VOLUME TWO

USERS MANUAL FOR PROGRAM RANDOM

Contract No. NAS8-21403

FINAL REPORT

COMPUTER PROGRAMS FOR
PREDICTION OF STRUCTURAL
VIBRATIONS DUE TO FLUCTUATING
PRESSURE ENVIRONMENTS

SPACE DIVISION

CHRYSLER CORPORATION

HUNTSVILLE OPERATIONS

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COMPUTER-PROGRAMS FOR PREDICTION OF STRUCTURAL VIBRATIONS
DUE TO FLUCTUATING PRESSURE ENVIRONMENTS

VOLUME TWO

USERS' MANUAL
FOR
PROGRAM RANDOM

Contract No. NAS8-21403

Prepared for

GEORGE C. MARSHALL SPACE FLIGHT CENTER
MARSHALL SPACE FLIGHT CENTER, ALABAMA 35812

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FOREWORD

The computer program presented in this report was developed for the Vibration and Acoustics Branch of the George C. Marshall Space Flight Center, National Aeronautics and Space Administration. This work has been accomplished by the Vibration and Acoustics Group, Structural Engineering Branch, Chrysler Corporation Space Division, Huntsville Operations.
SUMMARY

This computer program is to calculate the random vibrational response of a rectangular cylindrical shell panel cross-reinforced with ribs and stringers subjected to the excitation of fluctuating pressure environments. Three boundary conditions are considered: four edges simply supported; four edges clamped; and two opposite edges simply supported while the other two clamped. The special cases of a complete cylinder and a flat panel are included. This program is written so that either all three boundary conditions or any one boundary condition can be selected in any run. The normal mode approach is used in the formulations. Responses calculated are the acceleration, displacement, and stress spectral densities. Mean-square and root-mean-square values are also calculated. Output data are tabulated and plotted. This Manual is written according to the documentation requirements specified by the Computation Laboratory of MSFC. It contains three sections describing the problem, the programming, and the deck setup in detail.
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INTRODUCTION

Recent advancements in the mathematical formulations of solutions for structural responses due to random loading has made it feasible to develop computer programs for use by the structural engineer. The computer program reported in this manual calculates the random vibrational responses of rectangular cylindrical shell panels cross-reinforced with ribs and stringers. It is the result of a research project.

The program is written in FORTRAN IV language for the IBM 7094 computer. The results of this project are reported in two volumes.

1. Volume I - Theoretical Analyses

The first volume contains the equations, technical discussion of the program, and analyses of the results. The second volume is oriented to utilization of the programs.
SECTION I. PROBLEM

A. Abstract

This is a program to compute the vibrational responses of a rectangular cylindrical shell panel cross-reinforced with stiffeners, subjected to the excitation of fluctuating pressure environments. The boundary conditions considered are: four edges simply supported; four edges clamped, and two opposite edges simply supported while the other two clamped. The special cases of a complete cylinder and a flat panel are included. The normal mode is used in the formulations. The responses are calculated as acceleration, displacement, and stress spectral densities, and the overall mean-square and root-mean-square values. The output data are tabulated and plotted. The program is written so that either all three boundary conditions or any one boundary condition can be selected in any run.
B. TECHNICAL DESCRIPTION

This is a program written to calculate the random vibrational responses of rectangular cylindrical shell panels cross-reinforced with stiffeners. Three boundary conditions are considered: four edges simply supported; four edges clamped; and two edges simply supported while the other two edges clamped. Special cases of flat panel and complete cylinder are included. The one-third-octave spectrum of the excitation pressure is read in as input in any discrete frequency. The program will apply when either the whole panel or a portion of the panel is exposed to the excitation. The normal mode approach is used in the formulation. Analytical expressions for the joint acceptance are derived for all mode combinations. Contributions of the main terms as well as the cross terms are accounted for to obtain the responses. The responses at any point are calculated as displacement, acceleration and stress spectral densities. Mean-square and root-mean-square values of the responses are calculated by numerical integration. The response spectral densities are tabulated and plotted. The frequency range is from 5 (or lower) up to 5000 Hertz. One-nth-octave band is used for the frequency increment. The number of data points can be increased up to 500 for each spectral density plot. For each data point, 625 terms are summed to give the spectral density.

In addition to the excitation spectrum, the input data includes the geometric dimensions, material properties of the panel, and some control constants.

The program is written so that either all three boundary conditions or any one boundary condition can be calculated in any run.

Computed responses have been compared with experimental results, and the agreement is very good.
C. EQUATIONS

a. Subroutine RSR - Calculation of Response of Simply-Supported Rectangular Shell Panels Cross-Reinforced With Stiffeners

1. Natural Frequency

The undamped natural frequencies are given by

\[
\omega_{mn} = \pi^2 \left( \frac{M}{2} \right)^{1/2} \left[ D_x \left( \frac{m}{a} \right)^4 + 2H \left( \frac{mn}{a^2 b'} \right)^2 + D_y \left( \frac{n}{b} \right)^4 + \frac{Eh}{a^2 \pi} \left[ 1 + \left( \frac{2n}{bm} \right)^2 \right]^2 \right]^{1/2}
\]

\[M = \rho h + \rho'h'\]

\[\omega_{mn} = \text{frequency in rad./sec}\]

\[D_x = \frac{Eh^3}{12(1-\nu^2)} + \frac{E'I_1}{b_1}\]

\[D_y = \frac{Eh^3}{12(1-\nu^2)} + \frac{E'I_2}{a_1}\]

\[H = \frac{Eh^3}{12(1-\nu^2)}\]

Refer to Figure 1 for geometric dimensions.

\[a = \text{radius of shell panel (input)}\]

\[E = \text{Young's modulus of panel (input)}\]

\[E' = \text{Young's modulus of stiffeners (input)}\]

\[h = \text{Thickness of panel skin (input)}\]

\[h' = \text{Smeared-out thickness of stiffeners (input)}\]

\[\nu = \text{Poisson's ratio of panel (input)}\]

\[a_1 = \text{Spacing of y-direction stiffeners (input)}\]

\[b_1 = \text{Spacing of x-direction stiffeners (input)}\]

\[I_1 = \text{Moment of inertia of one x-direction stiffener with respect to neutral axis of cross-section of panel (input)}\]
2. Responses

The displacement response spectral density at point \( \mathbf{r}(x,y) \) is given by

\[
\Phi_{ww}(\mathbf{r},\omega) = S' \Phi_{pp}(\omega) \sum_{j,k,m,n} F_{jk}(\mathbf{r}) F_{mn}(\mathbf{r}) |H_{jk}| |H_{mn}| J_{jkmn}^2
\]

(2)

where

\[
\Phi_{ww}(\mathbf{r},\omega) = \text{Displacement spectral density in \( \text{in}^2/\text{rad/sec} \)}
\]

\[
S' = \text{Area of panel subjected to excitation (in}^2\text{)}
\]

\[
b' = \text{Circumferential width of panel subjected to excitation (input)}
\]

\[
\lambda' = \text{Longitudinal length of panel subjected to excitation (input)}
\]

\[
F_{jk}(\mathbf{r}) = \sin \frac{jk \pi x}{\lambda} \sin \frac{jm \pi y}{b} = \text{normal mode}
\]

(2B)

\[
F_{mn}(\mathbf{r}) = \sin \frac{nk \pi x}{\lambda} \sin \frac{nm \pi y}{b} = \text{normal mode}
\]

(2C)

\[
b = \text{Width of panel (along y-axis) (input)}
\]

\[
\lambda = \text{Length of panel (along x-axis) (input)}
\]

\[
M_{jk} = \frac{M_{mn}}{4} = \frac{Mb^2}{4}
\]

(2D)

\[
M = \rho h + \rho'h'
\]

(2E)

\[
\mathbf{r} = \text{Position vector of point concerned}
\]

\[
x,y = \text{Coordinates of } \mathbf{r} \text{ (input)}
\]
\[\omega = \text{Frequency in rad/sec.} = 2\pi f\]

\[f = \text{Frequency in Hertz (independent variable)}\]

\[j, k, m, n = \text{Mode indices}\]

\[\omega_{jk} = \text{Undamped natural frequencies given by Equation (1)}\]

The magnitudes of the frequency response functions are:

\[|H_{jk}| = \frac{1}{M_{jk} \left[ \left( \omega_{jk}^2 - \omega^2 \right)^2 + (2\epsilon_{jk}\omega_{jk})^2 \right]^{1/2}} \quad (2F)\]

\[|H_{mn}| = \frac{1}{M_{mn} \left[ \left( \omega_{mn}^2 - \omega^2 \right)^2 + (2\epsilon_{mn}\omega_{mn})^2 \right]^{1/2}} \quad (2G)\]

The joint acceptances squared for different mode combinations are given by

\[J_{jkmn}^2 = J_{jm}J_{kn} \frac{A_{jkmn}}{C_{jkmn}} \text{ for } j=m, k=n\]

\[J_{jkmn}^2 = J_{jm}J_{kn} \frac{A_{jkmn}}{C_{jkmn}} \text{ for } j=m, k\neq n\]

\[J_{jkmn}^2 = J_{jm}J_{kn} \frac{A_{jkmn}}{C_{jkmn}} \text{ for } j\neq m, k=n\]

\[J_{jkmn}^2 = J_{jm}J_{kn} \frac{A_{jkmn}}{C_{jkmn}} \text{ for } j\neq m, k\neq n \quad (2H)\]

where

\[J_{jm} = \frac{A_{j} \omega}{c} \left[ \frac{1}{\left( \frac{A_{j} \omega}{c} \right)^2 + (j\pi)^2} + \frac{1}{\left( \frac{A_{j} \omega}{c} \right)^2 + (m\pi)^2} \right] \]

\[+ \frac{A_{j} \omega}{c} \left[ \frac{1 - A_{j} \omega}{c} \left[ (-1)^j + i(-1)^m \right] \right] \]

\[\quad \times \left[ \frac{1}{\left( \frac{A_{j} \omega}{c} \right)^2 + (j\pi)^2} \right] \left[ \frac{1}{\left( \frac{A_{j} \omega}{c} \right)^2 + (m\pi)^2} \right] \quad (2I)\]
\[ J_{kn} = \frac{A_2 b \omega}{c} \left[ \frac{1}{\left( \frac{A_2 b \omega}{c} \right)^2 + (k \pi)^2} + \frac{1}{\left( \frac{A_2 b \omega}{c} \right)^2 + (n \pi)^2} \right] \]

\[ + (k \pi)(n \pi) \frac{2 + e}{c} \left[ \frac{(-1)^{k+1} + (-1)^{n+1}}{\left( \frac{A_2 b \omega}{c} \right)^2 + (k \pi)^2} \right] \left( \frac{A_2 b \omega}{c} \right)^2 + (n \pi)^2 \]

\[ J'_{jm} = (j \pi)(m \pi) \frac{2 + e}{c} \left[ \frac{(-1)^{j+1} + (-1)^{m+1}}{\left( \frac{A_1 \ell \omega}{c} \right)^2 + (j \pi)^2} \right] \left( \frac{A_1 \ell \omega}{c} \right)^2 + (m \pi)^2 \]

\[ + \left[ \frac{(-1)^{j-1} + (-1)^{j+1}}{2(j-m)} + \frac{(-1)^{j+1} - 1}{2(j+m)} \right] \left( \frac{A_1 \ell \omega}{c} \right)^2 + (j \pi)^2 \]

\[ + \left[ \frac{(-1)^{m-1} + (-1)^{m+1}}{2(m-j)} + \frac{(-1)^{m+1} - 1}{2(m+j)} \right] \left( \frac{A_1 \ell \omega}{c} \right)^2 + (j \pi)^2 \]

\[ J''_{kn} = (k \pi)(n \pi) \frac{2 + e}{c} \left[ \frac{(-1)^{k+1} + (-1)^{n+1}}{\left( \frac{A_2 b \omega}{c} \right)^2 + (k \pi)^2} \right] \left( \frac{A_2 b \omega}{c} \right)^2 + (n \pi)^2 \]

\[ + \left[ \frac{k-n}{2(k-n)} + \frac{k+1}{2(k+n)} \right] \left( \frac{A_2 b \omega}{c} \right)^2 + (n \pi)^2 \]

\[ + \left[ \frac{n-k}{2(n-k)} + \frac{n+k}{2(n+k)} \right] \left( \frac{A_2 b \omega}{c} \right)^2 + (k \pi)^2 \]

(2J, 2K, 2L)
where

\[ A_1 = \text{Decay constant in } x\text{-direction (input)} \]

\[ A_2 = \text{Decay constant in } y\text{-direction (input)} \]

\[ c = \text{Speed of sound (input)} \]

\[ A_{jkmn} = \left[ 1 - \left( \frac{\omega}{\omega_{jk}} \right)^2 \left[ 1 - \left( \frac{\omega}{\omega_{mn}} \right)^2 \right] + 4 \zeta_{jk} \zeta_{mn} \frac{\omega}{\omega_{jk} \omega_{mn}} \right] \]

\[ c_{jkmn}^2 = A_{jkmn}^2 + b_{jkmn}^2 \]

\[ B_{jkmn} = -2 \left\{ \frac{\zeta_{jk} \omega}{\omega_{jk}} \left[ 1 - \left( \frac{\omega}{\omega_{jk}} \right)^2 \right] - \frac{\omega_{mn} \omega}{\omega_{mn}} \left[ 1 - \left( \frac{\omega}{\omega_{jk}} \right)^2 \right] \right\} \]  (2L)

The excitation spectral density in \( (\text{ps}i)^2 \frac{\text{rad/sec}}{\text{rad/sec}} \),

\[ \phi_{pp}(\omega), \text{ is given by} \]

\[ \phi_{pp}(\omega) = \frac{1}{2\pi} \frac{S_{pp}(f) - 170.576}{10} \]  (10)

The excitation spectral density in decibels per Hertz, \( S_{pp}(f) \), is given by

\[ S_{pp}(f) = S_{3rd}(f) - 10 \log_{10} (0.23157f) \]  (2N)

where

\[ S_{3rd}(f) = \text{One-third octave excitation pressure level in decibels (input)} \]

The acceleration response spectral density at \( \hat{r}(x,y) \) in

\( \left( \frac{\text{inch}}{\text{sec}^2} \right)^2 \frac{1}{\text{rad/sec}} \) is given by
\[
\phi_{ww}(r, \omega) = \omega^4 \phi_{ww}(r, \omega)
\]  

The acceleration response spectral density in \(\frac{g^2}{\text{Hertz}}\) is given by

\[
S_{ww}(r, f) = 4.215093 \times 10^{-5} \phi_{ww}(r, \omega)
\]  

The mean-square acceleration in "g^2" is given by

\[
G^2(r) = \int S_{ww}(r, f) df
\]  

The root-mean-square acceleration in "g" is given by

\[
G(r) = \sqrt{G^2(r)}
\]  

