 CAUSE OF WIND-INDUCED VIBRATION

When a fluid flows over a cylindrical body, a higher fluid pressure develops at the leading edge of the cylinder causing the fluid to be forced around the body. As the fluid velocity increases, the boundary layer of the flow is forced to separate from the cylinder, somewhere between 80 to 140 degrees around the cylinder from the direction of the flow, depending on its velocity. The separated boundary layers become shear layers on opposite sides of the cylinder and trail behind defining the wake. Inside the shear layer, the fluid velocity varies such that the slowest flow is at the innermost region along the cylinder. Conversely, the outermost fluid contacts with the free stream flow at a higher velocity. This difference in shear layer flow velocity causes a rolling of the fluid into the lower pressure area of the wake behind the cylinder, resulting in vortex formation. This vortex exerts a lift force [Karman force (F_K)] equal to the stagnation pressure on the cylinder perpendicular to the longitudinal axis and to the flow. Equation 2 represents F_K, where the Karman-force coefficient (C_K) is estimated to be 1.0, according to Den Hartog (ref. 10).

$$\left.\begin{aligned} F_K &= C_K \frac{1}{2} \varrho V^2 A \\ F_K &= 2.1305x10^{-4} V^2(mph) D_o(in) L(ft) \end{aligned}\right\} \qquad (2)$$

As the cylinder displaces, another vortex begins to form opposite the first vortex, rotating in the opposite direction. The second vortex exerts a similar, but opposing, force on the cylinder. These vortices continue to form in an alternating regular pattern from opposite sides of the cylinder (figure 2).

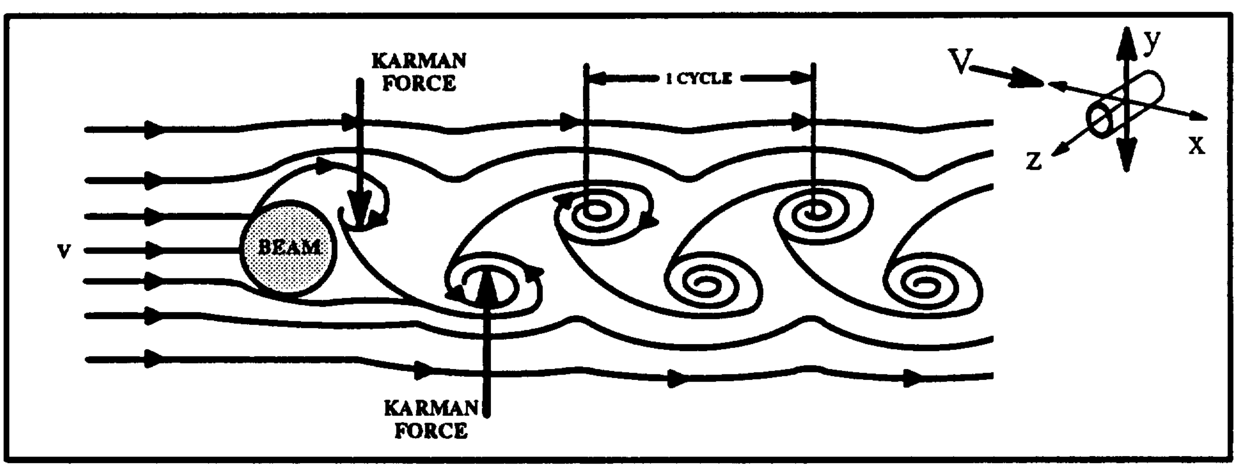


Figure 2. Transverse Oscillation

In addition to the transverse Karman force, the wind load exerts a force on the cylinder from the same direction of and in line with the flow (figure 3). Concurrently, the vortices behind the cylinder oppose the wind load with a drag force (per unit length), given by equation 3, where the drag coefficient (C_D) ranges between 0.8 and 160, depending on R and the surface roughness of the beam (ref. 7).

$$F_D = C_D \frac{1}{2} \varrho V^2 D_o \tag{3}$$

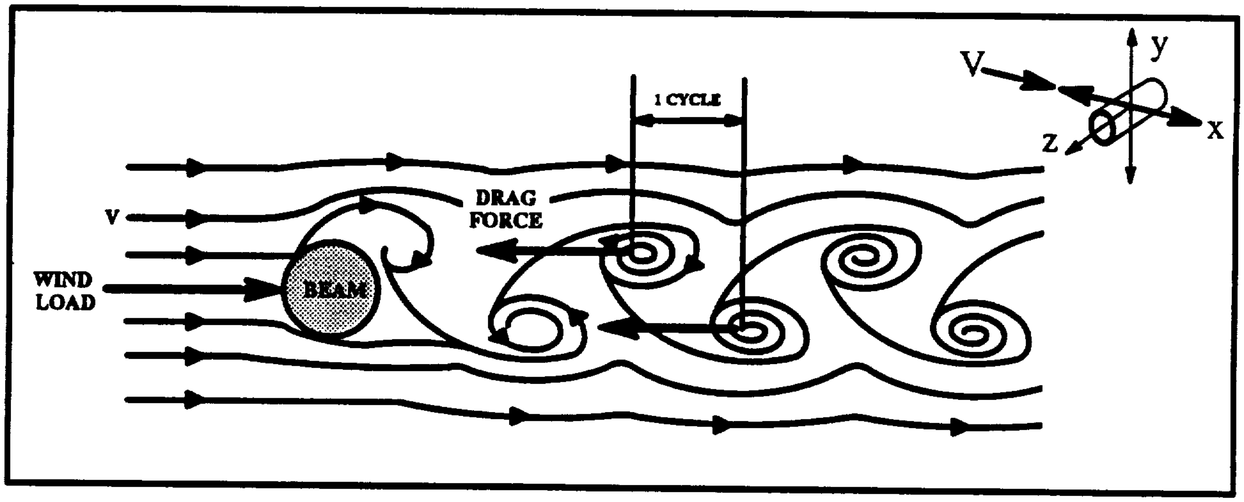


Figure 3. In-Line Oscillation

2.4 DETERMINATION OF THE WIND-INDUCED VIBRATION FREQUENCY

2.4.1 TRANSVERSE VIBRATION. A vibration transverse to the flow results as the cylinder oscillates between alternating vortices. The frequency of the cylinder's oscillation due to the lift forces (equation 4) is a function of the wind velocity (V), the outside diameter (D_o) of the cylinder, and the Strouhal number (S) (a coefficient of proportionality that is a function of R, and is approximately 0.22 for circular cylinders exhibiting Reynold's numbers in the laminar and transitional ranges).

$$f_L = \frac{SV}{D_o} = 0.22\frac{V}{D_o} = 3.872\frac{V(mph)}{D_o(in)} \tag{4}$$

2.4.2 IN-LINE VIBRATION. The in-line oscillation occurs at a frequency equal to that of the shedding of each individual vortex. In other words, the frequency of oscillation in line with the flow, due to the drag forces, is twice the frequency transverse to the flow (equation 5).

$$f_D = 2f_L \tag{5}$$

2.5 REYNOLD'S NUMBER

Before a beam can be analyzed for the effects of wind-induced vibration, the R must be calculated for the wind velocity range (where $0<V<V_{max}$) and then identified as either a shell or a tube. As R approaches 10^6, the wake becomes more turbulent, resulting in unpredictable vortex formation and shedding. If the shedding is irregular, oscillation frequencies are

nonperiodic. Therefore, the velocity at which R reaches 10^6 for each beam size corresponds to the maximum velocity for which the beam behavior can be analyzed using the methods in this study. The R for a cylindrical beam in a steady flow is given by equation 1.

2.6 CALCULATION OF FUNDAMENTAL TRANSVERSE NATURAL FREQUENCY

This subsection explains the procedures and formulas required to compute the transverse f_n by flexure of cylindrical beams subjected to only uniform axial loads, transverse bending loads, and no-load conditions. The formulas stated below have been converted to the units of each variable as contained in the list of Symbols and Notation. Refer to appendix B for the original equations and to figure A-1 in Appendix A for values of E for steel.

2.6.1 UNLOADED BEAMS.

This subsection describes the f_n of beams with no applied loads.

2.6.1.1 Tubes. Equation 6 represents the f_n of a tube with no applied loads. Refer to table B-1 in appendix B for values of λ_n, which differ for various support conditions and frequency modes.

$$f_n = 0.7090\frac{\lambda_n^2}{\pi L^2}\left[\frac{E(D_o^2+D_i^2)}{\mu}\right]^{1/2} Hz \tag{6}$$

2.6.1.2 Shells. Equation 7 represents the f_n of a shell subjected to no applied loads. Refer to equation B3 in appendix B to solve for $\bar{\lambda}_{ij}$. Poisson's ratio (ν) for steel is estimated to be 0.3, according to Salmon and Johnson (ref. 16).

$$f_n = 816.7987\frac{\bar{\lambda}_n}{\pi D_o}\left[\frac{E}{\mu(1-\nu^2)}\right]^{1/2} Hz \tag{7}$$

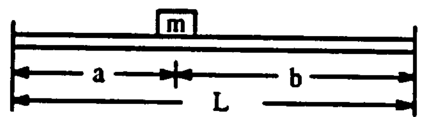
2.6.2 UNIFORM AXIAL LOADS.

Equation 8 represents the f_n of a beam subjected to a uniform axial load, P, where P is positive for compressive loads. This equation requires that the buckling load P_b be computed. Formulas for buckling loads are listed in table B-3.

$$\left.\begin{aligned} f_n &= 0.7090\frac{\lambda_n^2}{\pi L^2}\left\{\frac{E(D_o^2+D_i^2)}{\mu}\left[1-\frac{P}{|P_b|}\right]\right\}^{1/2} Hz \\ f_P &= f_{P=0}\left[1-\frac{P}{|P_b|}\right]^{1/2} Hz \end{aligned}\right\} \tag{8}$$

2.6.3 BENDING LOADS. The following subsections describe the placement of the concentrated bending loads and the resultant natural frequencies.

2.6.3.1 Concentrated Mass. The formula for transverse f_n of a beam carrying concentrated bending loads requires determination of the mass equivalence of the bending load P. The load is positioned at a distance "a" from one end and a distance "b" from the other so that the sum (a+b) equals the total length of the beam, as shown below.



2.6.3.2 Natural Frequency. Equations 9 and 11 represents the f_n of a beam subjected to concentrated masses causing bending loads.

For pinned end supports,

$$f_n = 0.1303\left[\frac{EI(a+b)}{a^2b^2[m+(\alpha_p+\beta_p)m_b]}\right]^{1/2} Hz \qquad (9)$$

where

$$\alpha_p = \frac{a}{(a+b)}\left[\frac{(2b+a)^2}{12b^2}+\frac{a^2}{28b^2}-\frac{a(2b+a)}{10b^2}\right] \qquad \beta_p = \frac{b}{(a+b)}\left[\frac{(2a+b)^2}{12a^2}+\frac{b^2}{28a^2}-\frac{b(2a+b)}{10a^2}\right] \qquad (10)$$

For welded end supports,

$$f_n = 1.042\left[\frac{EI}{L^3[m+(\alpha_p+\beta_p)m_b]}\right]^{1/2} Hz \qquad (11)$$

where

$$\alpha_p = \frac{a}{(a+b)}\left[\frac{(3a+b)^2}{28b^2}+\frac{9(a+b)^2}{20b^2}-\frac{(3a+b)(a+b)}{4b^2}\right] \qquad (12)$$

$$\beta_p = \frac{b}{(a+b)}\left[\frac{(3b+a)^2}{28a^2}+\frac{9(a+b)^2}{20a^2}-\frac{(3b+a)(a+b)}{4a^2}\right] \qquad (13)$$

2.7 OTHER VIBRATION

Beams are not limited to transverse vibration by flexure. Oscillations can occur from shear forces, torsion in a rotational plane, and extension and contraction along the longitudinal axis of the beam. These vibrations do not act in the same plane of motion as the wind-induced vibration; therefore, they individually do not cause transverse vibration in the beam. The results are also independent of the type of end supports used.

2.7.1 UNIFORM SHEAR VIBRATION. Shear vibration should be considered when analyzing short beams or higher modes of longer beams. Equation 14 represents the f_n due to shear forces.

$$f_n = 24.0652\frac{\lambda_n}{\pi L}\left[\frac{KE}{\mu(1+\nu)}\right]^{1/2} Hz \tag{14}$$

where

$$K = \frac{6(1+\nu)(1+p^2)^2}{(7+6\nu)(1+p^2)^2+(20+12\nu)p^2}\ ; \quad p = \frac{b}{a} \tag{15}$$

2.7.2 TORSIONAL VIBRATION. Equation 16 represents the f_n of a beam subjected to local twisting or rotation that induces a torsional vibration.

$$f_n = 34.0333\frac{\lambda_n}{\pi L}\left[\frac{E}{\mu(1+\nu)}\right]^{1/2} Hz \tag{16}$$

2.7.3 LONGITUDINAL VIBRATION. Equation 17 represents the f_n of contraction and extension along the length of the beam.

$$f_n = 34.033\frac{\lambda_n}{\pi L}\left[\frac{E}{\mu}\right]^{1/2} Hz \tag{17}$$

3. DISCUSSION

3.1 RESONANCE

Every structure has a natural frequency—a frequency at which it will vibrate when it is acted upon by a force. In this study, the structure is a cylindrical beam, and the applied force is the wind. The relationship between the beam's f_n and the frequency of the wind-induced vibration is shown in figure 4. The wavy line represents the wind-induced vibration frequency increasing with increasing wind velocity. The straight bars show the f_n of the beam decreasing as the beam length increases. As the maximum wind-induced vibration frequency nears the f_n of the beam (bar b), resonance will occur when the wind reaches the corresponding velocity. When the induced response will begin depends on the sharpness of resonance, which is a function of the damping characteristics of the beam. If the beam's fundamental modal frequency, f_1, lies within the wind-induced frequency range (bar a), resonance can also occur at any higher frequency modes lying in the range. The ideal situation would be to avoid resonance by selecting a beam whose natural frequency does not fall in the wind-induced vibration frequency range (as in bar c).

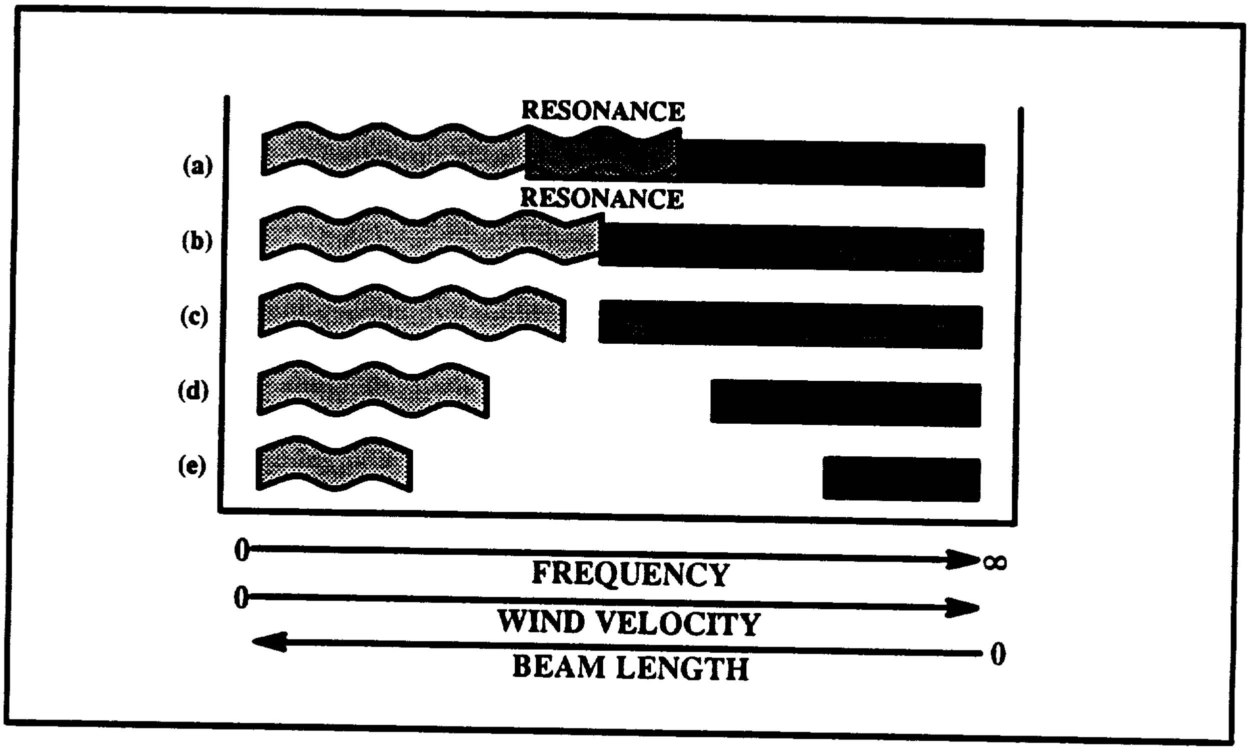


Figure 4. Wind Velocity and Beam Length Versus Frequency

However, as discussed in 2.3 and 2.5, there are two wind-induced oscillations that must be considered, each acting in different planes normal to the longitudinal axis of the beam, one twice the frequency of the other. Figure 5 shows an example of typical induced and natural frequency data for a 4-in NPS beam, secured with welded end supports and having a 0.125-in wall thickness. It can be seen that as the wind velocity increases, the induced vibration frequency increases with the in-line vibration frequency twice the transverse frequency. Also shown is the f_n decreasing as the beam's length increases. The simultaneously occurring in-line and transverse frequencies at the maximum steady-state wind velocity, 130 mph, correspond to two different beam lengths.

Since this study is concerned with the longest beam that would be affected by wind-induced vibration, the beam length associated with the in-line frequency would be the critical value. A longer beam would possibly become resonant at lower wind velocities.

WIND			BEAM  D_o = 4.50 in D_i = 4.25 in		
V (mph)	f_L (Hz) TRANSVERSE	f_D (Hz) IN-LINE	L/D_o	L (ft)	f_n (Hz)
0	0	0	9	3.4	666
10	9	18	10	3.8	539
20	17	34	11	4.1	446
30	26	52	12	4.5	375
40	34	68	13	4.9	319
50	43	86	14	5.3	275
60	52	104	15	5.6	240
70	60	120	16	6.0	211
80	69	138	17	6.4	187
90	77	154	18	6.8	166
100	86	172	19	7.1	149
110	95	190	20	7.5	135
120	103	206	21	7.9	122
130	112	224	22	8.3	111
140	120	240	23	8.6	102

Figure 5. Example of Induced and Natural Frequency Data

3.2 COMBINED LOADS

As mentioned in 2.7, shear, longitudinal, and torsional forces and moments are not a concern when dealing with transverse oscillations. They act in different planes of motion and the natural frequencies resulting in those planes are much higher than the frequencies in the transverse regions. These forces, though, do change the transverse f_n of the beam when one or more are combined with axial and bending loads.

Multiple loads reduce the f_n from 19 to 93 percent of the unloaded beam's f_n. The loads that contribute to bending—bending forces and moments—decrease the f_n the most. Combinations of loads can easily bring the f_n of a beam into the range of the wind-induced vibration frequency.

Since the relationship between the f_n, length, and diameter is nonlinear, the frequencies cannot be superposed to obtain the resultant frequency. Instead, for this study, a finite element analysis was done to determine what trend resulted when all possible load combinations were applied. This analysis used equation 18 to solve for the circular natural frequency (ω_n), and then converted to radian frequency (f_n), where [K] is the stiffness matrix, [λ] is the transformation matrix for converting local to global coordinates, and [M] is the consistent mass matrix. Refer to appendix B for details of these finite element analysis matrices.

$$\det\left|[K][\lambda] - \omega_n^2[M]\right| = 0 \tag{18}$$

3.3 SHELLS VERSUS TUBES

The beam must also be classified as either a shell or a tube. Shells and tubes are both assumed to be uniform and slender and to have constant thickness and are composed of a linear, elastic, homogeneous, isotropic material. Also, deformations considered are normal to the undeformed beam axis, and rotary inertia and shear deformations are neglected. The difference between them is that the shell walls are considered to be thin—less than 10 percent of the shell radius (r_o).

Unfortunately, there is disagreement in the literature regarding a standard formula or method for the f_n of shells. Equation 7 represents one of the methods available. It is therefore recommended that for shells, compute the f_n using both equations 6 and 7 and use the lowest resulting f_n for further analysis.

3.4 MULTIPLE STRUCTURES

This study focused on individual beams subjected to winds. But, if a beam is downstream of another structure, as in a structural array, the wake of the upstream structure may affect the response of the subject beam. The beam may react to both flow-induced vibration and a turbulent wake from the upstream structure, and both influences must be considered in the analysis.

3.5 METHODS OF REDUCING THE EFFECTS OF WIND-INDUCED VIBRATION

This subsection describes four methods of reducing the effects of wind-induced vibration, including changing the beam's damping properties, modifying the cross section, changing the reduced velocity, and adding vortex suppression devices.

3.5.1 INCREASE REDUCED DAMPING. Reduced damping is a relationship between the mass ratio and the damping ratio. If either of these ratios can be increased so that reduced damping is greater than 64 (equation 19), then the effects of wind-induced vibration would be negligible.

$$\frac{2m(2\pi\zeta)}{\mu D_o^2} > 64 \tag{19}$$

Considering that the damping factor is less than 0.001 for steel, according to Harris and Crede (ref. 11), to the resultant reduced damping relationship would compute to be approximately 0.01. If the beam could be filled solid with steel, the added mass would only increase the reduced damping relationship to approximately 0.09, not close to the required value of 64. Therefore, for steel cylindrical beams, this method would not be practical. The damping capabilities can be increased by allowing the beam to rub another structural member. This helps to absorb vibrational energy and reduce the amplitude of the oscillation.

3.5.2 TAPER THE CROSS SECTION. The formation of regular vortices in the wake can be prevented by tapering the cross section of the beam. This would essentially create an airfoil section (figure 6). The cross section should have a maximum angle of 8 to 10 degrees to the trailing edge giving a slope of 6 longitudinal units to every lateral unit. The stiffness of the section must be great enough to avoid flutter.

The geometry of a tapered cross section would be impractical for purposes at KSC because the direction of the wind must be fixed for this nonpivoting beam, and the cross section could be 2.5 feet (ft) to 6.5 ft wide, depending on the beam diameter. Also, KSC-STD-Z-0004 recommends that only readily available steel shapes be used in structural design.

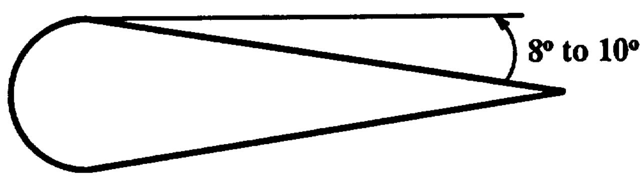


Figure 6. Tapered Cross Section

3.5.3 AVOID RESONANCE. A beam may begin to respond to a force within a range of frequencies on either side of the exact f_n. The size of this frequency range depends on the viscous and structural damping properties of the structure. An effective measure that considers both in-line and transverse oscillation frequencies is that of the reduced velocity (equation 20), a relationship between the f_n, V, and the D_o of the beam. If the reduced velocity is kept below 1, resonance will be avoided up to the specified wind velocity.

$$\frac{V}{f_n D_o} < 1 \tag{20}$$

or,

$$f_n > 17.6\frac{V(mph)}{D_o(in)} \tag{21}$$

The f_n increases as the L/D_o decreases. Therefore, the frequency can be increased effectively by decreasing the beam length, increasing the beam diameter, or both, until the beam exhibits the desired f_n.

Figure 7 recalls the example of data for a 4-in NPS beam to illustrate the application of equation 21. With maximum wind velocities of 130 mph, the beam f_n should be greater than 508.444 hertz (Hz) (equation 22). This frequency corresponds to an L/D_o between 10 and 11.

$$f_n > 17.6\frac{130mph}{4.5in} = 508.444Hz \tag{22}$$

With L/D_o=10, both in-line and transverse oscillation frequencies are successfully avoided in the wind-induced vibration frequency range.

WIND			BEAM D_o = 4.50 in, D_i = 4.25 in		
V (mph)	f_L (Hz) TRANSVERSE	f_D (Hz) IN-LINE	L/D_o	L (ft)	f_n (Hz)
0	0	0	9	3.4	666
10	9	18	10	3.8	539
20	17	34	11	4.1	446
30	26	52	12	4.5	375
40	34	68	13	4.9	319
50	43	86	14	5.3	275
60	52	104	15	5.6	240
70	60	120	16	6.0	211
80	69	138	17	6.4	187
90	77	154	18	6.8	166
100	86	172	19	7.1	149
110	95	190	20	7.5	135
120	103	206	21	7.9	122
130	112	224	22	8.3	111
140	120	240	23	8.6	102

Figure 7. Example of Reduced Velocity Frequency Versus Induced Vibration Frequencies

3.5.4 ADD VORTEX SUPPRESSION DEVICES. The following subsections describe various methods of reducing the effects of wind-induced vibration by adding devices that prevent flow separation and regular vortex formation in the wake. These devices reduce the beam response between 70 and 90 percent from the plain cylinder response when used along the center 40 percent of the beam, at the least.

3.5.4.1 Helical Strakes. A helical strake (figure 8) is a band, usually flat, fastened at a particular pitch, which is the length of beam required for the strake to encircle 360 degrees. The optimum configuration is to place three sharp-edged strakes, $0.1D_o$ high, at 120-degree intervals around the cylinder, with each strake at 60-degree angles to the beam.

Strakes are a simple and economical solution for dealing with wind-induced vibration. They can be flat, tapered pieces of steel welded to the beam or just tubing fastened with tie-wraps. The strakes can be positioned independent of the wind direction, and do not increase the dimensions of the beam excessively.

3.5.4.2 Perforated Shroud. A perforated shroud (figure 8) is a thin metal cylinder supported by struts around a beam. The surface of the shroud is perforated with uniform square or circular holes allowing 30- to 40-percent open area. This device provides many of the advantages of the helical strakes concerning wind direction and dimensional profile. Unfortunately, it may be difficult to prevent corrosion from forming in and behind the small openings.

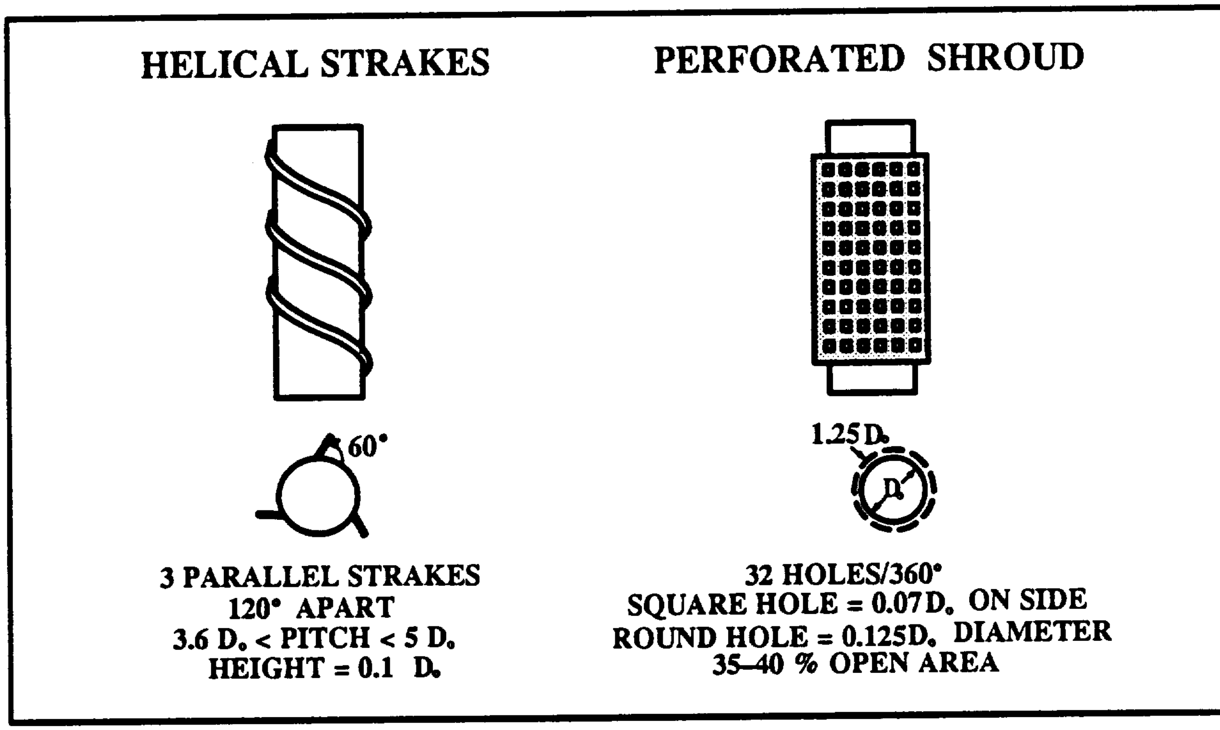


Figure 8. Vortex Suppression Devices (Helical Strakes and Perforated Shroud)

3.5.4.3 Axial Slats. Axial slats (figure 9) consist of flat strips of material placed side by side lengthwise on struts around the cylinder. The two foremost and two aftmost slats toward the wind direction are removed for improved performance. Usually 25 to 30 slats are used, sized so that there is 40-percent open area. This slat configuration would be effective when the wind direction is fixed. As with the perforated shroud, it may be difficult to control the corrosion with this device.

3.5.4.4 Splitter. The splitter (figure 9) is a flat rectangular piece of material secured lengthwise along the cylinder. It should be positioned opposite the direction of the flow. Its width ranges between $4D_o$ and $5D_o$, which could contribute to safety concerns around work areas. Also, this device is limited to flow from a fixed direction.

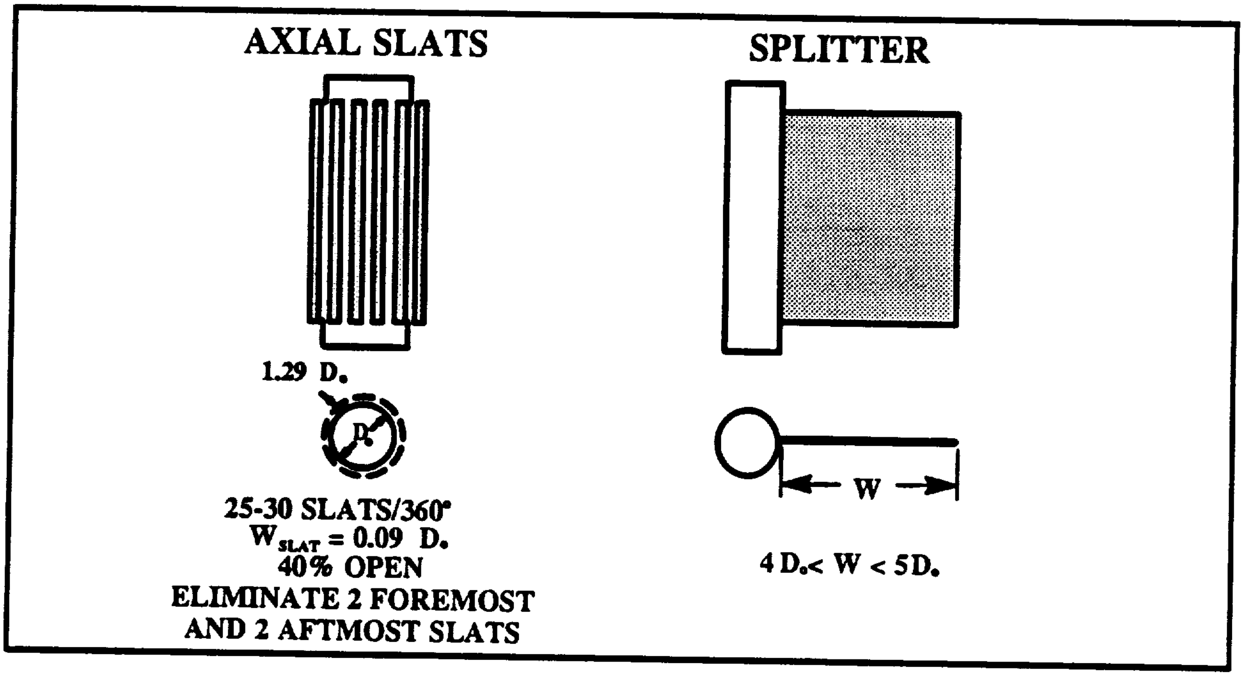


Figure 9. Vortex Suppression Devices (Axial Slats and Splitter)

3.5.4.5 Streamlined Fairing and Guide Vane. A streamlined fairing (figure 10) is basically an airfoil device placed over a portion of the cylinder. This device is similar to tapering the cross section of the beam (see 3.5.2) but different in that the fairing pivots about the cylinder as the wind changes direction. The length of the fairing ranges from $3D_o$ to $6D_o$, depending on the diameter, so this device may be inappropriate where space is a concern. Also, the pivoting fairing may be a safety hazard in work areas.

The guide vane (figure 10) is similar to the streamlined fairing in all aspects except that the vane area is shorter and wider.

3.5.4.6 Spoiler Plates. Spoiler plates (figure 11) are flat, square pieces of material ($D_o/3$ on a side) and fastened perpendicular to the cylinder in staggered rows $2D_o/3$ apart. They are most effective when four plates are placed 90 degrees apart around the cylinder. These protruding plates may present a safety hazard if used around work areas.

3.5.4.7 Ribbon Cable. Ribbons (figure 11) are an effective method of reducing vibration in cables not used for slide systems. They should be made of polyurethane film with a width between $1D_o$ and $2D_o$, a length between $6D_o$ to $10D_o$, and a spacing of $1D_o$ to $3D_o$ centers.

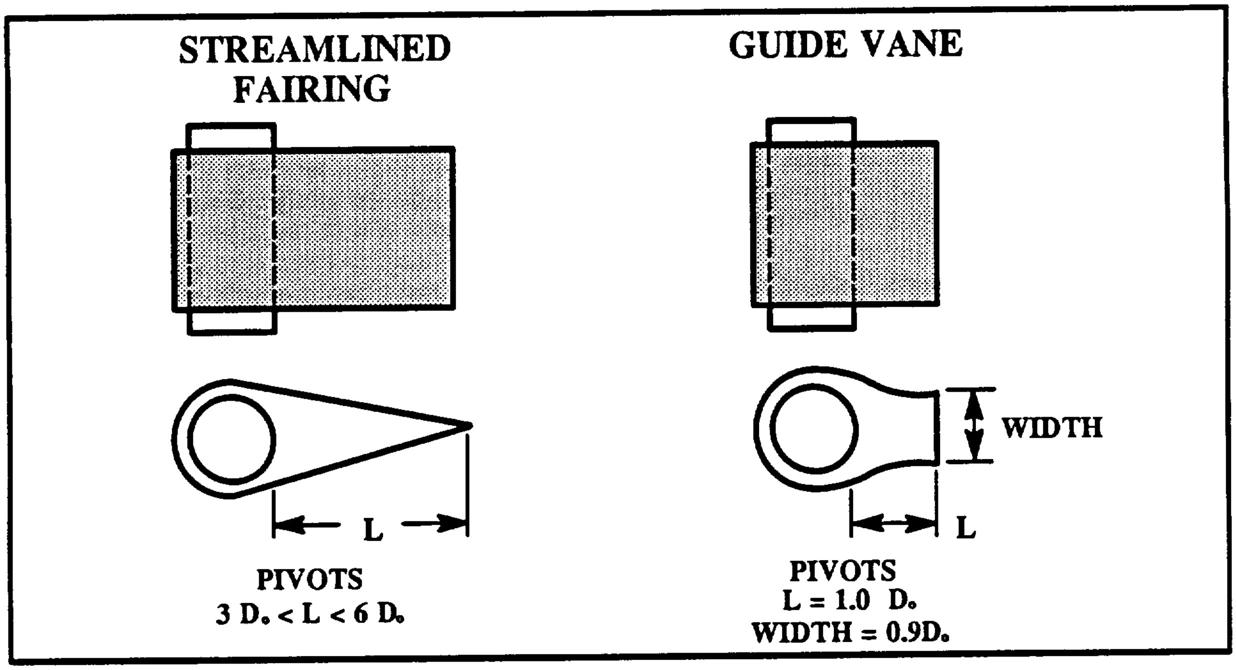


Figure 10. Vortex Suppression Devices (Streamlined Fairing and Guide Vane)

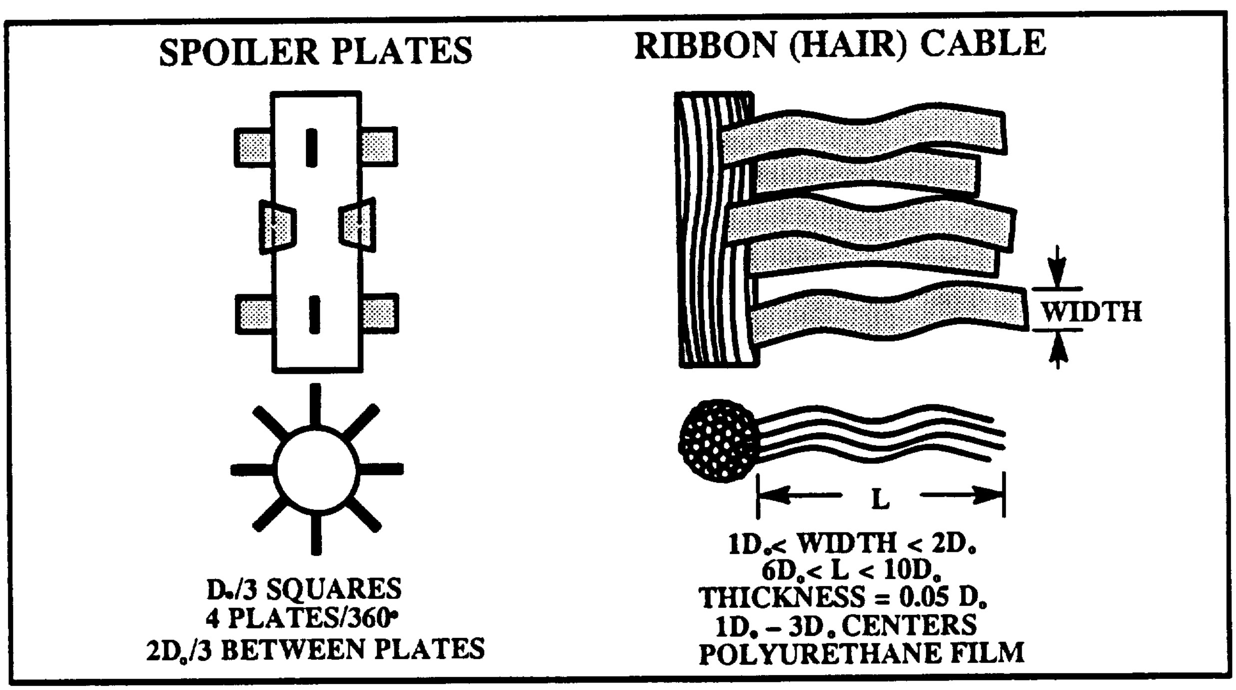


Figure 11. Vortex Suppression Devices (Spoiler Plates and Ribbon Cable)

4. SUMMARY OF RESULTS

Computations of the R for each beam diameter showed that R was more than 10^6 for diameters greater than 8 in at V=130 mph. These beams were limited in this analysis to maximum wind velocities associated with R equal to 10^6. If these beams must be analyzed for higher wind velocities, methods that deal with turbulent flow patterns and wakes must be used. Table C-1 (appendix C) lists R for each size beam at wind velocities ranging from 0 to 200 mph. Figure 12 shows the L/D_o associated with the cut-off frequency versus beam diameter for the transverse vibration in unloaded beams. The black bars represent the welded support condition, the lightest grey is the pinned supports, and the medium grey is the combination weld-pin connections. The horizontal line represents the L/D_o associated with the f_n at 130 mph for each diameter beam with welded end conditions, independent of R. The numbers above each group of bars is the maximum steady-state velocity for which that size beam is valid for this study with regard to R. The trends showed that at a particular wind velocity, 130 mph in this case, every size beam exhibited the same L/D_o corresponding to its particular cut-off frequency for each loading condition. But, because of the limitations with R, the larger beams' data showed higher L/D_o.

The chart shows that the greatest L/D_o avoiding the wind-induced vibration frequency range was produced in the welded end support condition for every size beam. In other words, the more rigid the support connection, the longer and more slender the beam can be before the effects of wind-induced vibration become a factor. This is true for any type of applied load.

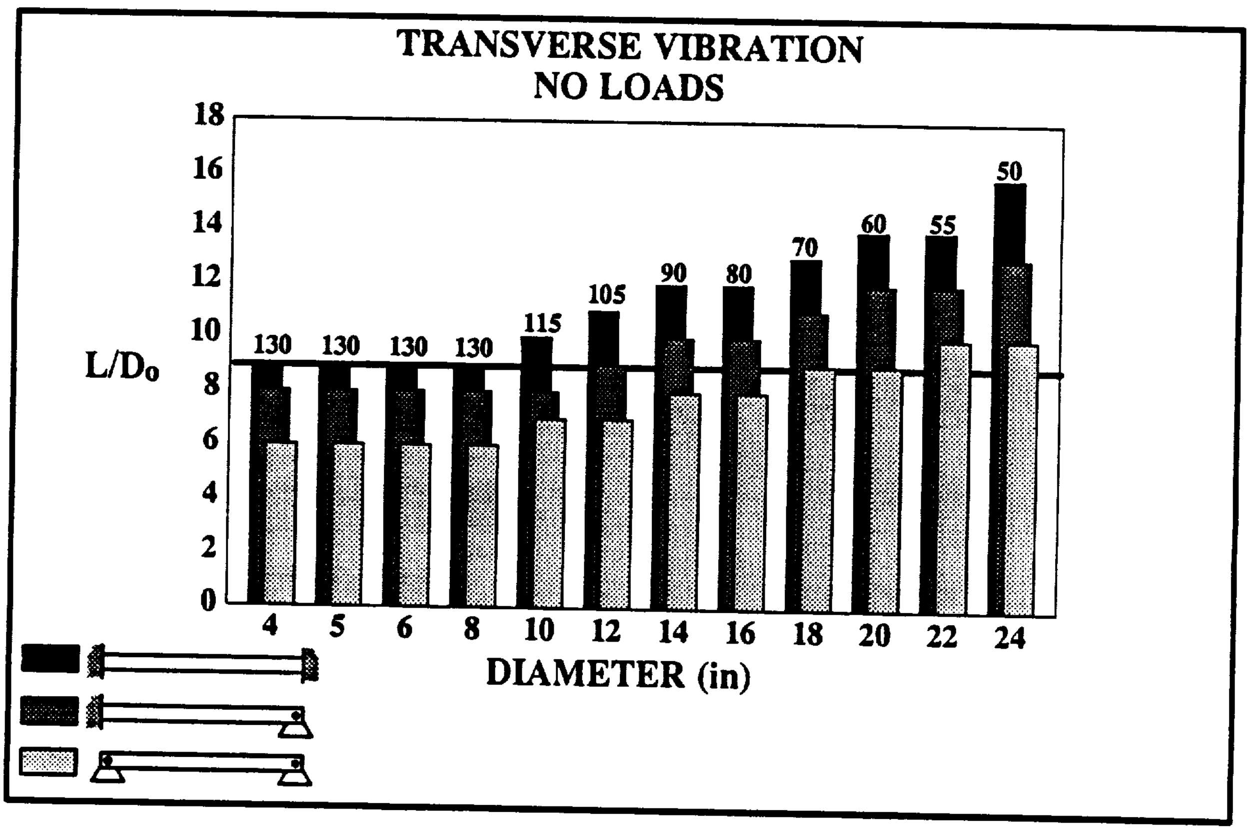


Figure 12. L/D_o Versus Diameter for Transverse Vibration in Unloaded Beams

Focusing on the rigid, welded support condition, the chart in figure 13 shows the effects of applied uniform axial loads on transverse vibration frequency in terms of L/D_o and beam diameter. The numbers above the bars indicate maximum steady-state wind velocities valid for each size beam; and the dark, striped, and white bars are the results from the application of 25, 50, and 75 percent buckling loads, respectively. The chart indicates that as the compressive axial load increases, the f_n of the beam decreases along with the corresponding L/D_o. Conversely, if uniform tensile loads are applied to the beam, the f_n would increase in the beam (equation 8) resulting in a greater cut-off L/D_o. The 25 percent buckling load situation produces almost no difference in the results compared to the transverse vibration in unloaded beams (figure 12). Therefore, the lower the compressive loading, the greater the L/D_o can be for a beam before it is affected by wind-induced vibration.

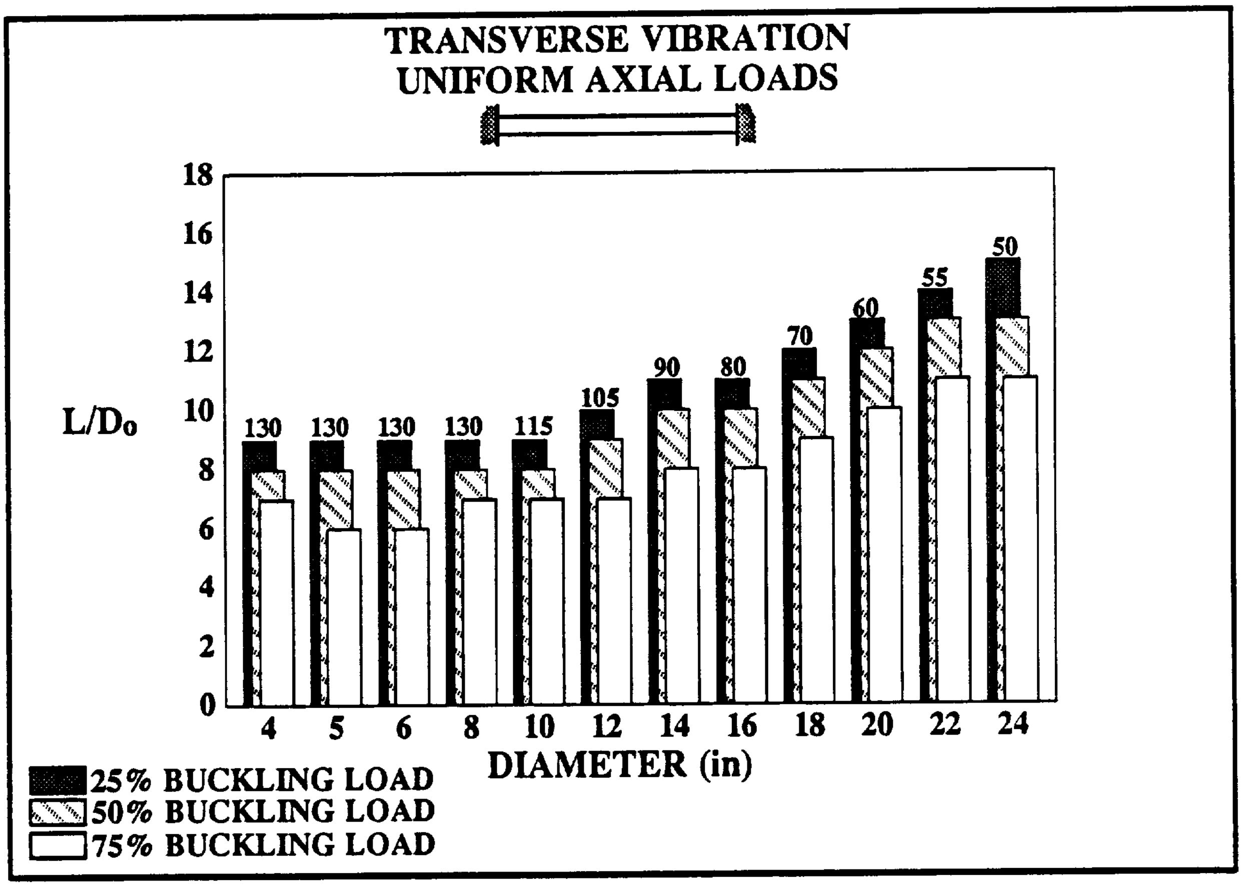


Figure 13. L/D_o Versus Diameter for Transverse Vibration in Beams Subjected to Uniform Axial Loads

Similarly, the L/D_o decreases as increasing bending loads are applied to the beam. This is shown in figure 14 with 25, 50, and 75 percent of maximum bending loads applied to the beams. The numbers above the bars are the maximum valid steady-state wind velocities for each beam in this analysis. The bending loads drastically reduce the f_n of the beams to the point where, whenever any of these loads are applied, wind-induced vibration should be considered.

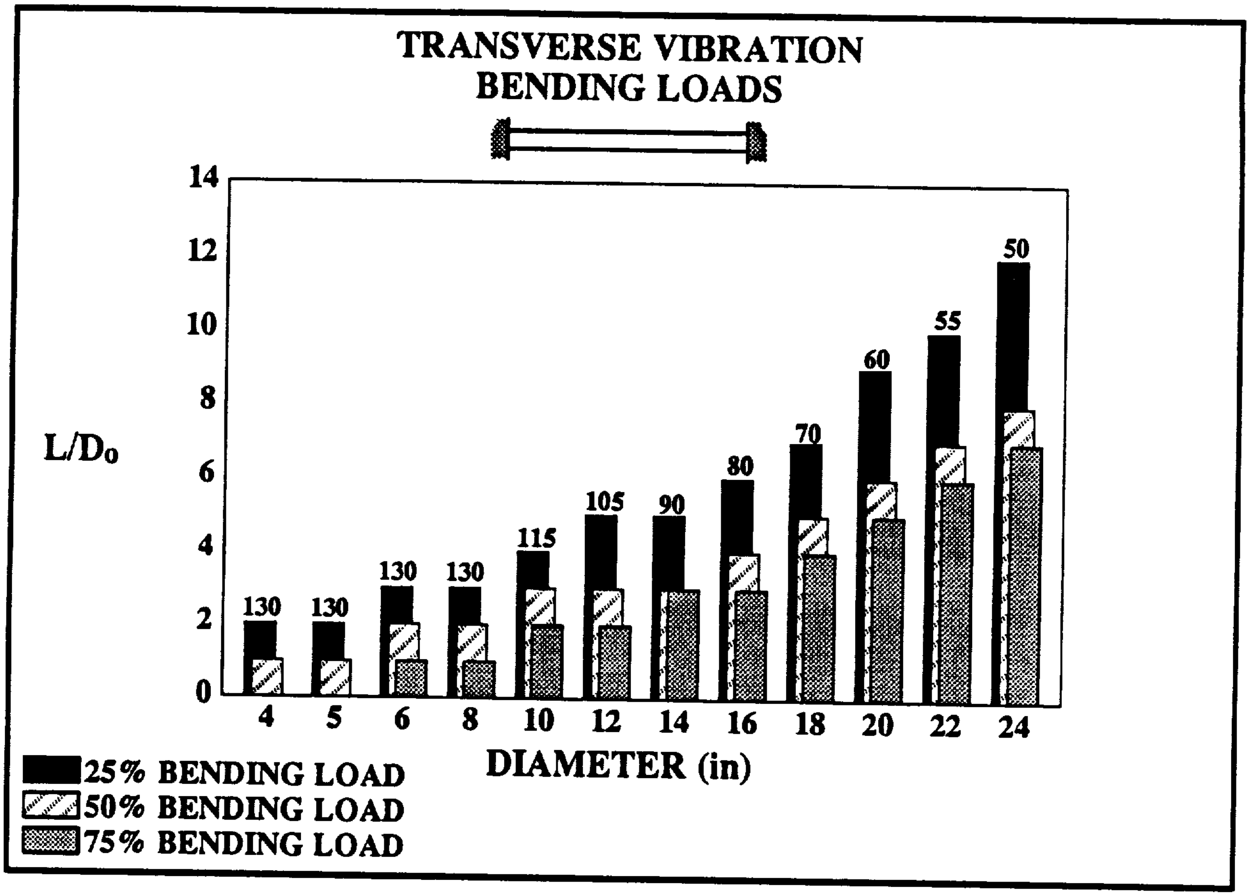


Figure 14. L/D_o Versus Diameter for Transverse Vibration in Beams Subjected to Bending Loads

Natural frequencies were computed for longitudinal, shear, and torsional applied loads. Tables of the results are located in appendix D for reference. These loads produce higher frequency vibrations in planes of motion other than transverse, like the wind-induced vibration, and are not a factor when considered individually. When they were applied in any combination with each other or applied axial and bending moments and forces, they helped to reduce the transverse f_n by 19 to 93 percent of that of the unloaded beam. This resulted in beams with lower L/D_o values being affected by the wind-induced vibration.

5. CONCLUSIONS AND RECOMMENDATIONS

It was concluded from this study that the regularly forming vortices in the cylinder wake exert lift (Karman) and drag forces on the cylinder causing it to oscillate in line and transverse to the flow. The effects of the wind-induced vibration can be minimized by decreasing the L/D_o—increasing the outside diameter or decreasing the length of the beam—or by adding a vortex suppression device (helical strakes), which can reduce the response of the beam by as much as 90 percent of a plain beam.

The conditions that resulted in the largest L/D_o that did not interfere with the resonance frequency range were produced in the unloaded beam with welded end support conditions. The results for the welded beam were greatest for all loading conditions compared to the pinned beam's results. The highest L/D_o values were also obtained for beams that carried less than 50 percent of the maximum applied axial and bending loads. The vibration from other applied loads—shear, longitudinal, torsional—create motion in planes other than transverse and do not contribute to the wind-induced response if each is the sole load applied to the beam. But, all loads must be considered when they are applied in any combination because together they can produce natural frequencies 19 to 93 percent less than those of unloaded beams.

Several recommendations were made based on these conclusions. First, only rigidly bolted or welded connections should be used to support the beams. Second, the L/D_o should be decreased, whenever possible, preventing the beam's induced response from lying within the resonance frequency range. This can be done by decreasing the overall length of the beam, adding rigid supports along the beam length, and increasing the beam diameter. Finally, helical strakes (or ribbons for cables) should be added to the beam to reduce the induced response in the beam when it must be designed with an unacceptable L/D_o.

APPENDIX A

MODULUS OF ELASTICITY VERSUS TEMPERATURE

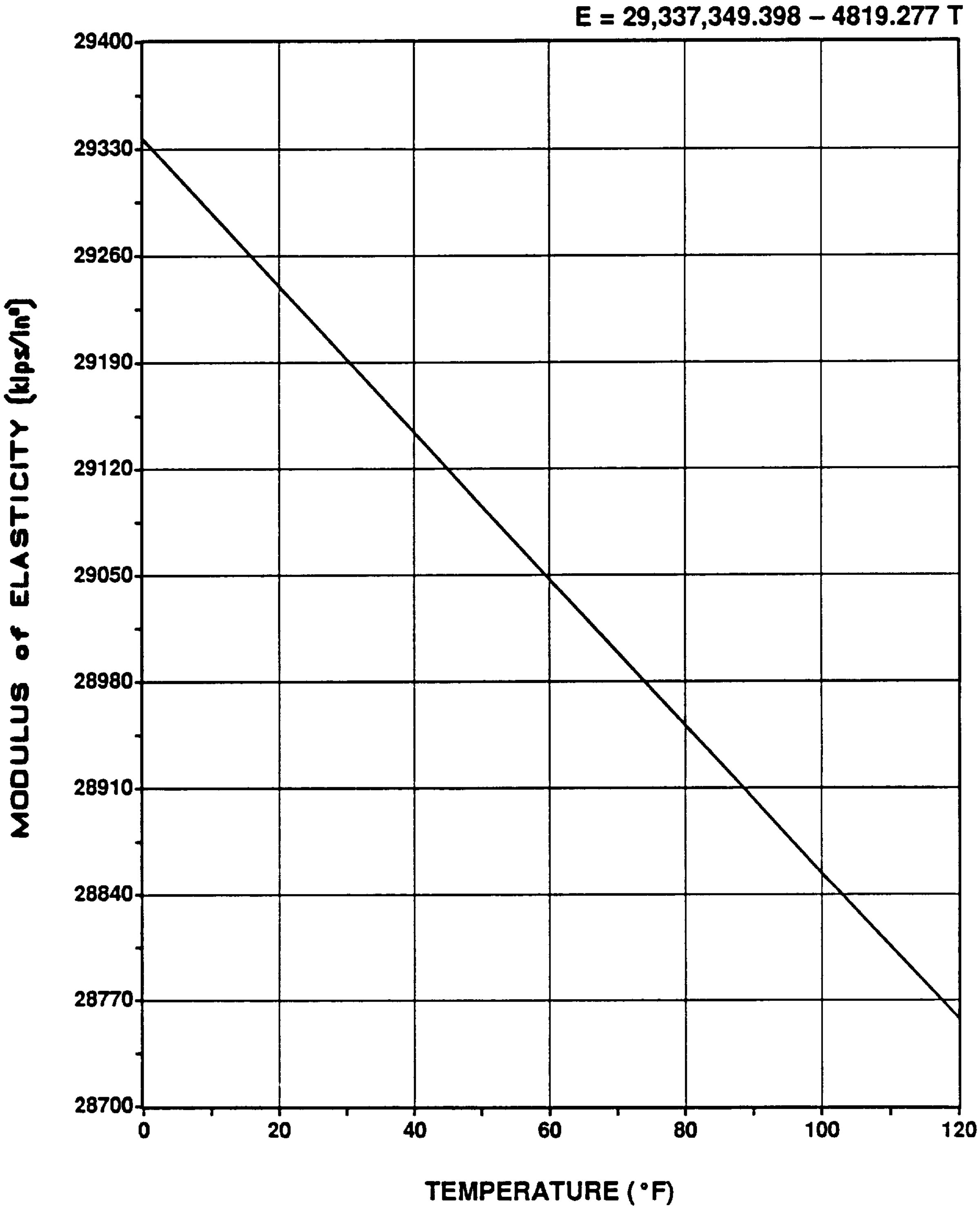


Figure A-1. Modulus of Elasticity of Steel Versus Temperature

APPENDIX B

FORMULAS

B.1 TRANSVERSE NATURAL FREQUENCY (Hz)

B.1.1 TUBES

Assumptions for tubes:

1. Uniform beams
2. Slender beams: $D_o << L$
3. Linear, elastic, homogeneous, isotropic materials
4. No axial loads are applied.
5. Plane sections remain plane, and only deformations normal to the undeformed beam axis are considered.
6. Plane of symmetry and plane of vibration are the same where the shear center of the beam and the center of mass coincide.

$$f_n = \frac{\lambda_n^2}{8\pi L^2}\left[\frac{E(D_o^2 + D_i^2)}{\mu}\right]^{1/2} \tag{B1}$$

where: n = 1, 2, 3, ...; mode number; number of axial half-waves
μ = material density
E = modulus of elasticity
L = beam length
D_o = beam outside diameter
D_i = beam inside diameter
λ = parameter for beam mode; see table B-1

B.1.2 SHELLS

Assumptions for shells:
1. Constant thickness
2. Walls are thin: $t < 0.1\ r_o$
3. Linear, elastic, homogeneous, isotropic materials
4. No applied loads
5. Deformation of the shell are small compared to the shell radius; straight lines are perpendicular to the midsurface of the shell and remain so during deformation.
6. Rotary inertia and shear deformation are neglected. Rotary inertia of concentrated mases can be neglected for the first mode but should be considered for all other modes.

$$f_n = \frac{\bar{\lambda}_{nj}}{2\pi r_o}\left[\frac{E}{\mu(1-\nu^2)}\right]^{1/2} \tag{B2}$$

where:

$$\bar{\lambda}^2_{nj} = \frac{B_n^4 + kj^2B_n^2\left[B_n^2 j^2 + 2\nu j^2(j^2-1)\alpha_1 + 2(1-\nu)(j^2-1)^2\alpha_2\right] + kj^4(j^2-1)^2}{B_n^2\alpha_2 + j^2(j^2+1)} \tag{B3}$$

$$B = \lambda_n \frac{r_o}{L} \qquad\qquad k = \frac{h^2}{12r_o^2}$$

h = shell wall thickness
j = 2, 3, 4, ...; number of circumferential waves
n = 1, 2, 3, ...; mode number; number of axial half-waves
ν = Poisson's ratio
μ = material density
E = modulus of elasticity
r_o = shell outside radius
α_1, α_2 = beam mode parameters; see table B-2
λ = parameter for beam mode; see table B-1

TABLE B-1. Parameter λ_n For Beam Modes

SUPPORT CONDITION	MODE					
	1	2	3	4	5	n > 5
1. Free-free	4.73004074	7.85320462	10.99560780	14.13716550	17.27875970	$(2n+1)\frac{\pi}{2}$
2. Free–sliding	2.36502037	5.49780392	8.63937983	11.78097245	14.92256510	$(4n-1)\frac{\pi}{4}$
3. Clamped-free	1.87510407	4.69409113	7.85475744	10.99554073	14.13716839	$(2n-1)\frac{\pi}{2}$
4. Free-pinned	3.92660231	7.06858275	10.21017612	13.35176878	16.49336143	$(4n+1)\frac{\pi}{4}$
5. Pinned-pinned	3.14159265	6.28318531	9.42477796	12.56637060	15.70796320	$n\pi$
6. Clamped-pinned	3.92660231	7.06858275	10.21017612	13.35176878	16.49336143	$(4n+1)\frac{\pi}{4}$
7. Clamped-clamped	4.73004074	7.85320462	10.99560780	14.13716550	17.27875970	$(2n+1)\frac{\pi}{2}$
8. Clamped-sliding	2.36502037	5.49780392	8.63937983	11.78097245	14.92256510	$(4n-1)\frac{\pi}{4}$
9. Sliding-pinned	1.57079633	4.71238898	7.85398163	10.99557430	14.13716690	$(2n-1)\frac{\pi}{2}$
10. Sliding-sliding	3.14159265	6.28318531	9.42477796	12.56637060	15.70796320	$n\pi$

TABLE B-2. Parameters α_1 and α_2 for Beam Modes

SUPPORT CONDITION	α	MODE				
		1	2	3	4	5
1. Free-free	α_1 α_2	0.5499 2.2116	0.7467 1.7662	0.8180 1.5456	0.8585 1.4244	0.8843 1.3473
2. Free-pinned	α_1 α_2	0.7467 1.7662	0.8585 1.4244	0.9021 1.2938	0.9251 1.2247	0.9394 1.1819
3. Clamped-free	α_1 α_2	−0.2441 1.3219	0.6033 1.4712	0.7440 1.2529	0.8182 1.1820	0.8585 1.1415
4. Clamped-pinned	α_1 α_2	0.7467 0.7467	0.8585 0.8585	0.9021 0.9021	0.9251 0.9251	0.9394 0.9394
5. Clamped-clamped	α_1 α_2	0.5499 0.5499	0.7467 0.7467	0.8180 0.8180	0.8585 0.8585	0.8843 0.8843
6. Pinned-pinned Sliding-sliding Sliding-pinned	α_1 α_2	0.5000 0.5000	0.5000 0.5000	0.5000 0.5000	0.5000 0.5000	0.5000 0.5000

B.2 NATURAL FREQUENCY DUE TO AXIAL LOADS (P>0 for Compressive Loads)

B.2.1 AXIAL LOADS APPLIED TO ONE END ONLY, OR LINEARLY VARYING ALONG BEAM LENGTH:

$$f_n = \frac{\lambda_n^2}{8\pi L^2}\left[\frac{E(D_o^2 + D_i^2)}{\mu}\right]^{1/2} \tag{B4}$$

B.2.2 AXIAL LOADS APPLIED TO BOTH ENDS:

If $\frac{|P_1|}{wL} >> 1$:

$$f_{P\neq 0} = f_{P=0}\left[1 - \frac{P\lambda_1^2}{|P_b|\lambda_n^2}\right]^{1/2} = \frac{\lambda^2}{8\pi L^2}\left[\frac{E(D_o^2 + D_i^2)}{\mu}\right]^{1/2}\left[1 - \frac{P\lambda_1^2}{|P_b|\lambda_n^2}\right]^{1/2} \tag{B5}$$

If $\frac{|P_1|}{wL} \approx 1$ or $\frac{|P_1|}{wL} << 1$: Then the load applied on one end is approximately equal to zero and use equation B1.

where:
- n = mode number = 1, 2, 3, ...
- λ = natural frequency parameter
- E = modulus of elasticity
- I = area moment of inertia about the neutral axis
- P = applied axial load
- w = axial traction = mg
- L = beam length
- D_o = outside diameter of beam
- D_i = inside diameter of beam
- μ = mass density of beam material
- P_b = buckling load, see table B-3

TABLE B-3. Buckling Loads (P_b)

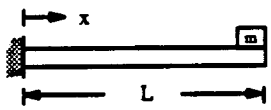
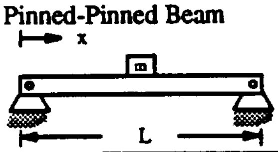
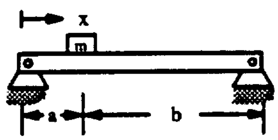
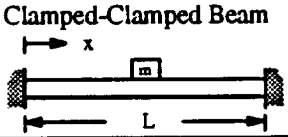
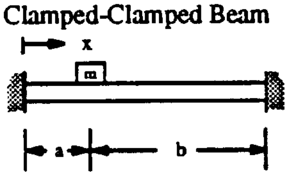
SUPPORT CONDITION	MODE SHAPE	P_b
1. Free-free	$\sin\frac{\pi x}{L}$	$\frac{\pi^2 EI}{L^2}$
2. Free–sliding	$\sin\frac{\pi x}{2L}$	$\frac{\pi^2 EI}{4L^2}$
3. Clamped-free	$1-\cos\frac{\pi x}{2L}$	$\frac{\pi^2 EI}{4L^2}$
4. Free-pinned	$\sin\frac{\pi x}{L}$	$\frac{\pi^2 EI}{L^2}$
5. Pinned-pinned	$\sin\frac{\pi x}{L}$	$\frac{\pi^2 EI}{L^2}$
6. Clamped-pinned	—	$\frac{2.05\pi^2 EI}{L^2}$
7. Clamped-clamped	$1-\cos\frac{2\pi x}{L}$	$\frac{4\pi^2 EI}{L^2}$
8. Clamped-sliding	$1-\cos\frac{\pi x}{L}$	$\frac{\pi^2 EI}{L^2}$
9. Sliding-pinned	$\cos\frac{\pi x}{2L}$	$\frac{\pi^2 EI}{4L^2}$
10. Sliding-sliding	$\cos\frac{\pi x}{L}$	$\frac{\pi^2 EI}{L^2}$

B.3 NATURAL FREQUENCY DUE TO BENDING FROM CONCENTRATED MASSES

TABLE B-4. Natural Frequency and Mode Shapes for Bending Loads

n = mode = 1, 2, 3, ...
I = area moment of inertia about neutral axis
E = modulus of elasticity

L = beam length (a+b)
m = concentrated mass
m_b = beam mass

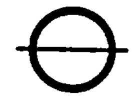
SUPPORT CONDITION	MODE SHAPE	NATURAL FREQUENCY
1. Mass, Cantilever Beam 	$\left(\frac{x}{L}\right)^3 - 3\left(\frac{x}{L}\right) + 2$	$\frac{1}{2\pi}\left[\frac{3EI}{L^3(m+0.24m_b)}\right]^{1/2}$
2. Center Mass Pinned-Pinned Beam 	$3\frac{x}{L} - 4\left(\frac{x}{L}\right)^3$	$\frac{2}{\pi}\left[\frac{3EI}{L^3(m+0.49m_b)}\right]^{1/2}$
3. Off-Center Mass Pinned-Pinned Beam 	$0 \le x \le a:$ $\left[2\left(1-\frac{x}{L}\right) - \frac{b^2}{L^2} - \left(1-\frac{x}{L}\right)^2\right]\left(\frac{x}{L}\right)$ $a \le x \le L:$ $\left[\frac{2b}{L} - \frac{b^2}{L^2} - \left(1-\frac{x}{L}\right)^2\right]\left(1-\frac{x}{L}\right)$	$\frac{1}{2\pi}\left[\frac{3EI(a+b)}{a^2b^2(m+(\alpha+\beta)m_b)}\right]^{1/2}$ $L = a+b$ $\alpha = \frac{a}{L}\left[\frac{(2b+a)^2}{12b^2} + \frac{a^2}{28b^2} - \frac{a(2b+a)}{10b^2}\right]$ $\beta = \frac{b}{L}\left[\frac{(2a+b)^2}{12a^2} + \frac{b^2}{28a^2} - \frac{b(2a+b)}{10a^2}\right]$
4. Center Mass Clamped-Clamped Beam 	$0 \le \frac{x}{L} \le \frac{1}{2}: \quad 3\left(\frac{x}{L}\right)^2 - 4\left(\frac{x}{L}\right)^3$	$\frac{4}{\pi}\left[\frac{3EI}{L^3(m+0.37m_b)}\right]^{1/2}$
5. Off-Center Mass Clamped-Clamped Beam 	$0 \le x \le a:$ $\left(\frac{x}{L}\right)^2\left(\frac{3ax}{L^2} + \frac{bx}{L^2} - \frac{3a}{L}\right)$ $a \le x \le L:$ $\left(1-\frac{x}{L}\right)^2\left[\frac{3b+a}{L}\left(1-\frac{x}{L}\right) - \frac{3b}{L}\right]$	$\frac{4}{\pi}\left[\frac{3EI}{L^3(m+(\alpha+\beta)m_b)}\right]^{1/2}$ $L = a+b$ $\alpha = \frac{a}{L}\left[\frac{(3a+b)^2}{28b^2} + \frac{9L^2}{20b^2} - \frac{L(3a+b)}{4b^2}\right]$ $\beta = \frac{b}{L}\left[\frac{(3b+a)^2}{28a^2} + \frac{9L^2}{20a^2} - \frac{L(3b+a)}{4a^2}\right]$

B.4 NATURAL FREQUENCY DUE TO UNIFORM SHEAR LOADS

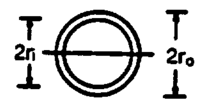
$$f_n = \frac{\lambda_n}{2\pi L}\left[\frac{KG}{\mu}\right]^{1/2} \tag{B6}$$

where: G = shear modulus = $G = \dfrac{E}{2(1+\nu)}$

K = shear coefficient = $K_{thinhollowO} = \dfrac{2(1+\nu)}{4+3\nu}$



$$K_{hollowO} = \frac{6(1+\nu)(1+m^2)^2}{(7+6\nu)(1+m^2)^2+(20+12\nu)m^2}$$



$$m = \frac{r_i}{r_o}$$

λ = natural frequency parameter; see table B-5
n = mode = 1, 2, 3, ...
μ = mass density of beam material
ν = Poisson's ratio for steel
r_i = inside radius of beam
r_o = inside radius of beam
L = beam length

B.5 NATURAL FREQUENCY DUE TO LONGITUDINAL LOADS

$$f_n = \frac{\lambda_n}{2\pi L}\left[\frac{E}{\mu}\right]^{1/2} \tag{B7}$$

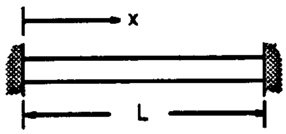
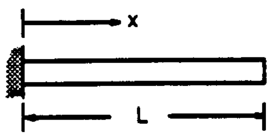
where: n = mode = 1, 2, 3, ...
μ = mass density of beam material
L = beam length
E = modulus of elasticity
λ = natural frequency parameter; see table B-5

B.6 NATURAL FREQUENCY DUE TO TORSIONAL LOADS

$$f_n = \frac{\lambda_n}{2\pi L}\left[\frac{CG}{\mu I_p}\right]^{1/2} \tag{B8}$$

where: n = mode = 1, 2, 3, ...
μ = mass density of beam material
λ = natural frequency parameter; see table B-5
G = shear modulus = $\dfrac{E}{2(1+\nu)}$
C = torsional constant of cross section = $\dfrac{\pi}{2}(r_o^4 - r_i^4)$
I_p = polar moment of inertia = $\dfrac{\pi}{4}(r_o^4 - r_i^4)$
L = beam length
ν = Poisson's ratio for steel
r_i = inside radius of beam
r_o = inside radius of beam

TABLE B-5. Mode Shapes and Natural Frequency Parameters for Uniform Shear, Longitudinal, and Torsional Vibration

SUPPORT CONDITION	MODE SHAPE	λ
1. Fixed-Fixed 	$\sin \frac{n\pi x}{L}$	$n\pi$
2. Fixed-Free 	$\sin \frac{\pi(2n-1)x}{2L}$	$\frac{(2n-1)\pi}{2}$

B.7 FINITE ELEMENT ANALYSIS

Determine the natural frequency f of a beam with combined loading by solving the determinant in equation B8 for ω, and then convert to hertz with equation B9. The total element stiffness matrix [K] and the consistent mass matrix [M] are given in tables B-6 and B-7, respectively. Table B-8 is the transformation matrix [λ] between local and global coordinate systems to be used with [K] if the beam is not aligned with the global coordinate system of the structure.

$$\det\left|[K][\lambda] - \omega_n^2[M]\right| = 0 \qquad \text{(B9)}$$

$$f_n = \frac{\omega_n}{2\pi} \qquad \text{(B10)}$$

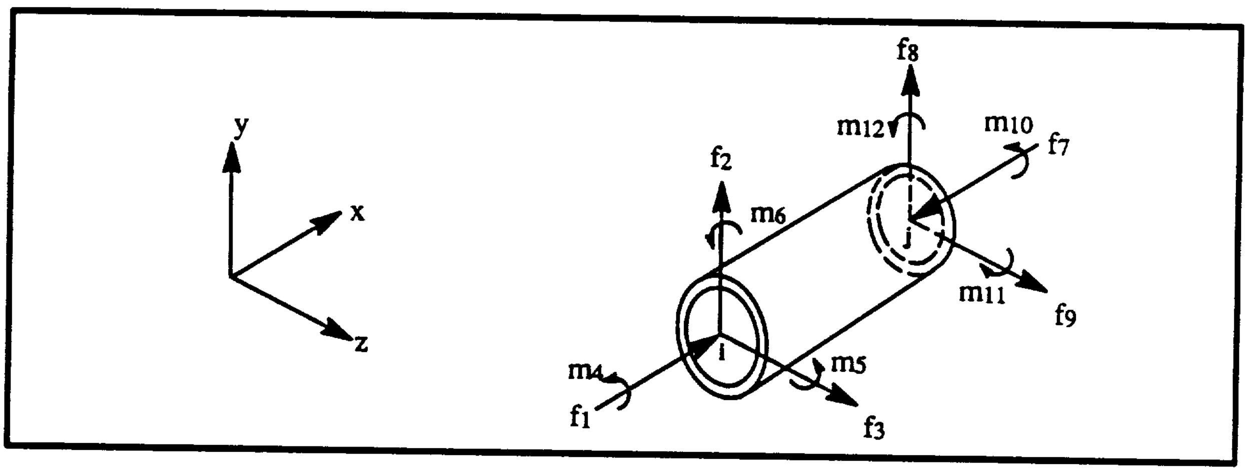


Figure B-1. Local Forces and Moments on a Beam Element

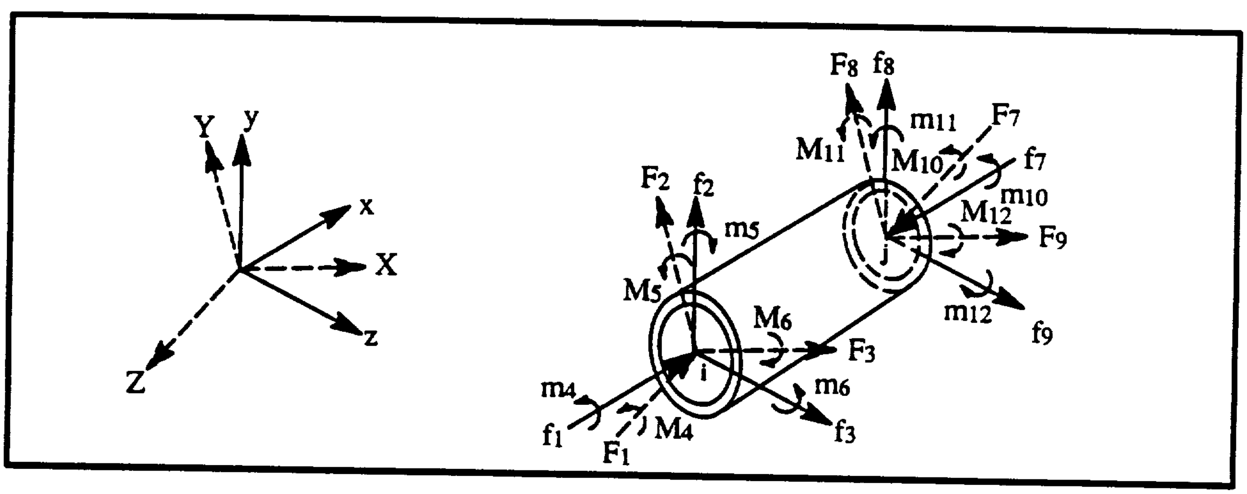


Figure B-2. Local and Global Forces and Moments on a Beam Element

Table B-6. Stiffness Matrix [K] for a Space Frame Element (With Respect to the Local Coordinate System)

$$
[K]=\begin{array}{cc}
\begin{array}{cccccccccccc} f_1 & f_2 & f_3 & m_4 & m_5 & m_6 & f_7 & f_8 & f_9 & m_{10} & m_{11} & m_{12} \end{array} & \\
\left[\begin{array}{cccccccccccc}
\frac{EA}{L} & 0 & 0 & 0 & 0 & 0 & -\frac{EA}{L} & 0 & 0 & 0 & 0 & 0 \\
0 & \frac{12EI_{zz}}{L^3} & 0 & 0 & 0 & \frac{6EI_{zz}}{L^2} & 0 & -\frac{12EI_{zz}}{L^3} & 0 & 0 & 0 & \frac{6EI_{zz}}{L^2} \\
0 & 0 & \frac{12EI_{yy}}{L^3} & 0 & -\frac{6EI_{yy}}{L^2} & 0 & 0 & 0 & -\frac{12EI_{yy}}{L^3} & 0 & -\frac{6EI_{yy}}{L^2} & 0 \\
0 & 0 & 0 & \frac{GJ}{L} & 0 & 0 & 0 & 0 & 0 & -\frac{GJ}{L} & 0 & 0 \\
0 & 0 & -\frac{6EI_{yy}}{L^2} & 0 & \frac{4EI_{yy}}{L} & 0 & 0 & 0 & \frac{6EI_{yy}}{L^2} & 0 & \frac{2EI_{yy}}{L} & 0 \\
0 & \frac{6EI_{zz}}{L^2} & 0 & 0 & 0 & \frac{4EI_{zz}}{L} & 0 & -\frac{6EI_{zz}}{L^2} & 0 & 0 & 0 & \frac{2EI_{zz}}{L} \\
-\frac{EA}{L} & 0 & 0 & 0 & 0 & 0 & \frac{EA}{L} & 0 & 0 & 0 & 0 & 0 \\
0 & -\frac{12EI_{zz}}{L^3} & 0 & 0 & 0 & -\frac{6EI_{zz}}{L^2} & 0 & \frac{12EI_{zz}}{L^3} & 0 & 0 & 0 & \frac{-6EI_{zz}}{L^2} \\
0 & 0 & -\frac{12EI_{yy}}{L^3} & 0 & \frac{6EI_{yy}}{L^2} & 0 & 0 & 0 & \frac{12EI_{yy}}{L^3} & 0 & \frac{6EI_{yy}}{L^2} & 0 \\
0 & 0 & 0 & -\frac{GJ}{L} & 0 & 0 & 0 & 0 & 0 & \frac{GJ}{L} & 0 & 0 \\
0 & 0 & -\frac{6EI_{yy}}{L^2} & 0 & \frac{2EI_{yy}}{L} & 0 & 0 & 0 & \frac{6EI_{yy}}{L^2} & 0 & \frac{4EI_{yy}}{L} & 0 \\
0 & \frac{6EI_{zz}}{L^2} & 0 & 0 & 0 & \frac{2EI_{zz}}{L} & 0 & \frac{-6EI_{zz}}{L^2} & 0 & 0 & 0 & \frac{4EI_{zz}}{L}
\end{array}\right] &
\begin{array}{c} f_1 \\ f_2 \\ f_3 \\ m_4 \\ m_5 \\ m_6 \\ f_7 \\ f_8 \\ f_9 \\ m_{10} \\ m_{11} \\ m_{12} \end{array}
\end{array}
$$

E = modulus of elasticity
A = cross sectional area
I_{yy} = area moment of inertia about the y-axis
I_{zz} = area moment of inertia about the z-axis
G = shear modulus
L = total length of the beam
J = polar moment of inertia

Table B-7. Consistent Mass Matrix [M] for a Space Frame Element

$$
[M] = \rho A L
\begin{array}{c}
\begin{array}{cccccccccccc}
f_1 & f_2 & f_3 & m_4 & m_5 & m_6 & f_7 & f_8 & f_9 & m_{10} & m_{11} & m_{12}
\end{array} \\
\left[\begin{array}{cccccccccccc}
\frac{1}{3} & 0 & 0 & 0 & 0 & 0 & \frac{1}{6} & 0 & 0 & 0 & 0 & 0 \\
0 & \frac{13}{35} & 0 & 0 & 0 & \frac{11}{210}L & 0 & \frac{9}{70} & 0 & 0 & 0 & -\frac{13}{420}L \\
0 & 0 & \frac{13}{35} & 0 & -\frac{11}{210}L & 0 & 0 & 0 & \frac{9}{70} & 0 & \frac{13}{420}L & 0 \\
0 & 0 & 0 & \frac{J}{3A} & 0 & 0 & 0 & 0 & 0 & \frac{J}{6A} & 0 & 0 \\
0 & 0 & -\frac{11}{210}L & 0 & \frac{L^2}{105} & 0 & 0 & 0 & -\frac{13}{420}L & 0 & -\frac{L^2}{140} & 0 \\
0 & \frac{11}{210}L & 0 & 0 & 0 & \frac{L^2}{105} & 0 & \frac{13}{420}L & 0 & 0 & 0 & -\frac{L^2}{140} \\
\frac{1}{6} & 0 & 0 & 0 & 0 & 0 & \frac{1}{3} & 0 & 0 & 0 & 0 & 0 \\
0 & \frac{9}{70} & 0 & 0 & 0 & \frac{13}{420}L & 0 & \frac{13}{35} & 0 & 0 & 0 & -\frac{11}{210}L \\
0 & 0 & \frac{9}{70} & 0 & -\frac{13}{420}L & 0 & 0 & 0 & \frac{13}{35} & 0 & \frac{11}{210}L & 0 \\
0 & 0 & 0 & \frac{J}{6A} & 0 & 0 & 0 & 0 & 0 & \frac{J}{3A} & 0 & 0 \\
0 & 0 & \frac{13}{420}L & 0 & -\frac{L^2}{140} & 0 & 0 & 0 & \frac{11}{210}L & 0 & \frac{L^2}{105} & 0 \\
0 & -\frac{13}{420}L & 0 & 0 & 0 & -\frac{L^2}{140} & 0 & -\frac{11}{210}L & 0 & 0 & 0 & \frac{L^2}{105}
\end{array}\right]
\end{array}
\begin{array}{c}
\\ f_1 \\ f_2 \\ f_3 \\ m_4 \\ m_5 \\ m_6 \\ f_7 \\ f_8 \\ f_9 \\ m_{10} \\ m_{11} \\ m_{12}
\end{array}
$$

E = modulus of elasticity
A = cross sectional area
L = total length of the beam
J = polar moment of inertia
ρ = material mass density of the beam

Table B-8. Transformation Matrix [λ] from Local to Global Coordinates

$$
\begin{Bmatrix} f_1 \\ f_2 \\ f_3 \\ m_4 \\ m_5 \\ m_6 \\ f_7 \\ f_8 \\ f_9 \\ m_{10} \\ m_{11} \\ m_{12} \end{Bmatrix}
=
\begin{bmatrix}
l_{ox} & m_{ox} & n_{ox} & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
l_{oy} & m_{oy} & n_{oy} & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
l_{oz} & m_{oz} & n_{oz} & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & l_{ox} & m_{ox} & n_{ox} & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & l_{oy} & m_{oy} & n_{oy} & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & l_{oz} & m_{oz} & n_{oz} & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & l_{ox} & m_{ox} & n_{ox} & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & l_{oy} & m_{oy} & n_{oy} & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & l_{oz} & m_{oz} & n_{oz} & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & l_{ox} & m_{ox} & n_{ox} \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & l_{oy} & m_{oy} & n_{oy} \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & l_{oz} & m_{oz} & n_{oz}
\end{bmatrix}
\begin{Bmatrix} F_1 \\ F_2 \\ F_3 \\ M_4 \\ M_5 \\ M_6 \\ F_7 \\ F_8 \\ F_9 \\ M_{10} \\ M_{11} \\ M_{12} \end{Bmatrix}
$$

$$L = \left[(X_j - X_i)^2 + (Y_j - Y_i)^2 + (Z_j - Z_i)^2\right]^{1/2}$$

$$d = (l_{ox}^2 + n_{ox}^2)^{1/2}$$

$$l_{ox} = \frac{X_j - X_i}{L} \qquad m_{ox} = \frac{Y_j - Y_i}{L} \qquad n_{ox} = \frac{Z_j - Z_i}{L}$$

$$l_{oy} = -\frac{l_{ox} m_{ox}}{d} \qquad m_{oy} = \frac{n_{ox}^2 + l_{ox}^2}{d} \qquad n_{oy} = -\frac{m_{ox} n_{ox}}{d}$$

$$l_{oz} = -\frac{n_{ox}}{d} \qquad m_{oz} = 0 \qquad n_{oz} = -\frac{l_{ox}}{d}$$

i = first local node of the beam
j = second local node of the beam

APPENDIX C

WIND-INDUCED VIBRATION FREQUENCY TABLES

Table C-1. REYNOLD'S NUMBER AND WIND-INDUCED VIBRATION FREQUENCY

NPS (in)	**4**		**5**		**6**		**8**	
D_o (in)	**4.500**		**5.563**		**6.625**		**8.625**	
V (mph)	**R**	**f (Hz)**	**R**	**f (Hz)**	**R**	**f (Hz)**	**R**	**f (Hz)**
0	0	0.0	0	0.0	0	0.0	0	0.0
5	17550	4.3	21696	3.5	25838	2.9	33638	2.2
10	35100	8.6	43391	7.0	51675	5.8	67275	4.5
15	52650	12.9	65087	10.4	77513	8.8	100913	6.7
20	70200	17.2	86783	13.9	103350	11.7	134550	9.0
25	87750	21.5	108479	17.4	129188	14.6	168188	11.2
30	105300	25.8	130174	20.9	155025	17.5	201825	13.5
35	122850	30.1	151870	24.4	180863	20.5	235463	15.7
40	140400	34.4	173566	27.8	206700	23.4	269100	18.0
45	157950	38.7	195261	31.3	232538	26.3	302738	20.2
50	175500	43.0	216957	34.8	258375	29.2	336375	22.4
55	193050	47.3	238653	38.3	284213	32.1	370013	24.7
60	210600	51.6	260348	41.8	310050	35.1	403650	26.9
65	228150	55.9	282044	45.2	335888	38.0	437288	29.2
70	245700	60.2	303740	48.7	361725	40.9	470925	31.4
75	263250	64.5	325436	52.2	387563	43.8	504563	33.7
80	280800	68.8	347131	55.7	413400	46.8	538200	35.9
85	298350	73.1	368827	59.2	439238	49.7	571838	38.2
90	315900	77.4	390523	62.6	465075	52.6	605475	40.4
95	333450	81.7	412218	66.1	490913	55.5	639113	42.6
100	351000	86.0	433914	69.6	516750	58.4	672750	44.9
105	368550	90.3	455610	73.1	542588	61.4	706388	47.1
110	386100	94.6	477305	76.6	568425	64.3	740025	49.4
115	403650	99.0	499001	80.0	594263	67.2	773663	51.6
120	421200	103.3	520697	83.5	620100	70.1	807300	53.9
125	438750	107.6	542393	87.0	645938	73.1	840938	56.1
130	**456300**	**111.9**	**564088**	**90.5**	**671775**	**76.0**	**874575**	**58.4**
135	473850	116.2	585784	94.0	697613	78.9	908213	60.6
140	491400	120.5	607480	97.4	723450	81.8	941850	62.8
145	508950	124.8	629175	100.9	749288	84.7	975488	65.1
150	526500	129.1	650871	104.4	775125	87.7	*1009125*	*67.3*
155	544050	133.4	672567	107.9	800963	90.6	*1042763*	*69.6*
160	561600	137.7	694262	111.4	826800	93.5	*1076400*	*71.8*
165	579150	142.0	715958	114.8	852638	96.4	*1110038*	*74.1*
170	596700	146.3	737654	118.3	878475	99.4	*1143675*	*76.3*
175	614250	150.6	759350	121.8	904313	102.3	*1177313*	*78.6*
180	631800	154.9	781045	125.3	930150	105.2	*1210950*	*80.8*
185	649350	159.2	802741	128.8	955988	108.1	*1244588*	*83.1*
190	666900	163.5	824437	132.2	981825	111.0	*1278225*	*85.3*
195	684450	167.8	846132	135.7	*1007663*	*114.0*	*1311863*	*87.5*
200	702000	172.1	867828	139.2	*1033500*	*116.9*	*1345500*	*89.8*

NOTE: **Italicized text represents values where $R > 10^6$ and, therefore, are not valid for this study.**
Bold text represents the maximum values of wind velocity and R studied for each beam diameter.

