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VERTICAL MOTION OF HIGHWAY BRIDGE STRUCTURES DUE TO AN EARTHQUAKE

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ABSTRACT

A study of the dynamic response of continuous highway bridge superstructures due to pulsating support settlements induced by an earthquake is presented. A governing differential equation for the dynamic behavior of bridge superstructures under pulsating support settlements has been formulated and a Fourier series type solution method is presented. The results thus obtained have been successfully compared to those obtained by a dynamic three moment equation. Four separate computer programs have been developed to facilitate the analysis and comparisons. The concept of dynamic amplification factors as the ratios of dynamic responses to static responses has been developed and subsequent charts are plotted. Unusually high dynamic amplifications are observed, particularly in shearing forces and the reasons for such high values have been traced.

KEY WORDS

Earthquake; Highway bridge; Pulsating support settlement; Dynamic three moment equation; Dynamic amplification factor; Natural frequency; Structural analysis; Structural design.

PREFACE

The investigation with interpretation as described in this report was sponsored by the National Science Foundation, under Grant No. PFR78-22845 covering the period January 1, 1979 through December 31, 1980.

The general investigation reported herein is under the supervision and Technical responsibility of Professors Chai Hong Yoo and Jao-Shiun Kao. Professor Yoo acts as principal investigator.

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I. INTRODUCTION

A. Statement of the Problem

One of the most prevalent and destructive forms of dynamic disturbances is the earthquake. Contrary to the commonly held belief that the California Coast is the only area subject to strong seismic disturbances, the records of the United States Coast and Geodetic Survey show that these destructive forces have been felt all over the country [22]*. Moreover, these records suggest that where significant shocks have occurred, reoccurrences are very probable, and that in regions of little seismic activity, major shocks are not to be ruled out entirely.

Up to the end of the nineteenth century, little, if any, attention was given to the earthquake forces in structural design. With the high concentration of the population in the twentieth century cities on one side, and with the development of displacement meters and accelerometers capable of recording earthquake motions on the other, more studies about the earthquake emerged in this century. The majority of these studies, however, focus on the horizontal component of the ground motion and on design provisions that would guard against failure due to this motion [9,10,13]. The vertical component of these forces may have a considerable effect on structures with larger horizontal dimensions such as highway bridges.

A review of the literature has revealed that the American highway and railroad bridge and design codes (AASHTO and AREA) do not specify any provisions against the vertical effect of eqrthquakes on bridges as opposed to the Japanese code which requires a vertical seismic coefficient of 0.1 to be considered in bridge design [1,7,19]. Recent

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*Numbers in square brackets refer to Reference numbers research reports on highway bridge structures [5,21] from the University of California, Berkeley, are rigorous but do not include the effects of pulsating support settlement on the superstructure. Dynamic differential support settlements are very likely to prevail during an earthquake because of the difference in vertical excitation as well as different soil properties under each support. It is therefore the objective of this investigation to establish appropriate mathematical models which will yield realistic and practical seismic responses for a reasonable range of bridge superstructures due to vertical disturbances. Further, computer programs are written to carry out time - history dynamic analysis as well as to determine natural frequencies of bridge superstructures.

B. Scope of Present Investigation

The present investigation is a study of the dynamic response of highway bridge superstructures due to pulsating support settlements induced by earthquake excitation.

Chapter II presents the formulation of a governing differential equation for the dynamic behavior of bridge superstructures under pulsating support settlements. A Fourier series type solution method is discussed. A dynamic three moment equation is also discussed in Chapter II. Chapter III describes the general characteristic of four computer programs developed and the necessary input scheme and variables. Chapter IV discusses the computer programs further by using an actual example bridge analysis. The accuracy of the solution of the two methods is presented. The concept of dynamic amplification factors is developed and subsequent charts are included. Chapter V presents certain conclusions and recommendations. Finally, sample input and output data and the listings of the computer programs are presented in the Appendices.

II. METHOD OF ANALYSIS

A. General Discussion

A highway bridge superstructure may be subjected to additional stresses from the vertical excitations of an earthquake, arising from:

1) The inertial force acting on the bridge as a result of the rigid body translation and
2) The effect of the dynamic differential settlement of one or more of the piers. The stresses due to the inertial force can be readily obtained by assuming that the bridge is subjected to an additional static-equivalent uniformly distributed load of a magnitude of ma, where m is mass per unit length of bridge superstructure and a is acceleration of the rigid body translation. More rigorous analyses using the finite element method are found in Ref. [5,21].

As discussed earlier, the additional stresses due to the dynamic differential settlements requier further analysis. Presented in this chapter is a mathematical formulation to determine the additional stresses and deflections resulting from these settlements.

B. Fourier Series Formulation

A multispan highway bridge superstructure is modelled by a wide continuous beam with both ends pinned and intermediate supports. The beam is considered elastic and prismatic and the effects of axial and shear deformations, rotary inertia, and damping are not included in the formulation simply to make the model reasonably uncomplicated. It is of interest to determine the maximum deflection, moment, shear, velocity and acceleration at any time for any point along the span of a continuous beam subjected to dynamic differential support settlements. The steps taken to determine the maximum values of these functions are as follows:

1) The intermediate supports are removed, leaving an ordinary simple beam for which the differential equation, the vibration frequencies and normalized shape functions are known.
2) In lieu of the removed intermediate supports, constraints equivalent to the presence of these supports are imposed on the beam. The constraints are first transformed to concentrated loads on the simple beam, and then substituted by a generalized Fourier series in terms of normalized shape functions of the simple beam.
3) The deflection of the simple beam at any point along the span is also represented as a generalized Fourier series in terms of normalized shape functions of the beam.
4) Using the constraints at the intermediate supports as the necessary boundary conditions, the deflection function of the continuous beam is determined.
5) By successive differentiation of the deflection function with respect to the longitudinal coordinate along the span or with respect to time, moment and shear or velocity and acceleration functions are determined for the continuous beam.
6) Numerical values and subsequently the maximum values of these functions are evaluated by means of a computer program developed.

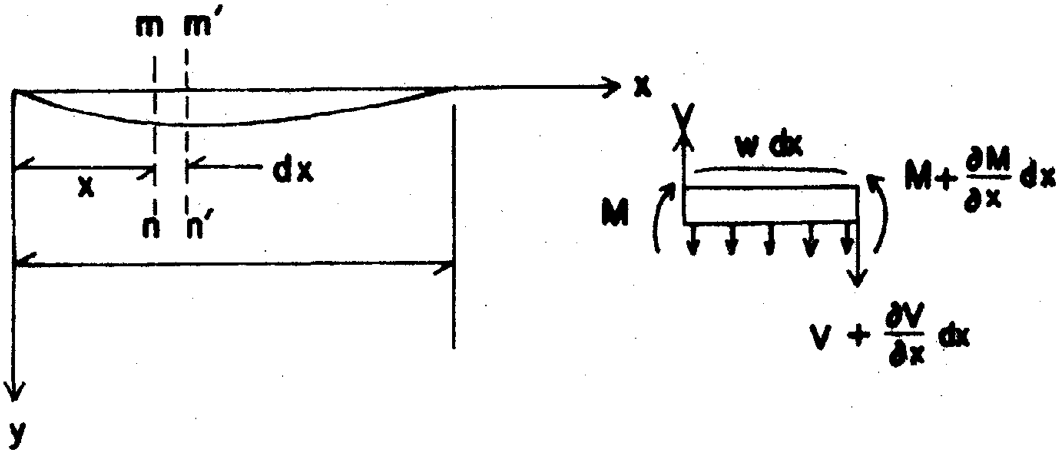
A similar procedure was used by Rogers [17] to investigate the dynamic behavior of a continuous beam subjected to a series of pulsating loads. Saibel and D'Appolonia [18] studied similar problems based on the energy of the system and Lagrangian constraints.

The differential equation governing the vibration behavior of a simple beam subjected to lateral forces as shown in Fig. 1 is given as

$$EI \frac{\partial^4 y}{\partial x^4} + m \frac{\partial^2 y}{\partial t^2} = w(x,t) \tag{1}$$

in which E is modulus of elasticity, I is moment of inertia of the beam cross section, m is mass per unit length and w(x,t) is distributed lateral load.

Fig. 1 - Coordinates and Force Elements



The natural frequencies of the simple beam are given as:

$$P_n = n^2 \pi^2 \sqrt{\frac{EI}{mL^4}} \tag{2}$$

in which P_n is the natural circular frequency of the simple beam vibrating in nth mode, and L is the span length of the simple beam. The normalized shape functions of the simple beams are readily obtainable and can be expressed as [4,14,17].

$$\bar{X}_n(x) = \sqrt{\frac{2}{mL}} \sin \frac{n\pi x}{L} \qquad (3)$$

in which $\bar{X}_n$ is the normalized shape function when the simple beam is vibrating in the nth mode. The deflection of the simple beam as a function of longitudinal coordinate and time is expressed as [4,17].

$$y(x,t) = \sum_n \sqrt{\frac{2}{mL}} \sin \frac{n\pi x}{L} q_n(t) \qquad (4)$$

in which $q_n(t)$ is a function of time only.

The constraints imposed by pulsating supports due to vertical earthquake excitations are idealized as the harmonic motions in this investigations.

$$y(x_i,t) = \Delta_i \sin (w_f t) \qquad (5)$$

in which x_i is the position of support i along the spar, Δ_i the amplitude of the ith support settlement, and w_f is the circular forcing frequency (i.e. the estimated earthquake vertical circular frequency at the bridge location). The forces which excite the motion given by Eq. (5) coincide in phase with the motion if damping is neglected. For a damped system, the forces are out of phase with the motion. As can be seen in

Eq. (4), the deflection or motion of the simple beam is given by a summation of the deflection modes from one to infinity. These modes are not necessarily in phase with each other, and thus the phase angle between the forces that produces the motion and the motion itself is a function of the mode of vibration. This can be written as

$$F_{in} = R_i \sin (w_f t - \alpha_n) \tag{6}$$

in which α_n is the phase angle between the force and the nth mode of vibration, R_i is the undetermined amplitude of the equivalent force for the support i due to the dynamic differential settlement, and F_{in} is the force at support i for the nth mode of vibration at any time t. If damping is neglected, F_{in} becomes simply:

$$F_{in} = R_i \sin w_f t \tag{7}$$

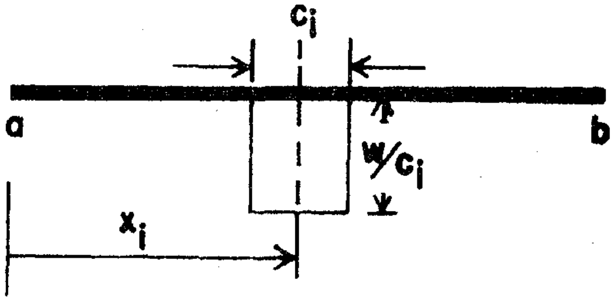
The Fourier series expression for F_{in} is given as

$$F_{in} = \sum_n A_{in} \bar{X}_n(x) \tag{8}$$

in which A_{in} is a constant for each model of vibration of the simple beam and is such that the series will correctly represent $F_{in}(t)$ along the span. Assuming that the concentrated load acts over an infinitely small distance c as shown in Fig. 2, and multiplying both sides of Eq. (8) by $m\, X_k(x)dx$ and integrating over the distance range leads to:

$$\int_{x_i - \frac{c}{2}}^{x_i + \frac{c}{2}} m\, F_{in}(t)\, \bar{X}_k(x)dx = \int_{x_i - \frac{c}{2}}^{x_i + \frac{c}{2}} m \sum_n A_{in}\bar{X}_n(x)\bar{X}_k(x)dx \tag{9}$$

Fig. 2 - Fourier Series Expression of a Concentrated Load



For a beam with no energy dissipation at its supports and with a constant flexural rigidity along its span, the shape functions are orthogonal functions, Eq. (9) reduces to:

$$\int_{x_i - \frac{c}{2}}^{x_i + \frac{c}{2}} m\, F_{in}\,(t)\; \bar{X}_n(x)dx = A_{in} \tag{10}$$

and in the limiting case when c approaches zero, Eq. (10) is evaluated in Stieltjes' sense as

$$A_{in} = m\, F_{in}(A)\; \bar{X}_n(x_i) \tag{11}$$

For a beam with a multiple of intermediate supports, the equivalent distributed load becomes

$$w(x,t) = \sum_i \sum_n m\, F_{in}\, \bar{X}_n(x_i)\; \bar{X}_n\,(x) \tag{12}$$

The deflection of the continuous beam can also be expressed in terms of normalized shape functions as follows

$$y(x,t) = \sum_n \bar{X}_n(x)\; q_n(t) \tag{13}$$

in which $q_n(t)$ is a function of time only for the nth mode of vibration. Eq. (12) is obtained by substitution of Eq. (3) into Eq. (4).

Substituting the expressing of $w(x,t)$ given in Eq. (11) into Eq. (1) yields:

$$EI \frac{\partial^4 y}{\partial x^4} + m \frac{\partial^2 y}{\partial t^2} = \sum_i \sum_n m\, F_{in}\, \bar{X}_n(x_i)\, \bar{X}_n(x) \tag{14}$$

Substituting the partial derivative of Eq. (13) into Eq. (14) gives:

$$\sum_n \frac{\partial^2}{\partial x^2} [EI\, \bar{X}_n''(x)]\, q_n(t) + \sum_n m\, \bar{X}_n(x)\ddot{q}_n(t) = \sum_i \sum_n m\, F_{in}\, \bar{X}_n(x_i)\, \bar{X}_u(x) \tag{15}$$

in which

$$\frac{\partial^2}{\partial x^2} [EI\, \bar{X}_n''(x)] = m\, p_n^2\, \bar{X}_n(x) \tag{16}$$

Subtituting Eq. (16) into Eq. (15) leads to

$$\ddot{q}_n(t) + P_n^2\, q_n(t) = \sum_i R_i\, \bar{X}_n(x_i) \quad \sin w_f t \tag{17}$$

Taking a solution to Eq. (17) to be

$$q_n(t) = D_{n1} \sin w_f t + D_{n2} \cos w_f t \tag{18}$$

Then

$$\dot{q}_n(t) = w_f\, D_{n1} \cos w_f t - w_f\, D_{n2} \sin w_f t \tag{19}$$

$$\ddot{q}_n(t) = -w_f^2\, D_{n1} \sin w_f t - w_f^2\, D_{n2} \cos w_f t \tag{20}$$

Substituting Eqs. (18) and (20) into Eq. (17) yields

$$-w_f^2(D_{n1} S \text{ in } w_f t + D_{n2} \text{ COS } w_f t) + P_n^2(P_{n1} S \text{ in } w_f t + D_{n2} \text{ COS } w_f t) \tag{21}$$

$$= \sum_i R_i \bar{X}_n(x_i) \text{ S in } w_f t$$

or

$$(P_n^2 - w_f^2)\, D_{n1} \, S_{in} \, w_f t + (P_n^2 - w_f^2)\, D_{n2} \text{ COS } w_f t \tag{22}$$

$$= \sum_i R_i \bar{X}_n(x_i) \text{ S in } w_f t$$

Equating the coefficients of sine and cosine functions on both sides gives

$$D_{n1} = \frac{\Sigma_i R_i \bar{X}_n(x_i)}{(P_n^2 - w_f^2)} \tag{23}$$

and

$$D_{n2} = o \tag{24}$$

Substituting Eqs. (18), (23) and(24) into Eq. (12) gives

$$y(x,t) = \sum_n \bar{X}_n(x) \frac{\Sigma_i R_i \bar{X}_n(x_i)}{P_n^2 - w_f^2} \sin w_f t \tag{25}$$

in which the magnitudes of the support force R_{is} can be determined from the constraints given by Eq. (5). Hence,

$$\sum_n \bar{X}_n (x_j) \frac{\Sigma_i R_i \bar{X}_n(x_i)}{P_n^2 - w_f^2} \sin w_f t = \Delta_j \sin w_f t \tag{26}$$

or

$$\sum_n \bar{X}_n(x_j) \frac{\Sigma_i R_i \bar{X}_n(x_i)}{P_n^2 - w_f^2} = \Delta_j \tag{27}$$

Eq. (27) is essentially a system of linear equations that has as many unknowns (R_{i_s}) as there are interior supports and can be solved readily.

It it of interest to note that Eq. (27) may also be used to evaluate the natural frequencies of the continuous beam. The system frequencies can be obtained by setting the constraints such that the deflection at each support is zero for every instant in in time. That is

$$y\ (x_j, t) \equiv 0 \text{ for all } t \tag{28}$$

which implies that

$$\Sigma_n\ \bar{X}_n\ (x_j)\ \frac{\Sigma_i R_i X_n(x_i)}{P_n^2 - w_f^2} = 0 \tag{29}$$

Eq. (29) is another system of linear equations. For a non-trival solution for R_{i_s}, the determinant must vanish. Using numerical methods (combined determinant search with convergency by Newton-Raphson method), a computer program has been developed to compute the system frequencies.

C. Dynamic Three Moment Equation

The governing differential equation for the free lateral vibration of an elastic beam with constant cross section shown in Fig. 1 is [4,6,12,14,15,20,23]

$$\frac{\partial^4 y}{\partial x^2} + \frac{m}{EI}\frac{\partial^2 y}{\partial y^2} = 0 \tag{30}$$

The solution of Eq. (30) for normal mode of vibration is given by

$$y = X \cdot q \tag{31}$$

in which

$$X = C_1 \sin \lambda x + C_2 \cos \lambda x + C_3 \sinh \lambda x + C_4 \cosh \lambda x \tag{32}$$

$$q = D_1 \sin pt + D_2 \cos pt \tag{33}$$

$$\lambda = \sqrt[4]{\frac{mp^2}{EI}} \tag{34}$$

X, the shape function, q, the time function, p, the circular frequency, C_1 to C_4 and D_1 and D_2 are the integration constants to be determined by boundary and initial conditions, respectively.

The moment and shear in the beam are

$$M = -EI \frac{\partial^2 y}{\partial x^2} \tag{35}$$

$$V = -EI \frac{\partial^3 y}{\partial x^3} \tag{36}$$

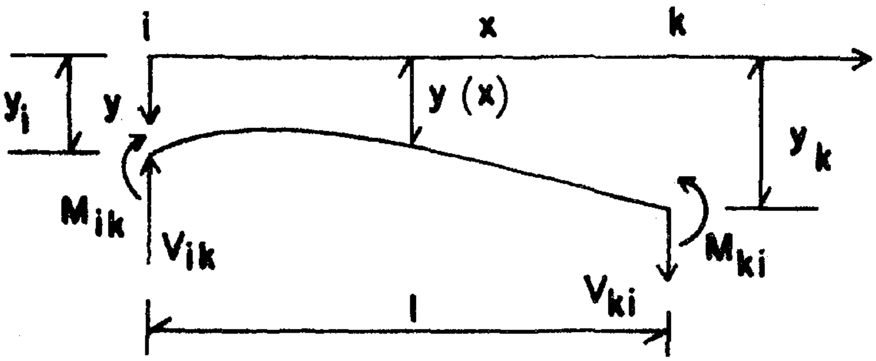
and in terms of shape function

$$\bar{M} = -EI \frac{\partial^2 X}{\partial x^3} \tag{37}$$

$$\bar{V} = -EI \frac{\partial^3 X}{\partial x^3} \tag{38}$$

Consider the case of a continuous beam with n spans, with (n-1) intermediate supports. Fig. 3 shows a typical interior span i ~ k with pulsating support settlements $y_i = \Delta_i \sin pt$ and $y_k = \Delta_k \sin pt$. The end condition to be satisfied may be interpreted for the shape function to be [14].

Fig. 3 - Boundary Conditions



$$X(0) = \Delta_i \tag{39}$$

$$X(\ell) = \Delta_k \tag{40}$$

$$X''(0) = -\frac{\overline{M}_{ik}}{EI} \tag{41}$$

$$X''(\ell) = -\frac{\overline{M}_{ki}}{EI} \tag{42}$$

Applying these four conditions, the four integral constants in Eq. (32) can be readily determined. Thus,

$$\begin{aligned} X(x) = {} & \frac{\overline{M}_{ik}}{2EI\lambda^2}\left[\frac{\sin\lambda(\ell-x)}{\sin\beta} - \frac{\sinh(\ell-x)}{\sinh\beta}\right] \\ & + \frac{\overline{M}_{ki}}{2EI\lambda^2}\left[\frac{\sin\lambda x}{\sin\beta} - \frac{\sinh\lambda x}{\sinh\beta}\right] \\ & + \frac{\Delta_i}{2}\left[\frac{\sin\lambda(\ell-x)}{\sin\beta} + \frac{\sinh\lambda(\ell-x)}{\sinh\beta}\right] \\ & + \frac{\Delta_k}{2}\left[\frac{\sin\lambda x}{\sin\beta} + \frac{\sinh\lambda x}{\sinh\beta}\right] \end{aligned} \tag{43}$$

in which $\beta = \lambda\ell$. The slopes $\Theta_i = X'(0)$, $\Theta_k = X'(\ell)$ take the following forms:

$$\Theta_i = \frac{\bar{M}_{ik}\ell}{2EI} H_1 (\beta) + \frac{\bar{M}_{ki}\ell}{2EI} H_2 (\beta) - \frac{\Delta_i}{2\ell} f_1 (\beta) + \frac{\Delta_k}{2\ell} f_2 (\beta) \tag{44}$$

$$\Theta_k = \frac{\bar{M}_{ki}\ell}{2EI} H_2 (\beta) - \frac{\bar{M}_{ki}\ell}{wEE2} H_1 (\beta) - \frac{\Delta_i}{2\ell} f_2 (\beta) + \frac{\Delta_i}{2\ell} f_1 (\beta) \tag{45}$$

in which

$$H_1 (\beta) = \frac{1}{\beta} (\coth \beta - \cot \beta) \tag{46}$$

$$H_2 (\beta) = \frac{1}{B} (\operatorname{cosec} \beta - \operatorname{cosech} \beta) \tag{47}$$

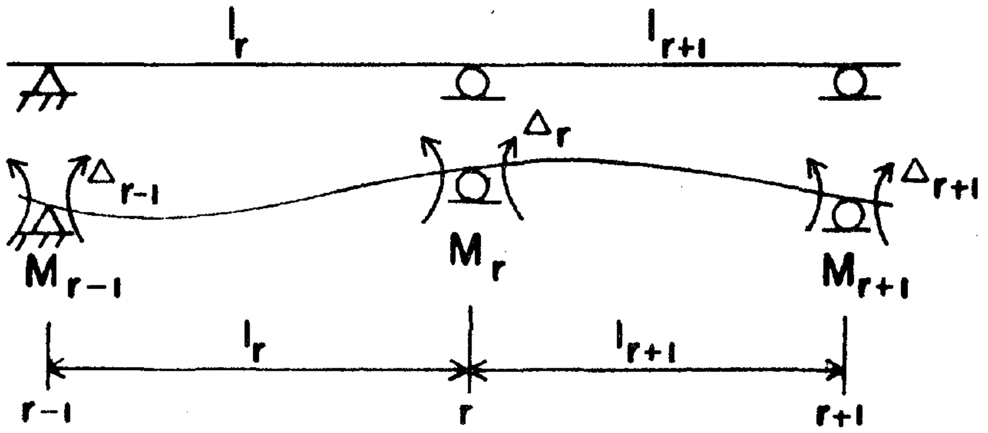
$$f_1 (\beta) = \beta (\coth B + \cot \beta) \tag{48}$$

$$f_2 (\beta) = \beta (\operatorname{cosec} B + \operatorname{cosech} \beta) \tag{49}$$

These quantities for various β values are given in Ref. [14].

Consider the two neighboring spans of a continuous beam as shown in Fig. 4.

Fig. 4 - Compatibility Conditions



Rewriting Eqs. (44) and (45) with appropriate notations given in Fig. 4 and making use of the condition of compatibility on the support 4, leads to the following equation:

$$\bar{M}_{r-1}\left[\frac{\ell_r}{I_r}H_2(\beta_r)\right] + \bar{M}_r\left[\frac{\ell_r}{I_r}H_1(\beta_r) + \frac{\ell_{r+1}}{I_{r+1}}\right] + M_{r+1}\left[\frac{\ell_{r+1}}{I_{r+1}}H_2(\beta_{r+1})\right]$$

$$= E\left\{\frac{f_2(\beta_r)}{\ell_r}\Delta_{r-1} - \left[\frac{f_1(\beta_{r+1})}{\ell_{r+1}} + \frac{f_1(\beta_r)}{I_r}\right]\Delta_r + \frac{f_2(\beta_{r+1})}{\ell_{r+1}}\Delta_{r+1}\right\} \tag{50}$$

Multiplying Eq. (50) by a constant quantity, I_c, and introducing reduced lengths of the span ($\ell_r' = \ell_r \frac{I_c}{I_r}$, $\ell_{r+1}' = \ell_{r+1}\frac{I_c}{I_{r+1}}$, etc.) yields

$$\bar{M}_{r-1}\left[\ell_r' H_2(\beta_r)\right] + \bar{M}_r\left[\ell_r' H_1(\beta_r) + \ell_{r+1}' H_1(\beta_{r+1}) + \bar{M}_{r+1}\left[\ell_{r+1}' H_2(\beta_{r+1})\right]\right.$$

$$= -EI_c\left\{\frac{f_2(\beta_r)}{\ell_r}\Delta_{r-1} - \left[\frac{f_1(\beta_r)}{\ell_r} + \frac{f_1(\beta_{r+1})}{\ell_{r+1}}\right]\Delta_r + \frac{f_2(\beta_{r+1})}{\ell_{r+1}}\Delta_{r+1}\right\} \tag{51}$$

in which $r = 1, 2, 3, \ldots, n$. Eq. (51) is known as dynamic three moment equation. It is equivalent to the three moment equation used in static analysis. It should be noted that when Δ_{r-1}, Δ_r, Δ_{r+1} are equal to zero, i.e. no support settlements, eq. (51) reduces to the same one as given in Ref. [4,17].

In a particular case when p (circular frequency) approaches to zero (hence $\beta = 0$), quantities shown in Eqs. (46), (47), (48), and (49) take $H_1(0) = 2/3$, $H_2(0) = 1/3$, $f_1(0) = f_2(0) = 2$.

Substituting these limiting values into Eq. (50) and rearranging yields

$$\bar{M}_{r-1}\frac{\ell_r}{I_r} + 2\bar{M}_r\left(\frac{\ell_r}{I_r} + \frac{\ell_{r+1}}{I_{r+1}}\right) + \bar{M}_{r+1}\frac{\ell_{r+1}}{I_{r+1}}$$

$$= -6E\left[\frac{\Delta_{r-1}}{\ell_r} + \left(\frac{1}{\ell_r} + \frac{1}{\ell_{r+1}}\right)\Delta_r + \frac{\Delta_{r+1}}{\Delta_{r+1}}\right] \tag{52}$$

Eq. (52) is a typical static three moment equation subjected to support settlements only.

The determination of the deflection, moment or shear at any point along the beam span necessitates the solution of the system of linear equations given in Eq. (50) or Eq. (51) as the first step. For any support settlement combination, the deflection amplitude at any location can then be determined by utilizing Eq. (43). Likewise, Eqs. (37) and (38) are used to determine the moment and shear at any point along the beam span are

$$\bar{M} = \frac{\bar{M}_{ik}}{2}\left[\frac{\sin\lambda(\ell-x)}{\sin\beta} + \frac{\sinh\lambda(\ell-x)}{\sinh\beta}\right] + \frac{\bar{M}_{ki}}{2}\left(\frac{\sin\lambda x}{\sin\beta} + \frac{\sinh\lambda x}{\sinh\beta}\right)$$

$$+ \frac{\Delta_i}{2}\left[\frac{\lambda^2\sin\lambda(\ell-x)}{\sin\beta} - \frac{\lambda^2\sinh\lambda(\ell-x)}{\sinh\beta}\right]EI + \frac{\Delta_k}{2}\left(\frac{\lambda^2\sin\lambda x}{\sin\beta} - \frac{\lambda^2\sinh\lambda x}{\sinh\beta}\right)EI \tag{53}$$

$$\bar{V} = \frac{\bar{M}_{ik}}{2}\left[\frac{\lambda\cos\lambda(\ell-x)}{\sin\beta} + \frac{\lambda\cosh\lambda(\ell-x)}{\sinh\beta}\right] + \frac{\bar{M}_{ki}}{2}\left(\frac{\lambda\cos\lambda x}{\sin\beta} + \frac{\lambda\cosh\lambda x}{\sinh\beta}\right)$$

$$+ \frac{\Delta_i}{2}\left[\frac{-\lambda^3\cos\lambda(\ell-x)}{\sin\beta} + \frac{\lambda^3\cosh\lambda(\ell-x)}{\sinh\beta}\right]EI + \frac{\Delta_k}{2}\left(\frac{\lambda^3\cos\lambda x}{\sin\beta} - \frac{\lambda^3\cosh\lambda x}{\sinh\beta}\right)EI \tag{54}$$

The fundamental circular frequency of the system can be determined using the dynamic three moment equation, Eq. (51) by equating the determinant for the unknown support moments to zero. For multispan continuous beams, Newton-Raphson type numerical method may be utilized.

D. Static Three Moment Equations

The homogeneous differential equation for flexure for an elastic beam with constant cross section is

$$EI \frac{\partial^4 y}{dx^4} = 0 \tag{55}$$

The solution of Eq. (55) is given by

$$y = C_1 x^3 + C_2 x^2 + C_3 x + C_4 \tag{56}$$

in which the integral constants C_1 to C_4 can be determined by the boundary conditions. The boundary conditions for the beam shown in Fig. 3 are

$$y\ (0) = \Delta_i \tag{57}$$

$$y\ (\ell) = \Delta_k \tag{58}$$

$$y''(0) = \frac{M_{ik}}{EI} \tag{59}$$

$$y''(\ell) = \frac{M_{ki}}{EI} \tag{60}$$

Applying these boundary conditions to Eq. (56) gives

$$y(x) = \left(\frac{x^3}{6\ell} - \frac{x^2}{2} - \frac{x\ell}{3}\right) \frac{M_{ik}}{EI} + \left(\frac{-x^3}{6\ell} + \frac{x\ell}{6}\right) \frac{M_{ki}}{EI} + \left(1 - \frac{x}{\ell}\right) \Delta_i + \left(\frac{x}{\ell}\right) \Delta_k \tag{61}$$

The moment and shear functions are

$$M(x) = (1 - \frac{x}{\ell})\, M_{ik} + (\frac{x}{\ell})\, M_{ki} \tag{62}$$

$$V(x) = \frac{M_{ik}}{\ell} + \frac{M_{ki}}{\ell} \tag{63}$$

Following a procedure similar to the one used in dynamic three moment equation, the static three moment equation is obtained as given in Eq. (52).

E. Limitation of Application

Recall Eqs. (29) and (50) which are used to determine the fundamental circular frequency of the system by setting the determinant for the unknown reactions or moments at each support equal to zero. However, the determinant does not have to vanish to satisfy the linear homogeneous equations, Eq. (29) or Eq. (50) for vibration modes composed of a series of the first vibration mode of an identical single span when the n spans are identical. Because of the symmetry, the reactions or moment at each interior support becomes zero and Eq. (29) and Eq. (50) are automatically satisfied regardless of the coefficient determinant. For these cases the frequencies are exactly equal to multiples of a simple beam frequencies and can thus be readily determined. Another approach to this difficulty is to use a slightly different span lengths within the range of numerical stability to avoid this phenomenon.

III. COMPUTER PROGRAMS

A. General Information

The formulations presented in Chapter II were programmed for use in a digital computer in ANSI Fortran program languages. A brief description of these computer programs and their input requirements is given in the next section of this chapter. Input and output examples are shown in Appendix I, while aprogram source listing is present in Appendix II. Two of the programs utilize the LINV3F subprogram developed by the International Mathematical and Statistical Library Company for the solution of systems of linear simultaneous equations and the determinant evaluation.

B. The Dynamic Fourier Series Program (DYNAMIC)

This program utilizes the Fourier series formulation presented in Chapter II. It has the capability of evaluating deflection, moment and shear induced by the pulsating intermediate bridge supports, as well as bridge natural frequencies. The program has three options. The first is to calculate the deflection, moment and shear. These functions may be evaluated for prescribed locations on the span over an input time range, or for specific instances of time over a distance range along the span. The second option is to determine the bridge natural frequencies only. When both the frequencies and the internal force functions are described, the third option must be used.

This program consists of a drive program and three subroutines in addition to the LINV3F subprogram of the IMSL programs library. The three subroutines are MAIN, FREQ and FX.

Subroutine MAIN consists of:

1) a read-write block, in which the options and parameters are read in and echoed.
2) a block for the determination of the loaded equivalent to the support settlements induced by the earthquake (see Eq. (26)). The LINV3F subprogram of the IMSL library is called for inversion in this block.
3) a block in which the functions are evaluated in accordance with Eq. (25) and its derivatives.
4) a block for the determination of the maximum values.
5) an output block for the functions evaluated.

When the second option is utilized, the MAIN subroutine calls FREQ subroutine and skips over the remaining blocks.

When the third option is chosen, MAIN calls FREQ before the execution of the remaining blocks. FREQ subroutine utilizes the Newton-Raphson method of search and successive convergence for the determination of the natural frequencies. This subroutine calls the FX subroutine to set up the matrix of coefficients, Eq. (29), for the evaluation of their determinant. The determinant evaluation is carried out by LINV3F subprograms.

It is very important that the input sequential order is strictly adhered to and consistent units are used throughout a problem. The input for this program is as follows:

CARD 1: HEAD

HEAD = a title composed of up to 80 alpha-numeric characters

CARD 2: NFREQ, NSPAN, NTERM, NPOINT, IOPT, IPLOT, IEQSP, TL, SM, E, XI, DT, TINT, WF

NFREQ = the number of natural frequencies desired

NSPAN = the number of spans

NTERM = the number of terms to be summed in fourier series

NPOINT = the number of locations to be investigated

IOPT = 1, when the calculation of deflection, moment and shear functions only is desired

= 2, when the calculation of the natural circular frequencies only is desired

= 3, when the calculation of the deflection, moment and shear functions as well as the natural frequencies is desired

IPLOT = 1, if an output file of data for the plotting is desired

= 0, if no such file is desired

IEQSP = 1, when the bridge consists of equal spans

= 0, when the bridge consists of unequal spans

TL = total length of the bridge

SM = mass per unit length

E = Young's modulus

XI = moment of inertia of the bridge cross section

DT = duration of earthquake

TINT = time increment within DT

WF = earthquake circular frequency

CARD 3: DEL(I)

DEL(I) = the amplitude of settlement of the ith support

CARD 4: XL(I)

XL(I) = the distance to the ith support measured from the left abutment

CARD 5: X(J)

X(J) = the distance coordinate of the jth point along the span measured from the left abutment

CARD 6: IMAX, EPS1

IMAX = the maximum number of iterations allowed for the determination of the natural frequencies

EPS1 = acceptable tolerance in the frequency computation

C. The Three Moment Equation Program (MOM3)

This program utilizes the dynamic three moment equation presented in the previous chapter. This program has the same three options available in the DYNAMIC program. It consists of a drive program and three subroutines. This program also utilizes the LINV3F subprogram of the IMSL library. The three subroutines of this program are MOMAIN, MOFREQ and MOFX.

1) an intialization and read-write block in which the options and parameters are read in and echoed out.

2) a block for the calculation of the moments at the supports in accordance with Eq. (50). The inversion is carried out by the use of LINV3F subprogram.

3) a block in which the functions are evaluated using, Eqs. (43), (53), and (54).

4) a block for the determination of the maximum values.

5) an output block for the function evaluated.

When the second option is chosen, the MOMAIN subroutine calls MOFREQ subroutine and skips over the last four blocks discussed aobve. When the third option is used, MOMAIN calls MOFREQ before the execution of the last four blocks. As in the DYNAMIC program, the MOFREQ subroutine utilizes the Newton-Raphson method for the determination of the natural frequencies. This subroutine then calls the MOFX to set up the matrix of coefficients of the moments for the evaluation of their determinant in accordance with Eq. (50). The determinant evaluation is performed by LINV3F program.

It is required that the input sequential order is strictly adhered to and consistent units are used through a problem. The input sequence and the meanings of the variables which are not explained previously are as follows:

CARD 1: HEAD

CARD 2: IOPT, NSPAN, IEQSP

Skip Card 3 if IOPT = 1

CARD 3: NFEQ, IMAX, EPS1

Skip Card 4 if IOPT = 2

CARD 4: ITYPE, NPOINT, WF, SXORT, XTINT

ITYPE = a four character alpha-numeric string that should be input as TIME when it is desired to have the variation of the functions with respect to time for specific locations on the bridge, or as DIST when it is desired to have the variation of the functions along the span at specific instances in time

NPOINT = the number of points along the span if ITYPE = TIME, or the number of points in time for which the functions are to be evaluated for specific points along the span if ITYPE = DIST

SXORT = the duration of an earthquake if ITYPE = TIME, or total span length if ITYPE = DIST

XTINT = time interval for the time-history if ITYPE = TIME, or distance interval along the span for which the functions are to be evaluated if ITYPE = DIST

CARD 5: SL(I), YM(I), SI(I), SSAM(2)

SL(I) = ith span, length

YM(I) = ith span, Young's modulus

SI(I) = ith span, moment of inertia

SSAM(I) = ith span, mass per unit length

Skip next two cards if IOPT = 2

CARD 6: DELMAX(J)

DELMAX(J) = the amplitude of the settlement of the jth support

CARD 7: XT(N)

XT(N) = the distance coordinate of nth point when ITYPE = TIME,
or
the time coordinate of nth point when ITYPE = DIST

D. The Static Three Moment Equation Program (MOM3ST)

This is a program to evaluate the deflection, moment, and shear along the span of a continuous beam subjected to static support settlements. It consists of a drive program and two subroutines. The drive program allocates memory spaces and has a flag to abort if the problem storage requirement exceeds the declared maximum. If the storage requirement is within allocated, the program calls STMAIN subroutine. This subroutine first sets up the coefficients of the unknown moments at the intermediate supports in accordance with Eq. (52). Then STMAIN calls SIMULE, which is an inversion subroutine, for the determination of these unknown moments. After the inversion, the control goes back to STMAIN. Next in STMAIN, is a loop for the determination of the deflection, moment and shear at the specified interval along the span. While these values are computed, a sorting is performed to determine and store the maximum values of each of these functions and the corresponding positions along the span.

The input sequence is as follows:

CARD 1: HEAD

CARD 2: NSPAN, TL, XINT

TL: = the total length of a continuous beam

XINT = the interval along the span for which the deflection, moment and shear are desired to be computed

For each span, a card as follows is required:

CARD 3: SL(2), YM(I), SI(I), SSAM(I)

CARD 4: DELMAX(J)

E. Dynamic Amplification (SAMIR)

This program computes the maximum dynamic amplification factor as the ratios of the dynamic functions (deflection, moment and shear) to the corresponding maximum static values. The evaluation of these dynamic functions is carried out by the Fourier series method but the dynamic three moment equation may serve the same purpose as well. This program consists of a drive program and two subroutines. The primary function of the drive program is to allocate the storage requirements. Most of the calculations are performed in the MAIN program which calls SIMULE subroutine for the inversion of the coefficients matrix in accordance with Eq. (26). Maximum dynamic functions along the span for each forcing frequency and the dynamic amplification factors for deflection, moment and shear are computed and these values may be plotted.

The input sequence and variables are given [2] as follows:

CARD 1: HEAD

CARD 2: NSPAN, NTERM, NOWS, NINT, IPLOT

NOWS = the number of natural frequencies within the range of the forcing frequencies.

NINT = the number of the fine subdivision on both sides of each natural frequency

IPLOT = 0, no plot is desired

= 1, output plots of the dynamic amplification is required

CARD 3: TL, SM, E, XI, XINT, WF1, WF2, WFINT, WSINT

WF1 = lower range of the forcing frequency

WF2 = upper

WFINT = the magnitude of the increment of the forcing frequency between WF1 and WF2

WSINT = the magnitude of the increment of the forcing frequency near the natural frequncy

CARD 4: DEL(I)

CARD 5: XI(I)

Skip the following card if NOWS = 0

CARD 6: WS(J)

WS: = system natural frequency

CARD 7: STDEF, STMOM, STSHR

STDEF = maximum static deflection

STMOM = maximum static moment

STSHR = maximum static shear

CARD 8: TOPDEF, TOPMOM,TOPSHR

TOPDEF = maximum value of dynamic amplification for deflections

TOPMOM = maximum value of dynamic amplification for moments

TOPSHR = maximum value of dynamic amplification for shear

IV. PARAMETER STUDIES

A. An Example Problem

A two span concrete bridge of total length of 60 feet and width of 32 feet is considered as an example to illustrate the use of the computer programs. A span of this bridge has a length of 33 feet and the other a length of 27 feet. The bridge has a haunch at the intermediate support. This bridge is on Wisconsin State Highway I in Richland County near Interstate Highway 80. Although the actual bridge will behave in a three dimensional way, it seems appropriate to model as a two dimensional structure using equivalent cross sectional properties. Therefore, the equivalent cross sectional properties are evaluated [3] as follows: Moment of inertia; 92,850 in^4, depth; 17 in. Considering the bridge to be of normal weight reinforced concrete, the mass per unit length, m, is 1.467 $lb\text{-}sec^2/in^2$. This bridge is analyzed under the effects of three forcing frequencies. Although the acceleration rather than the earthquake frequency is usually documented for earthquakes [23], the forcing frequency in this mathematical model can be readily derived from the acceleration by estimating the support settlements under the effect of the acceleration. With both the acceleration and support settlement known, the forcing frequency can be determined by

$$w_f = \sqrt{\frac{a}{\Delta_i}} \tag{64}$$

in which w_f is the forcing frequency, a is the acceleration due to the earthquake, Δ_i, is the expected support settlement under the effect of the earthquake acceleration. The relationship of parameters in Eq. (64) is tabulated in Table 1.

a	a	Δ_i	ω_f
%g	in/sec^2	in	rad/sec
25	96.6	.2415	20
33	128.8	.0805	40
33	128.8	.0057	150

Table 1 - Forcing Frequencies used in Example Problems

The dynamic response to these three frequencies can be seen in Figs. 5 through 13. From these figures it can be observed that the deflected shape varies drastically with the variation of the forcing frequency, and that for high frequencies the bridge superstructure exhibits more than one bend along its span. With no such deflected shapes, the curvature is sharper and thus the higher moments and shears.

For the case of the forcing frequency of 40 rad/sec, the maximum deflection occurs at 540 inches (45 feet) from the left abutment. The maximum moment occurs at 568.8 inches (47.4 feet) from this abutment, while the maximum shear occurs at 410.4 inches (34.2 feet) from it. Incidentally the fundamental natural frequency of this bridge is computed as 31.43 rad/sec.

B. Fourier Series Vs. Dynamic Three Moment Equation

In general a very good correlation was observed between the results obtained from the Fourier series method and the results obtained from the three moment equation method. It was observed, however, that more terms have to be summed as the number of spans in the bridge analyzed increase, if the same accuracy is desired. For example, it was observed that the summation of fit terms gave reasonable results for the frequency computation as well as the deflection, moment and shear functions for two span bridges, whereas one hundred and two hundred terms were needed to achieve the same accuracy for three and four span bridges, respectively. As expected the convergence of the deflection function is more rapid due to the n^4 term in the denominator of the deflection expression. Similarly the convergence of the moment function is faster than that of the shear function because of n^2 term in the denominator of the moment expression as compared to n in the shear expression. To illustrate the convergence of these three functions, the example problem was analyzed twice for a forcing frequency of 40 rad/sec., once by summing two hundred terms and once by summing only the first fifty terms. The results obtained from the summation of two hundred terms are shown in Figs. 5 through 7 whereas the functions obtained by summing 50 terms are shown in Figs. 14 through 16. An examination of these curves reveals that there is no noticeable difference for the deflection and moment curves. The shear curve is smoother (indicating a better convergence) with the summation of two hundred terms, yet the differences in shear magnitude are very small. It should be noted that the dynamic three moment equation yields exact solution because of the shape function used being the exact solution of the governing differential equation.