The stress spectral density in \((\text{psi})^2\) rad per sec \( \times \) is given by

\[
\phi_{\sigma\sigma}(r, \omega) = \gamma^2 \phi_{ww}(r, \omega)
\]  

where

\[
\phi_{ww}(r, \omega) \text{ is given by Equation (2)}
\]

\[
\gamma^2 = \gamma^2(r) = \frac{(E h_1)^2}{4(1-\nu^2)^2} \cdot \frac{Q_x^2 + Q_y^2}{Q_w^2}
\]

\[
h_1 = h + h_2
\]

\[
h_2 = \text{largest height of stiffeners at } r, \text{ see Figure 1 (input)}
\]
\[ Q_x = \sum_{m,n=1,3...} \left[ \left( \frac{m\pi}{\ell} \right)^2 + \nu \left( \frac{n\pi}{b} \right)^2 \right] \frac{\sin \frac{m\pi}{\ell} \sin \frac{n\pi}{b}}{\sin \left[ \frac{m\pi}{\ell} \right]^4 + 2\nu \left[ \frac{m\pi}{\ell} \right]^2 + D_y \left( \frac{n}{b} \right)^4} \]

\[ Q_y = \sum_{m,n=1,3...} \left[ \left( \frac{m\pi}{\ell} \right)^2 + \nu \left( \frac{n\pi}{b} \right)^2 \right] \frac{\sin \frac{m\pi}{\ell} \sin \frac{n\pi}{b}}{\sin \left[ \frac{m\pi}{\ell} \right]^4 + 2\nu \left[ \frac{m\pi}{\ell} \right]^2 + D_y \left( \frac{n}{b} \right)^4} \]

\[ Q_w = \sum_{m,n=1,3...} \frac{\sin \frac{m\pi}{\ell} \sin \frac{n\pi}{b}}{\sin \left[ \frac{m\pi}{\ell} \right]^4 + 2\nu \left[ \frac{m\pi}{\ell} \right]^2 + D_y \left( \frac{n}{b} \right)^4} \]

(7A)

The stress spectral density in \((\text{psi})^2/\text{Hertz}\) is given by

\[ S_{\sigma\sigma}(r,f) = 2\pi \Phi_{\sigma\sigma}(r,\omega) \] (8)

The mean-square stress is given by

\[ \sigma^2(r) = \int S_{\sigma\sigma}(r,f)df \] (9)

The root-mean-square stress is given by

\[ \sigma(r) = \left[ \sigma^2(r) \right]^{1/2} \] (10)

The displacement spectral density in \((\text{inch})^2/\text{Hertz}\) is

\[ S_{ww}(r,f) = 2\pi \Phi_{ww}(r,\omega) \] (11)

The mean-square displacement is

\[ w^2(r) = \int S_{ww}(r,f)df \] (12)

The root-mean-square displacement is

\[ w(r) = \sqrt{w^2(r)} \] (13)
b. SUBROUTINE RFR

DYNAMIC RESPONSE OF FOUR SIDES CLAMPED RECTANGULAR SHELL PANELS CROSS-REINFORCED WITH STIFFENERS

1. Natural Frequencies

The natural frequencies in radians per second are given by

\[ \omega_{11} = \pi^2 M^{-1/2} \left\{ D_x \left( \frac{1.5056}{b} \right)^4 + D_y \left( \frac{1.5056}{a} \right)^4 + 2H \left( \frac{1.2466}{2b} \right)^2 \right\} \]

\[ + \frac{Eh}{a^2 \pi^4 \left[ 1 + \left( \frac{b}{a} \right)^2 \right]^2} \left\{ \frac{1}{2} \right\}^{1/2} \]

\[ \omega_{1k} = \pi^2 M^{-1/2} \left\{ D_x \left( \frac{1.5056}{a} \right)^4 + D_y \left( \frac{k + \frac{1}{2}}{b} \right)^4 \right\} \]

\[ + 2H \frac{1.2466 (k + \frac{1}{2})[(k + \frac{1}{2}) - 0.6366]}{2 \pi^2 \left( \frac{b}{2} \right)^2} \]

\[ \frac{Eh}{a^2 \pi^4 \left[ 1 + \left( \frac{b}{a} \right)^2 \left( \frac{k}{b} \right)^2 \right]^2} \left\{ \frac{1}{2} \right\} \]

k = 2, 3, ...

\[ \omega_{jl} = \pi^2 M^{-1/2} \left\{ D_x \left( \frac{j + \frac{1}{2}}{a} \right)^4 + D_y \left( \frac{1.5056}{b} \right)^4 \right\} \]

\[ + 2H \frac{1.2466 (j + \frac{1}{2})[(j + \frac{1}{2}) - 0.6366]}{2 \pi^2 \left( \frac{b}{2} \right)^2} \]

\[ \frac{Eh}{a^2 \pi^4 \left[ 1 + \left( \frac{1.5056}{j + \frac{1}{2}} \right)^2 \left( \frac{b}{a} \right)^2 \right]^2} \left\{ \frac{1}{2} \right\} \]

j = 2, 3, ...

11
\[
\omega_{jk} = \pi^2 H^{-1/2} \left\{ D_x \left( \frac{j + \frac{1}{2}}{\xi} \right)^4 + D_y \left( \frac{k + \frac{1}{2}}{b} \right)^4 \right\} + \frac{(j + \frac{1}{2}) (k + \frac{1}{2})[(j + \frac{1}{2}) - 0.6366][(k + \frac{1}{2}) - 0.6366]}{\xi^2 b^2} + \frac{E_h}{a^2 \pi^4} \left[ 1 + \left( \frac{k + \frac{1}{2}}{j + \frac{1}{2}} \right)^2 \left( \frac{\xi}{b} \right)^2 \right]^{2/3} \right\}^{1/2} \]

\(j, k = 2, 3, \ldots\)  

(1D)

\[
D_x = \frac{E_h^3}{12 (1-\nu)^2} + \frac{E'I_1}{b_1}
\]

\[
D_y = \frac{E_h^3}{12 (1-\nu'^2)} + \frac{E'I_2}{a_1}
\]

\[
H = \frac{E_h^3}{12 (1-\nu^2)}
\]

\[
M = \rho h + \rho'h'
\]

(1E)

The natural frequencies in Hertz are given by

\[
f_{jk} = \frac{\omega_{jk}}{2\pi} \]

(2)

\[
E = \text{Young's modulus of panel (input)}
\]

\[
E' = \text{Young's modulus of stiffeners (input)}
\]

\[
h = \text{Thickness of panel skin (input)}
\]

\[
h' = \text{Smeared-out thickness of stiffeners (input)}
\]
\( v \) = Poisson's ratio of panel (input)
\( a \) = Radius of shell (input)
\( a_1 \) = Spacing of y-direction stiffeners (input)
\( b_1 \) = Spacing of x-direction stiffeners (input)
\( I_1 \) = Moment of inertia of one x-direction stiffener with respect to neutral axis of cross-section of panel (input)
\( I_2 \) = Moment of inertia of one y-direction stiffener with respect to neutral axis of cross-section of panel (input)
\( \rho \) = Mass density of panel skin (input)
\( \rho' \) = Mass density of stiffeners (input)

2. Responses

The displacement response spectral density at point \( r(x,y) \) is given by

\[
\phi_{ww}(r,\omega) = S' S_{pp}(\omega) \sum_{j,k,m,n=1,2,3...} F_{jk}(r) F_{mn}(r) |H_{jk}| |H_{mn}| J^2_{jkmn}
\]

where

\( \phi_{ww}(r,\omega) \) = displacement spectral density in \( \text{inch}^2 \text{ rad/sec} \)

\( S' \) = Area of panel subjected to excitation (\( \text{inch}^2 \))
\( b' \) = Width of panel subjected to excitation (input)
\( b' \) = Width of panel subjected to excitation (input)
\( l' \) = Length of panel subjected to excitation (input)

\( F_{jk}(r) = X_j Y_k \) = normal mode
\( F_{mn}(r) = X_m Y_n \) = normal mode

\( X_1 = X_1(x) = \cosh\frac{1.5056\pi x}{\ell} - \cos\frac{1.5056\pi x}{\ell} - 0.9825 \left( \sinh\frac{1.5056\pi x}{\ell} - \sin\frac{1.5056\pi x}{\ell} \right) \)
\[ Y_1 = Y_1(y) = \cosh \frac{1.5056\pi y}{b} - \cos \frac{1.5056\pi y}{b} - 0.9825 \left( \sinh \frac{1.5056\pi y}{b} - \sin \frac{1.5056\pi y}{b} \right) \]  

(4B)

\[ X_J = X_J(x) = \cosh \frac{(j + \frac{1}{2})\pi x}{\ell} - \cos \frac{(j + \frac{1}{2})\pi x}{\ell} - \sinh \frac{(j + \frac{1}{2})\pi x}{\ell} + \sin \frac{(j + \frac{1}{2})\pi x}{\ell} \]  

(4C)

\[ Y_K = Y_K(y) = \cosh \frac{(k + \frac{1}{2})\pi y}{b} - \cos \frac{(k + \frac{1}{2})\pi y}{b} - \sinh \frac{(k + \frac{1}{2})\pi y}{b} + \sin \frac{(k + \frac{1}{2})\pi y}{b} \]  

(4D)

\[ b = \text{Width of panel} \ (y=0 \ \text{to} \ y=b) \ (\text{input}) \]

\[ \ell = \text{Length of panel} \ (x=0 \ \text{to} \ x=\ell) \ (\text{input}) \]

\[ M_{jk} = M_{mn} = \frac{M_{bb}}{4} \]

\[ M = \rho h + \rho \ 'h' \]

\[ \mathbf{r} = \text{Position vector of point concerned} \]

\[ x,y = \text{Coordinates of} \ \mathbf{r} \ (\text{input}) \]

\[ \omega = \text{Frequency in rad/sec} = 2\pi f \]

\[ f = \text{Frequency in Hertz} \ (\text{independent variable}) \]

\[ j,k,m,n = \text{Mode indices} \]

\[ \omega_{jk} = \text{Undamped natural frequencies given by Equation (1)} \]
The magnitudes of the frequency response functions $H_{jk}$ and $H_{mn}$ are given by equations (2F) and (2G) in Section a.

The joint acceptance squared for different mode combinations are given by equations (2H) through (2L) in Section a.

The displacement spectral density in $\frac{\text{inches}^2}{\text{Hertz}}$ is given by

$$S_{\omega \omega}^{\dagger}(r,f) = 2\pi\Phi_{\omega \omega}^{\dagger}(r,\omega)$$  \hspace{1cm} (8)

The mean square displacement in $\text{inches}^2$ is

$$w^2(r) = \int S_{\omega \omega}^{\dagger}(r,f)df$$  \hspace{1cm} (9)

The root-mean square displacement in inches is

$$w(r) = \sqrt{\frac{w^2(r)}{w^2(r)}}$$  \hspace{1cm} (10)

The excitation spectral density in $\frac{\text{psi}^2}{\text{rad/sec}}$ is

$$S_{pp}(f) = \frac{\Phi_{pp}(\omega) - 170.576}{10}$$  \hspace{1cm} (11)

The excitation spectral density in decibels per Hertz, $S_{pp}(f)$, is given by

$$S_{pp}(f) = S_{3rd}(f) - 10 \log_{10}(0.23157f)$$  \hspace{1cm} (12)

where

$$S_{3rd}(f) = \text{One-third octave excitation pressure level in decibels (input)}$$

The excitation spectral density in $\text{psi}^2/\text{Hertz}$ is given by

$$S'_{pp}(f) = 2\pi\Phi_{pp}(\omega)$$  \hspace{1cm} (12A)
The acceleration response spectral density at \( \mathbf{r}(x,y) \) in \( \frac{\text{inch}^2}{\text{sec}^2} \cdot \frac{1}{\text{rad/sec}} \) is given by

\[
\phi_{\mathbf{w}w}(\mathbf{r},\omega) = \omega \phi_{\mathbf{w}w}(\mathbf{r},\omega)
\]

(13)

The acceleration response spectral density in \( \frac{g^2}{\text{Hertz}} \) is given by

\[
S_{\mathbf{w}w}(\mathbf{r},f) = 4.215093 \times 10^{-5} \phi_{\mathbf{w}w}(\mathbf{r},\omega)
\]

(14)

The mean-square acceleration in "\( g^2 \)" is given by

\[
\sigma^2(\mathbf{r}) = \int S_{\mathbf{w}w}(\mathbf{r},f) df
\]

(15)

The root-mean-square acceleration in "\( g \)" is given by

\[
G(\mathbf{r}) = \sqrt{\sigma^2(\mathbf{r})}
\]

(15A)

The stress spectral density in \( \frac{(\text{psi})^2}{\text{rad/sec}} \) is given by

\[
\phi_{\mathbf{g}g}(\mathbf{r},\omega) = \gamma^2(\mathbf{r}) \phi_{\mathbf{w}w}(\mathbf{r},\omega)
\]

(16)

where \( \phi_{\mathbf{w}w}(\mathbf{r},\omega) \) is given by Equation (3) and \( \gamma^2(\mathbf{r}) \) is given by Equation (7A) in Section a.

The stress spectral density in \( \frac{(\text{psi})^2}{\text{Hertz}} \) is given by

\[
S_{\mathbf{g}g}(\mathbf{r},f) = 2\pi \phi_{\mathbf{g}g}(\mathbf{r},\omega)
\]

(17)

The mean-square stress in \( (\text{psi})^2 \) is given by

\[
\sigma^2(\mathbf{r}) = \int S_{\mathbf{g}g}(\mathbf{r},f) df
\]

(18)
The root-mean-square stress in psi is given by

\[ \sigma(r) = [\sigma^2(r)]^{1/2} \]
c. SUBROUTINE RSF

DYNAMIC RESPONSE OF TWO OPPOSITE EDGES SIMPLY-SUPPORTED AND OTHER TWO CLAMPED RECTANGULAR SHELL PANELS UNDER RANDOM PRESSURE FIELD

Simply-Supported Edges: \( x = 0, x = \& \)
Fixed Sides: \( y = 0, y = b \)

1. Natural Frequencies

The natural frequencies in radians per second are given by

\[
\omega_{11} = \pi^2 M^{-1/2} \left\{ D_x \left( \frac{1}{\ell} \right)^4 + D_y \left( \frac{1.5056}{b} \right)^4 + 2H \left( \frac{1}{\ell} \right)^2 \left( \frac{1.1165}{b} \right)^2 \right. \\
+ \left. \frac{Eh}{a^2 \pi} \left[ 1 + \left( \frac{1}{1.5056} \right)^2 \left( \frac{\ell}{b} \right)^2 \right]^{1/2} \right\} (1A)
\]

\[
\omega_{1k} = \pi^2 M^{-1/2} \left\{ D_x \left( \frac{1}{\ell} \right)^4 + D_y \left( k + \frac{1}{2} \right)^4 + 2H \left( \frac{1}{\ell} \right)^2 \left( k + \frac{1}{2} \right)^2 \left( \frac{1}{b} \right)^2 \right. \\
+ \left. \frac{Eh}{a^2 \pi} \left[ 1 + \left( \frac{1}{k + \frac{1}{2}} \right)^2 \left( \frac{\ell}{b} \right)^2 \right]^{1/2} \right\} (1B)
\]

\( k = 2, 3, \ldots \)

\[
\omega_{j1} = \pi^2 M^{-1/2} \left\{ D_x \left( \frac{1}{\ell} \right)^4 + D_y \left( \frac{1.5056}{b} \right)^4 + 2H \left( \frac{1}{\ell} \right)^2 \left( \frac{1.1165}{b} \right)^2 \right. \\
+ \left. \frac{Eh}{a^2 \pi} \left[ 1 + \left( \frac{1}{1.5056} \right)^2 \left( \frac{\ell}{b} \right)^2 \right]^{1/2} \right\} (1C)
\]

