STATISTICAL ENERGY ANALYSIS
COMPUTER PROGRAM
USER'S GUIDE

November 1981
MDC G9915

Prepared by
R. W. Trudell
L. I. Yano

Approved by:
G. E. Kahre, Branch Chief
Vibration, Shock & Acoustics
Design & Technology
Engineering Division

(MCDONNELL DOUGLAS ASTRONAUTICS COMPANY) 118 p

MCDONNELL DOUGLAS ASTRONAUTICS COMPANY - HUNTINGTON BEACH
5301 Bolsa Avenue Huntington Beach, California 92647 (714) 896 3311
The work reported herein was performed for the National Aeronautics and Space Administration's Marshall Space Flight Center under contract NAS8-33191, Supplemental Agreements 2 and 3. This effort involved the development of a computer program to perform Statistical Energy Analysis. This volume constitutes the final deliverable item under the contract. A card deck of the computer program was forwarded previously by MDAC letter A3-130-GWJ-1283.

Programming was accomplished by S. J. Nygaard, McDonnell Douglas Automation Company - Huntington Beach.
## CONTENTS

<table>
<thead>
<tr>
<th>Section</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Section 1</td>
<td>INTRODUCTION</td>
<td>1-1</td>
</tr>
<tr>
<td>Section 2</td>
<td>A SUMMARY OF STATISTICAL ENERGY ANALYSIS PRINCIPLES</td>
<td>2-1</td>
</tr>
<tr>
<td>Section 3</td>
<td>EXAMPLES OF SEA PROGRAM APPLICATIONS</td>
<td>3-1</td>
</tr>
<tr>
<td>Section 4</td>
<td>SEA COMPUTER PROGRAM DESCRIPTION AND USAGE</td>
<td>4-1</td>
</tr>
<tr>
<td></td>
<td>4.1 Subroutine Description</td>
<td>4-1</td>
</tr>
<tr>
<td></td>
<td>4.2 Program Usage</td>
<td>4-6</td>
</tr>
<tr>
<td></td>
<td>4.2.1 Deck Setup and Sequence</td>
<td>4-6</td>
</tr>
<tr>
<td></td>
<td>4.2.2 Input - Drum/Disk</td>
<td>4-7</td>
</tr>
<tr>
<td></td>
<td>4.2.3 Output - Printout</td>
<td>4-13</td>
</tr>
<tr>
<td></td>
<td>4.2.4 Program Diagnostic Messages</td>
<td>4-13</td>
</tr>
<tr>
<td>Section 5</td>
<td>REFERENCES</td>
<td>5-1</td>
</tr>
<tr>
<td>Number</td>
<td>Description</td>
<td>Page</td>
</tr>
<tr>
<td>--------</td>
<td>-----------------------------------------------------------------------------</td>
<td>-------</td>
</tr>
<tr>
<td>3-1</td>
<td>SEA Model Elements for Acoustic Test Configuration</td>
<td>3-3</td>
</tr>
<tr>
<td>3-2</td>
<td>Two-Element SEA Model Example</td>
<td>3-5</td>
</tr>
<tr>
<td>3-3</td>
<td>Card 1, Example Case 1</td>
<td>3-6</td>
</tr>
<tr>
<td>3-4</td>
<td>Card 2, Example Case 1</td>
<td>3-7</td>
</tr>
<tr>
<td>3-5</td>
<td>Card 3, Example Case 1</td>
<td>3-8</td>
</tr>
<tr>
<td>3-6</td>
<td>Card 4, Example Case 1</td>
<td>3-9</td>
</tr>
<tr>
<td>3-7</td>
<td>Card 5, Example Case 1</td>
<td>3-10</td>
</tr>
<tr>
<td>3-8</td>
<td>Card 6, Example Case 1</td>
<td>3-12</td>
</tr>
<tr>
<td>3-9</td>
<td>Card 7, Example Case 1</td>
<td>3-13</td>
</tr>
<tr>
<td>3-10</td>
<td>Card 8, Example Case 1</td>
<td>3-14</td>
</tr>
<tr>
<td>3-11</td>
<td>Two-Element SEA Program Output - External Acoustic Excitation</td>
<td>3-16</td>
</tr>
<tr>
<td>3-12</td>
<td>Internal Acoustic Input Table for Example 1</td>
<td>3-20</td>
</tr>
<tr>
<td>4-1</td>
<td>Loadsheet 1</td>
<td>4-8</td>
</tr>
<tr>
<td>4-2</td>
<td>Loadsheet 2</td>
<td>4-9</td>
</tr>
<tr>
<td>4-3</td>
<td>Loadsheet 3</td>
<td>4-10</td>
</tr>
<tr>
<td>4-4</td>
<td>Loadsheet 4</td>
<td>4-11</td>
</tr>
<tr>
<td>4-5</td>
<td>Loadsheet 5</td>
<td>4-12</td>
</tr>
</tbody>
</table>
### TABLES

<table>
<thead>
<tr>
<th>Number</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>3-1</td>
<td>Two-Element SEA Vibration Prediction - External Acoustic Excitation</td>
<td>3-18</td>
</tr>
<tr>
<td>3-2</td>
<td>Two-Element SEA Vibration Prediction - External and Internal Acoustic Excitation</td>
<td>3-21</td>
</tr>
<tr>
<td>3-3</td>
<td>Sub-Element Breakdown for MEA Test Case</td>
<td>3-22</td>
</tr>
<tr>
<td>3-4</td>
<td>SEA Computer Program Output for MEA/Acoustic Excitation Case</td>
<td>3-23</td>
</tr>
</tbody>
</table>
Section 1
INTRODUCTION

Significant high frequency random vibration environments are generated during the operation of aerospace vehicles within the atmosphere. To achieve optimum vehicle design, vibration and acoustic criteria are developed early in the vehicle development program and are updated periodically as the design matures.

High frequency random vibration response prediction does not lend itself well to classical structural dynamics and such predictions are usually made by extrapolation from existing data banks. This method gives excellent results when similar structures are involved. However, as similarity decreases and associated extrapolations become large, uncertainty over accuracy also increases.

The efforts of numerous investigators (Maidanik, Lyons, et al.) have examined a more general high frequency random vibration analysis approach - the so-called Statistical Energy Analysis method. The SEA method is able to accomplish high frequency prediction of arbitrary structural configurations and is therefore a significant improvement over extrapolation methods when little or no previous data exist. The SEA method also represents a great improvement over normal mode methods for high frequency random vibration prediction because of the greatly reduced computational complexity associated with the more general SEA model elements and the attendant improvement in analysis turnaround time.

SEA has been developed for complex structures by MDAC under contract to MSFC (Ref. 1 and 2) over the past three years. The past year's effort has created a general SEA computer program which is described in this manual. The manual contains (1) a summary of SEA theory, (2) example problems of SEA program application, (3) a description of the computer program, and (4) a complete program listing (Appendices).
Section 2
A SUMMARY OF STATISTICAL ENERGY ANALYSIS PRINCIPLES

Statistical Energy Analysis (SEA) is a powerful tool for estimating the high frequency vibration spectra of complex systems. The analysis method is based on the estimation of the power flow between idealized gross elements of a vibrating system. The method is statistical in that averaging assumptions are made with regard to distribution of energy within an element, distribution of resonant modes, and the coupling between elements. These assumptions greatly simplify the computational complexity associated with normal mode methods. These same assumptions impose the limitation that point response predictions cannot be made.

The assumptions on which the method rests and their implications can be quite rigorously stated as follows:

1. The total vibrating system can be partitioned into SEA elements (with suitable boundary conditions) whose modes approximate the modes of the original vibrating system.

2. The modes of the elements of a system contain all of the vibratory energy of the system.

3. The energy in one frequency band of a system element is equally distributed among the modes of that element occurring in the frequency band.

4. Only modes occurring within the same frequency band are coupled.

5. For two coupled elements, all of the modes occurring in one of the elements in one frequency band are equally coupled to each mode occurring in the same frequency band in the other element.
Assumption 1 contains the fundamental existence basis for SEA: the concept of partitionability. This concept implies that a coupled vibrating system with system modes can be approximated by two or more separately idealized vibrating elements, each with its own independent mode set. These sets are coupled only in the sense of having power flow to and from each set across the partition boundary (later referred to as the "joint"). The approximation to this model exists in most structures having reflective boundaries in the higher frequencies. For example, a skin/stringer structure has higher order skin panel modes that are nearly the same frequency and shape as an ideally supported panel because the stringer is a comparatively massive boundary causing reflection of flexural waves from the skin panel. An SEA plate element could logically be equal to the panel area bounded by stringers or frames. Such elements will then have to be coupled with joint elements in order to develop an SEA model which emulates the vibratory power flow of the real structure.

Assumption 3 is the most important simplifying assumption of SEA because it eliminates the necessity to calculate generalized modal forces and responses. The conditions implicit in this assumption are usually approximated by the higher order modes of a structure in a reasonable bandwidth, say 1/3 octave. One-third octave bands represent a reasonable compromise between the necessity to get a fairly large number of modes (>20) in the band for good statistics and the necessity to have some frequency response resolution in the vibration prediction. The number of modes in a unit bandwidth can be estimated for simple structural forms (such as beams, plates, etc.) using algebraic expressions for modal density such as those given in Section 4 of this report. Estimation of modal density in this way is a considerable simplification over normal mode methods.

Given SEA elements with the properties described above it is now necessary to join them to permit power flow between the modes of one element and the modes of another. This is done with a parameter called the coupling loss factor \( \phi \) and leads to assumptions 4 and 5. Assumption 4 is directly linked to assumption 2 and the further assumption of a linear process. Assumption 5 follows directly from assumption 3 as part of the simplification associated with a statistical rather than explicit description of modes.
With these properties and assumptions we can now write the SEA equation systems as follows:

\[
\begin{bmatrix}
\alpha_{11} & \alpha_{12} & \alpha_{13} & \cdots & \alpha_{1j} \\
\alpha_{21} & \alpha_{22} & \alpha_{23} & \cdots & \alpha_{2j} \\
\alpha_{31} & \alpha_{32} & \alpha_{33} & \cdots & \alpha_{3j} \\
\end{bmatrix}
\begin{bmatrix}
\mathbf{E}_1 \\
\mathbf{E}_2 \\
\mathbf{E}_3 \\
\end{bmatrix} =
\begin{bmatrix}
\mathbf{S}_1 \\
\mathbf{S}_2 \\
\mathbf{S}_3 \\
\end{bmatrix}
\]

(1)

where

\[\alpha_{ij} = \begin{cases} -N_i \phi_{ij} & \text{if } i \neq j \\ \omega_n + \sum_{k=1}^{M} N_k \phi_{ik} & \text{if } i = j \end{cases}\]

\[N_i = \text{number of modes resonant in element } i\]

\[n_i = \text{element } i \text{ loss factor}\]

\[\phi_{ij} = \text{power transfer coefficient for coupling between modes in elements } i \text{ and } j\]

\[\omega = \text{center frequency of bandwidth}\]

\[E_i = m_i \frac{<a_i^2>}{\omega^2} = \text{total energy of element } i, \text{ } <a_i^2> \text{ being the mean square acceleration}\]

\[S_i = \text{external acoustic or mechanical excitation in the bandwidth of interest}\]

Note that the matrix \( \alpha \) is square but not symmetric. The lack of symmetry arises from the nature of the term \(-N_i \phi_{ij}\). Using the first two rows as an example the power balance equations are

\[(\omega_n + \sum_{k=1}^{M} N_k \phi_{1k}) \mathbf{E}_1 - N_1 \phi_{12} \mathbf{E}_2 - N_1 \sum_{k=2}^{M} \phi_{1k} \mathbf{E}_k = S_1\]

\[-N_2 \phi_{12} + (\omega_n + \sum_{k=1}^{M} N_k \phi_{2k}) \mathbf{E}_2 - N_2 \sum_{k=3}^{M} \phi_{1k} \mathbf{E}_k = S_2\]

2-3
Note that the "symmetric" positions $a_{21}$ and $a_{12}$ actually carry the number of modes belonging to the row number only. This unsymmetric form preserves the power flow both to and from each element.