Fig. 5 - Deflection (Two span, 33 ft-27 ft, ω_f = 40 rad/sec, Δ = .0805 in, n = 200 terms)

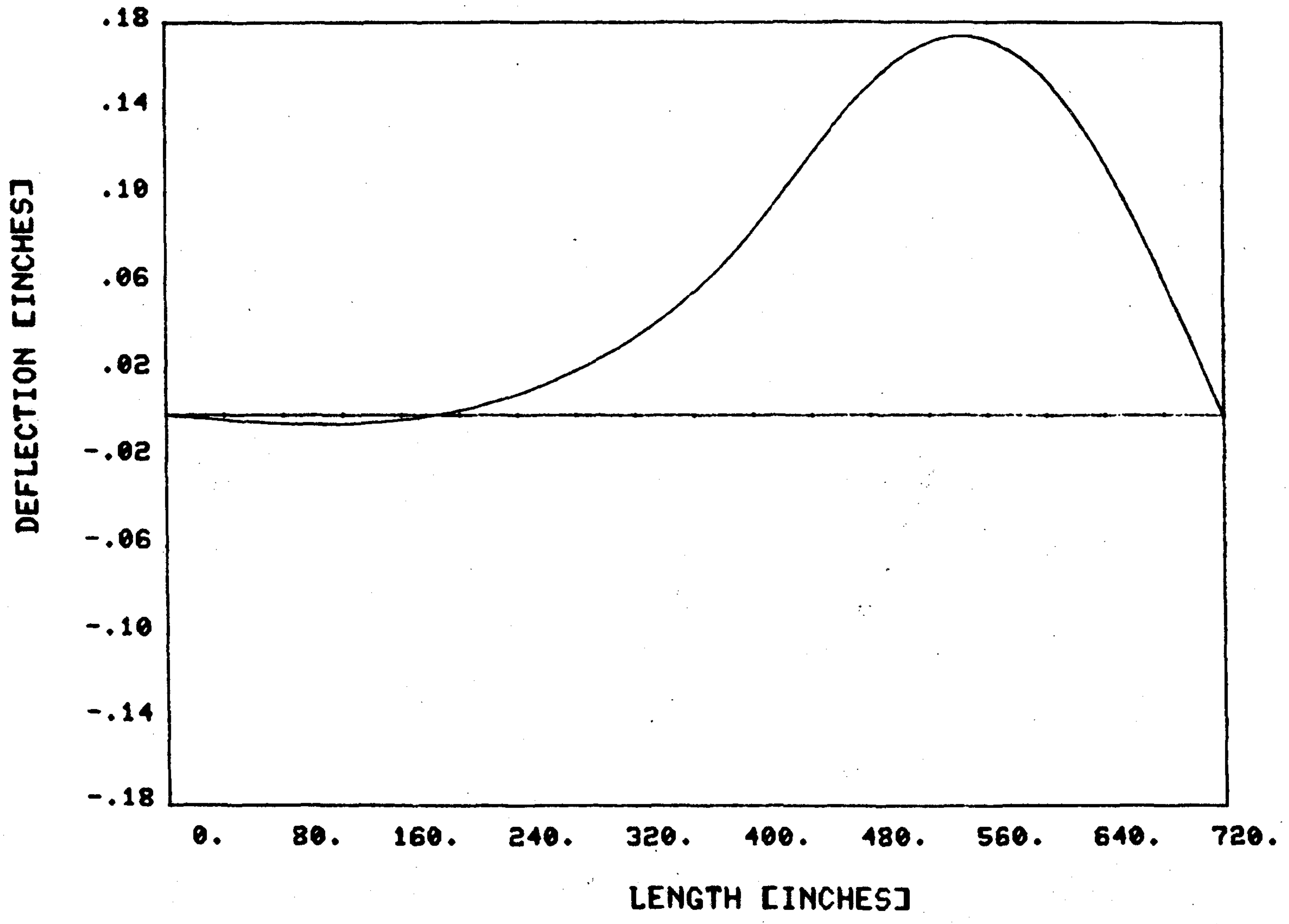


Fig. 6 - Moment (Two span, 33 ft-27 ft, ω_f = 40 rad/sec, Δ = .0805 in, n = 200 terms)

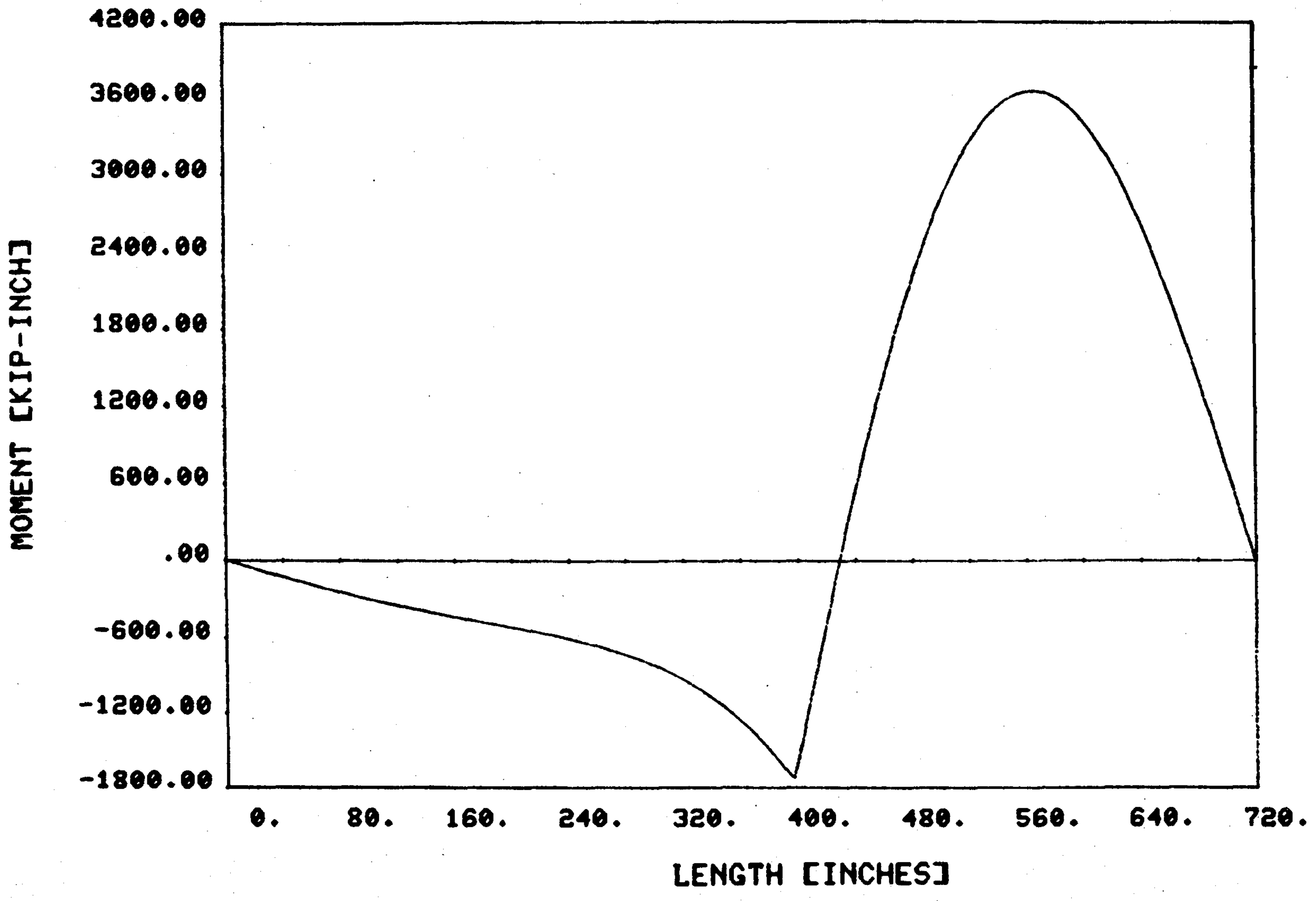


Fig. 7 - Shear (Two span, 33 ft-27 ft, ω_f = 40 rad/sec, Δ = .0805 in, n = 200 terms)

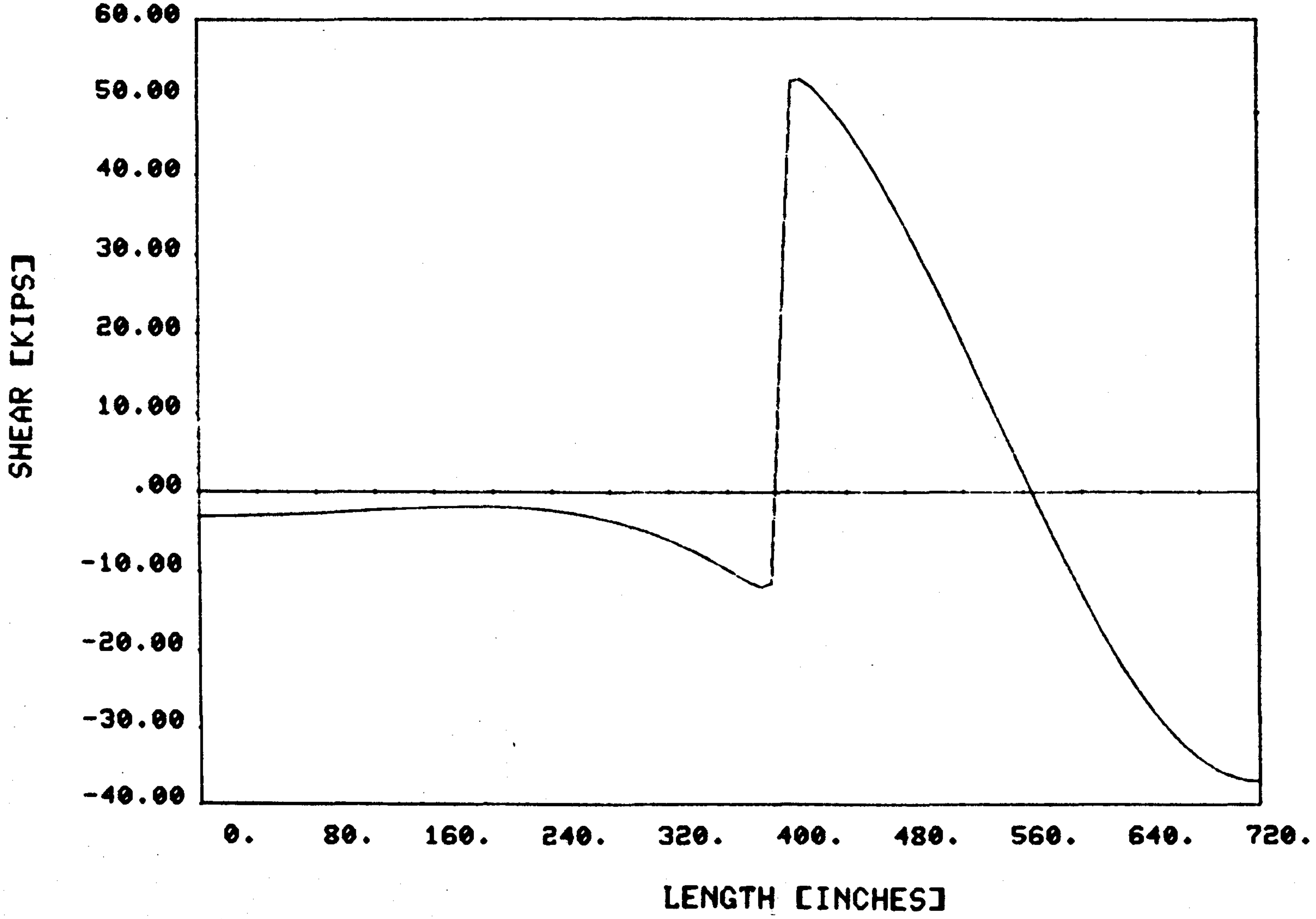
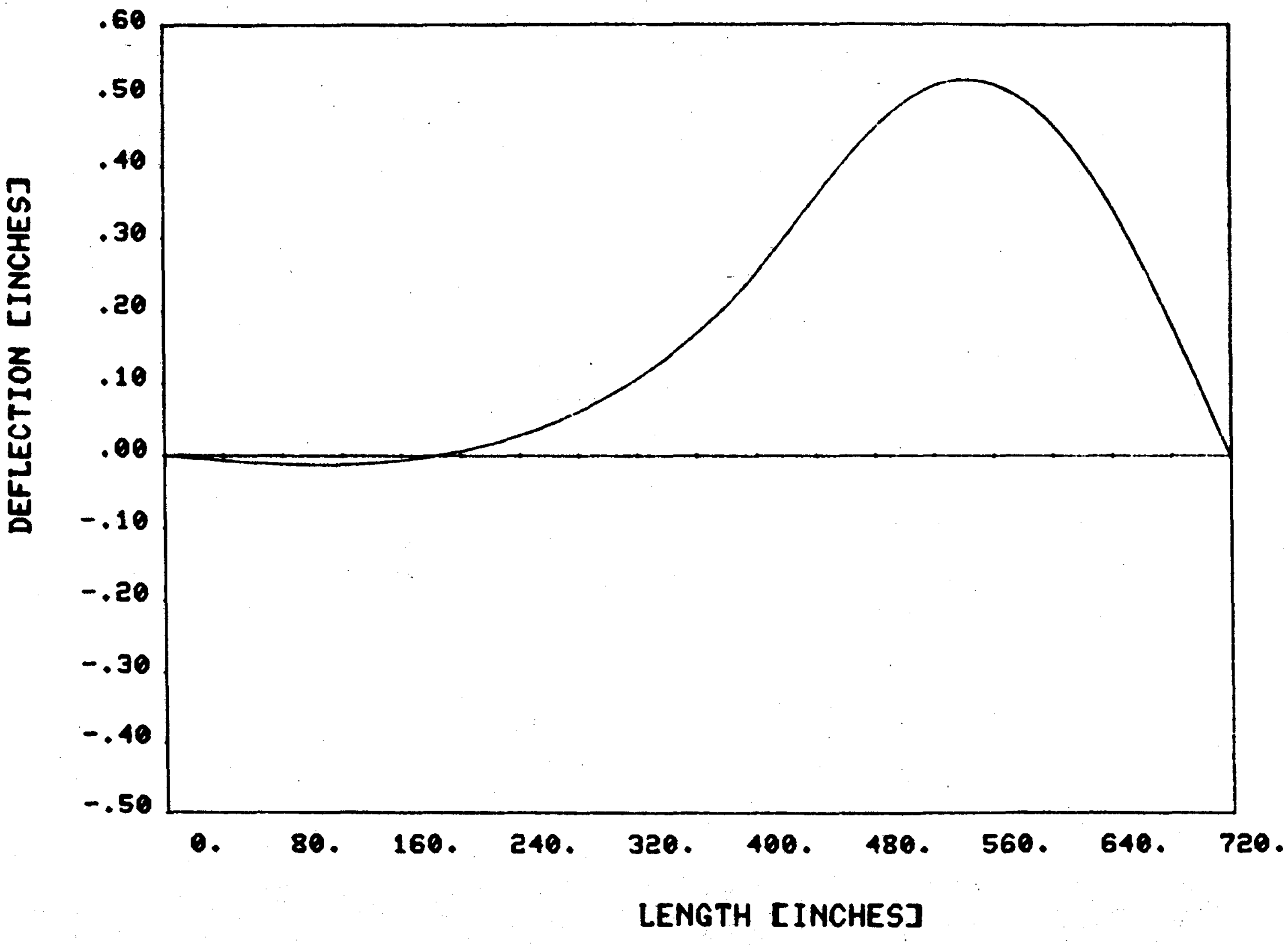


Fig. 8 - Deflection (Two span, 33 ft-27 ft, ω_f = 20 rad/sec, Δ = .2415 in, n = 200 terms)



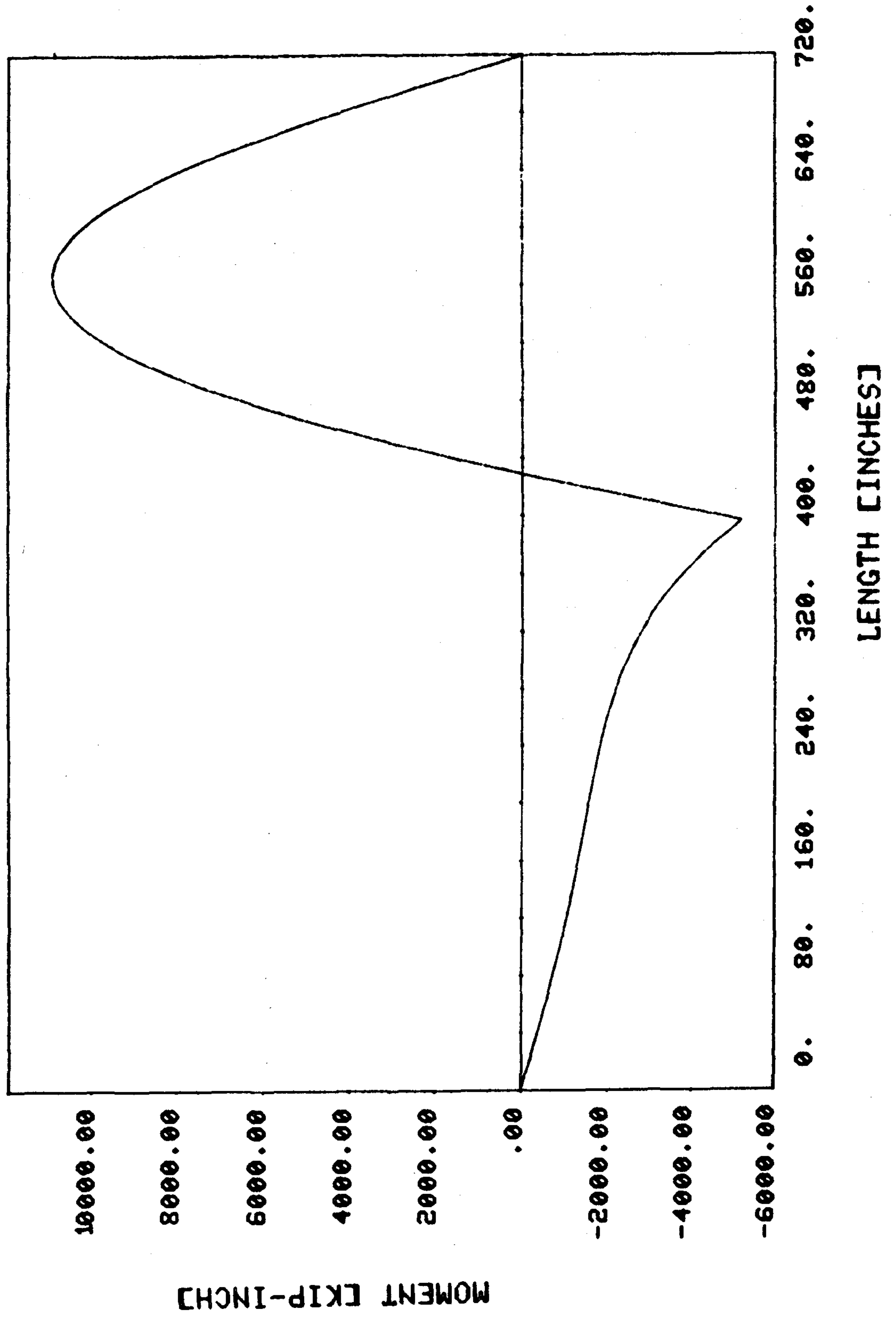


Fig. 9 - Moment (Two span, 33 ft-27 ft, ω_f = 20 rad/sec, Δ = .2415 in, n = 200 terms)

Fig. 10 - Shear (Two span, 33 ft-27 ft, ω_f = 20 rad/sec, Δ = .2415 in, n = 200 terms)

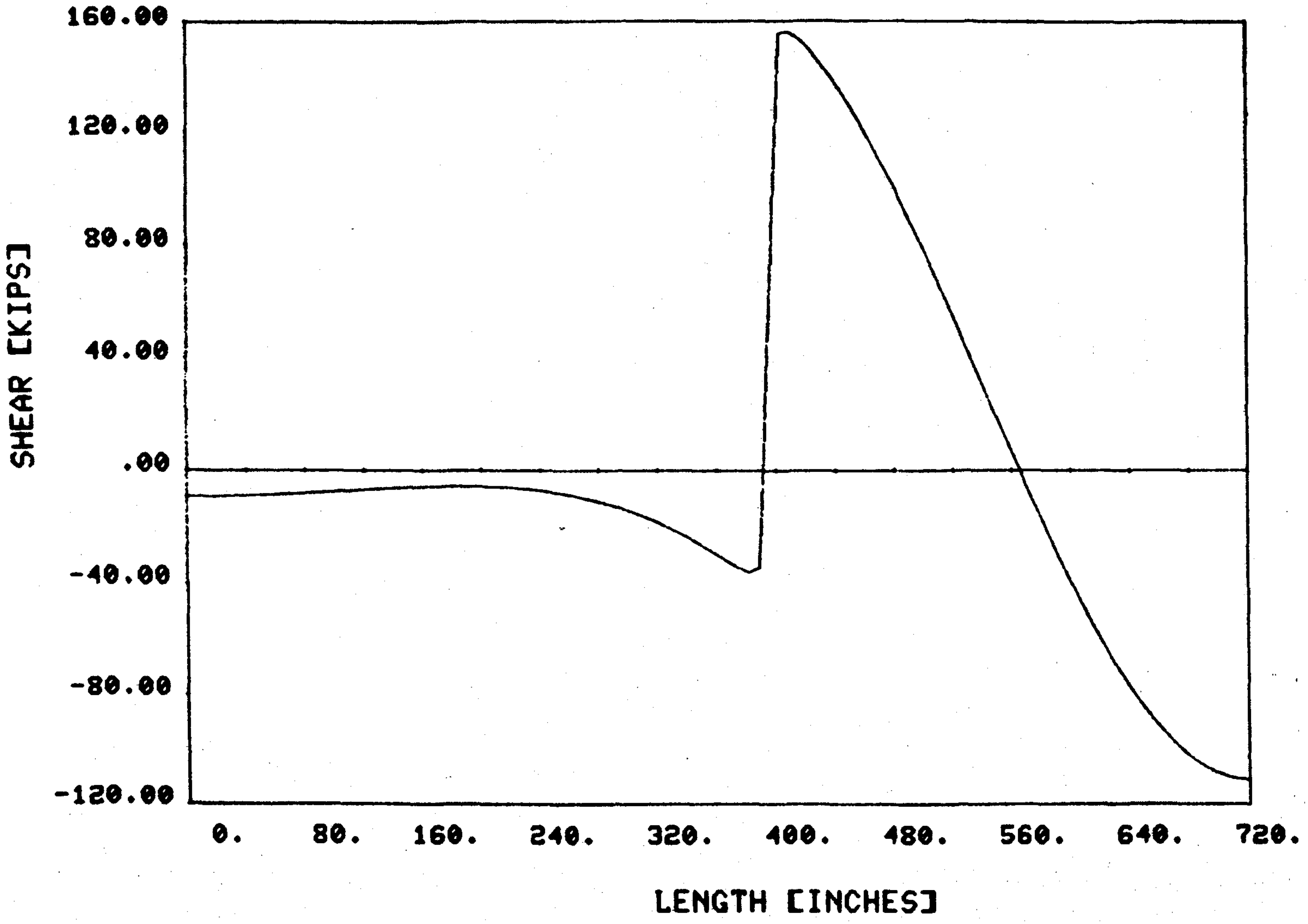


Fig. 11 - Deflection (Two span, 33 ft-27 ft, ω_f = 150 rad/sec, Δ = .0057 in, n = 200 terms)

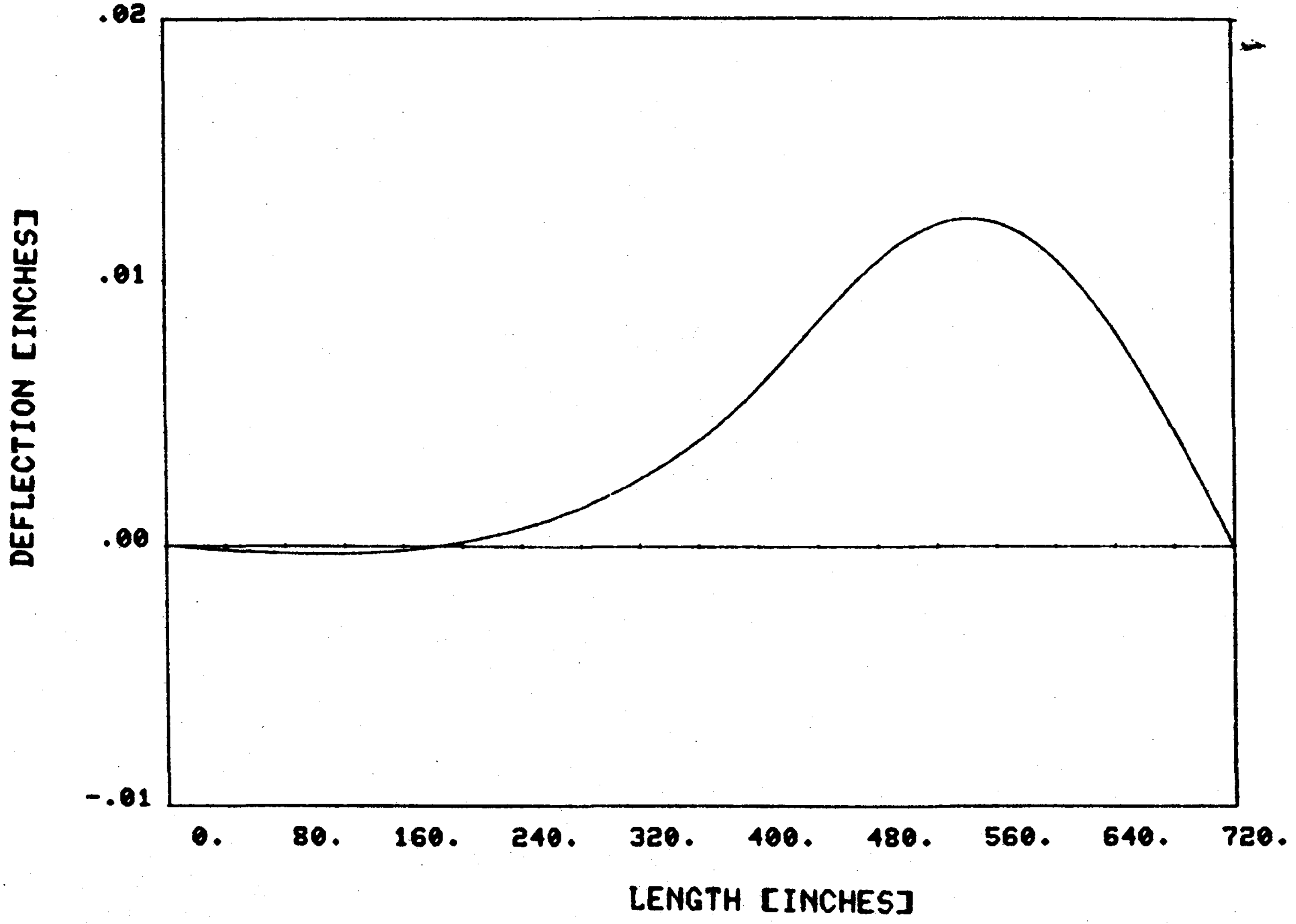


Fig. 12 - Moment (Two span, 33 ft-27 ft, ω_f = 150 rad/sec, Δ = .0057 in, n = 200 terms)

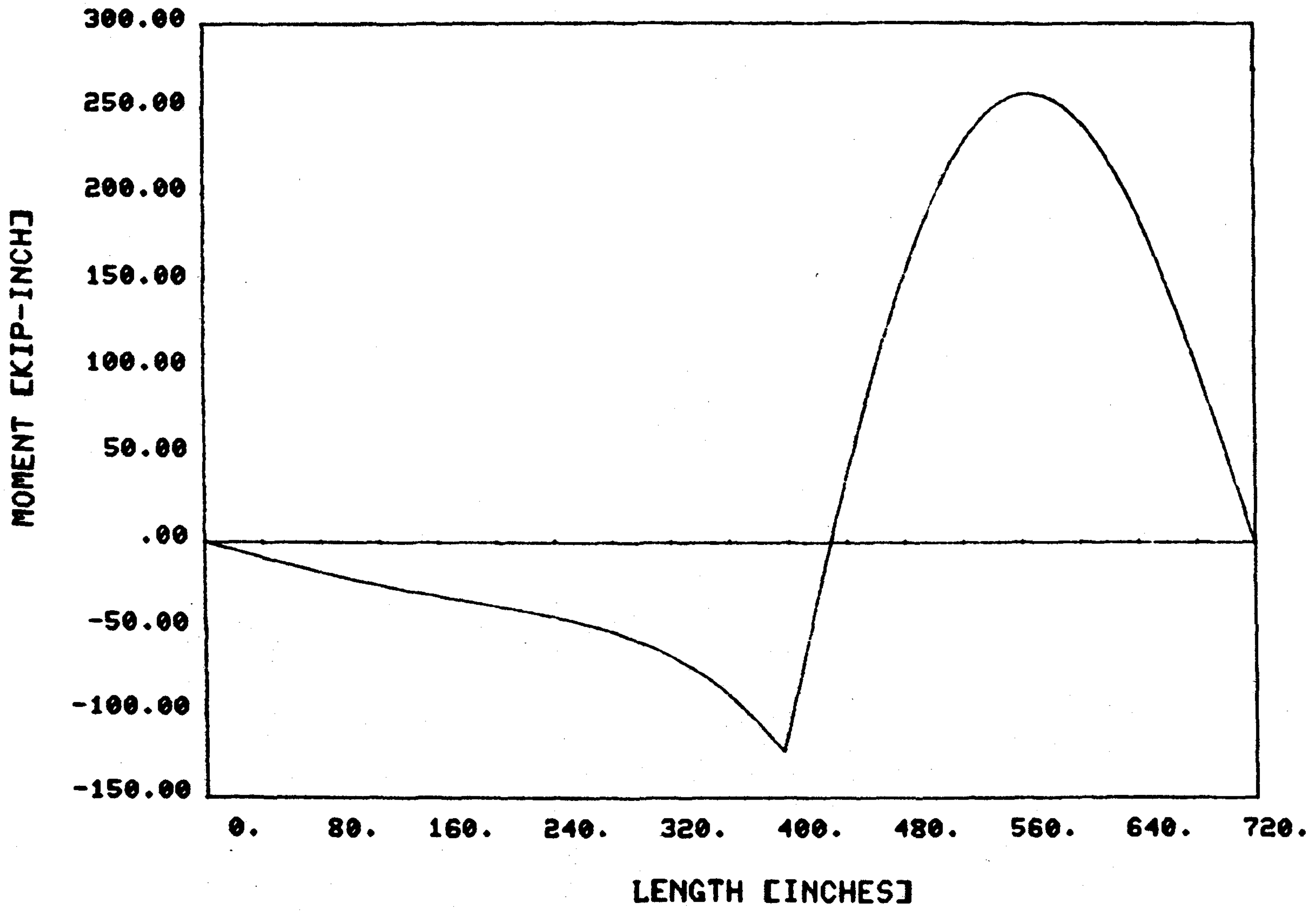
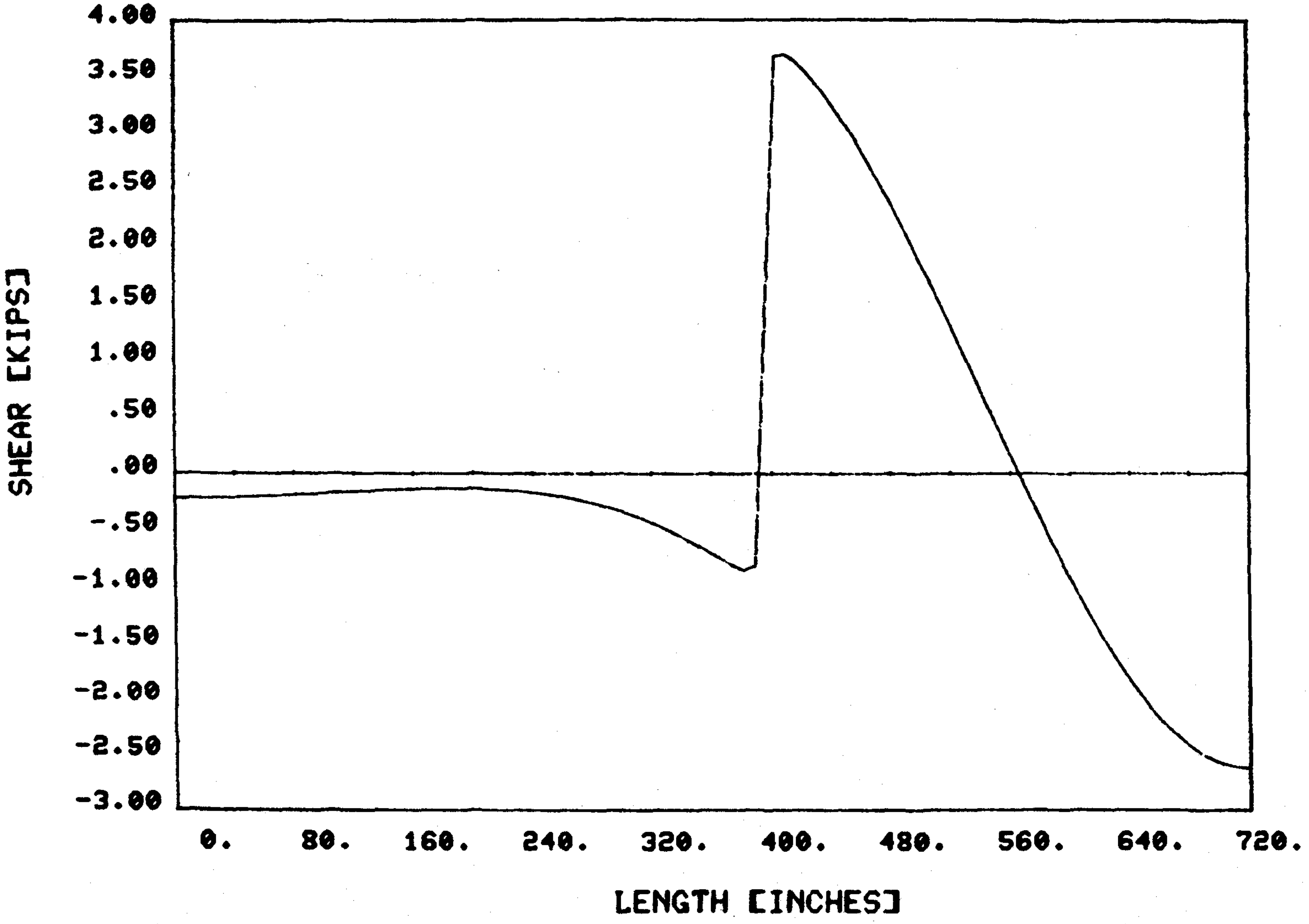


Fig. 13 - Shear (Two span, 33 ft-27 ft, ω_f = 150 rad/sec, Δ = .0057 in, n = 200 terms)



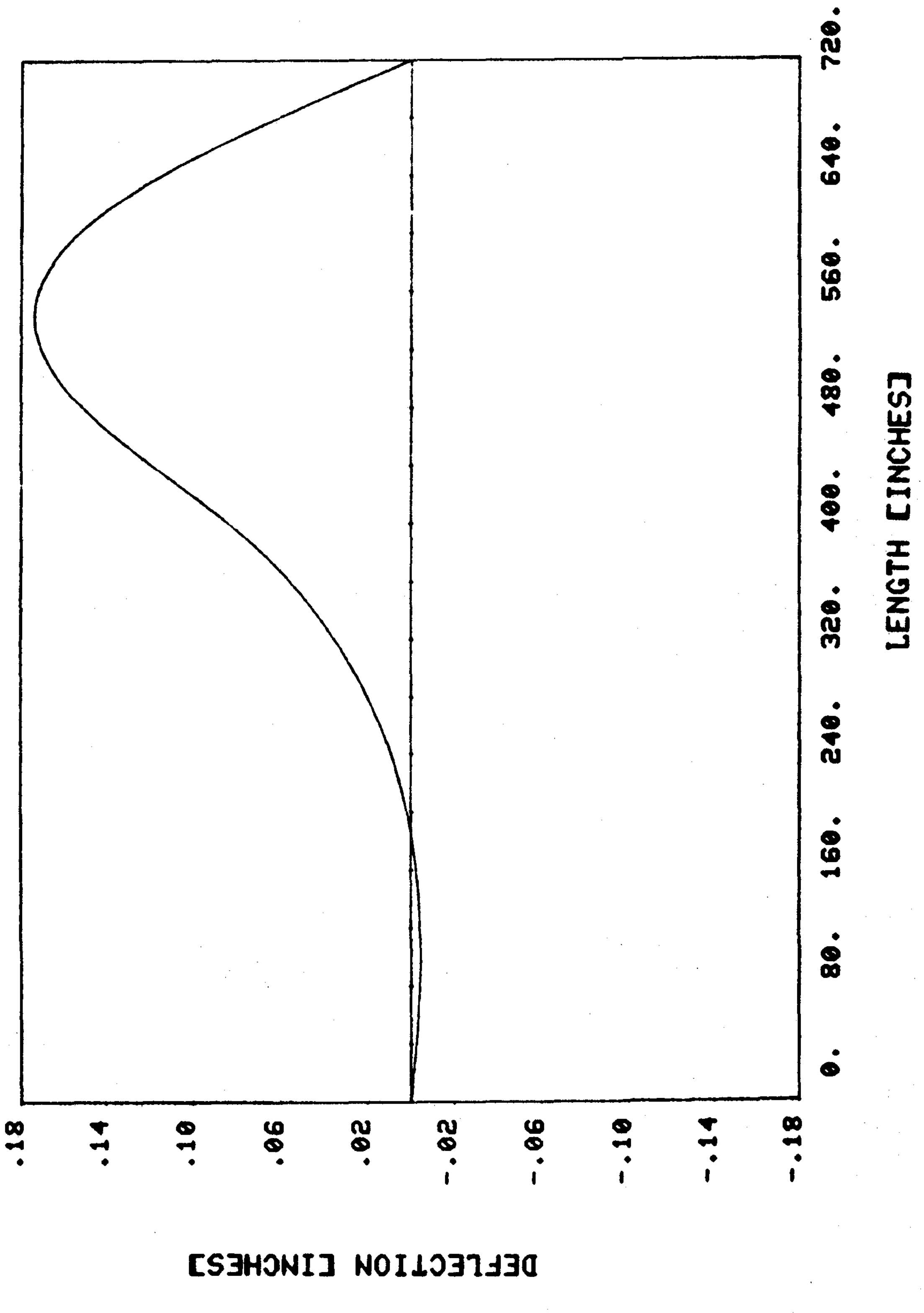


Fig. 14 - Deflection (Two span, 33 ft-27 ft, ω_f = 40 rad/sec, Δ = .0805 in, n = 50 terms)

Fig. 15 - Moment (Two span, 33 ft-27 ft, ω_f = 40 rad/sec, Δ = .0805 in, n = 50 terms)

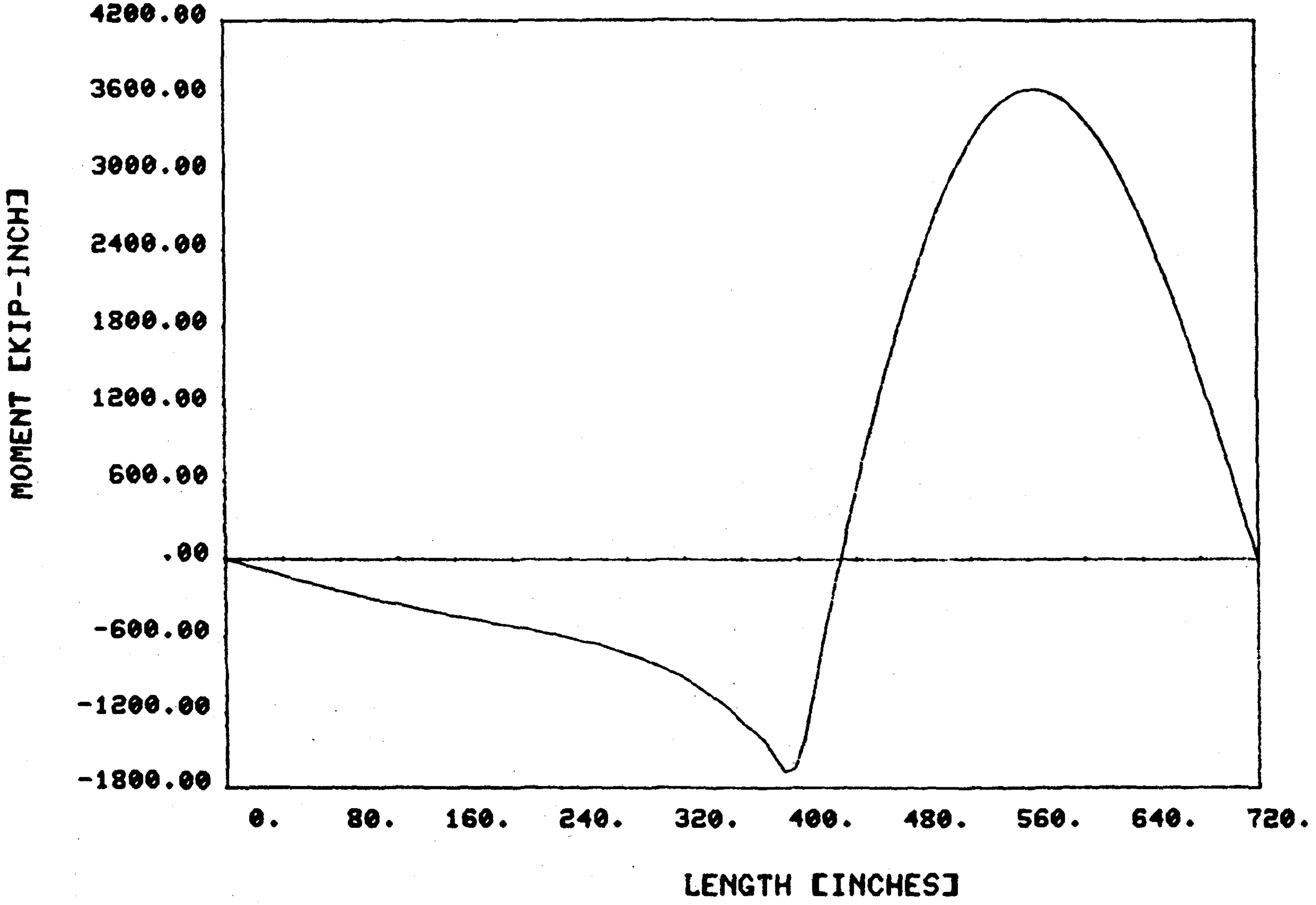
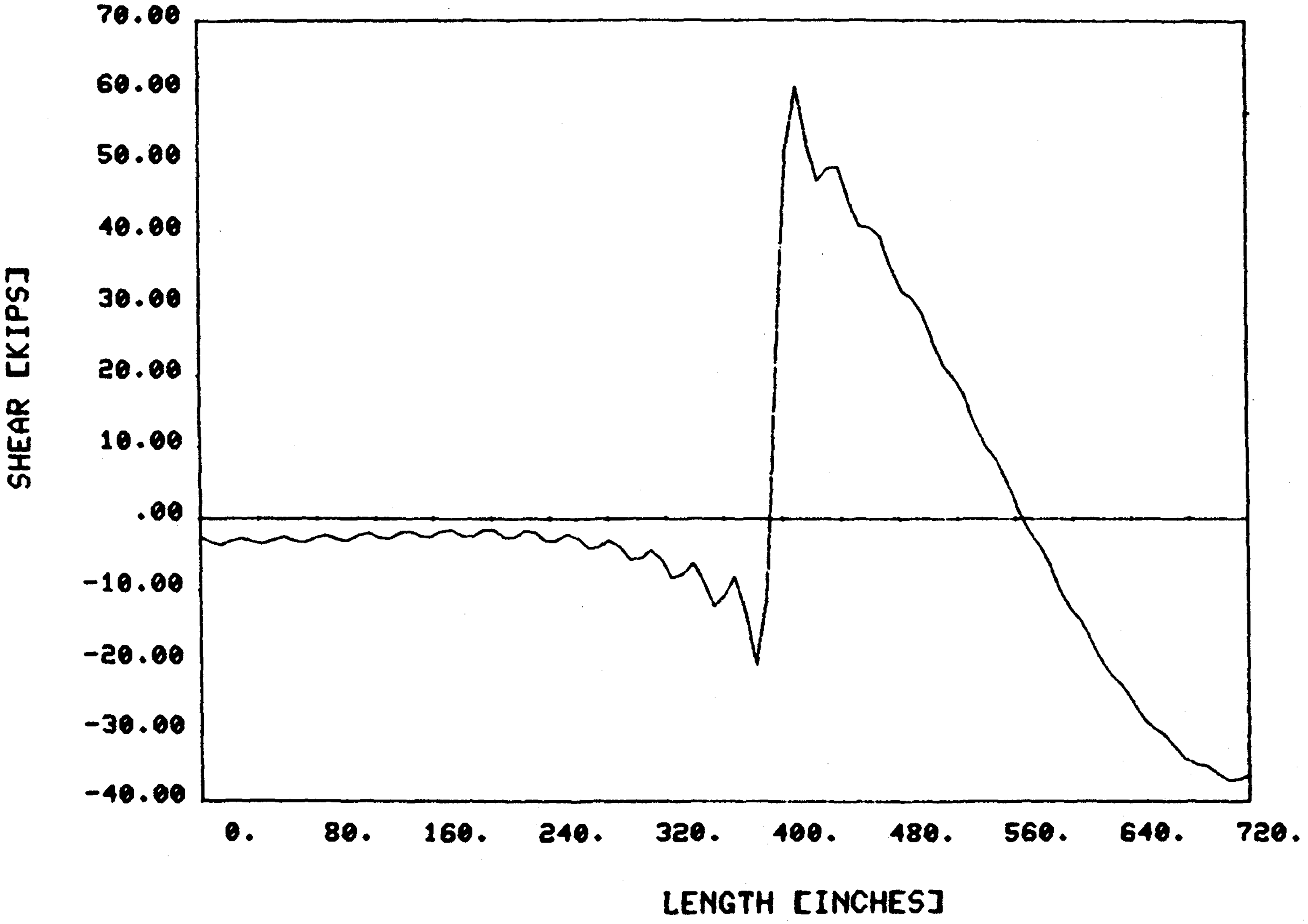


Fig. 16 - Shear (Two span, 33 ft-27 ft, ω_f = 40 rad/sec, Δ = .0805 in, n = 50 terms)



C. Development of Charts as Design Aids

With the computer programs developed, design aids for practical engineers can now be made. To illustrate this, sample charts were plotted for a two span bridge that has the intermediate support at a location fifty five percent of the total length from the left abutment. These charts can be used for bridges that have any combination of E, I, M, and L but that maintain a ratio of the intermediate support distance to the total length of .55. Similar charts for two span bridges with different intermediate support locations or for bridges with more than two spans can be readily developed by these programs.