Table C-1. REYNOLD'S NUMBER AND WIND-INDUCED VIBRATION FREQUENCY (CONT)

NPS (in)	10		12		14		16	
D_o (in)	10.750		12.000		14.000		16.000	
V (mph)	R	f (Hz)	R	f (Hz)	R	f (Hz)	R	f (Hz)
0	0	0.0	0	0.0	0	0.0	0	0.0
5	41925	1.8	46800	1.6	54600	1.4	62400	1.2
10	83850	3.6	93600	3.2	09200	2.8	124800	2.4
15	125775	5.4	140400	4.8	163800	4.1	187200	3.6
20	167700	7.2	187200	6.5	218400	5.5	249600	4.8
25	209625	9.0	234000	8.3	273000	6.9	312000	6.0
30	251550	10.8	280800	9.7	327600	8.3	374400	7.3
35	293475	12.6	327600	11.3	382200	9.7	436800	8.5
40	335400	14.4	374400	12.9	436800	11.1	499200	9.7
45	377325	16.2	421200	14.5	491400	12.4	561600	10.9
50	419250	18.0	468000	16.1	546000	13.8	624000	12.1
55	461175	19.8	514800	17.7	600600	15.2	686400	13.3
60	503100	21.6	561600	19.4	655200	16.6	748800	14.5
65	545025	23.4	608400	21.0	709800	18.0	811200	15.7
70	586950	25.2	655200	22.6	764400	19.4	873600	16.9
75	628875	27.0	702000	24.2	819000	20.7	936000	18.2
80	670800	28.8	748800	25.8	873600	22.1	**998400**	**19.4**
85	712725	30.6	795600	27.4	928200	23.5	*1060800*	*20.6*
90	754650	32.4	842400	29.0	**982800**	**24.9**	*1123200*	*21.8*
95	796575	34.2	889200	30.7	*1037400*	*26.3*	*1185600*	*23.0*
100	838500	36.0	936000	32.3	*1092000*	*27.7*	*1248000*	*24.2*
105	880425	37.8	**982800**	**33.9**	*1146600*	*29.0*	*1310400*	*25.4*
110	922350	39.6	*1029600*	*35.5*	*1201200*	*30.4*	*1372800*	*26.6*
115	**964275**	**41.4**	*1076400*	*37.1*	*1255800*	*31.8*	*1435200*	*27.8*
120	*1006200*	*43.2*	*1123200*	*38.7*	*1310400*	*33.2*	*1497600*	*29.0*
125	*1048125*	*45.0*	*1170000*	*40.3*	*1365000*	*34.6*	*1560000*	*30.3*
130	*1090050*	*46.8*	*1216800*	*41.9*	*1419600*	*36.0*	*1622400*	*31.5*
135	*1131975*	*48.6*	*1263600*	*43.6*	*1474200*	*37.3*	*1684800*	*32.7*
140	*1173900*	*50.4*	*1310400*	*45.2*	*1528800*	*38.7*	*1747200*	*33.9*
145	*1215825*	*52.2*	*1357200*	*46.8*	*1583400*	*40.1*	*1809600*	*35.1*
150	*1257750*	*54.0*	*1404000*	*48.4*	*1638000*	*41.5*	*1872000*	*36.3*
155	*1299675*	*55.8*	*1450800*	*50.0*	*1692600*	*42.9*	*1934400*	*37.5*
160	*1341600*	*57.6*	*1497600*	*51.6*	*1747200*	*44.3*	*1996800*	*38.7*
165	*1383525*	*59.4*	*1544400*	*53.2*	*1801800*	*45.6*	*2059200*	*39.9*
170	*1425450*	*61.2*	*1591200*	*54.9*	*1856400*	*47.0*	*2121600*	*41.1*
175	*1467375*	*63.0*	*1638000*	*56.5*	*1911000*	*48.4*	*2184000*	*42.4*
180	*1509300*	*64.8*	*1684800*	*58.1*	*1965600*	*49.8*	*2246400*	*43.6*
185	*1551225*	*66.6*	*1731600*	*59.7*	*2020200*	*51.2*	*2308800*	*44.8*
190	*1593150*	*68.4*	*1778400*	*61.3*	*2074800*	*52.5*	*2371200*	*46.0*
195	*1635075*	*70.2*	*1825200*	*62.9*	*2129400*	*53.9*	*2433600*	*47.2*
200	*1677000*	*72.0*	*1872000*	*64.5*	*2184000*	*55.3*	*2496000*	*48.4*

NOTE: **Italicized text represents values where $R>10^6$ and, therefore, are not valid for this study. Bold text represents the maximum values of wind velocity and R studied for each beam diameter.**

Table C-1. REYNOLD'S NUMBER AND WIND-INDUCED VIBRATION FREQUENCY (cont)

NPS (in)	18		20		22		24	
D_o (in)	18.000		20.000		22.000		24.000	
V (mph)	R	f (Hz)	R	f (Hz)	R	f (Hz)	R	f (Hz)
0	0	0.0	0	0.0	0	0.0	0	0.0
5	70200	1.1	78000	1.0	85800	0.9	93600	0.8
10	140400	2.2	156000	1.9	171600	1.8	187200	1.6
15	210600	3.2	234000	2.9	257400	2.6	280800	2.4
20	280800	4.3	312000	3.9	343200	3.5	374400	3.2
25	351000	5.4	390000	4.8	429000	4.4	468000	4.0
30	421200	6.5	468000	5.8	514800	5.3	561600	4.8
35	491400	7.5	546000	6.8	600600	6.2	655200	5.6
40	561600	8.6	624000	7.7	686400	7.0	748800	6.5
45	631800	9.7	702000	8.7	772200	7.9	842400	7.3
50	702000	10.8	780000	9.7	858000	8.8	**936000**	**8.1**
55	772200	11.8	858000	10.6	**943800**	**9.7**	*1029600*	*8.9*
60	842400	12.9	**936000**	**11.6**	*1029600*	*10.6*	*1123200*	*9.7*
65	912600	14.0	*1014000*	*12.6*	*1115400*	*11.4*	*1216800*	*10.5*
70	**982800**	**15.1**	*1092000*	*13.6*	*1201200*	*12.3*	*1310400*	*11.3*
75	*1053000*	*16.1*	*1170000*	*14.5*	*1287000*	*13.2*	*1404000*	*12.1*
80	*1123200*	*17.2*	*1248000*	*15.5*	*1372800*	*14.1*	*1497600*	*12.9*
85	*1193400*	*18.3*	*1326000*	*16.5*	*1458600*	*15.0*	*1591200*	*13.7*
90	*1263600*	*19.4*	*1404000*	*17.4*	*1544400*	*15.8*	*1684800*	*14.5*
95	*1333800*	*20.4*	*1482000*	*18.4*	*1630200*	*16.7*	*1778400*	*15.3*
100	*1404000*	*21.5*	*1560000*	*19.4*	*1716000*	*17.6*	*1872000*	*16.1*
105	*1474200*	*22.6*	*1638000*	*20.3*	*1801800*	*18.5*	*1965600*	*16.9*
110	*1544400*	*23.7*	*1716000*	*21.3*	*1887600*	*19.4*	*2059200*	*17.7*
115	*1614600*	*24.7*	*1794000*	*22.3*	*1973400*	*20.2*	*2152800*	*18.6*
120	*1684800*	*25.8*	*1872000*	*23.2*	*2059200*	*21.1*	*2246400*	*19.4*
125	*1755000*	*26.9*	*1950000*	*24.2*	*2145000*	*22.0*	*2340000*	*20.2*
130	*1825200*	*28.0*	*2028000*	*25.1*	*2220800*	*22.9*	*2433600*	*21.0*
135	*1895400*	*29.0*	*2106000*	*26.1*	*2316600*	*23.8*	*2527200*	*21.8*
140	*1965600*	*30.1*	*2184000*	*27.1*	*2402400*	*24.6*	*2620800*	*22.6*
145	*2035800*	*31.2*	*2262000*	*28.1*	*2488200*	*25.5*	*2714400*	*23.4*
150	*2106000*	*32.3*	*2340000*	*29.0*	*2574000*	*26.4*	*2808000*	*24.2*
155	*2176200*	*33.3*	*2418000*	*30.0*	*2659800*	*27.3*	*2901600*	*25.0*
160	*2246400*	*34.4*	*2496000*	*31.0*	*2745600*	*28.2*	*2995200*	*25.8*
165	*2316600*	*35.5*	*2574000*	*31.9*	*2831400*	*29.0*	*3088800*	*26.6*
170	*2386800*	*36.6*	*2652000*	*32.9*	*2917200*	*29.9*	*3182400*	*27.4*
175	*2457000*	*37.6*	*2730000*	*33.9*	*3003000*	*30.8*	*3276000*	*28.2*
180	*2527200*	*38.7*	*2808000*	*34.8*	*3088800*	*31.7*	*3369600*	*29.0*
185	*2597400*	*39.8*	*2886000*	*35.8*	*3174600*	*32.6*	*3463200*	*29.8*
190	*2667600*	*40.9*	*2964000*	*36.8*	*3260400*	*33.4*	*3556800*	*30.7*
195	*2737800*	*41.9*	*3042000*	*37.8*	*3346200*	*34.3*	*3650400*	*31.5*
200	*2808000*	*43.0*	*3120000*	*38.7*	*3432000*	*35.2*	*3744000*	*32.3*

NOTE: **Italicized text represents values where $R>10^6$ and, therefore, are not valid for this study. Bold text represents the maximum values of wind velocity and R studied for each beam diameter.**

Table C-2. CUTOFF VELOCITIES (MPH) AND CUTOFF FREQUENCIES (HZ) (EQUATION 20)

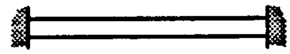
NPS (in)	DIAMETER	CUTOFF VELOCITY	CUTOFF FREQUENCY
4	4.500	130	508.4
5	5.563	130	411.3
6	6.625	130	345.4
8	8.625	130	265.3
10	10.750	115	188.3
12	12.750	105	144.9
14	14.000	90	113.1
16	16.000	80	88.0
18	18.000	70	68.4
20	20.000	60	52.8
22	22.000	55	44.0
24	24.000	50	36.7

APPENDIX D

NATURAL FREQUENCY TABLES

LIST OF TABLES

Table D-1.1. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) (Clamped-Clamped)



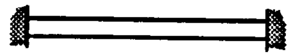
NPS = 4 in
D_o = 4.5 in
E = 28831000 lb/in^2

λ = 4.730041
μ = 489.535 lb/ft^3

t (in)	**0.125**	**0.156**	**0.188**	**0.219**	**0.237**	**0.250**	
D_i (in)	**4.250**	**4.188**	**4.124**	**4.062**	**4.026**	**4.000**	
W(lb/ft)	**5.84**	**7.24**	**8.66**	**10.01**	**10.79**	**11.35**	
L/D_o	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**L (ft)**
5.0	2157	2143	2127	2113	2105	2099	1.88
6.0	1498	1488	1477	1467	1462	1457	2.25
7.0	1101	1093	1085	1078	1074	1071	2.63
8.0	843	837	831	825	822	820	3.00
9.0	666	661	657	652	650	648	3.38
10.0	539	536	532	528	526	525	3.75
11.0	446	443	440	437	435	434	4.13
12.0	375	372	369	367	365	364	4.50
13.0	319	317	315	313	311	310	4.88
14.0	275	273	271	270	268	268	5.25
15.0	240	238	236	235	234	233	5.63
16.0	211	209	208	206	206	205	6.00
17.0	187	185	184	183	182	182	6.38
18.0	166	165	164	163	162	162	6.75
19.0	149	148	147	146	146	145	7.13
20.0	135	134	133	132	132	131	7.50

t (in)	**0.281**	**0.312**	**0.337**	**0.438**	**0.531**	**0.674**	
D_i (in)	**3.938**	**3.876**	**3.826**	**3.624**	**3.438**	**3.152**	
W(lb/ft)	**12.66**	**13.96**	**14.98**	**19.00**	**22.51**	**27.54**	
L/D_o	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**L (ft)**
5.0	2084	2070	2059	2014	1974	1915	1.88
6.0	1447	1438	1430	1399	1371	1330	2.25
7.0	1063	1056	1050	1027	1007	977	2.63
8.0	814	809	804	787	771	748	3.00
9.0	643	639	635	622	609	591	3.38
10.0	521	518	515	503	493	479	3.75
11.0	431	428	425	416	408	396	4.13
12.0	362	359	357	350	343	332	4.50
13.0	308	306	305	298	292	283	4.88
14.0	266	264	263	257	252	244	5.25
15.0	232	230	229	224	219	213	5.63
16.0	204	202	201	197	193	187	6.00
17.0	180	179	178	174	171	166	6.38
18.0	161	160	159	155	152	148	6.75
19.0	144	143	143	139	137	133	7.13
20.0	130	129	129	126	123	120	7.50

Table D-1.1. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz)
(Clamped-Clamped) (cont)



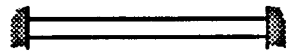
NPS = 5 in
D_o = 5.563 in
E = 28831000 lb/in^2

λ = 4.730041
μ = 489.535 lb/ft^3

t (in)	0.156	0.188	0.219	0.258	0.281	0.312	
D_i (in)	5.251	5.187	5.125	5.047	5.001	4.939	
W(lb/ft)	9.01	10.79	12.50	14.62	15.85	17.50	
L/D_o	f_n	f_n	f_n	f_n	f_n	f_n	L (ft)
5.0	1745	1735	1725	1713	1706	1697	2.32
6.0	1212	1205	1198	1190	1185	1178	2.78
7.0	890	885	880	874	870	866	3.25
8.0	682	678	674	669	666	663	3.71
9.0	538	535	532	529	527	524	4.17
10.0	436	434	431	428	427	424	4.64
11.0	360	358	356	354	352	351	5.10
12.0	303	301	299	297	296	295	5.56
13.0	258	257	255	253	252	251	6.03
14.0	223	221	220	219	218	216	6.49
15.0	194	193	192	190	190	189	6.95
16.0	170	169	168	167	167	166	7.42
17.0	151	150	149	148	148	147	7.88
18.0	135	134	133	132	132	131	8.34
19.0	121	120	119	119	118	117	8.81
20.0	109	108	108	107	107	106	9.27

t (in)	0.344	0.375	0.500	0.625	0.750	
D_i (in)	4.875	4.813	4.563	4.313	4.063	
W(lb/ft)	19.17	20.78	27.04	32.96	38.55	
L/D_o	f_n	f_n	f_n	f_n	f_n	L (ft)
5.0	1687	1678	1641	1605	1571	2.32
6.0	1172	1165	1140	1115	1091	2.78
7.0	861	856	837	819	802	3.25
8.0	659	855	641	627	614	3.71
9.0	521	518	506	495	485	4.17
10.0	422	419	410	401	393	4.64
11.0	349	347	339	332	325	5.10
12.0	293	291	285	279	273	5.56
13.0	250	248	243	237	232	6.03
14.0	215	214	209	205	200	6.49
15.0	187	186	182	178	175	6.95
16.0	165	164	160	157	153	7.42
17.0	146	145	142	139	136	7.88
18.0	130	129	127	124	121	8.34
19.0	117	116	114	111	109	8.81
20.0	105	105	103	100	98	9.27

Table D-1.1. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) (Clamped-Clamped) (cont)



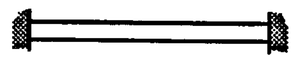
NPS = 6 in
D_o = 6.625 in
E = 28831000 lb/in^2

λ = 4.730041
μ = 489.535 lb/ft^3

t (in)	0.188	0.219	0.250	0.280	0.312	0.344	
D_i (in)	6.249	6.187	6.125	6.065	6.001	5.937	
W(lb/ft)	12.92	14.98	17.02	18.97	21.04	23.08	
L/D_o	f_n	f_n	f_n	f_n	f_n	f_n	L (ft)
5.0	1465	1458	1451	1444	1437	1431	2.76
6.0	1017	1012	1008	1003	998	993	3.31
7.0	747	744	740	737	733	730	3.86
8.0	572	569	567	564	562	559	4.42
9.0	452	450	448	446	444	442	4.97
10.0	366	364	363	361	359	358	5.52
11.0	303	301	300	298	297	296	6.07
12.0	254	253	252	251	250	248	6.63
13.0	217	216	215	214	213	212	7.18
14.0	187	186	185	184	183	182	7.73
15.0	163	162	161	160	160	159	8.28
16.0	143	142	142	141	140	140	8.83
17.0	127	126	126	125	124	124	9.39
18.0	113	112	112	111	111	110	9.94
19.0	101	101	100	100	100	99	10.49
20.0	92	91	91	90	90	89	11.04

t (in)	0.375	0.432	0.562	0.719	0.864	
D_i (in)	5.875	5.761	5.501	5.187	4.897	
W(lb/ft)	25.03	28.57	36.39	45.35	53.16	
L/D_o	f_n	f_n	f_n	f_n	f_n	L (ft)
5.0	1424	1412	1385	1353	1325	2.76
6.0	989	980	962	940	920	3.31
7.0	726	720	707	690	676	3.86
8.0	556	551	541	529	518	4.42
9.0	439	436	427	418	409	4.97
10.0	356	353	346	338	331	5.52
11.0	294	292	286	280	274	6.07
12.0	247	245	240	235	230	6.63
13.0	211	209	205	200	196	7.18
14.0	182	180	177	173	169	7.73
15.0	158	157	154	150	147	8.28
16.0	139	138	135	132	129	8.83
17.0	123	122	120	117	115	9.39
18.0	110	109	107	104	102	9.94
19.0	99	98	96	94	92	10.49
20.0	89	88	87	85	83	11.04

Table D-1.1. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz)
(Clamped-Clamped) (cont)



NPS = 8 in
D_o = 8.625 in
E = 28831000 lb/in^2

λ = 4.730041
μ = 489.535 lb/ft^3

t (in)	0.188	0.203	0.219	0.250	0.277	0.312	
D_i (in)	8.249	8.219	8.187	8.125	8.071	8.001	
W(lb/ft)	16.94	18.26	19.66	22.36	24.70	27.70	
L/D_o	f_n	f_n	f_n	f_n	f_n	f_n	L (ft)
5.0	1132	1130	1128	1124	1121	1116	3.59
6.0	786	785	784	781	778	775	4.31
7.0	578	577	576	574	572	569	5.03
8.0	442	442	441	439	438	436	5.75
9.0	349	349	348	347	346	345	6.47
10.0	283	283	282	281	280	279	7.19
11.0	234	234	233	232	232	231	7.91
12.0	197	196	196	195	195	194	8.63
13.0	168	167	167	166	166	165	9.34
14.0	144	144	144	143	143	142	10.06
15.0	126	126	125	125	125	124	10.78
16.0	111	110	110	110	109	109	11.50
17.0	98	98	98	97	97	97	12.22
18.0	87	87	87	87	86	86	12.94
19.0	78	78	78	78	78	77	13.66
20.0	71	71	71	70	70	70	14.38

t (in)	0.322	0.344	0.375	0.406	0.438	0.500	
D_i (in)	7.981	7.937	7.875	7.813	7.749	7.625	
W(lb/ft)	28.55	30.42	33.04	35.64	38.30	43.39	
L/D_o	f_n	f_n	f_n	f_n	f_n	f_n	L (ft)
5.0	1115	1112	1108	1104	1100	1092	3.59
6.0	774	772	770	767	764	759	4.31
7.0	569	567	565	563	561	557	5.03
8.0	436	434	433	431	430	427	5.75
9.0	344	343	342	341	340	337	6.47
10.0	279	278	277	276	275	273	7.19
11.0	230	230	229	228	227	226	7.91
12.0	194	193	192	192	191	190	8.63
13.0	165	165	164	163	163	162	9.34
14.0	142	142	141	141	140	139	10.06
15.0	124	124	123	123	122	121	10.78
16.0	109	109	108	108	107	107	11.50
17.0	96	96	96	96	95	94	12.22
18.0	86	86	86	85	85	84	12.94
19.0	77	77	77	76	76	76	13.66
20.0	70	70	69	69	69	68	14.38

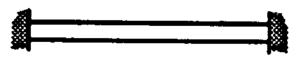
Table D-1.1. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz)
(Clamped-Clamped) (cont)

NPS = 8 in
D_o = 8.625 in
E = 28831000 lb/in^2

λ = 4.730041
μ = 489.535 lb/ft^3

t (in)	**0.594**	**0.719**	**0.812**	**0.875**	**0.906**	
D_i (in)	**7.437**	**7.187**	**7.001**	**6.875**	**6.813**	
W(lb/ft)	**50.95**	**60.71**	**67.76**	**72.42**	**74.69**	
L/D_o	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**L (ft)**
5.0	1081	1065	1054	1046	1043	3.59
6.0	750	740	732	727	724	4.31
7.0	551	543	538	534	532	5.03
8.0	422	416	412	409	407	5.75
9.0	333	329	325	323	322	6.47
10.0	270	266	263	262	261	7.19
11.0	223	220	218	216	215	7.91
12.0	188	185	183	182	181	8.63
13.0	160	158	156	155	154	9.34
14.0	138	136	134	133	133	10.06
15.0	120	118	117	116	116	10.78
16.0	106	104	103	102	102	11.50
17.0	93	92	91	91	90	12.22
18.0	83	82	81	81	80	12.94
19.0	75	74	73	72	72	13.66
20.0	68	67	66	65	65	14.38

Table D-1.1. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz)
(Clamped-Clamped) (cont)



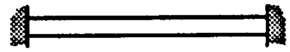
NPS = 10 in
D_o = 10.75 in
E = 28831000 lb/in^2

λ = 4.730041
μ = 489.535 lb/ft^3

t (in)	0.188	0.203	0.219	0.250	0.279	0.307	
D_i (in)	10.374	10.344	10.312	10.25	10.192	10.136	
W(lb/ft)	21.21	22.87	24.63	28.04	31.20	34.24	
L/D_o	f_n	f_n	f_n	f_n	f_n	f_n	L (ft)
5.0	912	911	910	907	905	902	4.48
6.0	634	633	632	630	628	627	5.38
7.0	466	465	464	463	462	460	6.27
8.0	356	356	355	354	353	352	7.17
9.0	282	281	281	280	279	279	8.06
10.0	228	228	227	227	226	226	8.96
11.0	189	188	188	187	187	186	9.85
12.0	158	158	158	157	157	157	10.75
13.0	135	135	135	134	134	133	11.65
14.0	116	116	116	116	115	115	12.54
15.0	101	101	101	101	101	100	13.44
16.0	89	89	89	89	88	88	14.33
17.0	79	79	79	78	78	78	15.23
18.0	70	70	70	70	70	70	16.13
19.0	63	63	63	63	63	62	17.02
20.0	57	57	57	57	57	56	17.92

t (in)	0.344	0.365	0.438	0.500	0.594	0.719	
D_i (in)	10.062	10.02	9.874	9.75	9.562	9.312	
W(lb/ft)	38.23	40.48	48.24	54.74	64.43	77.03	
L/D_o	f_n	f_n	f_n	f_n	f_n	f_n	L (ft)
5.0	899	898	891	886	879	869	4.48
6.0	625	623	619	616	610	603	5.38
7.0	459	458	455	452	448	443	6.27
8.0	351	351	348	346	343	339	7.17
9.0	278	277	275	274	271	268	8.06
10.0	225	224	223	222	220	217	8.96
11.0	186	185	184	183	182	179	9.85
12.0	156	156	155	154	153	151	10.75
13.0	133	133	132	131	130	128	11.65
14.0	115	114	114	113	112	111	12.54
15.0	100	100	99	98	98	97	13.44
16.0	88	88	87	87	86	85	14.33
17.0	78	78	77	77	76	75	15.23
18.0	69	69	69	68	68	67	16.13
19.0	62	62	62	61	61	60	17.02
20.0	56	56	56	55	55	54	17.92

Table D-1.1. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) (Clamped-Clamped) (cont)

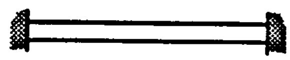


NPS = 10 in
D_o = 10.75 in
E = 28831000 lb/in^2

λ = 4.730041
μ = 489.535 lb/ft^3

t (in)	**0.844**	**1.000**	**1.125**	
D_i (in)	**9.062**	**8.75**	**8.5**	
W(lb/ft)	**89.29**	**104.13**	**115.64**	
L/D_o	**f_n**	**f_n**	**f_n**	**L (ft)**
5.0	859	847	837	4.48
6.0	596	588	581	5.38
7.0	438	432	427	6.27
8.0	335	331	327	7.17
9.0	265	261	258	8.06
10.0	215	212	209	8.96
11.0	177	175	173	9.85
12.0	149	147	145	10.75
13.0	127	125	124	11.65
14.0	110	108	107	12.54
15.0	95	94	93	13.44
16.0	84	83	82	14.33
17.0	74	73	72	15.23
18.0	66	65	65	16.13
19.0	59	59	58	17.02
20.0	54	53	52	17.92

Table D-1.1. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz)
(Clamped-Clamped) (cont)



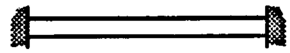
NPS = 12 in
D_o = 12.75 in
E = 28831000 lb/in^2

λ = 4.730041
μ = 489.535 lb/ft^3

t (in)	0.203	0.219	0.250	0.281	0.312	0.330	
D_i (in)	12.344	12.312	12.250	12.188	12.126	12.090	
W(lb/ft)	27.20	29.31	33.38	37.42	41.45	43.77	
L/D_o	f_n	f_n	f_n	f_n	f_n	f_n	L (ft)
5.0	771	770	768	766	764	763	5.31
6.0	535	534	533	532	531	530	6.38
7.0	393	393	392	391	390	389	7.44
8.0	301	301	300	299	298	298	8.50
9.0	238	238	237	236	236	235	9.56
10.0	193	192	192	191	191	191	10.63
11.0	159	159	159	158	158	158	11.69
12.0	134	134	133	133	133	132	12.75
13.0	114	114	114	113	113	113	13.81
14.0	98	98	98	98	97	97	14.88
15.0	86	86	85	85	85	85	15.94
16.0	75	75	75	75	75	74	17.00
17.0	67	67	66	66	66	66	18.06
18.0	59	59	59	59	59	59	19.13
19.0	53	53	53	53	53	53	20.19
20.0	48	48	48	48	48	48	21.25

t (in)	0.344	0.375	0.406	0.438	0.500	0.562	
D_i (in)	12.062	12.000	11.938	11.874	11.750	11.626	
W(lb/ft)	45.58	49.56	53.52	57.59	65.42	73.15	
L/D_o	f_n	f_n	f_n	f_n	f_n	f_n	L (ft)
5.0	762	760	758	756	753	749	5.31
6.0	529	528	527	525	523	520	6.38
7.0	389	388	387	386	384	382	7.44
8.0	298	297	296	295	294	293	8.50
9.0	235	235	234	233	232	231	9.56
10.0	191	190	190	189	188	187	10.63
11.0	157	157	157	156	156	155	11.69
12.0	132	132	132	131	131	130	12.75
13.0	113	112	112	112	111	111	13.81
14.0	97	97	97	96	96	96	14.88
15.0	85	84	84	84	84	83	15.94
16.0	74	74	74	74	74	73	17.00
17.0	66	66	66	65	65	65	18.06
18.0	59	59	59	58	58	58	19.13
19.0	53	53	53	52	52	52	20.19
20.0	48	48	47	47	47	47	21.25

Table D-1.1. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) (Clamped-Clamped) (cont)

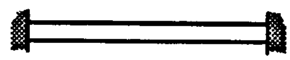


NPS = 12 in
D_o = 12.75 in
E = 28831000 lb/in^2

λ = 4.730041
μ = 489.535 lb/ft^3

t (in)	**0.688**	**0.844**	**1.000**	**1.250**	**1.312**	
D_i (in)	**11.374**	**11.062**	**10.750**	**10.250**	**10.126**	
W(lb/ft)	**88.63**	**107.32**	**125.49**	**153.53**	**160.27**	
L/D_o	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**L (ft)**
5.0	742	733	724	710	707	5.31
6.0	515	509	503	493	491	6.38
7.0	378	374	369	362	361	7.44
8.0	290	286	283	277	276	8.50
9.0	229	226	223	219	218	9.56
10.0	185	183	181	178	177	10.63
11.0	153	151	150	147	146	11.69
12.0	129	127	126	123	123	12.75
13.0	110	108	107	105	105	13.81
14.0	95	93	92	91	90	14.88
15.0	82	81	80	79	79	15.94
16.0	72	72	71	69	69	17.00
17.0	64	63	63	61	61	18.06
18.0	57	57	56	55	55	19.13
19.0	51	51	50	49	49	20.19
20.0	46	46	45	44	44	21.25

Table D-1.1. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) (Clamped-Clamped) (cont)



NPS = 14 in
D_o = 14.00 in
E = 28831000 lb/in^2

λ = 4.730041
μ = 489.535 lb/ft^3

t (in)	0.188	0.210	0.219	0.250	0.281	0.312	
D_i (in)	13.624	13.580	13.562	13.500	13.433	13.376	
W(lb/ft)	27.73	30.93	32.23	36.71	41.17	45.61	
L/D_o	f_n	f_n	f_n	f_n	f_n	f_n	L (ft)
5.0	703	702	702	700	699	697	5.83
6.0	489	488	487	486	485	484	7.00
7.0	359	358	358	357	357	356	8.17
8.0	275	274	274	274	273	272	9.33
9.0	217	217	217	216	216	215	10.50
10.0	176	176	175	175	175	174	11.67
11.0	145	145	145	145	144	144	12.83
12.0	122	122	122	122	121	121	14.00
13.0	104	104	104	104	103	103	15.17
14.0	90	90	90	89	89	89	16.33
15.0	78	78	78	78	78	77	17.50
16.0	69	69	69	68	68	68	18.67
17.0	61	61	61	61	60	60	19.83
18.0	54	54	54	54	54	54	21.00
19.0	49	49	49	49	48	48	22.17
20.0	44	44	44	44	44	44	23.33

t (in)	0.344	0.375	0.406	0.438	0.469	0.500	
D_i (in)	13.312	13.250	13.188	13.124	13.062	13.000	
W(lb/ft)	50.17	54.57	58.94	63.44	67.78	72.09	
L/D_o	f_n	f_n	f_n	f_n	f_n	f_n	L (ft)
5.0	696	694	693	691	690	688	5.83
6.0	483	482	481	480	479	478	7.00
7.0	355	354	353	353	352	351	8.17
8.0	272	271	271	270	269	269	9.33
9.0	215	214	214	213	213	212	10.50
10.0	174	174	173	173	172	172	11.67
11.0	144	143	143	143	142	142	12.83
12.0	121	121	120	120	120	119	14.00
13.0	103	103	102	102	102	102	15.17
14.0	89	89	88	88	88	88	16.33
15.0	77	77	77	77	77	76	17.50
16.0	68	68	68	67	67	67	18.67
17.0	60	60	60	60	60	60	19.83
18.0	54	54	53	53	53	53	21.00
19.0	48	48	48	48	48	48	22.17
20.0	43	43	43	43	43	43	23.33

Table D-1.1. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) (Clamped-Clamped) (cont)

NPS = 14 in
D_o = 14.00 in
E = 28831000 lb/in^2

λ = 4.730041
μ = 489.535 lb/ft^3

t (in)	**0.562**	**0.625**	**0.688**	**0.750**	**0.812**	**0.875**	
D_i (in)	**12.876**	**12.750**	**12.624**	**12.500**	**12.376**	**12.250**	
W(lb/ft)	**80.66**	**89.28**	**97.81**	**106.13**	**114.37**	**122.65**	
L/D_o	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**L (ft)**
5.0	685	682	679	676	673	670	5.83
6.0	476	474	471	469	467	465	7.00
7.0	349	348	346	345	343	342	8.17
8.0	268	266	265	264	263	262	9.33
9.0	211	210	210	209	208	207	10.50
10.0	171	170	170	169	168	167	11.67
11.0	142	141	140	140	139	138	12.83
12.0	119	118	118	117	117	116	14.00
13.0	101	101	100	100	100	99	15.17
14.0	87	87	87	86	86	85	16.33
15.0	76	76	75	75	75	74	17.50
16.0	67	67	66	66	66	65	18.67
17.0	59	59	59	58	58	58	19.83
18.0	53	53	52	52	52	52	21.00
19.0	47	47	47	47	47	46	22.17
20.0	43	43	42	42	42	42	23.33

t (in)	**0.938**	**1.000**	**1.062**	**1.125**	
D_i (in)	**12.124**	**12.000**	**11.876**	**11.750**	
W(lb/ft)	**130.85**	**138.84**	**146.74**	**154.69**	
L/D_o	**f_n**	**f_n**	**f_n**	**f_n**	**L (ft)**
5.0	667	664	661	658	5.83
6.0	463	461	459	457	7.00
7.0	340	339	337	336	8.17
8.0	261	259	258	257	9.33
9.0	206	205	204	203	10.50
10.0	167	166	165	165	11.67
11.0	138	137	137	136	12.83
12.0	116	115	115	114	14.00
13.0	99	98	98	97	15.17
14.0	85	85	84	84	16.33
15.0	74	74	73	73	17.50
16.0	65	65	65	64	18.67
17.0	58	57	57	57	19.83
18.0	51	51	51	51	21.00
19.0	46	46	46	46	22.17
20.0	42	42	41	41	23.33

Table D-1.1. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz)
(Clamped-Clamped) (cont)

NPS = 16 in
D_o = 16.00 in
E = 28831000 lb/in^2

λ = 4.730041
μ = 489.535 lb/ft^3

t (in)	**0.188**	**0.203**	**0.219**	**0.250**	**0.281**	**0.312**	
D_i (in)	**15.624**	**15.594**	**15.562**	**15.500**	**15.438**	**15.376**	
W(lb/ft)	**31.75**	**34.25**	**36.91**	**42.05**	**47.17**	**52.27**	
L/D_o	f_n	f_n	f_n	f_n	f_n	f_n	L (ft)
5.0	617	616	615	614	613	612	6.67
6.0	428	428	427	427	426	425	8.00
7.0	315	314	314	313	313	312	9.33
8.0	241	241	240	240	239	239	10.67
9.0	190	190	190	190	189	189	12.00
10.0	154	154	154	154	153	153	13.33
11.0	127	127	127	127	127	126	14.67
12.0	107	107	107	107	106	106	16.00
13.0	91	91	91	91	91	91	17.33
14.0	79	79	78	78	78	78	18.67
15.0	69	68	68	68	68	68	20.00
16.0	60	60	60	60	60	60	21.33
17.0	53	53	53	53	53	53	22.67
18.0	48	48	47	47	47	47	24.00
19.0	43	43	43	43	42	42	25.33
20.0	39	38	38	38	38	38	26.67

t (in)	**0.344**	**0.375**	**0.406**	**0.438**	**0.469**	**0.500**	
D_i (in)	**15.312**	**15.250**	**15.188**	**15.124**	**15.062**	**15.000**	
W(lb/ft)	**57.52**	**62.58**	**67.62**	**72.80**	**77.79**	**82.77**	
L/D_o	f_n	f_n	f_n	f_n	f_n	f_n	L (ft)
5.0	611	609	608	607	606	605	6.67
6.0	424	423	422	422	421	420	8.00
7.0	312	311	310	310	309	309	9.33
8.0	239	238	238	237	237	236	10.67
9.0	188	188	188	187	187	187	12.00
10.0	153	152	152	152	151	151	13.33
11.0	126	126	126	125	125	125	14.67
12.0	106	106	106	105	105	105	16.00
13.0	90	90	90	90	90	89	17.33
14.0	78	78	78	77	77	77	18.67
15.0	68	68	68	67	67	67	20.00
16.0	60	60	59	59	59	59	21.33
17.0	53	53	53	53	52	52	22.67
18.0	47	47	47	47	47	47	24.00
19.0	42	42	42	42	42	42	25.33
20.0	38	38	38	38	38	38	26.67

Table D-1.1. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) (Clamped-Clamped) (cont)

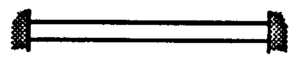
NPS = 16 in
D_o = 16.00 in
E = 28831000 lb/in^2

λ = 4.730041
μ = 489.535 lb/ft^3

t (in)	**0.562**	**0.625**	**0.688**	**0.750**	**0.812**	**0.875**	
D_i (in)	**14.876**	**14.750**	**14.624**	**14.500**	**14.376**	**14.250**	
W(lb/ft)	**92.66**	**102.63**	**112.51**	**122.15**	**131.71**	**141.34**	
L/D_o	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**L (ft)**
5.0	602	600	598	595	593	591	6.67
6.0	418	417	415	413	412	410	8.00
7.0	307	306	305	304	303	301	9.33
8.0	235	234	233	233	232	231	10.67
9.0	186	185	184	184	183	182	12.00
10.0	151	150	149	149	148	148	13.33
11.0	124	124	123	123	123	122	14.67
12.0	105	104	104	103	103	103	16.00
13.0	89	89	88	88	88	87	17.33
14.0	77	77	76	76	76	75	18.67
15.0	67	67	66	66	66	66	20.00
16.0	59	59	58	58	58	58	21.33
17.0	52	52	52	51	51	51	22.67
18.0	46	46	46	46	46	46	24.00
19.0	42	42	41	41	41	41	25.33
20.0	38	37	37	37	37	37	26.67

t (in)	**0.938**	**1.000**	**1.062**	**1.125**	**1.188**	**1.250**	
D_i (in)	**14.124**	**14.000**	**13.876**	**13.750**	**13.624**	**13.500**	
W(lb/ft)	**150.89**	**160.20**	**169.43**	**178.72**	**187.93**	**196.91**	
L/D_o	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**L (ft)**
5.0	588	586	584	582	579	577	6.67
6.0	409	407	405	404	402	401	8.00
7.0	300	299	298	297	296	294	9.33
8.0	230	229	228	227	226	225	10.67
9.0	182	181	180	180	179	178	12.00
10.0	147	147	146	145	145	144	13.33
11.0	122	121	121	120	120	119	14.67
12.0	102	102	101	101	101	100	16.00
13.0	87	87	86	86	86	85	17.33
14.0	75	75	74	74	74	74	18.67
15.0	65	65	65	65	64	64	20.00
16.0	57	57	57	57	57	56	21.33
17.0	51	51	51	50	50	50	22.67
18.0	45	45	45	45	45	45	24.00
19.0	41	41	40	40	40	40	25.33
20.0	37	37	36	36	36	36	26.67

Table D-1.1. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz)
(Clamped-Clamped) (cont)



NPS = 18 in
D_o = 18.00 in
E = 28831000 lb/in^2

λ = 4.730041
μ = 489.535 lb/ft^3

t (in)	0.188	0.219	0.250	0.281	0.312	0.344	
D_i (in)	17.624	17.562	17.500	17.438	17.376	17.312	
W(lb/ft)	35.76	41.59	47.39	53.18	58.94	64.87	
L/D_o	f_n	f_n	f_n	f_n	f_n	f_n	L (ft)
5.0	549	548	547	546	545	544	7.50
6.0	381	380	380	379	378	378	9.00
7.0	280	280	279	279	278	278	10.50
8.0	214	214	214	213	213	213	12.00
9.0	169	169	169	169	168	168	13.50
10.0	137	137	137	136	136	136	15.00
11.0	113	113	113	113	113	112	16.50
12.0	95	95	95	95	95	94	18.00
13.0	81	81	81	81	81	80	19.50
14.0	70	70	70	70	70	69	21.00
15.0	61	61	61	61	61	60	22.50
16.0	54	53	53	53	53	53	24.00
17.0	47	47	47	47	47	47	25.50
18.0	42	42	42	42	42	42	27.00
19.0	38	38	38	38	38	38	28.50
20.0	34	34	34	34	34	34	30.00

t (in)	0.375	0.406	0.438	0.469	0.500	0.562	
D_i (in)	17.250	17.188	17.124	17.062	17.000	16.876	
W(lb/ft)	70.59	76.29	82.15	87.81	93.45	104.67	
L/D_o	f_n	f_n	f_n	f_n	f_n	f_n	L (ft)
5.0	543	542	541	540	539	538	7.50
6.0	377	377	376	375	375	373	9.00
7.0	277	277	276	276	275	274	10.50
8.0	212	212	211	211	211	210	12.00
9.0	168	167	167	167	166	166	13.50
10.0	136	136	135	135	135	134	15.00
11.0	112	112	112	112	111	111	16.50
12.0	94	94	94	94	94	93	18.00
13.0	80	80	80	80	80	80	19.50
14.0	69	69	69	69	69	69	21.00
15.0	60	60	60	60	60	60	22.50
16.0	53	53	53	53	53	52	24.00
17.0	47	47	47	47	47	46	25.50
18.0	42	42	42	42	42	41	27.00
19.0	38	38	37	37	37	37	28.50
20.0	34	34	34	34	34	34	30.00

Table D-1.1. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) (Clamped-Clamped) (cont)

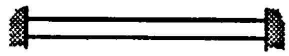
NPS = 18 in
D_o = 18.00 in
E = 28831000 lb/in^2

λ = 4.730041
μ = 489.535 lb/ft^3

t (in)	**0.625**	**0.688**	**0.750**	**0.812**	**0.875**	**0.938**	
D_i (in)	**16.750**	**16.624**	**16.500**	**16.376**	**16.250**	**16.124**	
W(lb/ft)	**115.98**	**127.21**	**138.17**	**149.06**	**160.03**	**170.92**	
L/D_o	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**L (ft)**
5.0	536	534	532	530	528	526	7.50
6.0	372	371	369	368	367	366	9.00
7.0	273	272	271	270	270	269	10.50
8.0	209	209	208	207	206	206	12.00
9.0	165	165	164	164	163	162	13.50
10.0	134	133	133	133	132	132	15.00
11.0	111	110	110	110	109	109	16.50
12.0	93	93	92	92	92	91	18.00
13.0	79	79	79	78	78	78	19.50
14.0	68	68	68	68	67	67	21.00
15.0	60	59	59	59	59	58	22.50
16.0	52	52	52	52	52	51	24.00
17.0	46	46	46	46	46	46	25.50
18.0	41	41	41	41	41	41	27.00
19.0	37	37	37	37	37	36	28.50
20.0	33	33	33	33	33	33	30.00

t (in)	**1.000**	**1.062**	**1.125**	**1.188**	**1.250**	
D_i (in)	**16.000**	**15.876**	**15.750**	**15.624**	**15.500**	
W(lb/ft)	**181.56**	**192.11**	**202.75**	**213.31**	**223.61**	
L/D_o	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**L (ft)**
5.0	525	523	521	519	517	7.50
6.0	364	363	362	361	359	9.00
7.0	268	267	266	265	264	10.50
8.0	205	204	204	203	202	12.00
9.0	162	161	161	160	160	13.50
10.0	131	131	130	130	129	15.00
11.0	108	108	108	107	107	16.50
12.0	91	91	90	90	90	18.00
13.0	78	77	77	77	77	19.50
14.0	67	67	66	66	66	21.00
15.0	58	58	58	58	57	22.50
16.0	51	51	51	51	51	24.00
17.0	45	45	45	45	45	25.50
18.0	40	40	40	40	40	27.00
19.0	36	36	36	36	36	28.50
20.0	33	33	33	32	32	30.00

Table D-1.1. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) (Clamped-Clamped) (cont)



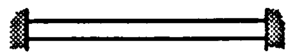
NPS = 20 in
D_o = 20.00 in
E = 28831000 lb/in^2

λ = 4.730041
μ = 489.535 lb/ft^3

t (in)	0.219	0.250	0.281	0.312	0.344	0.375	
D_i (in)	19.562	19.500	19.438	19.376	19.312	19.250	
W(lb/ft)	46.27	52.73	59.18	65.60	72.21	78.60	
L/D_o	f_n	f_n	f_n	f_n	f_n	f_n	L (ft)
5.0	494	493	492	491	491	490	8.33
6.0	343	342	342	341	341	340	10.00
7.0	252	251	251	251	250	250	11.67
8.0	193	193	192	192	192	191	13.33
9.0	152	152	152	152	151	151	15.00
10.0	123	123	123	123	123	122	16.67
11.0	102	102	102	102	101	101	18.33
12.0	86	86	85	85	85	85	20.00
13.0	73	73	73	73	73	72	21.67
14.0	63	63	63	63	63	62	23.33
15.0	55	55	55	55	55	54	25.00
16.0	48	48	48	48	48	48	26.67
17.0	43	43	43	43	42	42	28.33
18.0	38	38	38	38	38	38	30.00
19.0	34	34	34	34	34	34	31.67
20.0	31	31	31	31	31	31	33.33

t (in)	0.406	0.438	0.469	0.500	0.562	0.625	
D_i (in)	19.188	19.124	19.062	19.000	18.876	18.750	
W(lb/ft)	84.96	91.51	97.83	104.13	116.67	129.33	
L/D_o	f_n	f_n	f_n	f_n	f_n	f_n	L (ft)
5.0	489	488	488	487	485	484	8.33
6.0	340	339	339	338	337	336	10.00
7.0	250	249	249	248	248	247	11.67
8.0	191	191	190	190	190	189	13.33
9.0	151	151	150	150	150	149	15.00
10.0	122	122	122	122	121	121	16.67
11.0	101	101	101	101	100	100	18.33
12.0	85	85	85	85	84	84	20.00
13.0	72	72	72	72	72	72	21.67
14.0	62	62	62	62	62	62	23.33
15.0	54	54	54	54	54	54	25.00
16.0	48	48	48	48	47	47	26.67
17.0	42	42	42	42	42	42	28.33
18.0	38	38	38	38	37	37	30.00
19.0	34	34	34	34	34	33	31.67
20.0	31	31	30	30	30	30	33.33

Table D-1.1. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz)
(Clamped-Clamped) (cont)



NPS = 20 in
D_o = 20.00 in
E = 28831000 lb/in²

λ = 4.730041
μ = 489.535 lb/ft³

t (in)	**0.688**	**0.750**	**0.812**	**0.875**	**0.938**	**1.000**	
D_i (in)	**18.624**	**18.500**	**18.376**	**18.250**	**18.124**	**18.000**	
W(lb/ft)	**141.90**	**154.19**	**166.40**	**178.72**	**190.96**	**202.92**	
L/D_o	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**L (ft)**
5.0	482	481	479	478	476	475	8.33
6.0	335	334	333	332	331	330	10.00
7.0	246	245	245	244	243	242	11.67
8.0	188	188	187	187	186	185	13.33
9.0	149	148	148	147	147	147	15.00
10.0	121	120	120	119	119	119	16.67
11.0	100	99	99	99	98	98	18.33
12.0	84	83	83	83	83	82	20.00
13.0	71	71	71	71	70	70	21.67
14.0	62	61	61	61	61	61	23.33
15.0	54	53	53	53	53	53	25.00
16.0	47	47	47	47	47	46	26.67
17.0	42	42	41	41	41	41	28.33
18.0	37	37	37	37	37	37	30.00
19.0	33	33	33	33	33	33	31.67
20.0	30	30	30	30	30	30	33.33

t (in)	**1.062**	**1.125**	**1.188**	**1.250**	**1.312**	**1.375**	
D_i (in)	**17.876**	**17.750**	**17.624**	**17.500**	**17.376**	**17.250**	
W(lb/ft)	**214.80**	**226.78**	**238.68**	**250.31**	**261.86**	**273.51**	
L/D_o	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**L (ft)**
5.0	473	472	470	469	467	466	8.33
6.0	329	328	327	326	325	324	10.00
7.0	241	241	240	239	239	238	11.67
8.0	185	184	184	183	183	182	13.33
9.0	146	146	145	145	144	144	15.00
10.0	118	118	118	117	117	117	16.67
11.0	98	97	97	97	97	96	18.33
12.0	82	82	82	81	81	81	20.00
13.0	70	70	70	69	69	69	21.67
14.0	60	60	60	60	60	59	23.33
15.0	53	52	52	52	52	52	25.00
16.0	46	46	46	46	46	46	26.67
17.0	41	41	41	41	40	40	28.33
18.0	37	36	36	36	36	36	30.00
19.0	33	33	33	32	32	32	31.67
20.0	30	29	29	29	29	29	33.33

Table D-1.1. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz)
(Clamped-Clamped) (cont)

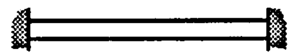
NPS = 22 in
D_o = 22.00 in
E = 28831000 lb/in^2

λ = 4.730041
μ = 489.535 lb/ft^3

t (in)	0.219	0.250	0.281	0.312	0.344	0.375	
D_i (in)	21.562	21.500	21.438	21.376	21.312	21.250	
W(lb/ft)	50.94	58.07	65.18	72.27	79.56	86.61	
L/D_o	f_n	f_n	f_n	f_n	f_n	f_n	L (ft)
5.0	449	449	448	447	447	446	9.17
6.0	312	312	311	311	310	310	11.00
7.0	229	229	229	228	228	228	12.83
8.0	175	175	175	175	174	174	14.67
9.0	139	138	138	138	138	138	16.50
10.0	112	112	112	112	112	112	18.33
11.0	93	93	93	92	92	92	20.17
12.0	78	78	78	78	78	77	22.00
13.0	66	66	66	66	66	66	23.83
14.0	57	57	57	57	57	57	25.67
15.0	50	50	50	50	50	50	27.50
16.0	44	44	44	44	44	44	29.33
17.0	39	39	39	39	39	39	31.17
18.0	35	35	35	35	34	34	33.00
19.0	31	31	31	31	31	31	34.83
20.0	28	28	28	28	28	28	36.67

t (in)	0.406	0.438	0.469	0.500	0.562	0.625	
D_i (in)	21.188	21.124	21.062	21.000	20.876	20.750	
W(lb/ft)	93.63	100.86	107.85	114.81	128.67	142.68	
L/D_o	f_n	f_n	f_n	f_n	f_n	f_n	L (ft)
5.0	445	445	444	444	442	441	9.17
6.0	309	309	308	308	307	306	11.00
7.0	227	227	227	226	226	225	12.83
8.0	174	174	173	173	173	172	14.67
9.0	137	137	137	137	137	136	16.50
10.0	111	111	111	111	111	110	18.33
11.0	92	92	92	92	91	91	20.17
12.0	77	77	77	77	77	77	22.00
13.0	66	66	66	66	65	65	23.83
14.0	57	57	57	57	56	56	25.67
15.0	49	49	49	49	49	49	27.50
16.0	43	43	43	43	43	43	29.33
17.0	39	38	38	38	38	38	31.17
18.0	34	34	34	34	34	34	33.00
19.0	31	31	31	31	31	31	34.83
20.0	28	28	28	28	28	28	36.67

Table D-1.1. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) (Clamped-Clamped) (cont)



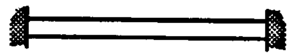
NPS = 22 in
D_o = 22.00 in
E = 28831000 lb/in^2

λ = 4.730041
μ = 489.535 lb/ft^3

t (in)	**0.688**	**0.750**	**0.812**	**0.875**	**0.938**	**1.000**	
D_i (in)	**20.624**	**20.500**	**20.376**	**20.250**	**20.124**	**20.000**	
W(lb/ft)	**156.60**	**170.21**	**183.75**	**197.41**	**211.00**	**224.28**	
L/D_o	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**L (ft)**
5.0	440	439	437	436	435	434	9.17
6.0	305	305	304	303	302	301	11.00
7.0	224	224	223	222	222	221	12.83
8.0	172	171	171	170	170	169	14.67
9.0	136	135	135	135	134	134	16.50
10.0	110	110	109	109	109	108	18.33
11.0	91	91	90	90	90	90	20.17
12.0	76	76	76	76	75	75	22.00
13.0	65	65	65	65	64	64	23.83
14.0	56	56	56	56	55	55	25.67
15.0	49	49	49	48	48	48	27.50
16.0	43	43	43	43	42	42	29.33
17.0	38	38	38	38	38	38	31.17
18.0	34	34	34	34	34	33	33.00
19.0	30	30	30	30	30	30	34.83
20.0	27	27	27	27	27	27	36.67

t (in)	**1.062**	**1.125**	**1.188**	**1.250**	**1.312**	**1.375**	
D_i (in)	**19.876**	**19.750**	**19.624**	**19.500**	**19.376**	**19.250**	
W(lb/ft)	**237.48**	**250.81**	**264.06**	**277.01**	**289.88**	**302.88**	
L/D_o	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**L (ft)**
5.0	432	431	430	429	428	426	9.17
6.0	300	299	299	298	297	296	11.00
7.0	221	220	219	219	218	217	12.83
8.0	169	168	168	167	167	167	14.67
9.0	133	133	133	132	132	132	16.50
10.0	108	108	107	107	107	107	18.33
11.0	89	89	89	89	88	88	20.17
12.0	75	75	75	74	74	74	22.00
13.0	64	64	64	63	63	63	23.83
14.0	55	55	55	55	55	54	25.67
15.0	48	48	48	48	48	47	27.50
16.0	42	42	42	42	42	42	29.33
17.0	37	37	37	37	37	37	31.17
18.0	33	33	33	33	33	33	33.00
19.0	30	30	30	30	30	30	34.83
20.0	27	27	27	27	27	27	36.67

Table D-1.1. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) (Clamped-Clamped) (cont)



NPS = 22 in
D_o = 22.00 in
E = 28831000 lb/in^2

λ = 4.730041
μ = 489.535 lb/ft^3

t (in)	1.438	1.500	
D_i (in)	19.124	19.000	
W(lb/ft)	315.79	328.41	
L/D_o	f_n	f_n	L (ft)
5.0	425	424	9.17
6.0	295	294	11.00
7.0	217	216	12.83
8.0	166	166	14.67
9.0	131	131	16.50
10.0	106	106	18.33
11.0	88	88	20.17
12.0	74	74	22.00
13.0	63	63	23.83
14.0	54	54	25.67
15.0	47	47	27.50
16.0	42	41	29.33
17.0	37	37	31.17
18.0	33	33	33.00
19.0	29	29	34.83
20.0	27	26	36.67

Table D-1.1. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) (Clamped-Clamped) (cont)

NPS = 24 in
D_o = 24.00 in
E = 28831000 lb/in^2

λ = 4.730041
μ = 489.535 lb/ft^3

t (in)	**0.250**	**0.281**	**0.312**	**0.344**	**0.375**	**0.406**	
D_i (in)	**23.500**	**23.438**	**23.376**	**23.312**	**23.250**	**23.188**	
W(lb/ft)	**63.41**	**71.18**	**78.93**	**86.91**	**94.62**	**102.31**	
L/D_o	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**L (ft)**
5.0	412	411	411	410	409	409	10.00
6.0	286	285	285	285	284	284	12.00
7.0	210	210	209	209	209	209	14.00
8.0	161	161	160	160	160	160	16.00
9.0	127	127	127	127	126	126	18.00
10.0	103	103	103	102	102	102	20.00
11.0	85	85	85	85	85	84	22.00
12.0	71	71	71	71	71	71	24.00
13.0	61	61	61	61	61	60	26.00
14.0	52	52	52	52	52	52	28.00
15.0	46	46	46	46	45	45	30.00
16.0	40	40	40	40	40	40	32.00
17.0	36	36	36	35	35	35	34.00
18.0	32	32	32	32	32	32	36.00
19.0	29	28	28	28	28	28	38.00
20.0	26	26	26	26	26	26	40.00

t (in)	**0.438**	**0.469**	**0.500**	**0.562**	**0.625**	**0.688**	
D_i (in)	**23.124**	**23.062**	**23.000**	**22.876**	**22.750**	**22.624**	
W(lb/ft)	**110.22**	**117.86**	**125.49**	**140.68**	**156.03**	**171.29**	
L/D_o	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**L (ft)**
5.0	408	408	407	406	405	404	10.00
6.0	284	283	283	282	281	281	12.00
7.0	208	208	208	207	207	206	14.00
8.0	160	159	159	159	158	158	16.00
9.0	126	126	126	125	125	125	18.00
10.0	102	102	102	102	101	101	20.00
11.0	84	84	84	84	84	84	22.00
12.0	71	71	71	71	70	70	24.00
13.0	60	60	60	60	60	60	26.00
14.0	52	52	52	52	52	52	28.00
15.0	45	45	45	45	45	45	30.00
16.0	40	40	40	40	40	39	32.00
17.0	35	35	35	35	35	35	34.00
18.0	32	31	31	31	31	31	36.00
19.0	28	28	28	28	28	28	38.00
20.0	26	25	25	25	25	25	40.00

Table D-1.1. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz)
(Clamped-Clamped) (cont)

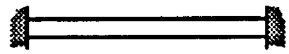
NPS = 24 in
D_o = 24.00 in
E = 28831000 lb/in^2

λ = 4.730041
μ = 489.535 lb/ft^3

t (in)	0.750	0.812	0.875	0.938	1.000	1.062	
D_i (in)	22.500	22.376	22.250	22.124	22.000	21.876	
W(lb/ft)	186.23	201.09	216.10	231.03	245.64	260.17	
L/D_o	f_n	f_n	f_n	f_n	f_n	f_n	L (ft)
5.0	403	402	401	400	399	398	10.00
6.0	280	279	278	278	277	276	12.00
7.0	206	205	205	204	204	203	14.00
8.0	157	157	157	156	156	155	16.00
9.0	124	124	124	123	123	123	18.00
10.0	101	101	100	100	100	99	20.00
11.0	83	83	83	83	82	82	22.00
12.0	70	70	70	69	69	69	24.00
13.0	60	59	59	59	59	59	26.00
14.0	51	51	51	51	51	51	28.00
15.0	45	45	45	44	44	44	30.00
16.0	39	39	39	39	39	39	32.00
17.0	35	35	35	35	35	34	34.00
18.0	31	31	31	31	31	31	36.00
19.0	28	28	28	28	28	28	38.00
20.0	25	25	25	25	25	25	40.00

t (in)	1.125	1.188	1.250	1.312	1.375	1.438	
D_i (in)	21.750	21.624	21.500	21.376	21.250	21.124	
W(lb/ft)	274.84	289.44	303.71	317.91	332.25	346.50	
L/D_o	f_n	f_n	f_n	f_n	f_n	f_n	L (ft)
5.0	397	396	395	394	393	392	10.00
6.0	276	275	274	273	273	272	12.00
7.0	202	202	201	201	200	200	14.00
8.0	155	155	154	154	153	153	16.00
9.0	122	122	122	122	121	121	18.00
10.0	99	99	99	98	98	98	20.00
11.0	82	82	82	81	81	81	22.00
12.0	69	69	69	68	68	68	24.00
13.0	59	59	58	58	58	58	26.00
14.0	51	50	50	50	50	50	28.00
15.0	44	44	44	44	44	44	30.00
16.0	39	39	39	38	38	38	32.00
17.0	34	34	34	34	34	34	34.00
18.0	31	31	30	30	30	30	36.00
19.0	27	27	27	27	27	27	38.00
20.0	25	25	25	25	25	24	40.00

Table D-1.1. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) (Clamped-Clamped) (cont)

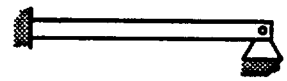


NPS = 24 in
D_o = 24.00 in
E = 28831000 lb/in^2

λ = 4.730041
μ = 489.535 lb/ft^3

t (in)	**1.500**	**1.562**	
D_i (in)	**21.000**	**20.876**	
W(lb/ft)	**360.45**	**374.31**	
L/D_o	**f_n**	**f_n**	**L (ft)**
5.0	391	390	10.00
6.0	271	271	12.00
7.0	199	199	14.00
8.0	153	152	16.00
9.0	121	120	18.00
10.0	98	97	20.00
11.0	81	81	22.00
12.0	68	68	24.00
13.0	58	58	26.00
14.0	50	50	28.00
15.0	43	43	30.00
16.0	38	38	32.00
17.0	34	34	34.00
18.0	30	30	36.00
19.0	27	27	38.00
20.0	24	24	40.00

Table D-1.2. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz)
(Clamped-Pinned)



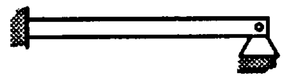
NPS = 4 in
D_o = 4.5 in
E = 28831000 lb/in^2

λ = 3.92660231
μ = 489.535 lb/ft^3

t (in)	**0.125**	**0.156**	**0.188**	**0.219**	**0.237**	**0.250**	
D_i (in)	**4.250**	**4.188**	**4.124**	**4.062**	**4.026**	**4.000**	
W(lb/ft)	**5.84**	**7.24**	**8.66**	**10.01**	**10.79**	**11.35**	
L/D_o	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**L (ft)**
5.0	1487	1477	1466	1456	1450	1446	1.88
6.0	1032	1025	1018	1011	1007	1004	2.25
7.0	759	753	748	743	740	738	2.63
8.0	581	577	573	569	567	565	3.00
9.0	459	456	453	449	448	446	3.38
10.0	372	369	367	364	363	362	3.75
11.0	307	305	303	301	300	299	4.13
12.0	258	256	255	253	252	251	4.50
13.0	220	218	217	215	215	214	4.88
14.0	190	188	187	186	185	184	5.25
15.0	165	164	163	162	161	161	5.63
16.0	145	144	143	142	142	141	6.00
17.0	129	128	127	126	125	125	6.38
18.0	115	114	113	112	112	112	6.75
19.0	103	102	102	101	100	100	7.13
20.0	93	92	92	91	91	90	7.50

t (in)	**0.281**	**0.312**	**0.337**	**0.438**	**0.531**	**0.674**	
D_i (in)	**3.938**	**3.876**	**3.826**	**3.624**	**3.438**	**3.152**	
W(lb/ft)	**12.66**	**13.96**	**14.98**	**19.00**	**22.51**	**27.54**	
L/D_o	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**L (ft)**
5.0	1436	1427	1419	1388	1360	1320	1.88
6.0	997	991	985	964	945	916	2.25
7.0	733	728	724	708	694	673	2.63
8.0	561	557	554	542	531	515	3.00
9.0	443	440	438	428	420	407	3.38
10.0	359	357	355	347	340	330	3.75
11.0	297	295	293	287	281	273	4.13
12.0	249	248	246	241	236	229	4.50
13.0	212	211	210	205	201	195	4.88
14.0	183	182	181	177	173	168	5.25
15.0	160	159	158	154	151	147	5.63
16.0	140	139	139	136	133	129	6.00
17.0	124	123	123	120	118	114	6.38
18.0	111	110	109	107	105	102	6.75
19.0	99	99	98	96	94	91	7.13
20.0	90	89	89	87	85	82	7.50

Table D-1.2. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz)
(Clamped-Pinned) (cont)



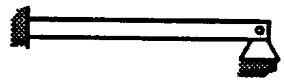
NPS = 5 in
D_o = 5.563 in
E = 28831000 lb/in^2

λ = 3.92660231
μ = 489.535 lb/ft^3

t (in)	**0.156**	**0.188**	**0.219**	**0.258**	**0.281**	**0.312**	
D_i (in)	**5.251**	**5.187**	**5.125**	**5.047**	**5.001**	**4.939**	
W(lb/ft)	**9.01**	**10.79**	**12.50**	**14.62**	**15.85**	**17.50**	
L/D_o	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**L (ft)**
5.0	1202	1195	1189	1181	1176	1169	2.32
6.0	835	830	826	820	816	812	2.78
7.0	613	610	607	602	600	597	3.25
8.0	470	467	464	461	459	457	3.71
9.0	371	369	367	364	363	361	4.17
10.0	301	299	297	295	294	292	4.64
11.0	248	247	246	244	243	242	5.10
12.0	209	208	206	205	204	203	5.56
13.0	178	177	176	175	174	173	6.03
14.0	153	152	152	151	150	149	6.49
15.0	134	133	132	131	131	130	6.95
16.0	117	117	116	115	115	114	7.42
17.0	104	103	103	102	102	101	7.88
18.0	93	92	92	91	91	90	8.34
19.0	83	83	82	82	81	81	8.81
20.0	75	75	74	74	73	73	9.27

t (in)	**0.344**	**0.375**	**0.500**	**0.625**	**0.750**	
D_i (in)	**4.875**	**4.813**	**4.563**	**4.313**	**4.063**	
W(lb/ft)	**19.17**	**20.78**	**27.04**	**32.96**	**38.55**	
L/D_o	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**L (ft)**
5.0	1163	1156	1131	1106	1083	2.32
6.0	807	803	785	768	752	2.78
7.0	593	590	577	564	552	3.25
8.0	454	452	442	432	423	3.71
9.0	359	357	349	341	334	4.17
10.0	291	289	283	277	271	4.64
11.0	240	239	234	229	224	5.10
12.0	202	201	196	192	188	5.56
13.0	172	171	167	164	160	6.03
14.0	148	147	144	141	138	6.49
15.0	129	128	126	123	120	6.95
16.0	114	113	110	108	106	7.42
17.0	101	100	98	96	94	7.88
18.0	90	89	87	85	84	8.34
19.0	81	80	78	77	75	8.81
20.0	73	72	71	69	68	9.27

Table D-1.2. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) (Clamped-Pinned) (cont)



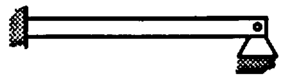
NPS = 6 in
D_o = 6.625 in
E = 28831000 lb/in^2

λ = 3.92660231
μ = 489.535 lb/ft^3

t (in)	0.188	0.219	0.250	0.280	0.312	0.344	
D_i (in)	6.249	6.187	6.125	6.065	6.001	5.937	
W(lb/ft)	12.92	14.98	17.02	18.97	21.04	23.08	
L/D_o	f_n	f_n	f_n	f_n	f_n	f_n	L (ft)
5.0	1009	1005	1000	995	991	986	2.76
6.0	701	698	694	691	688	685	3.31
7.0	515	513	510	508	505	503	3.86
8.0	394	392	391	389	387	385	4.42
9.0	311	310	309	307	306	304	4.97
10.0	252	251	250	249	248	246	5.52
11.0	209	208	207	206	205	204	6.07
12.0	175	174	174	173	172	171	6.63
13.0	149	149	148	147	147	146	7.18
14.0	129	128	128	127	126	126	7.73
15.0	112	112	111	111	110	110	8.28
16.0	99	98	98	97	97	96	8.83
17.0	87	87	86	86	86	85	9.39
18.0	78	78	77	77	76	76	9.94
19.0	70	70	69	69	69	68	10.49
20.0	63	63	62	62	62	62	11.04

t (in)	0.375	0.432	0.562	0.719	0.864	
D_i (in)	5.875	5.761	5.501	5.187	4.897	
W(lb/ft)	25.03	28.57	36.39	45.35	53.16	
L/D_o	f_n	f_n	f_n	f_n	f_n	L (ft)
5.0	981	973	954	932	913	2.76
6.0	681	676	663	648	634	3.31
7.0	501	496	487	476	466	3.86
8.0	383	380	373	364	357	4.42
9.0	303	300	295	288	282	4.97
10.0	245	243	239	233	228	5.52
11.0	203	201	197	193	189	6.07
12.0	170	169	166	162	159	6.63
13.0	145	144	141	138	135	7.18
14.0	125	124	122	119	116	7.73
15.0	109	108	106	104	101	8.28
16.0	96	95	93	91	89	8.83
17.0	85	84	83	81	79	9.39
18.0	76	75	74	72	70	9.94
19.0	68	67	66	65	63	10.49
20.0	61	61	60	58	57	11.04

Table D-1.2. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz)
(Clamped-Pinned) (cont)



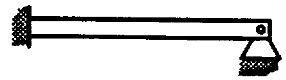
NPS = 8 in
D_o = 8.625 in
E = 28831000 lb/in^2

λ = 3.92660231
μ = 489.535 lb/ft^3

t (in)	0.188	0.203	0.219	0.250	0.277	0.312	
D_i (in)	8.249	8.219	8.187	8.125	8.071	8.001	
W(lb/ft)	16.94	18.26	19.66	22.36	24.70	27.70	
L/D_o	f_n	f_n	f_n	f_n	f_n	f_n	L (ft)
5.0	780	779	778	775	772	769	3.59
6.0	542	541	540	538	536	534	4.31
7.0	398	397	397	395	394	392	5.03
8.0	305	304	304	303	302	300	5.75
9.0	241	240	240	239	238	237	6.47
10.0	195	195	194	194	193	192	7.19
11.0	161	161	161	160	160	159	7.91
12.0	135	135	135	135	134	134	8.63
13.0	115	115	115	115	114	114	9.34
14.0	100	99	99	99	99	98	10.06
15.0	87	87	86	86	86	85	10.78
16.0	76	76	76	76	75	75	11.50
17.0	68	67	67	67	67	67	12.22
18.0	60	60	60	60	60	59	12.94
19.0	54	54	54	54	53	53	13.66
20.0	49	49	49	48	48	48	14.38

t (in)	0.322	0.344	0.375	0.406	0.438	0.500	
D_i (in)	7.981	7.937	7.875	7.813	7.749	7.625	
W(lb/ft)	28.55	30.42	33.04	35.64	38.30	43.39	
L/D_o	f_n	f_n	f_n	f_n	f_n	f_n	L (ft)
5.0	768	766	764	761	758	753	3.59
6.0	534	532	530	528	526	523	4.31
7.0	392	391	390	388	387	384	5.03
8.0	300	299	298	297	296	294	5.75
9.0	237	237	236	235	234	232	6.47
10.0	192	192	191	190	190	188	7.19
11.0	159	158	158	157	157	156	7.91
12.0	133	133	133	132	132	131	8.63
13.0	114	113	113	113	112	111	9.34
14.0	98	98	97	97	97	96	10.06
15.0	85	85	85	85	84	84	10.78
16.0	75	75	75	74	74	74	11.50
17.0	66	66	66	66	66	65	12.22
18.0	59	59	59	59	58	58	12.94
19.0	53	53	53	53	53	52	13.66
20.0	48	48	48	48	47	47	14.38

Table D-1.2. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) (Clamped-Pinned) (cont)

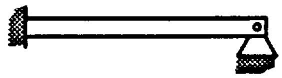


NPS = 8 in
D_o = 8.625 in
E = 28831000 lb/in^2

λ = 3.92660231
μ = 489.535 lb/ft^3

t (in)	**0.594**	**0.719**	**0.812**	**0.875**	**0.906**	
D_i (in)	**7.437**	**7.187**	**7.001**	**6.875**	**6.813**	
W(lb/ft)	**50.95**	**60.71**	**67.76**	**72.42**	**74.69**	
L/D_o	f_n	f_n	f_n	f_n	f_n	L (ft)
5.0	745	734	726	721	719	3.59
6.0	517	510	504	501	499	4.31
7.0	380	375	371	368	367	5.03
8.0	291	287	284	282	281	5.75
9.0	230	227	224	223	222	6.47
10.0	186	184	182	180	180	7.19
11.0	154	152	150	149	148	7.91
12.0	129	127	126	125	125	8.63
13.0	110	109	107	107	106	9.34
14.0	95	94	93	92	92	10.06
15.0	83	82	81	80	80	10.78
16.0	73	72	71	70	70	11.50
17.0	64	64	63	62	62	12.22
18.0	57	57	56	56	55	12.94
19.0	52	51	50	50	50	13.66
20.0	47	46	45	45	45	14.38

Table D-1.2. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) (Clamped-Pinned) (cont)



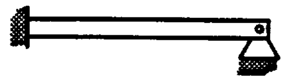
NPS = 10 in
D_o = 10.75 in
E = 28831000 lb/in^2

λ = 3.92660231
μ = 489.535 lb/ft^3

t (in)	0.188	0.203	0.219	0.250	0.279	0.307	
D_i (in)	10.374	10.344	10.312	10.25	10.192	10.136	
W(lb/ft)	21.21	22.87	24.63	28.04	31.20	34.24	
L/D_o	f_n	f_n	f_n	f_n	f_n	f_n	L (ft)
5.0	629	628	627	625	623	622	4.48
6.0	437	436	435	434	433	432	5.38
7.0	321	320	320	319	318	317	6.27
8.0	246	245	245	244	244	243	7.17
9.0	194	194	194	193	192	192	8.06
10.0	157	157	157	156	156	155	8.96
11.0	130	130	130	129	129	128	9.85
12.0	109	109	109	109	108	108	10.75
13.0	93	93	93	92	92	92	11.65
14.0	80	80	80	80	80	79	12.54
15.0	70	70	70	69	69	69	13.44
16.0	61	61	61	61	61	61	14.33
17.0	54	54	54	54	54	54	15.23
18.0	49	48	48	48	48	48	16.13
19.0	44	43	43	43	43	43	17.02
20.0	39	39	39	39	39	39	17.92

t (in)	0.344	0.365	0.438	0.500	0.594	0.719	
D_i (in)	10.062	10.02	9.874	9.75	9.562	9.312	
W(lb/ft)	38.23	40.48	48.24	54.74	64.43	77.03	
L/D_o	f_n	f_n	f_n	f_n	f_n	f_n	L (ft)
5.0	620	619	614	611	606	599	4.48
6.0	430	430	427	424	421	416	5.38
7.0	316	316	313	312	309	305	6.27
8.0	242	242	240	239	237	234	7.17
9.0	191	191	190	189	187	185	8.06
10.0	155	155	154	153	151	150	8.96
11.0	128	128	127	126	125	124	9.85
12.0	108	107	107	106	105	104	10.75
13.0	92	91	91	90	90	89	11.65
14.0	79	79	78	78	77	76	12.54
15.0	69	69	68	68	67	67	13.44
16.0	61	60	60	60	59	58	14.33
17.0	54	54	53	53	52	52	15.23
18.0	48	48	47	47	47	46	16.13
19.0	43	43	43	42	42	41	17.02
20.0	39	39	38	38	38	37	17.92

Table D-1.2. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) (Clamped-Pinned) (cont)

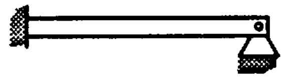


NPS = 10 in
D_o = 10.75 in
E = 28831000 lb/in^2

λ = 3.92660231
μ = 489.535 lb/ft^3

t (in)	**0.844**	**1.000**	**1.125**	
D_i (in)	**9.062**	**8.75**	**8.5**	
W(lb/ft)	**89.29**	**104.13**	**115.64**	
L/D_o	**f_n**	**f_n**	**f_n**	**L (ft)**
5.0	592	583	577	4.48
6.0	411	405	401	5.38
7.0	302	298	294	6.27
8.0	231	228	225	7.17
9.0	183	180	178	8.06
10.0	148	146	144	8.96
11.0	122	121	119	9.85
12.0	103	101	100	10.75
13.0	88	86	85	11.65
14.0	75	74	74	12.54
15.0	66	65	64	13.44
16.0	58	57	56	14.33
17.0	51	50	50	15.23
18.0	46	45	45	16.13
19.0	41	40	40	17.02
20.0	37	36	36	17.92

Table D-1.2. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) (Clamped-Pinned) (cont)



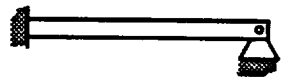
NPS = 12 in
D_o = 12.75 in
E = 28831000 lb/in^2

λ = 3.92660231
μ = 489.535 lb/ft^3

t (in)	0.203	0.219	0.250	0.281	0.312	0.330	
D_i (in)	12.344	12.312	12.250	12.188	12.126	12.090	
W(lb/ft)	27.20	29.31	33.38	37.42	41.45	43.77	
L/D_o	f_n	f_n	f_n	f_n	f_n	f_n	L (ft)
5.0	531	530	529	528	526	526	5.31
6.0	369	368	367	366	366	365	6.38
7.0	271	271	270	269	269	268	7.44
8.0	207	207	207	206	206	205	8.50
9.0	164	164	163	163	162	162	9.56
10.0	133	133	132	132	132	131	10.63
11.0	110	110	109	109	109	109	11.69
12.0	92	92	92	92	91	91	12.75
13.0	79	78	78	78	78	78	13.81
14.0	68	68	67	67	67	67	14.88
15.0	59	59	59	59	58	58	15.94
16.0	52	52	52	52	51	51	17.00
17.0	46	46	46	46	46	45	18.06
18.0	41	41	41	41	41	41	19.13
19.0	37	37	37	37	36	36	20.19
20.0	33	33	33	33	33	33	21.25

t (in)	0.344	0.375	0.406	0.438	0.500	0.562	
D_i (in)	12.062	12.000	11.938	11.874	11.750	11.626	
W(lb/ft)	45.58	49.56	53.52	57.59	65.42	73.15	
L/D_o	f_n	f_n	f_n	f_n	f_n	f_n	L (ft)
5.0	525	524	523	521	519	516	5.31
6.0	365	364	363	362	360	359	6.38
7.0	268	267	267	266	265	263	7.44
8.0	205	205	204	204	203	202	8.50
9.0	162	162	161	161	160	159	9.56
10.0	131	131	131	130	130	129	10.63
11.0	109	108	108	108	107	107	11.69
12.0	91	91	91	91	90	90	12.75
13.0	78	77	77	77	77	76	13.81
14.0	67	67	67	66	66	66	14.88
15.0	58	58	58	58	58	57	15.94
16.0	51	51	51	51	51	50	17.00
17.0	45	45	45	45	45	45	18.06
18.0	41	40	40	40	40	40	19.13
19.0	36	36	36	36	36	36	20.19
20.0	33	33	33	33	32	32	21.25

Table D-1.2. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz)
(Clamped-Pinned) (cont)

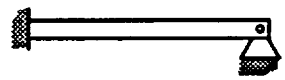


NPS = 12 in
D_o = 12.75 in
E = 28831000 lb/in^2

λ = 3.92660231
μ = 489.535 lb/ft^3

t (in)	**0.688**	**0.844**	**1.000**	**1.250**	**1.312**	
D_i (in)	**11.374**	**11.062**	**10.750**	**10.250**	**10.126**	
W(lb/ft)	**88.63**	**107.32**	**125.49**	**153.53**	**160.27**	
L/D_o	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**L (ft)**
5.0	511	505	499	489	487	5.31
6.0	355	351	347	340	338	6.38
7.0	261	258	255	250	249	7.44
8.0	200	197	195	191	190	8.50
9.0	158	156	154	151	150	9.56
10.0	128	126	125	122	122	10.63
11.0	106	104	103	101	101	11.69
12.0	89	88	87	85	85	12.75
13.0	76	75	74	72	72	13.81
14.0	65	64	64	62	62	14.88
15.0	57	56	55	54	54	15.94
16.0	50	49	49	48	48	17.00
17.0	44	44	43	42	42	18.06
18.0	39	39	39	38	38	19.13
19.0	35	35	35	34	34	20.19
20.0	32	32	31	31	30	21.25

Table D-1.2. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz)
(Clamped-Pinned) (cont)



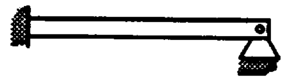
NPS = 14 in
D_o = 14.00 in
E = 28831000 lb/in^2

λ = 3.92660231
μ = 489.535 lb/ft^3

t (in)	0.188	0.210	0.219	0.250	0.281	0.312	
D_i (in)	13.624	13.580	13.562	13.500	13.433	13.376	
W(lb/ft)	27.73	30.93	32.23	36.71	41.17	45.61	
L/D_o	f_n	f_n	f_n	f_n	f_n	f_n	L (ft)
5.0	485	484	484	483	482	481	5.83
6.0	337	336	336	335	334	334	7.00
7.0	247	247	247	246	246	245	8.17
8.0	189	189	189	189	188	188	9.33
9.0	150	149	149	149	149	148	10.50
10.0	121	121	121	121	120	120	11.67
11.0	100	100	100	100	99	99	12.83
12.0	84	84	84	84	84	83	14.00
13.0	72	72	72	71	71	71	15.17
14.0	62	62	62	62	61	61	16.33
15.0	54	54	54	54	54	53	17.50
16.0	47	47	47	47	47	47	18.67
17.0	42	42	42	42	42	42	19.83
18.0	37	37	37	37	37	37	21.00
19.0	34	34	33	33	33	33	22.17
20.0	30	30	30	30	30	30	23.33

t (in)	0.344	0.375	0.406	0.438	0.469	0.500	
D_i (in)	13.312	13.250	13.188	13.124	13.062	13.000	
W(lb/ft)	50.17	54.57	58.94	63.44	67.78	72.09	
L/D_o	f_n	f_n	f_n	f_n	f_n	f_n	L (ft)
5.0	479	478	477	476	475	474	5.83
6.0	333	332	331	331	330	329	7.00
7.0	245	244	244	243	242	242	8.17
8.0	187	187	186	186	186	185	9.33
9.0	148	148	147	147	147	146	10.50
10.0	120	120	119	119	119	119	11.67
11.0	99	99	99	98	98	98	12.83
12.0	83	83	83	83	82	82	14.00
13.0	71	71	71	70	70	70	15.17
14.0	61	61	61	61	61	60	16.33
15.0	53	53	53	53	53	53	17.50
16.0	47	47	47	47	46	46	18.67
17.0	41	41	41	41	41	41	19.83
18.0	37	37	37	37	37	37	21.00
19.0	33	33	33	33	33	33	22.17
20.0	30	30	30	30	30	30	23.33

Table D-1.2. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz)
(Clamped-Pinned) (cont)



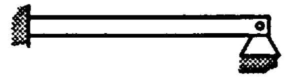
NPS = 14 in
D_o = 14.00 in
E = 28831000 lb/in²

λ = 3.92660231
μ = 489.535 lb/ft³

t (in)	0.562	0.625	0.688	0.750	0.812	0.875	
D_i (in)	12.876	12.750	12.624	12.500	12.376	12.250	
W(lb/ft)	80.66	89.28	97.81	106.13	114.37	122.65	
L/D_o	f_n	f_n	f_n	f_n	f_n	f_n	L (ft)
5.0	472	470	468	466	464	462	5.83
6.0	328	326	325	323	322	321	7.00
7.0	241	240	239	238	237	236	8.17
8.0	184	184	183	182	181	180	9.33
9.0	146	145	144	144	143	142	10.50
10.0	118	117	117	116	116	115	11.67
11.0	98	97	97	96	96	95	12.83
12.0	82	82	81	81	81	80	14.00
13.0	70	70	69	69	69	68	15.17
14.0	60	60	60	59	59	59	16.33
15.0	52	52	52	52	52	51	17.50
16.0	46	46	46	45	45	45	18.67
17.0	41	41	40	40	40	40	19.83
18.0	36	36	36	36	36	36	21.00
19.0	33	33	32	32	32	32	22.17
20.0	30	29	29	29	29	29	23.33

t (in)	0.938	1.000	1.062	1.125	
D_i (in)	12.124	12.000	11.876	11.750	
W(lb/ft)	130.85	138.84	146.74	154.69	
L/D_o	f_n	f_n	f_n	f_n	L (ft)
5.0	460	458	456	454	5.83
6.0	319	318	316	315	7.00
7.0	234	233	232	231	8.17
8.0	180	179	178	177	9.33
9.0	142	141	141	140	10.50
10.0	115	114	114	113	11.67
11.0	95	95	94	94	12.83
12.0	80	79	79	79	14.00
13.0	68	68	67	67	15.17
14.0	59	58	58	58	16.33
15.0	51	51	51	50	17.50
16.0	45	45	44	44	18.67
17.0	40	40	39	39	19.83
18.0	35	35	35	35	21.00
19.0	32	32	32	31	22.17
20.0	29	29	28	28	23.33

Table D-1.2. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) (Clamped-Pinned) (cont)



NPS = 16 in
D_o = 16.00 in
E = 28831000 lb/in^2

λ = 3.92660231
μ = 489.535 lb/ft^3

t (in)	0.188	0.203	0.219	0.250	0.281	0.312	
D_i (in)	15.624	15.594	15.562	15.500	15.438	15.376	
W(lb/ft)	31.75	34.25	36.91	42.05	47.17	52.27	
L/D_o	f_n	f_n	f_n	f_n	f_n	f_n	L (ft)
5.0	425	424	424	423	422	422	6.67
6.0	295	295	294	294	293	293	8.00
7.0	217	217	216	216	216	215	9.33
8.0	166	166	166	165	165	165	10.67
9.0	131	131	131	131	130	130	12.00
10.0	106	106	106	106	106	105	13.33
11.0	88	88	88	87	87	87	14.67
12.0	74	74	74	73	73	73	16.00
13.0	63	63	63	63	62	62	17.33
14.0	54	54	54	54	54	54	18.67
15.0	47	47	47	47	47	47	20.00
16.0	41	41	41	41	41	41	21.33
17.0	37	37	37	37	37	36	22.67
18.0	33	33	33	33	33	33	24.00
19.0	29	29	29	29	29	29	25.33
20.0	27	27	27	26	26	26	26.67

t (in)	0.344	0.375	0.406	0.438	0.469	0.500	
D_i (in)	15.312	15.250	15.188	15.124	15.062	15.000	
W(lb/ft)	57.52	62.58	67.62	72.80	77.79	82.77	
L/D_o	f_n	f_n	f_n	f_n	f_n	f_n	L (ft)
5.0	421	420	419	418	418	417	6.67
6.0	292	292	291	290	290	289	8.00
7.0	215	214	214	213	213	213	9.33
8.0	164	164	164	163	163	163	10.67
9.0	130	130	129	129	129	129	12.00
10.0	105	105	105	105	104	104	13.33
11.0	87	87	87	86	86	86	14.67
12.0	73	73	73	73	72	72	16.00
13.0	62	62	62	62	62	62	17.33
14.0	54	54	53	53	53	53	18.67
15.0	47	47	47	46	46	46	20.00
16.0	41	41	41	41	41	41	21.33
17.0	36	36	36	36	36	36	22.67
18.0	32	32	32	32	32	32	24.00
19.0	29	29	29	29	29	29	25.33
20.0	26	26	26	26	26	26	26.67

Table D-1.2. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz)
(Clamped-Pinned) (cont)

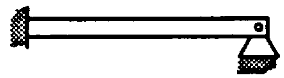
NPS = 16 in
D_o = 16.00 in
E = 28831000 lb/in^2

λ = 3.92660231
μ = 489.535 lb/ft^3

t (in)	0.562	0.625	0.688	0.750	0.812	0.875	
D_i (in)	14.876	14.750	14.624	14.500	14.376	14.250	
W(lb/ft)	92.66	102.63	112.51	122.15	131.71	141.34	
L/D_o	f_n	f_n	f_n	f_n	f_n	f_n	L (ft)
5.0	415	413	412	410	409	407	6.67
6.0	288	287	286	285	284	283	8.00
7.0	212	211	210	209	209	208	9.33
8.0	162	162	161	160	160	159	10.67
9.0	128	128	127	127	126	126	12.00
10.0	104	103	103	103	102	102	13.33
11.0	86	85	85	85	84	84	14.67
12.0	72	72	72	71	71	71	16.00
13.0	61	61	61	61	60	60	17.33
14.0	53	53	53	52	52	52	18.67
15.0	46	46	46	46	45	45	20.00
16.0	41	40	40	40	40	40	21.33
17.0	36	36	36	35	35	35	22.67
18.0	32	32	32	32	32	31	24.00
19.0	29	29	29	28	28	28	25.33
20.0	26	26	26	26	26	25	26.67

t (in)	0.938	1.000	1.062	1.125	1.188	1.250	
D_i (in)	14.124	14.000	13.876	13.750	13.624	13.500	
W(lb/ft)	150.89	160.20	169.43	178.72	187.93	196.91	
L/D_o	f_n	f_n	f_n	f_n	f_n	f_n	L (ft)
5.0	405	404	402	401	399	398	6.67
6.0	282	281	279	278	277	276	8.00
7.0	207	206	205	205	204	203	9.33
8.0	158	158	157	157	156	155	10.67
9.0	125	125	124	124	123	123	12.00
10.0	101	101	101	100	100	99	13.33
11.0	84	83	83	83	82	82	14.67
12.0	70	70	70	70	69	69	16.00
13.0	60	60	60	59	59	59	17.33
14.0	52	52	51	51	51	51	18.67
15.0	45	45	45	45	44	44	20.00
16.0	40	39	39	39	39	39	21.33
17.0	35	35	35	35	35	34	22.67
18.0	31	31	31	31	31	31	24.00
19.0	28	28	28	28	28	28	25.33
20.0	25	25	25	25	25	25	26.67

Table D-1.2. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz)
(Clamped-Pinned) (cont)



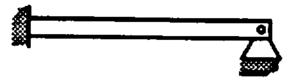
NPS = 18 in
D_o = 18.00 in
E = 28831000 lb/in²

λ = 3.92660231
μ = 489.535 lb/ft³

t (in)	**0.188**	**0.219**	**0.250**	**0.281**	**0.312**	**0.344**	
D_i (in)	**17.624**	**17.562**	**17.500**	**17.438**	**17.376**	**17.312**	
W(lb/ft)	**35.76**	**41.59**	**47.39**	**53.18**	**58.94**	**64.87**	
L/D_o	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**L (ft)**
5.0	378	378	377	376	376	375	7.50
6.0	263	262	262	261	261	260	9.00
7.0	193	193	192	192	192	191	10.50
8.0	148	147	147	147	147	146	12.00
9.0	117	117	116	116	116	116	13.50
10.0	95	94	94	94	94	94	15.00
11.0	78	78	78	78	78	77	16.50
12.0	66	66	65	65	65	65	18.00
13.0	56	56	56	56	56	55	19.50
14.0	48	48	48	48	48	48	21.00
15.0	42	42	42	42	42	42	22.50
16.0	37	37	37	37	37	37	24.00
17.0	33	33	33	33	32	32	25.50
18.0	29	29	29	29	29	29	27.00
19.0	26	26	26	26	26	26	28.50
20.0	24	24	24	24	23	23	30.00

t (in)	**0.375**	**0.406**	**0.438**	**0.469**	**0.500**	**0.562**	
D_i (in)	**17.250**	**17.188**	**17.124**	**17.062**	**17.000**	**16.876**	
W(lb/ft)	**70.59**	**76.29**	**82.15**	**87.81**	**93.45**	**104.67**	
L/D_o	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**L (ft)**
5.0	374	374	373	372	372	370	7.50
6.0	260	259	259	259	258	257	9.00
7.0	191	191	190	190	190	189	10.50
8.0	146	146	146	145	145	145	12.00
9.0	116	115	115	115	115	114	13.50
10.0	94	93	93	93	93	93	15.00
11.0	77	77	77	77	77	77	16.50
12.0	65	65	65	65	65	64	18.00
13.0	55	55	55	55	55	55	19.50
14.0	48	48	48	47	47	47	21.00
15.0	42	42	41	41	41	41	22.50
16.0	37	36	36	36	36	36	24.00
17.0	32	32	32	32	32	32	25.50
18.0	29	29	29	29	29	29	27.00
19.0	26	26	26	26	26	26	28.50
20.0	23	23	23	23	23	23	30.00

Table D-1.2. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz)
(Clamped-Pinned) (cont)



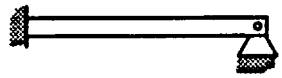
NPS = 18 in
D_o = 18.00 in
E = 28831000 lb/in^2

λ = 3.92660231
μ = 489.535 lb/ft^3

t (in)	0.625	0.688	0.750	0.812	0.875	0.938	
D_i (in)	16.750	16.624	16.500	16.376	16.250	16.124	
W(lb/ft)	115.98	127.21	138.17	149.06	160.03	170.92	
L/D_o	f_n	f_n	f_n	f_n	f_n	f_n	L (ft)
5.0	369	368	367	365	364	363	7.50
6.0	256	255	255	254	253	252	9.00
7.0	188	188	187	186	186	185	10.50
8.0	144	144	143	143	142	142	12.00
9.0	114	114	113	113	112	112	13.50
10.0	92	92	92	91	91	91	15.00
11.0	76	76	76	75	75	75	16.50
12.0	64	64	64	63	63	63	18.00
13.0	55	54	54	54	54	54	19.50
14.0	47	47	47	47	46	46	21.00
15.0	41	41	41	41	40	40	22.50
16.0	36	36	36	36	36	35	24.00
17.0	32	32	32	32	31	31	25.50
18.0	28	28	28	28	28	28	27.00
19.0	26	25	25	25	25	25	28.50
20.0	23	23	23	23	23	23	30.00

t (in)	1.000	1.062	1.125	1.188	1.250	
D_i (in)	16.000	15.876	15.750	15.624	15.500	
W(lb/ft)	181.56	192.11	202.75	213.31	223.61	
L/D_o	f_n	f_n	f_n	f_n	f_n	L (ft)
5.0	362	360	359	358	357	7.50
6.0	251	250	249	248	248	9.00
7.0	184	184	183	183	182	10.50
8.0	141	141	140	140	139	12.00
9.0	112	111	111	110	110	13.50
10.0	90	90	90	89	89	15.00
11.0	75	74	74	74	74	16.50
12.0	63	63	62	62	62	18.00
13.0	53	53	53	53	53	19.50
14.0	46	46	46	46	45	21.00
15.0	40	40	40	40	40	22.50
16.0	35	35	35	35	35	24.00
17.0	31	31	31	31	31	25.50
18.0	28	28	28	28	28	27.00
19.0	25	25	25	25	25	28.50
20.0	23	23	22	22	22	30.00

Table D-1.2. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) (Clamped-Pinned) (cont)



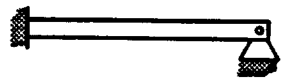
NPS = 20 in
D_o = 20.00 in
E = 28831000 lb/in^2

λ = 3.92660231
μ = 489.535 lb/ft^3

t (in)	0.219	0.250	0.281	0.312	0.344	0.375	
D_i (in)	19.562	19.500	19.438	19.376	19.312	19.250	
W(lb/ft)	46.27	52.73	59.18	65.60	72.21	78.60	
L/D_o	f_n	f_n	f_n	f_n	f_n	f_n	L (ft)
5.0	340	340	339	339	338	338	8.33
6.0	236	236	236	235	235	234	10.00
7.0	174	173	173	173	172	172	11.67
8.0	133	133	132	132	132	132	13.33
9.0	105	105	105	105	104	104	15.00
10.0	85	85	85	85	85	84	16.67
11.0	70	70	70	70	70	70	18.33
12.0	59	59	59	59	59	59	20.00
13.0	50	50	50	50	50	50	21.67
14.0	43	43	43	43	43	43	23.33
15.0	38	38	38	38	38	38	25.00
16.0	33	33	33	33	33	33	26.67
17.0	29	29	29	29	29	29	28.33
18.0	26	26	26	26	26	26	30.00
19.0	24	24	23	23	23	23	31.67
20.0	21	21	21	21	21	21	33.33

t (in)	0.406	0.438	0.469	0.500	0.562	0.625	
D_i (in)	19.188	19.124	19.062	19.000	18.876	18.750	
W(lb/ft)	84.96	91.51	97.83	104.13	116.67	129.33	
L/D_o	f_n	f_n	f_n	f_n	f_n	f_n	L (ft)
5.0	337	336	336	335	334	333	8.33
6.0	234	234	233	233	232	231	10.00
7.0	172	172	171	171	171	170	11.67
8.0	132	131	131	131	131	130	13.33
9.0	104	104	104	104	103	103	15.00
10.0	84	84	84	84	84	83	16.67
11.0	70	70	69	69	69	69	18.33
12.0	59	58	58	58	58	58	20.00
13.0	50	50	50	50	49	49	21.67
14.0	43	43	43	43	43	43	23.33
15.0	37	37	37	37	37	37	25.00
16.0	33	33	33	33	33	33	26.67
17.0	29	29	29	29	29	29	28.33
18.0	26	26	26	26	26	26	30.00
19.0	23	23	23	23	23	23	31.67
20.0	21	21	21	21	21	21	33.33

Table D-1.2. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) (Clamped-Pinned) (cont)



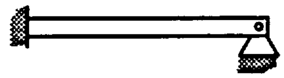
NPS = 20 in
D_o = 20.00 in
E = 28831000 lb/in^2

λ = 3.92660231
μ = 489.535 lb/ft^3

t (in)	0.688	0.750	0.812	0.875	0.938	1.000	
D_i (in)	18.624	18.500	18.376	18.250	18.124	18.000	
W(lb/ft)	141.90	154.19	166.40	178.72	190.96	202.92	
L/D_o	f_n	f_n	f_n	f_n	f_n	f_n	L (ft)
5.0	332	331	330	329	328	327	8.33
6.0	231	230	229	229	228	227	10.00
7.0	170	169	169	168	167	167	11.67
8.0	130	129	129	129	128	128	13.33
9.0	103	102	102	102	101	101	15.00
10.0	83	83	83	82	82	82	16.67
11.0	69	68	68	68	68	68	18.33
12.0	58	58	57	57	57	57	20.00
13.0	49	49	49	49	49	48	21.67
14.0	42	42	42	42	42	42	23.33
15.0	37	37	37	37	36	36	25.00
16.0	32	32	32	32	32	32	26.67
17.0	29	29	29	28	28	28	28.33
18.0	26	26	25	25	25	25	30.00
19.0	23	23	23	23	23	23	31.67
20.0	21	21	21	21	21	20	33.33

t (in)	1.062	1.125	1.188	1.250	1.312	1.375	
D_i (in)	17.876	17.750	17.624	17.500	17.376	17.250	
W(lb/ft)	214.80	226.78	238.68	250.31	261.86	273.51	
L/D_o	f_n	f_n	f_n	f_n	f_n	f_n	L (ft)
5.0	326	325	324	323	322	321	8.33
6.0	227	226	225	224	224	223	10.00
7.0	166	166	165	165	164	164	11.67
8.0	127	127	127	126	126	125	13.33
9.0	101	100	100	100	99	99	15.00
10.0	82	81	81	81	81	80	16.67
11.0	67	67	67	67	67	66	18.33
12.0	57	56	56	56	56	56	20.00
13.0	48	48	48	48	48	48	21.67
14.0	42	41	41	41	41	41	23.33
15.0	36	36	36	36	36	36	25.00
16.0	32	32	32	32	31	31	26.67
17.0	28	28	28	28	28	28	28.33
18.0	25	25	25	25	25	25	30.00
19.0	23	23	22	22	22	22	31.67
20.0	20	20	20	20	20	20	33.33

Table D-1.2. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) (Clamped-Pinned) (cont)



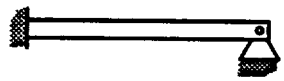
NPS = 22 in
D_o = 22.00 in
E = 28831000 lb/in^2

λ = 3.92660231
μ = 489.535 lb/ft^3

t (in)	**0.219**	**0.250**	**0.281**	**0.312**	**0.344**	**0.375**	
D_i (in)	**21.562**	**21.500**	**21.438**	**21.376**	**21.312**	**21.250**	
W(lb/ft)	**50.94**	**58.07**	**65.18**	**72.27**	**79.56**	**86.61**	
L/D_o	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**L (ft)**
5.0	310	309	309	308	308	307	9.17
6.0	215	215	214	214	214	213	11.00
7.0	158	158	157	157	157	157	12.83
8.0	121	121	121	120	120	120	14.67
9.0	96	95	95	95	95	95	16.50
10.0	77	77	77	77	77	77	18.33
11.0	64	64	64	64	64	64	20.17
12.0	54	54	54	54	53	53	22.00
13.0	46	46	46	46	46	45	23.83
14.0	39	39	39	39	39	39	25.67
15.0	34	34	34	34	34	34	27.50
16.0	30	30	30	30	30	30	29.33
17.0	27	27	27	27	27	27	31.17
18.0	24	24	24	24	24	24	33.00
19.0	21	21	21	21	21	21	34.83
20.0	19	19	19	19	19	19	36.67

t (in)	**0.406**	**0.438**	**0.469**	**0.500**	**0.562**	**0.625**	
D_i (in)	**21.188**	**21.124**	**21.062**	**21.000**	**20.876**	**20.750**	
W(lb/ft)	**93.63**	**100.86**	**107.85**	**114.81**	**128.67**	**142.68**	
L/D_o	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**L (ft)**
5.0	307	307	306	306	305	304	9.17
6.0	213	213	213	212	212	211	11.00
7.0	157	156	156	156	156	155	12.83
8.0	120	120	120	119	119	119	14.67
9.0	95	95	94	94	94	94	16.50
10.0	77	77	77	76	76	76	18.33
11.0	63	63	63	63	63	63	20.17
12.0	53	53	53	53	53	53	22.00
13.0	45	45	45	45	45	45	23.83
14.0	39	39	39	39	39	39	25.67
15.0	34	34	34	34	34	34	27.50
16.0	30	30	30	30	30	30	29.33
17.0	27	27	26	26	26	26	31.17
18.0	24	24	24	24	24	23	33.00
19.0	21	21	21	21	21	21	34.83
20.0	19	19	19	19	19	19	36.67