Each equation in the matrix states the following relationship for each element. The net power flow into element $i$ ($S_i$) equals the difference between (1) the power flow dissipated within the element ($\omega_i E_i$) plus the power flow lost to other elements across the joints

$$
E_i = \sum_{k=1}^{M} N_k \phi_{ik}
$$

and (2) the power flow added to element $i$ from all other elements

$$
N_i = \sum_{k=1}^{M} E_k \phi_{ik}, i \neq k
$$

It must be remembered that the coupling term $\phi_{ik}$ has nothing to do with coupling modes; it only relates the fractional amount of energy resident in the modes of element $i$ that flows to the modes of element $k$.

For all but the simplest of systems even the SEA equations can be laborious to evaluate by hand. The computer program described in the following sections performs all of the computations necessary to evaluate terms and solves the above system of equations for element energies and prints the results as vibration PSD or RMS levels for all elements. This program relieves the analyst of the necessity to have an extensive knowledge of how to compute SEA parameters and permits the use of SEA model sizes that would otherwise be intractable. The program is described in detail in Section 2; some SEA modeling examples and corresponding program inputs are described in Section 3.
Section 3
EXAMPLES OF SEA PROGRAM APPLICATIONS

An SEA computer program has been developed that performs the organization of specific problem solutions for up to a 20-element system. A number of different element and joint types are available to describe a wide variety of structural forms in terms of an SEA model. Random acoustic or mechanical excitation can be applied in 1/3 octave bands to any arbitrary number of elements within a given model. The resulting equations are then solved giving the vibration response spectrum for each element. This section illustrates the use of SEA and the computer program with specific examples. The basic analysis procedure is divided into three steps:

1. Idealization
2. Parameter Generation
3. Problem Solution

The idealization step must be performed entirely by the user as it consists of modeling the physical structure in terms of available SEA program elements - a conceptual process. The second step is one of simply providing the proper data to the program which then carries out the third step. These steps will be illustrated below with specific examples, and the SEA program elements will be discussed in detail.

The idealization step is by far the most crucial step in the process. It is here that the art of engineering judgement must reach a well developed state, balancing the realities of the structural article to be analyzed with the capabilities and assumptions implicit in the SEA process to
obtain a useful engineering solution. Consider the model shown in Figure 3-1. This is the basic form of all SEA models. It consists of elements, denoted as boxes, which may be plates, beams, etc., and joints denoted by connecting lines which correspond to the physical interfaces at the selected partitions.

The model shows the articles included in each SEA element and the connection relationships between or among the elements. To gain a better understanding of what these elements and connections are it is helpful to now explain in detail the various types available in the computer program. Each of the elements is made up of one or more sub-elements, the first of which is the main sub-element. The sub-element system provides a convenient way to compute and include the modal density and mass properties of individual structural pieces that make up the element on a piece-by-piece basis. However, the sub-element with the most important property being modelled in that SEA element should always be the first or main sub-element. The joint properties must also be consistent with this sub-element as it is the only one that can be coupled to other SEA main elements. An example is given by element 1 of the model. This element has structure elements exposed to an acoustic field and those that are not. The most important property is the reception of acoustic excitation and transmission of vibration through its boundaries to other main elements. That portion must therefore be sub-element 1.

It is often the case that structures are made of different materials; this condition is taken into account when the program sets up the solution. The program automatically recomputes properties (thickness, density, etc.) to match the elastic modulus of element 1, sub-element 1. Furthermore, only sub-element 1 of each element can receive acoustic excitation; the others contribute only to the modal density and to the element mass. Sub-element 1 will always be used for the structure element that is the main piece of the given SEA element because all other properties except mass and modal density will be those of this sub-element.

The types of sub-elements available are beams, plates, cylinders, membrane, and reverberant room. In general, beams, plates and cylinders can
Figure 3-1. SEA Model Elements for Acoustic Test Configuration

Element 1: Support Structure, Thermal Panels, Radiator, Interface Panel, Signal Distribution Panel and Components

Element 2: Power Distribution Panel and Components

Element 3: Data Acquisition Cold Plate and Components

Element 4: Solenoid Panel and Components

Element 5: Battery Cold Plate and Components

Element 6: Experiment Mounting Plates and Experiment Assembly

Acoustic Input

3-?
be freely mixed in describing a structure. The membrane sub-element should only be used as an ancillary sub-element (i.e., sub-element number > 1). The room sub-element requires special treatment in that the loss factor must be developed from the reverberation time \( n = 2.2/\text{fT}_{60} \) and the answers must be converted from \( q^2 \) to pressure using energy density relationship. The room sub-element must always be the only sub-element in that particular element.

Given these SEA elements, joint properties must now be developed to describe the power flow from the modes of one element to another. The program gives the user a choice of four types: (1) plate to plate, (2) beam to plate, (3) bolted joint, and (4) plate to acoustic. Each joint has two ends for accounting purposes and the word order used describes the A and B ends respectively. For example, in joint (2) the beam is always at the A end and plate is always at the B end. The joint loss factors are from the literature (cited in References 1 and 2) except for the bolted joint. This joint is a plate-to-plate joint with an additional insertion loss to account for internal losses in the joint due to fastener effects. The insertion loss is a load sheet input which provides to the user a more general purpose alternative to joints (1) and (2). Values of the inertia loss parameter for various fastener arrangements are not well defined, however, and must be the topic of continuing research. In the case of the Materials Experiment Assembly (MEA) analyzed during the last phase of this study, the empirically determined insertion loss factor was approximately 10 for each bolted joint.

With the basics of the program now given, two examples will be shown as a guide for program use. The first example will be a segment of skin stringer structure exposed to an acoustic field with an equipment panel on the opposite side. The second example will be a simplified MEA analysis.

The first case can be idealized with two SEA elements as shown in Figure 3-2. The relevant parameters are shown in the following table:
Skin Thickness 0.040"  
Segment Dimensions 18" x 72"  
Stringer Spacing 10" O.C.  
Stringer Dimensions 1-1/2" high x 1" wide with 3/4 flanges,.063 thick (full hat section)  
Internal Frames 400 in² of .063 thick aluminum  
Panel 1" honeycomb with .020 face sheets  
17 x 30 with 16 lb of small equipment items mounted on its surface.  
Panel riveted to frames at four places (U-shaped channels) .063" thick x 1-1/2" high  

The SEA element 1 shown in Figure 3-2 will consist of all structural elements in the table except the panel and its mounted equipment which is SEA element 2. From this information an elementary SEA analysis can be made. The load sheet entries are determined as follows and are shown in Figures 3-3 through 3-10 in the proper sequence.

![Diagram](image)

Figure 3-2. Two-Element SEA Model Example

Figure 3-3 shows the header card which basically describes the problem as consisting of two elements and eleven 1/3 octave bands from 250 to 2500 Hz and that the output will be a vibration PSD. Figure 3-4 describes element 1 as consisting of two sub-elements, the first of which is exposed to acoustic excitation, and describes the damping vs. frequency curve. Figure 3-5 shows the 1/3 octave sound pressure levels; Figures 3-6 and 3-7 describe the sub-element properties in detail.
LOADSHEET (1): HEADER CARD

- One required per case
- First card in sequence

<table>
<thead>
<tr>
<th>Card Columns</th>
<th>Value</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-2</td>
<td>Integer</td>
<td>Total number of elements in model (2 \leq E \leq 20)</td>
</tr>
<tr>
<td>3-4</td>
<td>Integer</td>
<td>Total number of analysis frequencies (1 \leq F \leq 40) (Analysis frequencies are spaced 1/3 octave apart)</td>
</tr>
<tr>
<td>5-14</td>
<td>Real</td>
<td>Lowest analysis frequency</td>
</tr>
<tr>
<td>15</td>
<td>Alpha</td>
<td>Units; (M = \text{metric (MKS)}, \text{default = English (in, lb, sec)})</td>
</tr>
<tr>
<td>16-18</td>
<td>Alpha</td>
<td>Output mode; RMS or PSD</td>
</tr>
</tbody>
</table>

Figure 3-3. Card 1, Example Case 1
LOADSHEET (2): SEA ELEMENT PROPERTIES CARD

- One required for each element (2 ≤ E ≤ 20)
- Must be in ascending numerical sequence

<table>
<thead>
<tr>
<th>Card Column</th>
<th>Value</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-2</td>
<td>Integer</td>
<td>Element number</td>
</tr>
<tr>
<td>3-4</td>
<td>Integer</td>
<td>Number of sub-elements (SE ≥ 1)</td>
</tr>
<tr>
<td>5</td>
<td>Alpha</td>
<td>Excitation type on this element (if any) A = acoustic M = direct mechanical</td>
</tr>
<tr>
<td>6-8</td>
<td>Alpha</td>
<td>If CC5 = A, leave blank; defaults to dB re 20 µbar If CC5 = M, RMS = 1/3 octave RMS g' s PSD = g^2/Hz input at 1/3 octave centers</td>
</tr>
<tr>
<td>9-18</td>
<td>Real</td>
<td>Element loss factor constant(η_0)</td>
</tr>
<tr>
<td>19-28</td>
<td>Real</td>
<td>Loss factor high frequency slope (s) such that η(f) = η_0 (f/f_0)^s</td>
</tr>
<tr>
<td>29-38</td>
<td>Real</td>
<td>Loss factor crossover frequency (f_0)</td>
</tr>
</tbody>
</table>

Figure 3-4. Card 2, Example Case 1
LOADSHEET (3): EXCITATION SPECTRUM CARD

- Must immediately follow element properties if LS#2, CC5 ≠ blank
- All entries are real numbers, and must be consistent with LS #2, CC6-8 (units) and LS #1, CC 3-4 (no. of frequencies - 40 max)
- Make entries across in order of increasing frequency

<table>
<thead>
<tr>
<th>1.470</th>
<th>1.475</th>
<th>1.480</th>
<th>1.490</th>
<th>1.500</th>
<th>1.500</th>
<th>1.500</th>
<th>1.500</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.500</td>
<td>1.505</td>
<td>1.500</td>
<td>1.500</td>
<td>1.500</td>
<td>1.500</td>
<td>1.500</td>
<td>1.500</td>
</tr>
</tbody>
</table>

