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EQUIVALENT SEISMIC DESIGN OF CURVED BOX GIRDER BRIDGES

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ABSTRACT

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Chapter I

INTRODUCTION

With the advent of the 1964 Alaskan Earthquake, the 1971 San Fernando Earthquake and more recently the 1978 Santa Barbara Earthquake (1), bridge structures in the USA have undergone considerable destructive forces.

These earthquakes have caused the bridge professionals to reassess the design techniques that have been applied, up until that time, for seismic design.

A prime force in such modifications has been the Highway Department for the State of California (CALTRANS) and the California based professional organization Applied Technology Council (ATC).

The present 1977 AASHTO bridge code (2), as related to seismic design, was greatly influenced by the work developed by CALTRANS. This code suggests an equivalent static force method for simple structures and when the structure is complex, for example curved bridges, a computer based response spectrum or dynamic analysis should be considered.

In this present 1977 AASHTO code, most engineers would utilize the seismic coefficient method (SCM), because computer oriented dynamic programs may not be available nor are they amenable for direct design. However, the utilization of the S.C.M., may give erroneous results when designing under seismic conditions (3), as experienced by CALTRANS. CALTRANS in fact has utilized the response spectrum technique for the design of many structures.

Because of these conditions and from experience gained from recent earthquakes, the FHWA decided to reassess the 1975 AASHTO code and in 1977 sponsored a research program directed by ATC (4). The work of this council, in part, is to prepare a new specification (5). Although this code will be an improvement over the past criteria, there are major areas of research still requiring investigation. These areas, as suggested recently by the delegates attending the "Workshop on Earthquake Resistance of Highway Bridges", (6) conducted by ATC, include:

1. "Conduct Parametric Studies for the Seismic Response of Common Types of Bridges to Determine the Effects of Geometry and Constraint on Overall Seismic Response"

   Parameters should include:

   a) Span length

   b) Curvature

   c) Column height and stiffness

   d) Material, etc.

2. "Perform Appropriate Dynamic Analysis on Curved Bridges", (7,8) and develop a simple procedure for the design of curved bridges.

3. "Develop a Practical and Accurate Method to Estimate the Fundamental Period of Bridges".

4. "Correlate Vibrational Characteristics of Existing Bridges with Theory".

5. "Prepare Summary of Dynamic Behavior and Characteristics".

These various areas of research are presently being studied and will encompass curved steel and concrete box girder bridges.

The techniques to be employed in the dynamic analysis of such structures can consist of:

i) response spectrum technique

ii) multi-mode method-response spectrum

iii) multi-mode time history analysis

These various methods are presently being used in this research. The method that was employed in the work described herein involves a space frame analysis of the general structure, computation of the equivalent natural frequency, then determination of the equivalent dynamic forces.

A comprehensive study of the influence of the various parameters, as will be illustrated, has resulted in a proposed equivalent static load analysis technique.

Chapter 2

THEORY

2.1 Computer Model

The general static response of curved bridge structures requires incorporation of the interaction between the bending and torsional forces (11,14,15,17, 25,26). Such interaction can be considered by solving Vlasov equations (26), or by development of the stiffness matrix (9) and appropriate restraint conditions.

The matrix oriented technique however is more versatile, in that a three dimensional model (space frame) can be considered. This then permits modeling of the structure such that the support conditions can represent the physical restraints. Also the induced actions can be applied in three directions, and thus simulate the various earthquake induced actions.

Therefore the study of the induced actions on a structure, when subjected to earthquakes, will be confined to utilization of a space frame matrix simulation. The basic modeling consists of series of typical elements, Fig. 1, attached rigidly together to form a continuous curved box girder bridge, Fig. 2.

The basic properties of each beam element consist of I_z, I_y and K_T, as shown in Fig. 3. Although warping and distortional properties (I_w, W_n, W_a) can be computed, they are not considered in this study, as it has been shown (17), that with proper bracing of the box girder, warping and distortional effects are negligible.

Therefore by proper evaluation of the stiffness of each beam element, and identifying each joint load, the static response of the continuous curved girder can be determined. The static response can then be utilized to determine the effective earthquake effects, using the response spectrum curves. The general procedure using this method will now be described.

The support restraints, to be imposed on the bridge model, can be identified as releases in the computer model. Because a space frame model is being utilized, six releases or restraints must be identified. For the bridge under study the following will be assumed.

2.2 Equivalent Dynamic Analysis

The natural frequency response of a single degree of freedom system can be predicted by the following (33 ∿ 36);

$$\omega = \sqrt{\frac{k}{m}} \tag{2-1}$$

where

k = spring constant

m = mass (w/g) or mass moment of inertia .

If the natural frequency ω of the system, as computed from (2-1) or some other technique, is reliable, then the corresponding induced vertical acceleration of the mass M created by an earthquake can be predicted by using the response spectrum curve given in Figures 4, 5, and 6. The resultant accelerations obtained therein are then used to determine the induced dynamic force

$$F = M \cdot a_{R.S.} \tag{2-2a}$$

where

$a_{R.S.} = \ddot{y}$ = linear acceleration obtained from response spectrum curves.

If the system is subjected to angular accelerations $\ddot{\theta}$, then the induced dynamic torque is

$$M = \overline{I}\ddot{\theta}_{RS} \tag{2-2b}$$

where:

$\bar{I}$ = mass moment of interia = $\int \rho r^2 dA = \rho_{steel} \int (x^2+y^2) dA + \rho_{concrete} \int (x^2+y^2) dA$

$\ddot{\theta}_{RS}$ = rotational acceleration obtained from the response curve

ρ = mass per unit area.

This type of procedure has been proposed elsewhere (3,4,5,6,7,8,12,13,19, 20,21,22) and requires a methodology which can accurately determine the natural frequency (ω) of the structure.

2.3 Natural Frequency

As indicated by Equation (2-1), the natural frequency of a SDOF system is given as a function of the spring stiffnesses (k) and the spring mass (m). If the system is a bridge structure the spring constant can be represented by:

$$k = \left(\frac{1}{\Delta}\right) \tag{2-3}$$

where:

Δ = induced maximum displacement caused by a unit load.

Therefore by determining the response of a given box girder bridge, when subjected to a unit load, an equivalent spring constant can be obtained. This constant, k, and the total mass of the bridge, will then permit evaluation of the natural frequency as given by Eq. (2-1).

In the instance of curved structures, the dynamic action can occur in three principal directions, and one primary rotation as shown in Figure 7. The resulting maximum displacement, induced by these unit loads, will then give the corresponding equivalent stiffnesses k_x, k_y, k_z and k_T. The corresponding natural frequencies can then be determined by applying Eq. (2-1).

2.4 Computer Program

A general computer program has been developed which will automatically determine the equivalent spring constant for the three translation directions

(k_x, k_y, k_z) and the one rotation (k_T), of a continuous, constant radius bridge. Section properties are automatically computed and utilized for determination of the stiffness matrix. Dead loads and masses are also computed and these used to determine the equivalent dynamic force, as given by Eq. (2-2). This dynamic force is then applied uniformly to the structure and the resulting deformations and actions determined.

The response spectra, Figures 4, 5, and 6, have also been incorporated into the program for direct use. Considering a constant 2% damping value for these types of bridges (13,20), the general curves can be written in the following form.

2.4.1 Horizontal Response Spectrum (Fig. 5).

The general curve can be written in three parts, segment $\overline{AB}$, segment $\overline{BC}$ and segment $\overline{CD}$. The acceleration equations representing each line for a corresponding frequency is given by the following, where A_H = horizontal response spectrum acceleration and f_H = horizontal frequency:

i) $f_H > 33$ Hz

$$A_H = 1.0 \text{ g}$$

ii) $9\text{Hz} < f_H \leq 33$ Hz ($\overline{AB}$)

$$\log A_H = \log 1.0 + \frac{(\log 3.54 - \log 1.0)}{(\log 33 - \log 9)} \times (\log 33 - \log f_H)$$

iii) $2.5 \text{ Hz} < f_H \leq 9$ Hz ($\overline{BC}$)

$$\log A_H = \log 3.54 + \frac{(\log 4.25 - \log 3.54)}{(\log 9 - \log 2.5)} \times (\log 9 - \log f_H)$$

iv) $0.25 \text{ Hz} < f_H \leq 2.5$ Hz ($\overline{CD}$)

$$\log A_H = \log 0.6 + \frac{(\log 4.25 - \log 0.6)}{(\log 2.5 - \log 0.25)} \times (\log f_H - \log 0.25)$$

2.4.2. Vertical Response Spectrum (Fig. 4).

Similarly the curve given in Fig. 4 can be written as follows, where A_v = vertical response spectrum acceleration and f_v = vertical frequency:

i) $9\text{Hz} < f_v \leq 33\text{Hz}$ $(\overline{AB})$

$$\log A_v = \log 1.0 + \frac{(\log 3.54 - \log 1.0)}{(\log 33 - \log 9)} \times (\log 33 - \log f_v)$$

ii) $3.6\text{ Hz} < f_v \leq 9\text{ Hz}$ $(\overline{BC''})$

$$\log A_v = \log 3.54 + \frac{(\log 4.0 - \log 3.54)}{(\log 9 - \log 3.6)} \times (\log 9 - \log f_v)$$

iii) $0.25\text{ Hz} < f_v \leq 3.6\text{ Hz}$ $(\overline{C''D'})$

$$\log A_v = \log 0.4 + \frac{(\log 4.0 - \log 0.4)}{(\log 3.6 - \log 0.25)} \times (\log f_v - \log 0.25)$$

2.4.3. Torsional Response Spectrum (Fig. 6)

The torsional response spectrum, for a 2% damping factor, can be represented by the following expressions, where A_θ = torsional response spectrum and f_θ = angular acceleration:

i) $f_\theta > 5\text{ Hz}$

$$A_\theta = 4 \times 10^{-3} \times 386$$

ii) $2\text{Hz} < f_\theta \leq 5\text{ Hz}$

$$\log A_\theta' = \log 0.004 - \frac{(\log 0.004 - \log 0.0017)}{(\log 5 - \log 2)} \times (\log 5 - \log f_\theta)$$

$$A_\theta = A_\theta' \times 386$$

iii) $0.5\text{ Hz} < f \leq 2\text{Hz}$

$$\log A_\theta' = \log 0.0017 - \frac{(\log 0.0017 - \log 0.0001)}{(\log 2 - \log 0.5)} \times (\log 2 - \log f_\theta)$$

$$A_\theta = A_\theta' \times 386$$

The program will automatically select eleven nodes for each span, with 10 members per span between the supports. The proper selection of the member properties corresponding to the basic input section lengths, are automatically determined.

The restraints assumed at the end supports in the six directions are:

$$\left.\begin{array}{l} \mathrm{Rx} = 1 \\ \mathrm{Ry} = 1 \\ \mathrm{Rz} = 1 \\ \mathrm{RMx} = 1 \\ \mathrm{RMy} = 0 \\ \mathrm{RMz} = 0 \end{array}\right\}\underline{\text{hinge}} \qquad \left.\begin{array}{l} \mathrm{Rx} = 0 \\ \mathrm{Ry} = 1 \\ \mathrm{Rz} = 1 \\ \mathrm{RMx} = 1 \\ \mathrm{RMy} = 0 \\ \mathrm{RMz} = 0 \end{array}\right\}\underline{\text{roller}} \qquad \begin{array}{l} 0 = \text{free} \\ 1 = \text{fix} \end{array}$$

The interior support restraints are assumed flexible by insertion of springs in the three displacement directions. The rotational restraints have the following conditions:

$$\left.\begin{array}{l} \mathrm{Rx} = 1 \\ \mathrm{Ry} = 1 \\ \mathrm{Rz} = 1 \\ \mathrm{RMx} = 1 \\ \mathrm{RMy} = 1 \\ \mathrm{RMz} = 1 \end{array}\right\} \qquad \left.\begin{array}{l} A \rightarrow 0 \\ \mathrm{Kt} \rightarrow 0 \\ \mathrm{Iy} \rightarrow 0 \\ \mathrm{Iz} \rightarrow \infty \end{array}\right\}$$

where: Iz simulates the R_y = effect and produces $R_y \times d = Mx$.

2.4.3. Computer Input

The required computer input data which represents the typical configuration of a curved box girder bridge structure, is given in Table 1. These sheets prescribe the variables and allocation of the format requirements. The variable designations are as follows:

<u>Sheet 1 of 5</u>

1) GENERAL DATA

NO. OF CROSS SECTIONS: The number of various girder section changes along entire bridge length

NO. OF BOXES: Number of boxes in bridge system

BOX LOCATION: Box type

Outside Box = 1

Inside Box = 2

MODULAR RATIO:

Es/Ec for SDL

Es/Ec for LL

YIELD STRESS OF STEEL (KSI):

Positive moment region

Negative moment region

2) GEOMETRY AND PROPERTIES

RADIUS OF CURVATURE: Radius to center line of box (feet)

CLEAR ROADWAY: Bridge roadway width between curbs (feet)

SPACING BETWEEN BOXES: The clear distance between boxes (web to web) included

UNIT WT. OF CONCRETE: Weight of concrete ($lbs/ft.^3$)

MISC. STEEL WT.: Weight of connectors, bracing, stiffeners etc. as a percentage (%) of the steel box beam weight

WT. OF WEARING SURFACE: Weight of wearing surface (asphalt etc.) in lbs. per sq. ft.

AREA OF MISC. CONCRETE: Total additional concrete area (in^2) across bridge width

COMP. STR. CONCRETE: Allowable strength of concrete (KSI)

3) SPAN LENGTHS

No. 1: Length of span 1 in feet, moving from left to right

No. 2 . . . No.8

<u>Sheet 2 of 5</u>

4) BEAM SECTION CHANGE

The length of each section in feet starting from the left support. along the entire girder.

5) STRUCTURAL DETAILS

SLAB DEPTH: Design slab thickness in inches, excluding wearing surface, used in composite design

INTEGRAL WEARING SURFACE: Thickness of integral wearing surface in inches

HAUNCH:

WIDTH: width of haunch (inches), Fig. 8

DEPTH: depth of haunch (inches), Fig. 8

UTILITY WT.: Weight of miscellaneous utilities,(i.e. cables, pipes, etc.) which are supported by the box (lbs./$ft.^2$) of surface area

RAILING WT.: Railing weight in lbs/linear foot of bridge

OVERHANG: Width of concrete slab (feet), extended beyond webs for:

OUTSIDE: Section, Fig. 8

INSIDE: Section, Fig. 8

CURB: Width and height of curbs (inches), Fig. 8

SIDEWALK: Width and thickness of side walks (inches), Fig. 8

ANGLE: Angle of slab with respect to horizontal (degrees), Fig. 9

Sheet 3 of 5

6) STEEL SECTION DETAILS (Fig. 9)

This card is used for each section variation, along length of beam, as designated by card 4.

SECT. No.: Section identification number, 1, 2, . . . along girder

INDEX: Indicates if the section is to be designated composite or non-composite;

NON-COMPOSITE = 1

COMPOSITE = 2

WEB ANGLE: Inclination of left and right web (degrees) with respect to vertical, Fig. 9

WEB DIMENSIONS: Depth (inches, and thickness (inches) of left and right web

TOP FLANGE DIMENSIONS: Width (inches) and thickness (inches) of top left and top right flanges

BOTTOM FLANGE DIMENSIONS: Width (inches) and thickness (inches) of bottom flange

7) BRACING AND STIFFENER DETAILS

SECT. NO: Section Identification

TYPE OF BRACING: Conformation of top lateral bracing (Fig. 10)

AREA OF BRACING: Cross sectional area (in^2) of top lateral bracing

DIAPHRAGM SPACING: Average spacing of cross diaphragms (inches)

BOTTOM FLANGE STIFF.:

No Flange Stiffener = 0

Have Flange Stiffener = 1

WEB STIFF.:

No Web Stiffener = 0

Have Web Stiffener = 1

Sheet 4 of 5

8) WEB AND BOTTOM FLANGE STIFFENER DATA

Properties of stiffener elements for each section are:

SECT. NO: Section identifcation

SPAC. OF WEB STIFF.: Transverse web stiffneer spacing (inches)

BOTTOM FLANGE DATA:

AREA: (in^2)

CENTROID: Distance (in.) from centroid of stiffener to bottom of bottom flange

INERTIA: Principal moment of inertia (in^4) of stiffener

NUMBER: Number of stiffeners

9) Structure ID

STRUCTURE NO: Identification or project no. of structure

NO. OF LOADING SYSTEMS:

Set = 4, for consideration of 3 actions and one rotation solution (Rx, Ry, Rz, Mx).

10) PIER SECTION: Ax

Area of interior vertical pier supports, computed as follows:

<u>Computation of Ax</u>

$$\Delta = \frac{PL}{AE}$$

$$\frac{AE}{L} = \frac{P}{\Delta} = k$$

$$\text{A equivalent} = \frac{k \times L}{Ec}$$

For a small element assume:

$$L = 2' = 24'' \qquad \frac{Es}{Ec} \approx 10$$

Therefore:

$$Ax = \frac{k \times L}{Ec} = \frac{k \times L}{Ec \times 10}$$

$$= \frac{k \times L}{Es} = \frac{k \times 24}{30 \times 10^3}$$

<u>Sheet 5 of 5</u>

11) UNIT LOAD JOINT DATA:

The number of unit loads applied to a given structure, generally = 1

12) LOADS APPLIED AT JOINTS:

The unit loads applied at a specific joint in order to compute k stiffness

A sample set of computer input data is given in Appendix A.

Span No.	Joint Index	X direction	Y direction	Z direction	Mx direction	My direction	Mz direction
1	6	1.0	0	0	0	0	0
	6	0	1.0	0	0	0	0
	6	0	0	1.0	0	0	0
	6	0	0	0	1.0	0	0
2	6	1.0	0	0	0	0	0
	6	0	1.0	0	0	0	0
	6	0	0	1.0	0	0	0
	6	0	0	0	1.0	0	0
3	16	1.0	0	0	0	0	0
	16	0	1.0	0	0	0	0
	16	0	0	1.0	0	0	0
	16	0	0	0	1.0	0	0
4	16	1.0	0	0	0	0	0
	16	0	1.0	0	0	0	0
	16	0	0	1.0	0	0	0
	16	0	0	0	1.0	0	0

2.4.4. Computer Output

Initially the program lists the basic input data for verification. Section properties are given, as are the dead loads, for each section. Following this preliminary information are the structural data, coordinates, member stiffnesses, lengths, then the joint restraints, unit load location and direction. Finally the resulting displacements and end actions.

Figures 1 and 11 illustrate the force and displacement notations.

The equivalent displacement and end actions represent the resulting forces created by the simulated earthquake action applied in the designated direction (Rx, Ry, Rz or Mx). These actions can then be used for designer after appropriate modification due to the high intensity of acceleration that was used for the response spectrum curves.

A sample set of computer output data is given in Appendix A.

Chapter 3

BRIDGE STUDIES

3.1 TYPICAL SECTIONS

In order to develop a simplified design technique, the response of various curved box girder bridges must be examined. Such box girders, which have been used in previous studies (11), will be utilized in this parametric study and are given in Table 2 and Figure 12. In this study only the three-lane, three-girder system will be considered because this is most typical of curved box girder structures (17).

It should also be noted that the sections given in Table 2, are for simple span designs. However, examination of continuous span data (17), indicates these sections can be used in the 0.8 L positive region, and for the 0.4 L negative region the bare steel section stiffeners will be doubled. Such an assumption will not greatly affect the results, as section variations only cause a 5/10% variation in moments and minimal variation in deformation.

The basic span length configruations that were examined are shown in Figure 13. The radius for these various structures that was used, varied from 200 feet to 999,999 feet.

3.2 COLUMN DETAILS

In order to include the influence of the flexibility of the piers, a survey was conducted to determine typical pier configurations and sizes. Such a survey has indicated that for a roadway of 44', using three boxes, a three-column bent is generally used. Such column bents generally have the following details:

Round Columns:

$2.5' \leq d \leq 3.0'$ diameter

$12 \sim 20$ #11 steel bars

Rectangular Columns:

$4' \times 12'$ dimension

$30 \sim 40$ #8/#9 steel bars

The height of the bents is $10' \sim 15'$, and the spacing between columns is $15' \sim 18'$.

Using this basic information, the section properties (Ix, Iz) of the round and rectangular column has been computed, as given in Table 3.

Utilizing these column stiffnesses and assuming a three-column bent type, the deformation of the bent caused by a unit load in transverse and longitudinal directions was determined, considering rigid pier caps. The equivalent spring constant was then determined from:

$$k_z = \frac{1}{\Delta} = \frac{L^3}{3\ E\ (3Ix)}$$

$$k_x = \frac{1}{\Delta} = \frac{L^3}{3\ E\ (3I_z)}$$

The resulting k_z and k_x values for the column heights of 10' and 15' are given in Tables 4 and 5.

Utilizing these equivalent pier stiffnesses, the internal piers can be modeled as shown in Figure 14.

3.3 ANALYSIS/RESULTS

3.3.1 General

Utilizing the basic box geometry, given in Table 2, and the support spring constants of

$$k_x = 0 \sim 2 \times 10^3 \qquad k_y = \infty \qquad k_z = 0.5 \times 10^3 \sim \infty$$

The equivalent seismic response of the single, two, three, and four span structures were examined. The result by natural frequencies (ωx, ωy, ωz, ωt) for all bridge spans and their corresponding induced acclerations have been obtained and are tabulated in Tables 6 through 35. Each Table gives ω and A for a constant span length and varying radius (200' $\sim$ 999,999'). For the continuous spans, the pier flexibilities, as given by k_x and k_z are also included as a variable. Three basic variations have been assumed:

$k_x = 0$, $k_z =$ Rigid

$k_x = .66 \times 10^3$, $k_z = 0.5 \times 10^3$

$k_x = 2 \times 10^3$, $k_z = 0.66 \times 10^3$

The effect of these stiffness variations will be shown when these data are plotted.

3.3.2 Trends

The data given in Tables 6 through 35 has been plotted, resulting in Figures 15 through 70. These data show the variation of natural frequencies in the three translation directions (x, y, z) and rotation modes as a function of radii and span lengths. As would be expected, the natural frequency decreases as more spans are added (stiffer). Also the more flexible the piers (as given by k_x, k_z), the lower the frequency.

These trends are also similar to the data obtained in a previous study(11), which utilized an energy technique in obtaining natural frequencies.

In general the following trends are noted:

$\omega x \sim$ longitudinal natural frequency varies as a function of R and L, Figures 15 through 24.

$\omega y \sim$ vertical natural frequency varies as a function of R and L, but primarily dependent on L, Figures 25 through 32.

$\omega z \sim$ transverse natural frequency varies as a function of R and L, but primarily dependent on L, Figures 33 through 40.

$\omega t \sim$ rotational natural frequency waves as a function of R and L, but primarily dependent on L, Figures 41 through 48.

The induced accelerations Ax, Ay, Az, At, as determined from the response spectra, have also been plotted as a function of ($\frac{L}{R}$) the span length. However, this relationship has only been examined for the single span, as shown in Figures 49 through 52.

The relationship between the corresponding accelerations for the continuous spans and the single span values have similarly been plotted as a function F, where:

$$Fx = \frac{\text{Ax (continuous span value)}}{\text{Ax (single span value)}}$$

versus the number of spans, radius per stiffnesses (kx, Kz) and span lengths.

For the respective span lengths of 50', 100', and 150', the relationship between Fx, Fy, Fz, and Ft are given in Figures 53 through 70. These data will then be used to develop appropriate design criteria.

3.4 MULTI MODE SOLUTIONS

In order to demonstrate the reliability of this simulated dynamic solution, the response of single and multi span bridges, with rigid and flexible column bents, have been examined using the SAP IV program (9). This computer program idealizes the bridge as a three dimensional unit and examines the dynamic response utilized dynamic mass natural techniques.

Examination of the dynamic response of single (1) span to five (5) spans, with rigid piers and straight girders, using SAP (9) has resulted in the data (ωx, ωy, ωz) shown in Table 36.

The response of a three or four span continuous curved structure or flexible bents has resulted in the data (ωx; ωy, ωz) as shown in Table 37.

Examination of the data given in Table 36, indicates that the comparisons between the resulting frequencies obtained from the Space Frame Structure (SFS) and SAP are reasonable. However, when examing the curved structural data, Table 37, only the ωx and ωy terms are in agreement. It should be noted, however, that the SAP solution does not provide for the angular frequency (ωt), and when comparing ωt obtained from the SFS with ωz, excellent agreement occurs. Therefore, it is reasonable to assume the SFS which gives ωz and ωt is a combination of the data given by ωz obtained from SAP.

Chapter 4

DESIGN CRITERIA

4.1 TRENDS

The seismic design of continuous curved box girders will be related to the response of single span curved girders. Therefore, it is necessary to determine the single span accelerations (Az, Ay, Az and At) with respect to the basic bridge geometry. Examination of Figures 49, 50, 51 and 52 indicates the following:

<u>Ax</u>

for $100' < L \leq 150'$ $\quad Ax = A \left(\frac{L}{R} \right)^2 + B$

<u>Ay</u>

for $L \geq 100'$ $\quad Ay = A\,(L) + B$

<u>Az</u>

for $L \geq 100'$ $\quad Az = 3.8$

<u>At</u>

for $L \geq 100'$ $\quad At = 1.5$

Using the data given in Figures 49 and 50 , the general equation for Ax and Ay results in the following:

$$Ax = 2.2 \left(\frac{L}{R} \right)^2 + 0.011\,L + 0.45$$

$$Ay = -\,0.016\,(L) + 4.7$$

The continuity factors F can similarly be described in analytical form. Examination of the data given in Figures 53 through 70 has resulted in the following four continuity factors:

Fx (longitudinal)

$$Fx = -0.02\ (L) + 3.75 + K$$

where: $K = 0.00125\ R$ for $R \leq 600'$

$K = 1.0$ for $R > 600'$

Fy (vertical)

$$Fy = -0.125\ (NS) - 0.002L + 1.35$$

where: NS = number of spans (2,3, or 4)

Fz (transverse)

$$Fz = -0.005L + 1.5$$

Ft (torsion)

$$Ft = -0.075\ (NS) + 1.15$$

where: NS = number of spans (2,3, or 4)

4.2 DESIGN APPROACH

The equivalent seismic design of curved box girder bridges will incorporate the primarily developed equations and the effective peak acceleration map (kp) shown in Figure 71. The general design equation is of these four:

$$EQ_n = Fn \cdot An \cdot M \cdot Kp \qquad \text{Translation}$$

$$EQn = Fn \cdot An \cdot \bar{I} \cdot Kp \qquad \text{Rotation}$$

where:

Fn = continuity factor in x, y, z or t directions

An = single span acceleration

Kp = effective peak acceleration modifying factor (Fig. 71)

$$M = w/g = \frac{\text{total weight of structure}}{\text{gravity}}$$

$\bar{I}$ = rotational mass movement of section = $\rho\int(x^2 + y^2)dA$

ρ = mass per unit area

EQ_n = total applied seismic force in x, y, z or t directions.

for the specific direction n, the continuity factor F and single span acceleration An are given by:

<u>Longitudinal Direction (x)</u>

$$Fx = -0.02\ (L) + 3.75 + K$$

$$K = 0.00125\ R \qquad \text{for } R \leq 600'$$

$$K = 1.0 \qquad R > 600'$$

$$Ax = 2.2\ \left(\frac{L}{R}\right)^2 + 0.011\ L + 0.45$$

<u>Vertical Direction (y)</u>

$$Fy = -0.125\ (NS) - 0.002L + 1.35$$

$$Ay = -0.016\ (L) + 4.7$$

<u>Transverse Direction (z)</u>

$$Fz = -0.005\ (L) + 1.5$$

$$Az = 3.8$$

<u>Torsional Direction (θ)</u>

$$Ft = -0.075\ (NS) + 1.15$$

$$At = 1.5$$

4.3 EXAMPLE

In order to illustrate the application of these proposed equations, consider the following two span box structures:

where: $L = 100', 100'$

$R = 600'$

the single span accelerations are:

<u>Ax</u>

$$Ax = 2.2\ \left(\frac{L}{R}\right)^2 + 0.011\ L + 0.45$$

$$= 2.2\ \left(\frac{100}{600}\right)^2 + 0.011\ (100) + 0.45$$

$$= 1.61$$

Ay

$$Ay = -0.016\ (L) + 4.7$$
$$= -0.016\ (100) + 4.7$$
$$= 3.1$$

Az

$$Az = 3.8$$

At

$$At = 1.5$$

the continuity factors can now be computed as:

Fx

$$Fx = -0.02\ (L) + 3.75 + K \qquad (K = 0.00125\ R, \quad R \leq 600')$$
$$= -0.02\ (100) + 3.75 + 0.00125\ (600)$$
$$= 2.5$$

Fy

$$Fy = -0.125\ (N.S.) - 0.002\ L + 1.35$$
$$= -0.125(2) - 0.002\ (100) + 1.35$$
$$= 0.9$$

Fz

$$Fz = -0.005\ (L) + 1.5$$
$$= -0.005\ (100) + 1.5$$
$$= 1.0$$

Ft

$$Ft = -0.075\ (N.S.) + 1.15$$
$$= -0.075\ (2) + 1.15$$
$$= 1.0$$

the weight of the bridge is computed as

$w = 442.15$ Kips

and the mass moment of inertia ($\bar{I}$) = 2273.63 Kip-in - sec^2

therefore, the induced seismic forces are computed as:

$$EQx = Fx \cdot Ax \left(\frac{W}{g}\right)$$

$$= (2.5)\ (1.61\ g) \cdot \frac{W}{g}$$

$$= 4.025\ W$$

$$EQy = Fy \cdot Ay \cdot \frac{W}{g}$$

$$= (3.1)\ (0.9\ g)\ \frac{W}{g}$$

$$= 2.79\ W$$

$$EQz = Fz \cdot Az \cdot \frac{W}{g}$$

$$= (1.0)\ (3.8\ g) \cdot \frac{W}{g}$$

$$= 3.8\ W$$

$$EQt = Ft \cdot At \cdot \bar{I}$$

$$= (1.0)\ (1.5)\ (\bar{I})$$

$$= 1.5\ \bar{I}$$

the equivalent induced uniform seismic forces q_x, q_y, q_z, q_t, are therefore:

$$q_x = \frac{EQx}{2 \times L} = \frac{4.025 \times 442.15}{2 \times 100 \times 12} = 0.7415 \text{ kips/in}$$

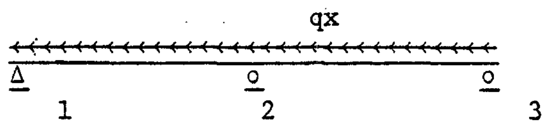
$$q_y = \frac{EQy}{2 \times L} = \frac{2.79 \times 442.15}{2 \times 100 \times 12} = 0.5140 \text{ kips/in}$$

$$q_z = \frac{EQz}{2 \times L} = \frac{3.8 \times 442.15}{2 \times 100 \times 12} = 0.7 \text{ kips/in}$$

$$q_t = \frac{EQt}{2 \times L} = \frac{1.5 \times 2273.63}{2 \times 100 \times 12} = 1.4210 \text{ kip-in/in}$$

Evaluation of the reactions of curved box girder bridge, using a straight spring gives:

i) x direction

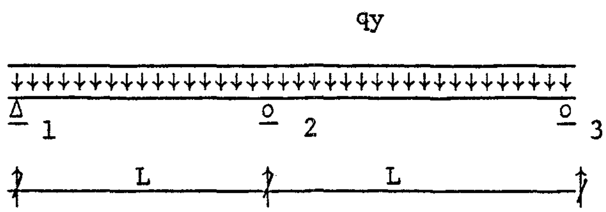


$Rx^1 = qx \cdot (2L) = EQx = 1779.65$ kips

$Rx^2 = 0$

$Rx^3 = 0$

ii) y direction



Ry^1	Ry^2	Ry^3
$= 0.375qyL$	$= 1.25qyL$	$= 0.375qyL$

$Ry^1 = 0.375qyL$

$= 0.375\ (0.5140)\ (100 \times 12)$

$= 231.3$ kips

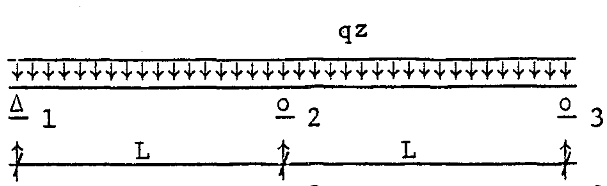
$Ry^2 = 1.25qyL$

$= 1.25\ (0.5140)\ (100 \times 12)$

$= 771$ kips

$Ry^3 = Ry^1 = 231.3$ kips

iii) z direction



Rz^1	Rz^2	Rz^3
$= 0.375qzL$	$= 1.25qzL$	$= 0.375qzL$

$Rz^1 = .075qzL$

$= 0.375\ (0.7)\ (100 \times 12)$

$= 315$ kips

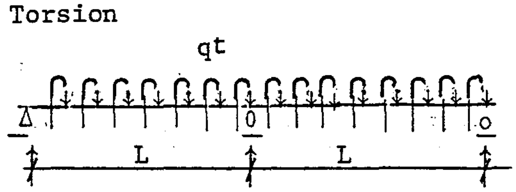
$Rz^2 = 1.25qzL$

$= 1.25\ (0.7)\ (100 \times 12)$

$= 1050$ kips

$Rz^3 = Rz^1 = 315$ kips

iv) Torsion



Rt^1	Rt^2	Rt^3
$= 0.375qtL$	$= 1.25qtL$	$= 0.375qtL$

$Rt^1 = 0.375qtL$

$= 0.375\ (1.4210)\ (100 \times 12)$

$= 639.45$ kip - in

$Rt^2 = 1.25qtL$

$= 1.25\ (1.4210)\ (100 \times 12)$

$= 2131.5$ kip - in

$Rt^3 = Rt^1 = 639.45$ kip - in

In the interior support, we use $Ry \times d = T$, $d = 48''$.

$$Ry = \frac{T}{d} = \frac{2131.5}{48} = 44.41 \text{ kips}$$

comparing these results with the results obtained from the (SFS) computer program gives:

Support No. / Direction		1		2		3	
		Eqs	program	Eqs	program	Eqs	program
x direction	Rx	1779.65	1298	0	223.9	0	0
y direction	Ry	231.3	250	771	775.3	231.3	250
z direction	Rz	315	417.5	1050	967.7	315	417.5
Torsion	T	639.45	869.8	44.41*	55.5*	639.45	869.8

* Ry x d= T

which shows reasonable agreement. If, however, curvature effects were to be included in transferring the total equivalent seismic force to the reactions, better agreement would occur. The computer input/output given in the above table is listed in Appendix A.

Chapter 5

Conclusions and Recommendations

This study is one of the methods to deal with the preliminary seismic design of curved box girder bridges. It provided very simple formulas to be used by designer. In order to get the equivalent seismic forces, four steps must be undertaken:

i) Estimate the single span accelerations Ax, Ay, Az, and At.

ii) Estimate the continuity factors Fx, Fy, Fz, and Ft.

iii) Estimate modifying factor Kp.

iv) Estimate total applied seismic forces EQn.

One example was shown in the procedures (excluded the modifying factor Kp) in Chapter 4, so the designer can easily follow the steps to reach the results.

Meanwhile, this method is compared to the results of SAP IV (Table 37). From the point of view of safety, we recommend that designer use the larger value of ωz and ωt in z direction.

Chapter 6

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APPENDIX A

TABLE 1.1

INPUT SHEET

no. of cross section (NDCROS)	no. of boxes (NOBX)	box location (IBOX)	no. of span (NSPAN)	E_s/E_c S. D. L (MOD1)	E_s/E_c L. L (MOD2)	steel positive yield stress (KSI) (FYP)	steel negative yield stress (KSI) (FYN)
5	10	15	20	25	30	40	50

IBOX = 1 outside girder
IBOX = 2 inside girder

radius of curvature (R) (FT)	clear roadway (CLRW) (FT)	spacing between boxes (SPBWBX) (IN)	unit wt. concrete (UWT) (PCF)	miscel. steel weight (PER) (%)	wt. of wearing surface (WWS) (PSF)	area of misc. concrete (ACONC) (IN^2)	comp str. concrete (FC) (KSI)
10	20	30	40	50	60	70	80

SPAN LENGTH (SPAN)

no. 1 (FT)	no. 2 (FT)	no. 3 (FT)	no. 4 (FT)	no. 5 (FT)	no. 6 (FT)	no. 7 (FT)	no. 8 (FT)
10	20	30	40	50	60	70	80

TABLE 1.2

INPUT SHEET

distance to next cross section (ASEC) (FT)
10

STRUCTURAL DETAILS												
slab	integral w.s.	haunch		utility	railing	outside overhang width	inside overhang width	curb		sidewalk		angle slab & horizontl.
depth	thicknes	width	depth	weight	weight			width	height	width	height	
(TSLAB)	(WSTHK)	(WHNCH)	(DHNCH)	(WUTIL)	(WRAIL)	(OVHGL)	(OVHG)	(WCURB)	(HCURB)	(WSDWK)	(TSDWK)	(AL3)
(IN)	(IN)	(IN)	(IN)	(PSF)	(LB/FT)	(FT)	(FT)	(IN)	(IN)	(IN)	(IN)	(X°)
6	12	18	24	30	36	42	48	54	60	66	72	78

TABLE 1.3

INPUT SHEET

STEEL SECTION DETAILS

sect. no.	index	angle between web and vertical		web				top flange				bottom flange	
				depth		thickness		width		thickness		width	thickness
		left	right	left	right	left	right	left	right	left	right		
	(INDEX)	(ALL)	(ALR)	(WBDL)	(WBDR)	(WBTL)	(WBTR)	(TFWL)	(TFWR)	(TFTL)	(TFTR)	(BFW)	(BFT)
		(X°)	(X°)	(IN)	(IN)	(IN)	(IN)	(IN)	(IN)	(IN)	(IN)	(IN)	(IN)
3	6	12	18	25	32	37	42	49	56	61	66	73	80

INDEX=1 non-comp.

INDEX=2 comp.

BRACING & STIFFENER INFORMATION

sect. no.	type of bracing	cross sect area of bracing menber	average spacing of diaphragm	bottom flagge stifferer	web stiff-ener
	(IBRAC)	(AD)	(S)	(IOS)	(IDW)
		(IN^2)	(IN)		
3	8	18	28	33	38

IBRAC=1~4 type of bracing

IOS=0 no bottom flange stiffener

IDW=0 no web stiffener

IOS=1 have bottom flange stiffener

IDW=1 have web stiffener

TABLE 1.4

INPUT SHEET

SKIP THE FOLLOWING CARD, IF IOS=0 & IDW=0

WEB AND BOTTOM FLANGE STIFFENER PROPERTIES

sect no.	spacing of web transverse stiffener (DOO) (IN)	cross section area of bot. fl. stiffener (STLA) (IN^2)	dis. from bot. fl. to centroid of bot. fl. stiffener (STLY) (IN)	moment of inertia of stiffener (STLI) (IN^4)	no. of stiffener (NOS)
3	13	23	33	43	48

structure number (ISN)	number of loading systems (NLS)
10	20

SKIP THE FOLLOWING CARD, IF NSPA=1 OR TORSIONAL CASE

equivalent pier area (AX)
10

TABLE 1.5

INPUT SHEET

number of loaded joints (NLJ)
10

ACTIONS APPLIED AT JOINTS

joint index (K)	loads applied in X direction A(6*K-5)	loads applied in Y direction A(6*K-4)	loads applied in Z direction A(6*K-3)	loads applied in MX direction A(6*K-2)	loads applied in MY direction A(6*K-1)	loads applied in MZ direction A(6*K-0)
5	15	25	35	45	55	65

TABLE 2

DIMENSIONS OF COMPOSITE SECTIONS

Bridge Type	Span (Ft.)	A'	B'	C'	D'	E'	F'	T1'	T2'	T3'	T4'	T5'
2L 2G		192"	96"	12"	19.44"	25.75"	42.0"	0.625"	0.375"	0.5"	0.0878"	0.947"
3L 3G	50	172"	86"	12"	19.47"	25.75"	37.0"	0.5625"	0.375"	0.5"	0.0980"	0.955"
4L 4G		160"	80"	12"	19.50"	25.75"	34.0"	0.5"	0.375"	0.5"	0.105"	0.958"
2L 2G		192"	96"	14"	48.125"	54.625"	41.0"	1.0"	0.5"	0.75"	0.0878"	1.019"
3L 3G	100	172"	86"	13"	48.125"	54.625"	36.5"	1.0"	0.4375"	0.75"	0.0980"	1.030"
4L 4G		160"	80"	12"	48.125"	54.625"	34.0"	1.0"	0.4375"	0.75"	0.105"	1.033"
2L 2G		192"	96"	14"	74.75"	81.5"	41.0"	1.5"	0.625"	1.0"	0.0878"	1.092"
3L 3G	150	172"	86"	13"	74.75"	81.5"	36.5"	1.5"	0.5625"	1.0"	0.0980"	1.106"
4L 4G		160"	80"	12"	74.75"	81.5"	34.0"	1.5"	0.5625"	1.0"	0.105"	1.108"

TABLE 3

unit: in^4

Section / I	d = 2.5' 12 ∿ #11	d = 2.5' 20 ∿ #11	d = 3' 12 ∿ #11	d = 3' 20 ∿ #11	4' x 12' 30 ∿ #8	4' x 12' 30 ∿ #9	4' x 12' 40 ∿ #8	4' x 12' 40 ∿ #9
I_x	57,224.38	68,666.78	108,197.86	125,364.46	1,419,378.7	1,443,946.1	1,455,010.5	1,489.364.1
I_z	57,224.38	68,666.78	108,197.86	125,364.46	12,662,059	12,853,253	12,845,053	13,084,978

TABLE 4

1 = 10'   unit: kips/in

Section / k	d = 2.5' 12 ∿ #11	d = 2.5' 20 ∿ #11	d = 3' 12 ∿ #11	d = 3' 20 ∿ #11	4' x 12' 30 ∿ #8	4' x 12' 30 ∿ #9	4' x12' 40 ∿ #8	4' x 12' 40 ∿ #9
k_x	3,576.52	4,291.67	6,762.37	7,835.28	88,711.17	90,246.63	90,938.16	93,085.26
k_z	894.13	1,072.92	1,690.59	1,958.82	197,844.67	200,832.08	200,703.95	204,452.63

TABLE 5

1 = 15'   unit: kips/in

Section / k	d = 2.5' 12 ∿ #11	d = 2.5' 20 ∿ #11	d = 3' 12 ∿ #11	d = 3' 20 ∿ #11	4' x 12' 30 ∿ #8	4' x 12' 30 ∿ #9	4' x 12' 40 ∿ #8	4' x 12' 40 ∿ #9
k_X	1,059.72	1,271.61	2,003.66	2,321.56	26,284.79	26,739.74	26,944.64	27,580.82
k_z	264.93	317.90	500.92	580.39	58,620.64	59,505.80	59,467.84	60,578.56

TABLE 6

Single - span L = 50'

R	ωx	ωy	ωz	ωt	Ax	Ay	Az	At
200'	35.9158	4.3514	18.4456	9.6710	1.0000	3.9002	1.7611	1.5440
400'	36.4921	4.3477	18.4018	9.6659	1.0000	3.9006	1.7652	1.5440
600'	36.6022	4.3470	18.3937	9.6650	1.0000	3.9007	1.7659	1.5440
800'	36.6410	4.3468	18.3908	9.6646	1.0000	3.9007	1.7662	1.5440
1000'	36.6590	4.3467	18.3895	9.6645	1.0000	3.9007	1.7663	1.5440
99999'	36.6989	4.3473	18.3909	9.6648	1.0000	3.9007	1.7662	1.5440

TABLE 7

Single-span L = 100'

R	ωx	ωy	ωz	ωt	Ax	Ay	Az	At
200'	15.0630	2.5248	4.7689	9.2812	2.1448	3.1036	3.8758	1.5440
400'	18.8986	2.5333	4.7197	9.2433	1.7200	3.1129	3.8816	1.5440
600'	20.0040	2.5351	4.7108	9.2362	1.6275	3.1148	3.8826	1.5440
800'	20.4403	2.5357	4.7076	9.2337	1.5937	3.1155	3.8830	1.5440
1000'	20.6523	2.5360	4.7061	9.2326	1.5777	3.1159	3.8832	1.5440
99999'	21.0478	2.5370	4.7045	9.2312	1.5489	3.1170	3.8834	1.5440

TABLE 8

Single-span   L = 150'

R	ωx	ωy	ωz	ωt	Ax	Ay	Az	At
200'	6.0479	1.7371	2.2139	8.9403	3.7465	2.2284	3.8327	1.5440
400'	9.9753	1.7689	2.1621	8.8420	3.2028	2.2645	3.7563	1.5440
600'	12.1542	1.7760	2.1527	8.8237	2.6427	2.2725	3.7424	1.5440
800'	13.3446	1.7785	2.1494	8.8173	2.4131	2.2754	3.7376	1.5440
1000'	14.0297	1.7797	2.1479	8.8143	2.2983	2.2767	3.7353	1.5440
99999'	15.5655	1.7820	2.1453	8.8092	2.0774	2.2793	3.7315	1.5440

TABLE 9

Two-span L = 50' kx = 0 kz = rigid

R	ωx	ωy	ωz	ωt	Ax	Ay	Az	At
200'	18.1913	3.7911	16.1296	6.8612	1.7851	3.9725	2.0067	1.5440
400'								
600'	24.5587	3.7798	15.9986	6.8367	1.3330	3.9741	2.0227	1.5440
800'								
1000'	25.4187	3.7789	15.9883	6.8347	1.2891	3.9742	2.0239	1.5440
99999'	25.9502	3.7790	15.9850	6.8341	1.2634	3.9742	2.0243	1.5440

TABLE 10

Two-span $L = 50'$ Flexible supports $kx = 2/3 \times 10^3$ $kz = 0.5 \times 10^3$

R	ωx	ωy	ωz	ωt	Ax	Ay	Az	At
200'	19.3243	3.7911	8.2563	6.8612	1.6831	3.9725	3.5838	1.5440
400'								
600'	25.8194	3.7798	8.1802	6.8367	1.2697	3.9741	3.5886	1.5440
800'								
1000'	26.3235	3.7789	8.1741	6.8347	1.2460	3.9742	3.5890	1.5440
99999'	26.5960	3.7790	8.1722	6.8341	1.2336	3.9742	3.5891	1.5440

TABLE 11

Two-span $L = 50'$ Flexible supports $kx = 2 \times 10^3$ $kz = 2/3 \times 10^3$

R	ωx	ωy	ωz	ωt	Ax	Ay	Az	At
200'	21.3638	3.7911	8.7618	6.8612	1.5266	3.9725	3.5536	1.5440
400'								
600'	26.9971	3.7798	8.6881	6.8367	1.2157	3.9741	3.5579	1.5440
800'								
1000'	27.4253	3.7789	8.6822	6.8347	1.1973	3.9742	3.5582	1.5440
99999'	27.6830	3.7790	8.6803	6.8341	1.1864	3.9742	3.5583	1.5440

TABLE 12

Three-span L = 50' kx = 0 kz = rigid

R	ωx	ωy	ωz	ωt	Ax	Ay	Az	At
200'	5.6220	2.7545	11.7717	4.9459	3.7859	3.3526	2.7262	1.5284
400'								
600'	9.9571	2.7620	11.6959	4.9333	3.2085	3.3607	2.7434	1.5248
800'								
1000'	10.9468	2.7627	11.6899	4.9323	2.9259	3.3614	2.7448	1.5245
99999'	11.6537	2.7636	11.6889	4.9321	2.7531	3.3622	2.7450	1.5244

TABLE 13

Three-span L = 50' Flexible supports $kx = 2/3 \times 10^3$ $kz = 0.5 \times 10^3$

R	ωx	ωy	ωz	ωt	Ax	Ay	Az	At
200'	7.6923	2.7545	4.7038	4.9459	3.6202	3.3526	3.8834	1.5284
400'								
600'	11.5862	2.7620	4.6944	4.9333	2.7687	3.3607	3.8845	1.5248
800'								
1000'	12.5285	2.7627	4.6937	4.9323	2.5659	3.3614	3.8846	1.5245
99999'	12.8588	2.7636	4.6933	4.9321	2.5017	3.3624	3.8847	1.5244

TABLE 14

Three-span   L = 50'   Flexible supports $kx = 2 \times 10^3$ $k_z = 2/3 \times 10^3$

R	ωx	ωy	ωz	ωt	Ax	Ay	Az	At
200'	10.6304	2.7545	5.2014	4.9459	3.0106	3.3526	3.8281	1.5284
400'								
600'	14.1001	2.7620	5.1970	4.9333	2.2872	3.3607	3.8286	1.5248
800'								
1000'	14.4632	2.7627	5.1965	4.9323	2.2313	3.3614	3.8286	1.5245
99999'	14.7060	2.7636	5.1967	4.9321	2.1954	3.3624	3.8286	1.5244

TABLE 15

Four-span L = 50' kx = 0 kz = rigid

R	ωx	ωy	ωz	ωt	Ax	Ay	Az	At
200'	2.9284	2.3545	10.1749	4.2442	4.1552	2.9174	3.1417	1.3249
400'								
600'	6.7866	2.3640	10.0226	4.2101	3.6855	2.9278	3.1881	1.3149
800'								
1000'	8.3647	2.3648	10.0107	4.2073	3.5771	2.9288	3.1918	1.3141
99999'	9.9384	2.3657	10.0060	4.2061	3.2143	2.9298	3.1932	1.3138

TABLE 16

Four-span $L = 50'$ Flexible supports $kx = 2/3 \times 10^3$ $kz = 0.5 \times 10^3$