It can be shown that the natural frequencies of a bridge can be expressed as

$$w_s = w_s' \sqrt{\frac{EI}{mL^4}} \tag{65}$$

in which w_s' is a dimensionless constant that depends only on the number of intermediate supports and their locations. Likewise the forcing frequency w_f may be transformed into non-dimensional entity as

$$w_f' = \frac{w_f}{\sqrt{\frac{EI}{mL^4}}}$$

With this new parameter as the abscissa, the dynamic amplification factor can now be plotted as explained in the SAMIR program. Once again these charts can be used for bridges with any combination of E, I, M, and L as long as they maintain the same value of the other two parameters; the number of intermediates and their relative locations. Figs. 17 through 46 are the dynamic amplification factors for deflection, moment and shear. The maximum static deflection, moment and shear along the bridge can be readily determined by the application of the static three moment equation, thus MOM3ST program or by any other readily available design tool. The information of the static response and the dynamic amplification factors leads to the dynamic analysis of bridges without actually conducting dynamic analysis. For example, using a static support settlement for the example bridge discussed in section A as .805 inches (see Table 1), the maximum static deflection is computed as .081045 inches, the maximum moment, 524300 lb-in (43.7 K-ft), the maximum shear 1,618.2 lbs (1.7182 kips). The output data from MOM3ST are given in Appendix 1.

The value of w_f' for an earthquake frequency of 40 rad/sec can be be obtained by Eq. (66)

$$w_f' = \frac{40}{\dfrac{3{,}000{,}000 \times 92850}{1.467 \times (720)^4}} = 47.58$$

The dynamic amplification factor for the deflection is read off in Fig. 17 as 2.15 corresponding to w_f' value of 47.58. Thus the maximum dynamic deflection expected is 2.15 x .081045 = 1.742 inches. The exact value is computed as 1.738 by using either DYNAMIC or MOM3 program. Likewise the DAF for moment and shear are read off from the plots as 7.0 and 36.0, respectively. Thus the dynamic moment and shear are 7 x 43.7 = 305.9 k-ft and 36 x 1.16182 = 58.255 kips. The exact values of these functions are 304.1 k-ft and 55.457 kips as computed by MOM3 program.

Fig. 17 - DAF, Deflection (Two span, L-.6L)

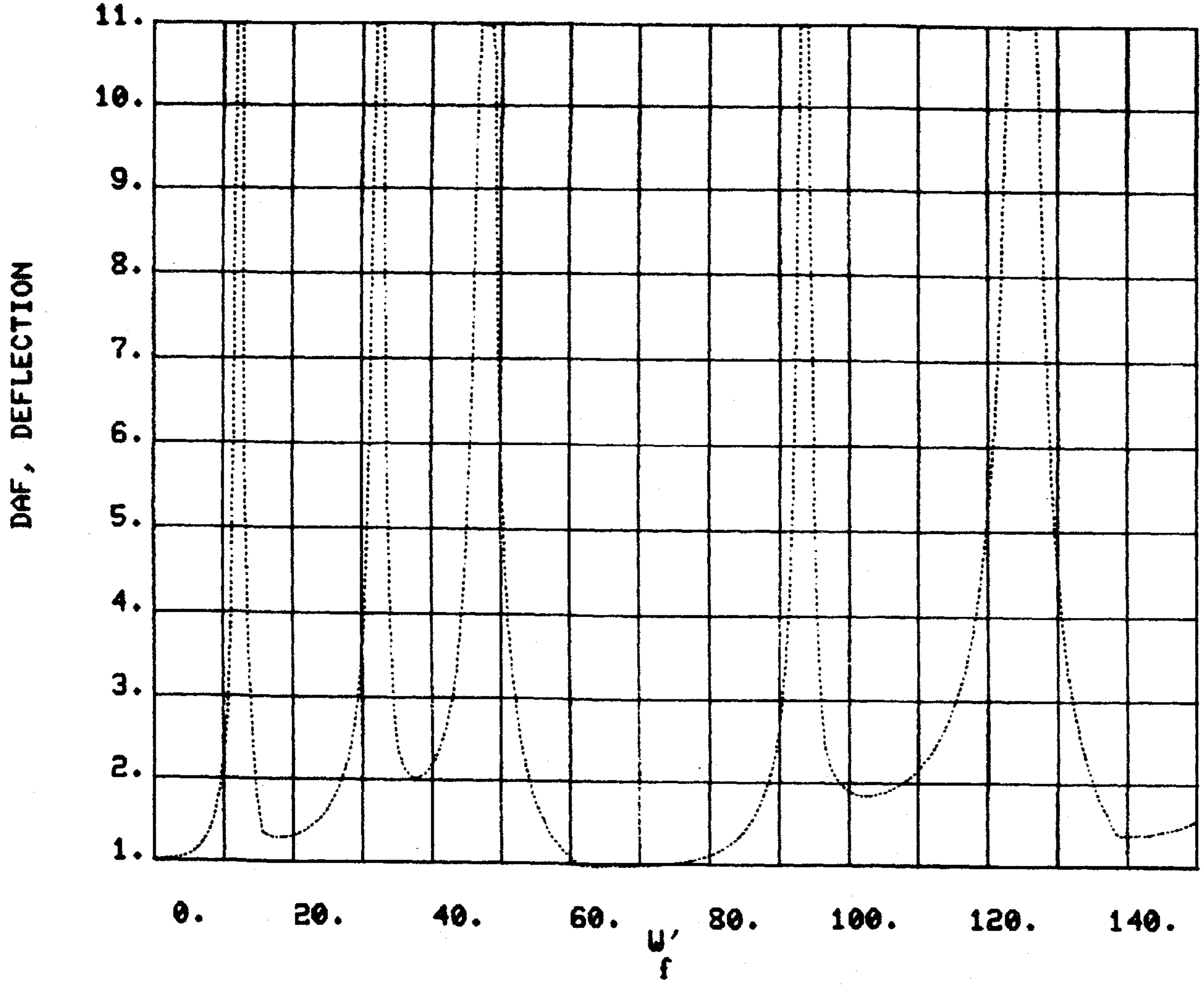
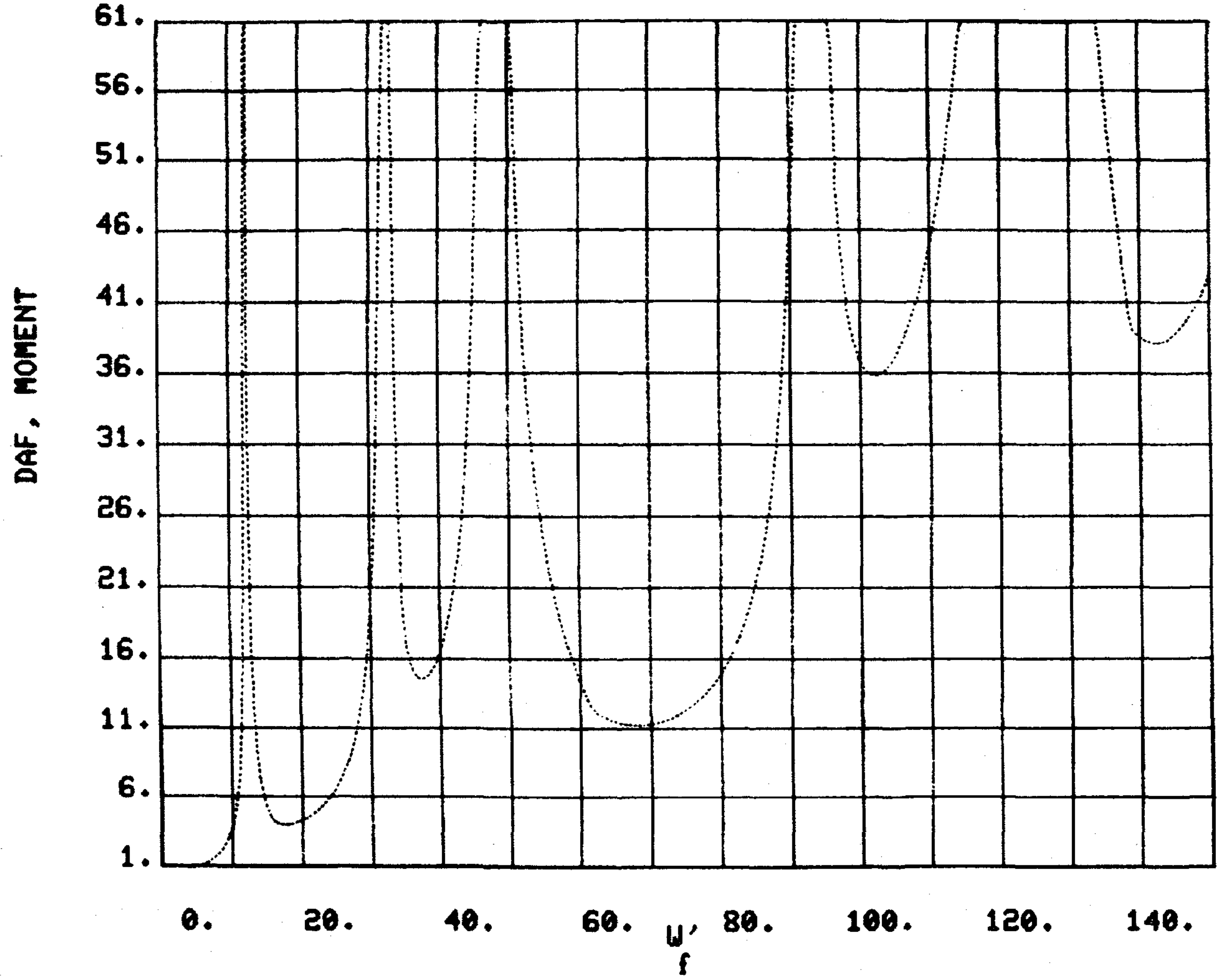


Fig. 18 - DAF, Moment (Two span, L-.6L)



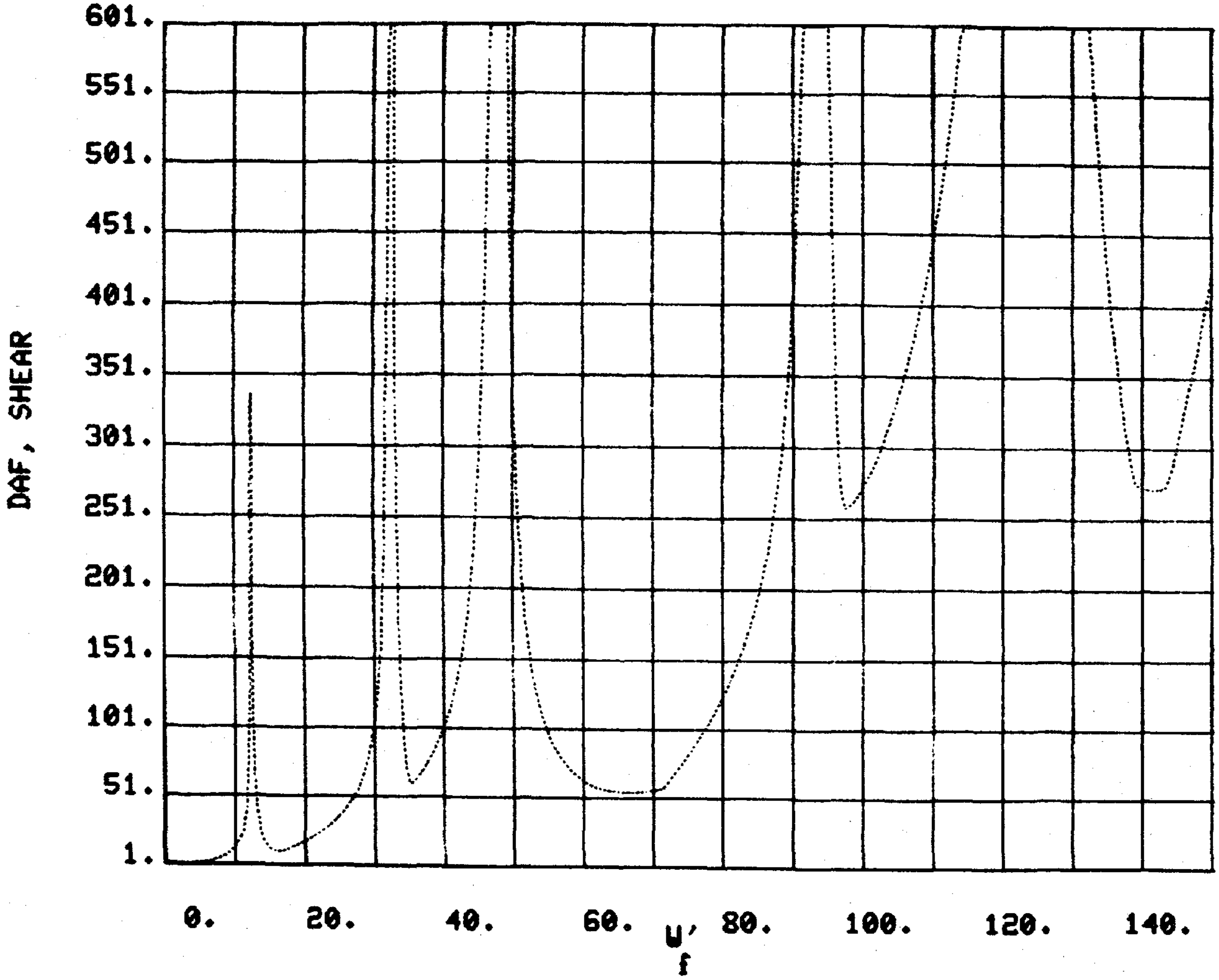


Fig. 19 - DAF, Shear (Two span, L-.6L)

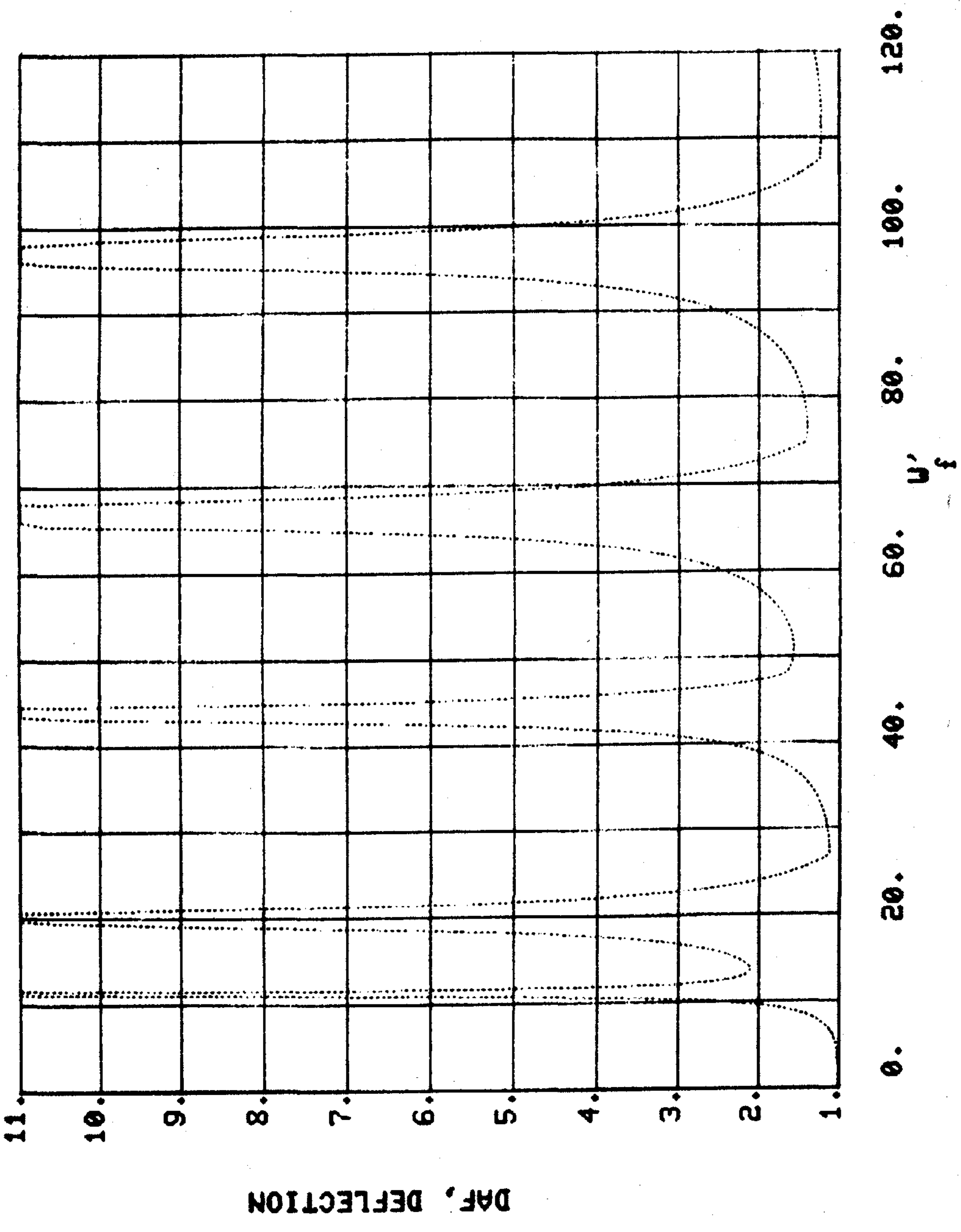


Fig. 20 - DAF, Deflection (Two span, L-.8182L)

Fig. 21 - DAF, Moment (Two span, L-.8182L)

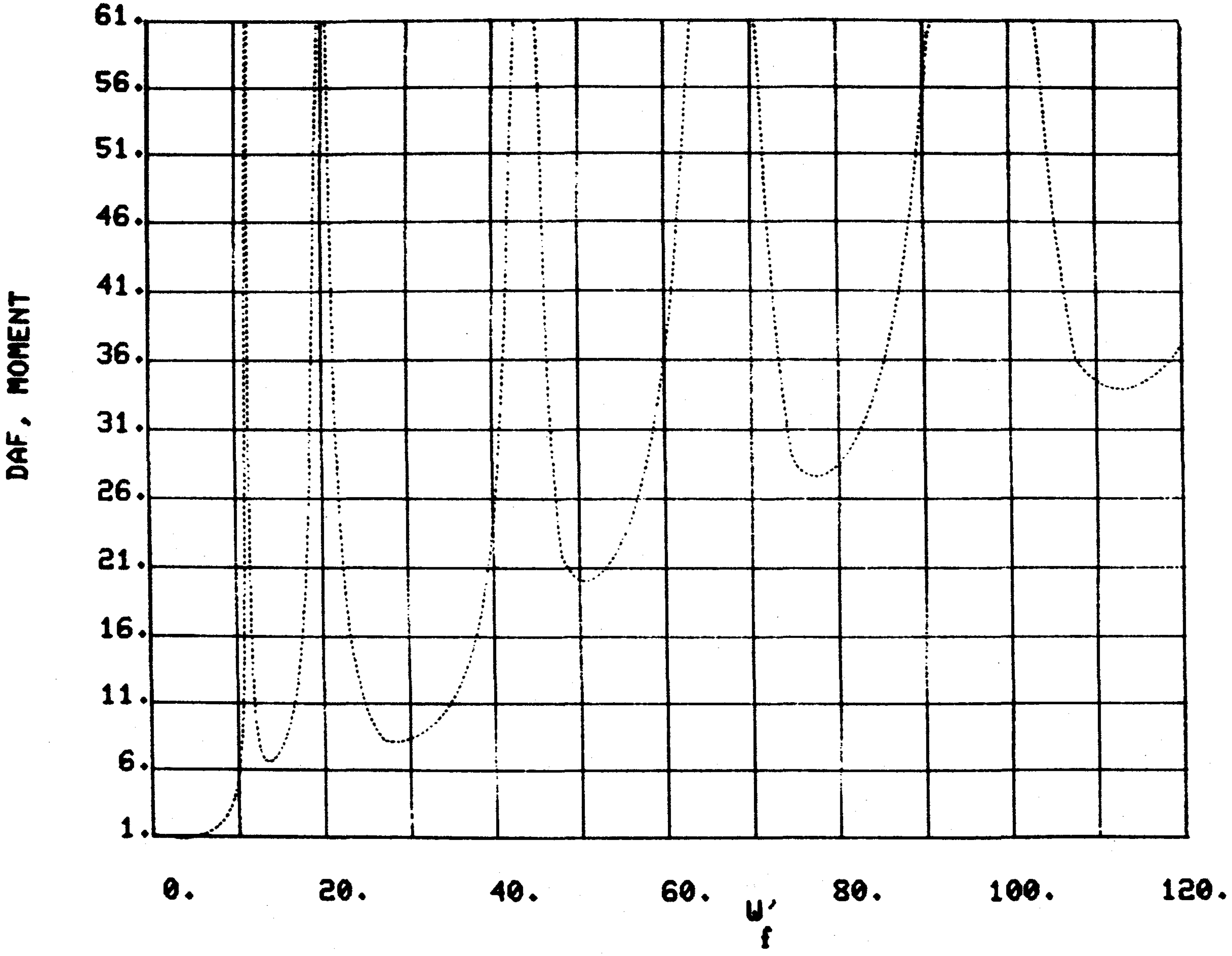


Fig. 22 - DAF, Shear (Two span, L-.8182L)

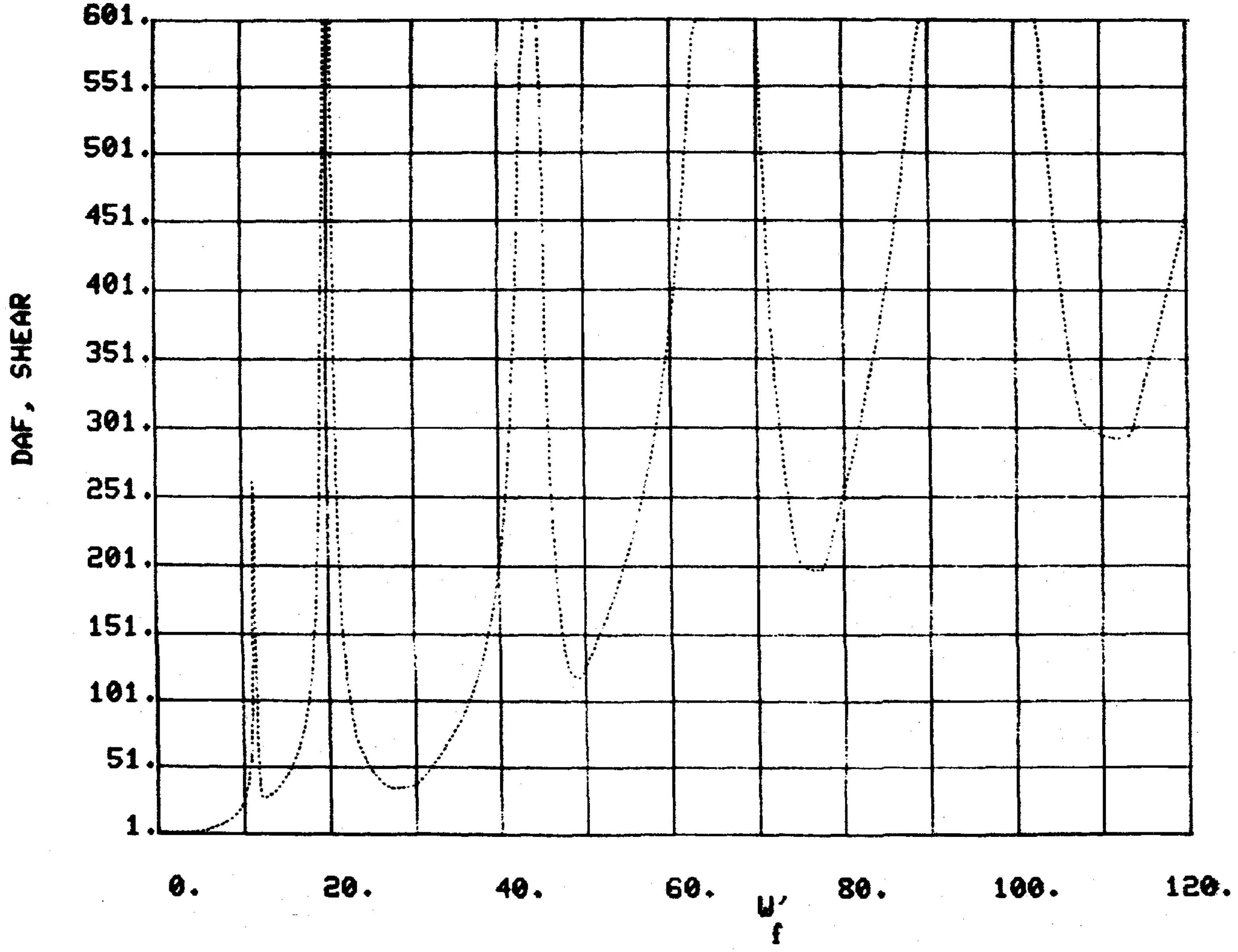
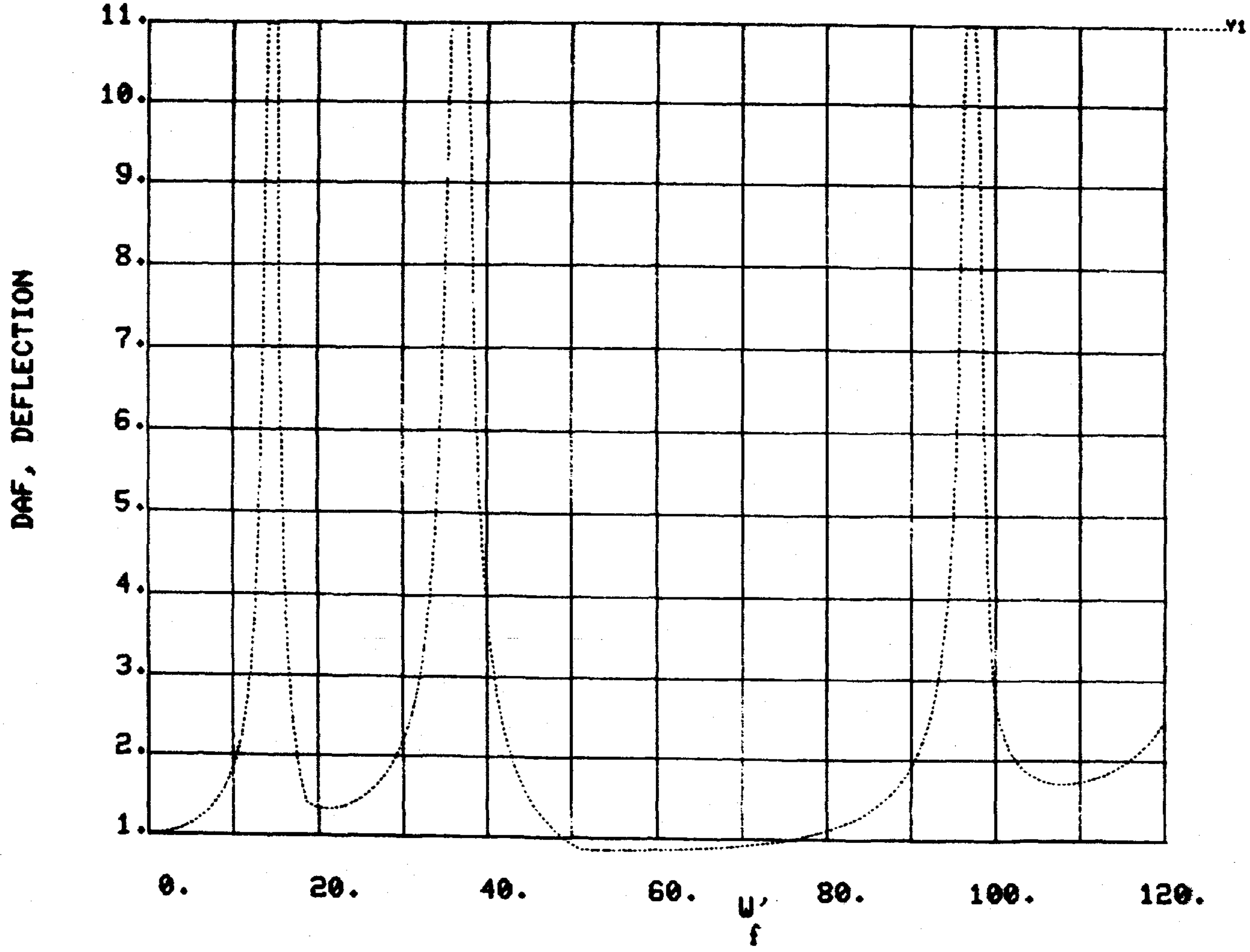


Fig. 23 - DAF, Deflection (Three span, .6L-L-.6L)



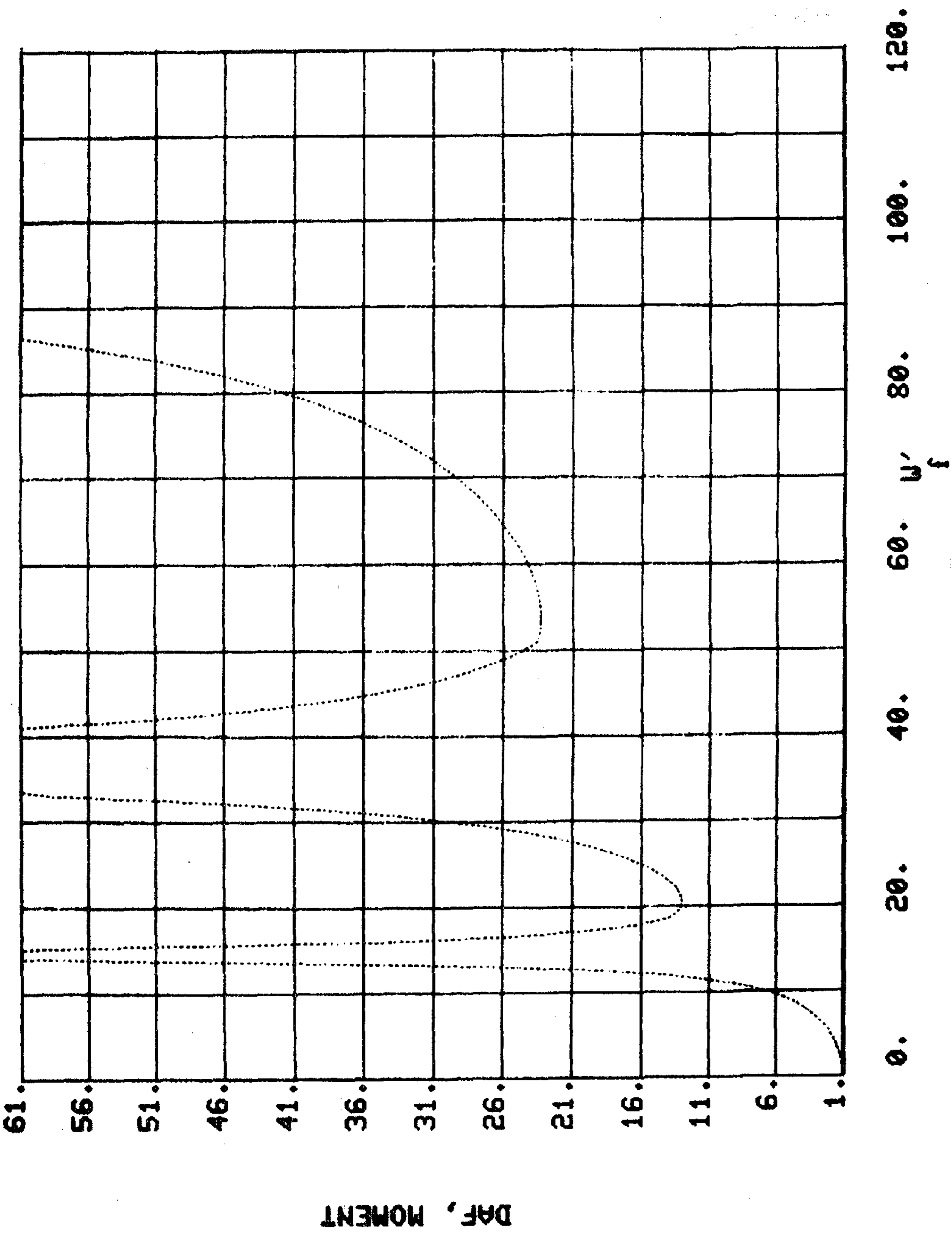


Fig. 24 - DAF, Moment (Three span, .6L-L-.6L)

Fig. 25 - DAF, Shear (Three span, .6L-L-.6L)

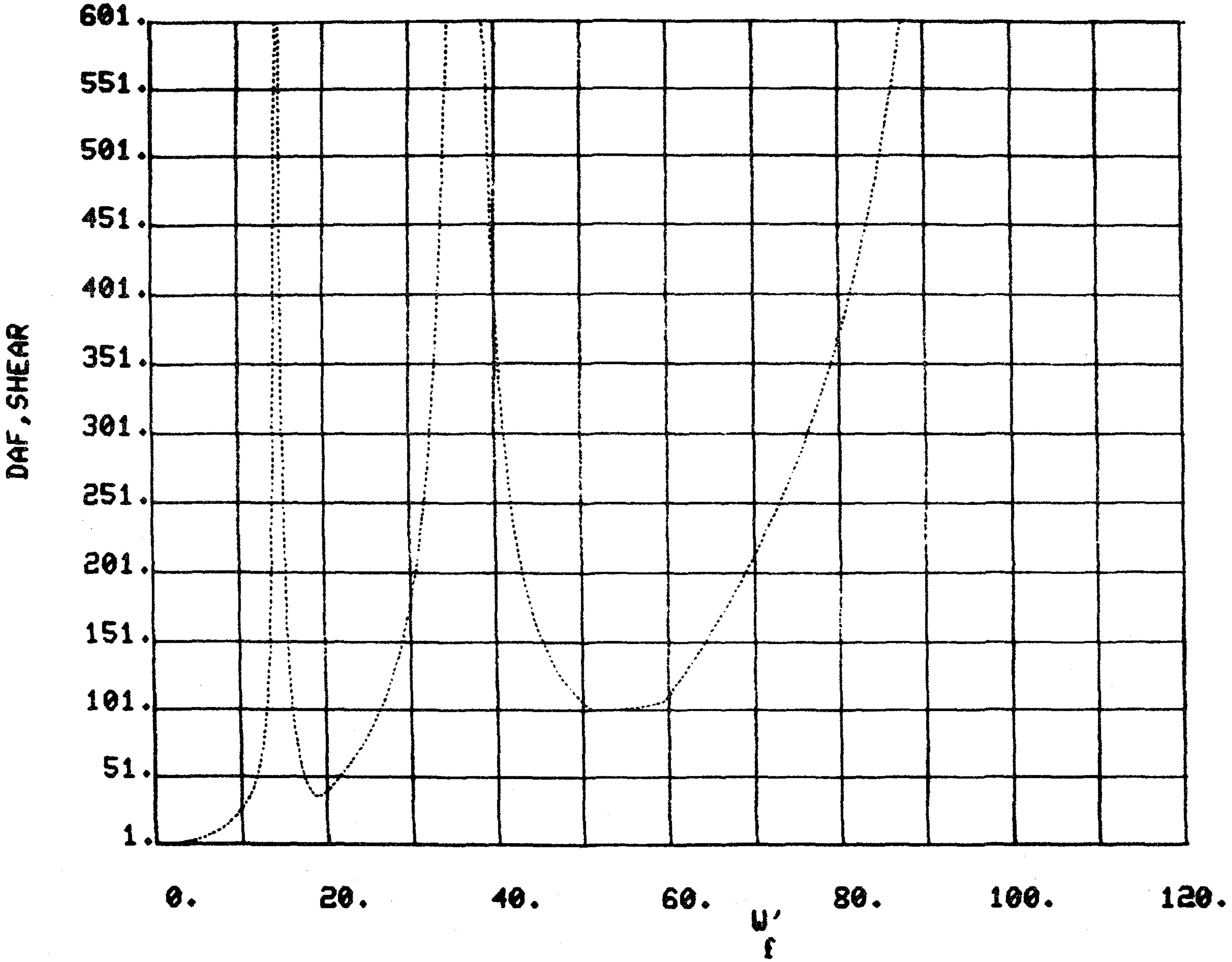
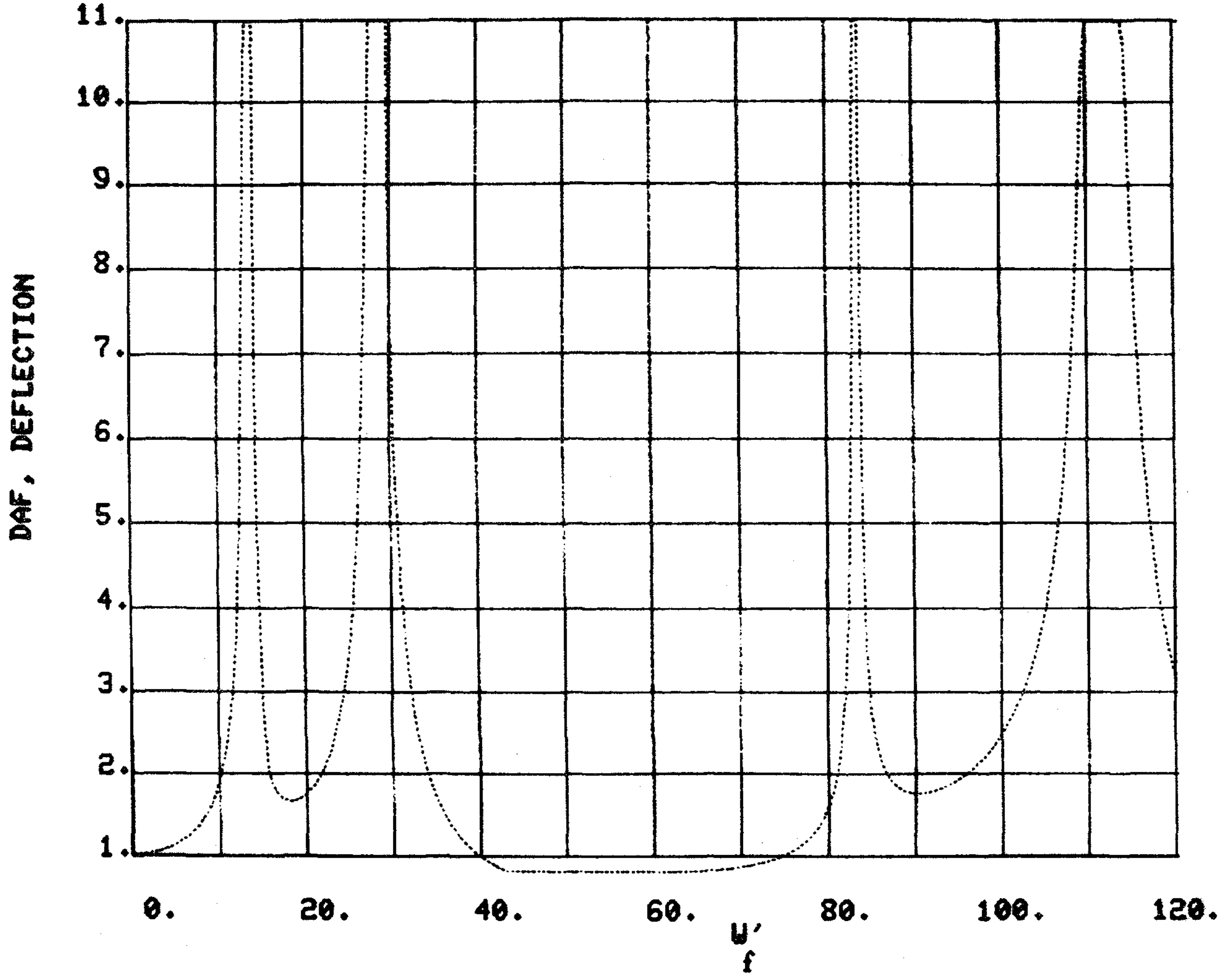


Fig. 26 - DAF, Deflection (Three span, .7L-L-.7L)



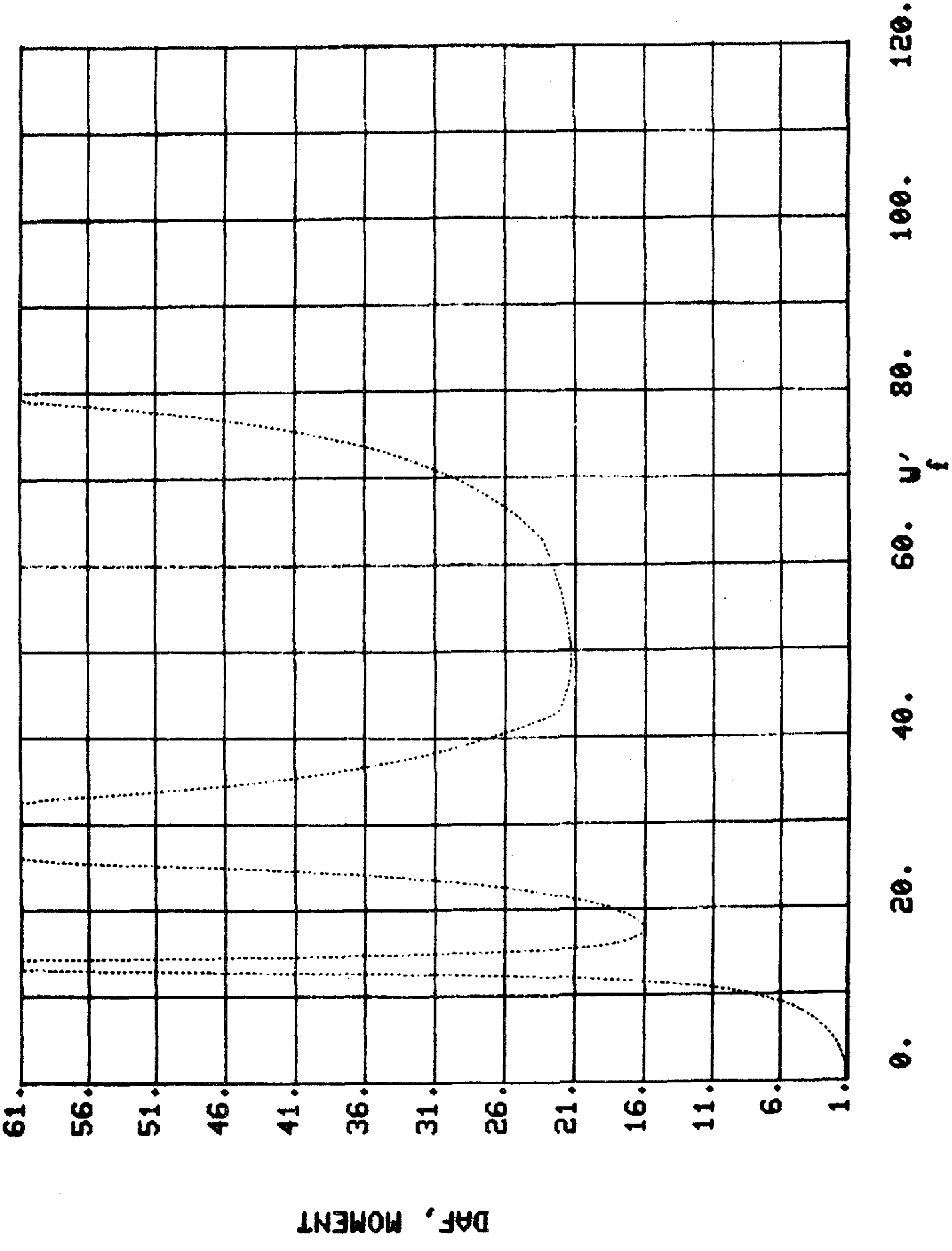


Fig. 27 - DAF, Moment (Three span, .7L-L-.7L)

Fig. 28 - DAF, Shear (Three span, .7L-L-.7L)

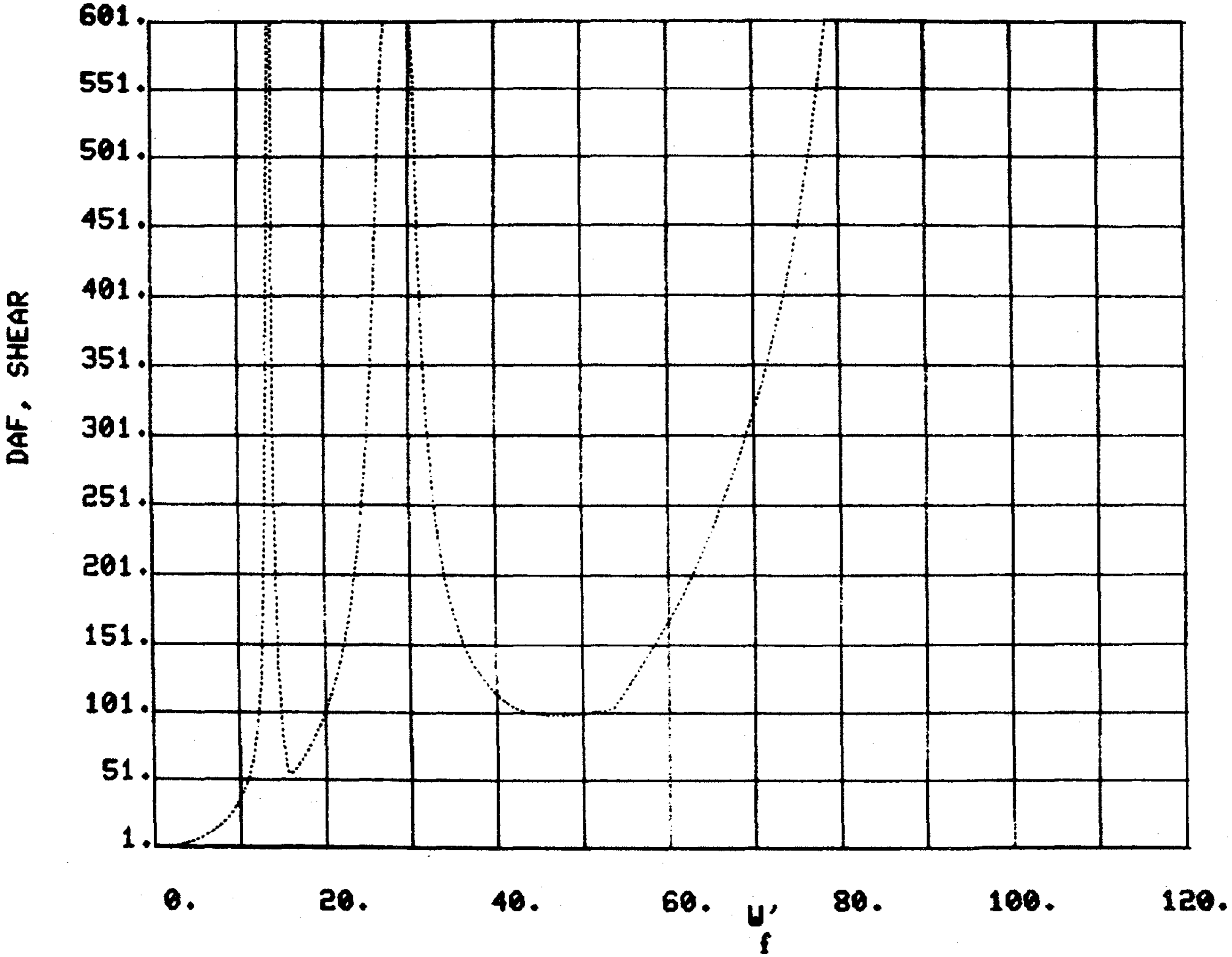


Fig. 29 - DAF, Deflection (Three span, .8L-L-.8L)