Table D-1.2. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz)
(Clamped-Pinned) (cont)



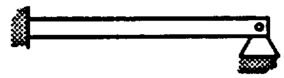
NPS = 22 in
D_o = 22.00 in
E = 28831000 lb/in^2

λ = 3.92660231
μ = 489.535 lb/ft^3

t (in)	0.688	0.750	0.812	0.875	0.938	1.000	
D_i (in)	20.624	20.500	20.376	20.250	20.124	20.000	
W(lb/ft)	156.60	170.21	183.75	197.41	211.00	224.28	
L/D_o	f_n	f_n	f_n	f_n	f_n	f_n	L (ft)
5.0	303	302	301	300	300	299	9.17
6.0	210	210	209	209	208	207	11.00
7.0	155	154	154	153	153	152	12.83
8.0	118	118	118	117	117	117	14.67
9.0	94	93	93	93	92	92	16.50
10.0	76	76	75	75	75	75	18.33
11.0	63	62	62	62	62	62	20.17
12.0	53	52	52	52	52	52	22.00
13.0	45	45	45	44	44	44	23.83
14.0	39	39	38	38	38	38	25.67
15.0	34	34	33	33	33	33	27.50
16.0	30	30	29	29	29	29	29.33
17.0	26	26	26	26	26	26	31.17
18.0	23	23	23	23	23	23	33.00
19.0	21	21	21	21	21	21	34.83
20.0	19	19	19	19	19	19	36.67

t (in)	1.062	1.125	1.188	1.250	1.312	1.375	
D_i (in)	19.876	19.750	19.624	19.500	19.376	19.250	
W(lb/ft)	237.48	250.81	264.06	277.01	289.88	302.88	
L/D_o	f_n	f_n	f_n	f_n	f_n	f_n	L (ft)
5.0	298	297	296	295	295	294	9.17
6.0	207	206	206	205	205	204	11.00
7.0	152	152	151	151	150	150	12.83
8.0	116	116	116	115	115	115	14.67
9.0	92	92	91	91	91	91	16.50
10.0	74	74	74	74	74	73	18.33
11.0	62	61	61	61	61	61	20.17
12.0	52	52	51	51	51	51	22.00
13.0	44	44	44	44	44	43	23.83
14.0	38	38	38	38	38	37	25.67
15.0	33	33	33	33	33	33	27.50
16.0	29	29	29	29	29	29	29.33
17.0	26	26	26	26	25	25	31.17
18.0	23	23	23	23	23	23	33.00
19.0	21	21	21	20	20	20	34.83
20.0	19	19	19	18	18	18	36.67

Table D-1.2. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) (Clamped-Pinned) (cont)

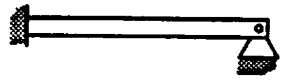


NPS = 22 in
D_o = 22.00 in
E = 28831000 lb/in^2

λ = 3.92660231
μ = 489.535 lb/ft^3

t (in)	**1.438**	**1.500**	
D_i (in)	**19.124**	**19.000**	
W(lb/ft)	**315.79**	**328.41**	
L/D_o	**f_n**	**f_n**	**L (ft)**
5.0	293	292	9.17
6.0	203	203	11.00
7.0	149	149	12.83
8.0	114	114	14.67
9.0	90	90	16.50
10.0	73	73	18.33
11.0	61	60	20.17
12.0	51	51	22.00
13.0	43	43	23.83
14.0	37	37	25.67
15.0	33	32	27.50
16.0	29	29	29.33
17.0	25	25	31.17
18.0	23	23	33.00
19.0	20	20	34.83
20.0	18	18	36.67

Table D-1.2. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) (Clamped-Pinned) (cont)



NPS = 24 in
D_o = 24.00 in
E = 28831000 lb/in^2

λ = 3.92660231
μ = 489.535 lb/ft^3

t (in)	0.250	0.281	0.312	0.344	0.375	0.406	
D_i (in)	23.500	23.438	23.376	23.312	23.250	23.188	
W(lb/ft)	63.41	71.18	78.93	86.91	94.62	102.31	
L/D_o	f_n	f_n	f_n	f_n	f_n	f_n	L (ft)
5.0	284	283	283	283	282	282	10.00
6.0	197	197	196	196	196	196	12.00
7.0	145	145	144	144	144	144	14.00
8.0	111	111	111	110	110	110	16.00
9.0	88	87	87	87	87	87	18.00
10.0	71	71	71	71	71	70	20.00
11.0	59	59	58	58	58	58	22.00
12.0	49	49	49	49	49	49	24.00
13.0	42	42	42	42	42	42	26.00
14.0	36	36	36	36	36	36	28.00
15.0	32	31	31	31	31	31	30.00
16.0	28	28	28	28	28	28	32.00
17.0	25	25	24	24	24	24	34.00
18.0	22	22	22	22	22	22	36.00
19.0	20	20	20	20	20	20	38.00
20.0	18	18	18	18	18	18	40.00

t (in)	0.438	0.469	0.500	0.562	0.625	0.688	
D_i (in)	23.124	23.062	23.000	22.876	22.750	22.624	
W(lb/ft)	110.22	117.86	125.49	140.68	156.03	171.29	
L/D_o	f_n	f_n	f_n	f_n	f_n	f_n	L (ft)
5.0	281	281	281	280	279	279	10.00
6.0	195	195	195	194	194	193	12.00
7.0	144	143	143	143	142	142	14.00
8.0	110	110	110	109	109	109	16.00
9.0	87	87	87	86	86	86	18.00
10.0	70	70	70	70	70	70	20.00
11.0	58	58	58	58	58	58	22.00
12.0	49	49	49	49	48	48	24.00
13.0	42	42	42	41	41	41	26.00
14.0	36	36	36	36	36	36	28.00
15.0	31	31	31	31	31	31	30.00
16.0	27	27	27	27	27	27	32.00
17.0	24	24	24	24	24	24	34.00
18.0	22	22	22	22	22	24	36.00
19.0	19	19	19	19	19	21	38.00
20.0	18	18	18	17	17	19	40.00

Table D-1.2. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz)
(Clamped-Pinned) (cont)

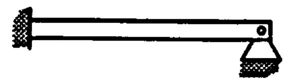
NPS = 24 in
D_o = 24.00 in
E = 28831000 lb/in^2

λ = 3.92660231
μ = 489.535 lb/ft^3

t (in)	0.750	0.812	0.875	0.938	1.000	1.062	
D_i (in)	22.500	22.376	22.250	22.124	22.000	21.876	
W(lb/ft)	186.23	201.09	216.10	231.03	245.64	260.17	
L/D_o	f_n	f_n	f_n	f_n	f_n	f_n	L (ft)
5.0	278	277	276	276	275	274	10.00
6.0	193	192	192	191	191	190	12.00
7.0	142	141	141	141	140	140	14.00
8.0	109	108	108	108	107	107	16.00
9.0	86	86	85	85	85	85	18.00
10.0	69	69	69	69	69	69	20.00
11.0	57	57	57	57	57	57	22.00
12.0	48	48	48	48	48	48	24.00
13.0	41	41	41	41	41	41	26.00
14.0	35	35	35	35	35	35	28.00
15.0	31	31	31	31	31	30	30.00
16.0	27	27	27	27	27	27	32.00
17.0	24	24	24	24	24	24	34.00
18.0	21	21	21	21	21	21	36.00
19.0	19	19	19	19	19	19	38.00
20.0	17	17	17	17	17	17	40.00

t (in)	1.125	1.188	1.250	1.312	1.375	1.438	
D_i (in)	21.750	21.624	21.500	21.376	21.250	21.124	
W(lb/ft)	274.84	289.44	303.71	317.91	332.25	346.50	
L/D_o	f_n	f_n	f_n	f_n	f_n	f_n	L (ft)
5.0	274	273	272	271	271	270	10.00
6.0	190	189	189	188	188	187	12.00
7.0	140	139	139	138	138	138	14.00
8.0	107	107	106	106	106	105	16.00
9.0	84	84	84	84	84	83	18.00
10.0	68	68	68	68	68	67	20.00
11.0	57	56	56	56	56	56	22.00
12.0	47	47	47	47	47	47	24.00
13.0	40	40	40	40	40	40	26.00
14.0	35	35	35	35	35	34	28.00
15.0	30	30	30	30	30	30	30.00
16.0	27	27	27	27	26	26	32.00
17.0	24	24	24	23	23	23	34.00
18.0	21	21	21	21	21	21	36.00
19.0	19	19	19	19	19	19	38.00
20.0	17	17	17	17	17	17	40.00

Table D-1.2. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz)
(Clamped-Pinned) (cont)

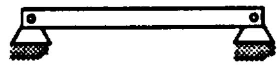


NPS = 24 in
D_o = 24.00 in
E = 28831000 lb/in^2

λ = 3.92660231
μ = 489.535 lb/ft^3

t (in)	1.500	1.562	
D_i (in)	21.000	20.876	
W(lb/ft)	360.45	374.31	
L/D_o	f_n	f_n	L (ft)
5.0	269	269	10.00
6.0	187	187	12.00
7.0	137	137	14.00
8.0	105	105	16.00
9.0	83	83	18.00
10.0	67	67	20.00
11.0	56	55	22.00
12.0	47	47	24.00
13.0	40	40	26.00
14.0	34	34	28.00
15.0	30	30	30.00
16.0	26	26	32.00
17.0	23	23	34.00
18.0	21	21	36.00
19.0	19	19	38.00
20.0	17	17	40.00

Table D-1.3. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz)
(Pinned-Pinned)



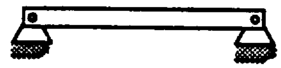
NPS = 4 in
D_o = 4.5 in
E = 28831000 lb/in^2

λ = 3.14159265
μ = 489.535 lb/ft^3

t (in)	**0.125**	**0.156**	**0.188**	**0.219**	**0.237**	**0.250**	
D_i (in)	**4.250**	**4.188**	**4.124**	**4.062**	**4.026**	**4.000**	
W(lb/ft)	**5.84**	**7.24**	**8.66**	**10.01**	**10.79**	**11.35**	
L/D_o	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**L (ft)**
5.0	952	945	939	932	928	926	1.88
6.0	661	656	652	647	645	643	2.25
7.0	486	482	479	476	474	472	2.63
8.0	372	369	367	364	363	362	3.00
9.0	294	292	290	288	287	286	3.38
10.0	238	236	235	233	232	231	3.75
11.0	197	195	194	193	192	191	4.13
12.0	165	164	163	162	161	161	4.50
13.0	141	140	139	138	137	137	4.88
14.0	121	121	120	119	118	118	5.25
15.0	106	105	104	104	103	103	5.63
16.0	93	92	92	91	91	90	6.00
17.0	82	82	81	81	80	80	6.38
18.0	73	73	72	72	72	71	6.75
19.0	66	65	65	65	64	64	7.13
20.0	59	59	59	58	58	58	7.50

t (in)	**0.281**	**0.312**	**0.337**	**0.438**	**0.531**	**0.674**	
D_i (in)	**3.938**	**3.876**	**3.826**	**3.624**	**3.438**	**3.152**	
W(lb/ft)	**12.66**	**13.96**	**14.98**	**19.00**	**22.51**	**27.54**	
L/D_o	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**L (ft)**
5.0	919	913	908	888	871	845	1.88
6.0	638	634	631	617	605	587	2.25
7.0	469	466	463	453	444	431	2.63
8.0	359	357	355	347	340	330	3.00
9.0	284	282	280	274	269	261	3.38
10.0	230	228	227	222	218	211	3.75
11.0	190	189	188	184	180	175	4.13
12.0	160	159	158	154	151	147	4.50
13.0	136	135	134	131	129	125	4.88
14.0	117	116	116	113	111	108	5.25
15.0	102	101	101	99	97	94	5.63
16.0	90	89	89	87	85	82	6.00
17.0	80	79	79	77	75	73	6.38
18.0	71	70	70	69	67	65	6.75
19.0	64	63	63	62	60	59	7.13
20.0	57	57	57	56	54	53	7.50

Table D-1.3. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) (Pinned-Pinned) (cont)



NPS = 5 in
D_o = 5.563 in
E = 28831000 lb/in^2

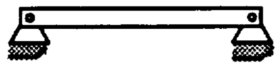
λ = 3.14159265
μ = 489.535 lb/ft^3

t (in)	0.156	0.188	0.219	0.258	0.281	0.312	
D_i (in)	5.251	5.187	5.125	5.047	5.001	4.939	
W(lb/ft)	9.01	10.79	12.50	14.62	15.85	17.50	
L/D_o	f_n	f_n	f_n	f_n	f_n	f_n	L (ft)
5.0	770	765	761	756	753	748	2.32
6.0	534	531	528	525	523	520	2.78
7.0	393	390	388	386	384	382	3.25
8.0	301	299	297	295	294	292	3.71
9.0	238	236	235	233	232	231	4.17
10.0	192	191	190	189	188	187	4.64
11.0	159	158	157	156	155	155	5.10
12.0	134	133	132	131	131	130	5.56
13.0	114	113	113	112	111	111	6.03
14.0	98	98	97	96	96	95	6.49
15.0	86	85	85	84	84	83	6.95
16.0	75	75	74	74	73	73	7.42
17.0	67	66	66	65	65	65	7.88
18.0	59	59	59	58	58	58	8.34
19.0	53	53	53	52	52	52	8.81
20.0	48	48	48	47	47	47	9.27

t (in)	0.344	0.375	0.500	0.625	0.750	
D_i (in)	4.875	4.813	4.563	4.313	4.063	
W(lb/ft)	19.17	20.78	27.04	32.96	38.55	
L/D_o	f_n	f_n	f_n	f_n	f_n	L (ft)
5.0	744	740	724	708	693	2.32
6.0	517	514	503	492	481	2.78
7.0	380	378	369	361	354	3.25
8.0	291	289	283	277	271	3.71
9.0	230	228	223	219	214	4.17
10.0	186	185	181	177	173	4.64
11.0	154	153	150	146	143	5.10
12.0	129	128	126	123	120	5.56
13.0	110	109	107	105	103	6.03
14.0	95	94	92	90	88	6.49
15.0	83	82	80	79	77	6.95
16.0	73	72	71	69	68	7.42
17.0	64	64	63	61	60	7.88
18.0	57	57	56	55	53	8.34
19.0	52	51	50	49	48	8.81
20.0	47	46	45	44	43	9.27

C-2

Table D-1.3. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz)
(Pinned-Pinned) (cont)



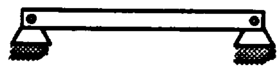
NPS = 6 in
D_o = 6.625 in
E = 28831000 lb/in^2

λ = 3.14159265
μ = 489.535 lb/ft^3

t (in)	0.188	0.219	0.250	0.280	0.312	0.344	
D_i (in)	6.249	6.187	6.125	6.065	6.001	5.937	
W(lb/ft)	12.92	14.98	17.02	18.97	21.04	23.08	
L/D_o	f_n	f_n	f_n	f_n	f_n	f_n	L (ft)
5.0	646	643	640	637	634	631	2.76
6.0	449	447	444	442	440	438	3.31
7.0	330	328	327	325	324	322	3.86
8.0	252	251	250	249	248	247	4.42
9.0	199	198	198	197	196	195	4.97
10.0	162	161	160	159	159	158	5.52
11.0	133	133	132	132	131	130	6.07
12.0	112	112	111	111	110	110	6.63
13.0	96	95	95	94	94	93	7.18
14.0	82	82	82	81	81	80	7.73
15.0	72	71	71	71	70	70	8.28
16.0	63	63	63	62	62	62	8.83
17.0	56	56	55	55	55	55	9.39
18.0	50	50	49	49	49	49	9.94
19.0	45	45	44	44	44	44	10.49
20.0	40	40	40	40	40	39	11.04

t (in)	0.375	0.432	0.562	0.719	0.864	
D_i (in)	5.875	5.761	5.501	5.187	4.897	
W(lb/ft)	25.03	28.57	36.39	45.35	53.16	
L/D_o	f_n	f_n	f_n	f_n	f_n	L (ft)
5.0	628	623	611	597	584	2.76
6.0	436	433	424	415	406	3.31
7.0	320	318	312	305	298	3.82
8.0	245	243	239	233	228	4.42
9.0	194	192	189	184	180	4.97
10.0	157	156	153	149	146	5.52
11.0	130	129	126	123	121	6.07
12.0	109	108	106	104	101	6.63
13.0	93	92	90	88	86	7.18
14.0	80	79	78	76	75	7.73
15.0	70	69	68	66	65	8.28
16.0	61	61	60	58	57	8.83
17.0	54	54	53	52	51	9.39
18.0	48	48	47	46	45	9.94
19.0	44	43	42	41	40	10.49
20.0	39	39	38	37	37	11.04

Table D-1.3. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz)
(Pinned-Pinned) (cont)



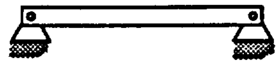
NPS = 8 in
D_o = 8.625 in
E = 28831000 lb/in^2

λ = 3.14159265
μ = 489.535 lb/ft^3

t (in)	0.188	0.203	0.219	0.250	0.277	0.312	
D_i (in)	8.249	8.219	8.187	8.125	8.071	8.001	
W(lb/ft)	16.94	18.26	19.66	22.36	24.70	27.70	
L/D_o	f_n	f_n	f_n	f_n	f_n	f_n	L (ft)
5.0	500	499	498	496	494	492	3.59
6.0	347	346	346	344	343	342	4.31
7.0	255	254	254	253	252	251	5.03
8.0	195	195	194	194	193	192	5.75
9.0	154	154	154	153	153	152	6.47
10.0	125	125	124	124	124	123	7.19
11.0	103	103	103	102	102	102	7.91
12.0	87	87	86	86	86	85	8.63
13.0	74	74	74	73	73	73	9.34
14.0	64	64	63	63	63	63	10.06
15.0	56	55	55	55	55	55	10.78
16.0	49	49	49	48	48	48	11.50
17.0	43	43	43	43	43	43	12.22
18.0	39	38	38	38	38	38	12.94
19.0	35	35	34	34	34	34	13.66
20.0	31	31	31	31	31	31	14.38

t (in)	0.322	0.344	0.375	0.406	0.438	0.500	
D_i (in)	7.981	7.937	7.875	7.813	7.749	7.625	
W(lb/ft)	28.55	30.42	33.04	35.64	38.30	43.39	
L/D_o	f_n	f_n	f_n	f_n	f_n	f_n	L (ft)
5.0	492	491	489	487	485	482	3.59
6.0	342	341	339	338	337	335	4.31
7.0	251	250	249	249	248	246	5.03
8.0	192	192	191	190	190	188	5.75
9.0	152	151	151	150	150	149	6.47
10.0	123	123	122	122	121	120	7.19
11.0	102	101	101	101	100	100	7.91
12.0	85	85	85	85	84	84	8.63
13.0	73	73	72	72	72	71	9.34
14.0	63	63	62	62	62	61	10.06
15.0	55	55	54	54	54	54	10.78
16.0	48	48	48	48	47	47	11.50
17.0	43	42	42	42	42	42	12.22
18.0	38	38	38	38	37	37	12.94
19.0	34	34	34	34	34	33	13.66
20.0	31	31	31	30	30	30	14.38

Table D-1.3. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz)
(Pinned-Pinned) (cont)



NPS = 8 in
D_o = 8.625 in
E = 28831000 lb/in^2

λ = 3.14159265
μ = 489.535 lb/ft^3

t (in)	**0.594**	**0.719**	**0.812**	**0.875**	**0.906**	
D_i (in)	**7.437**	**7.187**	**7.001**	**6.875**	**6.813**	
W(lb/ft)	**50.95**	**60.71**	**67.76**	**72.42**	**74.69**	
L/D_o	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**L (ft)**
5.0	477	470	465	462	460	3.59
6.0	331	326	323	321	319	4.31
7.0	243	240	237	236	235	5.03
8.0	186	184	182	180	180	5.75
9.0	147	145	144	142	142	6.47
10.0	119	117	116	115	115	7.19
11.0	98	97	96	95	95	7.91
12.0	83	82	81	80	80	8.63
13.0	71	70	69	68	68	9.34
14.0	61	60	59	59	59	10.06
15.0	53	52	52	51	51	10.78
16.0	47	46	45	45	45	11.50
17.0	41	41	40	40	40	12.22
18.0	37	36	36	36	35	12.94
19.0	33	33	32	32	32	13.66
20.0	30	29	29	29	29	14.38

Table D-1.3. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) (Pinned-Pinned) (cont)

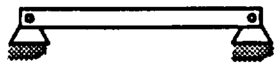
NPS = 10 in
D_o = 10.75 in
E = 28831000 lb/in^2

λ = 3.14159265
μ = 489.535 lb/ft^3

t (in)	0.188	0.203	0.219	0.250	0.279	0.307	
D_i (in)	10.374	10.344	10.312	10.25	10.192	10.136	
W(lb/ft)	21.21	22.87	24.63	28.04	31.20	34.24	
L/D_o	f_n	f_n	f_n	f_n	f_n	f_n	L (ft)
5.0	403	402	401	400	399	398	4.48
6.0	280	279	279	278	277	276	5.38
7.0	205	205	205	204	204	203	6.27
8.0	157	157	157	156	156	155	7.17
9.0	124	124	124	124	123	123	8.06
10.0	101	100	100	100	100	100	8.96
11.0	83	83	83	83	82	82	9.85
12.0	70	70	70	69	69	69	10.75
13.0	60	59	59	59	59	59	11.65
14.0	51	51	51	51	51	51	12.54
15.0	45	45	45	44	44	44	13.44
16.0	39	39	39	39	39	39	14.33
17.0	35	35	35	35	35	34	15.23
18.0	31	31	31	31	31	31	16.13
19.0	28	28	28	28	28	28	17.02
20.0	25	25	25	25	25	25	17.92

t (in)	0.344	0.365	0.438	0.500	0.594	0.719	
D_i (in)	10.062	10.02	9.874	9.75	9.562	9.312	
W(lb/ft)	38.23	40.48	48.24	54.74	64.43	77.03	
L/D_o	f_n	f_n	f_n	f_n	f_n	f_n	L (ft)
5.0	397	396	393	391	388	383	4.48
6.0	275	275	273	272	269	266	5.38
7.0	202	202	201	199	198	196	6.27
8.0	155	155	154	153	151	150	7.17
9.0	122	122	121	121	120	118	8.06
10.0	99	99	98	98	97	96	8.96
11.0	82	82	81	81	80	79	9.85
12.0	69	69	68	68	67	67	10.75
13.0	59	59	58	58	57	57	11.65
14.0	51	51	50	50	49	49	12.54
15.0	44	44	44	43	43	43	13.44
16.0	39	39	38	38	38	37	14.33
17.0	34	34	34	34	34	33	15.23
18.0	31	31	30	30	30	30	16.13
19.0	27	27	27	27	27	27	17.02
20.0	25	25	25	24	24	24	17.92

Table D-1.3. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz)
(Pinned-Pinned) (cont)

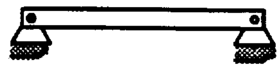


NPS = 10 in
D_o = 10.75 in
E = 28831000 lb/in^2

λ = 3.14159265
μ = 489.535 lb/ft^3

t (in)	0.844	1.000	1.125	
D_i (in)	9.062	8.75	8.5	
W(lb/ft)	89.29	104.13	115.64	
L/D_o	f_n	f_n	f_n	L (ft)
5.0	379	373	369	4.48
6.0	263	259	256	5.38
7.0	193	191	188	6.27
8.0	148	146	144	7.17
9.0	117	115	114	8.06
10.0	95	93	92	8.96
11.0	78	77	76	9.85
12.0	66	65	64	10.75
13.0	56	55	55	11.65
14.0	48	48	47	12.54
15.0	42	41	41	13.44
16.0	37	36	36	14.33
17.0	33	32	32	15.23
18.0	29	29	28	16.13
19.0	26	26	26	17.02
20.0	24	23	23	17.92

Table D-1.3. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) (Pinned-Pinned) (cont)



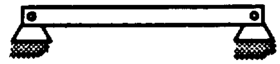
NPS = 12 in
D_o = 12.75 in
E = 28831000 lb/in^2

λ = 3.14159265
μ = 489.535 lb/ft^3

t (in)	0.203	0.219	0.250	0.281	0.312	0.330	
D_i (in)	12.344	12.312	12.250	12.188	12.126	12.090	
W(lb/ft)	27.20	29.31	33.38	37.42	41.45	43.77	
L/D_o	f_n	f_n	f_n	f_n	f_n	f_n	L (ft)
5.0	340	339	339	338	337	337	5.31
6.0	236	236	235	235	234	234	6.38
7.0	173	173	173	172	172	172	7.44
8.0	133	133	132	132	132	131	8.50
9.0	105	105	105	104	104	104	9.56
10.0	85	85	85	84	84	84	10.63
11.0	70	70	70	70	70	70	11.69
12.0	59	59	59	59	59	58	12.75
13.0	50	50	50	50	50	50	13.81
14.0	43	43	43	43	43	43	14.88
15.0	38	38	38	38	37	37	15.94
16.0	33	33	33	33	33	33	17.00
17.0	29	29	29	29	29	29	18.06
18.0	26	26	26	26	26	26	19.13
19.0	24	24	23	23	23	23	20.19
20.0	21	21	21	21	21	21	21.25

t (in)	0.344	0.375	0.406	0.438	0.500	0.562	
D_i (in)	12.062	12.000	11.938	11.874	11.750	11.626	
W(lb/ft)	45.58	49.56	53.52	57.59	65.42	73.15	
L/D_o	f_n	f_n	f_n	f_n	f_n	f_n	L (ft)
5.0	336	335	335	334	332	330	5.31
6.0	233	233	232	232	231	229	6.38
7.0	172	171	171	170	169	169	7.44
8.0	131	131	131	130	130	129	8.50
9.0	104	104	103	103	102	102	9.56
10.0	84	84	84	83	83	83	10.63
11.0	69	69	69	69	69	68	11.69
12.0	58	58	58	58	58	57	12.75
13.0	50	50	49	49	49	49	13.81
14.0	43	43	43	43	42	42	14.88
15.0	37	37	37	37	37	37	15.94
16.0	33	33	33	33	32	32	17.00
17.0	29	29	29	29	29	29	18.06
18.0	26	26	26	26	26	25	19.13
19.0	23	23	23	23	23	23	20.19
20.0	21	21	21	21	21	21	21.25

Table D-1.3. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) (Pinned-Pinned) (cont)

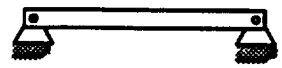


NPS = 12 in
D_o = 12.75 in
E = 28831000 lb/in^2

λ = 3.14159265
μ = 489.535 lb/ft^3

t (in)	**0.688**	**0.844**	**1.000**	**1.250**	**1.312**	
D_i (in)	**11.374**	**11.062**	**10.750**	**10.250**	**10.126**	
W(lb/ft)	**88.63**	**107.32**	**125.49**	**153.53**	**160.27**	
L/D_o	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**L (ft)**
5.0	327	323	319	313	312	5.31
6.0	227	225	222	218	217	6.38
7.0	167	165	163	160	159	7.44
8.0	128	126	125	122	122	8.50
9.0	101	100	99	97	96	9.56
10.0	82	81	80	78	78	10.63
11.0	68	67	66	65	64	11.69
12.0	57	56	55	54	54	12.75
13.0	48	48	47	46	46	13.81
14.0	42	41	41	40	40	14.88
15.0	36	36	35	35	35	15.94
16.0	32	32	31	31	30	17.00
17.0	28	28	28	27	27	18.06
18.0	25	25	25	24	24	19.13
19.0	23	22	22	22	22	20.19
20.0	20	20	20	20	19	21.25

Table D-1.3. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) (Pinned-Pinned) (cont)



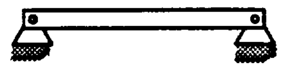
NPS = 14 in
D_o = 14.00 in
E = 28831000 lb/in^2

λ = 3.14159265
μ = 489.535 lb/ft^3

t (in)	0.188	0.210	0.219	0.250	0.281	0.312	
D_i (in)	13.624	13.580	13.562	13.500	13.433	13.376	
W(lb/ft)	27.73	30.93	32.23	36.71	41.17	45.61	
L/D_o	f_n	f_n	f_n	f_n	f_n	f_n	L (ft)
5.0	310	310	310	309	308	308	5.83
6.0	216	215	215	215	214	214	7.00
7.0	158	158	158	158	157	157	8.17
8.0	121	121	121	121	120	120	9.33
9.0	96	96	96	95	95	95	10.50
10.0	78	77	77	77	77	77	11.67
11.0	64	64	64	64	64	64	12.83
12.0	54	54	54	54	54	53	14.00
13.0	46	46	46	46	46	46	15.17
14.0	40	40	39	39	39	39	16.33
15.0	34	34	34	34	34	34	17.50
16.0	30	30	30	30	30	30	18.67
17.0	27	27	27	27	27	27	19.83
18.0	24	24	24	24	24	24	21.00
19.0	21	21	21	21	21	21	22.17
20.0	19	19	19	19	19	19	23.33

t (in)	0.344	0.375	0.406	0.438	0.469	0.500	
D_i (in)	13.312	13.250	13.188	13.124	13.062	13.000	
W(lb/ft)	50.17	54.57	58.94	63.44	67.78	72.09	
L/D_o	f_n	f_n	f_n	f_n	f_n	f_n	L (ft)
5.0	307	306	306	305	304	303	5.83
6.0	213	213	212	212	211	211	7.00
7.0	157	156	156	156	155	155	8.17
8.0	120	120	119	119	119	119	9.33
9.0	95	95	94	94	94	94	10.50
10.0	77	77	76	76	76	76	11.67
11.0	63	63	63	63	63	63	12.83
12.0	53	53	53	53	53	53	14.00
13.0	45	45	45	45	45	45	15.17
14.0	39	39	39	39	39	39	16.33
15.0	34	34	34	34	34	34	17.50
16.0	30	30	30	30	30	30	18.67
17.0	27	26	26	26	26	26	19.83
18.0	24	24	24	24	23	23	21.00
19.0	21	21	21	21	21	21	22.17
20.0	19	19	19	19	19	19	23.33

Table D-1.3. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz)
(Pinned-Pinned) (cont)



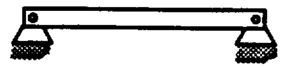
NPS = 14 in
D_o = 14.00 in
E = 28831000 lb/in^2

λ = 3.14159265
μ = 489.535 lb/ft^3

t (in)	**0.562**	**0.625**	**0.688**	**0.750**	**0.812**	**0.875**	
D_i (in)	**12.876**	**12.750**	**12.624**	**12.500**	**12.376**	**12.250**	
W(lb/ft)	**80.66**	**89.28**	**97.81**	**106.13**	**114.37**	**122.65**	
L/D_o	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**L (ft)**
5.0	302	301	299	298	297	296	5.83
6.0	210	209	208	207	206	205	7.00
7.0	154	153	153	152	151	151	8.17
8.0	118	118	117	116	116	115	9.33
9.0	93	93	92	92	92	91	10.50
10.0	76	75	75	75	74	74	11.67
11.0	62	62	62	62	61	61	12.83
12.0	52	52	52	52	52	51	14.00
13.0	45	44	44	44	44	44	15.17
14.0	39	38	38	38	38	38	16.33
15.0	34	33	33	33	33	33	17.50
16.0	30	29	29	29	29	29	18.67
17.0	26	26	26	26	26	26	19.83
18.0	23	23	23	23	23	23	21.00
19.0	21	21	21	21	21	20	22.17
20.0	19	19	19	19	19	18	23.33

t (in)	**0.938**	**1.000**	**1.062**	**1.125**	
D_i (in)	**12.124**	**12.000**	**11.876**	**11.750**	
W(lb/ft)	**130.85**	**138.84**	**146.74**	**154.69**	
L/D_o	**f_n**	**f_n**	**f_n**	**f_n**	**L (ft)**
5.0	294	293	292	290	5.83
6.0	204	203	203	202	7.00
7.0	150	149	149	148	8.17
8.0	115	114	114	113	9.33
9.0	91	90	90	90	10.50
10.0	74	73	73	73	11.67
11.0	61	61	60	60	12.83
12.0	51	51	51	50	14.00
13.0	44	43	43	43	15.17
14.0	38	37	37	37	16.33
15.0	33	33	32	32	17.50
16.0	29	29	28	28	18.67
17.0	25	25	25	25	19.83
18.0	23	23	23	22	21.00
19.0	20	20	20	20	22.17
20.0	18	18	18	18	23.33

Table D-1.3. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz)
(Pinned-Pinned) (cont)



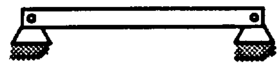
NPS = 16 in
D_o = 16.00 in
E = 28831000 lb/in^2

λ = 3.14159265
μ = 489.535 lb/ft^3

t (in)	**0.188**	**0.203**	**0.219**	**0.250**	**0.281**	**0.312**	
D_i (in)	**15.624**	**15.594**	**15.562**	**15.500**	**15.438**	**15.376**	
W(lb/ft)	**31.75**	**34.25**	**36.91**	**42.05**	**47.17**	**52.27**	
L/D_o	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	L (ft)
5.0	272	272	271	271	270	270	6.67
6.0	189	189	189	188	188	187	8.00
7.0	139	139	139	138	138	138	9.33
8.0	106	106	106	106	106	105	10.67
9.0	84	84	84	84	83	83	12.00
10.0	68	68	68	68	68	67	13.33
11.0	56	56	56	56	56	56	14.67
12.0	47	47	47	47	47	47	16.00
13.0	40	40	40	40	40	40	17.33
14.0	35	35	35	35	34	34	18.67
15.0	30	30	30	30	30	30	20.00
16.0	27	27	27	26	26	26	21.33
17.0	24	24	23	23	23	23	22.67
18.0	21	21	21	21	21	21	24.00
19.0	19	19	19	19	19	19	25.33
20.0	17	17	17	17	17	17	26.67

t (in)	**0.344**	**0.375**	**0.406**	**0.438**	**0.469**	**0.500**	
D_i (in)	**15.312**	**15.250**	**15.188**	**15.124**	**15.062**	**15.000**	
W(lb/ft)	**57.52**	**62.58**	**67.62**	**72.80**	**77.79**	**82.77**	
L/D_o	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	L (ft)
5.0	269	269	268	268	267	267	6.67
6.0	187	187	186	186	186	185	8.00
7.0	137	137	137	137	136	136	9.33
8.0	105	105	105	105	104	104	10.67
9.0	83	83	83	83	82	82	12.00
10.0	67	67	67	67	67	67	13.33
11.0	56	56	55	55	55	55	14.67
12.0	47	47	47	46	46	46	16.00
13.0	40	40	40	40	40	39	17.33
14.0	34	34	34	34	34	34	18.67
15.0	30	30	30	30	30	30	20.00
16.0	26	26	26	26	26	26	21.33
17.0	23	23	23	23	23	23	22.67
18.0	21	21	21	21	21	21	24.00
19.0	19	19	19	19	19	18	25.33
20.0	17	17	17	17	17	17	26.67

Table D-1.3. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) (Pinned-Pinned) (cont)



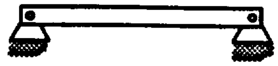
NPS = 16 in
D_o = 16.00 in
E = 28831000 lb/in^2

λ = 3.14159265
μ = 489.535 lb/ft^3

t (in)	0.562	0.625	0.688	0.750	0.812	0.875	
D_i (in)	14.876	14.750	14.624	14.500	14.376	14.250	
W(lb/ft)	92.66	102.63	112.51	122.15	131.71	141.34	
L/D_o	f_n	f_n	f_n	f_n	f_n	f_n	L (ft)
5.0	266	265	264	263	262	261	6.67
6.0	185	184	183	182	182	181	8.00
7.0	136	135	135	134	133	133	9.33
8.0	104	103	103	103	102	102	10.67
9.0	82	82	81	81	81	80	12.00
10.0	66	66	66	66	65	65	13.33
11.0	55	55	54	54	54	54	14.67
12.0	46	46	46	46	45	45	16.00
13.0	39	39	39	39	39	39	17.33
14.0	34	34	34	33	33	33	18.67
15.0	30	29	29	29	29	29	20.00
16.0	26	26	26	26	26	25	21.33
17.0	23	23	23	23	23	23	22.67
18.0	21	20	20	20	20	20	24.00
19.0	18	18	18	18	18	18	25.33
20.0	17	17	16	16	16	16	26.67

t (in)	0.938	1.000	1.062	1.125	1.188	1.250	
D_i (in)	14.124	14.000	13.876	13.750	13.624	13.500	
W(lb/ft)	150.89	160.20	169.43	178.72	187.93	196.91	
L/D_o	f_n	f_n	f_n	f_n	f_n	f_n	L (ft)
5.0	260	259	258	257	256	255	6.67
6.0	180	180	179	178	177	177	8.00
7.0	132	132	131	131	130	130	9.33
8.0	101	101	101	100	100	99	10.67
9.0	80	80	80	79	79	79	12.00
10.0	65	65	64	64	64	64	13.33
11.0	54	53	53	53	53	53	14.67
12.0	45	45	45	45	44	44	16.00
13.0	38	38	38	38	38	38	17.33
14.0	33	33	33	33	33	32	18.67
15.0	29	29	29	29	28	28	20.00
16.0	25	25	25	25	25	25	21.33
17.0	22	22	22	22	22	22	22.67
18.0	20	20	20	20	20	20	24.00
19.0	18	18	18	18	18	18	25.33
20.0	16	16	16	16	16	16	26.67

Table D-1.3. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz)
(Pinned-Pinned) (cont)



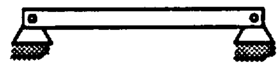
NPS = 18 in
D_o = 18.00 in
E = 28831000 lb/in^2

λ = 3.14159265
μ = 489.535 lb/ft^3

t (in)	0.188	0.219	0.250	0.281	0.312	0.344	
D_i (in)	17.624	17.562	17.500	17.438	17.376	17.312	
W(lb/ft)	35.76	41.59	47.39	53.18	58.94	64.87	
L/D_o	f_n	f_n	f_n	f_n	f_n	f_n	L (ft)
5.0	242	242	241	241	240	240	7.50
6.0	168	168	168	167	167	167	9.00
7.0	124	123	123	123	123	122	10.50
8.0	95	94	94	94	94	94	12.00
9.0	75	75	74	74	74	74	13.50
10.0	61	60	60	60	60	60	15.00
11.0	50	50	50	50	50	50	16.50
12.0	42	42	42	42	42	42	18.00
13.0	36	36	36	36	36	36	19.50
14.0	31	31	31	31	31	31	21.00
15.0	27	27	27	27	27	27	22.50
16.0	24	24	24	24	23	23	24.00
17.0	21	21	21	21	21	21	25.50
18.0	19	19	19	19	19	19	27.00
19.0	17	17	17	17	17	17	28.50
20.0	15	15	15	15	15	15	30.00

t (in)	0.375	0.406	0.438	0.469	0.500	0.562	
D_i (in)	17.250	17.188	17.124	17.062	17.000	16.876	
W(lb/ft)	70.59	76.29	82.15	87.81	93.45	104.67	
L/D_o	f_n	f_n	f_n	f_n	f_n	f_n	L (ft)
5.0	240	239	239	238	238	237	7.50
6.0	166	166	166	166	165	165	9.00
7.0	122	122	122	122	121	121	10.50
8.0	94	93	93	93	93	93	12.00
9.0	74	74	74	74	73	73	13.50
10.0	60	60	60	60	59	59	15.00
11.0	50	49	49	49	49	49	16.50
12.0	42	42	41	41	41	41	18.00
13.0	35	35	35	35	35	35	19.50
14.0	31	31	30	30	30	30	21.00
15.0	27	27	27	26	26	26	22.50
16.0	23	23	23	23	23	23	24.00
17.0	21	21	21	21	21	21	25.50
18.0	18	18	18	18	18	18	27.00
19.0	17	17	17	17	16	16	28.50
20.0	15	15	15	15	15	15	30.00

Table D-1.3. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz)
(Pinned-Pinned) (cont)



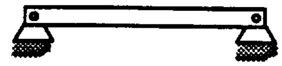
NPS = 18 in
D_o = 18.00 in
E = 28831000 lb/in^2

λ = 3.14159265
μ = 489.535 lb/ft^3

t (in)	0.625	0.688	0.750	0.812	0.875	0.938	
D_i (in)	16.750	16.624	16.500	16.376	16.250	16.124	
W(lb/ft)	115.98	127.21	138.17	149.06	160.03	170.92	
L/D_o	f_n	f_n	f_n	f_n	f_n	f_n	L (ft)
5.0	236	235	235	234	233	232	7.50
6.0	164	164	163	162	162	161	9.00
7.0	121	120	120	119	119	118	10.50
8.0	92	92	92	91	91	91	12.00
9.0	73	73	72	72	72	72	13.50
10.0	59	59	59	58	58	58	15.00
11.0	49	49	48	48	48	48	16.50
12.0	41	41	41	41	40	40	18.00
13.0	35	35	35	35	34	34	19.50
14.0	30	30	30	30	30	30	21.00
15.0	26	26	26	26	26	26	22.50
16.0	23	23	23	23	23	23	24.00
17.0	20	20	20	20	20	20	25.50
18.0	18	18	18	18	18	18	27.00
19.0	16	16	16	16	16	16	28.50
20.0	15	15	15	15	15	15	30.00

t (in)	1.000	1.062	1.125	1.188	1.250	
D_i (in)	16.000	15.876	15.750	15.624	15.500	
W(lb/ft)	181.56	192.11	202.75	213.31	223.61	
L/D_o	f_n	f_n	f_n	f_n	f_n	L (ft)
5.0	231	231	230	229	228	7.50
6.0	161	160	160	159	159	9.00
7.0	118	118	117	117	116	10.50
8.0	90	90	90	89	89	12.00
9.0	71	71	71	71	70	13.50
10.0	58	58	57	57	57	15.00
11.0	48	48	47	47	47	16.50
12.0	40	40	40	40	40	18.00
13.0	34	34	34	34	34	19.50
14.0	30	29	29	29	29	21.00
15.0	26	26	26	25	25	22.50
16.0	23	23	22	22	22	24.00
17.0	20	20	20	20	20	25.50
18.0	18	18	18	18	18	27.00
19.0	16	16	16	16	16	28.50
20.0	14	14	14	14	14	30.00

Table D-1.3. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) (Pinned-Pinned) (cont)



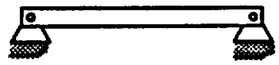
NPS = 20 in
D_o = 20.00 in
E = 28831000 lb/in^2

λ = 3.14159265
μ = 489.535 lb/ft^3

t (in)	0.219	0.250	0.281	0.312	0.344	0.375	
D_i (in)	19.562	19.500	19.438	19.376	19.312	19.250	
W(lb/ft)	46.27	52.73	59.18	65.60	72.21	78.60	
L/D_o	f_n	f_n	f_n	f_n	f_n	f_n	L (ft)
5.0	218	217	217	217	216	216	8.33
6.0	151	151	151	151	150	150	10.00
7.0	111	111	111	111	110	110	11.67
8.0	85	85	85	85	85	84	13.33
9.0	67	67	67	67	67	67	15.00
10.0	54	54	54	54	54	54	16.67
11.0	45	45	45	45	45	45	18.33
12.0	38	38	38	38	38	38	20.00
13.0	32	32	32	32	32	32	21.67
14.0	28	28	28	28	28	28	23.33
15.0	24	24	24	24	24	24	25.00
16.0	21	21	21	21	21	21	26.67
17.0	19	19	19	19	19	19	28.33
18.0	17	17	17	17	17	17	30.00
19.0	15	15	15	15	15	15	31.67
20.0	14	14	14	14	14	14	33.33

t (in)	0.406	0.438	0.469	0.500	0.562	0.625	
D_i (in)	19.188	19.124	19.062	19.000	18.876	18.750	
W(lb/ft)	84.96	91.51	97.83	104.13	116.67	129.33	
L/D_o	f_n	f_n	f_n	f_n	f_n	f_n	L (ft)
5.0	216	215	215	215	214	213	8.33
6.0	150	150	149	149	149	148	10.00
7.0	110	110	110	110	109	109	11.67
8.0	84	84	84	84	84	83	13.33
9.0	67	66	66	66	66	66	15.00
10.0	54	54	54	54	54	53	16.67
11.0	45	45	44	44	44	44	18.33
12.0	37	37	37	37	37	37	20.00
13.0	32	32	32	32	32	32	21.67
14.0	28	27	27	27	27	27	23.33
15.0	24	24	24	24	24	24	25.00
16.0	21	21	21	21	21	21	26.67
17.0	19	19	19	19	19	18	28.33
18.0	17	17	17	17	17	16	30.00
19.0	15	15	15	15	15	15	31.67
20.0	13	13	13	13	13	13	33.33

Table D-1.3. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz)
(Pinned-Pinned) (cont)



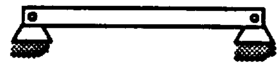
NPS = 20 in
D_o = 20.00 in
E = 28831000 lb/in^2

λ = 3.14159265
μ = 489.535 lb/ft^3

t (in)	**0.688**	**0.750**	**0.812**	**0.875**	**0.938**	**1.000**	
D_i (in)	**18.624**	**18.500**	**18.376**	**18.250**	**18.124**	**18.000**	
W(lb/ft)	**141.90**	**154.19**	**166.40**	**178.72**	**190.96**	**202.92**	
L/D_o	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**L (ft)**
5.0	213	212	211	211	210	209	8.33
6.0	148	147	147	146	146	145	10.00
7.0	109	108	108	108	107	107	11.67
8.0	83	83	83	82	82	82	13.33
9.0	66	65	65	65	65	65	15.00
10.0	53	53	53	53	53	52	16.67
11.0	44	44	44	44	43	43	18.33
12.0	37	37	37	37	36	36	20.00
13.0	31	31	31	31	31	31	21.67
14.0	27	27	27	27	27	27	23.33
15.0	24	24	23	23	23	23	25.00
16.0	21	21	21	21	21	20	26.67
17.0	18	18	18	18	18	18	28.33
18.0	16	16	16	16	16	16	30.00
19.0	15	15	15	15	15	15	31.67
20.0	13	13	13	13	13	13	33.33

t (in)	**1.062**	**1.125**	**1.188**	**1.250**	**1.312**	**1.375**	
D_i (in)	**17.876**	**17.750**	**17.624**	**17.500**	**17.376**	**17.250**	
W(lb/ft)	**214.80**	**226.78**	**238.68**	**250.31**	**261.86**	**273.51**	
L/D_o	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**L (ft)**
5.0	209	208	207	207	206	206	8.33
6.0	145	145	144	144	143	143	10.00
7.0	107	106	106	106	105	105	11.67
8.0	82	81	81	81	81	80	13.33
9.0	64	64	64	64	64	63	15.00
10.0	52	52	52	52	52	51	16.67
11.0	43	43	43	43	43	42	18.33
12.0	36	36	36	36	36	36	20.00
13.0	31	31	31	31	31	30	21.67
14.0	27	27	26	26	26	26	23.33
15.0	23	23	23	23	23	23	25.00
16.0	20	20	20	20	20	20	26.67
17.0	18	18	18	18	18	18	28.33
18.0	16	16	16	16	16	16	30.00
19.0	14	14	14	14	14	14	31.67
20.0	13	13	13	13	13	13	33.33

Table D-1.3. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz)
(Pinned-Pinned) (cont)



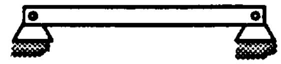
NPS = 22 in
D_o = 22.00 in
E = 28831000 lb/in^2

λ = 3.14159265
μ = 489.535 lb/ft^3

t (in)	0.219	0.250	0.281	0.312	0.344	0.375	
D_i (in)	21.562	21.500	21.438	21.376	21.312	21.250	
W(lb/ft)	50.94	58.07	65.18	72.27	79.56	86.61	
L/D_o	f_n	f_n	f_n	f_n	f_n	f_n	L (ft)
5.0	198	198	198	197	197	197	9.17
6.0	138	137	137	137	137	137	11.00
7.0	101	101	101	101	101	100	12.83
8.0	77	77	77	77	77	77	14.67
9.0	61	61	61	61	61	61	16.50
10.0	50	49	49	49	49	49	18.33
11.0	41	41	41	41	41	41	20.17
12.0	34	34	34	34	34	34	22.00
13.0	29	29	29	29	29	29	23.83
14.0	25	25	25	25	25	25	25.67
15.0	22	22	22	22	22	22	27.50
16.0	19	19	19	19	19	19	29.33
17.0	17	17	17	17	17	17	31.17
18.0	15	15	15	15	15	15	33.00
19.0	14	14	14	14	14	14	34.83
20.0	12	12	12	12	12	12	36.67

t (in)	0.406	0.438	0.469	0.500	0.562	0.625	
D_i (in)	21.188	21.124	21.062	21.000	20.876	20.750	
W(lb/ft)	93.63	100.86	107.85	114.81	128.67	142.68	
L/D_o	f_n	f_n	f_n	f_n	f_n	f_n	L (ft)
5.0	196	196	196	196	195	195	9.17
6.0	136	136	136	136	135	135	11.00
7.0	100	100	100	100	100	99	12.83
8.0	77	77	77	76	76	76	14.67
9.0	61	61	60	60	60	60	16.50
10.0	49	49	49	49	49	49	18.33
11.0	41	41	40	40	40	40	20.17
12.0	34	34	34	34	34	34	22.00
13.0	29	29	29	29	29	29	23.83
14.0	25	25	25	25	25	25	25.67
15.0	22	22	22	22	22	22	27.50
16.0	19	19	19	19	19	19	29.33
17.0	17	17	17	17	17	17	31.17
18.0	15	15	15	15	15	15	33.00
19.0	14	14	14	14	14	13	34.83
20.0	12	12	12	12	12	12	36.67

Table D-1.3. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) (Pinned-Pinned) (cont)



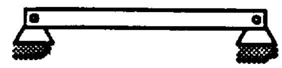
NPS = 22 in
D_o = 22.00 in
E = 28831000 lb/in^2

λ = 3.14159265
μ = 489.535 lb/ft^3

t (in)	**0.688**	**0.750**	**0.812**	**0.875**	**0.938**	**1.000**	
D_i (in)	**20.624**	**20.500**	**20.376**	**20.250**	**20.124**	**20.000**	
W(lb/ft)	**156.60**	**170.21**	**183.75**	**197.41**	**211.00**	**224.28**	
L/D_o	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**L (ft)**
5.0	194	193	193	192	192	191	9.17
6.0	135	134	134	134	133	133	11.00
7.0	99	99	98	98	98	98	12.83
8.0	76	76	75	75	75	75	14.67
9.0	60	60	60	59	59	59	16.50
10.0	48	48	48	48	48	48	18.33
11.0	40	40	40	40	40	40	20.17
12.0	34	34	33	33	33	33	22.00
13.0	29	29	29	28	28	28	23.83
14.0	25	25	25	25	24	24	25.67
15.0	22	21	21	21	21	21	27.50
16.0	19	19	19	19	19	19	29.33
17.0	17	17	17	17	17	17	31.17
18.0	15	15	15	15	15	15	33.00
19.0	13	13	13	13	13	13	34.83
20.0	12	12	12	12	12	12	36.67

t (in)	**1.062**	**1.125**	**1.188**	**1.250**	**1.312**	**1.375**	
D_i (in)	**19.876**	**19.750**	**19.624**	**19.500**	**19.376**	**19.250**	
W(lb/ft)	**237.48**	**250.81**	**264.06**	**277.01**	**289.88**	**302.88**	
L/D_o	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**L (ft)**
5.0	191	190	190	189	189	188	9.17
6.0	132	132	132	131	131	131	11.00
7.0	97	97	97	96	96	96	12.83
8.0	75	74	74	74	74	73	14.67
9.0	59	59	59	58	58	58	16.50
10.0	48	48	47	47	47	47	18.33
11.0	39	39	39	39	39	39	20.17
12.0	33	33	33	33	33	33	22.00
13.0	28	28	28	28	28	28	23.83
14.0	24	24	24	24	24	24	25.67
15.0	21	21	21	21	21	21	27.50
16.0	19	19	19	18	18	18	29.33
17.0	16	16	16	16	16	16	31.17
18.0	15	15	15	15	15	15	33.00
19.0	13	13	13	13	13	13	34.83
20.0	12	12	12	12	12	12	36.67

Table D-1.3. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) (Pinned-Pinned) (cont)

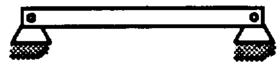


NPS = 22 in
D_o = 22.00 in
E = 28831000 lb/in^2

λ = 3.14159265
μ = 489.535 lb/ft^3

t (in)	**1.438**	**1.500**	
D_i (in)	**19.124**	**19.000**	
W(lb/ft)	**315.79**	**328.41**	
L/D_o	**f_n**	**f_n**	**L (ft)**
5.0	188	187	9.17
6.0	130	130	11.00
7.0	96	95	12.83
8.0	73	73	14.67
9.0	58	58	16.50
10.0	47	47	18.33
11.0	39	39	20.17
12.0	33	32	22.00
13.0	28	28	23.83
14.0	24	24	25.67
15.0	21	21	27.50
16.0	18	18	29.33
17.0	16	16	31.17
18.0	14	14	33.00
19.0	13	13	34.83
20.0	12	12	36.67

Table D-1.3. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) (Pinned-Pinned) (cont)



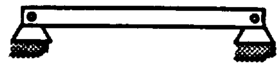
NPS = 24 in
D_o = 24.00 in
E = 28831000 lb/in²

λ = 3.14159265
μ = 489.535 lb/ft³

t (in)	**0.250**	**0.281**	**0.312**	**0.344**	**0.375**	**0.406**	
D_i (in)	**23.500**	**23.438**	**23.376**	**23.312**	**23.250**	**23.188**	
W(lb/ft)	**63.41**	**71.18**	**78.93**	**86.91**	**94.62**	**102.31**	
L/D_o	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**L (ft)**
5.0	182	181	181	181	181	180	10.00
6.0	126	126	126	126	125	125	12.00
7.0	93	93	92	92	92	92	14.00
8.0	71	71	71	71	71	70	16.00
9.0	56	56	56	56	56	56	18.00
10.0	45	45	45	45	45	45	20.00
11.0	38	37	37	37	37	37	22.00
12.0	32	31	31	31	31	31	24.00
13.0	27	27	27	27	27	27	26.00
14.0	23	23	23	23	23	23	28.00
15.0	20	20	20	20	20	20	30.00
16.0	18	18	18	18	18	18	32.00
17.0	16	16	16	16	16	16	34.00
18.0	14	14	14	14	14	14	36.00
19.0	13	13	13	13	13	12	38.00
20.0	11	11	11	11	11	11	40.00

t (in)	**0.438**	**0.469**	**0.500**	**0.562**	**0.625**	**0.688**	
D_i (in)	**23.124**	**23.062**	**23.000**	**22.876**	**22.750**	**22.624**	
W(lb/ft)	**110.22**	**117.86**	**125.49**	**140.68**	**156.03**	**171.29**	
L/D_o	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**L (ft)**
5.0	180	180	180	179	179	178	10.00
6.0	125	125	125	124	124	124	12.00
7.0	92	92	92	91	91	91	14.00
8.0	70	70	70	70	70	70	16.00
9.0	56	56	55	55	55	55	18.00
10.0	45	45	45	45	45	45	20.00
11.0	37	37	37	37	37	37	22.00
12.0	31	31	31	31	31	31	24.00
13.0	27	27	27	27	26	26	26.00
14.0	23	23	23	23	23	23	28.00
15.0	20	20	20	20	20	20	30.00
16.0	18	18	18	18	17	17	32.00
17.0	16	16	16	16	15	15	34.00
18.0	14	14	14	14	14	14	36.00
19.0	12	12	12	12	12	12	38.00
20.0	11	11	11	11	11	11	40.00

Table D-1.3. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) (Pinned-Pinned) (cont)



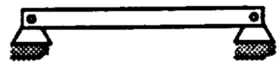
NPS = 24 in
D_o = 24.00 in
E = 28831000 lb/in²

λ = 3.14159265
μ = 489.535 lb/ft³

t (in)	0.750	0.812	0.875	0.938	1.000	1.062	
D_i (in)	22.500	22.376	22.250	22.124	22.000	21.876	
W(lb/ft)	186.23	201.09	216.10	231.03	245.64	260.17	
L/D_o	f_n	f_n	f_n	f_n	f_n	f_n	L (ft)
5.0	178	177	177	176	176	176	10.00
6.0	123	123	123	123	122	122	12.00
7.0	91	90	90	90	90	90	14.00
8.0	69	69	69	69	69	69	16.00
9.0	55	55	55	54	54	54	18.00
10.0	44	44	44	44	44	44	20.00
11.0	37	37	37	36	36	36	22.00
12.0	31	31	31	31	31	30	24.00
13.0	26	26	26	26	26	26	26.00
14.0	23	23	23	23	22	22	28.00
15.0	20	20	20	20	20	20	30.00
16.0	17	17	17	17	17	17	32.00
17.0	15	15	15	15	15	15	34.00
18.0	14	14	14	14	14	14	36.00
19.0	12	12	12	12	12	12	38.00
20.0	11	11	11	11	11	11	40.00

t (in)	1.125	1.188	1.250	1.312	1.375	1.438	
D_i (in)	21.750	21.624	21.500	21.376	21.250	21.124	
W(lb/ft)	274.84	289.44	303.71	317.91	332.25	346.50	
L/D_o	f_n	f_n	f_n	f_n	f_n	f_n	L (ft)
5.0	175	175	174	174	173	173	10.00
6.0	122	121	121	121	120	120	12.00
7.0	89	89	89	89	88	88	14.00
8.0	68	68	68	68	68	68	16.00
9.0	54	54	54	54	53	53	18.00
10.0	44	44	44	43	43	43	20.00
11.0	36	36	36	36	36	36	22.00
12.0	30	30	30	30	30	30	24.00
13.0	26	26	26	26	26	26	26.00
14.0	22	22	22	22	22	22	28.00
15.0	19	19	19	19	19	19	30.00
16.0	17	17	17	17	17	17	32.00
17.0	15	15	15	15	15	15	34.00
18.0	14	13	13	13	13	13	36.00
19.0	12	12	12	12	12	12	38.00
20.0	11	11	11	11	11	11	40.00

Table D-1.3. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) (Pinned-Pinned) (cont)



NPS = 24 in
D_o = 24.00 in
E = 28831000 lb/in^2

λ = 3.14159265
μ = 489.535 lb/ft^3

t (in)	**1.500**	**1.562**	
D_i (in)	**21.000**	**20.876**	
W(lb/ft)	**360.45**	**374.31**	
L/D_o	**f_n**	**f_n**	**L (ft)**
5.0	172	172	10.00
6.0	120	119	12.00
7.0	88	88	14.00
8.0	67	67	16.00
9.0	53	53	18.00
10.0	43	43	20.00
11.0	36	36	22.00
12.0	30	30	24.00
13.0	26	25	26.00
14.0	22	22	28.00
15.0	19	19	30.00
16.0	17	17	32.00
17.0	15	15	34.00
18.0	13	13	36.00
19.0	12	12	38.00
20.0	11	11	40.00

Table D-2.1. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) WITH APPLIED AXIAL LOADS (Clamped-Clamped)

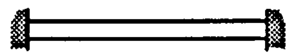
NPS = 4 in
D_o = 4.5 in
E = 28831000 lb/in^2

P/P_b = .25
λ = 4.730041
μ = 489.535 lb/ft^3

t (in)	**0.125**	**0.156**	**0.188**	**0.219**	**0.237**	**0.250**	
D_i (in)	**4.250**	**4.188**	**4.124**	**4.062**	**4.026**	**4.000**	
W(lb/ft)	**5.84**	**7.24**	**8.66**	**10.01**	**10.79**	**11.35**	
L/D_o	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**L (ft)**
5.0	1868	1856	1842	1830	1823	1817	1.88
6.0	1297	1289	1279	1271	1266	1262	2.25
7.0	953	947	940	934	930	927	2.63
8.0	730	725	720	715	712	710	3.00
9.0	577	573	569	565	563	561	3.38
10.0	467	464	461	457	456	454	3.75
11.0	386	383	381	378	377	375	4.13
12.0	324	322	320	318	316	316	4.50
13.0	276	274	273	271	270	269	4.88
14.0	238	237	235	233	232	232	5.25
15.0	208	206	205	203	203	202	5.63
16.0	182	181	180	179	178	177	6.00
17.0	162	161	159	158	158	157	6.38
18.0	144	143	142	141	141	140	6.75
19.0	129	129	128	127	126	126	7.13
20.0	117	116	115	114	114	114	7.50

t (in)	**0.281**	**0.312**	**0.337**	**0.438**	**0.531**	**0.674**	
D_i (in)	**3.938**	**3.876**	**3.826**	**3.624**	**3.438**	**3.152**	
W(lb/ft)	**12.66**	**13.96**	**14.98**	**19.00**	**22.51**	**27.54**	
L/D_o	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**L (ft)**
5.0	1805	1793	1783	1744	1709	1658	1.88
6.0	1253	1245	1238	1211	1187	1152	2.25
7.0	921	915	910	890	872	846	2.63
8.0	705	700	696	681	668	648	3.00
9.0	557	553	550	538	528	512	3.38
10.0	451	448	446	436	427	415	3.75
11.0	373	370	368	360	353	343	4.13
12.0	313	311	310	303	297	288	4.50
13.0	267	265	264	258	253	245	4.88
14.0	230	229	227	222	218	212	5.25
15.0	201	199	198	194	190	184	5.63
16.0	176	175	174	170	167	162	6.00
17.0	156	155	154	151	148	143	6.38
18.0	139	138	138	135	132	128	6.75
19.0	125	124	123	121	118	115	7.13
20.0	113	112	111	109	107	104	7.50

Table D-2.1. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) WITH APPLIED AXIAL LOADS (Clamped-Clamped) (cont)



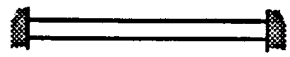
NPS = 4 in
D_o = 4.5 in
E = 28831000 lb/in^2

P/P_b = .50
λ = 4.730041
μ = 489.535 lb/ft^3

t (in)	**0.125**	**0.156**	**0.188**	**0.219**	**0.237**	**0.250**	
D_i (in)	**4.250**	**4.188**	**4.124**	**4.062**	**4.026**	**4.000**	
W(lb/ft)	**5.84**	**7.24**	**8.66**	**10.01**	**10.79**	**11.35**	
L/D_o	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**L (ft)**
5.0	1526	1515	1504	1494	1488	1484	1.88
6.0	1059	1052	1045	1038	1033	1030	2.25
7.0	778	773	768	762	759	757	2.63
8.0	596	592	588	584	581	580	3.00
9.0	471	468	464	461	459	458	3.38
10.0	381	379	376	374	372	371	3.75
11.0	315	313	311	309	307	307	4.13
12.0	265	263	261	259	258	258	4.50
13.0	226	224	223	221	220	220	4.88
14.0	195	193	192	191	190	189	5.25
15.0	170	168	167	166	165	165	5.63
16.0	149	148	147	146	145	145	6.00
17.0	132	131	130	129	129	128	6.38
18.0	118	117	116	115	115	114	6.75
19.0	106	105	104	103	103	103	7.13
20.0	95	95	94	93	93	93	7.50

t (in)	**0.281**	**0.312**	**0.337**	**0.438**	**0.531**	**0.674**	
D_i (in)	**3.938**	**3.876**	**3.826**	**3.624**	**3.438**	**3.152**	
W(lb/ft)	**12.66**	**13.96**	**14.98**	**19.00**	**22.51**	**27.54**	
L/D_o	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**L (ft)**
5.0	1474	1464	1456	1424	1396	1354	1.88
6.0	1023	1017	1011	989	969	940	2.25
7.0	752	747	743	727	712	691	2.63
8.0	576	572	569	556	545	529	3.00
9.0	455	452	449	440	431	418	3.38
10.0	368	366	364	356	349	339	3.75
11.0	304	302	301	294	288	280	4.13
12.0	256	254	253	247	242	235	4.50
13.0	218	217	215	211	206	200	4.88
14.0	188	187	186	182	178	173	5.25
15.0	164	163	162	158	155	150	5.63
16.0	144	143	142	139	136	132	6.00
17.0	127	127	126	123	121	117	6.38
18.0	114	113	112	110	108	104	6.75
19.0	102	101	101	99	97	94	7.13
20.0	92	91	91	89	87	85	7.50

Table D-2.1. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) WITH APPLIED AXIAL LOADS (Clamped-Clamped) (cont)



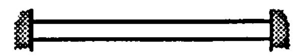
NPS = 4 in
D_o = 4.5 in
E = 28831000 lb/in²

P/P_b = .75
λ = 4.730041
μ = 489.535 lb/ft³

t (in)	0.125	0.156	0.188	0.219	0.237	0.250	
D_i (in)	4.250	4.188	4.124	4.062	4.026	4.000	
W(lb/ft)	5.84	7.24	8.66	10.01	10.79	11.35	
L/D_o	f_n	f_n	f_n	f_n	f_n	f_n	L (ft)
5.0	1079	1071	1064	1056	1052	1049	1.88
6.0	749	744	739	734	731	729	2.25
7.0	550	547	543	539	537	535	2.63
8.0	421	418	416	413	411	410	3.00
9.0	333	331	328	326	325	324	3.38
10.0	270	268	266	264	263	262	3.75
11.0	223	221	220	218	217	217	4.13
12.0	187	186	185	183	183	182	4.50
13.0	160	158	157	156	156	155	4.88
14.0	138	137	136	135	134	134	5.25
15.0	120	119	118	117	117	117	5.63
16.0	105	105	104	103	103	102	6.00
17.0	93	93	92	91	91	91	6.38
18.0	83	83	82	82	81	81	6.75
19.0	75	74	74	73	73	73	7.13
20.0	67	67	66	66	66	66	7.50

t (in)	0.281	0.312	0.337	0.438	0.531	0.674	
D_i (in)	3.938	3.876	3.826	3.624	3.438	3.152	
W(lb/ft)	12.66	13.96	14.98	19.00	22.51	27.54	
L/D_o	f_n	f_n	f_n	f_n	f_n	f_n	L (ft)
5.0	1042	1035	1029	1007	987	957	1.88
6.0	724	719	715	699	685	665	2.25
7.0	532	528	525	514	504	489	2.63
8.0	407	404	402	393	386	374	3.00
9.0	322	319	318	311	305	296	3.38
10.0	261	259	257	252	247	239	3.75
11.0	215	214	213	208	204	198	4.13
12.0	181	180	179	175	171	166	4.50
13.0	154	153	152	149	146	142	4.88
14.0	133	132	131	128	126	122	5.25
15.0	116	115	114	112	110	106	5.63
16.0	102	101	101	98	96	94	6.00
17.0	90	90	89	87	85	83	6.38
18.0	80	80	79	78	76	74	6.75
19.0	72	72	71	70	68	66	7.13
20.0	65	65	64	63	62	60	7.50

Table D-2.1. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) WITH APPLIED AXIAL LOADS (Clamped-Clamped) (cont)



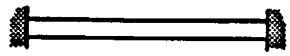
NPS = 5 in
D_o = 5.563 in
E = 28831000 lb/in^2

P/P_b = .25
λ = 4.730041
μ = 489.535 lb/ft^3

t (in)	**0.156**	**0.188**	**0.219**	**0.258**	**0.281**	**0.312**	
D_i (in)	**5.251**	**5.187**	**5.125**	**5.047**	**5.001**	**4.939**	
W(lb/ft)	**9.01**	**10.79**	**12.50**	**14.62**	**15.85**	**17.50**	
L/D_o	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**L (ft)**
5.0	1511	1502	1494	1484	1477	1469	2.32
6.0	1049	1043	1037	1030	1026	1020	2.78
7.0	771	766	762	757	754	750	3.25
8.0	590	587	584	580	577	574	3.71
9.0	466	464	461	458	456	453	4.17
10.0	378	376	373	371	369	367	4.64
11.0	312	310	309	307	305	304	5.10
12.0	262	261	259	258	257	255	5.56
13.0	224	222	221	219	219	217	6.03
14.0	193	192	191	189	188	187	6.49
15.0	168	167	166	165	164	163	6.95
16.0	148	147	146	145	144	143	7.42
17.0	131	130	129	128	128	127	7.88
18.0	117	116	115	114	114	113	8.34
19.0	105	104	103	103	102	102	8.81
20.0	94	94	93	93	92	92	9.27

t (in)	**0.344**	**0.375**	**0.500**	**0.625**	**0.750**	
D_i (in)	**4.875**	**4.813**	**4.563**	**4.313**	**4.063**	
W(lb/ft)	**19.17**	**20.78**	**27.04**	**32.96**	**38.55**	
L/D_o	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**L (ft)**
5.0	1461	1453	1421	1390	1361	2.32
6.0	1015	1009	987	966	945	2.78
7.0	745	741	725	709	694	3.25
8.0	571	568	555	543	531	3.71
9.0	451	448	439	429	420	4.17
10.0	365	363	355	348	340	4.64
11.0	302	300	294	287	281	5.10
12.0	254	252	247	241	236	5.56
13.0	216	215	210	206	201	6.03
14.0	186	185	181	177	174	6.49
15.0	162	161	158	154	151	6.95
16.0	143	142	139	136	133	7.42
17.0	126	126	123	120	118	7.88
18.0	113	112	110	107	105	8.34
19.0	101	101	98	96	94	8.81
20.0	91	91	89	87	85	9.27

Table D-2.1. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) WITH APPLIED AXIAL LOADS (Clamped-Clamped) (cont)



NPS = 5 in
D_o = 5.563 in
E = 28831000 lb/in^2

P/P_b = .50
λ = 4.730041
μ = 489.535 lb/ft^3

t (in)	0.156	0.188	0.219	0.258	0.281	0.312	
D_i (in)	5.251	5.187	5.125	5.047	5.001	4.939	
W(lb/ft)	9.01	10.79	12.50	14.62	15.85	17.50	
L/D_o	f_n	f_n	f_n	f_n	f_n	f_n	L (ft)
5.0	1234	1227	1220	1211	1206	1200	2.32
6.0	857	852	847	841	838	833	2.78
7.0	629	626	622	618	615	612	3.25
8.0	482	479	476	473	471	469	3.71
9.0	381	379	376	374	372	370	4.17
10.0	308	307	305	303	302	300	4.64
11.0	255	253	252	250	249	248	5.10
12.0	214	213	212	210	209	208	5.56
13.0	182	181	180	179	178	177	6.03
14.0	157	156	156	155	154	153	6.49
15.0	137	136	136	135	134	133	6.95
16.0	120	120	119	118	118	117	7.42
17.0	107	106	106	105	104	104	7.88
18.0	95	95	94	93	93	93	8.34
19.0	85	85	84	84	84	83	8.81
20.0	77	77	76	76	75	75	9.27

t (in)	0.344	0.375	0.500	0.625	0.750	
D_i (in)	4.875	4.813	4.563	4.313	4.063	
W(lb/ft)	19.17	20.78	27.04	32.96	38.55	
L/D_o	f_n	f_n	f_n	f_n	f_n	L (ft)
5.0	1193	1186	1160	1135	1111	2.32
6.0	828	824	806	788	771	2.78
7.0	609	605	592	579	567	3.25
8.0	466	463	453	443	434	3.71
9.0	368	366	358	350	343	4.17
10.0	298	297	290	284	278	4.64
11.0	246	245	240	235	230	5.10
12.0	207	206	201	197	193	5.56
13.0	176	175	172	168	164	6.03
14.0	152	151	148	145	142	6.49
15.0	133	132	129	126	123	6.95
16.0	116	116	113	111	108	7.42
17.0	103	103	100	98	96	7.88
18.0	92	92	90	88	86	8.34
19.0	83	82	80	79	77	8.81
20.0	75	74	73	71	69	9.27

Table D-2.1. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) WITH APPLIED AXIAL LOADS (Clamped-Clamped) (cont)

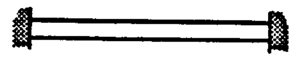
NPS = 5 in
D_o = 5.563 in
E = 28831000 lb/in^2

P/P_b = .75
λ = 4.730041
μ = 489.535 lb/ft^3

t (in)	0.156	0.188	0.219	0.258	0.281	0.312	
D_i (in)	5.251	5.187	5.125	5.047	5.001	4.939	
W(lb/ft)	9.01	10.79	12.50	14.62	15.85	17.50	
L/D_o	f_n	f_n	f_n	f_n	f_n	f_n	L (ft)
5.0	872	867	863	857	853	848	2.32
6.0	606	602	599	595	592	589	2.78
7.0	445	443	440	437	435	433	3.25
8.0	341	339	337	335	333	331	3.71
9.0	269	268	266	264	263	262	4.17
10.0	218	217	216	214	213	212	4.64
11.0	180	179	178	177	176	175	5.10
12.0	151	151	150	149	148	147	5.56
13.0	129	128	128	127	126	125	6.03
14.0	111	111	110	109	109	108	6.49
15.0	97	96	96	95	95	94	6.95
16.0	85	85	84	84	83	83	7.42
17.0	75	75	75	74	74	73	7.88
18.0	67	67	67	66	66	65	8.34
19.0	60	60	60	59	59	59	8.81
20.0	55	54	54	54	53	53	9.27

t (in)	0.344	0.375	0.500	0.625	0.750	
D_i (in)	4.875	4.813	4.563	4.313	4.063	
W(lb/ft)	19.17	20.78	27.04	32.96	38.55	
L/D_o	f_n	f_n	f_n	f_n	f_n	L (ft)
5.0	843	839	820	803	786	2.32
6.0	586	583	570	557	546	2.78
7.0	430	428	419	410	401	3.25
8.0	329	328	321	314	307	3.71
9.0	260	259	253	248	242	4.17
10.0	211	210	205	201	196	4.64
11.0	174	173	170	166	162	5.10
12.0	146	146	142	139	136	5.56
13.0	125	124	121	119	116	6.03
14.0	108	107	105	102	100	6.49
15.0	94	93	91	89	87	6.95
16.0	82	82	80	78	77	7.42
17.0	73	73	71	69	68	7.88
18.0	65	65	63	62	61	8.34
19.0	58	58	57	56	54	8.81
20.0	53	52	51	50	49	9.27

Table D-2.1. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) WITH APPLIED AXIAL LOADS (Clamped-Clamped) (cont)



NPS = 6 in
D_o = 6.625 in
E = 28831000 lb/in^2

P/P_b = .25
λ = 4.730041
μ = 489.535 lb/ft^3

t (in)	0.188	0.219	0.250	0.280	0.312	0.344	
D_i (in)	6.249	6.187	6.125	6.065	6.001	5.937	
W(lb/ft)	12.92	14.98	17.02	18.97	21.04	23.08	
L/D_o	f_n	f_n	f_n	f_n	f_n	f_n	L (ft)
5.0	1268	1262	1257	1251	1245	1239	2.76
6.0	881	877	873	869	864	860	3.31
7.0	647	644	641	638	635	632	3.86
8.0	495	493	491	489	486	484	4.42
9.0	391	390	388	386	384	382	4.97
10.0	317	316	314	313	311	310	5.52
11.0	262	261	260	258	257	256	6.07
12.0	220	219	218	217	216	215	6.63
13.0	188	187	186	185	184	183	7.18
14.0	162	161	160	160	159	158	7.73
15.0	141	140	140	139	138	138	8.28
16.0	124	123	123	122	122	121	8.83
17.0	110	109	109	108	108	107	9.39
18.0	98	97	97	97	96	96	9.94
19.0	88	87	87	87	86	86	10.49
20.0	79	79	79	78	78	77	11.04

t (in)	0.375	0.432	0.562	0.719	0.864	
D_i (in)	5.875	5.761	5.501	5.187	4.897	
W(lb/ft)	25.03	28.57	36.39	45.35	53.16	
L/D_o	f_n	f_n	f_n	f_n	f_n	L (ft)
5.0	1233	1223	1199	1172	1147	2.76
6.0	856	849	833	814	797	3.31
7.0	629	624	612	598	585	3.86
8.0	482	478	468	458	448	4.42
9.0	381	377	370	362	354	4.97
10.0	308	306	300	293	287	5.52
11.0	255	253	248	242	237	6.07
12.0	214	212	208	203	199	6.63
13.0	182	181	177	173	170	7.18
14.0	157	156	153	149	146	7.73
15.0	137	136	133	130	127	8.28
16.0	120	119	117	114	112	8.83
17.0	107	106	104	101	99	9.39
18.0	95	94	93	90	89	9.94
19.0	85	85	83	81	79	10.49
20.0	77	76	75	73	72	11.04

Table D-2.1. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) WITH APPLIED AXIAL LOADS (Clamped-Clamped) (cont)

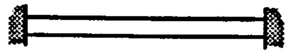
NPS = 6 in
D_o = 6.625 in
E = 28831000 lb/in^2

P/P_b = .50
λ = 4.730041
μ = 489.535 lb/ft^3

t (in)	**0.188**	**0.219**	**0.250**	**0.280**	**0.312**	**0.344**	
D_i (in)	**6.249**	**6.187**	**6.125**	**6.065**	**6.001**	**5.937**	
W(lb/ft)	**12.92**	**14.98**	**17.02**	**18.97**	**21.04**	**23.08**	
L/D_o	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	L (ft)
5.0	1036	1031	1026	1021	1016	1012	2.76
6.0	719	716	712	709	706	702	3.31
7.0	528	526	523	521	519	516	3.86
8.0	405	403	401	399	397	395	4.42
9.0	320	318	317	315	314	312	4.97
10.0	259	258	256	255	254	253	5.52
11.0	214	213	212	211	210	209	6.07
12.0	180	179	178	177	176	176	6.63
13.0	153	152	152	151	150	150	7.18
14.0	132	131	131	130	130	129	7.73
15.0	115	115	114	113	113	112	8.28
16.0	101	101	100	100	99	99	8.83
17.0	90	89	89	88	88	88	9.39
18.0	80	80	79	79	78	78	9.94
19.0	72	71	71	71	70	70	10.49
20.0	65	64	64	64	64	63	11.04

t (in)	**0.375**	**0.432**	**0.562**	**0.719**	**0.864**	
D_i (in)	**5.875**	**5.761**	**5.501**	**5.187**	**4.897**	
W(lb/ft)	**25.03**	**28.57**	**36.39**	**45.35**	**53.16**	
L/D_o	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	L (ft)
5.0	1007	998	979	957	937	2.76
6.0	699	693	680	664	651	3.31
7.0	514	509	500	488	478	3.86
8.0	393	390	382	374	366	4.42
9.0	311	308	302	295	289	4.97
10.0	252	250	245	239	234	5.52
11.0	208	206	202	198	194	6.07
12.0	175	173	170	166	163	6.63
13.0	149	148	145	142	139	7.18
14.0	128	127	125	122	119	7.73
15.0	112	111	109	106	104	8.28
16.0	98	97	96	93	91	8.83
17.0	87	86	85	83	81	9.39
18.0	78	77	76	74	72	9.94
19.0	70	69	68	66	65	10.49
20.0	63	62	61	60	59	11.04

Table D-2.1. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) WITH APPLIED AXIAL LOADS (Clamped-Clamped) (cont)



NPS = 6 in
D_o = 6.625 in
E = 28831000 lb/in^2

P/P_b = .75
λ = 4.730041
μ = 489.535 lb/ft^3

t (in)	0.188	0.219	0.250	0.280	0.312	0.344	
D_i (in)	6.249	6.187	6.125	6.065	6.001	5.937	
W(lb/ft)	12.92	14.98	17.02	18.97	21.04	23.08	
L/D_o	f_n	f_n	f_n	f_n	f_n	f_n	L (ft))
5.0	732	729	725	722	719	715	2.76
6.0	509	506	504	502	499	497	3.31
7.0	374	372	370	368	367	365	3.86
8.0	286	285	283	282	281	279	4.42
9.0	226	225	224	223	222	221	4.97
10.0	183	182	181	181	180	179	5.52
11.0	151	151	150	149	148	148	6.07
12.0	127	127	126	125	125	124	6.63
13.0	108	108	107	107	106	106	7.18
14.0	93	93	93	92	92	91	7.73
15.0	81	81	81	80	80	79	8.28
16.0	72	71	71	71	70	70	8.83
17.0	63	63	63	62	62	62	9.39
18.0	57	56	56	56	55	55	9.94
19.0	51	50	50	50	50	50	10.49
20.0	46	46	45	45	45	45	11.04

t (in)	0.375	0.432	0.562	0.719	0.864	
D_i (in)	5.875	5.761	5.501	5.187	4.897	
W(lb/ft)	25.03	28.57	36.39	45.35	53.16	
L/D_o	f_n	f_n	f_n	f_n	f_n	L (ft)
5.0	712	706	692	677	662	2.76
6.0	494	490	481	470	460	3.31
7.0	363	360	353	345	338	3.86
8.0	278	276	270	264	259	4.42
9.0	220	218	214	209	204	4.97
10.0	178	176	173	169	166	5.52
11.0	147	146	143	140	137	6.07
12.0	124	123	120	117	115	6.63
13.0	105	104	102	100	98	7.18
14.0	91	90	88	86	84	7.73
15.0	79	78	77	75	74	8.28
16.0	70	69	68	66	65	8.83
17.0	62	61	60	59	57	9.39
18.0	55	54	53	52	51	9.94
19.0	49	49	48	47	46	10.49
20.0	44	44	43	42	41	11.04

Table D-2.1. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) WITH APPLIED AXIAL LOADS (Clamped-Clamped) (cont)

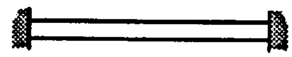
NPS = 8 in
D_o = 8.625 in
E = 28831000 lb/in^2

P/P_b = .25
λ = 4.730041
μ = 489.535 lb/ft^3

t (in)	**0.188**	**0.203**	**0.219**	**0.250**	**0.277**	**0.312**	
D_i (in)	**8.249**	**8.219**	**8.187**	**8.125**	**8.071**	**8.001**	
W(lb/ft)	**16.94**	**18.26**	**19.66**	**22.36**	**24.70**	**27.70**	
L/D_o	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**L (ft)**
5.0	981	979	977	974	971	967	3.59
6.0	681	680	679	676	674	671	4.31
7.0	500	499	499	497	495	493	5.03
8.0	383	382	382	380	379	378	5.75
9.0	303	302	302	301	300	298	6.47
10.0	245	245	244	243	243	242	7.19
11.0	203	202	202	201	201	200	7.91
12.0	170	170	170	169	169	168	8.63
13.0	145	145	145	144	144	143	9.34
14.0	125	125	125	124	124	123	10.06
15.0	109	109	109	108	108	107	10.78
16.0	96	96	95	95	95	94	11.50
17.0	85	85	85	84	84	84	12.22
18.0	76	76	75	75	75	75	12.94
19.0	68	68	68	67	67	67	13.66
20.0	61	61	61	61	61	60	14.38

t (in)	**0.322**	**0.344**	**0.375**	**0.406**	**0.438**	**0.500**	
D_i (in)	**7.981**	**7.937**	**7.875**	**7.813**	**7.749**	**7.625**	
W(lb/ft)	**28.55**	**30.42**	**33.04**	**35.64**	**38.30**	**43.39**	
L/D_o	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**L (ft)**
5.0	966	963	960	956	953	946	3.59
6.0	671	669	666	664	662	657	4.31
7.0	493	491	490	488	486	483	5.03
8.0	377	376	375	374	372	370	5.75
9.0	298	297	296	295	294	292	6.47
10.0	241	241	240	239	238	236	7.19
11.0	199	199	198	198	197	195	7.91
12.0	168	167	167	166	165	164	8.63
13.0	143	142	142	141	141	140	9.34
14.0	123	123	122	122	122	121	10.06
15.0	107	107	107	106	106	105	10.78
16.0	94	94	94	93	93	92	11.50
17.0	84	83	83	83	82	82	12.22
18.0	75	74	74	74	74	73	12.94
19.0	67	67	66	66	66	66	13.66
20.0	60	60	60	60	60	59	14.38

Table D-2.1. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) WITH APPLIED AXIAL LOADS (Clamped-Clamped) (cont)

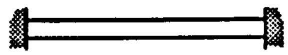


NPS = 8 in
D_o = 8.625 in
E = 28831000 lb/in^2

P/P_b = .25
λ = 4.730041
μ = 489.535 lb/ft^3

t (in)	**0.594**	**0.719**	**0.812**	**0.875**	**0.906**	
D_i (in)	**7.437**	**7.187**	**7.001**	**6.875**	**6.813**	
W(lb/ft)	**50.95**	**60.71**	**67.76**	**72.42**	**74.69**	
L/D_o	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	L (ft)
5.0	936	922	913	906	903	3.59
6.0	650	641	634	629	627	4.31
7.0	477	471	466	462	461	5.03
8.0	366	360	357	354	353	5.75
9.0	289	285	282	280	279	6.47
10.0	234	231	228	227	226	7.19
11.0	193	191	189	187	187	7.91
12.0	162	160	158	157	157	8.63
13.0	138	136	135	134	134	9.34
14.0	119	118	116	116	115	10.06
15.0	104	102	101	101	100	10.78
16.0	91	90	89	89	88	11.50
17.0	81	80	79	78	78	12.22
18.0	72	71	70	70	70	12.94
19.0	65	64	63	63	63	13.66
20.0	58	58	57	57	56	14.38

Table D-2.1. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) WITH APPLIED AXIAL LOADS (Clamped-Clamped) (cont)



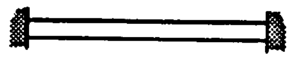
NPS = 8 in
D_o = 8.625 in
E = 28831000 lb/in^2

P/P_b = .50
λ = 4.730041
μ = 489.535 lb/ft^3

t (in)	**0.188**	**0.203**	**0.219**	**0.250**	**0.277**	**0.312**	
D_i (in)	**8.249**	**8.219**	**8.187**	**8.125**	**8.071**	**8.001**	
W(lb/ft)	**16.94**	**18.26**	**19.66**	**22.36**	**24.70**	**27.70**	
L/D_o	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**L (ft)**
5.0	801	799	798	795	792	789	3.59
6.0	556	555	554	552	550	548	4.31
7.0	409	408	407	406	404	403	5.03
8.0	313	312	312	311	310	308	5.75
9.0	247	247	246	245	245	244	6.47
10.0	200	200	199	199	198	197	7.19
11.0	165	165	165	164	164	163	7.91
12.0	139	139	139	138	138	137	8.63
13.0	118	118	118	118	117	117	9.34
14.0	102	102	102	101	101	101	10.06
15.0	89	89	89	88	88	88	10.78
16.0	78	78	78	78	77	77	11.50
17.0	69	69	69	69	69	68	12.22
18.0	62	62	62	61	61	61	12.94
19.0	55	55	55	55	55	55	13.66
20.0	50	50	50	50	50	49	14.38

t (in)	**0.322**	**0.344**	**0.375**	**0.406**	**0.438**	**0.500**	
D_i (in)	**7.981**	**7.937**	**7.875**	**7.813**	**7.749**	**7.625**	
W(lb/ft)	**28.55**	**30.42**	**33.04**	**35.64**	**38.30**	**43.39**	
L/D_o	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**L (ft)**
5.0	788	786	784	781	778	772	3.59
6.0	547	546	544	542	540	536	4.31
7.0	402	401	400	398	397	394	5.03
8.0	308	307	306	305	304	302	5.75
9.0	243	243	242	241	240	238	6.47
10.0	197	197	196	195	194	193	7.19
11.0	163	162	162	161	161	160	7.91
12.0	137	137	136	136	135	134	8.63
13.0	117	116	116	115	115	114	9.34
14.0	101	100	100	100	99	99	10.06
15.0	88	87	87	87	86	86	10.78
16.0	77	77	77	76	76	75	11.50
17.0	68	68	68	68	67	67	12.22
18.0	61	61	60	60	60	60	12.94
19.0	55	54	54	54	54	53	13.66
20.0	49	49	49	49	49	48	14.38

Table D-2.1. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) WITH APPLIED AXIAL LOADS (Clamped-Clamped) (cont)

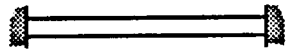


NPS = 8 in
D_o = 8.625 in
E = 28831000 lb/in^2

P/P_b = .50
λ = 4.730041
μ = 489.535 lb/ft^3

t (in)	**0.594**	**0.719**	**0.812**	**0.875**	**0.906**	
D_i (in)	**7.437**	**7.187**	**7.001**	**6.875**	**6.813**	
W(lb/ft)	**50.95**	**60.71**	**67.76**	**72.42**	**74.69**	
L/D_o	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**L (ft)**
5.0	764	753	745	740	737	3.59
6.0	531	523	518	514	512	4.31
7.0	390	384	380	378	376	5.03
8.0	298	294	291	289	288	5.75
9.0	236	232	230	228	228	6.47
10.0	191	188	186	185	184	7.19
11.0	158	156	154	153	152	7.91
12.0	133	131	129	128	128	8.63
13.0	113	111	110	109	109	9.34
14.0	97	96	95	94	94	10.06
15.0	85	84	83	82	82	10.78
16.0	75	74	73	72	72	11.50
17.0	66	65	64	64	64	12.22
18.0	59	58	58	57	57	12.94
19.0	53	52	52	51	51	13.66
20.0	48	47	47	46	46	14.38

Table D-2.1. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) WITH APPLIED AXIAL LOADS (Clamped-Clamped) (cont)



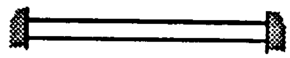
NPS = 8 in
D_o = 8.625 in
E = 28831000 lb/in^2

P/P_b = .75
λ = 4.730041
μ = 489.535 lb/ft^3

t (in)	0.188	0.203	0.219	0.250	0.277	0.312	
D_i (in)	8.249	8.219	8.187	8.125	8.071	8.001	
W(lb/ft)	16.94	18.26	19.66	22.36	24.70	27.70	
L/D_o	f_n	f_n	f_n	f_n	f_n	f_n	L (ft)
5.0	566	565	564	562	560	558	3.59
6.0	393	392	392	390	389	388	4.31
7.0	289	288	288	287	286	285	5.03
8.0	221	221	220	220	219	218	5.75
9.0	175	174	174	173	173	172	6.47
10.0	142	141	141	141	140	140	7.19
11.0	117	117	117	116	116	115	7.91
12.0	98	98	98	98	97	97	8.63
13.0	84	84	83	83	83	83	9.34
14.0	72	72	72	72	71	71	10.06
15.0	63	63	63	62	62	62	10.78
16.0	55	55	55	55	55	55	11.50
17.0	49	49	49	49	48	48	12.22
18.0	44	44	44	43	43	43	12.94
19.0	39	39	39	39	39	39	13.66
20.0	35	35	35	35	35	35	14.38

t (in)	0.322	0.344	0.375	0.406	0.438	0.500	
D_i (in)	7.981	7.937	7.875	7.813	7.749	7.625	
W(lb/ft)	28.55	30.42	33.04	35.64	38.30	43.39	
L/D_o	f_n	f_n	f_n	f_n	f_n	f_n	L (ft)
5.0	557	556	554	552	550	546	3.59
6.0	387	386	385	383	382	379	4.31
7.0	284	284	283	282	281	279	5.03
8.0	218	217	216	216	215	213	5.75
9.0	172	172	171	170	170	169	6.47
10.0	139	139	139	138	138	137	7.19
11.0	115	115	114	114	114	113	7.91
12.0	97	97	96	96	95	95	8.63
13.0	82	82	82	82	81	81	9.34
14.0	71	71	71	70	70	70	10.06
15.0	62	62	62	61	61	61	10.78
16.0	54	54	54	54	54	53	11.50
17.0	48	48	48	48	48	47	12.22
18.0	43	43	43	43	42	42	12.94
19.0	39	39	38	38	38	38	13.66
20.0	35	35	35	35	34	34	14.38

Table D-2.1. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) WITH APPLIED AXIAL LOADS (Clamped-Clamped) (cont)

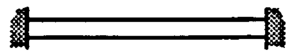


NPS = 8 in
D_o = 8.625 in
E = 28831000 lb/in^2

P/P_b = .75
λ = 4.730041
μ = 489.535 lb/ft^3

t (in)	**0.594**	**0.719**	**0.812**	**0.875**	**0.906**	
D_i (in)	**7.437**	**7.187**	**7.001**	**6.875**	**6.813**	
W(lb/ft)	**50.95**	**60.71**	**67.76**	**72.42**	**74.69**	
L/D_o	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	L (ft)
5.0	540	533	527	523	521	3.59
6.0	375	370	366	363	362	4.31
7.0	276	272	269	267	266	5.03
8.0	211	208	206	204	204	5.75
9.0	167	164	163	161	161	6.47
10.0	135	133	132	131	130	7.19
11.0	112	110	109	108	108	7.91
12.0	94	92	91	91	91	8.63
13.0	80	79	78	77	77	9.34
14.0	69	68	67	67	67	10.06
15.0	60	59	59	58	58	10.78
16.0	53	52	51	51	51	11.50
17.0	47	46	46	45	45	12.22
18.0	42	41	41	40	40	12.94
19.0	37	37	36	36	36	13.66
20.0	34	33	33	33	33	14.38

Table D-2.1. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) WITH APPLIED AXIAL LOADS (Clamped-Clamped) (cont)



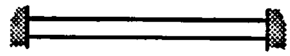
NPS = 10 in
D_o = 10.75 in
E = 28831000 lb/in^2

P/P_b = .25
λ = 4.730041
μ = 489.535 lb/ft^3

t (in)	**0.188**	**0.203**	**0.219**	**0.250**	**0.279**	**0.307**	
D_i (in)	**10.374**	**10.344**	**10.312**	**10.25**	**10.192**	**10.136**	
W(lb/ft)	**21.21**	**22.87**	**24.63**	**28.04**	**31.20**	**34.24**	
L/D_o	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**L (ft)**
5.0	790	789	788	786	784	781	4.48
6.0	549	548	547	546	544	543	5.38
7.0	403	403	402	401	400	399	6.27
8.0	309	308	308	307	306	305	7.17
9.0	244	244	243	242	242	241	8.06
10.0	198	197	197	196	196	195	8.96
11.0	163	163	163	162	162	161	9.85
12.0	137	137	137	136	136	136	10.75
13.0	117	117	117	116	116	116	11.65
14.0	101	101	100	100	100	100	12.54
15.0	88	88	88	87	87	87	13.44
16.0	77	77	77	77	77	76	14.33
17.0	68	68	68	68	68	68	15.23
18.0	61	61	61	61	60	60	16.13
19.0	55	55	55	54	54	54	17.02
20.0	49	49	49	49	49	49	17.92

t (in)	**0.344**	**0.365**	**0.438**	**0.500**	**0.594**	**0.719**	
D_i (in)	**10.062**	**10.02**	**9.874**	**9.75**	**9.562**	**9.312**	
W(lb/ft)	**38.23**	**40.48**	**48.24**	**54.74**	**64.43**	**77.03**	
L/D_o	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**L (ft)**
5.0	779	777	772	768	761	752	4.48
6.0	541	540	536	533	528	522	5.38
7.0	397	397	394	392	388	384	6.27
8.0	304	304	302	300	297	294	7.17
9.0	240	240	238	237	235	232	8.06
10.0	195	194	193	192	190	188	8.96
11.0	161	161	160	159	157	155	9.85
12.0	135	135	134	133	132	131	10.75
13.0	115	115	114	114	113	111	11.65
14.0	99	99	98	98	97	96	12.54
15.0	87	86	86	85	85	84	13.44
16.0	76	76	75	75	74	73	14.33
17.0	67	67	67	66	66	65	15.23
18.0	60	60	60	59	59	58	16.13
19.0	54	54	53	53	53	52	17.02
20.0	49	49	48	48	48	47	17.92