\( j = 2, 3, \ldots \)

\[
\omega_{jk} = \pi^2 M^{-1/2} \left\{ D_x \left( \frac{1}{\ell} \right)^4 + D_y \left( k + \frac{1}{2} \right)^4 + 2H \left( \frac{1}{\ell} \right)^2 \left( k + \frac{1}{2} \right)^2 \left( \frac{1}{b} \right)^2 \right. \\
+ \left. \frac{Eh}{a^2 \pi} \left[ 1 + \left( \frac{1}{k + \frac{1}{2}} \right)^2 \left( \frac{\ell}{b} \right)^2 \right]^{1/2} \right\} (1D)
\]

\( j, k = 2, 3, \ldots \)
The natural frequencies in hertz are given by

\[ f_{jk} = \frac{\omega_{jk}}{2\pi} \]  

\[ H = \frac{Eh^3}{12(1-\nu^2)} \]  

2. Responses

The formulation for responses for Subroutine RSF are the same as Subroutine RFR given in Section 2, except the normal modes are by the following expressions:
\[ F_{jk}(r) = X_j Y_k \] \hspace{1cm} (4) \\
\[ F_{mn}(r) = X_m Y_n \]

\[ X_j = X_j(x) = \sin \frac{j\pi x}{L} \]

\[ j = 1, 2, \ldots \] \hspace{1cm} (4A)

\[ Y_1 = Y_1(y) = \cosh \frac{1.505\pi y}{b} - \cos \frac{1.505\pi y}{b} \]

\[ -0.982 \left( \sinh \frac{1.505\pi y}{b} - \sin \frac{1.505\pi y}{b} \right) \] \hspace{1cm} (4B)

\[ Y_k = Y_k(y) = \cosh \frac{(k + \frac{1}{2})\pi y}{b} - \cos \frac{(k + \frac{1}{2})\pi y}{b} \]

\[ - \sinh \frac{(k + \frac{1}{2})\pi y}{b} + \sin \frac{(k + \frac{1}{2})\pi y}{b} \]

\[ k = 2, 3, \ldots \] \hspace{1cm} (4C)
D. DEFINITION OF TERMS

<table>
<thead>
<tr>
<th>MNEMONICS</th>
<th>FORMULAS</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>SPPF(I)</td>
<td>$S_{pp}(f)$</td>
<td>Excitation spectral density in decibels per Hertz.</td>
</tr>
<tr>
<td>FIPW(I)</td>
<td>$\Phi_{pp}(\omega)$</td>
<td>Excitation spectral density in (psi)$^2$rad per sec.</td>
</tr>
<tr>
<td>FNW(J,K)</td>
<td>$\omega_{jk}$</td>
<td>Neutral frequencies of panel</td>
</tr>
<tr>
<td>OMEGA(I)</td>
<td>$\omega$</td>
<td>Independent frequency variable for spectrum in rad/sec</td>
</tr>
<tr>
<td>POWJ2</td>
<td>$J^2_{jkmn}$</td>
<td>Joint acceptance squared</td>
</tr>
<tr>
<td>PIWV</td>
<td>$\Phi_{ww}(\tau,\omega)$</td>
<td>Displacement spectral density in inch$^2$/rad per sec</td>
</tr>
<tr>
<td>OMEG(I)</td>
<td>$f$</td>
<td>Independent frequency variable for spectrum in Hertz</td>
</tr>
<tr>
<td>SWW(I)</td>
<td>$S_{ww}(\tau,f)$</td>
<td>Displacement spectral density in in$^2$/Hertz</td>
</tr>
<tr>
<td>PIWG</td>
<td>$\Phi_{ww}(\tau,\omega)$</td>
<td>Acceleration spectral density in in$^2$/sec$^4$/rad per sec</td>
</tr>
<tr>
<td>PIWGI(I)</td>
<td>$S_{ww}(\tau,f)$</td>
<td>Acceleration spectral density in g$^2$/Hertz</td>
</tr>
<tr>
<td>PSSW</td>
<td>$\Phi_{\sigma\sigma}(\tau,\omega)$</td>
<td>Stress spectral density in psi$^2$/rad per sec</td>
</tr>
<tr>
<td>SSSF(I)</td>
<td>$S_{\sigma\sigma}(\tau,f)$</td>
<td>Stress spectral density in psi$^2$/Hertz</td>
</tr>
<tr>
<td>SPPP(I)</td>
<td>$S'_{pp}(f)$</td>
<td>Excitation spectral density in psi$^2$/Hertz</td>
</tr>
<tr>
<td>QX</td>
<td>$Q_X$</td>
<td>Quantity for the calculation of $\gamma^2$</td>
</tr>
<tr>
<td>QY</td>
<td>$Q_Y$</td>
<td>Quantity for the calculation of $\gamma^2$</td>
</tr>
<tr>
<td>QW</td>
<td>$Q_W$</td>
<td>Quantity for the calculation of $\gamma^2$</td>
</tr>
<tr>
<td>GAM2</td>
<td>$\gamma^2(\tau)$</td>
<td>Constant to change displacement spectral density into stress</td>
</tr>
<tr>
<td>PAS</td>
<td>$p_a^2$</td>
<td>Overall mean square excitation pressure</td>
</tr>
<tr>
<td>$W^2(\tau)$</td>
<td>$\text{ATS1}$</td>
<td>Mean square displacement</td>
</tr>
</tbody>
</table>
## D. DEFINITION OF TERMS (Continued)

<table>
<thead>
<tr>
<th>MNEMONICS</th>
<th>FORMULAS</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>$a^2(r)$</td>
<td>ATS2</td>
<td>Mean square stress</td>
</tr>
<tr>
<td>$G^2(r)$</td>
<td>ATS3</td>
<td>Mean square acceleration</td>
</tr>
<tr>
<td>$W(r)$</td>
<td>AT1</td>
<td>Root-mean square displacement</td>
</tr>
<tr>
<td>$\sigma(r)$</td>
<td>AT2</td>
<td>Root-mean square stress</td>
</tr>
<tr>
<td>$G(r)$</td>
<td>AT3</td>
<td>Root-mean square acceleration</td>
</tr>
</tbody>
</table>
E. SPECIAL OPTIONS

This program can be easily modified to calculate the acceleration spectral density in decibel scale referenced gravity acceleration, and compute the vibro-acoustic transfer function. Modification to calculate the average responses over the whole structure and to investigate the contribution of the cross terms to the response is also not difficult.

F. NUMERICAL METHODS OF SOLUTION

The calculation of the mean-square responses is by numerical integration of the area under the spectral density curve. However, the integration procedure is written inside the program and no integration subroutine is required.

G. TECHNICAL REFERENCES


H. RELATED PROJECTS

This computer program has been used in the project, "Comparative Analysis of Acoustic Testing Techniques," MSFC Contract NAS8-21425, which Chrysler Huntsville Operations is conducting from July 1, 1968, to July 31, 1969. Comparison of the computed responses with the experimental data shows good agreement.
SECTION II. PROGRAMMING

A. Library Subroutines

No non-system subroutine is required for this program.

B. Program Subroutines

This program contains a short main driver program and five subroutines which are called in the following order:

1. Subroutine PRNT is used to print the output data.
2. Subroutine GRIDIV is a general grid subroutine for the SC 4020 and is called by the plot routine in subroutines RSR, RFR and RSF.
3. Subroutine RSR is to calculate the frequencies and the responses of simply supported rectangular panels.
4. Subroutine RFR is to calculate the frequencies and the responses of the four-edges-clamped rectangular shell panels.
5. Subroutine RSF is to calculate the frequencies and the responses of panels with two edges simply supported, the other two clamped.

C. Special Input Tapes

None.

D. Special Output Tapes

A-8 is the plot tape used by the SC 4020 plotter.

E. Plots Generated

The following eleven plots are generated by this program. In all the plots, the frequency is the independent variable while the spectral density is the dependent variable.

a. Spectral density of the excitation pressure in decibles versus frequency in Hertz.
b. Spectral density of the excitation pressure in (psi)^2/Hertz versus the frequency in Hertz.

The following three plots are generated for each of the three boundary conditions:
c. Acceleration spectral density in g^2/Hertz versus frequency in Hertz.
d. Displacement spectral density in inch^2/Hertz versus frequency in Hertz.
e. Stress spectral density in (psi)^2/Hertz versus frequency in Hertz.
F. BLOCK DIAGRAMS
a. PROGRAM RANDOM

```
PROGRAM RANDOM

READ AND WRITE OUT INPUT DATA

CALL SUBROUTINES RSS, RFR, AND RSF DEPENDING ON NP

STOP
```

b. SUBROUTINE GRIDIV

```
SUBROUTINE GRIDIV

COMPUTE LABEL MARGINS

ERROR TEST AND SCALE

CLEAR ERROR INDICATOR

RETURN
```
c. SUBROUTINE RSR

SUBROUTINE RSR

WRITE HEADING
CALL CAMRAV
CALL SMXYV
CALCULATE EXCITATION SPECTRAL DENSITY
CALCULATE FREQUENCIES
CALCULATE CONSTANT TO CHANGE DISPLACEMENT INTO STRESS
CALCULATE EXCITATION PRESSURE FROM ONE-THIRD OCTAVE DATA

OMEGA >= (F3RD)(NRB)*2 PI

YES

NO

COMPUTE JOINT ACCEPTANCES

RETURN

WRITE 3 J oint acceptance

COMPUTE DISPLACEMENT, STRESS AND ACCELERATION

COMPUTE MEAN SQUARE AND ROOT-Mean SQUARE

END FILE 3
HI WIND 1
CALL PRNI
CALL SCONTV

PILOT DISPLACEMENT, STRESS ACCELERATION AND EXCITATION CALL CLEAN

RETURN
d. SUBROUTINE RFR

SUBROUTINE RFR

WRITE IFADING
CALL CAMRAV
CALL SXYV

CALCULATE EXCITATION SPECTRAL DENSITY

CALL NATURAL FREQUENCIES

COMPUTE CONSTANT TO CHANGE DISPLACEMENT INTO STRESS

CALCULATE EXCITATION PRESSURE FROM ONE-THIRD OCTAVE DATA

\[ \Omega \left( \frac{f^{3/2}}{n^{1/2} \pi} \right) \]

CALCULATE THE NORMAL MODE

CALCULATE JOINT ACCEPTANCES

RETURN
e. SUBROUTINE RSF

SUBROUTINE RSF

WRITE HEADING
CALL CAMRAV
CALL SMXYV

CALCULATE EXCITATION SPECTRAL DENSITY

CALCULATE NATURAL FREQUENCIES

COMPUTE CONSTANT TO CHANGE DISPLACEMENT INTO STRESS

CALCULATE EXCITATION PRESSURE FROM ONE-THIRD OCTAVE DATA

OMEGA > (F3RD)(NKR) \times 2\pi

YES

CALCULATE THE NORMAL MODE

CALCULATE JOINT ACCEPTANCES

A

NO

WRITE 3 JOINT ACCEPTANCES

CALL PRNI
CALL SCOUTV
PLOT DISPLACEMENT MAX STRESS, ACCELERATION AND EXCITATION

CALL CLEAN

RETURN

A

FOR I > 5

YES

COMPUTE MEAN SQUARE AND BOGIE MEAN SQUARE

A

NO

COMPUTE DISPLAY MINI MAX ACCELERATION AND EXCITATION
G. FLOW CHARTS
a  PROGRAM RANDOM

RANDOM

READ AND PRINT INPUT

IF NP =

1 2 3 4

CALL RSR   CALL RFR   CALL RSF

CALL RSR   CALL RFR   CALL RSF

STOP
b. SUBROUTINE GRIDV

```plaintext
SUBROUTINE GRIDV

N1 = -3

CALL SSTOPTV CALL BRUTEV

BEGIN LOOP

- (U)(0)

BEGIN 415 LOOP

390 LLL (i) = LL(i-1) LL(i) = LL(i-1) + LL(i) + 1

350 XYL (0)

MLD = MU(0) = XTY0 = LREFR(0) =

450 MIN(NM(1), NM(2))

660 CALL ERRPLV

662 CALL ERRPLV

C

CALL SRIDY

CALL SRIDY

CALL TRYCAV

CALL TRYCAV

CALL TRYCAV

CALL TRYCAV

END

CONTINUE

CALL SRIDY

CALL SRIDY

CALL TRYCAV

CALL TRYCAV

CALL TRYCAV

CALL TRYCAV

END

LOOP

CONTINUE

END

CONTINUE

END

CONTINUE

END

RETURN
```

c. SUBROUTINE RSR

INITIALIZE BCDX, BCDY, BCD11, BCD2, AND BCDY3
WRITE IFADING R:PPIND 3

CALL CAMRAV
CALL SMXIV
CALL SCOXV
SET CONSTANTS ICT, JA AND PI

CALCULATE SPPF (0), PIPP (0)

COMPUTE CONSTANTS HC, DX, DX AND EM

COMPUTE TF FHZ AND FNW (1, 3)

COMPUTE S, QX, QX AND QW

COMPUTE HI, GAME, OMEGA
ICT = 0, IC = 1

BEGIN 21 LOOP

BEGIN 40 LOOP

OMEGA = (F3RD(NGR) * 2 * PB)

[Flowchart diagram of the subroutine's logic]

END FILE 3
REIND 3
CALL PRNT
SET PLOT SCALES

CALL SMXIV
PLOT SPPF, SW, SSSF, SPPF, PIPP CALL CLEAN

RETURN
d. SUBROUTINE RFR

INITIALIZE BCDX, BCDY, BCX2, AND BCDY3
WRITE HEADING
REWIND 3

CALL CAMRAV
CALL SMOXV
CALL SMOYTV
SLI CONSTANTS ICT, JK AND PI

CALCULATE SPFP (I), FPFW (I)

COMPUTE CONSTANTS BC, DZ, DX AND DM

COMPUTE PHZ AND PNW (I, J)

COMPUTE S, QX, QY AND QW

COMPUTE HI, GAM2, OMEGA
ICT = 0, IC = 1

BEGIN 21 LOOP
BEGIN 40 LOOP

OMEGA = (F3RD(JA)*2 + PI)

KA = JA
COMPUTE FIPW

OMEGA = (F3RD(JA)*2 + PI)

IF POMEG > 5 THEN
CONTINUE

WRITE 3 ICT = ICT + 1

CALL GMEG (I)
SWW (I)
FNWG (I)
SSSF (I)
SPP (I)

IF IC = 1 THEN B

IF OMEGA > (F3RD(JER) + 2 + PI) THEN A

CONTINUE

IF IC = 2 THEN B

FT = OMEGA (I)
G1 = SWW(I)
G2 = SSSF(I)
G3 = FNWG(I)
ATS1 = 0 0
ATS2 = 0 0
ATS3 = 0 0

END FILE 3
REWIND 3
CALL PRNT
CALL CLEAN
e. SUBROUTINE RSF

SUBROUTINE RSF

INITIALIZE
ICDX, BCDY, BCDY1, BCDY2, BCD1, BCDY1
WRITE BLADING
REWIND 3

CALL CAMRAY
CALL SCOUTV
CALL SMXXV
Jr = 2
C1 = 0
PI = 1.415927

41

CALL CAMRAY
CALL SCOUTV
CALL SMXXV
Jr = 2
C1 = 0
PI = 1.415927

Calulate
SPF(i)
FWW(i)

COMPUTE
BC, DI, IX, SM, TCON

20

COMPUTE
FWW(i, k)

49

COMPUTE
S, QX, QY, AND GW

COMPUTE
HM, GAME, AND OMEGA

BEGIN 51 LOOP

BEGIN 50 LOOP

OMEGA =
(FIRD(IA)^2 * PI)

30

IA = IA + 1

25

RA = IA

COMPUTE
PIPP

45

PIW = 0.0

BEGIN 22 LOOP

211

COMPUTE
XJ, XM, IX, YN, FER, FAN

COMPUTE
HM, RK, MM, AC, BC, CC, PMEG, POW2, FWW

WRITE 3 ICT = ICT + 1

CONTINUE

BEGIN 31 LOOP

BEGIN 40 LOOP

OMEGA =
(FIRD(IN)^2 * PI)

98

KM = I-1

YES

B

10

IC = 2

F1 = PMEG(i)

G1 = SWW(i)

G2 = SSSF(i)

G3 = PWG1(i)

ATS1 = 0.0

ATS2 = 0.0

ATS3 = 0.0

RETURN
H. PROGRAM LISTING
PROGRAM RAND

COMPUTER PROGRAM FOR PREDICTION OF STRUCTURAL VIBRATIONS
DUE TO FLUCTUATING PRESSURE ENVIRONMENTS, COMBINATION
OF PROGRAMS RSRPC1, RFRPC1, AND RSFRP1, RECTANGULAR
CYLINDRICAL SHELL PANEL CROSS-REINFORCED WITH RIBS AND
STRINGERS, BOUNDARY CONDITIONS - FOUR EDGES SIMPLY-SUPPORTED,
FOUR EDGES CLAMPED, TWO OPPOSITE EDGES SIMPLY-SUPPORTED
WHILE OTHER CLAMPED, INPUT EXCITATION SPECTRAL DENSITY
AND OUTPUT DISPLACEMENT, STRESS AND ACCELERATION SPECTRAL
DENSITIES ARE PLOTFD IN GRAPHIC FORMS.
DEVELOPED BY CHRYSLER HUNTSVILLE OPERATIONS, UNDER MSFC

CONTRACT NAS8-21403.