R	ωx	ωy	ωz	ωt	Ax	Ay	Az	At
200'	6.4621	2.3545	4.1237	4.2442	3.7114	2.9174	3.9571	1.3249
400'								
600'	9.5492	2.3640	4.0841	4.2101	3.3418	2.9278	3.9625	1.3149
800'								
1000'	10.7409	2.3648	4.0811	4.2073	2.9804	2.9288	3.9629	1.3141
99999'	11.5100	2.3657	4.0797	4.2061	2.7865	2.9298	3.9631	1.3138

TABLE 17

Four-span $L = 50'$ Flexible supports $kx = 2 \times 10^3$ $kz = 2/3 \times 10^3$

R	ωx	ωy	ωz	ωt	Ax	Ay	Az	At
200'	10.5827	2.3545	4.5404	4.2442	3.0238	2.9174	3.9031	1.3249
400'								
600'	12.2370	2.3640	4.5062	4.2101	2.6253	2.9278	3.9073	1.3149
800'								
1000'	12.8634	2.3648	4.5037	4.2073	2.5008	2.9288	3.9076	1.3141
99999'	13.4248	2.3657	4.5026	4.2061	2.3990	2.9298	3.9077	1.3138

TABLE 18

Two-span L = 100' kx = 0 kz = rigid

R	ωx	ωy	ωz	ωt	Ax	Ay	Az	At
200'	3.5303	2.2099	4.2721	6.7217	4.0458	2.7582	3.9372	1.5440
400'								
600'	8.7350	2.2048	4.1076	6.5486	3.5551	2.7525	3.9593	1.5440
800'								
1000'	11.4612	2.2048	4.0953	6.5348	2.7980	2.7525	3.9610	1.5440
99999'	14.8831	2.2053	4.0893	6.5274	2.1700	2.7531	3.9618	1.5440

TABLE 19

Two-span $L = 100'$ Flexible supports $kx = 2/3 \times 10^3$ $kz = 0.5 \times 10^3$

R	ωx	ωy	ωz	ωt	Ax	Ay	Az	At
200'	4.8807	2.2099	3.2992	6.7217	3.8630	2.7582	4.0850	1.5440
400'								
600'	9.5909	2.2048	3.1929	6.5486	3.3276	2.7525	4.1042	1.5440
800'								
1000'	12.3202	2.2048	3.1841	6.5348	2.6081	2.7525	4.1058	1.5440
99999'	15.3731	2.2053	3.1797	6.5274	2.1027	2.7531	4.1066	1.5440

TABLE 20

Two-span $L = 100'$ Flexible supports $kx = 2 \times 10^3$ $kz = 2/3 \times 10^3$

R	ωx	ωy	ωz	ωt	Ax	Ay	Az	At
200'	6.8782	2.2099	3.4666	6.7217	3.6785	2.7582	4.0563	1.5440
400'								
600'	11.0614	2.2048	3.3440	6.5486	2.8964	2.7525	4.0772	1.5440
800'								
1000'	13.8468	2.2048	3.3349	6.5348	2.3279	2.7525	4.0788	1.5440
99999'	16.1650	2.2053	3.3303	6.5274	2.0024	2.7531	4.0796	1.5440

TABLE 21

Three-span   L = 100'   kx = 0   kz = rigid

R	ωx	ωy	ωz	ωt	Ax	Ay	Az	At
200'	1.1469	1.5773	3.0989	4.7996	2.1911	2.0458	4.1217	1.4861
400'								
600'	3.2250	1.6078	3.0008	4.7207	4.0983	2.0807	4.1407	1.4633
800'								
1000'	4.5641	1.6106	2.9935	4.7141	3.9002	2.0840	4.1421	1.4614
99999'	6.8604	1.6123	2.9896	4.7105	3.6798	2.0859	4.1429	1.4603

TABLE 22

Three-span $L = 100'$ Flexible supports $kx = 2/3 \times 10^3$ $kz = 0.5 \times 10^3$

R	ωx	ωy	ωz	ωt	Ax	Ay	Az	At
200'	3.3041	1.5773	2.2005	4.7996	4.0842	2.0458	3.8130	1.4861
400'								
600'	4.7934	1.6078	2.1798	4.7207	3.8730	2.0807	3.7826	1.4633
800'								
1000'	5.9013	1.6106	2.1781	4.7141	3.7598	2.0840	3.7800	1.4614
99999'	7.7505	1.6123	2.1772	4.7105	3.6163	2.0859	3.7787	1.4603

TABLE 23

Three-span L = 100' Flexible supports $kx = 2 \times 10^3$ $kz = 2/3 \times 10^3$

R	ωx	ωy	ωz	ωt	Ax	Ay	Az	At
200'	4.6871	1.5773	2.3433	4.7996	3.8854	2.0458	4.0224	1.4861
400'								
600'	6.7986	1.6078	2.3175	4.7207	3.6846	2.0807	3.9847	1.4633
800'								
1000'	7.8862	1.6106	2.3154	4.7141	3.6074	2.0840	3.9816	1.4614
99999'	9.0417	1.6123	2.3142	4.7105	3.5241	2.0859	3.9800	1.4603

TABLE 24

Four-span L = 100' kx = 0 kz = rigid

R	ωx	ωy	ωz	ωt	Ax	Ay	Az	At
200'	0.6396	1.3448	2.7942	4.2267	1.3336	1.7762	4.1831	1.3198
400'								
600'	2.1215	1.3750	2.5821	4.0403	3.6964	1.8115	4.2304	1.2654
800'								
1000'	3.2112	1.3782	2.5673	4.0254	4.1008	1.8153	4.2339	1.2610
99999'	5.8507	1.3802	2.5592	4.0171	3.7644	1.8175	4.2358	1.2586

TABLE 25

Four-span L = 100' Flexible supports $kx = 2/3 \times 10^3$ $kz = 0.5 \times 10^3$

R	ωx	ωy	ωz	ωt	Ax	Ay	Az	At
200'	3.8415	1.3448	1.9634	4.2267	3.9973	1.7762	3.4608	1.3198
400'								
600'	4.7895	1.3750	1.8624	4.0403	3.8734	1.18115	3.3088	1.2654
800'								
1000'	5.4168	1.3782	1.8555	4.0254	3.8060	1.8153	3.2984	1.2610
99999'	6.9829	1.3802	1.8517	4.0171	3.6705	1.8175	3.2926	1.2586

TABLE 26

Four-span L = 100' Flexible supports $kx = 2 \times 10^3$ $kz = 2/3 \times 10^3$

R	ωx	ωy	ωz	ωt	Ax	Ay	Az	At
200'	5.2873	1.3448	2.0781	4.2267	3.8192	1.7762	3.6320	1.3198
400'								
600'	6.6599	1.3750	1.9783	4.0403	3.6954	1.8115	3.4830	1.2654
800'								
1000'	7.1472	1.3782	1.9710	4.0254	3.6584	1.8153	3.4722	1.2610
99999'	8.2579	1.3802	1.9671	4.0171	3.5837	1.8175	3.4663	1.2586

TABLE 27

Two-span $L = 150'$ $kx = 0$ kz = rigid

R	ωx	ωy	ωz	ωt	Ax	Ay	Az	At
200'	1.2865	1.5402	2.0873	6.7520	2.4158	2.0030	3.6456	1.5440
400'								
600'	3.6723	1.5453	1.8862	6.2866	4.0231	2.0089	3.3447	1.5440
800'								
1000'	5.5936	1.5475	1.8722	6.2497	3.7886	2.0114	3.3236	1.5440
99999'	11.0065	1.5489	1.8647	6.2290	2.9105	2.0131	3.3123	1.5440

TABLE 28

Two-span L = 150' Flexible supports $kx = 2/3 \times 10^3$ $kz = 0.5 \times 10^3$

R	ωx	ωy	ωz	ωt	Ax	Ay	Az	At
200'	3.0908	1.5402	1.8564	6.7520	4.1233	2.0030	3.2997	1.5440
400'								
600'	4.5512	1.5453	1.6827	6.2866	3.9018	2.0089	3.0353	1.5440
800'								
1000'	6.3049	1.5475	1.6707	6.2497	3.7244	2.0114	3.0169	1.5440
99999'	11.3914	1.5489	1.6642	6.2290	2.8147	2.0131	3.0070	1.5440

TABLE 29

Two-span $L = 150'$ Flexible supports $kx = 2 \times 10^3$ $kz = 2/3 \times 10^3$

R	ωx	ωy	ωz	ωt	Ax	Ay	Az	At
200'	4.6613	1.5402	1.9036	6.7520	3.8885	2.0030	3.3709	1.5440
400'								
600'	5.9417	1.5453	1.7253	6.2866	3.7561	2.0089	3.1006	1.5440
800'								
1000'	7.5030	1.5475	1.7130	6.2497	3.6331	2.0114	3.0817	1.5440
99999'	12.0093	1.5489	1.7063	6.2290	2.6737	2.0131	3.0715	1.5440

TABLE 30

Three-span L = 150' Kx = 0 kz = rigid

R	ωx	ωy	ωz	ωt	Ax	Ay	Az	At
200'	0.4439	1.0655	1.4986	4.7315	0.9776	1.4451	2.7505	1.4664
400'								
600'	1.5345	1.1228	1.3761	4.5245	2.8065	1.5137	2.5581	1.4064
800'								
1000'	2.4018	1.1290	1.3679	4.5059	4.1077	1.5211	2.5452	1.4010
99999'	5.1318	1.1326	1.3635	4.4954	3.8355	1.5255	2.5383	1.3980

TABLE 31

Three-span   L = 150'   Flexible supports $kx = 2/3 \times 10^3$ $kz = 0.5 \times 10^3$

R	ωx	ωy	ωz	ωt	Ax	Ay	Az	At
200'	1.9092	1.0655	1.2508	4.7315	3.3793	1.4451	2.3587	1.4664
400'								
600'	3.0359	1.1228	1.1932	4.5245	4.1338	1.5137	2.2661	1.4064
800'								
1000'	3.6815	1.1290	1.1886	4.5059	4.0216	1.5211	2.2586	1.4010
99999'	5.8247	1.1326	1.1861	4.4954	3.7668	1.5255	2.2546	1.3980

TABLE 32

Three-span L = 150' Flexible supports $kx = 2 \times 10^3$ $kz = 2/3 \times 10^3$

R	ωx	ωy	ωz	ωt	Ax	Ay	Az	At
200'	2.2786	1.0655	1.2976	4.7315	3.9277	1.4451	2.4336	1.4664
400'								
600'	4.3134	1.1228	1.2315	4.5245	3.9317	1.5137	2.3278	1.4064
800'								
1000'	5.1929	1.1290	1.2263	4.5059	3.8290	1.5211	2.3194	1.4010
99999'	6.8208	1.1326	1.2236	4.4954	3.6829	1.5255	2.3150	1.3980

TABLE 33

Four-span L = 150' kx = 0 kz = rigid

R	ωx	ωy	ωz	ωt	Ax	Ay	Az	At
200'	0.2052	0.8864	1.5095	4.3692	0.5072	1.2277	2.7675	1.3613
400'								
600'	1.0276	0.9591	1.1924	3.8928	1.9958	1.3165	2.2647	1.222
800'								
1000'	1.6817	0.9656	1.1760	3.8549	3.0338	1.3244	2.2382	1.2111
99999'	4.3765	0.9696	1.1672	3.8337	3.9236	1.3292	2.2240	1.2048

TABLE 34

Four-span   L = 150'   Flexible supports $kx = 2/3 \times 10^3$ $kz = 0.5 \times 10^3$

R	ωx	ωy	ωz	ωt	Ax	Ay	Az	At
200'	1.9868	0.8864	1.1976	4.3692	3.4958	1.2277	2.2732	1.3613
400'								
600'	3.1095	0.9591	1.0271	3.8928	4.1197	1.3165	1.9948	1.2222
800'								
1000'	3.5232	0.9656	1.0155	3.8549	4.0469	1.3244	1.9757	1.2111
99999'	5.2539	0.9696	1.0092	3.8337	3.8226	1.3292	1.9653	1.2048

TABLE 35

Four-span $L = 150'$ Flexible supports $kx = 2 \times 10^3$ $kz = 2/3 \times 10^3$

R	ωx	ωy	ωz	ωt	Ax	Ay	Az	At
200'	1.9788	0.8864	1.2348	4.3692	3.4838	1.2277	2.3331	1.3613
400'								
600'	4.2550	0.9591	1.0605	3.8928	3.9394	1.3165	2.0500	1.2222
800'								
1000'	4.8298	0.9656	1.0485	3.8549	3.8688	1.3244	2.0302	1.2111
99999'	6.2305	0.9696	1.0420	3.8337	3.7307	1.3292	2.0194	1.2048

TABLE 36

SAP IV Multi-Mode

Frequency / No. of Span	ωx (CPS)	ωy (CPS)	ωz (CPS)
1	13.93 (21.05)	1.373 (2.54)	19.30 (4.70)
2	7.502 (14.88)	1.407 (2.21)	8.159 (4.09)
3	4.859 (6.86)	1.101 (1.61)	5.077 (2.99)
4	3.754 (5.85)	0.989 (1.38)	4.069 (2.56)
5	3.488	1.179	3.526

( ): SFS

Single-span 1 = 120'

Two-span 1 = 120' - 120

Three-span 1 = 120 - 160 - 120

Four-span 1 = 120 - 160 - 160 - 120

Five-span 1 = 120 - 120 - 160 - 120 - 120

TABLE 37

	ω_x (CPS)		ω_y (CPS)		Space Frame		SAP IV
	Space Frame	SAP IV	Space Frame	SAP IV	ω_z (CPS)	ω_t (CPS)	ω_z (CPS)
Three-span 150-180-150 FT Radius = 1000 Ft	3.682	4.282	1.129	1.823	1.189	4.506	4.715
Four-span 150-180-180 - 150 FT Radius = 1000 Ft	3.5232	3.444	0.966	1.639	1.016	3.855	3.950

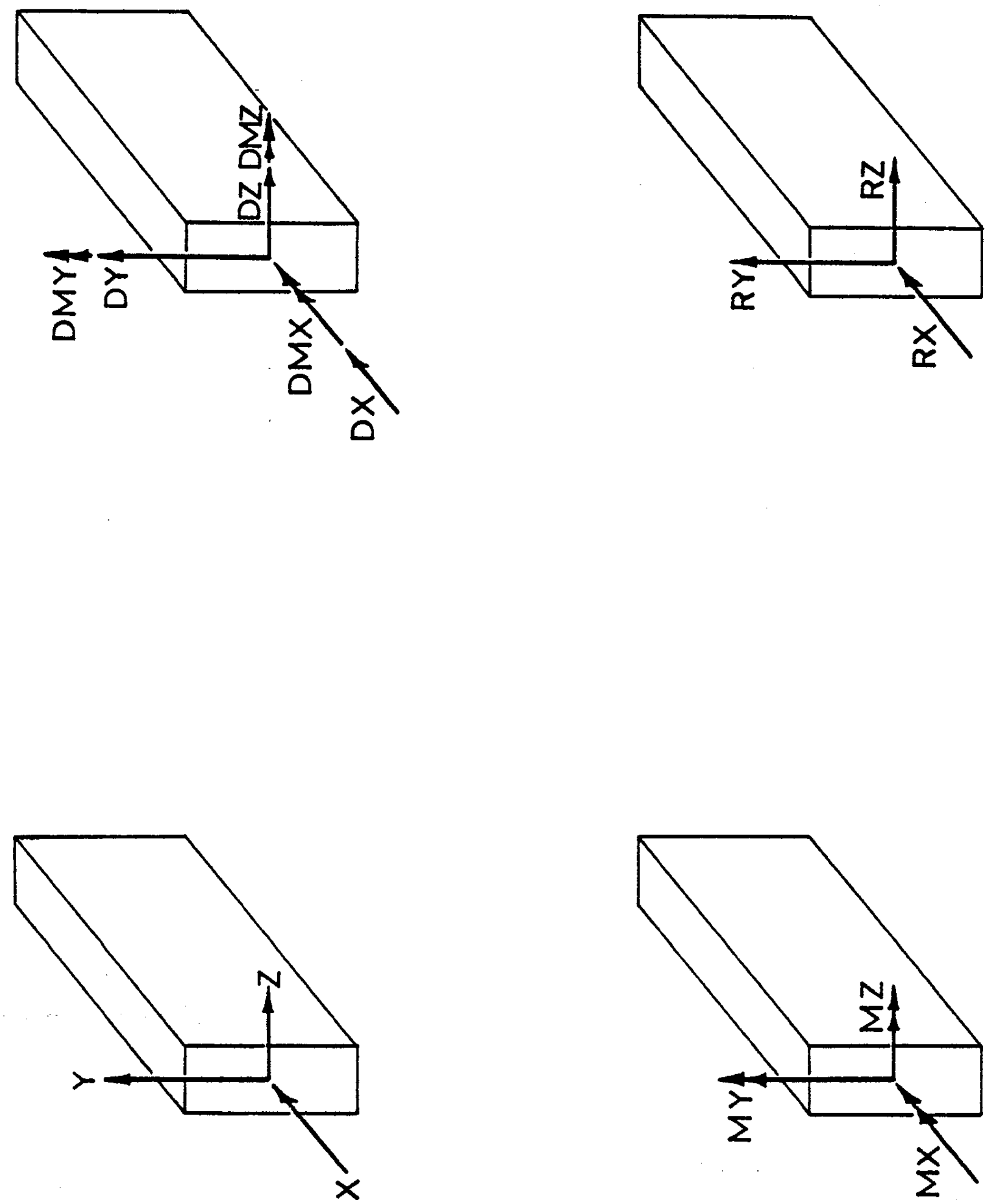


FIGURE 1

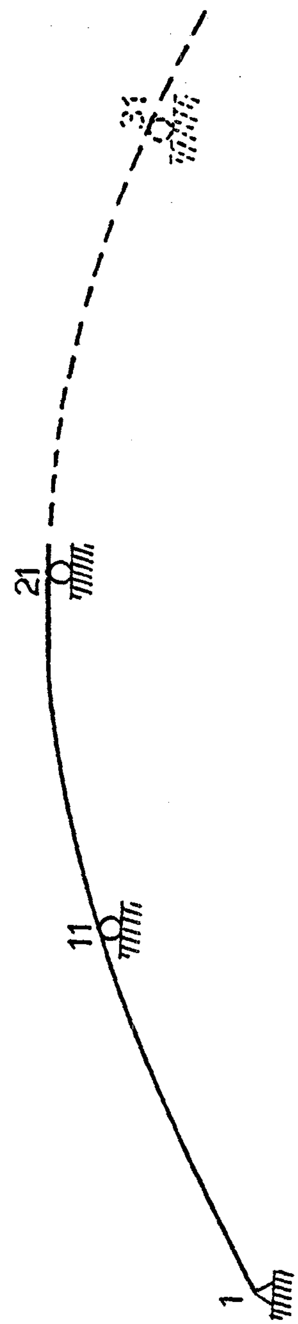


FIGURE 2

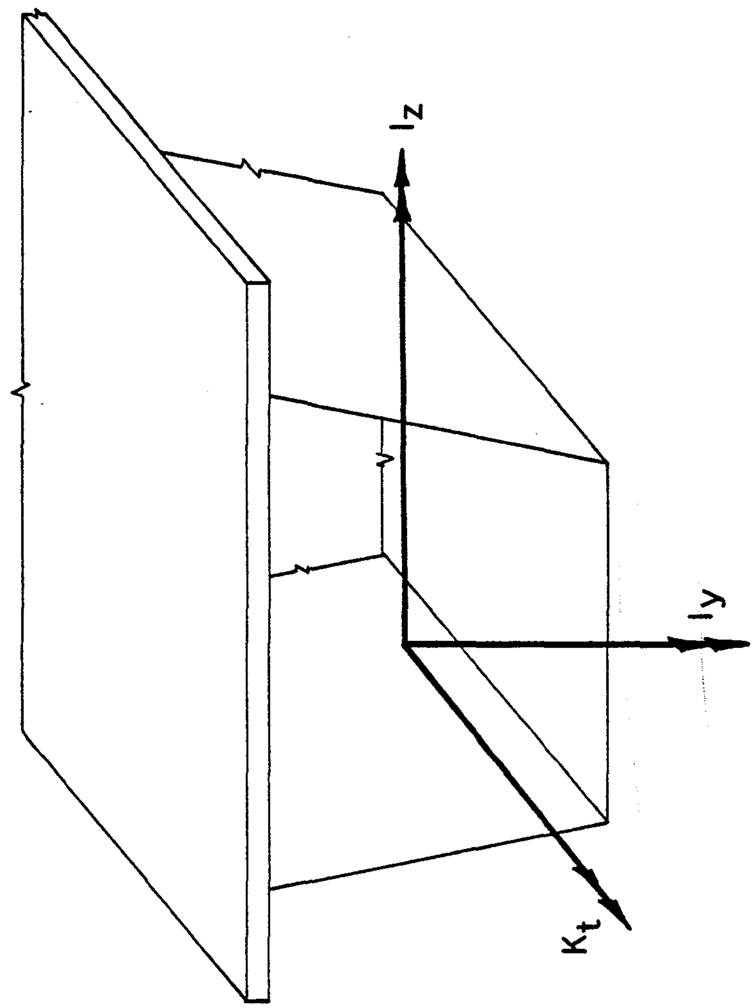


FIGURE 3

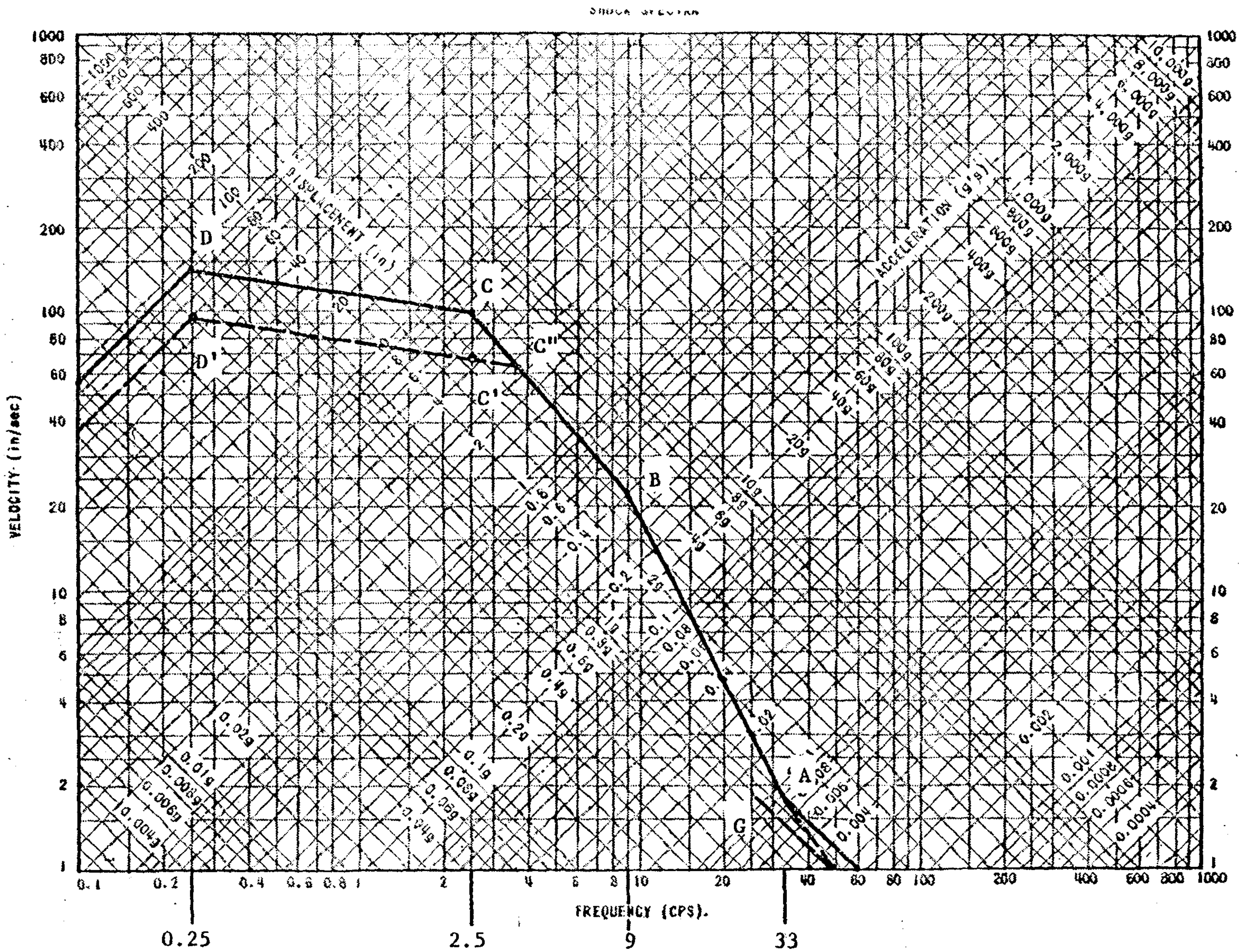


Figure 4 Vertical response spectrum for 1.0 g maximum ground acceleration

FIGURE 4

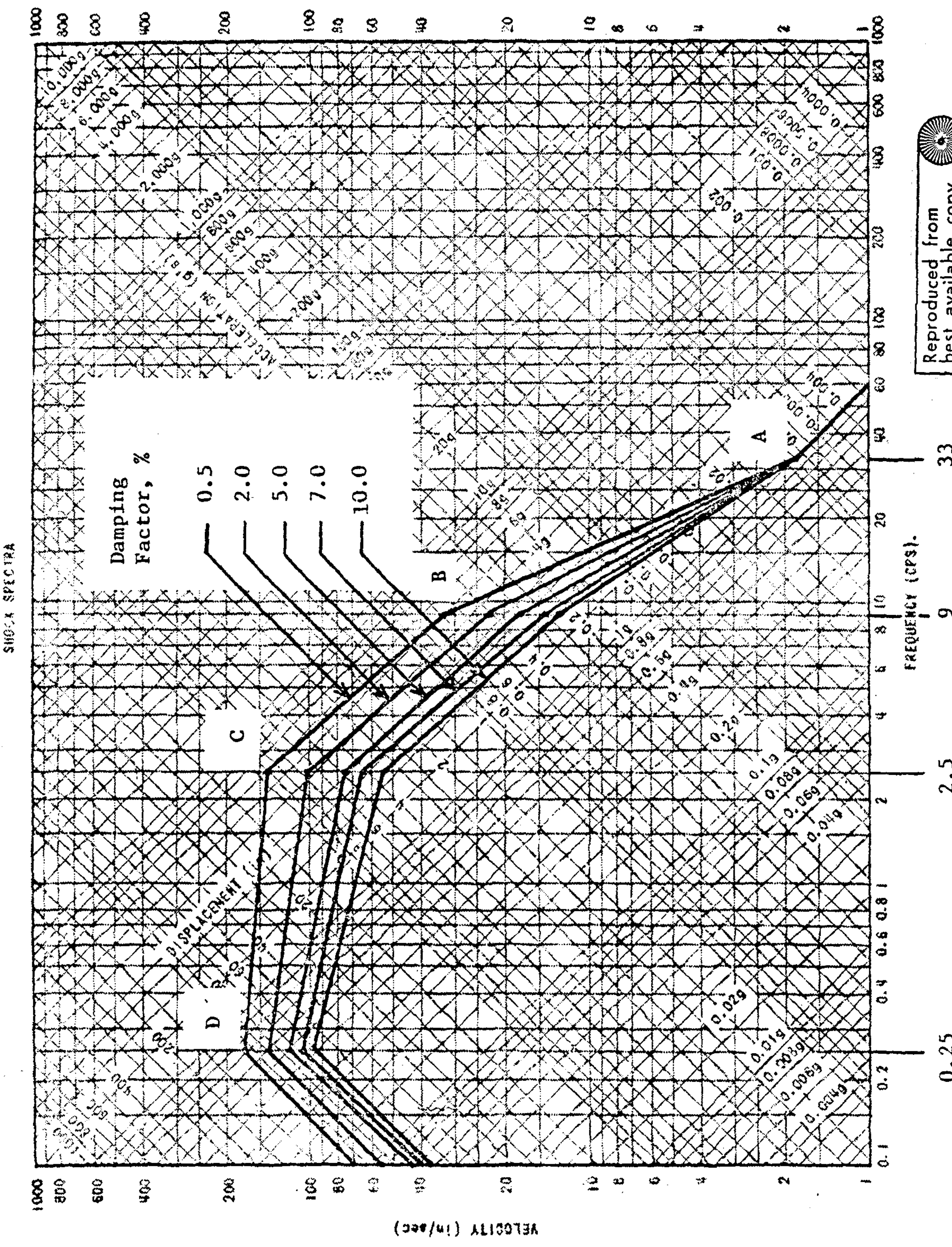
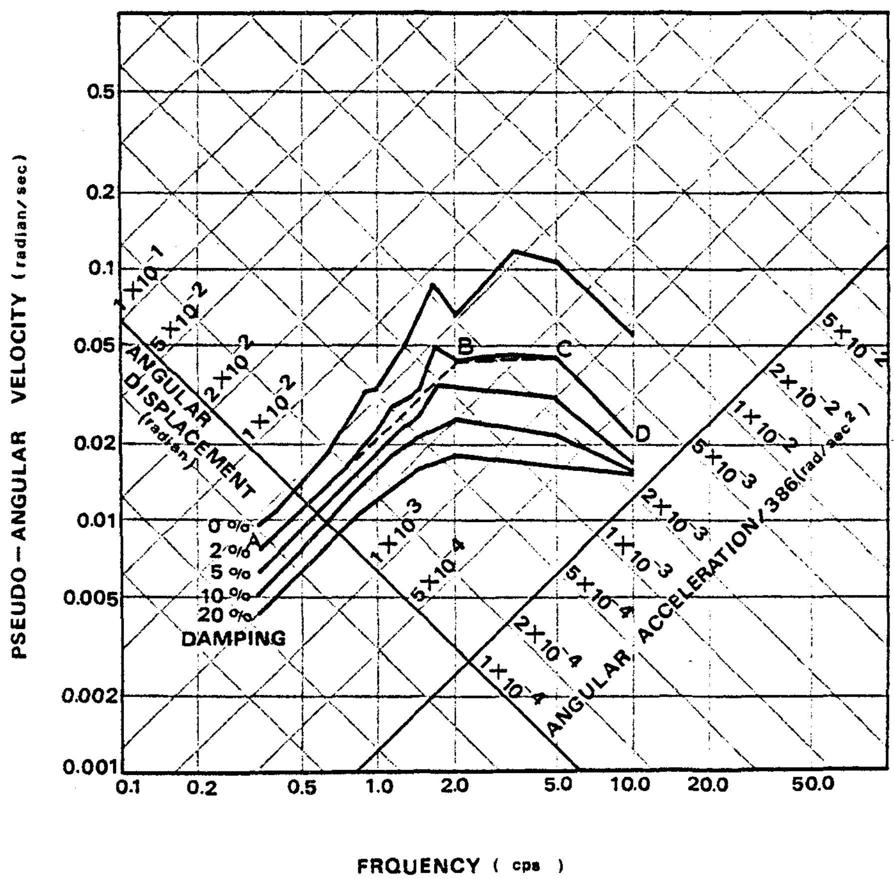


Figure 5 Horizontal response spectrum for 1.0 g maximum ground acceleration

FIGURE 5



MEAN TORSIONAL SPECTRUM (average shear velocity = 570 ft/s)

FIGURE 6

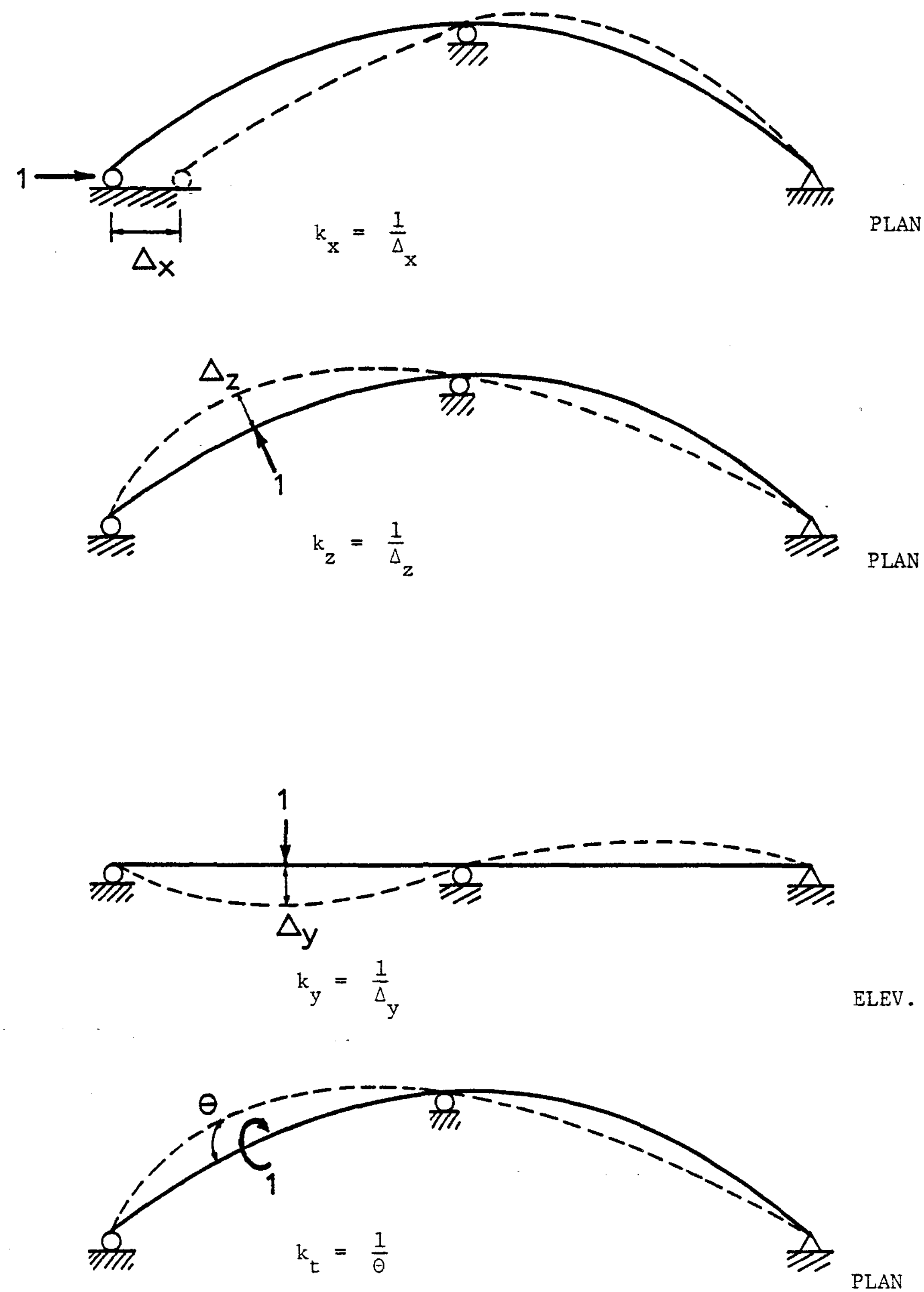
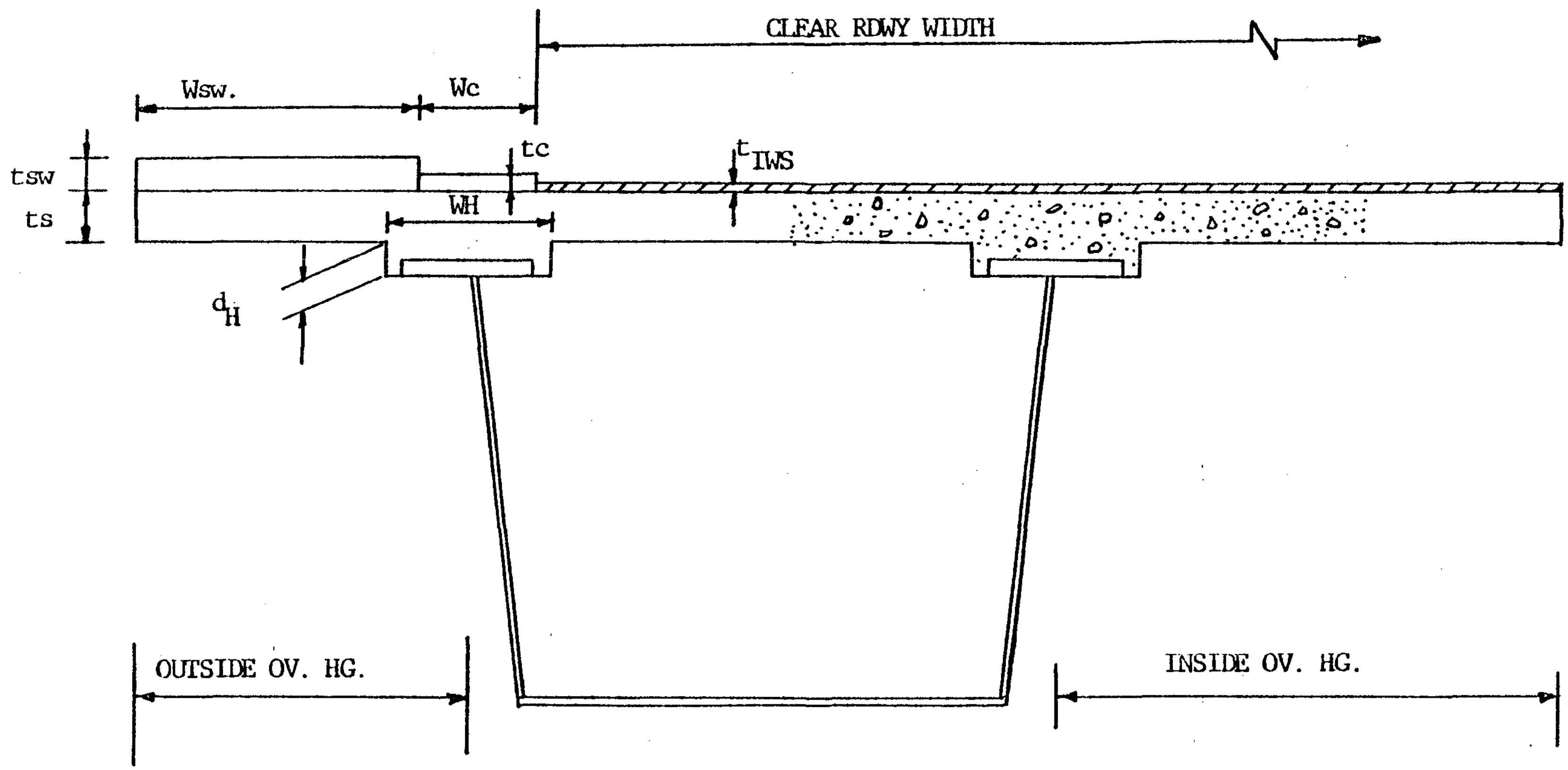

1
Δ_x
$k_x = \frac{1}{\Delta_x}$
PLAN
Δ_z
1
$k_z = \frac{1}{\Delta_z}$
PLAN
1
Δ_y
$k_y = \frac{1}{\Delta_y}$
ELEV.
Θ
1
$k_t = \frac{1}{\Theta}$
PLAN

FIGURE 7



STRUCTURAL DETAILS

FIGURE 8

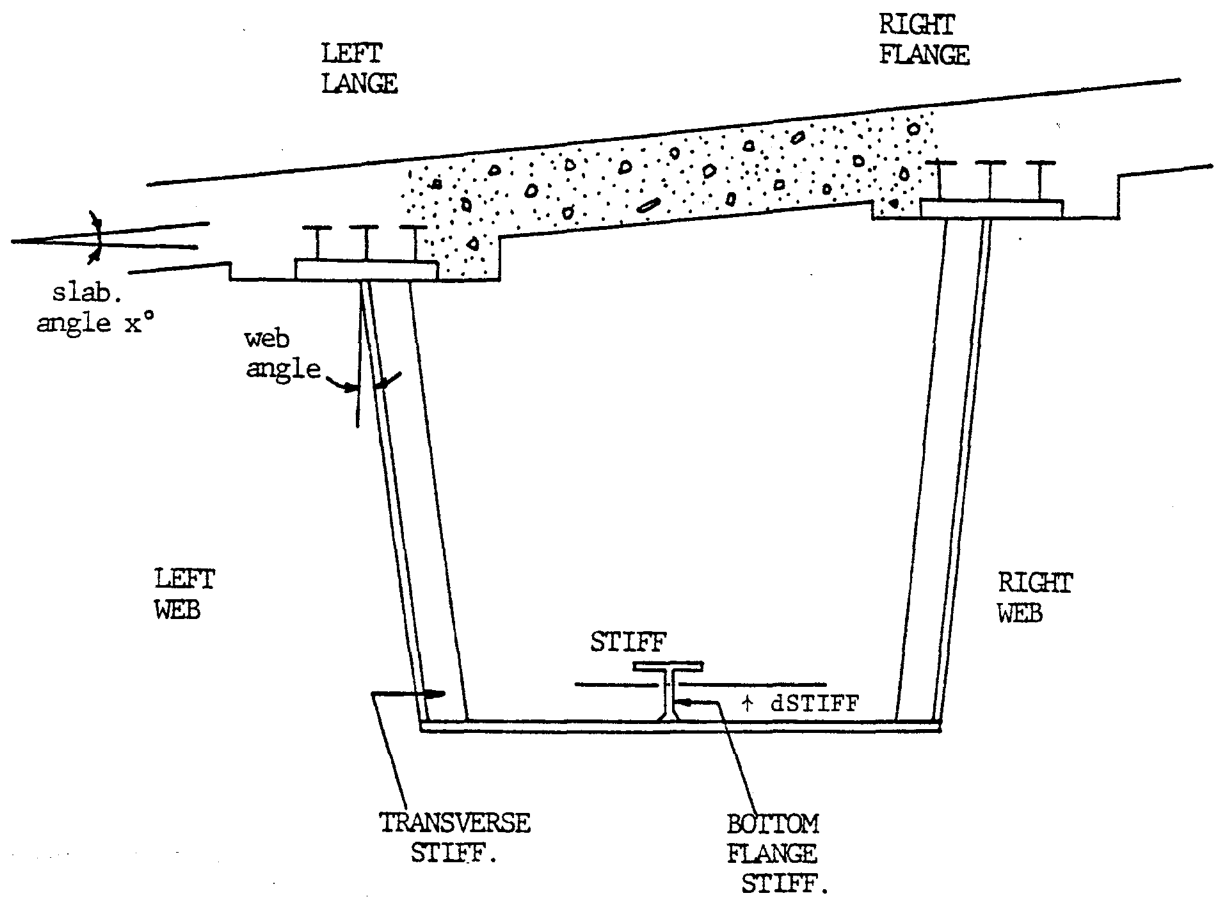
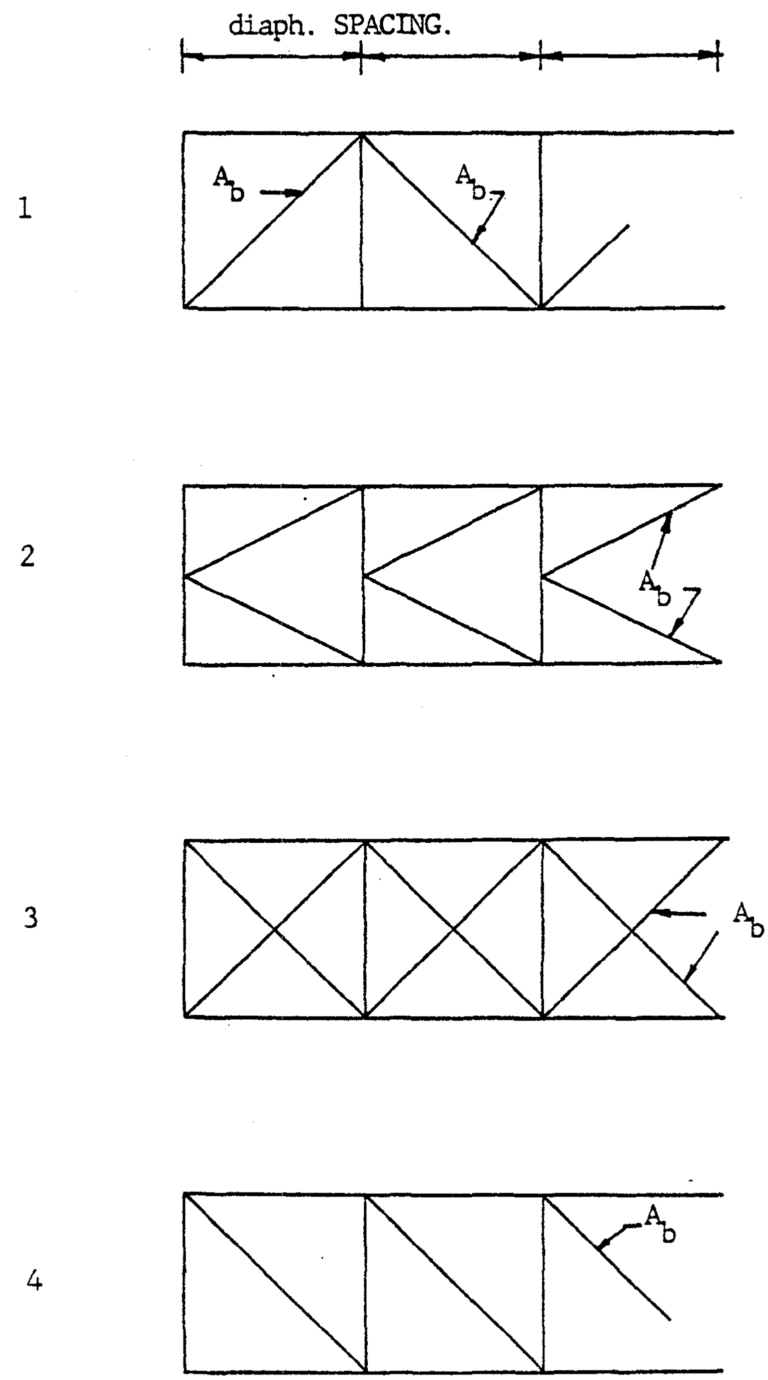

LEFT
LANGE
RIGHT
FLANGE
slab.
angle x°
web
angle
LEFT
WEB
RIGHT
WEB
STIFF
↑ dSTIFF
TRANSVERSE
STIFF.
BOTTOM
FLANGE
STIFF.

FIGURE 9

BRACING TYPES (TOP LATERAL)



A_b = Bracing Memb. Area.