Figure 3-5. Card 3, Example Case 1
LOADSHEET (4): SUB-ELEMENT PROPERTIES, CARDS 1 AND 2

- Must be consistent with Loadsheet 2, CC 3-4 (SE ≥ 1)
- Two cards (records) per sub-element
- Must follow associated element card and excitation card (if any)

DATA ENTRY DESCRIPTION

<table>
<thead>
<tr>
<th>Card Columns</th>
<th>Value</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-2</td>
<td>Integer</td>
<td>Sub-element number (Sub-element 1 is always the main sub-element)</td>
</tr>
<tr>
<td>3</td>
<td>Alpha</td>
<td>Sub-element type; B = beam, C = cylinder, M = membrane, P = plate, R = room (acoustic element)</td>
</tr>
<tr>
<td>4-13</td>
<td>Real</td>
<td>Mass density (B, C, M, P, R)</td>
</tr>
<tr>
<td>14-23</td>
<td>Real</td>
<td>Elastic modulus (B, C, M, P)</td>
</tr>
<tr>
<td>24-33</td>
<td>Real</td>
<td>Thickness (B, C, M, P)</td>
</tr>
<tr>
<td>34-43</td>
<td>Real</td>
<td>Area (section if B; surface if M or P)</td>
</tr>
<tr>
<td>44-53</td>
<td>Real</td>
<td>Poisson's ratio (C, P)</td>
</tr>
<tr>
<td>54-63</td>
<td>Real</td>
<td>Length (B, C)</td>
</tr>
<tr>
<td>64-73</td>
<td>Real</td>
<td>Pressure (M only)</td>
</tr>
<tr>
<td>1</td>
<td>Logical</td>
<td>Replace F with T if stiffness increase is desired (B, C, P)</td>
</tr>
<tr>
<td>2-11</td>
<td>Real</td>
<td>Radius (C only)</td>
</tr>
<tr>
<td>Card 2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>12-21</td>
<td>Real</td>
<td>Volume (R only)</td>
</tr>
<tr>
<td>22-31</td>
<td>Real</td>
<td>Speed of sound - Sub-element 1 only and if (\Gamma(P)) and CC5, LS2 = A, or (\Gamma(R)) unconditionally</td>
</tr>
<tr>
<td>32-41</td>
<td>Real</td>
<td>Added non-structural mass (B, C, M, P)</td>
</tr>
</tbody>
</table>

Figure 3-6. Card 4, Example Case 1
LOADSHEET (4): SUB-ELEMENT PROPERTIES, CARDS 1 AND 2

- Must be consistent with Loadsheet 2, CC 3-4 (SE ≥ 1)
- Two cards (records) per sub-element
- Must follow associated element card and excitation card (if any)

DATA ENTRY DESCRIPTION

<table>
<thead>
<tr>
<th>Card Column</th>
<th>Value</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-2</td>
<td>Integer</td>
<td>Sub-element number (Sub-element 1 is always the main sub-element)</td>
</tr>
<tr>
<td>3</td>
<td>Alpha</td>
<td>Sub-element type; B = beam, C = cylinder, M = membrane, P = plate, R = room (acoustic element)</td>
</tr>
<tr>
<td>4-13</td>
<td>Real</td>
<td>Mass density (B, C, M, P, R)</td>
</tr>
<tr>
<td>14-23</td>
<td>Real</td>
<td>Elastic modulus (B, C, M, P)</td>
</tr>
<tr>
<td>24-33</td>
<td>Real</td>
<td>Thickness (B, C, M, P)</td>
</tr>
<tr>
<td>34-43</td>
<td>Real</td>
<td>Area (section if B; surface if M or P)</td>
</tr>
<tr>
<td>44-53</td>
<td>Real</td>
<td>Poisson's ratio (C, P)</td>
</tr>
<tr>
<td>54-63</td>
<td>Real</td>
<td>Length (B, C)</td>
</tr>
<tr>
<td>64-73</td>
<td>Real</td>
<td>Pressure (M only)</td>
</tr>
<tr>
<td>1</td>
<td>Logical</td>
<td>Replace F with T if stiffness increase is desired (B, C, P)</td>
</tr>
<tr>
<td>2-11</td>
<td>Real</td>
<td>Radius (C only)</td>
</tr>
<tr>
<td>12-21</td>
<td>Real</td>
<td>Volume (R only)</td>
</tr>
<tr>
<td>22-31</td>
<td>Real</td>
<td>Speed of sound - Sub-element 1 only and if (P) and CC5, LS2 = A, or (R) unconditionally</td>
</tr>
<tr>
<td>32-41</td>
<td>Real</td>
<td>Added non-structural mass (B, C, M, P)</td>
</tr>
</tbody>
</table>

Figure 3-7. Card 5, Example Case 1
Sub-element 1 consists of the skin and stringer elements. The skin is used as the principal property because it is the major element being excited by the acoustic field. The stringers are added as a smeared mass because their internal resonant frequencies are very high and therefore would be expected only to load the skin in the frequency range of interest. Sub-element 2 (Figure 3-7) represents the properties of the internal frames and channels which mount the panel.

Figures 3-6 and 3-9 show the loadsheets for the inside equipment panel. Figure 3-8 defines the panel as Element 2, with one sub-element and constant damping vs. frequency. Figure 3-9 has the panel properties which have been equivalenced to an isotropic plate because the panel is a composite structure. Note that both the thickness and the density have been changed to be consistent. Any other equivalence could also be used, e.g. leave the thickness = 1.0 and the density and Young's modulus will be recalculated using

\[
\frac{1}{T} \sum e^{j\omega_t} = \rho_{\text{eff}}
\]

and

\[
E_{\text{eff}} = \frac{12E(1-\nu^2) \sum I_i}{bt^3}
\]

There is no requirement that sub-elements be of similar materials, but all plate, beam and cylinder sub-element properties must always be isotropic equivalents.

The weight of the components is treated as a non-structural mass. If half or more of the panel area were covered with these components, the \( F \) should be changed to a \( T \) as shown on the sheet to account for the reduction of modal density associated with stiffening of the panel by the components as reported in Reference 2.

Figure 3-10 describes the joint properties between the skin and the plate. Note that an added insertion loss factor of 2 is used to account for rivet effects.
LOADSHEET (2): SEA ELEMENT PROPERTIES CARD

- One required for each element \((2 \leq E \leq 20)\)
- Must be in ascending numerical sequence

<table>
<thead>
<tr>
<th>Card Column</th>
<th>Value</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-2</td>
<td>Integer</td>
<td>Element number</td>
</tr>
<tr>
<td>3-4</td>
<td>Integer</td>
<td>Number of sub-elements ((SE \geq 1))</td>
</tr>
<tr>
<td>5</td>
<td>Alpha</td>
<td>Excitation type on this element (if any) (A = ) acoustic, (M = ) direct mechanical</td>
</tr>
<tr>
<td>6-8</td>
<td>Alpha</td>
<td>If CC5 = A, leave blank; defaults to dB re 20 (\mu)bar</td>
</tr>
<tr>
<td></td>
<td></td>
<td>If CC5 = M, RMS = 1/3 octave RMS g's</td>
</tr>
<tr>
<td></td>
<td></td>
<td>PSD = (g^2/Hz) input at 1/3 octave centers</td>
</tr>
<tr>
<td>9-18</td>
<td>Real</td>
<td>Element loss factor constant (\eta_0)</td>
</tr>
<tr>
<td>19-28</td>
<td>Real</td>
<td>Loss factor high frequency slope ((s)) such that (\eta(f) = \eta_0 \left(\frac{f}{f_0}\right)^s)</td>
</tr>
<tr>
<td>29-38</td>
<td>Real</td>
<td>Loss factor crossover frequency ((f_0))</td>
</tr>
</tbody>
</table>

Figure 3-8. Card 6, Example Case 1
LOADSHEET (4): SUB-ELEMENT PROPERTIES, CARDS 1 AND 2

- Must be consistent with Loadsheet 2, CC 3-4 (SE ≥ 1)
- Two cards (records) per sub-element
- Must follow associated element card and excitation card (if any)

<table>
<thead>
<tr>
<th>Card Columns</th>
<th>Value</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-2</td>
<td>Integer</td>
<td>Sub-element number (Sub-element 1 is always the main sub-element)</td>
</tr>
<tr>
<td>3</td>
<td>Alpha</td>
<td>Sub-element type; B = beam, C = cylinder, M = membrane, P = plate R = room (acoustic element)</td>
</tr>
<tr>
<td>4-13</td>
<td>Real</td>
<td>Mass density (B, C, M, P, R)</td>
</tr>
<tr>
<td>14-23</td>
<td>Real</td>
<td>Elastic modulus (B, C, M, P)</td>
</tr>
<tr>
<td>24-33</td>
<td>Real</td>
<td>Thickness (B, C, M, P)</td>
</tr>
<tr>
<td>34-43</td>
<td>Real</td>
<td>Area (section if B; surface if M or P)</td>
</tr>
<tr>
<td>44-53</td>
<td>Real</td>
<td>Poisson's ratio (C, P)</td>
</tr>
<tr>
<td>54-63</td>
<td>Real</td>
<td>Length (B, C)</td>
</tr>
<tr>
<td>64-73</td>
<td>Real</td>
<td>Pressure (M only)</td>
</tr>
<tr>
<td>1</td>
<td>Logical</td>
<td>Replace F with T if stiffness increase is desired (B, C, P)</td>
</tr>
<tr>
<td>2-11</td>
<td>Real</td>
<td>Radius (C only)</td>
</tr>
</tbody>
</table>

Card 2

<table>
<thead>
<tr>
<th>Card Columns</th>
<th>Value</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>12-21</td>
<td>Real</td>
<td>Volume (R only)</td>
</tr>
<tr>
<td>22-31</td>
<td>Real</td>
<td>Speed of sound - Sub-element 1 only and if ((P) and CC5, LS2 = A, or ((R) unconditionally</td>
</tr>
<tr>
<td>32-41</td>
<td>Real</td>
<td>Added non-structural mass (B, C, M, P)</td>
</tr>
</tbody>
</table>

Figure 3-9. Card 7, Example Case 1
LOADSHEET (5): JOINT PROPERTIES

- Must follow all element and sub-element cards at end of deck.
- Must be consistent with elements being joined.