Table D-2.1. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) WITH APPLIED AXIAL LOADS (Clamped-Clamped) (cont)

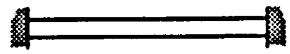


NPS = 10 in
D_o = 10.75 in
E = 28831000 lb/in^2

P/P_b = .25
λ = 4.730041
μ = 489.535 lb/ft^3

t (in)	**0.844**	**1.000**	**1.125**	
D_i (in)	**9.062**	**8.75**	**8.5**	
W(lb/ft)	**89.29**	**104.13**	**115.64**	
L/D_o	**f_n**	**f_n**	**f_n**	**L (ft)**
5.0	744	733	725	4.48
6.0	516	509	503	5.38
7.0	379	374	370	6.27
8.0	290	286	283	7.17
9.0	230	226	224	8.06
10.0	186	183	181	8.96
11.0	154	151	150	9.85
12.0	129	127	126	10.75
13.0	110	108	107	11.65
14.0	95	94	92	12.54
15.0	83	81	81	13.44
16.0	73	72	71	14.33
17.0	64	63	63	15.23
18.0	57	57	56	16.13
19.0	52	51	50	17.02
20.0	46	46	45	17.92

Table D-2.1. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) WITH APPLIED AXIAL LOADS (Clamped-Clamped) (cont)



NPS = 10 in
D_o = 10.75 in
E = 28831000 lb/in^2

P/P_b = .50
λ = 4.730041
μ = 489.535 lb/ft^3

t (in)	**0.188**	**0.203**	**0.219**	**0.250**	**0.279**	**0.307**	
D_i (in)	**10.374**	**10.344**	**10.312**	**10.25**	**10.192**	**10.136**	
W(lb/ft)	**21.21**	**22.87**	**24.63**	**28.04**	**31.20**	**34.24**	
L/D_o	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**L (ft)**
5.0	645	644	643	641	640	638	4.48
6.0	448	447	447	445	444	443	5.38
7.0	329	329	328	327	326	326	6.27
8.0	252	252	251	251	250	249	7.17
9.0	199	199	199	198	197	197	8.06
10.0	161	161	161	160	160	160	8.96
11.0	133	133	133	133	132	132	9.85
12.0	112	112	112	111	111	111	10.75
13.0	95	95	95	95	95	94	11.65
14.0	82	82	82	82	82	81	12.54
15.0	72	72	71	71	71	71	13.44
16.0	63	63	63	63	62	62	14.33
17.0	56	56	56	55	55	55	15.23
18.0	50	50	50	49	49	49	16.13
19.0	45	45	45	44	44	44	17.02
20.0	40	40	40	40	40	40	17.92

t (in)	**0.344**	**0.365**	**0.438**	**0.500**	**0.594**	**0.719**	
D_i (in)	**10.062**	**10.02**	**9.874**	**9.75**	**9.562**	**9.312**	
W(lb/ft)	**38.23**	**40.48**	**48.24**	**54.74**	**64.43**	**77.03**	
L/D_o	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**L (ft)**
5.0	636	635	630	627	621	614	4.48
6.0	442	441	438	435	431	427	5.38
7.0	324	324	322	320	317	313	6.27
8.0	248	248	246	245	243	240	7.17
9.0	196	196	195	193	192	190	8.06
10.0	159	159	158	157	155	154	8.96
11.0	131	131	130	129	128	127	9.85
12.0	110	110	109	109	108	107	10.75
13.0	94	94	93	93	92	91	11.65
14.0	81	81	80	80	79	78	12.54
15.0	71	71	70	70	69	68	13.44
16.0	62	62	62	61	61	60	14.33
17.0	55	55	55	54	54	53	15.23
18.0	49	49	49	48	48	47	16.13
19.0	44	44	44	43	43	43	17.02
20.0	40	40	39	39	39	38	17.92

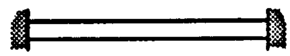
Table D-2.1. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) WITH APPLIED AXIAL LOADS (Clamped-Clamped) (cont)

NPS = 10 in
D_o = 10.75 in
E = 28831000 lb/in^2

P/P_b = .50
λ = 4.730041
μ = 489.535 lb/ft^3

t (in)	**0.844**	**1.000**	**1.125**	
D_i (in)	**9.062**	**8.75**	**8.5**	
W(lb/ft)	**89.29**	**104.13**	**115.64**	
L/D_o	**f_n**	**f_n**	**f_n**	**L (ft)**
5.0	607	599	592	4.48
6.0	422	416	411	5.38
7.0	310	305	302	6.27
8.0	237	234	231	7.17
9.0	187	185	183	8.06
10.0	152	150	148	8.96
11.0	125	124	122	9.85
12.0	105	104	103	10.75
13.0	90	89	88	11.65
14.0	77	76	75	12.54
15.0	67	67	66	13.44
16.0	59	58	58	14.33
17.0	53	52	51	15.23
18.0	47	46	46	16.13
19.0	42	41	41	17.02
20.0	38	37	37	17.92

Table D-2.1. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) WITH APPLIED AXIAL LOADS (Clamped-Clamped) (cont)



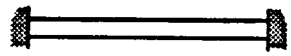
NPS = 10 in
D_o = 10.75 in
E = 28831000 lb/in^2

P/P_b = .75
λ = 4.730041
μ = 489.535 lb/ft^3

t (in)	0.188	0.203	0.219	0.250	0.279	0.307	
D_i (in)	10.374	10.344	10.312	10.25	10.192	10.136	
W(lb/ft)	21.21	22.87	24.63	28.04	31.20	34.24	
L/D_o	f_n	f_n	f_n	f_n	f_n	f_n	L (ft)
5.0	456	456	455	454	452	451	4.48
6.0	317	316	316	315	314	313	5.38
7.0	233	232	232	231	231	230	6.27
8.0	178	178	178	177	177	176	7.17
9.0	141	141	140	140	140	139	8.06
10.0	114	114	114	113	113	113	8.96
11.0	94	94	94	94	93	93	9.85
12.0	79	79	79	79	79	78	10.75
13.0	67	67	67	67	67	67	11.65
14.0	58	58	58	58	58	58	12.54
15.0	51	51	51	50	50	50	13.44
16.0	45	44	44	44	44	44	14.33
17.0	39	39	39	39	39	39	15.23
18.0	35	35	35	35	35	35	16.13
19.0	32	32	32	31	31	31	17.02
20.0	29	28	28	28	28	28	17.92

t (in)	0.344	0.365	0.438	0.500	0.594	0.719	
D_i (in)	10.062	10.02	9.874	9.75	9.562	9.312	
W(lb/ft)	38.23	40.48	48.24	54.74	64.43	77.03	
L/D_o	f_n	f_n	f_n	f_n	f_n	f_n	L (ft)
5.0	450	449	446	443	439	434	4.48
6.0	312	312	310	308	305	302	5.38
7.0	229	229	227	226	224	222	6.27
8.0	176	175	174	173	172	170	7.17
9.0	139	139	138	137	136	134	8.06
10.0	112	112	111	111	110	109	8.96
11.0	93	93	92	92	91	90	9.85
12.0	78	78	77	77	76	75	10.75
13.0	67	66	66	66	65	64	11.65
14.0	57	57	57	57	56	55	12.54
15.0	50	50	50	49	49	48	13.44
16.0	44	44	44	43	43	42	14.33
17.0	39	39	39	38	38	38	15.23
18.0	35	35	34	34	34	34	16.13
19.0	31	31	31	31	30	30	17.02
20.0	28	28	28	28	27	27	17.92

Table D-2.1. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) WITH APPLIED AXIAL LOADS (Clamped-Clamped) (cont)

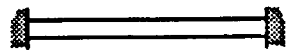


NPS = 10 in
D_o = 10.75 in
E = 28831000 lb/in^2

P/P_b = .75
λ = 4.730041
μ = 489.535 lb/ft^3

t (in)	**0.844**	**1.000**	**1.125**	
D_i (in)	**9.062**	**8.75**	**8.5**	
W(lb/ft)	**89.29**	**104.13**	**115.64**	
L/D_o	**f_n**	**f_n**	**f_n**	**L (ft)**
5.0	429	423	419	4.48
6.0	298	294	291	5.38
7.0	219	216	214	6.27
8.0	168	165	163	7.17
9.0	133	131	129	8.06
10.0	107	106	105	8.96
11.0	89	87	86	9.85
12.0	75	73	73	10.75
13.0	64	63	62	11.65
14.0	55	54	53	12.54
15.0	48	47	47	13.44
16.0	42	41	41	14.33
17.0	37	37	36	15.23
18.0	33	33	32	16.13
19.0	30	29	29	17.02
20.0	27	26	26	17.92

Table D-2.1. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) WITH APPLIED AXIAL LOADS (Clamped-Clamped) (cont)



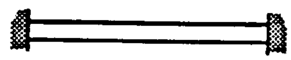
NPS = 12 in
D_o = 12.75 in
E = 28831000 lb/in^2

P/P_b = .25
λ = 4.730041
μ = 489.535 lb/ft^3

t (in)	**0.203**	**0.219**	**0.250**	**0.281**	**0.312**	**0.330**	
D_i (in)	**12.344**	**12.312**	**12.250**	**12.188**	**12.126**	**12.090**	
W(lb/ft)	**27.20**	**29.31**	**33.38**	**37.42**	**41.45**	**43.77**	
L/D_o	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**L (ft)**
5.0	667	666	665	663	662	661	5.31
6.0	463	463	462	461	459	459	6.38
7.0	340	340	339	338	338	337	7.44
8.0	261	260	260	259	258	258	8.50
9.0	206	206	205	205	204	204	9.56
10.0	167	167	166	166	165	165	10.63
11.0	138	138	137	137	137	137	11.69
12.0	116	116	115	115	115	115	12.75
13.0	99	99	98	98	98	98	13.81
14.0	85	85	85	85	84	84	14.88
15.0	74	74	74	74	74	73	15.94
16.0	65	65	65	65	65	65	17.00
17.0	58	58	58	57	57	57	18.06
18.0	51	51	51	51	51	51	19.13
19.0	46	46	46	46	46	46	20.19
20.0	42	42	42	41	41	41	21.25

t (in)	**0.344**	**0.375**	**0.406**	**0.438**	**0.500**	**0.562**	
D_i (in)	**12.062**	**12.000**	**11.938**	**11.874**	**11.750**	**11.626**	
W(lb/ft)	**45.58**	**49.56**	**53.52**	**57.59**	**65.42**	**73.15**	
L/D_o	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**L (ft)**
5.0	660	658	657	655	652	649	5.31
6.0	458	457	456	455	453	451	6.38
7.0	337	336	335	334	333	331	7.44
8.0	258	257	257	256	255	253	8.50
9.0	204	203	203	202	201	200	9.56
10.0	165	165	164	164	163	162	10.63
11.0	136	136	136	135	135	134	11.69
12.0	115	114	114	114	113	113	12.75
13.0	98	97	97	97	96	96	13.81
14.0	84	84	84	84	83	83	14.88
15.0	73	73	73	73	72	72	15.94
16.0	64	64	64	64	64	63	17.00
17.0	57	57	57	57	56	56	18.06
18.0	51	51	51	51	50	50	19.13
19.0	46	46	45	45	45	45	20.19
20.0	41	41	41	41	41	41	21.25

Table D-2.1. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) WITH APPLIED AXIAL LOADS (Clamped-Clamped) (cont)

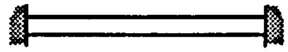


NPS = 12 in
D_o = 12.75 in
E = 28831000 lb/in^2

P/P_b = .25
λ = 4.730041
μ = 489.535 lb/ft^3

t (in)	**0.688**	**0.844**	**1.000**	**1.250**	**1.312**	
D_i (in)	**11.374**	**11.062**	**10.750**	**10.250**	**10.126**	
W(lb/ft)	**88.63**	**107.32**	**125.49**	**153.53**	**160.27**	
L/D_o	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**L (ft)**
5.0	642	635	627	615	612	5.31
6.0	446	441	435	427	425	6.38
7.0	328	324	320	314	312	7.44
8.0	251	248	245	240	239	8.50
9.0	198	196	194	190	189	9.56
10.0	161	159	157	154	153	10.63
11.0	133	131	130	127	126	11.69
12.0	112	110	109	107	106	12.75
13.0	95	94	93	91	91	13.81
14.0	82	81	80	78	78	14.88
15.0	71	71	70	68	68	15.94
16.0	63	62	61	60	60	17.00
17.0	56	55	54	53	53	18.06
18.0	50	49	48	47	47	19.13
19.0	44	44	43	43	42	20.19
20.0	40	40	39	38	38	21.25

Table D-2.1. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) WITH APPLIED AXIAL LOADS (Clamped-Clamped) (cont)



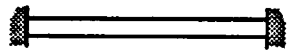
NPS = 12 in
D_o = 12.75 in
E = 28831000 lb/in^2

P/P_b = .50
λ = 4.730041
μ = 489.535 lb/ft^3

t (in)	0.203	0.219	0.250	0.281	0.312	0.330	
D_i (in)	12.344	12.312	12.250	12.188	12.126	12.090	
W(lb/ft)	27.20	29.31	33.38	37.42	41.45	43.77	
L/D_o	f_n	f_n	f_n	f_n	f_n	f_n	L (ft)
5.0	545	544	543	542	540	539	5.31
6.0	378	378	377	376	375	375	6.38
7.0	278	278	277	276	276	275	7.44
8.0	213	213	212	212	211	211	8.50
9.0	168	168	168	167	167	166	9.56
10.0	136	136	136	135	135	135	10.63
11.0	113	112	112	112	112	111	11.69
12.0	95	94	94	94	94	94	12.75
13.0	81	80	80	80	80	80	13.81
14.0	69	69	69	69	69	69	14.88
15.0	61	60	60	60	60	60	15.94
16.0	53	53	53	53	53	53	17.00
17.0	47	47	47	47	47	47	18.06
18.0	42	42	42	42	42	42	19.13
19.0	38	38	38	38	37	37	20.19
20.0	34	34	34	34	34	34	21.25

t (in)	0.344	0.375	0.406	0.438	0.500	0.562	
D_i (in)	12.062	12.000	11.938	11.874	11.750	11.626	
W(lb/ft)	45.58	49.56	53.52	57.59	65.42	73.15	
L/D_o	f_n	f_n	f_n	f_n	f_n	f_n	L (ft)
5.0	539	538	536	535	532	530	5.31
6.0	374	373	372	371	370	368	6.38
7.0	275	274	274	273	272	270	7.44
8.0	210	210	209	209	208	207	8.50
9.0	166	166	166	165	164	163	9.56
10.0	135	134	134	134	133	132	10.63
11.0	111	111	111	111	110	109	11.69
12.0	94	93	93	93	92	92	12.75
13.0	80	80	79	79	79	78	13.81
14.0	69	69	68	68	68	68	14.88
15.0	60	60	60	59	59	59	15.94
16.0	53	52	52	52	52	52	17.00
17.0	47	46	46	46	46	46	18.06
18.0	42	41	41	41	41	41	19.13
19.0	37	37	37	37	37	37	20.19
20.0	34	34	34	33	33	33	21.25

Table D-2.1. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) WITH APPLIED AXIAL LOADS (Clamped-Clamped) (cont)

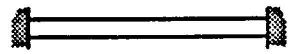


NPS = 12 in
D_o = 12.75 in
E = 28831000 lb/in^2

P/P_b = .50
λ = 4.730041
μ = 489.535 lb/ft^3

t (in)	0.688	0.844	1.000	1.250	1.312	
D_i (in)	11.374	11.062	10.750	10.250	10.126	
W(lb/ft)	88.63	107.32	125.49	153.53	160.27	
L/D_o	f_n	f_n	f_n	f_n	f_n	L (ft)
5.0	525	518	512	502	500	5.31
6.0	364	360	356	349	347	6.38
7.0	268	264	261	256	255	7.44
8.0	205	202	200	196	195	8.50
9.0	162	160	158	155	154	9.56
10.0	131	130	128	126	125	10.63
11.0	108	107	106	104	103	11.69
12.0	91	90	89	87	87	12.75
13.0	78	77	76	74	74	13.81
14.0	67	66	65	64	64	14.88
15.0	58	58	57	56	56	15.94
16.0	51	51	50	49	49	17.00
17.0	45	45	44	43	43	18.06
18.0	40	40	40	39	39	19.13
19.0	36	36	35	35	35	20.19
20.0	33	32	32	31	31	21.25

Table D-2.1. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) WITH APPLIED AXIAL LOADS (Clamped-Clamped) (cont)



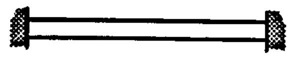
NPS = 12 in
D_o = 12.75 in
E = 28831000 lb/in^2

P/P_b = .75
λ = 4.730041
μ = 489.535 lb/ft^3

t (in)	0.203	0.219	0.250	0.281	0.312	0.330	
D_i (in)	12.344	12.312	12.250	12.188	12.126	12.090	
W(lb/ft)	27.20	29.31	33.38	37.42	41.45	43.77	
L/D_o	f_n	f_n	f_n	f_n	f_n	f_n	L (ft)
5.0	385	385	384	383	382	381	5.31
6.0	268	267	267	266	265	265	6.38
7.0	197	196	196	195	195	195	7.44
8.0	150	150	150	150	149	149	8.50
9.0	119	119	118	118	118	118	9.56
10.0	96	96	96	96	95	95	10.63
11.0	80	79	79	79	79	79	11.69
12.0	67	67	67	66	66	66	12.75
13.0	57	57	57	57	57	56	13.81
14.0	49	49	49	49	49	49	14.88
15.0	43	43	43	43	42	42	15.94
16.0	38	38	37	37	37	37	17.00
17.0	33	33	33	33	33	33	18.06
18.0	30	30	30	30	29	29	19.13
19.0	27	27	27	27	26	26	20.19
20.0	24	24	24	24	24	24	21.25

t (in)	0.344	0.375	0.406	0.438	0.500	0.562	
D_i (in)	12.062	12.000	11.938	11.874	11.750	11.626	
W(lb/ft)	45.58	49.56	53.52	57.59	65.42	73.15	
L/D_o	f_n	f_n	f_n	f_n	f_n	f_n	L (ft)
5.0	381	380	379	378	376	375	5.31
6.0	265	264	263	263	261	260	6.38
7.0	194	194	193	193	192	191	7.44
8.0	149	148	148	148	147	146	8.50
9.0	118	117	117	117	116	116	9.56
10.0	95	95	95	95	94	94	10.63
11.0	79	79	78	78	78	77	11.69
12.0	66	66	66	66	65	65	12.75
13.0	56	56	56	56	56	55	13.81
14.0	49	48	48	48	48	48	14.88
15.0	42	42	42	42	42	42	15.94
16.0	37	37	37	37	37	37	17.00
17.0	33	33	33	33	33	32	18.06
18.0	29	29	29	29	29	29	19.13
19.0	26	26	26	26	26	26	20.19
20.0	24	24	24	24	24	23	21.25

Table D-2.1. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) WITH APPLIED AXIAL LOADS (Clamped-Clamped) (cont)

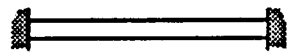


NPS = 12 in
D_o = 12.75 in
E = 28831000 lb/in^2

P/P_b = .75
λ = 4.730041
μ = 489.535 lb/ft^3

t (in)	**0.688**	**0.844**	**1.000**	**1.250**	**1.312**	
D_i (in)	**11.374**	**11.062**	**10.750**	**10.250**	**10.126**	
W(lb/ft)	**88.63**	**107.32**	**125.49**	**153.53**	**160.27**	
L/D_o	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**L (ft)**
5.0	371	366	362	355	353	5.31
6.0	258	254	251	247	245	6.38
7.0	189	187	185	181	180	7.44
8.0	145	143	141	139	138	8.50
9.0	114	113	112	110	109	9.56
10.0	93	92	91	89	88	10.63
11.0	77	76	75	73	73	11.69
12.0	64	64	63	62	61	12.75
13.0	55	54	54	53	52	13.81
14.0	47	47	46	45	45	14.88
15.0	41	41	40	39	39	15.94
16.0	36	36	35	35	35	17.00
17.0	32	32	31	31	31	18.06
18.0	29	28	28	27	27	19.13
19.0	26	25	25	25	24	20.19
20.0	23	23	23	22	22	21.25

Table D-2.1. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) WITH APPLIED AXIAL LOADS (Clamped-Clamped) (cont)



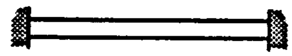
NPS = 14 in
D_o = 14.00 in
E = 28831000 lb/in^2

P/P_b = .25
λ = 4.730041
μ = 489.535 lb/ft^3

t (in)	**0.188**	**0.210**	**0.219**	**0.250**	**0.281**	**0.312**	
D_i (in)	**13.624**	**13.580**	**13.562**	**13.500**	**13.433**	**13.376**	
W(lb/ft)	**27.73**	**30.93**	**32.23**	**36.71**	**41.17**	**45.61**	
L/D_o	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**L (ft)**
5.0	609	608	608	607	605	604	5.83
6.0	423	422	422	421	420	419	7.00
7.0	311	310	310	309	309	308	8.17
8.0	238	238	237	237	236	236	9.33
9.0	188	188	188	187	187	186	10.50
10.0	152	152	152	152	151	151	11.67
11.0	126	126	126	125	125	125	12.83
12.0	106	106	106	105	105	105	14.00
13.0	90	90	90	90	90	89	15.17
14.0	78	78	78	77	77	77	16.33
15.0	68	68	68	67	67	67	17.50
16.0	59	59	59	59	59	59	18.67
17.0	53	53	53	52	52	52	19.83
18.0	47	47	47	47	47	47	21.00
19.0	42	42	42	42	42	42	22.17
20.0	38	38	38	38	38	38	23.33

t (in)	**0.344**	**0.375**	**0.406**	**0.438**	**0.469**	**0.500**	
D_i (in)	**13.312**	**13.250**	**13.188**	**13.124**	**13.062**	**13.000**	
W(lb/ft)	**50.17**	**54.57**	**58.94**	**63.44**	**67.78**	**72.09**	
L/D_o	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**L (ft)**
5.0	602	601	600	598	597	596	5.83
6.0	418	417	417	416	415	414	7.00
7.0	307	307	306	305	305	304	8.17
8.0	235	235	234	234	233	233	9.33
9.0	186	186	185	185	184	184	10.50
10.0	151	150	150	150	149	149	11.67
11.0	124	124	124	124	123	123	12.83
12.0	105	104	104	104	104	103	14.00
13.0	89	89	89	89	88	88	15.17
14.0	77	77	77	76	76	76	16.33
15.0	67	67	67	66	66	66	17.50
16.0	59	59	59	58	58	58	18.67
17.0	52	52	52	52	52	52	19.83
18.0	46	46	46	46	46	46	21.00
19.0	42	42	42	41	41	41	22.17
20.0	38	38	37	37	37	37	23.33

Table D-2.1. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) WITH APPLIED AXIAL LOADS (Clamped-Clamped) (cont)



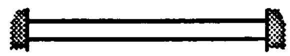
NPS = 14 in
D_o = 14.00 in
E = 28831000 lb/in^2

P/P_b = .25
λ = 4.730041
μ = 489.535 lb/ft^3

t (in)	0.562	0.625	0.688	0.750	0.812	0.875	
D_i (in)	12.876	12.750	12.624	12.500	12.376	12.250	
W(lb/ft)	80.66	89.28	97.81	106.13	114.37	122.65	
L/D_o	f_n	f_n	f_n	f_n	f_n	f_n	L (ft)
5.0	593	591	588	585	583	580	5.83
6.0	412	410	408	406	405	403	7.00
7.0	303	301	300	299	297	296	8.17
8.0	232	231	230	229	228	227	9.33
9.0	183	182	181	181	180	179	10.50
10.0	148	148	147	146	146	145	11.67
11.0	123	122	121	121	120	120	12.83
12.0	103	103	102	102	101	101	14.00
13.0	88	87	87	87	86	86	15.17
14.0	76	75	75	75	74	74	16.33
15.0	66	66	65	65	65	64	17.50
16.0	58	58	57	57	57	57	18.67
17.0	51	51	51	51	50	50	19.83
18.0	46	46	45	45	45	45	21.00
19.0	41	41	41	41	40	40	22.17
20.0	37	37	37	37	36	36	23.33

t (in)	0.938	1.000	1.062	1.125	
D_i (in)	12.124	12.000	11.876	11.750	
W(lb/ft)	130.85	138.84	146.74	154.69	
L/D_o	f_n	f_n	f_n	f_n	L (ft)
5.0	578	575	573	570	5.83
6.0	401	399	398	396	7.00
7.0	295	293	292	291	8.17
8.0	226	225	224	223	9.33
9.0	178	177	177	176	10.50
10.0	144	144	143	143	11.67
11.0	119	119	118	118	12.83
12.0	100	100	99	99	14.00
13.0	85	85	85	84	15.17
14.0	74	73	73	73	16.33
15.0	64	64	64	63	17.50
16.0	56	56	56	56	18.67
17.0	50	50	50	49	19.83
18.0	45	44	44	44	21.00
19.0	40	40	40	39	22.17
20.0	36	36	36	36	23.33

Table D-2.1. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) WITH APPLIED AXIAL LOADS (Clamped-Clamped) (cont)



NPS = 14 in
D_o = 14.00 in
E = 28831000 lb/in^2

P/P_b = .50
λ = 4.730041
μ = 489.535 lb/ft^3

t (in)	**0.188**	**0.210**	**0.219**	**0.250**	**0.281**	**0.312**	
D_i (in)	**13.624**	**13.580**	**13.562**	**13.500**	**13.433**	**13.376**	
W(lb/ft)	**27.73**	**30.93**	**32.23**	**36.71**	**41.17**	**45.61**	
L/D_o	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**L (ft)**
5.0	497	497	496	495	494	493	5.83
6.0	345	345	345	344	343	342	7.00
7.0	254	253	253	253	252	252	8.17
8.0	194	194	194	193	193	193	9.33
9.0	154	153	153	153	153	152	10.50
10.0	124	124	124	124	124	123	11.67
11.0	103	103	103	102	102	102	12.83
12.0	86	86	86	86	86	86	14.00
13.0	74	73	73	73	73	73	15.17
14.0	63	63	63	63	63	63	16.33
15.0	55	55	55	55	55	55	17.50
16.0	49	49	48	48	48	48	18.67
17.0	43	43	43	43	43	43	19.83
18.0	38	38	38	38	38	38	21.00
19.0	34	34	34	34	34	34	22.17
20.0	31	31	31	31	31	31	23.33

t (in)	**0.344**	**0.375**	**0.406**	**0.438**	**0.469**	**0.500**	
D_i (in)	**13.312**	**13.250**	**13.188**	**13.124**	**13.062**	**13.000**	
W(lb/ft)	**50.17**	**54.57**	**58.94**	**63.44**	**67.78**	**72.09**	
L/D_o	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**L (ft)**
5.0	492	491	490	489	488	486	5.83
6.0	342	341	340	339	339	338	7.00
7.0	251	250	250	249	249	248	8.17
8.0	192	192	191	191	190	190	9.33
9.0	152	151	151	151	150	150	10.50
10.0	123	123	122	122	122	122	11.67
11.0	102	101	101	101	101	101	12.83
12.0	85	85	85	85	85	84	14.00
13.0	73	73	72	72	72	72	15.17
14.0	63	63	62	62	62	62	16.33
15.0	55	55	54	54	54	54	17.50
16.0	48	48	48	48	48	48	18.67
17.0	43	42	42	42	42	42	19.83
18.0	38	38	38	38	38	38	21.00
19.0	34	34	34	34	34	34	22.17
20.0	31	31	31	31	30	30	23.33

Table D-2.1. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) WITH APPLIED AXIAL LOADS (Clamped-Clamped) (cont)

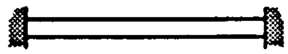
NPS = 14 in
D_o = 14.00 in
E = 28831000 lb/in^2

P/P_b = .50
λ = 4.730041
μ = 489.535 lb/ft^3

t (in)	0.562	0.625	0.688	0.750	0.812	0.875	
D_i (in)	12.876	12.750	12.624	12.500	12.376	12.250	
W(lb/ft)	80.66	89.28	97.81	106.13	114.37	122.65	
L/D_o	f_n	f_n	f_n	f_n	f_n	f_n	L (ft)
5.0	484	482	480	478	476	474	5.83
6.0	336	335	333	332	330	329	7.00
7.0	247	246	245	244	243	242	8.17
8.0	189	188	188	187	186	185	9.33
9.0	149	149	148	148	147	146	10.50
10.0	121	121	120	119	119	118	11.67
11.0	100	100	99	99	98	98	12.83
12.0	84	84	83	83	83	82	14.00
13.0	72	71	71	71	70	70	15.17
14.0	62	62	61	61	61	60	16.33
15.0	54	54	53	53	53	53	17.50
16.0	47	47	47	47	46	46	18.67
17.0	42	42	42	41	41	41	19.83
18.0	37	37	37	37	37	37	21.00
19.0	34	33	33	33	33	33	22.17
20.0	30	30	30	30	30	30	23.33

t (in)	0.938	1.000	1.062	1.125	
D_i (in)	12.124	12.000	11.876	11.750	
W(lb/ft)	130.85	138.84	146.74	154.69	
L/D_o	f_n	f_n	f_n	f_n	L (ft)
5.0	472	470	467	465	5.83
6.0	327	326	325	323	7.00
7.0	241	240	239	237	8.17
8.0	184	183	183	182	9.33
9.0	146	145	144	144	10.50
10.0	118	117	117	116	11.67
11.0	97	97	97	96	12.83
12.0	82	82	81	81	14.00
13.0	70	69	69	69	15.17
14.0	60	60	60	59	16.33
15.0	52	52	52	52	17.50
16.0	46	46	46	45	18.67
17.0	41	41	40	40	19.83
18.0	36	36	36	36	21.00
19.0	33	33	32	32	22.17
20.0	29	29	29	29	23.33

Table D-2.1. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) WITH APPLIED AXIAL LOADS (Clamped-Clamped) (cont)



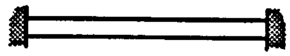
NPS = 14 in
D_o = 14.00 in
E = 28831000 lb/in^2

P/P_b = .75
λ = 4.730041
μ = 489.535 lb/ft^3

t (in)	**0.188**	**0.210**	**0.219**	**0.250**	**0.281**	**0.312**	
D_i (in)	**13.624**	**13.580**	**13.562**	**13.500**	**13.433**	**13.376**	
W(lb/ft)	**27.73**	**30.93**	**32.23**	**36.71**	**41.17**	**45.61**	
L/D_o	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**L (ft)**
5.0	352	351	351	350	349	349	5.83
6.0	244	244	244	243	243	242	7.00
7.0	179	179	179	179	178	178	8.17
8.0	137	137	137	137	136	136	9.33
9.0	109	108	108	108	108	108	10.50
10.0	88	88	88	88	87	87	11.67
11.0	73	73	73	72	72	72	12.83
12.0	61	61	61	61	61	61	14.00
13.0	52	52	52	52	52	52	15.17
14.0	45	45	45	45	45	44	16.33
15.0	39	39	39	39	39	39	17.50
16.0	34	34	34	34	34	34	18.67
17.0	30	30	30	30	30	30	19.83
18.0	27	27	27	27	27	27	21.00
19.0	24	24	24	24	24	24	22.17
20.0	22	22	22	22	22	22	23.33

t (in)	**0.344**	**0.375**	**0.406**	**0.438**	**0.469**	**0.500**	
D_i (in)	**13.312**	**13.250**	**13.188**	**13.124**	**13.062**	**13.000**	
W(lb/ft)	**50.17**	**54.57**	**58.94**	**63.44**	**67.78**	**72.09**	
L/D_o	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**L (ft)**
5.0	348	347	346	346	345	344	5.83
6.0	242	241	240	240	239	239	7.00
7.0	177	177	177	176	176	176	8.17
8.0	136	136	135	135	135	134	9.33
9.0	107	107	107	107	106	106	10.50
10.0	87	87	87	86	86	86	11.67
11.0	72	72	72	71	71	71	12.83
12.0	60	60	60	60	60	60	14.00
13.0	51	51	51	51	51	51	15.17
14.0	44	44	44	44	44	44	16.33
15.0	39	39	38	38	38	38	17.50
16.0	34	34	34	34	34	34	18.67
17.0	30	30	30	30	30	30	19.83
18.0	27	27	27	27	27	27	21.00
19.0	24	24	24	24	24	24	22.17
20.0	22	22	22	22	22	21	23.33

Table D-2.1. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) WITH APPLIED AXIAL LOADS (Clamped-Clamped) (cont)



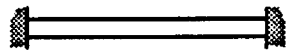
NPS = 14 in
D_o = 14.00 in
E = 28831000 lb/in^2

P/P_b = .75
λ = 4.730041
μ = 489.535 lb/ft^3

t (in)	0.562	0.625	0.688	0.750	0.812	0.875	
D_i (in)	12.876	12.750	12.624	12.500	12.376	12.250	
W(lb/ft)	80.66	89.28	97.81	106.13	114.37	122.65	
L/D_o	f_n	f_n	f_n	f_n	f_n	f_n	L (ft)
5.0	342	341	339	338	336	335	5.83
6.0	238	237	236	235	234	233	7.00
7.0	175	174	173	172	172	171	8.17
8.0	134	133	133	132	131	131	9.33
9.0	106	105	105	104	104	103	10.50
10.0	86	85	85	84	84	84	11.67
11.0	71	70	70	70	70	69	12.83
12.0	59	59	59	59	58	58	14.00
13.0	51	50	50	50	50	50	15.17
14.0	44	43	43	43	43	43	16.33
15.0	38	38	38	38	37	37	17.50
16.0	33	33	33	33	33	33	18.67
17.0	30	29	29	29	29	29	19.83
18.0	26	26	26	26	26	26	21.00
19.0	24	24	24	23	23	23	22.17
20.0	21	21	21	21	21	21	23.33

t (in)	0.938	1.000	1.062	1.125	
D_i (in)	12.124	12.000	11.876	11.750	
W(lb/ft)	130.85	138.84	146.74	154.69	
L/D_o	f_n	f_n	f_n	f_n	L (ft)
5.0	333	332	331	329	5.83
6.0	232	231	230	229	7.00
7.0	170	169	169	168	8.17
8.0	130	130	129	129	9.33
9.0	103	102	102	102	10.50
10.0	83	83	83	82	11.67
11.0	69	69	68	68	12.83
12.0	58	58	57	57	14.00
13.0	49	49	49	49	15.17
14.0	43	42	42	42	16.33
15.0	37	37	37	37	17.50
16.0	33	32	32	32	18.67
17.0	29	29	29	28	19.83
18.0	26	26	26	25	21.00
19.0	23	23	23	23	22.17
20.0	21	21	21	21	23.33

Table D-2.1. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) WITH APPLIED AXIAL LOADS (Clamped-Clamped) (cont)



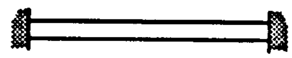
NPS = 16 in
Do = 16.00 in
E = 28831000 lb/in^2

P/P_b = .25
λ = 4.730041
μ = 489.535 lb/ft^3

t (in)	0.188	0.203	0.219	0.250	0.281	0.312	
D_i (in)	15.624	15.594	15.562	15.500	15.438	15.376	
W(lb/ft)	31.75	34.25	36.91	42.05	47.17	52.27	
L/D_o	f_n	f_n	f_n	f_n	f_n	f_n	L (ft)
5.0	534	533	533	532	531	530	6.67
6.0	371	370	370	369	369	368	8.00
7.0	272	272	272	271	271	270	9.33
8.0	209	208	208	208	207	207	10.67
9.0	165	165	164	164	164	164	12.00
10.0	133	133	133	133	133	132	13.33
11.0	110	110	110	110	110	109	14.67
12.0	93	93	93	92	92	92	16.00
13.0	79	79	79	79	79	78	17.33
14.0	68	68	68	68	68	68	18.67
15.0	59	59	59	59	59	59	20.00
16.0	52	52	52	52	52	52	21.33
17.0	46	46	46	46	46	46	22.67
18.0	41	41	41	41	41	41	24.00
19.0	37	37	37	37	37	37	25.33
20.0	33	33	33	33	33	33	26.67

t (in)	0.344	0.375	0.406	0.438	0.469	0.500	
D_i (in)	15.312	15.250	15.188	15.124	15.062	15.000	
W(lb/ft)	57.52	62.58	67.62	72.80	77.79	82.77	
L/D_o	f_n	f_n	f_n	f_n	f_n	f_n	L (ft)
5.0	529	528	527	526	525	524	6.67
6.0	367	367	366	365	364	364	8.00
7.0	270	269	269	268	268	267	9.33
8.0	207	206	206	205	205	205	10.67
9.0	163	163	163	162	162	162	12.00
10.0	132	132	132	131	131	131	13.33
11.0	109	109	109	109	108	108	14.67
12.0	92	92	91	91	91	91	16.00
13.0	78	78	78	78	78	77	17.33
14.0	67	67	67	67	67	67	18.67
15.0	59	59	59	58	58	58	20.00
16.0	52	52	51	51	51	51	21.33
17.0	46	46	46	45	45	45	22.67
18.0	41	41	41	41	40	40	24.00
19.0	37	37	36	36	36	36	25.33
20.0	33	33	33	33	33	33	26.67

Table D-2.1. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) WITH APPLIED AXIAL LOADS (Clamped-Clamped) (cont)



NPS = 16 in
D_o = 16.00 in
E = 28831000 lb/in^2

P/P_b = .25
λ = 4.730041
μ = 489.535 lb/ft^3

t (in)	0.562	0.625	0.688	0.750	0.812	0.875	
D_i (in)	14.876	14.750	14.624	14.500	14.376	14.250	
W(lb/ft)	92.66	102.63	112.51	122.15	131.71	141.34	
L/D_o	f_n	f_n	f_n	f_n	f_n	f_n	L (ft)
5.0	522	520	518	516	514	512	6.67
6.0	362	361	359	358	357	355	8.00
7.0	266	265	264	263	262	261	9.33
8.0	204	203	202	201	201	200	10.67
9.0	161	160	160	159	159	158	12.00
10.0	130	130	129	129	128	128	13.33
11.0	108	107	107	107	106	106	14.67
12.0	91	90	90	90	89	89	16.00
13.0	77	77	77	76	76	76	17.33
14.0	67	66	66	66	66	65	18.67
15.0	58	58	58	57	57	57	20.00
16.0	51	51	51	50	50	50	21.33
17.0	45	45	45	45	44	44	22.67
18.0	40	40	40	40	40	39	24.00
19.0	36	36	36	36	36	35	25.33
20.0	33	32	32	32	32	32	26.67

t (in)	0.938	1.000	1.062	1.125	1.188	1.250	
D_i (in)	14.124	14.000	13.876	13.750	13.624	13.500	
W(lb/ft)	150.89	160.20	169.43	178.72	187.93	196.91	
L/D_o	f_n	f_n	f_n	f_n	f_n	f_n	L (ft)
5.0	510	508	506	504	502	500	6.67
6.0	354	353	351	350	348	347	8.00
7.0	260	259	258	257	256	255	9.33
8.0	199	198	198	197	196	195	10.67
9.0	157	157	156	155	155	154	12.00
10.0	127	127	126	126	125	125	13.33
11.0	105	105	104	104	104	103	14.67
12.0	88	88	88	87	87	87	16.00
13.0	75	75	75	75	74	74	17.33
14.0	65	65	65	64	64	64	18.67
15.0	57	56	56	56	56	56	20.00
16.0	50	50	49	49	49	49	21.33
17.0	44	44	44	44	43	43	22.67
18.0	39	39	39	39	39	39	24.00
19.0	35	35	35	35	35	35	25.33
20.0	32	32	32	31	31	31	26.67

Table D-2.1. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) WITH APPLIED AXIAL LOADS (Clamped-Clamped) (cont)

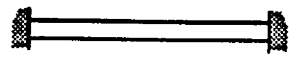
NPS = 16 in
D_o = 16.00 in
E = 28831000 lb/in^2

P/P_b = .50
λ = 4.730041
μ = 489.535 lb/ft^3

t (in)	**0.188**	**0.203**	**0.219**	**0.250**	**0.281**	**0.312**	
D_i (in)	**15.624**	**15.594**	**15.562**	**15.500**	**15.438**	**15.376**	
W(lb/ft)	**31.75**	**34.25**	**36.91**	**42.05**	**47.17**	**52.27**	
L/D_o	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**L (ft)**
5.0	436	436	435	434	433	433	6.67
6.0	303	302	302	302	301	300	8.00
7.0	222	222	222	222	221	221	9.33
8.0	170	170	170	170	169	169	10.67
9.0	135	134	134	134	134	134	12.00
10.0	109	109	109	109	108	108	13.33
11.0	90	90	90	90	90	89	14.67
12.0	76	76	76	75	75	75	16.00
13.0	64	64	64	64	64	64	17.33
14.0	56	56	56	55	55	55	18.67
15.0	48	48	48	48	48	48	20.00
16.0	43	43	42	42	42	42	21.33
17.0	38	38	38	38	37	37	22.67
18.0	34	34	34	34	33	33	24.00
19.0	30	30	30	30	30	30	25.33
20.0	27	27	27	27	27	27	26.67

t (in)	**0.344**	**0.375**	**0.406**	**0.438**	**0.469**	**0.500**	
D_i (in)	**15.312**	**15.250**	**15.188**	**15.124**	**15.062**	**15.000**	
W(lb/ft)	**57.52**	**62.58**	**67.62**	**72.80**	**77.79**	**82.77**	
L/D_o	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**L (ft)**
5.0	432	431	430	429	428	428	6.67
6.0	300	299	299	298	297	297	8.00
7.0	220	220	219	219	219	218	9.33
8.0	169	168	168	168	167	167	10.67
9.0	133	133	133	132	132	132	12.00
10.0	108	108	108	107	107	107	13.33
11.0	89	89	89	89	89	88	14.67
12.0	75	75	75	75	74	74	16.00
13.0	64	64	64	63	63	63	17.33
14.0	55	55	55	55	55	55	18.67
15.0	48	48	48	48	48	48	20.00
16.0	42	42	42	42	42	42	21.33
17.0	37	37	37	37	37	37	22.67
18.0	33	33	33	33	33	33	24.00
19.0	30	30	30	30	30	30	25.33
20.0	27	27	27	27	27	27	26.67

Table D-2.1. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) WITH APPLIED AXIAL LOADS (Clamped-Clamped) (cont)



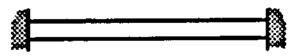
NPS = 16 in
D_o = 16.00 in
E = 28831000 lb/in^2

P/P$_b$ = .50
λ = 4.730041
μ = 489.535 lb/ft^3

t (in)	**0.562**	**0.625**	**0.688**	**0.750**	**0.812**	**0.875**	
D_i (in)	**14.876**	**14.750**	**14.624**	**14.500**	**14.376**	**14.250**	
W(lb/ft)	**92.66**	**102.63**	**112.51**	**122.15**	**131.71**	**141.34**	
L/D_o	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**L (ft)**
5.0	426	424	423	421	419	418	6.67
6.0	296	295	293	292	291	290	8.00
7.0	217	216	216	215	214	213	9.33
8.0	166	166	165	164	164	163	10.67
9.0	131	131	130	130	129	129	12.00
10.0	106	106	106	105	105	104	13.33
11.0	88	88	87	87	87	86	14.67
12.0	74	74	73	73	73	73	16.00
13.0	63	63	63	62	62	62	17.33
14.0	54	54	54	54	53	53	18.67
15.0	47	47	47	47	47	46	20.00
16.0	42	41	41	41	41	41	21.33
17.0	37	37	37	36	36	36	22.67
18.0	33	33	33	32	32	32	24.00
19.0	29	29	29	29	29	29	25.33
20.0	27	27	26	26	26	26	26.67

t (in)	**0.938**	**1.000**	**1.062**	**1.125**	**1.188**	**1.250**	
D_i (in)	**14.124**	**14.000**	**13.876**	**13.750**	**13.624**	**13.500**	
W(lb/ft)	**150.89**	**160.20**	**169.43**	**178.72**	**187.93**	**196.91**	
L/D_o	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**L (ft)**
5.0	416	414	413	411	410	408	6.67
6.0	289	288	287	286	285	283	8.00
7.0	212	211	211	210	209	208	9.33
8.0	163	162	161	161	160	159	10.67
9.0	128	128	127	127	126	126	12.00
10.0	104	104	103	103	102	102	13.33
11.0	86	86	85	85	85	84	14.67
12.0	72	72	72	71	71	71	16.00
13.0	62	61	61	61	61	60	17.33
14.0	53	53	53	52	52	52	18.67
15.0	46	46	46	46	46	45	20.00
16.0	41	40	40	40	40	40	21.33
17.0	36	36	36	36	35	35	22.67
18.0	32	32	32	32	32	31	24.00
19.0	29	29	29	28	28	28	25.33
20.0	26	26	26	26	26	26	26.67

Table D-2.1. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) WITH APPLIED AXIAL LOADS (Clamped-Clamped) (cont)



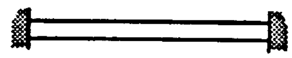
NPS = 16 in
D_o = 16.00 in
E = 28831000 lb/in^2

P/P_b = .75
λ = 4.730041
μ = 489.535 lb/ft^3

t (in)	0.188	0.203	0.219	0.250	0.281	0.312	
D_i (in)	15.624	15.594	15.562	15.500	15.438	15.376	
W(lb/ft)	31.75	34.25	36.91	42.05	47.17	52.27	
L/D_o	f_n	f_n	f_n	f_n	f_n	f_n	L (ft)
5.0	308	308	308	307	306	306	6.67
6.0	214	214	214	213	213	212	8.00
7.0	157	157	157	157	156	156	9.33
8.0	120	120	120	120	120	119	10.67
9.0	95	95	95	95	95	94	12.00
10.0	77	77	77	77	77	76	13.33
11.0	64	64	64	63	63	63	14.67
12.0	54	53	53	53	53	53	16.00
13.0	46	46	46	45	45	45	17.33
14.0	39	39	39	39	39	39	18.67
15.0	34	34	34	34	34	34	20.00
16.0	30	30	30	30	30	30	21.33
17.0	27	27	27	27	27	26	22.67
18.0	24	24	24	24	24	24	24.00
19.0	21	21	21	21	21	21	25.33
20.0	19	19	19	19	19	19	26.67

t (in)	0.344	0.375	0.406	0.438	0.469	0.500	
D_i (in)	15.312	15.250	15.188	15.124	15.062	15.000	
W(lb/ft)	57.52	62.58	67.62	72.80	77.79	82.77	
L/D_o	f_n	f_n	f_n	f_n	f_n	f_n	L (ft)
5.0	305	305	304	304	303	302	6.67
6.0	212	212	211	211	210	210	8.00
7.0	156	155	155	155	155	154	9.33
8.0	119	119	119	119	118	118	10.67
9.0	94	94	94	94	93	93	12.00
10.0	76	76	76	76	76	76	13.33
11.0	63	63	63	63	63	62	14.67
12.0	53	53	53	53	53	52	16.00
13.0	45	45	45	45	45	45	17.33
14.0	39	39	39	39	39	39	18.67
15.0	34	34	34	34	34	34	20.00
16.0	30	30	30	30	30	30	21.33
17.0	26	26	26	26	26	26	22.67
18.0	24	24	23	23	23	23	24.00
19.0	21	21	21	21	21	21	25.33
20.0	19	19	19	19	19	19	26.67

Table D-2.1. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) WITH APPLIED AXIAL LOADS (Clamped-Clamped) (cont)



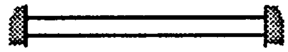
NPS = 16 in
D_o = 16.00 in
E = 28831000 lb/in^2

P/P_b = .75
λ = 4.730041
μ = 489.535 lb/ft^3

t (in)	**0.562**	**0.625**	**0.688**	**0.750**	**0.812**	**0.875**	
D_i (in)	**14.876**	**14.750**	**14.624**	**14.500**	**14.376**	**14.250**	
W(lb/ft)	**92.66**	**102.63**	**112.51**	**122.15**	**131.71**	**141.34**	
L/D_o	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**L (ft)**
5.0	301	300	299	298	297	295	6.67
6.0	209	208	208	207	206	205	8.00
7.0	154	153	152	152	151	151	9.33
8.0	118	117	117	116	116	115	10.67
9.0	93	93	92	92	92	91	12.00
10.0	75	75	75	74	74	74	13.33
11.0	62	62	62	62	61	61	14.67
12.0	52	52	52	52	51	51	16.00
13.0	45	44	44	44	44	44	17.33
14.0	38	38	38	38	38	38	18.67
15.0	33	33	33	33	33	33	20.00
16.0	29	29	29	29	29	29	21.33
17.0	26	26	26	26	26	26	22.67
18.0	23	23	23	23	23	23	24.00
19.0	21	21	21	21	21	20	25.33
20.0	19	19	19	19	19	18	26.67

t (in)	**0.938**	**1.000**	**1.062**	**1.125**	**1.188**	**1.250**	
D_i (in)	**14.124**	**14.000**	**13.876**	**13.750**	**13.624**	**13.500**	
W(lb/ft)	**150.89**	**160.20**	**169.43**	**178.72**	**187.93**	**196.91**	
L/D_o	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**L (ft)**
5.0	294	293	292	291	290	289	6.67
6.0	204	204	203	202	201	200	8.00
7.0	150	150	149	148	148	147	9.33
8.0	115	114	114	114	113	113	10.67
9.0	91	90	90	90	89	89	12.00
10.0	74	73	73	73	72	72	13.33
11.0	61	61	60	60	60	60	14.67
12.0	51	51	51	50	50	50	16.00
13.0	44	43	43	43	43	43	17.33
14.0	38	37	37	37	37	37	18.67
15.0	33	33	32	32	32	32	20.00
16.0	29	29	29	28	28	28	21.33
17.0	25	25	25	25	25	25	22.67
18.0	23	23	23	22	22	22	24.00
19.0	20	20	20	20	20	20	25.33
20.0	18	18	18	18	18	18	26.67

Table D-2.1. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) WITH APPLIED AXIAL LOADS (Clamped-Clamped) (cont)



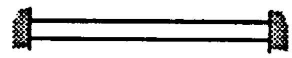
NPS = 18 in
D_o = 18.00 in
E = 28831000 lb/in^2

P/P_b = .25
λ = 4.730041
μ = 489.535 lb/ft^3

t (in)	**0.188**	**0.219**	**0.250**	**0.281**	**0.312**	**0.344**	
D_i (in)	**17.624**	**17.562**	**17.500**	**17.438**	**17.376**	**17.312**	
W(lb/ft)	**35.76**	**41.59**	**47.39**	**53.18**	**58.94**	**64.87**	
L/D_o	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	L (ft)
5.0	475	474	474	473	472	471	7.50
6.0	330	329	329	328	328	327	9.00
7.0	242	242	242	241	241	240	10.50
8.0	186	185	185	185	184	184	12.00
9.0	147	146	146	146	146	145	13.50
10.0	119	119	118	118	118	118	15.00
11.0	98	98	98	98	98	97	16.50
12.0	83	82	82	82	82	82	18.00
13.0	70	70	70	70	70	70	19.50
14.0	61	61	60	60	60	60	21.00
15.0	53	53	53	53	52	52	22.50
16.0	46	46	46	46	46	46	24.00
17.0	41	41	41	41	41	41	25.50
18.0	37	37	37	36	36	36	27.00
19.0	33	33	33	33	33	33	28.50
20.0	30	30	30	30	29	29	30.00

t (in)	**0.375**	**0.406**	**0.438**	**0.469**	**0.500**	**0.562**	
D_i (in)	**17.250**	**17.188**	**17.124**	**17.062**	**17.000**	**16.876**	
W(lb/ft)	**70.59**	**76.29**	**82.15**	**87.81**	**93.45**	**104.67**	
L/D_o	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	L (ft)
5.0	470	470	469	468	467	465	7.50
6.0	327	326	325	325	324	323	9.00
7.0	240	240	239	239	238	237	10.50
8.0	184	183	183	183	182	182	12.00
9.0	145	145	145	144	144	144	13.50
10.0	118	117	117	117	117	116	15.00
11.0	97	97	97	97	97	96	16.50
12.0	82	82	81	81	81	81	18.00
13.0	70	69	69	69	69	69	19.50
14.0	60	60	60	60	60	59	21.00
15.0	52	52	52	52	52	52	22.50
16.0	46	46	46	46	46	45	24.00
17.0	41	41	41	40	40	40	25.50
18.0	36	36	36	36	36	36	27.00
19.0	33	33	32	32	32	32	28.50
20.0	29	29	29	29	29	29	30.00

Table D-2.1. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) WITH APPLIED AXIAL LOADS (Clamped-Clamped) (cont)



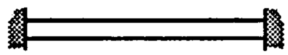
NPS = 18 in
D_o = 18.00 in
E = 28831000 lb/in²

P/P_b = .25
λ = 4.730041
μ = 489.535 lb/ft³

t (in)	**0.625**	**0.688**	**0.750**	**0.812**	**0.875**	**0.938**	
D_i (in)	**16.750**	**16.624**	**16.500**	**16.376**	**16.250**	**16.124**	
W(lb/ft)	**115.98**	**127.21**	**138.17**	**149.06**	**160.03**	**170.92**	
L/D_o	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**L (ft)**
5.0	464	462	461	459	457	456	7.50
6.0	322	321	320	319	318	317	9.00
7.0	237	236	235	234	233	233	10.50
8.0	181	181	180	179	179	178	12.00
9.0	143	143	142	142	141	141	13.50
10.0	116	116	115	115	114	114	15.00
11.0	96	96	95	95	95	94	16.50
12.0	81	80	80	80	79	79	18.00
13.0	69	68	68	68	68	67	19.50
14.0	59	59	59	59	58	58	21.00
15.0	52	51	51	51	51	51	22.50
16.0	45	45	45	45	45	45	24.00
17.0	40	40	40	40	40	39	25.50
18.0	36	36	36	35	35	35	27.00
19.0	32	32	32	32	32	32	28.50
20.0	29	29	29	29	29	28	30.00

t (in)	**1.000**	**1.062**	**1.125**	**1.188**	**1.250**	
D_i (in)	**16.000**	**15.876**	**15.750**	**15.624**	**15.500**	
W(lb/ft)	**181.56**	**192.11**	**202.75**	**213.31**	**223.61**	
L/D_o	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**L (ft)**
5.0	454	453	451	450	448	7.50
6.0	316	314	313	312	311	9.00
7.0	232	231	230	229	229	10.50
8.0	177	177	176	176	175	12.00
9.0	140	140	139	139	138	13.50
10.0	114	113	113	112	112	15.00
11.0	94	94	93	93	93	16.50
12.0	79	79	78	78	78	18.00
13.0	67	67	67	67	66	19.50
14.0	58	58	58	57	57	21.00
15.0	50	50	50	50	50	22.50
16.0	44	44	44	44	44	24.00
17.0	39	39	39	39	39	25.50
18.0	35	35	35	35	35	27.00
19.0	31	31	31	31	31	28.50
20.0	28	28	28	28	28	30.00

Table D-2.1. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) WITH APPLIED AXIAL LOADS (Clamped-Clamped) (cont)



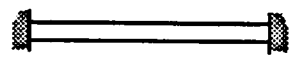
NPS = 18 in
D_o = 18.00 in
E = 28831000 lb/in^2

P/P_b = .50
λ = 4.730041
μ = 489.535 lb/ft^3

t (in)	**0.188**	**0.219**	**0.250**	**0.281**	**0.312**	**0.344**	
D_i (in)	**17.624**	**17.562**	**17.500**	**17.438**	**17.376**	**17.312**	
W(lb/ft)	**35.76**	**41.59**	**47.39**	**53.18**	**58.94**	**64.87**	
L/D_o	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**L (ft)**
5.0	388	387	387	386	385	385	7.50
6.0	269	269	269	268	268	267	9.00
7.0	198	198	197	197	197	196	10.50
8.0	152	151	151	151	151	150	12.00
9.0	120	120	119	119	119	119	13.50
10.0	97	97	97	97	96	96	15.00
11.0	80	80	80	80	80	79	16.50
12.0	67	67	67	67	67	67	18.00
13.0	57	57	57	57	57	57	19.50
14.0	49	49	49	49	49	49	21.00
15.0	43	43	43	43	43	43	22.50
16.0	38	38	38	38	38	38	24.00
17.0	34	34	33	33	33	33	25.50
18.0	30	30	30	30	30	30	27.00
19.0	27	27	27	27	27	27	28.50
20.0	24	24	24	24	24	24	30.00

t (in)	**0.375**	**0.406**	**0.438**	**0.469**	**0.500**	**0.562**	
D_i (in)	**17.250**	**17.188**	**17.124**	**17.062**	**17.000**	**16.876**	
W(lb/ft)	**70.59**	**76.29**	**82.15**	**87.81**	**93.45**	**104.67**	
L/D_o	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**L (ft)**
5.0	384	383	383	382	381	380	7.50
6.0	267	266	266	265	265	264	9.00
7.0	196	196	195	195	195	194	10.50
8.0	150	150	149	149	149	148	12.00
9.0	119	118	118	118	118	117	13.50
10.0	96	96	96	96	95	95	15.00
11.0	79	79	79	79	79	79	16.50
12.0	67	67	66	66	66	66	18.00
13.0	57	57	57	57	56	56	19.50
14.0	49	49	49	49	49	48	21.00
15.0	43	43	43	42	42	42	22.50
16.0	38	37	37	37	37	37	24.00
17.0	33	33	33	33	33	33	25.50
18.0	30	30	30	29	29	29	27.00
19.0	27	27	27	26	26	26	28.50
20.0	24	24	24	24	24	24	30.00

Table D-2.1. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) WITH APPLIED AXIAL LOADS (Clamped-Clamped) (cont)



NPS = 18 in
D_o = 18.00 in
E = 28831000 lb/in^2

P/P_b = .50
λ = 4.730041
μ = 489.535 lb/ft^3

t (in)	**0.625**	**0.688**	**0.750**	**0.812**	**0.875**	**0.938**	
D_i (in)	**16.750**	**16.624**	**16.500**	**16.376**	**16.250**	**16.124**	
W(lb/ft)	**115.98**	**127.21**	**138.17**	**149.06**	**160.03**	**170.92**	
L/D_o	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**L (ft)**
5.0	379	377	376	375	374	372	7.50
6.0	263	262	261	260	259	259	9.00
7.0	193	193	192	191	191	190	10.50
8.0	148	147	147	146	146	145	12.00
9.0	117	116	116	116	115	115	13.50
10.0	95	94	94	94	93	93	15.00
11.0	78	78	78	77	77	77	16.50
12.0	66	66	65	65	65	65	18.00
13.0	56	56	56	55	55	55	19.50
14.0	48	48	48	48	48	47	21.00
15.0	42	42	42	42	42	41	22.50
16.0	37	37	37	37	36	36	24.00
17.0	33	33	33	32	32	32	25.50
18.0	29	29	29	29	29	29	27.00
19.0	26	26	26	26	26	26	28.50
20.0	24	24	24	23	23	23	30.00

t (in)	**1.000**	**1.062**	**1.125**	**1.188**	**1.250**	
D_i (in)	**16.000**	**15.876**	**15.750**	**15.624**	**15.500**	
W(lb/ft)	**181.56**	**192.11**	**202.75**	**213.31**	**223.61**	
L/D_o	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**L (ft)**
5.0	371	370	368	367	366	7.50
6.0	258	257	256	255	254	9.00
7.0	189	189	188	187	187	10.50
8.0	145	144	144	143	143	12.00
9.0	114	114	114	113	113	13.50
10.0	93	92	92	92	91	15.00
11.0	77	76	76	76	76	16.50
12.0	64	64	64	64	64	18.00
13.0	55	55	55	54	54	19.50
14.0	47	47	47	47	47	21.00
15.0	41	41	41	41	41	22.50
16.0	36	36	36	36	36	24.00
17.0	32	32	32	32	32	25.50
18.0	29	29	28	28	28	27.00
19.0	26	26	26	25	25	28.50
20.0	23	23	23	23	23	30.00

Table D-2.1. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) WITH APPLIED AXIAL LOADS (Clamped-Clamped) (cont)

NPS = 18 in
D_o = 18.00 in
E = 28831000 lb/in^2

P/P_b = .75
λ = 4.730041
μ = 489.535 lb/ft^3

t (in)	0.188	0.219	0.250	0.281	0.312	0.344	
D_i (in)	17.624	17.562	17.500	17.438	17.376	17.312	
W(lb/ft)	35.76	41.59	47.39	53.18	58.94	64.87	
L/D_o	f_n	f_n	f_n	f_n	f_n	f_n	L (ft)
5.0	274	274	273	273	273	272	7.50
6.0	191	190	190	190	189	189	9.00
7.0	140	140	140	139	139	139	10.50
8.0	107	107	107	107	106	106	12.00
9.0	85	85	84	84	84	84	13.50
10.0	69	68	68	68	68	68	15.00
11.0	57	57	56	56	56	56	16.50
12.0	48	48	47	47	47	47	18.00
13.0	41	41	40	40	40	40	19.50
14.0	35	35	35	35	35	35	21.00
15.0	30	30	30	30	30	30	22.50
16.0	27	27	27	27	27	27	24.00
17.0	24	24	24	24	24	24	25.50
18.0	21	21	21	21	21	21	27.00
19.0	19	19	19	19	19	19	28.50
20.0	17	17	17	17	17	17	30.00

t (in)	0.375	0.406	0.438	0.469	0.500	0.562	
D_i (in)	17.250	17.188	17.124	17.062	17.000	16.876	
W(lb/ft)	70.59	76.29	82.15	87.81	93.45	104.67	
L/D_o	f_n	f_n	f_n	f_n	f_n	f_n	L (ft)
5.0	272	271	271	270	270	269	7.50
6.0	189	188	188	188	187	187	9.00
7.0	139	138	138	138	138	137	10.50
8.0	106	106	106	106	105	105	12.00
9.0	84	84	84	83	83	83	13.50
10.0	68	68	68	68	67	67	15.00
11.0	56	56	56	56	56	56	16.50
12.0	47	47	47	47	47	47	18.00
13.0	40	40	40	40	40	40	19.50
14.0	35	35	35	34	34	34	21.00
15.0	30	30	30	30	30	30	22.50
16.0	27	26	26	26	26	26	24.00
17.0	23	23	23	23	23	23	25.50
18.0	21	21	21	21	21	21	27.00
19.0	19	19	19	19	19	19	28.50
20.0	17	17	17	17	17	17	30.00

Table D-2.1. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) WITH APPLIED AXIAL LOADS (Clamped-Clamped) (cont)

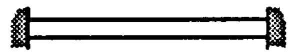
NPS = 18 in
D_o = 18.00 in
E = 28831000 lb/in^2

P/P_b = .75
λ = 4.730041
μ = 489.535 lb/ft^3

t (in)	**0.625**	**0.688**	**0.750**	**0.812**	**0.875**	**0.938**	
D_i (in)	**16.750**	**16.624**	**16.500**	**16.376**	**16.250**	**16.124**	
W(lb/ft)	**115.98**	**127.21**	**138.17**	**149.06**	**160.03**	**170.92**	
L/D_o	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**L (ft)**
5.0	268	267	266	265	264	263	7.50
6.0	186	185	185	184	183	183	9.00
7.0	137	136	136	135	135	134	10.50
8.0	105	104	104	104	103	103	12.00
9.0	83	82	82	82	82	81	13.50
10.0	67	67	66	66	66	66	15.00
11.0	55	55	55	55	55	54	16.50
12.0	46	46	46	46	46	46	18.00
13.0	40	39	39	39	39	39	19.50
14.0	34	34	34	34	34	34	21.00
15.0	30	30	30	29	29	29	22.50
16.0	26	26	26	26	26	26	24.00
17.0	23	23	23	23	23	23	25.50
18.0	21	21	21	20	20	20	27.00
19.0	19	18	18	18	18	18	28.50
20.0	17	17	17	17	17	16	30.00

t (in)	**1.000**	**1.062**	**1.125**	**1.188**	**1.250**	
D_i (in)	**16.000**	**15.876**	**15.750**	**15.624**	**15.500**	
W(lb/ft)	**181.56**	**192.11**	**202.75**	**213.31**	**223.61**	
L/D_o	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**L (ft)**
5.0	262	261	261	260	259	7.50
6.0	182	182	181	180	180	9.00
7.0	134	133	133	132	132	10.50
8.0	102	102	102	101	101	12.00
9.0	81	81	80	80	80	13.50
10.0	66	65	65	65	65	15.00
11.0	54	54	54	54	53	16.50
12.0	46	45	45	45	45	18.00
13.0	39	39	39	38	38	19.50
14.0	33	33	33	33	33	21.00
15.0	29	29	29	29	29	22.50
16.0	26	26	25	25	25	24.00
17.0	23	23	23	22	22	25.50
18.0	20	20	20	20	20	27.00
19.0	18	18	18	18	18	28.50
20.0	16	16	16	16	16	30.00

Table D-2.1. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) WITH APPLIED AXIAL LOADS (Clamped-Clamped) (cont)



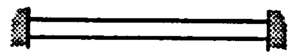
NPS = 20 in
D_o = 20.00 in
E = 28831000 lb/in^2

P/P_b = .25
λ = 4.730041
μ = 489.535 lb/ft^3

t (in)	**0.219**	**0.250**	**0.281**	**0.312**	**0.344**	**0.375**	
D_i (in)	**19.562**	**19.500**	**19.438**	**19.376**	**19.312**	**19.250**	
W(lb/ft)	**46.27**	**52.73**	**59.18**	**65.60**	**72.21**	**78.60**	
L/D_o	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**L (ft)**
5.0	428	427	426	426	425	424	8.33
6.0	297	296	296	296	295	295	10.00
7.0	218	218	217	217	217	216	11.67
8.0	167	167	166	166	166	166	13.33
9.0	132	132	132	131	131	131	15.00
10.0	107	107	107	106	106	106	16.67
11.0	88	88	88	88	88	88	18.33
12.0	74	74	74	74	74	74	20.00
13.0	63	63	63	63	63	63	21.67
14.0	55	54	54	54	54	54	23.33
15.0	48	47	47	47	47	47	25.00
16.0	42	42	42	42	41	41	26.67
17.0	37	37	37	37	37	37	28.33
18.0	33	33	33	33	33	33	30.00
19.0	30	30	30	29	29	29	31.67
20.0	27	27	27	27	27	27	33.33

t (in)	**0.406**	**0.438**	**0.469**	**0.500**	**0.562**	**0.625**	
D_i (in)	**19.188**	**19.124**	**19.062**	**19.000**	**18.876**	**18.750**	
W(lb/ft)	**84.96**	**91.51**	**97.83**	**104.13**	**116.67**	**129.33**	
L/D_o	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**L (ft)**
5.0	424	423	422	422	420	419	8.33
6.0	294	294	293	293	292	291	10.00
7.0	216	216	215	215	214	214	11.67
8.0	165	165	165	165	164	164	13.33
9.0	131	131	130	130	130	129	15.00
10.0	106	106	106	105	105	105	16.67
11.0	88	87	87	87	87	87	18.33
12.0	74	73	73	73	73	73	20.00
13.0	63	63	62	62	62	62	21.67
14.0	54	54	54	54	54	53	23.33
15.0	47	47	47	47	47	47	25.00
16.0	41	41	41	41	41	41	26.67
17.0	37	37	37	36	36	36	28.33
18.0	33	33	33	33	32	32	30.00
19.0	29	29	29	29	29	29	31.67
20.0	26	26	26	26	26	26	33.33

Table D-2.1. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) WITH APPLIED AXIAL LOADS (Clamped-Clamped) (cont)



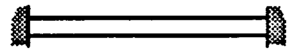
NPS = 20 in
D_o = 20.00 in
E = 28831000 lb/in^2

P/P_b = .25
λ = 4.730041
μ = 489.535 lb/ft^3

t (in)	**0.688**	**0.750**	**0.812**	**0.875**	**0.938**	**1.000**	
D_i (in)	**18.624**	**18.500**	**18.376**	**18.250**	**18.124**	**18.000**	
W(lb/ft)	**141.90**	**154.19**	**166.40**	**178.72**	**190.96**	**202.92**	
L/D_o	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**L (ft)**
5.0	418	416	415	414	412	411	8.33
6.0	290	289	288	287	286	286	10.00
7.0	213	212	212	211	210	210	11.67
8.0	163	163	162	162	161	161	13.33
9.0	129	128	128	128	127	127	15.00
10.0	104	104	104	103	103	103	16.67
11.0	86	86	86	85	85	85	18.33
12.0	73	72	72	72	72	71	20.00
13.0	62	62	61	61	61	61	21.67
14.0	53	53	53	53	53	52	23.33
15.0	46	46	46	46	46	46	25.00
16.0	41	41	41	40	40	40	26.67
17.0	36	36	36	36	36	36	28.33
18.0	32	32	32	32	32	32	30.00
19.0	29	29	29	29	29	28	31.67
20.0	26	26	26	26	26	26	33.33

t (in)	**1.062**	**1.125**	**1.188**	**1.250**	**1.312**	**1.375**	
D_i (in)	**17.876**	**17.750**	**17.624**	**17.500**	**17.376**	**17.250**	
W(lb/ft)	**214.80**	**226.78**	**238.68**	**250.31**	**261.86**	**273.51**	
L/D_o	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**L (ft)**
5.0	410	409	407	406	405	404	8.33
6.0	285	284	283	282	281	280	10.00
7.0	209	208	208	207	207	206	11.67
8.0	160	160	159	159	158	158	13.33
9.0	127	126	126	125	125	125	15.00
10.0	102	102	102	102	101	101	16.67
11.0	85	84	84	84	84	83	18.33
12.0	71	71	71	71	70	70	20.00
13.0	61	60	60	60	60	60	21.67
14.0	52	52	52	52	52	51	23.33
15.0	46	45	45	45	45	45	25.00
16.0	40	40	40	40	40	39	26.67
17.0	35	35	35	35	35	35	28.33
18.0	32	32	31	31	31	31	30.00
19.0	28	28	28	28	28	28	31.67
20.0	26	26	25	25	25	25	33.33

Table D-2.1. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) WITH APPLIED AXIAL LOADS (Clamped-Clamped) (cont)



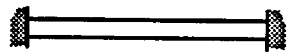
NPS = 20 in
D_o = 20.00 in
E = 28831000 lb/in^2

P/P_b = .50
λ = 4.730041
μ = 489.535 lb/ft^3

t (in)	**0.219**	**0.250**	**0.281**	**0.312**	**0.344**	**0.375**	
D_i (in)	**19.562**	**19.500**	**19.438**	**19.376**	**19.312**	**19.250**	
W(lb/ft)	**46.27**	**52.73**	**59.18**	**65.60**	**72.21**	**78.60**	
L/D_o	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**L (ft)**
5.0	349	349	348	347	347	346	8.33
6.0	242	242	242	241	241	241	10.00
7.0	178	178	178	177	177	177	11.67
8.0	136	136	136	136	136	135	13.33
9.0	108	108	107	107	107	107	15.00
10.0	87	87	87	87	87	87	16.67
11.0	72	72	72	72	72	72	18.33
12.0	61	61	60	60	60	60	20.00
13.0	52	52	51	51	51	51	21.67
14.0	45	44	44	44	44	44	23.33
15.0	39	39	39	39	39	38	25.00
16.0	34	34	34	34	34	34	26.67
17.0	30	30	30	30	30	30	28.33
18.0	27	27	27	27	27	27	30.00
19.0	24	24	24	24	24	24	31.67
20.0	22	22	22	22	22	22	33.33

t (in)	**0.406**	**0.438**	**0.469**	**0.500**	**0.562**	**0.625**	
D_i (in)	**19.188**	**19.124**	**19.062**	**19.000**	**18.876**	**18.750**	
W(lb/ft)	**84.96**	**91.51**	**97.83**	**104.13**	**116.67**	**129.33**	
L/D_o	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**L (ft)**
5.0	346	345	345	344	343	342	8.33
6.0	240	240	239	239	238	238	10.00
7.0	176	176	176	176	175	175	11.67
8.0	135	135	135	134	134	134	13.33
9.0	107	107	106	106	106	106	15.00
10.0	86	86	86	86	86	86	16.67
11.0	71	71	71	71	71	71	18.33
12.0	60	60	60	60	60	59	20.00
13.0	51	51	51	51	51	51	21.67
14.0	44	44	44	44	44	44	23.33
15.0	38	38	38	38	38	38	25.00
16.0	34	34	34	34	34	33	26.67
17.0	30	30	30	30	30	30	28.33
18.0	27	27	27	27	26	26	30.00
19.0	24	24	24	24	24	24	31.67
20.0	22	22	22	22	21	21	33.33

Table D-2.1. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) WITH APPLIED AXIAL LOADS (Clamped-Clamped) (cont)



NPS = 20 in
D_o = 20.00 in
E = 28831000 lb/in^2

P/P_b = .50
λ = 4.730041
μ = 489.535 lb/ft^3

t (in)	0.688	0.750	0.812	0.875	0.938	1.000	
D_i (in)	18.624	18.500	18.376	18.250	18.124	18.000	
W(lb/ft)	141.90	154.19	166.40	178.72	190.96	202.92	
L/D_o	f_n	f_n	f_n	f_n	f_n	f_n	L (ft)
5.0	341	340	339	338	337	336	8.33
6.0	237	236	235	235	234	233	10.00
7.0	174	173	173	172	172	171	11.67
8.0	133	133	132	132	132	131	13.33
9.0	105	105	105	104	104	104	15.00
10.0	85	85	85	84	84	84	16.67
11.0	70	70	70	70	70	69	18.33
12.0	59	59	59	59	58	58	20.00
13.0	50	50	50	50	50	50	21.67
14.0	43	43	43	43	43	43	23.33
15.0	38	38	38	38	37	37	25.00
16.0	33	33	33	33	33	33	26.67
17.0	29	29	29	29	29	29	28.33
18.0	26	26	26	26	26	26	30.00
19.0	24	24	23	23	23	23	31.67
20.0	21	21	21	21	21	21	33.33

t (in)	1.062	1.125	1.188	1.250	1.312	1.375	
D_i (in)	17.876	17.750	17.624	17.500	17.376	17.250	
W(lb/ft)	214.80	226.78	238.68	250.31	261.86	273.51	
L/D_o	f_n	f_n	f_n	f_n	f_n	f_n	L (ft)
5.0	335	334	333	332	331	330	8.33
6.0	232	232	231	230	230	229	10.00
7.0	171	170	170	169	169	168	11.67
8.0	131	130	130	130	129	129	13.33
9.0	103	103	103	102	102	102	15.00
10.0	84	83	83	83	83	82	16.67
11.0	69	69	69	69	68	68	18.33
12.0	58	58	58	58	57	57	20.00
13.0	50	49	49	49	49	49	21.67
14.0	43	43	42	42	42	42	23.33
15.0	37	37	37	37	37	37	25.00
16.0	33	33	32	32	32	32	26.67
17.0	29	29	29	29	29	29	28.33
18.0	26	26	26	26	26	25	30.00
19.0	23	23	23	23	23	23	31.67
20.0	21	21	21	21	21	21	33.33

Table D-2.1. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) WITH APPLIED AXIAL LOADS (Clamped-Clamped) (cont)

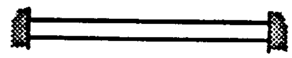
NPS = 20 in
D_o = 20.00 in
E = 28831000 lb/in^2

P/P_b = .75
λ = 4.730041
μ = 489.535 lb/ft^3

t (in)	**0.219**	**0.250**	**0.281**	**0.312**	**0.344**	**0.375**	
D_i (in)	**19.562**	**19.500**	**19.438**	**19.376**	**19.312**	**19.250**	
W(lb/ft)	**46.27**	**52.73**	**59.18**	**65.60**	**72.21**	**78.60**	
L/D_o	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**L (ft)**
5.0	247	246	246	246	245	245	8.33
6.0	171	171	171	171	170	170	10.00
7.0	126	126	126	125	125	125	11.67
8.0	96	96	96	96	96	96	13.33
9.0	76	76	76	76	76	76	15.00
10.0	62	62	62	61	61	61	16.67
11.0	51	51	51	51	51	51	18.33
12.0	43	43	43	43	43	43	20.00
13.0	37	36	36	36	36	36	21.67
14.0	31	31	31	31	31	31	23.33
15.0	27	27	27	27	27	27	25.00
16.0	24	24	24	24	24	24	26.67
17.0	21	21	21	21	21	21	28.33
18.0	19	19	19	19	19	19	30.00
19.0	17	17	17	17	17	17	31.67
20.0	15	15	15	15	15	15	33.33

t (in)	**0.406**	**0.438**	**0.469**	**0.500**	**0.562**	**0.625**	
D_i (in)	**19.188**	**19.124**	**19.062**	**19.000**	**18.876**	**18.750**	
W(lb/ft)	**84.96**	**91.51**	**97.83**	**104.13**	**116.67**	**129.33**	
L/D_o	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**L (ft)**
5.0	245	244	244	243	243	242	8.33
6.0	170	170	169	169	168	168	10.00
7.0	125	125	124	124	124	123	11.67
8.0	96	95	95	95	95	94	13.33
9.0	75	75	75	75	75	75	15.00
10.0	61	61	61	61	61	60	16.67
11.0	51	50	50	50	50	50	18.33
12.0	42	42	42	42	42	42	20.00
13.0	36	36	36	36	36	36	21.67
14.0	31	31	31	31	31	31	23.33
15.0	27	27	27	27	27	27	25.00
16.0	24	24	24	24	24	24	26.67
17.0	21	21	21	21	21	21	28.33
18.0	19	19	19	19	19	19	30.00
19.0	17	17	17	17	17	17	31.67
20.0	15	15	15	15	15	15	33.33

Table D-2.1. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) WITH APPLIED AXIAL LOADS (Clamped-Clamped) (cont)



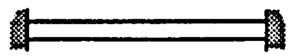
NPS = 20 in
D_o = 20.00 in
E = 28831000 lb/in^2

P/P_b = .75
λ = 4.730041
μ = 489.535 lb/ft^3

t (in)	0.688	0.750	0.812	0.875	0.938	1.000	
D_i (in)	18.624	18.500	18.376	18.250	18.124	18.000	
W(lb/ft)	141.90	154.19	166.40	178.72	190.96	202.92	
L/D_o	f_n	f_n	f_n	f_n	f_n	f_n	L (ft)
5.0	241	240	240	239	238	237	8.33
6.0	167	167	166	166	165	165	10.00
7.0	123	123	122	122	121	121	11.67
8.0	94	94	94	93	93	93	13.33
9.0	74	74	74	74	73	73	15.00
10.0	60	60	60	60	60	59	16.67
11.0	50	50	50	49	49	49	18.33
12.0	42	42	42	41	41	41	20.00
13.0	36	36	35	35	35	35	21.67
14.0	31	31	31	30	30	30	23.33
15.0	27	27	27	27	26	26	25.00
16.0	24	23	23	23	23	23	26.67
17.0	21	21	21	21	21	21	28.33
18.0	19	19	18	18	18	18	30.00
19.0	17	17	17	17	16	16	31.67
20.0	15	15	15	15	15	15	33.33

t (in)	1.062	1.125	1.188	1.250	1.312	1.375	
D_i (in)	17.876	17.750	17.624	17.500	17.376	17.250	
W(lb/ft)	214.80	226.78	238.68	250.31	261.86	273.51	
L/D_o	f_n	f_n	f_n	f_n	f_n	f_n	L (ft)
5.0	237	236	235	234	234	233	8.33
6.0	164	164	163	163	162	162	10.00
7.0	121	120	120	120	119	119	11.67
8.0	92	92	92	92	91	91	13.33
9.0	73	73	73	72	72	72	15.00
10.0	59	59	59	59	58	58	16.67
11.0	49	49	49	48	48	48	18.33
12.0	41	41	41	41	41	40	20.00
13.0	35	35	35	35	35	34	21.67
14.0	30	30	30	30	30	30	23.33
15.0	26	26	26	26	26	26	25.00
16.0	23	23	23	23	23	23	26.67
17.0	20	20	20	20	20	20	28.33
18.0	18	18	18	18	18	18	30.00
19.0	16	16	16	16	16	16	31.67
20.0	15	15	15	15	15	15	33.33

Table D-2.1. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) WITH APPLIED AXIAL LOADS (Clamped-Clamped) (cont)



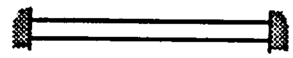
NPS = 22 in
D_o = 22.00 in
E = 28831000 lb/in²

P/P_b = .25
λ = 4.730041
μ = 489.535 lb/ft³

t (in)	**0.219**	**0.250**	**0.281**	**0.312**	**0.344**	**0.375**	
D_i (in)	**21.562**	**21.500**	**21.438**	**21.376**	**21.312**	**21.250**	
W(lb/ft)	**50.94**	**58.07**	**65.18**	**72.27**	**79.56**	**86.61**	
L/D_o	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**L (ft)**
5.0	389	388	388	387	387	386	9.17
6.0	270	270	269	269	269	268	11.00
7.0	198	198	198	198	197	197	12.83
8.0	152	152	152	151	151	151	14.67
9.0	120	120	120	120	119	119	16.50
10.0	97	97	97	97	97	97	18.33
11.0	80	80	80	80	80	80	20.17
12.0	68	67	67	67	67	67	22.00
13.0	58	57	57	57	57	57	23.83
14.0	50	50	49	49	49	49	25.67
15.0	43	43	43	43	43	43	27.50
16.0	38	38	38	38	38	38	29.33
17.0	34	34	34	34	33	33	31.17
18.0	30	30	30	30	30	30	33.00
19.0	27	27	27	27	27	27	34.83
20.0	24	24	24	24	24	24	36.67

t (in)	**0.406**	**0.438**	**0.469**	**0.500**	**0.562**	**0.625**	
D_i (in)	**21.188**	**21.124**	**21.062**	**21.000**	**20.876**	**20.750**	
W(lb/ft)	**93.63**	**100.86**	**107.85**	**114.81**	**128.67**	**142.68**	
L/D_o	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**L (ft)**
5.0	386	385	385	384	383	382	9.17
6.0	268	267	267	267	266	265	11.00
7.0	197	197	196	196	195	195	12.83
8.0	151	150	150	150	150	149	14.67
9.0	119	119	119	119	118	118	16.50
10.0	96	96	96	96	96	95	18.33
11.0	80	80	79	79	79	79	20.17
12.0	67	67	67	67	66	66	22.00
13.0	57	57	57	57	57	56	23.83
14.0	49	49	49	49	49	49	25.67
15.0	43	43	43	43	43	42	27.50
16.0	38	38	38	38	37	37	29.33
17.0	33	33	33	33	33	33	31.17
18.0	30	30	30	30	30	29	33.00
19.0	27	27	27	27	27	26	34.83
20.0	24	24	24	24	24	24	36.67

Table D-2.1. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) WITH APPLIED AXIAL LOADS (Clamped-Clamped) (cont)



NPS = 22 in
D_o = 22.00 in
E = 28831000 lb/in^2

P/P_b = .25
λ = 4.730041
μ = 489.535 lb/ft^3

t (in)	**0.688**	**0.750**	**0.812**	**0.875**	**0.938**	**1.000**	
D_i (in)	**20.624**	**20.500**	**20.376**	**20.250**	**20.124**	**20.000**	
W(lb/ft)	**156.60**	**170.21**	**183.75**	**197.41**	**211.00**	**224.28**	
L/D_o	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**L (ft)**
5.0	381	380	379	378	377	375	9.17
6.0	264	264	263	262	261	261	11.00
7.0	194	194	193	193	192	192	12.83
8.0	149	148	148	148	147	147	14.67
9.0	118	117	117	117	116	116	16.50
10.0	95	95	95	94	94	94	18.33
11.0	79	78	78	78	78	78	20.17
12.0	66	66	66	66	65	65	22.00
13.0	56	56	56	56	56	56	23.83
14.0	49	48	48	48	48	48	25.67
15.0	42	42	42	42	42	42	27.50
16.0	37	37	37	37	37	37	29.33
17.0	33	33	33	33	33	32	31.17
18.0	29	29	29	29	29	29	33.00
19.0	26	26	26	26	26	26	34.83
20.0	24	24	24	24	24	23	36.67

t (in)	**1.062**	**1.125**	**1.188**	**1.250**	**1.312**	**1.375**	
D_i (in)	**19.876**	**19.750**	**19.624**	**19.500**	**19.376**	**19.250**	
W(lb/ft)	**237.48**	**250.81**	**264.06**	**277.01**	**289.88**	**302.88**	
L/D_o	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**L (ft)**
5.0	374	373	372	371	370	369	9.17
6.0	260	259	259	258	257	256	11.00
7.0	191	190	190	189	189	188	12.83
8.0	146	146	145	145	145	144	14.67
9.0	116	115	115	115	114	114	16.50
10.0	94	93	93	93	93	92	18.33
11.0	77	77	77	77	76	76	20.17
12.0	65	65	65	64	64	64	22.00
13.0	55	55	55	55	55	55	23.83
14.0	48	48	47	47	47	47	25.67
15.0	42	41	41	41	41	41	27.50
16.0	37	36	36	36	36	36	29.33
17.0	32	32	32	32	32	32	31.17
18.0	29	29	29	29	29	28	33.00
19.0	26	26	26	26	26	26	34.83
20.0	23	23	23	23	23	23	36.67

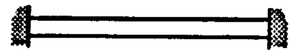
Table D-2.1. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) WITH APPLIED AXIAL LOADS (Clamped-Clamped) (cont)

NPS = 22 in
D_o = 22.00 in
E = 28831000 lb/in^2

P/P_b = .25
λ = 4.730041
μ = 489.535 lb/ft^3

t (in)	**1.438**	**1.500**	
D_i (in)	**19.124**	**19.000**	
W(lb/ft)	**315.79**	**328.41**	
L/D_o	**f_n**	**f_n**	**L (ft)**
5.0	368	367	9.17
6.0	256	255	11.00
7.0	188	187	12.83
8.0	144	143	14.67
9.0	114	113	16.50
10.0	92	92	18.33
11.0	76	76	20.17
12.0	64	64	22.00
13.0	54	54	23.83
14.0	47	47	25.67
15.0	41	41	27.50
16.0	36	36	29.33
17.0	32	32	31.17
18.0	28	28	33.00
19.0	25	25	34.83
20.0	23	23	36.67

Table D-2.1. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) WITH APPLIED AXIAL LOADS (Clamped-Clamped) (cont)



NPS = 22 in
D_o = 22.00 in
E = 28831000 lb/in^2

P/P_b = .50
λ = 4.730041
μ = 489.535 lb/ft^3

t (in)	**0.219**	**0.250**	**0.281**	**0.312**	**0.344**	**0.375**	
D_i (in)	**21.562**	**21.500**	**21.438**	**21.376**	**21.312**	**21.250**	
W(lb/ft)	**50.94**	**58.07**	**65.18**	**72.27**	**79.56**	**86.61**	
L/D_o	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	L (ft)
5.0	318	317	317	316	316	315	9.17
6.0	221	220	220	220	219	219	11.00
7.0	162	162	162	161	161	161	12.83
8.0	124	124	124	124	123	123	14.67
9.0	98	98	98	98	97	97	16.50
10.0	79	79	79	79	79	79	18.33
11.0	66	66	65	65	65	65	20.17
12.0	55	55	55	55	55	55	22.00
13.0	47	47	47	47	47	47	23.83
14.0	41	40	40	40	40	40	25.67
15.0	35	35	35	35	35	35	27.50
16.0	31	31	31	31	31	31	29.33
17.0	27	27	27	27	27	27	31.17
18.0	25	24	24	24	24	24	33.00
19.0	22	22	22	22	22	22	34.83
20.0	20	20	20	20	20	20	36.67

t (in)	**0.406**	**0.438**	**0.469**	**0.500**	**0.562**	**0.625**	
D_i (in)	**21.188**	**21.124**	**21.062**	**21.000**	**20.876**	**20.750**	
W(lb/ft)	**93.63**	**100.86**	**107.85**	**114.81**	**128.67**	**142.68**	
L/D_o	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	L (ft)
5.0	315	314	314	314	313	312	9.17
6.0	219	218	218	218	217	217	11.00
7.0	161	160	160	160	160	159	12.83
8.0	123	123	123	123	122	122	14.67
9.0	97	97	97	97	97	96	16.50
10.0	79	79	79	78	78	78	18.33
11.0	65	65	65	65	65	64	20.17
12.0	55	55	55	54	54	54	22.00
13.0	47	47	46	46	46	46	23.83
14.0	40	40	40	40	40	40	25.67
15.0	35	35	35	35	35	35	27.50
16.0	31	31	31	31	31	30	29.33
17.0	27	27	27	27	27	27	31.17
18.0	24	24	24	24	24	24	33.00
19.0	22	22	22	22	22	22	34.83
20.0	20	20	20	20	20	19	36.67

Table D-2.1. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) WITH APPLIED AXIAL LOADS (Clamped-Clamped) (cont)

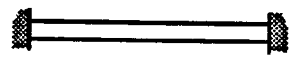
NPS = 22 in
D_o = 22.00 in
E = 28831000 lb/in^2

P/P_b = .50
λ = 4.730041
μ = 489.535 lb/ft^3

t (in)	0.688	0.750	0.812	0.875	0.938	1.000	
D_i (in)	20.624	20.500	20.376	20.250	20.124	20.000	
W(lb/ft)	156.60	170.21	183.75	197.41	211.00	224.28	
L/D_o	f_n	f_n	f_n	f_n	f_n	f_n	L (ft)
5.0	311	310	309	308	307	307	9.17
6.0	216	215	215	214	214	213	11.00
7.0	159	158	158	157	157	156	12.83
8.0	121	121	121	120	120	120	14.67
9.0	96	96	95	95	95	95	16.50
10.0	78	78	77	77	77	77	18.33
11.0	64	64	64	64	64	63	20.17
12.0	54	54	54	54	53	53	22.00
13.0	46	46	46	46	45	45	23.83
14.0	40	40	39	39	39	39	25.67
15.0	35	34	34	34	34	34	27.50
16.0	30	30	30	30	30	30	29.33
17.0	27	27	27	27	27	27	31.17
18.0	24	24	24	24	24	24	33.00
19.0	22	21	21	21	21	21	34.83
20.0	19	19	19	19	19	19	36.67

t (in)	1.062	1.125	1.188	1.250	1.312	1.375	
D_i (in)	19.876	19.750	19.624	19.500	19.376	19.250	
W(lb/ft)	237.48	250.81	264.06	277.01	289.88	302.88	
L/D_o	f_n	f_n	f_n	f_n	f_n	f_n	L (ft)
5.0	306	305	304	303	302	301	9.17
6.0	212	212	211	211	210	209	11.00
7.0	156	156	155	155	154	154	12.83
8.0	119	119	119	118	118	118	14.67
9.0	94	94	94	94	93	93	16.50
10.0	76	76	76	76	76	75	18.33
11.0	63	63	63	63	62	62	20.17
12.0	53	53	53	53	52	52	22.00
13.0	45	45	45	45	45	45	23.83
14.0	39	39	39	39	39	38	25.67
15.0	34	34	34	34	34	33	27.50
16.0	30	30	30	30	30	29	29.33
17.0	26	26	26	26	26	26	31.17
18.0	24	24	23	23	23	23	33.00
19.0	21	21	21	21	21	21	34.83
20.0	19	19	19	19	19	19	36.67

Table D-2.1. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) WITH APPLIED AXIAL LOADS (Clamped-Clamped) (cont)

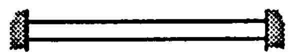


NPS = 22 in
D_o = 22.00 in
E = 28831000 lb/in²

P/P_b = .50
λ = 4.730041
μ = 489.535 lb/ft³

t (in)	**1.438**	**1.500**	
D_i (in)	**19.124**	**19.000**	
W(lb/ft)	**315.79**	**328.41**	
L/D_o	**f_n**	**f_n**	**L (ft)**
5.0	301	300	9.17
6.0	209	208	11.00
7.0	153	153	12.83
8.0	117	117	14.67
9.0	93	93	16.50
10.0	75	75	18.33
11.0	62	62	20.17
12.0	52	52	22.00
13.0	44	44	23.83
14.0	38	38	25.67
15.0	33	33	27.50
16.0	29	29	29.33
17.0	26	26	31.17
18.0	23	23	33.00
19.0	21	21	34.83
20.0	19	19	36.67

Table D-2.1. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) WITH APPLIED AXIAL LOADS (Clamped-Clamped) (cont)



NPS = 22 in
D_o = 22.00 in
E = 28831000 lb/in^2

P/P_b = .75
λ = 4.730041
μ = 489.535 lb/ft^3

t (in)	**0.219**	**0.250**	**0.281**	**0.312**	**0.344**	**0.375**	
D_i (in)	**21.562**	**21.500**	**21.438**	**21.376**	**21.312**	**21.250**	
W(lb/ft)	**50.94**	**58.07**	**65.18**	**72.27**	**79.56**	**86.61**	
L/D_o	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**L (ft)**
5.0	225	224	224	224	223	223	9.17
6.0	156	156	156	155	155	155	11.00
7.0	115	114	114	114	114	114	12.83
8.0	88	88	87	87	87	87	14.67
9.0	69	69	69	69	69	69	16.50
10.0	56	56	56	56	56	56	18.33
11.0	46	46	46	46	46	46	20.17
12.0	39	39	39	39	39	39	22.00
13.0	33	33	33	33	33	33	23.83
14.0	29	29	29	29	28	28	25.67
15.0	25	25	25	25	25	25	27.50
16.0	22	22	22	22	22	22	29.33
17.0	19	19	19	19	19	19	31.17
18.0	17	17	17	17	17	17	33.00
19.0	16	16	16	15	15	15	34.83
20.0	14	14	14	14	14	14	36.67

t (in)	**0.406**	**0.438**	**0.469**	**0.500**	**0.562**	**0.625**	
D_i (in)	**21.188**	**21.124**	**21.062**	**21.000**	**20.876**	**20.750**	
W(lb/ft)	**93.63**	**100.86**	**107.85**	**114.81**	**128.67**	**142.68**	
L/D_o	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**L (ft)**
5.0	223	222	222	222	221	221	9.17
6.0	155	154	154	154	154	153	11.00
7.0	114	113	113	113	113	113	12.83
8.0	87	87	87	87	86	86	14.67
9.0	69	69	69	68	68	68	16.50
10.0	56	56	56	55	55	55	18.33
11.0	46	46	46	46	46	46	20.17
12.0	39	39	39	38	38	38	22.00
13.0	33	33	33	33	33	33	23.83
14.0	28	28	28	28	28	28	25.67
15.0	25	25	25	25	25	25	27.50
16.0	22	22	22	22	22	22	29.33
17.0	19	19	19	19	19	19	31.17
18.0	17	17	17	17	17	17	33.00
19.0	15	15	15	15	15	15	34.83
20.0	14	14	14	14	14	14	36.67