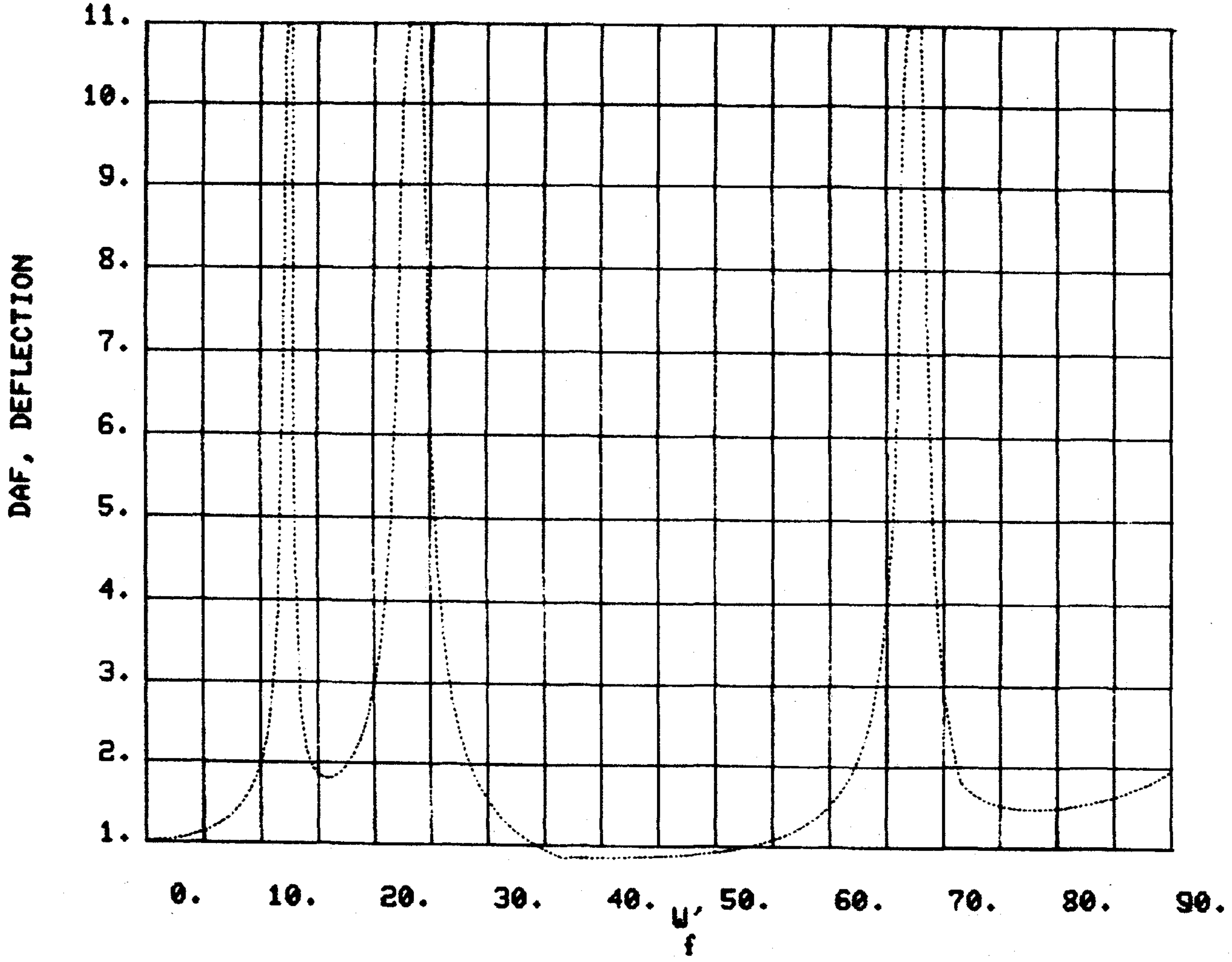
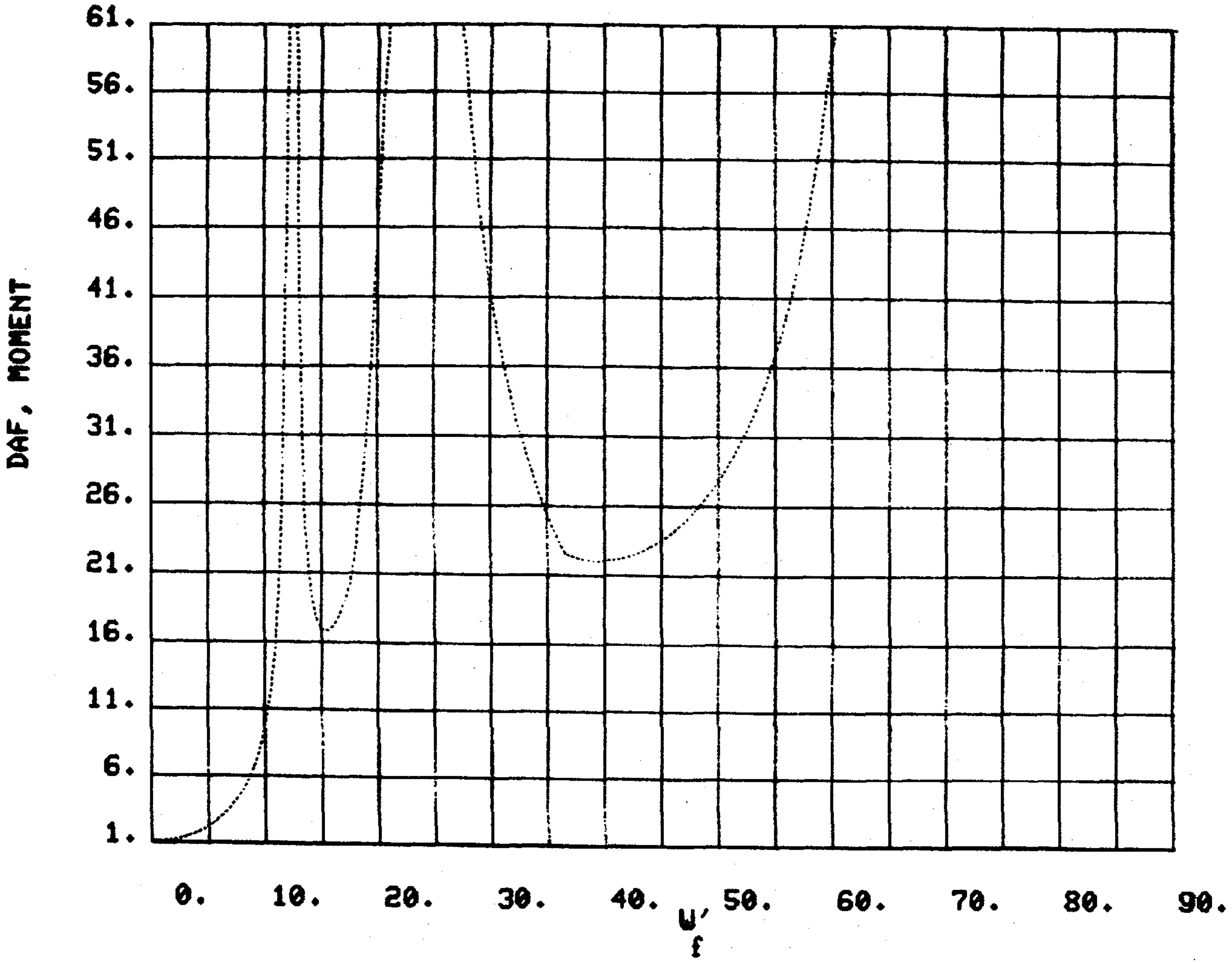


Fig. 30 - DAF, Moment (Three span, .8L-L-.8L)



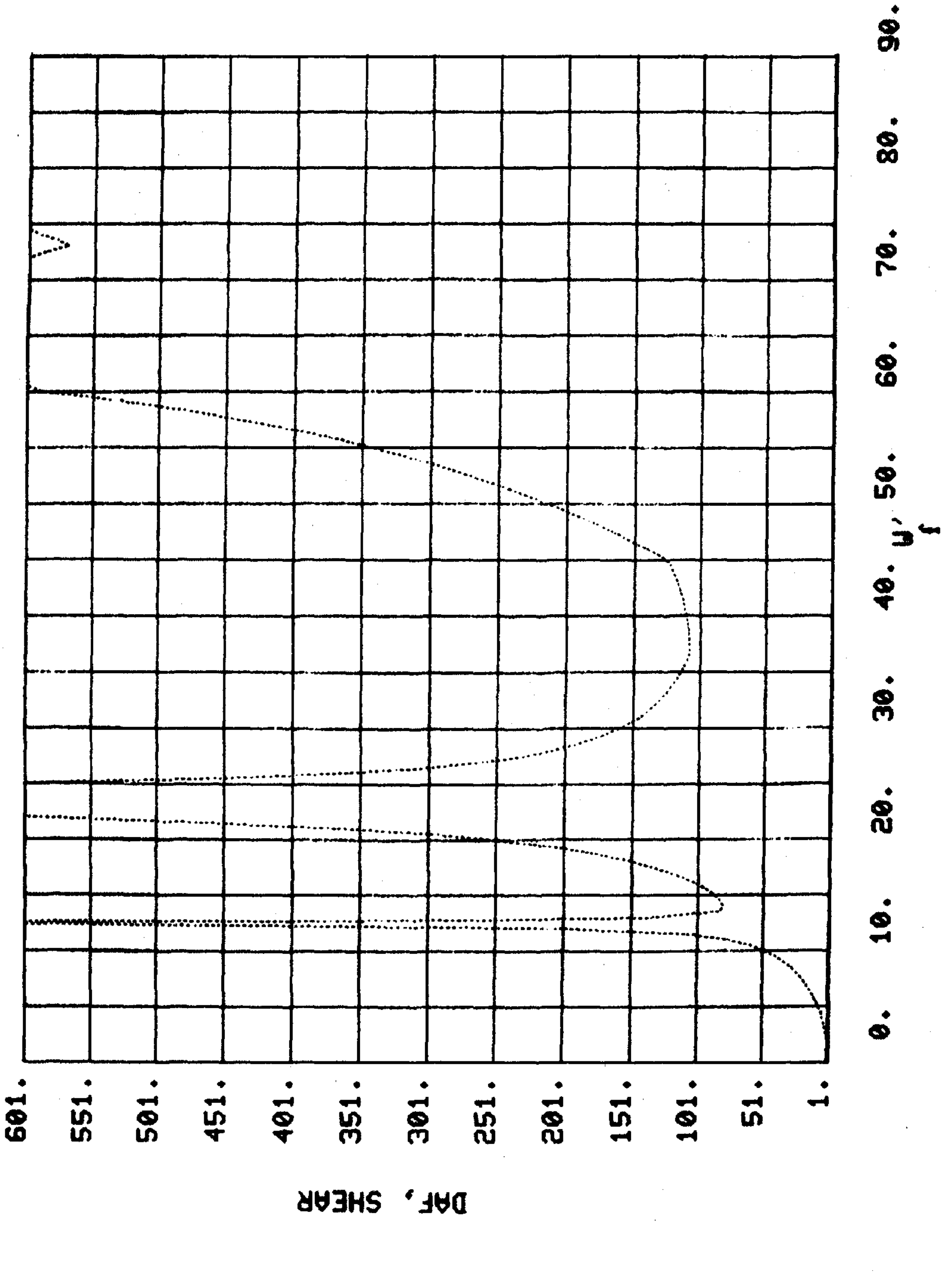


Fig. 31 - DAF, Shear (Three span, .8L-L-.8L)

Fig. 32 - DAF, Deflection (Three span, .7L-L-.9L)

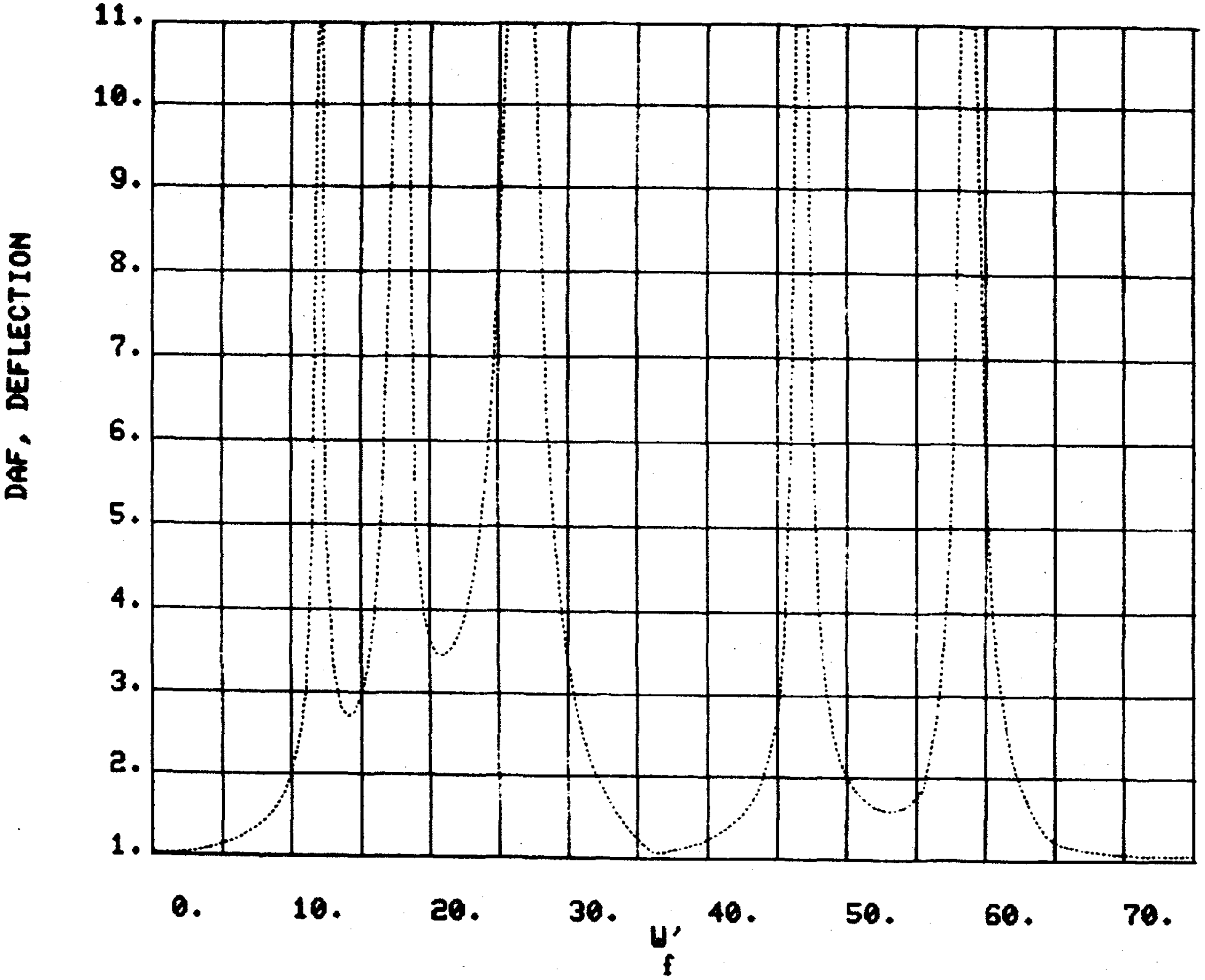


Fig. 33 - DAF, Moment (Three span, .7L-L-.9L)

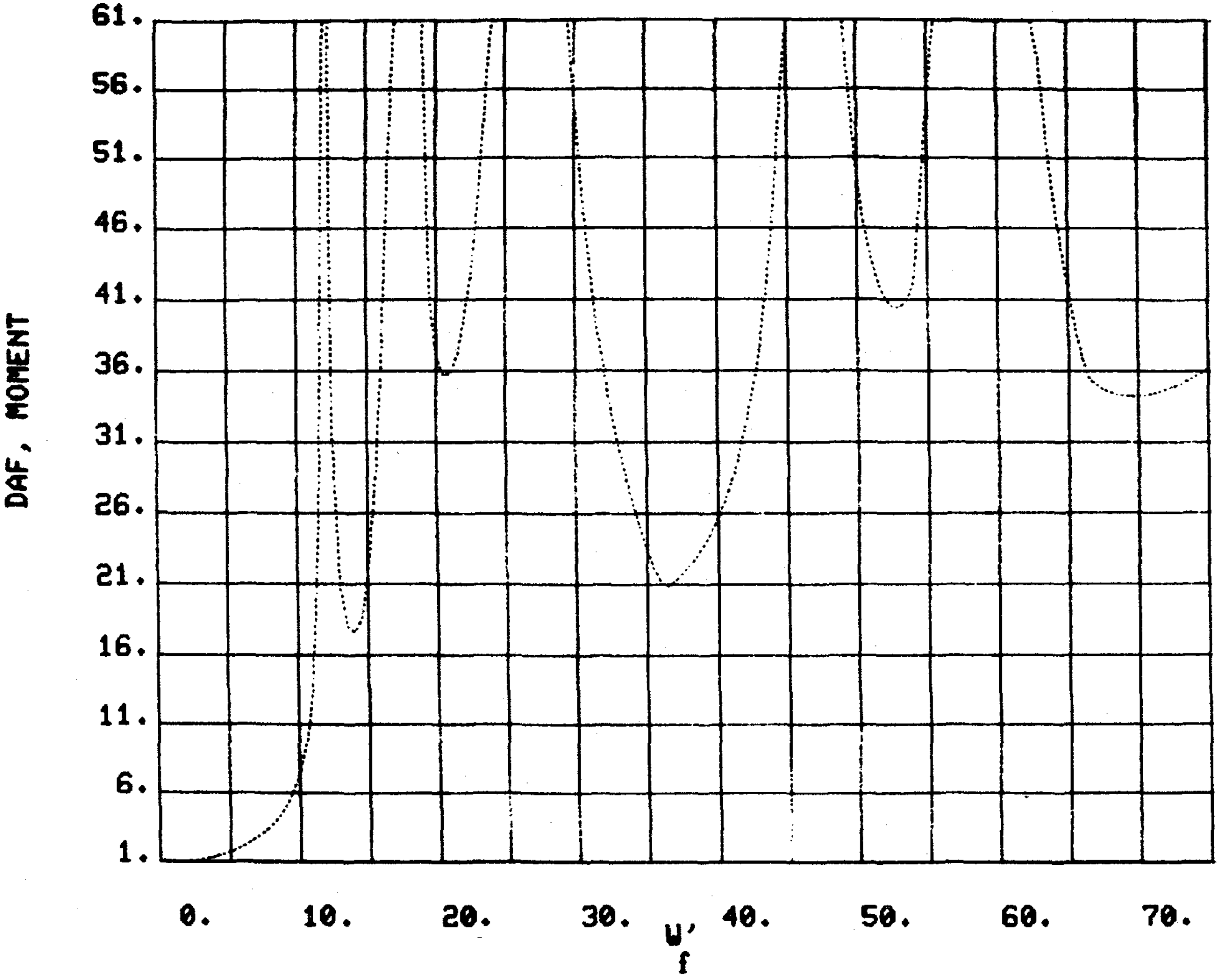


Fig. 34 - DAF, Shear (Three span, .7L-L-.9L)

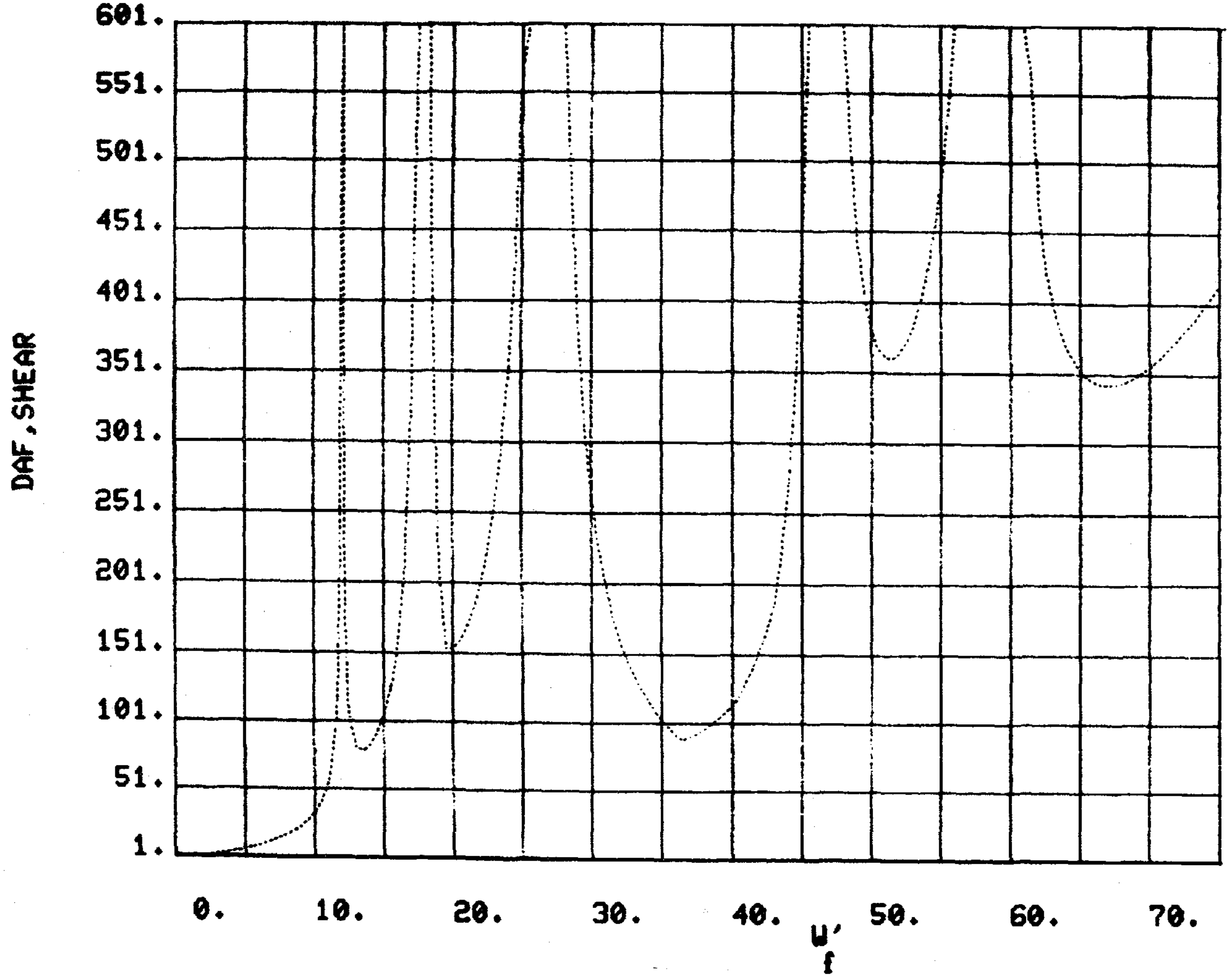


Fig. 35 - DAF, Deflection (Three span, .9L-L-.9L)

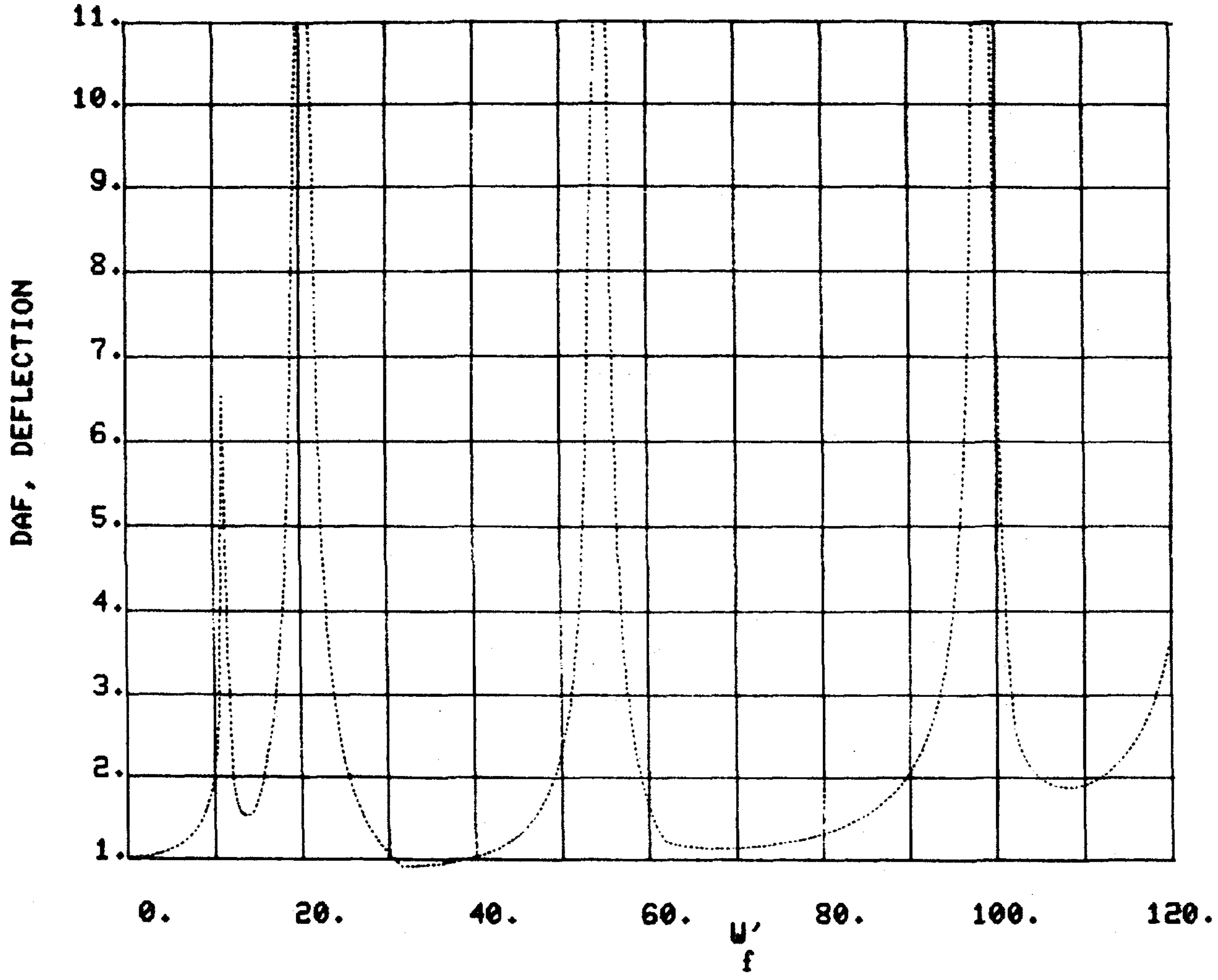
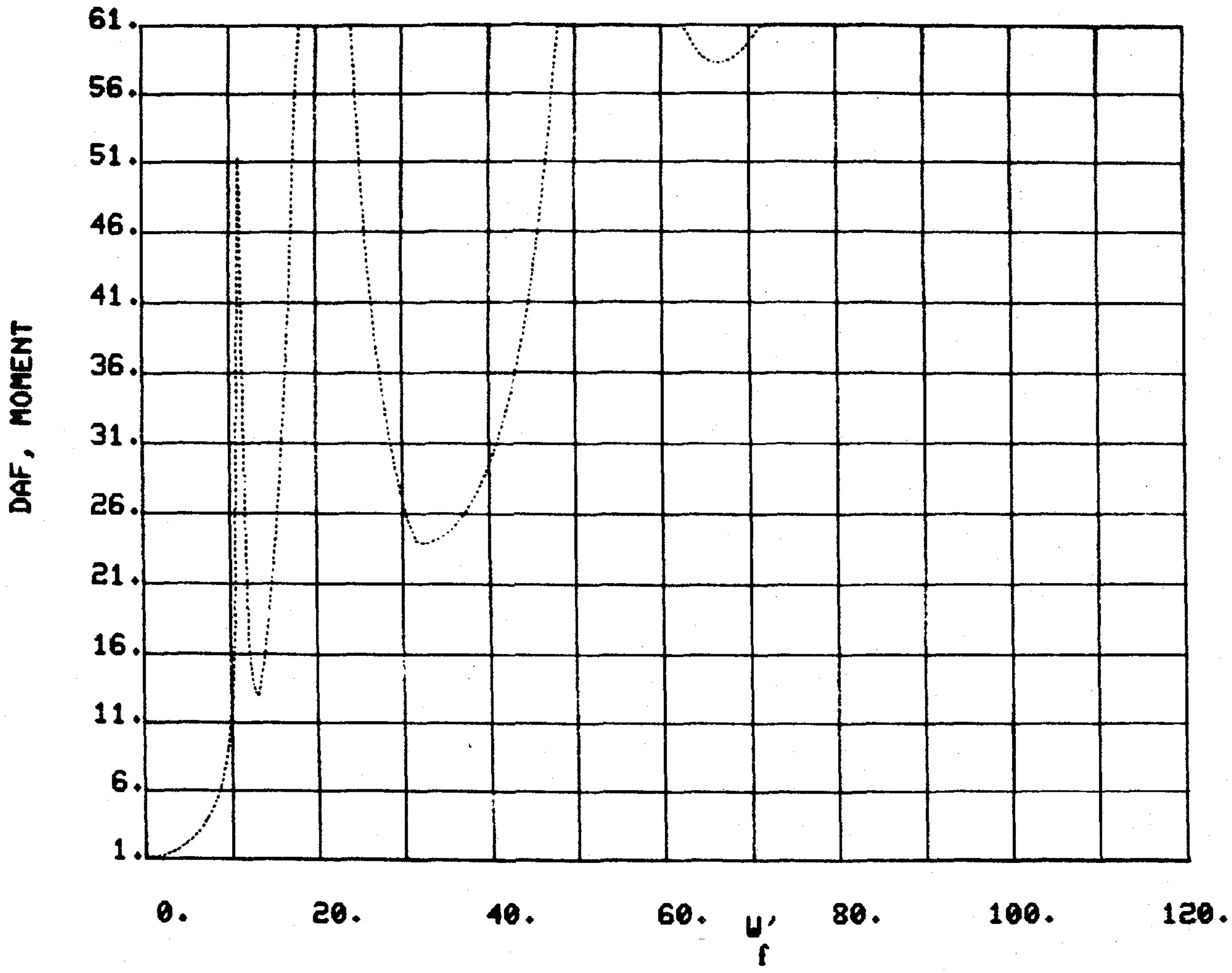


Fig. 36 - DAF, Moment (Three span, .9L-L-.9L)



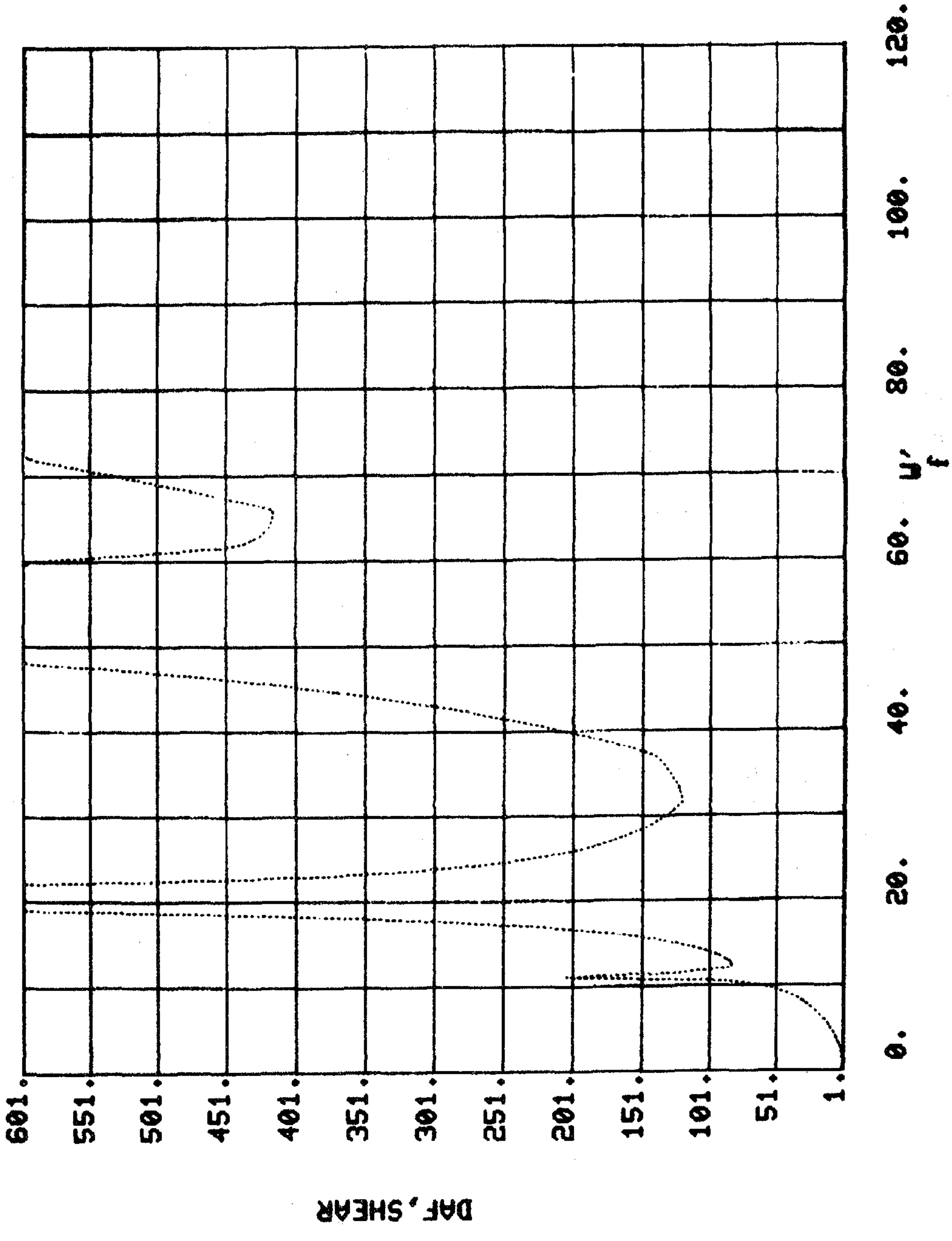


Fig. 37 - DAF, Shear (Three span, .9L-L-.9L)

Fig. 38 - DAF, Deflection (Four span, .5L-L-L-.5L)

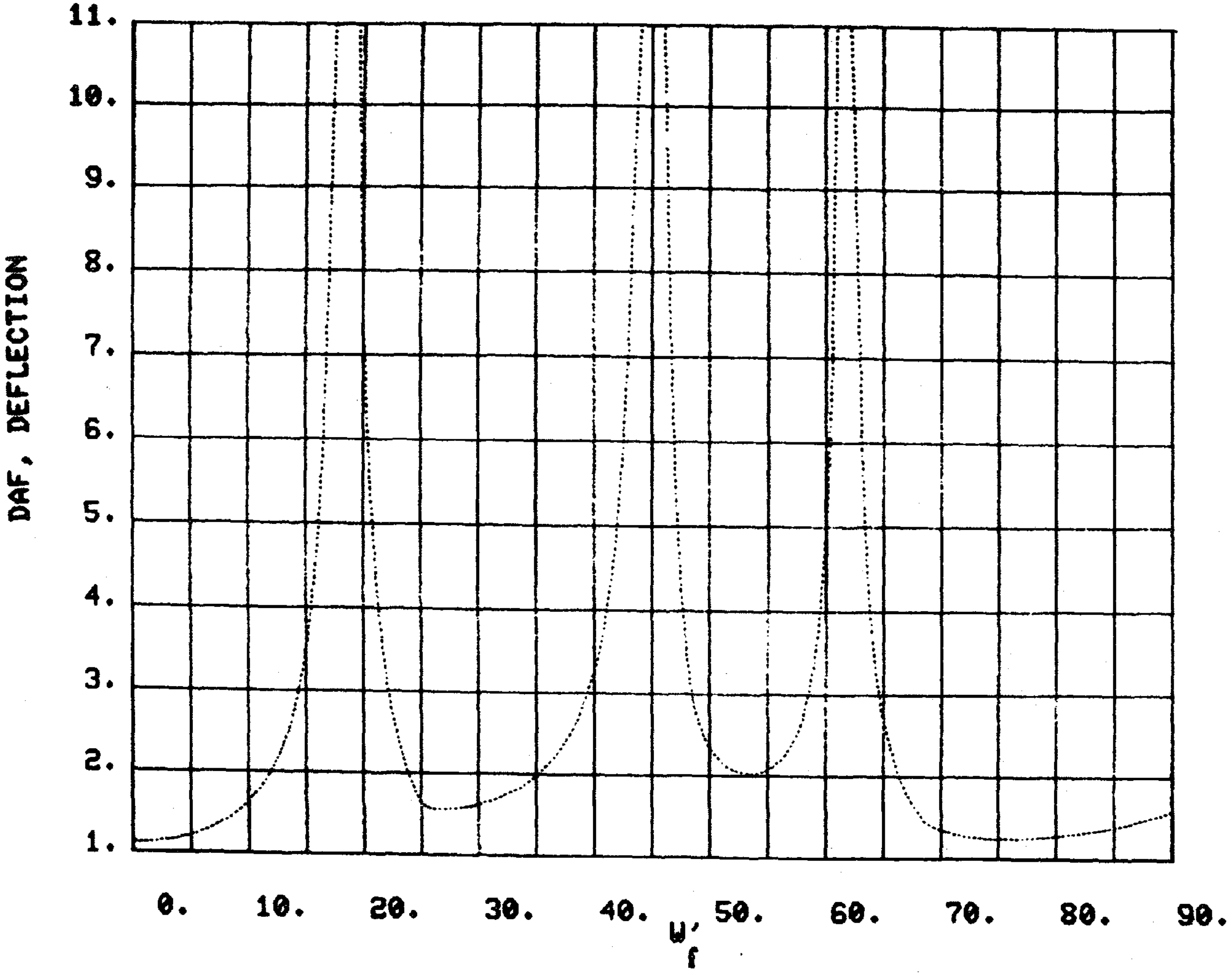


Fig. 39 - DAF, Moment (Four span, .5L-L-L-.5L)

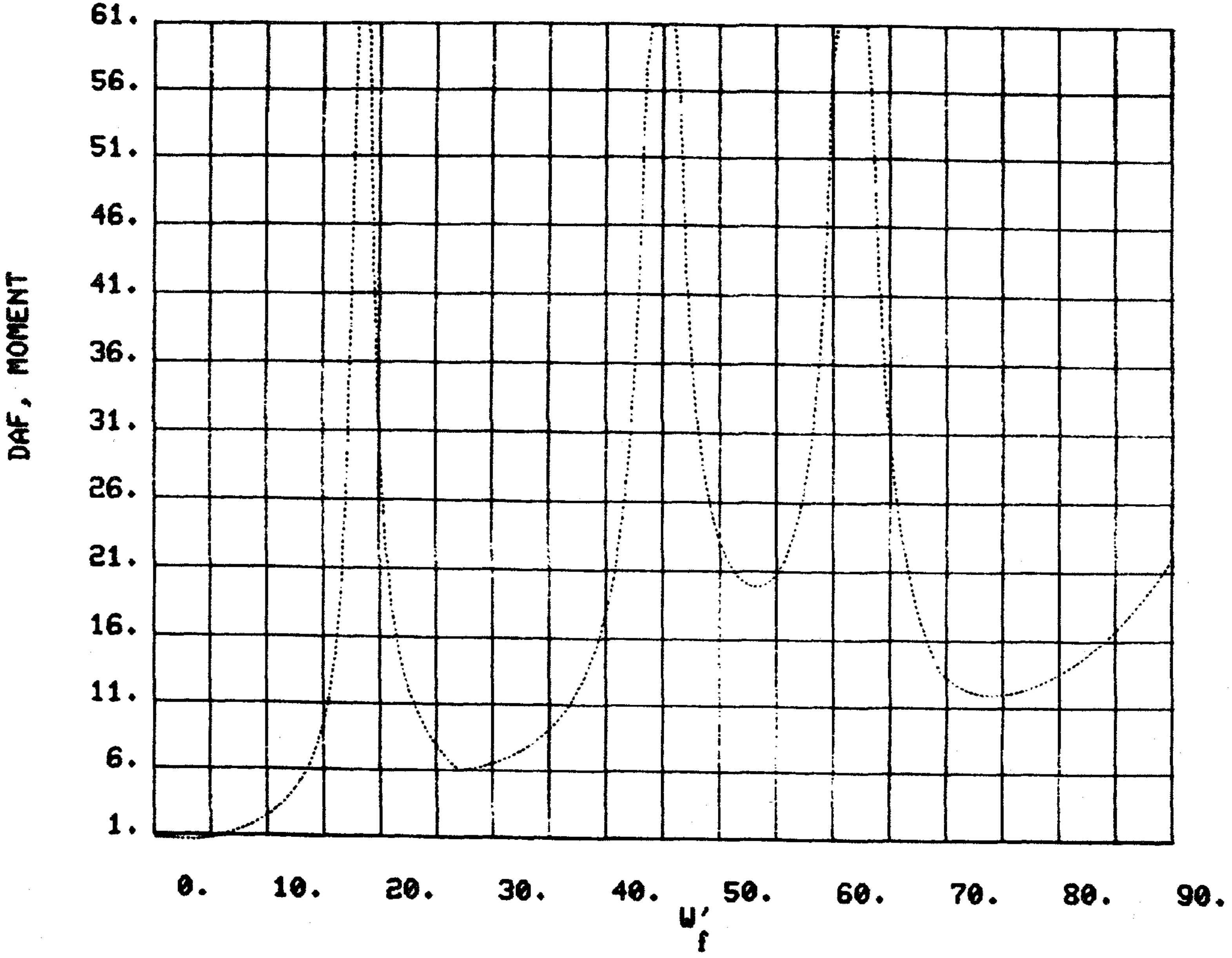


Fig. 40 - DAF, Shear (Four span, .5L-L-L-.5L)

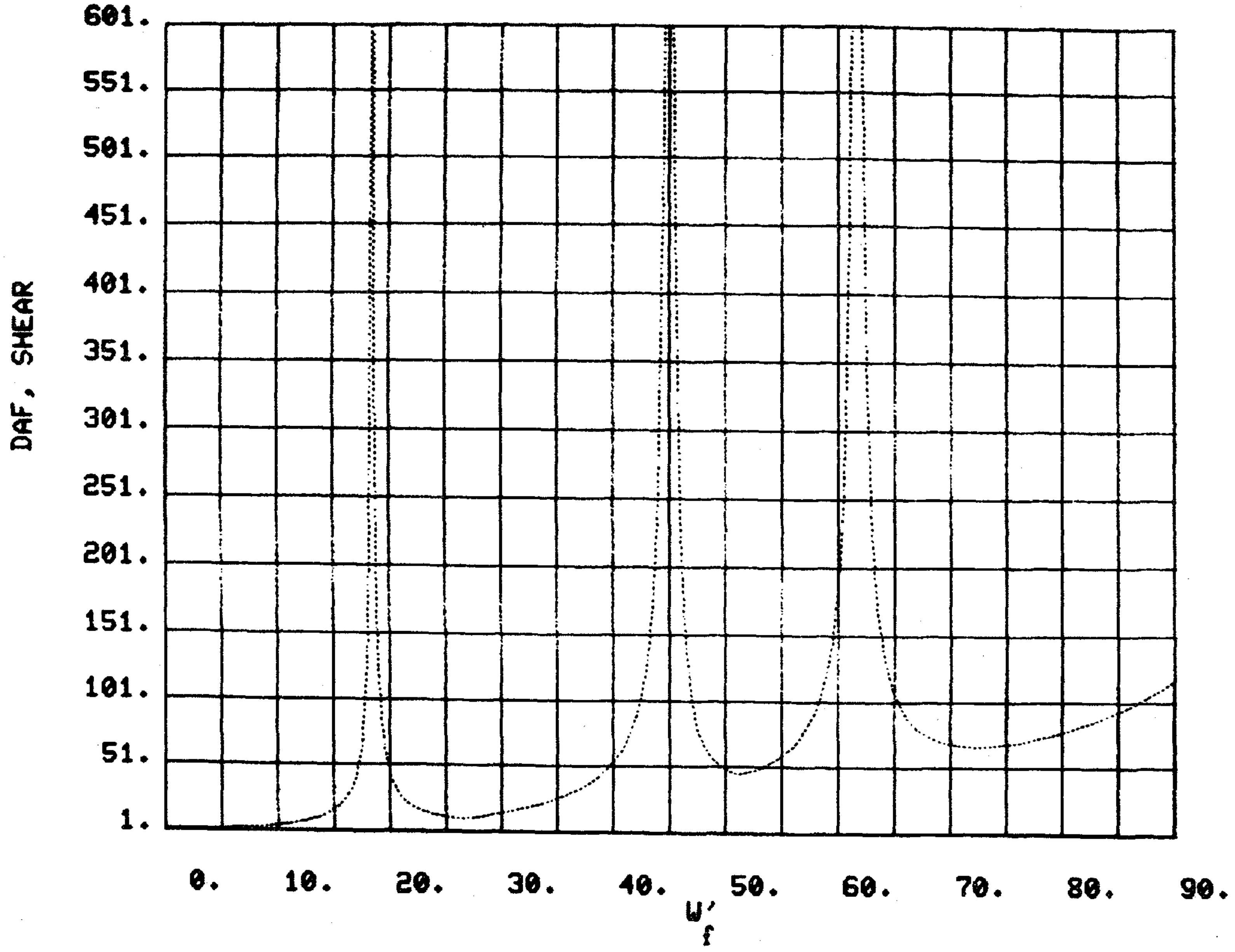


Fig. 41 - DAF, Deflection (Four span, .6L-L-L-.6L)