FIGURE 10

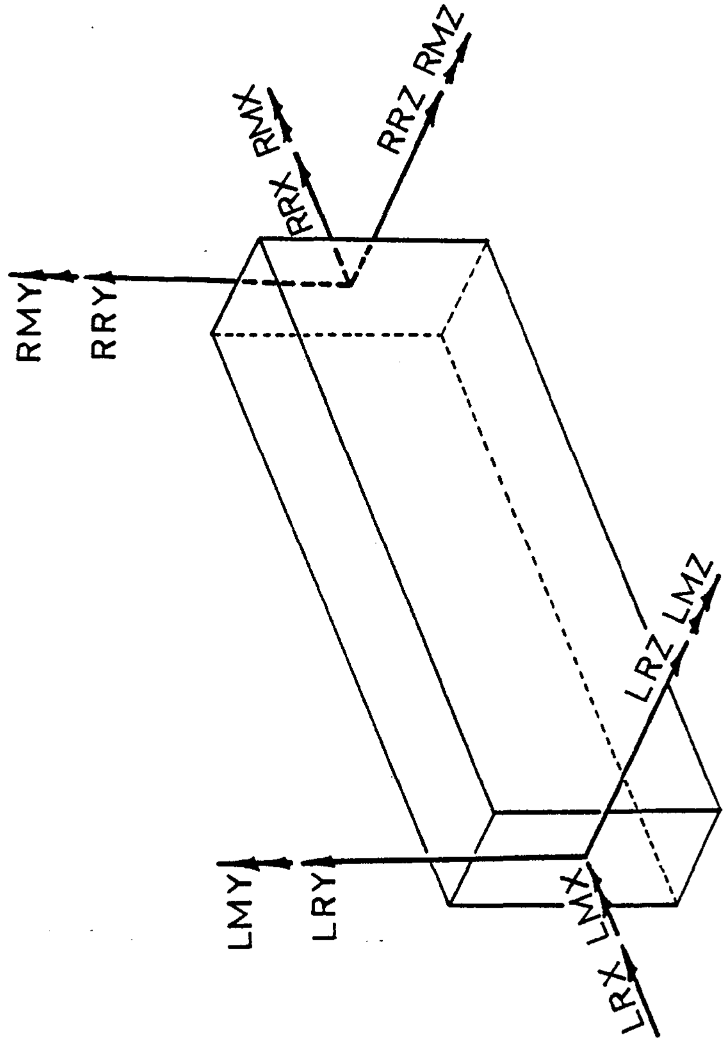


FIGURE 11

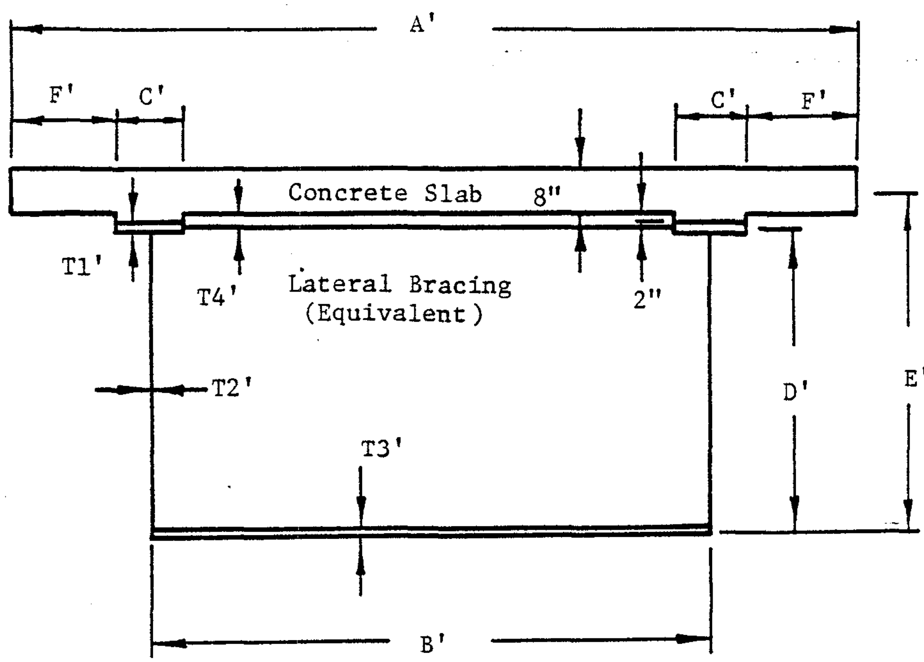
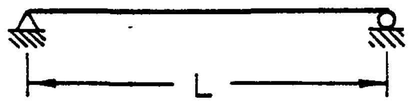

A'
F'
C'
C'
F'
Concrete Slab
8"
T1'
T4'
Lateral Bracing
(Equivalent)
2"
T2'
D'
E'
T3'
B'

FIGURE 12

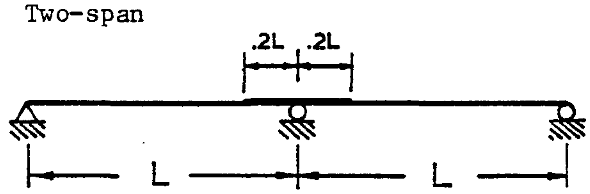
Span Lengths

Single-span



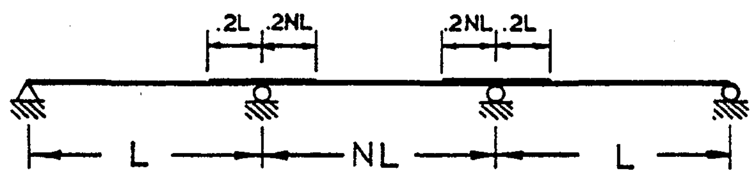
L = 50', 100', 150'

Two-span



L = 50', 100', 150'

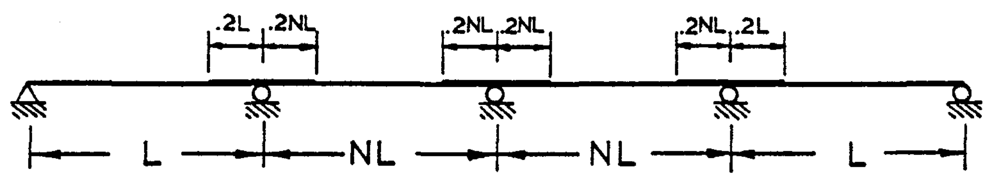
Three-span



L = 50', 100', 150'

N = 1.2

Four-span



L = 50', 100', 150'

N = 1.2

FIGURE 13

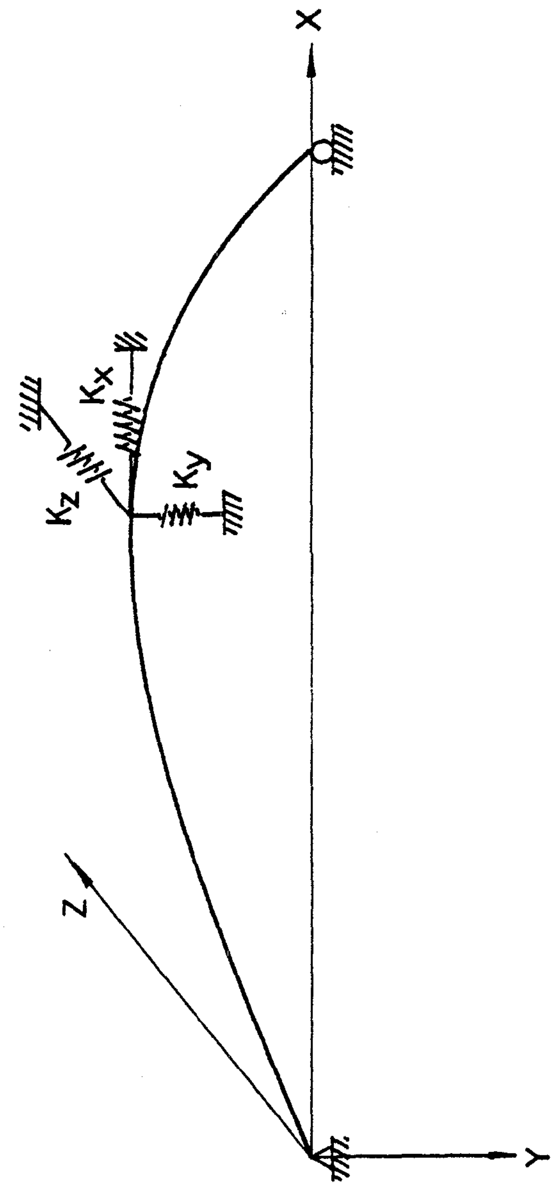


FIGURE 14

Single-span

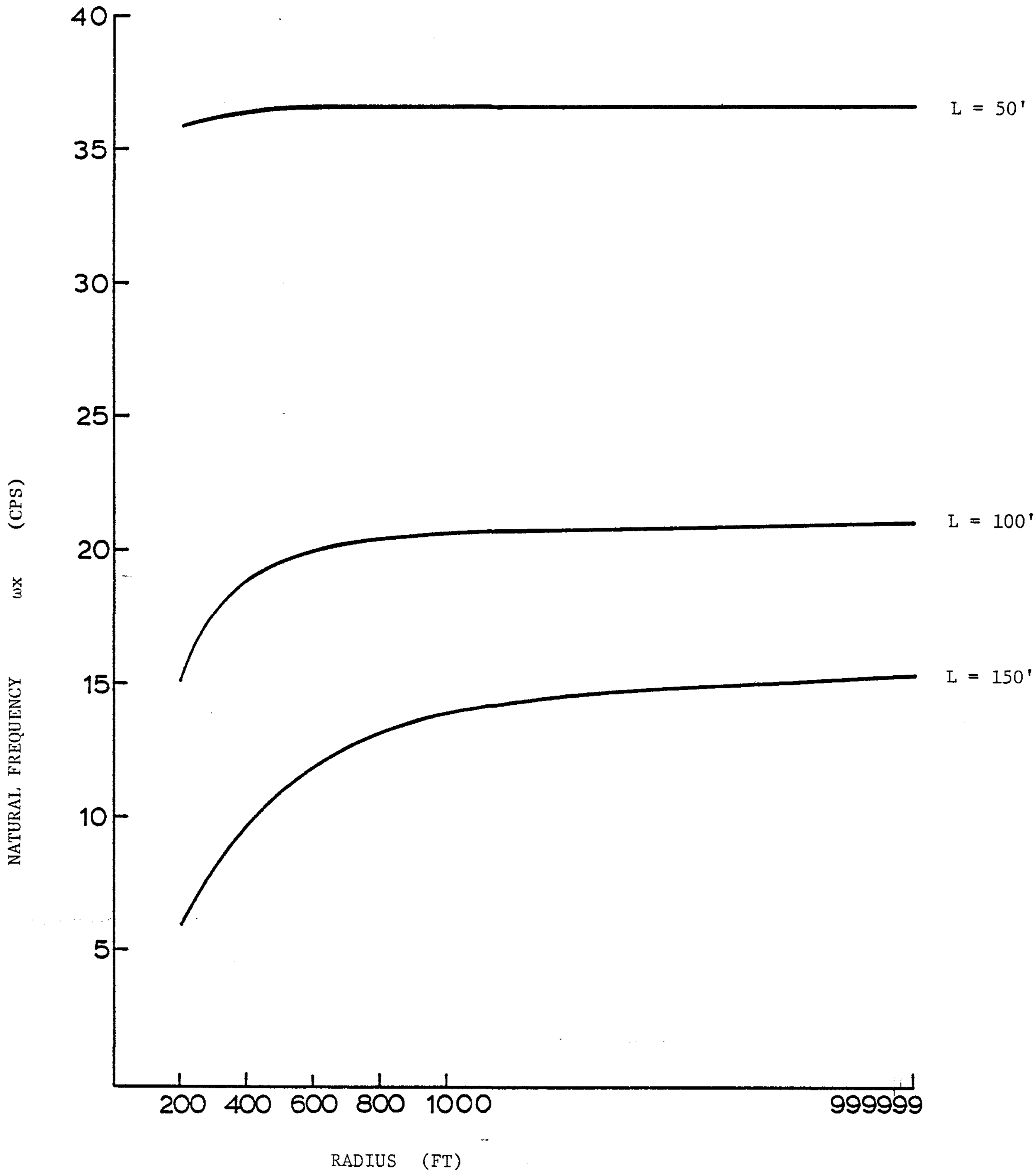


FIGURE 15

Two-span L = 50'

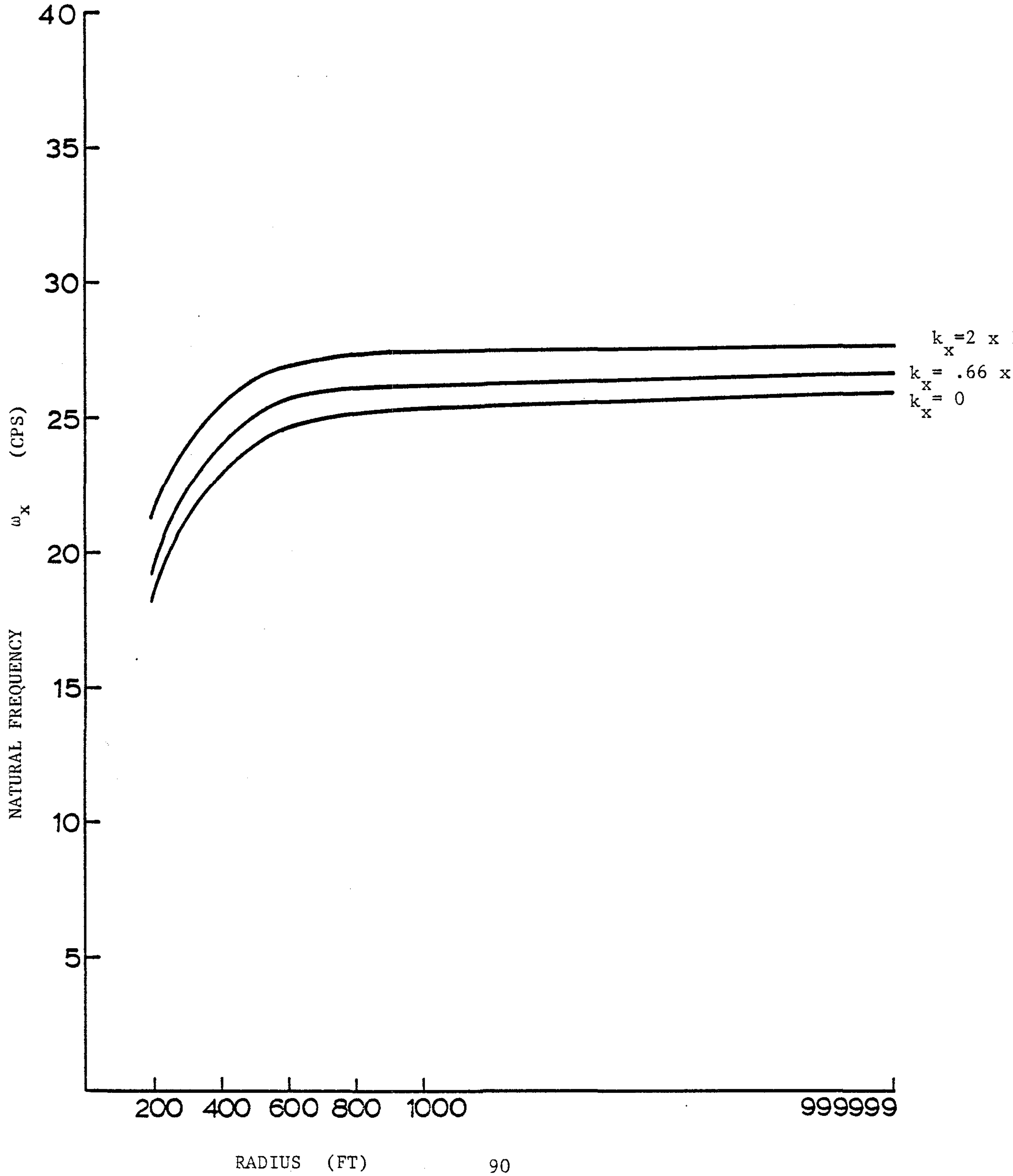


FIGURE 16

Two-span L = 100'

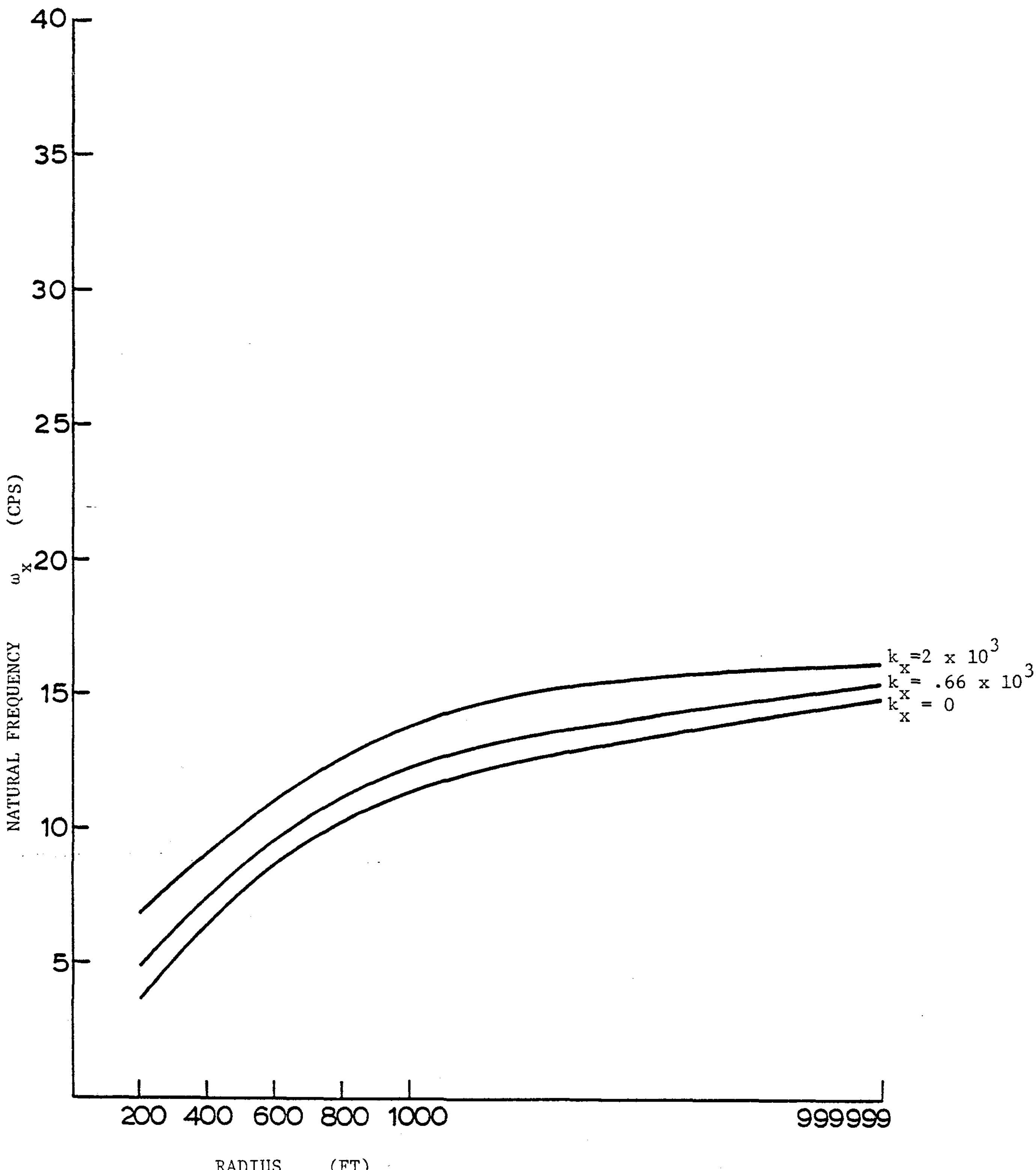


FIGURE 17

Two-span L = 150'

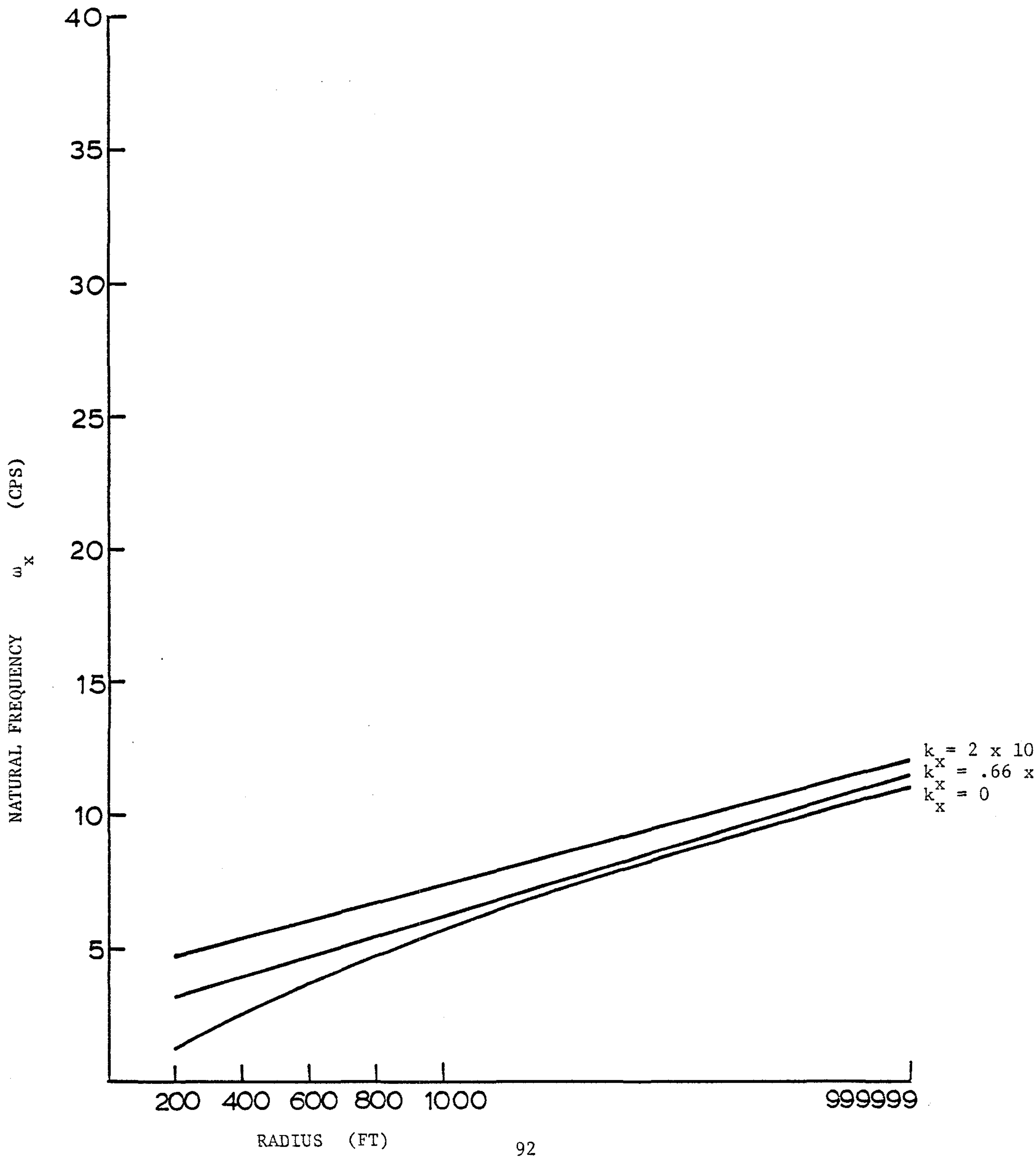


FIGURE 18

Three-span L = 50'

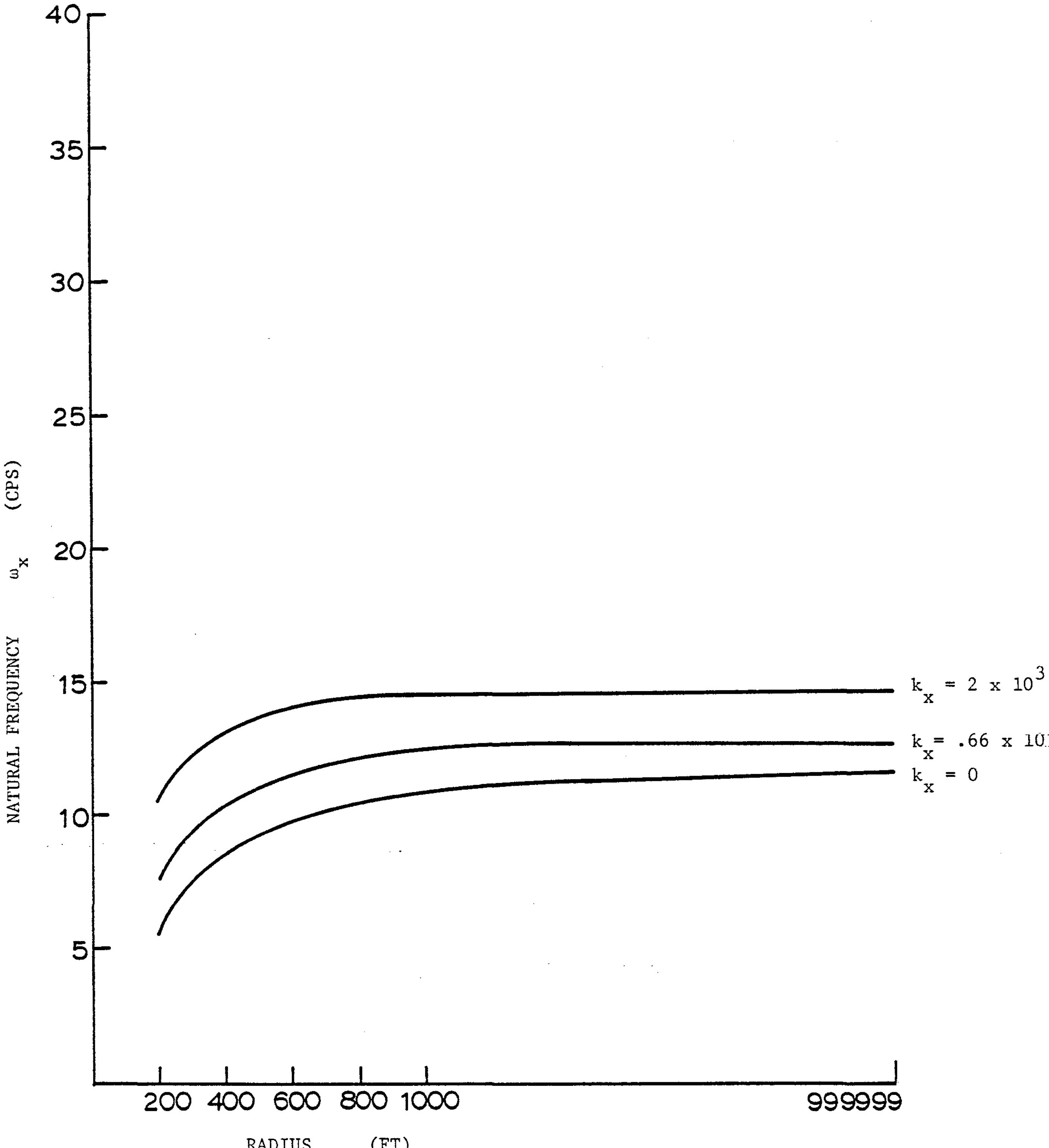


FIGURE 19

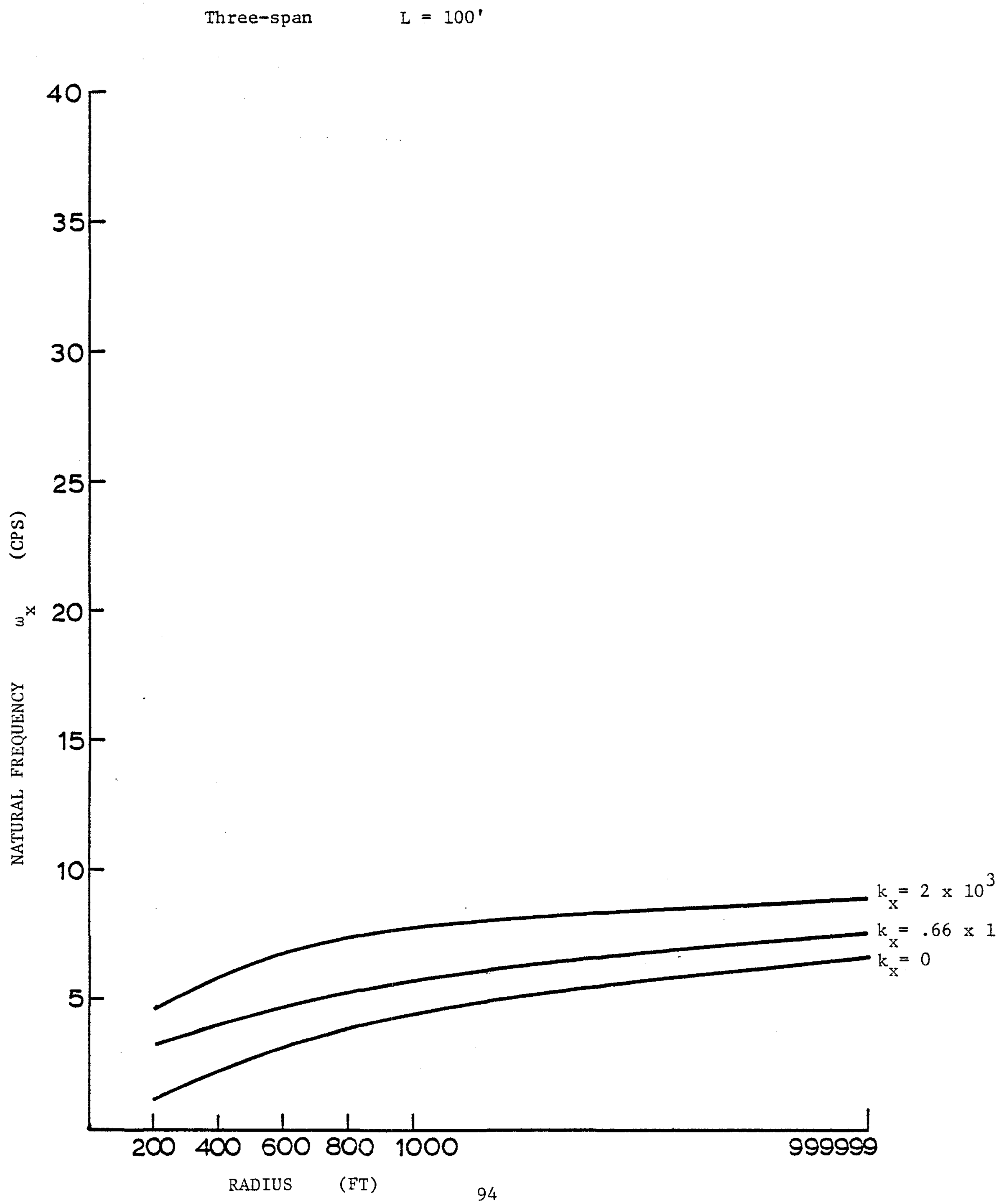

Three-span L = 100'
40
35
30
25
20
15
10
5
NATURAL FREQUENCY ωx (CPS)
200
400
600
800
1000
999999
RADIUS (FT)
kx = 2 x 10^3
kx = .66 x 1
kx = 0

FIGURE 20

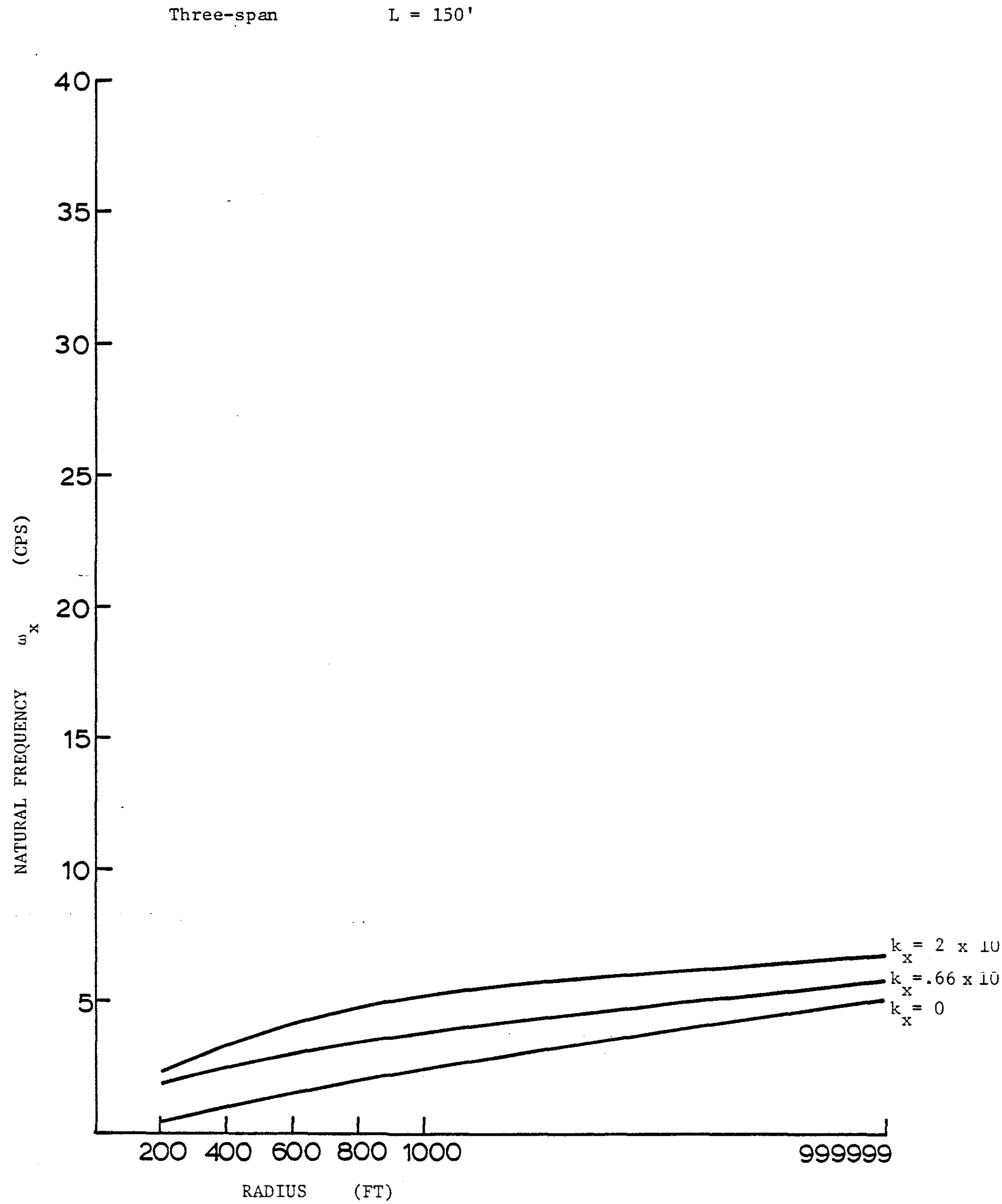
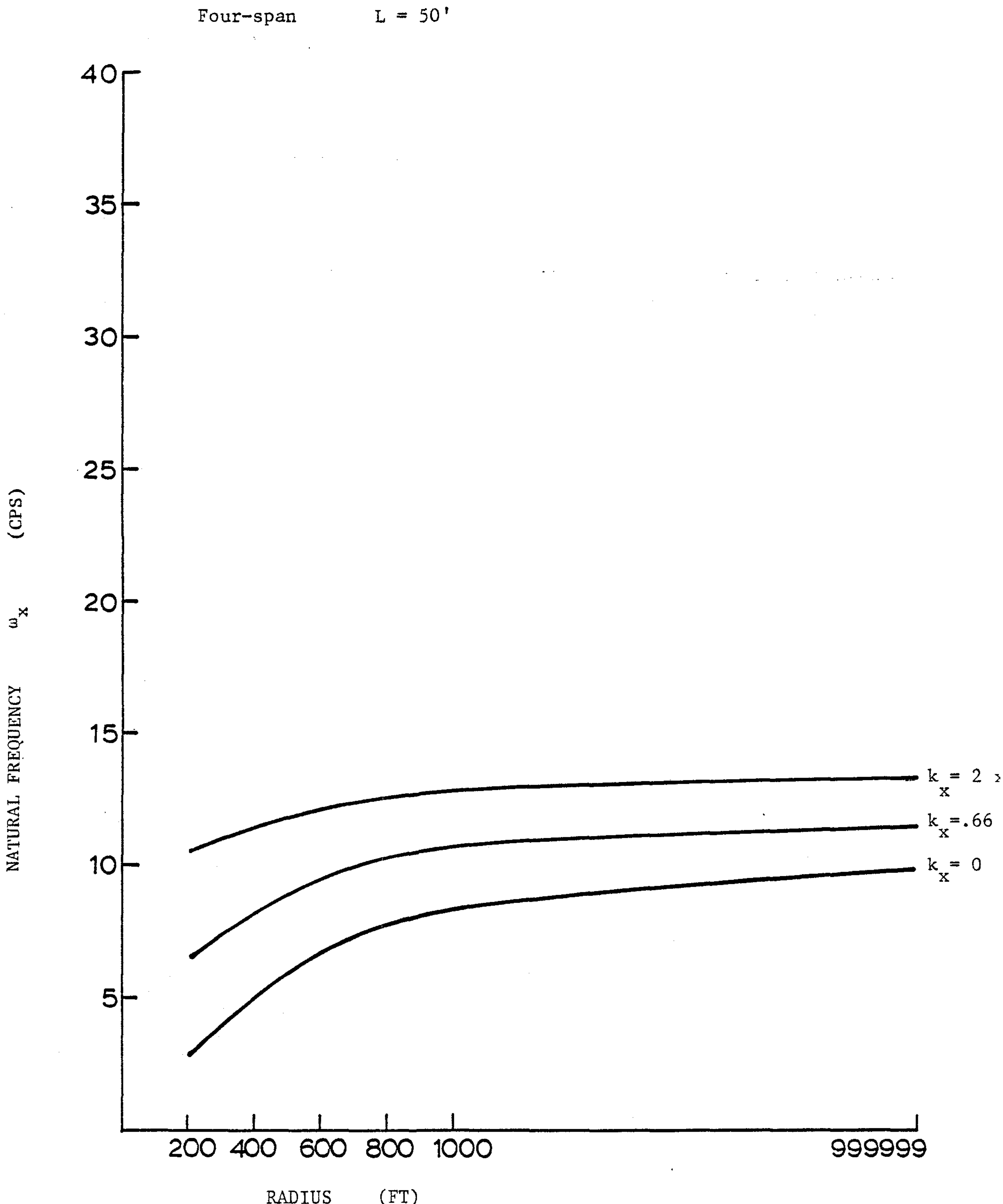

Three-span
L = 150'
40
35
30
25
20
15
10
5
NATURAL FREQUENCY ω
x
(CPS)
200 400 600 800 1000
999999
RADIUS (FT)
k
x
= 2 x 10
k
x
=.66 x 10
k
x
= 0

FIGURE 21



Four-span L = 50'
40
35
30
25
20
15
10
5
NATURAL FREQUENCY ω_x (CPS)
$k_x = 2$
$k_x = .66$
$k_x = 0$
200
400
600
800
1000
999999
RADIUS (FT)

FIGURE 22

Four-span L = 100'

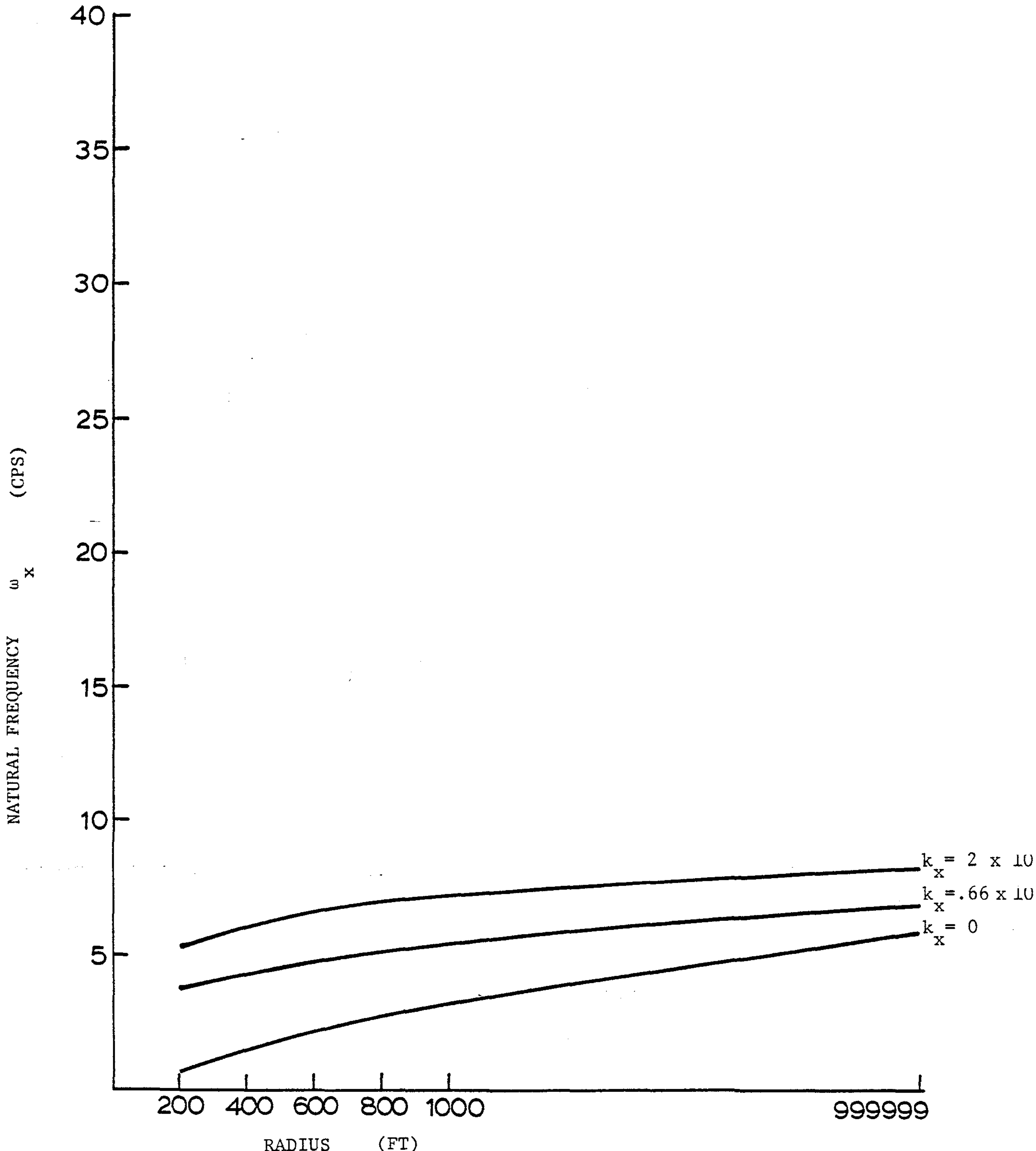


FIGURE 23

Four-span L = 150'

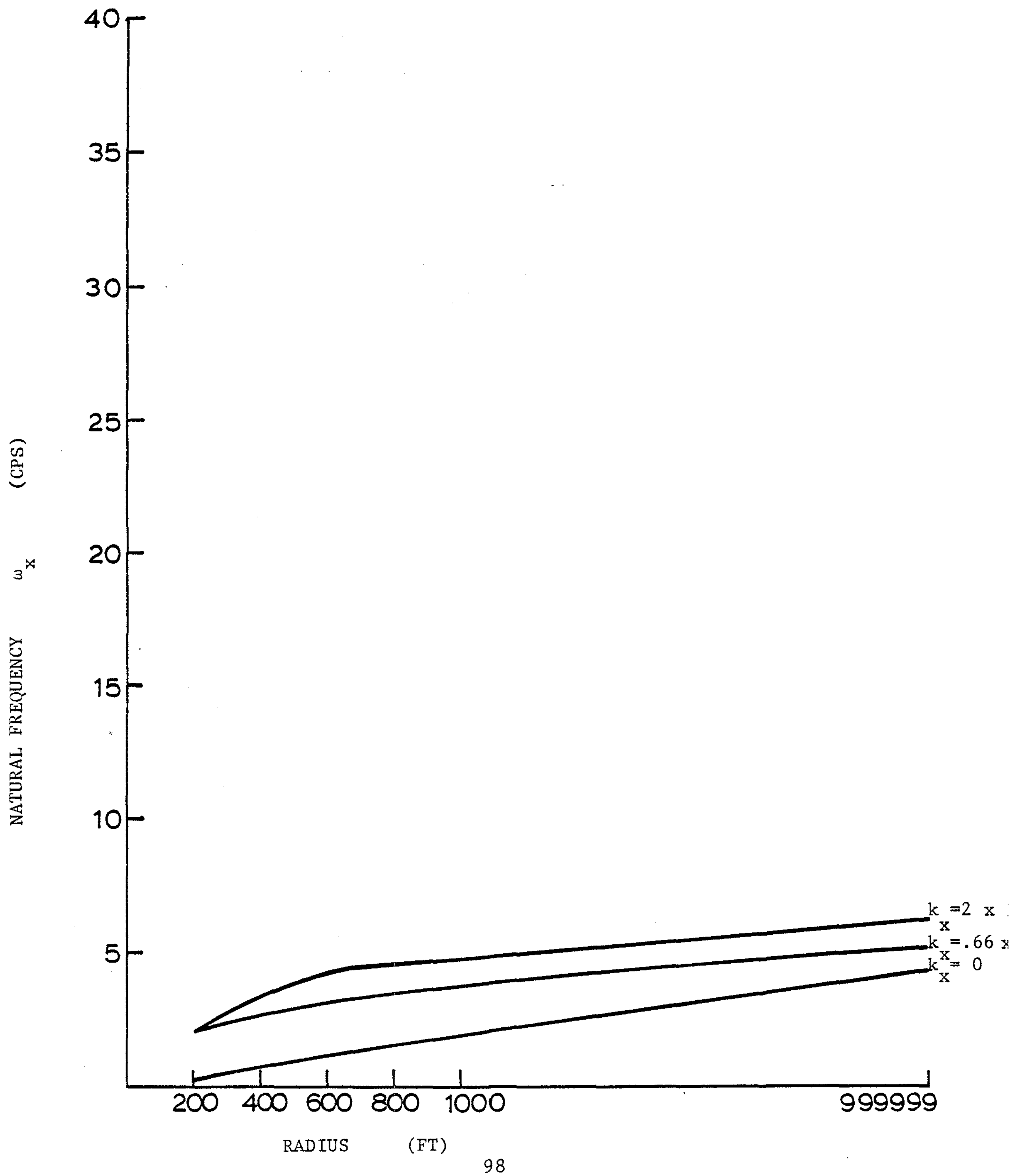


FIGURE 24

Single-span

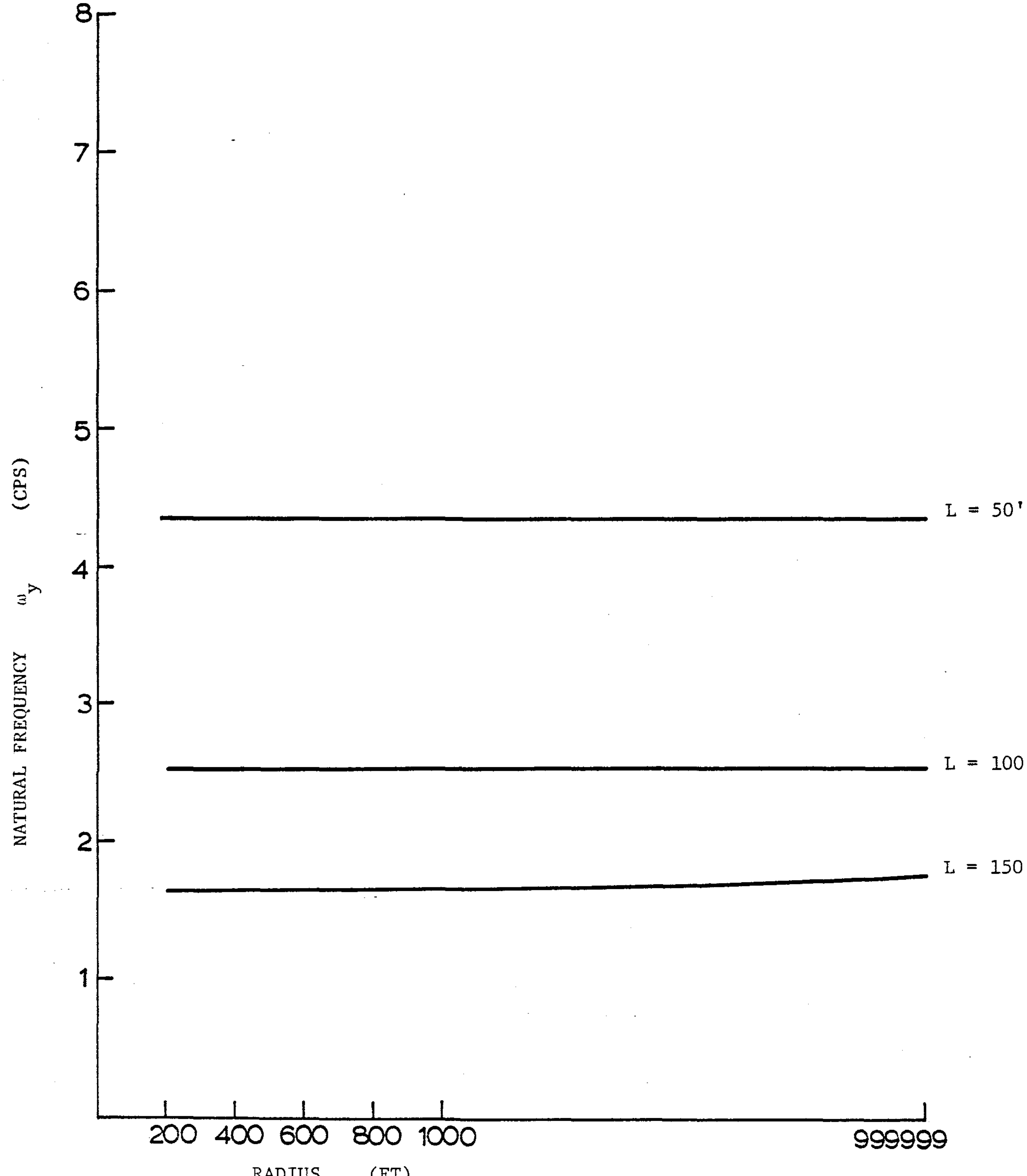


FIGURE 25

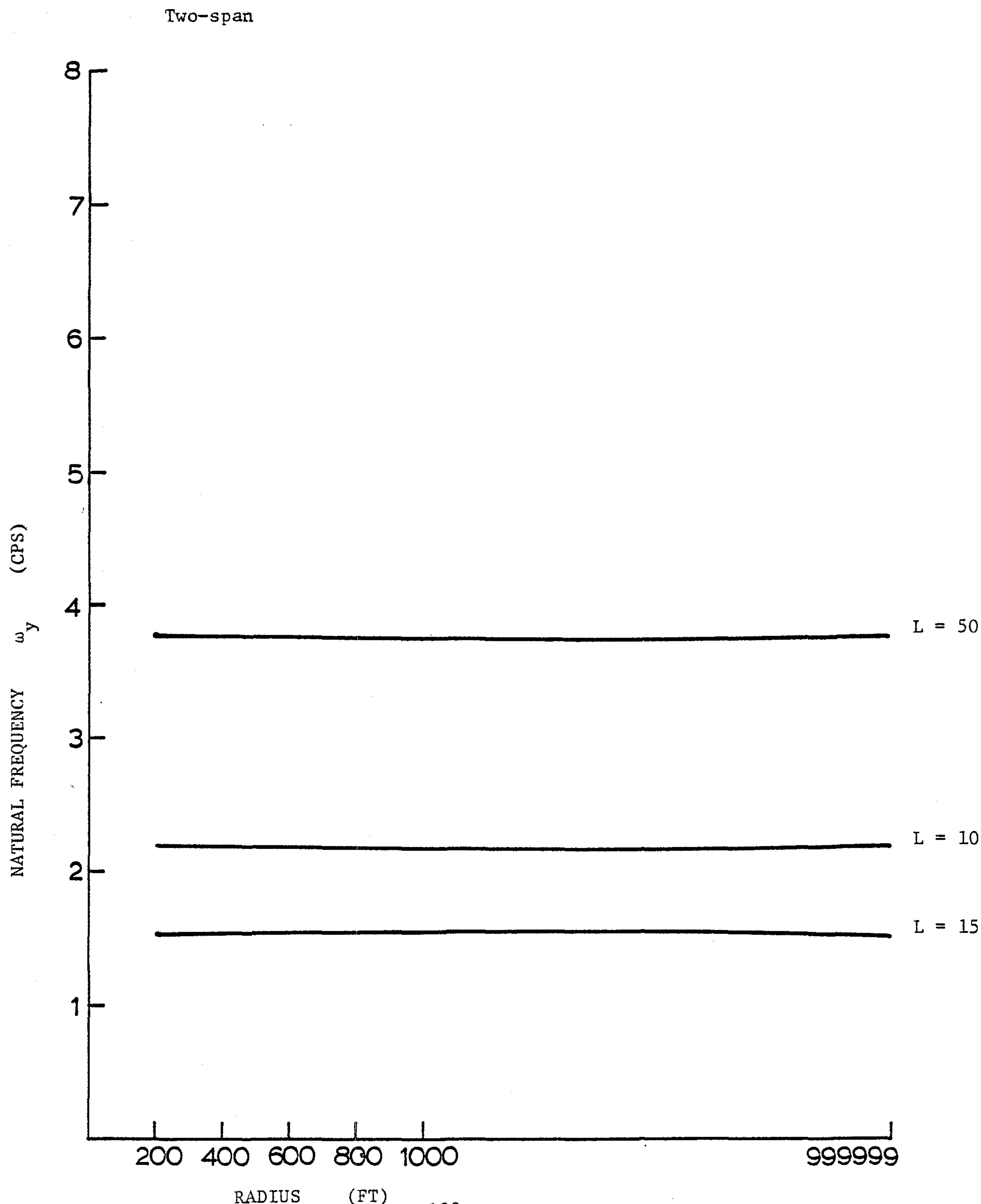

Two-span
8
7
6
5
4
3
2
1
NATURAL FREQUENCY ω_y (CPS)
L = 50
L = 10
L = 15
200
400
600
800
1000
999999
RADIUS (FT)