Table D-2.1. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) WITH APPLIED AXIAL LOADS (Clamped-Clamped) (cont)

NPS = 22 in
D_o = 22.00 in
E = 28831000 lb/in^2

P/P_b = .75
λ = 4.730041
μ = 489.535 lb/ft^3

t (in)	0.688	0.750	0.812	0.875	0.938	1.000	
D_i (in)	20.624	20.500	20.376	20.250	20.124	20.000	
W(lb/ft)	156.60	170.21	183.75	197.41	211.00	224.28	
L/D_o	f_n	f_n	f_n	f_n	f_n	f_n	L (ft)
5.0	220	219	219	218	217	217	9.17
6.0	153	152	152	151	151	151	11.00
7.0	112	112	112	111	111	111	12.83
8.0	86	86	85	85	85	85	14.67
9.0	68	68	67	67	67	67	16.50
10.0	55	55	55	55	54	54	18.33
11.0	45	45	45	45	45	45	20.17
12.0	38	38	38	38	38	38	22.00
13.0	33	32	32	32	32	32	23.83
14.0	28	28	28	28	28	28	25.67
15.0	24	24	24	24	24	24	27.50
16.0	21	21	21	21	21	21	29.33
17.0	19	19	19	19	19	19	31.17
18.0	17	17	17	17	17	17	33.00
19.0	15	15	15	15	15	15	34.83
20.0	14	14	14	14	14	14	36.67

t (in)	1.062	1.125	1.188	1.250	1.312	1.375	
D_i (in)	19.876	19.750	19.624	19.500	19.376	19.250	
W(lb/ft)	237.48	250.81	264.06	277.01	289.88	302.88	
L/D_o	f_n	f_n	f_n	f_n	f_n	f_n	L (ft)
5.0	216	216	215	214	214	213	9.17
6.0	150	150	149	149	148	148	11.00
7.0	110	110	110	109	109	109	12.83
8.0	84	84	84	84	83	83	14.67
9.0	67	67	66	66	66	66	16.50
10.0	54	54	54	54	53	53	18.33
11.0	45	45	44	44	44	44	20.17
12.0	38	37	37	37	37	37	22.00
13.0	32	32	32	32	32	32	23.83
14.0	28	27	27	27	27	27	25.67
15.0	24	24	24	24	24	24	27.50
16.0	21	21	21	21	21	21	29.33
17.0	19	19	19	19	18	18	31.17
18.0	17	17	17	17	16	16	33.00
19.0	15	15	15	15	15	15	34.83
20.0	14	13	13	13	13	13	36.67

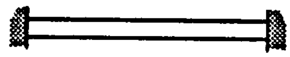
Table D-2.1. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) WITH APPLIED AXIAL LOADS (Clamped-Clamped) (cont)

NPS = 22 in
D_o = 22.00 in
E = 28831000 lb/in^2

P/P_b = .75
λ = 4.730041
μ = 489.535 lb/ft^3

t (in)	**1.438**	**1.500**	
D_i (in)	**19.124**	**19.000**	
W(lb/ft)	**315.79**	**328.41**	
L/D_o	**f_n**	**f_n**	**L (ft)**
5.0	213	212	9.17
6.0	148	147	11.00
7.0	108	108	12.83
8.0	83	83	14.67
9.0	66	65	16.50
10.0	53	53	18.33
11.0	44	44	20.17
12.0	37	37	22.00
13.0	31	31	23.83
14.0	27	27	25.67
15.0	24	24	27.50
16.0	21	21	29.33
17.0	18	18	31.17
18.0	16	16	33.00
19.0	15	15	34.83
20.0	13	13	36.67

Table D-2.1. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) WITH APPLIED AXIAL LOADS (Clamped-Clamped) (cont)



NPS = 24 in
D_o = 24.00 in
E = 28831000 lb/in^2

P/P_b = .25
λ = 4.730041
μ = 489.535 lb/ft^3

t (in)	**0.250**	**0.281**	**0.312**	**0.344**	**0.375**	**0.406**	
D_i (in)	**23.500**	**23.438**	**23.376**	**23.312**	**23.250**	**23.188**	
W(lb/ft)	**63.41**	**71.18**	**78.93**	**86.91**	**94.62**	**102.31**	
L/D_o	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**L (ft)**
5.0	356	356	356	355	355	354	10.00
6.0	248	247	247	247	246	246	12.00
7.0	182	182	181	181	181	181	14.00
8.0	139	139	139	139	139	138	16.00
9.0	110	110	110	110	109	109	18.00
10.0	89	89	89	89	89	89	20.00
11.0	74	74	73	73	73	73	22.00
12.0	62	62	62	62	62	61	24.00
13.0	53	53	53	53	52	52	26.00
14.0	45	45	45	45	45	45	28.00
15.0	40	40	40	39	39	39	30.00
16.0	35	35	35	35	35	35	32.00
17.0	31	31	31	31	31	31	34.00
18.0	28	27	27	27	27	27	36.00
19.0	25	25	25	25	25	25	38.00
20.0	22	22	22	22	22	22	40.00

t (in)	**0.438**	**0.469**	**0.500**	**0.562**	**0.625**	**0.688**	
D_i (in)	**23.124**	**23.062**	**23.000**	**22.876**	**22.750**	**22.624**	
W(lb/ft)	**110.22**	**117.86**	**125.49**	**140.68**	**156.03**	**171.29**	
L/D_o	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**L (ft)**
5.0	354	353	353	352	351	350	10.00
6.0	246	245	245	244	244	243	12.00
7.0	180	180	180	180	179	179	14.00
8.0	138	138	138	137	137	137	16.00
9.0	109	109	109	109	108	108	18.00
10.0	88	88	88	88	88	88	20.00
11.0	73	73	73	73	73	72	22.00
12.0	61	61	61	61	61	61	24.00
13.0	52	52	52	52	52	52	26.00
14.0	45	45	45	45	45	45	28.00
15.0	39	39	39	39	39	39	30.00
16.0	35	34	34	34	34	34	32.00
17.0	31	31	31	30	30	30	34.00
18.0	27	27	27	27	27	27	36.00
19.0	24	24	24	24	24	24	38.00
20.0	22	22	22	22	22	22	40.00

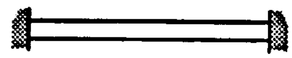
Table D-2.1. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) WITH APPLIED AXIAL LOADS (Clamped-Clamped) (cont)

NPS = 24 in | **P/P_b = .25**
D_o = 24.00 in | λ = 4.730041
E = 28831000 lb/in^2 | μ = 489.535 lb/ft^3

t (in)	**0.750**	**0.812**	**0.875**	**0.938**	**1.000**	**1.062**	
D_i (in)	**22.500**	**22.376**	**22.250**	**22.124**	**22.000**	**21.876**	
W(lb/ft)	**186.23**	**201.09**	**216.10**	**231.03**	**245.64**	**260.17**	
L/D_o	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**L (ft)**
5.0	349	348	347	346	345	345	10.00
6.0	242	242	241	241	240	239	12.00
7.0	178	178	177	177	176	176	14.00
8.0	136	136	136	135	135	135	16.00
9.0	108	107	107	107	107	106	18.00
10.0	87	87	87	87	86	86	20.00
11.0	72	72	72	72	71	71	22.00
12.0	61	60	60	60	60	60	24.00
13.0	52	52	51	51	51	51	26.00
14.0	45	44	44	44	44	44	28.00
15.0	39	39	39	38	38	38	30.00
16.0	34	34	34	34	34	34	32.00
17.0	30	30	30	30	30	30	34.00
18.0	27	27	27	27	27	27	36.00
19.0	24	24	24	24	24	24	38.00
20.0	22	22	22	22	22	22	40.00

t (in)	**1.125**	**1.188**	**1.250**	**1.312**	**1.375**	**1.438**	
D_i (in)	**21.750**	**21.624**	**21.500**	**21.376**	**21.250**	**21.124**	
W(lb/ft)	**274.84**	**289.44**	**303.71**	**317.91**	**332.25**	**346.50**	
L/D_o	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**L (ft)**
5.0	344	343	342	341	340	339	10.00
6.0	239	238	237	237	236	236	12.00
7.0	175	175	174	174	174	173	14.00
8.0	134	134	134	133	133	133	16.00
9.0	106	106	106	105	105	105	18.00
10.0	86	86	85	85	85	85	20.00
11.0	71	71	71	70	70	70	22.00
12.0	60	60	59	59	59	59	24.00
13.0	51	51	51	50	50	50	26.00
14.0	44	44	44	44	43	43	28.00
15.0	38	38	38	38	38	38	30.00
16.0	34	33	33	33	33	33	32.00
17.0	30	30	30	30	29	29	34.00
18.0	27	26	26	26	26	26	36.00
19.0	24	24	24	24	24	23	38.00
20.0	21	21	21	21	21	21	40.00

Table D-2.1. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) WITH APPLIED AXIAL LOADS (Clamped-Clamped) (cont)



NPS = 24 in
D_o = 24.00 in
E = 28831000 lb/in^2

P/P_b = .25
λ = 4.730041
μ = 489.535 lb/ft^3

t (in)	**1.500**	**1.562**	
D_i (in)	**21.000**	**20.876**	
W(lb/ft)	**360.45**	**374.31**	
L/D_o	**f_n**	**f_n**	**L (ft)**
5.0	338	338	10.00
6.0	235	234	12.00
7.0	173	172	14.00
8.0	132	132	16.00
9.0	104	104	18.00
10.0	85	84	20.00
11.0	70	70	22.00
12.0	59	59	24.00
13.0	50	50	26.00
14.0	43	43	28.00
15.0	38	38	30.00
16.0	33	33	32.00
17.0	29	29	34.00
18.0	26	26	36.00
19.0	23	23	38.00
20.0	21	21	40.00

Table D-2.1. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) WITH APPLIED AXIAL LOADS (Clamped-Clamped) (cont)

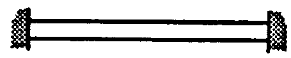
NPS = 24 in
D_o = 24.00 in
E = 28831000 lb/in^2

P/P_b = .50
λ = 4.730041
μ = 489.535 lb/ft^3

t (in)	0.250	0.281	0.312	0.344	0.375	0.406	
D_i (in)	23.500	23.438	23.376	23.312	23.250	23.188	
W(lb/ft)	63.41	71.18	78.93	86.91	94.62	102.31	
L/D_o	f_n	f_n	f_n	f_n	f_n	f_n	L (ft)
5.0	291	291	290	290	290	289	10.00
6.0	202	202	202	201	201	201	12.00
7.0	148	148	148	148	148	148	14.00
8.0	114	114	113	113	113	113	16.00
9.0	90	90	90	89	89	89	18.00
10.0	73	73	73	72	72	72	20.00
11.0	60	60	60	60	60	60	22.00
12.0	51	50	50	50	50	50	24.00
13.0	43	43	43	43	43	43	26.00
14.0	37	37	37	37	37	37	28.00
15.0	32	32	32	32	32	32	30.00
16.0	28	28	28	28	28	28	32.00
17.0	25	25	25	25	25	25	34.00
18.0	22	22	22	22	22	22	36.00
19.0	20	20	20	20	20	20	38.00
20.0	18	18	18	18	18	18	40.00

t (in)	0.438	0.469	0.500	0.562	0.625	0.688	
D_i (in)	23.124	23.062	23.000	22.876	22.750	22.624	
W(lb/ft)	110.22	117.86	125.49	140.68	156.03	171.29	
L/D_o	f_n	f_n	f_n	f_n	f_n	f_n	L (ft)
5.0	289	288	288	287	287	286	10.00
6.0	201	200	200	200	199	198	12.00
7.0	147	147	147	147	146	146	14.00
8.0	113	113	113	112	112	112	16.00
9.0	89	89	89	89	88	88	18.00
10.0	72	72	72	72	72	71	20.00
11.0	60	60	60	59	59	59	22.00
12.0	50	50	50	50	50	50	24.00
13.0	43	43	43	42	42	42	26.00
14.0	37	37	37	37	37	36	28.00
15.0	32	32	32	32	32	32	30.00
16.0	28	28	28	28	28	28	32.00
17.0	25	25	25	25	25	25	34.00
18.0	22	22	22	22	22	22	36.00
19.0	20	20	20	20	20	20	38.00
20.0	18	18	18	18	18	18	40.00

Table D-2.1. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) WITH APPLIED AXIAL LOADS (Clamped-Clamped) (cont)



NPS = 24 in
D_o = 24.00 in
E = 28831000 lb/in^2

P/P_b = .50
λ = 4.730041
μ = 489.535 lb/ft^3

t (in)	**0.750**	**0.812**	**0.875**	**0.938**	**1.000**	**1.062**	
D_i (in)	**22.500**	**22.376**	**22.250**	**22.124**	**22.000**	**21.876**	
W(lb/ft)	**186.23**	**201.09**	**216.10**	**231.03**	**245.64**	**260.17**	
L/D_o	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	L (ft)
5.0	285	284	284	283	282	281	10.00
6.0	198	197	197	196	196	195	12.00
7.0	145	145	145	144	144	144	14.00
8.0	111	111	111	110	110	110	16.00
9.0	88	88	88	87	87	87	18.00
10.0	71	71	71	71	71	70	20.00
11.0	59	59	59	58	58	58	22.00
12.0	49	49	49	49	49	49	24.00
13.0	42	42	42	42	42	42	26.00
14.0	36	36	36	36	36	36	28.00
15.0	32	32	32	31	31	31	30.00
16.0	28	28	28	28	28	27	32.00
17.0	25	25	25	24	24	24	34.00
18.0	22	22	22	22	22	22	36.00
19.0	20	20	20	20	20	19	38.00
20.0	18	18	18	18	18	18	40.00

t (in)	**1.125**	**1.188**	**1.250**	**1.312**	**1.375**	**1.438**	
D_i (in)	**21.750**	**21.624**	**21.500**	**21.376**	**21.250**	**21.124**	
W(lb/ft)	**274.84**	**289.44**	**303.71**	**317.91**	**332.25**	**346.50**	
L/D_o	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	L (ft)
5.0	281	280	279	278	278	277	10.00
6.0	195	194	194	193	193	192	12.00
7.0	143	143	142	142	142	141	14.00
8.0	110	109	109	109	108	108	16.00
9.0	87	86	86	86	86	86	18.00
10.0	70	70	70	70	69	69	20.00
11.0	58	58	58	58	57	57	22.00
12.0	49	49	48	48	48	48	24.00
13.0	42	41	41	41	41	41	26.00
14.0	36	36	36	36	35	35	28.00
15.0	31	31	31	31	31	31	30.00
16.0	27	27	27	27	27	27	32.00
17.0	24	24	24	24	24	24	34.00
18.0	22	22	22	21	21	21	36.00
19.0	19	19	19	19	19	19	38.00
20.0	18	17	17	17	17	17	40.00

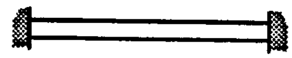
Table D-2.1. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) WITH APPLIED AXIAL LOADS (Clamped-Clamped) (cont)

NPS = 24 in
D_o = 24.00 in
E = 28831000 lb/in^2

P/P_b = .50
λ = 4.730041
μ = 489.535 lb/ft^3

t (in)	**1.500**	**1.562**	
D_i (in)	**21.000**	**20.876**	
W(lb/ft)	**360.45**	**374.31**	
L/D_o	**f_n**	**f_n**	**L (ft)**
5.0	276	276	10.00
6.0	192	191	12.00
7.0	141	141	14.00
8.0	108	108	16.00
9.0	85	85	18.00
10.0	69	69	20.00
11.0	57	57	22.00
12.0	48	48	24.00
13.0	41	41	26.00
14.0	35	35	28.00
15.0	31	31	30.00
16.0	27	27	32.00
17.0	24	24	34.00
18.0	21	21	36.00
19.0	19	19	38.00
20.0	17	17	40.00

Table D-2.1. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) WITH APPLIED AXIAL LOADS (Clamped-Clamped) (cont)



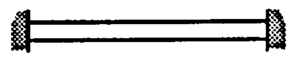
NPS = 24 in
D_o = 24.00 in
E = 28831000 lb/in^2

P/P_b = .75
λ = 4.730041
μ = 489.535 lb/ft^3

t (in)	0.250	0.281	0.312	0.344	0.375	0.406	
D_i (in)	23.500	23.438	23.376	23.312	23.250	23.188	
W(lb/ft)	63.41	71.18	78.93	86.91	94.62	102.31	
L/D_o	f_n	f_n	f_n	f_n	f_n	f_n	L (ft)
5.0	206	206	205	205	205	204	10.00
6.0	143	143	143	142	142	142	12.00
7.0	105	105	105	105	104	104	14.00
8.0	80	80	80	80	80	80	16.00
9.0	64	63	63	63	63	63	18.00
10.0	51	51	51	51	51	51	20.00
11.0	43	42	42	42	42	42	22.00
12.0	36	36	36	36	36	35	24.00
13.0	30	30	30	30	30	30	26.00
14.0	26	26	26	26	26	26	28.00
15.0	23	23	23	23	23	23	30.00
16.0	20	20	20	20	20	20	32.00
17.0	18	18	18	18	18	18	34.00
18.0	16	16	16	16	16	16	36.00
19.0	14	14	14	14	14	14	38.00
20.0	13	13	13	13	13	13	40.00

t (in)	0.438	0.469	0.500	0.562	0.625	0.688	
D_i (in)	23.124	23.062	23.000	22.876	22.750	22.624	
W(lb/ft)	110.22	117.86	125.49	140.68	156.03	171.29	
L/D_o	f_n	f_n	f_n	f_n	f_n	f_n	L (ft)
5.0	204	204	204	203	203	202	10.00
6.0	142	142	141	141	141	140	12.00
7.0	104	104	104	104	103	103	14.00
8.0	80	80	80	79	79	79	16.00
9.0	63	63	63	63	63	62	18.00
10.0	51	51	51	51	51	51	20.00
11.0	42	42	42	42	42	42	22.00
12.0	35	35	35	35	35	35	24.00
13.0	30	30	30	30	30	30	26.00
14.0	26	26	26	26	26	26	28.00
15.0	23	23	23	23	23	22	30.00
16.0	20	20	20	20	20	20	32.00
17.0	18	18	18	18	18	17	34.00
18.0	16	16	16	16	16	16	36.00
19.0	14	14	14	14	14	14	38.00
20.0	13	13	13	13	13	13	40.00

Table D-2.1. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) WITH APPLIED AXIAL LOADS (Clamped-Clamped) (cont)



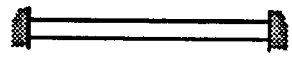
NPS = 24 in
D_o = 24.00 in
E = 28831000 lb/in^2

P/P_b = .75
λ = 4.730041
μ = 489.535 lb/ft^3

t (in)	0.750	0.812	0.875	0.938	1.000	1.062	
D_i (in)	22.500	22.376	22.250	22.124	22.000	21.876	
W(lb/ft)	186.23	201.09	216.10	231.03	245.64	260.17	
L/D_o	f_n	f_n	f_n	f_n	f_n	f_n	L (ft)
5.0	202	201	201	200	199	199	10.00
6.0	140	140	139	139	139	138	12.00
7.0	103	103	102	102	102	102	14.00
8.0	79	79	78	78	78	78	16.00
9.0	62	62	62	62	62	61	18.00
10.0	50	50	50	50	50	50	20.00
11.0	42	42	41	41	41	41	22.00
12.0	35	35	35	35	35	35	24.00
13.0	30	30	30	30	30	29	26.00
14.0	26	26	26	26	25	25	28.00
15.0	22	22	22	22	22	22	30.00
16.0	20	20	20	20	19	19	32.00
17.0	17	17	17	17	17	17	34.00
18.0	16	16	15	15	15	15	36.00
19.0	14	14	14	14	14	14	38.00
20.0	13	13	13	12	12	12	40.00

t (in)	1.125	1.188	1.250	1.312	1.375	1.438	
D_i (in)	21.750	21.624	21.500	21.376	21.250	21.124	
W(lb/ft)	274.84	289.44	303.71	317.91	332.25	346.50	
L/D_o	f_n	f_n	f_n	f_n	f_n	f_n	L (ft)
5.0	198	198	197	197	196	196	10.00
6.0	138	137	137	137	136	136	12.00
7.0	101	101	101	100	100	100	14.00
8.0	78	77	77	77	77	77	16.00
9.0	61	61	61	61	61	60	18.00
10.0	50	49	49	49	49	49	20.00
11.0	41	41	41	41	41	40	22.00
12.0	34	34	34	34	34	34	24.00
13.0	29	29	29	29	29	29	26.00
14.0	25	25	25	25	25	25	28.00
15.0	22	22	22	22	22	22	30.00
16.0	19	19	19	19	19	19	32.00
17.0	17	17	17	17	17	17	34.00
18.0	15	15	15	15	15	15	36.00
19.0	14	14	14	14	14	14	38.00
20.0	12	12	12	12	12	12	40.00

Table D-2.1. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) WITH APPLIED AXIAL LOADS (Clamped-Clamped) (cont)

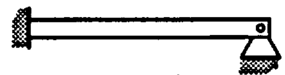


NPS = 24 in
D_o = 24.00 in
E = 28831000 lb/in^2

P/P_b = .75
λ = 4.730041
μ = 489.535 lb/ft^3

t (in)	**1.500**	**1.562**	
D_i (in)	**21.000**	**20.876**	
W(lb/ft)	**360.45**	**374.31**	
L/D_o	**f_n**	**f_n**	**L (ft)**
5.0	195	195	10.00
6.0	136	135	12.00
7.0	100	99	14.00
8.0	76	76	16.00
9.0	60	60	18.00
10.0	49	49	20.00
11.0	40	40	22.00
12.0	34	34	24.00
13.0	29	29	26.00
14.0	25	25	28.00
15.0	22	22	30.00
16.0	19	19	32.00
17.0	17	17	34.00
18.0	15	15	36.00
19.0	14	13	38.00
20.0	12	12	40.00

Table D-2.2. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) WITH APPLIED AXIAL LOADS (Clamped-Pinned)



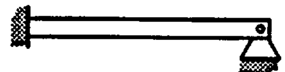
NPS = 4 in
D_o = 4.5 in
E = 28831000 lb/in^2

P/P_b = .25
λ = 3.92660231
μ = 489.535 lb/ft^3

t (in)	**0.125**	**0.156**	**0.188**	**0.219**	**0.237**	**0.250**	
D_i (in)	**4.250**	**4.188**	**4.124**	**4.062**	**4.026**	**4.000**	
W(lb/ft)	**5.84**	**7.24**	**8.66**	**10.01**	**10.79**	**11.35**	
L/D_o	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**L (ft)**
5.0	1288	1279	1270	1261	1256	1252	1.88
6.0	894	888	882	876	872	870	2.25
7.0	657	652	648	643	641	639	2.63
8.0	503	500	496	493	491	489	3.00
9.0	397	395	392	389	388	387	3.38
10.0	322	320	317	315	314	313	3.75
11.0	266	264	262	261	260	259	4.13
12.0	224	222	220	219	218	217	4.50
13.0	190	189	188	187	186	185	4.88
14.0	164	163	162	161	160	160	5.25
15.0	143	142	141	140	140	139	5.63
16.0	126	125	124	123	123	122	6.00
17.0	111	111	110	109	109	108	6.38
18.0	99	99	98	97	97	97	6.75
19.0	89	89	88	87	87	87	7.13
20.0	80	80	79	79	79	78	7.50

t (in)	**0.281**	**0.312**	**0.337**	**0.438**	**0.531**	**0.674**	
D_i (in)	**3.938**	**3.876**	**3.826**	**3.624**	**3.438**	**3.152**	
W(lb/ft)	**12.66**	**13.96**	**14.98**	**19.00**	**22.51**	**27.54**	
L/D_o	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**L (ft)**
5.0	1244	1235	1229	1202	1178	1143	1.88
6.0	864	858	853	835	818	794	2.25
7.0	635	630	627	613	601	583	2.63
8.0	486	483	480	469	460	446	3.00
9.0	384	381	379	371	364	353	3.38
10.0	311	309	307	300	294	286	3.75
11.0	257	255	254	248	243	236	4.13
12.0	216	214	213	209	205	198	4.50
13.0	184	183	182	178	174	169	4.88
14.0	159	158	157	153	150	146	5.25
15.0	138	137	137	134	131	127	5.63
16.0	121	121	120	117	115	112	6.00
17.0	108	107	106	104	102	99	6.38
18.0	96	95	95	93	91	88	6.75
19.0	86	86	85	83	82	79	7.13
20.0	78	77	77	75	74	71	7.50

Table D-2.2. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) WITH APPLIED AXIAL LOADS (Clamped-Pinned) (cont)



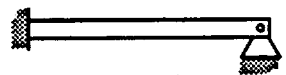
NPS = 4 in
D_o = 4.5 in
E = 28831000 lb/in^2

P/P_b = .50
λ = 3.92660231
μ = 489.535 lb/ft^3

t (in)	**0.125**	**0.156**	**0.188**	**0.219**	**0.237**	**0.250**	
D_i (in)	**4.250**	**4.188**	**4.124**	**4.062**	**4.026**	**4.000**	
W(lb/ft)	**5.84**	**7.24**	**8.66**	**10.01**	**10.79**	**11.35**	
L/D_o	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**L (ft)**
5.0	1051	1044	1037	1030	1026	1023	1.88
6.0	730	725	720	715	712	710	2.25
7.0	536	533	529	525	523	522	2.63
8.0	411	408	405	402	401	399	3.00
9.0	324	322	320	318	317	316	3.38
10.0	263	261	259	257	256	256	3.75
11.0	217	216	214	213	212	211	4.13
12.0	183	181	180	179	178	178	4.50
13.0	156	154	153	152	152	151	4.88
14.0	134	133	132	131	131	130	5.25
15.0	117	116	115	114	114	114	5.63
16.0	103	102	101	101	100	100	6.00
17.0	91	90	90	89	89	88	6.38
18.0	81	81	80	79	79	79	6.75
19.0	73	72	72	71	71	71	7.13
20.0	66	65	65	64	64	64	7.50

t (in)	**0.281**	**0.312**	**0.337**	**0.438**	**0.531**	**0.674**	
D_i (in)	**3.938**	**3.876**	**3.826**	**3.624**	**3.438**	**3.152**	
W(lb/ft)	**12.66**	**13.96**	**14.98**	**19.00**	**22.51**	**27.54**	
L/D_o	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**L (ft)**
5.0	1016	1009	1003	981	962	933	1.88
6.0	705	701	697	681	668	648	2.25
7.0	518	515	512	501	491	476	2.63
8.0	397	394	392	383	376	365	3.00
9.0	313	311	310	303	297	288	3.38
10.0	254	252	251	245	240	233	3.75
11.0	210	208	207	203	199	193	4.13
12.0	176	175	174	170	167	162	4.50
13.0	150	149	148	145	142	138	4.88
14.0	130	129	128	125	123	119	5.25
15.0	113	112	111	109	107	104	5.63
16.0	99	99	98	96	94	91	6.00
17.0	88	87	87	85	83	81	6.38
18.0	78	78	77	76	74	72	6.75
19.0	70	70	69	68	67	65	7.13
20.0	63	63	63	61	60	58	7.50

Table D-2.2. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) WITH APPLIED AXIAL LOADS (Clamped-Pinned) (cont)



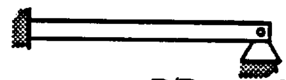
NPS = 4 in
D_o = 4.5 in
E = 28831000 lb/in^2

P/P_b = .75
λ = 3.92660231
μ = 489.535 lb/ft^3

t (in)	0.125	0.156	0.188	0.219	0.237	0.250	
D_i (in)	4.250	4.188	4.124	4.062	4.026	4.000	
W(lb/ft)	5.84	7.24	8.66	10.01	10.79	11.35	
L/D_o	f_n	f_n	f_n	f_n	f_n	f_n	L (ft)
5.0	743	738	733	728	725	723	1.88
6.0	516	513	509	506	504	502	2.25
7.0	379	377	374	371	370	369	2.63
8.0	290	288	286	284	283	282	3.00
9.0	229	228	226	225	224	223	3.38
10.0	186	185	183	182	181	181	3.75
11.0	154	153	151	150	150	149	4.13
12.0	129	128	127	126	126	126	4.50
13.0	110	109	108	108	107	107	4.88
14.0	95	94	94	93	92	92	5.25
15.0	83	82	81	81	81	80	5.63
16.0	73	72	72	71	71	71	6.00
17.0	64	64	63	63	63	63	6.38
18.0	57	57	57	56	56	56	6.75
19.0	51	51	51	50	50	50	7.13
20.0	46	46	46	46	45	45	7.50

t (in)	0.281	0.312	0.337	0.438	0.531	0.674	
D_i (in)	3.938	3.876	3.826	3.624	3.438	3.152	
W(lb/ft)	12.66	13.96	14.98	19.00	22.51	27.54	
L/D_o	f_n	f_n	f_n	f_n	f_n	f_n	L (ft)
5.0	718	713	709	694	680	660	1.88
6.0	499	495	493	482	472	458	2.25
7.0	366	364	362	354	347	337	2.63
8.0	281	279	277	271	266	258	3.00
9.0	222	220	219	214	210	204	3.38
10.0	180	178	177	173	170	165	3.75
11.0	148	147	147	143	141	136	4.13
12.0	125	124	123	120	118	115	4.50
13.0	106	106	105	103	101	98	4.88
14.0	92	91	90	89	87	84	5.25
15.0	80	79	79	77	76	73	5.63
16.0	70	70	69	68	66	64	6.00
17.0	62	62	61	60	59	57	6.38
18.0	55	55	55	54	52	51	6.75
19.0	50	49	49	48	47	46	7.13
20.0	45	45	44	43	43	41	7.50

Table D-2.2. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) WITH APPLIED AXIAL LOADS (Clamped-Pinned) (cont)



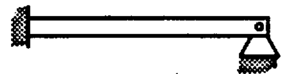
NPS = 5 in
D_o = 5.563 in
E = 28831000 lb/in^2

P/P_b = .25
λ = 3.92660231
μ = 489.535 lb/ft^3

t (in)	0.156	0.188	0.219	0.258	0.281	0.312	
D_i (in)	5.251	5.187	5.125	5.047	5.001	4.939	
W(lb/ft)	9.01	10.79	12.50	14.62	15.85	17.50	
L/D_o	f_n	f_n	f_n	f_n	f_n	f_n	L (ft)
5.0	1041	1035	1030	1022	1018	1013	2.32
6.0	723	719	715	710	707	703	2.78
7.0	531	528	525	522	519	517	3.25
8.0	407	404	402	399	398	396	3.71
9.0	321	320	318	316	314	313	4.17
10.0	260	259	257	256	255	253	4.64
11.0	215	214	213	211	210	209	5.10
12.0	181	180	179	177	177	176	5.56
13.0	154	153	152	151	151	150	6.03
14.0	133	132	131	130	130	129	6.49
15.0	116	115	114	114	113	113	6.95
16.0	102	101	101	100	99	99	7.42
17.0	90	90	89	88	88	88	7.88
18.0	80	80	79	79	79	78	8.34
19.0	72	72	71	71	71	70	8.81
20.0	65	65	64	64	64	63	9.27

t (in)	0.344	0.375	0.500	0.625	0.750	
D_i (in)	4.875	4.813	4.563	4.313	4.063	
W(lb/ft)	19.17	20.78	27.04	32.96	38.55	
L/D_o	f_n	f_n	f_n	f_n	f_n	L (ft)
5.0	1007	1001	979	958	938	2.32
6.0	699	695	680	665	651	2.78
7.0	514	511	500	489	478	3.25
8.0	393	391	383	374	366	3.71
9.0	311	309	302	296	289	4.17
10.0	252	250	245	240	234	4.64
11.0	208	207	202	198	194	5.10
12.0	175	174	170	166	163	5.56
13.0	149	148	145	142	139	6.03
14.0	128	128	125	122	120	6.49
15.0	112	111	109	106	104	6.95
16.0	98	98	96	94	92	7.42
17.0	87	87	85	83	81	7.88
18.0	78	77	76	74	72	8.34
19.0	70	69	68	66	65	8.81
20.0	63	63	61	60	59	9.27

Table D-2.2. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) WITH APPLIED AXIAL LOADS (Clamped-Pinned) (cont)



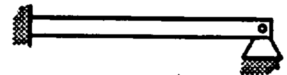
NPS = 5 in
D_o = 5.563 in
E = 28831000 lb/in^2

P/P_b = .50
λ = 3.92660231
μ = 489.535 lb/ft^3

t (in)	**0.156**	**0.188**	**0.219**	**0.258**	**0.281**	**0.312**	
D_i (in)	**5.251**	**5.187**	**5.125**	**5.047**	**5.001**	**4.939**	
W(lb/ft)	**9.01**	**10.79**	**12.50**	**14.62**	**15.85**	**17.50**	
L/D_o	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**L (ft)**
5.0	850	845	841	835	831	827	2.32
6.0	590	587	584	580	577	574	2.78
7.0	434	431	429	426	424	422	3.25
8.0	332	330	328	326	325	323	3.71
9.0	262	261	259	258	257	255	4.17
10.0	213	211	210	209	208	207	4.64
11.0	176	175	174	172	172	171	5.10
12.0	148	147	146	145	144	144	5.56
13.0	126	125	124	123	123	122	6.03
14.0	108	108	107	106	106	105	6.49
15.0	94	94	93	93	92	92	6.95
16.0	83	83	82	82	81	81	7.42
17.0	74	73	73	72	72	72	7.88
18.0	66	65	65	64	64	64	8.34
19.0	59	59	58	58	58	57	8.81
20.0	53	53	53	52	52	52	9.27

t (in)	**0.344**	**0.375**	**0.500**	**0.625**	**0.750**	
D_i (in)	**4.875**	**4.813**	**4.563**	**4.313**	**4.063**	
W(lb/ft)	**19.17**	**20.78**	**27.04**	**32.96**	**38.55**	
L/D_o	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**L (ft)**
5.0	822	818	800	782	766	2.32
6.0	571	568	555	543	532	2.78
7.0	419	417	408	399	391	3.25
8.0	321	319	312	306	299	3.71
9.0	254	252	247	241	236	4.17
10.0	206	204	200	196	191	4.64
11.0	170	169	165	162	158	5.10
12.0	143	142	139	136	133	5.56
13.0	122	121	118	116	113	6.03
14.0	105	104	102	100	98	6.49
15.0	91	91	89	87	85	6.95
16.0	80	80	78	76	75	7.42
17.0	71	71	69	68	66	7.88
18.0	63	63	62	60	59	8.34
19.0	57	57	55	54	53	8.81
20.0	51	51	50	49	48	9.27

Table D-2.2. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) WITH APPLIED AXIAL LOADS (Clamped-Pinned) (cont)



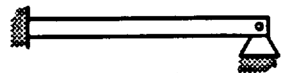
NPS = 5 in
D_o = 5.563 in
E = 28831000 lb/in^2

P/P_b = .75
λ = 3.92660231
μ = 489.535 lb/ft^3

t (in)	0.156	0.188	0.219	0.258	0.281	0.312	
D_i (in)	5.251	5.187	5.125	5.047	5.001	4.939	
W(lb/ft)	9.01	10.79	12.50	14.62	15.85	17.50	
L/D_o	f_n	f_n	f_n	f_n	f_n	f_n	L (ft)
4.0	939	934	929	922	919	913	1.85
5.0	601	598	594	590	588	585	2.32
6.0	417	415	413	410	408	406	2.78
7.0	307	305	303	301	300	298	3.25
8.0	235	233	232	231	230	228	3.71
9.0	186	184	183	182	181	180	4.17
10.0	150	149	149	148	147	146	4.64
11.0	124	123	123	122	121	121	5.10
12.0	104	104	103	102	102	101	5.56
13.0	89	88	88	87	87	86	6.03
14.0	77	76	76	75	75	75	6.49
15.0	67	66	66	66	65	65	6.95
16.0	59	58	58	58	57	57	7.42
17.0	52	52	51	51	51	51	7.88
18.0	46	46	46	46	45	45	8.34
19.0	42	41	41	41	41	40	8.81

t (in)	0.344	0.375	0.500	0.625	0.750	
D_i (in)	4.875	4.813	4.563	4.313	4.063	
W(lb/ft)	19.17	20.78	27.04	32.96	38.55	
L/D_o	f_n	f_n	f_n	f_n	f_n	L (ft)
4.0	908	903	883	864	846	1.85
5.0	581	578	565	553	541	2.32
6.0	404	401	393	384	376	2.78
7.0	297	295	288	282	276	3.25
8.0	227	226	221	216	211	3.71
9.0	179	178	175	171	167	4.17
10.0	145	145	141	138	135	4.64
11.0	120	119	117	114	112	5.10
12.0	101	100	98	96	94	5.56
13.0	86	86	84	82	80	6.03
14.0	74	74	72	71	69	6.49
15.0	65	64	63	61	60	6.95
16.0	57	56	55	54	53	7.42
17.0	50	50	49	48	47	7.88
18.0	45	45	44	43	42	8.34
19.0	40	40	39	38	37	8.81

Table D-2.2. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) WITH APPLIED AXIAL LOADS (Clamped-Pinned) (cont)



NPS = 6 in
D_o = 6.625 in
E = 28831000 lb/in^2

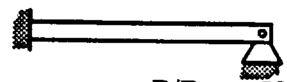
P/P_b = .25
λ = 3.92660231
μ = 489.535 lb/ft^3

t (in)	**0.188**	**0.219**	**0.250**	**0.280**	**0.312**	**0.344**	
D_i (in)	**6.249**	**6.187**	**6.125**	**6.065**	**6.001**	**5.937**	
W(lb/ft)	**12.92**	**14.98**	**17.02**	**18.97**	**21.04**	**23.08**	
L/D_o	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**L (ft)**
5.0	874	870	866	862	858	854	2.76
6.0	607	604	601	599	596	593	3.31
7.0	446	444	442	440	438	436	3.86
8.0	341	340	338	337	335	334	4.42
9.0	270	269	267	266	265	264	4.97
10.0	219	217	216	216	214	213	5.52
11.0	181	180	179	178	177	176	6.07
12.0	152	151	150	150	149	148	6.63
13.0	129	129	128	128	127	126	7.18
14.0	111	111	110	110	109	109	7.73
15.0	97	97	96	96	95	95	8.28
16.0	85	85	85	84	84	83	8.83
17.0	76	75	75	75	74	74	9.39
18.0	67	67	67	67	66	66	9.94
19.0	61	60	60	60	59	59	10.49
20.0	55	54	54	54	54	53	11.04

t (in)	**0.375**	**0.432**	**0.562**	**0.719**	**0.864**	
D_i (in)	**5.875**	**5.761**	**5.501**	**5.187**	**4.897**	
W(lb/ft)	**25.03**	**28.57**	**36.39**	**45.35**	**53.16**	
L/D_o	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**L (ft)**
5.0	850	843	826	808	791	2.76
6.0	590	585	574	561	549	3.31
7.0	434	430	422	412	403	3.86
8.0	332	329	323	315	309	4.42
9.0	262	260	255	249	244	4.97
10.0	212	211	207	202	198	5.52
11.0	176	174	171	167	163	6.07
12.0	148	146	143	140	137	6.63
13.0	126	125	122	119	117	7.18
14.0	108	107	105	103	101	7.73
15.0	94	94	92	90	88	8.28
16.0	83	82	81	79	77	8.83
17.0	74	73	71	70	68	9.39
18.0	66	65	64	62	61	9.94
19.0	59	58	57	56	55	10.49
20.0	53	53	52	50	49	11.04

C-3

Table D-2.2. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) WITH APPLIED AXIAL LOADS (Clamped-Pinned) (cont)



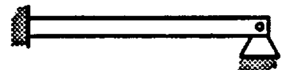
NPS = 6 in
D_o = 6.625 in
E = 28831000 lb/in²

P/P_b = .50
λ = 3.92660231
μ = 489.535 lb/ft³

t (in)	0.188	0.219	0.250	0.280	0.312	0.344	
D_i (in)	6.249	6.187	6.125	6.065	6.001	5.937	
W(lb/ft)	12.92	14.98	17.02	18.97	21.04	23.08	
L/D_o	f_n	f_n	f_n	f_n	f_n	f_n	L (ft)
5.0	714	710	707	704	700	697	2.76
6.0	496	493	491	489	486	484	3.31
7.0	364	362	361	359	357	356	3.86
8.0	279	277	276	275	274	272	4.42
9.0	220	219	218	217	216	215	4.97
10.0	178	178	177	176	175	174	5.52
11.0	147	147	146	145	145	144	6.07
12.0	124	123	123	122	122	121	6.63
13.0	106	105	105	104	104	103	7.18
14.0	91	91	90	90	89	89	7.73
15.0	79	79	79	78	78	77	8.28
16.0	70	69	69	69	68	68	8.83
17.0	62	61	61	61	61	60	9.39
18.0	55	55	55	54	54	54	9.94
19.0	49	49	49	49	49	48	10.49
20.0	45	44	44	44	44	44	11.04

t (in)	0.375	0.432	0.562	0.719	0.864	
D_i (in)	5.875	5.761	5.501	5.187	4.897	
W(lb/ft)	25.03	28.57	36.39	45.35	53.16	
L/D_o	f_n	f_n	f_n	f_n	f_n	L (ft)
5.0	694	688	675	659	646	2.76
6.0	482	478	469	458	448	3.31
7.0	354	351	344	336	329	3.86
8.0	271	269	264	258	252	4.42
9.0	214	212	208	203	199	4.97
10.0	173	172	169	165	161	5.52
11.0	143	142	139	136	133	6.07
12.0	120	119	117	114	112	6.63
13.0	103	102	100	98	95	7.18
14.0	89	88	86	84	82	7.73
15.0	77	76	75	73	72	8.28
16.0	68	67	66	64	63	8.83
17.0	60	60	58	57	56	9.39
18.0	54	53	52	51	50	9.94
19.0	48	48	47	46	45	10.49
20.0	43	43	42	41	40	11.04

Table D-2.2. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) WITH APPLIED AXIAL LOADS (Clamped-Pinned) (cont)



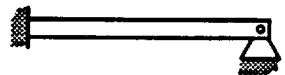
NPS = 6 in
D_o = 6.625 in
E = 28831000 lb/in^2

P/P_b = .75
λ = 3.92660231
μ = 489.535 lb/ft^3

t (in)	**0.188**	**0.219**	**0.250**	**0.280**	**0.312**	**0.344**	
D_i (in)	**6.249**	**6.187**	**6.125**	**6.065**	**6.001**	**5.937**	
W(lb/ft)	**12.92**	**14.98**	**17.02**	**18.97**	**21.04**	**23.08**	
L/D_o	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**L (ft)**
3.0	1402	1395	1389	1382	1376	1369	1.66
4.0	788	785	781	778	774	770	2.21
5.0	505	502	500	498	495	493	2.76
6.0	350	349	347	346	344	342	3.31
7.0	257	256	255	254	253	251	3.86
8.0	197	196	195	194	193	193	4.42
9.0	156	155	154	154	153	152	4.97
10.0	126	126	125	124	124	123	5.52
11.0	104	104	103	103	102	102	6.07
12.0	88	87	87	86	86	86	6.63
13.0	75	74	74	74	73	73	7.18
14.0	64	64	64	63	63	63	7.73
15.0	56	56	56	55	55	55	8.28
16.0	49	49	49	49	48	48	8.83
17.0	44	43	43	43	43	43	9.39
18.0	39	39	39	38	38	38	9.94

t (in)	**0.375**	**0.432**	**0.562**	**0.719**	**0.864**	
D_i (in)	**5.875**	**5.761**	**5.501**	**5.187**	**4.897**	
W(lb/ft)	**25.03**	**28.57**	**36.39**	**45.35**	**53.16**	
L/D_o	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**L (ft)**
3.0	1363	1351	1325	1295	1268	1.66
4.0	767	760	746	728	713	2.21
5.0	491	486	477	466	456	2.76
6.0	341	338	331	324	317	3.31
7.0	250	248	243	238	233	3.86
8.0	192	190	186	182	178	4.42
9.0	151	150	147	144	141	4.97
10.0	123	122	119	117	114	5.52
11.0	101	101	99	96	94	6.07
12.0	85	84	83	81	79	6.63
13.0	73	72	71	69	68	7.18
14.0	63	62	61	59	58	7.73
15.0	55	54	53	52	51	8.28
16.0	48	48	47	46	45	8.83
17.0	42	42	41	40	39	9.39
18.0	38	38	37	36	35	9.94

Table D-2.2. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) WITH APPLIED AXIAL LOADS (Clamped-Pinned) (cont)



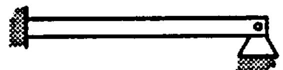
NPS = 8 in
D_o = 8.625 in
E = 28831000 lb/in^2

P/P_b = .25
λ = 3.92660231
μ = 489.535 lb/ft^3

t (in)	0.188	0.203	0.219	0.250	0.277	0.312	
D_i (in)	8.249	8.219	8.187	8.125	8.071	8.001	
W(lb/ft)	16.94	18.26	19.66	22.36	24.70	27.70	
L/D_o	f_n	f_n	f_n	f_n	f_n	f_n	L (ft)
4.0	1056	1054	1052	1048	1045	1041	2.88
5.0	676	675	673	671	669	666	3.59
6.0	469	468	468	466	464	463	4.31
7.0	345	344	344	342	341	340	5.03
8.0	264	264	263	262	261	260	5.75
9.0	209	208	208	207	206	206	6.47
10.0	169	169	168	168	167	167	7.19
11.0	140	139	139	139	138	138	7.91
12.0	117	117	117	116	116	116	8.63
13.0	100	100	100	99	99	99	9.34
14.0	86	86	86	86	85	85	10.06
15.0	75	75	75	75	74	74	10.78
16.0	66	66	66	66	65	65	11.50
17.0	58	58	58	58	58	58	12.22
18.0	52	52	52	52	52	51	12.94
19.0	47	47	47	46	46	46	13.66

t (in)	0.322	0.344	0.375	0.406	0.438	0.500	
D_i (in)	7.981	7.937	7.875	7.813	7.749	7.625	
W(lb/ft)	28.55	30.42	33.04	35.64	38.30	43.39	
L/D_o	f_n	f_n	f_n	f_n	f_n	f_n	L (ft)
4.0	1040	1037	1033	1030	1026	1019	2.88
5.0	665	664	661	659	657	652	3.59
6.0	462	461	459	458	456	453	4.31
7.0	339	339	337	336	335	333	5.03
8.0	260	259	258	257	256	255	5.75
9.0	205	205	204	203	203	201	6.47
10.0	166	166	165	165	164	163	7.19
11.0	137	137	137	136	136	135	7.91
12.0	116	115	115	114	114	113	8.63
13.0	98	98	98	97	97	96	9.34
14.0	85	85	84	84	84	83	10.06
15.0	74	74	73	73	73	72	10.78
16.0	65	65	65	64	64	64	11.50
17.0	58	57	57	57	57	56	12.22
18.0	51	51	51	51	51	50	12.94
19.0	46	46	46	46	45	45	13.66

Table D-2.2. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) WITH APPLIED AXIAL LOADS (Clamped-Pinned) (cont)

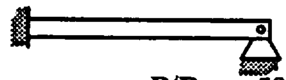


NPS = 8 in
D_o = 8.625 in
E = 28831000 lb/in²

P/P_b = .25
λ = 3.92660231
μ = 489.535 lb/ft³

t (in)	**0.594**	**0.719**	**0.812**	**0.875**	**0.906**	
D_i (in)	**7.437**	**7.187**	**7.001**	**6.875**	**6.813**	
W(lb/ft)	**50.95**	**60.71**	**67.76**	**72.42**	**74.69**	
L/D_o	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**L (ft)**
4.0	1008	993	983	976	972	2.88
5.0	645	636	629	625	622	3.59
6.0	448	441	437	434	432	4.31
7.0	329	324	321	319	318	5.03
8.0	252	248	246	244	243	5.75
9.0	199	196	194	193	192	6.47
10.0	161	159	157	156	156	7.19
11.0	133	131	130	129	129	7.91
12.0	112	110	109	108	108	8.63
13.0	95	94	93	92	92	9.34
14.0	82	81	80	80	79	10.06
15.0	72	71	70	69	69	10.78
16.0	63	62	61	61	61	11.50
17.0	56	55	54	54	54	12.22
18.0	50	49	49	48	48	12.94
19.0	45	44	44	43	43	13.66

Table D-2.2. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) WITH APPLIED AXIAL LOADS (Clamped-Pinned) (cont)



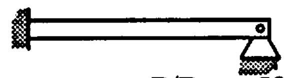
NPS = 8 in
D_o = 8.625 in
E = 28831000 lb/in^2

P/P_b = .50
λ = 3.92660231
μ = 489.535 lb/ft^3

t (in)	**0.188**	**0.203**	**0.219**	**0.250**	**0.277**	**0.312**	
D_i (in)	**8.249**	**8.219**	**8.187**	**8.125**	**8.071**	**8.001**	
W(lb/ft)	**16.94**	**18.26**	**19.66**	**22.36**	**24.70**	**27.70**	
L/D_o	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	L (ft)
4.0	862	861	859	856	853	850	2.88
5.0	552	551	550	548	546	544	3.59
6.0	383	383	382	380	379	378	4.31
7.0	282	281	281	280	279	278	5.03
8.0	216	215	215	214	213	212	5.75
9.0	170	170	170	169	169	168	6.47
10.0	138	138	137	137	137	136	7.19
11.0	114	114	114	113	113	112	7.91
12.0	96	96	95	95	95	94	8.63
13.0	82	81	81	81	81	80	9.34
14.0	70	70	70	70	70	69	10.06
15.0	61	61	61	61	61	60	10.78
16.0	54	54	54	53	53	53	11.50
17.0	48	48	48	47	47	47	12.22
18.0	43	43	42	42	42	42	12.94
19.0	38	38	38	38	38	38	13.66

t (in)	**0.322**	**0.344**	**0.375**	**0.406**	**0.438**	**0.500**	
D_i (in)	**7.981**	**7.937**	**7.875**	**7.813**	**7.749**	**7.625**	
W(lb/ft)	**28.55**	**30.42**	**33.04**	**35.64**	**38.30**	**43.39**	
L/D_o	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	L (ft)
4.0	849	847	844	841	838	832	2.88
5.0	543	542	540	538	536	532	3.59
6.0	377	376	375	374	372	370	4.31
7.0	277	276	275	275	274	272	5.03
8.0	212	212	211	210	209	208	5.75
9.0	168	167	167	166	165	164	6.47
10.0	136	135	135	135	134	133	7.19
11.0	112	112	112	111	111	110	7.91
12.0	94	94	94	93	93	92	8.63
13.0	80	80	80	80	79	79	9.34
14.0	69	69	69	69	68	68	10.06
15.0	60	60	60	60	60	59	10.78
16.0	53	53	53	53	52	52	11.50
17.0	47	47	47	47	46	46	12.22
18.0	42	42	42	42	41	41	12.94
19.0	38	38	37	37	37	37	13.66

Table D-2.2. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) WITH APPLIED AXIAL LOADS (Clamped-Pinned) (cont)

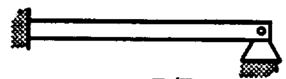


NPS = 8 in
D_o = 8.625 in
E = 28831000 lb/in^2

P/P_b = .50
λ = 3.92660231
μ = 489.535 lb/ft^3

t (in)	**0.594**	**0.719**	**0.812**	**0.875**	**0.906**	
D_i (in)	**7.437**	**7.187**	**7.001**	**6.875**	**6.813**	
W(lb/ft)	**50.95**	**60.71**	**67.76**	**72.42**	**74.69**	
L/D_o	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**L (ft)**
4.0	823	811	802	797	794	2.88
5.0	527	519	514	510	508	3.59
6.0	366	360	357	354	353	4.31
7.0	269	265	262	260	259	5.03
8.0	206	203	201	199	199	5.75
9.0	163	160	159	157	157	6.47
10.0	132	130	128	127	127	7.19
11.0	109	107	106	105	105	7.91
12.0	91	90	89	89	88	8.63
13.0	78	77	76	75	75	9.34
14.0	67	66	66	65	65	10.06
15.0	59	58	57	57	56	10.78
16.0	51	51	50	50	50	11.50
17.0	46	45	44	44	44	12.22
18.0	41	40	40	39	39	12.94
19.0	36	36	36	35	35	13.66

Table D-2.2. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) WITH APPLIED AXIAL LOADS (Clamped-Pinned) (cont)



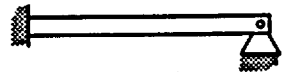
NPS = 8 in
D_o = 8.625 in
E = 28831000 lb/in^2

P/P_b = .75
λ = 3.92660231
μ = 489.535 lb/ft^3

t (in)	**0.188**	**0.203**	**0.219**	**0.250**	**0.277**	**0.312**	
D_i (in)	**8.249**	**8.219**	**8.187**	**8.125**	**8.071**	**8.001**	
W(lb/ft)	**16.94**	**18.26**	**19.66**	**22.36**	**24.70**	**27.70**	
L/D_o	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**L (ft)**
3.0	1084	1082	1080	1076	1073	1068	2.16
4.0	610	609	607	605	603	601	2.88
5.0	390	389	389	387	386	385	3.59
6.0	271	270	270	269	268	267	4.31
7.0	199	199	198	198	197	196	5.03
8.0	152	152	152	151	151	150	5.75
9.0	120	120	120	120	119	119	6.47
10.0	98	97	97	97	97	96	7.19
11.0	81	80	80	80	80	79	7.91
12.0	68	68	67	67	67	67	8.63
13.0	58	58	58	57	57	57	9.34
14.0	50	50	50	49	49	49	10.06
15.0	43	43	43	43	43	43	10.78
16.0	38	38	38	38	38	38	11.50
17.0	34	34	34	34	33	33	12.22
18.0	30	30	30	30	30	30	12.94

t (in)	**0.322**	**0.344**	**0.375**	**0.406**	**0.438**	**0.500**	
D_i (in)	**7.981**	**7.937**	**7.875**	**7.813**	**7.749**	**7.625**	
W(lb/ft)	**28.55**	**30.42**	**33.04**	**35.64**	**38.30**	**43.39**	
L/D_o	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**L (ft)**
3.0	1067	1064	1061	1057	1053	1045	2.16
4.0	600	599	597	594	592	588	2.88
5.0	384	383	382	380	379	376	3.59
6.0	267	266	265	264	263	261	4.31
7.0	196	196	195	194	193	192	5.03
8.0	150	150	149	149	148	147	5.75
9.0	119	118	118	117	117	116	6.47
10.0	96	96	95	95	95	94	7.19
11.0	79	79	79	79	78	78	7.91
12.0	67	67	66	66	66	65	8.63
13.0	57	57	56	56	56	56	9.34
14.0	49	49	49	49	48	48	10.06
15.0	43	43	42	42	42	42	10.78
16.0	38	37	37	37	37	37	11.50
17.0	33	33	33	33	33	33	12.22
18.0	30	30	29	29	29	29	12.94

Table D-2.2. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) WITH APPLIED AXIAL LOADS (Clamped-Pinned) (cont)

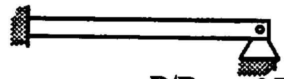


NPS = 8 in
D_o = 8.625 in
E = 28831000 lb/in^2

P/P_b = .75
λ = 3.92660231
μ = 489.535 lb/ft^3

t (in)	0.594	0.719	0.812	0.875	0.906	
D_i (in)	7.437	7.187	7.001	6.875	6.813	
W(lb/ft)	50.95	60.71	67.76	72.42	74.69	
L/D_o	f_n	f_n	f_n	f_n	f_n	L (ft)
3.0	1034	1020	1009	1002	998	2.16
4.0	582	573	567	563	561	2.88
5.0	372	367	363	361	359	3.59
6.0	259	255	252	250	250	4.31
7.0	190	187	185	184	183	5.03
8.0	145	143	142	141	140	5.75
9.0	115	113	112	111	111	6.47
10.0	93	92	91	90	90	7.19
11.0	77	76	75	75	74	7.91
12.0	65	64	63	63	62	8.63
13.0	55	54	54	53	53	9.34
14.0	47	47	46	46	46	10.06
15.0	41	41	40	40	40	10.78
16.0	36	36	35	35	35	11.50
17.0	32	32	31	31	31	12.22
18.0	29	28	28	28	28	12.94

Table D-2.2. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) WITH APPLIED AXIAL LOADS (Clamped-Pinned) (cont)



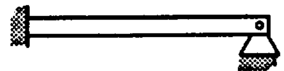
NPS = 10 in
D_o = 10.75 in
E = 28831000 lb/in^2

P/P_b = .25
λ = 3.92660231
μ = 489.535 lb/ft^3

t (in)	0.188	0.203	0.219	0.250	0.279	0.307	
D_i (in)	10.374	10.344	10.312	10.25	10.192	10.136	
W(lb/ft)	21.21	22.87	24.63	28.04	31.20	34.24	
L/D_o	f_n	f_n	f_n	f_n	f_n	f_n	L (ft)
3.0	1513	1511	1508	1504	1500	1496	2.69
4.0	851	850	848	846	844	841	3.58
5.0	545	544	543	541	540	539	4.48
6.0	378	378	377	376	375	374	5.38
7.0	278	277	277	276	275	275	6.27
8.0	213	212	212	211	211	210	7.17
9.0	168	168	168	167	167	166	8.06
10.0	136	136	136	135	135	135	8.96
11.0	113	112	112	112	112	111	9.85
12.0	95	94	94	94	94	93	10.75
13.0	81	80	80	80	80	80	11.65
14.0	69	69	69	69	69	69	12.54
15.0	61	60	60	60	60	60	13.44
16.0	53	53	53	53	53	53	14.33
17.0	47	47	47	47	47	47	15.23
18.0	42	42	42	42	42	42	16.13

t (in)	0.344	0.365	0.438	0.500	0.594	0.719	
D_i (in)	10.062	10.02	9.874	9.75	9.562	9.312	
W(lb/ft)	38.23	40.48	48.24	54.74	64.43	77.03	
L/D_o	f_n	f_n	f_n	f_n	f_n	f_n	L (ft)
3.0	1491	1488	1478	1469	1457	1440	2.69
4.0	839	837	831	827	819	810	3.58
5.0	537	536	532	529	524	518	4.48
6.0	373	372	369	367	364	360	5.38
7.0	274	273	271	270	268	264	6.27
8.0	210	209	208	207	205	203	7.17
9.0	166	165	164	163	162	160	8.06
10.0	134	134	133	132	131	130	8.96
11.0	111	111	110	109	108	107	9.85
12.0	93	93	92	92	91	90	10.75
13.0	79	79	79	78	78	77	11.65
14.0	68	68	68	67	67	66	12.54
15.0	60	60	59	59	58	58	13.44
16.0	52	52	52	52	51	51	14.33
17.0	46	46	46	46	45	45	15.23
18.0	41	41	41	41	40	40	16.13

Table D-2.2. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) WITH APPLIED AXIAL LOADS (Clamped-Pinned) (cont)

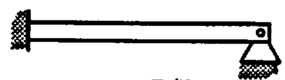


NPS = 10 in
D_o = 10.75 in
E = 28831000 lb/in^2

P/P_b = .25
λ = 3.92660231
μ = 489.535 lb/ft^3

t (in)	**0.844**	**1.000**	**1.125**	
D_i (in)	**9.062**	**8.75**	**8.5**	
W(lb/ft)	**89.29**	**104.13**	**115.64**	
L/D_o	**f_n**	**f_n**	**f_n**	**L (ft)**
3.0	1424	1403	1388	2.69
4.0	801	789	781	3.58
5.0	512	505	500	4.48
6.0	356	351	347	5.38
7.0	261	258	255	6.27
8.0	200	197	195	7.17
9.0	158	156	154	8.06
10.0	128	126	125	8.96
11.0	106	104	103	9.85
12.0	89	88	87	10.75
13.0	76	75	74	11.65
14.0	65	64	64	12.54
15.0	57	56	56	13.44
16.0	50	49	49	14.33
17.0	44	44	43	15.23
18.0	40	39	39	16.13

Table D-2.2. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) WITH APPLIED AXIAL LOADS (Clamped-Pinned) (cont)



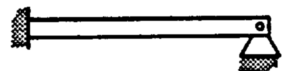
NPS = 10 in
D_o = 10.75 in
E = 28831000 lb/in²

P/P_b = .50
λ = 3.92660231
μ = 489.535 lb/ft³

t (in)	**0.188**	**0.203**	**0.219**	**0.250**	**0.279**	**0.307**	
D_i (in)	**10.374**	**10.344**	**10.312**	**10.25**	**10.192**	**10.136**	
W(lb/ft)	**21.21**	**22.87**	**24.63**	**28.04**	**31.20**	**34.24**	
L/D_o	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**L (ft)**
3.0	1235	1233	1232	1228	1225	1221	2.69
4.0	695	694	693	691	689	687	3.58
5.0	445	444	443	442	441	440	4.48
6.0	309	308	308	307	306	305	5.38
7.0	227	227	226	226	225	224	6.27
8.0	174	173	173	173	172	172	7.17
9.0	137	137	137	136	136	136	8.06
10.0	111	111	111	111	110	110	8.96
11.0	92	92	92	91	91	91	9.85
12.0	77	77	77	77	77	76	10.75
13.0	66	66	66	65	65	65	11.65
14.0	57	57	57	56	56	56	12.54
15.0	49	49	49	49	49	49	13.44
16.0	43	43	43	43	43	43	14.33
17.0	38	38	38	38	38	38	15.23
18.0	34	34	34	34	34	34	16.13

t (in)	**0.344**	**0.365**	**0.438**	**0.500**	**0.594**	**0.719**	
D_i (in)	**10.062**	**10.02**	**9.874**	**9.75**	**9.562**	**9.312**	
W(lb/ft)	**38.23**	**40.48**	**48.24**	**54.74**	**64.43**	**77.03**	
L/D_o	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**L (ft)**
3.0	1217	1215	1207	1200	1189	1176	2.69
4.0	685	683	679	675	669	661	3.58
5.0	438	437	434	432	428	423	4.48
6.0	304	304	302	300	297	294	5.38
7.0	224	223	222	220	218	216	6.27
8.0	171	171	170	169	167	165	7.17
9.0	135	135	134	133	132	131	8.06
10.0	110	109	109	108	107	106	8.96
11.0	91	90	90	89	88	87	9.85
12.0	76	76	75	75	74	73	10.75
13.0	65	65	64	64	63	63	11.65
14.0	56	56	55	55	55	54	12.54
15.0	49	49	48	48	48	47	13.44
16.0	43	43	42	42	42	41	14.33
17.0	38	38	38	37	37	37	15.23
18.0	34	34	34	33	33	33	16.13

Table D-2.2. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) WITH APPLIED AXIAL LOADS (Clamped-Pinned) (cont)

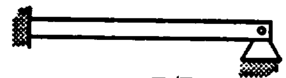


NPS = 10 in
D_o = 10.75 in
E = 28831000 lb/in^2

P/P_b = .50
λ = 3.92660231
μ = 489.535 lb/ft^3

t (in)	**0.844**	**1.000**	**1.125**	
D_i (in)	**9.062**	**8.75**	**8.5**	
W(lb/ft)	**89.29**	**104.13**	**115.64**	
L/D_o	**f_n**	**f_n**	**f_n**	**L (ft)**
L/D	L (ft.)			
3.0	1162	1146	1133	2.69
4.0	654	645	637	3.58
5.0	418	413	408	4.48
6.0	291	286	283	5.38
7.0	213	210	208	6.27
8.0	163	161	159	7.17
9.0	129	127	126	8.06
10.0	105	103	102	8.96
11.0	86	85	84	9.85
12.0	73	72	71	10.75
13.0	62	61	60	11.65
14.0	53	53	52	12.54
15.0	46	46	45	13.44
16.0	41	40	40	14.33
17.0	36	36	35	15.23
18.0	32	32	31	16.13

Table D-2.2. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) WITH APPLIED AXIAL LOADS (Clamped-Pinned) (cont)



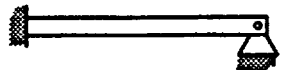
NPS = 10 in
D_o = 10.75 in
E = 28831000 lb/in^2

P/P_b = .75
λ = 3.92660231
μ = 489.535 lb/ft^3

t (in)	0.188	0.203	0.219	0.250	0.279	0.307	
D_i (in)	10.374	10.344	10.312	10.25	10.192	10.136	
W(lb/ft)	21.21	22.87	24.63	28.04	31.20	34.24	
L/D_o	f_n	f_n	f_n	f_n	f_n	f_n	L (ft)
3.0	873	872	871	868	866	864	2.69
4.0	491	491	490	488	487	486	3.58
5.0	314	314	313	313	312	311	4.48
6.0	218	218	218	217	216	216	5.38
7.0	160	160	160	159	159	159	6.27
8.0	123	123	122	122	122	121	7.17
9.0	97	97	97	96	96	96	8.06
10.0	79	78	78	78	78	78	8.96
11.0	65	65	65	65	64	64	9.85
12.0	55	55	54	54	54	54	10.75
13.0	47	46	46	46	46	46	11.65
14.0	40	40	40	40	40	40	12.54
15.0	35	35	35	35	35	35	13.44
16.0	31	31	31	31	30	30	14.33
17.0	27	27	27	27	27	27	15.23
18.0	24	24	24	24	24	24	16.13

t (in)	0.344	0.365	0.438	0.500	0.594	0.719	
D_i (in)	10.062	10.02	9.874	9.75	9.562	9.312	
W(lb/ft)	38.23	40.48	48.24	54.74	64.43	77.03	
L/D_o	f_n	f_n	f_n	f_n	f_n	f_n	L (ft)
3.0	861	859	853	848	841	831	2.69
4.0	484	483	480	477	473	468	3.58
5.0	310	309	307	305	303	299	4.48
6.0	215	215	213	212	210	208	5.38
7.0	158	158	157	156	154	153	6.27
8.0	121	121	120	119	118	117	7.17
9.0	96	95	95	94	93	92	8.06
10.0	77	77	77	76	76	75	8.96
11.0	64	64	63	63	63	62	9.85
12.0	54	54	53	53	53	52	10.75
13.0	46	46	45	45	45	44	11.65
14.0	40	39	39	39	39	38	12.54
15.0	34	34	34	34	34	33	13.44
16.0	30	30	30	30	30	29	14.33
17.0	27	27	27	26	26	26	15.23
18.0	24	24	24	24	23	23	16.13

Table D-2.2. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) WITH APPLIED AXIAL LOADS (Clamped-Pinned) (cont)

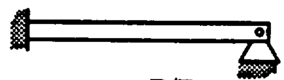


NPS = 10 in
D_o = 10.75 in
E = 28831000 lb/in^2

P/P_b = .75
λ = 3.92660231
μ = 489.535 lb/ft^3

t (in)	**0.844**	**1.000**	**1.125**	
D_i (in)	**9.062**	**8.75**	**8.5**	
W(lb/ft)	**89.29**	**104.13**	**115.64**	
L/D_o	**f_n**	**f_n**	**f_n**	**L (ft)**
3.0	822	810	801	2.69
4.0	462	456	451	3.58
5.0	296	292	288	4.48
6.0	205	203	200	5.38
7.0	151	149	147	6.27
8.0	116	114	113	7.17
9.0	91	90	89	8.06
10.0	74	73	72	8.96
11.0	61	60	60	9.85
12.0	51	51	50	10.75
13.0	44	43	43	11.65
14.0	38	37	37	12.54
15.0	33	32	32	13.44
16.0	29	28	28	14.33
17.0	26	25	25	15.23
18.0	23	23	22	16.13

Table D-2.2. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) WITH APPLIED AXIAL LOADS (Clamped-Pinned) (cont)



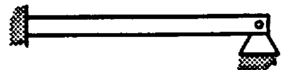
NPS = 12 in
D_o = 12.75 in
E = 28831000 lb/in^2

P/P_b = .25
λ = 3.92660231
μ = 489.535 lb/ft^3

t (in)	0.203	0.219	0.250	0.281	0.312	0.330	
D_i (in)	12.344	12.312	12.250	12.188	12.126	12.090	
W(lb/ft)	27.20	29.31	33.38	37.42	41.45	43.77	
L/D_o	f_n	f_n	f_n	f_n	f_n	f_n	L (ft)
3.0	1277	1276	1273	1270	1266	1265	3.19
4.0	719	718	716	714	712	711	4.25
5.0	460	459	458	457	456	455	5.31
6.0	319	319	318	317	317	316	6.38
7.0	235	234	234	233	233	232	7.44
8.0	180	179	179	179	178	178	8.50
9.0	142	142	141	141	141	141	9.56
10.0	115	115	115	114	114	114	10.63
11.0	95	95	95	94	94	94	11.69
12.0	80	80	80	79	79	79	12.75
13.0	68	68	68	68	67	67	13.81
14.0	59	59	58	58	58	58	14.88
15.0	51	51	51	51	51	51	15.94
16.0	45	45	45	45	45	44	17.00
17.0	40	40	40	40	39	39	18.06
18.0	35	35	35	35	35	35	19.13

t (in)	0.344	0.375	0.406	0.438	0.500	0.562	
D_i (in)	12.062	12.000	11.938	11.874	11.750	11.626	
W(lb/ft)	45.58	49.56	53.52	57.59	65.42	73.15	
L/D_o	f_n	f_n	f_n	f_n	f_n	f_n	L (ft)
3.0	1263	1260	1257	1254	1248	1242	3.19
4.0	711	709	707	705	702	699	4.25
5.0	455	454	453	451	449	447	5.31
6.0	316	315	314	314	312	310	6.38
7.0	232	231	231	230	229	228	7.44
8.0	178	177	177	176	175	175	8.50
9.0	140	140	140	139	139	138	9.56
10.0	114	113	113	113	112	112	10.63
11.0	94	94	94	93	93	92	11.69
12.0	79	79	79	78	78	78	12.75
13.0	67	67	67	67	66	66	13.81
14.0	58	58	58	58	57	57	14.88
15.0	51	50	50	50	50	50	15.94
16.0	44	44	44	44	44	44	17.00
17.0	39	39	39	39	39	39	18.06
18.0	35	35	35	35	35	34	19.13

Table D-2.2. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) WITH APPLIED AXIAL LOADS (Clamped-Pinned) (cont)

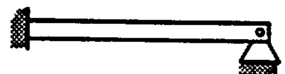


NPS = 12 in
D_o = 12.75 in
E = 28831000 lb/in^2

P/P_b = .25
λ = 3.92660231
μ = 489.535 lb/ft^3

t (in)	**0.688**	**0.844**	**1.000**	**1.250**	**1.312**	
D_i (in)	**11.374**	**11.062**	**10.750**	**10.250**	**10.126**	
W(lb/ft)	**88.63**	**107.32**	**125.49**	**153.53**	**160.27**	
L/D_o	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**L (ft)**
3.0	1230	1215	1200	1178	1172	3.19
4.0	692	683	675	662	659	4.25
5.0	443	437	432	424	422	5.31
6.0	307	304	300	294	293	6.38
7.0	226	223	220	216	215	7.44
8.0	173	171	169	166	165	8.50
9.0	137	135	133	131	130	9.56
10.0	111	109	108	106	105	10.63
11.0	91	90	89	88	87	11.69
12.0	77	76	75	74	73	12.75
13.0	65	65	64	63	62	13.81
14.0	56	56	55	54	54	14.88
15.0	49	49	48	47	47	15.94
16.0	43	43	42	41	41	17.00
17.0	38	38	37	37	36	18.06
18.0	34	34	33	33	33	19.13

Table D-2.2. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) WITH APPLIED AXIAL LOADS (Clamped-Pinned) (cont)



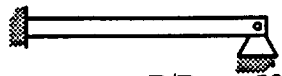
NPS = 12 in
D_o = 12.75 in
E = 28831000 lb/in^2

P/P_b = .50
λ = 3.92660231
μ = 489.535 lb/ft^3

t (in)	**0.203**	**0.219**	**0.250**	**0.281**	**0.312**	**0.330**	
D_i (in)	**12.344**	**12.312**	**12.250**	**12.188**	**12.126**	**12.090**	
W(lb/ft)	**27.20**	**29.31**	**33.38**	**37.42**	**41.45**	**43.77**	
L/D_o	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**L (ft)**
3.0	1043	1042	1039	1037	1034	1033	3.19
4.0	587	586	585	583	582	581	4.25
5.0	375	375	374	373	372	372	5.31
6.0	261	260	260	259	259	258	6.38
7.0	192	191	191	190	190	190	7.44
8.0	147	146	146	146	145	145	8.50
9.0	116	116	115	115	115	115	9.56
10.0	94	94	94	93	93	93	10.63
11.0	78	77	77	77	77	77	11.69
12.0	65	65	65	65	65	65	12.75
13.0	56	55	55	55	55	55	13.81
14.0	48	48	48	48	47	47	14.88
15.0	42	42	42	41	41	41	15.94
16.0	37	37	37	36	36	36	17.00
17.0	32	32	32	32	32	32	18.06
18.0	29	29	29	29	29	29	19.13

t (in)	**0.344**	**0.375**	**0.406**	**0.438**	**0.500**	**0.562**	
D_i (in)	**12.062**	**12.000**	**11.938**	**11.874**	**11.750**	**11.626**	
W(lb/ft)	**45.58**	**49.56**	**53.52**	**57.59**	**65.42**	**73.15**	
L/D_o	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**L (ft)**
3.0	1031	1029	1026	1024	1019	1014	3.19
4.0	580	579	577	576	573	570	4.25
5.0	371	370	370	369	367	365	5.31
6.0	258	257	257	256	255	254	6.38
7.0	189	189	189	188	187	186	7.44
8.0	145	145	144	144	143	143	8.50
9.0	115	114	114	114	113	113	9.56
10.0	93	93	92	92	92	91	10.63
11.0	77	77	76	76	76	75	11.69
12.0	64	64	64	64	64	63	12.75
13.0	55	55	55	55	54	54	13.81
14.0	47	47	47	47	47	47	14.88
15.0	41	41	41	41	41	41	15.94
16.0	36	36	36	36	36	36	17.00
17.0	32	32	32	32	32	32	18.06
18.0	29	29	29	28	28	28	19.13

Table D-2.2. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) WITH APPLIED AXIAL LOADS (Clamped-Pinned) (cont)

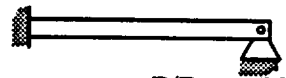


NPS = 12 in
D_o = 12.75 in
E = 28831000 lb/in^2

P/P_b = .50
λ = 3.92660231
μ = 489.535 lb/ft^3

t (in)	**0.688**	**0.844**	**1.000**	**1.250**	**1.312**	
D_i (in)	**11.374**	**11.062**	**10.750**	**10.250**	**10.126**	
W(lb/ft)	**88.63**	**107.32**	**125.49**	**153.53**	**160.27**	
L/D_o	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**L (ft)**
3.0	1004	992	980	961	957	3.19
4.0	565	558	551	541	538	4.25
5.0	361	357	353	346	344	5.31
6.0	251	248	245	240	239	6.38
7.0	184	182	180	177	176	7.44
8.0	141	140	138	135	135	8.50
9.0	112	110	109	107	106	9.56
10.0	90	89	88	87	86	10.63
11.0	75	74	73	72	71	11.69
12.0	63	62	61	60	60	12.75
13.0	53	53	52	51	51	13.81
14.0	46	46	45	44	44	14.88
15.0	40	40	39	38	38	15.94
16.0	35	35	34	34	34	17.00
17.0	31	31	31	30	30	18.06
18.0	28	28	27	27	27	19.13

Table D-2.2. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) WITH APPLIED AXIAL LOADS (Clamped-Pinned) (cont)



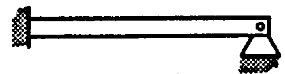
NPS = 12 in
D_o = 12.75 in
E = 28831000 lb/in^2

P/P_b = .75
λ = 3.92660231
μ = 489.535 lb/ft^3

t (in)	0.203	0.219	0.250	0.281	0.312	0.330	
D_i (in)	12.344	12.312	12.250	12.188	12.126	12.090	
W(lb/ft)	27.20	29.31	33.38	37.42	41.45	43.77	
L/D_o	f_n	f_n	f_n	f_n	f_n	f_n	L (ft)
3.0	737	737	735	733	731	730	3.19
4.0	415	414	413	412	411	411	4.25
5.0	265	265	265	264	263	263	5.31
6.0	184	184	184	183	183	183	6.38
7.0	135	135	135	135	134	134	7.44
8.0	104	104	103	103	103	103	8.50
9.0	82	82	82	81	81	81	9.56
10.0	66	66	66	66	66	66	10.63
11.0	55	55	55	55	54	54	11.69
12.0	46	46	46	46	46	46	12.75
13.0	39	39	39	39	39	39	13.81
14.0	34	34	34	34	34	34	14.88
15.0	29	29	29	29	29	29	15.94
16.0	26	26	26	26	26	26	17.00
17.0	23	23	23	23	23	23	18.06
18.0	20	20	20	20	20	20	19.13

t (in)	0.344	0.375	0.406	0.438	0.500	0.562	
D_i (in)	12.062	12.000	11.938	11.874	11.750	11.626	
W(lb/ft)	45.58	49.56	53.52	57.59	65.42	73.15	
L/D_o	f_n	f_n	f_n	f_n	f_n	f_n	L (ft)
3.0	729	728	726	724	721	717	3.19
4.0	410	409	408	407	405	403	4.25
5.0	263	262	261	261	259	258	5.31
6.0	182	182	181	181	180	179	6.38
7.0	134	134	133	133	132	132	7.44
8.0	103	102	102	102	101	101	8.50
9.0	81	81	81	80	80	80	9.56
10.0	66	65	65	65	65	65	10.63
11.0	54	54	54	54	54	53	11.69
12.0	46	45	45	45	45	45	12.75
13.0	39	39	39	39	38	38	13.81
14.0	33	33	33	33	33	33	14.88
15.0	29	29	29	29	29	29	15.94
16.0	26	26	26	25	25	25	17.00
17.0	23	23	23	23	22	22	18.06
18.0	20	20	20	20	20	20	19.13

Table D-2.2. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) WITH APPLIED AXIAL LOADS (Clamped-Pinned) (cont)

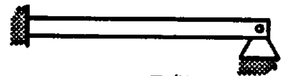


NPS = 12 in
D_o = 12.75 in
E = 28831000 lb/in^2

P/P_b = .75
λ = 3.92660231
μ = 489.535 lb/ft^3

t (in)	**0.688**	**0.844**	**1.000**	**1.250**	**1.312**	
D_i (in)	**11.374**	**11.062**	**10.750**	**10.250**	**10.126**	
W(lb/ft)	**88.63**	**107.32**	**125.49**	**153.53**	**160.27**	
L/D_o	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**L (ft)**
3.0	710	701	693	680	677	3.19
4.0	399	395	390	382	381	4.25
5.0	256	253	249	245	244	5.31
6.0	178	175	173	170	169	6.38
7.0	130	129	127	125	124	7.44
8.0	100	99	97	96	95	8.50
9.0	79	78	77	76	75	9.56
10.0	64	63	62	61	61	10.63
11.0	53	52	52	51	50	11.69
12.0	44	44	43	42	42	12.75
13.0	38	37	37	36	36	13.81
14.0	33	32	32	31	31	14.88
15.0	28	28	28	27	27	15.94
16.0	25	25	24	24	24	17.00
17.0	22	22	22	21	21	18.06
18.0	20	19	19	19	19	19.13

Table D-2.2. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) WITH APPLIED AXIAL LOADS (Clamped-Pinned) (cont)



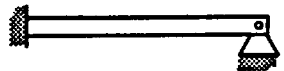
NPS = 14 in
D_o = 14.00 in
E = 28831000 lb/in^2

P/P_b = .25
λ = 3.92660231
μ = 489.535 lb/ft^3

t (in)	0.188	0.210	0.219	0.250	0.281	0.312	
D_i (in)	13.624	13.580	13.562	13.500	13.433	13.376	
W(lb/ft)	27.73	30.93	32.23	36.71	41.17	45.61	
L/D_o	f_n	f_n	f_n	f_n	f_n	f_n	L (ft)
3.0	1166	1164	1164	1161	1158	1156	3.50
4.0	656	655	655	653	652	650	4.67
5.0	420	419	419	418	417	416	5.83
6.0	292	291	291	290	290	289	7.00
7.0	214	214	214	213	213	212	8.17
8.0	164	164	164	163	163	163	9.33
9.0	130	129	129	129	129	128	10.50
10.0	105	105	105	104	104	104	11.67
11.0	87	87	87	86	86	86	12.83
12.0	73	73	73	73	72	72	14.00
13.0	62	62	62	62	62	62	15.17
14.0	54	53	53	53	53	53	16.33
15.0	47	47	47	46	46	46	17.50
16.0	41	41	41	41	41	41	18.67
17.0	36	36	36	36	36	36	19.83
18.0	32	32	32	32	32	32	21.00

t (in)	0.344	0.375	0.406	0.438	0.469	0.500	
D_i (in)	13.312	13.250	13.188	13.124	13.062	13.000	
W(lb/ft)	50.17	54.57	58.94	63.44	67.78	72.09	
L/D_o	f_n	f_n	f_n	f_n	f_n	f_n	L (ft)
3.0	1153	1151	1148	1146	1143	1141	3.50
4.0	649	647	646	644	643	642	4.67
5.0	415	414	413	412	412	411	5.83
6.0	288	288	287	286	286	285	7.00
7.0	212	211	211	210	210	209	8.17
8.0	162	162	161	161	161	160	9.33
9.0	128	128	128	127	127	127	10.50
10.0	104	104	103	103	103	103	11.67
11.0	86	86	85	85	85	85	12.83
12.0	72	72	72	72	71	71	14.00
13.0	61	61	61	61	61	61	15.17
14.0	53	53	53	53	52	52	16.33
15.0	46	46	46	46	46	46	17.50
16.0	41	40	40	40	40	40	18.67
17.0	36	36	36	36	36	36	19.83
18.0	32	32	32	32	32	32	21.00

Table D-2.2. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) WITH APPLIED AXIAL LOADS (Clamped-Pinned) (cont)



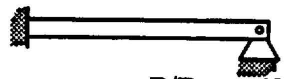
NPS = 14 in
D_o = 14.00 in
E = 28831000 lb/in^2

P/P_b = .25
λ = 3.92660231
μ = 489.535 lb/ft^3

t (in)	**0.562**	**0.625**	**0.688**	**0.750**	**0.812**	**0.875**	
D_i (in)	**12.876**	**12.750**	**12.624**	**12.500**	**12.376**	**12.250**	
W(lb/ft)	**80.66**	**89.28**	**97.81**	**106.13**	**114.37**	**122.65**	
L/D_o	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**L (ft)**
3.0	1136	1130	1125	1120	1116	1111	3.50
4.0	639	636	633	630	627	625	4.67
5.0	409	407	405	403	402	400	5.83
6.0	284	283	281	280	279	278	7.00
7.0	209	208	207	206	205	204	8.17
8.0	160	159	158	158	157	156	9.33
9.0	126	126	125	124	124	123	10.50
10.0	102	102	101	101	100	100	11.67
11.0	84	84	84	83	83	83	12.83
12.0	71	71	70	70	70	69	14.00
13.0	60	60	60	60	59	59	15.17
14.0	52	52	52	51	51	51	16.33
15.0	45	45	45	45	45	44	17.50
16.0	40	40	40	39	39	39	18.67
17.0	35	35	35	35	35	35	19.83
18.0	32	31	31	31	31	31	21.00

t (in)	**0.938**	**1.000**	**1.062**	**1.125**	
D_i (in)	**12.124**	**12.000**	**11.876**	**11.750**	
W(lb/ft)	**130.85**	**138.84**	**146.74**	**154.69**	
L/D_o	**f_n**	**f_n**	**f_n**	**f_n**	**L (ft)**
3.0	1106	1101	1096	1091	3.50
4.0	622	619	616	614	4.67
5.0	398	396	395	393	5.83
6.0	276	275	274	273	7.00
7.0	203	202	201	200	8.17
8.0	155	155	154	153	9.33
9.0	123	122	122	121	10.50
10.0	100	99	99	98	11.67
11.0	82	82	82	81	12.83
12.0	69	69	68	68	14.00
13.0	59	59	58	58	15.17
14.0	51	51	50	50	16.33
15.0	44	44	44	44	17.50
16.0	39	39	39	38	18.67
17.0	34	34	34	34	19.83
18.0	31	31	30	30	21.00

Table D-2.2. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) WITH APPLIED AXIAL LOADS (Clamped-Pinned) (cont)



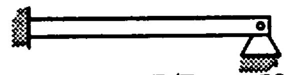
NPS = 14 in
D_o = 14.00 in
E = 28831000 lb/in^2

P/P_b = .50
λ = 3.92660231
μ = 489.535 lb/ft^3

t (in)	0.188	0.210	0.219	0.250	0.281	0.312	
D_i (in)	13.624	13.580	13.562	13.500	13.433	13.376	
W(lb/ft)	27.73	30.93	32.23	36.71	41.17	45.61	
L/D_o	f_n	f_n	f_n	f_n	f_n	f_n	L (ft)
3.0	952	951	950	948	946	944	3.50
4.0	536	535	534	533	532	531	4.67
5.0	343	342	342	341	341	340	5.83
6.0	238	238	238	237	236	236	7.00
7.0	175	175	175	174	174	173	8.17
8.0	134	134	134	133	133	133	9.33
9.0	106	106	106	105	105	105	10.50
10.0	86	86	86	85	85	85	11.67
11.0	71	71	71	71	70	70	12.83
12.0	60	59	59	59	59	59	14.00
13.0	51	51	51	50	50	50	15.17
14.0	44	44	44	44	43	43	16.33
15.0	38	38	38	38	38	38	17.50
16.0	33	33	33	33	33	33	18.67
17.0	30	30	30	30	29	29	19.83
18.0	26	26	26	26	26	26	21.00

t (in)	0.344	0.375	0.406	0.438	0.469	0.500	
D_i (in)	13.312	13.250	13.188	13.124	13.062	13.000	
W(lb/ft)	50.17	54.57	58.94	63.44	67.78	72.09	
L/D_o	f_n	f_n	f_n	f_n	f_n	f_n	L (ft)
3.0	942	940	938	935	933	931	3.50
4.0	530	529	527	526	525	524	4.67
5.0	339	338	338	337	336	335	5.83
6.0	235	235	234	234	233	233	7.00
7.0	173	173	172	172	171	171	8.17
8.0	132	132	132	132	131	131	9.33
9.0	105	104	104	104	104	103	10.50
10.0	85	85	84	84	84	84	11.67
11.0	70	70	70	70	69	69	12.83
12.0	59	59	59	58	58	58	14.00
13.0	50	50	50	50	50	50	15.17
14.0	43	43	43	43	43	43	16.33
15.0	38	38	38	37	37	37	17.50
16.0	33	33	33	33	33	33	18.67
17.0	29	29	29	29	29	29	19.83
18.0	26	26	26	26	26	26	21.00

Table D-2.2. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) WITH APPLIED AXIAL LOADS (Clamped-Pinned) (cont)



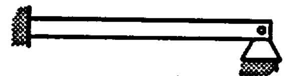
NPS = 14 in
D_o = 14.00 in
E = 28831000 lb/in^2

P/P_b = .50
λ = 3.92660231
μ = 489.535 lb/ft^3

t (in)	0.562	0.625	0.688	0.750	0.812	0.875	
D_i (in)	12.876	12.750	12.624	12.500	12.376	12.250	
W(lb/ft)	80.66	89.28	97.81	106.13	114.37	122.65	
L/D_o	f_n	f_n	f_n	f_n	f_n	f_n	L (ft)
3.0	927	923	919	915	911	907	3.50
4.0	522	519	517	515	512	510	4.67
5.0	334	332	331	329	328	326	5.83
6.0	232	231	230	229	228	227	7.00
7.0	170	170	169	168	167	167	8.17
8.0	130	130	129	129	128	128	9.33
9.0	103	103	102	102	101	101	10.50
10.0	83	83	83	82	82	82	11.67
11.0	69	69	68	68	68	67	12.83
12.0	58	58	57	57	57	57	14.00
13.0	49	49	49	49	49	48	15.17
14.0	43	42	42	42	42	42	16.33
15.0	37	37	37	37	36	36	17.50
16.0	33	32	32	32	32	32	18.67
17.0	29	29	29	28	28	28	19.83
18.0	26	26	26	25	25	25	21.00

t (in)	0.938	1.000	1.062	1.125	
D_i (in)	12.124	12.000	11.876	11.750	
W(lb/ft)	130.85	138.84	146.74	154.69	
L/D_o	f_n	f_n	f_n	f_n	L (ft)
3.0	903	899	895	891	3.50
4.0	508	506	503	501	4.67
5.0	325	324	322	321	5.83
6.0	226	225	224	223	7.00
7.0	166	165	164	164	8.17
8.0	127	126	126	125	9.33
9.0	100	100	99	99	10.50
10.0	81	81	81	80	11.67
11.0	67	67	67	66	12.83
12.0	56	56	56	56	14.00
13.0	48	48	48	47	15.17
14.0	41	41	41	41	16.33
15.0	36	36	36	36	17.50
16.0	32	32	31	31	18.67
17.0	28	28	28	28	19.83
18.0	25	25	25	25	21.00

Table D-2.2. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) WITH APPLIED AXIAL LOADS (Clamped-Pinned) (cont)



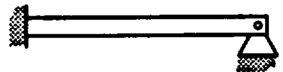
NPS = 14 in
D_o = 14.00 in
E = 28831000 lb/in^2

P/P_b = .75
λ = 3.92660231
μ = 489.535 lb/ft^3

t (in)	0.188	0.210	0.219	0.250	0.281	0.312	
D_i (in)	13.624	13.580	13.562	13.500	13.433	13.376	
W(lb/ft)	27.73	30.93	32.23	36.71	41.17	45.61	
L/D_o	f_n	f_n	f_n	f_n	f_n	f_n	L (ft)
3.0	673	672	672	670	669	667	3.50
4.0	379	378	378	377	376	375	4.67
5.0	242	242	242	241	241	240	5.83
6.0	168	168	168	168	167	167	7.00
7.0	124	123	123	123	123	123	8.17
8.0	95	95	94	94	94	94	9.33
9.0	75	75	75	74	74	74	10.50
10.0	61	61	60	60	60	60	11.67
11.0	50	50	50	50	50	50	12.83
12.0	42	42	42	42	42	42	14.00
13.0	36	36	36	36	36	36	15.17
14.0	31	31	31	31	31	31	16.33
15.0	27	27	27	27	27	27	17.50
16.0	24	24	24	24	24	23	18.67
17.0	21	21	21	21	21	21	19.83
18.0	19	19	19	19	19	19	21.00

t (in)	0.344	0.375	0.406	0.438	0.469	0.500	
D_i (in)	13.312	13.250	13.188	13.124	13.062	13.000	
W(lb/ft)	50.17	54.57	58.94	63.44	67.78	72.09	
L/D_o	f_n	f_n	f_n	f_n	f_n	f_n	L (ft)
3.0	666	664	663	661	660	658	3.50
4.0	375	374	373	372	371	370	4.67
5.0	240	239	239	238	238	237	5.83
6.0	166	166	166	165	165	165	7.00
7.0	122	122	122	121	121	121	8.17
8.0	94	93	93	93	93	93	9.33
9.0	74	74	74	73	73	73	10.50
10.0	60	60	60	60	59	59	11.67
11.0	50	49	49	49	49	49	12.83
12.0	42	42	41	41	41	41	14.00
13.0	35	35	35	35	35	35	15.17
14.0	31	31	30	30	30	30	16.33
15.0	27	27	27	26	26	26	17.50
16.0	23	23	23	23	23	23	18.67
17.0	21	21	21	21	21	21	19.83
18.0	18	18	18	18	18	18	21.00

Table D-2.2. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) WITH APPLIED AXIAL LOADS (Clamped-Pinned) (cont)



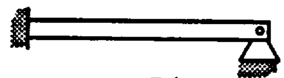
NPS = 14 in
D_o = 14.00 in
E = 28831000 lb/in^2

P/P_b = .75
λ = 3.92660231
μ = 489.535 lb/ft^3

t (in)	0.562	0.625	0.688	0.750	0.812	0.875	
D_i (in)	12.876	12.750	12.624	12.500	12.376	12.250	
W(lb/ft)	80.66	89.28	97.81	106.13	114.37	122.65	
L/D_o	f_n	f_n	f_n	f_n	f_n	f_n	L (ft)
3.0	656	653	650	647	644	641	3.50
4.0	369	367	365	364	362	361	4.67
5.0	236	235	234	233	232	231	5.83
6.0	164	163	162	162	161	160	7.00
7.0	120	120	119	119	118	118	8.17
8.0	92	92	91	91	91	90	9.33
9.0	73	73	72	72	72	71	10.50
10.0	59	59	58	58	58	58	11.67
11.0	49	49	48	48	48	48	12.83
12.0	41	41	41	40	40	40	14.00
13.0	35	35	35	34	34	34	15.17
14.0	30	30	30	30	30	29	16.33
15.0	26	26	26	26	26	26	17.50
16.0	23	23	23	23	23	23	18.67
17.0	20	20	20	20	20	20	19.83
18.0	18	18	18	18	18	18	21.00

t (in)	0.938	1.000	1.062	1.125	
D_i (in)	12.124	12.000	11.876	11.750	
W(lb/ft)	130.85	138.84	146.74	154.69	
L/D_o	f_n	f_n	f_n	f_n	L (ft)
3.0	638	636	633	630	3.50
4.0	359	357	356	354	4.67
5.0	230	229	228	227	5.83
6.0	160	159	158	157	7.00
7.0	117	117	116	116	8.17
8.0	90	89	89	89	9.33
9.0	71	71	70	70	10.50
10.0	57	57	57	57	11.67
11.0	47	47	47	47	12.83
12.0	40	40	40	39	14.00
13.0	34	34	34	34	15.17
14.0	29	29	29	29	16.33
15.0	26	25	25	25	17.50
16.0	22	22	22	22	18.67
17.0	20	20	20	20	19.83
18.0	18	18	18	17	21.00