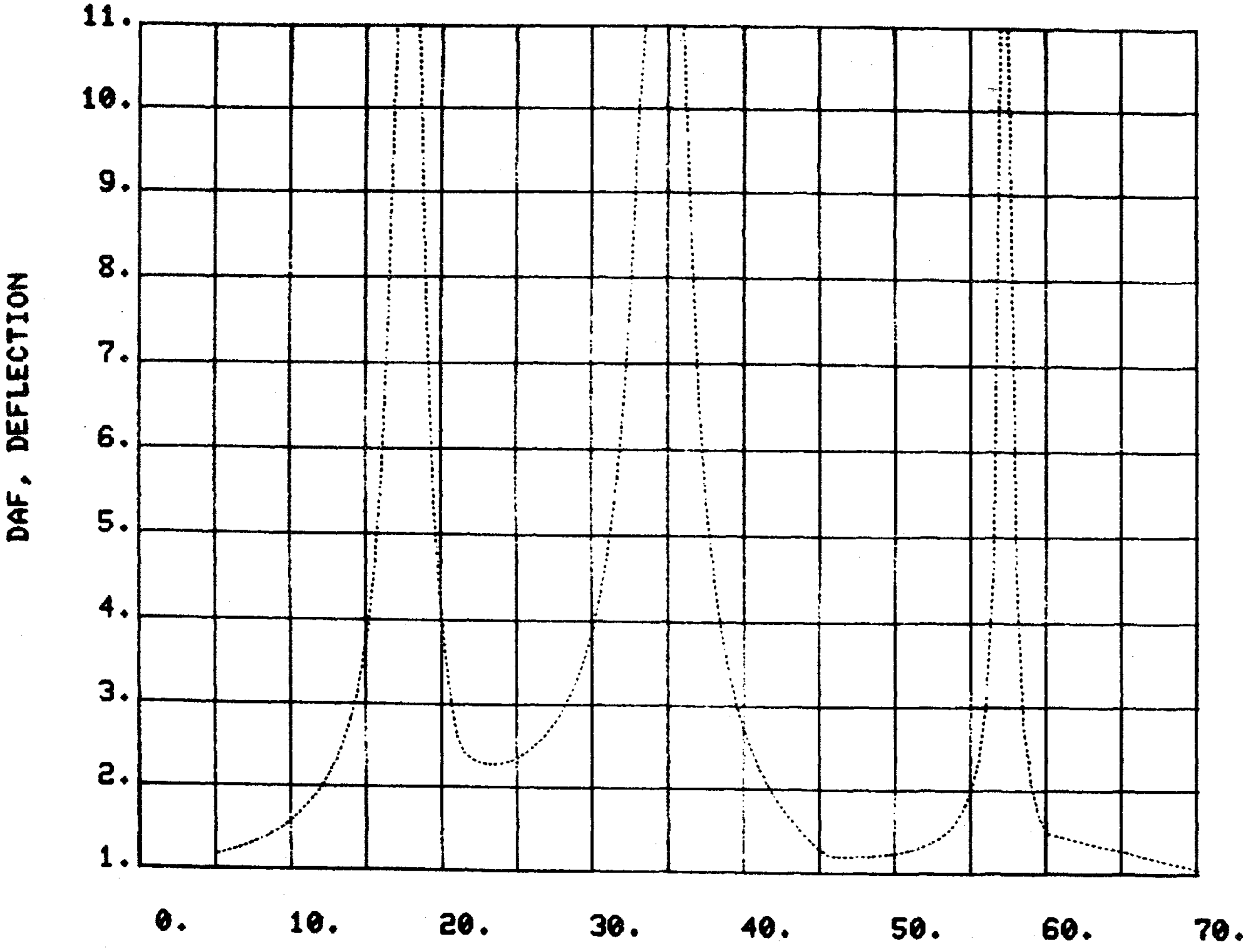


Fig. 41 - DAF, Moment (Four span, .6L-L-L-.6L)

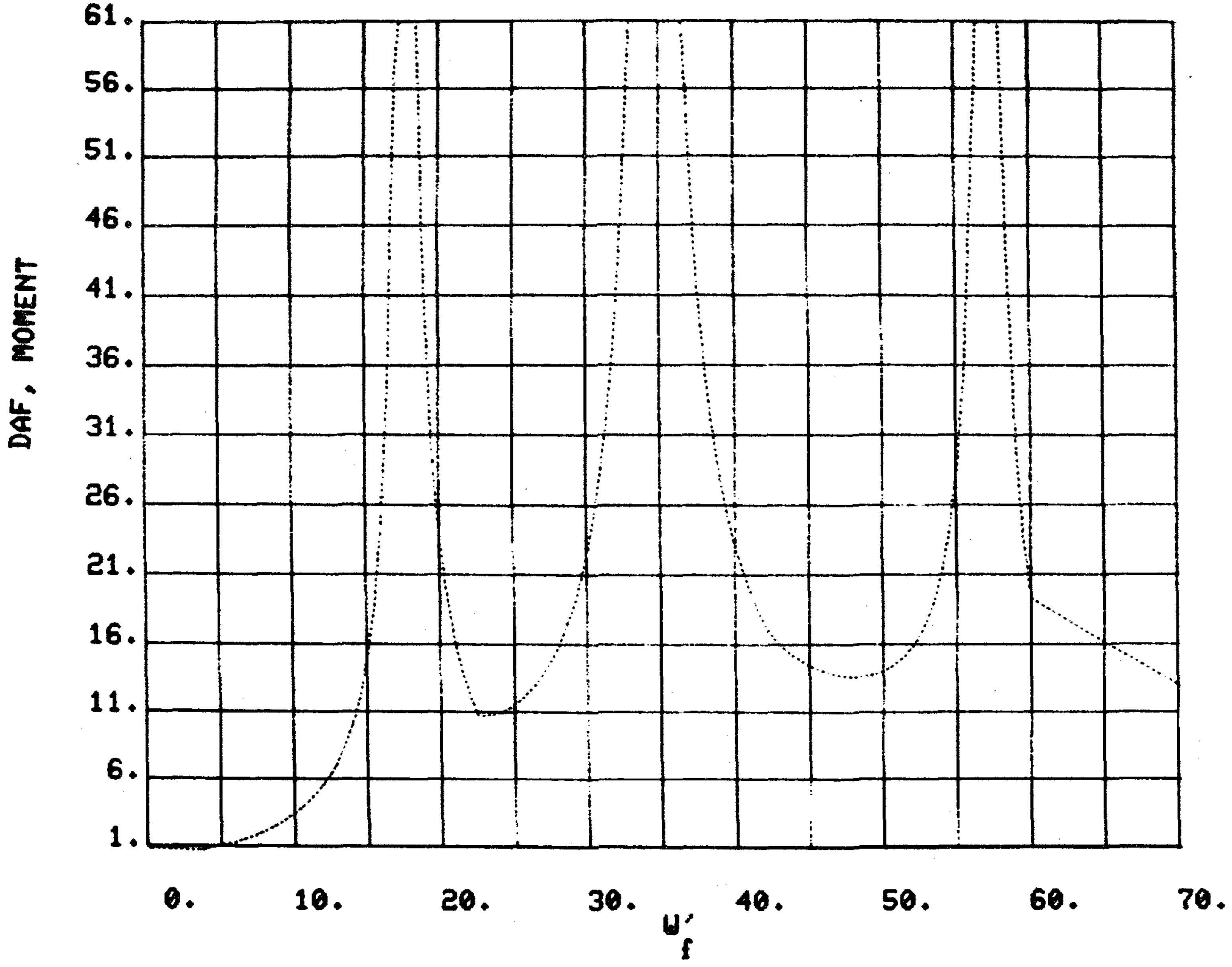


Fig. 41 - DAF, Shear (Four span, .6L-L-L-.6L)

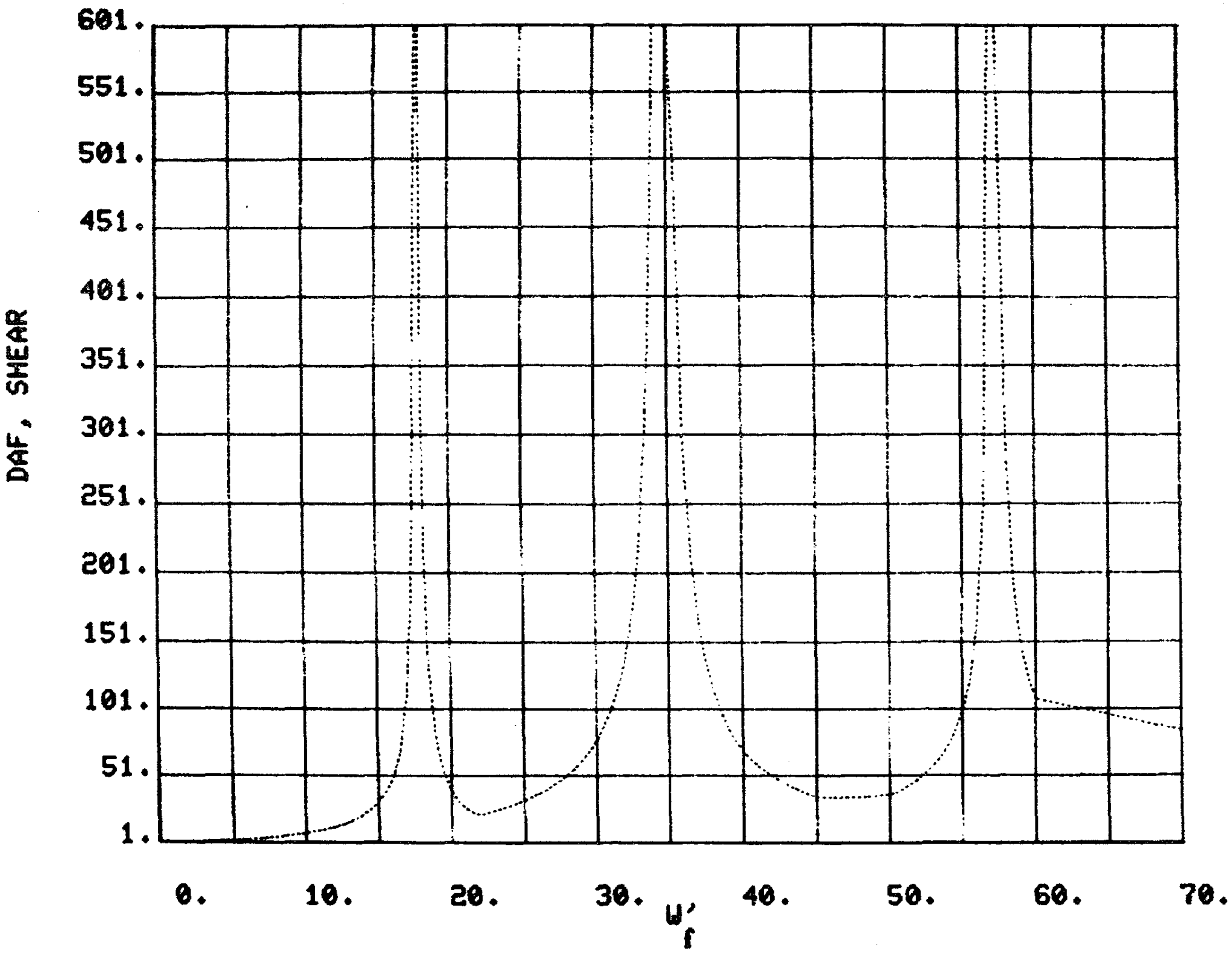


Fig. 44 - DAF, Deflection (Four span, .9L-L-L-.9L)

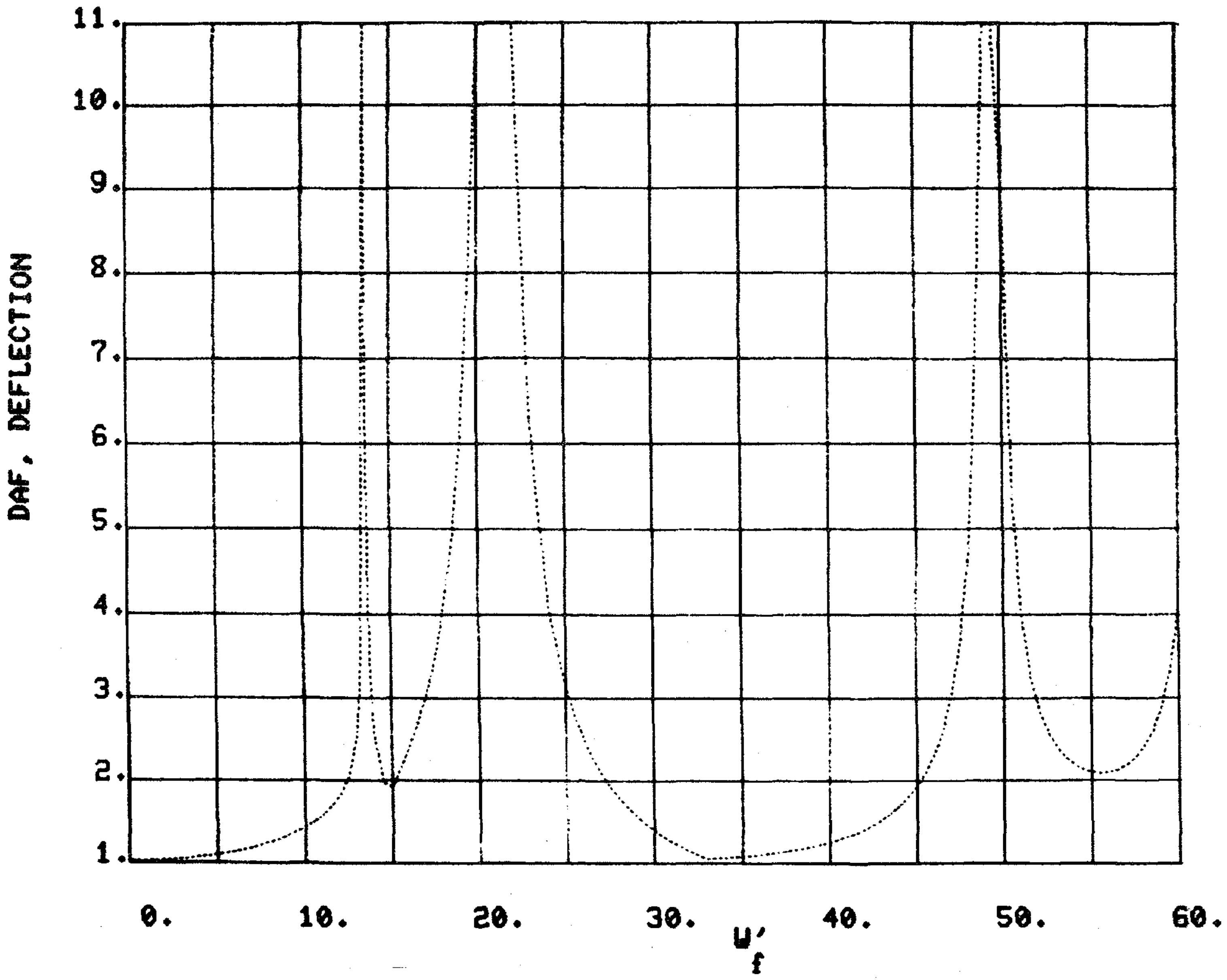


Fig. 44 - DAF, Moment (Four span, .9L-L-L-.9L)

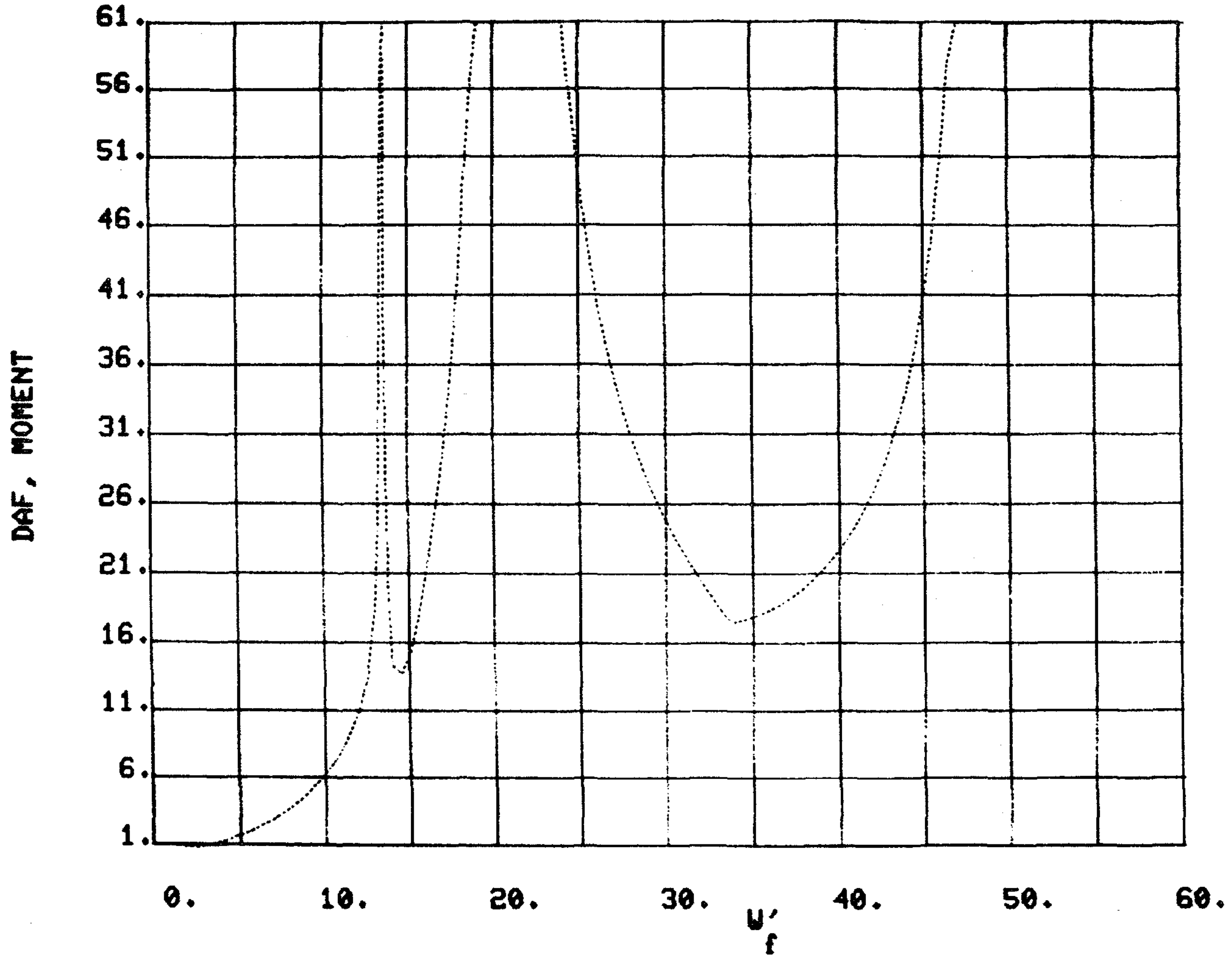
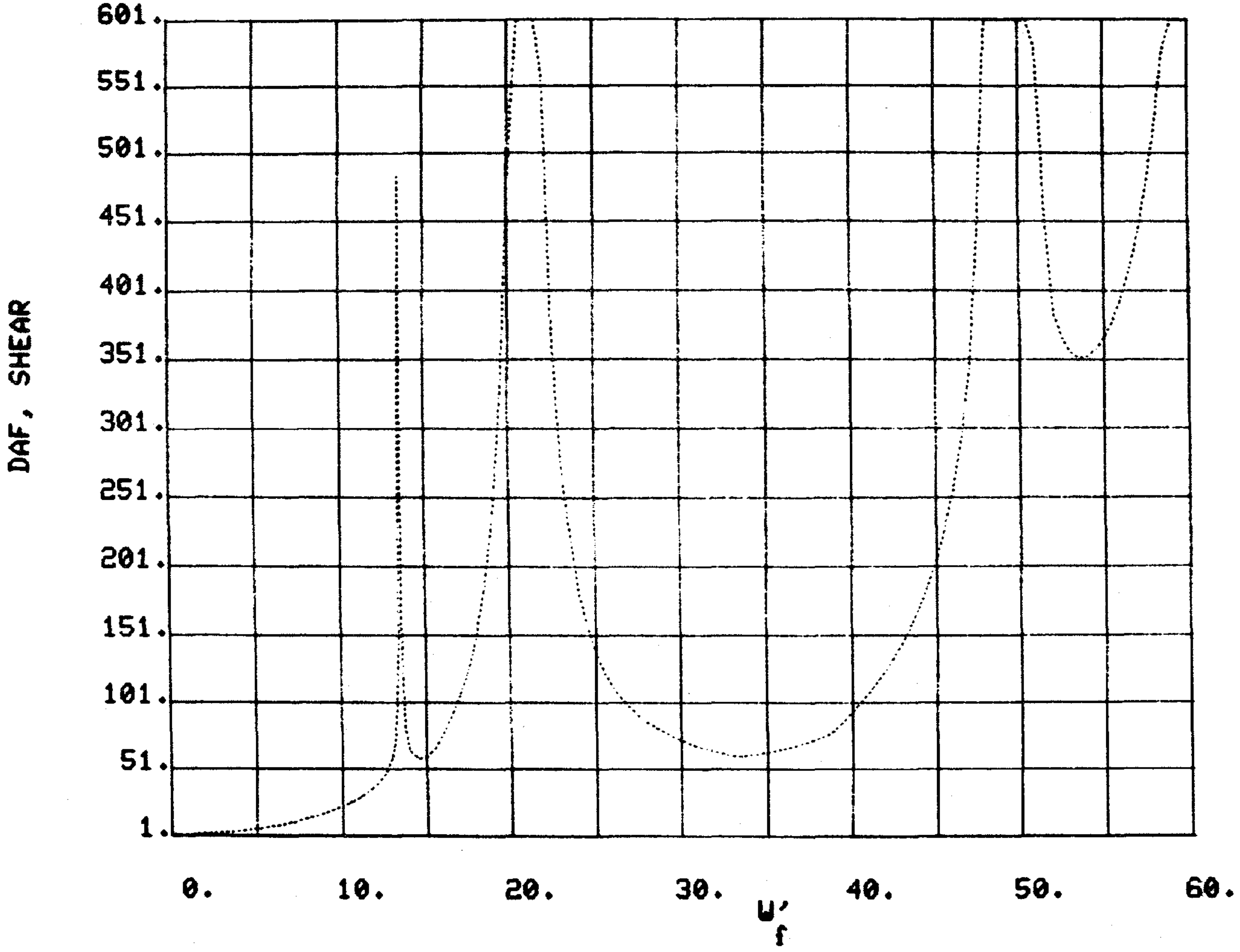


Fig. 44 - DAF, Shear (Four span, .9L-L-L-.9L)



V. SUMMARY AND CONCLUDING REMARKS

The dynamics of differential support settlements of highway bridges has been investigated. A governing differential equation due to pulsating support settlements has been derived. The deflection, moment, shear, velocity, and acceleration expressions were obtained in terms of Fourier series. Neglecting damping, these expressions were compared to the results obtained by the dynamic three moment equation. An excellent correlation was observed. The parameters in these expressions were nondimensionalized as much as possible and various plots were obtained for the dynamic amplification factors versus forcing frequencies. An example bridge has been used to illustrate how these dynamic amplification factors can be properly used.

Experiences of the bridge performances during the San Fernando Earthquake [8,11,16] suggest that a majority of those bridges which collapsed were subjected to unusually high shear. This investigation seems to verify those observation made after the San Fernando Earthquake. As can be seen in the charts, the dynamic amplification factors for shear are quite high especially under higher frequencies.

Further investigations are recommended about the damping characteristics of bridge structures. The peaks in the dynamic amplification factors, indicating the dynamic resonances, may or may not be feasible since no structures are completely damping free and a considerable dynamic oscillation (duration of vibration) is normally required to develop a full resonance phenomenon. Another important point is the fact that an actual earthquake motion is by no means a simple harmonic motion. A study correlating the validity of using a simple harmonic motion to represent a structural behavior due to an earthquake seems to be in order.

Finally, it is strongly recommended that accurate yield data collection regarding time dependent relative support settlements be devised and maintained for structures with a long horizontal dimension such as highway bridges. It is evident from this study that the dynamic support settlements have significant effects on the behavior of bridge superstructures.

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APPENDIX I

A. Sample input and output of the Dynamic Program

i) input

```
TWO SPAN BRIDGE 33FT-27FT, WF=40 RAD/SEC
3,2,200,12,3,0,0,720.,1.46653,3000000.,92850.,.03927,.003927,40.,
.0805,
396.,
0.,72.,144.,216.,288.,360.,396.,432.,504.,576.,648.,720.,
648.,720.,
1000,.000001,
```

ii) output

```
TWO SPAN BRIDGE 33FT-27FT, WF=40 RAD/SEC

BLANK COMMON ARRAY   2265

NATURAL FREQUENCIES AND PARTICULAR SOLUTION


DETERMINANT APPROACHING INFINITY FOR FREQ EQUAL TO   .82974D+01

DETERMINANT APPROACHING INFINITY FOR FREQ EQUAL TO   .33190D+02

DETERMINANT APPROACHING INFINITY FOR FREQ EQUAL TO   .74676D+02

FREQ (MODE 1 ) = .3143D+02 AFTER  138 ITRNS DET = -.3289D-08

FREQ (MODE 2 ) = .5559D+02 AFTER   32 ITRNS DET = -.1447D-10

FREQ (MODE 3 ) = .1218D+03 AFTER   39 ITRNS DET = -.5747D-09


TOTAL SPAN LENGTH                = .7200D+03
MASS DENSITY PER UNIT LENGTH     = .1467D+01
YOUNG'S MODULUS                  = .3000D+07
MOMENT OF INERTIA                = .9285D+05
```

```
DURATION OF EARTHQUAKE              = .3927D-01
TIME INCREMENT IN TIME HISTORY      = .3927D-02
EARTHQUAKE (ANGULAR) VELOCITY       = .4000D+02
NUMBER OF SPANS                     =         2
NUMBER OF MODES IN FREE VIBRN       =         3
NUMBER OF TERMS TO BE SUMMED        =       200
NUMBER OF LOCATIONS (T HISTORY)     =        12


TIME HISTORY FOR THE POINT( X= .000D+00 )

  TIME     PART-DISP PART-VELO PART-ACCL PART-MOMT PART-SHRF
 .000D+00  .000D+00  .000D+00  .000D+00  .000D+00  .000D+00
 .393D-02  .000D+00  .000D+00  .000D+00  .000D+00  .487D+03
 .785D-02  .000D+00  .000D+00  .000D+00  .000D+00  .961D+03
 .118D-01  .000D+00  .000D+00  .000D+00  .000D+00  .141D+04
 .157D-01  .000D+00  .000D+00  .000D+00  .000D+00  .183D+04
 .196D-01  .000D+00  .000D+00  .000D+00  .000D+00  .220D+04
 .236D-01  .000D+00  .000D+00  .000D+00  .000D+00  .252D+04
 .275D-01  .000D+00  .000D+00  .000D+00  .000D+00  .277D+04
 .314D-01  .000D+00  .000D+00  .000D+00  .000D+00  .296D+04
 .353D-01  .000D+00  .000D+00  .000D+00  .000D+00  .307D+04
 .393D-01  .000D+00  .000D+00  .000D+00  .000D+00  .311D+04

MAXIMUM ABSOLUTE VALUES

MAX ABS    .000D+00  .000D+00  .000D+00  .000D+00  .311D+04
CORR TIME  .393D-01  .393D-01  .393D-01  .393D-01  .393D-01


TIME HISTORY FOR THE POINT( X= .720D+02 )

  TIME     PART-DISP PART-VELO PART-ACCL PART-MOMT PART-SHRF
 .000D+00  .000D+00 -.148D+00  .000D+00  .000D+00  .000D+00
 .393D-02 -.578D-03 -.146D+00  .925D+00 -.348D+05  .432D+03
 .785D-02 -.114D-02 -.141D+00  .183D+01 -.688D+05  .854D+03
 .118D-01 -.168D-02 -.132D+00  .269D+01 -.101D+06  .125D+04
 .157D-01 -.217D-02 -.120D+00  .348D+01 -.131D+06  .162D+04
 .196D-01 -.261D-02 -.105D+00  .418D+01 -.157D+06  .195D+04
 .236D-01 -.299D-02 -.869D-01  .479D+01 -.180D+06  .224D+04
 .275D-01 -.329D-02 -.671D-01  .527D+01 -.198D+06  .246D+04
 .314D-01 -.352D-02 -.457D-01  .563D+01 -.212D+06  .263D+04
 .353D-01 -.365D-02 -.231D-01  .584D+01 -.220D+06  .273D+04
 .393D-01 -.370D-02  .543D-06  .592D+01 -.223D+06  .276D+04

MAXIMUM ABSOLUTE VALUES

MAX ABS    .370D-02  .148D+00  .592D+01  .223D+06  .276D+04
CORR TIME  .393D-01  .000D+00  .393D-01  .393D-01  .393D-01
```

```
TIME HISTORY FOR THE POINT( X= .144D+03 )

  TIME     PART-DISP PART-VELO PART-ACCL PART-MOMT PART-SHRF
 .000D+00  .000D+00 -.133D+00  .000D+00  .000D+00  .000D+00
 .393D-02 -.519D-03 -.131D+00  .830D+00 -.633D+05  .324D+03
 .785D-02 -.103D-02 -.126D+00  .164D+01 -.125D+06  .640D+03
 .118D-01 -.151D-02 -.118D+00  .241D+01 -.184D+06  .941D+03
 .157D-01 -.195D-02 -.107D+00  .312D+01 -.238D+06  .122D+04
 .196D-01 -.235D-02 -.938D-01  .375D+01 -.286D+06  .147D+04
 .236D-01 -.268D-02 -.780D-01  .429D+01 -.327D+06  .168D+04
 .275D-01 -.296D-02 -.603D-01  .473D+01 -.360D+06  .185D+04
 .314D-01 -.316D-02 -.410D-01  .505D+01 -.385D+06  .197D+04
 .353D-01 -.328D-02 -.208D-01  .524D+01 -.399D+06  .205D+04
 .393D-01 -.332D-02  .487D-06  .531D+01 -.404D+06  .207D+04

MAXIMUM ABSOLUTE VALUES

MAX ABS    .332D-02  .133D+00  .531D+01  .404D+06  .207D+04
CORR TIME  .393D-01  .000D+00  .393D-01  .393D-01  .383D-01


TIME HISTORY FOR THE POINT( X= .216D+03 )

  TIME     PART-DISP PART-VELO PART-ACCL PART-MOMT PART-SHRF
 .000D+00  .000D+00  .181D+00  .000D+00  .000D+00  .000D+00
 .393D-02  .709D-03  .179D+00 -.113D+01 -.866D+05  .315D+03
 .785D-02  .140D-02  .172D+00 -.224D+01 -.171D+06  .622D+03
 .118D-01  .206D-02  .161D+00 -.329D+01 -.251D+06  .914D+03
 .157D-01  .266D-02  .147D+00 -.426D+01 -.325D+06  .118D+04
 .196D-01  .320D-02  .128D+00 -.513D+01 -.391D+06  .142D+04
 .236D-01  .367D-02  .107D+00 -.588D+01 -.448D+06  .163D+04
 .275D-01  .404D-02  .823D-01 -.646D+01 -.493D+06  .179D+04
 .314D-01  .431D-02  .560D-01 -.689D+01 -.526D+06  .192D+04
 .353D-01  .447D-02  .283D-01 -.716D+01 -.547D+06  .198D+04
 .393D-01  .453D-02 -.866D-08 -.725D+01 -.554D+06  .201D+04

MAXIMUM ABSOLUTE VALUES

MAX ABS    .453D-02  .181D+00  .725D+01  .554D+06  .201D+04
CORR TIME  .393D-01  .000D+00  .393D-01  .383D-01  .393D-01


TIME HISTORY FOR THE POINT( X= .288D+03 )

  TIME     PART-DISP PART-VELO PART-ACCL PART-MOMT PART-SHRF
 .000D+00  .000D+00  .911D+00  .000D+00  .000D+00  .000D+00
```

```
   .393D-02   .353D-02   .000D+00  -.570D+01  -.120D+06   .835D+03
   .785D-02   .704D-02   .866D+00  -.113D+02  -.237D+06   .125D+04
   .118D-01   .103D-01   .812D+00  -.165D+02  -.349D+06   .184D+04
   .157D-01   .134D-01   .737D+00  -.214D+02  -.452D+06   .239D+04
   .196D-01   .161D-01   .644D+00  -.258D+02  -.543D+06   .287D+04
   .236D-01   .184D-01   .535D+00  -.295D+02  -.621D+06   .328D+04
   .275D-01   .203D-01   .414D+00  -.325D+02  -.684D+06   .362D+04
   .314D-01   .217D-01   .281D+00  -.347D+02  -.731D+06   .386D+04
   .353D-01   .225D-01   .142D+00  -.360D+02  -.759D+06   .401D+04
   .393D-01   .228D-01  -.335D-05  -.364D+02  -.768D+06   .406D+04

 MAXIMUM ABSOLUTE VALUES

 MAX ABS      .228D-01   .911D+00   .364D+02   .768D+06   .406D+04
 CORR TIME    .393D-01   .000D+00   .393D-01   .393D-01   .393D-01


 TIME HISTORY FOR THE POINT( X= .360D+03 )

    TIME     PART-DISP  PART-VELO  PART-ACCL  PART-MOMT  PART-SHRF
   .000D+00   .000D+00   .223D+01   .000D+00   .000D+00   .000D+00
   .393D-02   .872D-02   .220D+01  -.140D+02  -.199D+06   .156D+04
   .785D-02   .172D-01   .212D+01  -.276D+02  -.394D+06   .307D+04
   .118D-01   .253D-01   .199D+01  -.405D+02  -.579D+06   .452D+04
   .157D-01   .328D-01   .180D+01  -.524D+02  -.749D+06   .585D+04
   .196D-01   .394D-01   .158D+01  -.631D+02  -.901D+06   .703D+04
   .236D-01   .451D-01   .131D+01  -.722D+02  -.103D+07   .805D+04
   .275D-01   .497D-01   .101D+01  -.795D+02  -.114D+07   .886D+04
   .314D-01   .530D-01   .689D+00  -.848D+02  -.121D+07   .946D+04
   .353D-01   .551D-01   .349D+00  -.881D+02  -.126D+07   .983D+04
   .393D-01   .557D-01  -.819D-05  -.892D+02  -.127D+07   .995D+04

 MAXIMUM ABSOLUTE VALUES

 MAX ABS      .557D-01   .223D+01   .892D+02   .127D+07   .995D+04
 CORR TIME    .393D-01   .000D+00   .393D-01   .393D-01   .393D-01


 TIME HISTORY FOR THE POINT( X= .396D+03 )

    TIME     PART-DISP  PART-VELO  PART-ACCL  PART-MOMT  PART-SHRF
   .000D+00   .000D+00   .322D+01   .000D+00   .000D+00   .000D+00
   .393D-02   .126D-01   .318D+01  -.201D+02  -.270D+06  -.316D+04
   .785D-02   .249D-01   .306D+01  -.398D+02  -.534D+06  -.625D+04
   .118D-01   .365D-01   .287D+01  -.585D+02  -.785D+06  -.918D+04
   .157D-01   .473D-01   .261D+01  -.757D+02  -.102D+07  -.119D+05
   .196D-01   .569D-01   .228D+01  -.911D+02  -.122D+07  -.143D+05
   .236D-01   .651D-01   .189D+01  -.104D+03  -.140D+07  -.164D+05
   .275D-01   .717D-01   .146D+01  -.115D+03  -.154D+07  -.180D+05
```

```
 .314D-01   .788D-01   .995D+00 -.122D+03 -.164D+07 -.192D+05
 .353D-01   .795D-01   .504D+00 -.127D+03 -.171D+07 -.200D+05
 .393D-01   .805D-01 -.118D-04 -.129D+03 -.173D+07 -.202D+05

MAXIMUM ABSOLUTE VALUES

MAX ABS     .805D-01   .322D+01   .129D+03   .173D+07   .202D+05
CORR TIME   .393D-01   .000D+00   .393D-01   .393D-01   .393D-01


TIME HISTORY FOR THE POINT( X= .432D+03 )

  TIME     PART-DISP PART-VELO PART-ACCL PART-MOMT PART-SHRF
 .000D+00   .000D+00   .446D+01   .000D+00   .000D+00   .000D+00
 .393D-02   .174D-01   .440D+01 -.279D+02   .241D+05 -.751D+04
 .785D-02   .344D-01   .424D+01 -.551D+02   .476D+05 -.148D+05
 .118D-01   .506D-01   .397D+01 -.810D+02   .699D+05 -.218D+05
 .157D-01   .655D-01   .361D+01 -.105D+03   .906D+05 -.282D+05
 .196D-01   .788D-01   .315D+01 -.126D+03   .109D+06 -.340D+05
 .236D-01   .902D-01   .262D+01 -.144D+03   .125D+06 -.389D+05
 .275D-01   .993D-01   .202D+01 -.159D+03   .137D+06 -.428D+05
 .314D-01   .106D+00   .138D+01 -.170D+03   .147D+06 -.457D+05
 .353D-01   .110D+00   .697D+00 -.176D+03   .152D+06 -.474D+05
 .393D-01   .111D+00 -.164D-04 -.178D+03   .154D+06 -.480D+05

MAXIMUM ABSOLUTE VALUES

MAX ABS     .111D+00   .446D+01   .178D+03   .154D+06   .480D+05
CORR TIME   .393D-01   .000D+00   .393D-01   .393D-01   .393D-01


TIME HISTORY FOR THE POINT( X= .504D+03 )

  TIME     PART-DISP PART-VELO PART-ACCL PART-MOMT PART-SHRF
 .000D+00   .000D+00   .658D+01   .000D+00   .000D+00   .000D+00
 .393D-02   .257D-01   .649D+01 -.411D+02   .448D+06 -.388D+04
 .785D-02   .508D-01   .625D+01 -.813D+02   .886D+06 -.766D+04
 .118D-01   .746D-01   .586D+01 -.119D+03   .130D+07 -.112D+05
 .157D-01   .966D-01   .532D+01 -.155D+03   .168D+07 -.146D+05
 .196D-01   .116D+00   .465D+01 -.186D+03   .203D+07 -.175D+05
 .236D-01   .133D+00   .386D+01 -.213D+03   .232D+07 -.200D+05
 .275D-01   .146D+00   .299D+01 -.234D+03   .255D+07 -.221D+05
 .314D-01   .156D+00   .203D+01 -.250D+03   .273D+07 -.236D+05
 .353D-01   .162D+00   .103D+01 -.260D+03   .283D+07 -.245D+05
 .393D-01   .164D+00 -.242D-04 -.263D+03   .287D+07 -.248D+05

MAXIMUM ABSOLUTE VALUES

MAX ABS     .164D+00   .658D+01   .263D+03   .287D+07   .248D+05
CORR TIME   .393D-01   .000D+00   .393D-01   .393D-01   .393D-01
```

```
TIME HISTORY FOR THE POINT( X= .576D+03 )

  TIME     PART-DISP PART-VELO PART-ACCL PART-MOMT PART-SHRF
 .000D+00  .000D+00  .668D+01  .000D+00  .000D+00  .000D+00
 .393D-02  .261D-01  .660D+01 -.418D+02  .568D+06  .631D+03
 .785D-02  .516D-01  .635D+01 -.826D+02  .112D+07  .125D+04
 .118D-01  .758D-01  .595D+01 -.121D+03  .165D+07  .183D+04
 .157D-01  .982D-01  .540D+01 -.157D+03  .213D+07  .237D+04
 .196D-01  .118D+00  .472D+01 -.189D+03  .257D+07  .285D+04
 .236D-01  .135D+00  .393D+01 -.216D+03  .294D+07  .326D+04
 .275D-01  .149D+00  .303D+01 -.238D+03  .324D+07  .359D+04
 .314D-01  .159D+00  .206D+01 -.254D+03  .345D+07  .384D+04
 .353D-01  .165D+00  .105D+01 -.264D+03  .359D+07  .398D+04
 .393D-01  .167D+00 -.245D-04 -.267D+03  .363D+07  .403D+04

MAXIMUM ABSOLUTE VALUES

MAX ABS    .167D+00  .668D+01  .267D+03  .363D+07  .403D+04
CORR TIME  .393D-01  .000D+00  .393D-01  .393D-01  .393D-01


TIME HISTORY FOR THE POINT( X= .648D+03 )

  TIME     PART-DISP PART-VELO PART-ACCL PART-MOMT PART-SHRF
 .000D+00  .000D+00  .421D+01  .000D+00  .000D+00  .000D+00
 .393D-02  .165D-01  .415D+01 -.283D+02  .381D+06  .435D+04
 .785D-02  .325D-01  .400D+01 -.520D+02  .752D+06  .860D+04
 .118D-01  .477D-01  .375D+01 -.764D+02  .110D+07  .126D+05
 .157D-01  .618D-01  .340D+01 -.989D+02  .143D+07  .164D+05
 .198D-01  .744D-01  .297D+01 -.119D+03  .172D+07  .187D+05
 .236D-01  .851D-01  .247D+01 -.136D+03  .197D+07  .225D+05
 .275D-01  .937D-01  .191D+01 -.150D+03  .217D+07  .248D+05
 .314D-01  .100D+00  .130D+01 -.160D+03  .231D+07  .265D+05
 .353D-01  .104D+00  .658D+00 -.166D+03  .240D+07  .275D+05
 .393D-01  .105D+00 -.155D-04 -.168D+03  .243D+07  .278D+05

MAXIMUM ABSOLUTE VALUES

MAX ABS    .105D+00  .421D+01  .168D+03  .243D+07  .278D+05
CORR TIME  .383D-01  .000D+00  .393D-01  .393D-01  .393D-01
```

```
TIME HISTORY FOR THE POINT( X= .720D+03 )

  TIME     PART-DISP  PART-VELO  PART-ACCL  PART-MOMT  PART-SHRF
 .000D+00  .000D+00   .863D-14   .000D+00   .000D+00   .000D+00
 .393D-02  .337D-16   .852D-14  -.540D-13   .647D-09   .580D+04
 .785D-02  .666D-16   .820D-14  -.107D-12   .128D-08   .114D+05
 .118D-01  .979D-16   .769D-14  -.157D-12   .188D-08   .168D+05
 .157D-01  .127D-15   .698D-14  -.203D-12   .243D-08   .218D+05
 .196D-01  .152D-15   .610D-14  -.244D-12   .292D-08   .262D+05
 .236D-01  .174D-15   .507D-14  -.279D-12   .334D-08   .300D+05
 .275D-01  .192D-15   .392D-14  -.307D-12   .368D-08   .330D+05
 .314D-01  .205D-15   .267D-14  -.328D-12   .393D-08   .352D+05
 .353D-01  .213D-15   .135D-14  -.341D-12   .408D-08   .366D+05
 .393D-01  .216D-15  -.317D-19  -.345D-12   .413D-08   .370D+05

MAXIMUM ABSOLUTE VALUES

MAX ABS    .216D-15   .863D-14   .345D-12   .413D-08   .370D+05
CORR TIME  .393D-01   .000D+00   .393D-01   .393D-01   .393D-01
*STOP*
```