<table>
<thead>
<tr>
<th>Card Columns</th>
<th>Value</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-2</td>
<td>Integer</td>
<td>Element number of A end of joint</td>
</tr>
<tr>
<td>3-4</td>
<td>Integer</td>
<td>Element number of B end of joint</td>
</tr>
<tr>
<td>5-6</td>
<td>Alpha</td>
<td>Joint type: PP = plate-to-plate, BP = beam-to-plate, BJ = bolted joint, PA = plate to acoustic</td>
</tr>
<tr>
<td>7-8</td>
<td>Integer</td>
<td>No. of sides exposed to acoustic input (1 or 2 for PA only)</td>
</tr>
<tr>
<td>9-18</td>
<td>Real</td>
<td>Joint length</td>
</tr>
<tr>
<td>19-28</td>
<td>Real</td>
<td>Thickness of A end of joint</td>
</tr>
<tr>
<td>29-38</td>
<td>Real</td>
<td>Thickness of B end of joint</td>
</tr>
<tr>
<td>39-48</td>
<td>Real</td>
<td>Acoustic space mass density (P/RT)</td>
</tr>
<tr>
<td>49-58</td>
<td>Real</td>
<td>Beam length (BP only)</td>
</tr>
<tr>
<td>59-68</td>
<td>Real</td>
<td>Energy reduction factor (BJ only)</td>
</tr>
</tbody>
</table>

Figure 3-10. Card B, Example Case 1
These data are then assembled as a file which the program reads as an input.

The corresponding program output is shown in Figure 3-11 and consists of a labeled list of the input data, a display of the element modal densities, and a table of vibration responses. The adequacy of the SEA model with regard to assumptions 4 and 5 can be checked using the modal density tables of the figure. For example, element 1 contains more than 20 modes per 1/3 octave over the entire analysis range, whereas element 2 has far fewer. Since frequency response will be smoother with more modes per band, it is expected that the panel prediction will be poorer than the skin predictions. Specifically, the actual panel response may have some peaks which exceed the SEA prediction.

The SEA response prediction is shown in Table 3-1. The levels for element 1 are high compared to the criteria published in Reference 3, but one must remember that this estimate includes a space average over the skin. The stringer and frame vibration levels which are inputs to the panel are a factor of ~100 less.

Simple changes can be made to improve the prediction. For example, an internal acoustic field can be put on the panel by also placing an A in card column 5 of Figure 3-8 and entering the appropriate table immediately after, as shown in Figure 3-12. The results of this modification are shown in Table 3-2. As can be seen, the panel vibration increases considerably and critical frequency behavior is evident around 625 Hz. It should be noted that SEA often overpredicts in the critical frequency region. This simple example illustrates some of the possibilities of SEA with the help of this computer program.

A more extensive example is that of the MEA done in the previous phase. The input for this six-element model (Fig. 3-1) is extensive and much too elaborate to be explained in detail here, but the breakdown of the sub-elements used is given in Table 3-3. The input listing is given in Appendix III and the output is shown in Table 3-4.

A mechanical vibration input may also be applied if the known vibration level is included as an additional element. Load sheet 2 card column 5
**STATISTICAL ENERGY ANALYSIS OF COMPLEX STRUCTURES**

<table>
<thead>
<tr>
<th>RECORD NUMBER</th>
<th>DATA READ FROM UNIT 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>NUMBER OF ELEMENTS = 2</td>
</tr>
<tr>
<td></td>
<td>NUMBER OF ANALYSIS FREQUENCIES = 11</td>
</tr>
<tr>
<td></td>
<td>FIRST ANALYSIS FREQUENCY = 2.50000E+02</td>
</tr>
<tr>
<td></td>
<td>TYPE OF UNITS =</td>
</tr>
<tr>
<td></td>
<td>TYPE OF OUTPUT = PSD</td>
</tr>
<tr>
<td>2</td>
<td>ELEMENT NUMBER = 1</td>
</tr>
<tr>
<td></td>
<td>NUMBER OF SUB-ELEMENTS = 2</td>
</tr>
<tr>
<td></td>
<td>TYPE OF EXCITATION = A</td>
</tr>
<tr>
<td></td>
<td>TYPE OF MECHANICAL INPUT =</td>
</tr>
<tr>
<td></td>
<td>DAMPING = 1.00000E-01</td>
</tr>
<tr>
<td></td>
<td>SLOPE = -1.00000E+00</td>
</tr>
<tr>
<td></td>
<td>STARTING FREQUENCY = 2.50000E+02</td>
</tr>
<tr>
<td></td>
<td>SOUND PRESSURE LEVELS</td>
</tr>
<tr>
<td>3</td>
<td>1.17000E+02 1.97500E+02 1.45000E+02 1.90000E+02</td>
</tr>
<tr>
<td></td>
<td>1.49500E+02 1.50000E+02 1.50000E+02 1.50000E+02</td>
</tr>
<tr>
<td>4</td>
<td>1.50000E+02 1.50000E+02 1.50000E+02 0.0</td>
</tr>
<tr>
<td></td>
<td>0.0</td>
</tr>
<tr>
<td></td>
<td>0.0</td>
</tr>
<tr>
<td>5</td>
<td>SUB-ELEMENT NUMBER = 1</td>
</tr>
<tr>
<td></td>
<td>TYPE OF SUB-ELEMENT = P</td>
</tr>
<tr>
<td></td>
<td>DENSITY = 2.61700E-04</td>
</tr>
<tr>
<td></td>
<td>MODULUS OF ELASTICITY = 1.00000E+07</td>
</tr>
<tr>
<td></td>
<td>THICKNESS = 0.00000E-02</td>
</tr>
<tr>
<td></td>
<td>AREA = 1.23600E+03</td>
</tr>
<tr>
<td></td>
<td>POISSONS RATIO = 3.30000E-01</td>
</tr>
<tr>
<td></td>
<td>LENGTH = 0.0</td>
</tr>
<tr>
<td></td>
<td>PRESSURE = 0.0</td>
</tr>
<tr>
<td>6</td>
<td>STIFFNESS REDUCTION REQUIRED = F</td>
</tr>
<tr>
<td></td>
<td>RADIUS = 0.0</td>
</tr>
<tr>
<td></td>
<td>VOLUME = 0.0</td>
</tr>
<tr>
<td></td>
<td>SPEED OF SOUND IN ROOM MEDIUM = 1.54000E+04</td>
</tr>
<tr>
<td></td>
<td>ADDED MASS = 1.30500E-02</td>
</tr>
<tr>
<td>7</td>
<td>SUB-ELEMENT NUMBER = 2</td>
</tr>
<tr>
<td></td>
<td>TYPE OF SUB-ELEMENT = P</td>
</tr>
<tr>
<td></td>
<td>DENSITY = 2.61700E-04</td>
</tr>
<tr>
<td></td>
<td>MODULUS OF ELASTICITY = 1.30000E+07</td>
</tr>
<tr>
<td></td>
<td>THICKNESS = 6.30000E-02</td>
</tr>
<tr>
<td></td>
<td>AREA = 5.00000E+02</td>
</tr>
<tr>
<td></td>
<td>POISSONS RATIO = 3.30000E-01</td>
</tr>
<tr>
<td></td>
<td>LENGTH = 0.0</td>
</tr>
<tr>
<td></td>
<td>PRESSURE = 0.0</td>
</tr>
<tr>
<td>8</td>
<td>STIFFNESS REDUCTION REQUIRED = F</td>
</tr>
<tr>
<td></td>
<td>RADIUS = 0.0</td>
</tr>
<tr>
<td></td>
<td>VOLUME = 0.0</td>
</tr>
<tr>
<td></td>
<td>SPEED OF SOUND IN ROOM MEDIUM = 0.0</td>
</tr>
<tr>
<td></td>
<td>ADDED MASS = 0.0</td>
</tr>
</tbody>
</table>

(Continued)

Figure 3-11. Two-Element SEA Program Output - External Acoustic Excitation

3-16
ELEMENT NUMBER = 2
NUMBER OF SUB-ELEMENTS = 1
TYPE OF EXCITATION =
TYPE OF MECHANICAL INPUT =
DAMPING = 5.000000E-02
SLOPE = 0.
STARTING FREQUENCY = 0.

SUB-ELEMENT NUMBER = 1
TYPE OF SUB-ELEMENT = P
DENSITY = 1.000000E+05
MODULUS OF ELASTICITY = 1.000000E+07
THICKNESS = 3.000000E-01
AREA = 5.100000E+02
POISSONS RATIO = 0.300000E+01
LENGTH = 0.
PRESSURE = 0.

STIFFNESS REDUCTION REQUIRED = F
RADIUS = 0.
VOLUME = 0.
SPEED OF SOUND IN ROOM MEDIUM = 0.
ADDED MASS = 4.150000E+02

<table>
<thead>
<tr>
<th>CENTER</th>
<th>MODAL DENSITY - MODES/(RAD/SEC)</th>
</tr>
</thead>
<tbody>
<tr>
<td>FREQUENCY</td>
<td>ELEMENT 1</td>
</tr>
<tr>
<td>250.00</td>
<td>5.3663E-02</td>
</tr>
<tr>
<td>312.50</td>
<td>5.3663E-02</td>
</tr>
<tr>
<td>400.00</td>
<td>5.3663E-02</td>
</tr>
<tr>
<td>500.00</td>
<td>5.3663E-02</td>
</tr>
<tr>
<td>625.00</td>
<td>5.3663E-02</td>
</tr>
<tr>
<td>797.50</td>
<td>5.3663E-02</td>
</tr>
<tr>
<td>1000.00</td>
<td>5.3663E-02</td>
</tr>
<tr>
<td>1250.00</td>
<td>5.3663E-02</td>
</tr>
<tr>
<td>1575.00</td>
<td>5.3663E-02</td>
</tr>
<tr>
<td>2000.00</td>
<td>5.3663E-02</td>
</tr>
<tr>
<td>2500.00</td>
<td>5.3663E-02</td>
</tr>
</tbody>
</table>

RECORD NUMBER

DATA READ FROM UNIT 3

12 FIRST ELEMENT = 1
SECOND ELEMENT = 2
TYPE OF JOINT = 9J
NUMBER OF SIDES = 0
JOINT LENGTH = 3.600000E+01
THICKNESS OF FIRST ELEMENT = 4.000000E-02
THICKNESS OF SECOND ELEMENT = 3.000000E-01
ACOUSTIC SPACE DENSITY = 0.
BEAM LENGTH = 0.
INSERTION LOSS FACTOR = 2.000000E+00

Figure 3-11 (Continued)
Table 3-1
TWO-ELEMENT SEA VIBRATION PREDICTION
EXTERNAL ACOUSTIC EXCITATION

<table>
<thead>
<tr>
<th>Center Frequency (Hz)</th>
<th>PSD Levels (G^2/Hz)</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Element 1</td>
<td>Element 2</td>
<td></td>
</tr>
<tr>
<td>250.0</td>
<td>4.90675E+01</td>
<td>3.38593E-01</td>
<td></td>
</tr>
<tr>
<td>312.5</td>
<td>3.59925E+01</td>
<td>2.37220E-01</td>
<td></td>
</tr>
<tr>
<td>400.0</td>
<td>2.53599E+01</td>
<td>1.58301E-01</td>
<td></td>
</tr>
<tr>
<td>500.0</td>
<td>2.11177E+01</td>
<td>1.25095E-01</td>
<td></td>
</tr>
<tr>
<td>625.0</td>
<td>1.53027E+01</td>
<td>8.85583E-02</td>
<td></td>
</tr>
<tr>
<td>787.5</td>
<td>1.17827E+01</td>
<td>6.21389E-02</td>
<td></td>
</tr>
<tr>
<td>1000.0</td>
<td>7.83661E+01</td>
<td>3.86783E-02</td>
<td></td>
</tr>
<tr>
<td>1250.0</td>
<td>5.44536E+00</td>
<td>2.51832E-02</td>
<td></td>
</tr>
<tr>
<td>1575.0</td>
<td>3.81675E+00</td>
<td>1.64492E-02</td>
<td></td>
</tr>
<tr>
<td>2000.0</td>
<td>2.72180E+00</td>
<td>1.08695E-02</td>
<td></td>
</tr>
<tr>
<td>2500.0</td>
<td>2.05294E+00</td>
<td>7.61286E-03</td>
<td></td>
</tr>
</tbody>
</table>

3-18
for that element would contain an M and the vibration spectrum description would follow. The only restriction is that this element may not also have an acoustic input as it will be eliminated in the solution because the energy level is already known.