FIGURE 26

Three-span

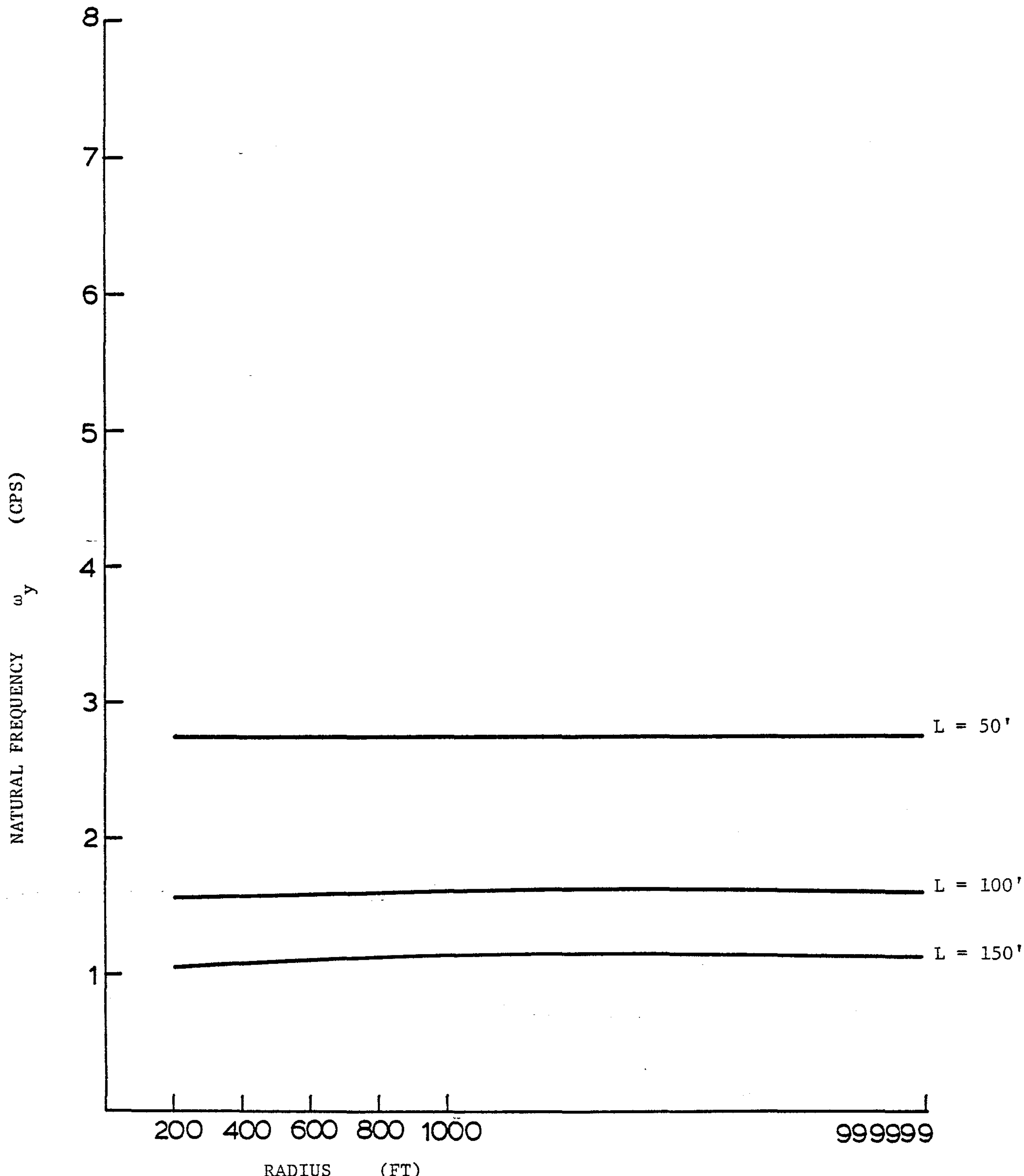


FIGURE 27

Four-span

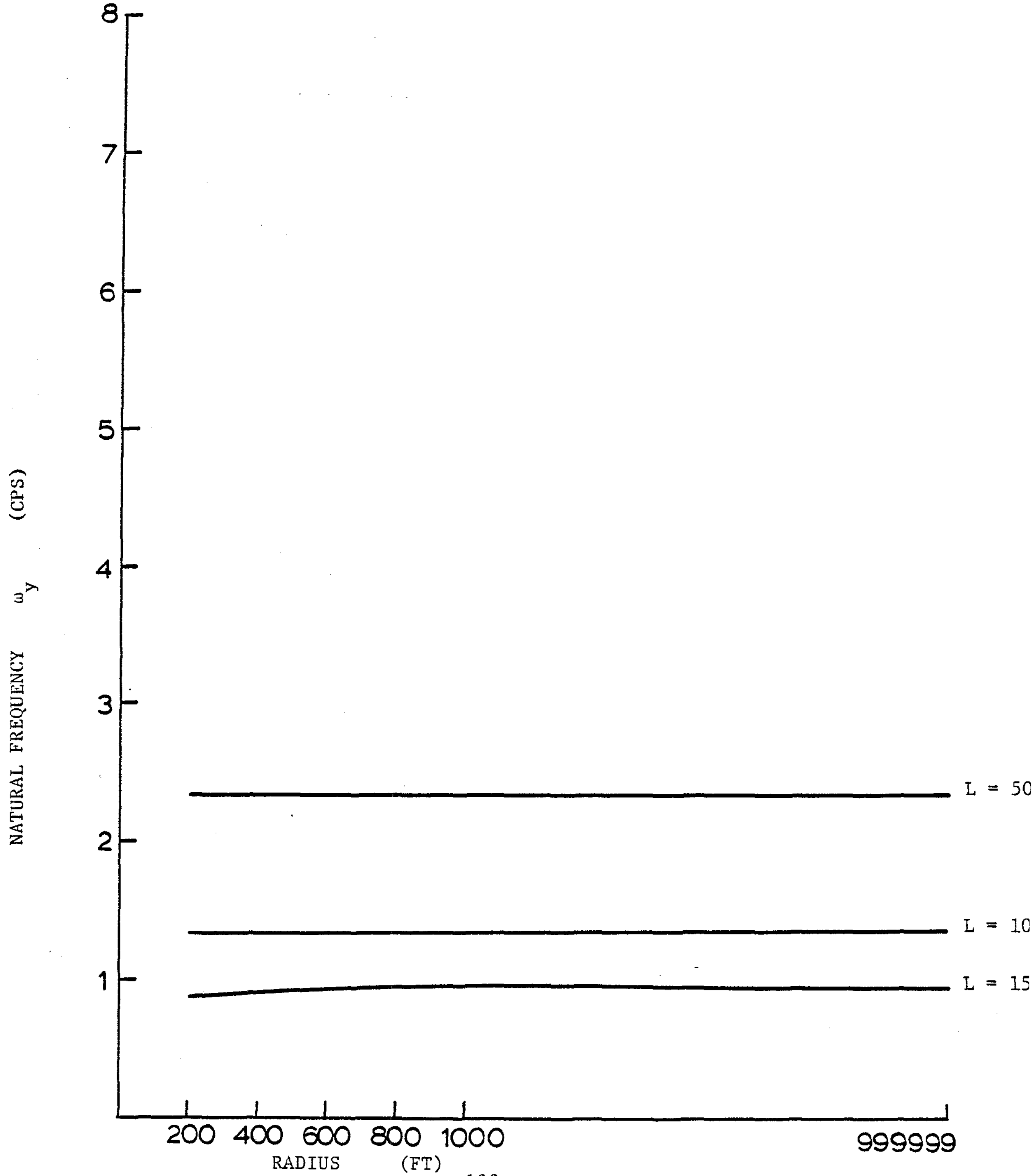


FIGURE 28

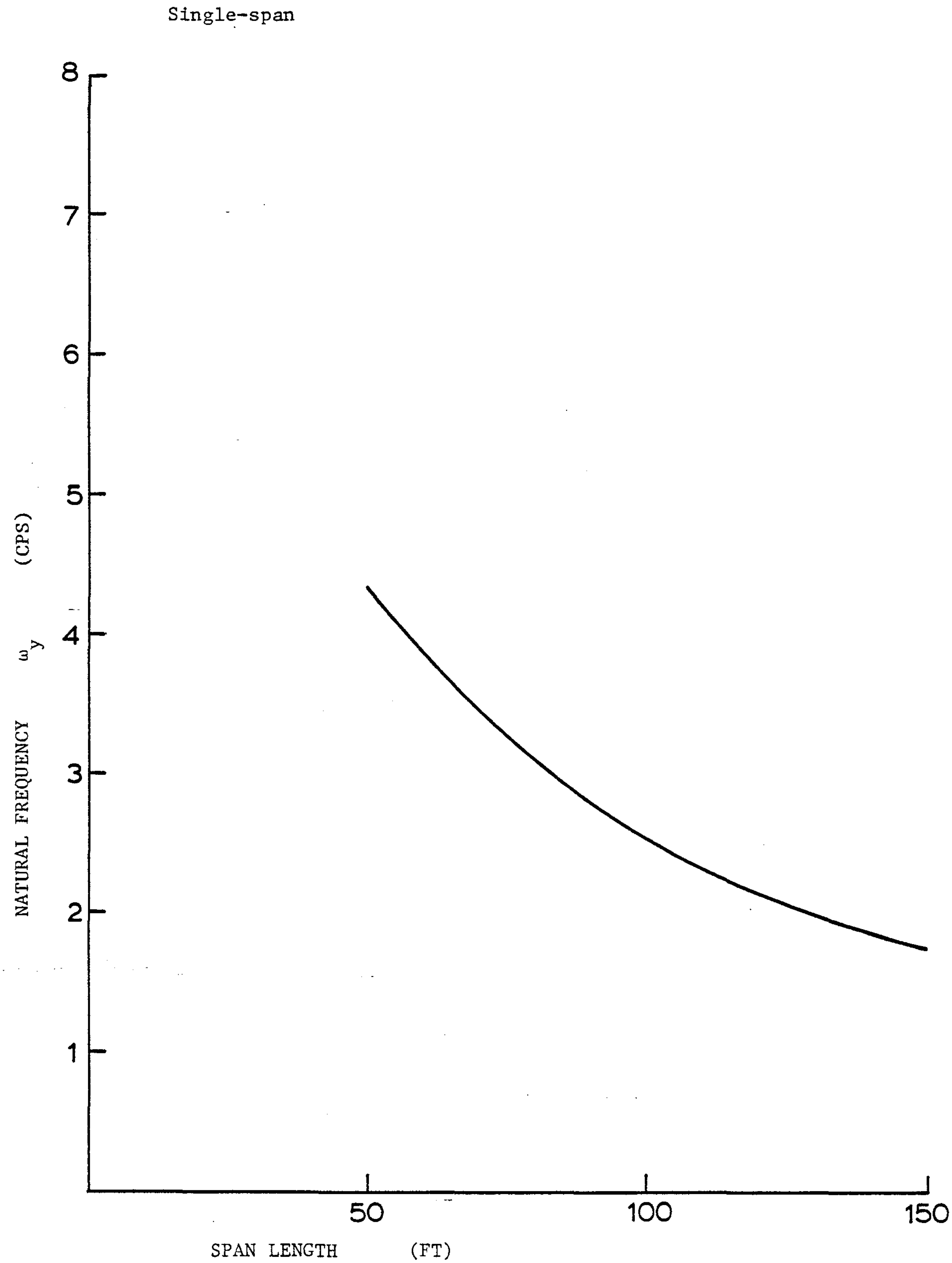

Single-span
8
7
6
5
4
3
2
1
NATURAL FREQUENCY ω_y (CPS)
50
100
150
SPAN LENGTH (FT)

FIGURE 29

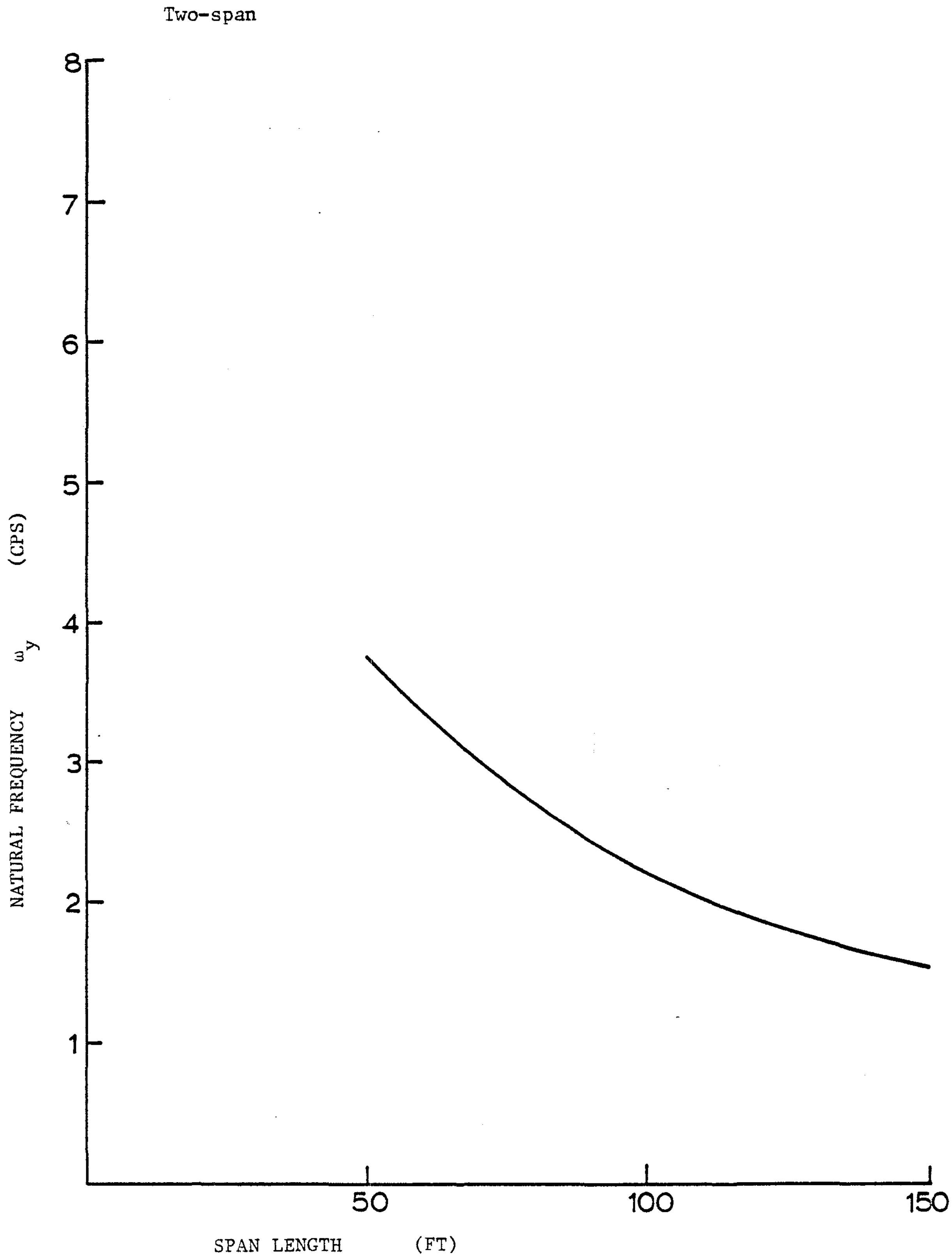

Two-span
8
7
6
5
4
3
2
1
NATURAL FREQUENCY ω_y (CPS)
50
100
150
SPAN LENGTH (FT)

FIGURE 30

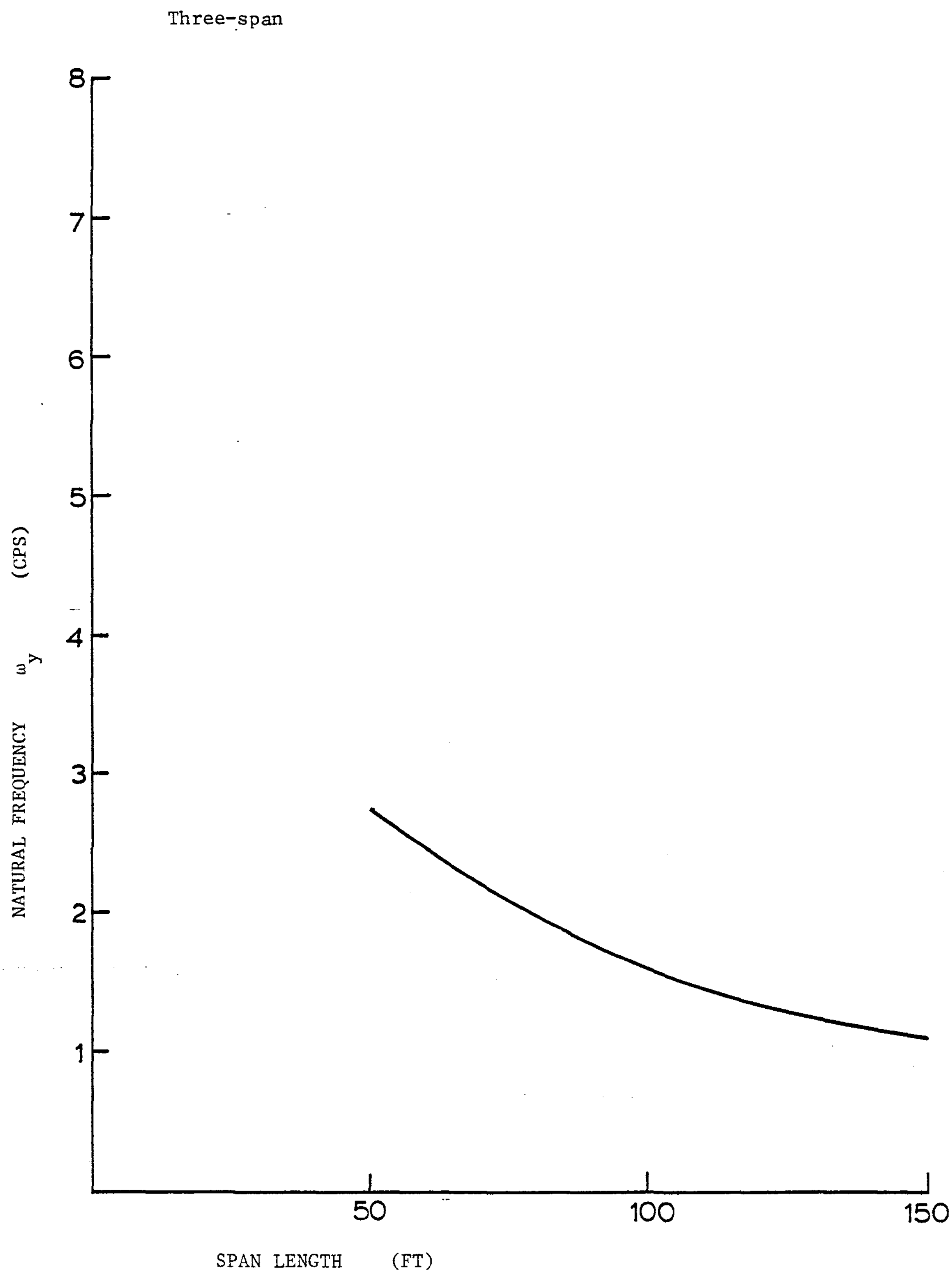

Three-span
8
7
6
5
4
3
2
1
NATURAL FREQUENCY ω_y (CPS)
50
100
150
SPAN LENGTH (FT)

FIGURE 31

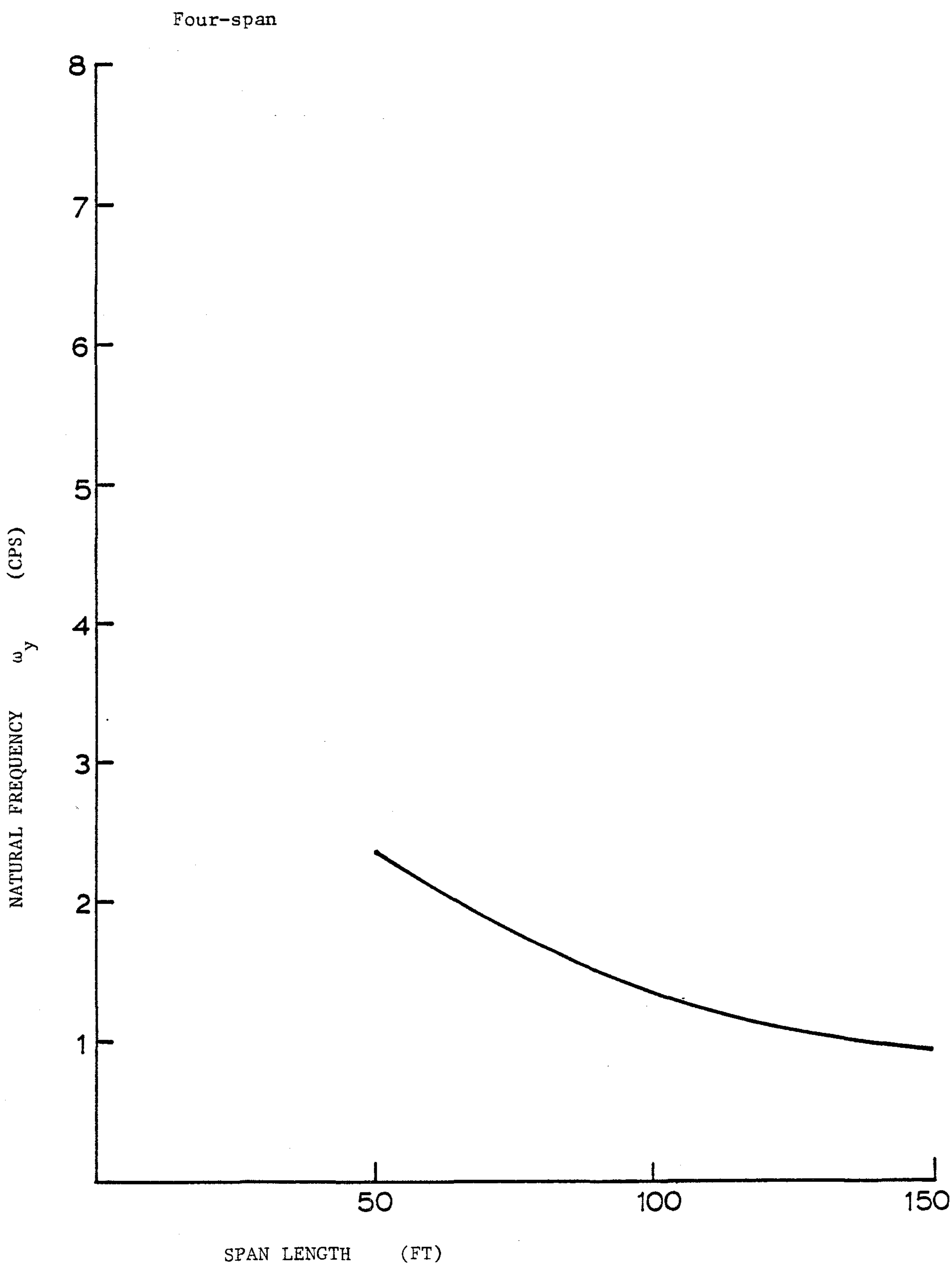
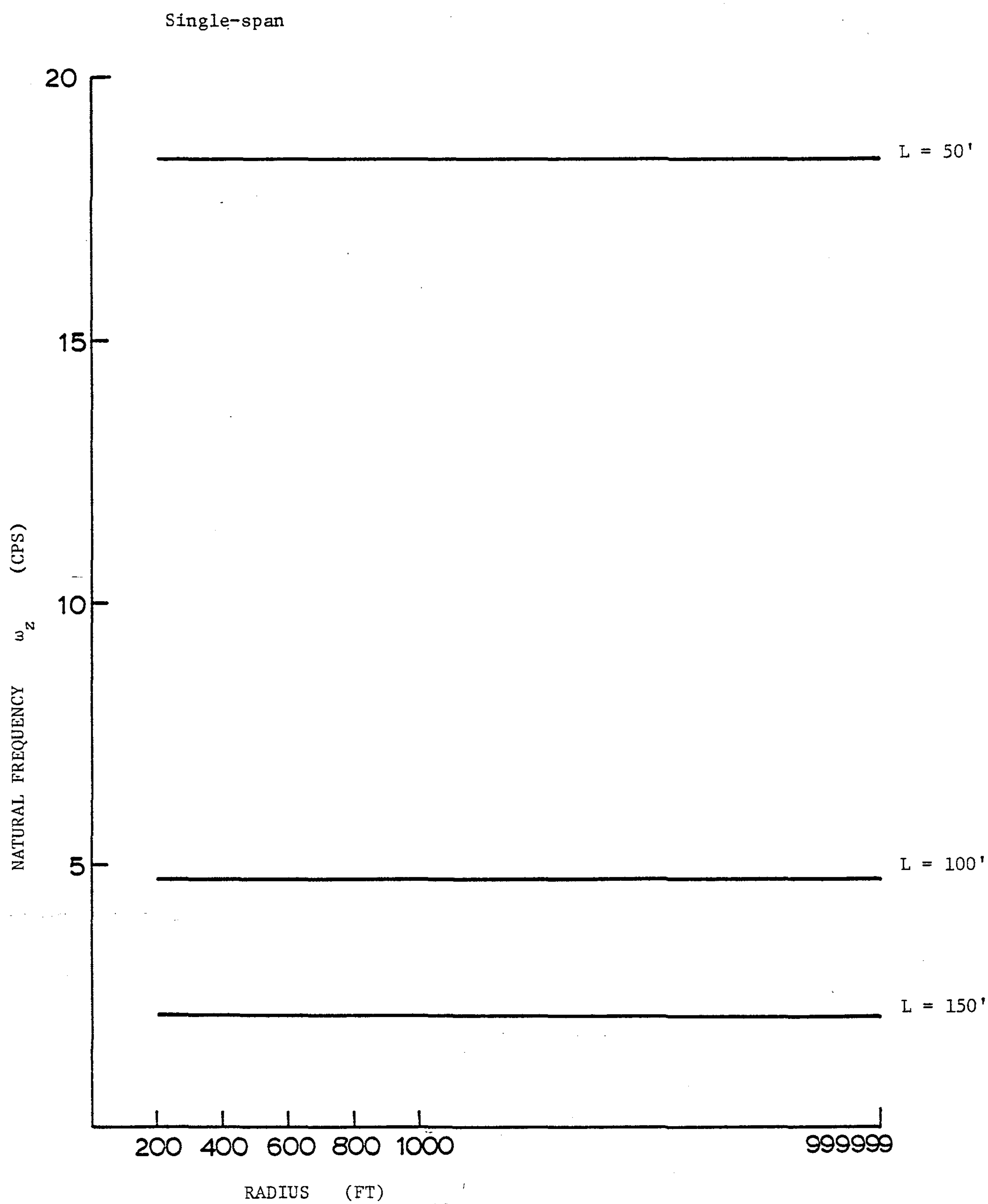

Four-span
8
7
6
5
4
3
2
1
NATURAL FREQUENCY ω_y (CPS)
50
100
150
SPAN LENGTH (FT)

FIGURE 32



Single-span
20
15
10
5
NATURAL FREQUENCY ω_z (CPS)
L = 50'
L = 100'
L = 150'
200
400
600
800
1000
999999
RADIUS (FT)

FIGURE 33

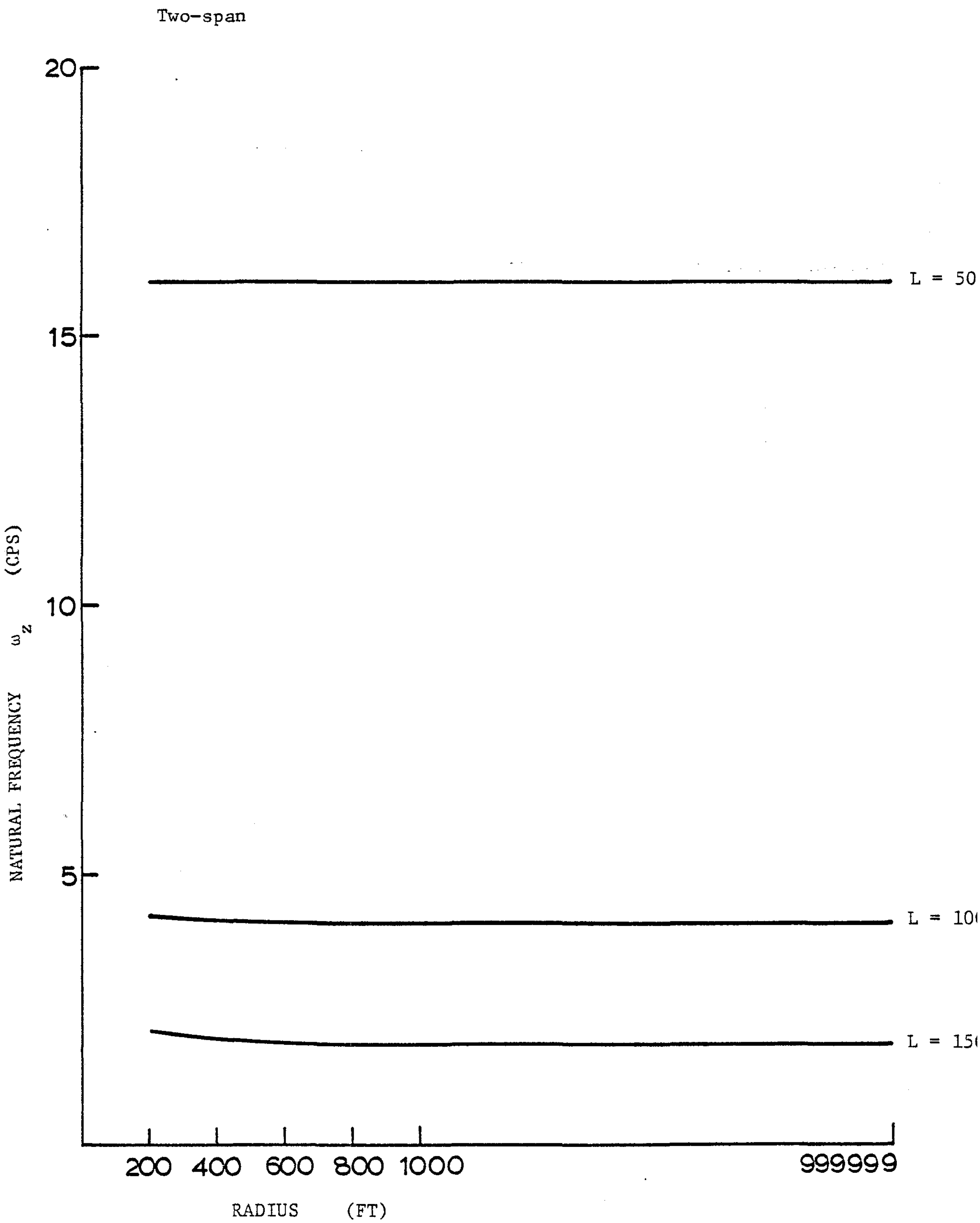

Two-span
20
15
10
5
NATURAL FREQUENCY ω_z (CPS)
L = 50
L = 10
L = 15
200 400 600 800 1000 999999
RADIUS (FT)

FIGURE 34

Three-span

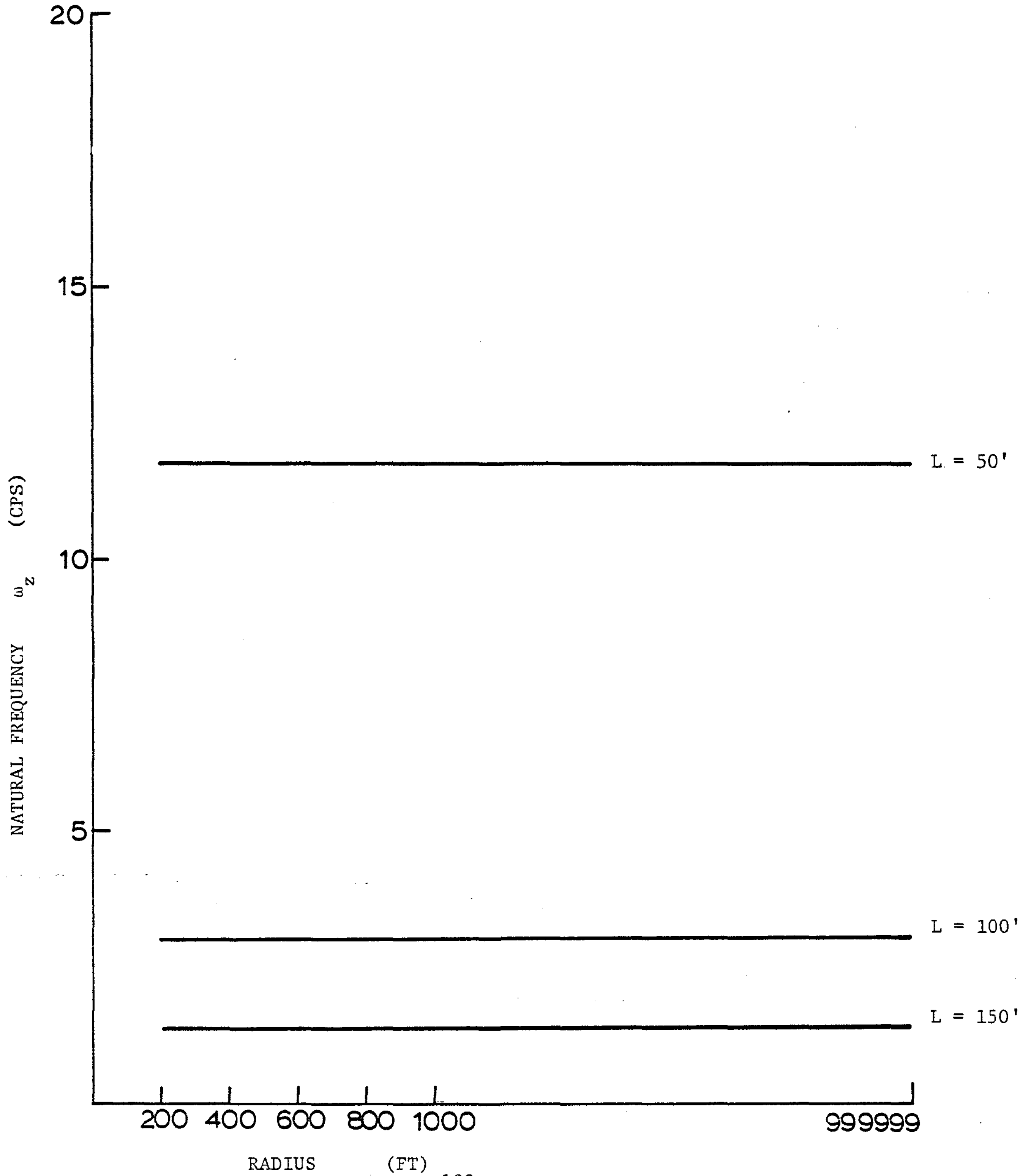


FIGURE 35

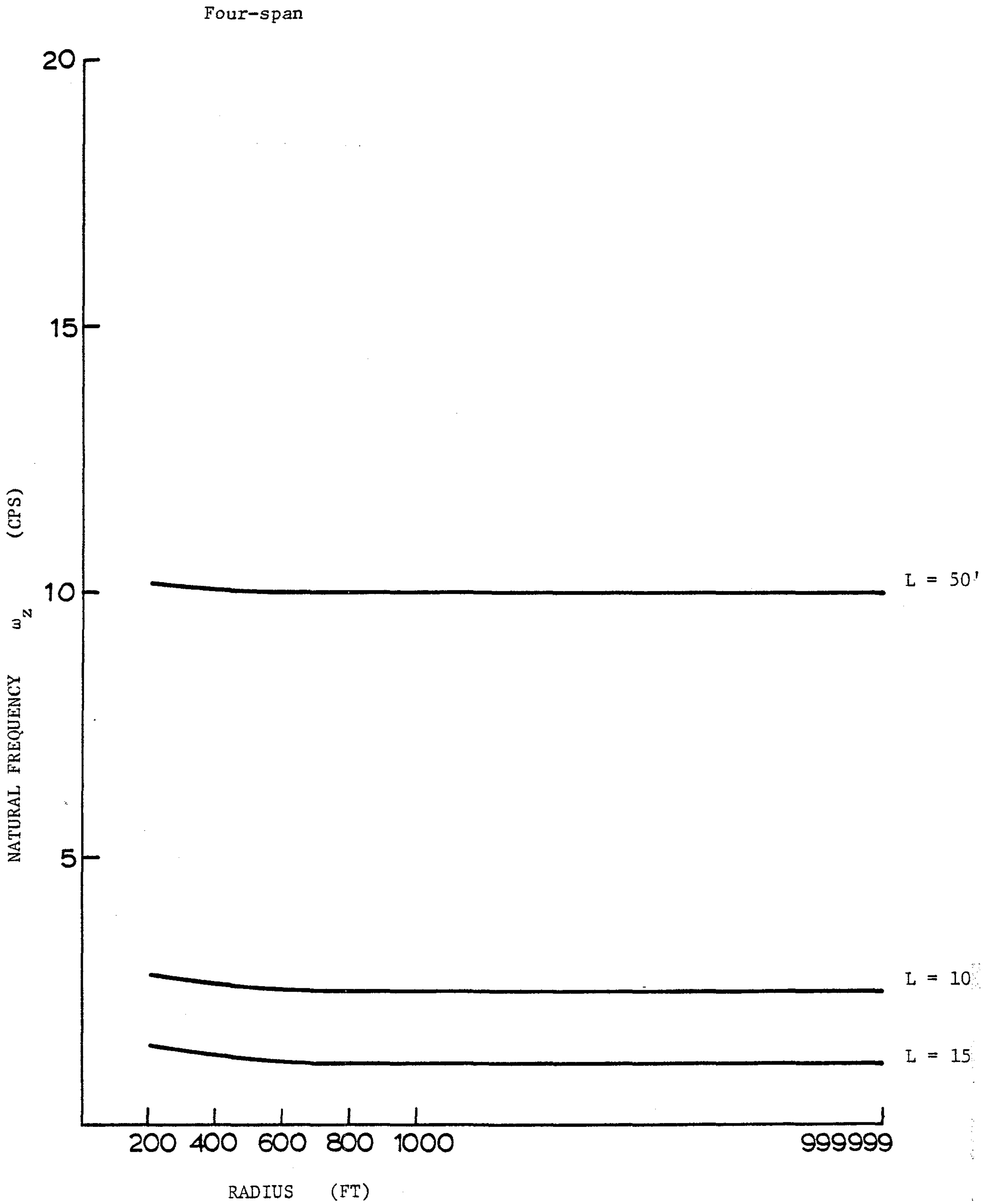

Four-span
20
15
10
5
NATURAL FREQUENCY ω_z (CPS)
L = 50'
L = 10
L = 15
200
400
600
800
1000
999999
RADIUS (FT)

FIGURE 36

Single-span

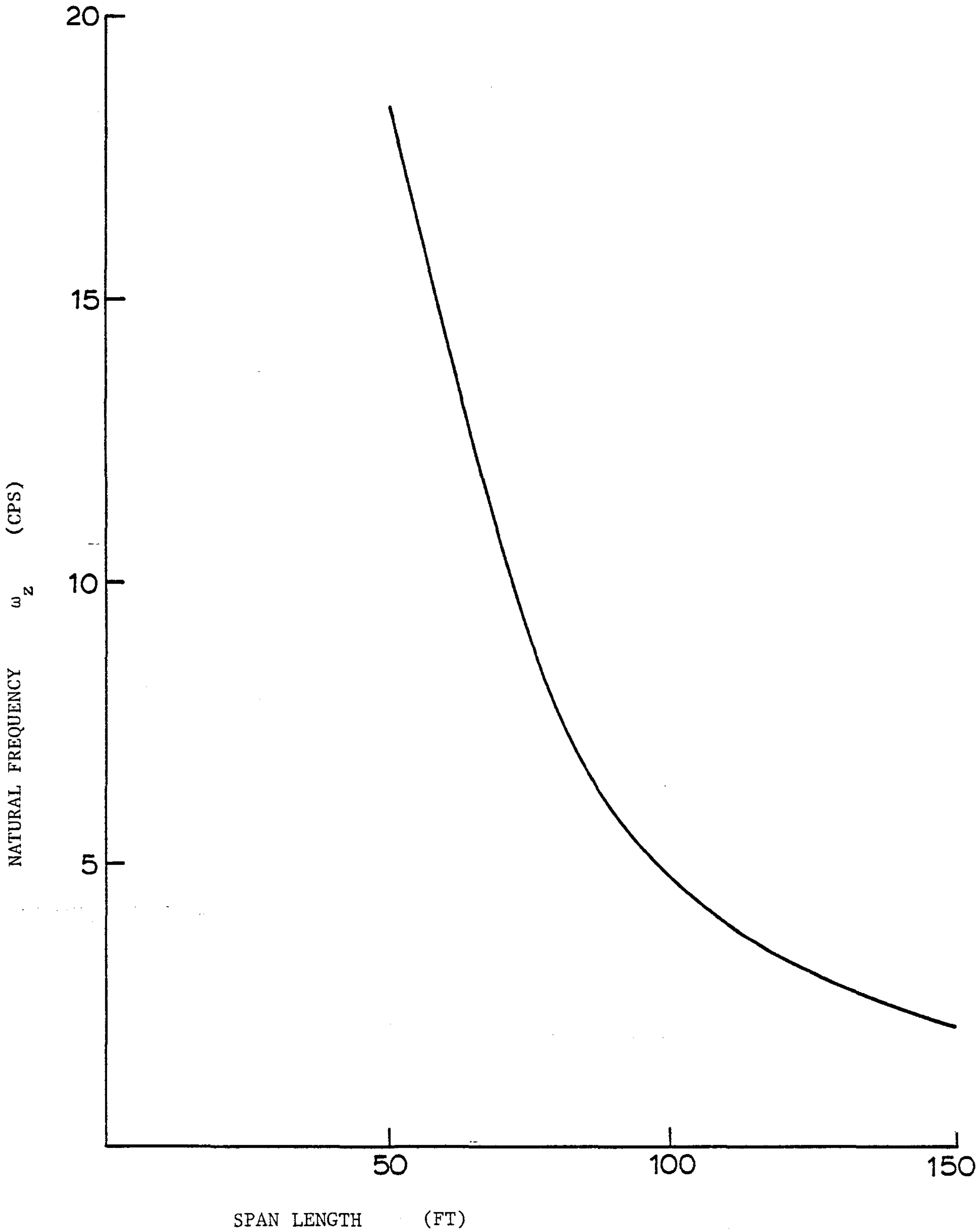


FIGURE 37

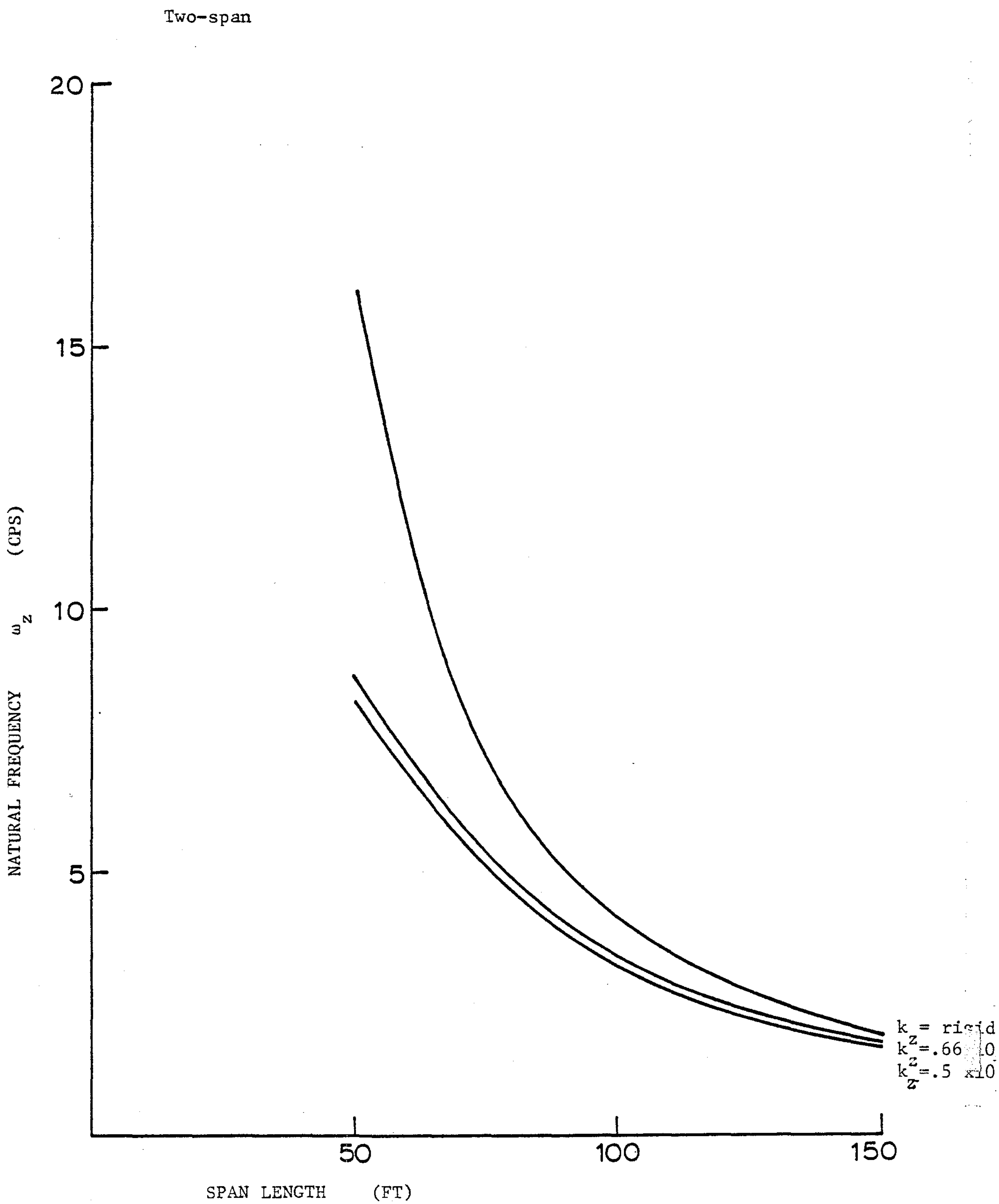

Two-span
20
15
10
5
NATURAL FREQUENCY ω_z (CPS)
50
100
150
SPAN LENGTH (FT)
k_z = rigid
k_z=.66 10
k_z=.5 x10