B) Sample input and output of the MOM3 Program

i) input

```
TWO SPAN BRIDGE 33FT-27FT, WF=40 RAD/SEC
3,2,0,
5,1000,.00001,
DIST 1,40.,720.,7.2,
396.,3000000.,92850.,1.46653,
324.,3000000.,92850.,1.46653,
.0805,
999.,
```

ii) output

```
 TWO SPAN BRIDGE 33FT-27FT, WF=40 RAD/SEC

 BLANK COMMON SIZE   462

 DETERMINANT APPROACHING INFINITY FOR FREQ EQUAL TO   .27429D+02

 DETERMINANT APPROACHING INFINITY FOR FREQ EQUAL TO   .40875D+02

 DETERMINANT APPROACHING INFINITY FOR FREQ EQUAL TO   .10972D+03

 DETERMINANT APPROACHING INFINITY FOR FREQ EQUAL TO   .16390D+03

 DETERMINANT APPROACHING INFINITY FOR FREQ EQUAL TO   .24686D+03

 FREQ (MODE 1 ) = .3143D+02 AFTER   21 ITRNS DET =  .7750D-06

 FREQ (MODE 2 ) = .5559D+02 AFTER   21 ITRNS DET =  .5134D-06

 FREQ (MODE 3 ) = .1218D+03 AFTER    9 ITRNS DET =  .4101D-05

 FREQ (MODE 4 ) = .1858D+03 AFTER    7 ITRNS DET =  .4475D-05

 FREQ (MODE 5 ) = .2697D+03 AFTER    4 ITRNS DET =  .4176D-05

 NSPAN                               =         2
 FORCING FREQUENCY(RAD/SEC)          = .4000D+02
 TOTAL SPAN LENGTH                   = .7200D+03
```

```
DITANCE INERVAL ALONG THE SPAN      = .7200D+01
NO. OF POINTS IN TIME               =         1

FOR THE SPAN NO. 1

THE SPAN LENGTH IS                  = .3960D+03
YOUNGS MODULUS IS                   = .3000D+07
THE MOMENT OF INERTIA IS            = .9285D+05
THE MASS PER UNIT LENGTH IS         = .1467D+01

FOR THE SPAN NO. 2

THE SPAN LENGTH IS                  = .3240D+03
YOUNGS MODULUS IS                   = .3000D+07
THE MOMENT OF INERTIA IS            = .9285D+05
THE MASS PER UNIT LENGTH IS         = .1467D+01

FOR THE SUPPORT NO. 1

THE AMPLITUDE OF SETTLEMENT IS      = .8050D-01


MAXIMUM PARTICULAR RESPONSE ALONG THE SPAN (T=  .39270D-01)


                DIST          PART DISP        PART MOM       PART SHEAR
                ----          ---------        --------       ----------

             .00000D+00      .00000D+00       .00000D+00     -.32101D+04
             .72000D+01     -.43986D-03      -.23103D+05     -.32063D+04
             .14400D+02     -.87541D-03      -.46153D+05     -.31852D+04
             .21600D+02     -.13024D-02      -.69097D+05     -.31768D+04
             .28800D+02     -.17165D-02      -.91882D+05     -.31513D+04
             .36000D+02     -.21135D-02      -.11446D+06     -.31189D+04
             .43200D+02     -.24892D-02      -.13678D+06     -.30800D+04
             .50400D+02     -.28395D-02      -.15880D+06     -.30349D+04
             .57600D+02     -.31602D-02      -.18047D+06     -.29842D+04
             .64800D+02     -.34473D-02      -.20176D+06     -.29283D+04
             .72000D+02     -.36969D-02      -.22263D+06     -.28679D+04
             .79200D+02     -.39051D-02      -.24305D+06     -.28037D+04
             .86400D+02     -.40681D-02      -.26299D+06     -.27362D+04
             .93600D+02     -.41821D-02      -.28244D+06     -.26665D+04
             .10080D+03     -.42435D-02      -.30138D+06     -.25952D+04
             .10800D+03     -.42489D-02      -.31981D+06     -.25234D+04
             .11520D+03     -.41948D-02      -.33772D+06     -.24520D+04
             .12240D+03     -.40778D-02      -.35512D+06     -.23820D+04
             .12960D+03     -.38947D-02      -.37203D+06     -.23146D+04
             .13680D+03     -.36424D-02      -.38846D+06     -.22508D+04
             .14400D+03     -.33178D-02      -.40445D+06     -.21919D+04
             .15120D+03     -.29180D-02      -.42004D+06     -.21391D+04
             .15840D+03     -.24400D-02      -.43528D+06     -.20938D+04
```

```
.16560D+03     -.18809D-02     -.45021D+06     -.20572D+04
.17280D+03     -.12381D-02     -.46492D+06     -.20307D+04
.18000D+03     -.50880D-03     -.47948D+06     -.20158D+04
.18720D+03      .30976D-03     -.49398D+06     -.20140D+04
.19440D+03      .12203D-02     -.50852D+06     -.20268D+04
.20160D+03      .22254D-02     -.52321D+06     -.20558D+04
.20880D+03      .33279D-02     -.53817D+06     -.21025D+04
.21600D+03      .45306D-02     -.55353D+06     -.21688D+04
.22320D+03      .58363D-02     -.56945D+06     -.22562D+04
.23040D+03      .72480D-02     -.58607D+06     -.23666D+04
.23760D+03      .87688D-02     -.60358D+06     -.25017D+04
.24480D+03      .10402D-01     -.62216D+06     -.26635D+04
.25200D+03      .12151D-01     -.64201D+06     -.28538D+04
.25920D+03      .14019D-01     -.66333D+06     -.30747D+04
.26640D+03      .16011D-01     -.68636D+06     -.33282D+04
.27360D+03      .18131D-01     -.71134D+06     -.36164D+04
.28080D+03      .20383D-01     -.73853D+06     -.39416D+04
.28800D+03      .22773D-01     -.76819D+06     -.43059D+04
.29520D+03      .25305D-01     -.80063D+06     -.47119D+04
.30240D+03      .27987D-01     -.83615D+06     -.51618D+04
.30960D+03      .30824D-01     -.87507D+06     -.56584D+04
.31680D+03      .33824D-01     -.91775D+06     -.62042D+04
.32400D+03      .36995D-01     -.96454D+06     -.68022D+04
.33120D+03      .40346D-01     -.10158D+07     -.74553D+04
.33840D+03      .43886D-01     -.10720D+07     -.81665D+04
.34560D+03      .47625D-01     -.11336D+07     -.89393D+04
.35280D+03      .51576D-01     -.12009D+07     -.97769D+04
.36000D+03      .55750D-01     -.12745D+07     -.10683D+05
.36720D+03      .60161D-01     -.13549D+07     -.11662D+05
.37440D+03      .64825D-01     -.14426D+07     -.12717D+05
.38160D+03      .69757D-01     -.15383D+07     -.13854D+05
.38880D+03      .74976D-01     -.16423D+07     -.15076D+05
.39600D+03      .80500D-01     -.17556D+07     -.16389D+05
.40320D+03      .86335D-01     -.13511D+07      .55457D+05
.41040D+03      .92422D-01     -.95722D+06      .53948D+05
.41760D+03      .98686D-01     -.57455D+06      .52333D+05
.42480D+03      .10506D+00     -.20388D+06      .50612D+05
.43200D+03      .11147D+00      .15401D+06      .48783D+05
.43920D+03      .11785D+00      .49834D+06      .46846D+05
.44640D+03      .12414D+00      .82834D+06      .44802D+05
.45360D+03      .13027D+00      .11432D+07      .42653D+05
.46080D+03      .13620D+00      .14423D+07      .40401D+05
.46800D+03      .14185D+00      .17248D+07      .38052D+05
.47520D+03      .14719D+00      .19900D+07      .35610D+05
.48240D+03      .15215D+00      .22374D+07      .33081D+05
.48960D+03      .15670D+00      .24662D+07      .30471D+05
.49680D+03      .16079D+00      .26760D+07      .27789D+05
.50400D+03      .16438D+00      .28662D+07      .25041D+05
.51120D+03      .16744D+00      .30364D+07      .22238D+05
.51840D+03      .16993D+00      .31863D+07      .19387D+05
.52560D+03      .17183D+00      .33155D+07      .16499D+05
```

```
                     .53280D+03      .17311D+00      .34238D+07      .13585D+05
                     .54000D+03      .17376D+00      .35111D+07      .10654D+05
                     .54720D+03      .17375D+00      .35772D+07      .77172D+04
                     .55440D+03      .17308D+00      .36222D+07      .47864D+04
                     .56160D+03      .17174D+00      .36462D+07      .18727D+04
                     .56880D+03      .16971D+00      .36493D+07     -.10126D+04
                     .57600D+03      .16701D+00      .36317D+07     -.38579D+04
                     .58320D+03      .16363D+00      .35938D+07     -.66519D+04
                     .59040D+03      .15959D+00      .35361D+07     -.93832D+04
                     .59760D+03      .15488D+00      .34589D+07     -.12041D+05
                     .60480D+03      .14954D+00      .33629D+07     -.14613D+05
                     .61200D+03      .14356D+00      .32487D+07     -.17090D+05
                     .61920D+03      .13699D+00      .31171D+07     -.19460D+05
                     .62640D+03      .12983D+00      .29688D+07     -.21715D+05
                     .63360D+03      .12212D+00      .28047D+07     -.23844D+05
                     .64080D+03      .11389D+00      .26257D+07     -.25838D+05
                     .64800D+03      .10517D+00      .24329D+07     -.27689D+05
                     .65520D+03      .95995D-01      .22274D+07     -.29389D+05
                     .66240D+03      .86409D-01      .20101D+07     -.30931D+05
                     .66960D+03      .76448D-01      .17824D+07     -.32307D+05
                     .67680D+03      .66156D-01      .15453D+07     -.33512D+05
                     .68400D+03      .55576D-01      .13002D+07     -.34540D+05
                     .69120D+03      .44754D-01      .10484D+07     -.35388D+05
                     .69840D+03      .33738D-01      .79106D+06     -.36052D+05
                     .70560D+03      .22574D-01      .52966D+06     -.36527D+05
                     .71280D+03      .11312D-01      .26552D+06     -.36814D+05
                     .72000D+03      .89370D-16      .20981D-08     -.36909D+05

 MAX VALUES                          .17376D+00      .36493D+07      .55457D+05
 AT DIST                             .54000D+03      .56880D+03      .40320D+03

*STOP*
```

C) Sample input and output of the MOMST Program

i) input

```
TWO SPAN BRIDGE 33FT-27FT
2,720.,7.2,
396.,3000000.,92850.,1.46653,
324.,3000000.,92850.,1.46653,
.0805,
```

ii) output

```
 TWO SPAN BRIDGE 33FT-27FT


 BLANK COMMON SIZE   634


 NSPAN                                =         2
 TOTAL SPAN LENGTH                    = .7200D+03
 X INTERVAL ALONG THE SPAN            = .7200D+01


 FOR THE SPAN NO. 1

 THE SPAN LENGTH IS                   = .3960D+03
 YOUNGS MODULUS IS                    = .3000D+07
 THE MOMENT OF INERTIA IS             = .9285D+05
 THE MASS PER UNIT LENGTH IS          = .1467D+01

 FOR THE SPAN NO. 2

 THE SPAN LENGTH IS                   = .3240D+03
 YOUNGS MODULUS IS                    = .3000D+07
 THE MOMENT OF INERTIA IS             = .9285D+05
 THE MASS PER UNIT LENGTH IS          = .1467D+01

 FOR THE SUPPORT NO. 1

 THE SETTLEMENT IS                    = .8050D-01
```

```
   DIST          DISP           MOM          SHEAR
   ----          ----           ---          -----

.00000E+00    .00000E+00    .00000E+00    .13240E+04
.72000E+01    .23578E-02    .95327E+04    .13240E+04
.14400E+02    .47138E-02    .19065E+05    .13240E+04
.21600E+02    .70663E-02    .28598E+05    .13240E+04
.28800E+02    .94134E-02    .38131E+05    .13240E+04
.36000E+02    .11753E-01    .47864E+05    .13240E+04
.43200E+02    .14085E-01    .57196E+05    .13240E+04
.50400E+02    .16405E-01    .66729E+05    .13240E+04
.57600E+02    .18713E-01    .76262E+05    .13240E+04
.64800E+02    .21007E-01    .85795E+05    .13240E+04
.72000E+02    .23285E-01    .95327E+05    .13240E+04
.79200E+02    .25545E-01    .10486E+06    .13240E+04
.86400E+02    .27786E-01    .11439E+06    .13240E+04
.93600E+02    .30005E-01    .12393E+06    .13240E+04
.10080E+03    .32202E-01    .13346E+06    .13240E+04
.10800E+03    .34373E-01    .14299E+06    .13240E+04
.11520E+03    .36518E-01    .15252E+06    .13240E+04
.12240E+03    .38635E-01    .16206E+06    .13240E+04
.12960E+03    .40721E-01    .17159E+06    .13240E+04
.13680E+03    .42775E-01    .18112E+06    .13240E+04
.14400E+03    .44796E-01    .19065E+06    .13240E+04
.15120E+03    .46781E-01    .20019E+06    .13240E+04
.15840E+03    .48729E-01    .20972E+06    .13240E+04
.16560E+03    .50638E-01    .21925E+06    .13240E+04
.17280E+03    .52506E-01    .22879E+06    .13240E+04
.18000E+03    .54332E-01    .23832E+06    .13240E+04
.18720E+03    .56113E-01    .24785E+06    .13240E+04
.19440E+03    .57848E-01    .25738E+06    .13240E+04
.20160E+03    .59535E-01    .26692E+06    .13240E+04
.20880E+03    .61173E-01    .27645E+06    .13240E+04
.21600E+03    .62759E-01    .28598E+06    .13240E+04
.22320E+03    .64292E-01    .29551E+06    .13240E+04
.23040E+03    .65770E-01    .30505E+06    .13240E+04
.23760E+03    .67191E-01    .31458E+06    .13240E+04
.24480E+03    .68553E-01    .32411E+06    .13240E+04
.25200E+03    .69855E-01    .33365E+06    .13240E+04
.25920E+03    .71095E-01    .34318E+06    .13240E+04
.26640E+03    .72272E-01    .35271E+06    .13240E+04
.27360E+03    .73382E-01    .36224E+06    .13240E+04
.28080E+03    .74425E-01    .37178E+06    .13240E+04
.28800E+03    .75399E-01    .38131E+06    .13240E+04
.29520E+03    .76302E-01    .39084E+06    .13240E+04
.30240E+03    .77133E-01    .40037E+06    .13240E+04
.30960E+03    .77888E-01    .40991E+06    .13240E+04
.31680E+03    .78568E-01    .41944E+06    .13240E+04
.32400E+03    .79169E-01    .42897E+06    .13240E+04
.33120E+03    .79691E-01    .43851E+06    .13240E+04
.33840E+03    .80131E-01    .44804E+06    .13240E+04
.34560E+03    .80488E-01    .45757E+06    .13240E+04
```

```
              .35280E+03        .80759E-01        .46710E+06         .13240E+04
              .36000E+03        .80944E-01        .47664E+06         .13240E+04
              .36720E+03        .81039E-01        .48617E+06         .13240E+04
              .37440E+03        .81045E-01        .49570E+06         .13240E+04
              .38160E+03        .80958E-01        .50523E+06         .13240E+04
              .38880E+03        .80777E-01        .51477E+06         .13240E+04
              .39600E+03        .80500E-01        .52430E+06         .13240E+04
              .40320E+03        .80126E-01        .51265E+06        -.16182E+04
              .41040E+03        .79657E-01        .50100E+06        -.16182E+04
              .41760E+03        .79095E-01        .48935E+06        -.16182E+04
              .42480E+03        .78442E-01        .47770E+06        -.16182E+04
              .43200E+03        .77699E-01        .46604E+06        -.16182E+04
              .43920E+03        .76870E-01        .45439E+06        -.16182E+04
              .44640E+03        .75957E-01        .44274E+06        -.16182E+04
              .45360E+03        .74961E-01        .43109E+06        -.16182E+04
              .46080E+03        .73884E-01        .41944E+06        -.16182E+04
              .46800E+03        .72730E-01        .40779E+06        -.16182E+04
              .47520E+03        .71500E-01        .39614E+06        -.16182E+04
              .48240E+03        .70196E-01        .38449E+06        -.16182E+04
              .48960E+03        .68821E-01        .37284E+06        -.16182E+04
              .49680E+03        .67376E-01        .36118E+06        -.16182E+04
              .50400E+03        .65864E-01        .34953E+06        -.16182E+04
              .51120E+03        .64286E-01        .33788E+06        -.16182E+04
              .51840E+03        .62647E-01        .32623E+06        -.16182E+04
              .52560E+03        .60946E-01        .31458E+06        -.16182E+04
              .53280E+03        .59187E-01        .30293E+06        -.16182E+04
              .54000E+03        .57371E-01        .29128E+06        -.16182E+04
              .54720E+03        .55501E-01        .27963E+06        -.16182E+04
              .55440E+03        .53579E-01        .26798E+06        -.16182E+04
              .56160E+03        .51607E-01        .25632E+06        -.16182E+04
              .56880E+03        .49588E-01        .24467E+06        -.16182E+04
              .57600E+03        .47523E-01        .23302E+06        -.16182E+04
              .58320E+03        .45415E-01        .22137E+06        -.16182E+04
              .59040E+03        .43265E-01        .20972E+06        -.16182E+04
              .59760E+03        .41076E-01        .19807E+06        -.16182E+04
              .60480E+03        .38851E-01        .18642E+06        -.16182E+04
              .61200E+03        .36591E-01        .17477E+06        -.16182E+04
              .61920E+03        .34298E-01        .16312E+06        -.16182E+04
              .62640E+03        .31975E-01        .15146E+06        -.16182E+04
              .63360E+03        .29624E-01        .13981E+06        -.16182E+04
              .64080E+03        .27247E-01        .12816E+06        -.16182E+04
              .64800E+03        .24846E-01        .11651E+06        -.16182E+04
              .65520E+03        .22423E-01        .10486E+06        -.16182E+04
              .66240E+03        .19981E-01        .93209E+05        -.16182E+04
              .66960E+03        .17521E-01        .81558E+05        -.16182E+04
              .67680E+03        .15046E-01        .69907E+05        -.16182E+04
              .68400E+03        .12558E-01        .58256E+05        -.16182E+04
              .69120E+03        .10060E-01        .46604E+05        -.16182E+04
              .69840E+03        .75524E-02        .34953E+05        -.16182E+04
              .70560E+03        .50385E-02        .23302E+05        -.16182E+04
              .71280E+03        .25203E-02        .11651E+05        -.16182E+04
              .72000E+03        .17875E-16        .11642E-09        -.16182E+04


MAX VALUES                      .81045E-01        .52430E+06        -.16182E+04
AT DIST                         .37440E+03        .39600E+03         .72000E+03
```

D) Sample input and output of the SAMIR Program

i) input

```
THREE SPAN BRIDGE, .8L-L.8L
3,200,5,5,1,
2.6,1.,1.,1.,.01,0.,90.,.5,.1,
1.,1.,
.8,1.8,
12.49,19.06,23.47,47.79,67.37,
1.2038,1.6304,2.038,
15.,90.,600.,
```

ii) output

```
THREE SPAN BRIDGE, .8L-L.8L


BLANK COMMON ARRAY    6036


NUMBER OF SPANS                      =          3
TOTAL SPAN LENGTH                    =  .2600D+01
MASS DENSITY PER UNIT LENGTH         =  .1000D+01
YOUNG'S MODULUS                      =  .1000D+01
MOMENT OF INERTIA                    =  .1000D+01
NUMBER OF TERMS TO BE SUMMED         =        200

SUPPORT DISTANCES FROM LEFT ABUTEMENT

SUPPORT NO.  1                       =  .8000D+00
SUPPORT NO.  2                       =  .1800D+01

SUPPORT SETTLEMENTS

SUPPORT NO.  1                       =  .1000D+01
SUPPORT NO.  2                       =  .1000D+01

            MAXIMUM DYNAMIC AMPLIFICATION FACTORS FOR DEFLECTION FUNCTION
```

```
FREQUENCY

.00000E+00     .10000E+01
.50000E+00     .10011E+01
.10000E+01     .10044E+01
.15000E+01     .10099E+01
.20000E+01     .10178E+01
.25000E+01     .10281E+01
.30000E+01     .10410E+01
.35000E+01     .10568E+01
.40000E+01     .10757E+01
.45000E+01     .10982E+01
.50000E+01     .11246E+01
.55000E+01     .11557E+01
.60000E+01     .11923E+01
.65000E+01     .12354E+01
.70000E+01     .12866E+01
.75000E+01     .13480E+01
.80000E+01     .14226E+01
.85000E+01     .15150E+01
.90000E+01     .16321E+01
.95000E+01     .17858E+01
.10000E+02     .19971E+01
.10500E+02     .23082E+01
.11000E+02     .28176E+01
.11500E+02     .38224E+01
.11990E+02     .67097E+01
.12000E+02     .68281E+01
.12090E+02     .81585E+01
.12190E+02     .10566E+02
.12290E+02     .15364E+02
.12390E+02     .29652E+02
.12500E+02     .32122E+03
.12590E+02     .28327E+02
.12690E+02     .13604E+02
.12790E+02     .87250E+01
.12890E+02     .62879E+01
.12990E+02     .48248E+01
.13000E+02     .47100E+01
.13500E+02     .26326E+01
.14000E+02     .21590E+01
.14500E+02     .19481E+01
.15000E+02     .18468E+01
.15500E+02     .18055E+01
.16000E+02     .18027E+01
.16500E+02     .18303E+01
.17000E+02     .18839E+01
.17500E+02     .19644E+01
.18000E+02     .20736E+01
.18500E+02     .22167E+01
.18560E+02     .22366E+01
.18660E+02     .22712E+01
.18760E+02     .23077E+01
.18860E+02     .23461E+01
.18960E+02     .23865E+01
.19000E+02     .24033E+01
.19160E+02     .24739E+01
```

```
.19260E+02      .25212E+01
.19360E+02      .25712E+01
.19460E+02      .26243E+01
.19500E+02      .26464E+01
.19560E+02      .26804E+01
.20000E+02      .29693E+01
.20500E+02      .34109E+01
.21000E+02      .40402E+01
.21500E+02      .50026E+01
.22000E+02      .66317E+01
.22500E+02      .99680E+01
.22970E+02      .19259E+02
.23000E+02      .20490E+02
.23070E+02      .24087E+02
.23170E+02      .32180E+02
.23270E+02      .48532E+02
.23370E+02      .98952E+02
.23500E+02      .27902E+03
.23570E+02      .91124E+02
.23670E+02      .46397E+02
.23770E+02      .31098E+02
.23870E+02      .23373E+02
.23970E+02      .18715E+02
.24000E+02      .17658E+02
.24500E+02      .90819E+01
.25000E+02      .61010E+01
.25500E+02      .46083E+01
.26000E+02      .37329E+01
.26500E+02      .31449E+01
.27000E+02      .27224E+01
.27500E+02      .24040E+01
.28000E+02      .21553E+01
.28500E+02      .19556E+01
.29000E+02      .17918E+01
.29500E+02      .16549E+01
.30000E+02      .15388E+01
.30500E+02      .14391E+01
.31000E+02      .13525E+01
.31500E+02      .12767E+01
.32000E+02      .12096E+01
.32500E+02      .11500E+01
.33000E+02      .10965E+01
.33500E+02      .10484E+01
.34000E+02      .10048E+01
.34500E+02      .96517E+00
.35000E+02      .92893E+00
.35500E+02      .89569E+00
.36000E+02      .86508E+00
.36500E+02      .83680E+00
.37000E+02      .83741E+00
.37500E+02      .83802E+00
.38000E+02      .83862E+00
.38500E+02      .83950E+00
.39000E+02      .84055E+00
.39500E+02      .84161E+00
.40000E+02      .84268E+00
.40500E+02      .84377E+00
```

```
.41000E+02      .84503E+00
.41500E+02      .84668E+00
.42000E+02      .84837E+00
.42500E+02      .85010E+00
.43000E+02      .85198E+00
.43500E+02      .85441E+00
.44000E+02      .85692E+00
.44500E+02      .85950E+00
.45000E+02      .86270E+00
.45500E+02      .86618E+00
.46000E+02      .86978E+00
.46500E+02      .87413E+00
.47000E+02      .87883E+00
.47290E+02      .88164E+00
.47390E+02      .88262E+00
.47490E+02      .88363E+00
.47500E+02      .88375E+00
.47590E+02      .88481E+00
.47690E+02      .88600E+00
.47890E+02      .88840E+00
.47990E+02      .88962E+00
.48000E+02      .88974E+00
.48090E+02      .89084E+00
.48190E+02      .89208E+00
.48290E+02      .89333E+00
.48500E+02      .89599E+00
.49000E+02      .90298E+00
.49500E+02      .91083E+00
.50000E+02      .91906E+00
.50500E+02      .92879E+00
.51000E+02      .93905E+00
.51500E+02      .95053E+00
.52000E+02      .96320E+00
.52500E+02      .97680E+00
.53000E+02      .99238E+00
.53500E+02      .10090E+01
.54000E+02      .10277E+01
.54500E+02      .10482E+01
.55000E+02      .10705E+01
.55500E+02      .10958E+01
.56000E+02      .11233E+01
.56500E+02      .11542E+01
.57000E+02      .11885E+01
.57500E+02      .12263E+01
.58000E+02      .12697E+01
.58500E+02      .13179E+01
.59000E+02      .13723E+01
.59500E+02      .14349E+01
.60000E+02      .15057E+01
.60500E+02      .15879E+01
.61000E+02      .16839E+01
.61500E+02      .17960E+01
.62000E+02      .19306E+01
.62500E+02      .20935E+01
.63000E+02      .22933E+01
.63500E+02      .25467E+01
.64000E+02      .28764E+01
```

```
.64500E+02     .33201E+01
.65000E+02     .39526E+01
.65500E+02     .49266E+01
.66000E+02     .66083E+01
.66500E+02     .10216E+02
.66870E+02     .17526E+02
.66970E+02     .21808E+02
.67000E+02     .23541E+02
.67070E+02     .28922E+02
.67170E+02     .43062E+02
.67270E+02     .84807E+02
.67470E+02     .88453E+02
.67500E+02     .67579E+02
.67570E+02     .43527E+02
.67670E+02     .28798E+02
.67770E+02     .21478E+02
.67870E+02     .17100E+02
.68000E+02     .13495E+02
.68500E+02     .73820E+01
.69000E+02     .50267E+01
.69500E+02     .37769E+01
.70000E+02     .30015E+01
.70500E+02     .24771E+01
.71000E+02     .20965E+01
.71500E+02     .18072E+01
.72000E+02     .17189E+01
.72500E+02     .16604E+01
.73000E+02     .16143E+01
.73500E+02     .15776E+01
.74000E+02     .15483E+01
.74500E+02     .15249E+01
.75000E+02     .15064E+01
.75500E+02     .14918E+01
.76000E+02     .14807E+01
.76500E+02     .14725E+01
.77000E+02     .14669E+01
.77500E+02     .14635E+01
.78000E+02     .14621E+01
.78500E+02     .14626E+01
.79000E+02     .14649E+01
.79500E+02     .14687E+01
.80000E+02     .14748E+01
.80500E+02     .14824E+01
.81000E+02     .14915E+01
.81500E+02     .15019E+01
.82000E+02     .15137E+01
.82500E+02     .15268E+01
.83000E+02     .15414E+01
.83500E+02     .15574E+01
.84000E+02     .15748E+01
.84500E+02     .15937E+01
.85000E+02     .16151E+01
.85500E+02     .16383E+01
.86000E+02     .16633E+01
.86500E+02     .16901E+01
.87000E+02     .17189E+01
.87500E+02     .17498E+01
```

```
.88000E+02      .17829E+01
.88500E+02      .18185E+01
.89000E+02      .18567E+01
.89500E+02      .18987E+01
.90000E+02      .19444E+01


     MAXIMUM DYNAMIC AMPLIFICATION FACTORS FOR MOMENT FUNCTION



FREQUENCY

.00000E+00      .10005E+01
.50000E+00      .10103E+01
.10000E+01      .10411E+01
.15000E+01      .10930E+01
.20000E+01      .11667E+01
.25000E+01      .12633E+01
.30000E+01      .13842E+01
.35000E+01      .15314E+01
.40000E+01      .17073E+01
.45000E+01      .19153E+01
.50000E+01      .21594E+01
.55000E+01      .24450E+01
.60000E+01      .27791E+01
.65000E+01      .31709E+01
.70000E+01      .36330E+01
.75000E+01      .41829E+01
.80000E+01      .48455E+01
.85000E+01      .56579E+01
.90000E+01      .66780E+01
.95000E+01      .80017E+01
.10000E+02      .98007E+01
.10500E+02      .12418E+02
.11000E+02      .16651E+02
.11500E+02      .24909E+02
.11990E+02      .48427E+02
.12000E+02      .49389E+02
.12090E+02      .60190E+02
.12190E+02      .79723E+02
.12290E+02      .11862E+03
.12390E+02      .23438E+03
.12500E+02      .26077E+04
.12590E+02      .23521E+03
.12690E+02      .11591E+03
.12790E+02      .76355E+02
.12890E+02      .56581E+02
.12990E+02      .44695E+02
.13000E+02      .43761E+02
.13500E+02      .24695E+02
.14000E+02      .19774E+02
.14500E+02      .17748E+02
.15000E+02      .16942E+02
.15500E+02      .16820E+02
.16000E+02      .17160E+02
.16500E+02      .17877E+02
```

```
.17000E+02        .18935E+02
.17500E+02        .20362E+02
.18000E+02        .23005E+02
.18500E+02        .26969E+02
.18560E+02        .27495E+02
.18660E+02        .28399E+02
.18760E+02        .29338E+02
.18860E+02        .30317E+02
.18960E+02        .31336E+02
.19000E+02        .31756E+02
.19160E+02        .33511E+02
.19260E+02        .34672E+02
.19360E+02        .35888E+02
.19460E+02        .37163E+02
.19500E+02        .37690E+02
.19560E+02        .38500E+02
.20000E+02        .45275E+02
.20500E+02        .55354E+02
.21000E+02        .69448E+02
.21500E+02        .90627E+02
.22000E+02        .12614E+03
.22500E+02        .19826E+03
.22970E+02        .39835E+03
.23000E+02        .42481E+03
.23070E+02        .50215E+03
.23170E+02        .67606E+03
.23270E+02        .10274E+04
.23370E+02        .21105E+04
.23500E+02        .60086E+04
.23570E+02        .19724E+04
.23670E+02        .10115E+04
.23770E+02        .68282E+03
.23870E+02        .51682E+03
.23970E+02        .41668E+03
.24000E+02        .39395E+03
.24500E+02        .20921E+03
.25000E+02        .14479E+03
.25500E+02        .11196E+03
.26000E+02        .92016E+02
.26500E+02        .78584E+02
.27000E+02        .68898E+02
.27500E+02        .61564E+02
.28000E+02        .55802E+02
.28500E+02        .51142E+02
.29000E+02        .47285E+02
.29500E+02        .44028E+02
.30000E+02        .41233E+02
.30500E+02        .38801E+02
.31000E+02        .36657E+02
.31500E+02        .34746E+02
.32000E+02        .33027E+02
.32500E+02        .31466E+02
.33000E+02        .30038E+02
.33500E+02        .28721E+02
.34000E+02        .27498E+02
.34500E+02        .26356E+02
.35000E+02        .25283E+02
```

```
.35500E+02     .24280E+02
.36000E+02     .23374E+02
.36500E+02     .22552E+02
.37000E+02     .22375E+02
.37500E+02     .22232E+02
.38000E+02     .22122E+02
.38500E+02     .22052E+02
.39000E+02     .22012E+02
.39500E+02     .21999E+02
.40000E+02     .22011E+02
.40500E+02     .22048E+02
.41000E+02     .22108E+02
.41500E+02     .22191E+02
.42000E+02     .22309E+02
.42500E+02     .22450E+02
.43000E+02     .22614E+02
.43500E+02     .22801E+02
.44000E+02     .23010E+02
.44500E+02     .23243E+02
.45000E+02     .23499E+02
.45500E+02     .23788E+02
.46000E+02     .24108E+02
.46500E+02     .24455E+02
.47000E+02     .24829E+02
.47290E+02     .25059E+02
.47390E+02     .25141E+02
.47490E+02     .25224E+02
.47500E+02     .25232E+02
.47590E+02     .25308E+02
.47690E+02     .25393E+02
.47890E+02     .25568E+02
.47990E+02     .25657E+02
.48000E+02     .25666E+02
.48090E+02     .25748E+02
.48190E+02     .25839E+02
.48290E+02     .25932E+02
.48500E+02     .26132E+02
.49000E+02     .26633E+02
.49500E+02     .27176E+02
.50000E+02     .27768E+02
.50500E+02     .28403E+02
.51000E+02     .29083E+02
.51500E+02     .29814E+02
.52000E+02     .30600E+02
.52500E+02     .31444E+02
.53000E+02     .32354E+02
.53500E+02     .33335E+02
.54000E+02     .34395E+02
.54500E+02     .35561E+02
.55000E+02     .36828E+02
.55500E+02     .38206E+02
.56000E+02     .39710E+02
.56500E+02     .41357E+02
.57000E+02     .43166E+02
.57500E+02     .45163E+02
.58000E+02     .47375E+02
.58500E+02     .49839E+02
```

```
.59000E+02      .52601E+02
.59500E+02      .55741E+02
.60000E+02      .59311E+02
.60500E+02      .63402E+02
.61000E+02      .68134E+02
.61500E+02      .73672E+02
.62000E+02      .80237E+02
.62500E+02      .88147E+02
.63000E+02      .97860E+02
.63500E+02      .11007E+03
.64000E+02      .12590E+03
.64500E+02      .14722E+03
.65000E+02      .17751E+03
.65500E+02      .22402E+03
.66000E+02      .30444E+03
.66500E+02      .47694E+03
.66870E+02      .82554E+03
.66970E+02      .10298E+04
.67000E+02      .11124E+04
.67070E+02      .13690E+04
.67170E+02      .20434E+04
.67270E+02      .40344E+04
.67470E+02      .42291E+04
.67500E+02      .32336E+04
.67570E+02      .20864E+04
.67670E+02      .13839E+04
.67770E+02      .10348E+04
.67870E+02      .82605E+03
.68000E+02      .65411E+03
.68500E+02      .36222E+03
.69000E+02      .24961E+03
.69500E+02      .18988E+03
.70000E+02      .15283E+03
.70500E+02      .12758E+03
.71000E+02      .10926E+03
.71500E+02      .95329E+02
.72000E+02      .90381E+02
.72500E+02      .86975E+02
.73000E+02      .84335E+02
.73500E+02      .82281E+02
.74000E+02      .80687E+02
.74500E+02      .79465E+02
.75000E+02      .78547E+02
.75500E+02      .77886E+02
.76000E+02      .77444E+02
.76500E+02      .77191E+02
.77000E+02      .77107E+02
.77500E+02      .77174E+02
.78000E+02      .77377E+02
.78500E+02      .77708E+02
.79000E+02      .78156E+02
.79500E+02      .78718E+02
.80000E+02      .79387E+02
.80500E+02      .80160E+02
.81000E+02      .81037E+02
.81500E+02      .82015E+02
.82000E+02      .83095E+02
```

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.82500E+02      .84278E+02
.83000E+02      .85565E+02
.83500E+02      .86959E+02
.84000E+02      .88464E+02
.84500E+02      .90085E+02
.85000E+02      .91825E+02
.85500E+02      .93692E+02
.86000E+02      .95692E+02
.86500E+02      .97834E+02
.87000E+02      .10013E+03
.87500E+02      .10258E+03
.88000E+02      .10521E+03
.88500E+02      .10803E+03
.89000E+02      .11105E+03
.89500E+02      .11429E+03
.90000E+02      .11778E+03


      MAXIMUM DYNAMIC AMPLIFICATION FACTORS FOR SHEAR FUNCTION



FREQUENCY

.00000E+00      .10584E+01
.50000E+00      .10065E+01
.10000E+01      .10246E+01
.15000E+01      .10547E+01
.20000E+01      .11610E+01
.25000E+01      .18602E+01
.30000E+01      .27271E+01
.35000E+01      .37696E+01
.40000E+01      .49984E+01
.45000E+01      .64266E+01
.50000E+01      .80711E+01
.55000E+01      .99536E+01
.60000E+01      .12102E+02
.65000E+01      .14553E+02
.70000E+01      .17356E+02
.75000E+01      .20577E+02
.80000E+01      .24314E+02
.85000E+01      .28705E+02
.90000E+01      .33969E+02
.95000E+01      .40463E+02
.10000E+02      .48823E+02
.10500E+02      .60310E+02
.11000E+02      .77859E+02
.11500E+02      .11029E+03
.11990E+02      .19870E+03
.12000E+02      .20227E+03
.12090E+02      .24225E+03
.12190E+02      .31425E+03
.12290E+02      .45712E+03
.12390E+02      .88133E+03
.12500E+02      .95204E+04
.12590E+02      .83632E+03
.12690E+02      .39915E+03
```

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.12790E+02        .25382E+03
.12890E+02        .18088E+03
.12990E+02        .13734E+03
.13000E+02        .13396E+03
.13500E+02        .83851E+02
.14000E+02        .81431E+02
.14500E+02        .83790E+02
.15000E+02        .88535E+02
.15500E+02        .94954E+02
.16000E+02        .10284E+03
.16500E+02        .11222E+03
.17000E+02        .12325E+03
.17500E+02        .13623E+03
.18000E+02        .15159E+03
.18500E+02        .16997E+03
.18560E+02        .17243E+03
.18660E+02        .17664E+03
.18760E+02        .18103E+03
.18860E+02        .18561E+03
.18960E+02        .19038E+03
.19000E+02        .19234E+03
.19160E+02        .20056E+03
.19260E+02        .20600E+03
.19360E+02        .21170E+03
.19460E+02        .21767E+03
.19500E+02        .22014E+03
.19560E+02        .22394E+03
.20000E+02        .25567E+03
.20500E+02        .30277E+03
.21000E+02        .36843E+03
.21500E+02        .46674E+03
.22000E+02        .63102E+03
.22500E+02        .96357E+03
.22970E+02        .18841E+04
.23000E+02        .20058E+04
.23070E+02        .23613E+04
.23170E+02        .31607E+04
.23270E+02        .47753E+04
.23370E+02        .97526E+04
.23500E+02        .27554E+05
.23570E+02        .90078E+04
.23670E+02        .45924E+04
.23770E+02        .30817E+04
.23870E+02        .23187E+04
.23970E+02        .18583E+04
.24000E+02        .17538E+04
.24500E+02        .90346E+03
.25000E+02        .60597E+03
.25500E+02        .45355E+03
.26000E+02        .36029E+03
.26500E+02        .29691E+03
.27000E+02        .25811E+03
.27500E+02        .22967E+03
.28000E+02        .20980E+03
.28500E+02        .19379E+03
.29000E+02        .18061E+03
.29500E+02        .16954E+03
```

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.30000E+02     .16010E+03
.30500E+02     .15196E+03
.31000E+02     .14537E+03
.31500E+02     .13993E+03
.32000E+02     .13513E+03
.32500E+02     .13085E+03
.33000E+02     .12702E+03
.33500E+02     .12356E+03
.34000E+02     .12042E+03
.34500E+02     .11756E+03
.35000E+02     .11494E+03
.35500E+02     .11263E+03
.36000E+02     .11074E+03
.36500E+02     .10900E+03
.37000E+02     .10882E+03
.37500E+02     .10881E+03
.38000E+02     .10896E+03
.38500E+02     .10926E+03
.39000E+02     .10970E+03
.39500E+02     .11028E+03
.40000E+02     .11100E+03
.40500E+02     .11185E+03
.41000E+02     .11283E+03
.41500E+02     .11394E+03
.42000E+02     .11518E+03
.42500E+02     .11655E+03
.43000E+02     .11806E+03
.43500E+02     .11970E+03
.44000E+02     .12148E+03
.44500E+02     .12341E+03
.45000E+02     .12636E+03
.45500E+02     .13423E+03
.46000E+02     .14228E+03
.46500E+02     .15052E+03
.47000E+02     .15897E+03
.47290E+02     .16398E+03
.47390E+02     .16572E+03
.47490E+02     .16747E+03
.47500E+02     .16765E+03
.47590E+02     .16924E+03
.47690E+02     .17101E+03
.47890E+02     .17459E+03
.47990E+02     .17639E+03
.48000E+02     .17657E+03
.48090E+02     .17821E+03
.48190E+02     .18003E+03
.48290E+02     .18187E+03
.48500E+02     .18576E+03
.49000E+02     .19524E+03
.49500E+02     .20503E+03
.50000E+02     .21516E+03
.50500E+02     .22566E+03
.51000E+02     .23656E+03
.51500E+02     .24790E+03
.52000E+02     .25972E+03
.52500E+02     .27206E+03
.53000E+02     .28498E+03
```

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.53500E+02      .29854E+03
.54000E+02      .31281E+03
.54500E+02      .32786E+03
.55000E+02      .34378E+03
.55500E+02      .36069F+03
.56000E+02      .37870E+03
.56500E+02      .39797E+03
.57000E+02      .41866E+03
.57500E+02      .44099E+03
.58000E+02      .46522E+03
.58500E+02      .49165E+03
.59000E+02      .52068E+03
.59500E+02      .55278E+03
.60000E+02      .58857E+03
.60500E+02      .62885E+03
.61000E+02      .67465E+03
.61500E+02      .72738E+03
.62000E+02      .78894E+03
.62500E+02      .86204E+03
.63000E+02      .95062E+03
.63500E+02      .10606E+04
.64000E+02      .12016E+04
.64500E+02      .13897E+04
.65000E+02      .16545E+04
.65500E+02      .20575E+04
.66000E+02      .27498E+04
.66500E+02      .42285E+04
.66870E+02      .72092E+04
.66970E+02      .89541E+04
.67000E+02      .96601E+04
.67070E+02      .11852E+05
.67170E+02      .17611E+05
.67270E+02      .34612E+05
.67470E+02      .35942E+05
.67500E+02      .27441E+05
.67570E+02      .17646E+05
.67670E+02      .11646E+05
.67770E+02      .86646E+04
.67870E+02      .68808E+04
.68000E+02      .54112E+04
.68500E+02      .29131E+04
.69000E+02      .19456E+04
.69500E+02      .14295E+04
.70000E+02      .11202E+04
.70500E+02      .91114E+03
.71000E+02      .75801E+03
.71500E+02      .64639E+03
.72000E+02      .61133E+03
.72500E+02      .58861E+03
.73000E+02      .57120E+03
.73500E+02      .57958E+03
.74000E+02      .59186E+03
.74500E+02      .60476E+03
.75000E+02      .61822E+03
.75500E+02      .63224E+03
.76000E+02      .64681E+03
.76500E+02      .66192E+03
```

```
.77000E+02      .67758E+03
.77500E+02      .69380E+03
.78000E+02      .71060E+03
.78500E+02      .72799E+03
.79000E+02      .74599E+03
.79500E+02      .76462E+03
.80000E+02      .78393E+03
.80500E+02      .80393E+03
.81000E+02      .82467E+03
.81500E+02      .84618E+03
.82000E+02      .86851E+03
.82500E+02      .89171E+03
.83000E+02      .91583E+03
.83500E+02      .94093E+03
.84000E+02      .96707E+03
.84500E+02      .99433E+03
.85000E+02      .10228E+04
.85500E+02      .10525E+04
.86000E+02      .10836E+04
.86500E+02      .11163E+04
.87000E+02      .11505E+04
.87500E+02      .11864E+04
.88000E+02      .12243E+04
.88500E+02      .12642E+04
.89000E+02      .13064E+04
.89500E+02      .13511E+04
.90000E+02      .13985E+04
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APPENDIX II

```
 C DYNAMIC
C     COMPUTER PROGRAM TO INVESTIGATE THE DYNAMIC RESPONSE              DYNA0001
C     OF MULTISPAN GIRDERS SUBJECTED TO PULSATING SUPPORT               DYNA0002
C     SETTLEMENTS INDUCED BY VERTICAL EARTHQUAKE MOTION                 DYNA0003
C                                                                       DYNA0004
C     ****************************************************              DYNA0005
C                                                                       DYNA0006
C     PROGRAMMED BY DR. C. YOO                                          DYNA0007
C     AUGUST 1979                                                       DYNA0008
C     ON XEROX SIGMA 9, MARQUETTE UNIVERSITY                            DYNA0009
C                                                                       DYNA0010
C     ****************************************************              DYNA0011
C                                                                       DYNA0012
C     INPUT VARIABLES                                                   DYNA0013
C                                                                       DYNA0014
C     HEAD=HEADING (UP TO 80 ALPHANUMERIC CHARACTER)                    DYNA0015
C     NFRQ=NUMBER OF MODES IN FREE VIBRATION CONSIDERED                 DYNA0016
C     IMAX=MAXIMUM NUMBER OF ITERATIONS IN NATURAL FREQUENCY ROUTINE    DYNA0017
C     EPS1=TOLERANCE IN NATURAL FREQUENCY ROUTINE                       DYNA0018
C     NSPAN=NUMBER OF SPANS (2 OR MORE)                                 DYNA0019
C     NTERM=NUMBER OF TERMS TO BE SUMMED FOR INFINITE                   DYNA0020
C           SERIES (5 OR MORE)                                          DYNA0021
C     NPOINT=NUMBER OF LOCATIONS ALONG THE GIRDER LENGTH                DYNA0022
C            FOR WHICH THE TIME HISTORY IS SOUGHT                       DYNA0023
C     IOPT=1: PARTICULAR SOLUTION                                       DYNA0024
C         =2: COMPUTATION OF NATURAL CIRCULAR FREQUENCIES ONLY          DYNA0025
C     IPLOT=0 IF NO PLOT DATA FILE IS DESIRED                           DYNA0026
C          =1 OR ANY INTEGER IF A PLOT DATA FILE IS DESIRED             DYNA0027
C     IEQSP=0: THERE ARE NO EQUAL SPANS                                 DYNA0028
C          =1 OR ANY INTEGER IF THERE ARE EQUAL SPANS                   DYNA0029
C     TL=TOTAL SPAN LENGTH                                              DYNA0030
C     SM=MASS DENSITY PER UNIT LENGTH OF THE GIRDER                     DYNA0031
C     E=YOUNG'S  MODULUS                                                DYNA0032
C     XI=MOMENT OF INERTIA OF THE GIRDER                                DYNA0033
C     DT=DURATION OF EARTHQUAKE                                         DYNA0034
C     TINT=TIME INCREMENT FOR THE TIME HISTORY                          DYNA0035
C     WF=ANGULAR (CIRCULAR) VELOCITY OF EARTHQUAKE (RAD/SEC)            DYNA0036
C     DEL(I)=MAXIMUM AMPLITUDE OF SUPPORT SETTLEMENTS RELATIVE          DYNA0037
C            TO BOTH END ABUTMENTS                                      DYNA0038
C     XL(I)=X-COORDINATE OF INTERNAL SUPPORT                            DYNA0039
C     X(I)=X-COORDINATE ON THE GIRDER FOR WHICH THE TIME                DYNA0040
C          HISTORY IS SOUGHT                                            DYNA0041
C                                                                       DYNA0042
C     ..................... X                                           DYNA0043
C     .                                                                 DYNA0044
C     .                                                                 DYNA0045
C     .         CARTESIAN COORDINATE                                    DYNA0046
C     .                                                                 DYNA0047
C     .                                                                 DYNA0048
C                                                                       DYNA0049
C     Y                                                                 DYNA0050
C                                                                       DYNA0051
C     INPUT SEQUENCE                                                    DYNA0052
C                                                                       DYNA0053
C      NO CARDS     VARIABLES                                 FORMAT    DYNA0054
C         1         HEAD                                      20A4      DYNA0055
C         1         NFRQ,NSPAN,NTERM,NPOINT,IOPT,IPLOT,       7I5,7G10.0 DYNA0056
C                   IEQSP,TL,SM,E,XI,DT,TINT,WF                         DYNA0057
C         1         DEL(I)                                    10G10.0   DYNA0058
C         1         XL(I)                                     10G10.0   DYNA0059
C     IF(IOPT.EQ.1) SKIP THE FOLLOWING CARD                             DYNA0060
C         1         X(I)                                      10G10.0   DYNA0061
C     IF(IOPT.EQ.1) SKIP THE FOLLOWING CARD                             DYNA0062
C         1         IMAX,EPS1                                 I10,G10.0 DYNA0063
C                                                                       DYNA0064
      IMPLICIT DOUBLE PRECISION(A-H,O-Z)                                DYNA0065
      REAL HEAD(20),AA(10000)                                           DYNA0066
      DIMENSION A(5000),LKI(10000)                                      DYNA0067
      COMMON AA                                                         DYNA0068
      EQUIVALENCE (AA(1),A(1)),(AA(1),LKI(1))                           DYNA0069
      COMMON/SETUP/TL,SM,E,XI,DT,TINT,WF,EPS1,PAI,EX,CX,NSPAN,NTERM,    DYNA0070
     1 NPOINT,NS1,NT,IN,IO,IO2,IOPT,IPLOT,IMAX,NFRQ,NTERM1,IEQSP        DYNA0071
      IN=5                                                              DYNA0072
      IO=6                                                              DYNA0073
      IO2=3                                                             DYNA0074
      IDS=2                                                             DYNA0075
```