DIMENSION FNW(IOIO),F3RD(40),S3RD(40),SPPP(400)
DIMENSION FIPW(40),SPPF(40),OMEG(400),PIWG1(400)
DIMENSION SWW(400),SSSF(400)
COMMON /INPUT/ PL,B,RHO,HSCIX,Y,FTNN,A1,C,PLP,BP,
142,E,EP,VIP,AL1,BL1,AL1,AL2,H2,HP,RAD,RHOP,RLA
COMMON /OUTPUT/ FNW,F3RD,S3RD,FIPW,SPPF,OMEG,PIWG1,SWW,
1SSSF,SPPP,N3R,KM,JK,ICT,PAS,ATS1,ATS2,ATS3,AT1,AT?,AT3,
20X,0Y,OU,GM2,IRD

READ AND PRINT INPUT DATA
READ (5,133) NP,N3R
READ(5,5)PL,B,RHO,HS
READ(5,5)CI,X,Y,FINN
READ (5,5)A1,C,PLP,BP
READ (5,5)A2,E,EP,VIP
READ (5,5)AL1,BL1,AL1,AL2
READ (5,5)H2,HP,RAD,RHOP
READ (5,8)(F3RD(I),S3RD(I),I=1,N3R)
WRITE (6,103) PL,BpRHO,HS,CIDX,Y,FINN,A1,C
WRITE (6,132) PLP,BP,A2,E,EP,VIP,AL1,BL1,AL1,AL2,H2,HP,RAD,RHOP
GO TO (200,201,202,200),NP

C CALCULATING RESPONSES OF FOUR EDGES SIMPLY-SUPPORTED PANEL

200 CALL RSR
IF (NP .NE. 4) GO TO 99
C CALCULATING RESPONSES OF FOUR EDGES CLAMPED PANEL

201 CALL RFR
IF (NP .NE. 4) GO TO 99
C CALCULATING RESPONSES OF TWO OPPOSITE EDGES SIMPLY-SUPPORTED
C WHILE OTHER TWO CLAMPED PANEL

202 CALL RSF
99 STOP
5 FORMAT(4F15.8)
8 FORMAT(8F8,1)
103 FORMAT(1H1,10X,16HINPUT DATA ,,,
120H PL = PANEL LENGTH =E12.5,,/
218H B = PANEL WIDTH =E12.5,,/
330H RHO = MASS DENSITY OF PANEL =E12.5,,/
423H HS = PANEL THICKNESS =E12.5,,/
521H CI = DAMPING RATIO =E12.5,,/
629H X = COORDINATE OF VECTOR R =E12.5,,/
729H Y = COORDINATE OF VECTOR R =E12.5,,/
862H FINN = ONE NTH OCTAVE FREQUENCY INCREMENT =
9,E12.5,,/34H A1 = DECAYING CONSTANT - LENGTH = E12.5,,/
$21H C = \text{SPEED OF SOUND} = E12.5$

132 FORMAT(48H PLP = LENGTH OF PANEL SUBJECTED TO EXCITATION =E12.5/,
146H BP = WIDTH OF PANEL SUBJECTED TO EXCITATION =E12.5/,
233H A2 = DECAYING CONSTANT - WIDTH =E12.5/,
330H E = YOUNGS MODULUS OF PANEL =E12.5/,
436H EP = YOUNGS MODULUS OF STIFFENERS =E12.5/,
533H VIP = POISSONS RATIO =E12.5/,
631H A1 = SPACING OF Y - DIRECTION STIFFENERS =E12.5/,
744H BL1 = SPACING OF X - DIRECTION STIFFENERS =E12.5/,
857H A12 = MOMENT OF INERTIA OF ONE Y - DIRECTION STIFFENER =E12.5/,
97/57H A12 = MOMENT OF INERTIA OF ONE X - DIRECTION STIFFENER =
$E12.5/,48H H2 = \text{LARGEST HEIGHT OF STIFFENERS AT VECTOR R} = E12.5$, 
$7/43H HP = \text{SMEARED-OUT THICKNESS OF STIFFENERS} = E12.5,$
$536H RHOP = \text{MASS DENSITY OF STIFFENERS} = E12.5,$
133 FORMAT(415)

END

$IBFTC PNT$

SUBROUTINE PRNT

DIMENSION FNW(10,10),F3RD(40),S3RD(40),SPPP(400)
DIMENSION FIPW(40),SPPF(40),OMEG(400),PIWG1(400)
DIMENSION SWW(400),SSSF(400)

COMMON /INPUT/ PLB,RHOHS,CI,X,Y,FINN,A1,C,PLP,BP,
IA2,E,EP,AL1,BL1,A11,A12,H2,HP,RAD,RHOP,RLA

COMMON /OUTPUT/ FNW,F3RD,S3RD,FIPW,SPPF,OMEG,PIWG1,SWW,
1SSSF,SPPP,N3R,KM,KJ,ICT,PAS,ATS1,ATS2,ATS3,AT1,AT2,AT3,
20X,QY,QW,GAM2,1RD

PI=3.1415927

WRITE (6,110)
DO 200 I=1,N3R
200 WRITE (6,115) F3RD(I),S3RD(I),SPPP(I),FIPW(I)
WRITE (6,100)
DO 201 J=1,9
201 WRITE (6,120) J,K,FHZ,FNW(J,K)
WRITE (6,125)
WRITE (6,130) ( OMEG(I),SWW(I),SSSF(I),PIWG1(I),SPPP(I),I=1,KM)
206 IF (JK,EQ,2) GO TO 203
WRITE (6,102) ATS1,ATS2,ATS3
WRITE (6,101) AT1,AT2,AT3
WRITE (6,131) QX,QY,QW,GAM2,FINN
GO TO 204
203 WRITE (6,102) ATS1,ATS2,ATS3,PAS
PA=SQRT(PAS)
WRITE (6,101) AT1,AT2,AT3,PA
WRITE (6,131) QX,QY,QW,GAM2,FINN
GO TO 204
204 WRITE (6,105)
IF (ICT,EQ,0) GO TO 208
DO 202 I=1,ICT
READ (3) POMEG,J,K,M,N,POWJ2
202 WRITE (6,104) POMEG,J,K,M,N,POWJ2
REWIND 3
208 WRITE (6,50)
RETURN
50 FORMAT(12H1) END OF DATA
100 FORMAT(1H1, 36H NATURAL FREQUENCIES '//, 2X4HJ K, 1
10X3HFHZ, 20X3HPNW/16X2HHz, 18X7HRAD/SEC//)
101 FORMAT(13H RMS VALUE , 4E16.8//)
102 FORMAT(13H MS VALUE, 4E16.8//)
104 FORMAT(F12.5, 4I13, 3E15.8)
105 FORMAT(11H FREQUENCY, 5X, 4HMODE, 5X, 16H JOINT ACCEPTANCE, //,
14X, 5HHERTZ, 6X, 7HINDICES, 8X, 6HSQUARE, //, 14X, 10HJ K M N, //)
107 FORMAT(11X, 30H OVERALL MEAN-SQUARE PRESSURE =, 6E15.7)
110 FORMAT(///, 38X16H INPUT EXCITATION //, RX14HONE-3RD OCTAVE, 7X20HONE-3R
1D OCTAVE LEVEL, 7X16HSPECTRAL DENSITY, 7X16HSPECTRAL DENSITY//RX14HME
2AN FREQUENCY, 12X11HIN DECIBELS, 11X17HIN DECIBELS/HERTZ, 6X17HIN PSI
3 SQ/RAD/SEC/14X4HF3PD, 19X4HS3RD, 22X4HSPPF, 20X4H1PW//)
115 FORMAT(F20.3, 3XF20.3, 6XE20.5)
120 FORMAT(213, F15.5, 7X, F15.5)
125 FORMAT(13H FREQUENCY, 3X, 12H DISPLACEMENT, 7X, 6H STRESS, 7X,
112H ACCELERATION, 5X, 10H EXCITATION, //, 18X, 8H RESPONSE, 4X,
216H RESPONSE, //, 4X, 8H RESPONSE, //, 6X, 5HHERTZ, 3X, 16H INCH SQ/HERTZ, 
2X, 12H PSI SQ/HERTZ, 5X, 10HG SQ/HERTZ, 4X, 14H PSI SQ/RAD/SEC, //)
130 FORMAT(F3, F12.5, 4E16.8)
131 FORMAT(///, 38X16H INPUT EXCITATION //, RX14HONE-3RD OCTAVE, 7X20HONE-3R
1D OCTAVE LEVEL, 7X16HSPECTRAL DENSITY, 7X16HSPECTRAL DENSITY//RX14HME
2AN FREQUENCY, 12X11HIN DECIBELS, 11X17HIN DECIBELS/HERTZ, 6X17HIN PSI
3 SQ/RAD/SEC/14X4HF3PD, 19X4HS3RD, 22X4HSPPF, 20X4H1PW//)
END
$IBFC GRID
SUBROUTINE GRIDIV (L,XL,XU,YL,YU,DX,DY,NN,MM,II,JJ,NX,NY)
C GENERAL GRID SUBROUTINE FOR SC4020 --- LINEAR OR NONLINEAR IN -
C EITHER VERTICAL OR HORIZONTAL
DIMENSION XYL(2), XYU(2), DXY(2), NM(2), IJ(2), NXY(2), XYLAB(2), LREFR(12)
K(2), LLL(2), LLLU(2), LL(2), LLLU(2), MT(2), MTU(2), MTL(2), MTLU(2), ITT(2)
2, ISPACE(2), ITOP(2)
EQUIVALENCE (ITOP(1), MMOH), (ITOP(2), MUV)
C STOP TYPE --- MAY NOT NEED
NY=-3
70 CALL STOPTV
CALL BRITEV
IF(L-2) 95, 110, 95
95 IND=L-1
100 CALL FRAMEV(IND)
110 CALL SETMOV (MTL(1), MTU(1), MTL(2), MTU(2))
CALL SETCOV (IWRITE, IWRITE)
CALL MSXYV (K(1), K(2))
120 XYL(1)=XL
XYU(2)=YL
XYU(1)=XY
XYU(2)=XY
DXY(1)=DX
DXY(2)=DY
NM(1)=NN
NM(2)=NN
IJ(1)=II
IJ(2)=JJ
NXY(1)=NX
NXY(2)=NY
DO 230 I= 1,2
C

ISPAC(E(I))=O
LUU(I)=O
IF(NXY(I)) 229,230,230
229 NXY(I)=7-NXY(I)
230 CONTINUE
IF(NXY(2)) 240,244,240
24n ISPAC(E(1)=NXY(2)*IWID+IWID+6
LUU(2)=IHIGH+6
244 IF(NX) 245,250,246
245 ISPAC(E(2)=IHIGH/2
246 ISPAC(E(2)=ISPAC(E(2)+IHIGH+6
LUU(1)=(NXY(1)*IWID)/2
250 CALL HOLDOV(IND)

C
COMPUTE LABEL MARGINS, IF IND IS ZERO

30n DO 445 I=1,2
LLL(I)=ISPAC(E(I)
XYLAB(I)=XYL(I)
31n IF(-IJ(I)) 330,360,360
33n IF(XYL(I)) 340,360,340
34n IF(XYL(I)*XYU(I)) 350,350,360
35n XYLAB(I)=0.0
355 LLL(I)=O
36n IF(NXY(I)) 370,380,370
37n LLL(I)=MAX0(LUU(I)+TWID+2,LLL(I))
38n IF(IND) 420, 390,420
39n LLL(I)=LLL(I)
- LUU(I)=LUU(I)
42n ML(I)=LLL(I)+MTL(I)
MU(I)=LUU(I)+MTU(I)
44n ITT(I)=ML(I)+MU(I)
449 LREFR(I)=MTL(I)+3

C
END OF LOOP FROM 30

46n IF (MIN0(NM(I),NM(I))) 465,660,660
465 IT=MAX0(ITT(I),ITT(1))
48n MU(1)=IT-ML(1)
MU(2)=IT-ML(2)

C
ERROR TESTS AND SCALE

66n IF(K(I)) 662,669,662
669 CALL ERRNLV(XYL(1),XYU(1),ML(1),MU(1),DXY(1))
XYLAB(1)=XYL(1)
GO TO 670
669 CALL ERRNLV(XYL(1),XYU(1),ML(1),MU(1),DXY(1))
GO TO 670
67n CALL XSCALV (XYL(1),XYU(1),ML(1),MU(1))
- IF (K(1)) 682,692,682
682 CALL ERRNLV (XYL(1),XYU(1),ML(1),mu(1),DXY(1))
XYLAB(2)=XYL(1)
GO TO 700
682 CALL ERRNLV (XYL(2),XYU(2),ML(2),MU(2),DXY(2))
XYLAB(2)=XYL(2)
GO TO 700
682 CALL ERRNLV (XYL(2),XYU(2),ML(2),MU(2),DXY(2))
GO TO 700
692 CALL ERRNLV (XYL(2),XYU(2),ML(2),MU(2),DXY(2))
70n CALL XSCALV (X YL(2),XYU(2),ML(2),MU(2))
ITT(1)=NXV(XYLAB(1))-ISPAC(E(1)
ITT(2)=NYV(XYLAB(2))-ISPAC(E(2)
DO 790 I=1,2
ITOP(I)=1023-MU(I)
758 IF(I1(1)) 760,780,780
76n IF(-IJ(I)) 770,790,790