FIGURE 38

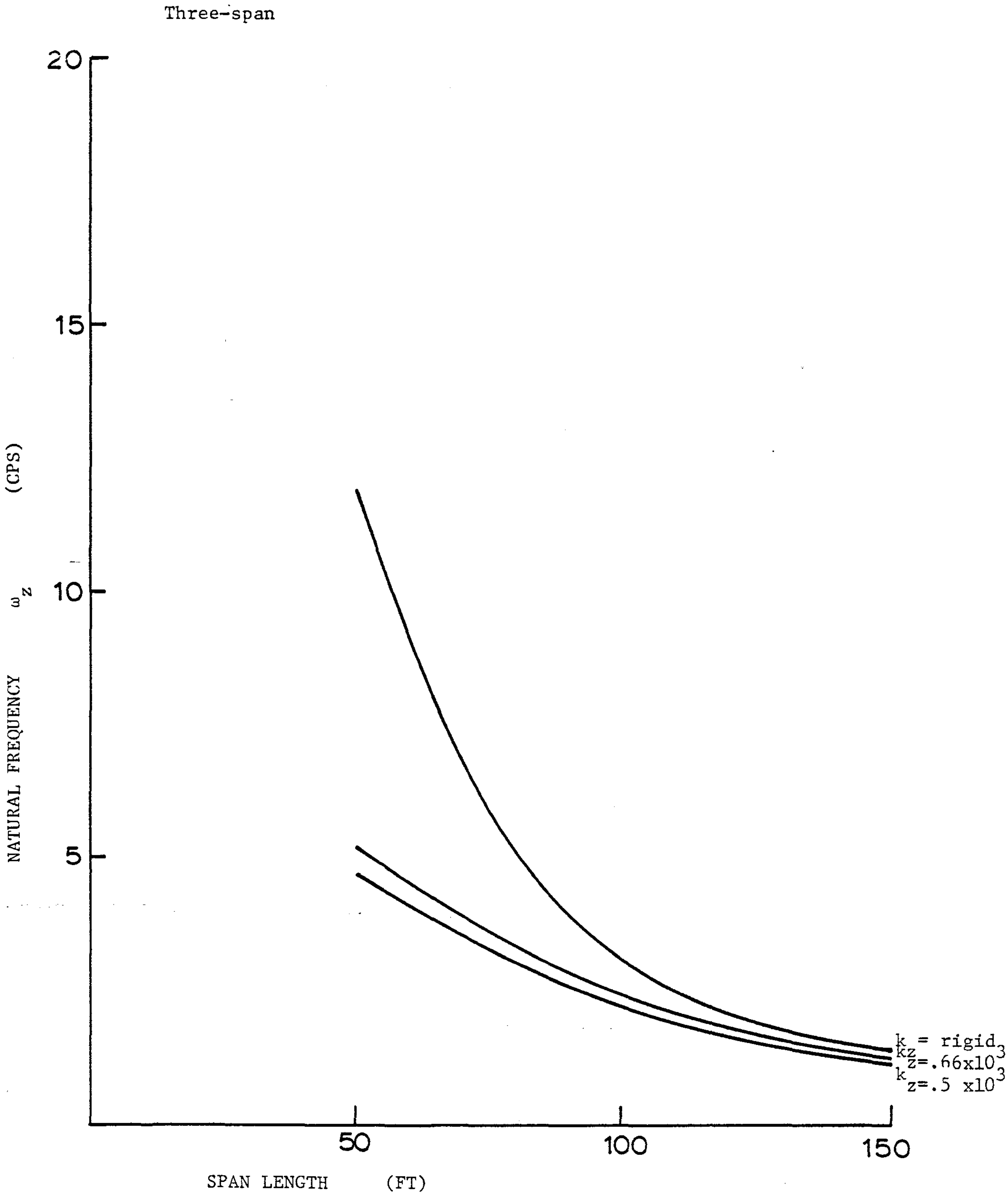

Three-span
20
15
10
5
NATURAL FREQUENCY ω z (CPS)
k = rigid
kz=.66x10^3
kz=.5 x10^3
50
100
150
SPAN LENGTH (FT)

FIGURE 39

Four-span

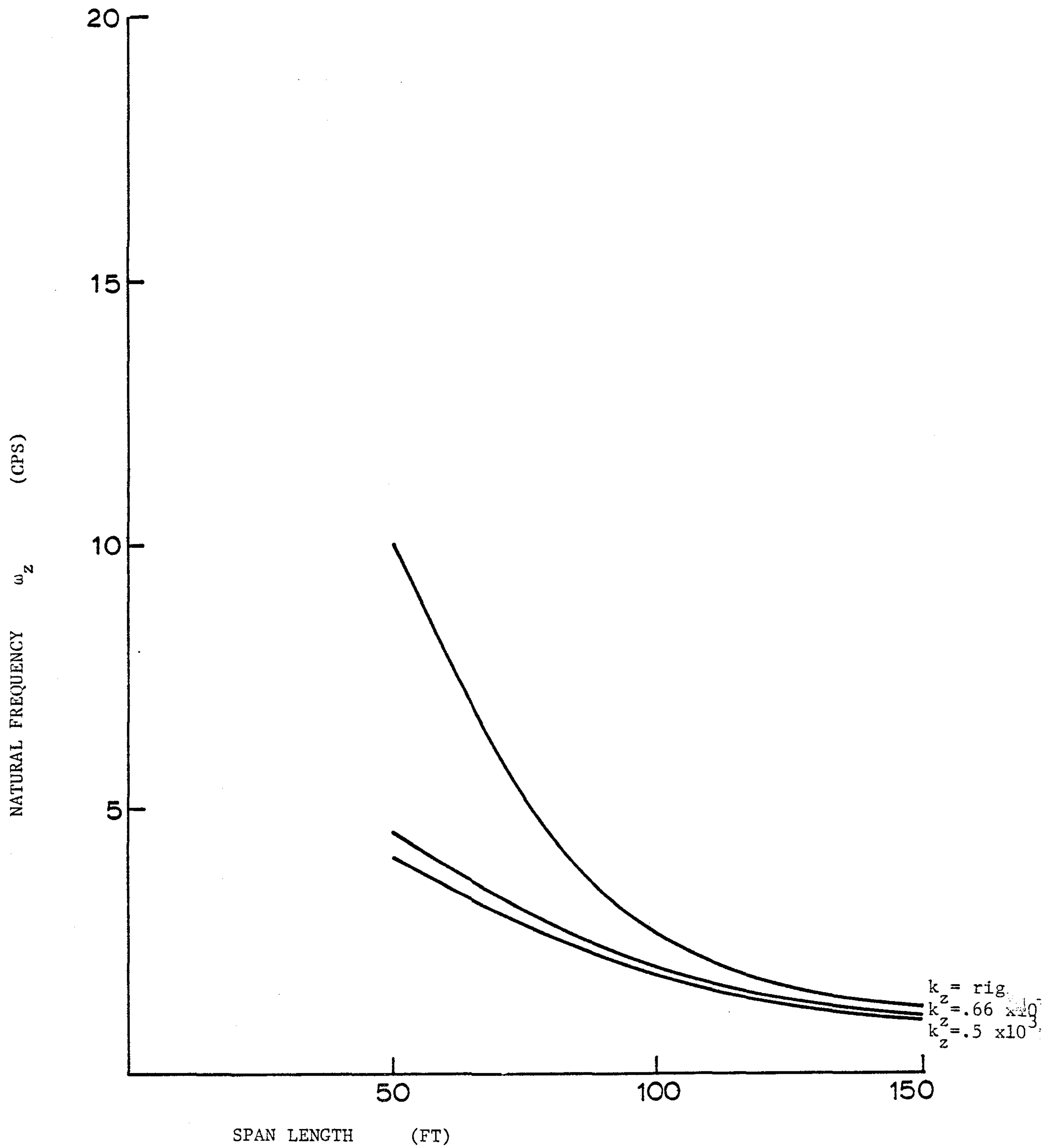


FIGURE 40

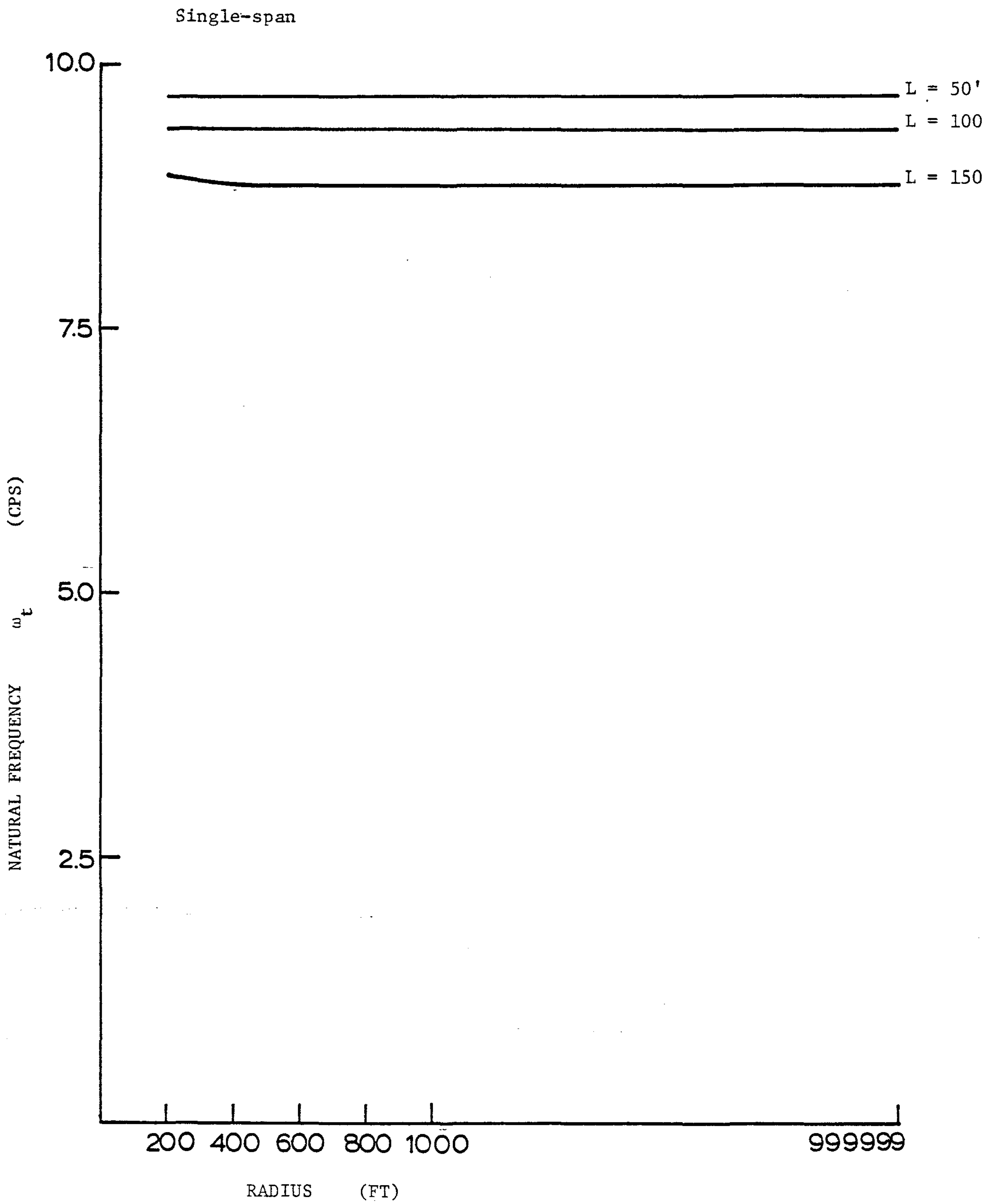

Single-span
10.0
7.5
5.0
2.5
NATURAL FREQUENCY ω_t (CPS)
L = 50'
L = 100'
L = 150'
200 400 600 800 1000
999999
RADIUS (FT)

FIGURE 41

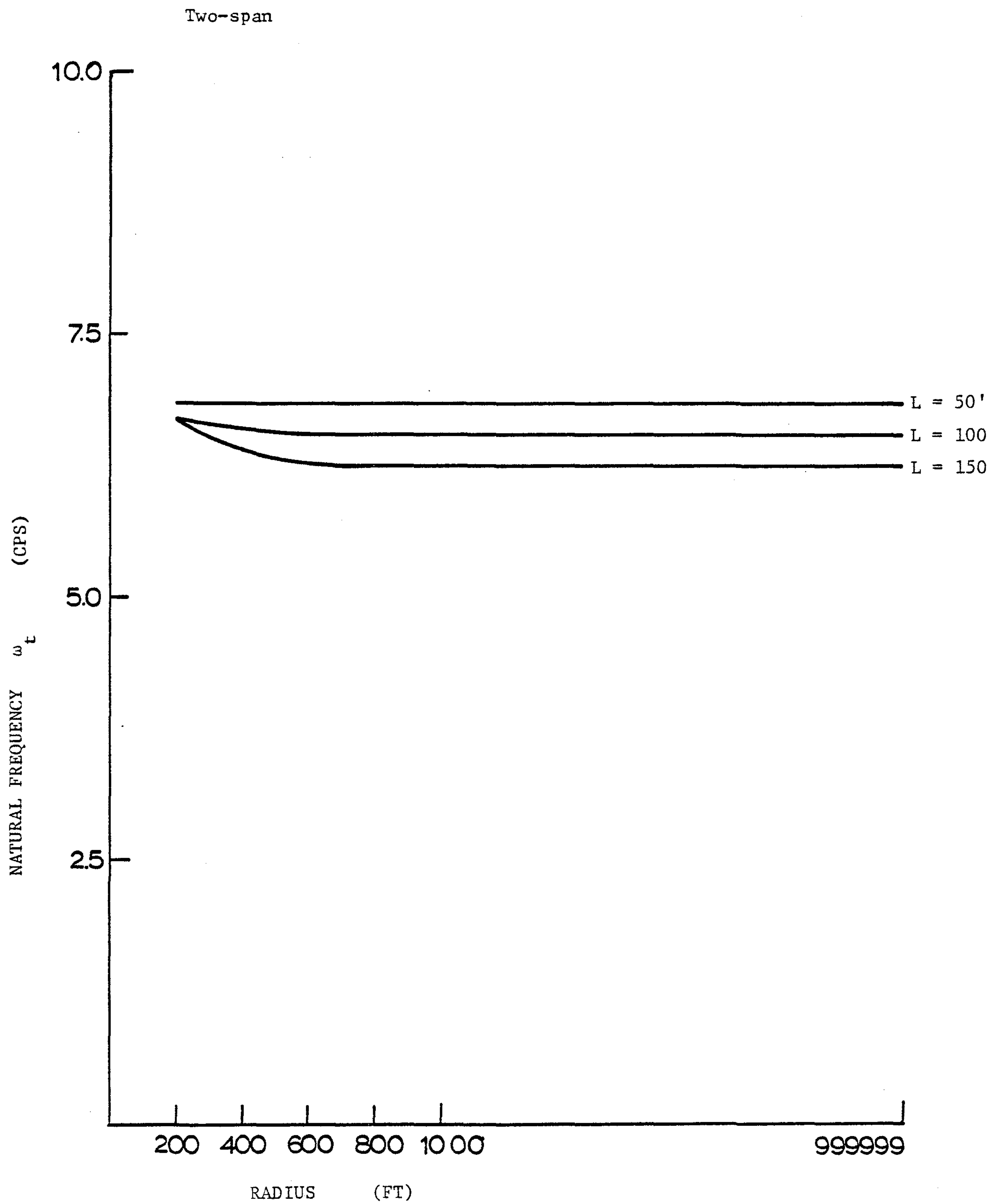

Two-span
10.0
7.5
5.0
2.5
NATURAL FREQUENCY ω_t (CPS)
L = 50'
L = 100
L = 150
200
400
600
800
1000
999999
RADIUS (FT)

FIGURE 42

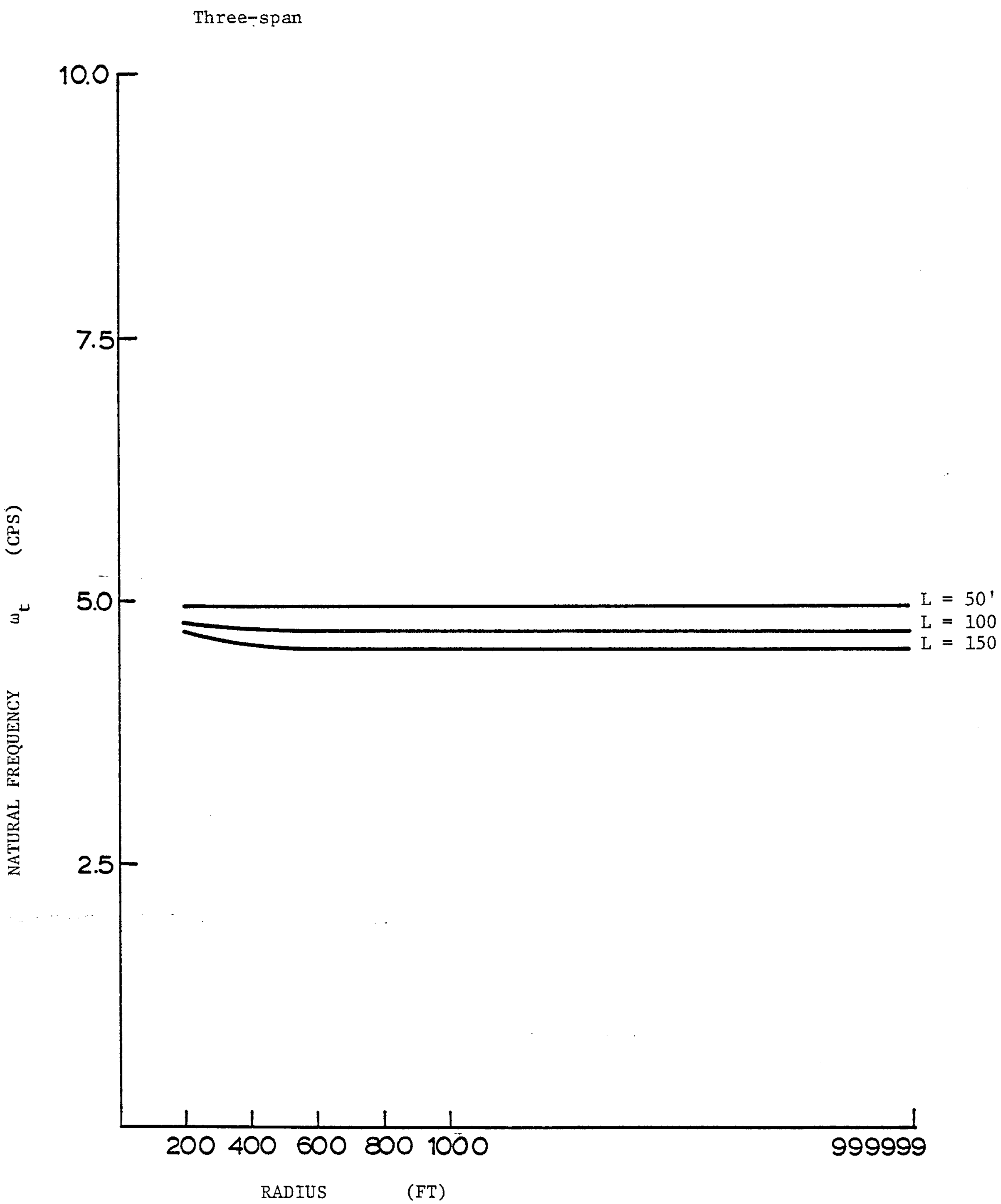

Three-span
10.0
7.5
5.0
2.5
NATURAL FREQUENCY ω_t (CPS)
L = 50'
L = 100'
L = 150'
200 400 600 800 1000
999999
RADIUS (FT)

FIGURE 43

Four-span

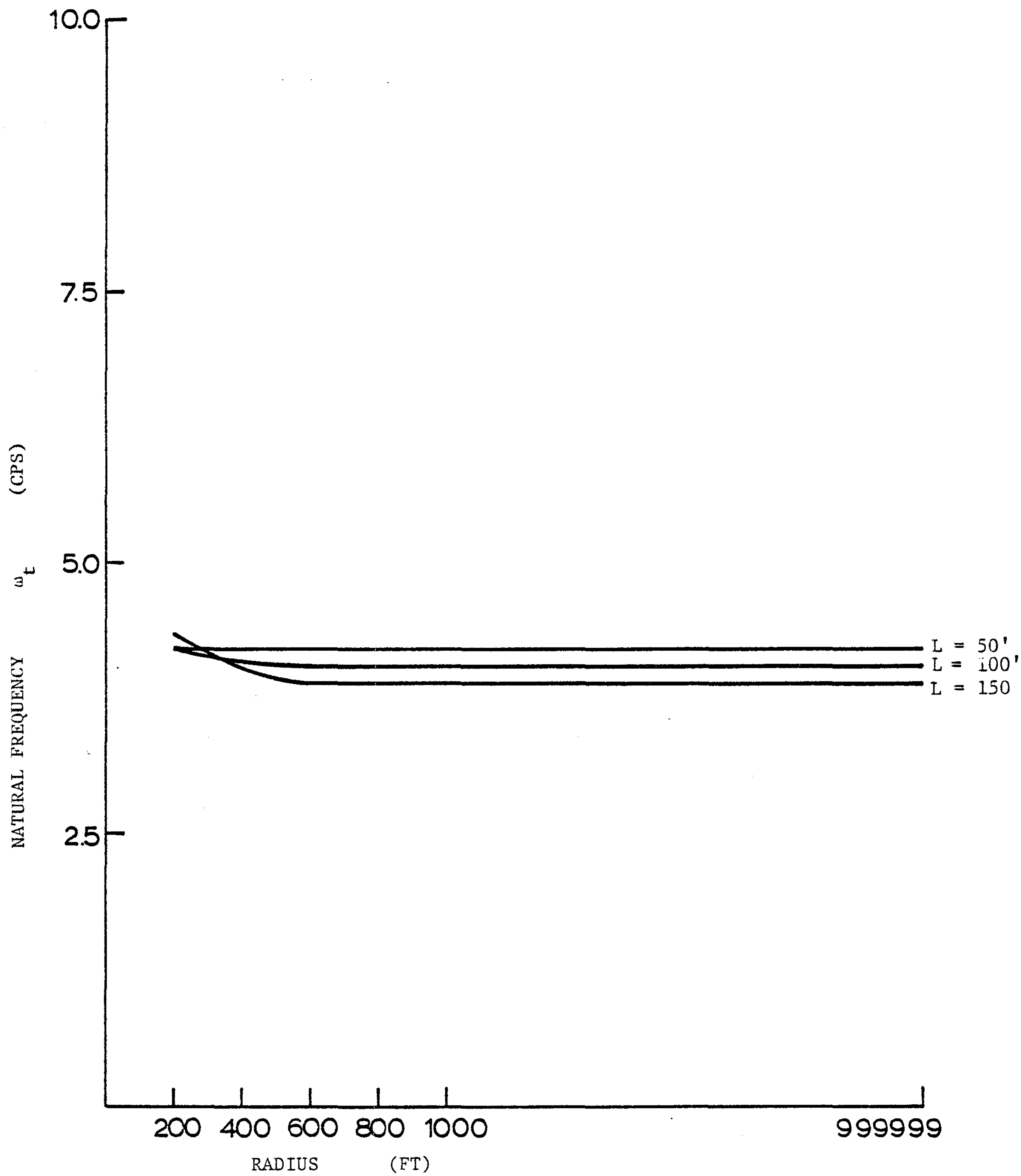
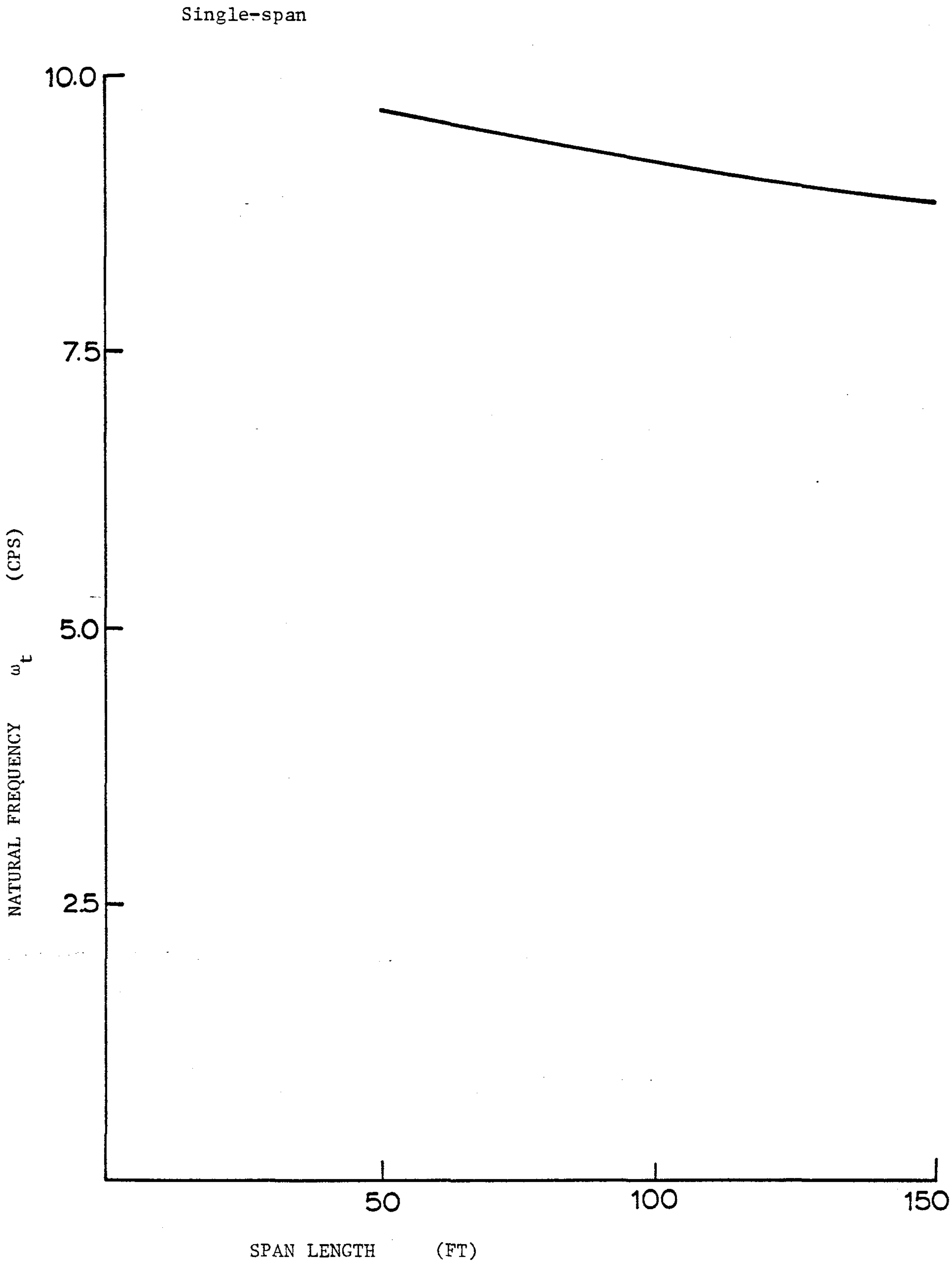


FIGURE 44



Single-span
10.0
7.5
5.0
2.5
NATURAL FREQUENCY ω_t (CPS)
50
100
150
SPAN LENGTH (FT)

FIGURE 45

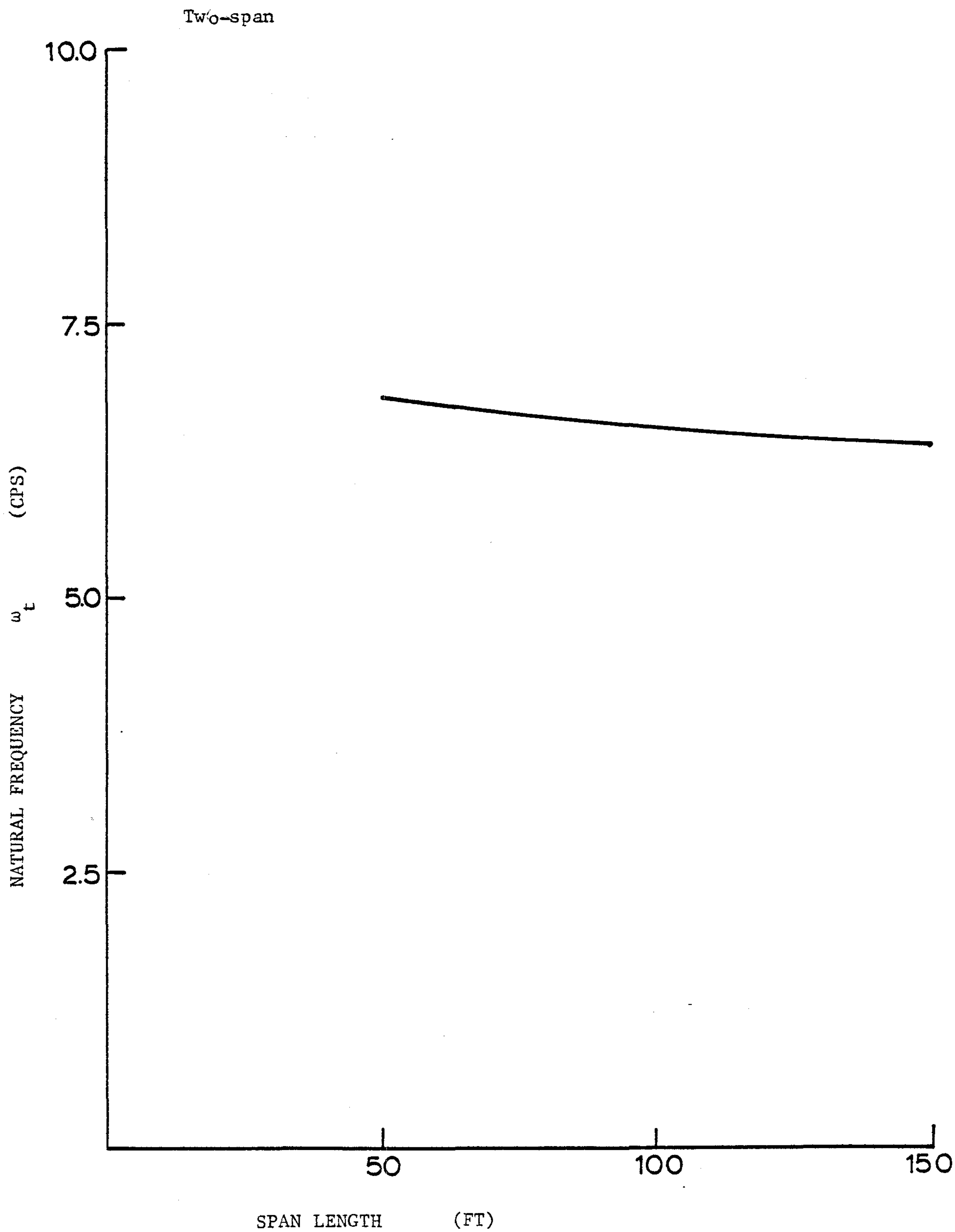

Two-span
10.0
7.5
5.0
2.5
NATURAL FREQUENCY ω_t (CPS)
50
100
150
SPAN LENGTH (FT)

FIGURE 46

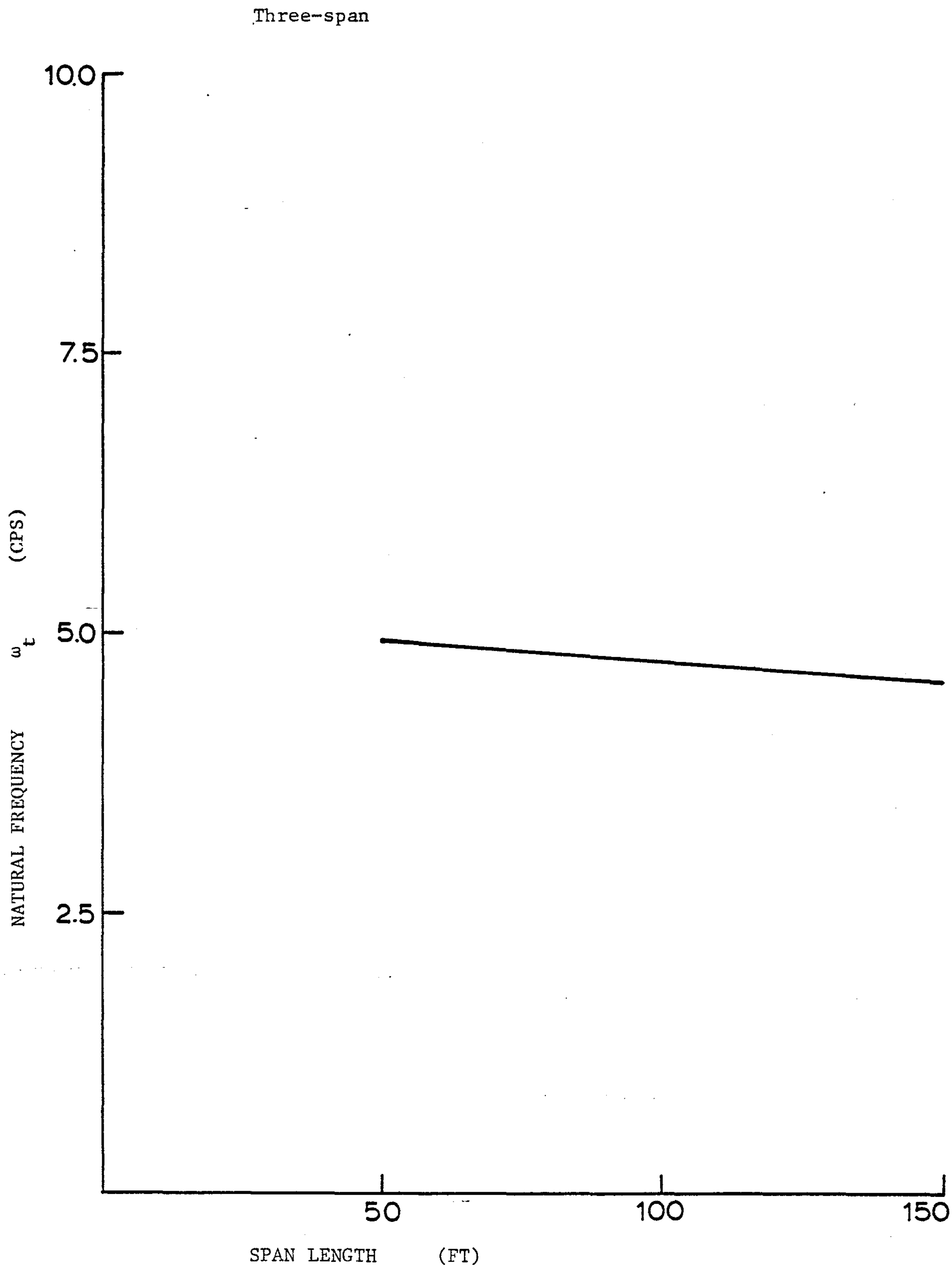

Three-span
10.0
7.5
5.0
2.5
NATURAL FREQUENCY ω_t (CPS)
50
100
150
SPAN LENGTH (FT)

FIGURE 47

Four-span

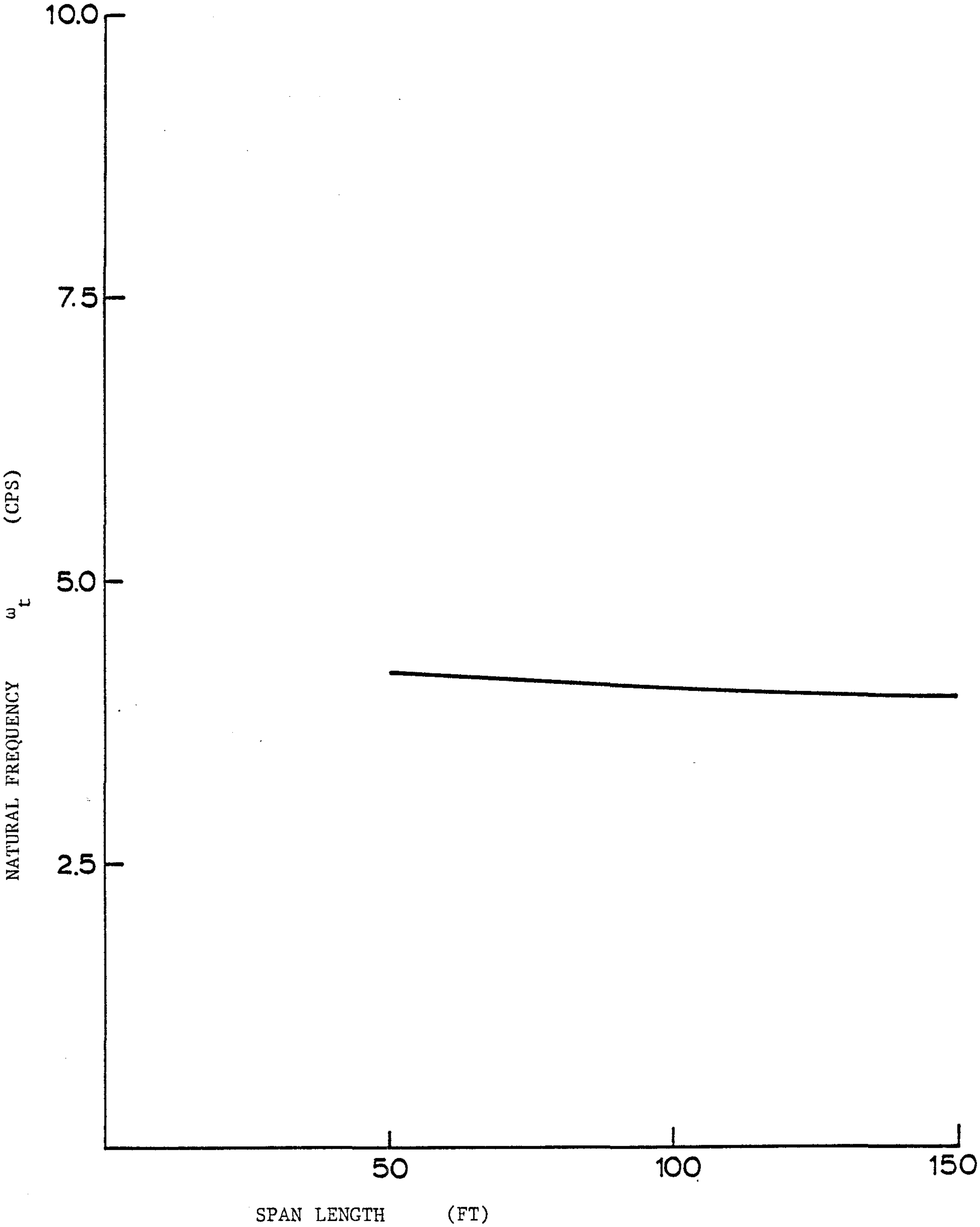


FIGURE 48

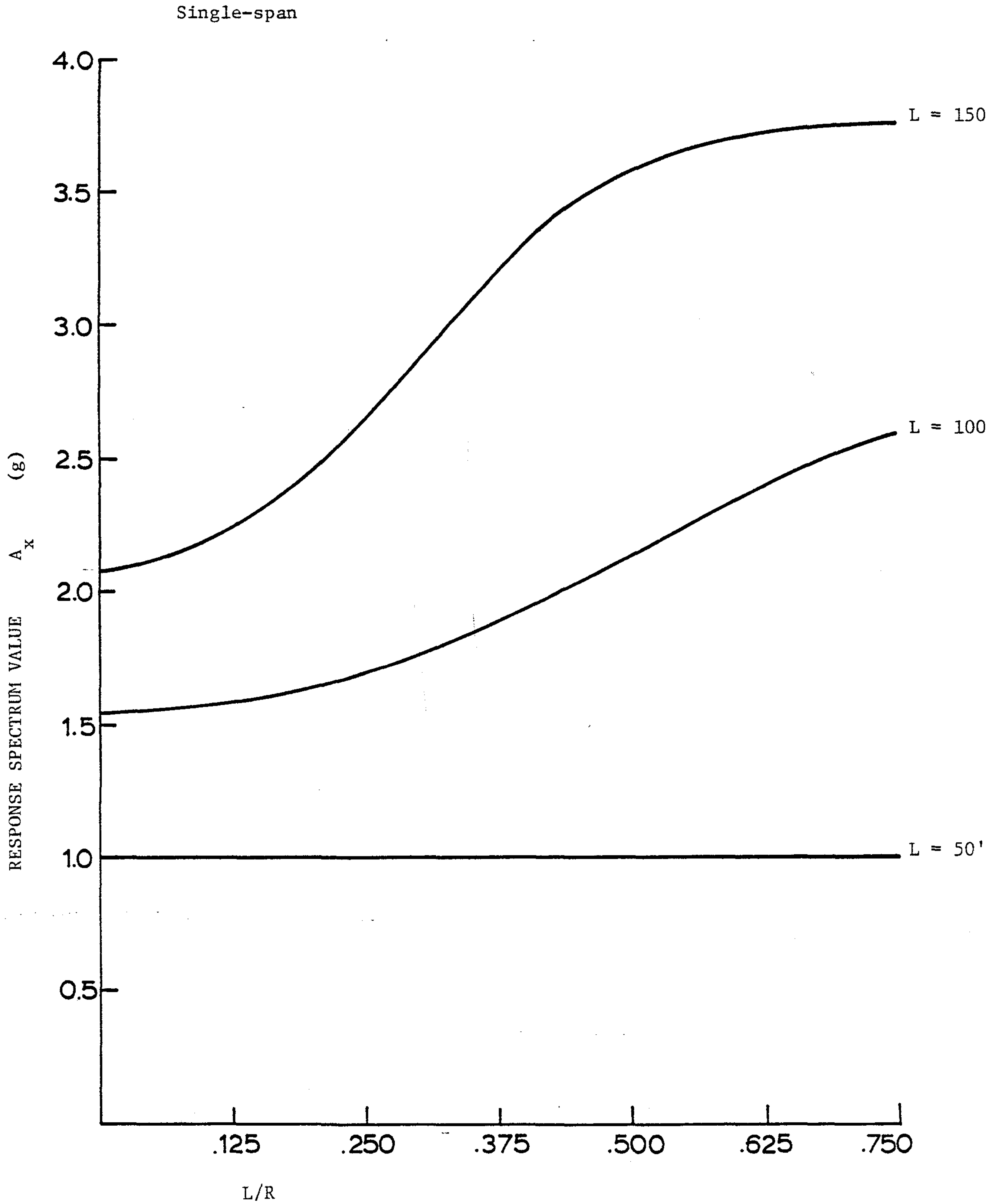
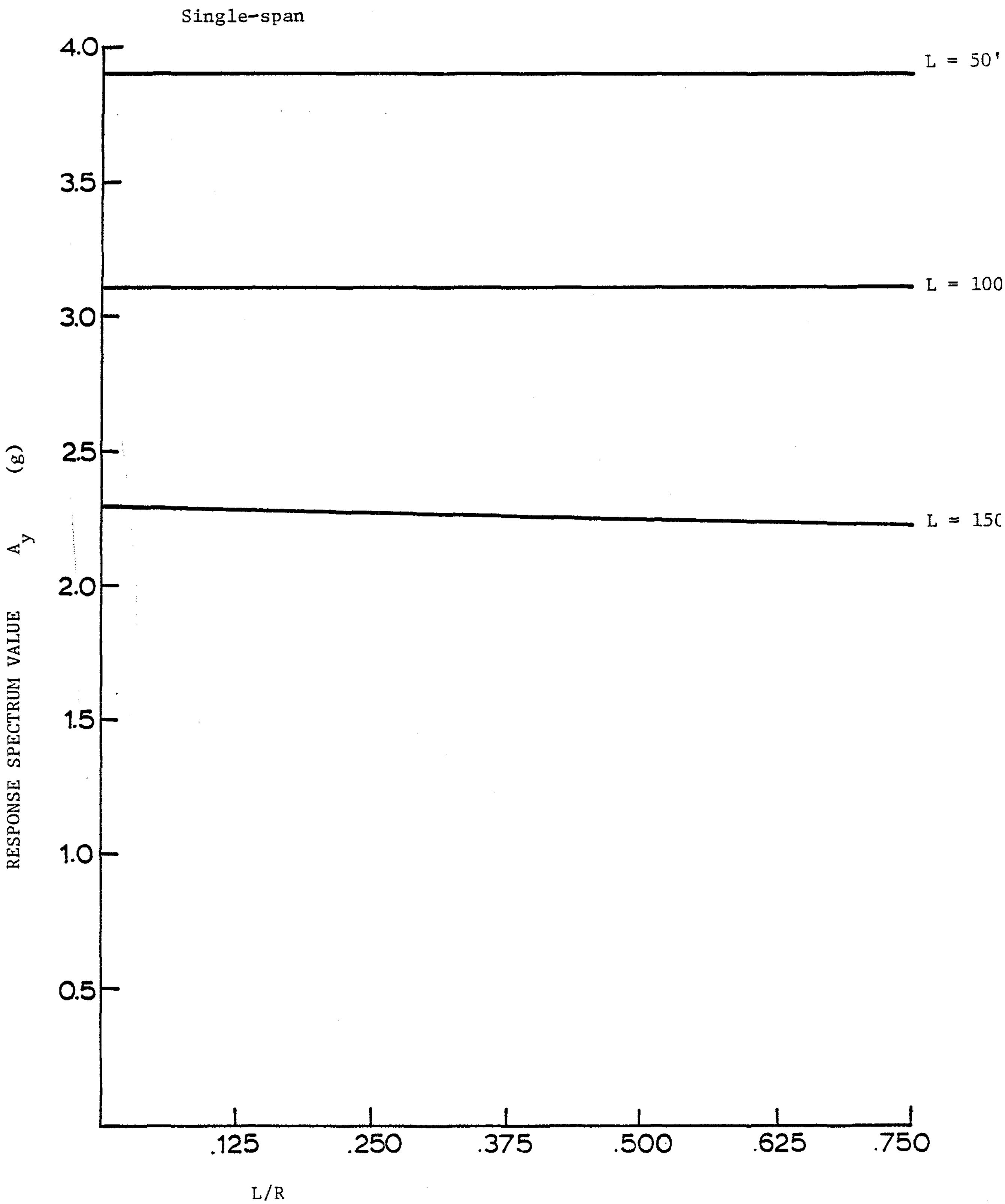
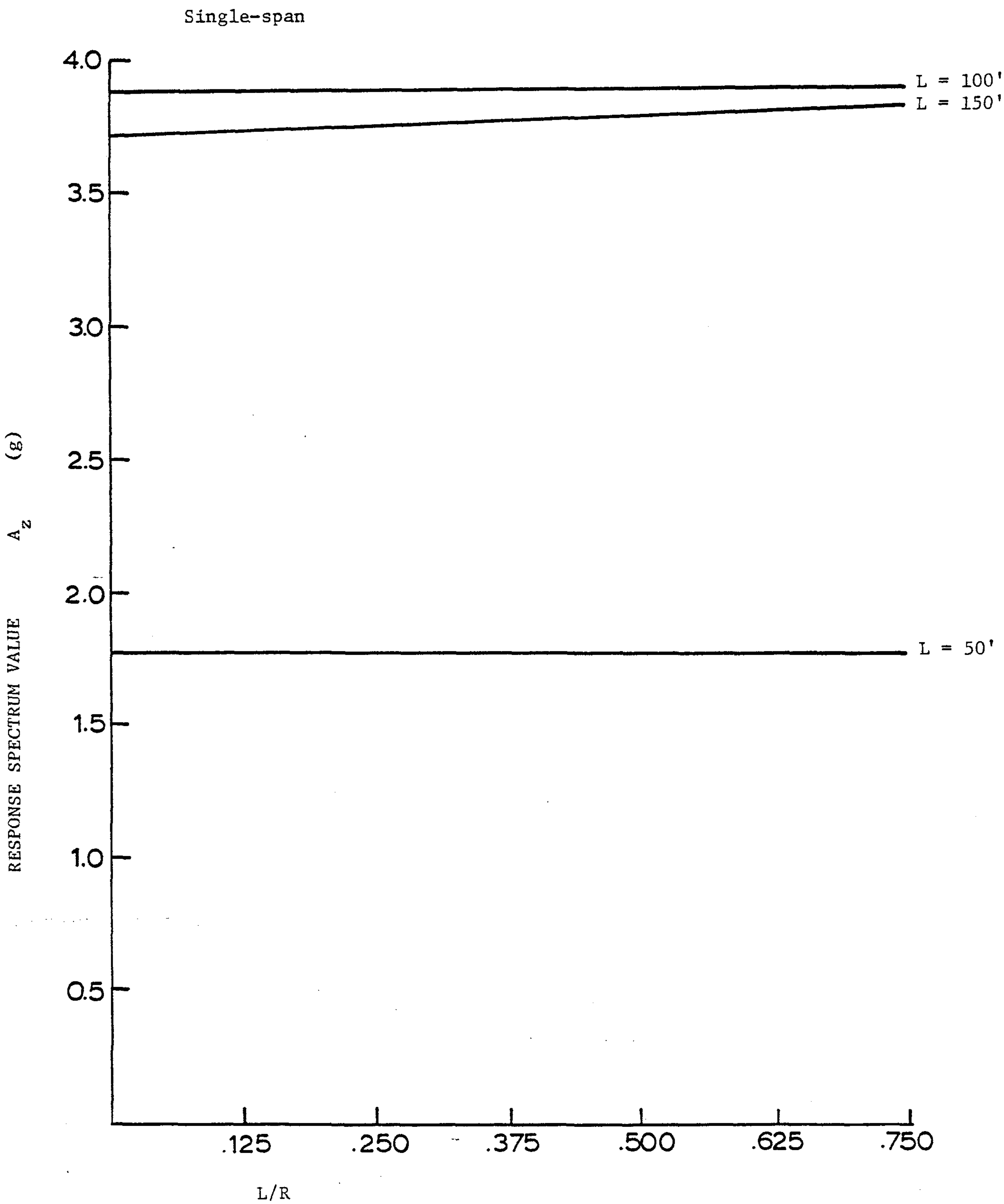

Single-span
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
RESPONSE SPECTRUM VALUE A_x (g)
L = 150'
L = 100'
L = 50'
.125
.250
.375
.500
.625
.750
L/R