The possible permutations and combinations of elements, sub-elements, and other factors which this computer program can create go far beyond the ability to document in this report. These few examples give some insight into the processes involved in the performance of SEA using this program. Although determination of some of the parameters such as damping and insertion loss is still a difficult and often obscure process which requires substantial future improvement, this computer program provides a significant step toward streamlining and simplifying SEA for the analyst.
LOADSHEET (3): EXCITATION SPECTRUM CARD

- Must immediately follow element properties if LS #2, CC5 ≠ blank
- All entries are real numbers, and must be consistent with LS #2, CC6-8 (units) and LS #1, CC 3-4 (no. of frequencies - 40 max)
- Make entries across in order of increasing frequency

```
<p>| | | | | | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>146.5</td>
<td>147.0</td>
<td>147.0</td>
<td>147.5</td>
<td>148.0</td>
<td>148.0</td>
<td>148.0</td>
<td>148.0</td>
</tr>
<tr>
<td>146.5</td>
<td>147.0</td>
<td>147.0</td>
<td>147.5</td>
<td>148.0</td>
<td>148.0</td>
<td>148.0</td>
<td>148.0</td>
</tr>
</tbody>
</table>
```

Figure 3-12. Internal Acoustic Input Table for Example 1
Table 3-2
TWO-ELEMENT SEA VIBRATION PREDICTION
EXTERNAL AND INTERNAL ACOUSTIC EXCITATION

<table>
<thead>
<tr>
<th>Center Frequency (Hz)</th>
<th>PSD Levels (G²/Hz)</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Element 1</td>
<td>Element 2</td>
<td></td>
</tr>
<tr>
<td>250.0</td>
<td>4.96984E+01</td>
<td>9.69548E-01</td>
<td></td>
</tr>
<tr>
<td>312.5</td>
<td>3.67160E+01</td>
<td>1.04475E+00</td>
<td></td>
</tr>
<tr>
<td>400.0</td>
<td>2.62012E+01</td>
<td>1.21999E+00</td>
<td></td>
</tr>
<tr>
<td>500.0</td>
<td>2.26040E+01</td>
<td>2.29959E+00</td>
<td></td>
</tr>
<tr>
<td>625.0</td>
<td>2.05716E+01</td>
<td>7.59740E+00</td>
<td></td>
</tr>
<tr>
<td>787.5</td>
<td>1.40047E+01</td>
<td>3.98634E+00</td>
<td></td>
</tr>
<tr>
<td>1000.0</td>
<td>8.75443E+00</td>
<td>1.86390E+00</td>
<td></td>
</tr>
<tr>
<td>1250.0</td>
<td>5.75084E+00</td>
<td>7.03965E-01</td>
<td></td>
</tr>
<tr>
<td>1575.0</td>
<td>3.94377E+00</td>
<td>3.33085E-01</td>
<td></td>
</tr>
<tr>
<td>2000.0</td>
<td>2.76144E+00</td>
<td>1.22184E-01</td>
<td></td>
</tr>
<tr>
<td>2500.0</td>
<td>2.06547E+00</td>
<td>4.69292E-02</td>
<td></td>
</tr>
</tbody>
</table>
Table 3-3
SUB-ELEMENT BREAKDOWN FOR MEA TEST CASE

<table>
<thead>
<tr>
<th>ELEMENT 1</th>
<th>ELEMENT 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sub-element</td>
<td>Sub-element</td>
</tr>
<tr>
<td>1</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td></td>
</tr>
<tr>
<td>5 } Support Structure</td>
<td>6 ELEMENT 3</td>
</tr>
<tr>
<td>7 }</td>
<td>Sub-element</td>
</tr>
<tr>
<td>8 }</td>
<td>1 Data Acquisition Cold</td>
</tr>
<tr>
<td>9 } 2</td>
<td></td>
</tr>
<tr>
<td>10 } 3</td>
<td></td>
</tr>
<tr>
<td>11 } Interface Support Structure</td>
<td>12 ELEMENT 4</td>
</tr>
<tr>
<td>13 }</td>
<td>Sub-element</td>
</tr>
<tr>
<td>14 } 1 Solenoid Panel</td>
<td></td>
</tr>
<tr>
<td>15 } 2</td>
<td></td>
</tr>
<tr>
<td>16 } 3</td>
<td></td>
</tr>
<tr>
<td>17 } Support Brace Assembly</td>
<td>17 ELEMENT 5</td>
</tr>
<tr>
<td>18 } and Gusset</td>
<td>Sub-element</td>
</tr>
<tr>
<td>19 } 1</td>
<td></td>
</tr>
<tr>
<td>20 } Pressure Sensor and Voltage</td>
<td>2</td>
</tr>
<tr>
<td>Regulator Panels</td>
<td>3</td>
</tr>
<tr>
<td>20 }</td>
<td></td>
</tr>
</tbody>
</table>

3-22
### Table 3-4
SEA COMPUTER PROGRAM OUTPUT
FOR MEA/Acoustic EXCITATION CASE

<table>
<thead>
<tr>
<th>CENTER FREQ (Hz)</th>
<th>PSD LEVELS (G•2/Hz)</th>
<th>CENTER FREQ (Hz)</th>
<th>PSD LEVELS (G•2/Hz)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>ELEMENT 1</td>
<td>ELEMENT 2</td>
<td>ELEMENT 3</td>
</tr>
<tr>
<td>31.50</td>
<td>1.37117E+01</td>
<td>6.40344E-02</td>
<td>1.23604E-02</td>
</tr>
<tr>
<td>35.39</td>
<td>1.3943E+01</td>
<td>5.33723E-02</td>
<td>1.16254E-02</td>
</tr>
<tr>
<td>50.40</td>
<td>1.53532E+01</td>
<td>5.01950E-02</td>
<td>1.01534E-02</td>
</tr>
<tr>
<td>63.00</td>
<td>1.37834E+01</td>
<td>4.58005E-02</td>
<td>9.7559E-03</td>
</tr>
<tr>
<td>78.75</td>
<td>1.40493E+01</td>
<td>4.16226E-02</td>
<td>9.20447E-03</td>
</tr>
<tr>
<td>99.23</td>
<td>1.4114E+01</td>
<td>3.74861E-02</td>
<td>8.53649E-03</td>
</tr>
<tr>
<td>126.00</td>
<td>1.39473E+01</td>
<td>3.30110E-02</td>
<td>7.79522E-03</td>
</tr>
<tr>
<td>157.50</td>
<td>1.37790E+01</td>
<td>2.40971E-02</td>
<td>5.87560E-03</td>
</tr>
<tr>
<td>198.45</td>
<td>1.02517E+01</td>
<td>1.32083E-02</td>
<td>4.8923E-03</td>
</tr>
<tr>
<td>252.00</td>
<td>7.25089E+00</td>
<td>1.21935E-02</td>
<td>3.20463E-03</td>
</tr>
<tr>
<td>315.00</td>
<td>4.73043E+00</td>
<td>8.57629E-03</td>
<td>2.19525E-03</td>
</tr>
<tr>
<td>375.75</td>
<td>3.1003E+01</td>
<td>6.04840E-03</td>
<td>1.51521E-03</td>
</tr>
<tr>
<td>504.00</td>
<td>1.9571E+00</td>
<td>4.13889E-03</td>
<td>1.6107E-03</td>
</tr>
<tr>
<td>630.00</td>
<td>8.21163E-01</td>
<td>1.36311E-03</td>
<td>4.615E-04</td>
</tr>
<tr>
<td>787.50</td>
<td>3.47357E-01</td>
<td>3.51231E-04</td>
<td>1.58790E-04</td>
</tr>
<tr>
<td>922.25</td>
<td>2.82657E-02</td>
<td>2.4496E-04</td>
<td>5.6956E-05</td>
</tr>
<tr>
<td>1260.00</td>
<td>4.96000E-02</td>
<td>1.1506E-04</td>
<td>3.1542E-05</td>
</tr>
<tr>
<td>1575.00</td>
<td>2.77660E-02</td>
<td>3.55134E-05</td>
<td>1.6567E-05</td>
</tr>
<tr>
<td>1984.50</td>
<td>1.24863E-02</td>
<td>4.13076E-05</td>
<td>8.61054E-06</td>
</tr>
<tr>
<td>2520.00</td>
<td>5.74855E-03</td>
<td>2.05337E-05</td>
<td>4.2849E-06</td>
</tr>
<tr>
<td>3150.00</td>
<td>2.52043E-03</td>
<td>1.06828E-05</td>
<td>2.2132E-06</td>
</tr>
<tr>
<td>3937.50</td>
<td>1.40151E-03</td>
<td>6.12303E-06</td>
<td>1.22397E-06</td>
</tr>
<tr>
<td>5040.00</td>
<td>8.43835E-04</td>
<td>3.77799E-06</td>
<td>7.33066E-07</td>
</tr>
</tbody>
</table>
Section 4

SEA COMPUTER PROGRAM DESCRIPTION AND USAGE

This section describes the computer code and the input requirements for problem solutions.

The program was written in ASCII Fortran V for the MS^C UNIVAC 1108 with the EXECB operating system resident in the computer. The program is designed to be run in the demand/interactive mode using the system editor to assemble and sequence the load sheet information.

The SEA computer code uses a main program whose function is essentially to call the various subroutines in the correct order. First called are two subroutines, EPROP and JINPUT, which read user-supplied data. Then for each analysis frequency, three other subroutines (JPROP, EXCITE, and ANSWER) are called to perform the various calculations. The subroutine ANSWER calls the UNIVAC library subroutine GASSEM from SYS $MATHSTAT$. Finally, subroutine RITER is called to print the solution. The complete program listing is given in Appendix I and the program flow charts are given in Appendix II.