Table D-2.2. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) WITH APPLIED AXIAL LOADS (Clamped-Pinned) (cont)



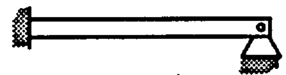
NPS = 16 in
D_o = 16.00 in
E = 28831000 lb/in^2

P/P_b = .25
λ = 3.92660231
μ = 489.535 lb/ft^3

t (in)	**0.188**	**0.203**	**0.219**	**0.250**	**0.281**	**0.312**	
D_i (in)	**15.624**	**15.594**	**15.562**	**15.500**	**15.438**	**15.376**	
W(lb/ft)	**31.75**	**34.25**	**36.91**	**42.05**	**47.17**	**52.27**	
L/D_o	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**L (ft)**
3.0	1022	1021	1020	1018	1016	1014	4.00
4.0	575	574	574	573	572	571	5.33
5.0	368	368	367	367	366	365	6.67
6.0	256	255	255	255	254	254	8.00
7.0	188	188	187	187	187	186	9.33
8.0	144	144	143	143	143	143	10.67
9.0	114	113	113	113	113	113	12.00
10.0	92	92	92	92	91	91	13.33
11.0	76	76	76	76	76	75	14.67
12.0	64	64	64	64	64	63	16.00
13.0	54	54	54	54	54	54	17.33
14.0	47	47	47	47	47	47	18.67
15.0	41	41	41	41	41	41	20.00
16.0	36	36	36	36	36	36	21.33
17.0	32	32	32	32	32	32	22.67
18.0	28	28	28	28	28	28	24.00

t (in)	**0.344**	**0.375**	**0.406**	**0.438**	**0.469**	**0.500**	
D_i (in)	**15.312**	**15.250**	**15.188**	**15.124**	**15.062**	**15.000**	
W(lb/ft)	**57.52**	**62.58**	**67.62**	**72.80**	**77.79**	**82.77**	
L/D_o	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**L (ft)**
3.0	1012	1010	1008	1006	1004	1002	4.00
4.0	569	568	567	566	565	564	5.33
5.0	364	364	363	362	362	361	6.67
6.0	253	253	252	252	251	251	8.00
7.0	186	186	185	185	184	184	9.33
8.0	142	142	142	142	141	141	10.67
9.0	112	112	112	112	112	111	12.00
10.0	91	91	91	91	90	90	13.33
11.0	75	75	75	75	75	75	14.67
12.0	63	63	63	63	63	63	16.00
13.0	54	54	54	54	53	53	17.33
14.0	46	46	46	46	46	46	18.67
15.0	40	40	40	40	40	40	20.00
16.0	36	36	35	35	35	35	21.33
17.0	32	31	31	31	31	31	22.67
18.0	28	28	28	28	28	28	24.00

Table D-2.2. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) WITH APPLIED AXIAL LOADS (Clamped-Pinned) (cont)



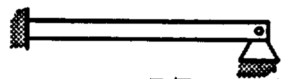
NPS = 16 in
D_o = 16.00 in
E = 28831000 lb/in^2

P/P_b = .25
λ = 3.92660231
μ = 489.535 lb/ft^3

t (in)	**0.562**	**0.625**	**0.688**	**0.750**	**0.812**	**0.875**	
D_i (in)	**14.876**	**14.750**	**14.624**	**14.500**	**14.376**	**14.250**	
W(lb/ft)	**92.66**	**102.63**	**112.51**	**122.15**	**131.71**	**141.34**	
L/D_o	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**L (ft)**
3.0	999	995	991	987	983	979	4.00
4.0	562	559	557	555	553	551	5.33
5.0	359	358	357	355	354	353	6.67
6.0	250	249	248	247	246	245	8.00
7.0	183	183	182	181	181	180	9.33
8.0	140	140	139	139	138	138	10.67
9.0	111	111	110	110	109	109	12.00
10.0	90	90	89	89	88	88	13.33
11.0	74	74	74	73	73	73	14.67
12.0	62	62	62	62	61	61	16.00
13.0	53	53	53	53	52	52	17.33
14.0	46	46	45	45	45	45	18.67
15.0	40	40	40	39	39	39	20.00
16.0	35	35	35	35	35	34	21.33
17.0	31	31	31	31	31	30	22.67
18.0	28	28	28	27	27	27	24.00

t (in)	**0.938**	**1.000**	**1.062**	**1.125**	**1.188**	**1.250**	
D_i (in)	**14.124**	**14.000**	**13.876**	**13.750**	**13.624**	**13.500**	
W(lb/ft)	**150.89**	**160.20**	**169.43**	**178.72**	**187.93**	**196.91**	
L/D_o	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**L (ft)**
3.0	975	972	968	964	961	957	4.00
4.0	549	547	545	542	540	538	5.33
5.0	351	350	348	347	346	344	6.67
6.0	244	243	242	241	240	239	8.00
7.0	179	178	178	177	176	176	9.33
8.0	137	137	136	136	135	135	10.67
9.0	108	108	108	107	107	106	12.00
10.0	88	87	87	87	86	86	13.33
11.0	73	72	72	72	71	71	14.67
12.0	61	61	61	60	60	60	16.00
13.0	52	52	52	51	51	51	17.33
14.0	45	45	44	44	44	44	18.67
15.0	39	39	39	39	38	38	20.00
16.0	34	34	34	34	34	34	21.33
17.0	30	30	30	30	30	30	22.67
18.0	27	27	27	27	27	27	24.00

Table D-2.2. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) WITH APPLIED AXIAL LOADS (Clamped-Pinned) (cont)



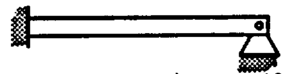
NPS = 16 in
D_o = 16.00 in
E = 28831000 lb/in^2

P/P_b = .50
λ = 3.92660231
μ = 489.535 lb/ft^3

t (in)	0.188	0.203	0.219	0.250	0.281	0.312	
D_i (in)	15.624	15.594	15.562	15.500	15.438	15.376	
W(lb/ft)	31.75	34.25	36.91	42.05	47.17	52.27	
L/D_o	f_n	f_n	f_n	f_n	f_n	f_n	L (ft)
3.0	835	834	833	831	830	828	4.00
4.0	469	469	469	468	467	466	5.33
5.0	300	300	300	299	299	298	6.67
6.0	209	208	208	208	207	207	8.00
7.0	153	153	153	153	152	152	9.33
8.0	117	117	117	117	117	116	10.67
9.0	93	93	93	92	92	92	12.00
10.0	75	75	75	75	75	75	13.33
11.0	62	62	62	62	62	62	14.67
12.0	52	52	52	52	52	52	16.00
13.0	44	44	44	44	44	44	17.33
14.0	38	38	38	38	38	38	18.67
15.0	33	33	33	33	33	33	20.00
16.0	29	29	29	29	29	29	21.33
17.0	26	26	26	26	26	26	22.67
18.0	23	23	23	23	23	23	24.00

t (in)	0.344	0.375	0.406	0.438	0.469	0.500	
D_i (in)	15.312	15.250	15.188	15.124	15.062	15.000	
W(lb/ft)	57.52	62.58	67.62	72.80	77.79	82.77	
L/D_o	f_n	f_n	f_n	f_n	f_n	f_n	L (ft)
3.0	826	825	823	822	820	818	4.00
4.0	465	464	463	462	461	460	5.33
5.0	298	297	296	296	295	295	6.67
6.0	207	206	206	205	205	205	8.00
7.0	152	152	151	151	151	150	9.33
8.0	116	116	116	116	115	115	10.67
9.0	92	92	91	91	91	91	12.00
10.0	74	74	74	74	74	74	13.33
11.0	61	61	61	61	61	61	14.67
12.0	52	52	51	51	51	51	16.00
13.0	44	44	44	44	44	44	17.33
14.0	38	38	38	38	38	38	18.67
15.0	33	33	33	33	33	33	20.00
16.0	29	29	29	29	29	29	21.33
17.0	26	26	26	26	26	25	22.67
18.0	23	23	23	23	23	23	24.00

Table D-2.2. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) WITH APPLIED AXIAL LOADS (Clamped-Pinned) (cont)



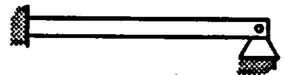
NPS = 16 in
D_o = 16.00 in
E = 28831000 lb/in^2

P/P_b = .50
λ = 3.92660231
μ = 489.535 lb/ft^3

t (in)	0.562	0.625	0.688	0.750	0.812	0.875	
D_i (in)	14.876	14.750	14.624	14.500	14.376	14.250	
W(lb/ft)	92.66	102.63	112.51	122.15	131.71	141.34	
L/D_o	f_n	f_n	f_n	f_n	f_n	f_n	L (ft)
3.0	815	812	809	806	803	800	4.00
4.0	459	457	455	453	452	450	5.33
5.0	294	292	291	290	289	288	6.67
6.0	204	203	202	201	201	200	8.00
7.0	150	149	149	148	147	147	9.33
8.0	115	114	114	113	113	112	10.67
9.0	91	90	90	90	89	89	12.00
10.0	73	73	73	73	72	72	13.33
11.0	61	60	60	60	60	59	14.67
12.0	51	51	51	50	50	50	16.00
13.0	43	43	43	43	43	43	17.33
14.0	37	37	37	37	37	37	18.67
15.0	33	32	32	32	32	32	20.00
16.0	29	29	28	28	28	28	21.33
17.0	25	25	25	25	25	25	22.67
18.0	23	23	22	22	22	22	24.00

t (in)	0.938	1.000	1.062	1.125	1.188	1.250	
D_i (in)	14.124	14.000	13.876	13.750	13.624	13.500	
W(lb/ft)	150.89	160.20	169.43	178.72	187.93	196.91	
L/D_o	f_n	f_n	f_n	f_n	f_n	f_n	L (ft)
3.0	796	793	790	787	784	781	4.00
4.0	448	446	445	443	441	439	5.33
5.0	287	286	285	283	282	281	6.67
6.0	199	198	198	197	196	195	8.00
7.0	146	146	145	145	144	143	9.33
8.0	112	112	111	111	110	110	10.67
9.0	88	88	88	87	87	87	12.00
10.0	72	71	71	71	71	70	13.33
11.0	59	59	59	59	58	58	14.67
12.0	50	50	49	49	49	49	16.00
13.0	42	42	42	42	42	42	17.33
14.0	37	36	36	36	36	36	18.67
15.0	32	32	32	31	31	31	20.00
16.0	28	28	28	28	28	27	21.33
17.0	25	25	25	25	24	24	22.67
18.0	22	22	22	22	22	22	24.00

Table D-2.2. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) WITH APPLIED AXIAL LOADS (Clamped-Pinned) (cont)



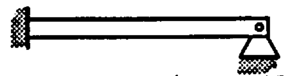
NPS = 16 in
D_o = 16.00 in
E = 28831000 lb/in^2

P/P_b = .75
λ = 3.92660231
μ = 489.535 lb/ft^3

t (in)	**0.188**	**0.203**	**0.219**	**0.250**	**0.281**	**0.312**	
D_i (in)	**15.624**	**15.594**	**15.562**	**15.500**	**15.438**	**15.376**	
W(lb/ft)	**31.75**	**34.25**	**36.91**	**42.05**	**47.17**	**52.27**	
L/D_o	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**L (ft)**
3.0	590	590	589	588	587	586	4.00
4.0	332	332	331	331	330	329	5.33
5.0	212	212	212	212	211	211	6.67
6.0	148	147	147	147	147	146	8.00
7.0	108	108	108	108	108	108	9.33
8.0	83	83	83	83	83	82	10.67
9.0	66	66	65	65	65	65	12.00
10.0	53	53	53	53	53	53	13.33
11.0	44	44	44	44	44	44	14.67
12.0	37	37	37	37	37	37	16.00
13.0	31	31	31	31	31	31	17.33
14.0	27	27	27	27	27	27	18.67
15.0	24	24	24	24	23	23	20.00
16.0	21	21	21	21	21	21	21.33
17.0	18	18	18	18	18	18	22.67
18.0	16	16	16	16	16	16	24.00

t (in)	**0.344**	**0.375**	**0.406**	**0.438**	**0.469**	**0.500**	
D_i (in)	**15.312**	**15.250**	**15.188**	**15.124**	**15.062**	**15.000**	
W(lb/ft)	**57.52**	**62.58**	**67.62**	**72.80**	**77.79**	**82.77**	
L/D_o	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**L (ft)**
3.0	584	583	582	581	580	579	4.00
4.0	329	328	327	327	326	326	5.33
5.0	210	210	210	209	209	208	6.67
6.0	146	146	146	145	145	145	8.00
7.0	107	107	107	107	107	106	9.33
8.0	82	82	82	82	82	81	10.67
9.0	65	65	65	65	64	64	12.00
10.0	53	52	52	52	52	52	13.33
11.0	43	43	43	43	43	43	14.67
12.0	37	36	36	36	36	36	16.00
13.0	31	31	31	31	31	31	17.33
14.0	27	27	27	27	27	27	18.67
15.0	23	23	23	23	23	23	20.00
16.0	21	21	20	20	20	20	21.33
17.0	18	18	18	18	18	18	22.67
18.0	16	16	16	16	16	16	24.00

Table D-2.2. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) WITH APPLIED AXIAL LOADS (Clamped-Pinned) (cont)



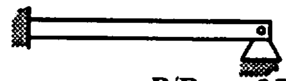
NPS = 16 in
D_o = 16.00 in
E = 28831000 lb/in^2

P/P$_b$ = .75
λ = 3.92660231
μ = 489.535 lb/ft^3

t (in)	0.562	0.625	0.688	0.750	0.812	0.875	
D_i (in)	14.876	14.750	14.624	14.500	14.376	14.250	
W(lb/ft)	92.66	102.63	112.51	122.15	131.71	141.34	
L/D_o	f_n	f_n	f_n	f_n	f_n	f_n	L (ft)
3.0	577	574	572	570	568	565	4.00
4.0	324	323	322	321	319	318	5.33
5.0	208	207	206	205	204	204	6.67
6.0	144	144	143	142	142	141	8.00
7.0	106	105	105	105	104	104	9.33
8.0	81	81	80	80	80	80	10.67
9.0	64	64	64	63	63	63	12.00
10.0	52	52	51	51	51	51	13.33
11.0	43	43	43	42	42	42	14.67
12.0	36	36	36	36	35	35	16.00
13.0	31	31	30	30	30	30	17.33
14.0	26	26	26	26	26	26	18.67
15.0	23	23	23	23	23	23	20.00
16.0	20	20	20	20	20	20	21.33
17.0	18	18	18	18	18	18	22.67
18.0	16	16	16	16	16	16	24.00

t (in)	0.938	1.000	1.062	1.125	1.188	1.250	
D_i (in)	14.124	14.000	13.876	13.750	13.624	13.500	
W(lb/ft)	150.89	160.20	169.43	178.72	187.93	196.91	
L/D_o	f_n	f_n	f_n	f_n	f_n	f_n	L (ft)
3.0	563	561	559	557	555	552	4.00
4.0	317	316	314	313	312	311	5.33
5.0	203	202	201	200	200	199	6.67
6.0	141	140	140	139	139	138	8.00
7.0	103	103	103	102	102	101	9.33
8.0	79	79	79	78	78	78	10.67
9.0	63	62	62	62	62	61	12.00
10.0	51	50	50	50	50	50	13.33
11.0	42	42	42	41	41	41	14.67
12.0	35	35	35	35	35	35	16.00
13.0	30	30	30	30	30	29	17.33
14.0	26	26	26	26	25	25	18.67
15.0	23	22	22	22	22	22	20.00
16.0	20	20	20	20	19	19	21.33
17.0	18	17	17	17	17	17	22.67
18.0	16	16	16	15	15	15	24.00

Table D-2.2. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) WITH APPLIED AXIAL LOADS (Clamped-Pinned) (cont)



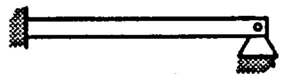
NPS = 18 in
D_o = 18.00 in
E = 28831000 lb/in²

P/P_b = .25
λ = 3.92660231
μ = 489.535 lb/ft³

t (in)	0.188	0.219	0.250	0.281	0.312	0.344	
D_i (in)	17.624	17.562	17.500	17.438	17.376	17.312	
W(lb/ft)	35.76	41.59	47.39	53.18	58.94	64.87	
L/D_o	f_n	f_n	f_n	f_n	f_n	f_n	L (ft)
3.0	910	908	907	905	904	902	4.50
4.0	512	511	510	509	508	507	6.00
5.0	328	327	326	326	325	325	7.50
6.0	227	227	227	226	226	225	9.00
7.0	167	167	167	166	166	166	10.50
8.0	128	128	127	127	127	127	12.00
9.0	101	101	101	101	100	100	13.50
10.0	82	82	82	81	81	81	15.00
11.0	68	68	67	67	67	67	16.50
12.0	57	57	57	57	56	56	18.00
13.0	48	48	48	48	48	48	19.50
14.0	42	42	42	42	41	41	21.00
15.0	36	36	36	36	36	36	22.50
16.0	32	32	32	32	32	32	24.00
17.0	28	28	28	28	28	28	25.50
18.0	25	25	25	25	25	25	27.00

t (in)	0.375	0.406	0.438	0.469	0.500	0.562	
D_i (in)	17.250	17.188	17.124	17.062	17.000	16.876	
W(lb/ft)	70.59	76.29	82.15	87.81	93.45	104.67	
L/D_o	f_n	f_n	f_n	f_n	f_n	f_n	L (ft)
3.0	900	899	897	896	894	891	4.50
4.0	506	506	505	504	503	501	6.00
5.0	324	324	323	322	322	321	7.50
6.0	225	225	224	224	224	223	9.00
7.0	165	165	165	165	164	164	10.50
8.0	127	126	126	126	126	125	12.00
9.0	100	100	100	100	99	99	13.50
10.0	81	81	81	81	80	80	15.00
11.0	67	67	67	67	67	66	16.50
12.0	56	56	56	56	56	56	18.00
13.0	48	48	48	48	48	47	19.50
14.0	41	41	41	41	41	41	21.00
15.0	36	36	36	36	36	36	22.50
16.0	32	32	32	31	31	31	24.00
17.0	28	28	28	28	28	28	25.50
18.0	25	25	25	25	25	25	27.00

Table D-2.2. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) WITH APPLIED AXIAL LOADS (Clamped-Pinned) (cont)



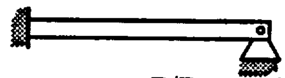
NPS = 18 in
D_o = 18.00 in
E = 28831000 lb/in^2

P/P_b = .25
λ = 3.92660231
μ = 489.535 lb/ft^3

t (in)	0.625	0.688	0.750	0.812	0.875	0.938	
D_i (in)	16.750	16.624	16.500	16.376	16.250	16.124	
W(lb/ft)	115.98	127.21	138.17	149.06	160.03	170.92	
L/D_o	f_n	f_n	f_n	f_n	f_n	f_n	L (ft)
3.0	888	885	882	879	876	873	4.50
4.0	499	498	496	494	493	491	6.00
5.0	320	319	317	316	315	314	7.50
6.0	222	221	220	220	219	218	9.00
7.0	163	163	162	161	161	160	10.50
8.0	125	124	124	124	123	123	12.00
9.0	99	98	98	98	97	97	13.50
10.0	80	80	79	79	79	79	15.00
11.0	66	66	66	65	65	65	16.50
12.0	55	55	55	55	55	55	18.00
13.0	47	47	47	47	47	46	19.50
14.0	41	41	40	40	40	40	21.00
15.0	36	35	35	35	35	35	22.50
16.0	31	31	31	31	31	31	24.00
17.0	28	28	27	27	27	27	25.50
18.0	25	25	24	24	24	24	27.00

t (in)	1.000	1.062	1.125	1.188	1.250	
D_i (in)	16.000	15.876	15.750	15.624	15.500	
W(lb/ft)	181.56	192.11	202.75	213.31	223.61	
L/D_o	f_n	f_n	f_n	f_n	f_n	L (ft)
3.0	870	867	864	861	858	4.50
4.0	489	488	486	484	483	6.00
5.0	313	312	311	310	309	7.50
6.0	217	217	216	215	214	9.00
7.0	160	159	159	158	158	10.50
8.0	122	122	121	121	121	12.00
9.0	97	96	96	96	95	13.50
10.0	78	78	78	77	77	15.00
11.0	65	64	64	64	64	16.50
12.0	54	54	54	54	54	18.00
13.0	46	46	46	46	46	19.50
14.0	40	40	40	40	39	21.00
15.0	35	35	35	34	34	22.50
16.0	31	30	30	30	30	24.00
17.0	27	27	27	27	27	25.50
18.0	24	24	24	24	24	27.00

Table D-2.2. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) WITH APPLIED AXIAL LOADS (Clamped-Pinned) (cont)



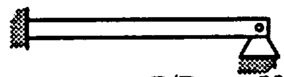
NPS = 18 in
D_o = 18.00 in
E = 28831000 lb/in^2

P/P_b = .50
λ = 3.92660231
μ = 489.535 lb/ft^3

t (in)	0.188	0.219	0.250	0.281	0.312	0.344	
D_i (in)	17.624	17.562	17.500	17.438	17.376	17.312	
W(lb/ft)	35.76	41.59	47.39	53.18	58.94	64.87	
L/D_o	f_n	f_n	f_n	f_n	f_n	f_n	L (ft)
3.0	743	742	740	739	738	736	4.50
4.0	418	417	416	416	415	414	6.00
5.0	267	267	266	266	266	265	7.50
6.0	186	185	185	185	184	184	9.00
7.0	136	136	136	136	135	135	10.50
8.0	104	104	104	104	104	104	12.00
9.0	83	82	82	82	82	82	13.50
10.0	67	67	67	67	66	66	15.00
11.0	55	55	55	55	55	55	16.50
12.0	46	46	46	46	46	46	18.00
13.0	40	39	39	39	39	39	19.50
14.0	34	34	34	34	34	34	21.00
15.0	30	30	30	30	30	29	22.50
16.0	26	26	26	26	26	26	24.00
17.0	23	23	23	23	23	23	25.50
18.0	21	21	21	21	20	20	27.00

t (in)	0.375	0.406	0.438	0.469	0.500	0.562	
D_i (in)	17.250	17.188	17.124	17.062	17.000	16.876	
W(lb/ft)	70.59	76.29	82.15	87.81	93.45	104.67	
L/D_o	f_n	f_n	f_n	f_n	f_n	f_n	L (ft)
3.0	735	734	733	731	730	728	4.50
4.0	414	413	412	411	411	409	6.00
5.0	265	264	264	263	263	262	7.50
6.0	184	183	183	183	183	182	9.00
7.0	135	135	135	134	134	134	10.50
8.0	103	103	103	103	103	102	12.00
9.0	82	82	81	81	81	81	13.50
10.0	66	66	66	66	66	65	15.00
11.0	55	55	54	54	54	54	16.50
12.0	46	46	46	46	46	45	18.00
13.0	39	39	39	39	39	39	19.50
14.0	34	34	34	34	34	33	21.00
15.0	29	29	29	29	29	29	22.50
16.0	26	26	26	26	26	26	24.00
17.0	23	23	23	23	23	23	25.50
18.0	20	20	20	20	20	20	27.00

Table D-2.2. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) WITH APPLIED AXIAL LOADS (Clamped-Pinned) (cont)



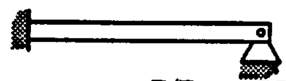
NPS = 18 in
D_o = 18.00 in
E = 28831000 lb/in^2

P/P_b = .50
λ = 3.92660231
μ = 489.535 lb/ft^3

t (in)	**0.625**	**0.688**	**0.750**	**0.812**	**0.875**	**0.938**	
D_i (in)	**16.750**	**16.624**	**16.500**	**16.376**	**16.250**	**16.124**	
W(lb/ft)	**115.98**	**127.21**	**138.17**	**149.06**	**160.03**	**170.92**	
L/D_o	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**L (ft)**
3.0	725	722	720	718	715	713	4.50
4.0	408	406	405	404	402	401	6.00
5.0	261	260	259	258	257	257	7.50
6.0	181	181	180	179	179	178	9.00
7.0	133	133	132	132	131	131	10.50
8.0	102	102	101	101	101	100	12.00
9.0	81	80	80	80	79	79	13.50
10.0	65	65	65	65	64	64	15.00
11.0	54	54	54	53	53	53	16.50
12.0	45	45	45	45	45	45	18.00
13.0	39	38	38	38	38	38	19.50
14.0	33	33	33	33	33	33	21.00
15.0	29	29	29	29	29	29	22.50
16.0	25	25	25	25	25	25	24.00
17.0	23	22	22	22	22	22	25.50
18.0	20	20	20	20	20	20	27.00

t (in)	**1.000**	**1.062**	**1.125**	**1.188**	**1.250**	
D_i (in)	**16.000**	**15.876**	**15.750**	**15.624**	**15.500**	
W(lb/ft)	**181.56**	**192.11**	**202.75**	**213.31**	**223.61**	
L/D_o	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**L (ft)**
3.0	710	708	705	703	700	4.50
4.0	399	398	397	395	394	6.00
5.0	256	255	254	253	252	7.50
6.0	178	177	176	176	175	9.00
7.0	130	130	130	129	129	10.50
8.0	100	100	99	99	98	12.00
9.0	79	79	78	78	78	13.50
10.0	64	64	63	63	63	15.00
11.0	53	53	52	52	52	16.50
12.0	44	44	44	44	44	18.00
13.0	38	38	38	37	37	19.50
14.0	33	32	32	32	32	21.00
15.0	28	28	28	28	28	22.50
16.0	25	25	25	25	25	24.00
17.0	22	22	22	22	22	25.50
18.0	20	20	20	20	19	27.00

Table D-2.2. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) WITH APPLIED AXIAL LOADS (Clamped-Pinned) (cont)



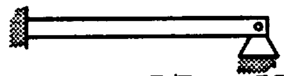
NPS = 18 in
D_o = 18.00 in
E = 28831000 lb/in^2

P/P_b = .75
λ = 3.92660231
μ = 489.535 lb/ft^3

t (in)	0.188	0.219	0.250	0.281	0.312	0.344	
D_i (in)	17.624	17.562	17.500	17.438	17.376	17.312	
W(lb/ft)	35.76	41.59	47.39	53.18	58.94	64.87	
L/D_o	f_n	f_n	f_n	f_n	f_n	f_n	L (ft)
3.0	525	524	523	523	522	521	4.50
4.0	295	295	294	294	293	293	6.00
5.0	189	189	188	188	188	187	7.50
6.0	131	131	131	131	130	130	9.00
7.0	96	96	96	96	96	96	10.50
8.0	74	74	74	73	73	73	12.00
9.0	58	58	58	58	58	58	13.50
10.0	47	47	47	47	47	47	15.00
11.0	39	39	39	39	39	39	16.50
12.0	33	33	33	33	33	33	18.00
13.0	28	28	28	28	28	28	19.50
14.0	24	24	24	24	24	24	21.00
15.0	21	21	21	21	21	21	22.50
16.0	18	18	18	18	18	18	24.00
17.0	16	16	16	16	16	16	25.50
18.0	15	15	15	15	14	14	27.00

t (in)	0.375	0.406	0.438	0.469	0.500	0.562	
D_i (in)	17.250	17.188	17.124	17.062	17.000	16.876	
W(lb/ft)	70.59	76.29	82.15	87.81	93.45	104.67	
L/D_o	f_n	f_n	f_n	f_n	f_n	f_n	L (ft)
3.0	520	519	518	517	516	514	4.50
4.0	292	292	291	291	290	289	6.00
5.0	187	187	186	186	186	185	7.50
6.0	130	130	130	129	129	129	9.00
7.0	95	95	95	95	95	94	10.50
8.0	73	73	73	73	73	72	12.00
9.0	58	58	58	57	57	57	13.50
10.0	47	47	47	47	46	46	15.00
11.0	39	39	39	38	38	38	16.50
12.0	32	32	32	32	32	32	18.00
13.0	28	28	28	28	27	27	19.50
14.0	24	24	24	24	24	24	21.00
15.0	21	21	21	21	21	21	22.50
16.0	18	18	18	18	18	18	24.00
17.0	16	16	16	16	16	16	25.50
18.0	14	14	14	14	14	14	27.00

Table D-2.2. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) WITH APPLIED AXIAL LOADS (Clamped-Pinned) (cont)



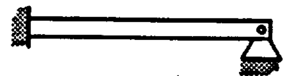
NPS = 18 in
D_o = 18.00 in
E = 28831000 lb/in^2

P/P_b = .75
λ = 3.92660231
μ = 489.535 lb/ft^3

t (in)	**0.625**	**0.688**	**0.750**	**0.812**	**0.875**	**0.938**	
D_i (in)	**16.750**	**16.624**	**16.500**	**16.376**	**16.250**	**16.124**	
W(lb/ft)	**115.98**	**127.21**	**138.17**	**149.06**	**160.03**	**170.92**	
L/D_o	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**L (ft)**
3.0	513	511	509	507	506	504	4.50
4.0	288	287	286	285	284	283	6.00
5.0	185	184	183	183	182	181	7.50
6.0	128	128	127	127	126	126	9.00
7.0	94	94	94	93	93	93	10.50
8.0	72	72	72	71	71	71	12.00
9.0	57	57	57	56	56	56	13.50
10.0	46	46	46	46	46	45	15.00
11.0	38	38	38	38	38	37	16.50
12.0	32	32	32	32	32	31	18.00
13.0	27	27	27	27	27	27	19.50
14.0	24	23	23	23	23	23	21.00
15.0	21	20	20	20	20	20	22.50
16.0	18	18	18	18	18	18	24.00
17.0	16	16	16	16	16	16	25.50
18.0	14	14	14	14	14	14	27.00

t (in)	**1.000**	**1.062**	**1.125**	**1.188**	**1.250**	
D_i (in)	**16.000**	**15.876**	**15.750**	**15.624**	**15.500**	
W(lb/ft)	**181.56**	**192.11**	**202.75**	**213.31**	**223.61**	
L/D_o	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**L (ft)**
3.0	502	500	499	497	495	4.50
4.0	282	281	281	280	279	6.00
5.0	181	180	180	179	178	7.50
6.0	126	125	125	124	124	9.00
7.0	92	92	92	91	91	10.50
8.0	71	70	70	70	70	12.00
9.0	56	56	55	55	55	13.50
10.0	45	45	45	45	45	15.00
11.0	37	37	37	37	37	16.50
12.0	31	31	31	31	31	18.00
13.0	27	27	27	26	26	19.50
14.0	23	23	23	23	23	21.00
15.0	20	20	20	20	20	22.50
16.0	18	18	18	17	17	24.00
17.0	16	16	16	15	15	25.50
18.0	14	14	14	14	14	27.00

Table D-2.2. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) WITH APPLIED AXIAL LOADS (Clamped-Pinned) (cont)



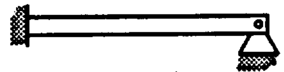
NPS = 20 in
D_o = 20.00 in
E = 28831000 lb/in²

P/P_b = .25
λ = 3.92660231
μ = 489.535 lb/ft³

t (in)	**0.219**	**0.250**	**0.281**	**0.312**	**0.344**	**0.375**	
D_i (in)	**19.562**	**19.500**	**19.438**	**19.376**	**19.312**	**19.250**	
W(lb/ft)	**46.27**	**52.73**	**59.18**	**65.60**	**72.21**	**78.60**	
L/D_o	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**L (ft)**
3.0	818	817	816	815	813	812	5.00
4.0	460	460	459	458	457	457	6.67
5.0	295	294	294	293	293	292	8.33
6.0	205	204	204	204	203	203	10.00
7.0	150	150	150	150	149	149	11.67
8.0	115	115	115	115	114	114	13.33
9.0	91	91	91	91	90	90	15.00
10.0	74	74	73	73	73	73	16.67
11.0	61	61	61	61	60	60	18.33
12.0	51	51	51	51	51	51	20.00
13.0	44	44	43	43	43	43	21.67
14.0	38	38	37	37	37	37	23.33
15.0	33	33	33	33	33	32	25.00
16.0	29	29	29	29	29	29	26.67
17.0	25	25	25	25	25	25	28.33
18.0	23	23	23	23	23	23	30.00

t (in)	**0.406**	**0.438**	**0.469**	**0.500**	**0.562**	**0.625**	
D_i (in)	**19.188**	**19.124**	**19.062**	**19.000**	**18.876**	**18.750**	
W(lb/ft)	**84.96**	**91.51**	**97.83**	**104.13**	**116.67**	**129.33**	
L/D_o	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**L (ft)**
3.0	811	809	808	807	804	802	5.00
4.0	456	455	455	454	453	451	6.67
5.0	292	291	291	291	290	289	8.33
6.0	203	202	202	202	201	200	10.00
7.0	149	149	148	148	148	147	11.67
8.0	114	114	114	113	113	113	13.33
9.0	90	90	90	90	89	89	15.00
10.0	73	73	73	73	72	72	16.67
11.0	60	60	60	60	60	60	18.33
12.0	51	51	51	50	50	50	20.00
13.0	43	43	43	43	43	43	21.67
14.0	37	37	37	37	37	37	23.33
15.0	32	32	32	32	32	32	25.00
16.0	29	28	28	28	28	28	26.67
17.0	25	25	25	25	25	25	28.33
18.0	23	22	22	22	22	22	30.00

Table D-2.2. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) WITH APPLIED AXIAL LOADS (Clamped-Pinned) (cont)



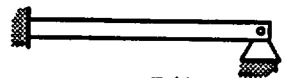
NPS = 20 in
D_o = 20.00 in
E = 28831000 lb/in^2

P/P_b = .25
λ = 3.92660231
μ = 489.535 lb/ft^3

t (in)	**0.688**	**0.750**	**0.812**	**0.875**	**0.938**	**1.000**	
D_i (in)	**18.624**	**18.500**	**18.376**	**18.250**	**18.124**	**18.000**	
W(lb/ft)	**141.90**	**154.19**	**166.40**	**178.72**	**190.96**	**202.92**	
L/D_o	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**L (ft)**
3.0	799	797	794	792	790	787	5.00
4.0	450	448	447	446	444	443	6.67
5.0	288	287	286	285	284	283	8.33
6.0	200	199	199	198	197	197	10.00
7.0	147	146	146	145	145	145	11.67
8.0	112	112	112	111	111	111	13.33
9.0	89	89	88	88	88	87	15.00
10.0	72	72	72	71	71	71	16.67
11.0	59	59	59	59	59	59	18.33
12.0	50	50	50	50	49	49	20.00
13.0	43	42	42	42	42	42	21.67
14.0	37	37	36	36	36	36	23.33
15.0	32	32	32	32	32	31	25.00
16.0	28	28	28	28	28	28	26.67
17.0	25	25	25	25	25	25	28.33
18.0	22	22	22	22	22	22	30.00

t (in)	**1.062**	**1.125**	**1.188**	**1.250**	**1.312**	**1.375**	
D_i (in)	**17.876**	**17.750**	**17.624**	**17.500**	**17.376**	**17.250**	
W(lb/ft)	**214.80**	**226.78**	**238.68**	**250.31**	**261.86**	**273.51**	
L/D_o	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**L (ft)**
3.0	785	782	780	777	775	773	5.00
4.0	441	440	439	437	436	435	6.67
5.0	282	282	281	280	279	278	8.33
6.0	196	196	195	194	194	193	10.00
7.0	144	144	143	143	142	142	11.67
8.0	110	110	110	109	109	109	13.33
9.0	87	87	87	86	86	86	15.00
10.0	71	70	70	70	70	70	16.67
11.0	58	58	58	58	58	57	18.33
12.0	49	49	49	49	48	48	20.00
13.0	42	42	42	41	41	41	21.67
14.0	36	36	36	36	36	35	23.33
15.0	31	31	31	31	31	31	25.00
16.0	28	28	27	27	27	27	26.67
17.0	24	24	24	24	24	24	28.33
18.0	22	22	22	22	22	21	30.00

Table D-2.2. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) WITH APPLIED AXIAL LOADS (Clamped-Pinned) (cont)



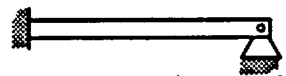
NPS = 20 in
D_o = 20.00 in
E = 28831000 lb/in^2

P/P_b = .50
λ = 3.92660231
μ = 489.535 lb/ft^3

t (in)	0.219	0.250	0.281	0.312	0.344	0.375	
D_i (in)	19.562	19.500	19.438	19.376	19.312	19.250	
W(lb/ft)	46.27	52.73	59.18	65.60	72.21	78.60	
L/D_o	f_n	f_n	f_n	f_n	f_n	f_n	L (ft)
3.0	668	667	666	665	664	663	5.00
4.0	376	375	375	374	374	373	6.67
5.0	241	240	240	239	239	239	8.33
6.0	167	167	167	166	166	166	10.00
7.0	123	123	122	122	122	122	11.67
8.0	94	94	94	94	93	93	13.33
9.0	74	74	74	74	74	74	15.00
10.0	60	60	60	60	60	60	16.67
11.0	50	50	50	49	49	49	18.33
12.0	42	42	42	42	42	41	20.00
13.0	36	36	35	35	35	35	21.67
14.0	31	31	31	31	30	30	23.33
15.0	27	27	27	27	27	27	25.00
16.0	23	23	23	23	23	23	26.67
17.0	21	21	21	21	21	21	28.33
18.0	19	19	19	18	18	18	30.00

t (in)	0.406	0.438	0.469	0.500	0.562	0.625	
D_i (in)	19.188	19.124	19.062	19.000	18.876	18.750	
W(lb/ft)	84.96	91.51	97.83	104.13	116.67	129.33	
L/D_o	f_n	f_n	f_n	f_n	f_n	f_n	L (ft)
3.0	662	661	660	659	657	655	5.00
4.0	372	372	371	371	369	368	6.67
5.0	238	238	238	237	236	236	8.33
6.0	165	165	165	165	164	164	10.00
7.0	122	121	121	121	121	120	11.67
8.0	93	93	93	93	92	92	13.33
9.0	74	73	73	73	73	73	15.00
10.0	60	59	59	59	59	59	16.67
11.0	49	49	49	49	49	49	18.33
12.0	41	41	41	41	41	41	20.00
13.0	35	35	35	35	35	35	21.67
14.0	30	30	30	30	30	30	23.33
15.0	26	26	26	26	26	26	25.00
16.0	23	23	23	23	23	23	26.67
17.0	21	21	21	21	20	20	28.33
18.0	18	18	18	18	18	18	30.00

Table D-2.2. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) WITH APPLIED AXIAL LOADS (Clamped-Pinned) (cont)



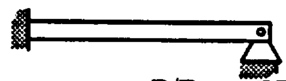
NPS = 20 in
D_o = 20.00 in
E = 28831000 lb/in^2

P/P_b = .50
λ = 3.92660231
μ = 489.535 lb/ft^3

t (in)	0.688	0.750	0.812	0.875	0.938	1.000	
D_i (in)	18.624	18.500	18.376	18.250	18.124	18.000	
W(lb/ft)	141.90	154.19	166.40	178.72	190.96	202.92	
L/D_o	f_n	f_n	f_n	f_n	f_n	f_n	L (ft)
3.0	653	651	649	647	645	643	5.00
4.0	367	366	365	364	363	361	6.67
5.0	235	234	234	233	232	231	8.33
6.0	163	163	162	162	161	161	10.00
7.0	120	120	119	119	118	118	11.67
8.0	92	92	91	91	91	90	13.33
9.0	73	72	72	72	72	71	15.00
10.0	59	59	58	58	58	58	16.67
11.0	49	48	48	48	48	48	18.33
12.0	41	41	41	40	40	40	20.00
13.0	35	35	35	34	34	34	21.67
14.0	30	30	30	30	30	30	23.33
15.0	26	26	26	26	26	26	25.00
16.0	23	23	23	23	23	23	26.67
17.0	20	20	20	20	20	20	28.33
18.0	18	18	18	18	18	18	30.00

t (in)	1.062	1.125	1.188	1.250	1.312	1.375	
D_i (in)	17.876	17.750	17.624	17.500	17.376	17.250	
W(lb/ft)	214.80	226.78	238.68	250.31	261.86	273.51	
L/D_o	f_n	f_n	f_n	f_n	f_n	f_n	L (ft)
3.0	641	639	637	635	633	631	5.00
4.0	360	359	358	357	356	355	6.67
5.0	231	230	229	229	228	227	8.33
6.0	160	160	159	159	158	158	10.00
7.0	118	117	117	117	116	116	11.67
8.0	90	90	90	89	89	89	13.33
9.0	71	71	71	71	70	70	15.00
10.0	58	57	57	57	57	57	16.67
11.0	48	48	47	47	47	47	18.33
12.0	40	40	40	40	40	39	20.00
13.0	34	34	34	34	34	34	21.67
14.0	29	29	29	29	29	29	23.33
15.0	26	26	25	25	25	25	25.00
16.0	23	22	22	22	22	22	26.67
17.0	20	20	20	20	20	20	28.33
18.0	18	18	18	18	18	18	30.00

Table D-2.2. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) WITH APPLIED AXIAL LOADS (Clamped-Pinned) (cont)



NPS = 20 in
D_o = 20.00 in
E = 28831000 lb/in²

P/P$_b$ = .75
λ = 3.92660231
μ = 489.535 lb/ft³

t (in)	**0.219**	**0.250**	**0.281**	**0.312**	**0.344**	**0.375**	
D_i (in)	**19.562**	**19.500**	**19.438**	**19.376**	**19.312**	**19.250**	
W(lb/ft)	**46.27**	**52.73**	**59.18**	**65.60**	**72.21**	**78.60**	
L/D_o	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**L (ft)**
3.0	472	472	471	470	470	469	5.00
4.0	266	265	265	265	264	264	6.67
5.0	170	170	170	169	169	169	8.33
6.0	118	118	118	118	117	117	10.00
7.0	87	87	87	86	86	86	11.67
8.0	66	66	66	66	66	66	13.33
9.0	52	52	52	52	52	52	15.00
10.0	43	42	42	42	42	42	16.67
11.0	35	35	35	35	35	35	18.33
12.0	30	29	29	29	29	29	20.00
13.0	25	25	25	25	25	25	21.67
14.0	22	22	22	22	22	22	23.33
15.0	19	19	19	19	19	19	25.00
16.0	17	17	17	17	17	16	26.67
17.0	15	15	15	15	15	15	28.33
18.0	13	13	13	13	13	13	30.00

t (in)	**0.406**	**0.438**	**0.469**	**0.500**	**0.562**	**0.625**	
D_i (in)	**19.188**	**19.124**	**19.062**	**19.000**	**18.876**	**18.750**	
W(lb/ft)	**84.96**	**91.51**	**97.83**	**104.13**	**116.67**	**129.33**	
L/D_o	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**L (ft)**
3.0	468	467	467	466	464	463	5.00
4.0	263	263	262	262	261	260	6.67
5.0	169	168	168	168	167	167	8.33
6.0	117	117	117	116	116	116	10.00
7.0	86	86	86	86	85	85	11.67
8.0	66	66	66	66	65	65	13.33
9.0	52	52	52	52	52	51	15.00
10.0	42	42	42	42	42	42	16.67
11.0	35	35	35	35	35	34	18.33
12.0	29	29	29	29	29	29	20.00
13.0	25	25	25	25	25	25	21.67
14.0	21	21	21	21	21	21	23.33
15.0	19	19	19	19	19	19	25.00
16.0	16	16	16	16	16	16	26.67
17.0	15	15	15	15	14	14	28.33
18.0	13	13	13	13	13	13	30.00

Table D-2.2. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) WITH APPLIED AXIAL LOADS (Clamped-Pinned) (cont)

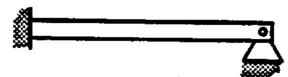
NPS = 20 in
D_o = 20.00 in
E = 28831000 lb/in^2

P/P_b = .75
λ = 3.92660231
μ = 489.535 lb/ft^3

t (in)	**0.688**	**0.750**	**0.812**	**0.875**	**0.938**	**1.000**	
D_i (in)	**18.624**	**18.500**	**18.376**	**18.250**	**18.124**	**18.000**	
W(lb/ft)	**141.90**	**154.19**	**166.40**	**178.72**	**190.96**	**202.92**	
L/D_o	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**L (ft)**
3.0	462	460	459	457	456	454	5.00
4.0	260	259	258	257	256	256	6.67
5.0	166	166	165	165	164	164	8.33
6.0	115	115	115	114	114	114	10.00
7.0	85	85	84	84	84	83	11.67
8.0	65	65	65	64	64	64	13.33
9.0	51	51	51	51	51	50	15.00
10.0	42	41	41	41	41	41	16.67
11.0	34	34	34	34	34	34	18.33
12.0	29	29	29	29	28	28	20.00
13.0	25	25	24	24	24	24	21.67
14.0	21	21	21	21	21	21	23.33
15.0	18	18	18	18	18	18	25.00
16.0	16	16	16	16	16	16	26.67
17.0	14	14	14	14	14	14	28.33
18.0	13	13	13	13	13	13	30.00

t (in)	**1.062**	**1.125**	**1.188**	**1.250**	**1.312**	**1.375**	
D_i (in)	**17.876**	**17.750**	**17.624**	**17.500**	**17.376**	**17.250**	
W(lb/ft)	**214.80**	**226.78**	**238.68**	**250.31**	**261.86**	**273.51**	
L/D_o	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**L (ft)**
3.0	453	452	450	449	447	446	5.00
4.0	255	254	253	252	252	251	6.67
5.0	163	163	162	162	161	161	8.33
6.0	113	113	113	112	112	112	10.00
7.0	83	83	83	82	82	82	11.67
8.0	64	64	63	63	63	63	13.33
9.0	50	50	50	50	50	50	15.00
10.0	41	41	41	40	40	40	16.67
11.0	34	34	33	33	33	33	18.33
12.0	28	28	28	28	28	28	20.00
13.0	24	24	24	24	24	24	21.67
14.0	21	21	21	21	21	20	23.33
15.0	18	18	18	18	18	18	25.00
16.0	16	16	16	16	16	16	26.67
17.0	14	14	14	14	14	14	28.33
18.0	13	13	13	12	12	12	30.00

Table D-2.2. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) WITH APPLIED AXIAL LOADS (Clamped-Pinned) (cont)



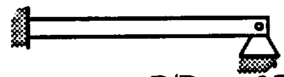
NPS = 22 in
D_o = 22.00 in
E = 28831000 lb/in^2

P/P_b = .25
λ = 3.92660231
μ = 489.535 lb/ft^3

t (in)	0.219	0.250	0.281	0.312	0.344	0.375	
D_i (in)	21.562	21.500	21.438	21.376	21.312	21.250	
W(lb/ft)	50.94	58.07	65.18	72.27	79.56	86.61	
L/D_o	f_n	f_n	f_n	f_n	f_n	f_n	L (ft)
3.0	745	744	743	742	740	739	5.50
4.0	419	418	418	417	417	416	7.33
5.0	268	268	267	267	267	266	9.17
6.0	186	186	186	185	185	185	11.00
7.0	137	137	136	136	136	136	12.83
8.0	105	105	104	104	104	104	14.67
9.0	83	83	83	82	82	82	16.50
10.0	67	67	67	67	67	67	18.33
11.0	55	55	55	55	55	55	20.17
12.0	47	46	46	46	46	46	22.00
13.0	40	40	40	39	39	39	23.83
14.0	34	34	34	34	34	34	25.67
15.0	30	30	30	30	30	30	27.50
16.0	26	26	26	26	26	26	29.33
17.0	23	23	23	23	23	23	31.17
18.0	21	21	21	21	21	21	33.00

t (in)	0.406	0.438	0.469	0.500	0.562	0.625	
D_i (in)	21.188	21.124	21.062	21.000	20.876	20.750	
W(lb/ft)	93.63	100.86	107.85	114.81	128.67	142.68	
L/D_o	f_n	f_n	f_n	f_n	f_n	f_n	L (ft)
3.0	738	737	736	735	733	731	5.50
4.0	415	415	414	414	412	411	7.33
5.0	266	265	265	265	264	263	9.17
6.0	185	184	184	184	183	183	11.00
7.0	136	135	135	135	135	134	12.83
8.0	104	104	104	103	103	103	14.67
9.0	82	82	82	82	81	81	16.50
10.0	66	66	66	66	66	66	18.33
11.0	55	55	55	55	55	54	20.17
12.0	46	46	46	46	46	46	22.00
13.0	39	39	39	39	39	39	23.83
14.0	34	34	34	34	34	34	25.67
15.0	30	29	29	29	29	29	27.50
16.0	26	26	26	26	26	26	29.33
17.0	23	23	23	23	23	23	31.17
18.0	21	20	20	20	20	20	33.00

Table D-2.2. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) WITH APPLIED AXIAL LOADS (Clamped-Pinned) (cont)



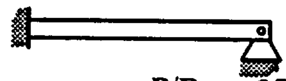
NPS = 22 in
D_o = 22.00 in
E = 28831000 lb/in^2

P/P_b = .25
λ = 3.92660231
μ = 489.535 lb/ft^3

t (in)	**0.688**	**0.750**	**0.812**	**0.875**	**0.938**	**1.000**	
D_i (in)	**20.624**	**20.500**	**20.376**	**20.250**	**20.124**	**20.000**	
W(lb/ft)	**156.60**	**170.21**	**183.75**	**197.41**	**211.00**	**224.28**	
L/D_o	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**L (ft)**
3.0	729	727	725	723	721	719	5.50
4.0	410	409	408	407	405	404	7.33
5.0	262	262	261	260	259	259	9.17
6.0	182	182	181	181	180	180	11.00
7.0	134	134	133	133	132	132	12.83
8.0	103	102	102	102	101	101	14.67
9.0	81	81	81	80	80	80	16.50
10.0	66	65	65	65	65	65	18.33
11.0	54	54	54	54	54	53	20.17
12.0	46	45	45	45	45	45	22.00
13.0	39	39	39	38	38	38	23.83
14.0	33	33	33	33	33	33	25.67
15.0	29	29	29	29	29	29	27.50
16.0	26	26	25	25	25	25	29.33
17.0	23	23	23	23	22	22	31.17
18.0	20	20	20	20	20	20	33.00

t (in)	**1.062**	**1.125**	**1.188**	**1.250**	**1.312**	**1.375**	
D_i (in)	**19.876**	**19.750**	**19.624**	**19.500**	**19.376**	**19.250**	
W(lb/ft)	**237.48**	**250.81**	**264.06**	**277.01**	**289.88**	**302.88**	
L/D_o	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**L (ft)**
3.0	717	715	713	711	709	707	5.50
4.0	403	402	401	400	399	398	7.33
5.0	258	257	257	256	255	254	9.17
6.0	179	179	178	178	177	177	11.00
7.0	132	131	131	131	130	130	12.83
8.0	101	101	100	100	100	99	14.67
9.0	80	79	79	79	79	79	16.50
10.0	65	64	64	64	64	64	18.33
11.0	53	53	53	53	53	53	20.17
12.0	45	45	45	44	44	44	22.00
13.0	38	38	38	38	38	38	23.83
14.0	33	33	33	33	33	32	25.67
15.0	29	29	29	28	28	28	27.50
16.0	25	25	25	25	25	25	29.33
17.0	22	22	22	22	22	22	31.17
18.0	20	20	20	20	20	20	33.00

Table D-2.2. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) WITH APPLIED AXIAL LOADS (Clamped-Pinned) (cont)

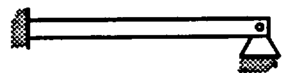


NPS = 22 in
D_o = 22.00 in
E = 28831000 lb/in^2

P/P_b = .25
λ = 3.92660231
μ = 489.535 lb/ft^3

t (in)	**1.438**	**1.500**	
D_i (in)	**19.124**	**19.000**	
W(lb/ft)	**315.79**	**328.41**	
L/D_o	**f_n**	**f_n**	**L (ft)**
3.0	705	703	5.50
4.0	396	395	7.33
5.0	254	253	9.17
6.0	176	176	11.00
7.0	129	129	12.83
8.0	99	99	14.67
9.0	78	78	16.50
10.0	63	63	18.33
11.0	52	52	20.17
12.0	44	44	22.00
13.0	38	37	23.83
14.0	32	32	25.67
15.0	28	28	27.50
16.0	25	25	29.33
17.0	22	22	31.17
18.0	20	20	33.00

Table D-2.2. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) WITH APPLIED AXIAL LOADS (Clamped-Pinned) (cont)



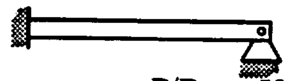
NPS = 22 in
D_o = 22.00 in
E = 28831000 lb/in^2

P/P_b = .50
λ = 3.92660231
μ = 489.535 lb/ft^3

t (in)	**0.219**	**0.250**	**0.281**	**0.312**	**0.344**	**0.375**	
D_i (in)	**21.562**	**21.500**	**21.438**	**21.376**	**21.312**	**21.250**	
W(lb/ft)	**50.94**	**58.07**	**65.18**	**72.27**	**79.56**	**86.61**	
L/D_o	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**L (ft)**
3.0	608	607	606	605	605	604	5.50
4.0	342	342	341	341	340	340	7.33
5.0	219	219	218	218	218	217	9.17
6.0	152	152	152	151	151	151	11.00
7.0	112	112	111	111	111	111	12.83
8.0	86	85	85	85	85	85	14.67
9.0	68	67	67	67	67	67	16.50
10.0	55	55	55	54	54	54	18.33
11.0	45	45	45	45	45	45	20.17
12.0	38	38	38	38	38	38	22.00
13.0	32	32	32	32	32	32	23.83
14.0	28	28	28	28	28	28	25.67
15.0	24	24	24	24	24	24	27.50
16.0	21	21	21	21	21	21	29.33
17.0	19	19	19	19	19	19	31.17
18.0	17	17	17	17	17	17	33.00

t (in)	**0.406**	**0.438**	**0.469**	**0.500**	**0.562**	**0.625**	
D_i (in)	**21.188**	**21.124**	**21.062**	**21.000**	**20.876**	**20.750**	
W(lb/ft)	**93.63**	**100.86**	**107.85**	**114.81**	**128.67**	**142.68**	
L/D_o	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**L (ft)**
3.0	603	602	601	600	599	597	5.50
4.0	339	339	338	338	337	336	7.33
5.0	217	217	216	216	216	215	9.17
6.0	151	151	150	150	150	149	11.00
7.0	111	111	110	110	110	110	12.83
8.0	85	85	85	84	84	84	14.67
9.0	67	67	67	67	67	66	16.50
10.0	54	54	54	54	54	54	18.33
11.0	45	45	45	45	45	44	20.17
12.0	38	38	38	38	37	37	22.00
13.0	32	32	32	32	32	32	23.83
14.0	28	28	28	28	27	27	25.67
15.0	24	24	24	24	24	24	27.50
16.0	21	21	21	21	21	21	29.33
17.0	19	19	19	19	19	19	31.17
18.0	17	17	17	17	17	17	33.00

Table D-2.2. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) WITH APPLIED AXIAL LOADS (Clamped-Pinned) (cont)



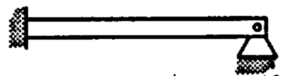
NPS = 22 in
D_o = 22.00 in
E = 28831000 lb/in^2

P/P_b = .50
λ = 3.92660231
μ = 489.535 lb/ft^3

t (in)	0.688	0.750	0.812	0.875	0.938	1.000	
D_i (in)	20.624	20.500	20.376	20.250	20.124	20.000	
W(lb/ft)	156.60	170.21	183.75	197.41	211.00	224.28	
L/D_o	f_n	f_n	f_n	f_n	f_n	f_n	L (ft)
3.0	595	594	592	590	589	587	5.50
4.0	335	334	333	332	331	330	7.33
5.0	214	214	213	212	212	211	9.17
6.0	149	148	148	148	147	147	11.00
7.0	109	109	109	108	108	108	12.83
8.0	84	83	83	83	83	83	14.67
9.0	66	66	66	66	65	65	16.50
10.0	54	53	53	53	53	53	18.33
11.0	44	44	44	44	44	44	20.17
12.0	37	37	37	37	37	37	22.00
13.0	32	32	32	31	31	31	23.83
14.0	27	27	27	27	27	27	25.67
15.0	24	24	24	24	24	23	27.50
16.0	21	21	21	21	21	21	29.33
17.0	19	18	18	18	18	18	31.17
18.0	17	16	16	16	16	16	33.00

t (in)	1.062	1.125	1.188	1.250	1.312	1.375	
D_i (in)	19.876	19.750	19.624	19.500	19.376	19.250	
W(lb/ft)	237.48	250.81	264.06	277.01	289.88	302.88	
L/D_o	f_n	f_n	f_n	f_n	f_n	f_n	L (ft)
3.0	585	584	582	580	579	577	5.50
4.0	329	328	327	326	326	325	7.33
5.0	211	210	209	209	208	208	9.17
6.0	146	146	145	145	145	144	11.00
7.0	107	107	107	107	106	106	12.83
8.0	82	82	82	82	81	81	14.67
9.0	65	65	65	64	64	64	16.50
10.0	53	53	52	52	52	52	18.33
11.0	44	43	43	43	43	43	20.17
12.0	37	36	36	36	36	36	22.00
13.0	31	31	31	31	31	31	23.83
14.0	27	27	27	27	27	26	25.67
15.0	23	23	23	23	23	23	27.50
16.0	21	21	20	20	20	20	29.33
17.0	18	18	18	18	18	18	31.17
18.0	16	16	16	16	16	16	33.00

Table D-2.2. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) WITH APPLIED AXIAL LOADS (Clamped-Pinned) (cont)

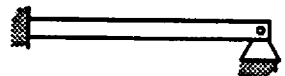


NPS = 22 in
D_o = 22.00 in
E = 28831000 lb/in^2

P/P_b = .50
λ = 3.92660231
μ = 489.535 lb/ft^3

t (in)	**1.438**	**1.500**	
D_i (in)	**19.124**	**19.000**	
W(lb/ft)	**315.79**	**328.41**	
L/D_o	**f_n**	**f_n**	**L (ft)**
3.0	575	574	5.50
4.0	324	323	7.33
5.0	207	207	9.17
6.0	144	143	11.00
7.0	106	105	12.83
8.0	81	81	14.67
9.0	64	64	16.50
10.0	52	52	18.33
11.0	43	43	20.17
12.0	36	36	22.00
13.0	31	31	23.83
14.0	26	26	25.67
15.0	23	23	27.50
16.0	20	20	29.33
17.0	18	18	31.17
18.0	16	16	33.00

Table D-2.2. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) WITH APPLIED AXIAL LOADS (Clamped-Pinned) (cont)



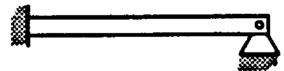
NPS = 22 in
D_o = 22.00 in
E = 28831000 lb/in^2

P/P_b = .75
λ = 3.92660231
μ = 489.535 lb/ft^3

t (in)	0.219	0.250	0.281	0.312	0.344	0.375	
D_i (in)	21.562	21.500	21.438	21.376	21.312	21.250	
W(lb/ft)	50.94	58.07	65.18	72.27	79.56	86.61	
L/D_o	f_n	f_n	f_n	f_n	f_n	f_n	L (ft)
3.0	430	429	429	428	428	427	5.50
4.0	242	242	241	241	240	240	7.33
5.0	155	155	154	154	154	154	9.17
6.0	107	107	107	107	107	107	11.00
7.0	79	79	79	79	79	78	12.83
8.0	60	60	60	60	60	60	14.67
9.0	48	48	48	48	48	47	16.50
10.0	39	39	39	39	38	38	18.33
11.0	32	32	32	32	32	32	20.17
12.0	27	27	27	27	27	27	22.00
13.0	23	23	23	23	23	23	23.83
14.0	20	20	20	20	20	20	25.67
15.0	17	17	17	17	17	17	27.50
16.0	15	15	15	15	15	15	29.33
17.0	13	13	13	13	13	13	31.17
18.0	12	12	12	12	12	12	33.00

t (in)	0.406	0.438	0.469	0.500	0.562	0.625	
D_i (in)	21.188	21.124	21.062	21.000	20.876	20.750	
W(lb/ft)	93.63	100.86	107.85	114.81	128.67	142.68	
L/D_o	f_n	f_n	f_n	f_n	f_n	f_n	L (ft)
3.0	426	426	425	425	423	422	5.50
4.0	240	239	239	239	238	237	7.33
5.0	153	153	153	153	152	152	9.17
6.0	107	106	106	106	106	106	11.00
7.0	78	78	78	78	78	78	12.83
8.0	60	60	60	60	60	59	14.67
9.0	47	47	47	47	47	47	16.50
10.0	38	38	38	38	38	38	18.33
11.0	32	32	32	32	31	31	20.17
12.0	27	27	27	27	26	26	22.00
13.0	23	23	23	23	23	22	23.83
14.0	20	20	20	19	19	19	25.67
15.0	17	17	17	17	17	17	27.50
16.0	15	15	15	15	15	15	29.33
17.0	13	13	13	13	13	13	31.17
18.0	12	12	12	12	12	12	33.00

Table D-2.2. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) WITH APPLIED AXIAL LOADS (Clamped-Pinned) (cont)



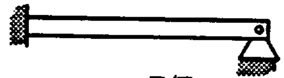
NPS = 22 in
D_o = 22.00 in
E = 28831000 lb/in^2

P/P_b = .75
λ = 3.92660231
μ = 489.535 lb/ft^3

t (in)	0.688	0.750	0.812	0.875	0.938	1.000	
D_i (in)	20.624	20.500	20.376	20.250	20.124	20.000	
W(lb/ft)	156.60	170.21	183.75	197.41	211.00	224.28	
L/D_o	f_n	f_n	f_n	f_n	f_n	f_n	L (ft)
3.0	421	420	419	417	416	415	5.50
4.0	237	236	235	235	234	233	7.33
5.0	152	151	151	150	150	149	9.17
6.0	105	105	105	104	104	104	11.00
7.0	77	77	77	77	76	76	12.83
8.0	59	59	59	59	59	58	14.67
9.0	47	47	47	46	46	46	16.50
10.0	38	38	38	38	37	37	18.33
11.0	31	31	31	31	31	31	20.17
12.0	26	26	26	26	26	26	22.00
13.0	22	22	22	22	22	22	23.83
14.0	19	19	19	19	19	19	25.67
15.0	17	17	17	17	17	17	27.50
16.0	15	15	15	15	15	15	29.33
17.0	13	13	13	13	13	13	31.17
18.0	12	12	12	12	12	12	33.00

t (in)	1.062	1.125	1.188	1.250	1.312	1.375	
D_i (in)	19.876	19.750	19.624	19.500	19.376	19.250	
W(lb/ft)	237.48	250.81	264.06	277.01	289.88	302.88	
L/D_o	f_n	f_n	f_n	f_n	f_n	f_n	L (ft)
3.0	414	413	411	410	409	408	5.50
4.0	233	232	231	231	230	230	7.33
5.0	149	149	148	148	147	147	9.17
6.0	103	103	103	103	102	102	11.00
7.0	76	76	76	75	75	75	12.83
8.0	58	58	58	58	58	57	14.67
9.0	46	46	46	46	45	45	16.50
10.0	37	37	37	37	37	37	18.33
11.0	31	31	31	31	30	30	20.17
12.0	26	26	26	26	26	26	22.00
13.0	22	22	22	22	22	22	23.83
14.0	19	19	19	19	19	19	25.67
15.0	17	17	16	16	16	16	27.50
16.0	15	15	14	14	14	14	29.33
17.0	13	13	13	13	13	13	31.17
18.0	11	11	11	11	11	11	33.00

Table D-2.2. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) WITH APPLIED AXIAL LOADS (Clamped-Pinned) (cont)

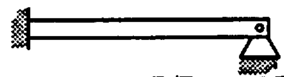


NPS = 22 in
D_o = 22.00 in
E = 28831000 lb/in^2

P/P_b = .75
λ = 3.92660231
μ = 489.535 lb/ft^3

t (in)	**1.438**	**1.500**	
D_i (in)	**19.124**	**19.000**	
W(lb/ft)	**315.79**	**328.41**	
L/D_o	**f_n**	**f_n**	**L (ft)**
3.0	407	406	5.50
4.0	229	228	7.33
5.0	146	146	9.17
6.0	102	101	11.00
7.0	75	75	12.83
8.0	57	57	14.67
9.0	45	45	16.50
10.0	37	37	18.33
11.0	30	30	20.17
12.0	25	25	22.00
13.0	22	22	23.83
14.0	19	19	25.67
15.0	16	16	27.50
16.0	14	14	29.33
17.0	13	13	31.17
18.0	11	11	33.00

Table D-2.2. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) WITH APPLIED AXIAL LOADS (Clamped-Pinned) (cont)



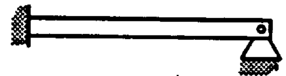
NPS = 24 in
D_o = 24.00 in
E = 28831000 lb/in^2

P/P_b = .25
λ = 3.92660231
μ = 489.535 lb/ft^3

t (in)	**0.250**	**0.281**	**0.312**	**0.344**	**0.375**	**0.406**	
D_i (in)	**23.500**	**23.438**	**23.376**	**23.312**	**23.250**	**23.188**	
W(lb/ft)	**63.41**	**71.18**	**78.93**	**86.91**	**94.62**	**102.31**	
L/D_o	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**L (ft)**
3.0	682	681	681	680	679	678	6.00
4.0	384	383	383	382	382	381	8.00
5.0	246	245	245	245	244	244	10.00
6.0	171	170	170	170	170	169	12.00
7.0	125	125	125	125	125	125	14.00
8.0	96	96	96	96	95	95	16.00
9.0	76	76	76	76	75	75	18.00
10.0	61	61	61	61	61	61	20.00
11.0	51	51	51	51	50	50	22.00
12.0	43	43	43	42	42	42	24.00
13.0	36	36	36	36	36	36	26.00
14.0	31	31	31	31	31	31	28.00
15.0	27	27	27	27	27	27	30.00
16.0	24	24	24	24	24	24	32.00
17.0	21	21	21	21	21	21	34.00
18.0	19	19	19	19	19	19	36.00

t (in)	**0.438**	**0.469**	**0.500**	**0.562**	**0.625**	**0.688**	
D_i (in)	**23.124**	**23.062**	**23.000**	**22.876**	**22.750**	**22.624**	
W(lb/ft)	**110.22**	**117.86**	**125.49**	**140.68**	**156.03**	**171.29**	
L/D_o	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**L (ft)**
3.0	677	676	675	674	672	670	6.00
4.0	381	380	380	379	378	377	8.00
5.0	244	243	243	242	242	241	10.00
6.0	169	169	169	168	168	168	12.00
7.0	124	124	124	124	123	123	14.00
8.0	95	95	95	95	94	94	16.00
9.0	75	75	75	75	75	74	18.00
10.0	61	61	61	61	60	60	20.00
11.0	50	50	50	50	50	50	22.00
12.0	42	42	42	42	42	42	24.00
13.0	36	36	36	36	36	36	26.00
14.0	31	31	31	31	31	31	28.00
15.0	27	27	27	27	27	27	30.00
16.0	24	24	24	24	24	24	32.00
17.0	21	21	21	21	21	21	34.00
18.0	19	19	19	19	19	19	36.00

Table D-2.2. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) WITH APPLIED AXIAL LOADS (Clamped-Pinned) (cont)



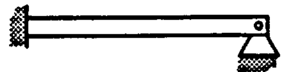
NPS = 24 in
D_o = 24.00 in
E = 28831000 lb/in^2

P/P_b = .25
λ = 3.92660231
μ = 489.535 lb/ft^3

t (in)	**0.750**	**0.812**	**0.875**	**0.938**	**1.000**	**1.062**	
D_i (in)	**22.500**	**22.376**	**22.250**	**22.124**	**22.000**	**21.876**	
W(lb/ft)	**186.23**	**201.09**	**216.10**	**231.03**	**245.64**	**260.17**	
L/D_o	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**L (ft)**
3.0	668	667	665	663	661	660	6.00
4.0	376	375	374	373	372	371	8.00
5.0	241	240	239	239	238	237	10.00
6.0	167	167	166	166	165	165	12.00
7.0	123	122	122	122	121	121	14.00
8.0	94	94	93	93	93	93	16.00
9.0	74	74	74	74	73	73	18.00
10.0	60	60	60	60	60	59	20.00
11.0	50	50	49	49	49	49	22.00
12.0	42	42	42	41	41	41	24.00
13.0	36	35	35	35	35	35	26.00
14.0	31	31	31	30	30	30	28.00
15.0	27	27	27	27	26	26	30.00
16.0	23	23	23	23	23	23	32.00
17.0	21	21	21	21	21	21	34.00
18.0	19	19	18	18	18	18	36.00

t (in)	**1.125**	**1.188**	**1.250**	**1.312**	**1.375**	**1.438**	
D_i (in)	**21.750**	**21.624**	**21.500**	**21.376**	**21.250**	**21.124**	
W(lb/ft)	**274.84**	**289.44**	**303.71**	**317.91**	**332.25**	**346.50**	
L/D_o	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**L (ft)**
3.0	658	656	655	653	651	649	6.00
4.0	370	369	368	367	366	365	8.00
5.0	237	236	236	235	234	234	10.00
6.0	164	164	164	163	163	162	12.00
7.0	121	121	120	120	120	119	14.00
8.0	93	92	92	92	92	91	16.00
9.0	73	73	73	73	72	72	18.00
10.0	59	59	59	59	59	58	20.00
11.0	49	49	49	49	48	48	22.00
12.0	41	41	41	41	41	41	24.00
13.0	35	35	35	35	35	35	26.00
14.0	30	30	30	30	30	30	28.00
15.0	26	26	26	26	26	26	30.00
16.0	23	23	23	23	23	23	32.00
17.0	20	20	20	20	20	20	34.00
18.0	18	18	18	18	18	18	36.00

Table D-2.2. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) WITH APPLIED AXIAL LOADS (Clamped-Pinned) (cont)

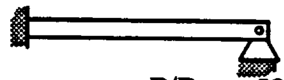


NPS = 24 in
D_o = 24.00 in
E = 28831000 lb/in²

P/P$_b$ = .25
λ = 3.92660231
μ = 489.535 lb/ft³

t (in)	**1.500**	**1.562**	
D_i (in)	**21.000**	**20.876**	
W(lb/ft)	**360.45**	**374.31**	
L/D_o	**f_n**	**f_n**	**L (ft)**
3.0	648	646	6.00
4.0	364	363	8.00
5.0	233	233	10.00
6.0	162	162	12.00
7.0	119	119	14.00
8.0	91	91	16.00
9.0	72	72	18.00
10.0	58	58	20.00
11.0	48	48	22.00
12.0	40	40	24.00
13.0	34	34	26.00
14.0	30	30	28.00
15.0	26	26	30.00
16.0	23	23	32.00
17.0	20	20	34.00
18.0	18	18	36.00

Table D-2.2. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) WITH APPLIED AXIAL LOADS (Clamped-Pinned) (cont)



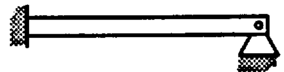
NPS = 24 in
D_o = 24.00 in
E = 28831000 lb/in²

P/P_b = .50
λ = 3.92660231
μ = 489.535 lb/ft³

t (in)	0.250	0.281	0.312	0.344	0.375	0.406	
D_i (in)	23.500	23.438	23.376	23.312	23.250	23.188	
W(lb/ft)	63.41	71.18	78.93	86.91	94.62	102.31	
L/D_o	f_n	f_n	f_n	f_n	f_n	f_n	L (ft)
3.0	557	556	556	555	554	554	6.00
4.0	313	313	313	312	312	311	8.00
5.0	201	200	200	200	200	199	10.00
6.0	139	139	139	139	139	138	12.00
7.0	102	102	102	102	102	102	14.00
8.0	78	78	78	78	78	78	16.00
9.0	62	62	62	62	62	62	18.00
10.0	50	50	50	50	50	50	20.00
11.0	41	41	41	41	41	41	22.00
12.0	35	35	35	35	35	35	24.00
13.0	30	30	30	30	30	29	26.00
14.0	26	26	26	25	25	25	28.00
15.0	22	22	22	22	22	22	30.00
16.0	20	20	20	20	19	19	32.00
17.0	17	17	17	17	17	17	34.00
18.0	15	15	15	15	15	15	36.00

t (in)	0.438	0.469	0.500	0.562	0.625	0.688	
D_i (in)	23.124	23.062	23.000	22.876	22.750	22.624	
W(lb/ft)	110.22	117.86	125.49	140.68	156.03	171.29	
L/D_o	f_n	f_n	f_n	f_n	f_n	f_n	L (ft)
3.0	553	552	551	550	548	547	6.00
4.0	311	311	310	309	309	308	8.00
5.0	199	199	198	198	197	197	10.00
6.0	138	138	138	137	137	137	12.00
7.0	102	101	101	101	101	100	14.00
8.0	78	78	78	77	77	77	16.00
9.0	61	61	61	61	61	61	18.00
10.0	50	50	50	49	49	49	20.00
11.0	41	41	41	41	41	41	22.00
12.0	35	35	34	34	34	34	24.00
13.0	29	29	29	29	29	29	26.00
14.0	25	25	25	25	25	25	28.00
15.0	22	22	22	22	22	22	30.00
16.0	19	19	19	19	19	19	32.00
17.0	17	17	17	17	17	17	34.00
18.0	15	15	15	15	15	15	36.00

Table D-2.2. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) WITH APPLIED AXIAL LOADS (Clamped-Pinned) (cont)



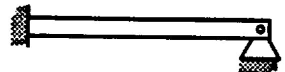
NPS = 24 in
D_o = 24.00 in
E = 28831000 lb/in^2

P/P_b = .50
λ = 3.92660231
μ = 489.535 lb/ft^3

t (in)	0.750	0.812	0.875	0.938	1.000	1.062	
D_i (in)	22.500	22.376	22.250	22.124	22.000	21.876	
W(lb/ft)	186.23	201.09	216.10	231.03	245.64	260.17	
L/D_o	f_n	f_n	f_n	f_n	f_n	f_n	L (ft)
3.0	546	544	543	541	540	539	6.00
4.0	307	306	305	305	304	303	8.00
5.0	196	196	195	195	194	194	10.00
6.0	136	136	136	135	135	135	12.00
7.0	100	100	100	99	99	99	14.00
8.0	77	77	76	76	76	76	16.00
9.0	61	60	60	60	60	60	18.00
10.0	49	49	49	49	49	48	20.00
11.0	41	40	40	40	40	40	22.00
12.0	34	34	34	34	34	34	24.00
13.0	29	29	29	29	29	29	26.00
14.0	25	25	25	25	25	25	28.00
15.0	22	22	22	22	22	22	30.00
16.0	19	19	19	19	19	19	32.00
17.0	17	17	17	17	17	17	34.00
18.0	15	15	15	15	15	15	36.00

t (in)	1.125	1.188	1.250	1.312	1.375	1.438	
D_i (in)	21.750	21.624	21.500	21.376	21.250	21.124	
W(lb/ft)	274.84	289.44	303.71	317.91	332.25	346.50	
L/D_o	f_n	f_n	f_n	f_n	f_n	f_n	L (ft)
3.0	537	536	534	533	532	530	6.00
4.0	302	301	301	300	299	298	8.00
5.0	193	193	192	192	191	191	10.00
6.0	134	134	134	133	133	133	12.00
7.0	99	98	98	98	98	97	14.00
8.0	76	75	75	75	75	75	16.00
9.0	60	60	59	59	59	59	18.00
10.0	48	48	48	48	48	48	20.00
11.0	40	40	40	40	40	39	22.00
12.0	34	33	33	33	33	33	24.00
13.0	29	29	28	28	28	28	26.00
14.0	25	25	25	24	24	24	28.00
15.0	21	21	21	21	21	21	30.00
16.0	19	19	19	19	19	19	32.00
17.0	17	17	17	17	17	17	34.00
18.0	15	15	15	15	15	15	36.00

Table D-2.2. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) WITH APPLIED AXIAL LOADS (Clamped-Pinned) (cont)

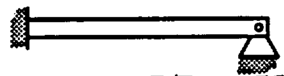


NPS = 24 in
D_o = 24.00 in
E = 28831000 lb/in²

P/P_b = .50
λ = 3.92660231
μ = 489.535 lb/ft³

t (in)	1.500	1.562	
D_i (in)	21.000	20.876	
W(lb/ft)	360.45	374.31	
L/D_o	f_n	f_n	L (ft)
3.0	529	528	6.00
4.0	298	297	8.00
5.0	190	190	10.00
6.0	132	132	12.00
7.0	97	97	14.00
8.0	74	74	16.00
9.0	59	59	18.00
10.0	48	47	20.00
11.0	39	39	22.00
12.0	33	33	24.00
13.0	28	28	26.00
14.0	24	24	28.00
15.0	21	21	30.00
16.0	19	19	32.00
17.0	16	16	34.00
18.0	15	15	36.00

Table D-2.2. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) WITH APPLIED AXIAL LOADS (Clamped-Pinned) (cont)



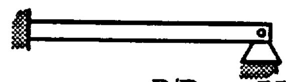
NPS = 24 in
D_o = 24.00 in
E = 28831000 lb/in^2

P/P_b = .75
λ = 3.92660231
μ = 489.535 lb/ft^3

t (in)	**0.250**	**0.281**	**0.312**	**0.344**	**0.375**	**0.406**	
D_i (in)	**23.500**	**23.438**	**23.376**	**23.312**	**23.250**	**23.188**	
W(lb/ft)	**63.41**	**71.18**	**78.93**	**86.91**	**94.62**	**102.31**	
L/D_o	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**L (ft)**
3.0	394	393	393	392	392	391	6.00
4.0	222	221	221	221	220	220	8.00
5.0	142	142	141	141	141	141	10.00
6.0	98	98	98	98	98	98	12.00
7.0	72	72	72	72	72	72	14.00
8.0	55	55	55	55	55	55	16.00
9.0	44	44	44	44	44	43	18.00
10.0	35	35	35	35	35	35	20.00
11.0	29	29	29	29	29	29	22.00
12.0	25	25	25	25	24	24	24.00
13.0	21	21	21	21	21	21	26.00
14.0	18	18	18	18	18	18	28.00
15.0	16	16	16	16	16	16	30.00
16.0	14	14	14	14	14	14	32.00
17.0	12	12	12	12	12	12	34.00
18.0	11	11	11	11	11	11	36.00

t (in)	**0.438**	**0.469**	**0.500**	**0.562**	**0.625**	**0.688**	
D_i (in)	**23.124**	**23.062**	**23.000**	**22.876**	**22.750**	**22.624**	
W(lb/ft)	**110.22**	**117.86**	**125.49**	**140.68**	**156.03**	**171.29**	
L/D_o	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**L (ft)**
3.0	391	390	390	389	388	387	6.00
4.0	220	220	219	219	218	218	8.00
5.0	141	141	140	140	140	139	10.00
6.0	98	98	97	97	97	97	12.00
7.0	72	72	72	71	71	71	14.00
8.0	55	55	55	55	55	54	16.00
9.0	43	43	43	43	43	43	18.00
10.0	35	35	35	35	35	35	20.00
11.0	29	29	29	29	29	29	22.00
12.0	24	24	24	24	24	24	24.00
13.0	21	21	21	21	21	21	26.00
14.0	18	18	18	18	18	18	28.00
15.0	16	16	16	16	16	15	30.00
16.0	14	14	14	14	14	14	32.00
17.0	12	12	12	12	12	12	34.00
18.0	11	11	11	11	11	11	36.00

Table D-2.2. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) WITH APPLIED AXIAL LOADS (Clamped-Pinned) (cont)



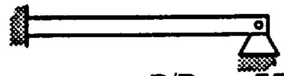
NPS = 24 in
D_o = 24.00 in
E = 28831000 lb/in^2

P/P_b = .75
λ = 3.92660231
μ = 489.535 lb/ft^3

t (in)	0.750	0.812	0.875	0.938	1.000	1.062	
D_i (in)	22.500	22.376	22.250	22.124	22.000	21.876	
W(lb/ft)	186.23	201.09	216.10	231.03	245.64	260.17	
L/D_o	f_n	f_n	f_n	f_n	f_n	f_n	L (ft)
3.0	386	385	384	383	382	381	6.00
4.0	217	216	216	215	215	214	8.00
5.0	139	139	138	138	137	137	10.00
6.0	96	96	96	96	95	95	12.00
7.0	71	71	71	70	70	70	14.00
8.0	54	54	54	54	54	54	16.00
9.0	43	43	43	43	42	42	18.00
10.0	35	35	35	34	34	34	20.00
11.0	29	29	29	28	28	28	22.00
12.0	24	24	24	24	24	24	24.00
13.0	21	20	20	20	20	20	26.00
14.0	18	18	18	18	18	17	28.00
15.0	15	15	15	15	15	15	30.00
16.0	14	14	13	13	13	13	32.00
17.0	12	12	12	12	12	12	34.00
18.0	11	11	11	11	11	11	36.00

t (in)	1.125	1.188	1.250	1.312	1.375	1.438	
D_i (in)	21.750	21.624	21.500	21.376	21.250	21.124	
W(lb/ft)	274.84	289.44	303.71	317.91	332.25	346.50	
L/D_o	f_n	f_n	f_n	f_n	f_n	f_n	L (ft)
3.0	380	379	378	377	376	375	6.00
4.0	214	213	213	212	211	211	8.00
5.0	137	136	136	136	135	135	10.00
6.0	95	95	94	94	94	94	12.00
7.0	70	70	69	69	69	69	14.00
8.0	53	53	53	53	53	53	16.00
9.0	42	42	42	42	42	42	18.00
10.0	34	34	34	34	34	34	20.00
11.0	28	28	28	28	28	28	22.00
12.0	24	24	24	24	23	23	24.00
13.0	20	20	20	20	20	20	26.00
14.0	17	17	17	17	17	17	28.00
15.0	15	15	15	15	15	15	30.00
16.0	13	13	13	13	13	13	32.00
17.0	12	12	12	12	12	12	34.00
18.0	11	11	10	10	10	10	36.00

Table D-2.2. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) WITH APPLIED AXIAL LOADS (Clamped-Pinned) (cont)

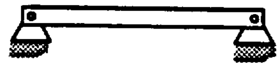


NPS = 24 in
D_o = 24.00 in
E = 28831000 lb/in^2

P/P_b = .75
λ = 3.92660231
μ = 489.535 lb/ft^3

t (in)	**1.500**	**1.562**	
D_i (in)	**21.000**	**20.876**	
W(lb/ft)	**360.45**	**374.31**	
L/D_o	**f_n**	**f_n**	**L (ft)**
3.0	374	373	6.00
4.0	210	210	8.00
5.0	135	134	10.00
6.0	94	93	12.00
7.0	69	69	14.00
8.0	53	52	16.00
9.0	42	41	18.00
10.0	34	34	20.00
11.0	28	28	22.00
12.0	23	23	24.00
13.0	20	20	26.00
14.0	17	17	28.00
15.0	15	15	30.00
16.0	13	13	32.00
17.0	12	12	34.00
18.0	10	10	36.00

Table D-2.3. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) WITH APPLIED AXIAL LOADS (Pinned-Pinned)



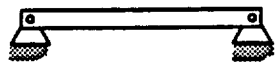
NPS = 4 in
D_o = 4.5 in
E = 28831000 lb/in²

P/P_b = .25
λ = 3.1415926
μ = 489.535 lb/ft³

t (in)	0.125	0.156	0.188	0.219	0.237	0.250	
D_i (in)	4.250	4.188	4.124	4.062	4.026	4.000	
W(lb/ft)	5.84	7.24	8.66	10.01	10.79	11.35	
L/D_o	f_n	f_n	f_n	f_n	f_n	f_n	L (ft)
5.0	824	819	813	807	804	802	1.88
6.0	572	568	564	561	558	557	2.25
7.0	421	418	415	412	410	409	2.63
8.0	322	320	317	315	314	313	3.00
9.0	254	253	251	249	248	247	3.38
10.0	206	205	203	202	201	200	3.75
11.0	170	169	168	167	166	166	4.13
12.0	143	142	141	140	140	139	4.50
13.0	122	121	120	119	119	119	4.88
14.0	105	104	104	103	103	102	5.25
15.0	92	91	90	90	89	89	5.63
16.0	80	80	79	79	79	78	6.00
17.0	71	71	70	70	70	69	6.38
18.0	64	63	63	62	62	62	6.75
19.0	57	57	56	56	56	56	7.13
20.0	52	51	51	50	50	50	7.50

t (in)	0.281	0.312	0.337	0.438	0.531	0.674	
D_i (in)	3.938	3.876	3.826	3.624	3.438	3.152	
W(lb/ft)	12.66	13.96	14.98	19.00	22.51	27.54	
L/D_o	f_n	f_n	f_n	f_n	f_n	f_n	L (ft)
5.0	796	791	787	769	754	732	1.88
6.0	553	549	546	534	524	508	2.25
7.0	406	403	401	393	385	373	2.63
8.0	311	309	307	301	295	286	3.00
9.0	246	244	243	237	233	226	3.38
10.0	199	198	197	192	189	183	3.75
11.0	165	163	163	159	156	151	4.13
12.0	138	137	137	134	131	127	4.50
13.0	118	117	116	114	112	108	4.88
14.0	102	101	100	98	96	93	5.25
15.0	88	88	87	85	84	81	5.63
16.0	78	77	77	75	74	71	6.00
17.0	69	68	68	67	65	63	6.38
18.0	61	61	61	59	58	56	6.75
19.0	55	55	54	53	52	51	7.13
20.0	50	49	49	48	47	46	7.50

Table D-2.3. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) WITH APPLIED AXIAL LOADS (Pinned-Pinned) (cont)



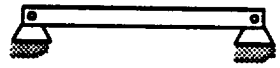
NPS = 4 in
D_o = 4.5 in
E = 28831000 lb/in^2

P/P_b = .50
λ = 3.1415926
μ = 489.535 lb/ft^3

t (in)	0.125	0.156	0.188	0.219	0.237	0.250	
D_i (in)	4.250	4.188	4.124	4.062	4.026	4.000	
W(lb/ft)	5.84	7.24	8.66	10.01	10.79	11.35	
L/D_o	f_n	f_n	f_n	f_n	f_n	f_n	L (ft)
4.0	1051	1044	1037	1030	1026	1023	1.50
5.0	673	668	664	659	656	655	1.88
6.0	467	464	461	458	456	455	2.25
7.0	343	341	339	336	335	334	2.63
8.0	263	261	259	257	256	256	3.00
9.0	208	206	205	203	203	202	3.38
10.0	168	167	166	165	164	164	3.75
11.0	139	138	137	136	136	135	4.13
12.0	117	116	115	114	114	114	4.50
13.0	100	99	98	97	97	97	4.88
14.0	86	85	85	84	84	83	5.25
15.0	75	74	74	73	73	73	5.63
16.0	66	65	65	64	64	64	6.00
17.0	58	58	57	57	57	57	6.38
18.0	52	52	51	51	51	51	6.75
19.0	47	46	46	46	45	45	7.13

t (in)	0.281	0.312	0.337	0.438	0.531	0.674	
D_i (in)	3.938	3.876	3.826	3.624	3.438	3.152	
W(lb/ft)	12.66	13.96	14.98	19.00	22.51	27.54	
L/D_o	f_n	f_n	f_n	f_n	f_n	f_n	L (ft)
4.0	1016	1009	1003	982	962	933	1.50
5.0	650	646	642	628	616	597	1.88
6.0	451	448	446	436	428	415	2.25
7.0	332	329	328	320	314	305	2.63
8.0	254	252	251	245	241	233	3.00
9.0	201	199	198	194	190	184	3.38
10.0	163	161	161	157	154	149	3.75
11.0	134	133	133	130	127	123	4.13
12.0	113	112	111	109	107	104	4.50
13.0	96	96	95	93	91	88	4.88
14.0	83	82	82	80	79	76	5.25
15.0	72	72	71	70	68	66	5.63
16.0	63	63	63	61	60	58	6.00
17.0	56	56	56	54	53	52	6.38
18.0	50	50	50	48	48	46	6.75
19.0	45	45	44	44	43	41	7.13

Table D-2.3. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) WITH APPLIED AXIAL LOADS (Pinned-Pinned) (cont)



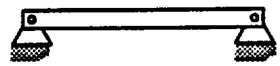
NPS = 4 in
D_o = 4.5 in
E = 28831000 lb/in^2

P/P_b = .75
λ = 3.1415926
μ = 489.535 lb/ft^3

t (in)	**0.125**	**0.156**	**0.188**	**0.219**	**0.237**	**0.250**	
D_i (in)	**4.250**	**4.188**	**4.124**	**4.062**	**4.026**	**4.000**	
W(lb/ft)	**5.84**	**7.24**	**8.66**	**10.01**	**10.79**	**11.35**	
L/D_o	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**L (ft)**
3.0	1322	1313	1303	1295	1289	1286	1.13
4.0	744	738	733	728	725	723	1.50
5.0	476	473	469	466	464	463	1.88
6.0	330	328	326	324	322	321	2.25
7.0	243	241	239	238	237	236	2.63
8.0	186	185	183	182	181	181	3.00
9.0	147	146	145	144	143	143	3.38
10.0	119	118	117	117	116	116	3.75
11.0	98	98	97	96	96	96	4.13
12.0	83	82	81	81	81	80	4.50
13.0	70	70	69	69	69	68	4.88
14.0	61	60	60	59	59	59	5.25
15.0	53	53	52	52	52	51	5.63
16.0	46	46	46	46	45	45	6.00
17.0	41	41	41	40	40	40	6.38
18.0	37	36	36	36	36	36	6.75

t (in)	**0.281**	**0.312**	**0.337**	**0.438**	**0.531**	**0.674**	
D_i (in)	**3.938**	**3.876**	**3.826**	**3.624**	**3.438**	**3.152**	
W(lb/ft)	**12.66**	**13.96**	**14.98**	**19.00**	**22.51**	**27.54**	
L/D_o	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**L (ft)**
3.0	1277	1268	1261	1234	1209	1173	1.13
4.0	718	713	710	694	680	660	1.50
5.0	460	457	454	444	435	422	1.88
6.0	319	317	315	308	302	293	2.25
7.0	235	233	232	227	222	215	2.63
8.0	180	178	177	174	170	165	3.00
9.0	142	141	140	137	134	130	3.38
10.0	115	114	114	111	109	106	3.75
11.0	95	94	94	92	90	87	4.13
12.0	80	79	79	77	76	73	4.50
13.0	68	68	67	66	64	62	4.88
14.0	59	58	58	57	56	54	5.25
15.0	51	51	50	49	48	47	5.63
16.0	45	45	44	43	43	41	6.00
17.0	40	39	39	38	38	37	6.38
18.0	35	35	35	34	34	33	6.75

Table D-2.3. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) WITH APPLIED AXIAL LOADS (Pinned-Pinned) (cont)



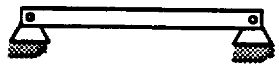
NPS = 5 in
D_o = 5.563 in
E = 28831000 lb/in^2

P/P_b = .25
λ = 3.1415926
μ = 489.535 lb/ft^3

t (in)	0.156	0.188	0.219	0.258	0.281	0.312	
D_i (in)	5.251	5.187	5.125	5.047	5.001	4.939	
W(lb/ft)	9.01	10.79	12.50	14.62	15.85	17.50	
L/D_o	f_n	f_n	f_n	f_n	f_n	f_n	L (ft)
5.0	667	663	659	654	652	648	2.32
6.0	463	460	458	454	453	450	2.78
7.0	340	338	336	334	333	331	3.25
8.0	260	259	257	256	255	253	3.71
9.0	206	205	203	202	201	200	4.17
10.0	167	166	165	164	163	162	4.64
11.0	138	137	136	135	135	134	5.10
12.0	116	115	114	114	113	113	5.56
13.0	99	98	97	97	96	96	6.03
14.0	85	85	84	83	83	83	6.49
15.0	74	74	73	73	72	72	6.95
16.0	65	65	64	64	64	63	7.42
17.0	58	57	57	57	56	56	7.88
18.0	51	51	51	50	50	50	8.34
19.0	46	46	46	45	45	45	8.81
20.0	42	41	41	41	41	41	9.27

t (in)	0.344	0.375	0.500	0.625	0.750	
D_i (in)	4.875	4.813	4.563	4.313	4.063	
W(lb/ft)	19.17	20.78	27.04	32.96	38.55	
L/D_o	f_n	f_n	f_n	f_n	f_n	L (ft)
5.0	644	641	627	613	600	2.32
6.0	448	445	435	426	417	2.78
7.0	329	327	320	313	306	3.25
8.0	252	250	245	240	234	3.71
9.0	199	198	193	189	185	4.17
10.0	161	160	157	153	150	4.64
11.0	133	132	130	127	124	5.10
12.0	112	111	109	106	104	5.56
13.0	95	95	93	91	89	6.03
14.0	82	82	80	78	77	6.49
15.0	72	71	70	68	67	6.95
16.0	63	63	61	60	59	7.42
17.0	56	55	54	53	52	7.88
18.0	50	49	48	47	46	8.34
19.0	45	44	43	42	42	8.81
20.0	40	40	39	38	38	9.27

Table D-2.3. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) WITH APPLIED AXIAL LOADS (Pinned-Pinned) (cont)



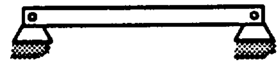
NPS = 5 in
D_o = 5.563 in
E = 28831000 lb/in²

P/P_b = .50
λ = 3.1415926
μ = 489.535 lb/ft³

t (in)	0.156	0.188	0.219	0.258	0.281	0.312	
D_i (in)	5.251	5.187	5.125	5.047	5.001	4.939	
W(lb/ft)	9.01	10.79	12.50	14.62	15.85	17.50	
L/D_o	f_n	f_n	f_n	f_n	f_n	f_n	L (ft)
4.0	850	845	841	835	832	827	1.85
5.0	544	541	538	534	532	529	2.32
6.0	378	376	374	371	370	368	2.78
7.0	278	276	275	273	272	270	3.25
8.0	213	211	210	209	208	207	3.71
9.0	168	167	166	165	164	163	4.17
10.0	136	135	135	134	133	132	4.64
11.0	112	112	111	110	110	109	5.10
12.0	94	94	93	93	92	92	5.56
13.0	81	80	80	79	79	78	6.03
14.0	69	69	69	68	68	68	6.49
15.0	60	60	60	59	59	59	6.95
16.0	53	53	53	52	52	52	7.42
17.0	47	47	47	46	46	46	7.88
18.0	42	42	42	41	41	41	8.34
19.0	38	37	37	37	37	37	8.81

t (in)	0.344	0.375	0.500	0.625	0.750	
D_i (in)	4.875	4.813	4.563	4.313	4.063	
W(lb/ft)	19.17	20.78	27.04	32.96	38.55	
L/D_o	f_n	f_n	f_n	f_n	f_n	L (ft)
4.0	822	818	800	782	766	1.85
5.0	526	523	512	501	490	2.32
6.0	365	363	355	348	340	2.78
7.0	268	267	261	255	250	3.25
8.0	206	204	200	196	191	3.71
9.0	162	162	158	155	151	4.17
10.0	132	131	128	125	123	4.64
11.0	109	108	106	103	101	5.10
12.0	91	91	89	87	85	5.56
13.0	78	77	76	74	72	6.03
14.0	67	67	65	64	63	6.49
15.0	58	58	57	56	54	6.95
16.0	51	51	50	49	48	7.42
17.0	46	45	44	43	42	7.88
18.0	41	40	39	39	38	8.34
19.0	36	36	35	35	34	8.81