FIGURE 49



Single-span
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
RESPONSE SPECTRUM VALUE A_y (g)
L = 50'
L = 100
L = 15(
.125
.250
.375
.500
.625
.750
L/R

FIGURE 50



Single-span
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
L = 100'
L = 150'
L = 50'
RESPONSE SPECTRUM VALUE A_z (g)
.125
.250
.375
.500
.625
.750
L/R

FIGURE 51

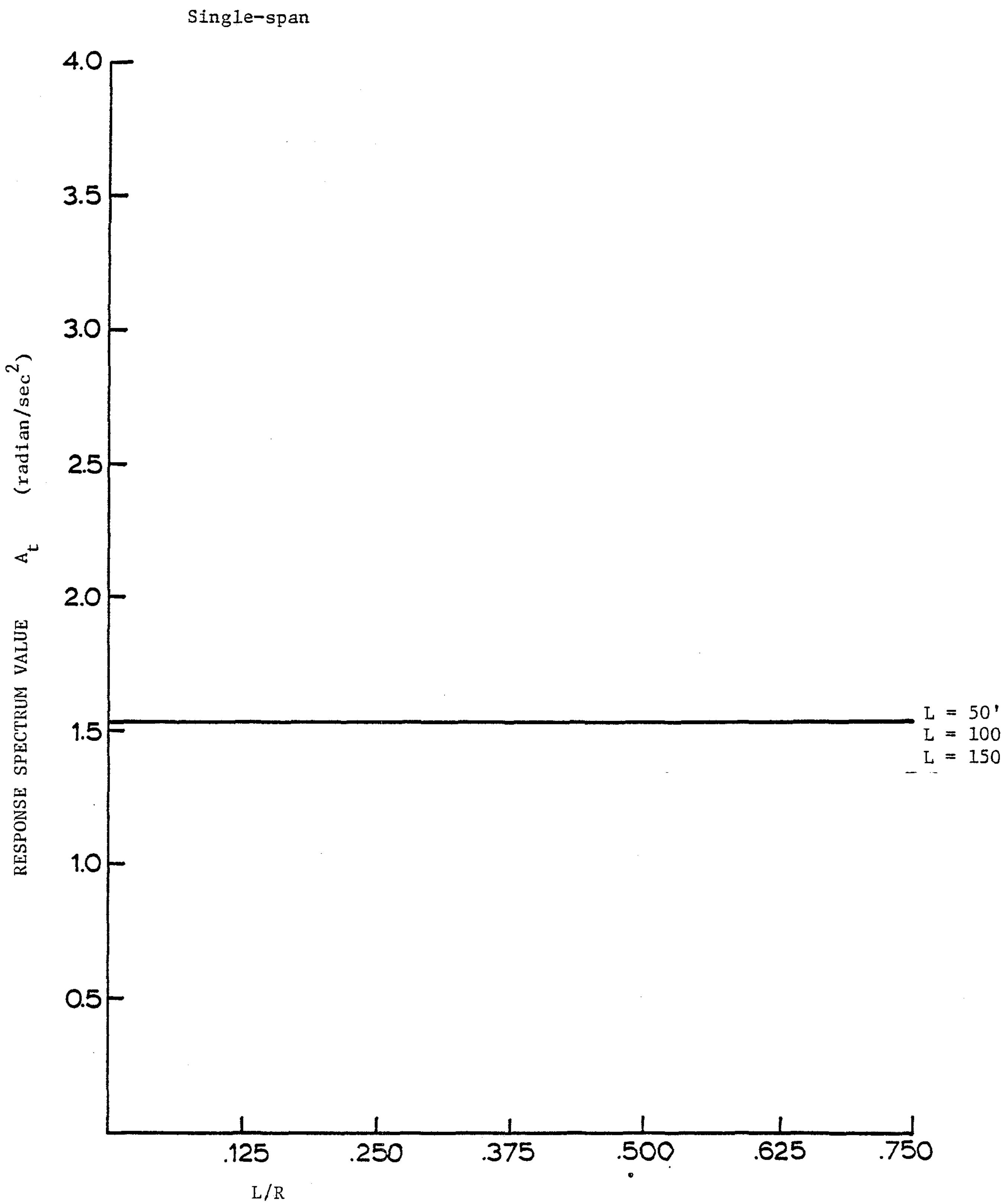

Single-span
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
RESPONSE SPECTRUM VALUE A_t (radian/sec^2)
L = 50'
L = 100
L = 150
.125
.250
.375
.500
.625
.750
L/R

FIGURE 52

$L = 50'$ $K_x = 0$ $K_z = \text{rigid}$

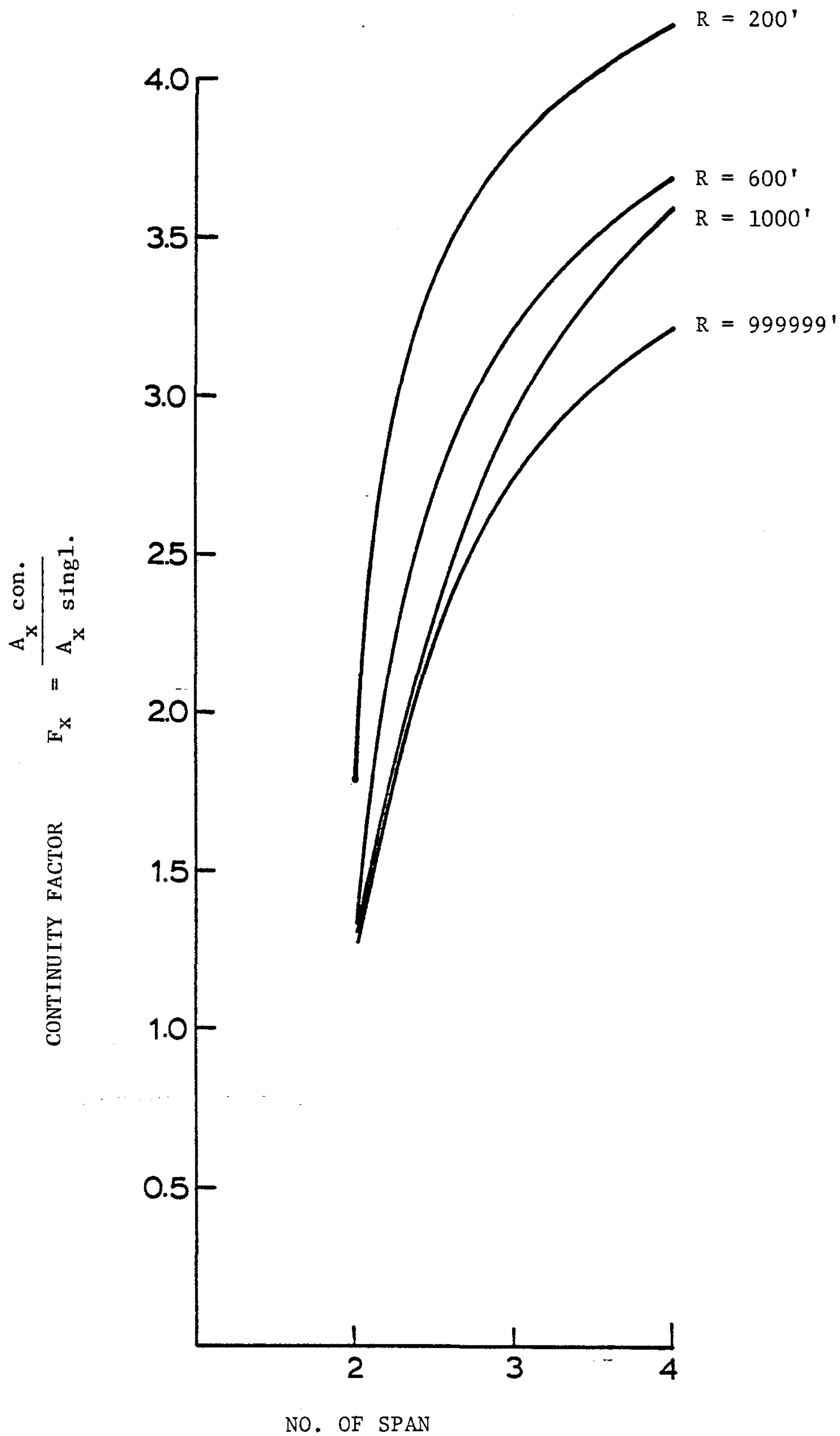


FIGURE 53

$L = 50'$ $K_x = 2/3 \times 10^3$ $K_z = 0.5 \times 10^3$

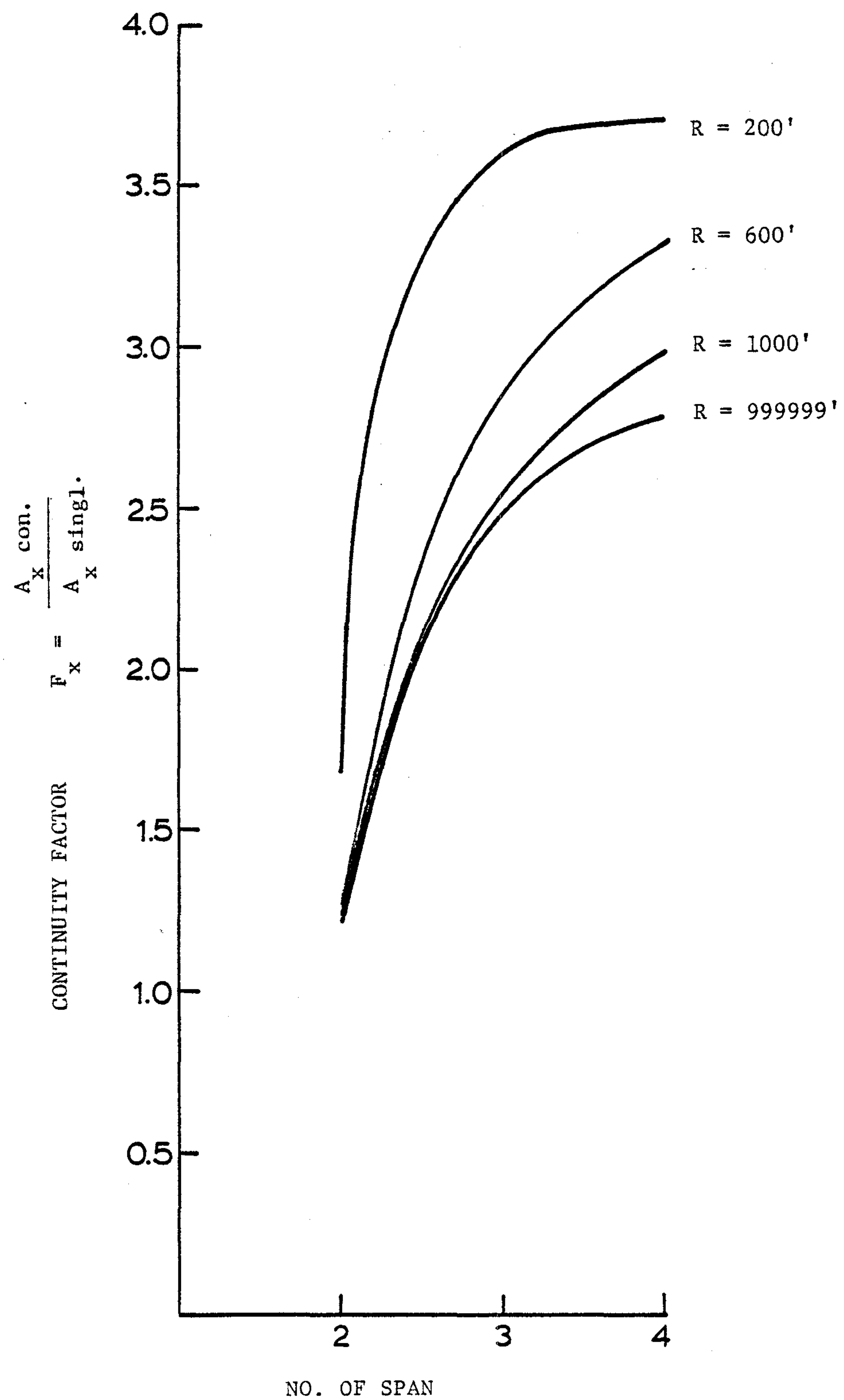


FIGURE 54

$L = 50'$ $K_x = 2 \times 10^3$ $Kz = 2/3 \times 10^3$

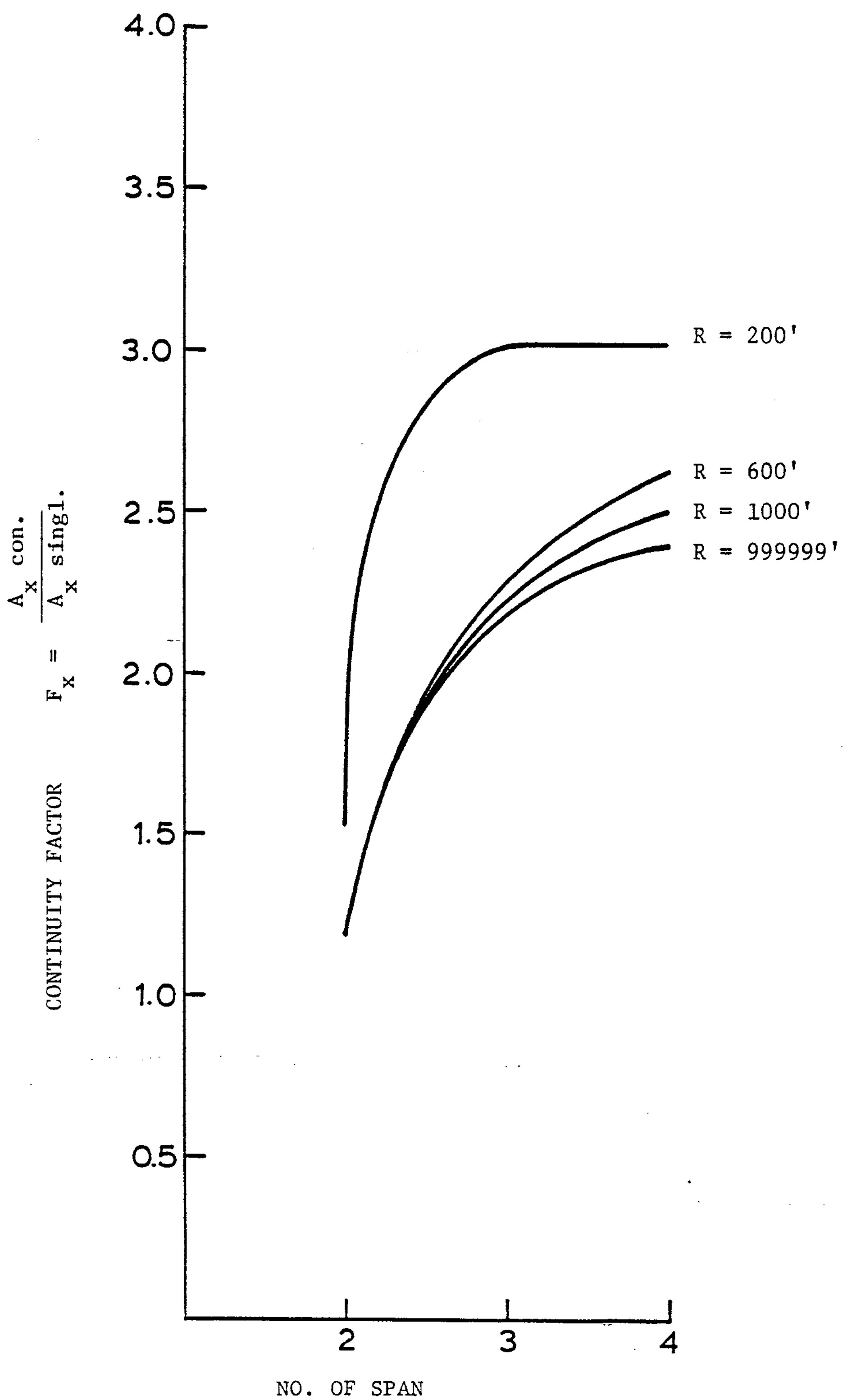


FIGURE 55

$L = 100'$ $K_x = 0$ $K_z = \text{rigid}$

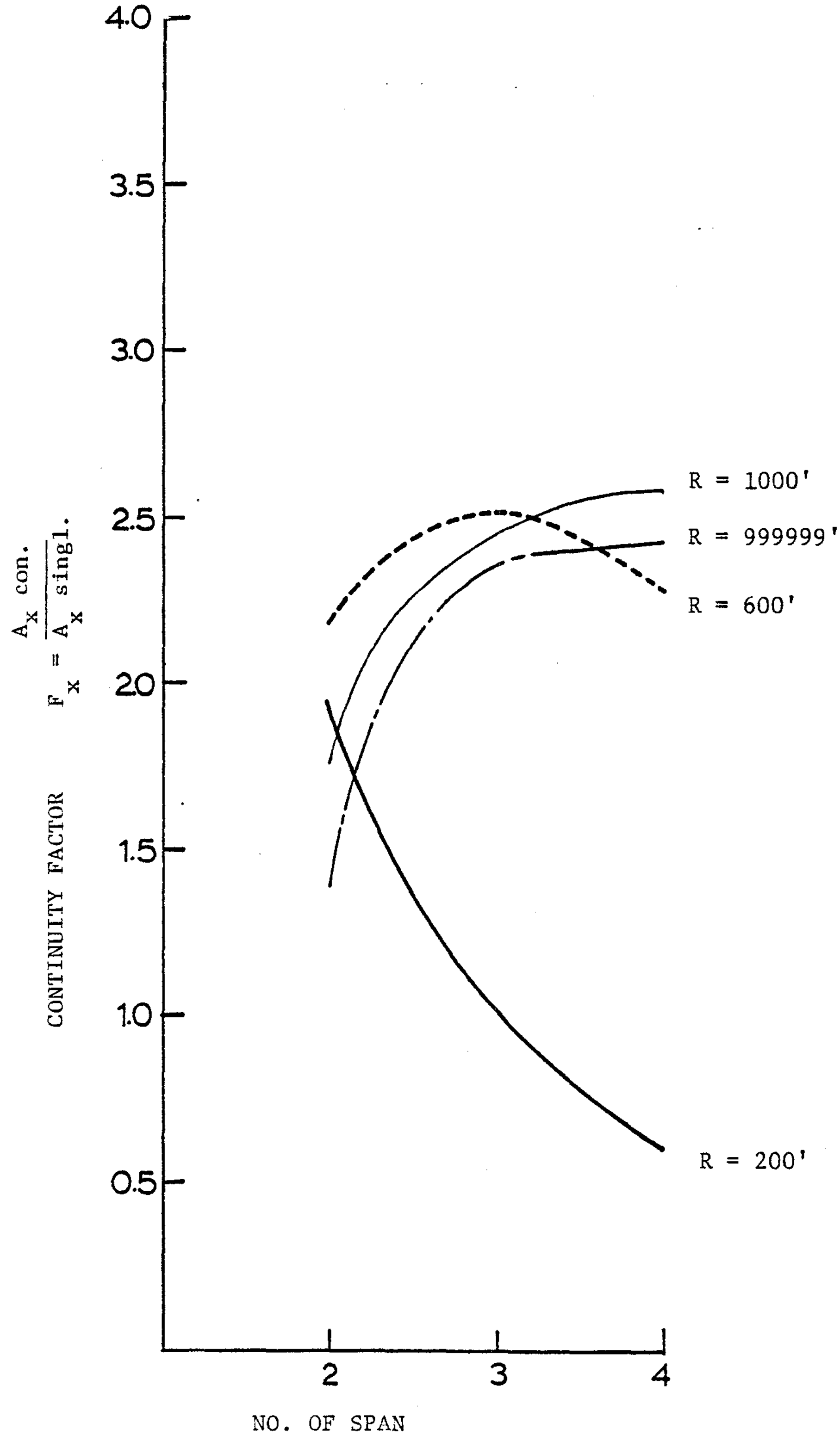


FIGURE 56

$L = 100'$ $K_x = 2/3 \times 10^3$ $K_z = 0.5 \times 10^3$

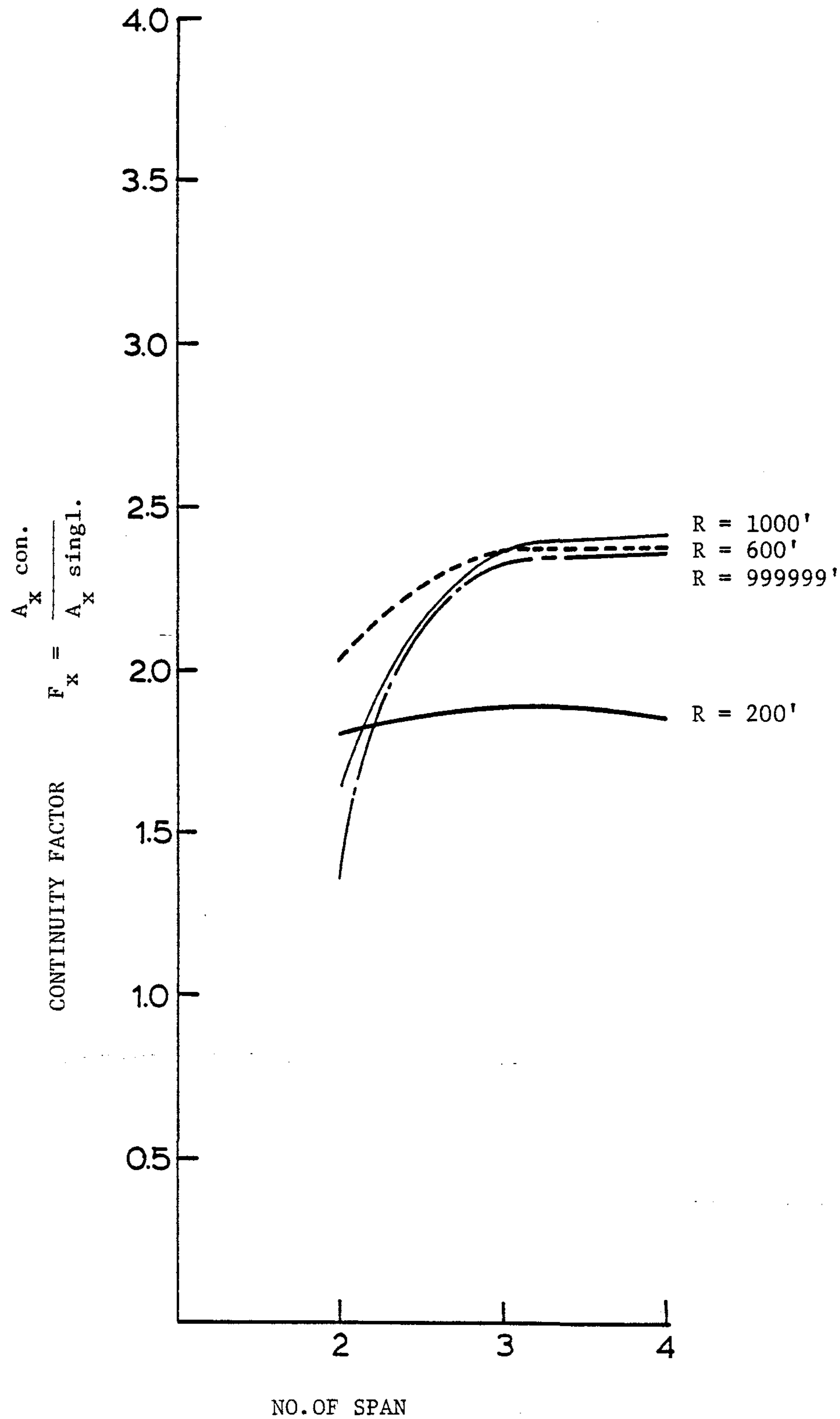


FIGURE 57

$L = 100'$ $K_x = 2 \times 10^3$ $K_z = 2/3 \times 10^3$

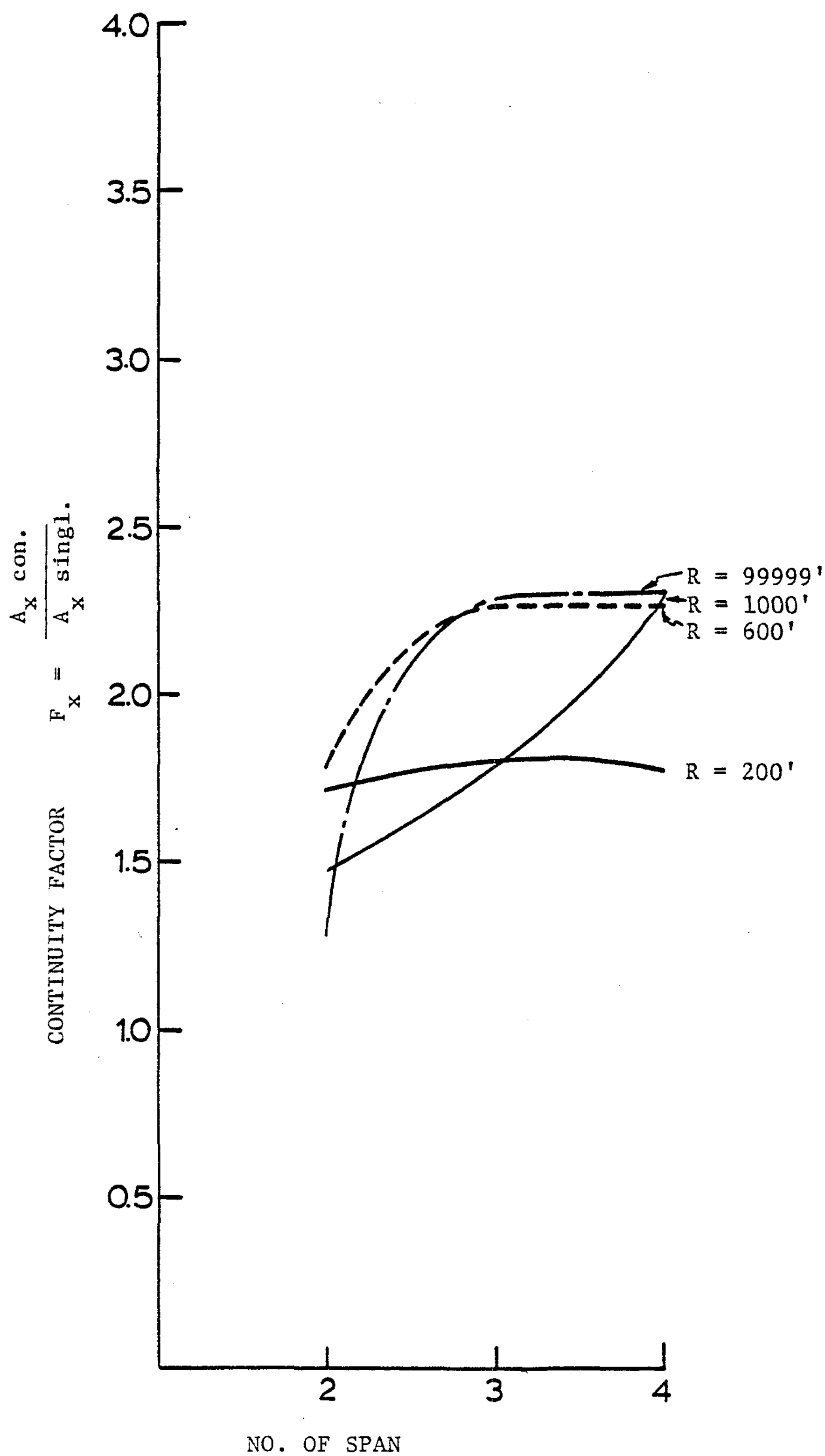


FIGURE 58

$L = 150'$ $K_x = 0$ $K_z = \text{rigid}$

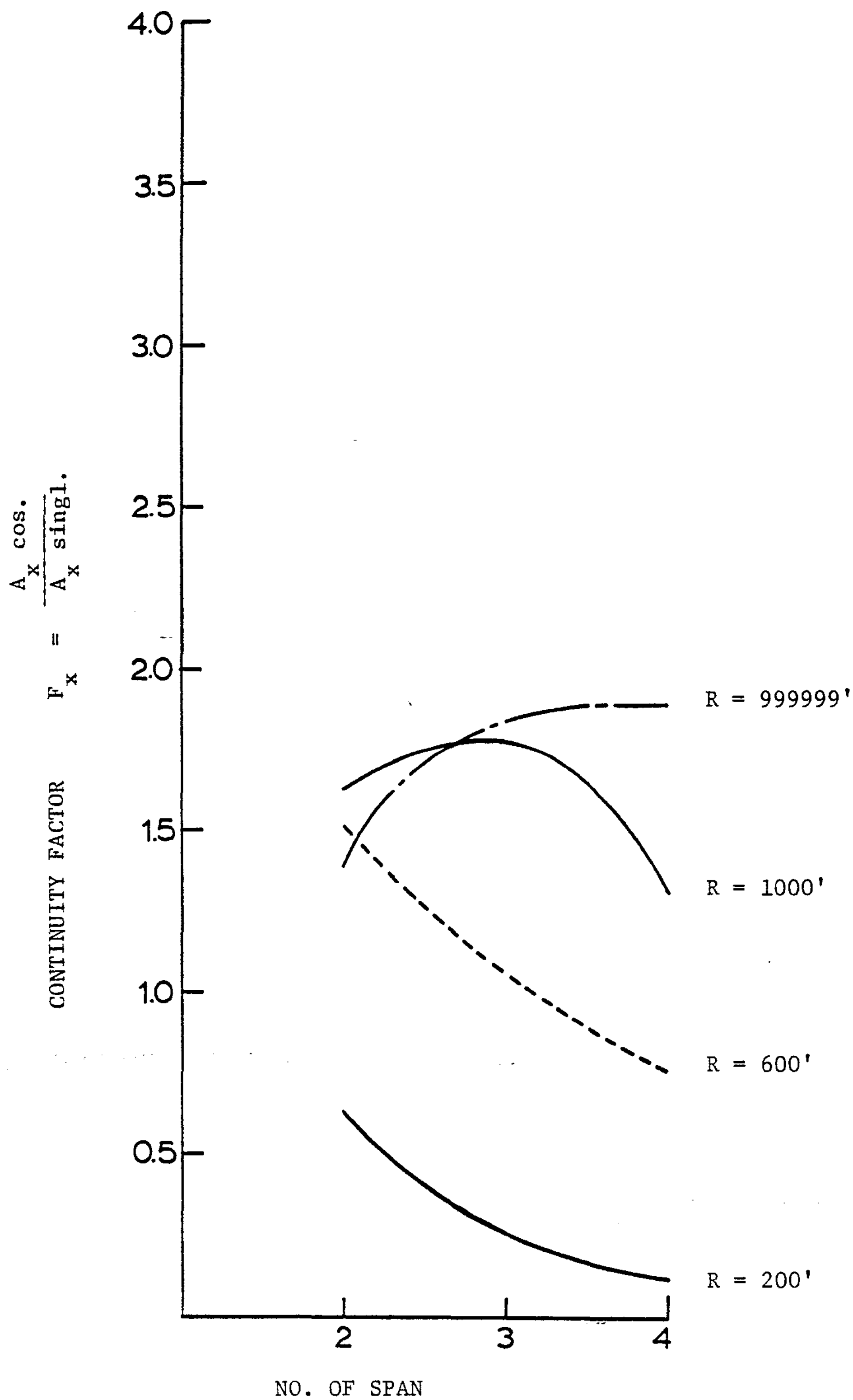


FIGURE 59

$L = 150'$ $\quad K_x = 2/3 \times 10^3$ $\quad K_z = 0.5 \times 10^3$

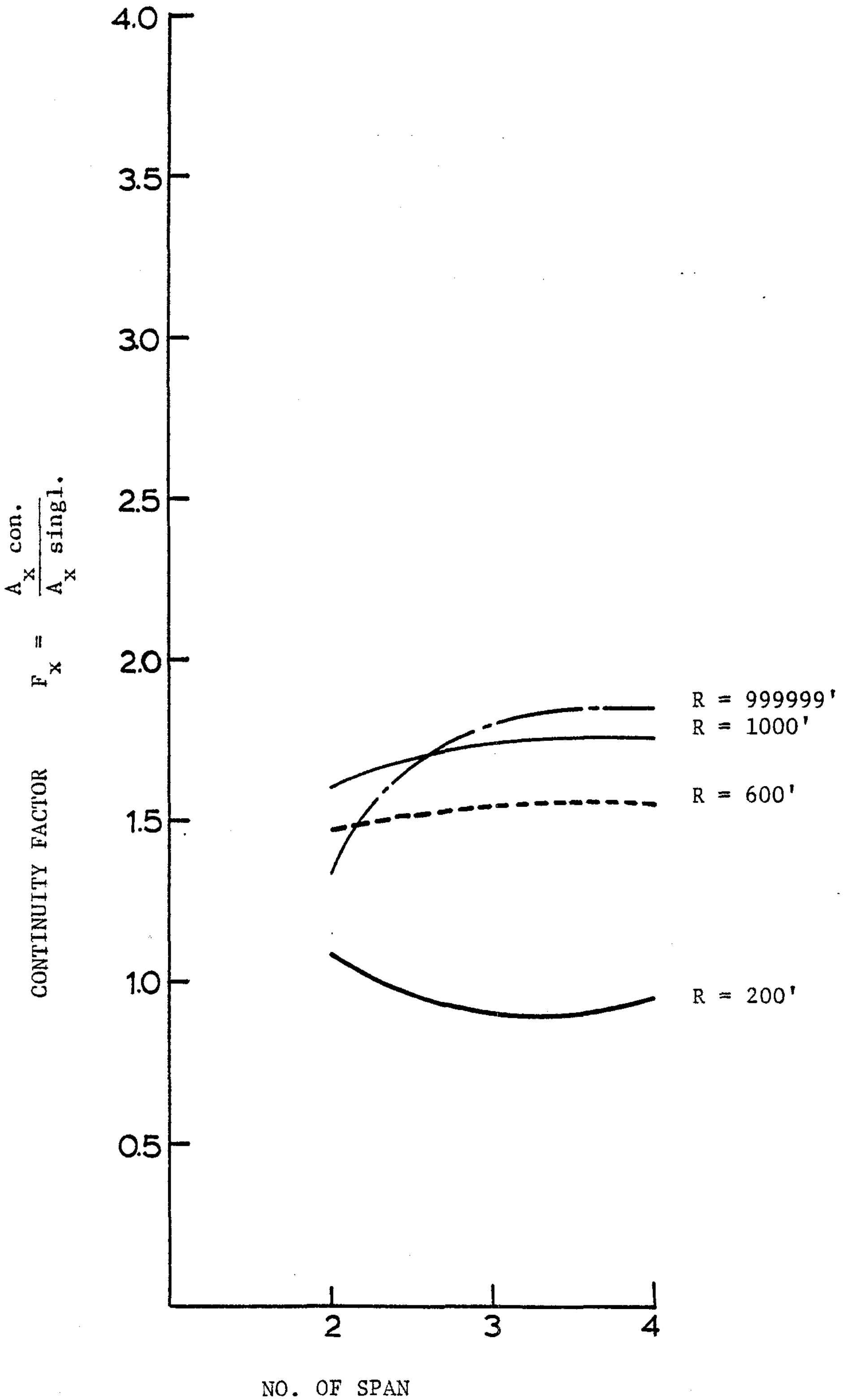


FIGURE 60

$L = 150'$ $K_x = 2 \times 10^3$ $K_z = 2/3 \times 10^3$

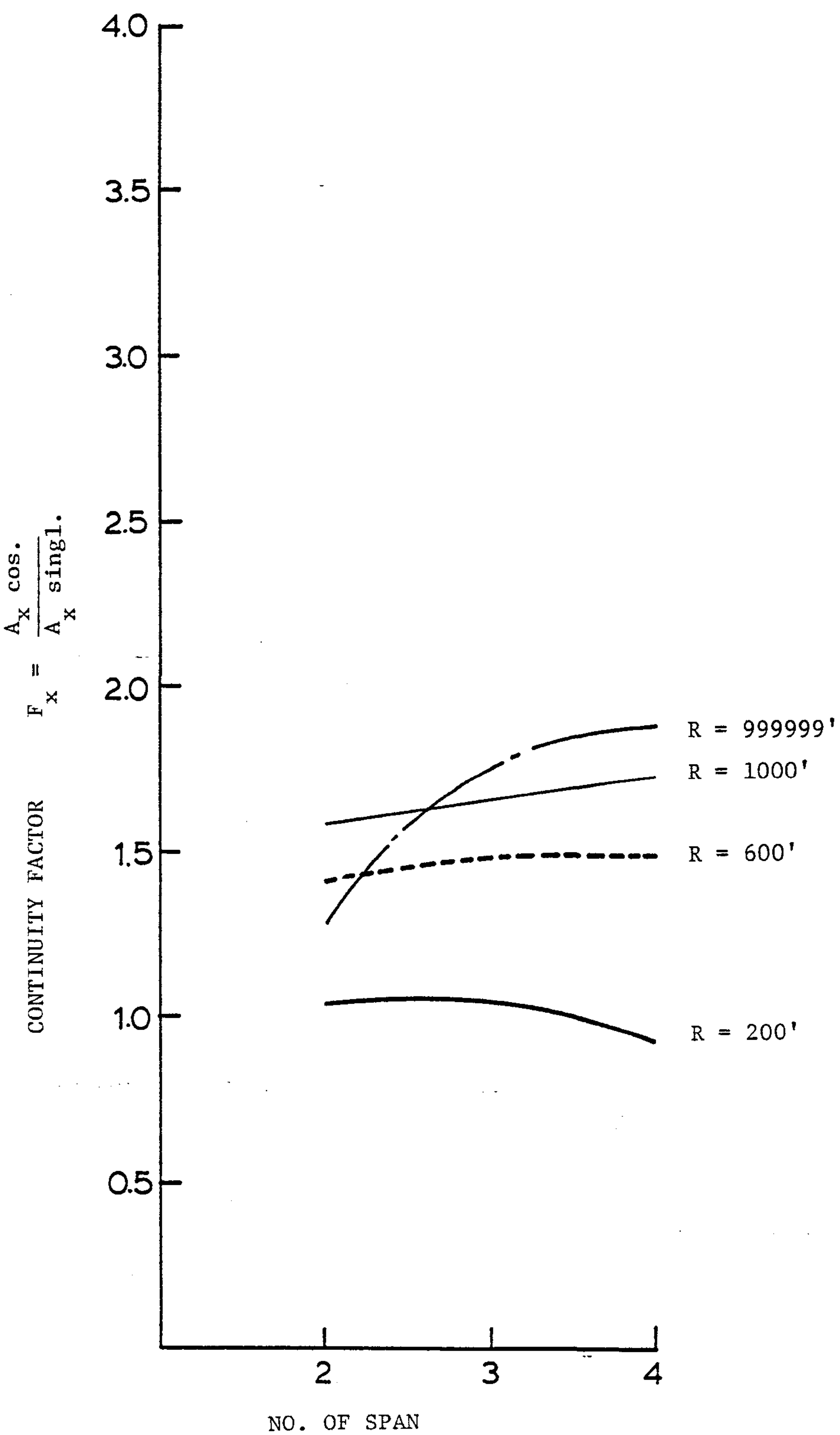


FIGURE 61

L = 50'

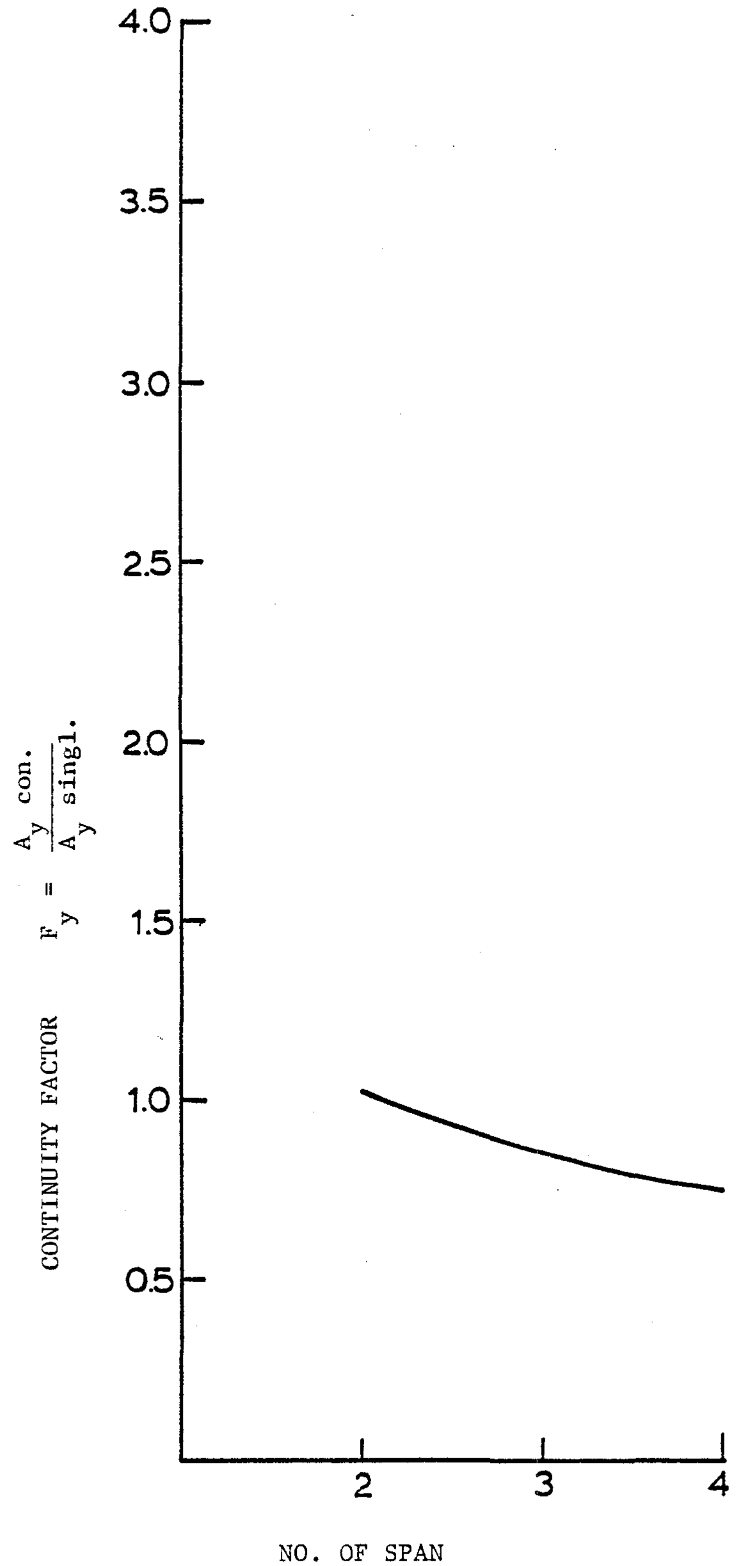


FIGURE 62

L = 100'