40
770 IJ(I)=-IJ(I)
    GO TO 300
780 LREFR(I)=IT(I)+2
790 CONTINUE
805 LREFR(1)=LREFR(1)+IWIDE+IWIDE/2
    LREFR(2)=LREFR(2)+IHIGH/2
810 IF(K(1)) 820,850,820
820 CALL NONLNV(1,LREFR(1),ML(2),MUV,XYL(1),XYU(1),DXY(1),NM(1),IJ(1)
1,NX,IWIDE)
    GO TO 870
850 CALL LINRV(i,LREFR(P),ML(2),MUV,XYL(1),XYU(1),DXY(1),NM(2),IJ(2)
1,1X,IWIDE)
870 IF(K(2)) 880,910,880
880 CALL NONLNV(2,LREFR(1),ML(1),MUH,XYL(2),XYU(2),DXY(2),NM(2),IJ(2)
1,NX,IHIG)
910 GO TO 924
910 CALL LINRV(2,LREFR(i),ML(2),MUH,XYL(2),XYU(2),DXY(2),NM(2),IJ(2)
1,1X,IHIG)
C TO CLEAR ERROR INDICATOR --IF GRID DATA IN ERROR ,ERROR INDICATORS
C 1MIGHT NOT BE CLEARED
924 K(1)=NXV(XYL(1))
    K(2)=NYV(XYL(2))
930 RETURN
END

$ORIGIN A
$IBF1C RSR1
SUBROUTINE RSR
C PROGRAM NUMBER 823-1002-6
C RSRPC1
C CALCULATION OF RESPONSE OF SIMPLY SUPPORTED RECTANGULAR PANELS
C CROSS-REINFORCED WITH STIFFENERS
C INPUT PARAMETERS
C PL  = PANEL LENGTH
C B   = PANEL WIDTH
C RHO = MASS DENSITY OF PANEL
C HS  = PANEL THICKNESS
C CI  = DAMPING RATIO
C X   = COORDINATE OF VECTOR R
C Y   = COORDINATE OF VECTOR R
C FINN = ONE NTH OCTAVE FREQUENCY INCREMENT
C A   = CONSTANT
C C = SPEED OF SOUND
C PLP = LENGTH OF PANEL UNDER EXCITATION
C BP  = WIDTH OF PANEL UNDER EXCITATION
C F3RD = ONE-THIRD OCTAVE BAND CENTER FREQUENCY
C S3RD = SOUND PRESSURE LEVEL
DIMENSION FNW(10,10),F3RD(40),S3RD(40),RCDX(12),BCDY(12)
DIMENSION FIPW(40),SPFW(40),OMEG(400),PIWG1(400),RCDY(12)
DIMENSION BCDY2(12),SWW(400),SSSF(400),RCDY3(12)
DIMENSION SPPP(400)
COMMON /OUTPUT/ FNW,F3RD,S3RD,FIPW,SPFW,OMEG,PIWG1,SWW,
1SSSF,SPPP,N3R,KMJK,ICT,PAS,ATS1,ATS2,ATS3,AT1,AT2,AT3,
2QX,OY,GW,GAM2,IRD
COMMON /INPUT/ PL,B,RHO,HS,CI,X,Y,FINN,A1,C,PLP,BP,
1A2,E,EP,VIP,AL1,BL1,Al1,A12,H2,HP,RA,RO,P,RLA
DATA RCDX/72HFREQUENCY (H7)
  1
DATA BCDY/72HACCELERATION G SQ/HZ
  1
DATA BCDY2/72HDISPLACEMENT INCH SQ/HERTZ
  1
DATA BCDY3/72HSTRESS SPECTRAL DENSITY PSI SQ/HERTZ
  1
DATA BCDY4/72HSPPF DB/HZ
  1
WRITE (6,10a)
ICK=1
1001 REWIND 3
JK=1
PI=3.1415927
SMI= 1.E10
SMX= 1.E-10
SSM= 1.E10
SSMXY= 1.E-10
PIMI= 1.E10
PIMXY= 1.E-10
CALL CAMRAV(9)
  CALL SNWYV(I,0)
C CALCULATE EXCITATION SPECTRAL DENSITY
  DO 9 I=1,N3R
  SPPF(I)=S3RD(I)-1.E-10,*ALOGIO(0,2315*3RD(I))
  FIPV(I)=1./(2.0*PI)**10.0**((SPPF(I)-170.576)/10.0)
  CONTINUE
C CALCULATE NATURAL FREQUENCIES
  HC=HC+EP*A12/AL1
  DX=HC+EP*A11/BL1
  BM=RHO*HS*RHOP*HP
  DO 20 I=1,9
     DO 20 J=1,9
     RH=!
     RN:.J
     FHZ=DX*(RM /PL)**4.2,*HC*(RM*RN/(PL*B))**2+DY*(RN/B)**4
     1+E*HS/(RAD*RAD*(PI)**4*(1.+(PL*RN/(R*RM))**2)**2)
     FNW(I,J)=PI*PI*SQR(1./BH)*SQR(FHZ)
  20 CONTINUE
C CALCULATE CONSTANT TO CHANGE DISPLACEMENT INTO STRESS
  QX=0.0
  QY=0.0
  QW=0.0
  S=BP*PLP
  DO 49 IJ=1,5,2
     DO 49 IK=1,5,2
     RM=1
     RN=1
     FSIN=SIN(RM*PI*X/PL)*SIN(RN*PI*Y/R)
     QCON=RM*RN*(DX*(RH/PL)**4.2,*HC*(RM*RN/(PL*B))**2+DY*(RN/B)**4)
     QX=QX+(RM*PI/PL)**2*VIP*(RN*PI/B)**2*(FSIN/QCON)
     QY=QY+(RN*PI/B)**2*VIP*(RM*PI/PL)**2*(FSIN/QCON)
     QW=QW+FSIN/QCON
C CALCULATE EXCITATION PRESSURE FROM ONE-THIRD OCTAVE DATA

1000 CON = 2.0**(1.0/FNW)
OMEGA = F3RD(1)*2.0*PI
ICT = 0
IC = 1
DO 21 I = 1, 1400
N3R1 = N3R - 1
DO 40 JA = 1, N3R1
IF (OMEGA .GT. (F3RD(N3R)*2.0*PI)) GO TO 99
IF (OMEGA = (F3RD(JA)*2.0*PI)) 25, 25, 30
25 KA = JA
GO TO 35
30 IA = JA + 1
IF (OMEGA = (F3RD(IA)*2.0*PI)) 25, 25, 40
35 PIP = FIPW(KA) + FIPW(IA) - FIPW(KA) + (OMEGA - F3RD(KA)*2.0*PI) / (F3RD
1(KA + 1) - F3RD(KA))*2.0*PI)
GO TO 45
40 CONTINUE
45 PIW = 0.0
DO 22 J = 1, 5
DO 22 K = 1, 5
DO 22 M = 1, 5
DO 22 N = 1, 5
RK = K
RN = N
RJ = J
RM = M
FM1 = SIN(RJ*PI*X/PL)*SIN(RK*PI*Y/B)
FM2 = SIN(RM*PI*X/PL)*SIN(RN*PI*Y/B)
RMA = RHO*HS*B*PL/4.0
HJK = ABS(1.0/((FM1) + (OMEGA) - (OMEGA)**2
1 + (2.0*CI*FNW(J, K)*OMEGA))**2))
HMN = ABS(1.0/((FM2) + (OMEGA) - (OMEGA)**2
1 + (2.0*CI*FNW(M, N)*OMEGA))**2))
C CALCULATE JOINT ACCEPTANCES
AC = (1.0 - (OMEGA/OMEGA(M, N)**2)*1.0 - (OMEGA/OMEGA(J, K)**2)*2.0)*C
BC = -2.0*(CI*OMEGA/OMEGA(M, N)**2) - CI*OMEGA/
1(FNW(M, N)*1.0 - (OMEGA/OMEGA(J, K)**2))
CC = AC + BC
CON1 = A1*OMEGA*PL/C*(A1*OMEGA*PL/C)
CON2 = RJ*PI
CON3 = RM*PI
CON6 = CON2*CON3*(2.0*EXP(-A1*PL*OMEGA/C)*((-1)*((J+1) + (-1)**1(M+1))))
1/(CON1 + CON2 + CON2 + CON1*CON3 + CON3))
CON7 = RK*PI
CON8 = RN*PI
IF (J .NE. M) GO TO 46
PJUM = A1*PL*OMEGA/C/2*(1/(CON1 + CON2 + CON2) +
1/(CON1 + CON3 + CON3) + CON6)
GO TO 47
46 PJUM = CON6*RM/(CON1 + CON3 + CON3)*((-1)*J-M-1.)/(2.*
1(RJ-RM))*(((-1)*J-M-1.)/(2.*(RJ-RM)))
2 *RJ /((CON1+CON2*CON3)*((-1.)*(M-J)-1.)/(2.*(RM-RJ))
3+((1.*(-1.))*(M-J)-1.)/(2.*(RM+RJ))
47 CON1 = (A2*OMEGA*R /C)*(A2*OMEGA*B /C)
CON6 = CON7*CON8 *((-1.)*((N+1))
1((CON1+CON7*CON7)*((CON1+CON8*CON8))
IF(K .NE. N) GO TO 48
PJKN = (A2*PL*OMEGA/C/2.*((CON1+CON7*CON7)*
1,/(CON1+CON8*CON8)) + CON4)
GO TO 23
48 PJKN = CON6 RN /((CON1+CON8*CON8)*((-1.)*(K-N)-1.)/(2.*
1(RK-RN)) + ((-1.)*(K-N)-1.)/(2.*(RK+RN)))
2 +RK /((CON1+CON7*CON7)*((-1.)*((N-K)-1.)/(2.*(RN-RK))
3+((-1.)*((N-K)-1.)/(2.*(RN+RK))))
23 POMEG = OMEGA/(2.*PI)
POWJ2 = PJKN*AC/SQRT(CC)
PIW = PIW*F1*FM*HJK*HM*POWJ2
IF (POMEG .GT. 5.) GO TO 22
WRITE (3) POMEG , J, K, M, N, POWJ2
ICT = ICT + 1
22 CONTINUE
OMEG(I) = OMEGA/(2.*PI)
C CALCULATE DISPLACEMENT, STRESS, AND ACCELERATION
PIW = PIW*F1*F3*PIPP
SWW(I) = PIW/2.*PI
PIW = OMEGA**4*PIWW
PIW1(I) = 4.21593E-05*PIW
PWW = GAM2*PIW
SSSF(I) = 2.*PI*PWW
PPPP(I) = 2.*PI*PIWW
C CALCULATE MEAN SQUARE
IF (IC .NE. I) GO TO 41
F1 = OMEGA(I)
G1 = SWW(I)
G3 = PWW1(I)
ATS1 = 0.0
ATS2 = 0.0
ATS3 = 0.0
IC = 2
GO TO 21
41 ATS1 = ATS1+F1*(G1+SWW(I))/2.*(OMEGA(I)-F1)
ATS2 = ATS2+F1*(G2+SSSF(I))/2.*(OMEGA(I)-F1)
ATS3 = ATS3+F1*(G3+PIW1(I))/2.*(OMEGA(I)-F1)
C CALCULATE ROOT-MEAN SQUARE
F1 = OMEGA(I)
G1 = SWW(I)
G3 = PIW1(I)
IF (SWW(I), LT. SWBI) SWBI = SWW(I)
IF (SWW(I), GT. SWMX) SWMX = SWW(I)
IF (SSSF(I), LT. SSMI) SSMI = SSSF(I)
IF (SSSF(I), GT. SSNX) SSNX = SSSF(I)
IF (PIW1(I), LT. PIWI) PIWI = PIW1(I)
IF (PIW1(I), GT. PIIX) PIIX = PIW1(I)
OMEGA = OMEGA* CON
CONTINUE
KM=I
GO TO 98
KM=I-1
END FILE 3
REWIND 3
AT1=SORT(ATS1)
AT2=SORT(ATS2)
AT3=SORT(ATS3)
CALL PRNT
DSW = SWMX/1,E9
DSS = SSMX/1,E9
DPI = PIMX/1,E9
DO 301 I=1,KM
IF(SW(I) .LT. DSW) SW(I)=DSW
IF(SSSF(I) .LT. DSS) SSSF(I)=DSS
IF(PIWGI(I) .LT. DPI) PIWG1(I)=DPI
301 CONTINUE
PLOT EXCITATION, DISPLACEMENT, STRESS, AND ACCELERATION
CALL QUIK3V(-1,44,BCDX,BCDY1,-N3RF3RD,SPPF)
CALL SCOUTV
CALL SMXYV(1,1)
CALL QUIK3V(-1,44,BCDX,BCDY2,-KM,OMEG,SWW)
WRITE (16,106) AT1,FINN
CALL QUIK3V(-1,44,BCDX,BCDY3,-KM,OMEG,SSSF)
WRITE (16,106) AT2,FINN
CALL QUIK3V(-1,44,BCDX,BCDY,-KM,DMEG,PIWGI)
WRITE (16,106) AT3,FINN
CALL CLEAN
106 FORMAT(11X,31H ROOT-MEAN-SQUARE RESPONSE = E15.7,5X,6HFINN = IF6.2#1OX,6HRSRPC1)
108 FORMAT(96HICALCULATION OF RESPONSE OF SIMPLY SUPPORTED RECTANGULAR PANELS CROSS-REINFORCED WITH STIFFENERS)
RETURN
END