Table D-2.3. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) WITH APPLIED AXIAL LOADS (Pinned-Pinned) (cont)



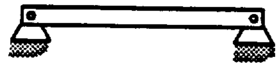
NPS = 5 in
D_o = 5.563 in
E = 28831000 lb/in^2

P/P_b = .75
λ = 3.1415926
μ = 489.535 lb/ft^3

t (in)	0.156	0.188	0.219	0.258	0.281	0.312	
D_i (in)	5.251	5.187	5.125	5.047	5.001	4.939	
W(lb/ft)	9.01	10.79	12.50	14.62	15.85	17.50	
L/D_o	f_n	f_n	f_n	f_n	f_n	f_n	L (ft)
3.0	1069	1063	1057	1050	1045	1040	1.39
4.0	601	598	595	590	588	585	1.85
5.0	385	383	381	378	376	374	2.32
6.0	267	266	264	262	261	260	2.78
7.0	196	195	194	193	192	191	3.25
8.0	150	149	149	148	147	146	3.71
9.0	119	118	117	117	116	116	4.17
10.0	96	96	95	94	94	94	4.64
11.0	80	79	79	78	78	77	5.10
12.0	67	66	66	66	65	65	5.56
13.0	57	57	56	56	56	55	6.03
14.0	49	49	49	48	48	48	6.49
15.0	43	43	42	42	42	42	6.95
16.0	38	37	37	37	37	37	7.42
17.0	33	33	33	33	33	32	7.88
18.0	30	30	29	29	29	29	8.34

t (in)	0.344	0.375	0.500	0.625	0.750	
D_i (in)	4.875	4.813	4.563	4.313	4.063	
W(lb/ft)	19.17	20.78	27.04	32.96	38.55	
L/D_o	f_n	f_n	f_n	f_n	f_n	L (ft)
3.0	1034	1028	1005	984	963	1.39
4.0	581	578	566	553	541	1.85
5.0	372	370	362	354	347	2.32
6.0	258	257	251	246	241	2.78
7.0	190	189	185	181	177	3.25
8.0	145	145	141	138	135	3.71
9.0	115	114	112	109	107	4.17
10.0	93	93	90	89	87	4.64
11.0	77	76	75	73	72	5.10
12.0	65	64	63	61	60	5.56
13.0	55	55	54	52	51	6.03
14.0	47	47	46	45	44	6.49
15.0	41	41	40	39	39	6.95
16.0	36	36	35	35	34	7.42
17.0	32	32	31	31	30	7.88
18.0	29	29	28	27	27	8.34

Table D-2.3. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) WITH APPLIED AXIAL LOADS (Pinned-Pinned) (cont)



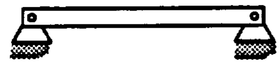
NPS = 6 in
D_o = 6.625 in
E = 28831000 lb/in^2

P/P_b = .25
λ = 3.1415926
μ = 489.535 lb/ft^3

t (in)	0.188	0.219	0.250	0.280	0.312	0.344	
D_i (in)	6.249	6.187	6.125	6.065	6.001	5.937	
W(lb/ft)	12.92	14.98	17.02	18.97	21.04	23.08	
L/D_o	f_n	f_n	f_n	f_n	f_n	f_n	L (ft)
4.0	874	870	866	862	858	854	2.21
5.0	559	557	554	552	549	547	2.76
6.0	389	387	385	383	381	380	3.31
7.0	285	284	283	282	280	279	3.86
8.0	219	218	217	216	215	213	4.42
9.0	173	172	171	170	169	169	4.97
10.0	140	139	139	138	137	137	5.52
11.0	116	115	115	114	113	113	6.07
12.0	97	97	96	96	95	95	6.63
13.0	83	82	82	82	81	81	7.18
14.0	71	71	71	70	70	70	7.73
15.0	62	62	62	61	61	61	8.28
16.0	55	54	54	54	54	53	8.83
17.0	48	48	48	48	48	47	9.39
18.0	43	43	43	43	42	42	9.94
19.0	39	39	38	38	38	38	10.49

t (in)	0.375	0.432	0.562	0.719	0.864	
D_i (in)	5.875	5.761	5.501	5.187	4.897	
W(lb/ft)	25.03	28.57	36.39	45.35	53.16	
L/D_o	f_n	f_n	f_n	f_n	f_n	L (ft)
4.0	850	843	827	808	791	2.21
5.0	544	539	529	517	506	2.76
6.0	378	375	367	359	351	3.31
7.0	278	275	270	264	258	3.86
8.0	212	211	207	202	198	4.42
9.0	168	166	163	160	156	4.97
10.0	136	135	132	129	127	5.52
11.0	112	111	109	107	105	6.07
12.0	94	94	92	90	88	6.63
13.0	80	80	78	76	75	7.18
14.0	69	69	67	66	65	7.73
15.0	60	60	59	57	56	8.28
16.0	53	53	52	50	49	8.83
17.0	47	47	46	45	44	9.39
18.0	42	42	41	40	39	9.94
19.0	38	37	37	36	35	10.49

Table D-2.3. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) WITH APPLIED AXIAL LOADS (Pinned-Pinned) (cont)



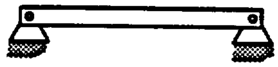
NPS = 6 in
D_o = 6.625 in
E = 28831000 lb/in^2

P/P_b = .50
λ = 3.1415926
μ = 489.535 lb/ft^3

t (in)	0.188	0.219	0.250	0.280	0.312	0.344	
D_i (in)	6.249	6.187	6.125	6.065	6.001	5.937	
W(lb/ft)	12.92	14.98	17.02	18.97	21.04	23.08	
L/D_o	f_n	f_n	f_n	f_n	f_n	f_n	L (ft)
3.0	897	893	889	885	881	876	1.66
4.0	505	502	500	498	495	493	2.21
5.0	323	322	320	319	317	316	2.76
6.0	224	223	222	221	220	219	3.31
7.0	165	164	163	163	162	161	3.86
8.0	126	126	125	124	124	123	4.42
9.0	100	99	99	98	98	97	4.97
10.0	81	80	80	80	79	79	5.52
11.0	67	66	66	66	66	65	6.07
12.0	56	56	56	55	55	55	6.63
13.0	48	48	47	47	47	47	7.18
14.0	41	41	41	41	40	40	7.73
15.0	36	36	36	35	35	35	8.28
16.0	32	31	31	31	31	31	8.83
17.0	28	28	28	28	27	27	9.39
18.0	25	25	25	25	24	24	9.94

t (in)	0.375	0.432	0.562	0.719	0.864	
D_i (in)	5.875	5.761	5.501	5.187	4.897	
W(lb/ft)	25.03	28.57	36.39	45.35	53.16	
L/D_o	f_n	f_n	f_n	f_n	f_n	L (ft)
3.0	872	865	848	829	812	1.66
4.0	491	487	477	466	457	2.21
5.0	314	311	305	298	292	2.76
6.0	218	216	212	207	203	3.31
7.0	160	159	156	152	149	3.86
8.0	123	122	119	117	114	4.42
9.0	97	96	94	92	90	4.97
10.0	79	78	76	75	73	5.52
11.0	65	64	63	62	60	6.07
12.0	55	54	53	52	51	6.63
13.0	46	46	45	44	43	7.18
14.0	40	40	39	38	37	7.73
15.0	35	35	34	33	32	8.28
16.0	31	30	30	29	29	8.83
17.0	27	27	26	26	25	9.39
18.0	24	24	24	23	23	9.94

Table D-2.3. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) WITH APPLIED AXIAL LOADS (Pinned-Pinned) (cont)



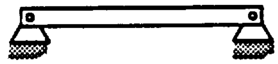
NPS = 6 in
D_o = 6.625 in
E = 28831000 lb/in^2

P/P_b = .75
λ = 3.1415926
μ = 489.535 lb/ft^3

t (in)	0.188	0.219	0.250	0.280	0.312	0.344	
D_i (in)	6.249	6.187	6.125	6.065	6.001	5.937	
W(lb/ft)	12.92	14.98	17.02	18.97	21.04	23.08	
L/D_o	f_n	f_n	f_n	f_n	f_n	f_n	L (ft)
5.0	323	322	320	319	317	316	2.76
6.0	224	223	222	221	220	219	3.31
7.0	165	164	163	163	162	161	3.86
8.0	126	126	125	124	124	123	4.42
9.0	100	99	99	98	98	97	4.97
10.0	81	80	80	80	79	79	5.52
11.0	67	66	66	66	66	65	6.07
12.0	56	56	56	55	55	55	6.63
13.0	48	48	47	47	47	47	7.18
14.0	41	41	41	41	40	40	7.73
15.0	36	36	36	35	35	35	8.28
16.0	32	31	31	31	31	31	8.83
17.0	28	28	28	28	27	27	9.39
18.0	25	25	25	25	24	24	9.94
19.0	22	22	22	22	22	22	10.49
20.0	20	20	20	20	20	20	11.04

t (in)	0.375	0.432	0.562	0.719	0.864	
D_i (in)	5.875	5.761	5.501	5.187	4.897	
W(lb/ft)	25.03	28.57	36.39	45.35	53.16	
L/D_o	f_n	f_n	f_n	f_n	f_n	L (ft)
5.0	314	311	305	298	292	2.76
6.0	218	216	212	207	203	3.31
7.0	160	159	156	152	149	3.86
8.0	123	122	119	117	114	4.42
9.0	97	96	94	92	90	4.97
10.0	79	78	76	75	73	5.52
11.0	65	64	63	62	60	6.07
12.0	55	54	53	52	51	6.63
13.0	46	46	45	44	43	7.18
14.0	40	40	39	38	37	7.73
15.0	35	35	34	33	32	8.28
16.0	31	30	30	29	29	8.83
17.0	27	27	26	26	25	9.39
18.0	24	24	24	23	23	9.94
19.0	22	22	21	21	20	10.49
20.0	20	19	19	19	18	11.04

Table D-2.3. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) WITH APPLIED AXIAL LOADS (Pinned-Pinned) (cont)



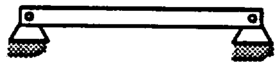
NPS = 8 in
D_o = 8.625 in
E = 28831000 lb/in^2

P/P_b = .25
λ = 3.1415926
μ = 489.535 lb/ft^3

t (in)	**0.188**	**0.203**	**0.219**	**0.250**	**0.277**	**0.312**	
D_i (in)	**8.249**	**8.219**	**8.187**	**8.125**	**8.071**	**8.001**	
W(lb/ft)	**16.94**	**18.26**	**19.66**	**22.36**	**24.70**	**27.70**	
L/D_o	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**L (ft)**
3.0	1202	1200	1197	1193	1189	1185	2.16
4.0	676	675	674	671	669	666	2.88
5.0	433	432	431	429	428	426	3.59
6.0	300	300	299	298	297	296	4.31
7.0	221	220	220	219	218	218	5.03
8.0	169	169	168	168	167	167	5.75
9.0	134	133	133	133	132	132	6.47
10.0	108	108	108	107	107	107	7.19
11.0	89	89	89	89	88	88	7.91
12.0	75	75	75	75	74	74	8.63
13.0	64	64	64	64	63	63	9.34
14.0	55	55	55	55	55	54	10.06
15.0	48	48	48	48	48	47	10.78
16.0	42	42	42	42	42	42	11.50
17.0	37	37	37	37	37	37	12.22
18.0	33	33	33	33	33	33	12.94

t (in)	**0.322**	**0.344**	**0.375**	**0.406**	**0.438**	**0.500**	
D_i (in)	**7.981**	**7.937**	**7.875**	**7.813**	**7.749**	**7.625**	
W(lb/ft)	**28.55**	**30.42**	**33.04**	**35.64**	**38.30**	**43.39**	
L/D_o	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**L (ft)**
3.0	1183	1180	1176	1172	1167	1159	2.16
4.0	666	664	661	659	657	652	2.88
5.0	426	425	423	422	420	417	3.59
6.0	296	295	294	293	292	290	4.31
7.0	217	217	216	215	214	213	5.03
8.0	166	166	165	165	164	163	5.75
9.0	131	131	131	130	130	129	6.47
10.0	106	106	106	105	105	104	7.19
11.0	88	88	87	87	87	86	7.91
12.0	74	74	73	73	73	72	8.63
13.0	63	63	63	62	62	62	9.34
14.0	54	54	54	54	54	53	10.06
15.0	47	47	47	47	47	46	10.78
16.0	42	41	41	41	41	41	11.50
17.0	37	37	37	36	36	36	12.22
18.0	33	33	33	33	32	32	12.94

Table D-2.3. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) WITH APPLIED AXIAL LOADS (Pinned-Pinned) (cont)

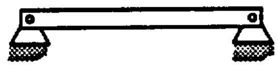


NPS = 8 in
D_o = 8.625 in
E = 28831000 lb/in^2

P/P_b = .25
λ = 3.1415926
μ = 489.535 lb/ft^3

t (in)	**0.594**	**0.719**	**0.812**	**0.875**	**0.906**	
D_i (in)	**7.437**	**7.187**	**7.001**	**6.875**	**6.813**	
W(lb/ft)	**50.95**	**60.71**	**67.76**	**72.42**	**74.69**	
L/D_o	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**L (ft)**
3.0	1147	1130	1118	1111	1107	2.16
4.0	645	636	629	625	622	2.88
5.0	413	407	403	400	398	3.59
6.0	287	283	280	278	277	4.31
7.0	211	208	205	204	203	5.03
8.0	161	159	157	156	156	5.75
9.0	127	126	124	123	123	6.47
10.0	103	102	101	100	100	7.19
11.0	85	84	83	83	82	7.91
12.0	72	71	70	69	69	8.63
13.0	61	60	60	59	59	9.34
14.0	53	52	51	51	51	10.06
15.0	46	45	45	44	44	10.78
16.0	40	40	39	39	39	11.50
17.0	36	35	35	35	34	12.22
18.0	32	31	31	31	31	12.94

Table D-2.3. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) WITH APPLIED AXIAL LOADS (Pinned-Pinned) (cont)



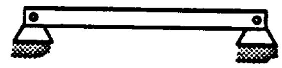
NPS = 8 in
D_o = 8.625 in
E = 28831000 lb/in^2

P/P_b = .50
λ = 3.1415926
μ = 489.535 lb/ft^3

t (in)	**0.188**	**0.203**	**0.219**	**0.250**	**0.277**	**0.312**	
D_i (in)	**8.249**	**8.219**	**8.187**	**8.125**	**8.071**	**8.001**	
W(lb/ft)	**16.94**	**18.26**	**19.66**	**22.36**	**24.70**	**27.70**	
L/D_o	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**L (ft)**
3.0	981	979	978	974	971	967	2.16
4.0	552	551	550	548	546	544	2.88
5.0	353	353	352	351	350	348	3.59
6.0	245	245	244	244	243	242	4.31
7.0	180	180	180	179	178	178	5.03
8.0	138	138	137	137	137	136	5.75
9.0	109	109	109	108	108	107	6.47
10.0	88	88	88	88	87	87	7.19
11.0	73	73	73	72	72	72	7.91
12.0	61	61	61	61	61	60	8.63
13.0	52	52	52	52	52	52	9.34
14.0	45	45	45	45	45	44	10.06
15.0	39	39	39	39	39	39	10.78
16.0	34	34	34	34	34	34	11.50
17.0	31	31	30	30	30	30	12.22
18.0	27	27	27	27	27	27	12.94

t (in)	**0.322**	**0.344**	**0.375**	**0.406**	**0.438**	**0.500**	
D_i (in)	**7.981**	**7.937**	**7.875**	**7.813**	**7.749**	**7.625**	
W(lb/ft)	**28.55**	**30.42**	**33.04**	**35.64**	**38.30**	**43.39**	
L/D_o	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**L (ft)**
3.0	966	964	960	957	953	946	2.16
4.0	543	542	540	538	536	532	2.88
5.0	348	347	346	344	343	341	3.59
6.0	242	241	240	239	238	237	4.31
7.0	177	177	176	176	175	174	5.03
8.0	136	136	135	135	134	133	5.75
9.0	107	107	107	106	106	105	6.47
10.0	87	87	86	86	86	85	7.19
11.0	72	72	71	71	71	70	7.91
12.0	60	60	60	60	60	59	8.63
13.0	51	51	51	51	51	50	9.34
14.0	44	44	44	44	44	43	10.06
15.0	39	39	38	38	38	38	10.78
16.0	34	34	34	34	34	33	11.50
17.0	30	30	30	30	30	29	12.22
18.0	27	27	27	27	26	26	12.94

Table D-2.3. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) WITH APPLIED AXIAL LOADS (Pinned-Pinned) (cont)

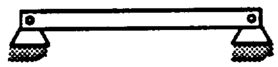


NPS = 8 in
D_o = 8.625 in
E = 28831000 lb/in^2

P/P_b = .50
λ = 3.1415926
μ = 489.535 lb/ft^3

t (in)	**0.594**	**0.719**	**0.812**	**0.875**	**0.906**	
D_i (in)	**7.437**	**7.187**	**7.001**	**6.875**	**6.813**	
W(lb/ft)	**50.95**	**60.71**	**67.76**	**72.42**	**74.69**	
L/D_o	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**L (ft)**
3.0	936	923	913	907	904	2.16
4.0	527	519	514	510	508	2.88
5.0	337	332	329	326	325	3.59
6.0	234	231	228	227	226	4.31
7.0	172	170	168	167	166	5.03
8.0	132	130	128	128	127	5.75
9.0	104	103	101	101	100	6.47
10.0	84	83	82	82	81	7.19
11.0	70	69	68	67	67	7.91
12.0	59	58	57	57	56	8.63
13.0	50	49	49	48	48	9.34
14.0	43	42	42	42	41	10.06
15.0	37	37	37	36	36	10.78
16.0	33	32	32	32	32	11.50
17.0	29	29	28	28	28	12.22
18.0	26	26	25	25	25	12.94

Table D-2.3. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) WITH APPLIED AXIAL LOADS (Pinned-Pinned) (cont)



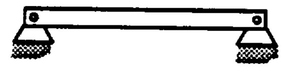
NPS = 8 in
D_o = 8.625 in
E = 28831000 lb/in^2

P/P_b = .75
λ = 3.1415926
μ = 489.535 lb/ft^3

t (in)	**0.188**	**0.203**	**0.219**	**0.250**	**0.277**	**0.312**	
D_i (in)	**8.249**	**8.219**	**8.187**	**8.125**	**8.071**	**8.001**	
W(lb/ft)	**16.94**	**18.26**	**19.66**	**22.36**	**24.70**	**27.70**	
L/D_o	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**L (ft)**
2.0	1561	1558	1555	1550	1545	1539	1.44
3.0	694	693	691	689	687	684	2.16
4.0	390	390	389	387	386	385	2.88
5.0	250	249	249	248	247	246	3.59
6.0	173	173	173	172	172	171	4.31
7.0	127	127	127	127	126	126	5.03
8.0	98	97	97	97	97	96	5.75
9.0	77	77	77	77	76	76	6.47
10.0	62	62	62	62	62	62	7.19
11.0	52	52	51	51	51	51	7.91
12.0	43	43	43	43	43	43	8.63
13.0	37	37	37	37	37	36	9.34
14.0	32	32	32	32	32	31	10.06
15.0	28	28	28	28	27	27	10.78
16.0	24	24	24	24	24	24	11.50
17.0	22	22	22	21	21	21	12.22

t (in)	**0.322**	**0.344**	**0.375**	**0.406**	**0.438**	**0.500**	
D_i (in)	**7.981**	**7.937**	**7.875**	**7.813**	**7.749**	**7.625**	
W(lb/ft)	**28.55**	**30.42**	**33.04**	**35.64**	**38.30**	**43.39**	
L/D_o	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**L (ft)**
2.0	1537	1533	1528	1522	1517	1506	1.44
3.0	683	681	679	677	674	669	2.16
4.0	384	383	382	381	379	376	2.88
5.0	246	245	244	244	243	241	3.59
6.0	171	170	170	169	169	167	4.31
7.0	125	125	125	124	124	123	5.03
8.0	96	96	95	95	95	94	5.75
9.0	76	76	75	75	75	74	6.47
10.0	61	61	61	61	61	60	7.19
11.0	51	51	50	50	50	50	7.91
12.0	43	43	42	42	42	42	8.63
13.0	36	36	36	36	36	36	9.34
14.0	31	31	31	31	31	31	10.06
15.0	27	27	27	27	27	27	10.78
16.0	24	24	24	24	24	24	11.50
17.0	21	21	21	21	21	21	12.22

Table D-2.3. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) WITH APPLIED AXIAL LOADS (Pinned-Pinned) (cont)

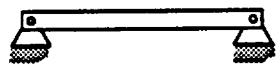


NPS = 8 in
D_o = 8.625 in
E = 28831000 lb/in^2

P/P_b = .75
λ = 3.1415926
μ = 489.535 lb/ft^3

t (in)	**0.594**	**0.719**	**0.812**	**0.875**	**0.906**	
D_i (in)	**7.437**	**7.187**	**7.001**	**6.875**	**6.813**	
W(lb/ft)	**50.95**	**60.71**	**67.76**	**72.42**	**74.69**	
L/D_o	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**L (ft)**
2.0	1490	1468	1453	1443	1438	1.44
3.0	662	653	646	641	639	2.16
4.0	372	367	363	361	359	2.88
5.0	238	235	232	231	230	3.59
6.0	166	163	161	160	160	4.31
7.0	122	120	119	118	117	5.03
8.0	93	92	91	90	90	5.75
9.0	74	73	72	71	71	6.47
10.0	60	59	58	58	58	7.19
11.0	49	49	48	48	48	7.91
12.0	41	41	40	40	40	8.63
13.0	35	35	34	34	34	9.34
14.0	30	30	30	29	29	10.06
15.0	26	26	26	26	26	10.78
16.0	23	23	23	23	22	11.50
17.0	21	20	20	20	20	12.22

Table D-2.3. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) WITH APPLIED AXIAL LOADS (Pinned-Pinned) (cont)



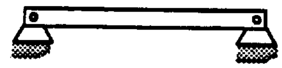
NPS = 10 in
D_o = 10.75 in
E = 28831000 lb/in^2

P/P_b = .25
λ = 3.1415926
μ = 489.535 lb/ft^3

t (in)	**0.188**	**0.203**	**0.219**	**0.250**	**0.279**	**0.307**	
D_i (in)	**10.374**	**10.344**	**10.312**	**10.25**	**10.192**	**10.136**	
W(lb/ft)	**21.21**	**22.87**	**24.63**	**28.04**	**31.20**	**34.24**	
L/D_o	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**L (ft)**
3.0	968	967	965	963	960	958	2.69
4.0	545	544	543	542	540	539	3.58
5.0	349	348	348	347	346	345	4.48
6.0	242	242	241	241	240	239	5.38
7.0	178	178	177	177	176	176	6.27
8.0	136	136	136	135	135	135	7.17
9.0	108	107	107	107	107	106	8.06
10.0	87	87	87	87	86	86	8.96
11.0	72	72	72	72	71	71	9.85
12.0	61	60	60	60	60	60	10.75
13.0	52	51	51	51	51	51	11.65
14.0	44	44	44	44	44	44	12.54
15.0	39	39	39	39	38	38	13.44
16.0	34	34	34	34	34	34	14.33
17.0	30	30	30	30	30	30	15.23
18.0	27	27	27	27	27	27	16.13

t (in)	**0.344**	**0.365**	**0.438**	**0.500**	**0.594**	**0.719**	
D_i (in)	**10.062**	**10.02**	**9.874**	**9.75**	**9.562**	**9.312**	
W(lb/ft)	**38.23**	**40.48**	**48.24**	**54.74**	**64.43**	**77.03**	
L/D_o	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**L (ft)**
3.0	954	952	946	941	932	922	2.69
4.0	537	536	532	529	525	519	3.58
5.0	344	343	341	339	336	332	4.48
6.0	239	238	237	235	233	230	5.38
7.0	175	175	174	173	171	169	6.27
8.0	134	134	133	132	131	130	7.17
9.0	106	106	105	105	104	102	8.06
10.0	86	86	85	85	84	83	8.96
11.0	71	71	70	70	69	69	9.85
12.0	60	60	59	59	58	58	10.75
13.0	51	51	50	50	50	49	11.65
14.0	44	44	43	43	43	42	12.54
15.0	38	38	38	38	37	37	13.44
16.0	34	33	33	33	33	32	14.33
17.0	30	30	29	29	29	29	15.23
18.0	27	26	26	26	26	26	16.13

Table D-2.3. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) WITH APPLIED AXIAL LOADS (Pinned-Pinned) (cont)

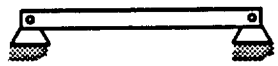


NPS = 10 in
D_o = 10.75 in
E = 28831000 lb/in^2

P/P_b = .25
λ = 3.1415926
μ = 489.535 lb/ft^3

t (in)	**0.844**	**1.000**	**1.125**	
D_i (in)	**9.062**	**8.75**	**8.5**	
W(lb/ft)	**89.29**	**104.13**	**115.64**	
L/D_o	**f_n**	**f_n**	**f_n**	**L (ft)**
3.0	911	898	888	2.69
4.0	513	505	500	3.58
5.0	328	323	320	4.48
6.0	228	225	222	5.38
7.0	167	165	163	6.27
8.0	128	126	125	7.17
9.0	101	100	99	8.06
10.0	82	81	80	8.96
11.0	68	67	66	9.85
12.0	57	56	56	10.75
13.0	49	48	47	11.65
14.0	42	41	41	12.54
15.0	36	36	36	13.44
16.0	32	32	31	14.33
17.0	28	28	28	15.23
18.0	25	25	25	16.13

Table D-2.3. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) WITH APPLIED AXIAL LOADS (Pinned-Pinned) (cont)



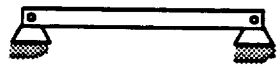
NPS = 10 in
D_o = 10.75 in
E = 28831000 lb/in^2

P/P_b = .50
λ = 3.1415926
μ = 489.535 lb/ft^3

t (in)	**0.188**	**0.203**	**0.219**	**0.250**	**0.279**	**0.307**	
D_i (in)	**10.374**	**10.344**	**10.312**	**10.25**	**10.192**	**10.136**	
W(lb/ft)	**21.21**	**22.87**	**24.63**	**28.04**	**31.20**	**34.24**	
L/D_o	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**L (ft)**
2.0	1779	1776	1774	1769	1764	1759	1.79
3.0	791	789	788	786	784	782	2.69
4.0	445	444	443	442	441	440	3.58
5.0	285	284	284	283	282	281	4.48
6.0	198	197	197	197	196	195	5.38
7.0	145	145	145	144	144	144	6.27
8.0	111	111	111	111	110	110	7.17
9.0	88	88	88	87	87	87	8.06
10.0	71	71	71	71	71	70	8.96
11.0	59	59	59	58	58	58	9.85
12.0	49	49	49	49	49	49	10.75
13.0	42	42	42	42	42	42	11.65
14.0	36	36	36	36	36	36	12.54
15.0	32	32	32	31	31	31	13.44
16.0	28	28	28	28	28	27	14.33
17.0	25	25	25	24	24	24	15.23

t (in)	**0.344**	**0.365**	**0.438**	**0.500**	**0.594**	**0.719**	
D_i (in)	**10.062**	**10.02**	**9.874**	**9.75**	**9.562**	**9.312**	
W(lb/ft)	**38.23**	**40.48**	**48.24**	**54.74**	**64.43**	**77.03**	
L/D_o	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**L (ft)**
2.0	1753	1750	1738	1728	1713	1693	1.79
3.0	779	778	772	768	761	753	2.69
4.0	438	437	435	432	428	423	3.58
5.0	281	280	278	276	274	271	4.48
6.0	195	194	193	192	190	188	5.38
7.0	143	143	142	141	140	138	6.27
8.0	110	109	109	108	107	106	7.17
9.0	87	86	86	85	85	84	8.06
10.0	70	70	70	69	69	68	8.96
11.0	58	58	57	57	57	56	9.85
12.0	49	49	48	48	48	47	10.75
13.0	41	41	41	41	41	40	11.65
14.0	36	36	35	35	35	35	12.54
15.0	31	31	31	31	30	30	13.44
16.0	27	27	27	27	27	26	14.33
17.0	24	24	24	24	24	23	15.23

Table D-2.3. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) WITH APPLIED AXIAL LOADS (Pinned-Pinned) (cont)

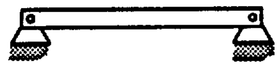


NPS = 10 in
D_o = 10.75 in
E = 28831000 lb/in^2

P/P_b = .50
λ = 3.1415926
μ = 489.535 lb/ft^3

t (in)	**0.844**	**1.000**	**1.125**	
D_i (in)	**9.062**	**8.75**	**8.5**	
W(lb/ft)	**89.29**	**104.13**	**115.64**	
L/D_o	**f_n**	**f_n**	**f_n**	**L (ft)**
2.0	1674	1650	1632	1.79
3.0	744	734	725	2.69
4.0	419	413	408	3.58
5.0	268	264	261	4.48
6.0	186	183	181	5.38
7.0	137	135	133	6.27
8.0	105	103	102	7.17
9.0	83	82	81	8.06
10.0	67	66	65	8.96
11.0	55	55	54	9.85
12.0	47	46	45	10.75
13.0	40	39	39	11.65
14.0	34	34	33	12.54
15.0	30	29	29	13.44
16.0	26	26	25	14.33
17.0	23	23	23	15.23

Table D-2.3. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) WITH APPLIED AXIAL LOADS (Pinned-Pinned) (cont)



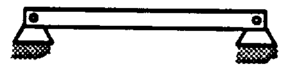
NPS = 10 in
D_o = 10.75 in
E = 28831000 lb/in^2

P/P_b = .75
λ = 3.1415926
μ = 489.535 lb/ft^3

t (in)	0.188	0.203	0.219	0.250	0.279	0.307	
D_i (in)	10.374	10.344	10.312	10.25	10.192	10.136	
W(lb/ft)	21.21	22.87	24.63	28.04	31.20	34.24	
L/D_o	f_n	f_n	f_n	f_n	f_n	f_n	L (ft)
2.0	1258	1256	1254	1251	1247	1244	1.79
3.0	559	558	557	556	554	553	2.69
4.0	314	314	314	313	312	311	3.58
5.0	201	201	201	200	200	199	4.48
6.0	140	140	139	139	139	138	5.38
7.0	103	103	102	102	102	102	6.27
8.0	79	79	78	78	78	78	7.17
9.0	62	62	62	62	62	61	8.06
10.0	50	50	50	50	50	50	8.96
11.0	42	42	41	41	41	41	9.85
12.0	35	35	35	35	35	35	10.75
13.0	30	30	30	30	30	29	11.65
14.0	26	26	26	26	25	25	12.54
15.0	22	22	22	22	22	22	13.44
16.0	20	20	20	20	19	19	14.33
17.0	17	17	17	17	17	17	15.23

t (in)	0.344	0.365	0.438	0.500	0.594	0.719	
D_i (in)	10.062	10.02	9.874	9.75	9.562	9.312	
W(lb/ft)	38.23	40.48	48.24	54.74	64.43	77.03	
L/D_o	f_n	f_n	f_n	f_n	f_n	f_n	L (ft)
2.0	1240	1237	1229	1222	1211	1197	1.79
3.0	551	550	546	543	538	532	2.69
4.0	310	309	307	305	303	299	3.58
5.0	198	198	197	196	194	192	4.48
6.0	138	137	137	136	135	133	5.38
7.0	101	101	100	100	99	98	6.27
8.0	77	77	77	76	76	75	7.17
9.0	61	61	61	60	60	59	8.06
10.0	50	49	49	49	48	48	8.96
11.0	41	41	41	40	40	40	9.85
12.0	34	34	34	34	34	33	10.75
13.0	29	29	29	29	29	28	11.65
14.0	25	25	25	25	25	24	12.54
15.0	22	22	22	22	22	21	13.44
16.0	19	19	19	19	19	19	14.33
17.0	17	17	17	17	17	17	15.23

Table D-2.3. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) WITH APPLIED AXIAL LOADS (Pinned-Pinned) (cont)



NPS = 10 in
D_o = 10.75 in
E = 28831000 lb/in^2

P/P_b = .75
λ = 3.1415926
μ = 489.535 lb/ft^3

t (in)	**0.844**	**1.000**	**1.125**	
D_I (in)	**9.062**	**8.75**	**8.5**	
W(lb/ft)	**89.29**	**104.13**	**115.64**	
L/D_o	**f_n**	**f_n**	**f_n**	**L (ft)**
2.0	1184	1167	1154	1.79
3.0	526	519	513	2.69
4.0	296	292	288	3.58
5.0	189	187	185	4.48
6.0	132	130	128	5.38
7.0	97	95	94	6.27
8.0	74	73	72	7.17
9.0	58	58	57	8.06
10.0	47	47	46	8.96
11.0	39	39	38	9.85
12.0	33	32	32	10.75
13.0	28	28	27	11.65
14.0	24	24	24	12.54
15.0	21	21	21	13.44
16.0	18	18	18	14.33
17.0	16	16	16	15.23

Table D-2.3. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) WITH APPLIED AXIAL LOADS (Pinned-Pinned) (cont)

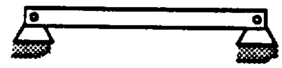
NPS = 12 in
D_o = 12.75 in
E = 28831000 lb/in^2

P/P_b = .25
λ = 3.1415926
μ = 489.535 lb/ft^3

t (in)	0.203	0.219	0.250	0.281	0.312	0.330	
D_i (in)	12.344	12.312	12.250	12.188	12.126	12.090	
W(lb/ft)	27.20	29.31	33.38	37.42	41.45	43.77	
L/D_o	f_n	f_n	f_n	f_n	f_n	f_n	L (ft)
3.0	818	817	815	813	811	810	3.19
4.0	460	459	458	457	456	455	4.25
5.0	294	294	293	293	292	291	5.31
6.0	204	204	204	203	203	202	6.38
7.0	150	150	150	149	149	149	7.44
8.0	115	115	115	114	114	114	8.50
9.0	91	91	91	90	90	90	9.56
10.0	74	73	73	73	73	73	10.63
11.0	61	61	61	60	60	60	11.69
12.0	51	51	51	51	51	51	12.75
13.0	44	43	43	43	43	43	13.81
14.0	38	37	37	37	37	37	14.88
15.0	33	33	33	33	32	32	15.94
16.0	29	29	29	29	29	28	17.00
17.0	25	25	25	25	25	25	18.06
18.0	23	23	23	23	23	22	19.13

t (in)	0.344	0.375	0.406	0.438	0.500	0.562	
D_i (in)	12.062	12.000	11.938	11.874	11.750	11.626	
W(lb/ft)	45.58	49.56	53.52	57.59	65.42	73.15	
L/D_o	f_n	f_n	f_n	f_n	f_n	f_n	L (ft)
3.0	809	807	805	803	799	795	3.19
4.0	455	454	453	452	449	447	4.25
5.0	291	290	290	289	288	286	5.31
6.0	202	202	201	201	200	199	6.38
7.0	149	148	148	147	147	146	7.44
8.0	114	113	113	113	112	112	8.50
9.0	90	90	89	89	89	88	9.56
10.0	73	73	72	72	72	72	10.63
11.0	60	60	60	60	59	59	11.69
12.0	51	50	50	50	50	50	12.75
13.0	43	43	43	43	43	42	13.81
14.0	37	37	37	37	37	37	14.88
15.0	32	32	32	32	32	32	15.94
16.0	28	28	28	28	28	28	17.00
17.0	25	25	25	25	25	25	18.06
18.0	22	22	22	22	22	22	19.13

Table D-2.3. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) WITH APPLIED AXIAL LOADS (Pinned-Pinned) (cont)

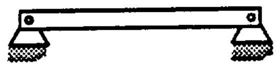


NPS = 12 in
D_o = 12.75 in
E = 28831000 lb/in^2

P/P_b = .25
λ = 3.1415926
μ = 489.535 lb/ft^3

t (in)	**0.688**	**0.844**	**1.000**	**1.250**	**1.312**	
D_i (in)	**11.374**	**11.062**	**10.750**	**10.250**	**10.126**	
W(lb/ft)	**88.63**	**107.32**	**125.49**	**153.53**	**160.27**	
L/D_o	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**L (ft)**
3.0	787	778	768	754	750	3.19
4.0	443	437	432	424	422	4.25
5.0	283	280	277	271	270	5.31
6.0	197	194	192	188	188	6.38
7.0	145	143	141	138	138	7.44
8.0	111	109	108	106	105	8.50
9.0	87	86	85	84	83	9.56
10.0	71	70	69	68	68	10.63
11.0	59	58	57	56	56	11.69
12.0	49	49	48	47	47	12.75
13.0	42	41	41	40	40	13.81
14.0	36	36	35	35	34	14.88
15.0	31	31	31	30	30	15.94
16.0	28	27	27	26	26	17.00
17.0	25	24	24	23	23	18.06
18.0	22	22	21	21	21	19.13

Table D-2.3. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) WITH APPLIED AXIAL LOADS (Pinned-Pinned) (cont)



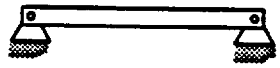
NPS = 12 in
D_o = 12.75 in
E = 28831000 lb/in^2

P/P_b = .50
λ = 3.1415926
μ = 489.535 lb/ft^3

t (in)	**0.203**	**0.219**	**0.250**	**0.281**	**0.312**	**0.330**	
D_i (in)	**12.344**	**12.312**	**12.250**	**12.188**	**12.126**	**12.090**	
W(lb/ft)	**27.20**	**29.31**	**33.38**	**37.42**	**41.45**	**43.77**	
L/D_o	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**L (ft)**
2.0	1502	1500	1497	1493	1489	1487	2.13
3.0	668	667	665	664	662	661	3.19
4.0	376	375	374	373	372	372	4.25
5.0	240	240	239	239	238	238	5.31
6.0	167	167	166	166	165	165	6.38
7.0	123	122	122	122	122	121	7.44
8.0	94	94	94	93	93	93	8.50
9.0	74	74	74	74	74	73	9.56
10.0	60	60	60	60	60	59	10.63
11.0	50	50	49	49	49	49	11.69
12.0	42	42	42	41	41	41	12.75
13.0	36	36	35	35	35	35	13.81
14.0	31	31	31	30	30	30	14.88
15.0	27	27	27	27	26	26	15.94
16.0	23	23	23	23	23	23	17.00
17.0	21	21	21	21	21	21	18.06

t (in)	**0.344**	**0.375**	**0.406**	**0.438**	**0.500**	**0.562**	
D_i (in)	**12.062**	**12.000**	**11.938**	**11.874**	**11.750**	**11.626**	
W(lb/ft)	**45.58**	**49.56**	**53.52**	**57.59**	**65.42**	**73.15**	
L/D_o	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**L (ft)**
2.0	1486	1482	1478	1475	1468	1461	2.13
3.0	660	659	657	655	652	649	3.19
4.0	371	371	370	369	367	365	4.25
5.0	238	237	237	236	235	234	5.31
6.0	165	165	164	164	163	162	6.38
7.0	121	121	121	120	120	119	7.44
8.0	93	93	92	92	92	91	8.50
9.0	73	73	73	73	72	72	9.56
10.0	59	59	59	59	59	58	10.63
11.0	49	49	49	49	49	48	11.69
12.0	41	41	41	41	41	41	12.75
13.0	35	35	35	35	35	35	13.81
14.0	30	30	30	30	30	30	14.88
15.0	26	26	26	26	26	26	15.94
16.0	23	23	23	23	23	23	17.00
17.0	21	21	20	20	20	20	18.06

Table D-2.3. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) WITH APPLIED AXIAL LOADS (Pinned-Pinned) (cont)

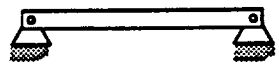


NPS = 12 in
D_o = 12.75 in
E = 28831000 lb/in²

P/P_b = .50
λ = 3.1415926
μ = 489.535 lb/ft³

t (in)	0.688	0.844	1.000	1.250	1.312	
D_i (in)	11.374	11.062	10.750	10.250	10.126	
W(lb/ft)	88.63	107.32	125.49	153.53	160.27	
L/D_o	f_n	f_n	f_n	f_n	f_n	L (ft)
2.0	1446	1429	1412	1385	1378	2.13
3.0	643	635	627	615	613	3.19
4.0	362	357	353	346	345	4.25
5.0	231	229	226	222	221	5.31
6.0	161	159	157	154	153	6.38
7.0	118	117	115	113	113	7.44
8.0	90	89	88	87	86	8.50
9.0	71	71	70	68	68	9.56
10.0	58	57	56	55	55	10.63
11.0	48	47	47	46	46	11.69
12.0	40	40	39	38	38	12.75
13.0	34	34	33	33	33	13.81
14.0	30	29	29	28	28	14.88
15.0	26	25	25	25	25	15.94
16.0	23	22	22	22	22	17.00
17.0	20	20	20	19	19	18.06

Table D-2.3. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) WITH APPLIED AXIAL LOADS (Pinned-Pinned) (cont)



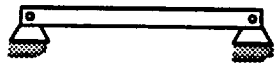
NPS = 12 in
D_o = 12.75 in
E = 28831000 lb/in^2

P/P_b = .75
λ = 3.1415926
μ = 489.535 lb/ft^3

t (in)	**0.203**	**0.219**	**0.250**	**0.281**	**0.312**	**0.330**	
D_i (in)	**12.344**	**12.312**	**12.250**	**12.188**	**12.126**	**12.090**	
W(lb/ft)	**27.20**	**29.31**	**33.38**	**37.42**	**41.45**	**43.77**	
L/D_o	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**L (ft)**
2.0	1062	1061	1058	1056	1053	1052	2.13
3.0	472	471	470	469	468	467	3.19
4.0	266	265	265	264	263	263	4.25
5.0	170	170	169	169	169	168	5.31
6.0	118	118	118	117	117	117	6.38
7.0	87	87	86	86	86	86	7.44
8.0	66	66	66	66	66	66	8.50
9.0	52	52	52	52	52	52	9.56
10.0	42	42	42	42	42	42	10.63
11.0	35	35	35	35	35	35	11.69
12.0	30	29	29	29	29	29	12.75
13.0	25	25	25	25	25	25	13.81
14.0	22	22	22	22	21	21	14.88
15.0	19	19	19	19	19	19	15.94
16.0	17	17	17	16	16	16	17.00
17.0	15	15	15	15	15	15	18.06

t (in)	**0.344**	**0.375**	**0.406**	**0.438**	**0.500**	**0.562**	
D_i (in)	**12.062**	**12.000**	**11.938**	**11.874**	**11.750**	**11.626**	
W(lb/ft)	**45.58**	**49.56**	**53.52**	**57.59**	**65.42**	**73.15**	
L/D_o	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**L (ft)**
2.0	1051	1048	1045	1043	1038	1033	2.13
3.0	467	466	465	463	461	459	3.19
4.0	263	262	261	261	259	258	4.25
5.0	168	168	167	167	166	165	5.31
6.0	117	116	116	116	115	115	6.38
7.0	86	86	85	85	85	84	7.44
8.0	66	65	65	65	65	65	8.50
9.0	52	52	52	51	51	51	9.56
10.0	42	42	42	42	42	41	10.63
11.0	35	35	35	34	34	34	11.69
12.0	29	29	29	29	29	29	12.75
13.0	25	25	25	25	25	24	13.81
14.0	21	21	21	21	21	21	14.88
15.0	19	19	19	19	18	18	15.94
16.0	16	16	16	16	16	16	17.00
17.0	15	15	14	14	14	14	18.06

Table D-2.3. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) WITH APPLIED AXIAL LOADS (Pinned-Pinned) (cont)

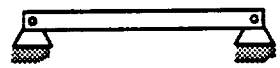


NPS = 12 in
D_o = 12.75 in
E = 28831000 lb/in^2

P/P_b = .75
λ = 3.1415926
μ = 489.535 lb/ft^3

t (in)	**0.688**	**0.844**	**1.000**	**1.250**	**1.312**	
D_i (in)	**11.374**	**11.062**	**10.750**	**10.250**	**10.126**	
W(lb/ft)	**88.63**	**107.32**	**125.49**	**153.53**	**160.27**	
L/D_o	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**L (ft)**
2.0	1023	1010	998	979	975	2.13
3.0	455	449	444	435	433	3.19
4.0	256	253	250	245	244	4.25
5.0	164	162	160	157	156	5.31
6.0	114	112	111	109	108	6.38
7.0	83	82	81	80	80	7.44
8.0	64	63	62	61	61	8.50
9.0	51	50	49	48	48	9.56
10.0	41	40	40	39	39	10.63
11.0	34	33	33	32	32	11.69
12.0	28	28	28	27	27	12.75
13.0	24	24	24	23	23	13.81
14.0	21	21	20	20	20	14.88
15.0	18	18	18	17	17	15.94
16.0	16	16	16	15	15	17.00
17.0	14	14	14	14	13	18.06

Table D-2.3. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) WITH APPLIED AXIAL LOADS (Pinned-Pinned) (cont)



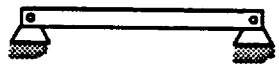
NPS = 14 in
D_o = 14.00 in
E = 28831000 lb/in^2

P/P_b = .25
λ = 3.1415926
μ = 489.535 lb/ft^3

t (in)	0.188	0.210	0.219	0.250	0.281	0.312	
D_i (in)	13.624	13.580	13.562	13.500	13.433	13.376	
W(lb/ft)	27.73	30.93	32.23	36.71	41.17	45.61	
L/D_o	f_n	f_n	f_n	f_n	f_n	f_n	L (ft)
2.0	1680	1677	1676	1672	1669	1665	2.33
3.0	747	745	745	743	742	740	3.50
4.0	420	419	419	418	417	416	4.67
5.0	269	268	268	268	267	266	5.83
6.0	187	186	186	186	185	185	7.00
7.0	137	137	137	137	136	136	8.17
8.0	105	105	105	105	104	104	9.33
9.0	83	83	83	83	82	82	10.50
10.0	67	67	67	67	67	67	11.67
11.0	56	55	55	55	55	55	12.83
12.0	47	47	47	46	46	46	14.00
13.0	40	40	40	40	39	39	15.17
14.0	34	34	34	34	34	34	16.33
15.0	30	30	30	30	30	30	17.50
16.0	26	26	26	26	26	26	18.67
17.0	23	23	23	23	23	23	19.83

t (in)	0.344	0.375	0.406	0.438	0.469	0.500	
D_i (in)	13.312	13.250	13.188	13.124	13.062	13.000	
W(lb/ft)	50.17	54.57	58.94	63.44	67.78	72.09	
L/D_o	f_n	f_n	f_n	f_n	f_n	f_n	L (ft)
2.0	1661	1657	1654	1650	1646	1643	2.33
3.0	738	737	735	733	732	730	3.50
4.0	415	414	413	412	412	411	4.67
5.0	266	265	265	264	263	263	5.83
6.0	185	184	184	183	183	183	7.00
7.0	136	135	135	135	134	134	8.17
8.0	104	104	103	103	103	103	9.33
9.0	82	82	82	81	81	81	10.50
10.0	66	66	66	66	66	66	11.67
11.0	55	55	55	55	54	54	12.83
12.0	46	46	46	46	46	46	14.00
13.0	39	39	39	39	39	39	15.17
14.0	34	34	34	34	34	34	16.33
15.0	30	29	29	29	29	29	17.50
16.0	26	26	26	26	26	26	18.67
17.0	23	23	23	23	23	23	19.83

Table D-2.3. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) WITH APPLIED AXIAL LOADS (Pinned-Pinned) (cont)



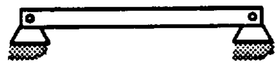
NPS = 14 in
D_o = 14.00 in
E = 28831000 lb/in^2

P/P_b = .25
λ = 3.1415926
μ = 489.535 lb/ft^3

t (in)	0.562	0.625	0.688	0.750	0.812	0.875	
D_i (in)	12.876	12.750	12.624	12.500	12.376	12.250	
W(lb/ft)	80.66	89.28	97.81	106.13	114.37	122.65	
L/D_o	f_n	f_n	f_n	f_n	f_n	f_n	L (ft)
2.0	1635	1628	1621	1614	1607	1600	2.33
3.0	727	724	720	717	714	711	3.50
4.0	409	407	405	403	402	400	4.67
5.0	262	261	259	258	257	256	5.83
6.0	182	181	180	179	179	178	7.00
7.0	134	133	132	132	131	131	8.17
8.0	102	102	101	101	100	100	9.33
9.0	81	80	80	80	79	79	10.50
10.0	65	65	65	65	64	64	11.67
11.0	54	54	54	53	53	53	12.83
12.0	45	45	45	45	45	44	14.00
13.0	39	39	38	38	38	38	15.17
14.0	33	33	33	33	33	33	16.33
15.0	29	29	29	29	29	28	17.50
16.0	26	25	25	25	25	25	18.67
17.0	23	23	22	22	22	22	19.83

t (in)	0.938	1.000	1.062	1.125	
D_i (in)	12.124	12.000	11.876	11.750	
W(lb/ft)	130.85	138.84	146.74	154.69	
L/D_o	f_n	f_n	f_n	f_n	L (ft)
2.0	1592	1585	1579	1572	2.33
3.0	708	705	702	698	3.50
4.0	398	396	395	393	4.67
5.0	255	254	253	251	5.83
6.0	177	176	175	175	7.00
7.0	130	129	129	128	8.17
8.0	100	99	99	98	9.33
9.0	79	78	78	78	10.50
10.0	64	63	63	63	11.67
11.0	53	52	52	52	12.83
12.0	44	44	44	44	14.00
13.0	38	38	37	37	15.17
14.0	32	32	32	32	16.33
15.0	28	28	28	28	17.50
16.0	25	25	25	25	18.67
17.0	22	22	22	22	19.83

Table D-2.3. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) WITH APPLIED AXIAL LOADS (Pinned-Pinned) (cont)



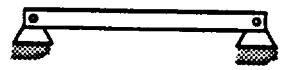
NPS = 14 in
D_o = 14.00 in
E = 28831000 lb/in^2

P/P_b = .50
λ = 3.1415926
μ = 489.535 lb/ft^3

t (in)	0.188	0.210	0.219	0.250	0.281	0.312	
D_i (in)	13.624	13.580	13.562	13.500	13.433	13.376	
W(lb/ft)	27.73	30.93	32.23	36.71	41.17	45.61	
L/D_o	f_n	f_n	f_n	f_n	f_n	f_n	L (ft)
2.0	1371	1369	1368	1365	1362	1359	2.33
3.0	610	609	608	607	605	604	3.50
4.0	343	342	342	341	341	340	4.67
5.0	219	219	219	218	218	217	5.83
6.0	152	152	152	152	151	151	7.00
7.0	112	112	112	111	111	111	8.17
8.0	86	86	86	85	85	85	9.33
9.0	68	68	68	67	67	67	10.50
10.0	55	55	55	55	54	54	11.67
11.0	45	45	45	45	45	45	12.83
12.0	38	38	38	38	38	38	14.00
13.0	32	32	32	32	32	32	15.17
14.0	28	28	28	28	28	28	16.33
15.0	24	24	24	24	24	24	17.50
16.0	21	21	21	21	21	21	18.67
17.0	19	19	19	19	19	19	19.83

t (in)	0.344	0.375	0.406	0.438	0.469	0.500	
D_i (in)	13.312	13.250	13.188	13.124	13.062	13.000	
W(lb/ft)	50.17	54.57	58.94	63.44	67.78	72.09	
L/D_o	f_n	f_n	f_n	f_n	f_n	f_n	L (ft)
2.0	1356	1353	1350	1347	1344	1341	2.33
3.0	603	601	600	599	597	596	3.50
4.0	339	338	338	337	336	335	4.67
5.0	217	217	216	216	215	215	5.83
6.0	151	150	150	150	149	149	7.00
7.0	111	110	110	110	110	109	8.17
8.0	85	85	84	84	84	84	9.33
9.0	67	67	67	67	66	66	10.50
10.0	54	54	54	54	54	54	11.67
11.0	45	45	45	45	44	44	12.83
12.0	38	38	38	37	37	37	14.00
13.0	32	32	32	32	32	32	15.17
14.0	28	28	28	27	27	27	16.33
15.0	24	24	24	24	24	24	17.50
16.0	21	21	21	21	21	21	18.67
17.0	19	19	19	19	19	19	19.83

Table D-2.3. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) WITH APPLIED AXIAL LOADS (Pinned-Pinned) (cont)



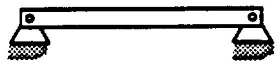
NPS = 14 in
D_o = 14.00 in
E = 28831000 lb/in^2

P/P_b = .50
λ = 3.1415926
μ = 489.535 lb/ft^3

t (in)	0.562	0.625	0.688	0.750	0.812	0.875	
D_i (in)	12.876	12.750	12.624	12.500	12.376	12.250	
W(lb/ft)	80.66	89.28	97.81	106.13	114.37	122.65	
L/D_o	f_n	f_n	f_n	f_n	f_n	f_n	L (ft)
2.0	1335	1329	1323	1318	1312	1306	2.33
3.0	593	591	588	586	583	580	3.50
4.0	334	332	331	329	328	326	4.67
5.0	214	213	212	211	210	209	5.83
6.0	148	148	147	146	146	145	7.00
7.0	109	109	108	108	107	107	8.17
8.0	83	83	83	82	82	82	9.33
9.0	66	66	65	65	65	64	10.50
10.0	53	53	53	53	52	52	11.67
11.0	44	44	44	44	43	43	12.83
12.0	37	37	37	37	36	36	14.00
13.0	32	31	31	31	31	31	15.17
14.0	27	27	27	27	27	27	16.33
15.0	24	24	24	23	23	23	17.50
16.0	21	21	21	21	20	20	18.67
17.0	18	18	18	18	18	18	19.83

t (in)	0.938	1.000	1.062	1.125	
D_i (in)	12.124	12.000	11.876	11.750	
W(lb/ft)	130.85	138.84	146.74	154.69	
L/D_o	f_n	f_n	f_n	f_n	L (ft)
2.0	1300	1295	1289	1283	2.33
3.0	578	575	573	570	3.50
4.0	325	324	322	321	4.67
5.0	208	207	206	205	5.83
6.0	144	144	143	143	7.00
7.0	106	106	105	105	8.17
8.0	81	81	81	80	9.33
9.0	64	64	64	63	10.50
10.0	52	52	52	51	11.67
11.0	43	43	43	42	12.83
12.0	36	36	36	36	14.00
13.0	31	31	31	30	15.17
14.0	27	26	26	26	16.33
15.0	23	23	23	23	17.50
16.0	20	20	20	20	18.67
17.0	18	18	18	18	19.83

Table D-2.3. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) WITH APPLIED AXIAL LOADS (Pinned-Pinned) (cont)



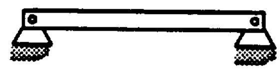
NPS = 14 in
D_o = 14.00 in
E = 28831000 lb/in^2

P/P_b = .75
λ = 3.1415926
μ = 489.535 lb/ft^3

t (in)	0.188	0.210	0.219	0.250	0.281	0.312	
D_i (in)	13.624	13.580	13.562	13.500	13.433	13.376	
W(lb/ft)	27.73	30.93	32.23	36.71	41.17	45.61	
L/D_o	f_n	f_n	f_n	f_n	f_n	f_n	L (ft)
2.0	970	968	968	965	963	961	2.33
3.0	431	430	430	429	428	427	3.50
4.0	242	242	242	241	241	240	4.67
5.0	155	155	155	154	154	154	5.83
6.0	108	108	108	107	107	107	7.00
7.0	79	79	79	79	79	78	8.17
8.0	61	61	60	60	60	60	9.33
9.0	48	48	48	48	48	47	10.50
10.0	39	39	39	39	39	38	11.67
11.0	32	32	32	32	32	32	12.83
12.0	27	27	27	27	27	27	14.00
13.0	23	23	23	23	23	23	15.17
14.0	20	20	20	20	20	20	16.33
15.0	17	17	17	17	17	17	17.50
16.0	15	15	15	15	15	15	18.67
17.0	13	13	13	13	13	13	19.83

t (in)	0.344	0.375	0.406	0.438	0.469	0.500	
D_i (in)	13.312	13.250	13.188	13.124	13.062	13.000	
W(lb/ft)	50.17	54.57	58.94	63.44	67.78	72.09	
L/D_o	f_n	f_n	f_n	f_n	f_n	f_n	L (ft)
2.0	959	957	955	953	951	948	2.33
3.0	426	425	424	423	422	422	3.50
4.0	240	239	239	238	238	237	4.67
5.0	153	153	153	152	152	152	5.83
6.0	107	106	106	106	106	105	7.00
7.0	78	78	78	78	78	77	8.17
8.0	60	60	60	60	59	59	9.33
9.0	47	47	47	47	47	47	10.50
10.0	38	38	38	38	38	38	11.67
11.0	32	32	32	31	31	31	12.83
12.0	27	27	27	26	26	26	14.00
13.0	23	23	23	23	22	22	15.17
14.0	20	20	19	19	19	19	16.33
15.0	17	17	17	17	17	17	17.50
16.0	15	15	15	15	15	15	18.67
17.0	13	13	13	13	13	13	19.83

Table D-2.3. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) WITH APPLIED AXIAL LOADS (Pinned-Pinned) (cont)



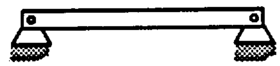
NPS = 14 in
D_o = 14.00 in
E = 28831000 lb/in²

P/P_b = .75
λ = 3.1415926
μ = 489.535 lb/ft³

t (in)	**0.562**	**0.625**	**0.688**	**0.750**	**0.812**	**0.875**	
D_i (in)	**12.876**	**12.750**	**12.624**	**12.500**	**12.376**	**12.250**	
W(lb/ft)	**80.66**	**89.28**	**97.81**	**106.13**	**114.37**	**122.65**	
L/D_o	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**L (ft)**
2.0	944	940	936	932	928	923	2.33
3.0	420	418	416	414	412	410	3.50
4.0	236	235	234	233	232	231	4.67
5.0	151	150	150	149	148	148	5.83
6.0	105	104	104	104	103	103	7.00
7.0	77	77	76	76	76	75	8.17
8.0	59	59	58	58	58	58	9.33
9.0	47	46	46	46	46	46	10.50
10.0	38	38	37	37	37	37	11.67
11.0	31	31	31	31	31	31	12.83
12.0	26	26	26	26	26	26	14.00
13.0	22	22	22	22	22	22	15.17
14.0	19	19	19	19	19	19	16.33
15.0	17	17	17	17	16	16	17.50
16.0	15	15	15	15	14	14	18.67
17.0	13	13	13	13	13	13	19.83

t (in)	**0.938**	**1.000**	**1.062**	**1.125**	
D_i (in)	**12.124**	**12.000**	**11.876**	**11.750**	
W(lb/ft)	**130.85**	**138.84**	**146.74**	**154.69**	
L/D_o	**f_n**	**f_n**	**f_n**	**f_n**	**L (ft)**
2.0	919	915	911	907	2.33
3.0	409	407	405	403	3.50
4.0	230	229	228	227	4.67
5.0	147	146	146	145	5.83
6.0	102	102	101	101	7.00
7.0	75	75	74	74	8.17
8.0	57	57	57	57	9.33
9.0	45	45	45	45	10.50
10.0	37	37	36	36	11.67
11.0	30	30	30	30	12.83
12.0	26	25	25	25	14.00
13.0	22	22	22	21	15.17
14.0	19	19	19	19	16.33
15.0	16	16	16	16	17.50
16.0	14	14	14	14	18.67
17.0	13	13	13	13	19.83

Table D-2.3. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) WITH APPLIED AXIAL LOADS (Pinned-Pinned) (cont)



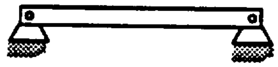
NPS = 16 in
D_o = 16.00 in
E = 28831000 lb/in^2

P/P_b = .25
λ = 3.1415926
μ = 489.535 lb/ft^3

t (in)	**0.188**	**0.203**	**0.219**	**0.250**	**0.281**	**0.312**	
D_i (in)	**15.624**	**15.594**	**15.562**	**15.500**	**15.438**	**15.376**	
W(lb/ft)	**31.75**	**34.25**	**36.91**	**42.05**	**47.17**	**52.27**	
L/D_o	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**L (ft)**
2.0	1472	1471	1469	1466	1464	1461	2.67
3.0	654	654	653	652	651	649	4.00
4.0	368	368	367	367	366	365	5.33
5.0	236	235	235	235	234	234	6.67
6.0	164	163	163	163	163	162	8.00
7.0	120	120	120	120	119	119	9.33
8.0	92	92	92	92	91	91	10.67
9.0	73	73	73	72	72	72	12.00
10.0	59	59	59	59	59	58	13.33
11.0	49	49	49	48	48	48	14.67
12.0	41	41	41	41	41	41	16.00
13.0	35	35	35	35	35	35	17.33
14.0	30	30	30	30	30	30	18.67
15.0	26	26	26	26	26	26	20.00
16.0	23	23	23	23	23	23	21.33
17.0	20	20	20	20	20	20	22.67

t (in)	**0.344**	**0.375**	**0.406**	**0.438**	**0.469**	**0.500**	
D_i (in)	**15.312**	**15.250**	**15.188**	**15.124**	**15.062**	**15.000**	
W(lb/ft)	**57.52**	**62.58**	**67.62**	**72.80**	**77.79**	**82.77**	
L/D_o	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**L (ft)**
2.0	1458	1455	1452	1449	1447	1444	2.67
3.0	648	647	645	644	643	642	4.00
4.0	364	364	363	362	362	361	5.33
5.0	233	233	232	232	231	231	6.67
6.0	162	162	161	161	161	160	8.00
7.0	119	119	119	118	118	118	9.33
8.0	91	91	91	91	90	90	10.67
9.0	72	72	72	72	71	71	12.00
10.0	58	58	58	58	58	58	13.33
11.0	48	48	48	48	48	48	14.67
12.0	40	40	40	40	40	40	16.00
13.0	35	34	34	34	34	34	17.33
14.0	30	30	30	30	30	29	18.67
15.0	26	26	26	26	26	26	20.00
16.0	23	23	23	23	23	23	21.33
17.0	20	20	20	20	20	20	22.67

Table D-2.3. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) WITH APPLIED AXIAL LOADS (Pinned-Pinned) (cont)



NPS = 16 in
D_o = 16.00 in
E = 28831000 lb/in^2

P/P_b = .25
λ = 3.1415926
μ = 489.535 lb/ft^3

t (in)	**0.562**	**0.625**	**0.688**	**0.750**	**0.812**	**0.875**	
D_i (in)	**14.876**	**14.750**	**14.624**	**14.500**	**14.376**	**14.250**	
W(lb/ft)	**92.66**	**102.63**	**112.51**	**122.15**	**131.71**	**141.34**	
L/D_o	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**L (ft)**
2.0	1438	1433	1427	1421	1416	1410	2.67
3.0	639	637	634	632	629	627	4.00
4.0	360	358	357	355	354	353	5.33
5.0	230	229	228	227	227	226	6.67
6.0	160	159	159	158	157	157	8.00
7.0	117	117	116	116	116	115	9.33
8.0	90	90	89	89	88	88	10.67
9.0	71	71	70	70	70	70	12.00
10.0	58	57	57	57	57	56	13.33
11.0	48	47	47	47	47	47	14.67
12.0	40	40	40	39	39	39	16.00
13.0	34	34	34	34	34	33	17.33
14.0	29	29	29	29	29	29	18.67
15.0	26	25	25	25	25	25	20.00
16.0	22	22	22	22	22	22	21.33
17.0	20	20	20	20	20	20	22.67

t (in)	**0.938**	**1.000**	**1.062**	**1.125**	**1.188**	**1.250**	
D_i (in)	**14.124**	**14.000**	**13.876**	**13.750**	**13.624**	**13.500**	
W(lb/ft)	**150.89**	**160.20**	**169.43**	**178.72**	**187.93**	**196.91**	
L/D_o	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**L (ft)**
2.0	1405	1400	1394	1389	1383	1378	2.67
3.0	624	622	620	617	615	612	4.00
4.0	351	350	349	347	346	345	5.33
5.0	225	224	223	222	221	220	6.67
6.0	156	156	155	154	154	153	8.00
7.0	115	114	114	113	113	112	9.33
8.0	88	87	87	87	86	86	10.67
9.0	69	69	69	69	68	68	12.00
10.0	56	56	56	56	55	55	13.33
11.0	46	46	46	46	46	46	14.67
12.0	39	39	39	39	38	38	16.00
13.0	33	33	33	33	33	33	17.33
14.0	29	29	28	28	28	28	18.67
15.0	25	25	25	25	25	28	20.00
16.0	22	22	22	22	22	24	21.33
17.0	19	19	19	19	19	22	22.67

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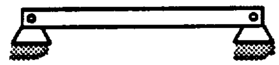
Table D-2.3. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) WITH APPLIED AXIAL LOADS (Pinned-Pinned) (cont)



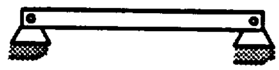
NPS = 16 in
D_o = 16.00 in
E = 28831000 lb/in^2

P/P_b = .50
λ = 3.1415926
μ = 489.535 lb/ft^3

t (in)	0.188	0.203	0.219	0.250	0.281	0.312	
D_i (in)	15.624	15.594	15.562	15.500	15.438	15.376	
W(lb/ft)	31.75	34.25	36.91	42.05	47.17	52.27	
L/D_o	f_n	f_n	f_n	f_n	f_n	f_n	L (ft)
2.0	1202	1201	1200	1197	1195	1193	2.67
3.0	534	534	533	532	531	530	4.00
4.0	301	300	300	299	299	298	5.33
5.0	192	192	192	192	191	191	6.67
6.0	134	133	133	133	133	133	8.00
7.0	98	98	98	98	98	97	9.33
8.0	75	75	75	75	75	75	10.67
9.0	59	59	59	59	59	59	12.00
10.0	48	48	48	48	48	48	13.33
11.0	40	40	40	40	40	39	14.67
12.0	33	33	33	33	33	33	16.00
13.0	28	28	28	28	28	28	17.33
14.0	25	25	24	24	24	24	18.67
15.0	21	21	21	21	21	21	20.00
16.0	19	19	19	19	19	19	21.33
17.0	17	17	17	17	17	17	22.67

t (in)	0.344	0.375	0.406	0.438	0.469	0.500	
D_i (in)	15.312	15.250	15.188	15.124	15.062	15.000	
W(lb/ft)	57.52	62.58	67.62	72.80	77.79	82.77	
L/D_o	f_n	f_n	f_n	f_n	f_n	f_n	L (ft)
2.0	1190	1188	1186	1183	1181	1179	2.67
3.0	529	528	527	526	525	524	4.00
4.0	298	297	296	296	295	295	5.33
5.0	190	190	190	189	189	189	6.67
6.0	132	132	132	131	131	131	8.00
7.0	97	97	97	97	96	96	9.33
8.0	74	74	74	74	74	74	10.67
9.0	59	59	59	58	58	58	12.00
10.0	48	48	47	47	47	47	13.33
11.0	39	39	39	39	39	39	14.67
12.0	33	33	33	33	33	33	16.00
13.0	28	28	28	28	28	28	17.33
14.0	24	24	24	24	24	24	18.67
15.0	21	21	21	21	21	21	20.00
16.0	19	19	19	18	18	18	21.33
17.0	16	16	16	16	16	16	22.67

Table D-2.3. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) WITH APPLIED AXIAL LOADS (Pinned-Pinned) (cont)



NPS = 16 in
D_o = 16.00 in
E = 28831000 lb/in^2

P/P_b = .50
λ = 3.1415926
μ = 489.535 lb/ft^3

t (in)	0.562	0.625	0.688	0.750	0.812	0.875	
D_i (in)	14.876	14.750	14.624	14.500	14.376	14.250	
W(lb/ft)	92.66	102.63	112.51	122.15	131.71	141.34	
L/D_o	f_n	f_n	f_n	f_n	f_n	f_n	L (ft)
2.0	1174	1170	1165	1161	1156	1152	2.67
3.0	522	520	518	516	514	512	4.00
4.0	294	292	291	290	289	288	5.33
5.0	188	187	186	186	185	184	6.67
6.0	130	130	129	129	128	128	8.00
7.0	96	95	95	95	94	94	9.33
8.0	73	73	73	73	72	72	10.67
9.0	58	58	58	57	57	57	12.00
10.0	47	47	47	46	46	46	13.33
11.0	39	39	39	38	38	38	14.67
12.0	33	32	32	32	32	32	16.00
13.0	28	28	28	27	27	27	17.33
14.0	24	24	24	24	24	24	18.67
15.0	21	21	21	21	21	20	20.00
16.0	18	18	18	18	18	18	21.33
17.0	16	16	16	16	16	16	22.67

t (in)	0.938	1.000	1.062	1.125	1.188	1.250	
D_i (in)	14.124	14.000	13.876	13.750	13.624	13.500	
W(lb/ft)	150.89	160.20	169.43	178.72	187.93	196.91	
L/D_o	f_n	f_n	f_n	f_n	f_n	f_n	L (ft)
2.0	1147	1143	1138	1134	1130	1125	2.67
3.0	510	508	506	504	502	500	4.00
4.0	287	286	285	283	282	281	5.33
5.0	184	183	182	181	181	180	6.67
6.0	127	127	126	126	126	125	8.00
7.0	94	93	93	93	92	92	9.33
8.0	72	71	71	71	71	70	10.67
9.0	57	56	56	56	56	56	12.00
10.0	46	46	46	45	45	45	13.33
11.0	38	38	38	37	37	37	14.67
12.0	32	32	32	31	31	31	16.00
13.0	27	27	27	27	27	27	17.33
14.0	23	23	23	23	23	23	18.67
15.0	20	20	20	20	20	20	20.00
16.0	18	18	18	18	18	18	21.33
17.0	16	16	16	16	16	16	22.67

Table D-2.3. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) WITH APPLIED AXIAL LOADS (Pinned-Pinned) (cont)

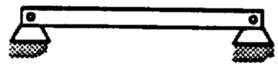
NPS = 16 in
D_o = 16.00 in
E = 28831000 lb/in^2

P/P_b = .75
λ = 3.1415926
μ = 489.535 lb/ft^3

t (in)	0.188	0.203	0.219	0.250	0.281	0.312	
D_i (in)	15.624	15.594	15.562	15.500	15.438	15.376	
W(lb/ft)	31.75	34.25	36.91	42.05	47.17	52.27	
L/D_o	f_n	f_n	f_n	f_n	f_n	f_n	L (ft)
2.0	850	849	848	847	845	843	2.67
3.0	378	377	377	376	376	375	4.00
4.0	212	212	212	212	211	211	5.33
5.0	136	136	136	135	135	135	6.67
6.0	94	94	94	94	94	94	8.00
7.0	69	69	69	69	69	69	9.33
8.0	53	53	53	53	53	53	10.67
9.0	42	42	42	42	42	42	12.00
10.0	34	34	34	34	34	34	13.33
11.0	28	28	28	28	28	28	14.67
12.0	24	24	24	24	23	23	16.00
13.0	20	20	20	20	20	20	17.33
14.0	17	17	17	17	17	17	18.67
15.0	15	15	15	15	15	15	20.00
16.0	13	13	13	13	13	13	21.33
17.0	12	12	12	12	12	12	22.67

t (in)	0.344	0.375	0.406	0.438	0.469	0.500	
D_i (in)	15.312	15.250	15.188	15.124	15.062	15.000	
W(lb/ft)	57.52	62.58	67.62	72.80	77.79	82.77	
L/D_o	f_n	f_n	f_n	f_n	f_n	f_n	L (ft)
2.0	842	840	838	837	835	834	2.67
3.0	374	373	373	372	371	370	4.00
4.0	210	210	210	209	209	208	5.33
5.0	135	134	134	134	134	133	6.67
6.0	94	93	93	93	93	93	8.00
7.0	69	69	68	68	68	68	9.33
8.0	53	53	52	52	52	52	10.67
9.0	42	41	41	41	41	41	12.00
10.0	34	34	34	33	33	33	13.33
11.0	28	28	28	28	28	28	14.67
12.0	23	23	23	23	23	23	16.00
13.0	20	20	20	20	20	20	17.33
14.0	17	17	17	17	17	17	18.67
15.0	15	15	15	15	15	15	20.00
16.0	13	13	13	13	13	13	21.33
17.0	12	12	12	12	12	12	22.67

Table D-2.3. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) WITH APPLIED AXIAL LOADS (Pinned-Pinned) (cont)



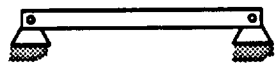
NPS = 16 in
D_o = 16.00 in
E = 28831000 lb/in^2

P/P_b = .75
λ = 3.1415926
μ = 489.535 lb/ft^3

t (in)	0.562	0.625	0.688	0.750	0.812	0.875	
D_I (in)	14.876	14.750	14.624	14.500	14.376	14.250	
W(lb/ft)	92.66	102.63	112.51	122.15	131.71	141.34	
L/D_o	f_n	f_n	f_n	f_n	f_n	f_n	L (ft)
2.0	830	827	824	821	818	814	2.67
3.0	369	368	366	365	363	362	4.00
4.0	208	207	206	205	204	204	5.33
5.0	133	132	132	131	131	130	6.67
6.0	92	92	92	91	91	90	8.00
7.0	68	68	67	67	67	66	9.33
8.0	52	52	51	51	51	51	10.67
9.0	41	41	41	41	40	40	12.00
10.0	33	33	33	33	33	33	13.33
11.0	27	27	27	27	27	27	14.67
12.0	23	23	23	23	23	23	16.00
13.0	20	20	19	19	19	19	17.33
14.0	17	17	17	17	17	17	18.67
15.0	15	15	15	15	15	14	20.00
16.0	13	13	13	13	13	13	21.33
17.0	11	11	11	11	11	11	22.67

t (in)	0.938	1.000	1.062	1.125	1.188	1.250	
D_I (in)	14.124	14.000	13.876	13.750	13.624	13.500	
W(lb/ft)	150.89	160.20	169.43	178.72	187.93	196.91	
L/D_o	f_n	f_n	f_n	f_n	f_n	f_n	L (ft)
2.0	811	808	805	802	799	796	2.67
3.0	361	359	358	356	355	354	4.00
4.0	203	202	201	200	200	199	5.33
5.0	130	129	129	128	128	127	6.67
6.0	90	90	89	89	89	88	8.00
7.0	66	66	66	65	65	65	9.33
8.0	51	51	50	50	50	50	10.67
9.0	40	40	40	40	39	39	12.00
10.0	32	32	32	32	32	32	13.33
11.0	27	27	27	27	26	26	14.67
12.0	23	22	22	22	22	22	16.00
13.0	19	19	19	19	19	19	17.33
14.0	17	16	16	16	16	16	18.67
15.0	14	14	14	14	14	14	20.00
16.0	13	13	13	13	12	12	21.33
17.0	11	11	11	11	11	11	22.67

Table D-2.3. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) WITH APPLIED AXIAL LOADS (Pinned-Pinned) (cont)



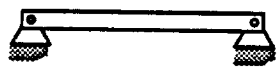
NPS = 18 in
D_o = 18.00 in
E = 28831000 lb/in²

P/P_b = .25
λ = 3.1415926
μ = 489.535 lb/ft³

t (in)	**0.188**	**0.219**	**0.250**	**0.281**	**0.312**	**0.344**	
D_i (in)	**17.624**	**17.562**	**17.500**	**17.438**	**17.376**	**17.312**	
W(lb/ft)	**35.76**	**41.59**	**47.39**	**53.18**	**58.94**	**64.87**	
L/D_o	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**L (ft)**
2.0	1310	1308	1306	1304	1301	1299	3.00
3.0	582	581	580	579	578	577	4.50
4.0	328	327	326	326	325	325	6.00
5.0	210	209	209	209	208	208	7.50
6.0	146	145	145	145	145	144	9.00
7.0	107	107	107	106	106	106	10.50
8.0	82	82	82	81	81	81	12.00
9.0	65	65	64	64	64	64	13.50
10.0	52	52	52	52	52	52	15.00
11.0	43	43	43	43	43	43	16.50
12.0	36	36	36	36	36	36	18.00
13.0	31	31	31	31	31	31	19.50
14.0	27	27	27	27	27	27	21.00
15.0	23	23	23	23	23	23	22.50
16.0	20	20	20	20	20	20	24.00
17.0	18	18	18	18	18	18	25.50

t (in)	**0.375**	**0.406**	**0.438**	**0.469**	**0.500**	**0.562**	
D_i (in)	**17.250**	**17.188**	**17.124**	**17.062**	**17.000**	**16.876**	
W(lb/ft)	**70.59**	**76.29**	**82.15**	**87.81**	**93.45**	**104.67**	
L/D_o	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**L (ft)**
2.0	1297	1295	1292	1290	1288	1283	3.00
3.0	576	575	574	573	572	570	4.50
4.0	324	324	323	323	322	321	6.00
5.0	207	207	207	206	206	205	7.50
6.0	144	144	144	143	143	143	9.00
7.0	106	106	105	105	105	105	10.50
8.0	81	81	81	81	80	80	12.00
9.0	64	64	64	64	64	63	13.50
10.0	52	52	52	52	52	51	15.00
11.0	43	43	43	43	43	42	16.50
12.0	36	36	36	36	36	36	18.00
13.0	31	31	31	31	30	30	19.50
14.0	26	26	26	26	26	26	21.00
15.0	23	23	23	23	23	23	22.50
16.0	20	20	20	20	20	20	24.00
17.0	18	18	18	18	18	18	25.50

Table D-2.3. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) WITH APPLIED AXIAL LOADS (Pinned-Pinned) (cont)



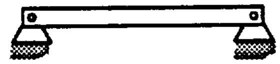
NPS = 18 in
D_o = 18.00 in
E = 28831000 lb/in^2

P/P_b = .25
λ = 3.1415926
μ = 489.535 lb/ft^3

t (in)	0.625	0.688	0.750	0.812	0.875	0.938	
D_i (in)	16.750	16.624	16.500	16.376	16.250	16.124	
W(lb/ft)	115.98	127.21	138.17	149.06	160.03	170.92	
L/D_o	f_n	f_n	f_n	f_n	f_n	f_n	L (ft)
2.0	1279	1274	1270	1266	1261	1257	3.00
3.0	568	566	564	563	561	559	4.50
4.0	320	319	318	316	315	314	6.00
5.0	205	204	203	203	202	201	7.50
6.0	142	142	141	141	140	140	9.00
7.0	104	104	104	103	103	103	10.50
8.0	80	80	79	79	79	79	12.00
9.0	63	63	63	63	62	62	13.50
10.0	51	51	51	51	50	50	15.00
11.0	42	42	42	42	42	42	16.50
12.0	36	35	35	35	35	35	18.00
13.0	30	30	30	30	30	30	19.50
14.0	26	26	26	26	26	26	21.00
15.0	23	23	23	23	22	22	22.50
16.0	20	20	20	20	20	20	24.00
17.0	18	18	18	18	17	17	25.50

t (in)	1.000	1.062	1.125	1.188	1.250	
D_i (in)	16.000	15.876	15.750	15.624	15.500	
W(lb/ft)	181.56	192.11	202.75	213.31	223.61	
L/D_o	f_n	f_n	f_n	f_n	f_n	L (ft)
2.0	1253	1248	1244	1240	1236	3.00
3.0	557	555	553	551	549	4.50
4.0	313	312	311	310	309	6.00
5.0	200	200	199	198	198	7.50
6.0	139	139	138	138	137	9.00
7.0	102	102	102	101	101	10.50
8.0	78	78	78	77	77	12.00
9.0	62	62	61	61	61	13.50
10.0	50	50	50	50	49	15.00
11.0	41	41	41	41	41	16.50
12.0	35	35	35	34	34	18.00
13.0	30	30	29	29	29	19.50
14.0	26	25	25	25	25	21.00
15.0	22	22	22	22	22	22.50
16.0	20	20	19	19	19	24.00
17.0	17	17	17	17	17	25.50

Table D-2.3. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) WITH APPLIED AXIAL LOADS (Pinned-Pinned) (cont)



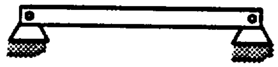
NPS = 18 in
D_o = 18.00 in
E = 28831000 lb/in^2

P/P_b = .50
λ = 3.1415926
μ = 489.535 lb/ft^3

t (in)	0.188	0.219	0.250	0.281	0.312	0.344	
D_i (in)	17.624	17.562	17.500	17.438	17.376	17.312	
W(lb/ft)	35.76	41.59	47.39	53.18	58.94	64.87	
L/D_o	f_n	f_n	f_n	f_n	f_n	f_n	L (ft)
2.0	1070	1068	1066	1064	1063	1061	3.00
3.0	475	475	474	473	472	471	4.50
4.0	267	267	267	266	266	265	6.00
5.0	171	171	171	170	170	170	7.50
6.0	119	119	118	118	118	118	9.00
7.0	87	87	87	87	87	87	10.50
8.0	67	67	67	67	66	66	12.00
9.0	53	53	53	53	52	52	13.50
10.0	43	43	43	43	43	42	15.00
11.0	35	35	35	35	35	35	16.50
12.0	30	30	30	30	30	29	18.00
13.0	25	25	25	25	25	25	19.50
14.0	22	22	22	22	22	22	21.00
15.0	19	19	19	19	19	19	22.50
16.0	17	17	17	17	17	17	24.00
17.0	15	15	15	15	15	15	25.50

t (in)	0.375	0.406	0.438	0.469	0.500	0.562	
D_i (in)	17.250	17.188	17.124	17.062	17.000	16.876	
W(lb/ft)	70.59	76.29	82.15	87.81	93.45	104.67	
L/D_o	f_n	f_n	f_n	f_n	f_n	f_n	L (ft)
2.0	1059	1057	1055	1053	1051	1048	3.00
3.0	471	470	469	468	467	466	4.50
4.0	265	264	264	263	263	262	6.00
5.0	169	169	169	169	168	168	7.50
6.0	118	117	117	117	117	116	9.00
7.0	86	86	86	86	86	86	10.50
8.0	66	66	66	66	66	65	12.00
9.0	52	52	52	52	52	52	13.50
10.0	42	42	42	42	42	42	15.00
11.0	35	35	35	35	35	35	16.50
12.0	29	29	29	29	29	29	18.00
13.0	25	25	25	25	25	25	19.50
14.0	22	22	22	21	21	21	21.00
15.0	19	19	19	19	19	19	22.50
16.0	17	17	16	16	16	16	24.00
17.0	15	15	15	15	15	15	25.50

Table D-2.3. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) WITH APPLIED AXIAL LOADS (Pinned-Pinned) (cont)



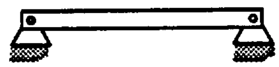
NPS = 18 in
D_o = 18.00 in
E = 28831000 lb/in^2

P/P_b = .50
λ = 3.1415926
μ = 489.535 lb/ft^3

t (in)	**0.625**	**0.688**	**0.750**	**0.812**	**0.875**	**0.938**	
D_i (in)	**16.750**	**16.624**	**16.500**	**16.376**	**16.250**	**16.124**	
W(lb/ft)	**115.98**	**127.21**	**138.17**	**149.06**	**160.03**	**170.92**	
L/D_o	f_n	f_n	f_n	f_n	f_n	f_n	L (ft)
2.0	1044	1041	1037	1033	1030	1026	3.00
3.0	464	462	461	459	458	456	4.50
4.0	261	260	259	258	257	257	6.00
5.0	167	166	166	165	165	164	7.50
6.0	116	116	115	115	114	114	9.00
7.0	85	85	85	84	84	84	10.50
8.0	65	65	65	65	64	64	12.00
9.0	52	51	51	51	51	51	13.50
10.0	42	42	41	41	41	41	15.00
11.0	35	34	34	34	34	34	16.50
12.0	29	29	29	29	29	29	18.00
13.0	25	25	25	24	24	24	19.50
14.0	21	21	21	21	21	21	21.00
15.0	19	18	18	18	18	18	22.50
16.0	16	16	16	16	16	16	24.00
17.0	14	14	14	14	14	14	25.50

t (in)	**1.000**	**1.062**	**1.125**	**1.188**	**1.250**	
D_i (in)	**16.000**	**15.876**	**15.750**	**15.624**	**15.500**	
W(lb/ft)	**181.56**	**192.11**	**202.75**	**213.31**	**223.61**	
L/D_o	f_n	f_n	f_n	f_n	f_n	L (ft)
2.0	1023	1019	1016	1012	1009	3.00
3.0	455	453	451	450	448	4.50
4.0	256	255	254	253	252	6.00
5.0	164	163	163	162	161	7.50
6.0	114	113	113	112	112	9.00
7.0	83	83	83	83	82	10.50
8.0	64	64	63	63	63	12.00
9.0	51	50	50	50	50	13.50
10.0	41	41	41	40	40	15.00
11.0	34	34	34	33	33	16.50
12.0	28	28	28	28	28	18.00
13.0	24	24	24	24	24	19.50
14.0	21	21	21	21	21	21.00
15.0	18	18	18	18	18	22.50
16.0	16	16	16	16	16	24.00
17.0	14	14	14	14	14	25.50

Table D-2.3. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) WITH APPLIED AXIAL LOADS (Pinned-Pinned) (cont)



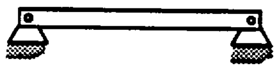
NPS = 18 in
D_o = 18.00 in
E = 28831000 lb/in^2

P/P_b = .75
λ = 3.1415926
μ = 489.535 lb/ft^3

t (in)	**0.188**	**0.219**	**0.250**	**0.281**	**0.312**	**0.344**	
D_i (in)	**17.624**	**17.562**	**17.500**	**17.438**	**17.376**	**17.312**	
W(lb/ft)	**35.76**	**41.59**	**47.39**	**53.18**	**58.94**	**64.87**	
L/D_o	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**L (ft)**
2.0	757	755	754	753	751	750	3.00
3.0	336	336	335	334	334	333	4.50
4.0	189	189	188	188	188	187	6.00
5.0	121	121	121	120	120	120	7.50
6.0	84	84	84	84	83	83	9.00
7.0	62	62	62	61	61	61	10.50
8.0	47	47	47	47	47	47	12.00
9.0	37	37	37	37	37	37	13.50
10.0	30	30	30	30	30	30	15.00
11.0	25	25	25	25	25	25	16.50
12.0	21	21	21	21	21	21	18.00
13.0	18	18	18	18	18	18	19.50
14.0	15	15	15	15	15	15	21.00
15.0	13	13	13	13	13	13	22.50
16.0	12	12	12	12	12	12	24.00
17.0	10	10	10	10	10	10	25.50

t (in)	**0.375**	**0.406**	**0.438**	**0.469**	**0.500**	**0.562**	
D_i (in)	**17.250**	**17.188**	**17.124**	**17.062**	**17.000**	**16.876**	
W(lb/ft)	**70.59**	**76.29**	**82.15**	**87.81**	**93.45**	**104.67**	
L/D_o	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**L (ft)**
2.0	749	747	746	745	744	741	3.00
3.0	333	332	332	331	330	329	4.50
4.0	187	187	187	186	186	185	6.00
5.0	120	120	119	119	119	119	7.50
6.0	83	83	83	83	83	82	9.00
7.0	61	61	61	61	61	60	10.50
8.0	47	47	47	47	46	46	12.00
9.0	37	37	37	37	37	37	13.50
10.0	30	30	30	30	30	30	15.00
11.0	25	25	25	25	25	24	16.50
12.0	21	21	21	21	21	21	18.00
13.0	18	18	18	18	18	18	19.50
14.0	15	15	15	15	15	15	21.00
15.0	13	13	13	13	13	13	22.50
16.0	12	12	12	12	12	12	24.00
17.0	10	10	10	10	10	10	25.50

Table D-2.3. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) WITH APPLIED AXIAL LOADS (Pinned-Pinned) (cont)



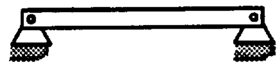
NPS = 18 in
D_o = 18.00 in
E = 28831000 lb/in^2

P/P_b = .75
λ = 3.1415926
μ = 489.535 lb/ft^3

t (in)	0.625	0.688	0.750	0.812	0.875	0.938	
D_I (in)	16.750	16.624	16.500	16.376	16.250	16.124	
W(lb/ft)	115.98	127.21	138.17	149.06	160.03	170.92	
L/D_o	f_n	f_n	f_n	f_n	f_n	f_n	L (ft)
2.0	738	736	733	731	728	726	3.00
3.0	328	327	326	325	324	323	4.50
4.0	185	184	183	183	182	181	6.00
5.0	118	118	117	117	117	116	7.50
6.0	82	82	81	81	81	81	9.00
7.0	60	60	60	60	59	59	10.50
8.0	46	46	46	46	46	45	12.00
9.0	36	36	36	36	36	36	13.50
10.0	30	29	29	29	29	29	15.00
11.0	24	24	24	24	24	24	16.50
12.0	21	20	20	20	20	20	18.00
13.0	17	17	17	17	17	17	19.50
14.0	15	15	15	15	15	15	21.00
15.0	13	13	13	13	13	13	22.50
16.0	12	11	11	11	11	11	24.00
17.0	10	10	10	10	10	10	25.50

t (in)	1.000	1.062	1.125	1.188	1.250	
D_I (in)	16.000	15.876	15.750	15.624	15.500	
W(lb/ft)	181.56	192.11	202.75	213.31	223.61	
L/D_o	f_n	f_n	f_n	f_n	f_n	L (ft)
2.0	723	721	718	716	713	3.00
3.0	321	320	319	318	317	4.50
4.0	181	180	180	179	178	6.00
5.0	116	115	115	115	114	7.50
6.0	80	80	80	80	79	9.00
7.0	59	59	59	58	58	10.50
8.0	45	45	45	45	45	12.00
9.0	36	36	35	35	35	13.50
10.0	29	29	29	29	29	15.00
11.0	24	24	24	24	24	16.50
12.0	20	20	20	20	20	18.00
13.0	17	17	17	17	17	19.50
14.0	15	15	15	15	15	21.00
15.0	13	13	13	13	13	22.50
16.0	11	11	11	11	11	24.00
17.0	10	10	10	10	10	25.50

Table D-2.3. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) WITH APPLIED AXIAL LOADS (Pinned-Pinned) (cont)



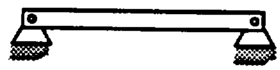
NPS = 20 in
D_o = 20.00 in
E = 28831000 lb/in^2

P/P_b = .25
λ = 3.1415926
μ = 489.535 lb/ft^3

t (in)	0.219	0.250	0.281	0.312	0.344	0.375	
D_i (in)	19.562	19.500	19.438	19.376	19.312	19.250	
W(lb/ft)	46.27	52.73	59.18	65.60	72.21	78.60	
L/D_o	f_n	f_n	f_n	f_n	f_n	f_n	L (ft)
2.0	1179	1177	1175	1173	1171	1170	3.33
3.0	524	523	522	521	521	520	5.00
4.0	295	294	294	293	293	292	6.67
5.0	189	188	188	188	187	187	8.33
6.0	131	131	131	130	130	130	10.00
7.0	96	96	96	96	96	95	11.67
8.0	74	74	73	73	73	73	13.33
9.0	58	58	58	58	58	58	15.00
10.0	47	47	47	47	47	47	16.67
11.0	39	39	39	39	39	39	18.33
12.0	33	33	33	33	33	32	20.00
13.0	28	28	28	28	28	28	21.67
14.0	24	24	24	24	24	24	23.33
15.0	21	21	21	21	21	21	25.00
16.0	18	18	18	18	18	18	26.67
17.0	16	16	16	16	16	16	28.33

t (in)	0.406	0.438	0.469	0.500	0.562	0.625	
D_i (in)	19.188	19.124	19.062	19.000	18.876	18.750	
W(lb/ft)	84.96	91.51	97.83	104.13	116.67	129.33	
L/D_o	f_n	f_n	f_n	f_n	f_n	f_n	L (ft)
2.0	1168	1166	1164	1162	1159	1155	3.33
3.0	519	518	517	517	515	513	5.00
4.0	292	291	291	291	290	289	6.67
5.0	187	187	186	186	185	185	8.33
6.0	130	130	129	129	129	128	10.00
7.0	95	95	95	95	95	94	11.67
8.0	73	73	73	73	72	72	13.33
9.0	58	58	57	57	57	57	15.00
10.0	47	47	47	46	46	46	16.67
11.0	39	39	38	38	38	38	18.33
12.0	32	32	32	32	32	32	20.00
13.0	28	28	28	28	27	27	21.67
14.0	24	24	24	24	24	24	23.33
15.0	21	21	21	21	21	21	25.00
16.0	18	18	18	18	18	18	26.67
17.0	16	16	16	16	16	16	28.33

Table D-2.3. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) WITH APPLIED AXIAL LOADS (Pinned-Pinned) (cont)



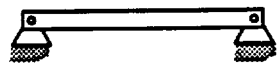
NPS = 20 in
D_o = 20.00 in
E = 28831000 lb/in^2