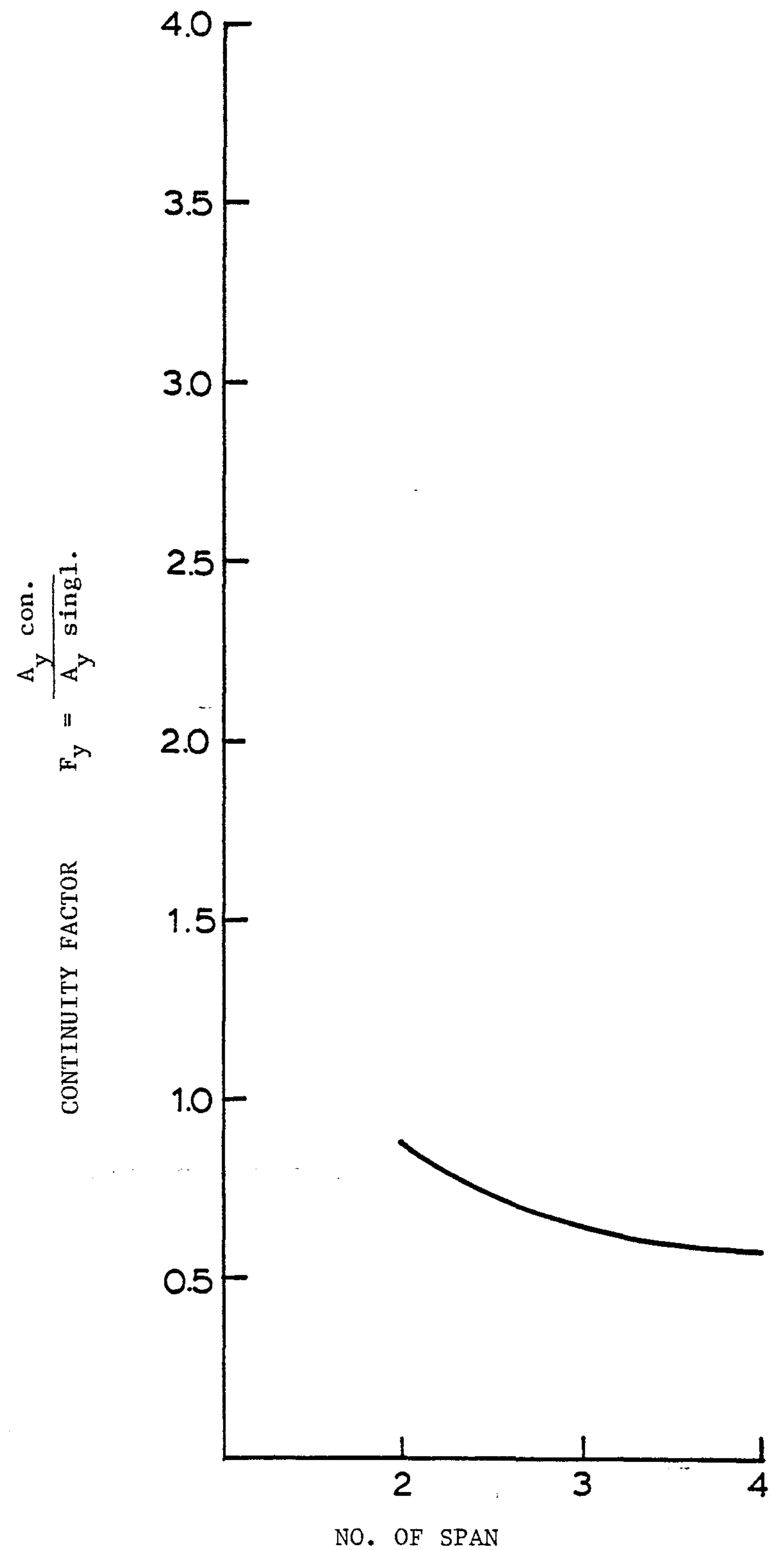


FIGURE 63

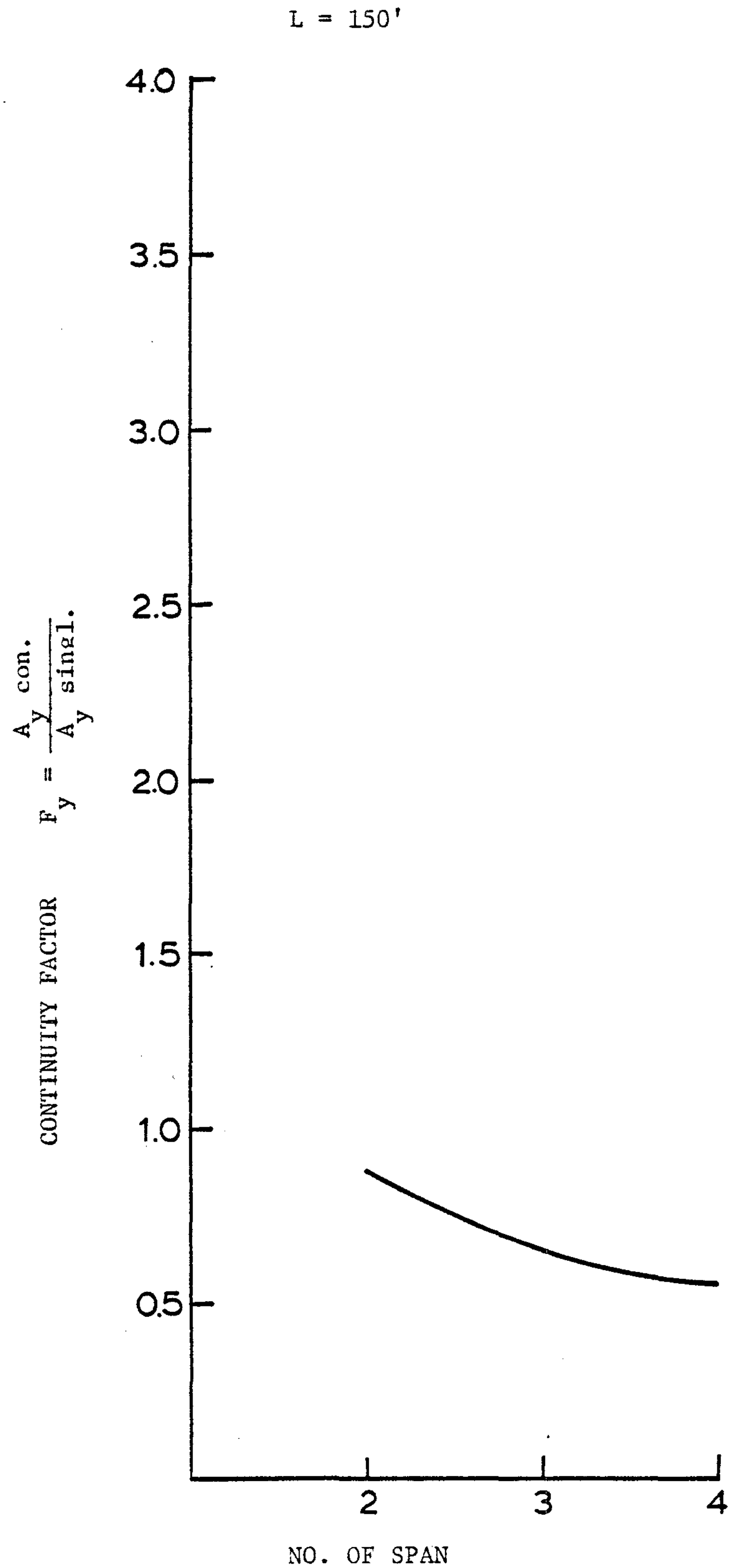
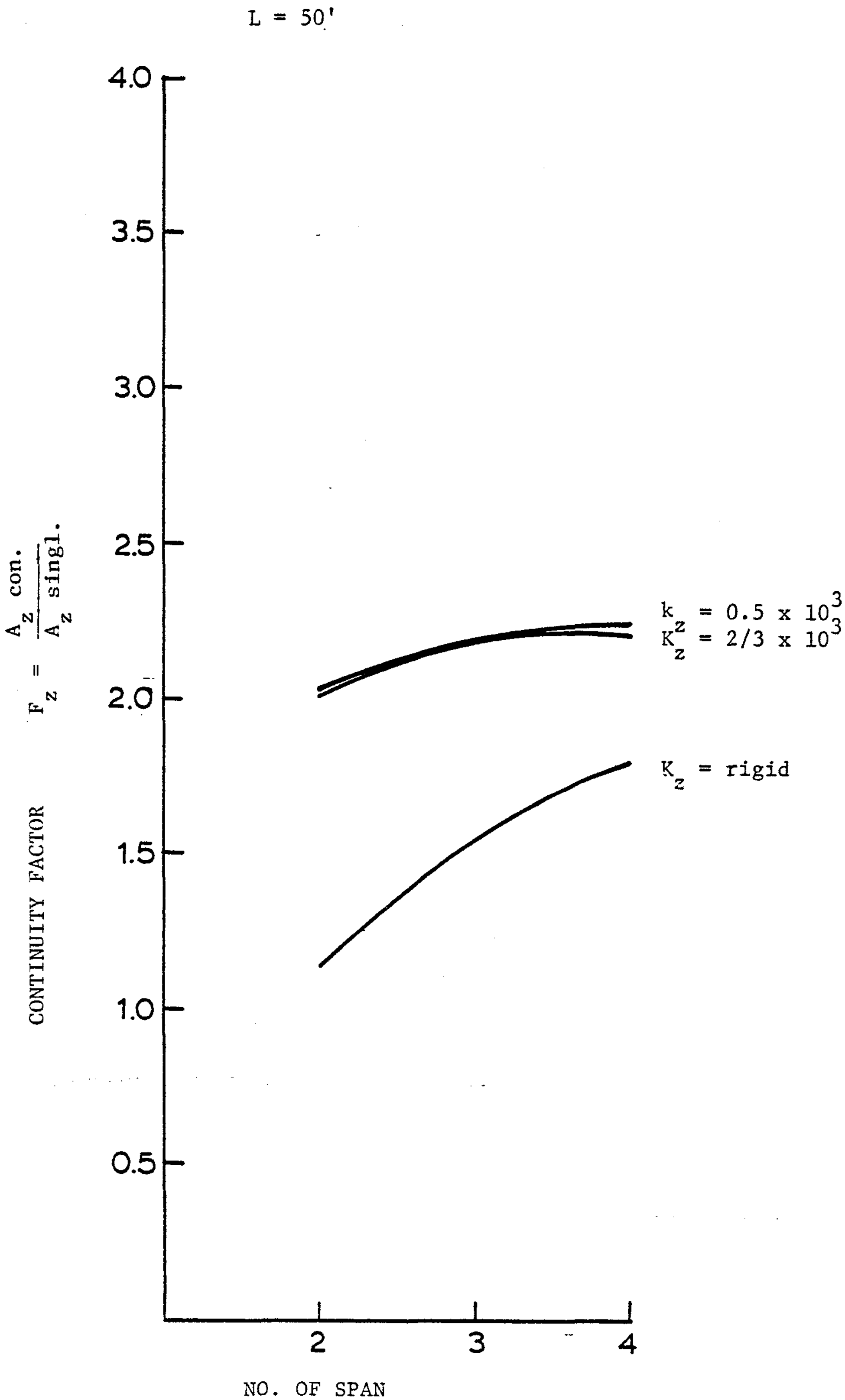
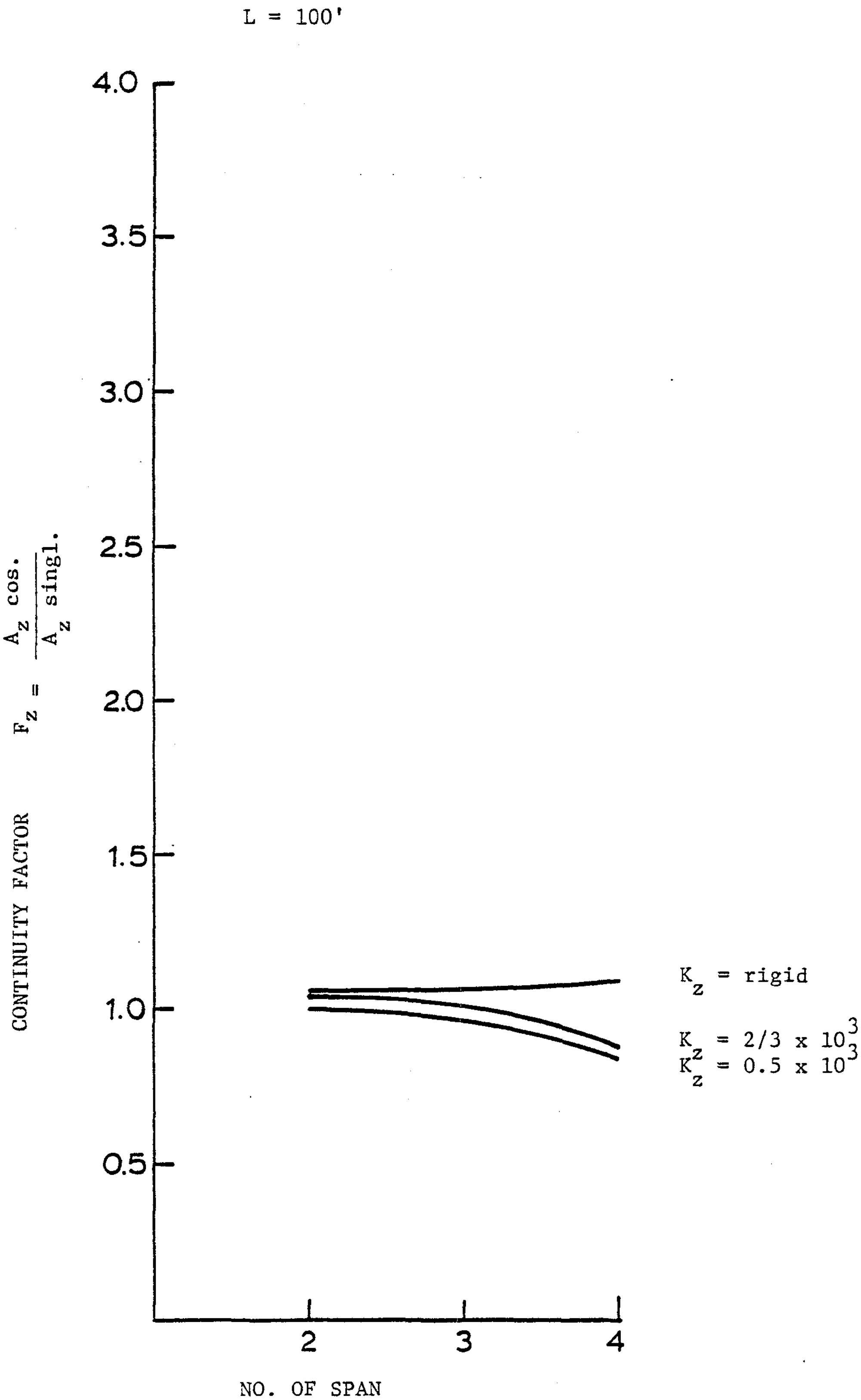

L = 150'
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
CONTINUITY FACTOR $F_y = \frac{A_y \text{ con.}}{A_y \text{ singl.}}$
2
3
4
NO. OF SPAN

FIGURE 64



L = 50'
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
CONTINUITY FACTOR $F_z = \frac{A_z \text{ con.}}{A_z \text{ singl.}}$
$k_z = 0.5 \times 10^3$
$K_z = 2/3 \times 10^3$
K_z = rigid
2
3
4
NO. OF SPAN

FIGURE 65



L = 100'
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
CONTINUITY FACTOR $F_z = \frac{A_z \cos.}{A_z \text{singl.}}$
K_z = rigid
$K_z = 2/3 \times 10^3$
$K_z = 0.5 \times 10^3$
2
3
4
NO. OF SPAN

FIGURE 66

L = 150'

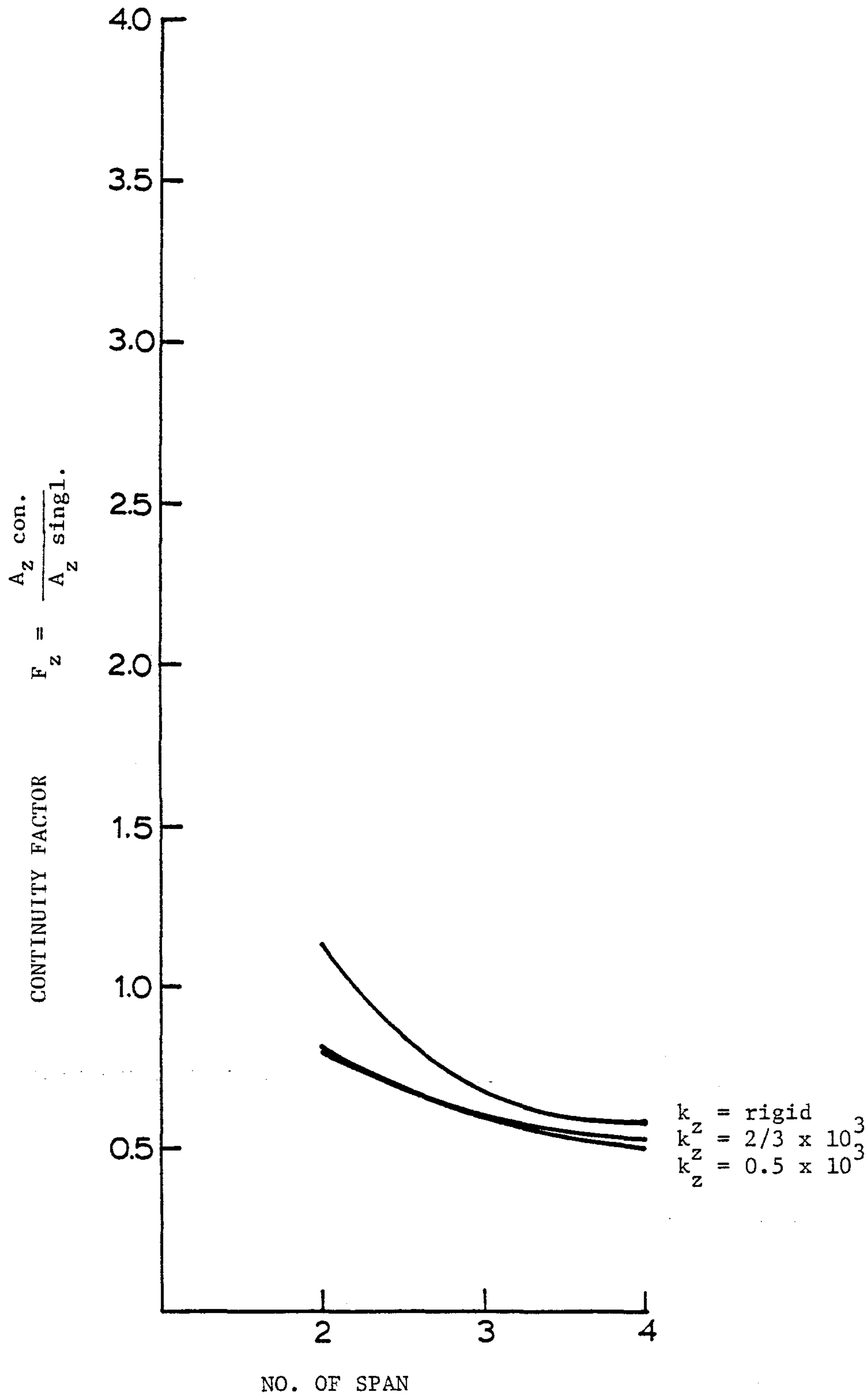


FIGURE 67

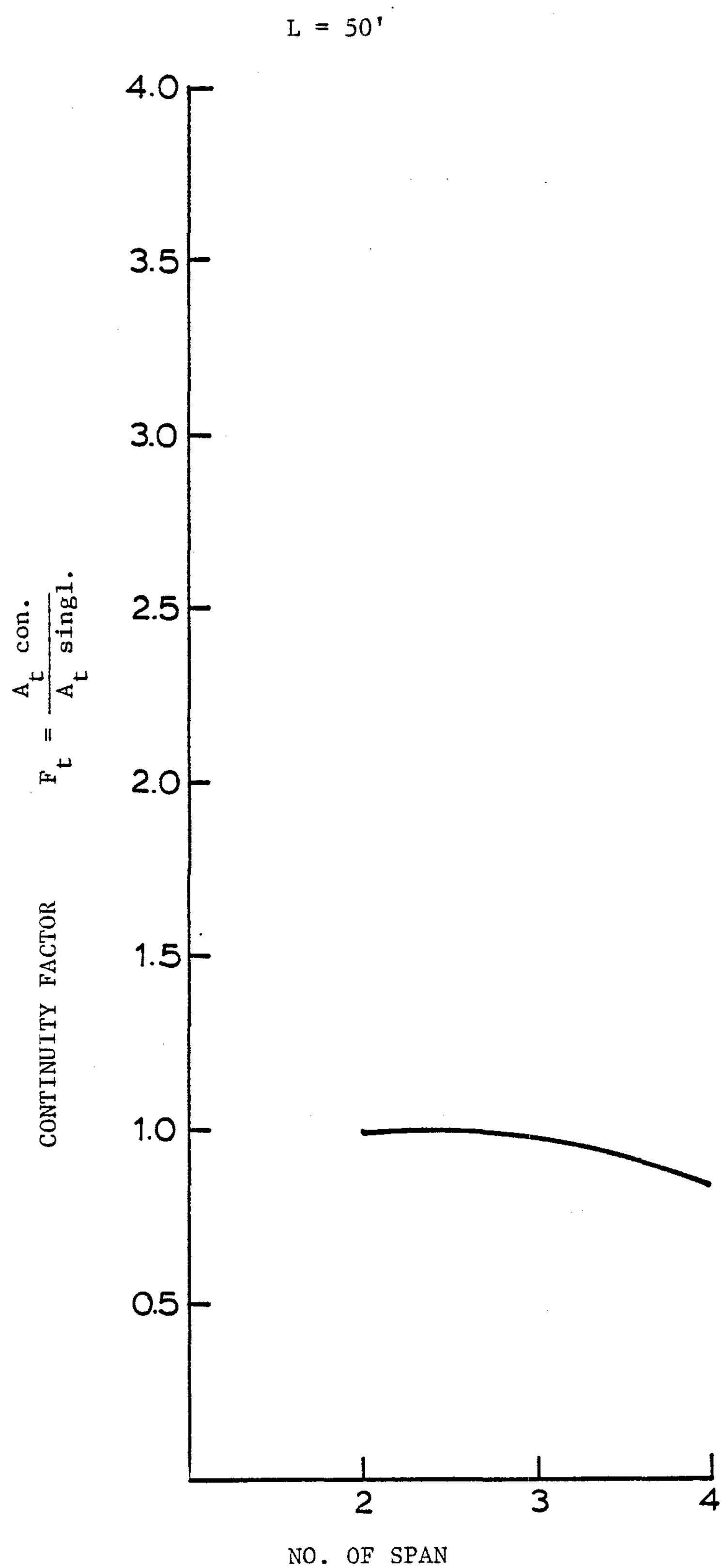

L = 50'
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
CONTINUITY FACTOR $F_t = \frac{A_t \text{ con.}}{A_t \text{ singl.}}$
2
3
4
NO. OF SPAN

FIGURE 68

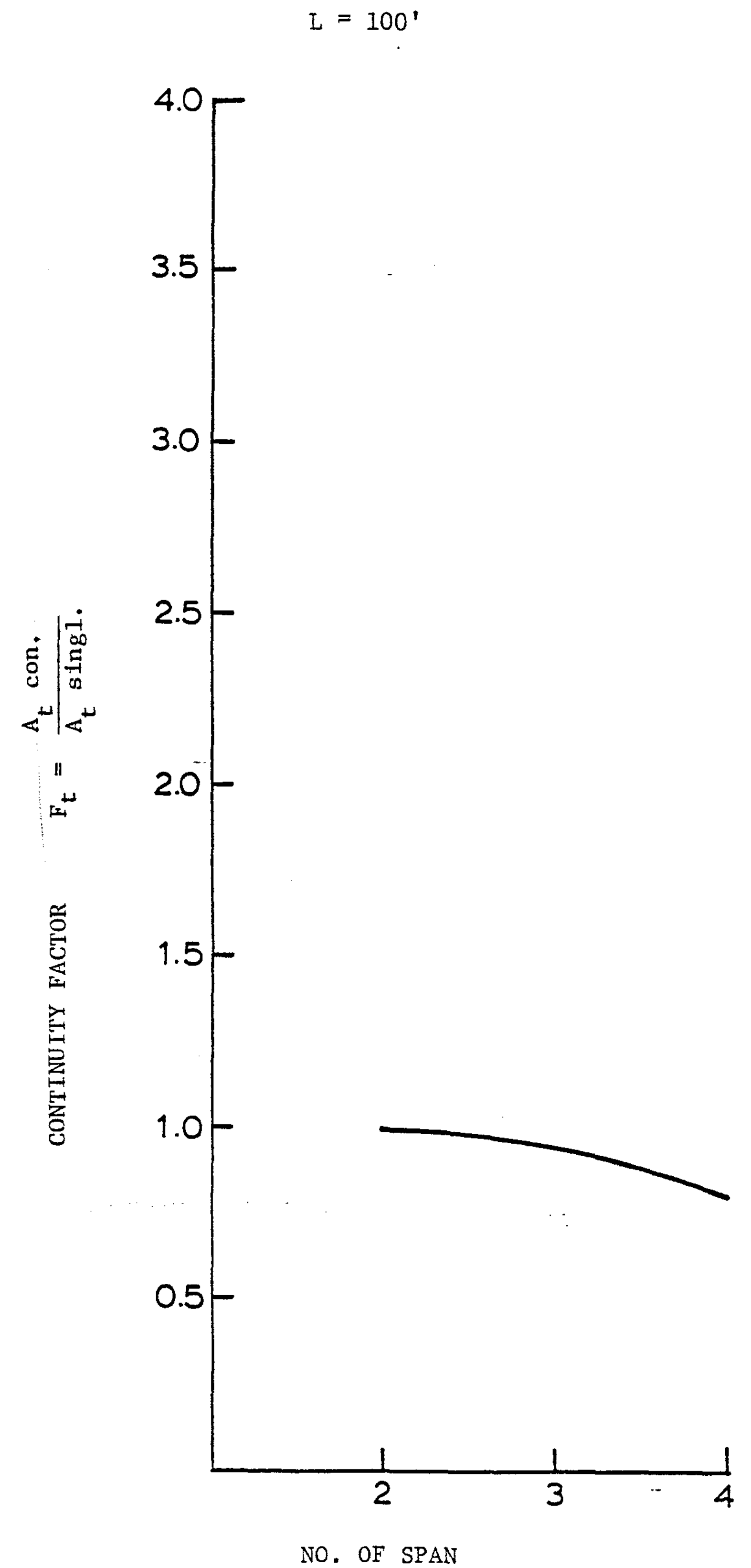

L = 100'
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
CONTINUITY FACTOR $F_t = \frac{A_t \text{ con.}}{A_t \text{ singl.}}$
2
3
4
NO. OF SPAN

FIGURE 69

L = 150'

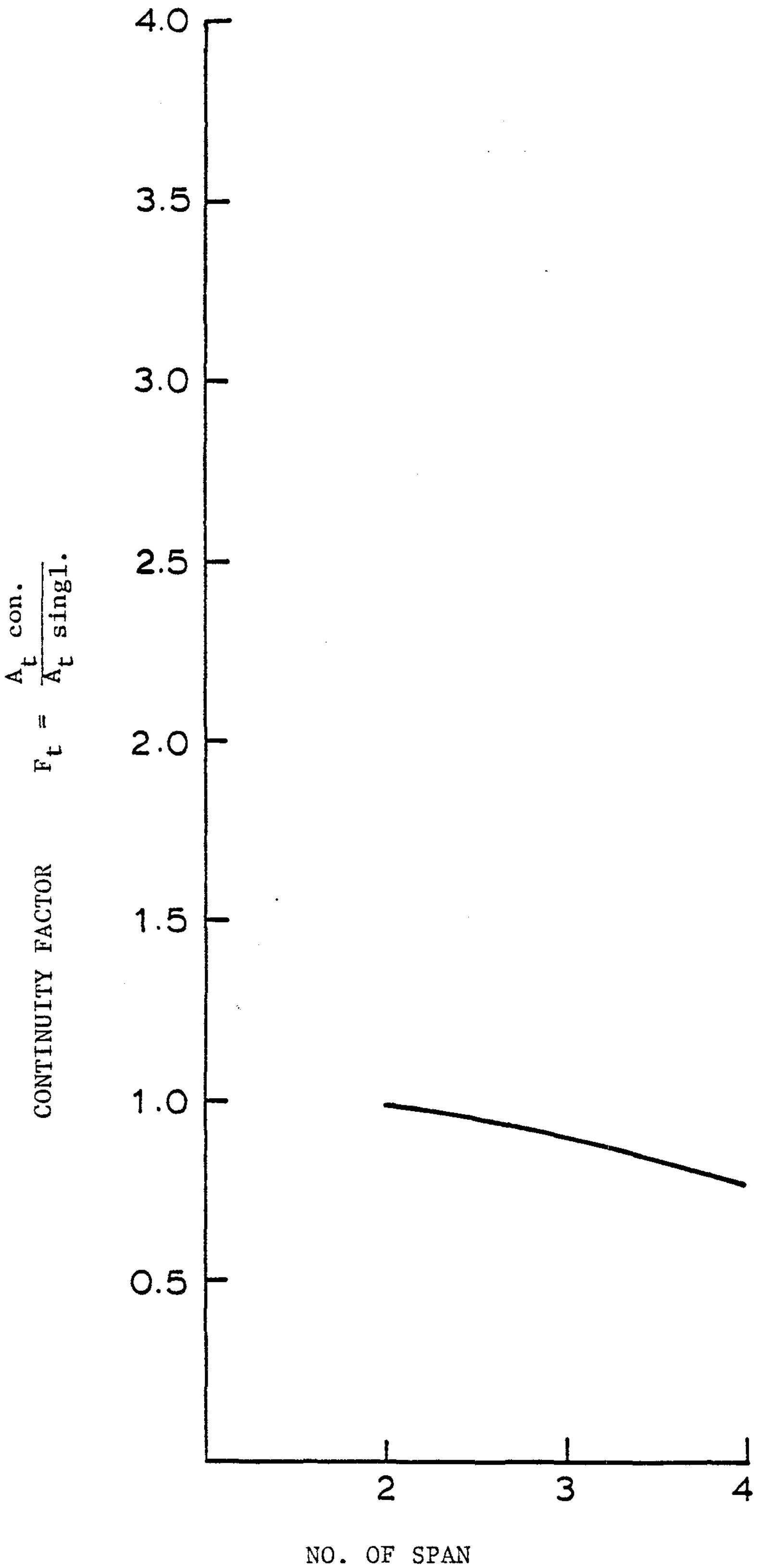
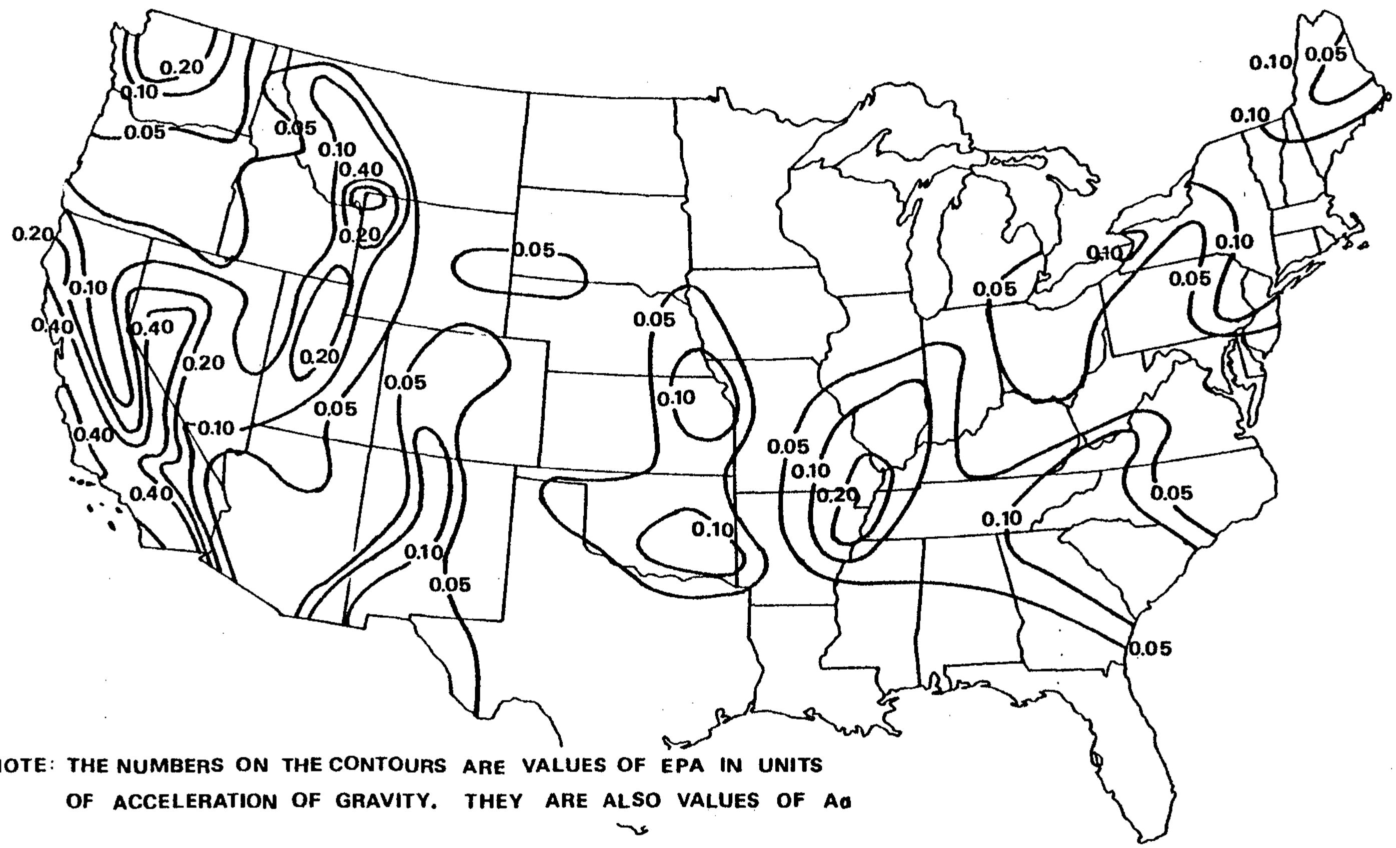


FIGURE 70



NOTE: THE NUMBERS ON THE CONTOURS ARE VALUES OF EPA IN UNITS OF ACCELERATION OF GRAVITY. THEY ARE ALSO VALUES OF Aa

Figure 71 MODIFYING FACTOR-K_p

```
LIN*DATA(1).CASE1(12)
         3   3   2   2   24    8      36.      50.
            600.    42.     50.     150.     11.0       0.      9.0      4.0
            100.    100.
             80.
             40.
         8.0  0.0  15.0   2.0   0.0  50.0  2.08  2.08
       1  213.97713.977  57.0  57.0 0.5  0.5   15.0   15.0 1.1251.125  92.0 0.875
       1   1      4.11      144.0   1     1
       1     72.0      7.35      5.25      40.6    1
       2  213.97713.977  57.0  57.0 0.5  0.5   15.0   15.0 2.0002.000  92.0  1.125
       2   1      4.11      144.0   1     1
       2     72.0      7.35      5.25      40.6    1
       3  213.97713.977  57.0  57.0 0.5  0.5   15.0   15.0 1.1251.125  92.0 0.875
       3   1      4.11      144.0   1     1
       3     72.0      7.35      5.25      40.6    1
             1         4
          0.533
             1
         6        1.
        999999.
             1
         6                 1.
           0.4
             1
         6                            1.
             1
         6                                       1.
**

@XQT,FSO IC1.ABS
```

```
*******************
* GIRDER GEOMETRY *
*******************

    SPAN LENGTH                    =   200.000 FT.
    RADIUS OF CURVATURE            =   600.000 FT.
    NUMBER OF INTERIOR SUPPORTS    =         1
    NUMBER OF BOX                  =         3
```

```
**********************
* STRUCTURAL DETAILS *
**********************
```

DESIGN SLAB DEPTH (IN)	INTEGRAL WS THICKNESS (IN)	HAUNCH WIDTH (IN)	HAUNCH DEPTH (IN)	UTILITY WEIGHT (PSF)	RAILING WEIGHT (LB/FT)	OVERHANG WIDTH RIGHT (FT)	OVERHANG WIDTH LEFT (FT)
8.000	.000	15.000	2.000	.000	50.000	2.080	2.080

CURB WIDTH (IN)	CURB HEIGHT (IN)	SIDEWALK WIDTH (IN)	SIDEWALK HEIGHT (IN)	CLEAR ROADWAY (FT)	SPACING BETWEEN BOX (IN)	ANGLE BETWEEN SLAB & HORIZONTAL (RADIAN)
.000	.000	.000	.000	42.000	50.000	.000

```
**********************************
* CONCRETE AND STEEL PROPERTIES *
**********************************
```

WT. OF WEARING SURF. (PSF)	AREA OF MISC. CONCRETE (IN**2)	ES/EC FOR S.D.L.	ES/EC FOR L.L.	COMP. STRENGTH CONCRETE (KSI)	WT OF CONCRETE (PCF)	STEEL STRENGTH (KSI) POSIT.	STEEL STRENGTH (KSI) NEG.
.000	9.000	24	8	4.000	150.000	36.0	50.0

```
*******************
** SECTION NO. 1 **
*******************
```

(1) SECTION LENGTH (FT.) = 80.000

(2) PLATE SIZES:

ANGLE BETWEEN WEB & VERTICAL LEFT (RADIAN)	ANGLE BETWEEN WEB & VERTICAL RIGHT (RADIAN)	WEB DEPTH LEFT (IN)	WEB DEPTH RIGHT (IN)	WEB THICKNESS LEFT (IN)	WEB THICKNESS RIGHT (IN)	TOP FLANGE WIDTH LEFT (IN)	TOP FLANGE WIDTH RIGHT (IN)	TOP FLANGE THICKNESS LEFT (IN)	TOP FLANGE THICKNESS RIGHT (IN)	BOTTOM FLANGE WIDTH (IN)	BOTTOM FLANGE THICKNESS (IN)
.244	.244	57.000	57.000	.500	.500	15.000	15.000	1.125	1.125	92.000	.875

(3) SECTION PROPERTIES :

		DL. NON-COMP.	LL. COMP.	SDL. COMP.	CONC. N= 8	CONC. N= 24
(A) BENDING:						
[1] MOM. INERTIA	IZ=	103234.402	228798.312	158092.387		
	IY=	346239.711	729325.484	473934.965		
	IZY=	.000	.000	.000		
[2] SECTION MODULUS	STZLL=	-2710.529	-10232.333	-5065.624	-58599.882	-94656.975
	STYLL=	5115.275	10774.906	7001.818	68491.386	133522.535
	STZLR=	-2710.529	-10232.333	-5065.624	.000	.000
	STYLR=	6571.583	13842.500	8995.222	.000	.000
	STZRR=	-2710.529	-10232.333	-5065.624	-58599.882	-94656.975
	STYRR=	-5115.275	-10774.906	-7001.818	-68491.386	-133522.535
	STZRL=	-2710.529	-10232.333	-5065.624	.000	.000
	STYRL=	-6571.583	-13842.500	-8995.222	.000	.000
	SBZL=	4936.242	6244.551	5688.590		
	SBYL=	7526.950	15854.902	10302.934		
	SBZR=	4936.242	6244.551	5688.590		
	SBYR=	-7526.950	-15854.902	-10302.934		
[3] 1ST MOM. INERTIA	QZL1=	-985.174	-1902.029	-1370.468		
	QZL2=	-881.725	-1572.495	-1183.823		
	QZR1=	-985.174	-1902.029	-1370.468		
	QZR2=	-881.725	-1572.495	-1183.823		
	QYL1=	2069.804	4652.211	2890.104		
	QYL2=	2567.659	5577.029	3570.782		
	QYR1=	-2069.281	-4651.648	-2889.563		
	QYR2=	-2567.659	-5577.029	-3570.782		
(B) DISTORSION:						
	LA4=	.000	.000	.000		
	CAN=	25625008.000	13277534.000	19642432.250		
	CON=	19131461.250	35674854.000	29309956.250		
	WAA=	1105148592128.000	2905880887296.000	2231556636672.000		
	RRO=	.486	.511	.512		
(C) TORSION:						
WARPING	IW=	86662025.000	10444485.625	6104939.562		
ST. VENANT	KT=	34480.359	395742.707	309744.258		
(D) NORMAL WARPING:						
	WNTLL=	219.215	48.013	228.969		
	WNTLR=	1406.729	48.013	228.969		
	WNTRR=	-219.215	-46.440	-233.124		
	WNTRL=	-1406.729	-46.440	-233.124		

WNBL=	-1172.177	308.550	-79.686
WNBR=	1172.177	-311.895	84.262

(4) STIFFENER & BRACING DETAILS :

(A) BRACING:

	TYPE	AREA (IN**2)	DIAPH SPACING (IN)	EQ. PLATE THICK (IN)
DEAD LOAD (NON-COMP):	1	4.1100	144.0000	.0262
SDL. LOAD (COMP.) :	1	4.1100	144.0000	.5507
LL. LOAD (COMP.) :	1	4.1100	144.0000	1.2173

(B) STIFFENERS:

BOTTOM FLANGE : NUMBER STIFFENERS = 1
AREA = 7.350
INERTIA = 40.600

WEB : SPACING = 72.000

(5) LOADING INFORMATION :

	UNIFORM LOADING (K/IN)	UNIFORM TORQUE (K-IN/IN)
DEAD LOAD =	.1811	.0000
SUP. DEAD LOAD =	.0028	.0000

****
** SECTION NO. 2 **
****

(1) SECTION LENGTH (FT.) = 40.000

(2) PLATE SIZES:

ANGLE BETWEEN WEB & VERTICAL (RADIAN)		WEB DEPTH		WEB THICKNESS		TOP FLANGE WIDTH		TOP FLANGE THICKNESS		BOTTOM FLANGE	
LEFT	RIGHT	LEFT (IN)	RIGHT (IN)	LEFT (IN)	RIGHT (IN)	LEFT (IN)	RIGHT (IN)	LEFT (IN)	RIGHT (IN)	WIDTH (IN)	THICKNESS (IN)
.244	.244	57.000	57.000	.500	.500	15.000	15.000	2.000	2.000	92.000	1.125

(3) SECTION PROPERTIES :

		DL. NON-COMP.	LL. COMP.	SDL. COMP.	CONC. N= 8	CONC. N= 24
(A) BENDING:						
[1] MOM. INERTIA	IZ=	151229.031	278607.371	204409.426		
	IY=	458045.828	841131.602	585741.078		
	IZY=	.000	.000	.000		
[2] SECTION MODULUS	STZLL=	-4123.779	-11743.061	-6538.502	-70254.988	-124949.650
	STYLL=	6767.076	12426.707	8653.619	78991.164	165021.871
	STZLR=	-4123.779	-11743.061	-6538.502	.000	.000
	STYLR=	8693.648	15964.565	11117.287	.000	.000
	STZRR=	-4123.779	-11743.061	-6538.502	-70254.988	-124949.650
	STYRR=	-6767.076	-12426.707	-8653.619	-78991.164	-165021.871
	STZRL=	-4123.779	-11743.061	-6538.502	.000	.000
	STYRL=	-8693.648	-15964.565	-11117.287	.000	.000
	SBZL=	6448.295	7654.107	7082.162		
	SBYL=	9957.518	18285.469	12733.502		
	SBZR=	6448.295	7654.107	7082.162		
	SBYR=	-9957.518	-18285.469	-12733.502		
[3] 1ST MOM. INERTIA	QZL1=	-1379.888	-2289.619	-1749.517		
	QZL2=	-1251.455	-1969.052	-1551.305		
	QZR1=	-1379.888	-2289.619	-1749.517		
	QZR2=	-1251.455	-1969.052	-1551.305		
	QYL1=	2799.590	5455.951	3657.822		
	QYL2=	3357.618	6366.989	4360.742		
	QYR1=	-2799.061	-5455.389	-3657.279		
	QYR2=	-3357.618	-6366.989	-4360.742		
(B) DISTORSION:						
	LA4=	.000	.000	.000		
	CAN=	24886808.000	13580869.875	19101127.500		
	CON=	20363166.000	35532495.000	30012237.750		
	WAA=	1511094927360.000	3436357812224.000	2765597999104.000		
	RRO=	.504	.511	.512		
(C) TORSION:						
WARPING	IW=	117249462.000	25563129.750	9257963.500		
ST. VENANT	KT=	36536.856	429431.301	355741.148		
(D) NORMAL WARPING:						
	WNTLL=	60.783	-27.595	100.201		
	WNTLR=	1305.191	-27.595	100.201		
	WNTRR=	-60.783	28.163	-98.603		
	WNTRL=	-1305.191	28.163	-98.803		

WNBL=	-1269.436	547.046	172.891
WNBR=	1269.436	-548.160	-174.443

(4) STIFFENER & BRACING DETAILS :

(A) BRACING:

	TYPE	AREA (IN**2)	DIAPH SPACING (IN)	EQ. PLATE THICK (IN)
DEAD LOAD (NON-COMP):	1	4.1100	144.0000	.0271
SDL. LOAD (COMP.) :	1	4.1100	144.0000	.7197
LL. LOAD (COMP.) :	1	4.1100	144.0000	1.3864

(B) STIFFENERS:

BOTTOM FLANGE : NUMBER STIFFENERS = 1
AREA = 7.350
INERTIA = 40.600

WEB : SPACING = 72.000

(5) LOADING INFORMATION :