4.1 SUBROUTINE DESCRIPTION

Subroutine EPROP reads user-supplied data giving element and sub-element properties and calls one of five subroutines (BEAM, MEMBR, PLATE, ROOM, or CYLIN) to calculate element modal densities. See Appendix I for the list of variables read by EPROP. EPROP first reads a record giving the number of elements, number of analysis frequencies, the first frequency, and the type of units (metric or English). EPROP checks that the number of elements and analysis frequencies is within the bounds allowed by the program, since memory is reserved with maximum values in mind. Then EPROP creates a table of analysis frequencies by multiplying each element of a
predefined 1/3 octave table by the first frequency. The predefined table consists of a series of frequencies, each of which is approximately one-third octave higher than the preceding one, and the first one of which is equal to 1. EPROP then reads element properties. If the type of excitation indicated on this read operation is acoustic, EPROP then reads a list of sound pressure levels for each analysis frequency for this element. Next, sub-element properties are read. Included in sub-element properties is the type of sub-element. Depending on whether this is a beam, membrane, plate, room or cylinder, EPROP calls the appropriate subroutine to calculate the modal density.

Subroutines BEAM, MEMBR, PLATE, ROOM and CYLIN calculate the modal density for a sub-element which is a beam, membrane, plate, room or cylinder, respectively. First, the part of the equation which is not frequency dependent is calculated. If stiffness reduction has been indicated, this partial value is multiplied by 1/2. Then for each analysis frequency, the rest of the modal density equation is computed and the result summed to element modal density. The sub-element mass is summed to the element mass. If this is the first sub-element for the given element, it is assumed to be the main sub-element and element properties other than mass are set equal to the properties of this sub-element. The following equations are used to calculate modal densities:

**Beam:**

\[ n(\omega) = \frac{L}{2\pi} \left( \omega \sqrt{\frac{Et^2}{12\rho}} \right)^{-\frac{1}{2}} \]

**Membrane:**

\[ n(\omega) = \frac{A}{2\pi^2} \frac{\omega_0^2}{t} \]

**Plate:**

\[ n(\omega) = \frac{A}{4\pi} \left( \frac{Et^2}{12\rho(1-\nu^2)} \right)^{-\frac{1}{2}} \]

**Room:**

\[ n(\omega) = \frac{V_0 \omega^2}{2\pi^2 c^2} \]

**Cylindrical shell:**

\[ A \left( \frac{Et^2}{12\rho(1-\nu^2)} \right)^{-\frac{1}{2}} \]

\[ n(\omega) = \begin{cases} \frac{A}{4\pi} \left( \frac{Et^2}{12\rho(1-\nu^2)} \right)^{-\frac{1}{2}} & \text{if } \omega r \left( \frac{\rho}{E} \right)^{\frac{1}{2}} > 1 \\ A \left( \frac{Et^2}{12\rho(1-\nu^2)} \right)^{-\frac{1}{2}} \left( \omega r \left( \frac{\rho}{E} \right)^{\frac{1}{2}} \right)^{\frac{1}{2}} & \text{if } \omega r \left( \frac{\rho}{E} \right)^{\frac{1}{2}} < 1 \end{cases} \]

4-2
Subroutine JINPUT reads joint properties supplied by the user. See Appendix I for a list of the variables read by JINPUT. JINPUT checks that element numbers are within range (i.e., less than or equal to the number of elements in the system) and that no pair of element numbers is input more than once. JINPUT keeps a running total of the number of pairs input and continues reading until the end of file is encountered. JINPUT checks to see that at least one pair of elements was read.

Subroutine JPROP calculates coupling coefficients based on the data read by JINPUT, using one of the following equations, depending on the type of joint as read by JINPUT:

Plate to plate at right angles:

$$\phi_{12} = \frac{1.07L}{\pi AN_2} \left( \frac{\rho_1 (1-\nu_1^2)}{E_1} \right)^{1/2} V_2 T$$

$$A = n_2 t_1 \left( \frac{E_2}{12 \rho_1 (1-\nu_1^2)} \right)$$

$$T = \begin{cases} 
\frac{8}{27} & \text{if } t_1 > \frac{t_2}{2} \\
\frac{t_1}{t_2} & \text{if } t_1 < \frac{t_2}{2}
\end{cases}$$

Beam to plate (cantilevered):

$$\phi_{12} = \frac{2\pi f_b}{N_2 4L}$$

Plate to acoustic space:

$$\phi_{12} = \left( \frac{4.33 \pi c_s^2}{f \omega^2 V_2} \right) \left( \frac{\rho_1 \sigma}{\rho_A} \right)$$
Bolted or riveted joints:

1) Calculate PHI as if for a plate-to-plate rigid joint.
2) Reduce PHI by insertion loss factor.

<table>
<thead>
<tr>
<th>Symbol</th>
<th>FORTRAN Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \phi )</td>
<td>PHI</td>
<td>Coupling Coefficient</td>
</tr>
<tr>
<td>L</td>
<td>JL</td>
<td>Joint Length</td>
</tr>
<tr>
<td>N</td>
<td>MODES</td>
<td>Number of Modes in Bandwidth</td>
</tr>
<tr>
<td>( \omega )</td>
<td>OMEGA</td>
<td>( 2\pi ) Times the Frequency</td>
</tr>
<tr>
<td>t</td>
<td>T</td>
<td>Thickness</td>
</tr>
<tr>
<td>E</td>
<td>EE</td>
<td>Modulus of Elasticity</td>
</tr>
<tr>
<td>( \rho )</td>
<td>DENSE</td>
<td>Density</td>
</tr>
<tr>
<td>( \gamma )</td>
<td>EGAMMA</td>
<td>Poisson's Ratio</td>
</tr>
<tr>
<td>( \tau )</td>
<td>TAU</td>
<td>Thickness Ratio</td>
</tr>
<tr>
<td>( n )</td>
<td>N</td>
<td>Modal Density</td>
</tr>
<tr>
<td>f</td>
<td>FREQ</td>
<td>Frequency</td>
</tr>
<tr>
<td>b</td>
<td>BW</td>
<td>Beam Width</td>
</tr>
<tr>
<td>c</td>
<td>EC</td>
<td>Speed of Sound in Room Medium</td>
</tr>
<tr>
<td>V</td>
<td>VOL</td>
<td>Volume</td>
</tr>
<tr>
<td>( a )</td>
<td>NS</td>
<td>Number of Sides</td>
</tr>
<tr>
<td>( \sigma )</td>
<td>SIGMA</td>
<td>Radiation Efficiency</td>
</tr>
<tr>
<td>( \rho A )</td>
<td>ASD</td>
<td>Acoustic Space Density</td>
</tr>
</tbody>
</table>

Function SIGF returns a value for the radiation efficiency of a panel. A single argument, \( X \), is passed to SIGF. The value of \( X \) is the ratio of the analysis frequency to the critical frequency. An internal table of 16 values of the log of the radiation efficiency for \( 0 < X < 4 \) is maintained. The first value, 0, is the value of \( X \) for which SIGF is a minimum. When \( X = 0 \), SIGF = -1.8. Each subsequent value of the internal table is the value of \( X \) for which SIGF increases by 0.2 over the previous value. The 13th value in the table is 1. Since this is the 12th value after the 1st, SIGF = \( 12 \times 0.2 + (-1.8) = 0.6 \) when \( X = 1 \). This is the maximum value of SIGF. SIGF = 0 for \( X = 4 \), the final value of the table. The value of SIGF is calculated by finding the least value of the table that is greater than \( X \). This value and the preceding one give two values of SIGF that differ by 0.2. Linear interpolation is then used to find the actual value of SIGF.

Subroutine EXCITE calculates acoustic and mechanical energy inputs for the elements of the system. These values are initially set to 0. Then for each element, the acoustic or mechanical energy input is calculated.
according to the following equations, depending on the type of excitation as read by EPROP:

Acoustic:  \[ S = \frac{0.66 \pi \frac{c^2}{3} \langle p^2 \rangle \sigma N}{\omega \sin} \]
\[ \langle p^2 \rangle = 10^{5 \text{SPL}/10}(8.41 \times 10^{-10}) \]

Mechanical in grms:  \[ E = \frac{m}{\omega^2} g_{\text{rms}}^2 \]

Mechanical in PSD Levels:  \[ E = \frac{m}{\omega^2} \text{PSD} \cdot g^2 \cdot \frac{f}{4.33} \]

<table>
<thead>
<tr>
<th>Symbol</th>
<th>FORTRAN Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>S</td>
<td>S</td>
<td>Acoustic Energy Input</td>
</tr>
<tr>
<td>c</td>
<td>EC</td>
<td>Speed of Sound in Room Medium</td>
</tr>
<tr>
<td>A</td>
<td>A</td>
<td>Surface Area Exposed to Sound Field</td>
</tr>
<tr>
<td>\sigma</td>
<td>SIGMA</td>
<td>Radiation Efficiency</td>
</tr>
<tr>
<td>N</td>
<td>MODES</td>
<td>Number of Modes in Bandwidth</td>
</tr>
<tr>
<td>\omega</td>
<td>OMEGA</td>
<td>(2\pi) Times the Frequency</td>
</tr>
<tr>
<td>m</td>
<td>MSUB</td>
<td>Mass</td>
</tr>
<tr>
<td>SPL</td>
<td>SPL</td>
<td>Sound Pressure Level</td>
</tr>
<tr>
<td>E</td>
<td>E</td>
<td>Element Energy Level</td>
</tr>
<tr>
<td>g_{\text{rms}}</td>
<td>MECH</td>
<td>Mechanical Input</td>
</tr>
<tr>
<td>g</td>
<td>G</td>
<td>Gravitational Constant</td>
</tr>
<tr>
<td>PSD</td>
<td>MECH</td>
<td>Mechanical Input</td>
</tr>
<tr>
<td>f</td>
<td>FREQ</td>
<td>Frequency</td>
</tr>
</tbody>
</table>

Subroutine ANSWER solves the SEA system of equations for element energy levels. First, element damping is determined. If the damping is constant, it is equal to the value read by EPROP. Otherwise the following equation is used:

\[ n_2 = n_{f_s}(\frac{f}{f})^{s} \]

<table>
<thead>
<tr>
<th>Symbol</th>
<th>FORTRAN Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>(n_2)</td>
<td>ETA2</td>
<td>Element Damping</td>
</tr>
<tr>
<td>(n_f)</td>
<td>ETA</td>
<td>Constant Level of Damping</td>
</tr>
<tr>
<td>(f_s)</td>
<td>SFREQ</td>
<td>Start Frequency</td>
</tr>
<tr>
<td>(s)</td>
<td>SLOPE</td>
<td>Slope</td>
</tr>
</tbody>
</table>

Next, the elements of the alpha matrix of equation 1, Section 1, are calculated.
If there are any elements for which the energy levels (the E matrix) are already known, these are eliminated from the equation as shown by the following example: Suppose the system has six elements and the second and fifth have known energy levels. Then the equation becomes:

\[
\begin{bmatrix}
\alpha_{11} & \alpha_{13} & \alpha_{14} & \alpha_{16} \\
\alpha_{31} & \alpha_{33} & \alpha_{34} & \alpha_{36} \\
\alpha_{41} & \alpha_{43} & \alpha_{44} & \alpha_{46} \\
\alpha_{61} & \alpha_{63} & \alpha_{64} & \alpha_{66}
\end{bmatrix}
\begin{bmatrix}
E_1 \\
E_3 \\
E_4 \\
E_6
\end{bmatrix} =
\begin{bmatrix}
S_1 - \alpha_{12}E_2 - \alpha_{15}E_5 \\
S_3 - \alpha_{32}E_2 - \alpha_{35}E_5 \\
S_4 - \alpha_{42}E_2 - \alpha_{45}E_5 \\
S_6 - \alpha_{62}E_2 - \alpha_{65}E_5
\end{bmatrix}
\]