P/P_b = .25
λ = 3.1415926
μ = 489.535 lb/ft^3

t (in)	**0.688**	**0.750**	**0.812**	**0.875**	**0.938**	**1.000**	
D_i (in)	**18.624**	**18.500**	**18.376**	**18.250**	**18.124**	**18.000**	
W(lb/ft)	**141.90**	**154.19**	**166.40**	**178.72**	**190.96**	**202.92**	
L/D_o	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**L (ft)**
2.0	1151	1148	1144	1141	1137	1134	3.33
3.0	512	510	509	507	505	504	5.00
4.0	288	287	286	285	284	283	6.67
5.0	184	184	183	183	182	181	8.33
6.0	128	128	127	127	126	126	10.00
7.0	94	94	93	93	93	93	11.67
8.0	72	72	72	71	71	71	13.33
9.0	57	57	57	56	56	56	15.00
10.0	46	46	46	46	45	45	16.67
11.0	38	38	38	38	38	37	18.33
12.0	32	32	32	32	32	31	20.00
13.0	27	27	27	27	27	27	21.67
14.0	23	23	23	23	23	23	23.33
15.0	20	20	20	20	20	20	25.00
16.0	18	18	18	18	18	18	26.67
17.0	16	16	16	16	16	16	28.33

t (in)	**1.062**	**1.125**	**1.188**	**1.250**	**1.312**	**1.375**	
D_i (in)	**17.876**	**17.750**	**17.624**	**17.500**	**17.376**	**17.250**	
W(lb/ft)	**214.80**	**226.78**	**238.68**	**250.31**	**261.86**	**273.51**	
L/D_o	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**L (ft)**
2.0	1130	1127	1123	1120	1116	1113	3.33
3.0	502	501	499	498	496	495	5.00
4.0	283	282	281	280	279	278	6.67
5.0	181	180	180	179	179	178	8.33
6.0	126	125	125	124	124	124	10.00
7.0	92	92	92	91	91	91	11.67
8.0	71	70	70	70	70	70	13.33
9.0	56	56	55	55	55	55	15.00
10.0	45	45	45	45	45	45	16.67
11.0	37	37	37	37	37	37	18.33
12.0	31	31	31	31	31	31	20.00
13.0	27	27	27	27	26	26	21.67
14.0	23	23	23	23	23	23	23.33
15.0	20	20	20	20	20	20	25.00
16.0	18	18	18	17	17	17	26.67
17.0	16	16	16	15	15	15	28.33

Table D-2.3. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) WITH APPLIED AXIAL LOADS (Pinned-Pinned) (cont)



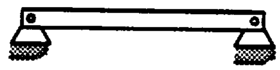
NPS = 20 in
D_o = 20.00 in
E = 28831000 lb/in^2

P/P_b = .50
λ = 3.1415926
μ = 489.535 lb/ft^3

t (in)	0.219	0.250	0.281	0.312	0.344	0.375	
D_i (in)	19.562	19.500	19.438	19.376	19.312	19.250	
W(lb/ft)	46.27	52.73	59.18	65.60	72.21	78.60	
L/D_o	f_n	f_n	f_n	f_n	f_n	f_n	L (ft)
2.0	962	961	959	958	956	955	3.33
3.0	428	427	426	426	425	424	5.00
4.0	241	240	240	239	239	239	6.67
5.0	154	154	154	153	153	153	8.33
6.0	107	107	107	106	106	106	10.00
7.0	79	78	78	78	78	78	11.67
8.0	60	60	60	60	60	60	13.33
9.0	48	47	47	47	47	47	15.00
10.0	38	38	38	38	38	38	16.67
11.0	32	32	32	32	32	32	18.33
12.0	27	27	27	27	27	27	20.00
13.0	23	23	23	23	23	23	21.67
14.0	20	20	20	20	20	19	23.33
15.0	17	17	17	17	17	17	25.00
16.0	15	15	15	15	15	15	26.67
17.0	13	13	13	13	13	13	28.33

t (in)	0.406	0.438	0.469	0.500	0.562	0.625	
D_i (in)	19.188	19.124	19.062	19.000	18.876	18.750	
W(lb/ft)	84.96	91.51	97.83	104.13	116.67	129.33	
L/D_o	f_n	f_n	f_n	f_n	f_n	f_n	L (ft)
2.0	953	952	950	949	946	943	3.33
3.0	424	423	422	422	420	419	5.00
4.0	238	238	238	237	237	236	6.67
5.0	153	152	152	152	151	151	8.33
6.0	106	106	106	105	105	105	10.00
7.0	78	78	78	77	77	77	11.67
8.0	60	59	59	59	59	59	13.33
9.0	47	47	47	47	47	47	15.00
10.0	38	38	38	38	38	38	16.67
11.0	32	31	31	31	31	31	18.33
12.0	26	26	26	26	26	26	20.00
13.0	23	23	22	22	22	22	21.67
14.0	19	19	19	19	19	19	23.33
15.0	17	17	17	17	17	17	25.00
16.0	15	15	15	15	15	15	26.67
17.0	13	13	13	13	13	13	28.33

Table D-2.3. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) WITH APPLIED AXIAL LOADS (Pinned-Pinned) (cont)



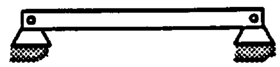
NPS = 20 in
D_o = 20.00 in
E = 28831000 lb/in^2

P/P_b = .50
λ = 3.1415926
μ = 489.535 lb/ft^3

t (in)	0.688	0.750	0.812	0.875	0.938	1.000	
D_i (in)	18.624	18.500	18.376	18.250	18.124	18.000	
W(lb/ft)	141.90	154.19	166.40	178.72	190.96	202.92	
L/D_o	f_n	f_n	f_n	f_n	f_n	f_n	L (ft)
2.0	940	937	934	931	928	926	3.33
3.0	418	417	415	414	413	411	5.00
4.0	235	234	234	233	232	231	6.67
5.0	150	150	149	149	149	148	8.33
6.0	104	104	104	103	103	103	10.00
7.0	77	77	76	76	76	76	11.67
8.0	59	59	58	58	58	58	13.33
9.0	46	46	46	46	46	46	15.00
10.0	38	37	37	37	37	37	16.67
11.0	31	31	31	31	31	31	18.33
12.0	26	26	26	26	26	26	20.00
13.0	22	22	22	22	22	22	21.67
14.0	19	19	19	19	19	19	23.33
15.0	17	17	17	17	17	16	25.00
16.0	15	15	15	15	15	14	26.67
17.0	13	13	13	13	13	13	28.33

t (in)	1.062	1.125	1.188	1.250	1.312	1.375	
D_i (in)	17.876	17.750	17.624	17.500	17.376	17.250	
W(lb/ft)	214.80	226.78	238.68	250.31	261.86	273.51	
L/D_o	f_n	f_n	f_n	f_n	f_n	f_n	L (ft)
2.0	923	920	917	914	911	909	3.33
3.0	410	409	408	406	405	404	5.00
4.0	231	230	229	229	228	227	6.67
5.0	148	147	147	146	146	145	8.33
6.0	103	102	102	102	101	101	10.00
7.0	75	75	75	75	74	74	11.67
8.0	58	57	57	57	57	57	13.33
9.0	46	45	45	45	45	45	15.00
10.0	37	37	37	37	36	36	16.67
11.0	31	30	30	30	30	30	18.33
12.0	26	26	25	25	25	25	20.00
13.0	22	22	22	22	22	22	21.67
14.0	19	19	19	19	19	19	23.33
15.0	16	16	16	16	16	16	25.00
16.0	14	14	14	14	14	14	26.67
17.0	13	13	13	13	13	13	28.33

Table D-2.3. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) WITH APPLIED AXIAL LOADS (Pinned-Pinned) (cont)



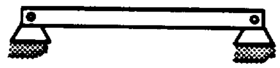
NPS = 20 in
D_o = 20.00 in
E = 28831000 lb/in^2

P/P_b = .75
λ = 3.1415926
μ = 489.535 lb/ft^3

t (in)	**0.219**	**0.250**	**0.281**	**0.312**	**0.344**	**0.375**	
D_i (in)	**19.562**	**19.500**	**19.438**	**19.376**	**19.312**	**19.250**	
W(lb/ft)	**46.27**	**52.73**	**59.18**	**65.60**	**72.21**	**78.60**	
L/D_o	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**L (ft)**
2.0	681	679	678	677	676	675	3.33
3.0	302	302	302	301	301	300	5.00
4.0	170	170	170	169	169	169	6.67
5.0	109	109	109	108	108	108	8.33
6.0	76	75	75	75	75	75	10.00
7.0	56	55	55	55	55	55	11.67
8.0	43	42	42	42	42	42	13.33
9.0	34	34	34	33	33	33	15.00
10.0	27	27	27	27	27	27	16.67
11.0	22	22	22	22	22	22	18.33
12.0	19	19	19	19	19	19	20.00
13.0	16	16	16	16	16	16	21.67
14.0	14	14	14	14	14	14	23.33
15.0	12	12	12	12	12	12	25.00
16.0	11	11	11	11	11	11	26.67
17.0	9	9	9	9	9	9	28.33

t (in)	**0.406**	**0.438**	**0.469**	**0.500**	**0.562**	**0.625**	
D_i (in)	**19.188**	**19.124**	**19.062**	**19.000**	**18.876**	**18.750**	
W(lb/ft)	**84.96**	**91.51**	**97.83**	**104.13**	**116.67**	**129.33**	
L/D_o	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**L (ft)**
2.0	674	673	672	671	669	667	3.33
3.0	300	299	299	298	297	296	5.00
4.0	169	168	168	168	167	167	6.67
5.0	108	108	108	107	107	107	8.33
6.0	75	75	75	75	74	74	10.00
7.0	55	55	55	55	55	54	11.67
8.0	42	42	42	42	42	42	13.33
9.0	33	33	33	33	33	33	15.00
10.0	27	27	27	27	27	27	16.67
11.0	22	22	22	22	22	22	18.33
12.0	19	19	19	19	19	19	20.00
13.0	16	16	16	16	16	16	21.67
14.0	14	14	14	14	14	14	23.33
15.0	12	12	12	12	12	12	25.00
16.0	11	11	11	10	10	10	26.67
17.0	9	9	9	9	9	9	28.33

Table D-2.3. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) WITH APPLIED AXIAL LOADS (Pinned-Pinned) (cont)



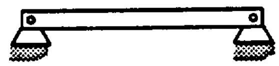
NPS = 20 in
D_o = 20.00 in
E = 28831000 lb/in^2

P/P_b = .75
λ = 3.1415926
μ = 489.535 lb/ft^3

t (in)	**0.688**	**0.750**	**0.812**	**0.875**	**0.938**	**1.000**	
D_i (in)	**18.624**	**18.500**	**18.376**	**18.250**	**18.124**	**18.000**	
W(lb/ft)	**141.90**	**154.19**	**166.40**	**178.72**	**190.96**	**202.92**	
L/D_o	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**L (ft)**
2.0	665	663	661	659	657	655	3.33
3.0	295	295	294	293	292	291	5.00
4.0	166	166	165	165	164	164	6.67
5.0	106	106	106	105	105	105	8.33
6.0	74	74	73	73	73	73	10.00
7.0	54	54	54	54	54	53	11.67
8.0	42	41	41	41	41	41	13.33
9.0	33	33	33	33	32	32	15.00
10.0	27	27	26	26	26	26	16.67
11.0	22	22	22	22	22	22	18.33
12.0	18	18	18	18	18	18	20.00
13.0	16	16	16	16	16	15	21.67
14.0	14	14	13	13	13	13	23.33
15.0	12	12	12	12	12	12	25.00
16.0	10	10	10	10	10	10	26.67
17.0	9	9	9	9	9	9	28.33

t (in)	**1.062**	**1.125**	**1.188**	**1.250**	**1.312**	**1.375**	
D_i (in)	**17.876**	**17.750**	**17.624**	**17.500**	**17.376**	**17.250**	
W(lb/ft)	**214.80**	**226.78**	**238.68**	**250.31**	**261.86**	**273.51**	
L/D_o	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**L (ft)**
2.0	652	650	648	646	644	642	3.33
3.0	290	289	288	287	286	286	5.00
4.0	163	163	162	162	161	161	6.67
5.0	104	104	104	103	103	103	8.33
6.0	72	72	72	72	72	71	10.00
7.0	53	53	53	53	53	52	11.67
8.0	41	41	41	40	40	40	13.33
9.0	32	32	32	32	32	32	15.00
10.0	26	26	26	26	26	26	16.67
11.0	22	22	21	21	21	21	18.33
12.0	18	18	18	18	18	18	20.00
13.0	15	15	15	15	15	15	21.67
14.0	13	13	13	13	13	13	23.33
15.0	12	12	12	11	11	11	25.00
16.0	10	10	10	10	10	10	26.67
17.0	9	9	9	9	9	9	28.33

Table D-2.3. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) WITH APPLIED AXIAL LOADS (Pinned-Pinned) (cont)



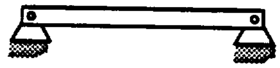
NPS = 22 in
D_o = 22.00 in
E = 28831000 lb/in^2

P/P_b = .25
λ = 3.1415926
μ = 489.535 lb/ft^3

t (in)	0.219	0.250	0.281	0.312	0.344	0.375	
D_i (in)	21.562	21.500	21.438	21.376	21.312	21.250	
W(lb/ft)	50.94	58.07	65.18	72.27	79.56	86.61	
L/D_o	f_n	f_n	f_n	f_n	f_n	f_n	L (ft)
2.0	1073	1071	1070	1068	1067	1065	3.67
3.0	477	476	475	475	474	473	5.50
4.0	268	268	267	267	267	266	7.33
5.0	172	171	171	171	171	170	9.17
6.0	119	119	119	119	119	118	11.00
7.0	88	87	87	87	87	87	12.83
8.0	67	67	67	67	67	67	14.67
9.0	53	53	53	53	53	53	16.50
10.0	43	43	43	43	43	43	18.33
11.0	35	35	35	35	35	35	20.17
12.0	30	30	30	30	30	30	22.00
13.0	25	25	25	25	25	25	23.83
14.0	22	22	22	22	22	22	25.67
15.0	19	19	19	19	19	19	27.50
16.0	17	17	17	17	17	17	29.33
17.0	15	15	15	15	15	15	31.17

t (in)	0.406	0.438	0.469	0.500	0.562	0.625	
D_i (in)	21.188	21.124	21.062	21.000	20.876	20.750	
W(lb/ft)	93.63	100.86	107.85	114.81	128.67	142.68	
L/D_o	f_n	f_n	f_n	f_n	f_n	f_n	L (ft)
2.0	1064	1062	1060	1059	1056	1053	3.67
3.0	473	472	471	471	469	468	5.50
4.0	266	265	265	265	264	263	7.33
5.0	170	170	170	169	169	168	9.17
6.0	118	118	118	118	117	117	11.00
7.0	87	87	87	86	86	86	12.83
8.0	66	66	66	66	66	66	14.67
9.0	53	52	52	52	52	52	16.50
10.0	43	42	42	42	42	42	18.33
11.0	35	35	35	35	35	35	20.17
12.0	30	29	29	29	29	29	22.00
13.0	25	25	25	25	25	25	23.83
14.0	22	22	22	22	22	21	25.67
15.0	19	19	19	19	19	19	27.50
16.0	17	17	17	17	17	16	29.33
17.0	15	15	15	15	15	15	31.17

Table D-2.3. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) WITH APPLIED AXIAL LOADS (Pinned-Pinned) (cont)



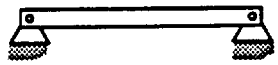
NPS = 22 in
D_o = 22.00 in
E = 28831000 lb/in^2

P/P_b = .25
λ = 3.1415926
μ = 489.535 lb/ft^3

t (in)	0.688	0.750	0.812	0.875	0.938	1.000	
D_i (in)	20.624	20.500	20.376	20.250	20.124	20.000	
W(lb/ft)	156.60	170.21	183.75	197.41	211.00	224.28	
L/D_o	f_n	f_n	f_n	f_n	f_n	f_n	L (ft)
2.0	1050	1047	1044	1041	1038	1035	3.67
3.0	467	465	464	463	461	460	5.50
4.0	262	262	261	260	260	259	7.33
5.0	168	168	167	167	166	166	9.17
6.0	117	116	116	116	115	115	11.00
7.0	86	85	85	85	85	85	12.83
8.0	66	65	65	65	65	65	14.67
9.0	52	52	52	51	51	51	16.50
10.0	42	42	42	42	42	41	18.33
11.0	35	35	35	34	34	34	20.17
12.0	29	29	29	29	29	29	22.00
13.0	25	25	25	25	25	25	23.83
14.0	21	21	21	21	21	21	25.67
15.0	19	19	19	19	18	18	27.50
16.0	16	16	16	16	16	16	29.33
17.0	15	14	14	14	14	14	31.17

t (in)	1.062	1.125	1.188	1.250	1.312	1.375	
D_i (in)	19.876	19.750	19.624	19.500	19.376	19.250	
W(lb/ft)	237.48	250.81	264.06	277.01	289.88	302.88	
L/D_o	f_n	f_n	f_n	f_n	f_n	f_n	L (ft)
2.0	1032	1029	1026	1024	1021	1018	3.67
3.0	459	458	456	455	454	452	5.50
4.0	258	257	257	256	255	254	7.33
5.0	165	165	164	164	163	163	9.17
6.0	115	114	114	114	113	113	11.00
7.0	84	84	84	84	83	83	12.83
8.0	65	64	64	64	64	64	14.67
9.0	51	51	51	51	50	50	16.50
10.0	41	41	41	41	41	41	18.33
11.0	34	34	34	34	34	34	20.17
12.0	29	29	29	28	28	28	22.00
13.0	24	24	24	24	24	24	23.83
14.0	21	21	21	21	21	21	25.67
15.0	18	18	18	18	18	18	27.50
16.0	16	16	16	16	16	16	29.33
17.0	14	14	14	14	14	14	31.17

Table D-2.3. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) WITH APPLIED AXIAL LOADS (Pinned-Pinned) (cont)

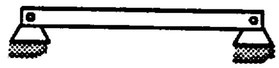


NPS = 22 in
D_o = 22.00 in
E = 28831000 lb/in^2

P/P_b = .25
λ = 3.1415926
μ = 489.535 lb/ft^3

t (in)	**1.438**	**1.500**	
D_i (in)	**19.124**	**19.000**	
W(lb/ft)	**315.79**	**328.41**	
L/D_o	**f_n**	**f_n**	**L (ft)**
2.0	1015	1012	3.67
3.0	451	450	5.50
4.0	254	253	7.33
5.0	162	162	9.17
6.0	113	112	11.00
7.0	83	83	12.83
8.0	63	63	14.67
9.0	50	50	16.50
10.0	41	40	18.33
11.0	34	33	20.17
12.0	28	28	22.00
13.0	24	24	23.83
14.0	21	21	25.67
15.0	18	18	27.50
16.0	16	16	29.33
17.0	14	14	31.17

Table D-2.3. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) WITH APPLIED AXIAL LOADS (Pinned-Pinned) (cont)



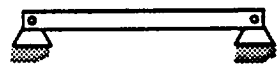
NPS = 22 in
D_o = 22.00 in
E = 28831000 lb/in^2

P/P_b = .50
λ = 3.1415926
μ = 489.535 lb/ft^3

t (in)	**0.219**	**0.250**	**0.281**	**0.312**	**0.344**	**0.375**	
D_i (in)	**21.562**	**21.500**	**21.438**	**21.376**	**21.312**	**21.250**	
W(lb/ft)	**50.94**	**58.07**	**65.18**	**72.27**	**79.56**	**86.61**	
L/D_o	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**L (ft)**
2.0	876	875	873	872	871	870	3.67
3.0	389	389	388	388	387	386	5.50
4.0	219	219	218	218	218	217	7.33
5.0	140	140	140	140	139	139	9.17
6.0	97	97	97	97	97	97	11.00
7.0	71	71	71	71	71	71	12.83
8.0	55	55	55	55	54	54	14.67
9.0	43	43	43	43	43	43	16.50
10.0	35	35	35	35	35	35	18.33
11.0	29	29	29	29	29	29	20.17
12.0	24	24	24	24	24	24	22.00
13.0	21	21	21	21	21	21	23.83
14.0	18	18	18	18	18	18	25.67
15.0	16	16	16	16	15	15	27.50
16.0	14	14	14	14	14	14	29.33
17.0	12	12	12	12	12	12	31.17

t (in)	**0.406**	**0.438**	**0.469**	**0.500**	**0.562**	**0.625**	
D_i (in)	**21.188**	**21.124**	**21.062**	**21.000**	**20.876**	**20.750**	
W(lb/ft)	**93.63**	**100.86**	**107.85**	**114.81**	**128.67**	**142.68**	
L/D_o	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**L (ft)**
2.0	868	867	866	865	862	860	3.67
3.0	386	385	385	384	383	382	5.50
4.0	217	217	216	216	216	215	7.33
5.0	139	139	139	138	138	138	9.17
6.0	96	96	96	96	96	96	11.00
7.0	71	71	71	71	70	70	12.83
8.0	54	54	54	54	54	54	14.67
9.0	43	43	43	43	43	42	16.50
10.0	35	35	35	35	34	34	18.33
11.0	29	29	29	29	29	28	20.17
12.0	24	24	24	24	24	24	22.00
13.0	21	21	20	20	20	20	23.83
14.0	18	18	18	18	18	18	25.67
15.0	15	15	15	15	15	15	27.50
16.0	14	14	14	14	13	13	29.33
17.0	12	12	12	12	12	12	31.17

Table D-2.3. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) WITH APPLIED AXIAL LOADS (Pinned-Pinned) (cont)



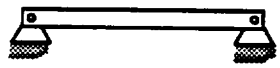
NPS = 22 in
D_o = 22.00 in
E = 28831000 lb/in^2

P/P_b = .50
λ = 3.1415926
μ = 489.535 lb/ft^3

t (in)	**0.688**	**0.750**	**0.812**	**0.875**	**0.938**	**1.000**	
D_i (in)	**20.624**	**20.500**	**20.376**	**20.250**	**20.124**	**20.000**	
W(lb/ft)	**156.60**	**170.21**	**183.75**	**197.41**	**211.00**	**224.28**	
L/D_o	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**L (ft)**
2.0	857	855	853	850	848	845	3.67
3.0	381	380	379	378	377	376	5.50
4.0	214	214	213	213	212	211	7.33
5.0	137	137	136	136	136	135	9.17
6.0	95	95	95	94	94	94	11.00
7.0	70	70	70	69	69	69	12.83
8.0	54	53	53	53	53	53	14.67
9.0	42	42	42	42	42	42	16.50
10.0	34	34	34	34	34	34	18.33
11.0	28	28	28	28	28	28	20.17
12.0	24	24	24	24	24	23	22.00
13.0	20	20	20	20	20	20	23.83
14.0	17	17	17	17	17	17	25.67
15.0	15	15	15	15	15	15	27.50
16.0	13	13	13	13	13	13	29.33
17.0	12	12	12	12	12	12	31.17

t (in)	**1.062**	**1.125**	**1.188**	**1.250**	**1.312**	**1.375**	
D_i (in)	**19.876**	**19.750**	**19.624**	**19.500**	**19.376**	**19.250**	
W(lb/ft)	**237.48**	**250.81**	**264.06**	**277.01**	**289.88**	**302.88**	
L/D_o	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**L (ft)**
2.0	843	841	838	836	833	831	3.67
3.0	375	374	373	371	370	369	5.50
4.0	211	210	210	209	208	208	7.33
5.0	135	134	134	134	133	133	9.17
6.0	94	93	93	93	93	92	11.00
7.0	69	69	68	68	68	68	12.83
8.0	53	53	52	52	52	52	14.67
9.0	42	42	41	41	41	41	16.50
10.0	34	34	34	33	33	33	18.33
11.0	28	28	28	28	28	27	20.17
12.0	23	23	23	23	23	23	22.00
13.0	20	20	20	20	20	20	23.83
14.0	17	17	17	17	17	17	25.67
15.0	15	15	15	15	15	15	27.50
16.0	13	13	13	13	13	13	29.33
17.0	12	12	12	12	12	12	31.17

Table D-2.3. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) WITH APPLIED AXIAL LOADS (Pinned-Pinned) (cont)

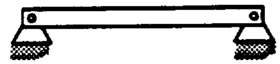


NPS = 22 in
D_o = 22.00 in
E = 28831000 lb/in^2

P/P_b = .50
λ = 3.1415926
μ = 489.535 lb/ft^3

t (in)	**1.438**	**1.500**	
D_i (in)	**19.124**	**19.000**	
W(lb/ft)	**315.79**	**328.41**	
L/D_o	**f_n**	**f_n**	**L (ft)**
2.0	829	826	3.67
3.0	368	367	5.50
4.0	207	207	7.33
5.0	133	132	9.17
6.0	92	92	11.00
7.0	68	67	12.83
8.0	52	52	14.67
9.0	41	41	16.50
10.0	33	33	18.33
11.0	27	27	20.17
12.0	23	23	22.00
13.0	20	20	23.83
14.0	17	17	25.67
15.0	15	15	27.50
16.0	13	13	29.33
17.0	11	11	31.17

Table D-2.3. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) WITH APPLIED AXIAL LOADS (Pinned-Pinned) (cont)



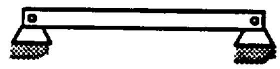
NPS = 22 in
D_o = 22.00 in
E = 28831000 lb/in^2

P/P_b = .75
λ = 3.1415926
μ = 489.535 lb/ft^3

t (in)	0.219	0.250	0.281	0.312	0.344	0.375	
D_i (in)	21.562	21.500	21.438	21.376	21.312	21.250	
W(lb/ft)	50.94	58.07	65.18	72.27	79.56	86.61	
L/D_o	f_n	f_n	f_n	f_n	f_n	f_n	L (ft)
2.0	619	618	618	617	616	615	3.67
3.0	275	275	274	274	274	273	5.50
4.0	155	155	154	154	154	154	7.33
5.0	99	99	99	99	99	98	9.17
6.0	69	69	69	69	68	68	11.00
7.0	51	50	50	50	50	50	12.83
8.0	39	39	39	39	38	38	14.67
9.0	31	31	30	30	30	30	16.50
10.0	25	25	25	25	25	25	18.33
11.0	20	20	20	20	20	20	20.17
12.0	17	17	17	17	17	17	22.00
13.0	15	15	15	15	15	15	23.83
14.0	13	13	13	13	13	13	25.67
15.0	11	11	11	11	11	11	27.50
16.0	10	10	10	10	10	10	29.33
17.0	9	9	9	9	9	9	31.17

t (in)	0.406	0.438	0.469	0.500	0.562	0.625	
D_i (in)	21.188	21.124	21.062	21.000	20.876	20.750	
W(lb/ft)	93.63	100.86	107.85	114.81	128.67	142.68	
L/D_o	f_n	f_n	f_n	f_n	f_n	f_n	L (ft)
2.0	614	613	612	611	610	608	3.67
3.0	273	273	272	272	271	270	5.50
4.0	154	153	153	153	152	152	7.33
5.0	98	98	98	98	98	97	9.17
6.0	68	68	68	68	68	68	11.00
7.0	50	50	50	50	50	50	12.83
8.0	38	38	38	38	38	38	14.67
9.0	30	30	30	30	30	30	16.50
10.0	25	25	24	24	24	24	18.33
11.0	20	20	20	20	20	20	20.17
12.0	17	17	17	17	17	17	22.00
13.0	15	15	14	14	14	14	23.83
14.0	13	13	12	12	12	12	25.67
15.0	11	11	11	11	11	11	27.50
16.0	10	10	10	10	10	9	29.33
17.0	8	8	8	8	8	8	31.17

Table D-2.3. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) WITH APPLIED AXIAL LOADS (Pinned-Pinned) (cont)



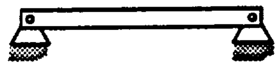
NPS = 22 in
D_o = 22.00 in
E = 28831000 lb/in^2

P/P_b = .75
λ = 3.1415926
μ = 489.535 lb/ft^3

t (in)	0.688	0.750	0.812	0.875	0.938	1.000	
D_i (in)	20.624	20.500	20.376	20.250	20.124	20.000	
W(lb/ft)	156.60	170.21	183.75	197.41	211.00	224.28	
L/D_o	f_n	f_n	f_n	f_n	f_n	f_n	L (ft)
2.0	606	605	603	601	599	598	3.67
3.0	269	269	268	267	266	266	5.50
4.0	152	151	151	150	150	149	7.33
5.0	97	97	96	96	96	96	9.17
6.0	67	67	67	67	67	66	11.00
7.0	49	49	49	49	49	49	12.83
8.0	38	38	38	38	37	37	14.67
9.0	30	30	30	30	30	30	16.50
10.0	24	24	24	24	24	24	18.33
11.0	20	20	20	20	20	20	20.17
12.0	17	17	17	17	17	17	22.00
13.0	14	14	14	14	14	14	23.83
14.0	12	12	12	12	12	12	25.67
15.0	11	11	11	11	11	11	27.50
16.0	9	9	9	9	9	9	29.33
17.0	8	8	8	8	8	8	31.17

t (in)	1.062	1.125	1.188	1.250	1.312	1.375	
D_i (in)	19.876	19.750	19.624	19.500	19.376	19.250	
W(lb/ft)	237.48	250.81	264.06	277.01	289.88	302.88	
L/D_o	f_n	f_n	f_n	f_n	f_n	f_n	L (ft)
2.0	596	594	593	591	589	588	3.67
3.0	265	264	263	263	262	261	5.50
4.0	149	149	148	148	147	147	7.33
5.0	95	95	95	95	94	94	9.17
6.0	66	66	66	66	65	65	11.00
7.0	49	49	48	48	48	48	12.83
8.0	37	37	37	37	37	37	14.67
9.0	29	29	29	29	29	29	16.50
10.0	24	24	24	24	24	24	18.33
11.0	20	20	20	20	19	19	20.17
12.0	17	17	16	16	16	16	22.00
13.0	14	14	14	14	14	14	23.83
14.0	12	12	12	12	12	12	25.67
15.0	11	11	11	11	10	10	27.50
16.0	9	9	9	9	9	9	29.33
17.0	8	8	8	8	8	8	31.17

Table D-2.3. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) WITH APPLIED AXIAL LOADS (Pinned-Pinned) (cont)

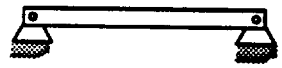


NPS = 22 in
D_o = 22.00 in
E = 28831000 lb/in^2

P/P_b = .75
λ = 3.1415926
μ = 489.535 lb/ft^3

t (in)	**1.438**	**1.500**	
D_i (in)	**19.124**	**19.000**	
W(lb/ft)	**315.79**	**328.41**	
L/D_o	**f_n**	**f_n**	**L (ft)**
2.0	586	584	3.67
3.0	260	260	5.50
4.0	147	146	7.33
5.0	94	93	9.17
6.0	65	65	11.00
7.0	48	48	12.83
8.0	37	37	14.67
9.0	29	29	16.50
10.0	23	23	18.33
11.0	19	19	20.17
12.0	16	16	22.00
13.0	14	14	23.83
14.0	12	12	25.67
15.0	10	10	27.50
16.0	9	9	29.33
17.0	8	8	31.17

Table D-2.3. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) WITH APPLIED AXIAL LOADS (Pinned-Pinned) (cont)



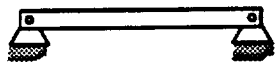
NPS = 24 in
D_o = 24.00 in
E = 28831000 lb/in^2

P/P_b = .25
λ = 3.1415926
μ = 489.535 lb/ft^3

t (in)	0.250	0.281	0.312	0.344	0.375	0.406	
D_i (in)	23.500	23.438	23.376	23.312	23.250	23.188	
W(lb/ft)	63.41	71.18	78.93	86.91	94.62	102.31	
L/D_o	f_n	f_n	f_n	f_n	f_n	f_n	L (ft)
2.0	983	981	980	979	978	976	4.00
3.0	437	436	436	435	435	434	6.00
4.0	246	245	245	245	244	244	8.00
5.0	157	157	157	157	156	156	10.00
6.0	109	109	109	109	109	108	12.00
7.0	80	80	80	80	80	80	14.00
8.0	61	61	61	61	61	61	16.00
9.0	49	48	48	48	48	48	18.00
10.0	39	39	39	39	39	39	20.00
11.0	32	32	32	32	32	32	22.00
12.0	27	27	27	27	27	27	24.00
13.0	23	23	23	23	23	23	26.00
14.0	20	20	20	20	20	20	28.00
15.0	17	17	17	17	17	17	30.00
16.0	15	15	15	15	15	15	32.00
17.0	14	14	14	14	14	14	34.00

t (in)	0.438	0.469	0.500	0.562	0.625	0.688	
D_i (in)	23.124	23.062	23.000	22.876	22.750	22.624	
W(lb/ft)	110.22	117.86	125.49	140.68	156.03	171.29	
L/D_o	f_n	f_n	f_n	f_n	f_n	f_n	L (ft)
2.0	975	974	973	970	968	965	4.00
3.0	433	433	432	431	430	429	6.00
4.0	244	243	243	243	242	241	8.00
5.0	156	156	156	155	155	154	10.00
6.0	108	108	108	108	108	107	12.00
7.0	80	79	79	79	79	79	14.00
8.0	61	61	61	61	60	60	16.00
9.0	48	48	48	48	48	48	18.00
10.0	39	39	39	39	39	39	20.00
11.0	32	32	32	32	32	32	22.00
12.0	27	27	27	27	27	27	24.00
13.0	23	23	23	23	23	23	26.00
14.0	20	20	20	20	20	20	28.00
15.0	17	17	17	17	17	17	30.00
16.0	15	15	15	15	15	15	32.00
17.0	13	13	13	13	13	13	34.00

Table D-2.3. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) WITH APPLIED AXIAL LOADS (Pinned-Pinned) (cont)



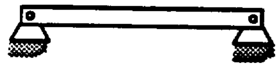
NPS = 24 in
D_o = 24.00 in
E = 28831000 lb/in^2

P/P_b = .25
λ = 3.1415926
μ = 489.535 lb/ft^3

t (in)	**0.750**	**0.812**	**0.875**	**0.938**	**1.000**	**1.062**	
D_i (in)	**22.500**	**22.376**	**22.250**	**22.124**	**22.000**	**21.876**	
W(lb/ft)	**186.23**	**201.09**	**216.10**	**231.03**	**245.64**	**260.17**	
L/D_o	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**L (ft)**
2.0	963	960	958	955	953	950	4.00
3.0	428	427	426	424	423	422	6.00
4.0	241	240	239	239	238	238	8.00
5.0	154	154	153	153	152	152	10.00
6.0	107	107	106	106	106	106	12.00
7.0	79	78	78	78	78	78	14.00
8.0	60	60	60	60	60	59	16.00
9.0	48	47	47	47	47	47	18.00
10.0	39	38	38	38	38	38	20.00
11.0	32	32	32	32	31	31	22.00
12.0	27	27	27	27	26	26	24.00
13.0	23	23	23	23	23	22	26.00
14.0	20	20	20	19	19	19	28.00
15.0	17	17	17	17	17	17	30.00
16.0	15	15	15	15	15	15	32.00
17.0	13	13	13	13	13	13	34.00

t (in)	**1.125**	**1.188**	**1.250**	**1.312**	**1.375**	**1.438**	
D_i (in)	**21.750**	**21.624**	**21.500**	**21.376**	**21.250**	**21.124**	
W(lb/ft)	**274.84**	**289.44**	**303.71**	**317.91**	**332.25**	**346.50**	
L/D_o	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**L (ft)**
2.0	948	945	943	940	938	935	4.00
3.0	421	420	419	418	417	416	6.00
4.0	237	236	236	235	234	234	8.00
5.0	152	151	151	150	150	150	10.00
6.0	105	105	105	104	104	104	12.00
7.0	77	77	77	77	77	76	14.00
8.0	59	59	59	59	59	58	16.00
9.0	47	47	47	46	46	46	18.00
10.0	38	38	38	38	38	37	20.00
11.0	31	31	31	31	31	31	22.00
12.0	26	26	26	26	26	26	24.00
13.0	22	22	22	22	22	22	26.00
14.0	19	19	19	19	19	19	28.00
15.0	17	17	17	17	17	17	30.00
16.0	15	15	15	15	15	15	32.00
17.0	13	13	13	13	13	13	34.00

Table D-2.3. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) WITH APPLIED AXIAL LOADS (Pinned-Pinned) (cont)

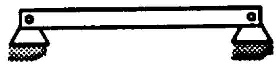


NPS = 24 in
D_o = 24.00 in
E = 28831000 lb/in^2

P/P_b = .25
λ = 3.1415926
μ = 489.535 lb/ft^3

t (in)	**1.500**	**1.562**	
D_i (in)	**21.000**	**20.876**	
W(lb/ft)	**360.45**	**374.31**	
L/D_o	**f_n**	**f_n**	**L (ft)**
2.0	933	931	4.00
3.0	415	414	6.00
4.0	233	233	8.00
5.0	149	149	10.00
6.0	104	103	12.00
7.0	76	76	14.00
8.0	58	58	16.00
9.0	46	46	18.00
10.0	37	37	20.00
11.0	31	31	22.00
12.0	26	26	24.00
13.0	22	22	26.00
14.0	19	19	28.00
15.0	17	17	30.00
16.0	15	15	32.00
17.0	13	13	34.00

Table D-2.3. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) WITH APPLIED AXIAL LOADS (Pinned-Pinned) (cont)



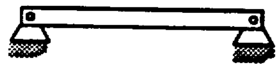
NPS = 24 in
D_o = 24.00 in
E = 28831000 lb/in^2

P/P_b = .50
λ = 3.1415926
μ = 489.535 lb/ft^3

t (in)	**0.250**	**0.281**	**0.312**	**0.344**	**0.375**	**0.406**	
D_i (in)	**23.500**	**23.438**	**23.376**	**23.312**	**23.250**	**23.188**	
W(lb/ft)	**63.41**	**71.18**	**78.93**	**86.91**	**94.62**	**102.31**	
L/D_o	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**L (ft)**
2.0	802	801	800	799	798	797	4.00
3.0	357	356	356	355	355	354	6.00
4.0	201	200	200	200	200	199	8.00
5.0	128	128	128	128	128	128	10.00
6.0	89	89	89	89	89	89	12.00
7.0	66	65	65	65	65	65	14.00
8.0	50	50	50	50	50	50	16.00
9.0	40	40	40	39	39	39	18.00
10.0	32	32	32	32	32	32	20.00
11.0	27	26	26	26	26	26	22.00
12.0	22	22	22	22	22	22	24.00
13.0	19	19	19	19	19	19	26.00
14.0	16	16	16	16	16	16	28.00
15.0	14	14	14	14	14	14	30.00
16.0	13	13	13	12	12	12	32.00
17.0	11	11	11	11	11	11	34.00

t (in)	**0.438**	**0.469**	**0.500**	**0.562**	**0.625**	**0.688**	
D_i (in)	**23.124**	**23.062**	**23.000**	**22.876**	**22.750**	**22.624**	
W(lb/ft)	**110.22**	**117.86**	**125.49**	**140.68**	**156.03**	**171.29**	
L/D_o	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**L (ft)**
2.0	796	795	794	792	790	788	4.00
3.0	354	353	353	352	351	350	6.00
4.0	199	199	199	198	197	197	8.00
5.0	127	127	127	127	126	126	10.00
6.0	88	88	88	88	88	88	12.00
7.0	65	65	65	65	64	64	14.00
8.0	50	50	50	50	49	49	16.00
9.0	39	39	39	39	39	39	18.00
10.0	32	32	32	32	32	32	20.00
11.0	26	26	26	26	26	26	22.00
12.0	22	22	22	22	22	22	24.00
13.0	19	19	19	19	19	19	26.00
14.0	16	16	16	16	16	16	28.00
15.0	14	14	14	14	14	14	30.00
16.0	12	12	12	12	12	12	32.00
17.0	11	11	11	11	11	11	34.00

Table D-2.3. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) WITH APPLIED AXIAL LOADS (Pinned-Pinned) (cont)



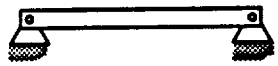
NPS = 24 in
D_o = 24.00 in
E = 28831000 lb/in^2

P/P_b = .50
λ = 3.1415926
μ = 489.535 lb/ft^3

t (in)	**0.750**	**0.812**	**0.875**	**0.938**	**1.000**	**1.062**	
D_i (in)	**22.500**	**22.376**	**22.250**	**22.124**	**22.000**	**21.876**	
W(lb/ft)	**186.23**	**201.09**	**216.10**	**231.03**	**245.64**	**260.17**	
L/D_o	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**L (ft)**
2.0	786	784	782	780	778	776	4.00
3.0	349	348	347	347	346	345	6.00
4.0	196	196	195	195	194	194	8.00
5.0	126	125	125	125	124	124	10.00
6.0	87	87	87	87	86	86	12.00
7.0	64	64	64	64	63	63	14.00
8.0	49	49	49	49	49	48	16.00
9.0	39	39	39	39	38	38	18.00
10.0	31	31	31	31	31	31	20.00
11.0	26	26	26	26	26	26	22.00
12.0	22	22	22	22	22	22	24.00
13.0	19	19	19	18	18	18	26.00
14.0	16	16	16	16	16	16	28.00
15.0	14	14	14	14	14	14	30.00
16.0	12	12	12	12	12	12	32.00
17.0	11	11	11	11	11	11	34.00

t (in)	**1.125**	**1.188**	**1.250**	**1.312**	**1.375**	**1.438**	
D_i (in)	**21.750**	**21.624**	**21.500**	**21.376**	**21.250**	**21.124**	
W(lb/ft)	**274.84**	**289.44**	**303.71**	**317.91**	**332.25**	**346.50**	
L/D_o	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**L (ft)**
2.0	774	772	770	768	766	764	4.00
3.0	344	343	342	341	340	339	6.00
4.0	193	193	192	192	191	191	8.00
5.0	124	123	123	123	123	122	10.00
6.0	86	86	86	85	85	85	12.00
7.0	63	63	63	63	63	62	14.00
8.0	48	48	48	48	48	48	16.00
9.0	38	38	38	38	38	38	18.00
10.0	31	31	31	31	31	31	20.00
11.0	26	26	25	25	25	25	22.00
12.0	21	21	21	21	21	21	24.00
13.0	18	18	18	18	18	18	26.00
14.0	16	16	16	16	16	16	28.00
15.0	14	14	14	14	14	14	30.00
16.0	12	12	12	12	12	12	32.00
17.0	11	11	11	11	11	11	34.00

Table D-2.3. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) WITH APPLIED AXIAL LOADS (Pinned-Pinned) (cont)

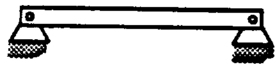


NPS = 24 in
D_o = 24.00 in
E = 28831000 lb/in^2

P/P_b = .50
λ = 3.1415926
μ = 489.535 lb/ft^3

t (in)	**1.500**	**1.562**	
D_i (in)	**21.000**	**20.876**	
W(lb/ft)	**360.45**	**374.31**	
L/D_o	**f_n**	**f_n**	**L (ft)**
2.0	762	760	4.00
3.0	339	338	6.00
4.0	190	190	8.00
5.0	122	122	10.00
6.0	85	84	12.00
7.0	62	62	14.00
8.0	48	47	16.00
9.0	38	38	18.00
10.0	30	30	20.00
11.0	25	25	22.00
12.0	21	21	24.00
13.0	18	18	26.00
14.0	16	16	28.00
15.0	14	14	30.00
16.0	12	12	32.00
17.0	11	11	34.00

Table D-2.3. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) WITH APPLIED AXIAL LOADS (Pinned-Pinned) (cont)



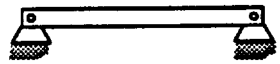
NPS = 24 in
D_o = 24.00 in
E = 28831000 lb/in^2

P/P_b = .75
λ = 3.1415926
μ = 489.535 lb/ft^3

t (in)	**0.250**	**0.281**	**0.312**	**0.344**	**0.375**	**0.406**	
D_i (in)	**23.500**	**23.438**	**23.376**	**23.312**	**23.250**	**23.188**	
W(lb/ft)	**63.41**	**71.18**	**78.93**	**86.91**	**94.62**	**102.31**	
L/D_o	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**L (ft)**
2.0	567	567	566	565	564	564	4.00
3.0	252	252	252	251	251	251	6.00
4.0	142	142	141	141	141	141	8.00
5.0	91	91	91	90	90	90	10.00
6.0	63	63	63	63	63	63	12.00
7.0	46	46	46	46	46	46	14.00
8.0	35	35	35	35	35	35	16.00
9.0	28	28	28	28	28	28	18.00
10.0	23	23	23	23	23	23	20.00
11.0	19	19	19	19	19	19	22.00
12.0	16	16	16	16	16	16	24.00
13.0	13	13	13	13	13	13	26.00
14.0	12	12	12	12	12	12	28.00
15.0	10	10	10	10	10	10	30.00
16.0	9	9	9	9	9	9	32.00
17.0	8	8	8	8	8	8	34.00

t (in)	**0.438**	**0.469**	**0.500**	**0.562**	**0.625**	**0.688**	
D_i (in)	**23.124**	**23.062**	**23.000**	**22.876**	**22.750**	**22.624**	
W(lb/ft)	**110.22**	**117.86**	**125.49**	**140.68**	**156.03**	**171.29**	
L/D_o	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**L (ft)**
2.0	563	562	562	560	559	557	4.00
3.0	250	250	250	249	248	248	6.00
4.0	141	141	140	140	140	139	8.00
5.0	90	90	90	90	89	89	10.00
6.0	63	62	62	62	62	62	12.00
7.0	46	46	46	46	46	45	14.00
8.0	35	35	35	35	35	35	16.00
9.0	28	28	28	28	28	28	18.00
10.0	23	22	22	22	22	22	20.00
11.0	19	19	19	19	18	18	22.00
12.0	16	16	16	16	16	15	24.00
13.0	13	13	13	13	13	13	26.00
14.0	11	11	11	11	11	11	28.00
15.0	10	10	10	10	10	10	30.00
16.0	9	9	9	9	9	9	32.00
17.0	8	8	8	8	8	8	34.00

Table D-2.3. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) WITH APPLIED AXIAL LOADS (Pinned-Pinned) (cont)



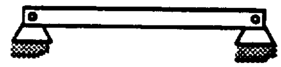
NPS = 24 in
D_o = 24.00 in
E = 28831000 lb/in^2

P/P_b = .75
λ = 3.1415926
μ = 489.535 lb/ft^3

t (in)	**0.750**	**0.812**	**0.875**	**0.938**	**1.000**	**1.062**	
D_i (in)	**22.500**	**22.376**	**22.250**	**22.124**	**22.000**	**21.876**	
W(lb/ft)	**186.23**	**201.09**	**216.10**	**231.03**	**245.64**	**260.17**	
L/D_o	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**L (ft)**
2.0	556	554	553	551	550	549	4.00
3.0	247	246	246	245	244	244	6.00
4.0	139	139	138	138	137	137	8.00
5.0	89	89	88	88	88	88	10.00
6.0	62	62	61	61	61	61	12.00
7.0	45	45	45	45	45	45	14.00
8.0	35	35	35	34	34	34	16.00
9.0	27	27	27	27	27	27	18.00
10.0	22	22	22	22	22	22	20.00
11.0	18	18	18	18	18	18	22.00
12.0	15	15	15	15	15	15	24.00
13.0	13	13	13	13	13	13	26.00
14.0	11	11	11	11	11	11	28.00
15.0	10	10	10	10	10	10	30.00
16.0	9	9	9	9	9	9	32.00
17.0	8	8	8	8	8	8	34.00

t (in)	**1.125**	**1.188**	**1.250**	**1.312**	**1.375**	**1.438**	
D_i (in)	**21.750**	**21.624**	**21.500**	**21.376**	**21.250**	**21.124**	
W(lb/ft)	**274.84**	**289.44**	**303.71**	**317.91**	**332.25**	**346.50**	
L/D_o	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**L (ft)**
2.0	547	546	544	543	541	540	4.00
3.0	243	243	242	241	241	240	6.00
4.0	137	136	136	136	135	135	8.00
5.0	88	87	87	87	87	86	10.00
6.0	61	61	60	60	60	60	12.00
7.0	45	45	44	44	44	44	14.00
8.0	34	34	34	34	34	34	16.00
9.0	27	27	27	27	27	27	18.00
10.0	22	22	22	22	22	22	20.00
11.0	18	18	18	18	18	18	22.00
12.0	15	15	15	15	15	15	24.00
13.0	13	13	13	13	13	13	26.00
14.0	11	11	11	11	11	11	28.00
15.0	10	10	10	10	10	10	30.00
16.0	9	9	9	8	8	8	32.00
17.0	8	8	8	8	7	7	34.00

Table D-2.3. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) WITH APPLIED AXIAL LOADS (Pinned-Pinned) (cont)

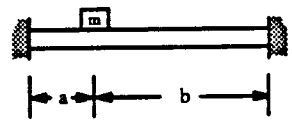


NPS = 24 in
D_o = 24.00 in
E = 28831000 lb/in^2

P/P_b = .75
λ = 3.1415926
μ = 489.535 lb/ft^3

t (in)	**1.500**	**1.562**	
D_i (in)	**21.000**	**20.876**	
W(lb/ft)	**360.45**	**374.31**	
L/D_o	**f_n**	**f_n**	**L (ft)**
2.0	539	537	4.00
3.0	239	239	6.00
4.0	135	134	8.00
5.0	86	86	10.00
6.0	60	60	12.00
7.0	44	44	14.00
8.0	34	34	16.00
9.0	27	27	18.00
10.0	22	21	20.00
11.0	18	18	22.00
12.0	15	15	24.00
13.0	13	13	26.00
14.0	11	11	28.00
15.0	10	10	30.00
16.0	8	8	32.00
17.0	7	7	34.00

Table D-3.1. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) OF A BEAM WITH CONCENTRATED LOADING (Clamped-Clamped)



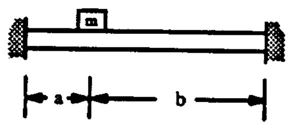
a = 0.5L
b = 0.5L
α = 0.1857
β = 0.1857

% maximum bending load = **75**
yield strength (4"–12" D) = 30000 lb/in^2
yield strength (14"–24" D) = 42000 lb/in^2
E = 28831000 lb/in^2

NPS (in)	**4**	**5**	**6**	**8**	**10**	**12**
D_o (in)	**4.50**	**5.56**	**6.63**	**8.63**	**10.75**	**12.75**
D_i (in)	**4.25**	**5.25**	**6.25**	**8.25**	**10.37**	**12.34**
W(lb/ft)	**5.84**	**9.01**	**12.92**	**16.94**	**21.21**	**27.20**
L/D_o	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**
2.0	366	329	301	264	236	217
4.0	183	164	151	132	118	109
6.0	122	110	100	88	79	72
8.0	91	82	75	66	59	54
10.0	73	66	60	53	47	43
12.0	61	55	50	44	39	36
14.0	52	47	43	38	34	31
16.0	46	41	38	33	30	27
18.0	41	37	33	29	26	24
20.0	37	33	30	26	24	22
22.0	33	30	27	24	21	20
24.0	30	27	25	22	20	18

NPS (in)	**14**	**16**	**18**	**20**	**22**	**24**
D_o (in)	**14.00**	**16.00**	**18.00**	**20.00**	**22.00**	**24.00**
D_i (in)	**13.62**	**15.62**	**17.62**	**19.56**	**21.56**	**23.50**
W(lb/ft)	**27.73**	**31.75**	**35.76**	**46.27**	**50.94**	**63.41**
L/D_o	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**
2.0	175	164	154	147	140	134
4.0	88	82	77	73	70	67
6.0	58	55	51	49	47	45
8.0	44	41	39	37	35	33
10.0	35	33	31	29	28	27
12.0	29	27	26	24	23	22
14.0	25	23	22	21	20	19
16.0	22	20	19	18	17	17
18.0	19	18	17	16	16	15
20.0	18	16	15	15	14	13
22.0	16	15	14	13	13	12
24.0	15	14	13	12	12	11

Table D-3.1. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) OF A BEAM WITH CONCENTRATED LOADING (Clamped-Clamped) (cont)



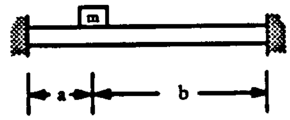
a = 0.5L
b = 0.5L
α = 0.1857
β = 0.1857

% maximum bending load = 50
yield strength (4"–12" D) = 30000 lb/in^2
yield strength (14"–24" D) = 42000 lb/in^2
E = 28831000 lb/in^2

NPS (in)	4	5	6	8	10	12
D_o (in)	4.50	5.56	6.63	8.63	10.75	12.75
D_i (in)	4.25	5.25	6.25	8.25	10.37	12.34
W(lb/ft)	5.84	9.01	12.92	16.94	21.21	27.20
L/D_o	f_n	f_n	f_n	f_n	f_n	f_n
2.0	448	403	369	323	290	266
4.0	224	201	184	162	145	133
6.0	149	134	123	108	97	89
8.0	112	101	92	81	72	66
10.0	90	81	74	65	58	53
12.0	75	67	61	54	48	44
14.0	64	58	53	46	41	38
16.0	56	50	46	40	36	33
18.0	50	45	41	36	32	30
20.0	45	40	37	32	29	27
22.0	41	37	34	29	26	24
24.0	37	34	31	27	24	22

NPS (in)	14	16	18	20	22	24
D_o (in)	14.00	16.00	18.00	20.00	22.00	24.00
D_i (in)	13.62	15.62	17.62	19.56	21.56	23.50
W(lb/ft)	27.73	31.75	35.76	46.27	50.94	63.41
L/D_o	f_n	f_n	f_n	f_n	f_n	f_n
2.0	215	201	189	179	171	164
4.0	107	100	95	90	86	82
6.0	72	67	63	60	57	55
8.0	54	50	47	45	43	41
10.0	43	40	38	36	34	33
12.0	36	33	32	30	29	27
14.0	31	29	27	26	24	23
16.0	27	25	24	22	21	20
18.0	24	22	21	20	19	18
20.0	21	20	19	18	17	16
22.0	20	18	17	16	16	15
24.0	18	17	16	15	14	14

Table D-3.1. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) OF A BEAM WITH CONCENTRATED LOADING (Clamped-Clamped) (cont)



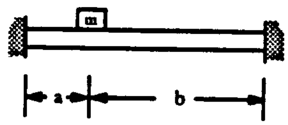
$a = 0.5L$
$b = 0.5L$
$\alpha = 0.1857$
$\beta = 0.1857$

% maximum bending load = 25
yield strength (4"–12" D) = 30000 lb/in^2
yield strength (14"–24" D) = 42000 lb/in^2
E = 28831000 lb/in^2

NPS (in)	**4**	**5**	**6**	**8**	**10**	**12**
D_o (in)	**4.50**	**5.56**	**6.63**	**8.63**	**10.75**	**12.75**
D_i (in)	**4.25**	**5.25**	**6.25**	**8.25**	**10.37**	**12.34**
W(lb/ft)	**5.84**	**9.01**	**12.92**	**16.94**	**21.21**	**27.20**
L/D_o	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**
2.0	633	569	522	457	410	376
4.0	317	285	261	229	205	188
6.0	211	190	174	152	137	125
8.0	158	142	130	114	102	94
10.0	127	114	104	91	82	75
12.0	106	95	87	76	68	63
14.0	90	81	75	65	59	54
16.0	79	71	65	57	51	47
18.0	70	63	58	51	46	42
20.0	63	57	52	46	41	38
22.0	58	52	47	42	37	34
24.0	53	47	43	38	34	31

NPS (in)	**14**	**16**	**18**	**20**	**22**	**24**
D_o (in)	**14.00**	**16.00**	**18.00**	**20.00**	**22.00**	**24.00**
D_i (in)	**13.62**	**15.62**	**17.62**	**19.56**	**21.56**	**23.50**
W(lb/ft)	**27.73**	**31.75**	**35.76**	**46.27**	**50.94**	**63.41**
L/D_o	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**
2.0	303	284	268	254	242	232
4.0	152	142	134	127	121	116
6.0	101	95	89	85	81	77
8.0	76	71	67	63	61	58
10.0	61	57	54	51	48	46
12.0	51	47	45	42	40	39
14.0	43	41	38	36	35	33
16.0	38	35	33	32	30	29
18.0	34	32	30	28	27	26
20.0	30	28	27	25	24	23
22.0	28	26	24	23	22	21
24.0	25	24	22	21	20	19

Table D-3.1. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) OF A BEAM WITH CONCENTRATED LOADING (Clamped-Clamped) (cont)



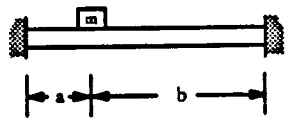
a = 0.25L
b = 0.75L
α = 0.0690
β = 0.5786

% maximum bending load = 75
yield strength (4"–12" D) = 30000 lb/in²
yield strength (14"–24" D) = 42000 lb/in²
E = 28831000 lb/in²

NPS (in)	4	5	6	8	10	12
D_o (in)	4.50	5.56	6.63	8.63	10.75	12.75
D_i (in)	4.25	5.25	6.25	8.25	10.37	12.34
W(lb/ft)	5.84	9.01	12.92	16.94	21.21	27.20
L/D_o	f_n	f_n	f_n	f_n	f_n	f_n
2.0	366	329	301	264	236	217
4.0	183	164	151	132	118	109
6.0	122	110	100	88	79	72
8.0	91	82	75	66	59	54
10.0	73	66	60	53	47	43
12.0	61	55	50	44	39	36
14.0	52	47	43	38	34	31
16.0	46	41	38	33	30	27
18.0	41	37	33	29	26	24
20.0	37	33	30	26	24	22
22.0	33	30	27	24	21	20
24.0	30	27	25	22	20	18

NPS (in)	14	16	18	20	22	24
D_o (in)	14.00	16.00	18.00	20.00	22.00	24.00
D_i (in)	13.62	15.62	17.62	19.56	21.56	23.50
W(lb/ft)	27.73	31.75	35.76	46.27	50.94	63.41
L/D_o	f_n	f_n	f_n	f_n	f_n	f_n
2.0	175	164	154	147	140	134
4.0	88	82	77	73	70	67
6.0	58	55	51	49	47	45
8.0	44	41	39	37	35	33
10.0	35	33	31	29	28	27
12.0	29	27	26	24	23	22
14.0	25	23	22	21	20	19
16.0	22	20	19	18	17	17
18.0	19	18	17	16	16	15
20.0	18	16	15	15	14	13
22.0	16	15	14	13	13	12
24.0	15	14	13	12	12	11

Table D-3.1. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) OF A BEAM WITH CONCENTRATED LOADING (Clamped-Clamped) (cont)



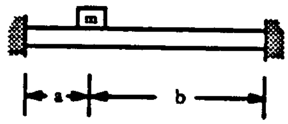
a = 0.25L
b = 0.75L
α = 0.0690
β = 0.5786

% maximum bending load = 50
yield strength (4"–12" D) = 30000 lb/in^2
yield strength (14"–24" D) = 42000 lb/in^2
E = 28831000 lb/in^2

NPS (in)	4	5	6	8	10	12
D_o (in)	4.50	5.56	6.63	8.63	10.75	12.75
D_i (in)	4.25	5.25	6.25	8.25	10.37	12.34
W(lb/ft)	5.84	9.01	12.92	16.94	21.21	27.20
L/D_o	f_n	f_n	f_n	f_n	f_n	f_n
2.0	448	403	369	323	290	266
4.0	224	201	184	162	145	133
6.0	149	134	123	108	97	89
8.0	112	101	92	81	72	66
10.0	90	81	74	65	58	53
12.0	75	67	61	54	48	44
14.0	64	58	53	46	41	38
16.0	56	50	46	40	36	33
18.0	50	45	41	36	32	30
20.0	45	40	37	32	29	27
22.0	41	37	34	29	26	24
24.0	37	34	31	27	24	22

NPS (in)	14	16	18	20	22	24
D_o (in)	14.00	16.00	18.00	20.00	22.00	24.00
D_i (in)	13.62	15.62	17.62	19.56	21.56	23.50
W(lb/ft)	27.73	31.75	35.76	46.27	50.94	63.41
L/D_o	f_n	f_n	f_n	f_n	f_n	f_n
2.0	215	201	189	179	171	164
4.0	107	100	95	90	86	82
6.0	72	67	63	60	57	55
8.0	54	50	47	45	43	41
10.0	43	40	38	36	34	33
12.0	36	33	32	30	29	27
14.0	31	29	27	26	24	23
16.0	27	25	24	22	21	20
18.0	24	22	21	20	19	18
20.0	21	20	19	18	17	16
22.0	20	18	17	16	16	15
24.0	18	17	16	15	14	14

Table D-3.1. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) OF A BEAM WITH CONCENTRATED LOADING (Clamped-Clamped) (cont)



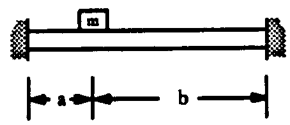
$a = 0.25L$
$b = 0.75L$
$\alpha = 0.0690$
$\beta = 0.5786$

% maximum bending load = **25**
yield strength (4"–12" D) = 30000 lb/in²
yield strength (14"–24" D) = 42000 lb/in²
E = 28831000 lb/in²

NPS (in)	4	5	6	8	10	12
D_o (in)	4.50	5.56	6.63	8.63	10.75	12.75
D_i (in)	4.25	5.25	6.25	8.25	10.37	12.34
W(lb/ft)	5.84	9.01	12.92	16.94	21.21	27.20
L/D_o	f_n	f_n	f_n	f_n	f_n	f_n
2.0	633	569	522	457	410	376
4.0	317	285	261	229	205	188
6.0	211	190	174	152	137	125
8.0	158	142	130	114	102	94
10.0	127	114	104	91	82	75
12.0	106	95	87	76	68	63
14.0	90	81	75	65	59	54
16.0	79	71	65	57	51	47
18.0	70	63	58	51	46	42
20.0	63	57	52	46	41	38
22.0	58	52	47	42	37	34
24.0	53	47	43	38	34	31

NPS (in)	14	16	18	20	22	24
D_o (in)	14.00	16.00	18.00	20.00	22.00	24.00
D_i (in)	13.62	15.62	17.62	19.56	21.56	23.50
W(lb/ft)	27.73	31.75	35.76	46.27	50.94	63.41
L/D_o	f_n	f_n	f_n	f_n	f_n	f_n
2.0	303	284	268	254	242	232
4.0	152	142	134	127	121	116
6.0	101	95	89	85	81	77
8.0	76	71	67	63	61	58
10.0	61	57	54	51	48	46
12.0	51	47	45	42	40	39
14.0	43	41	38	36	35	33
16.0	38	35	33	32	30	29
18.0	34	32	30	28	27	26
20.0	30	28	27	25	24	23
22.0	28	26	24	23	22	21
24.0	25	24	22	21	20	19

Table D-3.1. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) OF A BEAM WITH CONCENTRATED LOADING (Clamped-Clamped) (cont)



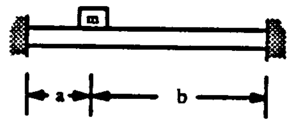
a = 0.05L
b = 0.95L
α = 0.0121
β = 9.6357

% maximum bending load = 75
yield strength (4"–12" D) = 30000 lb/in²
yield strength (14"–24" D) = 42000 lb/in²
E = 28831000 lb/in²

NPS (in)	**4**	**5**	**6**	**8**	**10**	**12**
D_o (in)	**4.50**	**5.56**	**6.63**	**8.63**	**10.75**	**12.75**
D_i (in)	**4.25**	**5.25**	**6.25**	**8.25**	**10.37**	**12.34**
W(lb/ft)	**5.84**	**9.01**	**12.92**	**16.94**	**21.21**	**27.20**
L/D_o	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**
2.0	365	328	301	264	236	217
4.0	183	164	151	132	118	109
6.0	122	110	100	88	79	72
8.0	91	82	75	66	59	54
10.0	73	66	60	53	47	43
12.0	61	55	50	44	39	36
14.0	52	47	43	38	34	31
16.0	46	41	38	33	30	27
18.0	41	37	33	29	26	24
20.0	37	33	30	26	24	22
22.0	33	30	27	24	21	20
24.0	30	27	25	22	20	18

NPS (in)	**14**	**16**	**18**	**20**	**22**	**24**
D_o (in)	**14.00**	**16.00**	**18.00**	**20.00**	**22.00**	**24.00**
D_i (in)	**13.62**	**15.62**	**17.62**	**19.56**	**21.56**	**23.50**
W(lb/ft)	**27.73**	**31.75**	**35.76**	**46.27**	**50.94**	**63.41**
L/D_o	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**
2.0	175	164	154	147	140	134
4.0	88	82	77	73	70	67
6.0	58	55	51	49	47	45
8.0	44	41	39	37	35	33
10.0	35	33	31	29	28	27
12.0	29	27	26	24	23	22
14.0	25	23	22	21	20	19
16.0	22	20	19	18	17	17
18.0	19	18	17	16	16	15
20.0	18	16	15	15	14	13
22.0	16	15	14	13	13	12
24.0	15	14	13	12	12	11

Table D-3.1. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) OF A BEAM WITH CONCENTRATED LOADING (Clamped-Clamped) (cont)



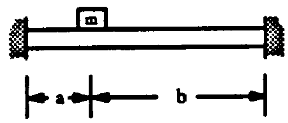
a = 0.05L
b = 0.95L
α = 0.0121
β = 9.6357

% maximum bending load = **50**
yield strength (4"–12" D) = 30000 lb/in^2
yield strength (14"–24" D) = 42000 lb/in^2
E = 28831000 lb/in^2

NPS (in)	**4**	**5**	**6**	**8**	**10**	**12**
D_o (in)	**4.50**	**5.56**	**6.63**	**8.63**	**10.75**	**12.75**
D_i (in)	**4.25**	**5.25**	**6.25**	**8.25**	**10.37**	**12.34**
W(lb/ft)	**5.84**	**9.01**	**12.92**	**16.94**	**21.21**	**27.20**
L/D_o	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**
2.0	447	402	369	323	290	266
4.0	224	201	184	162	145	133
6.0	149	134	123	108	97	89
8.0	112	101	92	81	72	66
10.0	90	81	74	65	58	53
12.0	75	67	61	54	48	44
14.0	64	58	53	46	41	38
16.0	56	50	46	40	36	33
18.0	50	45	41	36	32	30
20.0	45	40	37	32	29	27
22.0	41	37	34	29	26	24
24.0	37	34	31	27	24	22

NPS (in)	**14**	**16**	**18**	**20**	**22**	**24**
D_o (in)	**14.00**	**16.00**	**18.00**	**20.00**	**22.00**	**24.00**
D_i (in)	**13.62**	**15.62**	**17.62**	**19.56**	**21.56**	**23.50**
W(lb/ft)	**27.73**	**31.75**	**35.76**	**46.27**	**50.94**	**63.41**
L/D_o	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**
2.0	214	201	189	179	171	164
4.0	107	100	95	90	86	82
6.0	72	67	63	60	57	55
8.0	54	50	47	45	43	41
10.0	43	40	38	36	34	33
12.0	36	33	32	30	29	27
14.0	31	29	27	26	24	23
16.0	27	25	24	22	24	23
18.0	24	22	21	20	21	20
20.0	21	20	19	18	19	18
22.0	20	18	17	16	17	16
24.0	18	17	16	15	16	15

Table D-3.1. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) OF A BEAM WITH CONCENTRATED LOADING (Clamped-Clamped) (cont)



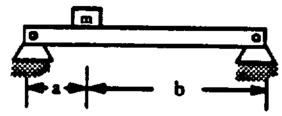
$a = 0.05L$
$b = 0.95L$
$\alpha = 0.0121$
$\beta = 9.6357$

% maximum bending load = 25
yield strength (4"–12" D) = 30000 lb/in^2
yield strength (14"–24" D) = 42000 lb/in^2
E = 28831000 lb/in^2

NPS (in)	**4**	**5**	**6**	**8**	**10**	**12**
D_o (in)	**4.50**	**5.56**	**6.63**	**8.63**	**10.75**	**12.75**
D_i (in)	**4.25**	**5.25**	**6.25**	**8.25**	**10.37**	**12.34**
W(lb/ft)	**5.84**	**9.01**	**12.92**	**16.94**	**21.21**	**27.20**
L/D_o	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**
2.0	631	568	521	457	409	376
4.0	316	284	261	229	205	188
6.0	211	190	174	152	137	125
8.0	158	142	130	114	102	94
10.0	127	114	104	91	82	75
12.0	105	95	87	76	68	63
14.0	90	81	75	65	59	54
16.0	79	71	65	57	51	47
18.0	70	63	58	51	46	42
20.0	63	57	52	46	41	38
22.0	58	52	47	42	37	34
24.0	53	47	43	38	34	31

NPS (in)	**14**	**16**	**18**	**20**	**22**	**24**
D_o (in)	**14.00**	**16.00**	**18.00**	**20.00**	**22.00**	**24.00**
D_i (in)	**13.62**	**15.62**	**17.62**	**19.56**	**21.56**	**23.50**
W(lb/ft)	**27.73**	**31.75**	**35.76**	**46.27**	**50.94**	**63.41**
L/D_o	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**
2.0	303	284	267	254	242	232
4.0	152	142	134	127	121	116
6.0	101	95	89	85	81	77
8.0	76	71	67	63	60	58
10.0	61	57	54	51	48	46
12.0	51	47	45	42	40	39
14.0	43	41	38	36	35	33
16.0	38	35	33	32	30	29
18.0	34	32	30	28	27	26
20.0	30	28	27	25	24	23
22.0	28	26	24	23	22	21
24.0	25	24	22	21	20	19

Table D-3.2. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) OF A BEAM WITH CONCENTRATED LOADING (Pinned-Pinned)



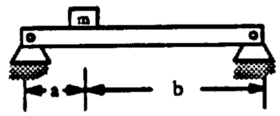
a = 0.5L
b = 0.5L
α = 0.2429
β = 0.2429

% maximum bending load = 75
yield strength (4"–12" D) = 30000 lb/in²
yield strength (14"–24" D) = 42000 lb/in²
E = 28831000 lb/in²

NPS (in)	**4**	**5**	**6**	**8**	**10**	**12**
D_o (in)	**4.50**	**5.56**	**6.63**	**8.63**	**10.75**	**12.75**
D_i (in)	**4.25**	**5.25**	**6.25**	**8.25**	**10.37**	**12.34**
W(lb/ft)	**5.84**	**9.01**	**12.92**	**16.94**	**21.21**	**27.20**
L/D_o	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**
2.0	183	164	151	132	118	109
4.0	91	82	75	66	59	54
6.0	61	55	50	44	39	36
8.0	46	41	38	33	30	27
10.0	37	33	30	26	24	22
12.0	30	27	25	22	20	18
14.0	26	23	22	19	17	16
16.0	23	21	19	17	15	14
18.0	20	18	17	15	13	12
20.0	18	16	15	13	12	11
22.0	17	15	14	12	11	10
24.0	15	14	13	11	10	9

NPS (in)	**14**	**16**	**18**	**20**	**22**	**24**
D_o (in)	**14.00**	**16.00**	**18.00**	**20.00**	**22.00**	**24.00**
D_i (in)	**13.62**	**15.62**	**17.62**	**19.56**	**21.56**	**23.50**
W(lb/ft)	**27.73**	**31.75**	**35.76**	**46.27**	**50.94**	**63.41**
L/D_o	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**
2.0	88	82	77	73	70	67
4.0	44	41	39	37	35	33
6.0	29	27	26	24	23	22
8.0	22	20	19	18	17	17
10.0	18	16	15	15	14	13
12.0	15	14	13	12	12	11
14.0	13	12	11	10	10	10
16.0	11	10	10	9	9	8
18.0	10	9	9	8	8	7
20.0	9	8	8	7	7	7
22.0	8	7	7	7	6	6
24.0	7	7	6	6	6	6

Table D-3.2. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) OF A BEAM WITH CONCENTRATED LOADING (Pinned-Pinned) (cont)



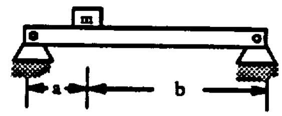
a = 0.5L
b = 0.5L
α = 0.2429
β = 0.2429

% maximum bending load = **50**
yield strength (4"–12" D) = 30000 lb/in^2
yield strength (14"–24" D) = 42000 lb/in^2
E = 28831000 lb/in^2

NPS (in)	**4**	**5**	**6**	**8**	**10**	**12**
D_o (in)	**4.50**	**5.56**	**6.63**	**8.63**	**10.75**	**12.75**
D_i (in)	**4.25**	**5.25**	**6.25**	**8.25**	**10.37**	**12.34**
W(lb/ft)	**5.84**	**9.01**	**12.92**	**16.94**	**21.21**	**27.20**
L/D_o	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**
2.0	224	201	184	162	145	133
4.0	112	101	92	81	72	67
6.0	75	67	62	54	48	44
8.0	56	50	46	40	36	33
10.0	45	40	37	32	29	27
12.0	37	34	31	27	24	22
14.0	32	29	26	23	21	19
16.0	28	25	23	20	18	17
18.0	25	22	21	18	16	15
20.0	22	20	18	16	14	13
22.0	20	18	17	15	13	12
24.0	19	17	15	13	12	11

NPS (in)	**14**	**16**	**18**	**20**	**22**	**24**
D_o (in)	**14.00**	**16.00**	**18.00**	**20.00**	**22.00**	**24.00**
D_i (in)	**13.62**	**15.62**	**17.62**	**19.56**	**21.56**	**23.50**
W(lb/ft)	**27.73**	**31.75**	**35.76**	**46.27**	**50.94**	**63.41**
L/D_o	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**
2.0	107	100	95	90	86	82
4.0	54	50	47	45	43	41
6.0	36	33	32	30	29	27
8.0	27	25	24	22	21	20
10.0	21	20	19	18	17	16
12.0	18	17	16	15	14	14
14.0	15	14	14	13	12	12
16.0	13	13	12	11	11	10
18.0	12	11	11	10	10	9
20.0	11	10	9	9	9	8
22.0	10	9	9	8	8	7
24.0	9	8	8	7	7	7

Table D-3.2. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) OF A BEAM WITH CONCENTRATED LOADING (Pinned-Pinned) (cont)



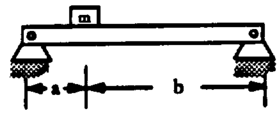
a = 0.5L
b = 0.5L
α = 0.2429
β = 0.2429

% maximum bending load = 25
yield strength (4"–12" D) = 30000 lb/in²
yield strength (14"–24" D) = 42000 lb/in²
E = 28831000 lb/in²

NPS (in)	4	5	6	8	10	12
D_o (in)	4.50	5.56	6.63	8.63	10.75	12.75
D_i (in)	4.25	5.25	6.25	8.25	10.37	12.34
W(lb/ft)	5.84	9.01	12.92	16.94	21.21	27.20
L/D_o	f_n	f_n	f_n	f_n	f_n	f_n
2.0	316	284	261	229	205	188
4.0	158	142	130	114	102	94
6.0	105	95	87	76	68	63
8.0	79	71	65	57	51	47
10.0	63	57	52	46	41	38
12.0	53	47	43	38	34	31
14.0	45	41	37	33	29	27
16.0	40	36	33	29	26	24
18.0	35	32	29	25	23	21
20.0	32	28	26	23	20	19
22.0	29	26	24	21	19	17
24.0	26	24	22	19	17	16

NPS (in)	14	16	18	20	22	24
D_o (in)	14.00	16.00	18.00	20.00	22.00	24.00
D_i (in)	13.62	15.62	17.62	19.56	21.56	23.50
W(lb/ft)	27.73	31.75	35.76	46.27	50.94	63.41
L/D_o	f_n	f_n	f_n	f_n	f_n	f_n
2.0	152	142	134	127	121	116
4.0	76	71	67	63	61	58
6.0	51	47	45	42	40	39
8.0	38	35	33	32	30	29
10.0	30	28	27	25	24	23
12.0	25	24	22	21	20	19
14.0	22	20	19	18	17	17
16.0	19	18	17	16	15	14
18.0	17	16	15	14	13	13
20.0	15	14	13	13	12	12
22.0	14	13	12	12	11	11
24.0	13	12	11	11	10	10

Table D-3.2. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) OF A BEAM WITH CONCENTRATED LOADING (Pinned-Pinned) (cont)



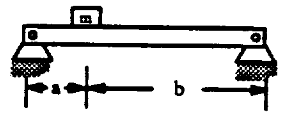
a = 0.25L
b = 0.75L
α = 0.0950
β = 0.6786

% maximum bending load = 75
yield strength (4"–12" D) = 30000 lb/in²
yield strength (14"–24" D) = 42000 lb/in²
E = 28831000 lb/in²

NPS (in)	**4**	**5**	**6**	**8**	**10**	**12**
D_o (in)	**4.50**	**5.56**	**6.63**	**8.63**	**10.75**	**12.75**
D_i (in)	**4.25**	**5.25**	**6.25**	**8.25**	**10.37**	**12.34**
W(lb/ft)	**5.84**	**9.01**	**12.92**	**16.94**	**21.21**	**27.20**
L/D_o	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**
2.0	243	219	201	176	158	145
4.0	122	110	100	88	79	72
6.0	81	73	67	59	53	48
8.0	61	55	50	44	39	36
10.0	49	44	40	35	32	29
12.0	41	37	33	29	26	24
14.0	35	31	29	25	23	21
16.0	30	27	25	22	20	18
18.0	27	24	22	20	18	16
20.0	24	22	20	18	16	14
22.0	22	20	18	16	14	13
24.0	20	18	17	15	13	12

NPS (in)	**14**	**16**	**18**	**20**	**22**	**24**
D_o (in)	**14.00**	**16.00**	**18.00**	**20.00**	**22.00**	**24.00**
D_i (in)	**13.62**	**15.62**	**17.62**	**19.56**	**21.56**	**23.50**
W(lb/ft)	**27.73**	**31.75**	**35.76**	**46.27**	**50.94**	**63.41**
L/D_o	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**
2.0	117	109	103	98	93	89
4.0	58	55	52	49	47	45
6.0	39	36	34	33	31	30
8.0	29	27	26	24	23	22
10.0	23	22	21	20	19	18
12.0	19	18	17	16	16	15
14.0	17	16	15	14	13	13
16.0	15	14	13	12	12	11
18.0	13	12	11	11	10	10
20.0	12	11	10	10	9	9
22.0	11	10	9	9	8	8
24.0	10	9	9	8	8	7

Table D-3.2. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) OF A BEAM WITH CONCENTRATED LOADING (Pinned-Pinned) (cont)



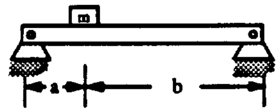
a = 0.25L
b = 0.75L
α = 0.0950
β = 0.6786

% maximum bending load = **50**
yield strength (4"–12" D) = 30000 lb/in^2
yield strength (14"–24" D) = 42000 lb/in^2
E = 28831000 lb/in^2

NPS (in)	**4**	**5**	**6**	**8**	**10**	**12**
D_o (in)	**4.50**	**5.56**	**6.63**	**8.63**	**10.75**	**12.75**
D_i (in)	**4.25**	**5.25**	**6.25**	**8.25**	**10.37**	**12.34**
W(lb/ft)	**5.84**	**9.01**	**12.92**	**16.94**	**21.21**	**27.20**
L/D_o	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**
2.0	297	268	246	215	193	177
4.0	149	134	123	108	97	89
6.0	99	89	82	72	64	59
8.0	75	67	61	54	48	44
10.0	60	54	49	43	39	35
12.0	50	45	41	36	32	30
14.0	43	38	35	31	28	25
16.0	37	34	31	27	24	22
18.0	33	30	27	24	21	20
20.0	30	27	25	22	19	18
22.0	27	24	22	20	18	16
24.0	25	22	21	18	16	15

NPS (in)	**14**	**16**	**18**	**20**	**22**	**24**
D_o (in)	**14.00**	**16.00**	**18.00**	**20.00**	**22.00**	**24.00**
D_i (in)	**13.62**	**15.62**	**17.62**	**19.56**	**21.56**	**23.50**
W(lb/ft)	**27.73**	**31.75**	**35.76**	**46.27**	**50.94**	**63.41**
L/D_o	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**
2.0	143	134	126	120	114	109
4.0	72	67	63	60	57	55
6.0	48	45	42	40	38	36
8.0	36	33	32	30	29	27
10.0	29	27	25	24	23	22
12.0	24	22	21	20	19	18
14.0	20	19	18	17	16	18
16.0	18	17	16	15	14	16
18.0	16	15	14	13	13	14
20.0	14	13	13	12	11	12
22.0	13	12	11	11	10	11
24.0	12	11	11	10	10	10

Table D-3.2. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) OF A BEAM WITH CONCENTRATED LOADING (Pinned-Pinned) (cont)



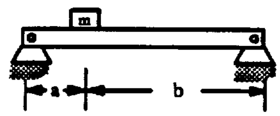
a = 0.25L
b = 0.75L
α = 0.0950
β = 0.6786

% maximum bending load = 25
yield strength (4"–12" D) = 30000 lb/in^2
yield strength (14"–24" D) = 42000 lb/in^2
E = 28831000 lb/in^2

NPS (in)	**4**	**5**	**6**	**8**	**10**	**12**
D_o (in)	**4.50**	**5.56**	**6.63**	**8.63**	**10.75**	**12.75**
D_i (in)	**4.25**	**5.25**	**6.25**	**8.25**	**10.37**	**12.34**
W(lb/ft)	**5.84**	**9.01**	**12.92**	**16.94**	**21.21**	**27.20**
L/D_o	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**
2.0	418	377	347	304	273	251
4.0	210	189	174	152	136	125
6.0	140	126	116	102	91	84
8.0	105	95	87	76	68	63
10.0	84	76	70	61	55	50
12.0	70	63	58	51	46	42
14.0	60	54	50	44	39	36
16.0	53	47	43	38	34	31
18.0	47	42	39	34	30	28
20.0	42	38	35	30	27	25
22.0	38	35	32	28	25	23
24.0	35	32	29	25	23	21

NPS (in)	**14**	**16**	**18**	**20**	**22**	**24**
D_o (in)	**14.00**	**16.00**	**18.00**	**20.00**	**22.00**	**24.00**
D_i (in)	**13.62**	**15.62**	**17.62**	**19.56**	**21.56**	**23.50**
W(lb/ft)	**27.73**	**31.75**	**35.76**	**46.27**	**50.94**	**63.41**
L/D_o	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**
2.0	202	189	178	169	161	154
4.0	101	95	89	85	81	77
6.0	67	63	59	56	54	52
8.0	51	47	45	42	40	39
10.0	40	38	36	34	32	31
12.0	34	32	30	28	27	26
14.0	29	27	25	24	23	22
16.0	25	24	22	21	20	19
18.0	22	21	20	19	18	17
20.0	20	19	18	17	16	15
22.0	18	17	16	15	15	14
24.0	17	16	15	14	13	13

Table D-3.2. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) OF A BEAM WITH CONCENTRATED LOADING (Pinned-Pinned) (cont)



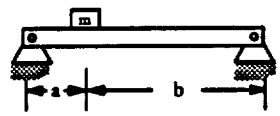
$a = 0.05L$
$b = 0.95L$
$\alpha = 0.0170$
$\beta = 9.2557$

% maximum bending load = 75
yield strength (4"–12" D) = 30000 lb/in²
yield strength (14"–24" D) = 42000 lb/in²
E = 28831000 lb/in²

NPS (in)	**4**	**5**	**6**	**8**	**10**	**12**
D_o (in)	**4.50**	**5.56**	**6.63**	**8.63**	**10.75**	**12.75**
D_i (in)	**4.25**	**5.25**	**6.25**	**8.25**	**10.37**	**12.34**
W(lb/ft)	**5.84**	**9.01**	**12.92**	**16.94**	**21.21**	**27.20**
L/D_o	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**
2.0	711	724	722	702	669	636
4.0	430	423	410	383	355	333
6.0	312	301	287	264	242	226
8.0	246	234	221	201	184	171
10.0	203	191	180	163	148	137
12.0	173	162	152	137	124	115
14.0	151	140	131	118	107	99
16.0	133	124	116	103	94	86
18.0	120	111	103	92	83	77
20.0	109	100	93	83	75	69
22.0	100	92	85	76	68	63
24.0	92	84	78	70	63	58

NPS (in)	**14**	**16**	**18**	**20**	**22**	**24**
D_o (in)	**14.00**	**16.00**	**18.00**	**20.00**	**22.00**	**24.00**
D_i (in)	**13.62**	**15.62**	**17.62**	**19.56**	**21.56**	**23.50**
W(lb/ft)	**27.73**	**31.75**	**35.76**	**46.27**	**50.94**	**63.41**
L/D_o	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**	**f_n**
2.0	532	505	480	459	440	422
4.0	274	258	244	233	222	213
6.0	184	173	164	156	149	143
8.0	139	131	123	117	112	107
10.0	112	105	99	94	90	86
12.0	93	87	82	78	75	72
14.0	80	75	71	67	64	61
16.0	70	66	62	59	56	54
18.0	62	58	55	52	50	48
20.0	56	53	50	47	45	43
22.0	51	48	45	43	41	39
24.0	47	44	41	39	37	36

Table D-3.2. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) OF A BEAM WITH CONCENTRATED LOADING (Pinned-Pinned) (cont)



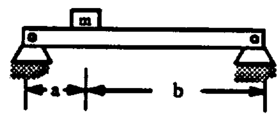
$a = 0.05L$
$b = 0.95L$
$\alpha = 0.0170$
$\beta = 9.2557$

% maximum bending load = 50
yield strength (4"–12" D) = 30000 lb/in²
yield strength (14"–24" D) = 42000 lb/in²
E = 28831000 lb/in²

NPS (in)	4	5	6	8	10	12
D_o (in)	4.50	5.56	6.63	8.63	10.75	12.75
D_i (in)	4.25	5.25	6.25	8.25	10.37	12.34
W(lb/ft)	5.84	9.01	12.92	16.94	21.21	27.20
L/D_o	f_n	f_n	f_n	f_n	f_n	f_n
2.0	654	652	639	606	568	535
4.0	382	368	352	323	297	276
6.0	272	258	243	220	201	186
8.0	212	198	186	167	152	140
10.0	173	161	151	135	122	113
12.0	147	136	127	113	102	94
14.0	127	117	109	97	88	81
16.0	112	103	96	85	77	71
18.0	101	92	86	76	68	63
20.0	91	83	77	68	62	57
22.0	83	76	70	62	56	52
24.0	77	70	65	57	51	47

NPS (in)	14	16	18	20	22	24
D_o (in)	14.00	16.00	18.00	20.00	22.00	24.00
D_i (in)	13.62	15.62	17.62	19.56	21.56	23.50
W(lb/ft)	27.73	31.75	35.76	46.27	50.94	63.41
L/D_o	f_n	f_n	f_n	f_n	f_n	f_n
2.0	443	418	397	378	362	347
4.0	226	212	201	191	182	175
6.0	152	142	134	128	122	117
8.0	114	107	101	96	92	88
10.0	91	86	81	77	73	70
12.0	76	72	67	64	61	59
14.0	65	61	58	55	52	50
16.0	57	54	51	48	46	44
18.0	51	48	45	43	41	39
20.0	46	43	41	38	37	35
22.0	42	39	37	35	33	32
24.0	38	36	34	32	31	29

Table D-3.2. FUNDAMENTAL TRANSVERSE FREQUENCY (Hz) OF A BEAM WITH CONCENTRATED LOADING (Pinned-Pinned) (cont)



a = 0.05L
b = 0.95L
α = 0.0170
β = 9.2557

% maximum bending load = 25
yield strength (4"–12" D) = 30000 lb/in²
yield strength (14"–24" D) = 42000 lb/in²
E = 28831000 lb/in²

NPS (in)	4	5	6	8	10	12
D_o (in)	4.50	5.56	6.63	8.63	10.75	12.75
D_i (in)	4.25	5.25	6.25	8.25	10.37	12.34
W(lb/ft)	5.84	9.01	12.92	16.94	21.21	27.20
L/D_o	f_n	f_n	f_n	f_n	f_n	f_n
2.0	609	598	580	542	503	471
4.0	348	330	313	285	260	241
6.0	244	229	215	193	175	162
8.0	189	175	164	146	132	122
10.0	154	142	132	118	106	98
12.0	130	119	111	98	89	82
14.0	112	103	95	85	76	70
16.0	99	91	84	74	67	61
18.0	88	81	75	66	59	55
20.0	80	73	67	59	54	49
22.0	73	66	61	54	49	45
24.0	67	61	56	50	45	41

NPS (in)	14	16	18	20	22	24
D_o (in)	14.00	16.00	18.00	20.00	22.00	24.00
D_i (in)	13.62	15.62	17.62	19.56	21.56	23.50
W(lb/ft)	27.73	31.75	35.76	46.27	50.94	63.41
L/D_o	f_n	f_n	f_n	f_n	f_n	f_n
2.0	387	365	346	329	315	302
4.0	197	185	174	166	158	152
6.0	132	124	117	111	106	101
8.0	99	93	88	83	79	76
10.0	79	74	70	67	64	61
12.0	66	62	59	56	53	51
14.0	57	53	50	48	45	44
16.0	50	47	44	42	40	38
18.0	44	41	39	37	35	34
20.0	40	37	35	33	32	30
22.0	36	34	32	30	29	28
24.0	33	31	29	28	27	25

Table D-4. UNIFORM SHEAR BEAMS (Clamped or Pinned)

E (Modulus of Elasticity)	= 2.883×10^7 lb/in^2
λ	= 3.1416
μ	= 489.54 lb/ft^3
v (Poisson's Ratio)	= 0.03
G (Shear Modulus)	= 1.400×10^7 lb/in^2
K (Shear Coefficient)	= 0.50
mass is positioned at 0.5L	

NPS (in) L/D$_o$	4 f_n	5 f_n	6 f_n	8 f_n	10 f_n	12 f_n
5.0	1351	1093	918	705	565	477
10.0	675	546	459	352	283	238
15.0	450	364	306	235	188	159
20.0	338	273	229	176	141	119
25.0	270	219	184	141	113	95
30.0	225	182	153	117	94	79
35.0	193	156	131	101	81	68
40.0	169	137	115	88	71	60
45.0	150	121	102	78	63	53
50.0	135	109	92	70	57	48
55.0	123	99	83	64	51	43
60.0	113	91	76	59	47	40
65.0	104	84	71	54	43	37
70.0	96	78	66	50	40	34
75.0	90	73	61	47	38	32

NPS (in) L/D$_o$	14 f_n	16 f_n	18 f_n	20 f_n	22 f_n	24 f_n
5.0	434	380	338	304	276	253
10.0	217	190	169	152	138	127
15.0	145	127	113	101	92	84
20.0	109	95	84	76	69	63
25.0	87	76	68	61	55	51
30.0	72	63	56	51	46	42
35.0	62	54	48	43	39	36
40.0	54	47	42	38	35	32
45.0	48	42	38	34	31	28
50.0	43	38	34	30	28	25
55.0	39	35	31	28	25	23
60.0	36	32	28	25	23	21
65.0	33	29	26	23	21	19
70.0	31	27	24	22	20	18
75.0	29	25	23	20	18	17

Table D-5. LONGITUDINAL VIBRATION OF UNIFORM BEAMS (Clamped or Pinned)

E = 2.883×10^7 lb/in^2
λ = 3.14159
μ = 489.535 lb/ft^3

NPS (in) L/D$_o$	4 f_n	5 f_n	6 f_n	8 f_n	10 f_n	12 f_n
5.0	13839	3563	2992	2298	1844	1555
10.0	2202	1782	1496	1149	922	777
15.0	1468	1188	997	766	615	518
20.0	1101	891	748	575	461	389
25.0	881	713	598	460	369	311
30.0	734	594	499	383	307	259
35.0	629	509	427	328	263	222
40.0	551	445	374	287	230	194
45.0	489	396	332	255	205	173
50.0	440	356	299	230	184	155
55.0	400	324	272	209	168	141
60.0	367	297	249	192	154	130
65.0	339	274	230	177	142	120
70.0	315	255	214	164	132	111
75.0	294	238	199	153	123	104

NPS (in) L/D$_o$	14 f_n	16 f_n	18 f_n	20 f_n	22 f_n	24 f_n
5.0	1416	1239	1101	991	901	826
10.0	708	619	551	496	451	413
15.0	472	413	367	330	300	275
20.0	354	310	275	248	225	206
25.0	283	248	220	198	180	165
30.0	236	206	184	165	150	138
35.0	202	177	157	142	129	118
40.0	177	155	138	124	113	103
45.0	157	138	122	110	100	92
50.0	142	124	110	99	90	83
55.0	129	113	100	90	82	75
60.0	118	103	92	83	75	69
65.0	109	95	85	76	69	64
70.0	101	88	79	71	64	59
75.0	94	83	73	66	60	55

Table D-6. TORSIONAL VIBRATION OF UNIFORM SHAFTS (Clamped or Pinned)

E (Modulus of Elasticity) = 2.883 x 10^7 lb/in^2
G (Shear Modulus) = 1.110 x 10^7 lb/in^2
λ = 3.1416
μ = 489.54 lb/ft^3
v (Poisson's Ratio) = 0.3

NPS (in)	4	5	6	8	10	12
L/D_o	f_n	f_n	f_n	f_n	f_n	f_n
5.0	3863	3125	2624	2016	1617	1364
10.0	1932	1563	1312	1008	809	682
15.0	1288	1042	875	672	539	455
20.0	966	781	656	504	404	341
25.0	773	625	525	403	323	273
30.0	644	521	437	336	270	227
35.0	552	446	375	288	231	195
40.0	483	391	328	252	202	170
45.0	429	347	292	224	180	152
50.0	386	313	262	202	162	136
55.0	351	284	239	183	147	124
60.0	322	260	219	168	135	114
65.0	297	240	202	155	124	105
70.0	276	223	187	144	116	97
75.0	258	208	175	134	108	91

NPS (in)	14	16	18	20	22	24
L/D_o	f_n	f_n	f_n	f_n	f_n	f_n
5.0	1242	1087	966	869	790	724
10.0	621	543	483	435	395	362
15.0	414	362	322	290	263	241
20.0	310	272	241	217	198	181
25.0	248	217	193	174	158	145
30.0	207	181	161	145	132	121
35.0	177	155	138	124	113	103
40.0	155	136	121	109	99	91
45.0	138	121	107	97	88	80
50.0	124	109	97	87	79	72
55.0	113	99	88	79	72	66
60.0	103	91	80	72	66	60
65.0	96	84	74	67	61	56
70.0	89	78	69	62	56	52
75.0	83	72	64	58	53	48

APPENDIX E

REFERENCES

REFERENCES

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13. ABSTRACT (Maximum 200 words)
This study determined which cylindrical beams, identified by the length-to-diameter ratio (L/D_o), may develop oscillations causing excessive beam displacement and failure when subjected to 130-mph maximum steady-state winds. The beam sizes studied included standard pipe sizes and thicknesses of grade X42 steel supported by pinned and rigid (welded) end connections and with various loading conditions. The procedure included determining the causes and effects of wind-induced vibration, deriving formulas for wind-induced vibration and beam natural frequencies for different applied loads, and computing the results using spreadsheet and finite element programs. Results and analysis showed that vibration was caused by Karman vortex shedding in the cylinder wake when the Reynold's number was below 10^6 (over 10^6, vortex formation is irregular and this analysis does not apply); induced vibration frequency increases with wind velocity; the beam natural frequency decreases with increased beam length; resonance may occur when the beam natural frequency coincides with the induced vibration frequency; welded connections produced optimum L/D_o ratios when limiting axial and bending loads to 50 percent maximum; combinations of loads produced unfavorably low L/D_o values; and vortex suppression devices, such as helical strakes, significantly improve vibration behavior.

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