$ORIGIN A
$IBFTC RFR1
SUBROUTINE RFR
C PROGRAM NUMBER 823-1002-7
C RFRPC1
C DYNAMIC RESPONSE OF FOUR-SIDE FIXED RECTANGULAR SHELL PANELS CROSS-REINFORCED WITH STIFFENERS
C INPUT PARAMETERS
C PL = PANEL LENGTH
C B = PANEL WIDTH
C RHO = MASS DENSITY OF PANEL
C HS = PANEL THICKNESS
C CI = DAMPING RATIO
C X = COORDINATE OF VECTOR R
C Y = COORDINATE OF VECTOR R
C FINN = CONSTANT TO DETERMINE OCTAVE BAND CENTER FREQUENCIES
C A1 = CONSTANT
C C = SPEED OF SOUND
C BP = LENGTH OF PANEL UNDER EXCITATION
C PLP = WIDTH OF PANEL UNDER EXCITATION
F3RD = ONE-THIRD OCTAVE BAND CENTER FREQUENCY
S3RD = SOUND PRESSURE LEVEL
DIMENSION FNW(10,10),F3RD(40),S3RD(40),BCDX(12),BCDY(12)
DIMENSION FIPW(40),SPPF(40),OMEG(400),PIWG1(400),BCDY1(12)
DIMENSION BCDY2(12),SWW(400),SSSF(400),BCDY3(12),BCDY4(12)
DIMENSION SPPP(400)
COMMON /OUTPUT/ FNW,F3RD,S3RD,FIPW,SPPF,OMEG,PIWG1,SWW,
1SSSF,SPPP,N3R,KM,JK,ICT,PAS,ATS1,ATS2,ATS3,AT1,AT2,AT3,
2QX,QY,QW,GAM2,IRD
COMMON /INPUT/ PLB,RHO,HS,CIXY,FINN,AjCPLPEP,
1A2pFEP,VIPALI,BL1,AL2,AL12,H2,HP,RAH,RHOP,RLA
DATA BCDX/72HFREQUENCY (HZ)
DATA BCDY/72HACCELERATION G SQ/HZ
DATA BCDY2/72HDISPLACEMENT INCH SQ/HERTZ
DATA BCDY3/72HSTRESS SPECTRAL DENSITY PSI SQ/HERTZ
DATA BCDY1/72HSPPF DS/HZ
DATA BCDY4/72HSPECTRAL DENSITY PSI SQ/HERTZ
WRITE (6,108)
REWIND 3
JK=2
ICT=0
PI=3.1415927
SWMI=1.E10
SWMX=1.E-10
SSMI=1.E10
SSMX=1.E-10
PIMI=1.E10
PIMX=1.E-10
CALL CAHRAV(9)
CALL SMYYV(1,0)
C EQUATIONS 11 AND 12
C CALCULATE EXCITATION SPECTRAL DENSITY
DO 9 I=1,N3R
SPPF(I)=S3RD(I)*10.10ALOG10(0.2315*F3RD(I))
FIPW(I)=1.0/(2.0*PI)*10.0**{(SPPF(I)-170.576)/10.0}
CONTINUE
C CALCULATE NATURAL FREQUENCIES
C EQUATIONS 1 AND 2
HC=EH*HS*HS*/(12.*{1.1*VIP*VIP})
DY=HC*EP*AI2/AL1
DX=HC*EP*AI1/BL1
BM = RHO*HS*RHOP*HP
FCON = PI*PI/SQRT(BM)
DO 20 J=1,9
DO 20 K=1,9
RJ = J
RK = K
IF(J .NE. 1 .AND. K .NE. 1) GO TO 18
IF(J .EQ. 1 .AND. K .NE. 1) GO TO 16
C CALCULATE CONSTANT TO CHANGE DISPERSION INTO STRESS
C EQUATION 16
QX=0.0
QY=0.0
QW=0.0
S=BP*PLP
DO 49 IJ=1,5,2
DO 49 IK=1,5,2
RM=1J
RN=1K
FSIN=SIN(RM*PI*X/PL)*SIN(RN*PI*Y/R)
QCON=RM*RN*(DX*RM/PL)**2+HC*(RM*RN/(PL*8B)**2+DY*(RN/B)**4)
QX=OX+(QM*PI/PL)**2+VIP*(RM*PI/B)**2*(FSIN/QCON)
QY=QY+U(RN/PI)**2*VIP*(QY/PL**2)*CFSN/0CON)
QW=QW±FS!N
H1=HS*H2
GAME=H1*H1/(4,*{1,-VIP*VIP)**2)/QX/QY/(QW/QW)
C CALCULATE EXCITATION PRESSURE FROM ONE-THIRD OCTAVE DATA
1000 CON= 2.0*(1.0/FINN)
OMEGA=F3VD(1)*2.0*PI
IC=1
DO 21 I=1,400
N3R=3N3R-1
DO 40 JA=1,N3R1
IF ( OMEGA ,GT, (F3RD(N3R)*2,*PI)) GO TO 99
IF(0MEGA-(F3RD(JA)*2,*PI))25,25,30
25 KA=JA
GO TO 35
30 IA=JA+1
IF(OMEGA-(F3RD(JA)*2,*PI))25,25,40
35 PIP=P-F[3PD(KA)*F[3PD(KA+1)-FIPW(KA)]*(OMEGA-F3RD(KA)*2,*PI)/(F3RD
1(KA+1)-F3RD(KA))*2,*PI)
GO TO 45
40 CONTINUE
45 PIW=0.0
DO 22 J=1,5
DO 22 K=1,5
DO 22 N=1,5
DO 22 M=1,5
RJ=J
RK=K
RM=M
RN=N
   CALCULATE THE NORMAL MODE
   EQUATION 4
   CX1 = 1.5056*PI*X/PL
   CY1 = 1.5056*PI*Y/B
   CXJ = (RJ+.5)*PI*X/PL
   CXM = (RM+.5)*PI*X/PL
   CYK = (RK+.5)*PI*Y/R
   CYN = (RN+.5)*PI*Y/B
   CHX1 = (EXP(CX1)+EXP(-CX1))/2.
   SHX1 = (EXP(CX1)-EXP(-CX1))/2.
   CHY1 = (EXP(CY1)+EXP(-CY1))/2.
   SHY1 = (EXP(CY1)-EXP(-CY1))/2.
   CHXJ = (EXP(CXJ)+EXP(-CXJ))/2.
   SHXJ = (EXP(CXJ)-EXP(-CXJ))/2.
   CHXM = (EXP(CXM)+EXP(-CXM))/2.
   SHXM = (EXP(CXM)-EXP(-CXM))/2.
   CHYK = (EXP(CYK)+EXP(-CYK))/2.
   SHYK = (EXP(CYK)-EXP(-CYK))/2.
   CHYN = (EXP(CYN)+EXP(-CYN))/2.
   SHYN = (EXP(CYN)-EXP(-CYN))/2.
   IF(J .GT. 1) GO TO 210
   XJ = CHX1-COS(CX1)-.9825*(SHX1-SIN(CX1))
   GO TO 211
  210 XJ = CHXJ-COS(CXJ)-(SHXJ-SIN(CXJ))
  211 IF (K .GT. 1) GO TO 212
      YK = CHY1-COS(CY1)-.9825*(SHY1-SIN(CY1))
      GO TO 213
  212 YK = CHYK-COS(CYK)-(SHYK-SIN(CYK))
  213 IF(M .GT. 1) GO TO 214
      XM = CHX1-COS(CX1)-.9825*(SHX1-SIN(CX1))
      GO TO 215
  214 XM = CHXM-COS(CXM)-(SHXM-SIN(CXM))
  215 IF(N .GT. 1) GO TO 216
      YN = CHY1-COS(CY1)-.9825*(SHY1-SIN(CY1))
      GO TO 217
  216 YN = CHYN-COS(CYN)-(SHYN-SIN(CYN))
  217 FJK = XJ*YK
         FMN = XM*YN
   EQUATION 5
   RMA=RHO*HS*B/PL/4.0
   EQUATION 6
   HJK=ABS(1./((RMA*SQRT((FNW(J,K)*FNW(J,K)-OMEGA*OMEGA)**2
   1.*(2.*CI*FNW(J,K)*OMEGA)**2)))
   HNN=ABS(1./((RMA*SQRT((FNW(M,N)*FNW(M,N)-OMEGA*OMEGA)**2
   1.*(2.*CI*FNW(M,N)*OMEGA)**2)))
   CALCULATE JOINT ACCEPTANCES
   EQUATION 7
   AC=(1.-OMEGA/FNW(J,K)**2)*(1.-OMEGA/FNW(M,N)**2)*4.*CI*CI*OMEGA
   1A**2/(FNW(J,K)*FNW(M,N))
BC = -2.0*(CI*OMEGA/FNW(J,K))*(1.0-(OMEGA/FNW(M,N))**(2)) - CI*OMEGA/FNW(M,N)*(1.0-(OMEGA/FNW(J,K))**(2))
CC = AC*AC + BC*BC
CON1 = (A1*OMEGA*PL/C)*(A1*OMEGA*PL/C)
CON2 = RJ*PI
CON3 = RM*PI
CON6 = CON2 + CON3*((2.0+EXP(-A1*PL*OMEGA/C))**(-1.0)***(J+1)**((-1.0)***(J+1)*((-1.0)**(N+1)))**((CON1 + CON2*CON2) + (CON1 + CON3*CON3))
CON7 = RK*PI
CON8 = RN*PI
IF (J .NE. M) GO TO 46
PJMJ = (A1*PL*OMEGA/C/2.0*(1.0/(CON1 + CON2*CON2) + 1.0/(CON1 + CON3*CON3)) + CON6)
GO TO 47
46 PJMJ = CON6 + RM / (CON1 + CON3*CON3)*((J-M-1.0)/(2.0**(1.0)) + (J-M-1.0)/(2.0*(RM-RJ)) + (J-M-1.0)/(2.0*(RM-RJ))
Go TO 47
47 CON1 = (A2*OMEGA*R/C)*(A2*OMEGA*R/C)
CON6 = CON7 = CON8*2.0*EXP(-A2*R*OMEGA/C)**((-1.0)***(K+1)**((-1.0)***(K+1)*((-1.0)**(N+1)))**((CON1 + CON7*CON7) + (CON1 + CON8*CON8))
IF (K .NE. N) GO TO 48
PJKN = (A2*B*OMEGA/C/2.0*(1.0/(CON1 + CON7*CON7) + 1.0/(CON1 + CON8*CON8)) + CON6)
GO TO 23
48 PJKN = CON6 + RN / (CON1 + CON8*CON8)*((K-N-1.0)/(2.0**(1.0)) + (K-N-1.0)/(2.0*(RN-RK)) + (K-N-1.0)/(2.0*(RN-RK))
Go TO 23
23 POMEG = OMEGA/(2.0*PI)
PQWJ2 = PJMJ*PJKN*AC/SQRT(CC)
PIW = PQWJ*PJKN*FMN*HMN*POWJ2
IF (POMEG .GT. 5.0) GO TO 22
WRITE (3) POMEG, J, K, M, N, PQWJ2
ICT = ICT + 1
Go TO 22
CONTINUE
OME(
C CALCULATE DISPLACEMENT, STRESS, AND ACCELERATION
C EQUATIONS 8, 13, 14, 16, AND 17
PIWW = PIWW + SS*PIPP
SWW(I) = PIWW + SS*PIWW
PIWG = OMEGA**4*PIWW
PIWG1(I) = 4.215093E-05*PIWG
PSS = GAM2*PIWW
SSSF(I) = 2.0*PI*PIWW
C EQUATION 12A
SPPP(I) = 2.0*PI*PIPP
IF (IC .NE. 1) GO TO 41
C MEAN SQUARE EQUATIONS
Q1 = OMEG(I)
Q2 = PIWG1(I)
Q3 = PIWG1(I)
Q4 = SPPP(I)
ATS1 = 0.0
ATS2=0.0
ATS3=0.0
ATS4=0.0
IC=2
GO TO 21

ATS1=ATS1+(G1+SWW(I))/2.*(OMEG(I)-Fi)
ATS2=ATS2+(G2+SSSF(I))/2.*(OMEG(I)-Fi)
ATS3=ATS3+(G3+PIWG1(I))/2.*(OMEG(I)-Fi)
ATS4=ATS4+(G4+SPPP(I))/2.*(OMEG(I)-Fi)

C

ROOT-MEAN SQUARE EQUATIONS

F1=OMEG(I)
G1=SWW(I)
G2=SSSF(I)
G3=PIWG1(I)
G4=SPPP(I)

IF(SWW(I),LT. SWMI) SWMI=SWW(I)
IF(SWW(I),GT. SWMX) SWMX=SWW(I)
IF(SSSF(I),LT. SSMI) SSMI=SSSF(I)
IF(SSSF(I),GT. SSMM) SSMM=SSSF(I)
IF(PIWG1(I),LT. PIMI) PIMI=PIWG1(I)
IF(PIWG1(I),GT. PIMX) PIMX=PIWG1(I)

DSW = SWMX/1.E9
DSS = SSMM/1.E9
DPI = PIMX/1.E9

OMEGA = OMEGA* CON

21 CONTINUE

KM=I
GO TO 98

99 KM=I+1

C EQUATION 12B

98 PAS=ATS4
AT1=SORT(ATS1)
AT2=SORT(ATS2)
AT3=SORT(ATS3)
AT4=SORT(ATS4)

PA=AT4
RLA=170.576+10.*ALOG10(PAS)
END FILE 3
REWRIND 3
CALL PRNT
IF(DSW .LE. SWMI) GO TO 302
DO 301 I=1,KM
IF(SWW(I),LT. DSW) SWW(I)=DSW
301 CONTINUE
302 IF(DSS .LE. SSMI) GO TO 304
DO 303 I=1,KM
IF(SSSF(I),LT. DSS) SSSF(I)=DSS
303 CONTINUE
304 IF(DPI .LE. PIMI) GO TO 306
DO 305 I=1,KM
IF(PIWG1(I),LT. DPI) PIWG1(I)=DPI
305 CONTINUE

C PLOT EXCITATION, DISPLACEMENT, STRESS, AND ACCELERATION

306 CALL SCOUTV
CALL QUIK3V(-1,44,BCDX,BCDY1,-N3R,F3RD,SPPF)
WRITE (16,109) RLA
CALL SMXYV(1,1)
CALL GUIK3V(-1,44,BCDX,BCDY2,-KM,OMEG,SWW)
WRITE (16,106) ATI,FINN
CALL GUIK3V(-1,44,BCDX,BCDY3,-KM,OMEG,SSSF)
WRITE (16,106) AT2,FINN
CALL GUIK3V(-1,44,BCDX,BCDY4,-KM,OMEG,PIWG1)
WRITE (16,106) AT3,FINN
CALL GUIK3V(-1,44,BCDX,BCDY4,-KM,OMEG,SPPP)
WRITE (16,107) PA
CALL CLEAN
106 FORMAT(11X,31H ROOT-MEAN-SQUARE RESPONSE = E15.7,5X,6HFINN =
1F6.2,10X,6HRFRPC1 )
107 FORMAT(11X,30H ROOT-MEAN-SQUARE PRESSURE = ,E15.7)
108 FORMAT(94H DYNAMIC RESPONSE OF FOUR-SIDE FIXED RECTANGULAR SHELL PANELS CROSS-REINFORCED WITH STIFFENERS)
109 FORMAT(11X,24HOVERALL PRESSURE LEVEL = E15.7,8HDECIBELS)
RETURN
END