Since (for example) \( S_1 = \alpha_{11}E_1 + \alpha_{12}E_2 + \alpha_{13}E_3 + \alpha_{14}E_4 + \alpha_{15}E_5 + \alpha_{16}E_6 \), it can be seen that this has the same solution as the original equation. ANSWER recalculates the values of the S matrix and calls SOLVE to eliminate the unnecessary rows and columns from the matrices and find the solution. The solution is then used to calculate the average acceleration with the formula

\[ \langle a \rangle = E \frac{\omega^2}{m} \]

<table>
<thead>
<tr>
<th>Symbol</th>
<th>FORTRAN Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \langle a \rangle )</td>
<td>ABAR</td>
<td>Average Acceleration</td>
</tr>
<tr>
<td>E</td>
<td>E</td>
<td>Element Energy Levels</td>
</tr>
<tr>
<td>( \omega )</td>
<td>OMEGA</td>
<td>( 2\pi ) Times the Frequency</td>
</tr>
<tr>
<td>m</td>
<td>MASS</td>
<td>Mass</td>
</tr>
</tbody>
</table>

Subroutine SOLVE solves the SEA system of equations. It copies the alpha and S matrices to new matrices, leaving out those rows and columns which were to be eliminated. It then calls MATHSTAT library subroutine GASSEM to solve the equation. SOLVE then puts the solution in the element energy array E, and subroutine RITER prints the solution.

4.2 PROGRAM USAGE

4.2.1 Deck Setup and Sequence

At present, the source program resides on element C of file S1, so that it is necessary to compile and collect it before execution. The program
reads the SEA load sheet data on logical unit 3, which must be created by the user with the text editor or data processor, using the Q option so that file 3 is in ASCII code. The following sequence of control statements illustrates the creation of file 3 and the execution of the program:

@RUN ...
@ASG,C 3.
@ED,IQ 3.

Statements creating file 3
EXIT
@ASG,A S1
@FTN,N S1.C,REL
@MAP,IN SYM,ABS
LIB SYS$**MATHSTAT$.
LIB SYS$**MSFC$.
LIB SYS$**MSFC$.
END
@XQT ABS
@FIN

4.2.2 Input - Drum/Disk

The only input for the program is on logical unit 3, which contains the user's data. This file consists of the following five types of records:

1. Initial information used to process the other records.
2. Element properties.
3. Sound pressure levels or mechanical inputs.
4. Sub-element properties.
5. Joint properties.

The arrangement of these records and their data elements is shown on the following five loadsheet pages (Figures 4-1 through 4-5).
LOADSHEET (1): HEADER CARD

- One required per case
- First card in sequence

<table>
<thead>
<tr>
<th>Card Columns</th>
<th>Value</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-2</td>
<td>Integer</td>
<td>Total number of elements in model (2 ≤ E ≤ 20)</td>
</tr>
</tbody>
</table>
| 3-4          | Integer | Total number of analysis frequencies (1 ≤ F ≤ 40)  
(Analysis frequencies are spaced 1/3 octave apart) |
| 5-14         | Real   | Lowest analysis frequency |
| 15           | Alpha  | Units; M = metric (MKS), default = English (in, lb, sec) |
| 16-18        | Alpha  | Output mode; RMS or PSD |

Figure 4-1. Loadsheet 1
LOADSHEET (2): SEA ELEMENT PROPERTIES CARD

- One required for each element (2 ≤ E ≤ 20)
- Must be in ascending numerical sequence

<table>
<thead>
<tr>
<th>Card Column</th>
<th>Value</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-2</td>
<td>Integer</td>
<td>Element number</td>
</tr>
<tr>
<td>3-4</td>
<td>Integer</td>
<td>Number of sub-elements (SE ≥ 1)</td>
</tr>
<tr>
<td>5</td>
<td>Alpha</td>
<td>Excitation type on this element (if any) M = direct mechanical</td>
</tr>
<tr>
<td>6-8</td>
<td>Alpha</td>
<td>If CC5 = A, leave blank; defaults to dB re 20 µbar If CC5 = M, RMS = 1/3 octave RMS g's PSD = g²/Hz input at 1/3 octave centers</td>
</tr>
<tr>
<td>9-18</td>
<td>Real</td>
<td>If CC5 = A, input surface area exposed to acoustic excitation (consistent units)</td>
</tr>
<tr>
<td>19-28</td>
<td>Real</td>
<td>Element loss factor constant (η₀)</td>
</tr>
<tr>
<td>29-38</td>
<td>Real</td>
<td>Loss factor high frequency slope (s) such that η(f) = η₀(f/f₀)⁵</td>
</tr>
<tr>
<td>39-48</td>
<td>Real</td>
<td>Loss factor crossover frequency (f₀)</td>
</tr>
</tbody>
</table>

Figure 4-2. Loadsheet 2
LOADSHEET (3): EXCITATION SPECTRUM CARD

- Must immediately follow element properties if LS#2, CC5 ≠ blank
- All entries are real numbers, and must be consistent with LS #2, CC6-8 (units) and LS #1, CC 3-4 (no. of frequencies - 40 max)
- Make entries across in order of increasing frequency

Figure 4-3. Loadsheet 3
LOADSHEET (4): SUB-ELEMENT PROPERTIES, CARDS 1 AND 2

- Must be consistent with Loadsheet 2, CC 3-4 (SE ≥ 1)
- Two cards (records) per sub-element
- Must follow associated element card and excitation card (if any)

DATA ENTRY DESCRIPTION

<table>
<thead>
<tr>
<th>Card Columns</th>
<th>Value</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-2</td>
<td>Integer</td>
<td>Sub-element number</td>
</tr>
<tr>
<td>3</td>
<td>Alpha</td>
<td>Sub-element type; B = beam, C = cylinder, M = membrane, P = plate, R = room (acoustic element)</td>
</tr>
<tr>
<td>4-13</td>
<td>Real</td>
<td>Mass density (B, C, M, P, R)</td>
</tr>
<tr>
<td>14-23</td>
<td>Real</td>
<td>Elastic modulus (B, C, M, P)</td>
</tr>
<tr>
<td>24-33</td>
<td>Real</td>
<td>Thickness (B, C, M, P)</td>
</tr>
<tr>
<td>34-43</td>
<td>Real</td>
<td>Area (section if B; surface if M or P)</td>
</tr>
<tr>
<td>44-53</td>
<td>Real</td>
<td>Poisson's ratio (C, P)</td>
</tr>
<tr>
<td>54-63</td>
<td>Real</td>
<td>Length (B, C)</td>
</tr>
<tr>
<td>64-73</td>
<td>Real</td>
<td>Pressure (M only)</td>
</tr>
<tr>
<td>1</td>
<td>Logical</td>
<td>Replace F with T if stiffness increase is desired (B, C, P)</td>
</tr>
<tr>
<td>2-11</td>
<td>Real</td>
<td>Radius (C only)</td>
</tr>
<tr>
<td>Card 2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>12-21</td>
<td>Real</td>
<td>Volume (R only)</td>
</tr>
<tr>
<td>22-31</td>
<td>Real</td>
<td>Speed of sound (R, or if LS #2, CC5 = A)</td>
</tr>
<tr>
<td>32-41</td>
<td>Real</td>
<td>Added non-structural mass (B, C, M, P)</td>
</tr>
</tbody>
</table>

Figure 4-4. Loadsheet 4
LOADSHEET (5): JOINT PROPERTIES

- Must follow all element and sub-element cards at end of deck.
- Must be consistent with elements being joined.

DATA ENTRY DESCRIPTION

<table>
<thead>
<tr>
<th>Card Columns</th>
<th>Value</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-2</td>
<td>Integer</td>
<td>Element number of A end of joint</td>
</tr>
<tr>
<td>3-4</td>
<td>Integer</td>
<td>Element number of B end of joint</td>
</tr>
<tr>
<td>5-6</td>
<td>Alpha</td>
<td>Joint type: PP = plate-to-plate, BP = beam-to-plate, BJ = bolted joint, PA = plate to acoustic</td>
</tr>
<tr>
<td>7-8</td>
<td>Integer</td>
<td>No. of sides exposed to acoustic input (1 or 2)</td>
</tr>
<tr>
<td>9-18</td>
<td>Real</td>
<td>Joint length</td>
</tr>
<tr>
<td>19-28</td>
<td>Real</td>
<td>Thickness of A end of joint</td>
</tr>
<tr>
<td>29-38</td>
<td>Real</td>
<td>Thickness of B end of joint</td>
</tr>
<tr>
<td>39-48</td>
<td>Real</td>
<td>Acoustic space mass density (P/RT)</td>
</tr>
<tr>
<td>49-58</td>
<td>Real</td>
<td>Beam length (BP only)</td>
</tr>
<tr>
<td>59-68</td>
<td>Real</td>
<td>Bolt spacing (BJ only)</td>
</tr>
</tbody>
</table>

Figure 4-5. Loadsheet 5
4.2.3 Output - Printout
The output consists of a list of input parameters, calculated modal densities, and calculated PSD levels (or $G_{rms}$, if this was specified on input by the user) for each element for each analysis frequency, arranged in five columns below a heading. The first column is the frequencies, the other four columns list the PSD levels for elements 1 to 4. This is followed by five more columns below a new heading and containing the frequencies and PSD levels for elements 5 to 8. This is repeated until all the elements have been listed.

4.2.4 Program Diagnostic Messages
The program can produce the error messages listed below. Suggestions for their cause and correction are also given. Lower case x's indicate values (usually, but not always, integers) that depend on the particular error.

*** ERROR *** THE INPUT FILE IS EMPTY. THE END OF FILE WAS ENCOUNTERED WHILE TRYING TO READ THE FIRST INPUT RECORD. THIS ERROR WAS DISCOVERED BY SUBROUTINE EPROP.

*** ERROR *** WHILE TRYING TO READ ELEMENT PROPERTIES, THE END OF FILE WAS ENCOUNTERED BEFORE INPUT RECORD xxxx. THIS ERROR WAS DISCOVERED BY SUBROUTINE EPROP.

*** ERROR *** WHILE TRYING TO READ SUB-ELEMENT PROPERTIES, THE END OF FILE WAS ENCOUNTERED BEFORE INPUT RECORD xxxx. THIS ERROR WAS DISCOVERED BY SUBROUTINE EPROP.

*** ERROR *** WHILE TRYING TO READ SOUND PRESSURE LEVELS, THE END OF FILE WAS ENCOUNTERED BEFORE INPUT RECORD xxxx. THIS ERROR WAS DISCOVERED BY SUBROUTINE EPROP.