```
  998 READ(IN,500,END=999) HEAD
  500 FORMAT(20A4)
      WRITE(IO,600) HEAD
  600 FORMAT(1H1,20A4)
      READ(IN,501) NFRQ,NSPAN,NTERM,NPOINT,IOPT,IPLOT,IEQSP,TL,SM,E,
     1 XI,DT,TINT,WF
  501 FORMAT(7I5,7G10.0)
      NS1=NSPAN-1
      NTERM1=NTERM+20
C
      NT=DT/TINT+1
      IF(NT.LT.2) NT=2
      IF(NS1.EQ.0) GO TO 996
      N2=1+NS1
      N3=N2+NS1
      N4=N3+NPOINT
      N5=N4+NT
      N6=N5+NT
      N7=N6+NT
      N8=N7+NT
      N9=N8+NT
      N10=N9+NT
      N11=N10+NTERM
      N12=N11+NTERM
      N13=N12+NS1*NTERM1
      N14=N13+NTERM
      N15=N14+NTERM1
      N16=N15+NFRQ
      N17=N16+NFRQ
      N18=N17+NS1
      N19=N18+NS1*NS1
      N20=(N19+NS1*2)*IDS
      NSIZE=N20+NFRQ
      IF(NSIZE.GT.10000) GO TO 997
      WRITE(IO,601) NSIZE
  601 FORMAT(//' ','BLANK COMMON ARRAY',I7)
      CALL MAIN(A(1),A(N2),A(N3),A(N4),A(N5),A(N6),A(N7),
     1 A(N8),A(N9),A(N10),A(N11),A(N12),A(N13),A(N14),A(N15),
     2 A(N16),A(N17),A(N18),A(N19),LKI(N20),HEAD)
      GO TO 998
  997 WRITE(IO,602) NSIZE
  602 FORMAT(//' ','YOUR BLANK COMMON ARRAY MUST BE',I7)
      GO TO 998
  996 WRITE(IO,603) NSPAN
  603 FORMAT(//' ','THIS IS NOT A MULTISPAN GIRDER',I5)
      GO TO 998
  999 STOP
      END
      SUBROUTINE MAIN(DEL,XL,X,PY,PYT,PYT2,PM,PQ,TT,XTC,XT,
     1 XN,DN,P,FRQ,DET,RP,RCOEF,WKAREA,ITN,HEAD)
      IMPLICIT DOUBLE PRECISION(A-H,O-Z)
      REAL HEAD(20)
      DIMENSION DEL(NS1),XL(NS1),X(NPOINT),PY(NT),PYT(NT),PYT2(NT),
     1 PM(NT),PQ(NT),TT(NT),XTC(NTERM),XT(NTERM),XN(NS1,NTERM1),
     2 DN(NTERM),P(NTERM1),FRQ(NFRQ),DET(NFRQ),RP(NS1),RCOEF(NS1,NS1),
     3 WKAREA(1),ITN(NFRQ)
      COMMON/SETUP/TL,SM,E,XI,DT,TINT,WF,EPS1,PAI,EX,CX,NSPAN,NTERM,
     1 NPOINT,NS1,NT,IN,IO,IO2,IOPT,IPLOT,IMAX,NFRQ,NTERM1,IEQSP
C
C     COMMON FACTORS
C
      EX=E*XI/(SM*TL**4)
      WF2=WF**2
      PAI=DATAN(1.D0)*4.
      CX=DSQRT(2./(SM*TL))
      GO TO (201,202,203),IOPT
  201 WRITE(IO,701)
  701 FORMAT(//' ','PARTICULAR SOLUTION'//)
      GO TO 205
  203 WRITE(IO,702)
  702 FORMAT(//' ','NATURAL FREQUENCIES AND PARTICULAR SOLUTION'//)
      GO TO 205
  202 WRITE(IO,703)
  703 FORMAT(//' ','COMPUTATION OF NATURAL CIRCULAR FREQUENCIES ONLY'//)
  205 READ(IN,500) (DEL(I),I=1,NS1)
```

```
  500 FORMAT(10G10.0)
      READ(IN,500) (XL(I),I=1,NS1)
      IF(IOPT.EQ.2) GO TO 704
      READ(IN,500) (X(I),I=1,NPOINT)
      IF(IOPT.EQ.1) GO TO 705
  704 READ(IN,501) IMAX,EPS1
  501 FORMAT(I10,G10.0)
  705 DO 215 N=1,NTERM1
      PAIN=N*PAI
      PAINTL=PAIN/TL
      P(N)=DSQRT(PAIN**4*EX)
      DO 215 I=1,NS1
  215 XN(I,N)=CX*DSIN(PAINTL*XL(I))
      IF(IOPT.EQ.1) GO TO 208
      CALL FREQ(P,XN,FRQ,DET,ITN,RCOEF,WKAREA)
      IF(IOPT.EQ.2) GO TO 59
C
C     ECHO PRINTING OF PARAMETERS
C
  208 WRITE(IO,699) TL,SM,E,XI,DT,TINT,WF,NSPAN,NFRQ,NTERM,NPOINT
  699 FORMAT(//'0','TOTAL SPAN LENGTH                     =',D10.4/
     1           ' ','MASS DENSITY PER UNIT LENGTH      =',D10.4/
     2           ' ','YOUNG''S MODULUS                    =',D10.4/
     3           ' ','MOMENT OF INERTIA                 =',D10.4/
     4           ' ','DURATION OF EARTHQUAKE            =',D10.4/
     5           ' ','TIME INCREMENT IN TIME HISTORY    =',D10.4/
     6           ' ','EARTHQUAKE (ANGULAR) VELOCITY     =',D10.4/
     8           ' ','NUMBER OF SPANS                   =',I10/
     8           ' ','NUMBER OF MODES IN FREE VIBRN     =',I10/
     9           ' ','NUMBER OF TERMS TO BE SUMMED      =',I10/
     A           ' ','NUMBER OF LOCATIONS (T HISTORY)   =',I10)
      DO 150 I1=1,NS1
      DO 150 I2=1,NS1
  150 RCOEF(I1,I2)=0.
      DO 100 N=1,NTERM
      PAIN=PAI*N
      PAINTL=PAIN/TL
      DEN=P(N)**2-WF2
      ADEN=DABS(DEN)
      IF(ADEN.LT..0001) GO TO 100
      DO 100 I1=1,NS1
      DO 100 I2=1,NS1
      RCOEF(I1,I2)=RCOEF(I1,I2)+XN(I1,N)*XN(I2,N)/DEN
  100 CONTINUE
      DO 105 I=1,NS1
  105 RP(I)=DEL(I)
      D1=-1.
      CALL LINV3F(RCOEF,RP,2,NS1,NS1,D1,D2,WKAREA,IER)
      DO 50 NP=1,NPOINT
      DO 51 K=1,NT
      PY(K)=0.
      PYT(K)=0.
      PYT2(K)=0.
      PM(K)=0.
      PQ(K)=0.
  211 T=(K-1)*TINT
      TT(K)=T
      DO 45 N=1,NTERM
      SWT=WF*T
      SWTSIN=DSIN(SWT)
      SWTCOS=DCOS(SWT)
      PAIN=N*PAI
      PAINTL=PAIN/TL
      DEN=P(N)**2-WF2
      ADEN=DABS(DEN)
      IF(ADEN.LT..0001) GO TO 45
      DN(N)=0.
      DO 44 I=1,NS1
   44 DN(N)=DN(N)+RP(I)*XN(I,N)/DEN
   42 XTC(N)=CX*DCOS(PAINTL*X(NP))
      XT(N)=CX*DSIN(PAINTL*X(NP))
      PY(K)=PY(K)+XT(N)*DN(N)*SWTSIN
      PYT(K)=PYT(K)+XT(N)*DN(N)*WF*SWTCOS
      PYT2(K)=PYT2(K)+XT(N)*DN(N)*(-WF**2*SWTSIN)
      PM(K)=PM(K)+(PAINTL**2*XT(N)*DN(N)*SWTSIN)*E*XI
```

```
      PQ(K)=PQ(K)-(PAINTL**3*XTC(N)*DN(N)*SWTSIN)*E*XI                  DYNA0226
   45 CONTINUE                                                          DYNA0227
   51 CONTINUE                                                          DYNA0228
      WRITE(IO,700)                                                     DYNA0229
  700 FORMAT(//)                                                        DYNA0230
      WRITE(IO,605) X(NP)                                               DYNA0231
  605 FORMAT(1H1,'TIME HISTORY FOR THE POINT( X=',D9.3,' )'/)           DYNA0232
      WRITE(IO,606)                                                     DYNA0233
  606 FORMAT(' ','  TIME    PART-DISP PART-VELO PART-ACCL PART-MOMT'    DYNA0234
     1 ' PART-SHRF')                                                    DYNA0235
      APY=0.                                                            DYNA0236
      APYT=0.                                                           DYNA0237
      APYT2=0.                                                          DYNA0238
      APM=0.                                                            DYNA0239
      APQ=0.                                                            DYNA0240
      DO 52 I=1,NT                                                      DYNA0241
      IF(APY-DABS(PY(I))) 62,62,63                                      DYNA0242
   62 TPY=TT(I)                                                         DYNA0243
      APY=DABS(PY(I))                                                   DYNA0244
   63 IF(APYT-DABS(PYT(I))) 66,66,67                                    DYNA0245
   66 TPYT=TT(I)                                                        DYNA0246
      APYT=DABS(PYT(I))                                                 DYNA0247
   67 IF(APYT2-DABS(PYT2(I))) 70,70,71                                  DYNA0248
   70 TPYT2=TT(I)                                                       DYNA0249
      APYT2=DABS(PYT2(I))                                               DYNA0250
   71 IF(APM-DABS(PM(I))) 74,74,75                                      DYNA0251
   74 TPM=TT(I)                                                         DYNA0252
      APM=DABS(PM(I))                                                   DYNA0253
   75 IF(APQ-DABS(PQ(I))) 78,78,79                                      DYNA0254
   78 TPQ=TT(I)                                                         DYNA0255
      APQ=DABS(PQ(I))                                                   DYNA0256
   79 CONTINUE                                                          DYNA0257
   52 WRITE(IO,607) TT(I),PY(I),PYT(I),PYT2(I),PM(I),PQ(I)              DYNA0258
      WRITE(IO,610)                                                     DYNA0259
  607 FORMAT(6D10.3)                                                    DYNA0260
  610 FORMAT(/' ','MAXIMUM ABSOLUTE VALUES'/)                           DYNA0261
      WRITE(IO,611) APY,APYT,APYT2,APM,APQ                              DYNA0262
  611 FORMAT(' MAX ABS  ',5D10.3)                                       DYNA0263
      WRITE(IO,612) TPY,TPYT,TPYT2,TPM,TPQ                              DYNA0264
  612 FORMAT(' CORR TIME',5D10.3)                                       DYNA0265
   50 CONTINUE                                                          DYNA0266
   59 IF(IPLOT.EQ.0)GO TO 999                                           DYNA0267
      WRITE(IO2,800)HEAD                                                DYNA0268
  800 FORMAT(20A4)                                                      DYNA0269
      WRITE(IO2,801)NFRQ,NS1,NTERM                                      DYNA0270
  801 FORMAT(3I5)                                                       DYNA0271
      WRITE(IO2,802)TL,E,XI,WF,CX                                       DYNA0272
  802 FORMAT(3D25.16)                                                   DYNA0273
      WRITE(IO2,802)(P(N),N=1,NTERM)                                    DYNA0274
      WRITE(IO2,802)(DN(N),N=1,NTERM)                                   DYNA0275
      DO 7 I=1,NS1                                                      DYNA0276
    7 WRITE(IO2,802)(XN(I,N),N=1,NTERM)                                 DYNA0277
      WRITE(IO2,803)(XL(I),I=1,NS1)                                     DYNA0278
  803 FORMAT(5E15.5)                                                    DYNA0279
  999 RETURN                                                            DYNA0280
      END                                                               DYNA0281
      SUBROUTINE FREQ(P,XN,FRQ,DET,ITN,RCOEF,WKAREA)                    DYNA0282
      IMPLICIT DOUBLE PRECISION(A-H,O-Z)                                DYNA0283
      DIMENSION P(1),DET(1),FRQ(1),ITN(1),XN(NS1,1),RCOEF(NS1,1),       DYNA0284
     *           WKAREA(1)                                              DYNA0285
      COMMON/SETUP/TL,SM,E,XI,DT,TINT,WF,EPS1,PAI,EX,CX,NSPAN,NTERM,    DYNA0286
     1 NPOINT,NS1,NT,IN,IO,IO2,IOPT,IPLOT,IMAX,NFRQ,NTERM1,IEQSP        DYNA0287
      FMAX=1.D+4                                                        DYNA0288
      DO 53 I=1,NFRQ                                                    DYNA0289
      FRQ(I)=0.0                                                        DYNA0290
      DET(I)=0.0                                                        DYNA0291
   53 ITN(I)=0                                                          DYNA0292
      IF(IEQSP.EQ.0) GO TO 70                                           DYNA0293
      DO 72 I=1,NFRQ                                                    DYNA0294
      JFRQ=1+(I-1)*NSPAN                                                DYNA0295
      IF(JFRQ.GT.NFRQ) GO TO 73                                         DYNA0296
   72 FRQ(JFRQ)=(NSPAN*PAI*I)**2*DSQRT(E*XI/(SM*TL**4))                 DYNA0297
   73 CONTINUE                                                          DYNA0298
   70 DO 74 I=1,NFRQ                                                    DYNA0299
      IF(FRQ(I).GT.0.0) GO TO 74                                        DYNA0300
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      IF(I.EQ.1) GO TO 75
      X1=FRQ(I-1)*1.05
      GO TO 76
   75 X1=P(1)
   76 DELX=X1/50.
      ITR=1
   32 CALL FX(FX1,X1,P,XN,RCOEF,WKAREA)
   34 X2=X1+DELX
      CALL FX(FX2,X2,P,XN,RCOEF,WKAREA)
      IF(FX1*FX2) 37,35,38
   35 XD=X2
      DET(I)=FX2
   50 FRQ(I)=XD
      ITN(I)=ITR
      GO TO 74
   38 ITR=ITR+1
      IF(ITR.GT.IMAX) GO TO 901
      X1=X2
      FX1=FX2
      GO TO 34
   37 IF(DABS(FX2).GT.FMAX*DABS(FX1)) GO TO 60
      IF(DABS(FX1).GT.FMAX*DABS(FX2)) GO TO 60
      X3=(X1*FX2-X2*FX1)/(FX2-FX1)
      GO TO 61
   60 X3=(X1+X2)/2.
   61 CALL FX(FX3,X3,P,XN,RCOEF,WKAREA)
      IF(DABS(FX3).GT.EPS1) GO TO 39
      XD=X3
      DET(I)=FX3
      GO TO 50
   39 IF(DABS(FX3).LT.FMAX) GO TO 40
      WRITE(IO,600) X3
  600 FORMAT(/' ','DETERMINANT APPROACHING INFINITY FOR FREQ EQUAL TO '
     1 ,D12.5)
      X1=X3+DELX
      ITR=0
      GO TO 32
   40 IF(FX1*FX3) 42,44,41
   44 XD=X3
      DET(I)=FX3
      GO TO 50
   41 ITR=ITR+1
      IF(ITR.GT.IMAX) GO TO 901
      X1=X3
      FX1=FX3
      GO TO 37
   42 ITR=ITR+1
      IF(ITR.GT.IMAX) GO TO 901
      X2=X3
      FX2=FX3
      GO TO 37
  901 WRITE(IO,601) ITR,EPS1
  601 FORMAT(/' ','NO CONVERGENCE INCREASE IMAX',I6,' OR ',
     1 'EPS1',D12.4)
   74 CONTINUE
      DO 79 I=1,NFRQ
   79 WRITE(IO,602) I,FRQ(I),ITN(I),DET(I)
  602 FORMAT(/' ','FREQ (MODE',I2,' ) = ',D9.4,' AFTER',I5,' ITRNS',
     1 ' DET = ',D10.4)
      RETURN
      END
      SUBROUTINE FX(DETER,WS,P,XN,RCOEF,WKAREA)
      IMPLICIT DOUBLE PRECISION(A-H,O-Z)
      DIMENSION P(1),XN(NS1,1),RCOEF(NS1,1),WKAREA(1)
      COMMON/SETUP/TL,SM,E,XI,DT,TINT,WF,EPS1,PAI,EX,CX,NSPAN,NTERM,
     1 NPOINT,NS1,NT,IN,IO,IO2,IOPT,IPLOT,IMAX,NFRQ,NTERM1,IEQSP
      DO 7 I1=1,NS1
      DO 7 I2=1,NS1
    7 RCOEF(I1,I2)=0.
      DO 10 N=1,NTERM1
      PAIN=PAI*N
      PAINTL=PAIN/TL
      DEN=P(N)**2-WS**2
      IF(DABS(DEN).LT..1D-50) GO TO 10
      DO 10 I1=1,NS1
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      DO 10 I2=1,NS1                                                    DYNA0376
      RCOEF(I1,I2)=RCOEF(I1,I2)+XN(I1,N)*XN(I2,N)/DEN                   DYNA0377
   10 CONTINUE                                                          DYNA0378
      D1=0.                                                             DYNA0379
      CALL LINV3F(RCOEF,B,4,NS1,NS1,D1,D2,WKAREA,IER)                   DYNA0380
      IF(D2.LT.200.)GO TO 12                                            DYNA0381
      WRITE(IO,600)WS                                                   DYNA0382
  600 FORMAT(' DETERMINANT APPROACING INFINITY FOR FREQ EQUAL TO '      DYNA0383
     1        D12.5)                                                    DYNA0384
      GO TO 13                                                          DYNA0385
   12 DETER=D1*2**D2                                                    DYNA0386
   13 IF(IER.NE.65.)GO TO 15                                            DYNA0387
      WRITE(IO,555)                                                     DYNA0388
  555 FORMAT(/' A SINGULAR MATRIX WAS ENCOUNTERED.'/)                   DYNA0389
   15 RETURN                                                            DYNA0390
      END                                                               DYNA0391
```

```
C MOM3
C    A COMPUTER PROGRAM TO EVALUATE THE FORCED VIBRATION DISP-       *
C    LACEMENTS,MOMENT AND SHEAR FOR A CONTINUEOUS BEAM,USING        *
C    THE DYNAMIC THREE MOMENT EQUATION.                              *
C                                                                    *
C*********************************************************************
C                                                                    *
C    PROGRAMMED SPRING 1980 FOR XEROX SIGMA 9                        *
C    AT MARQUETTE UNIVERSITY                                         *
C                                                                    *
C*********************************************************************
C                                                                    *
C    DEFINITION OF VARIABLES :                                       *
C                                                                    *
C    HEAD      = TITLE COMPOSED OF UP TO 80 ALPHANUMERIC CHARACTERS  *
C    NSPAN     = THE NO. OF SPANS                                    *
C    WF=       = FORCING FREQUENCY (RAD/SEC)                         *
C    SL(I)     = SPAN LENGTH OF SPAN I                               *
C    YM(I)     = YOUNG'S MODULUS OF SPAN I                           *
C    SI(I)     = MOMENT OF INERTIA OF SPAN I                         *
C    SSAM(I)   = MASS OF SPAN I                                      *
C    DELMAX(J) = AMPLITUDE OF VIBRATION OF SUPPORT J                 *
C    ITYPE     = ALPHANUMERIC STRING OF FOUR CHARACTERS THAT SHOULD  *
C                BE INPUT AS ' TIME 'WHEN THE DISPLACEMENT,MOMENT,   *
C                SHEAR AS A FUNCTION OF TIME AT SPECIFIC POINTS ALONG*
C                THE BEAM SPAN.ITYOE SHOULD BE INPUT AS ' DIST ' WHEN*
C                THESE FUNCTIONS ARE DESIRED TO BE EVALUATED W.R.T   *
C                DISTANCE ALONG THE SPAN AT CERTAIN POINTS IN TIME   *
C                                                                    *
C    THE FOLLOWING DEFINITIONS HOLD WHEN ITYPE=TIME                  *
C                                                                    *
C    NPOINT    = NO. OF POINTS WHOSE TIME HISTORY ARE SOUGHT         *
C    XT(N)     = THE X COORDINATE OF THE POINT N WHERE               *
C                THE TIME HISTORY IS SOUGHT                          *
C    SXORT     = DURATION OF EARTHQUAKE                              *
C    XTINT     = TIME INTERVAL FOR THE TIME HISTORY                  *
C                                                                    *
C    THE FOLLOWING DEFINITIONS HOLD WHEN ITYPE=DIST                  *
C                                                                    *
C    NPOINT    = THE  NUMBER OF POINTS IN TIME FOR WHICH THE         *
C                FUNCTIONS  ARE TO BE EVALUATED FOR  SPECIFIC POINTS *
C                ALONG THE BEAM SPAN.                                *
C    XT(N)     = THE TIME COORDINATE OF POINT N                      *
C                 IF XT(N) IS INPUT AS 999. THEN THE PROGRAM         *
C                 AUTOMATICALLY  CHOSES THE TIME FOR MAX PARTICULAR  *
C                 RESPONSE T=PI/(2.*WF)                              *
C    SXORT     = TOTAL SPAN LENGTH                                   *
C    XTINT     = DISTANCE INTERVAL ALONG THE SPAN FOR WHICH          *
C                THE FUNCTIONS ARE TO BE EVALUATED                   *
C                                                                    *
C*********************************************************************
C                                                                    *
C    INPUT CARDS SEQUENCE :                                          *
C                                                                    *
C    NO. OF                                                          *
C    CARDS            VARIABLES                         FORMAT       *
C                                                                    *
C       1             HEAD                              (20A4)       *
C       1             IOPT,NSPAN,IEQSP                  (3I5)        *
C       1             NFRQ,IMAX,EPS1                    (2I5,G10.0)  *
C       1             ITYPE,NPOINT,WF,SXORT,XTINT       (A4,I5,3G10.0 *
C    NSPAN            SL(I),YM(I),SI(I),SSAM(I)         (4G10.0)     *
C    NSPAN-1          DELMAX(J)                         (10G10.0)    *
C    NPOINT           XT(N)                             (10G10.0)    *
C                                                                    *
C*********************************************************************
C                                                                    *
      IMPLICIT DOUBLE PRECISION(A-H,O-Z)
      DIMENSION HEAD(20),NN(2000)
      COMMON /SETUP/ WF,SXORT,XTINT,EPS1,PI,NSPAN,NSUP,NPOINT,NXORT,
     *              NFRQ,IMAX,IN,IO,IOPT,ITYPE,IEQSP
      COMMON A(1000)
      EQUIVALENCE(A(1),NN(1))
      IN=5
      IO=6
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  999 READ(IN,500,END=997) HEAD                                           MOM30075
  500 FORMAT(20A4)                                                        MOM30076
      WRITE(IO,600)HEAD                                                   MOM30077
  600 FORMAT(1H1,///' ',20A4)                                             MOM30078
      READ(IN,501)IOPT,NSPAN,IEQSP                                        MOM30079
  501 FORMAT(3I5)                                                         MOM30080
      IF(IOPT.EQ.1)GO TO 105                                              MOM30081
      READ(IN,503)NFRQ,IMAX,EPS1                                          MOM30082
  503 FORMAT(2I5,G10.0)                                                   MOM30083
      NXORT=0                                                             MOM30084
      NPOINT=0                                                            MOM30085
      IF(IOPT.EQ.2)GO TO 110                                              MOM30086
  105 READ(IN,504) ITYPE,NPOINT,WF,SXORT,XTINT                            MOM30087
  504 FORMAT(A4,I5,3G10.0)                                                MOM30088
      NXORT=SXORT/XTINT+1                                                 MOM30089
  110 NSUP=NSPAN-1                                                        MOM30090
      L2=1+NSPAN                                                          MOM30091
      L3=L2+NSPAN                                                         MOM30092
      L4=L3+NSPAN                                                         MOM30093
      L5=L4+NSPAN                                                         MOM30094
      L6=L5+NSUP                                                          MOM30095
      L7=L6+NSUP                                                          MOM30096
      L8=L7+NSUP                                                          MOM30097
      L9=L8+NPOINT                                                        MOM30098
      L10=L9+NXORT                                                        MOM30099
      L11=L10+NXORT                                                       MOM30100
      L12=L11+NSUP**2                                                     MOM30101
      L13=L12+NFRQ                                                        MOM30102
      L14=L13+NFRQ                                                        MOM30103
      L15=2*(L14+2*NSUP)+1                                                MOM30104
      NSIZE=L15+NFRQ                                                      MOM30105
      WRITE(IO,602) NSIZE                                                 MOM30106
  602 FORMAT(//' ','BLANK COMMON SIZE',I6)                                MOM30107
      IF(NSIZE.GT.2000) GO TO 998                                         MOM30108
      CALL MOMAIN(A(1),A(L2),A(L3),A(L4),A(L5),A(L6),A(L7),A(L8),A(L9),  MOM30109
     1 A(L10),A(L11),A(L12),A(L13),A(L14),NN(L15))                        MOM30110
      GO TO 999                                                           MOM30111
  998 WRITE(IO,601) NSIZE                                                 MOM30112
  601 FORMAT(//' ','INCREASE BLANK COMMON ARRAY UP TO ',I6)               MOM30113
  997 STOP                                                                MOM30114
      END                                                                 MOM30115
      SUBROUTINE MOMAIN(SL,YM,SI,SSAM,DELMAX,TM,VECTOR,XT,X,T,            MOM30116
     1 ALPHA,FRQ,DET,WKAREA,ITN)                                          MOM30117
      IMPLICIT DOUBLE PRECISION(A-H,O-Z)                                  MOM30118
      DIMENSION SL(NSPAN),YM(NSPAN),SI(NSPAN),SSAM(NSPAN),                MOM30119
     1 DELMAX(NSUP),TM(NSUP),VECTOR(NSUP),XT(NPOINT),                     MOM30120
     2 ALPHA(NSUP,NSUP),X(NXORT),T(NXORT),FRQ(NFRQ),DET(NFRQ),            MOM30121
     3 WKAREA(2*NSUP),ITN(NFRQ)                                           MOM30122
      COMMON /SETUP/ WF,SXORT,XTINT,EPS1,PI,NSPAN,NSUP,NPOINT,NXORT,      MOM30123
     *               NFRQ,IMAX,IN,IO,IOPT,ITYPE,IEQSP                     MOM30124
C                                                                         MOM30125
C     INITIALIZATION, READ WRITE BLOCK                                    MOM30126
C                                                                         MOM30127
      PI=2.*DASIN(1.D0)                                                   MOM30128
      DO 5 I=1,NSPAN                                                      MOM30129
    5 READ(IN,503)SL(I),YM(I),SI(I),SSAM(I)                               MOM30130
      IF(IOPT.EQ.2)GO TO 177                                              MOM30131
      DO 10 I=1,NSUP                                                      MOM30132
   10 READ(IN,503)DELMAX(I)                                               MOM30133
      READ (IN,503)(XT(I),I=1,NPOINT)                                     MOM30134
  503 FORMAT(10G10.3)                                                     MOM30135
  177 IF(IOPT.EQ.1)GO TO 7                                                MOM30136
      CALL MOFREQ(FRQ,DET,ITN,ALPHA,VECTOR,WKAREA,SL,YM,SSAM,SI)          MOM30137
      IF(IOPT.EQ.2) GO TO 17                                              MOM30138
    7 IF(ITYPE.NE.4HDIST)GO TO 15                                         MOM30139
      WRITE(IO,601)NSPAN,WF,SXORT,XTINT,NPOINT                            MOM30140
  601 FORMAT(///' NSPAN                             ='I10,/,              MOM30141
     *         ' FORCING FREQUENCY(RAD/SEC)         ='D10.4,/,            MOM30142
     *         ' TOTAL SPAN LENGTH                  ='D10.4,/,            MOM30143
     *         ' DITANCE INERVAL ALONG THE SPAN     ='D10.4,/,            MOM30144
     *         ' NO. OF POINTS IN TIME              ='I10)                MOM30145
      GO TO 17                                                            MOM30146
   15 WRITE(IO,602)NSPAN,WF,SXORT,XTINT,NPOINT                            MOM30147
  602 FORMAT(///' NSPAN                             ='I10,/,              MOM30148
     *         ' FORCING FREQUENCY(RAD/SEC)         ='D10.4,/,            MOM30149
     *         ' DURATION OF EARTHQUAKE             ='D10.4,/,            MOM30150
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     *          ' TIME INCREMENT IN TIME HISTORY        ='D10.4,/,          MOM30151
     *          ' NO. OF POINTS WHERE HISTORY SOUGHT    ='I10)              MOM30152
  17 DO 20 I=1,NSPAN                                                        MOM30153
  20 WRITE(IO,603)I,SL(I),YM(I),SI(I),SSAM(I)                               MOM30154
 603 FORMAT(// FOR THE SPAN NO.'I2//,                                       MOM30155
     *          ' THE SPAN LENGTH IS                    ='D10.4,/,          MOM30156
     *          ' YOUNGS MODULUS IS                     ='D10.4,/,          MOM30157
     *          ' THE MOMENT OF INERTIA IS              ='D10.4,/,          MOM30158
     *          ' THE MASS PER UNIT LENGTH IS           ='D10.4)            MOM30159
      IF(IOPT.EQ.2)GO TO 999                                                MOM30160
      DO 25 I=1,NSUP                                                        MOM30161
  25 WRITE(IO,604)I,DELMAX(I)                                               MOM30162
 604 FORMAT(/,' FOR THE SUPPORT NO.'I2//,                                   MOM30163
     *          ' THE AMPLITUDE OF SETTLEMENT IS        ='D10.4)            MOM30164
C                                                                           MOM30165
C     CALCULATION OF THE DYNAMIC MOMENTS AT THE INTERIOR SUPPORTS           MOM30166
C                                                                           MOM30167
      DO 125 I=1,NSUP                                                       MOM30168
      DO 125 J=1,NSUP                                                       MOM30169
 125 ALPHA(I,J)=0.                                                          MOM30170
      DO 150 IR=1,NSUP                                                      MOM30171
      GAMMA=0.                                                              MOM30172
      GAMMAL=0.                                                             MOM30173
      GAMMAR=0.                                                             MOM30174
      IRR=IR+1                                                              MOM30175
      IRL=IR-1                                                              MOM30176
      BR=(SSAM(IR)*WF**2/(YM(IR)*SI(IR)))**.25*SL(IR)                       MOM30177
      H1BR=(DCOSH(BR)/DSINH(BR)-DCOS(BR)/DSIN(BR))/BR                       MOM30178
      F1BR=(DCOSH(BR)/DSINH(BR)+DCOS(BR)/DSIN(BR))*BR                       MOM30179
      BR1=(SSAM(IRR)*WF**2/(YM(IRR)*SI(IRR)))**.25*SL(IRR)                  MOM30180
      H1BR1=(DCOSH(BR1)/DSINH(BR1)-DCOS(BR1)/DSIN(BR1))/BR1                 MOM30181
      F1BR1=(DCOSH(BR1)/DSINH(BR1)+DCOS(BR1)/DSIN(BR1))*BR1                 MOM30182
      ALPHA(IR,IR)=SL(IR)*H1BR/SI(IR)+SL(IRR)*H1BR1/SI(IRR)                 MOM30183
      GAMMA=(F1BR/SL(IR)+F1BR1/SL(IRR))*DELMAX(IR)*YM(IR)                   MOM30184
      IF(NSUP.EQ.1)GO TO 140                                                MOM30185
      H2BR=(1./DSIN(BR)-1./DSINH(BR))/BR                                    MOM30186
      F2BR=(1./DSIN(BR)+1./DSINH(BR))*BR                                    MOM30187
      H2BR1=(1./DSIN(BR1)-1./DSINH(BR1))/BR1                                MOM30188
      F2BR1=(1./DSIN(BR1)+1./DSINH(BR1))*BR1                                MOM30189
      IF(IR.EQ.1)GO TO 135                                                  MOM30190
 130 ALPHA(IR,IRL)=H2BR*SL(IR)/SI(IR)                                       MOM30191
      GAMMAL=-F2BR*DELMAX(IRL)*YM(IR)/SL(IR)                                MOM30192
      IF(IR.EQ.NSUP) GO TO 140                                              MOM30193
 135 ALPHA(IR,IRR)=H2BR1*SL(IRR)/SI(IRR)                                    MOM30194
      GAMMAR=-F2BR1*DELMAX(IRR)*YM(IRR)/SL(IRR)                             MOM30195
 140 VECTOR(IR)=GAMMAL+GAMMA+GAMMAR                                         MOM30196
 150 CONTINUE                                                               MOM30197
      IF(NSUP.GT.1) GO TO 175                                               MOM30198
      TM(1)=VECTOR(1)/ALPHA(1,1)                                            MOM30199
      GO TO 200                                                             MOM30200
 175 DO 180 I=1,NSUP                                                        MOM30201
 180 TM(I)=VECTOR(I)                                                        MOM30202
      D1=-1.                                                                MOM30203
      CALL LINV3F(ALPHA,TM,2,NSUP,NSUP,D1,D2,WKAREA,IER)                    MOM30204
      IF(IER.EQ.65)GO TO 500                                                MOM30205
C                                                                           MOM30206
C     CALCULATION OF THE DISP,MOM,SHEAR FUNCTIONS                           MOM30207
C                                                                           MOM30208
 200 DO 400 NP=1,NPOINT                                                     MOM30209
      YMAX=0.                                                               MOM30210
      RMMAX=0.                                                              MOM30211
      QMAX=0.                                                               MOM30212
      IF(ITYPE.NE.4HTIME)GO TO 210                                          MOM30213
      DO 205 I=1,NXORT                                                      MOM30214
      X(I)=XT(NP)                                                           MOM30215
      T(I)=(I-1)*XTINT                                                      MOM30216
 205 CONTINUE                                                               MOM30217
      WRITE(IO,605)XT(NP)                                                   MOM30218
 605 FORMAT(1H1// TIME HISTORY FOR THE POINT ( X='G10.3,')')                MOM30219
      GO TO 230                                                             MOM30220
 210 IF(XT(NP).EQ.999.)GO TO 220                                            MOM30221
      DO 215 I=1,NXORT                                                      MOM30222
      X(I)=(I-1)*XTINT                                                      MOM30223
      T(I)=XT(NP)                                                           MOM30224
 215 CONTINUE                                                               MOM30225
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      WRITE(IO,606)XT(NP)                                               MOM30226
  606 FORMAT(1H1//' PARTICULAR RESPONSE ALONG THE SPAN AT  T='D12.5)    MOM30227
      GO TO 230                                                         MOM30228
  220 DO 225 I=1,NXORT                                                  MOM30229
      X(I)=(I-1)*XTINT                                                  MOM30230
      T(I)=PI/(2.*WF)                                                   MOM30231
  225 CONTINUE                                                          MOM30232
      WRITE(IO,607)T(1)                                                 MOM30233
  607 FORMAT(1H1//' MAXIMUM PARTICULAR RESPONSE ALONG THE SPAN (T=',    MOM30234
     *       D12.5,')')                                                 MOM30235
  230 WRITE(IO,608)ITYPE                                                MOM30236
  608 FORMAT(//15X,A4,9X,'PART DISP',6X,'PART MOM',6X,'PART SHEAR'/,    MOM30237
     *        15X,4(1H-),9X,9(1H-),6X,8(1H-),6X,10(1H-),/)              MOM30238
      DO 399 I=1,NXORT                                                  MOM30239
      XL=0.                                                             MOM30240
      XR=0.                                                             MOM30241
      DO 250 N=1,NSPAN                                                  MOM30242
      XR=XR+SL(N)                                                       MOM30243
      IF((X(I).LT.XL).OR.(X(I).GT.XR))GO            TO 235              MOM30244
      SPANL=SL(N)                                                       MOM30245
      SPANX=X(I)-XL                                                     MOM30246
      ISUP=N-1                                                          MOM30247
      KSUP=N                                                            MOM30248
      NSP=N                                                             MOM30249
      GO TO 255                                                         MOM30250
  235 XL=XL+SL(N)                                                       MOM30251
  250 CONTINUE                                                          MOM30252
  255 XLAMDA=(SSAM(NSP)*WF**2/(YM(NSP)*SI(NSP)))**.25                   MOM30253
      B1=XLAMDA*(SPANL-SPANX)                                           MOM30254
      B2=XLAMDA*SPANX                                                   MOM30255
      BETA=XLAMDA*SPANL                                                 MOM30256
      V1=DSIN(B1)                                                       MOM30257
      V2=DSIN(B2)                                                       MOM30258
      V3=DSIN(BETA)                                                     MOM30259
      V4=DSINH(B1)                                                      MOM30260
      V5=DSINH(B2)                                                      MOM30261
      V6=DSINH(BETA)                                                    MOM30262
      V7=2*YM(NSP)*SI(NSP)*XLAMDA**2                                    MOM30263
      C1=DCOS(B1)                                                       MOM30264
      C2=DCOS(B2)                                                       MOM30265
      C4=DCOSH(B1)                                                      MOM30266
      C5=DCOSH(B2)                                                      MOM30267
      XX1=0.                                                            MOM30268
      XX2=0.                                                            MOM30269
      XX3=0.                                                            MOM30270
      XX4=0.                                                            MOM30271
      XM1=0.                                                            MOM30272
      XM2=0.                                                            MOM30273
      XM3=0.                                                            MOM30274
      XM4=0.                                                            MOM30275
      XQ1=0.                                                            MOM30276
      XQ2=0,                                                            MOM30277
      XQ3=0.                                                            MOM30278
      XQ4=0.                                                            MOM30279
      IF(NSP.EQ.1) GO TO 260                                            MOM30280
      XX1=TM(ISUP)*(V1/V3-V4/V6)/V7                                     MOM30281
      XX3=DELMAX(ISUP)*(V1/V3+V4/V6)/2.                                 MOM30282
      XM1=TM(ISUP)*(V1/V3+V4/V6)/2.                                     MOM30283
      XM3=DELMAX(ISUP)*XLAMDA**2*YM(NSP)*SI(NSP)*(V1/V3-V4/V6)/2.       MOM30284
      XQ1=TM(ISUP)*(-XLAMDA)*(C1/V3+C4/V6)/2.                           MOM30285
      XQ3=-DELMAX(ISUP)*XLAMDA**3*YM(NSP)*SI(NSP)*(C1/V3-C4/V6)/2.      MOM30286
  260 IF(NSP.EQ.NSPAN)GO TO 265                                         MOM30287
      XX2=TM(KSUP)*(V2/V3-V5/V6)/V7                                     MOM30288
      XX4=DELMAX(KSUP)*(V2/V3+V5/V6)/2.                                 MOM30289
      XM2=TM(KSUP)*(V2/V3+V5/V6)/2.                                     MOM30290
      XM4=DELMAX(KSUP)*XLAMDA**2*YM(NSP)*SI(NSP)*(V2/V3-V5/V6)/2.       MOM30291
      XQ2=TM(KSUP)*XLAMDA*(C2/V3+C5/V6)/2.                              MOM30292
      XQ4=DELMAX(KSUP)*XLAMDA**3*YM(NSP)*SI(NSP)*(C2/V3-C5/V6)/2.       MOM30293
  265 XX=XX1+XX2+XX3+XX4                                                MOM30294
      XM=XM1+XM2+XM3+XM4                                                MOM30295
      XQ=XQ1+XQ2+XQ3+XQ4                                                MOM30296
      WFT=WF*T(I)                                                       MOM30297
      Y=XX*DSIN(WFT)                                                    MOM30298
      RM=XM*DSIN(WFT)                                                   MOM30299
      Q=XQ*DSIN(WFT)                                                    MOM30300
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  270 IF(ITYPE.NE.4HDIST)GO TO 300                                      MOM30301
      IF(DABS(YMAX).GT.DABS(Y))GO TO 275                                MOM30302
      YMAX=Y                                                            MOM30303
      XTYMAX=X(I)                                                       MOM30304
  275 IF(DABS(RMMAX).GT.DABS(RM))GO TO 280                              MOM30305
      RMMAX=RM                                                          MOM30306
      XTMMAX=X(I)                                                       MOM30307
  280 IF(DABS(QMAX).GT.DABS(Q))GO TO 285                                MOM30308
      QMAX=Q                                                            MOM30309
      XTQMAX=X(I)                                                       MOM30310
  285 WRITE(IO,609)X(I),Y,RM,Q                                          MOM30311
      GO TO 399                                                         MOM30312
  300 IF(DABS(YMAX).GT.DABS(Y))GO TO 305                                MOM30313
      YMAX=Y                                                            MOM30314
      XTYMAX=T(I)                                                       MOM30315
  305 IF(DABS(RMMAX).GT.DABS(RM))GO TO 310                              MOM30316
      RMMAX=RM                                                          MOM30317
      XTMMAX=T(I)                                                       MOM30318
  310 IF(DABS(QMAX).GT.DABS(Q))GO TO 315                                MOM30319
      QMAX=Q                                                            MOM30320
      XTQMAX=T(I)                                                       MOM30321
  315 WRITE(IO,609)T(I),Y,RM,Q                                          MOM30322
  399 CONTINUE                                                          MOM30323
  400 CONTINUE                                                          MOM30324
  609 FORMAT(7X,4D15.5)                                                 MOM30325
      WRITE(IO,610)YMAX,RMMAX,QMAX,ITYPE,XTYMAX,XTMMAX,XTQMAX           MOM30326
  610 FORMAT(///'  MAX VALUES'10X,3D15.5,/'  AT 'A4,13X,3D15.5,//)      MOM30327
      GO TO 999                                                         MOM30328
  500 WRITE(IO,611)                                                     MOM30329
  611 FORMAT(///' ','SINGULAR MATRIX ENCOUNTERED'//)                    MOM30330
  999 RETURN                                                            MOM30331
      END                                                               MOM30332
      SUBROUTINE MOFREQ(FRQ,DET,ITN,ALPHA,VECTOR,WKAREA,SL,YM,SSAM,SI)  MOM30333
      IMPLICIT DOUBLE PRECISION(A-H,O-Z)                                MOM30334
      DIMENSION DET(1),FRQ(1),ALPHA(NSUP,1),VECTOR(1),                  MOM30335
     *          WKAREA(1),SL(1),YM(1),SSAM(1),SI(1),ITN(1)              MOM30336
      COMMON /SETUP/ WF,SXORT,XTINT,EPS1,PI,NSPAN,NSUP,NPOINT,NXORT,    MOM30337
     *               NFRQ,IMAX,IN,IO,IOPT,ITYPE,IEQSP                   MOM30338
      FMAX=1.D+4                                                        MOM30339
      PNMIN=1.D+50                                                      MOM30340
      DO 53 I=1,NFRQ                                                    MOM30341
      FRQ(I)=0.0                                                        MOM30342
      DET(I)=0.0                                                        MOM30343
   53 ITN(I)=0                                                          MOM30344
      IF(IEQSP.EQ.0) GO TO 70                                           MOM30345
      TL=0.0                                                            MOM30346
      DO 71 I=1,NFRQ                                                    MOM30347
   71 TL=TL+SL(I)                                                       MOM30348
      DO 72 I=1,NFRQ                                                    MOM30349
      JFRQ=1+(I-1)*NSPAN                                                MOM30350
      IF(JFRQ.GT.NFRQ) GO TO 73                                         MOM30351
   72 FRQ(JFRQ)=(NSPAN*PI*I)**2*DSQRT(YM(1)*SI(1)/(SSAM(1)*TL**4))      MOM30352
   73 CONTINUE                                                          MOM30353
   70 DO 74 I=1,NFRQ                                                    MOM30354
      IF(FRQ(I).GT.0.0) GO TO 74                                        MOM30355
      IF(I.EQ.1) GO TO 75                                               MOM30356
      X1=FRQ(I-1)*1.05                                                  MOM30357
      GO TO 76                                                          MOM30358
   75 DO 100 II=1,NSUP                                                  MOM30359
      PN=DSQRT(YM(II)*SI(II)/(SSAM(II)*SL(II)**4))*PI*2                 MOM30360
      IF(PN.GT.PNMIN)GO TO 100                                          MOM30361
      PNMIN=PN                                                          MOM30362
  100 CONTINUE                                                          MOM30363
      X1=PNMIN*.5                                                       MOM30364
   76 DELX=X1/50.                                                       MOM30365
      ITR=1                                                             MOM30366
   32 CALL MOFX(FX1,X1,ALPHA,VECTOR,WKAREA,SL,YM,SSAM,SI)               MOM30367
   34 X2=X1+DELX                                                        MOM30368
      CALL MOFX(FX2,X2,ALPHA,VECTOR,WKAREA,SL,YM,SSAM,SI)               MOM30369
      IF(DABS(FX2).LT.EPS1)GO TO 35                                     MOM30370
      IF(FX1*FX2) 37,35,38                                              MOM30371
   35 XD=X2                                                             MOM30372
      DET(I)=FX2                                                        MOM30373
   50 FRQ(I)=XD                                                         MOM30374
      ITN(I)=ITR                                                        MOM30375
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      GO TO 74                                                          MOM30376
   38 ITR=ITR+1                                                         MOM30377
      IF(ITR.GT.IMAX) GO TO 901                                         MOM30378
      X1=X2                                                             MOM30379
      FX1=FX2                                                           MOM30380
      GO TO 34                                                          MOM30381
   37 IF(DABS(FX2).GT.FMAX*DABS(FX1)) GO TO 60                          MOM30382
      IF(DABS(FX1).GT.FMAX*DABS(FX2)) GO TO 60                          MOM30383
      X3=(X1*FX2-X2*FX1)/(FX2-FX1)                                      MOM30384
      GO TO 61                                                          MOM30385
   60 X3=(X1+X2)/2.                                                     MOM30386
   61 CALL MOFX(FX3,X3,ALPHA,VECTOR,WKAREA,SL,YM,SSAM,SI)               MOM30387
      IF(DABS(FX3).GT.EPS1) GO TO 39                                    MOM30388
      XD=X3                                                             MOM30389
      DET(I)=FX3                                                        MOM30390
      GO TO 50                                                          MOM30391
   39 IF(DABS(FX3).LT.FMAX) GO TO 40                                    MOM30392
      WRITE(IO,600) X3                                                  MOM30393
  600 FORMAT(/' ','DETERMINANT APPROACHING INFINITY FOR FREQ EQUAL TO ' MOM30394
     1 ,D12.5)                                                          MOM30395
      X1=X3+DELX                                                        MOM30396
      ITR=0                                                             MOM30397
      GO TO 32                                                          MOM30398
   40 IF(FX1*FX3) 42,44,41                                              MOM30399
   44 XD=X3                                                             MOM30400
      DET(I)=FX3                                                        MOM30401
      GO TO 50                                                          MOM30402
   41 ITR=ITR+1                                                         MOM30403
      IF(ITR.GT.IMAX) GO TO 901                                         MOM30404
      X1=X3                                                             MOM30405
      FX1=FX3                                                           MOM30406
      GO TO 37                                                          MOM30407
   42 ITR=ITR+1                                                         MOM30408
      IF(ITR.GT.IMAX) GO TO 901                                         MOM30409
      X2=X3                                                             MOM30410
      FX2=FX3                                                           MOM30411
      GO TO 37                                                          MOM30412
  901 WRITE(IO,601) ITR,EPS1                                            MOM30413
  601 FORMAT(/' ','NO CONVERGENCE INCREASE IMAX',I6,' OR ',             MOM30414
     1 'EPS1',D12.4)                                                    MOM30415
   74 CONTINUE                                                          MOM30416
      DO 79 I=1,NFRQ                                                    MOM30417
   79 WRITE(IO,602) I,FRQ(I),ITN(I),DET(I)                              MOM30418
  602 FORMAT(/' ','FREQ (MODE',I2,' ) = ',D9.4,' AFTER',I5,' ITRNS',    MOM30419
     1 ' DET = ',D10.4)                                                 MOM30420
      RETURN                                                            MOM30421
      END                                                               MOM30422
      SUBROUTINE MOFX(DETER,WS,ALPHA,VECTOR,WKAREA,SL,YM,SSAM,SI)       MOM30423
      IMPLICIT DOUBLE PRECISION(A-H,O-Z)                                MOM30424
      DIMENSION ALPHA(NSUP,1),WKAREA(1),SL(1),YM(1),SI(1),SSAM(1),      MOM30425
     1          VECTOR(1)                                               MOM30426
      COMMON /SETUP/ WF,SXORT,XTINT,EPS1,PI,NSPAN,NSUP,NPOINT,NXORT,    MOM30427
     *               NFRQ,IMAX,IN,IO,IOPT,ITYPE,IEQSP                   MOM30428
      DO 125 I=1,NSUP                                                   MOM30429
      DO 125 J=1,NSUP                                                   MOM30430
  125 ALPHA(I,J)=0.                                                     MOM30431
      DO 150 IR=1,NSUP                                                  MOM30432
      IRR=IR+1                                                          MOM30433
      IRL=IR-1                                                          MOM30434
      BR=(SSAM(IR)*WS**2/(YM(IR)*SI(IR)))**.25*SL(IR)                   MOM30435
      H1BR=(DCOSH(BR)/DSINH(BR)-DCOS(BR)/DSIN(BR))/BR                   MOM30436
      BR1=(SSAM(IRR)*WS**2/(YM(IRR)*SI(IRR)))**.25*SL(IRR)              MOM30437
      H1BR1=(DCOSH(BR1)/DSINH(BR1)-DCOS(BR1)/DSIN(BR1))/BR1             MOM30438
      ALPHA(IR,IR)=SL(IR)*H1BR/SI(IR)+SL(IRR)*H1BR1/SI(IRR)             MOM30439
      IF(NSUP.EQ.1)GO TO 150                                            MOM30440
      H2BR=(1./DSIN(BR)-1./DSINH(BR))/BR                                MOM30441
      H2BR1=(1./DSIN(BR1)-1./DSINH(BR1))/BR1                            MOM30442
      IF(IR.EQ.1)GO TO 135                                              MOM30443
  130 ALPHA(IR,IRL)=H2BR*SL(IR)/SI(IR)                                  MOM30444
      IF(IR.EQ.NSUP) GO TO 150                                          MOM30445
  135 ALPHA(IR,IRR)=H2BR1*SL(IRR)/SI(IRR)                               MOM30446
  150 CONTINUE                                                          MOM30447
      D1=0.                                                             MOM30448
      CALL LINV3F(ALPHA,VECTOR,4,NSUP,NSUP,D1,D2,WKAREA,IER)            MOM30449
      IF(D2.LT.200)GO TO 12                                             MOM30450
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      WRITE(IO,600)WS                                                   MOM30451
  600 FORMAT('DETERMINANT APROACHING INFINITY FOR FREQ EQUAL TO ',      MOM30452
     1       D12.5)                                                     MOM30453
      GO TO 13                                                          MOM30454
   12 DETER=D1*2**D2                                                    MOM30455
   13 IF(IER.NE.65)GO TO 15                                             MOM30456
      WRITE(IO,601)                                                     MOM30457
  601 FORMAT(/' A SINGULAR MATRIX WAS ENCOUNTERED.'/)                   MOM30458
   15 RETURN                                                            MOM30459
      END                                                               MOM30460
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 C MOM3ST
C     A COMPUTER PROGRAM TO EVALUATE THE DISPLACEMENTS,                 M3ST0001
C     MOMENTS AND SHEAR ALONG THE LENGTH OF A CONTINUOUS                M3ST0002
C     BEAM SUBJECTED TO STATIC SUPPORT SETTLEMENTS, USING               M3ST0003
C     THE STATIC THREE MOMENT EQUATION.                                 M3ST0004
C                                                                       M3ST0005
C*******************************************************************    M3ST0006
C                                                                       M3ST0007
C     PROGRAMMED SPRING 1980 FOR XEROX SIGMA 9                          M3ST0008
C     BY SAMIR ACRA                                                     M3ST0009
C     AT MARQUETTE UNIVERSITY                                           M3ST0010
C                                                                       M3ST0011
C*******************************************************************    M3ST0012
C                                                                       M3ST0013
C     DEFINITION OF VARIABLES :                                         M3ST0014
C                                                                       M3ST0015
C     HEAD       = TITLE COMPOSED OF UP TO 80 ALPHANUMERIC CHARACTERS   M3ST0016
C     NSPAN      = THE NO. OF SPANS                                     M3ST0017
C     TL         = TOTAL SPAN LENGTH                                    M3ST0018
C     XINT       = INTERVAL ALONG SPAN AT WHICH THE FUNCTIONS           M3ST0019
C                  ARE TO BE EVALUATED                                  M3ST0020
C     SL(I)      = SPAN LENGTH OF SPAN I                                M3ST0021
C     YM(I)      = YOUNG'S MODULUS OF SPAN I                            M3ST0022
C     SI(I)      = MOMENT OF INERTIA OF SPAN I                          M3ST0023
C     SSAM(I)    = MASS OF SPAN I                                       M3ST0024
C     DELMAX(J)  = AMPLITUDE OF VIBRATION OF INTERIOR SUPPORT J         M3ST0025
C                  THERE ARE NSPAN-1 INTERIOR SUPPORTS.                 M3ST0026
C                                                                       M3ST0027
C*******************************************************************    M3ST0028
C                                                                       M3ST0029
C     INPUT CARDS SEQUENCE :                                            M3ST0030
C                                                                       M3ST0031
C     NO. OF                                                            M3ST0032
C     CARDS           VARIABLES                          FORMAT         M3ST0033
C                                                                       M3ST0034
C        1            HEAD                               (20A4)         M3ST0035
C        1            NSPAN,TL,XINT                      (I5,2G10.0)    M3ST0036
C     NSPAN           SL(I),YM(I),SI(I),SSAM(I)          (4G10.0)       M3ST0037
C     NSPAN-1         DELMAX(J)                          (10G10.0)      M3ST0038
C                                                                       M3ST0039
C*******************************************************************    M3ST0040
C                                                                       M3ST0041
      IMPLICIT DOUBLE PRECISION(A-H,O-Z)                                M3ST0042
      REAL AA(2500)                                                     M3ST0043
      DIMENSION HEAD(20),NN(2500)                                       M3ST0044
      COMMON A(1000)                                                    M3ST0045
      EQUIVALENCE(A(1),NN(1)),(A(1),AA(1))                              M3ST0046
      IN=5                                                              M3ST0047
      IO=6                                                              M3ST0048
  999 READ(IN,500,END=997) HEAD                                         M3ST0049
  500 FORMAT(20A4)                                                      M3ST0050
      WRITE(IO,600) HEAD                                                M3ST0051
  600 FORMAT(1H1,//' ',20A4)                                            M3ST0052
      READ(IN,501) NSPAN,TL,XINT                                        M3ST0053
  501 FORMAT(I5,2G10.0)                                                 M3ST0054
      NSUP=NSPAN-1                                                      M3ST0055
      NX=TL/XINT+1                                                      M3ST0056
      L2=1+NSPAN                                                        M3ST0057
      L3=L2+NSPAN                                                       M3ST0058
      L4=L3+NSPAN                                                       M3ST0059
      L5=L4+NSPAN                                                       M3ST0060
      L6=L5+NSUP                                                        M3ST0061
      L7=L6+NSUP                                                        M3ST0062
      L8=L7+NSUP                                                        M3ST0063
      L9=L8+NX                                                          M3ST0064
      L10=(L9+NSUP**2)*2                                                M3ST0065
      L11=L10+NX                                                        M3ST0066
      L12=L11+NX                                                        M3ST0067
      L13=L12+NX                                                        M3ST0068
      L14=L13+NX                                                        M3ST0069
      NSIZE=L14+NSUP*2                                                  M3ST0070
      WRITE(IO,602) NSIZE                                               M3ST0071
  602 FORMAT(//' ','BLANK COMMON SIZE',I6)                              M3ST0072
      IF(NSIZE.GT.2500) GO TO 998                                       M3ST0073
      CALL STMAIN(A(1),A(L2),A(L3),A(L4),A(L5),A(L6),A(L7),A(L8),A(L9), M3ST0074
     1 TL,XINT,AA(L10),AA(L11),AA(L12),AA(L13),NN(L14),NSPAN,NSUP,      M3ST0075
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     2 NX,IN,IO)                                                        M3ST0076
      GO TO 999                                                         M3ST0077
  998 WRITE(IO,601) NSIZE                                               M3ST0078
  601 FORMAT(//' ','INCREASE BLANK COMMON ARRAY UP TO ',I6)             M3ST0079
  997 STOP                                                              M3ST0080
      END                                                               M3ST0081
      SUBROUTINE STMAIN(SL,YM,SI,SSAM,DELMAX,TM,VECTOR,X,ALPHA,         M3ST0082
     1 TL,XINT,RX,XX,XM,XQ,INDEX,NSPAN,NSUP,NX,IN,IO)                   M3ST0083
      IMPLICIT DOUBLE PRECISION(A-H,O-Z)                                M3ST0084
      REAL RX(NX),XX(NX),XM(NX),XQ(NX)                                  M3ST0085
      DIMENSION SL(NSPAN),YM(NSPAN),SI(NSPAN),SSAM(NSPAN),              M3ST0086
     1 DELMAX(NSUP),TM(NSUP),VECTOR(NSUP),X(NX),                        M3ST0087
     2 ALPHA(NSUP,NSUP),INDEX(NSUP,2)                                   M3ST0088
      MSING=1                                                           M3ST0089
C                                                                       M3ST0090
C     RAED WRITE BLOCK                                                  M3ST0091
C                                                                       M3ST0092
      DO 5 I=1,NSPAN                                                    M3ST0093
    5 READ(IN,503)SL(I),YM(I),SI(I),SSAM(I)                             M3ST0094
      READ(IN,503)(DELMAX(I),I=1,NSUP)                                  M3ST0095
  503 FORMAT(10G10.3)                                                   M3ST0096
      WRITE(IO,606)NSPAN,TL,XINT                                        M3ST0097
  606 FORMAT(//' NSPAN                               ='I10,/,           M3ST0098
     *         ' TOTAL SPAN LENGTH                   ='D10.4,/,         M3ST0099
     *         ' X INTERVAL ALONG THE SPAN           ='D10.4/)          M3ST0100
      DO 201 I=1,NSPAN                                                  M3ST0101
  201 WRITE(IO,607)I,SL(I),YM(I),SI(I),SSAM(I)                          M3ST0102
  607 FORMAT(/' FOR THE SPAN NO.'I2//,                                  M3ST0103
     *         ' THE SPAN LENGTH IS                  ='D10.4,/,         M3ST0104
     *         ' YOUNGS MODULUS IS                   ='D10.4,/,         M3ST0105
     *         ' THE MOMENT OF INERTIA IS            ='D10.4,/,         M3ST0106
     *         ' THE MASS PER UNIT LENGTH IS         ='D10.4)           M3ST0107
      DO 202 I=1,NSUP                                                   M3ST0108
  202 WRITE(IO,608)I,DELMAX(I)                                          M3ST0109
  608 FORMAT(/,' FOR THE SUPPORT NO.'I2//,                              M3ST0110
     *         ' THE SETTLEMENT IS                   ='D10.4)           M3ST0111
      WRITE(IO,601)                                                     M3ST0112
  601 FORMAT(1H1,//15X,'DIST'11X,'DISP',11X,'MOM',10X,'',               M3ST0113
     *        'SHEAR',/,15X,4(1H-),11X,4(1H-),11X,3(1H-),11X,5(1H-),/)  M3ST0114
C                                                                       M3ST0115
C     CALCULATION OF THE STATIC MOMENTS AT THE INTERIOR SUPPORTS        M3ST0116
C                                                                       M3ST0117
      DO 25 I=1,NSUP                                                    M3ST0118
      DO 25 J=1,NSUP                                                    M3ST0119
   25 ALPHA(I,J)=0.                                                     M3ST0120
      DO 100 IR=1,NSUP                                                  M3ST0121
      GAMMA=0.                                                          M3ST0122
      GAMMAL=0.                                                         M3ST0123
      GAMMAR=0.                                                         M3ST0124
      IRR=IR+1                                                          M3ST0125
      IRL=IR-1                                                          M3ST0126
      ALPHA(IR,IR)=2.*(SL(IR)/(YM(I)*SI(IR))+SL(IRR)/(YM(IRR)*SI(IRR))) M3ST0127
      GAMMA=(6./SL(IR)+6./SL(IRR))*DELMAX(IR)                           M3ST0128
      IF(NSUP.EQ.1)GO TO 50                                             M3ST0129
      IF(IR.EQ.1)GO TO 45                                               M3ST0130
   40 ALPHA(IR,IRL)=SL(IR)/(YM(IR)*SI(IR))                              M3ST0131
      GAMMAL=-6.*DELMAX(IRL)/SL(IR)                                     M3ST0132
      IF(IR.EQ.NSUP) GO TO 50                                           M3ST0133
   45 ALPHA(IR,IRR)=SL(IRR)/(YM(IRR)*SI(IRR))                           M3ST0134
      GAMMAR=-6.*DELMAX(IRR)/SL(IRR)                                    M3ST0135
   50 VECTOR(IR)=GAMMAL+GAMMA+GAMMAR                                    M3ST0136
  100 CONTINUE                                                          M3ST0137
      IF(NSUP.GT.1) GO TO 105                                           M3ST0138
      TM(1)=VECTOR(1)/ALPHA(1,1)                                        M3ST0139
      GO TO 109                                                         M3ST0140
  105 CALL SIMULE(NSUP,ALPHA,VECTOR,INDEX,MSING)                        M3ST0141
      IF(MSING.EQ.0) GO TO 400                                          M3ST0142
      DO 106 I=1,NSUP                                                   M3ST0143
  106 TM(I)=0.                                                          M3ST0144
      DO 107 I=1,NSUP                                                   M3ST0145
      DO 107 J=1,NSUP                                                   M3ST0146
  107 TM(I)=TM(I)+ALPHA(I,J)*VECTOR(J)                                  M3ST0147
C                                                                       M3ST0148
C     CALCULATION OF THE DISP,MOM,SHEAR FUNCTIONS ALONG THE SPANS       M3ST0149
C                                                                       M3ST0150
```