	UNIFORM LOADING (K/IN)	UNIFORM TORQUE (K-IN/IN)
DEAD LOAD =	.1966	.0000
SUP. DEAD LOAD =	.0028	.0000

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*******************
** SECTION NO. 3 **
*******************
```

(1) SECTION LENGTH (FT.) = 80.000

(2) PLATE SIZES:

ANGLE BETWEEN WEB & VERTICAL (RADIAN)		WEB DEPTH		WEB THICKNESS		TOP FLANGE WIDTH		TOP FLANGE THICKNESS		BOTTOM FLANGE	
LEFT	RIGHT	LEFT (IN)	RIGHT (IN)	LEFT (IN)	RIGHT (IN)	LEFT (IN)	RIGHT (IN)	LEFT (IN)	RIGHT (IN)	WIDTH (IN)	THICKNESS (IN)
.244	.244	57.000	57.000	.500	.500	15.000	15.000	1.125	1.125	92.000	.875

(3) SECTION PROPERTIES :

		DL. NON-COMP.	LL. COMP.	SDL. COMP.	CONC. N= 8	CONC. N= 24
(A) BENDING:						
[1] MOM. INERTIA	IZ=	103234.402	228798.312	158092.387		
	IY=	346239.711	729325.484	473934.965		
	IZY=	.000	.000	.000		
[2] SECTION MODULUS	STZLL=	-2710.529	-10232.333	-5065.624	-58599.882	-94656.975
	STYLL=	5115.275	10774.906	7001.818	68491.386	133522.535
	STZLR=	-2710.529	-10232.333	-5065.624	.000	.000
	STYLR=	6571.583	13842.500	8995.222	.000	.000
	STZRR=	-2710.529	-10232.333	-5065.624	-58599.882	-94656.975
	STYRR=	-5115.275	-10774.906	-7001.818	-68491.386	-133522.535
	STZRL=	-2710.529	-10232.333	-5065.624	.000	.000
	STYRL=	-6571.583	-13842.500	-8995.222	.000	.000
	SBZL=	4936.242	6244.551	5688.590		
	SBYL=	7526.950	15854.902	10302.934		
	SBZR=	4936.242	6244.551	5688.590		
	SBYR=	-7526.950	-15854.902	-10302.934		
[3] 1ST MOM. INERTIA	QZL1=	-985.174	-1902.029	-1370.468		
	QZL2=	-881.725	-1572.495	-1183.823		
	QZR1=	-985.174	-1902.029	-1370.468		
	QZR2=	-881.725	-1572.495	-1183.823		
	QYL1=	2069.804	4652.211	2890.104		
	QYL2=	2567.659	5577.029	3570.782		
	QYR1=	-2069.281	-4651.648	-2889.563		
	QYR2=	-2567.659	-5577.029	-3570.782		
(B) DISTORSION:						
	LA4=	.000	.000	.000		
	CAN=	25625008.000	13277534.000	19642432.250		
	CON=	19131461.250	35674854.000	29309956.250		
	WAA=	110514859212 8.000	2905880887296.000	2231556636672.000		
	RRO=	.486	.511	.512		
(C) TORSION:						
WARPING	IW=	86662025.000	10452643.875	6104939.562		
ST. VENANT	KT=	34480.359	395742.707	309744.258		
(D) NORMAL WARPING:						
	WNTLL=	219.215	42.625	228.969		
	WNTLR=	1406.729	42.625	228.969		
	WNTRR=	-219.215	-43.599	-233.124		
	WNTRL=	-1406.729	-43.599	-233.124		

WNBL=	-1172.177	308.200	-79.686
WNBR=	1172.177	-306.128	84.262

(4) STIFFENER & BRACING DETAILS :

(A) BRACING:

	TYPE	AREA (IN**2)	DIAPH SPACING (IN)	EQ. PLATE THICK (IN)
DEAD LOAD (NON-COMP):	1	4.1100	144.0000	.0262
SDL. LOAD (COMP.) :	1	4.1100	144.0000	.5507
LL. LOAD (COMP.) :	1	4.1100	144.0000	1.2173

(B) STIFFENERS:

BOTTOM FLANGE : NUMBER STIFFENERS = 1
AREA = 7.350
INERTIA = 40.600

WEB : SPACING = 72.000

(5) LOADING INFORMATION :

	UNIFORM LOADING (K/IN)	UNIFORM TORQUE (K-IN/IN)
DEAD LOAD =	.1811	.0000
SUP. DEAD LOAD =	.0028	.0000

BRIDGE TOTAL WEIGHT:

TOTAL CONCRETE WEIGHT (K)	TOTAL STEEL WEIGHT (K)	TOTAL WEIGHT (K)	TOTAL CONCRETE VOLUME (CUBIC YARD)
298.19970	143.95056	442.15026	73.62956

--------------------STRUCTURE NUMBER 1--------------------

STRUCTURE DATA

M	N	NJ	NR	NRJ	E	G
21	119	22	13	3	29000.	11197.

COORDINATES OF JOINTS

JOINT	X	Y	Z
1	.00	.00	.00
2	118.50	.00	18.92
3	237.29	.00	35.86
4	356.36	.00	50.82
5	475.65	.00	63.80
6	595.15	.00	74.78
7	714.81	.00	83.77
8	834.60	.00	90.77
9	954.50	.00	95.77
10	1074.46	.00	98.77
11	1194.45	.00	99.77
12	1314.45	.00	98.77
13	1434.41	.00	95.77
14	1554.30	.00	90.77
15	1674.10	.00	83.77
16	1793.76	.00	74.78
17	1913.25	.00	63.80
18	2032.55	.00	50.82
19	2151.61	.00	35.86
20	2270.41	.00	18.92
21	2388.90	.00	.00
22	1218.45	.00	99.77

MEMBER INFORMATION

MEMBER	JJ	JK	AX	KT	YI	ZI	IAA	LENGTH
1	1	2	213.67	395742.71	729325.48	228798.31	0	120.00
2	2	3	213.67	395742.71	729325.48	228798.31	0	120.00
3	3	4	213.67	395742.71	729325.48	228798.31	0	120.00
4	4	5	213.67	395742.71	729325.48	228798.31	0	120.00
5	5	6	213.67	395742.71	729325.48	228798.31	0	120.00
6	6	7	213.67	395742.71	729325.48	228798.31	0	120.00
7	7	8	213.67	395742.71	729325.48	228798.31	0	120.00
8	8	9	213.67	395742.71	729325.48	228798.31	0	120.00
9	9	10	229.59	429431.30	458045.83	151229.03	0	120.00
10	10	11	229.59	429431.30	458045.83	151229.03	0	120.00
11	11	12	229.59	429431.30	458045.83	151229.03	0	120.00
12	12	13	229.59	429431.30	458045.83	151229.03	0	120.00
13	13	14	213.67	395742.71	729325.48	228798.31	0	120.00
14	14	15	213.67	395742.71	729325.48	228798.31	0	120.00
15	15	16	213.67	395742.71	729325.48	228798.31	0	120.00
16	16	17	213.67	395742.71	729325.48	228798.31	0	120.00
17	17	18	213.67	395742.71	729325.48	228798.31	0	120.00
18	18	19	213.67	395742.71	729325.48	228798.31	0	120.00
19	19	20	213.67	395742.71	729325.48	228798.31	0	120.00
20	20	21	213.67	395742.71	729325.48	228798.31	0	120.00
21	11	22	.53	1.00	1.00	1.00	0	24.00

JOINT RESTRAINTS

JOINT	RRX	RRY	RRZ	RMX	RMY	RMZ
1	1	1	1	1	0	0
21	0	1	1	1	0	0
22	1	1	1	1	1	1

IUBW= 12

LOADING NO. 1

NLJ
1

ACTIONS APPLIED AT JOINTS

JOINT	RX	RY	RZ	MX	MY	MZ
6	1.00	.00	.00	.00	.00	.00

JOINT DISPLACEMENTS

JOINT	DX	DY	DZ	DMX	DMY	DMZ
1	.0000	.0000	.0000	.0000	.1490-05	.0000
2	.4479-04	.0000	-.1725-03	.0000	.1455-05	.0000
3	.8557-04	.0000	-.3376-03	.0000	.1355-05	.0000
4	.1217-03	.0000	-.4881-03	.0000	.1200-05	.0000
5	.1530-03	.0000	-.6179-03	.0000	.1000-05	.0000
6	.1798-03	.0000	-.7221-03	.0000	.7656-06	.0000
7	.1835-03	.0000	-.7996-03	.0000	.5315-06	.0000
8	.1843-03	.0000	-.8509-03	.0000	.3279-06	.0000
9	.1833-03	.0000	-.8796-03	.0000	.1536-06	.0000
10	.1813-03	.0000	-.8836-03	.0000	-.7964-07	.0000
11	.1790-03	.0000	-.8622-03	.0000	-.2704-06	.0000
12	.1794-03	.0000	-.8200-03	.0000	-.4298-06	.0000
13	.1809-03	.0000	-.7598-03	.0000	-.5722-06	.0000
14	.1839-03	.0000	-.6863-03	.0000	-.6511-06	.0000
15	.1887-03	.0000	-.6041-03	.0000	-.7194-06	.0000
16	.1954-03	.0000	-.5145-03	.0000	-.7772-06	.0000
17	.2042-03	.0000	-.4187-03	.0000	-.8244-06	.0000
18	.2151-03	.0000	-.3180-03	.0000	-.8610-06	.0000
19	.2282-03	.0000	-.2138-03	.0000	-.8872-06	.0000
20	.2433-03	.0000	-.1074-03	.0000	-.9029-06	.0000
21	.2604-03	.0000	.0000	.0000	-.9081-06	.0000
22	.0000	.0000	.0000	.0000	.0000	.0000

MEMBER END-ACTIONS

MEMBER	LRX	LRY	LRZ	LMX	LMY	LMZ	RRX	RRY	RRZ	RMX	RMY	RMZ
1	-.8795+00	.0000	.1027+00	.0000	-.3815-04	.0000	.8795+00	.0000	-.1027+00	.0000	-.1233+02	.0000
2	-.8811+00	.0000	.8806-01	.0000	.1233+02	.0000	.8811+00	.0000	-.8806-01	.0000	-.2289+02	.0000
3	-.8824+00	.0000	.7337-01	.0000	.2289+02	.0000	.8824+00	.0000	-.7337-01	.0000	-.3170+02	.0000
4	-.8835+00	.0000	.5865-01	.0000	.3170+02	.0000	.8835+00	.0000	-.5865-01	.0000	-.3874+02	.0000
5	-.8844+00	.0000	.4392-01	.0000	.3874+02	.0000	.8844+00	.0000	-.4392-01	.0000	-.4401+02	.0000
6	.1122+00	.0000	-.4575-01	.0000	.4401+02	.0000	-.1122+00	.0000	.4575-01	.0000	-.3852+02	.0000
7	.1129+00	.0000	-.4387-01	.0000	.3852+02	.0000	-.1129+00	.0000	.4387-01	.0000	-.3325+02	.0000
8	.1137+00	.0000	-.4197-01	.0000	.3325+02	.0000	-.1137+00	.0000	.4197-01	.0000	-.2822+02	.0000
9	.1143+00	.0000	-.4007-01	.0000	.2822+02	.0000	-.1143+00	.0000	.4007-01	.0000	-.2341+02	.0000
10	.1150+00	.0000	-.7815-01	.0000	.2341+02	.0000	-.1150+00	.0000	.3815-01	.0000	-.1883+02	.0000
11	.1338-03	.0000	-.1557-01	.0000	.1857+02	.0000	-.1338-03	.0000	.1557-01	.0000	-.1670+02	.0000
12	.3930-03	.0000	-.1556-01	.0000	.1670+02	.0000	-.3930-03	.0000	.1556-01	.0000	-.1484+02	.0000
13	.6515-03	.0000	-.1555-01	.0000	.1484+02	.0000	-.6515-03	.0000	.1555-01	.0000	-.1297+02	.0000
14	.9097-03	.0000	-.1553-01	.0000	.1297+02	.0000	-.9097-03	.0000	.1553-01	.0000	-.1111+02	.0000
15	.1168-02	.0000	-.1550-01	.0000	.1111+02	.0000	-.1168-02	.0000	.1550-01	.0000	-.9247+01	.0000
16	.1425-02	.0000	-.1548-01	.0000	.9247+01	.0000	-.1425-02	.0000	.1548-01	.0000	-.7390+01	.0000
17	.1682-02	.0000	-.1545-01	.0000	.7390+01	.0000	-.1682-02	.0000	.1545-01	.0000	-.5536+01	.0000
18	.1938-02	.0000	-.1542-01	.0000	.5536+01	.0000	-.1938-02	.0000	.1542-01	.0000	-.3686+01	.0000
19	.2194-02	.0000	-.1538-01	.0000	.3686+01	.0000	-.2194-02	.0000	.1538-01	.0000	-.1841+01	.0000
20	.2449-02	.0000	-.1534-01	.0000	.1841+01	.0000	-.2449-02	.0000	.1534-01	.0000	.0000	.0000
21	.1153+00	.0000	-.2162-01	.0000	.2592+00	.0000	-.1153+00	.0000	.2162-01	.0000	.2598+00	.0000

EQUIVALENT CASE
SUPPORT REACTIONS

JOINT	ARX	ARY	ARZ	AMX	AMY	AMZ
1	.1298+04	.0000	.9502+02	.0000	.0000	.0000
21	.0000	.0000	-.5516+02	.0000	.0000	.0000
22	.2239+03	.0000	-.3974+02	.0000	-.4771+03	.0000

STRUCTURE DATA

M	N	NJ	NR	NRJ	E	G
21	119	22	13	3	29000.	11197.

COORDINATES OF JOINTS

JOINT	X	Y	Z
1	.00	.00	.00
2	118.50	.00	18.92
3	237.29	.00	35.86
4	356.36	.00	50.82
5	475.65	.00	63.80
6	595.15	.00	74.78
7	714.81	.00	83.77
8	834.60	.00	90.77
9	954.50	.00	95.77
10	1074.46	.00	98.77
11	1194.45	.00	99.77
12	1314.45	.00	98.77
13	1434.41	.00	95.77
14	1554.30	.00	90.77
15	1674.10	.00	83.77
16	1793.76	.00	74.78
17	1913.25	.00	63.80
18	2032.55	.00	50.82
19	2151.61	.00	35.86
20	2270.41	.00	18.92
21	2388.90	.00	.00
22	1194.45	24.00	99.77

MEMBER INFORMATION

MEMBER	JJ	JK	AX	KT	YI	ZI	IAA	LENGTH
1	1	2	213.67	395742.71	729325.48	228798.31	0	120.00
2	2	3	213.67	395742.71	729325.48	228798.31	0	120.00
3	3	4	213.67	395742.71	729325.48	228798.31	0	120.00
4	4	5	213.67	395742.71	729325.48	228798.31	0	120.00
5	5	6	213.67	395742.71	729325.48	228798.31	0	120.00
6	6	7	213.67	395742.71	729325.48	228798.31	0	120.00
7	7	8	213.67	395742.71	729325.48	228798.31	0	120.00
8	8	9	213.67	395742.71	729325.48	228798.31	0	120.00
9	9	10	229.59	429431.30	458045.83	151229.03	0	120.00
10	10	11	229.59	429431.30	458045.83	151229.03	0	120.00
11	11	12	229.59	429431.30	458045.83	151229.03	0	120.00
12	12	13	229.59	429431.30	458045.83	151229.03	0	120.00
13	13	14	213.67	395742.71	729325.48	228798.31	0	120.00
14	14	15	213.67	395742.71	729325.48	228798.31	0	120.00
15	15	16	213.67	395742.71	729325.48	228798.31	0	120.00
16	16	17	213.67	395742.71	729325.48	228798.31	0	120.00
17	17	18	213.67	395742.71	729325.48	228798.31	0	120.00
18	18	19	213.67	395742.71	729325.48	228798.31	0	120.00
19	19	20	213.67	395742.71	729325.48	228798.31	0	120.00
20	20	21	213.67	395742.71	729325.48	228798.31	0	120.00
21	11	22	999999.00	1.00	1.00	1.00	0	24.00

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JOINT RESTRAINTS

JOINT	RRX	RRY	RRZ	RMX	RMY	RMZ
1	1	1	1	1	0	0
21	0	1	1	1	0	0
22	1	1	1	1	1	1

LOADING NO. 2

NLJ
1

ACTIONS APPLIED AT JOINTS

JOINT	RX	RY	RZ	MX	MY	MZ
6	.00	1.00	.00	.00	.00	.00

JOINT DISPLACEMENTS

JOINT	DX	DY	DZ	DMX	DMY	DMZ
1	.0000	.0000	.0000	.0000	-.2318-08	.1066-04
2	-.8503-07	.1247-02	.2656-06	-.3309-06	-.2257-08	.1018-04
3	-.1637-06	.2392-02	.5185-06	-.5182-06	-.2085-08	.8811-05
4	-.2349-06	.3323-02	.7468-06	-.5696-06	-.1827-08	.6535-05
5	-.2985-06	.3928-02	.9417-06	-.4923-06	-.1508-08	.3355-05
6	-.3552-06	.4099-02	.1097-05	-.2940-06	-.1153-08	-.7304-06
7	-.4060-06	.3766-02	.1210-05	-.6338-07	-.7869-09	-.4641-05
8	-.4525-06	.3039-02	.1280-05	.1108-06	-.4335-09	-.7297-05
9	-.4960-06	.2066-02	.1311-05	.2391-06	-.1180-09	-.8699-05
10	-.5349-06	.9894-03	.1299-05	.3269-06	.2847-09	-.8922-05
11	-.5737-06	.5453-09	.1247-05	.3841-06	.5483-09	-.7246-05
12	-.5744-06	-.7169-03	.1171-05	.4362-06	.7233-09	-.4753-05
13	-.5768-06	-.1149-02	.1074-05	.4873-06	.8798-09	-.2524-05
14	-.5814-06	-.1370-02	.9635-06	.5019-06	.9665-09	-.1224-05
15	-.5884-06	-.1444-02	.8432-06	.4977-06	.1041-08	-.9736-07
16	-.5980-06	-.1392-02	.7146-06	.4734-06	.1105-08	.8564-06
17	-.6104-06	-.1237-02	.5794-06	.4275-06	.1157-08	.1638-05
18	-.6257-06	-.9980-03	.4389-06	.3586-06	.1197-08	.2247-05
19	-.6438-06	-.6981-03	.2945-06	.2654-06	.1226-08	.2684-05
20	-.6646-06	-.3582-03	.1478-06	.1463-06	.1243-08	.2949-05
21	-.6882-06	.0000	.0000	.0000	.1249-08	.3044-05
22	.0000	.0000	.0000	.0000	.0000	.0000

MEMBER END-ACTIONS

MEMBER	LRX	LRY	LRZ	LMX	LMY	LMZ	RRX	RRY	RRZ	RMX	RMY	RMZ
1	.2173-02	-.4214+00	-.1804-03	.1482+02	.6706-07	-.2366+01	-.2173-02	.4214+00	.1804-03	-.1482+02	.2164-01	-.4820+02
2	.2176-02	-.4214+00	-.1441-03	.1401+02	-.2164-01	.4844+02	-.2176-02	.4214+00	.1441-03	-.1401+02	.3893-01	-.9900+02
3	.2178-02	-.4214+00	-.1078-03	.1236+02	-.3893-01	.9922+02	-.2178-02	.4214+00	.1078-03	-.1236+02	.5187-01	-.1498+03
4	.2180-02	-.4214+00	-.7151-04	.9860+01	-.5187-01	.1500+03	-.2180-02	.4214+00	.7151-04	-.9860+01	.6045-01	-.2005+03
5	.2180-02	-.4214+00	-.3519-04	.6517+01	-.6045-01	.2007+03	-.2180-02	.4214+00	.3519-04	-.6517+01	.6468-01	-.2512+03
6	.2181-02	.5786+00	.1150-05	.2329+01	-.6468-01	.2513+03	-.2181-02	-.5786+00	-.1150-05	-.2329+01	.6454-01	-.1819+03
7	.2180-02	.5786+00	.3749-04	-.7027+00	-.6454-01	.1819+03	-.2180-02	-.5786+00	-.3749-04	.7027+00	.6004-01	-.1125+03
8	.2180-02	.5786+00	.7382-04	-.2577+01	-.6004-01	.1124+03	-.2180-02	-.5786+00	-.7382-04	.2577+01	.5118-01	-.4301+02
9	.2178-02	.5786+00	.1101-03	-.3293+01	-.5118-01	.4296+02	-.2178-02	-.5786+00	-.1101-03	.3293+01	.3797-01	.2647+02
10	.2176-02	.5786+00	.1464-03	-.2852+01	-.3797-01	-.2652+02	-.2176-02	-.5786+00	-.1464-03	.2852+01	.2040-01	.9595+02
11	-.1594-06	-.8033-01	.1710-04	-.1255+01	-.2040-01	-.9595+02	.1594-06	.8033-01	-.1710-04	.1255+01	.1835-01	.8631+02
12	-.4429-06	-.8033-01	.1709-04	.1839+00	-.1835-01	-.8632+02	.4429-06	.8033-01	-.1709-04	-.1839+00	.1630-01	.7668+02
13	-.7264-06	-.8033-01	.1708-04	.1462+01	-.1630-01	-.7667+02	.7264-06	.8033-01	-.1708-04	-.1462+01	.1425-01	.6703+02

14	-.1008-05	-.8032-01	.1706-04	.2579+01	-.1425-01	-.6699+02	.1008-05	.8032-01	-.1706-04	-.2579+01	.1220-01	.5736+02
15	-.1290-05	-.8032-01	.1703-04	.3534+01	-.1220-01	-.5730+02	.1290-05	.8032-01	-.1703-04	-.3534+01	.1016-01	.4767+02
16	-.1571-05	-.8032-01	.1700-04	.4328+01	-.1016-01	-.4760+02	.1571-05	.8032-01	-.1700-04	-.4328+01	.8117-02	.3796+02
17	-.1851-05	-.8031-01	.1697-04	.4960+01	-.8117-02	-.3789+02	.1851-05	.8031-01	-.1697-04	-.4960+01	.6081-02	.2825+02
18	-.2133-05	-.8031-01	.1693-04	.5430+01	-.6081-02	-.2816+02	.2133-05	.8031-01	-.1693-04	-.5430+01	.4049-02	.1852+02
19	-.2412-05	-.8031-01	.1689-04	.5738+01	-.4049-02	-.1843+02	.2412-05	.8031-01	-.1689-04	-.5738+01	.2022-02	.8794+01
20	-.2691-05	-.8031-01	.1685-04	.5884+01	-.2022-02	-.8697+01	.2691-05	.8031-01	-.1685-04	-.5684+01	.0000	-.9395+00
21	.6589+00	-.2175-02	.1474-03	.2558-06	-.2233-02	-.3485-01	-.6589+00	.2175-02	-.1474-03	-.2558-06	-.1305-02	-.1734-01

SUPPORT REACTIONS

JOINT	ARX	ARY	ARZ	AMX	AMY	AMZ
1	.2175-02	-.4214+00	.1646-03	.1500+02	.0000	.0000
21	.0000	.8031-01	-.1706-04	-.5959+01	.0000	.0000
22	-.2175-02	-.6589+00	-.1474-03	.1305-02	-.2558-06	-.1734-01

EQUIVALENT CASE
JOINT DISPLACEMENTS

JOINT	DX	DY	DZ	DMX	DMY	DMZ
1	.0000	.0000	.0000	.0000	-.1542-05	-.3200-02
2	-.2892-04	-.3696+00	.1823-03	.5769-04	-.1530-05	-.2950-02
3	-.5439-04	-.6859+00	.3620-03	.5090-04	-.1492-05	-.2302-02
4	-.7611-04	-.9081+00	.5362-03	.1908-05	-.1429-05	-.1392-02
5	-.9396-04	-.1013+01	.7016-03	-.7044-04	-.1340-05	-.3570-03
6	-.1080-03	-.9921+00	.8552-03	-.1508-03	-.1226-05	.6659-03
7	-.1183-03	-.8563+00	.9939-03	-.2271-03	-.1087-05	.1539-02
8	-.1252-03	-.6314+00	.1115-02	-.2908-03	-.9220-06	.2125-02
9	-.1292-03	-.3606+00	.1214-02	-.3370-03	-.7313-06	.2285-02
10	-.1308-03	-.1125+00	.1281-02	-.3558-03	-.3866-06	.1674-02
11	-.1310-03	-.6417-06	.1305-02	-.3592-03	-.8104-09	.1725-07
12	-.1312-03	-.1125+00	.1282-02	-.3558-03	.3851-06	-.1674-02
13	-.1328-03	-.3606+00	.1214-02	-.3370-03	.7301-06	-.2285-02
14	-.1369-03	-.6314+00	.1115-02	-.2908-03	.9212-06	-.2125-02
15	-.1439-03	-.8563+00	.9945-03	-.2271-03	.1087-05	-.1539-02
16	-.1543-03	-.9921+00	.8558-03	-.1508-03	.1227-05	-.6659-03
17	-.1684-03	-.1013+01	.7021-03	-.7045-04	.1341-05	.3570-03
18	-.1863-03	-.9081+00	.5366-03	.1906-05	.1430-05	.1392-02
19	-.2081-03	-.6858+00	.3623-03	.5090-04	.1493-05	.2302-02
20	-.2336-03	-.3696+00	.1824-03	.5768-04	.1531-05	.2950-02
21	-.2627-03	.0000	.0000	.0000	.1544-05	.3200-02
22	.0000	.0000	.0000	.0000	.0000	.0000

EQUIVALENT CASE
MEMBER END-ACTIONS

MEMBER	LRX	LRY	LRZ	LMX	LMY	LMZ	RRX	RRY	RRZ	RMX	RMY	RMZ
1	-.9247-02	.2499+03	-.3692-01	-.3558+04	.3052-04	.5680+03	.9247-02	-.1861+03	.3692-01	.3558+04	.4430+01	.2559+05
2	-.8630-02	.1861+03	-.3707-01	-.3131+04	-.4430+01	-.2565+05	.8630-02	-.1224+03	.3707-01	.3131+04	.8879+01	.4416+05
3	-.8011-02	.1224+03	-.3721-01	-.2394+04	-.8879+01	-.4420+05	.8011-02	-.5861+02	.3721-01	.2394+04	.1334+02	.5506+05
4	-.7390-02	.5861+02	-.3734-01	-.1476+04	-.1334+02	-.5509+05	.7390-02	.5144+01	.3734-01	.1476+04	.1783+02	.5830+05
5	-.6767-02	-.5142+01	-.3747-01	-.5044+03	-.1782+02	-.5832+05	.6767-02	.6890+02	.3747-01	.5044+03	.2232+02	.5387+05
6	-.6142-02	-.6889+02	-.3758-01	.3935+03	-.2232+02	-.5388+05	.6142-02	.1326+03	.3758-01	-.3935+03	.2683+02	.4178+05
7	-.5515-02	-.1326+03	-.3768-01	.1090+04	-.2683+02	-.4177+05	.5515-02	.1964+03	.3768-01	-.1090+04	.3135+02	.2203+05
8	-.4886-02	-.1964+03	-.3777-01	.1457+04	-.3135+02	-.2201+05	.4886-02	.2602+03	.3777-01	-.1457+04	.3588+02	-.5387+04
9	-.4255-02	-.2602+03	-.3785-01	.1367+04	-.3588+02	.5410+04	.4255-02	.3239+03	.3785-01	-.1367+04	.4043+02	-.4045+05
10	-.3624-02	-.3239+03	-.3792-01	.6924+03	-.4043+02	.4047+05	.3624-02	.3877+03	.3792-01	-.6924+03	.4498+02	-.8317+05
11	-.3187-03	.3877+03	.3768-01	-.6924+03	-.4498+02	.8317+05	.3187-03	-.3239+03	-.3768-01	.6924+03	.4046+02	-.4047+05
12	-.9464-03	.3239+03	.3767-01	-.1367+04	-.4046+02	.4045+05	.9464-03	-.2602+03	-.3767-01	.1367+04	.3594+02	-.5411+04
13	-.1573-02	.2602+03	.3764-01	-.1457+04	-.3594+02	.5387+04	.1573-02	-.1964+03	-.3764-01	.1457+04	.3142+02	.2201+05
14	-.2199-02	.1964+03	.3760-01	-.1090+04	-.3142+02	-.2203+05	.2199-02	-.1326+03	-.3760-01	.1090+04	.2691+02	.4177+05

15	-.2825-02	.1326+03	.3756-01	-.3935+03	-.2691+02	-.4178+05	.2825-02	-.6889+02	-.3756-01	.3935+03	.2240+02	.5387+05
16	-.3448-02	.6890+02	.3749-01	.5044+03	-.2240+02	-.5387+05	.3448-02	-.5142+01	-.3749-01	-.5044+03	.1790+02	.5832+05
17	-.4072-02	.5145+01	.3742-01	.1476+04	-.1790+02	-.5830+05	.4072-02	.5861+02	-.3742-01	-.1476+04	.1341+02	.5509+05
18	-.4694-02	-.5861+02	.3735-01	.2394+04	-.1341+02	-.5506+05	.4694-02	.1224+03	-.3735-01	-.2394+04	.8931+01	.4420+05
19	-.5315-02	-.1224+03	.3726-01	.3130+04	-.8931+01	-.4416+05	.5315-02	.1861+03	-.3726-01	-.3130+04	.4460+01	.2565+05
20	-.5934-02	-.1861+03	.3717-01	.3557+04	-.4460+01	-.2559+05	.5934-02	.2499+03	-.3717-01	-.3557+04	.0000	-.5680+03
21	-.7753+03	.3302-02	-.7564-01	-.3781-06	.1342+01	.3965-01	.7753+03	-.3302-02	.7564-01	.3781-06	.4737+00	.3961-01

EQUIVALENT CASE
SUPPORT REACTIONS

JOINT	ARX	ARY	ARZ	AMX	AMY	AMZ
1	-.3310-02	.2499+03	-.3792-01	-.3603+04	.0000	.0000
21	.0000	.2499+03	-.3764-01	-.3603+04	.0000	.0000
22	.3302-02	.7753+03	.7564-01	-.4737+00	.3781-06	.3961-01

STRUCTURE DATA

M	N	NJ	NR	NRJ	E	G
21	119	22	13	3	29000.	11197.

COORDINATES OF JOINTS

JOINT	X	Y	Z
1	.00	.00	.00
2	118.50	.00	18.92
3	237.29	.00	35.86
4	356.36	.00	50.82
5	475.65	.00	63.80
6	595.15	.00	74.78
7	714.81	.00	83.77
8	834.60	.00	90.77
9	954.50	.00	95.77
10	1074.46	.00	98.77
11	1194.45	.00	99.77
12	1314.45	.00	98.77
13	1434.41	.00	95.77
14	1554.30	.00	90.77
15	1674.10	.00	83.77
16	1793.76	.00	74.78
17	1913.25	.00	63.80
18	2032.55	.00	50.82
19	2151.61	.00	35.86
20	2270.41	.00	18.92
21	2388.90	.00	.00
22	1194.45	.00	123.77

MEMBER INFORMATION

MEMBER	JJ	JK	AX	KT	YI	ZI	IAA	LENGTH
1	1	2	213.67	395742.71	729325.48	228798.31	0	120.00
2	2	3	213.67	395742.71	729325.48	228798.31	0	120.00
3	3	4	213.67	395742.71	729325.48	228798.31	0	120.00
4	4	5	213.67	395742.71	729325.48	228798.31	0	120.00
5	5	6	213.67	395742.71	729325.48	228798.31	0	120.00
6	6	7	213.67	395742.71	729325.48	228798.31	0	120.00
7	7	8	213.67	395742.71	729325.48	228798.31	0	120.00
8	8	9	213.67	395742.71	729325.48	228798.31	0	120.00
9	9	10	229.59	429431.30	458045.83	151229.03	0	120.00
10	10	11	229.59	429431.30	458045.83	151229.03	0	120.00
11	11	12	229.59	429431.30	458045.83	151229.03	0	120.00

12	12	13	229.59	429431.30	458045.83	151229.03	0	120.00
13	13	14	213.67	395742.71	729325.48	228798.31	0	120.00
14	14	15	213.67	395742.71	729325.48	228798.31	0	120.00
15	15	16	213.67	395742.71	729325.48	228798.31	0	120.00
16	16	17	213.67	395742.71	729325.48	228798.31	0	120.00
17	17	18	213.67	395742.71	729325.48	228798.31	0	120.00
18	18	19	213.67	395742.71	729325.48	228798.31	0	120.00
19	19	20	213.67	395742.71	729325.48	228798.31	0	120.00
20	20	21	213.67	395742.71	729325.48	228798.31	0	120.00
21	11	22	.40	1.00	1.00	1.00	0	24.00

JOINT RESTRAINTS

JOINT	RRX	RRY	RRZ	RMX	RMY	RMZ
1	1	1	1	1	0	0
21	0	1	1	1	0	0
22	1	1	1	1	1	1

IUBW= 12

LOADING NO. 3

NLJ
1

ACTIONS APPLIED AT JOINTS

JOINT	RX	RY	RZ	MX	MY	MZ
6	.00	.00	1.00	.00	.00	.00

JOINT DISPLACEMENTS

JOINT	DX	DY	DZ	DMX	DMY	DMZ
1	.0000	.0000	.0000	.0000	-.4783-05	.0000
2	-.8803-04	.0000	.5609-03	.0000	-.4629-05	.0000
3	-.1616-03	.0000	.1087-02	.0000	-.4167-05	.0000
4	-.2174-03	.0000	.1540-02	.0000	-.3396-05	.0000
5	-.2537-03	.0000	.1884-02	.0000	-.2316-05	.0000
6	-.2709-03	.0000	.2081-02	.0000	-.9258-06	.0000
7	-.2735-03	.0000	.2106-02	.0000	.4359-06	.0000
8	-.2673-03	.0000	.1991-02	.0000	.1430-05	.0000
9	-.2587-03	.0000	.1778-02	.0000	.2055-05	.0000
10	-.2520-03	.0000	.1502-02	.0000	.2463-05	.0000
11	-.2495-03	.0000	.1211-02	.0000	.2285-05	.0000
12	-.2516-03	.0000	.9640-03	.0000	.1836-05	.0000
13	-.2565-03	.0000	.7682-03	.0000	.1435-05	.0000
14	-.2631-03	.0000	.6098-03	.0000	.1213-05	.0000
15	-.2710-03	.0000	.4763-03	.0000	.1021-05	.0000
16	-.2795-03	.0000	.3642-03	.0000	.8579-06	.0000
17	-.2882-03	.0000	.2699-03	.0000	.7249-06	.0000
18	-.2970-03	.0000	.1899-03	.0000	.6215-06	.0000
19	-.3058-03	.0000	.1206-03	.0000	.5478-06	.0000
20	-.3148-03	.0000	.5849-04	.0000	.5036-06	.0000
21	-.3243-03	.0000	.0000	.0000	.4889-06	.0000
22	.0000	.0000	.0000	.0000	.0000	.0000

MEMBER END-ACTIONS

MEMBER	LRX	LRY	LRZ	LMX	LMY	LMZ	RRX	RRY	RRZ	RMX	RMY	RMZ
1	-.7782-01	.0000	-.4518+00	.0000	.1831-03	.0000	.7782-01	.0000	.4518+00	.0000	.5422+02	.0000
2	-.7028-01	.0000	-.4531+00	.0000	-.5422+02	.0000	.7028-01	.0000	.4531+00	.0000	.1086+03	.0000
3	-.6272-01	.0000	-.4542+00	.0000	-.1086+03	.0000	.6272-01	.0000	.4542+00	.0000	.1631+03	.0000

4	-.5514-01	.0000	-.4552+00	.0000	-.1631+03	.0000	.5514-01	.0000	.4552+00	.0000	.2177+03	.0000
5	-.4755-01	.0000	-.4560+00	.0000	-.2177+03	.0000	.4755-01	.0000	.4560+00	.0000	.2724+03	.0000
6	.3499-01	.0000	.5404+00	.0000	-.2724+03	.0000	-.3499-01	.0000	-.5404+00	.0000	.2076+03	.0000
7	.2598-01	.0000	.5409+00	.0000	-.2076+03	.0000	-.2598-01	.0000	-.5409+00	.0000	.1427+03	.0000
8	.1696-01	.0000	.5412+00	.0000	-.1427+03	.0000	-.1696-01	.0000	-.5412+00	.0000	.7773+02	.0000
9	.7939-02	.0000	.5415+00	.0000	-.7773+02	.0000	-.7939-02	.0000	-.5415+00	.0000	.1275+02	.0000
10	-.1085-02	.0000	.5415+00	.0000	-.1275+02	.0000	.1085-02	.0000	-.5415+00	.0000	-.5223+02	.0000
11	.3583-03	.0000	-.4376-01	.0000	.5229+02	.0000	-.3583-03	.0000	.4376-01	.0000	-.4704+02	.0000
12	.1088-02	.0000	-.4375-01	.0000	.4704+02	.0000	-.1088-02	.0000	.4375-01	.0000	-.4179+02	.0000
13	.1818-02	.0000	-.4373-01	.0000	.4179+02	.0000	-.1818-02	.0000	.4373-01	.0000	-.3654+02	.0000
14	.2547-02	.0000	-.4370-01	.0000	.3654+02	.0000	-.2547-02	.0000	.4370-01	.0000	-.3130+02	.0000
15	.3276-02	.0000	-.4366-01	.0000	.3130+02	.0000	-.3276-02	.0000	.4366-01	.0000	-.2606+02	.0000
16	.4005-02	.0000	-.4360-01	.0000	.2606+02	.0000	-.4005-02	.0000	.4360-01	.0000	-.2083+02	.0000
17	.4732-02	.0000	-.4353-01	.0000	.2083+02	.0000	-.4732-02	.0000	.4353-01	.0000	-.1560+02	.0000
18	.5457-02	.0000	-.4344-01	.0000	.1560+02	.0000	-.5457-02	.0000	.4344-01	.0000	-.1039+02	.0000
19	.6182-02	.0000	-.4335-01	.0000	.1039+02	.0000	-.6182-02	.0000	.4335-01	.0000	-.5189+01	.0000
20	.6904-02	.0000	-.4324-01	.0000	.5189+01	.0000	-.6904-02	.0000	.4324-01	.0000	-.1144-04	.0000
21	.5852+00	.0000	.5591-02	.0000	-.6433-01	.0000	-.5852+00	.0000	-.5591-02	.0000	-.6985-01	.0000

SUPPORT REACTIONS

JOINT	ARX	ARY	ARZ	AMX	AMY	AMZ
1	-.5603-02	.0000	-.4584+00	.0000	.0000	.0000
21	.0000	.0000	.4379-01	.0000	.0000	.0000
22	.5591-02	.0000	-.5852+00	.0000	-.6985-01	.0000

EQUIVALENT CASE
JOINT DISPLACEMENTS

JOINT	DX	DY	DZ	DMX	DMY	DMZ
1	.0000	.0000	.0000	.0000	.3769-02	.0000
2	.6919-01	.0000	-.4422+00	.0000	.3649-02	.0000
3	.1271+00	.0000	-.8576+00	.0000	.3311-02	.0000
4	.1719+00	.0000	-.1224+01	.0000	.2814-02	.0000
5	.2035+00	.0000	-.1525+01	.0000	.2221-02	.0000
6	.2233+00	.0000	-.1753+01	.0000	.1591-02	.0000
7	.2337+00	.0000	-.1906+01	.0000	.9869-03	.0000
8	.2375+00	.0000	-.1993+01	.0000	.4682-03	.0000
9	.2376+00	.0000	-.2025+01	.0000	.9629-04	.0000
10	.2361+00	.0000	-.2017+01	.0000	-.1653-03	.0000
11	.2346+00	.0000	-.2002+01	.0000	.5823-06	.0000
12	.2332+00	.0000	-.2017+01	.0000	.1668-03	.0000
13	.2318+00	.0000	-.2025+01	.0000	-.9485-04	.0000
14	.2320+00	.0000	-.1993+01	.0000	-.4671-03	.0000
15	.2359+00	.0000	-.1907+01	.0000	-.9862-03	.0000
16	.2465+00	.0000	-.1753+01	.0000	-.1591-02	.0000
17	.2664+00	.0000	-.1525+01	.0000	-.2221-02	.0000
18	.2981+00	.0000	-.1224+01	.0000	-.2815-02	.0000
19	.3430+00	.0000	-.8580+00	.0000	-.3312-02	.0000
20	.4011+00	.0000	-.4424+00	.0000	-.3651-02	.0000
21	.4704+00	.0000	.0000	.0000	-.3771-02	.0000
22	.0000	.0000	.0000	.0000	.0000	.0000

EQUIVALENT CASE
MEMBER END-ACTIONS

MEMBER	LRX	LRY	LRZ	LMX	LMY	LMZ	RRX	RRY	RRZ	RMX	RMY	RMZ
1	.7168+02	.0000	.4114+03	.0000	-.1096+00	.0000	-.7168+02	.0000	-.3208+03	.0000	-.4393+05	.0000
2	.6632+02	.0000	.3220+03	.0000	.4393+05	.0000	-.6632+02	.0000	-.2315+03	.0000	-.7714+05	.0000
3	.6245+02	.0000	.2325+03	.0000	.7714+05	.0000	-.6245+02	.0000	-.1420+03	.0000	-.9961+05	.0000
4	.6008+02	.0000	.1430+03	.0000	.9961+05	.0000	-.6008+02	.0000	-.5249+02	.0000	-.1113+06	.0000

5	.5919+02	.0000	.5350+02	.0000	.1113+06	.0000	-.5919+02	.0000	.3704+02	.0000	-.1123+06	.0000
6	.5980+02	.0000	-.3604+02	.0000	.1123+06	.0000	-.5980+02	.0000	.1266+03	.0000	-.1026+06	.0000
7	.6190+02	.0000	-.1256+03	.0000	.1026+06	.0000	-.6190+02	.0000	.2161+03	.0000	-.8207+05	.0000
8	.6550+02	.0000	-.2150+03	.0000	.8207+05	.0000	-.6550+02	.0000	.3056+03	.0000	-.5084+05	.0000
9	.7058+02	.0000	-.3044+03	.0000	.5084+05	.0000	-.7058+02	.0000	.3949+03	.0000	-.8881+04	.0000
10	.7715+02	.0000	-.3937+03	.0000	.8881+04	.0000	-.7715+02	.0000	.4842+03	.0000	.4380+05	.0000
11	.7124+02	.0000	.4847+03	.0000	.4387+05	.0000	-.7124+02	.0000	-.3942+03	.0000	-.8869+04	.0000
12	.6466+02	.0000	.3953+03	.0000	.8869+04	.0000	-.6466+02	.0000	-.3048+03	.0000	-.5088+05	.0000
13	.5957+02	.0000	.3058+03	.0000	.5088+05	.0000	-.5957+02	.0000	-.2153+03	.0000	-.8215+05	.0000
14	.5597+02	.0000	.2163+03	.0000	.8215+05	.0000	-.5597+02	.0000	-.1258+03	.0000	-.1027+06	.0000
15	.5387+02	.0000	.1267+03	.0000	.1027+06	.0000	-.5387+02	.0000	-.3615+02	.0000	-.1124+06	.0000
16	.5326+02	.0000	.3706+02	.0000	.1124+06	.0000	-.5326+02	.0000	.5348+02	.0000	-.1115+06	.0000
17	.5414+02	.0000	-.5257+02	.0000	.1115+06	.0000	-.5414+02	.0000	.1431+03	.0000	-.9971+05	.0000
18	.5651+02	.0000	-.1422+03	.0000	.9971+05	.0000	-.5651+02	.0000	.2327+03	.0000	-.7722+05	.0000
19	.6038+02	.0000	-.2317+03	.0000	.7722+05	.0000	-.6038+02	.0000	.3223+03	.0000	-.4398+05	.0000
20	.6574+02	.0000	-.3212+03	.0000	.4398+05	.0000	-.6574+02	.0000	.4118+03	.0000	.3152-01	.0000
21	-.9677+03	.0000	-.5906+01	.0000	.7087+02	.0000	.9677+03	.0000	.5906+01	.0000	.7087+02	.0000

EQUIVALENT CASE
SUPPORT REACTIONS

JOINT	ARX	ARY	ARZ	AMX	AMY	AMZ
1	.5917+01	.0000	.4175+03	.0000	.0000	.0000
21	.0000	.0000	.4170+03	.0000	.0000	.0000
22	-.5906+01	.0000	.9677+03	.0000	.7087+02	.0000

STRUCTURE DATA

M	N	NJ	NR	NRJ	E	G
22	119	23	19	4	29000.	11197.

COORDINATES OF JOINTS

JOINT	X	Y	Z
1	.00	.00	.00
2	118.50	.00	18.92
3	237.29	.00	35.86
4	356.36	.00	50.82
5	475.65	.00	63.80
6	595.15	.00	74.78
7	714.81	.00	83.77
8	834.60	.00	90.77
9	954.50	.00	95.77
10	1074.46	.00	98.77
11	1194.45	.00	99.77
12	1314.45	.00	98.77
13	1434.41	.00	95.77
14	1554.30	.00	90.77
15	1674.10	.00	83.77
16	1793.76	.00	74.78
17	1913.25	.00	63.80
18	2032.55	.00	50.82
19	2151.61	.00	35.86
20	2270.41	.00	18.92
21	2388.90	.00	.00
22	1194.45	.00	123.77
23	1194.45	.00	75.77

MEMBER INFORMATION

MEMBER	JJ	JK	AX	KT	YI	ZI	IAA	LENGTH

1	1	2	213.67	395742.71	729325.48	228798.31	0	120.00
2	2	3	213.67	395742.71	729325.48	228798.31	0	120.00
3	3	4	213.67	395742.71	729325.48	228798.31	0	120.00
4	4	5	213.67	395742.71	729325.48	228798.31	0	120.00
5	5	6	213.67	395742.71	729325.48	228798.31	0	120.00
6	6	7	213.67	395742.71	729325.48	228798.31	0	120.00
7	7	8	213.67	395742.71	729325.48	228798.31	0	120.00
8	8	9	213.67	395742.71	729325.48	228798.31	0	120.00
9	9	10	229.59	429431.30	458045.83	151229.03	0	120.00
10	10	11	229.59	429431.30	458045.83	151229.03	0	120.00
11	11	12	229.59	429431.30	458045.83	151229.03	0	120.00
12	12	13	229.59	429431.30	458045.83	151229.03	0	120.00
13	13	14	213.67	395742.71	729325.48	228798.31	0	120.00
14	14	15	213.67	395742.71	729325.48	228798.31	0	120.00
15	15	16	213.67	395742.71	729325.48	228798.31	0	120.00
16	16	17	213.67	395742.71	729325.48	228798.31	0	120.00
17	17	18	213.67	395742.71	729325.48	228798.31	0	120.00
18	18	19	213.67	395742.71	729325.48	228798.31	0	120.00
19	19	20	213.67	395742.71	729325.48	228798.31	0	120.00
20	20	21	213.67	395742.71	729325.48	228798.31	0	120.00
21	11	22	.01	1.00	1.00	99999999.00	0	24.00
22	11	23	.01	1.00	1.00	99999999.00	0	24.00

IUBW= 12

JOINT RESTRAINTS

JOINT	RRX	RRY	RRZ	RMX	RMY	RMZ
1	1	1	1	1	0	0
21	0	1	1	1	0	0
22	1	1	1	1	1	1
23	1	1	1	1	1	1

LOADING NO. 4

NLJ
1

ACTIONS APPLIED AT JOINTS

JOINT	RX	RY	RZ	MX	MY	MZ
6	.00	.00	.00	1.00	.00	.00

JOINT DISPLACEMENTS

JOINT	DX	DY	DZ	DMX	DMY	DMZ
1	.0000	.0000	.0000	.0000	.0000	.1532-08
2	.0000	.9665-07	.0000	.1322-07	.0000	.2205-08
3	.0000	.5627-07	.0000	.2648-07	.0000	.2772-08
4	.0000	-.8133-07	.0000	.3975-07	.0000	.3233-08
5	.0000	-.2762-06	.0000	.5305-07	.0000	.3588-08
6	.0000	-.4882-06	.0000	.6637-07	.0000	.3835-08
7	.0000	-.5959-06	.0000	.5267-07	.0000	.3303-08
8	.0000	-.5498-06	.0000	.3897-07	.0000	.2812-08
9	.0000	-.3999-06	.0000	.2526-07	.0000	.2361-08
10	.0000	-.1980-06	.0000	.1263-07	.0000	.1944-08
11	.0000	-.6409-14	.0000	.5228-12	.0000	.1453-08
12	.0000	.1437-06	.0000	-.1724-10	.0000	.9520-09
13	.0000	.2305-06	.0000	-.3481-10	.0000	.5042-09
14	.0000	.2747-06	.0000	-.4565-10	.0000	.2431-09
15	.0000	.2896-06	.0000	-.5272-10	.0000	.1697-10
16	.0000	.2794-06	.0000	-.5573-10	.0000	-.1744-09
17	.0000	.2482-06	.0000	-.5441-10	.0000	-.3311-09
18	.0000	.2004-06	.0000	-.4846-10	.0000	-.4532-09
19	.0000	.1402-06	.0000	-.3760-10	.0000	-.5407-09

20	.0000	.7200-07	.0000	-.2154-10	.0000	-.5937-09
21	.0000	.0000	.0000	.0000	.0000	-.6122-09
22	.0000	.0000	.0000	.0000	.0000	.0000
23	.0000	.0000	.0000	.0000	.0000	.0000

MEMBER END-ACTIONS

MEMBER	LRX	LRY	LRZ	LMX	LMY	LMZ	RRX	RRY	RRZ	RMX	RMY	RMZ
1	.0000	-.1614-04	.0000	-.4861+00	.0000	.7762-01	.0000	.1614-04	.0000	.4861+00	.0000	-.7956-01
2	.0000	-.1614-04	.0000	-.4874+00	.0000	.7144-01	.0000	.1614-04	.0000	.4874+00	.0000	-.7338-01
3	.0000	-.1614-04	.0000	-.4885+00	.0000	.6525-01	.0000	.1614-04	.0000	.4885+00	.0000	-.6718-01
4	.0000	-.1614-04	.0000	-.4896+00	.0000	.5903-01	.0000	.1614-04	.0000	.4896+00	.0000	-.6097-01
5	.0000	-.1614-04	.0000	-.4905+00	.0000	.5280-01	.0000	.1614-04	.0000	.4905+00	.0000	-.5474-01
6	.0000	-.1614-04	.0000	.5058+00	.0000	-.2838-01	.0000	.1614-04	.0000	-.5058+00	.0000	.2644-01
7	.0000	-.1614-04	.0000	.5062+00	.0000	-.1801-01	.0000	.1614-04	.0000	-.5062+00	.0000	.1607-01
8	.0000	-.1613-04	.0000	.5064+00	.0000	-.7632-02	.0000	.1613-04	.0000	-.5064+00	.0000	.5696-02
9	.0000	-.1613-04	.0000	.5064+00	.0000	.2744-02	.0000	.1613-04	.0000	-.5064+00	.0000	-.4680-02
10	.0000	-.1613-04	.0000	.5062+00	.0000	.1312-01	.0000	.1613-04	.0000	-.5062+00	.0000	-.1505-01
11	.0000	.1614-04	.0000	.5443-03	.0000	.1928-01	.0000	-.1614-04	.0000	-.5443-03	.0000	-.1734-01
12	.0000	.1614-04	.0000	.2553-03	.0000	.1735-01	.0000	-.1614-04	.0000	-.2553-03	.0000	-.1541-01
13	.0000	.1614-04	.0000	-.1603-05	.0000	.1541-01	.0000	-.1614-04	.0000	.1603-05	.0000	-.1348-01
14	.0000	.1613-04	.0000	-.2262-03	.0000	.1348-01	.0000	-.1613-04	.0000	.2262-03	.0000	-.1154-01
15	.0000	.1613-04	.0000	-.4185-03	.0000	.1153-01	.0000	-.1613-04	.0000	.4185-03	.0000	-.9597-02
16	.0000	.1613-04	.0000	-.5784-03	.0000	.9589-02	.0000	-.1613-04	.0000	.5784-03	.0000	-.7653-02
17	.0000	.1613-04	.0000	-.7058-03	.0000	.7642-02	.0000	-.1613-04	.0000	.7058-03	.0000	-.5706-02
18	.0000	.1613-04	.0000	-.8008-03	.0000	.5694-02	.0000	-.1613-04	.0000	.8008-03	.0000	-.3758-02
19	.0000	.1613-04	.0000	-.8634-03	.0000	.3744-02	.0000	-.1613-04	.0000	.8634-03	.0000	-.1808-02
20	.0000	.1613-04	.0000	-.8934-03	.0000	.1793-02	.0000	-.1613-04	.0000	.8934-03	.0000	.1426-03
21	.0000	-.1581-01	.0000	.6778-06	.0000	-.2529+00	.0000	.1581-01	.0000	-.6778-06	.0000	-.1265+00
22	.0000	.1578-01	.0000	-.6778-06	.0000	.2525+00	.0000	-.1578-01	.0000	.6778-06	.0000	.1262+00

SUPPORT REACTIONS

JOINT	ARX	ARY	ARZ	AMX	AMY	AMZ
1	.0000	-.1614-04	.0000	-.4923+00	.0000	.0000
21	.0000	-.1613-04	.0000	.9047-03	.0000	.0000
22	.0000	.1581-01	.0000	.1265+00	.0000	-.6778-06
23	.0000	-.1578-01	.0000	.1262+00	.0000	-.6778-06

EQUIVALENT CASE
JOINT DISPLACEMENTS

JOINT	DX	DY	DZ	DMX	DMY	DMZ
1	.0000	.0000	.0000	.0000	.0000	-.3746-05
2	.0000	-.2999-03	.0000	-.2099-04	.0000	-.4709-05
3	.0000	-.3864-03	.0000	-.3729-04	.0000	-.5100-05
4	.0000	-.3423-03	.0000	-.4886-04	.0000	-.5024-05
5	.0000	-.2346-03	.0000	-.5570-04	.0000	-.4584-05
6	.0000	-.1149-03	.0000	-.5780-04	.0000	-.3886-05
7	.0000	-.1887-04	.0000	-.5515-04	.0000	-.3035-05
8	.0000	.3373-04	.0000	-.4774-04	.0000	-.2136-05
9	.0000	.3882-04	.0000	-.3557-04	.0000	-.1293-05
10	.0000	.1729-04	.0000	-.1998-04	.0000	-.5154-06
11	.0000	-.4404-10	.0000	-.1838-08	.0000	-.5651-11
12	.0000	.1729-04	.0000	-.1998-04	.0000	.5154-06
13	.0000	.3881-04	.0000	-.3557-04	.0000	.1293-05
14	.0000	.3373-04	.0000	-.4774-04	.0000	.2136-05
15	.0000	-.1887-04	.0000	-.5515-04	.0000	.3035-05
16	.0000	-.1149-03	.0000	-.5780-04	.0000	.3886-05
17	.0000	-.2346-03	.0000	-.5570-04	.0000	.4584-05
18	.0000	-.3423-03	.0000	-.4886-04	.0000	.5024-05
19	.0000	-.3864-03	.0000	-.3729-04	.0000	.5100-05
20	.0000	-.2999-03	.0000	-.2099-04	.0000	.4709-05
21	.0000	.0000	.0000	.0000	.0000	.3746-05

22	.0000	.0000	.0000	.0000	.0000	.0000
23	.0000	.0000	.0000	.0000	.0000	.0000

EQUIVALENT CASE
MEMBER END-ACTIONS

MEMBER	LRX	LRY	LRZ	LMX	LMY	LMZ	RRX	RRY	RRZ	RMX	RMY	RMZ
1	.0000	-.1109+00	.0000	.8589+03	.0000	-.1371+03	.0000	.1109+00	.0000	-.6834+03	.0000	.1238+03
2	.0000	-.1109+00	.0000	.6854+03	.0000	-.1124+03	.0000	.1109+00	.0000	-.5098+03	.0000	.9913+02
3	.0000	-.1109+00	.0000	.5114+03	.0000	-.9062+02	.0000	.1109+00	.0000	-.3359+03	.0000	.7731+02
4	.0000	-.1109+00	.0000	.3371+03	.0000	-.7170+02	.0000	.1109+00	.0000	-.1616+03	.0000	.5840+02
5	.0000	-.1109+00	.0000	.1626+03	.0000	-.5570+02	.0000	.1109+00	.0000	.1294+02	.0000	.4239+02
6	.0000	-.1109+00	.0000	-.1224+02	.0000	-.4260+02	.0000	.1109+00	.0000	.1878+03	.0000	.2930+02
7	.0000	-.1109+00	.0000	-.1872+03	.0000	-.3243+02	.0000	.1109+00	.0000	.3628+03	.0000	.1912+02
8	.0000	-.1109+00	.0000	-.3624+03	.0000	-.2516+02	.0000	.1109+00	.0000	.5379+03	.0000	.1186+02
9	.0000	-.1109+00	.0000	-.5376+03	.0000	-.2082+02	.0000	.1109+00	.0000	.7132+03	.0000	.7520+01
10	.0000	-.1109+00	.0000	-.7129+03	.0000	-.1940+02	.0000	.1109+00	.0000	.8885+03	.0000	.6100+01
11	.0000	.1109+00	.0000	.8885+03	.0000	-.6100+01	.0000	-.1109+00	.0000	-.7129+03	.0000	.1940+02
12	.0000	.1109+00	.0000	.7132+03	.0000	-.7520+01	.0000	-.1109+00	.0000	-.5376+03	.0000	.2082+02
13	.0000	.1109+00	.0000	.5379+03	.0000	-.1186+02	.0000	-.1109+00	.0000	-.3624+03	.0000	.2516+02
14	.0000	.1109+00	.0000	.3628+03	.0000	-.1912+02	.0000	-.1109+00	.0000	-.1872+03	.0000	.3243+02
15	.0000	.1109+00	.0000	.1878+03	.0000	-.2930+02	.0000	-.1109+00	.0000	-.1224+02	.0000	.4260+02
16	.0000	.1109+00	.0000	.1294+02	.0000	-.4240+02	.0000	-.1109+00	.0000	.1626+03	.0000	.5570+02
17	.0000	.1109+00	.0000	-.1616+03	.0000	-.5840+02	.0000	-.1109+00	.0000	.3371+03	.0000	.7170+02
18	.0000	.1109+00	.0000	-.3359+03	.0000	-.7731+02	.0000	-.1109+00	.0000	.5114+03	.0000	.9062+02
19	.0000	.1109+00	.0000	-.5098+03	.0000	-.9913+02	.0000	-.1109+00	.0000	.6854+03	.0000	.1124+03
20	.0000	.1109+00	.0000	-.6834+03	.0000	-.1238+03	.0000	-.1109+00	.0000	.8589+03	.0000	.1371+03
21	.0000	.5541+02	.0000	-.2637-08	.0000	.8871+03	.0000	-.5541+02	.0000	.2637-08	.0000	.4429+03
22	.0000	-.5563+02	.0000	.2637-08	.0000	-.8897+03	.0000	.5563+02	.0000	-.2637-08	.0000	-.4455+03

EQUIVALENT CASE
SUPPORT REACTIONS

JOINT	ARX	ARY	ARZ	AMX	AMY	AMZ
1	.0000	-.1109+00	.0000	.8698+03	.0000	.0000
21	.0000	-.1109+00	.0000	.8698+03	.0000	.0000
22	.0000	-.5541+02	.0000	-.4429+03	.0000	.2637-08
23	.0000	.5563+02	.0000	-.4455+03	.0000	.2637-08

DYNAMIC INFORMATION

TOTAL MASS = 1.1443

EQUIVALENT STIFFNESS KX = 3839.9819

EQUIVALENT STIFFNESS KY = 244.

EQUIVALENT STIFFNESS KZ = 474.7227

EQUIVALENT STIFFNESS KT = 15067591.

FREQUENCY WX = 9.2197

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      FREQUENCY WY   =      2.3239

      FREQUENCY WZ   =      3.2417

      FREQUENCY WT   =     12.9563

SPECTRUM VALUE AX    =      3.4579

SPECTRUM VALUE AY    =      2.8839

SPECTRUM VALUE AZ    =      4.0953

SPECTRUM VALUE AT    =      1.5440
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