$ORIGIN A
$IBFTC RSF1
SUBROUTINE RSF
C PROGRAM NUMBER R23-1002-7A
C RSFRPI
C DYNAMIC RESPONSE OF TWO-OPPOSITE-SIDE SIMPLY-SUPPORTED
C AND OTHER TWO SIDES FIXED RECTANGULAR SHELL PANELS
C UNDER RANDOM PRESSURE FIELD
C INPUT PARAMETERS
C PL = PANEL LENGTH
C B = PANEL WIDTH
C RHO = MASS DENSITY OF PANEL
C HS = PANEL THICKNESS
C CI = DAMPING RATIO
C X = COORDINATE OF VECTOR R
C Y = COORDINATE OF VECTOR R
C FINN = CONSTANT TO DETERMINE OCTAVE BAND CENTER FREQUENCIES
C A1 = CONSTANT
C C = SPEED OF SOUND
C BP = LENGTH OF PANEL UNDER EXCITATION
C PLP = WIDTH OF PANEL UNDER EXCITATION
C F3RD = ONE-THIRD OCTAVE BAND CENTER FREQUENCY
C S3RD = SOUND PRESSURE LEVEL
DIMENSION FNW(IOIOhF3RD(40),S3RD(40),BCDX(12),BCDY(12)
DIMENSION FIPW(40),SPPF(40),OMEG(400),PIWG1(400),BCDY1(12)
DIMENSION BCDY2(12),SWW(400),SSSF(400),BCDY3(12),BCDY4(12)
DIMENSION SPPP(400)
COMMON /OUTPUT/ FNW,F3RD,S3RD,FIPW,SPPF,OMEG,PIWG1,SWW,
1 SSSF,SPPP,N3R,KM,JK,ICT,PAS,ATS1,ATS2,ATS3,AT1,AT2,AT3,
2RX,OY,QW,GAM2,IRD)
COMMON /INPUT/ PL,B,RHO,HS,CI,X,Y,FINN,A1,C,PLP,BP,
1A2,E,EP,VIP,AL1,AL2,H2,HP,RAD,RHOP,RLA
DATA BCDX/72HFREQUENCY (HZ)
1 /
DATA BCDY/72HACCELERATION G SG/HZ
1 /
DATA BCDY2/72HDISPLACEMENT INCH SQ/HERTZ
1
DATA BCDY3/72HSTRESS SPECTRAL DENSITY PSI SQ/HERTZ
1
DATA BCDY1/72HSPFF DR/HZ
1
DATA BCDY4/72HSPECTRAL DENSITY PSI SQ/HERTZ
1
WRITE (6,108)
SWM= 1.0E10
SWMX= 1.0E-10
SSM= 1.0E10
SSMX= 1.0E-10
PIM= 1.0E10
PIMX= 1.0E-10
REWIND 3
JK=2
ICT=0
PI=3.1415927
CALL CAMRAY(9)
CALL SMXYV(1,0)
C CALCULATE EXCITATION SPECTRAL DENSITY
C EQUATIONS 11 AND 12
DO 9 I=1,N3R
SPPF(I)=S3RD(I)-10.0*ALOG10(0.2315*F3RD(I))
FIPW(I)=1./(2.0*PI)*10.0*(SPPF(I)-170.576)/10.0
CONTINUE
C CALCULATE NATURAL FREQUENCIES
C EQUATIONS 1 AND 2
HC=E*HS*HS/(12.0*(1.0-VIP**2))
DY=HC+EP*A1Z/AL1
DX=HC+EP*A11/BL1
BM = RH0*HS*RH0*HP
FCON = PI*PI/SQRT(BM)
DO 20 J=1,9
DO 20 K=1,9
RJ = J
RK = K
IF(J .NE. 1 ,AND, K .NE. 1) GO TO 18
IF(J .EQ. 1 ,AND, K .NE. 1) GO TO 16
IF(J .NE. 1 ,AND, K .EQ. 1) GO TO 17
FHZ = DX*(1./PL)**4+DY*(1.5056/8)**4+2.*(HC/(1./PL)**(1./PL)**
1*(1.1165/B)**(1.1165/B)*E*HS/(RAD*RAD*(PI)**4*(1. + (1./1.5056)**(1./
21.5056)*)*(PL/B)*(PL/B))**2)
GO TO 19
16 FHZ = DX*(1./PL)**4+DY*((RK+.5)/B)**4
1+2.*HC*(1./PL)**2*(((RK+.5)*(RK+.5)=-.6366))/(B*B))
2*E*HS/(RAD*RAD*(PI)**4*(1. + (1./(RK+.5)))**2*(PL/B)*(PL/B))**2)
GO TO 19
17 FHZ = DX*(RJ /PL)**4+DY*(1.5056/B)**4
1+2.*HC*(RJ/PL**(RJ/PL)**(1.1165/B)**(1.1165/B)
2*E*HS/(RAD*RAD*(PI)**4*(1. + (RJ/1.5056)**(1.5056)**2*(PL/B)*(PL/B))**2)
GO TO 19
18 FHZ = DX*(RJ /PL)**4+DY*(1.5056/B)**4
1+2.*HC*(RJ/PL**(RJ/PL)**(1.5056)**2*(PL/B)*(PL/B))**2)
GO TO 19
52
\[2 + E \times HS/\{(RAD) \times (RAD) \times (PI) \times 4 \times (1 + (RJ)/(RK + 0.5))\} \times 2\]

\[3 \times (PL/B) \times (PL/B) \times + 2\]

\[19 \text{ FNW(J,K) = FCON} \text{ SQR}(FHZ)\]

\[20 \text{ CONTINUE}\]

C CALCULATE CONSTANT TO CHANGE DISPLACEMENT INTO STRESS

C EQUATION 16
QX=0,0
QY=0,0
QW=0,0
S=BP*PLP
DO 49 IJ=1,5,2
DO 49 IK=t,5,2
RM=IJ
RN=IK
FSIN=SIN(RM*PI*X/PL5*SIN(RN*PI*Y/R)
OCON=RM*RN*(DY*(RM/PLI**4+2*HC*(RM*RN/(PL*Bll**2+DY*(RN/B)**4)
QX=OX*[((RM*PI/PL)**?*VIP*(RN*PI/B)**2)*(FSIN/OCON)
QY=OY*(((RN*PI/B)**2+VIP*(RM*PI/PL)**2)*(FSIN/OCON)
QW=QW+FSIN/OCON
H1=HS+H2
GAM2=F*HI*H*E/(4.4eI.-VIP*VIP)**2)*(QX*eX+QY*Oy)/(OW*oW))

C CALCULATE EXCITATION PRESSURE FROM ONE-THIRD OCTAVE DATA

C EQUATION 3
DO 22 J=1,5
DO 22 K=1,5
DO 22 M=1,5
DO 22 N=1,5
RJ=J
RK=K
RM=M
RN=N

C CALCULATE THE NORMAL MODE

C EQUATION 4
XJ=SIN(RJ*PI*X/PL)
XM=SIN(RM*PI*X/PL)
CY1 = 1.5056*PI*Y/8
CYK = (RK+.5)*PI*Y/R
$\text{CHY}_1 = (\exp(CY_1) + \exp(-CY_1))/2.$
$\text{SHY}_1 = (\exp(CY_1) - \exp(-CY_1))/2.$
$\text{CHY}_K = (\exp(CY_K) + \exp(-CY_K))/2.$
$\text{SHY}_K = (\exp(CY_K) - \exp(-CY_K))/2.$

211 IF (K .GT. 1) GO TO 212

212 YK = $\text{CHY}_1 \cdot \cos(CY_1) - 9.825 \cdot (\text{SHY}_1 \cdot \sin(CY_1))$

GO TO 215

215 YN = $\text{CHY}_1 \cdot \cos(CY_1) - 9.825 \cdot (\text{SHY}_1 \cdot \sin(CY_1))$

GO TO 217

216 YN = $\text{CHY}_N \cdot \cos(CY_N) - (\text{SHY}_N \cdot \sin(CY_N))$

217 FJK = $\text{XJ}^* \cdot \text{YK}$

C EQUATION 5

RMA = $\rho \cdot H_S \cdot B \cdot PL / 4.0$

C EQUATION 6

HJK = $\text{ABS}(1, / (\text{RMA} \cdot \text{SORT}(\text{FNW}(J, K) \cdot \text{FNW}(J, K) - \Omega_E \cdot \Omega_E)^{**2}$
$+ (2. * CI \cdot \text{FNW}(J, K) \cdot \Omega_E)^{**2}))$

HNN = $\text{ABS}(1, / (\text{RMA} \cdot \text{SORT}(\text{FNW}(M, N) \cdot \text{FNW}(M, N) - \Omega_E \cdot \Omega_E)^{**2}$
$+ (2. * CI \cdot \text{FNW}(M, N) \cdot \Omega_E)^{**2})$

C CALCULATE JOINT ACCEPTANCES

C EQUATION 7

AC = $(1. - (\Omega_E / \text{FNW}(J, K))^{**2}) \cdot (1. - (\Omega_E / \text{FNW}(M, N))^{**2}) + 4. * CI \cdot CI \cdot \Omega_E$

1 + $(2. \cdot CI \cdot \text{FNW}(J, K) \cdot \Omega_E)^{**2})$

BC = $-2. * (CI \cdot \Omega_E / \text{FNW}(J, K)) \cdot (1. - (\Omega_E / \text{FNW}(M, N))^{**2}) - CI \cdot \Omega_E /$

1 + $(2. \cdot CI \cdot \text{FNW}(M, N) \cdot \Omega_E)^{**2})$

CC = AC + BC

CON1 = RJ * PI

CON3 = RM * PI

CON6 = CON2 * CON3 * ((2. * EXP(-A1 * PI * OMEGA / C)) / ((CON1 + CON2 + CON2) * (CON1 + CON3 + CON3)))

CON7 = RK * PI

CON8 = RN * PI

IF (J .NE. M) GO TO 46

PJYM = $(A1 \cdot PI \cdot OMEGA / C) / 2. * (1. / (CON1 + CON2 + CON2) +$

11. / (CON1 + CON3 + CON3) + CON6)

GO TO 47

46 PJYM = CON6 + RM / (CON1 + CON3 + CON3) * ((-1.)*((J-M)-1.)/(2. *$

1*(RJ-RM))+((-1.)*((J+M)-1.)/(2. *(RJ+RM)))) -

2 * RJ / (CON1 + CON2 + CON2) * ((-1.)*((M-J)-1.)/(2. *(RM-RJ)) +$

3 + ((-1.)*((M+J)-1.)/(2. *(RM+RJ)))

47 CON1 = $(A2 \cdot OMEGA \cdot R / C) \cdot (A2 \cdot OMEGA \cdot R / C) /$

CON6 * CON7 + CON8 * ((2. * EXP(-A2 * B * OMEGA / C)) / ((CON1 + CON7 + CON7) * (CON1 + CON8 + CON8)))

IF (K .NE. N) GO TO 48

PJKN = $(A2 * B \cdot OMEGA / C) / 2. * (1. / (CON1 + CON7 + CON7) *$

11. / (CON1 + CON8 + CON8) + CON6)

GO TO 23

48 PJKN = CON6 + RN / (CON1 + CON6 + CON8) * ((-1.)*((K-N)-1.)/(2. *$

1*(RK-RN))+((-1.)*((K+N)-1.)/(2. *(RK+RN)))$
2 *RK /(CON1+CON7*CON7)*((-1.)*(N-K)-1.)/(2.*(RN-RK))
3+((-1.)**(N+K)-1.)/(2.*(RN+RK))
23 POME =OMEGA/(2.*PI)
POWJ =PJ*M+PK/N*SQRT(CC)
PIWW =PIWW*FJK*FMN*HJK*HMN*POWJ
IF (POME < GT.5.) GO TO 22
WRITE (3) POME ,J,K,M,N,POWJ
22 CONTINUE
OMEG(I)=OMEGA/(2.*PI)
C CALCULATE DISPLACEMENT, STRFSS, AND ACCELERATION
C EQUATIONS 8, 13, 14, 16, AND 17
PIWW =PIWW*5.*S*PIPB
SWW(I)=PIWW*2.*PI
PIWG =OMEGA**4.*PIWW
PIWG(I)=4.2150Q3F-d5*PIWG
PSW =OMEGA**2.*PIWW
SSSF(I)=2.*,PI*PSW
SPPP(I)=2.*,PI*PIPB
IF (IC .NE. I) GO TO 41
C MEAN SQUARE EQUATIONS
F1=OMEG(I)
G1=SWW(I)
G2=SSSF(I)
G3=PIWG(I)
G4=SPPP(I)
ATS1=0,0
ATS2=0,0
ATS3=0,0
ATS4=0,0
IC=2
GO TO 21
41 ATS1=ATS1+(G1+SWW(I))/2.*(OMEG(I)-F1)
ATS2=ATS2+(G2+SSSF(I))/2.*(OMEG(I)-F1)
ATS3=ATS3+(G3+PIWG(I))/2.*(OMEG(I)-F1)
ATS4=ATS4+(G4+SPPP(I))/2.*(OMEG(I)-F1)
C ROOT-MEAN SQUARE EQUATIONS
F1=OMEG(I)
G1=SWW(I)
G2=SSSF(I)
G3=PIWG(I)
G4=SPPP(I)
IF(SWW(I),LT,SWM) SWM=SWW(I)
IF(SWW(I),GT,SMX) SMX=SWW(I)
IF(SSSF(I),LT,SMI)SMI=SSSF(I)
IF(SSSF(I),GT,SMX)SMX=SSSF(I)
IF(PIWG(I),LT,PIM) PIM=PIWG(I)
IF(PIWG(I),GT,PIMX) PIMX=PIWG(I)
OMEGA=OMEGA*CON
21 CONTINUE
KM=I
GO TO 98
99 KM=I-1
98 PAX=ATS4
AT1=SORT(ATS1)
AT2=SQRT(AT4)
AT3=SQRT(AT5)
AT4=SQRT(AT6)
PA=AT4
RLA=170.576*10. ALOG10(PAS)
END FILE
REWIND 3
CALL PRNT
DSW = SWMX/1,E9
DSS = SSSM/1,E9
DPI = PIMX/1,E9
DO 301 I=1,KM
IF(SWW(I),LT, DSW) SWW(I)=DSW
IF(SSSF(I),LT, DSS) SSSF(I)=DSS
IF(PIWGI(I),LT, DPI) PIWG(I)=DPI
CONTINUE
C PLOT EXCITATION, DISPLACEMENT, STRESS, AND ACCELERATION
CALL QUIK3V(-1,44,BCDX,RCDY1,-N3R,F3RD,SPPF)
WRITE (16,109) RLA
CALL SMXYV(I,1,1)
CALL QUIK3V(-1,44,BCDX,RCDY2,-KM,OMEG,SWW)
WRITE (16,106) AT1,FINN
CALL QUIK3V(-1,44,BCDX,RCDY3,-KM,OMEG,SSSF)
WRITE (16,106) AT2,FINN
CALL QUIK3V(-1,44,BCDX,RCDY4,-KM,OMEG,PIWG1)
WRITE (16,106) AT3,FINN
CALL QUIK3V(-1,44,BCDX,RCDY4,-KM,OMEG,SPPF)
WRITE (16,106) PA
CALL CLEAN
106 FORMAT(11X,31H ROOT-MEAN-SQUARE RESPONSE = E15.7,5X,6HFINN = 
1F6.2,10X,6HFRSPF1 )
107 FORMAT(11X,30H ROOT-MEAN-SQUARE PRESSURE =,E15.7)
108 FORMAT(107H1D)DYNAMIC RESPONSE OF TWO-OPPPOSITE-SIDE SIMPLY-SUPPORTED 
1 AND OTHER TWO SIDES FIXED RECTANGULAR SHELL PANELS,,/
228H UNDER RANDOM PRESSURE FIELD)
109 FORMAT(11X,24H OVERALL PRESSURE LEVEL = E15.7,8HDECIRELS)
RETURN
END
$DATA
4 31
47.50 58.375 .000251 .1
9, .04 .23.75 29.1875 30.0
10, 13500. .45, 50.
0, 10000000. 12000000. .3
11, 14.6 .5
1, 12.9 .12 100. .00026
5.0 129.0 6.3 131.0 8.0 133.0 10.0 135.0
12.5 136.5 16.0 138.0 20.0 139.0 25.0 140.5
31.5 142.0 40.0 143.0 50.0 144.0 63.0 145.0
80.0 145.5 100.0 146.0 125.0 146.5 160.0 146.5
200.0 147.0 250.0 147.0 315.0 146.0 400.0 145.5
500.0 145.5 630.0 144.0 800.0 142.5 1000.0 141.0
1250.0 139.5 1600.0 137.5 2000.0 136.0 2500.0 134.5
3150. 133. 4000. 131. 5000. 129.5
56
I. METHODS OF VERIFICATION

Comparison of the computed results with experimental data is the best verification. Verification can also be obtained by hand calculation of the responses according to the simple formulas by assuming the structure vibrates in its fundamental mode.