```
  109 DO 210 I=1,NX                                                     M3ST0151
      X(I)=(I-1)*XINT                                                   M3ST0152
      XL=0.                                                             M3ST0153
      XR=0.                                                             M3ST0154
      DO 110 N=1,NSPAN                                                  M3ST0155
      XR=XR+SL(N)                                                       M3ST0156
      IF((X(I).LT.XL).OR.(X(I).GT.XR))GO TO 108                         M3ST0157
      SPANL=SL(N)                                                       M3ST0158
      SPANX=X(I)-XL                                                     M3ST0159
      ISUP=N-1                                                          M3ST0160
      KSUP=N                                                            M3ST0161
      NSP=N                                                             M3ST0162
      GO TO 120                                                         M3ST0163
  108 XL=XL+SL(N)                                                       M3ST0164
  110 CONTINUE                                                          M3ST0165
  120 XX1=0.                                                            M3ST0166
      XX2=0.                                                            M3ST0167
      XX3=0.                                                            M3ST0168
      XX4=0.                                                            M3ST0169
      XM1=0.                                                            M3ST0170
      XM2=0.                                                            M3ST0171
      XQ1=0.                                                            M3ST0172
      XQ2=0.                                                            M3ST0173
      IF(NSP.EQ.1) GO TO 125                                            M3ST0174
      XX1=(SPANX**3/(6.*SPANL)-SPANX**2/2.+SPANX*SPANL/3.)*             M3ST0175
     *     TM(ISUP)/(YM(N)*SI(N))                                       M3ST0176
      XX3=(1.-SPANX/SPANL)*DELMAX(ISUP)                                 M3ST0177
      XM1=(1.-SPANX/SPANL)*TM(ISUP)                                     M3ST0178
      XQ1=-TM(ISUP)/SPANL                                               M3ST0179
  125 IF(NSP.EQ.NSPAN)GO TO 130                                         M3ST0180
      XX2=(-SPANX**3/(6.*SPANL)+SPANX*SPANL/6.)*TM(KSUP)/(YM(N)*SI(N)) M3ST0181
      XX4=(SPANX/SPANL)*DELMAX(KSUP)                                    M3ST0182
      XM2=TM(KSUP)*SPANX/SL(N)                                          M3ST0183
      XQ2=TM(KSUP)/SPANL                                                M3ST0184
  130 XX(I)=XX1+XX2+XX3+XX4                                             M3ST0185
      XM(I)=XM1+XM2                                                     M3ST0186
      XQ(I)=XQ1+XQ2                                                     M3ST0187
      WRITE(IO,602)X(I),XX(I),XM(I),XQ(I)                               M3ST0188
  210 CONTINUE                                                          M3ST0189
  602 FORMAT(7X,4E15.5)                                                 M3ST0190
      XXMAX=0.                                                          M3ST0191
      XMMAX=0.                                                          M3ST0192
      XQMAX=0.                                                          M3ST0193
      DO 220 I=1,NX                                                     M3ST0194
      IF(ABS(XX(I)).LT.ABS(XXMAX))GO TO 212                             M3ST0195
      XXMAX=XX(I)                                                       M3ST0196
      X1=X(I)                                                           M3ST0197
  212 IF(ABS(XM(I)).LT.ABS(XMMAX))GO TO 214                             M3ST0198
      XMMAX=XM(I)                                                       M3ST0199
      X2=X(I)                                                           M3ST0200
  214 IF(ABS(XQ(I)).LT.ABS(XQMAX))GO TO 220                             M3ST0201
      XQMAX=XQ(I)                                                       M3ST0202
      X3=X(I)                                                           M3ST0203
  220 CONTINUE                                                          M3ST0204
      WRITE(IO,610)XXMAX,XMMAX,XQMAX,X1,X2,X3                           M3ST0205
  610 FORMAT(//'  MAX VALUES'10X,3E15.5,/'  AT DIST'13X,3E15.5,//)      M3ST0206
      GO TO 401                                                         M3ST0207
  400 WRITE(IO,402)                                                     M3ST0208
  402 FORMAT(//' ','SINGULAR MATRIX ENCOUNTERED'//)                     M3ST0209
  401 RETURN                                                            M3ST0210
      END                                                               M3ST0211
      SUBROUTINE SIMULE(N,A,B,INDEX,MSING)                              M3ST0212
C                                                                       M3ST0213
C     THIS IS AN INVERSION AND SIMULTANEOUS EQUATION SOLVER             M3ST0214
C                                                                       M3ST0215
      IMPLICIT DOUBLE PRECISION(A-H,O-Z)                                M3ST0216
      DIMENSION INDEX(N,2),A(N,N),B(1)                                  M3ST0217
      DO 100 I=1,N                                                      M3ST0218
      INDEX(I,1)=0                                                      M3ST0219
  100 CONTINUE                                                          M3ST0220
      II=0                                                              M3ST0221
  109 AMAX=-1                                                           M3ST0222
      DO 110 I=1,N                                                      M3ST0223
      IF (INDEX(I,1))110,111,110                                        M3ST0224
  111 DO 112 J=1,N                                                      M3ST0225
```

```
      IF (INDEX(J,1))112,113,112                                        M3ST0226
  113 TEMP=DABS(A(I,J))                                                 M3ST0227
      IF (TEMP-AMAX)112,112,114                                         M3ST0228
  114 IROW=I                                                            M3ST0229
      ICOL=J                                                            M3ST0230
      AMAX=TEMP                                                         M3ST0231
  112 CONTINUE                                                          M3ST0232
  110 CONTINUE                                                          M3ST0233
      IF(AMAX)225,115,116                                               M3ST0234
  116 INDEX(ICOL,1)=IROW                                                M3ST0235
      IF (IROW-ICOL)119,118,119                                         M3ST0236
  119 DO 120 J=1,N                                                      M3ST0237
      TEMP=A(IROW,J)                                                    M3ST0238
      A(IROW,J)=A(ICOL,J)                                               M3ST0239
  120 A(ICOL,J)=TEMP                                                    M3ST0240
      II=II+1                                                           M3ST0241
      INDEX(II,2)=ICOL                                                  M3ST0242
  118 PIVOT=A(ICOL,ICOL)                                                M3ST0243
      A(ICOL,ICOL)=1.0                                                  M3ST0244
      PIVOT=1./PIVOT                                                    M3ST0245
      DO 121 J=1,N                                                      M3ST0246
  121 A(ICOL,J)=A(ICOL,J)*PIVOT                                         M3ST0247
      DO 122 I=1,N                                                      M3ST0248
      IF (I-ICOL)123,122,123                                            M3ST0249
  123 TEMP=A(I,ICOL)                                                    M3ST0250
      A(I,ICOL)=0.0                                                     M3ST0251
      DO 124 J=1,N                                                      M3ST0252
  124 A(I,J)=A(I,J)-A(ICOL,J)*TEMP                                      M3ST0253
  122 CONTINUE                                                          M3ST0254
      GO TO 109                                                         M3ST0255
  125 ICOL=INDEX (II,2)                                                 M3ST0256
      IROW= INDEX(ICOL,1)                                               M3ST0257
      DO 126 I=1,N                                                      M3ST0258
      TEMP=A(I,IROW)                                                    M3ST0259
      A(I,IROW)=A(I,ICOL)                                               M3ST0260
  126 A(I,ICOL)=TEMP                                                    M3ST0261
      II=II-1                                                           M3ST0262
  225 IF(II)125,127,125                                                 M3ST0263
  127 GO TO 130                                                         M3ST0264
  115 MSING=0                                                           M3ST0265
  130 RETURN                                                            M3ST0266
      END                                                               M3ST0267
```

```
C SAMIR
C     INPUT SEQUENCE
C
C       NO CARDS      VARIABLES                                 FORMAT
C            1        HEAD                                       20A4
C            1        NSPAN,NTERM,NOWS,NINT,IPLOT                5I5
C            1        TL,SM,E,XI,XINT,WF1,WF2,WFINT,WSINT        9G10.0
C            1        (DEL(I),I=1,NSPAN-1)                      10G10.0
C            1        (XL(I),I=1,NSPAN-1)                       10G10.0
C          IF(NOWS.EQ.0)SKIP THE FOLLOWING CARD
C            1        (WS(I),I=1,NWS)                           10G10.0
C            1        STDEF,STMOM,STSHR                          3G10.0
C            1        TOPDEF,TOPMOM,TOPSHR                       3G10.0
C
      IMPLICIT DOUBLE PRECISION(A-H,O-Z)
      REAL HEAD(20),AA(10000)
      DIMENSION A(5000),LKI(10000)
      LIMSIZ=10000
      COMMON AA
      EQUIVALENCE (AA(1),A(1)),(AA(1),LKI(1))
      COMMON /SETUP/TL,SM,E,XI,EX,CX,PAI,WF1,WF2,WFINT,XINT,WSINT,
     1 NSPAN,NTERM,NS1,NOWF,NOWFT,IN,IO,IO2,NX,IPLOT,
     2 NOWS,NINT
      IN=5
      IO=6
      IO2=3
      IDS=2
  998 READ(IN,500,END=999) HEAD
  500 FORMAT(20A4)
      WRITE(IO,600) HEAD
  600 FORMAT(1H1,20A4)
      READ(IN,501)NSPAN,NTERM,NOWS,NINT,IPLOT
  501 FORMAT(5I5)
      READ(IN,502)TL,SM,E,XI,XINT,WF1,WF2,WFINT,WSINT
  502 FORMAT(9G10.0)
      NS1=NSPAN-1
      NS2=NS1-1
      NX=TL/XINT+1
      NOWF=(WF2-WF1)/WFINT+1
      NOWFT=NOWF+2*NINT*NOWS
      IF(NS1.EQ.0) GO TO 996
      N2=1+NS1
      N3=N2+NS1
      N4=N3+NX
      N5=N4+NX
      N6=N5+NX
      N7=N6+NX
      N8=N7+NTERM
      N9=N8+NTERM
      N10=N9+(NS1*NTERM)
      N11=N10+NS1
      N12=N11+(NS1*NS1)
      N13=N12+NOWFT
      N14=N13+NOWFT
      N15=N14+NOWFT
      N16=N15+NOWFT
      N17=(N16+NOWS)*IDS
      N18=N17+NOWFT
      N19=N18+NOWFT
      NSIZE=N19+2*NS1
      IF(NSIZE.GT.LIMSIZ) GO TO 997
      WRITE(IO,601) NSIZE
  601 FORMAT(//' ','BLANK COMMON ARRAY',I7)
      CALL MAIN(A(1),A(N2),A(N3),A(N4),A(N5),A(N6),A(N7),
     1 A(N8),A(N9),A(N10),A(N11),A(N12),A(N13),A(N14),A(N15),
     2 A(N16),AA(N17),AA(N18),LKI(N19))
      GO TO 998
  997 WRITE(IO,602) NSIZE
  602 FORMAT(//' ','YOUR BLANK COMMON ARRAY MUST BE',I7)
      GO TO 998
  996 WRITE(IO,603) NSPAN
  603 FORMAT(//' ','THIS IS NOT A MULTISPAN GIRDER',I5)
      GO TO 998
  999 STOP
      END
```

```
      SUBROUTINE MAIN(DEL,XL,X,PY,PM,PQ,DN,P,XN,RP,RCOEF,               SAMI0075
     1                 WF,DAFPY,DAFFM,DAFPQ,WS,RX,RY,INDEX)             SAMI0076
      IMPLICIT DOUBLE PRECISION(A-H,O-Z)                                SAMI0077
      REAL RX(NOWFT),RY(NOWFT)                                          SAMI0078
      DIMENSION DEL(NS1),XL(NS1),X(NX),PY(NX),PM(NX),PQ(NX),            SAMI0079
     1 DN(NTERM),P(NTERM),XN(NS1,NTERM),RP(NS1),                        SAMI0080
     2 RCOEF(NS1,NS1),WF(NOWFT),DAFPY(NOWFT),                           SAMI0081
     3 DAFPM(NOWFT),DAFPQ(NOWFT),WS(NOWS),INDEX(2*NS1)                  SAMI0082
      COMMON /SETUP/TL,SM,E,XI,EX,CX,PAI,WF1,WF2,WFINT,XINT,WSINT,      SAMI0083
     1 NSPAN,NTERM,NS1,NOWF,NOWFT,IN,IO,IO2,NX,IPLOT,                   SAMI0084
     2 NOWS,NINT                                                        SAMI0085
C                                                                       SAMI0086
C     READ WRITE BLOCK                                                  SAMI0087
C                                                                       SAMI0088
      READ(IN,500) (DEL(I),I=1,NS1)                                     SAMI0089
  500 FORMAT(10G10.0)                                                   SAMI0090
      READ(IN,500) (XL(I),I=1,NS1)                                      SAMI0091
      IF(NOWS.EQ.0)GO TO 5                                              SAMI0092
      READ(IN,500) (WS(I),I=1,NOWS)                                     SAMI0093
    5 READ(IN,500)STDEF,STMOM,STSHR                                     SAMI0094
      READ(IN,500)TOPDEF,TOPMOM,TOPSHR                                  SAMI0095
      WRITE(IO,699) NSPAN,TL,SM,E,XI,NTERM                              SAMI0096
  699 FORMAT(//'0','NUMBER OF SPANS                        =',I10/      SAMI0097
     8           ' ','TOTAL SPAN LENGTH                    =',D10.4/    SAMI0098
     1           ' ','MASS DENSITY PER UNIT LENGTH         =',D10.4/    SAMI0099
     2           ' ','YOUNG''S MODULUS                      =',D10.4/   SAMI0100
     3           ' ','MOMENT OF INERTIA                    =',D10.4/    SAMI0101
     9           ' ','NUMBER OF TERMS TO BE SUMMED         =',I10/      SAMI0102
     C          /' ','SUPPORT DISTANCES FROM LEFT ABUTEMENT'/)          SAMI0103
      DO 30 I=1,NS1                                                     SAMI0104
   30 WRITE(IO,698)I,XL(I)                                              SAMI0105
  698 FORMAT(' ','SUPPORT NO.'I3,'                     ='D10.4)         SAMI0106
      WRITE(IO,697)                                                     SAMI0107
  697 FORMAT(/,' ','SUPPORT SETTLEMENTS'/)                              SAMI0108
      DO 35 I=1,NS1                                                     SAMI0109
   35 WRITE(IO,698)I,DEL(I)                                             SAMI0110
      MSING=1                                                           SAMI0111
C                                                                       SAMI0112
C     COMMON FACTORS                                                    SAMI0113
C                                                                       SAMI0114
      EX=E*XI/(SM*TL**4)                                                SAMI0115
      PAI=DATAN(1.D0)*4.                                                SAMI0116
      CX=DSQRT(2./(SM*TL))                                              SAMI0117
      DO 215 N=1,NTERM                                                  SAMI0118
      PAIN=N*PAI                                                        SAMI0119
      PAINTL=PAIN/TL                                                    SAMI0120
      P(N)=DSQRT(PAIN**4*EX)                                            SAMI0121
      DO 215 I=1,NS1                                                    SAMI0122
  215 XN(I,N)=CX*DSIN(PAINTL*XL(I))                                     SAMI0123
C                                                                       SAMI0124
C     CALCULATION OF THE EXTRA FINE WF LOCATIONS NEAR THE SYSTEM        SAMI0125
C     FREQUENCIES                                                       SAMI0126
C                                                                       SAMI0127
      DO 50 NWF=1,NOWF                                                  SAMI0128
   50 WF(NWF)=WF1+(NWF-1)*WFINT                                         SAMI0129
      IF(NOWS.EQ.0)GO TO 65                                             SAMI0130
      DO 55 NWS=1,NOWS                                                  SAMI0131
      DO 55 I=1,NINT                                                    SAMI0132
      INDX1=NOWF+(NWS-1)*NINT+I                                         SAMI0133
      WF(INDX1)=WS(NWS)+DFLOAT(I)*WSINT                                 SAMI0134
   55 CONTINUE                                                          SAMI0135
      DO 60 NWS=1,NOWS                                                  SAMI0136
      DO 60 I=1,NINT                                                    SAMI0137
      INDX2=NOWF+NINT*NOWS+(NWS-1)*NINT+I                               SAMI0138
      WF(INDX2)=WS(NWS)-DFLOAT(I)*WSINT                                 SAMI0139
   60 CONTINUE                                                          SAMI0140
C                                                                       SAMI0141
C     REARRANGING THE WF ARRAY IN INCREASING ORDER                      SAMI0142
C                                                                       SAMI0143
   65 DO 70 II=1,NOWFT-1                                                SAMI0144
      DO 70 I=II+1,NOWFT                                                SAMI0145
      IF(WF(II).LE.WF(I)) GO TO 70                                      SAMI0146
      DUMMY=WF(II)                                                      SAMI0147
      WF(II)=WF(I)                                                      SAMI0148
      WF(I)=DUMMY                                                       SAMI0149
   70 CONTINUE                                                          SAMI0150
```

```
      WRITE(IO,602)
  602 FORMAT('1'//20X'MAXIMUM DYNAMIC DEFLECTIONS'//)
      WRITE(IO,605)
  605 FORMAT(/,5X'FREQUENCY'/)
      DO 410 NWF=1,NOWFT
      WRITE(IO,604)WF(NWF),DAFPY(NWF)
  410 CONTINUE
  604 FORMAT(5D15.5)
      WRITE(IO,606)
  606 FORMAT('1'//20X'MAXIMUM DYNAMIC MOMENT VALUES'//)
      WRITE(IO,605)
      DO 420 NWF=1,NOWFT
      WRITE(IO,604)WF(NWF),DAFPM(NWF)
  420 CONTINUE
      WRITE(IO,608)
  608 FORMAT('1'//20X'MAXIMIUM DYNAMIC SHEAR VALUES'//)
      WRITE(IO,605)
      DO 430 NWF=1,NOWFT
      WRITE(IO,604)WF(NWF),DAFPQ(NWF)
  430 CONTINUE
      WRITE(IO,610)
  610 FORMAT('1'//10X'MAXIMUM DYNAMIC AMPLIFICATION FACTORS FOR',
     1       ' DEFLECTION FUNCTIONS'//)
      WRITE(IO,605)
      DO 440 NWF=1,NOWFT
  440 DAFPY(NWF)=DABS(DAFPY(NWF)/STDEF)
      DO 450 NWF=1,NOWFT
      WRITE(IO,604)WF(NWF),DAFPY(NWF)
  450 CONTINUE
      WRITE(IO,612)
  612 FORMAT('1'//10X'MAXIMUM DYNAMIC AMPLIFICATION FACTORS FOR'
     1       ' MOMENT FUNCTIONS'//)
      WRITE(IO,605)
      DO 460 NWF=1,NOWFT
  460 DAFPM(NWF)=DABS(DAFPM(NWF)/STMOM)
      DO 470 NWF=1,NOWFT
      WRITE(IO,604)WF(NWF),DAFPM(NWF)
  470 CONTINUE
      WRITE(IO,614)
  614 FORMAT('1'//10X'MAXIMUM DYNAMIC AMPLIFICATION FACTORS FOR'
     1           ' SHEAR FUNCTIONS'//)
      WRITE(IO,605)
      DO 480 NWF=1,NOWFT
  480 DAFPQ(NWF)=DABS(DAFPQ(NWF)/STSHR)
      DO 490 NWF=1,NOWFT
      WRITE(IO,604)WF(NWF),DAFPQ(NWF)
  490 CONTINUE
      IF(IPLOT.NE.1)GO TO 1000
C
C     PLOTTING BLOCK
C
      CALL LIMITS(0.,11.,50.)
      DO 525 NWF=1,NOWFT
      RX(NWF)=WF(NWF)
  525 CONTINUE
      DO 540 NWF=1,NOWFT
      IF(DAFPY(NWF).GT.TOPDEF)DAFPY(NWF)=TOPDEF
      RY(NWF)=DAFPY(NWF)
  540 CONTINUE
      CALL EPLOT(RX,RY,NOWFT,0,1,5)
      DO 550 NWF=1,NOWFT
      IF(DAFPM(NWF).GT.TOPMOM)DAFPM(NWF)=TOPMOM
      RY(NWF)=DAFPM(NWF)
  550 CONTINUE
      CALL EPLOT(RX,RY,NOWFT,0,1,5)
      DO 560 NWF=1,NOWFT
      IF(DAFPQ(NWF).GT.TOPSHR)DAFPQ(NWF)=TOPSHR
      RY(NWF)=DAFPQ(NWF)
  560 CONTINUE
      CALL EPLOT(RX,RY,NOWFT,0,1,5)
      GO TO 1000
  998 WRITE(IO,620)
  620 FORMAT(///'  A SINGULAR MATRIX WAS ENCOUNTERED')
 1000 RETURN
      END
```

```
C
C     CALCULATION OF THE DEFLECTION,MOMENT,SHEAR ALONG THE SPAN
C
      DO 999 NWF=1,NOWFT
      WF2=WF(NWF)**2
      PYMAX=0.
      PMMAX=0.
      PQMAX=0.
      DO 105 I1=1,NS1
      DO 105 I2=1,NS1
  105 RCOEF(I1,I2)=0.
      DO 150 N=1,NTERM
      PAIN=PAI*N
      PAINTL=PAIN/TL
      DEN=P(N)**2-WF2
      ADEN=DABS(DEN)
      IF(ADEN.LT..1D-50) GO TO 150
      DO 145 I1=1,NS1
      DO 145 I2=1,NS1
      RCOEF(I1,I2)=RCOEF(I1,I2)+XN(I1,N)*XN(I2,N)/DEN
  145 CONTINUE
  150 CONTINUE
      IF(NS1.GT.1)GO TO 170
      RP(1)=DEL(1)/RCOEF(1,1)
      GO TO 185
  170 CALL SIMULE(NS1,RCOEF,DEL,INDEX,MSING)
      IF(MSING.EQ.0)GO TO 998
      DO 175 I=1,NS1
  175 RP(I)=0.
      DO 180 I=1,NS1
      DO 180 J=1,NS1
  180 RP(I)=RP(I)+RCOEF(I,J)*DEL(J)
  185 DO 777 K=1,NX
      X(K)=(K-1)*XINT
      PY(K)=0.
      PM(K)=0.
      PQ(K)=0.
      DO 45 N=1,NTERM
      PAIN=N*PAI
      PAINTL=PAIN/TL
      DEN=P(N)**2-WF2
      ADEN=DABS(DEN)
      IF(ADEN.LT..1D-50) GO TO 45
      DN(N)=0.
      DO 44 I=1,NS1
   44 DN(N)=DN(N)+RP(I)*XN(I,N)/DEN
      XT=CX*DSIN(PAINTL*X(K))
      XTC=CX*DCOS(PAINTL*X(K))
      PY(K)=PY(K)+XT*DN(N)
      PM(K)=PM(K)+(PAINTL**2*XT*DN(N))*E*XI
      PQ(K)=PQ(K)+(PAINTL**3*XTC*DN(N))*E*XI
   45 CONTINUE
      DO 190 I=1,NS1
      IF(X(K).NE.XL(I))GO TO 190
      PQ(K)=0.
  190 CONTINUE
C
C     STORAGE OF MAXIMUM VALUES ALONG THE SPAN FOR EACH FORCING
C     FREQUENCY
C
      IF(DABS(PY(K)).LE.DABS(PYMAX))GO TO 305
      PYMAX=PY(K)
  305 IF(DABS(PM(K)).LE.DABS(PMMAX))GO TO 310
      PMMAX=PM(K)
  310 IF(DABS(PQ(K)).LE.DABS(PQMAX))GO TO 777
      PQMAX=PQ(K)
  777 CONTINUE
      DAFPY(NWF)=PYMAX
      DAFPM(NWF)=PMMAX
      DAFPQ(NWF)=PQMAX
  999 CONTINUE
C
C     OUTPUT OF RESULTS
C
```

```
      SUBROUTINE SIMULE(N,A,B,INDEX,MSING)                              SAMI0300
C                                                                       SAMI0301
C     THIS IS AN INVERSION AND SIMULTANEOUS EQUATION SOLVER             SAMI0302
C                                                                       SAMI0303
      IMPLICIT DOUBLE PRECISION(A-H,O-Z)                                SAMI0304
      DIMENSION INDEX(N,2),A(N,N),B(1)                                  SAMI0305
      DO 100 I=1,N                                                      SAMI0306
      INDEX(I,1)=0                                                      SAMI0307
  100 CONTINUE                                                          SAMI0308
      II=0                                                              SAMI0309
  109 AMAX=-1                                                           SAMI0310
      DO 110 I=1,N                                                      SAMI0311
      IF (INDEX(I,1))110,111,110                                        SAMI0312
  111 DO 112 J=1,N                                                      SAMI0313
      IF (INDEX(J,1))112,113,112                                        SAMI0314
  113 TEMP=DABS(A(I,J))                                                 SAMI0315
      IF (TEMP-AMAX)112,112,114                                         SAMI0316
  114 IROW=I                                                            SAMI0317
      ICOL=J                                                            SAMI0318
      AMAX=TEMP                                                         SAMI0319
  112 CONTINUE                                                          SAMI0320
  110 CONTINUE                                                          SAMI0321
      IF(AMAX)225,115,116                                               SAMI0322
  116 INDEX(ICOL,1)=IROW                                                SAMI0323
      IF (IROW-ICOL)119,118,119                                         SAMI0324
  119 DO 120 J=1,N                                                      SAMI0325
      TEMP=A(IROW,J)                                                    SAMI0326
      A(IROW,J)=A(ICOL,J)                                               SAMI0327
  120 A(ICOL,J)=TEMP                                                    SAMI0328
      II=II+1                                                           SAMI0329
      INDEX(II,2)=ICOL                                                  SAMI0330
  118 PIVOT=A(ICOL,ICOL)                                                SAMI0331
      A(ICOL,ICOL)=1.0                                                  SAMI0332
      PIVOT=1./PIVOT                                                    SAMI0333
      DO 121 J=1,N                                                      SAMI0334
  121 A(ICOL,J)=A(ICOL,J)*PIVOT                                         SAMI0335
      DO 122 I=1,N                                                      SAMI0336
      IF (I-ICOL)123,122,123                                            SAMI0337
  123 TEMP=A(I,ICOL)                                                    SAMI0338
      A(I,ICOL)=0.0                                                     SAMI0339
      DO 124 J=1,N                                                      SAMI0340
  124 A(I,J)=A(I,J)-A(ICOL,J)*TEMP                                      SAMI0341
  122 CONTINUE                                                          SAMI0342
      GO TO 109                                                         SAMI0343
  125 ICOL=INDEX (II,2)                                                 SAMI0344
      IROW= INDEX(ICOL,1)                                               SAMI0345
      DO 126 I=1,N                                                      SAMI0346
      TEMP=A(I,IROW)                                                    SAMI0347
      A(I,IROW)=A(I,ICOL)                                               SAMI0348
  126 A(I,ICOL)=TEMP                                                    SAMI0349
      II=II-1                                                           SAMI0350
  225 IF(II)125,127,125                                                 SAMI0351
  127 GO TO 130                                                         SAMI0352
  115 MSING=0                                                           SAMI0353
  130 RETURN                                                            SAMI0354
      END                                                               SAMI0355
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