The root-mean-square responses are computed, printed, and plotted out as output. Good engineering judgement on these rms responses may also serve as a check of the results.
SECTION III. DECK SET-UP

A. Computer Configuration

1. Computer IBM 7094
2. Core Size 32K
3. Language FORTRAN IV
4. Operating System IBSYS
5. Plotter Required SC4020
6. Punch NO
7. Tape Assignments

<table>
<thead>
<tr>
<th>Physical Unit</th>
<th>Logical Unit</th>
<th>System Function</th>
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</thead>
<tbody>
<tr>
<td>A2</td>
<td>5</td>
<td>Input</td>
</tr>
<tr>
<td>A4</td>
<td>3</td>
<td>System Scratch</td>
</tr>
<tr>
<td>A8</td>
<td></td>
<td>SC 4020 Output</td>
</tr>
<tr>
<td>B3</td>
<td>2</td>
<td>Print Output</td>
</tr>
<tr>
<td>B3</td>
<td></td>
<td>System Scratch Overlay</td>
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</tbody>
</table>

B. Estimated Running Time

Execution time is approximately 55 minutes for all three boundary conditions, for frequency range 5 to 5000 Hertz, and frequency increment FINN = 33.

C. Restart Procedure

None

D. Deck Sequence

1. $JOB CARD
2. $EXECUTE CARD
3. $IBJOB CARD
4. $IBFTC CARD
5. SOURCE DECK (RANDOM)
6. $IBFTC CARD
7. SOURCE DECK (SUBROUTINE PRNT)
8. $IBFTC CARD
9. SOURCE DECK (SUBROUTINE GRIDIV)
10. $ORIGIN CARD
11. $IBFTC CARD
12. SOURCE DECK (SUBROUTINE RSR)
13. $ORIGIN CARD
14. $IBFTC CARD
15. SOURCE DECK (SUBROUTINE RFR)
16. $ORIGIN CARD
17. $IBFTC CARD
18. SOURCE DECK (SUBROUTINE RSF)
19. $DATA CARD
20. DATA DECK
E. INPUT DATA

Refer to Figure 1 for geometric dimensions.

<table>
<thead>
<tr>
<th>NOTATION</th>
<th>DEFINITION</th>
<th>CARD</th>
</tr>
</thead>
<tbody>
<tr>
<td>FORMULAS</td>
<td>MNEMONICS</td>
<td>NO.</td>
</tr>
</tbody>
</table>
| NP       | Program desired - NP = 1 (RSR)  
NP = 2 (RFR), NP = 3 (RSF),  
NP = 4 (ALL) | 1    | I5    | Col. 5 |
| N3R      | Number of data points in the one-
third octave band excitation spectrum | 1    | I5    | Col. 6-10 Right Justified |
| l        | PL        | Axial length of panel (inches)  
(Along x-axis) | 2    | E15.8 | Col. 1-15 |
| b        | B         | Width of Panel (inches)  
(Along y-axis) | 2    | E15.8 | Col. 16-30 |
| p        | RHO       | Mass density of panel skin  
(lbf·sec²/in⁴) | 2    | E15.8 | Col. 31-45 |
| h        | HS        | Thickness of panel skin (inches) | 2    | E15.8 | Col. 46-60 |
| ξ_{jk}   | CI        | Damping ratio of panel | 3    | E15.8 | Col. 1-15 |
| x        | X         | Coordinate of \( r \) (inches) | 3    | E15.8 | Col. 16-30 |
| y        | Y         | Coordinate of \( r \) (inches) | 3    | E15.8 | Col. 31-45 |
| n        | FINN      | One-nth octave frequency increment | 3    | E15.8 | Col. 46-60 |
| A_{1}    | Al        | Correlation decay constant in  
axial length-direction | 4    | E15.8 | Col. 1-15 |
| c        | C         | Speed of sound (in/sec) | 4    | E15.8 | Col. 16-30 |
| l'       | PLP       | Length of panel subjected to  
excitation (inches) | 4    | E15.8 | Col. 31-45 |
| b'       | BP        | Width of panel subjected to  
excitation (inches) | 4    | E15.8 | Col. 46-60 |
E. INPUT DATA (Continued)

<table>
<thead>
<tr>
<th>NOTATION</th>
<th>DEFINITION</th>
<th>CARD</th>
</tr>
</thead>
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<td><strong>FORMULAS</strong></td>
<td><strong>MNEMONICS</strong></td>
<td><strong>NO.</strong></td>
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<tr>
<td>$A_2$</td>
<td>A2</td>
<td>Correlation decay constant in circumferential width-direction</td>
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<tr>
<td>$E$</td>
<td>E</td>
<td>Young's modulus of panel skin (lbf/in²)</td>
</tr>
<tr>
<td>$E'$</td>
<td>EP</td>
<td>Young's modulus of stiffeners (lbf/in²)</td>
</tr>
<tr>
<td>$\nu$</td>
<td>VIP</td>
<td>Poisson's ratio of panel skin</td>
</tr>
<tr>
<td>$a_1$</td>
<td>AL1</td>
<td>Spacing of width-direction stiffeners (inches)</td>
</tr>
<tr>
<td>$b_1$</td>
<td>BL1</td>
<td>Spacing of length-direction stiffeners (inches)</td>
</tr>
<tr>
<td>$I_1$</td>
<td>AI1</td>
<td>Moment of inertia of one length-direction stiffener with respect to neutral axis (inch⁴)</td>
</tr>
<tr>
<td>$I_2$</td>
<td>AI2</td>
<td>Moment of inertia of one width-direction stiffener with respect to neutral axis (inch⁴)</td>
</tr>
<tr>
<td>$h_2$</td>
<td>H2</td>
<td>Largest height of stiffeners at point investigated (inches)</td>
</tr>
<tr>
<td>$h'$</td>
<td>HP</td>
<td>Smeared-out thickness of stiffeners (inches)</td>
</tr>
<tr>
<td>$a$</td>
<td>RAD</td>
<td>Radius of panel (inches)</td>
</tr>
<tr>
<td>$\rho$</td>
<td>RHOP</td>
<td>Mass density of stiffeners (lbf·sec²/in⁴)</td>
</tr>
<tr>
<td>$f$</td>
<td>F3RD</td>
<td>Frequencies (Hertz)</td>
</tr>
<tr>
<td>$S_{3r}(I)$</td>
<td>S3RD</td>
<td>One-third octave pressure level spectrum of excitation (decibels) Per Card</td>
</tr>
</tbody>
</table>

Use as many cards as necessary for F3RD and S3RD

61
F. **Restrictions and Limitations**

\[ N3R \leq 40 \]

\[ \text{FINN} \leq 38 \]

G. **Diagnostics**

None

H. **Quantity of Output**

For case with frequency range of 5-5000 Hertz and frequency increment \( \text{FINN} = 33 \), the printed output will be 20 pages per boundary condition. Plots will be 5 per boundary condition.
### I. Output Definitions

<table>
<thead>
<tr>
<th>NOTATION</th>
<th>DEFINITION</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \ell )</td>
<td>Axial length of panel (inches)</td>
</tr>
<tr>
<td>( b )</td>
<td>Width of panel (inches)</td>
</tr>
<tr>
<td>( \rho )</td>
<td>Mass density of panel skin ((\text{lbf-sec}^2/\text{in}^4))</td>
</tr>
<tr>
<td>( h )</td>
<td>Thickness of panel skin (inches)</td>
</tr>
<tr>
<td>( \zeta_{jk} )</td>
<td>Damping ratio of panel</td>
</tr>
<tr>
<td>( x )</td>
<td>Coordinate of ( r ) (inches)</td>
</tr>
<tr>
<td>( y )</td>
<td>Coordinate of ( \hat{r} ) (inches)</td>
</tr>
<tr>
<td>( n )</td>
<td>One-nth octave frequency increment</td>
</tr>
<tr>
<td>( A_1 )</td>
<td>Correlation decay constant in axial length-direction</td>
</tr>
<tr>
<td>( c )</td>
<td>Speed of sound ((\text{in/sec}))</td>
</tr>
<tr>
<td>( \ell' )</td>
<td>Length of panel subjected to excitation (inches)</td>
</tr>
<tr>
<td>( b' )</td>
<td>Width of panel subjected to excitation (inches)</td>
</tr>
<tr>
<td>( A_2 )</td>
<td>Correlation decay constant in circumferential width-direction</td>
</tr>
<tr>
<td>( E )</td>
<td>Young's modulus of panel skin ((\text{lbf/in}^2))</td>
</tr>
<tr>
<td>( E' )</td>
<td>Young's modulus of stiffeners ((\text{lbf/in}^2))</td>
</tr>
<tr>
<td>( \nu )</td>
<td>Poisson's ratio of panel skin</td>
</tr>
<tr>
<td>( a_1 )</td>
<td>Spacing of width-direction stiffeners (inches)</td>
</tr>
<tr>
<td>( b_1 )</td>
<td>Spacing of length-direction stiffeners (inches)</td>
</tr>
<tr>
<td>( I_1 )</td>
<td>Moment of inertia of one length-direction with respect to neutral axis ((\text{inch}^4))</td>
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### I. Output Definitions (Continued)

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<th>DEFINITION</th>
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<tbody>
<tr>
<td>( I_2 )</td>
<td>Moment of inertia of one width-direction stiffener with respect to neutral axis (inch^4)</td>
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<tr>
<td>( h_2 )</td>
<td>Largest height of stiffeners at point investigated (inches)</td>
</tr>
<tr>
<td>( h' )</td>
<td>Smeared-out thickness of stiffeners (inches)</td>
</tr>
<tr>
<td>( a )</td>
<td>Radius of panel (inches)</td>
</tr>
<tr>
<td>( \rho' )</td>
<td>Mass density of stiffeners (lbf·sec^2/in.4)</td>
</tr>
<tr>
<td>( f )</td>
<td>Frequencies (Hertz)</td>
</tr>
<tr>
<td>( S_{3r}(f) )</td>
<td>One-third octave pressure level spectrum of excitation (decibels)</td>
</tr>
<tr>
<td>( S_{pp}(f) )</td>
<td>Excitation spectral density (db/Hz)</td>
</tr>
<tr>
<td>( \phi_{pp}(\omega) )</td>
<td>Excitation spectral density (psi^2/rad/sec)</td>
</tr>
<tr>
<td>( J )</td>
<td>Mode</td>
</tr>
<tr>
<td>( k )</td>
<td>Point</td>
</tr>
<tr>
<td>( f )</td>
<td>Natural frequencies (Hz)</td>
</tr>
<tr>
<td>( \omega_{jk} )</td>
<td>Natural frequencies (rad/sec)</td>
</tr>
<tr>
<td>( f )</td>
<td>Frequency (independent variable) (Hz)</td>
</tr>
<tr>
<td>( S_{ww}(r,f) )</td>
<td>Displacement spectral density (inch^2/Hz)</td>
</tr>
<tr>
<td>( S_{ss}(r,f) )</td>
<td>Stress spectral density (psi^2/Hz)</td>
</tr>
<tr>
<td>( S_{ww}(r,f) )</td>
<td>Acceleration spectral density (g^2/Hz)</td>
</tr>
<tr>
<td>( S_{pp}(f) )</td>
<td>Excitation spectral density (psi^2/rad/sec)</td>
</tr>
<tr>
<td>( w^2(r) )</td>
<td>Mean square displacement (inch^2)</td>
</tr>
<tr>
<td>( \sigma^2(r) )</td>
<td>Mean square stress (psi)^2</td>
</tr>
<tr>
<td>( G^2(r) )</td>
<td>Mean square acceleration (g^2)</td>
</tr>
<tr>
<td>( w(r) )</td>
<td>Root-mean square displacement (inch)</td>
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</table>
## I. Output Definitions (Continued)

<table>
<thead>
<tr>
<th>FORMULAS</th>
<th>MNEMONICS</th>
<th>DEFINITION</th>
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<tbody>
<tr>
<td>$\sigma(r)$</td>
<td>AT2</td>
<td>Root-mean square stress (psi)</td>
</tr>
<tr>
<td>$G(r)$</td>
<td>AT3</td>
<td>Root-mean square acceleration (g)</td>
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<tr>
<td>$Q_x$</td>
<td>QX</td>
<td>Quantity for the calculation of $\gamma^2$</td>
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<tr>
<td>$Q_y$</td>
<td>QY</td>
<td>Quantity for the calculation of $\gamma^2$</td>
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<tr>
<td>$Q_w$</td>
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<td>Quantity for the calculation of $\gamma^2$</td>
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<tr>
<td>$\gamma^2(r)$</td>
<td>GAM2</td>
<td>Constant to change displacement spectral density into stress</td>
</tr>
<tr>
<td>$j, k, m, n$</td>
<td>J,K,M,N</td>
<td>Mode Indices</td>
</tr>
<tr>
<td>$J_{jkmn}^2$</td>
<td>POWJ2</td>
<td>Joint acceptance squared</td>
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### J. Operator Instruction Card

**7094- INSTRUCTIONS**

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<th>STACK</th>
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</table>

**IF EXCEEDS MAX**

- FAST TAPES A B C D

**INPUT TAPES**

- J8006
- J8016
- J8026
- J8046

**WORK TAPES**

- LOGIC REEL NO DEN
- LOGIC

**LINES OF OUTPUT (1000's)**

- MAXIMUM TIME
- HOURS MINUTES

**PROGRAMMER COMMENTS**

**NUMBER OF CASES**

**OPERATOR COMMENTS**

- MAX EXCEEDED
- RETURN TO SYS
- LINE MAX

**OUTPUT TAPES ONLY**

<table>
<thead>
<tr>
<th>REEL NO</th>
<th>LOGIC</th>
<th>DEN</th>
<th>UNIT NO OF CPYS</th>
<th>SAVE TAPE</th>
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<tbody>
<tr>
<td>B-1</td>
<td>B</td>
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<tr>
<td>A-8</td>
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**NO FILES**

- NO FRAMES

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<th>DENSITY</th>
<th>COPY FLO</th>
<th>KALVAR</th>
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<tbody>
<tr>
<td>P</td>
<td>F</td>
<td>5</td>
<td>B</td>
</tr>
<tr>
<td>P</td>
<td>F</td>
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MSFC - Form 533 (Rev February 1966)
K. **Save Labels**

None
**L. INPUT FORM (SAMPLE CASE)**

<table>
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<th>10</th>
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**RMS VALUE**: 0.11197398E-01

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**FINN** = -30.0
N. **Sample Plots**

Figure 2 through 4 are three sample plots of this program.
Figure 1. Geometry of rectangular cylindrical shell panel cross-reinforced with stiffeners.
FIGURE 2. SAMPLE PLOT: ACCELERATION SPECTRAL DENSITY AT CENTER OF FOUR EDGES SIMPLY-SUPPORTED RECTANGULAR CURVED PANEL CROSS-REINFORCED WITH STIFFENERS
FIGURE 3. SAMPLE PLOT: DISPLACEMENT SPECTRAL DENSITY AT CENTER OF FOUR EDGES CLAMPED RECTANGULAR CURVED PANEL CROSS-REINFORCED WITH STIFFENERS
FIGURE 4. SAMPLE PLOT: STRESS SPECTRAL DENSITY AT CENTER OF TWO OPPOSITE EDGES SIMPLY-SUPPORTED WHILE OTHER TWO CLAMPED RECTANGULAR CURVED PANEL CROSS-REINFORCED WITH STIFFENERS
FINAL REPORT

COMPUTER PROGRAMS FOR PREDICTION OF STRUCTURAL VIBRATIONS DUE TO FLUCTUATING PRESSURE ENVIRONMENTS

VOLUME TWO
USERS' MANUAL FOR PROGRAM RANDOM

By Tsin Nien Lee

and James Kermit Moore

Approved: Wayne L. Swanson
Wayne L. Swanson, Supervisor
Vibration and Acoustics Group

George Martin, Manager
Structural Engineering Branch
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