*** ERROR *** WHILE TRYING TO READ MECHANICAL INPUTS, THE END OF FILE WAS ENCOUNTERED BEFORE INPUT RECORD xxxx. THIS ERROR WAS DISCOVERED BY SUBROUTINE EPROP.
*** ERROR *** THE END OF FILE WAS REACHED BEFORE ANY INFORMATION
ABOUT JOINT PROPERTIES WAS READ. THIS ERROR WAS DISCOVERED BY
SUBROUTINE JINPUT.

These errors are the result of an incomplete data file. The data file
cannot end before joint properties for at least one pair of elements are
read. The message indicates what kind of data the program was looking
for when the end of file was encountered.

*** ERROR *** A FORTRAN ERROR OCCURRED WHILE TRYING TO READ
ELEMENT PROPERTIES ON INPUT RECORD xxxx. THIS ERROR WAS DISCOVERED
BY SUBROUTINE EPROP.

*** ERROR *** A FORTRAN ERROR OCCURRED WHILE TRYING TO READ
SUB-ELEMENT PROPERTIES ON INPUT RECORDS xxxx AND xxxx. THIS ERROR
WAS DISCOVERED BY SUBROUTINE EPROP.

*** ERROR *** A FORTRAN ERROR OCCURRED WHILE TRYING TO READ THE
FIRST INPUT RECORD. THIS ERROR WAS DISCOVERED BY SUBROUTINE EPROP.

*** ERROR *** A FORTRAN ERROR OCCURRED WHILE TRYING TO READ SOUND
PRESSURE LEVELS ON OR BEFORE INPUT RECORD xxxx. THIS ERROR WAS
DISCOVERED BY SUBROUTINE EPROP.

*** ERROR *** A FORTRAN ERROR OCCURRED WHILE TRYING TO READ MECHANICAL INPUTS ON OR BEFORE INPUT RECORD xxxx. THIS ERROR WAS
DISCOVERED BY SUBROUTINE EPROP.

*** ERROR *** WHILE ATTEMPTING TO READ JOINT PROPERTIES, A FORTRAN
ERROR OCCURRED ON INPUT RECORD xxxx. THIS ERROR WAS DISCOVERED BY
SUBROUTINE JINPUT.

A FORTRAN error is usually the result of invalid characters appearing in
a data field; for example, alphabetic characters appearing where the
program expects to read an integer. This is likely to occur if data
RECORDS are missing or out of order; for example, if an element proper-
ties record says there are four sub-elements for that element, but records

4-14
for only three sub-elements are present. A FORTRAN error on the first record may indicate that the data file was not given the name 3. If the external file name is not 3, the internal file name should be made 3 by a USE statement.

*** ERROR *** THE NUMBER OF ELEMENTS WAS GIVEN AS xx. IT MUST BE BETWEEN 2 AND 20 INCLUSIVE. THIS ERROR WAS DISCOVERED BY SUBROUTINE EPROP.

*** ERROR *** THE NUMBER OF ANALYSIS FREQUENCIES WAS GIVEN AS xx. IT MUST BE BETWEEN 1 AND 40 INCLUSIVE. THIS ERROR WAS DISCOVERED BY SUBROUTINE EPROP.

*** ERROR *** THE TYPE OF MECHANICAL INPUT GIVEN FOR ELEMENT xx ON INPUT RECORD xxxx IS xxx. THIS IS NOT A VALID TYPE. THE TYPE MUST BE RMS OR PSD. THIS ERROR WAS DISCOVERED BY SUBROUTINE EPROP.

*** ERROR *** TYPE _ x ON INPUT RECORD xxxx IS AN INVALID TYPE. TYPE MUST BE B, M, P, C, OR R. THIS ERROR WAS DISCOVERED BY SUBROUTINE EPROP.

*** ERROR *** THE TYPE OF JOINT GIVEN FOR ELEMENT PAIR xx AND xx ON INPUT RECORD xxxx IS xx. THIS IS NOT A VALID TYPE. THE TYPE MUST BE PP, BP, BJ, OR PA. THIS ERROR WAS DISCOVERED BY SUBROUTINE JPROP.

*** ERROR *** THE DETERMINANT OF THE SEA EQUATION MATRIX IS 0. HENCE THERE IS NO SOLUTION. THIS ERROR WILL CAUSE THE PROGRAM TO ABORT. THIS ERROR WAS DISCOVERED BY SUBROUTINE SOLVE.

These messages are self explanatory. If any of the errors listed thus far occur, the subroutine in which they occur will continue processing. Before control is transferred to another subroutine, however, the following message is printed and the program is aborted through a CALL FERR statement:

BECAUSE OF THE ERRORS LISTED ABOVE, THE SEA PROGRAM WILL ABORT.
The following errors will not cause the program to abort, but may put the
results in error:

*** WARNING *** ON INPUT RECORD xxx THE ELEMENT NUMBER WAS GIVEN AS xx, WHICH IS OUT OF ORDER. IT HAS BEEN CHANGED TO xx. THIS ERROR WAS DISCOVERED BY SUBROUTINE EPROP.

Element properties are stored in arrays in the order in which they are
read. If elements are referenced in the joint properties section in any
other order, that is, when they are referenced as one element of a pair,
the results are almost certainly erroneous.

*** WARNING *** ON INPUT RECORD xxxx THE SUB-ELEMENT NUMBER WAS GIVEN AS xx, WHICH IS OUT OF ORDER. IT SHOULD BE xx. THIS ERROR WAS DISCOVERED BY SUBROUTINE EPROP.

Sub-element properties are not stored in arrays so this is not likely to
result in an error. If other errors occur, this message probably indi-
cates that there are missing or extraneous records.

*** WARNING *** ON INPUT RECORD xxxx, ONE OR BOTH MEMBERS OF THE ELEMENT PAIR xx AND xx WAS EITHER LESS THAN 1 OR GREATER THAN xx, THE TOTAL NUMBER OF ELEMENTS. THIS PAIR WILL BE IGNORED. THIS ERROR WAS DISCOVERED BY SUBROUTINE JINPUT.

*** WARNING *** THE ELEMENT PAIR xx AND xx ON INPUT RECORD xxxx WAS PREVIOUSLY READ ON INPUT RECORD xxxx. THE FIRST VALUES WILL BE USED. THIS ERROR WAS DISCOVERED BY SUBROUTINE JINPUT.

*** WARNING *** ON INPUT RECORD xxxx, BOTH ELEMENT NUMBERS WERE GIVEN AS xx. THEY MUST BE DIFFERENT. THIS RECORD WILL BE IGNORED. THIS ERROR WAS DISCOVERED BY SUBROUTINE JINPUT.

These errors result in the indicated record being ignored. Whether or
not the results are erroneous depends on whether the indicated record is
necessary to the results.

In addition, data which causes overflow, negative arguments to the square
root functions, etc., will produce ASCII FORTRAN diagnostics.
Section 5
REFERENCES


11/4/81

FINAL SEA

UNIVAC
**** SEA PROGRAM ****

STATISTICAL ENERGY ANALYSIS OF COMPLEX STRUCTURES

INPUT IS READ FROM UNIT 3 IN ASCII CODE
OUTPUT IS WRITTEN TO UNIT 6, THE PRINTER (OR TERMINAL IN DEMAND MODE)
THE FOLLOWING VARIABLES ARE USED IN THIS PROGRAM UNIT:

NAME TYPE DESCRIPTION
AF INT ANALYSIS FREQUENCY ORIGINAL (FROM 1 TO NUMAF)
FREQ REAL FREQUENCY
TABLE(4F) REAL TABLE OF ANALYSIS FREQUENCIES
NUMAF INT NUMBER OF ANALYSIS FREQUENCIES
OMEGA REAL 2*PI*FREQUENCY

THE FOLLOWING COMMON BLOCKS ARE USED:
BLOCK OTHER PROGRAMS USING THIS COMMON BLOCK

C INTEGER AR
LOGICAL ERROR
COMMON /CB/S, FTA(4F), NUMAF, FREQ
COMMON /CBO/ ERROR
COMMON /CB2/ ERROR
COMMON /CBO2/ FREQ, AF, OMEGA
DATA PI /3.141592/ 26 FORMAT (1X,5F18.9)
+ 1 WILL ABORT(1)
_return 0 MAIN 36
CALL EPROP TO READ ELEMENT PROPERTIES INPUT
CALL EPROP (AS)
CALL JINPUT TO READ JOINT PROPERTIES INPUT
CALL INPUT
C IF AN ERROR HAS OCCURRED ON INPUT, WRITE A MESSAGE AND
TERMINATE THE PROGRAM.
C IF (.NOT. ERROR) GO TO 10
WRITE (6,30)
CALL FREQ
C DO FOR EACH ANALYSIS FREQUENCY
10 DO 20 AF = 1,NUMAF
DEFINE THE CURRENT ANALYSIS FREQUENCY
FREQ = FTAB(AF)
OMEGA = 2.*PI.*FREQ
CALL JPROP TO CALCULATE JOINT PROPERTIES
CALL JPROP
CALL EXCITE TO DETERMINE ENERGY SOURCES FROM EXCITATION INPUTS
CALL EXCITE
CALL ANSWER TO SOLVE THE SEA EQUATIONS FOR ELEMENT ENERGIES
CALL ANSWER
20 CONTINUE
C CALL RITER TO WRITE CLT THE ANSWER
SUBROUTINE FPROP

C THIS SUBROUTINE READS ELEMENT AND SLAB-ELEMENT PROPERTIES FROM UNIT

C AND CALLS THE APPROPRIATE SUBROUTINE, DEPENDING ON THE TYPE OF

C SUB-ELEMENT, TO CALCULATE ELEMENT MODAL DENSITIES. FPROP IS CALLED

C FROM THE MAIN PROGRAM.

C THE FOLLOWING VARIABLES ARE USED IN THIS PROGRAM UNIT:

C NAME    TYPE      DESCRIPTION

C A       REAL      AREA
C C       REAL      SPEED OF SOUND IN ROOM MEDIUM
C E       REAL      MODULUS OF ELASTICITY
C ELMNUM  INT       ELEMENT NUMBER
C ETAE(20) REAL      DAMPING
C ETPE(20) CHAR      TYPE OF EXCITATION
C FREQ1   REAL      FIRST ANALYSIS FREQUENCY
C FTRP(40) REAL      TABLE OF ANALYSES FREQUENCIES
C G       REAL      GRAVITATIONAL CONSTANT
C GDP DISREAL      POISSON'S RATIO
C GI      REAL      GRAVITATIONAL CONSTANT IN METRIC UNITS
C IRP     INT       NUMBER OF INPUT RECORDS READ
C L       REAL      LENGTH
C M       REAL      PASS
C MAIN    LOG       TRUE IF SUB-ELEMENT IS MAIN SUB-ELEMENT
C MECCH(20) REAL      MECHANICAL INPUT
C MECNTY(20) CHAR      TYPE OF MECHANICAL INPUT
C N       INT       NUMBER OF ANALYSIS FREQUENCIES
C NULPEL  INT       NUMBER OF ELEMENTS
C NULSLAB INT       NUMBER OF SUB-ELEMENTS
C NTYPE    INT       TYPE OF OUTPUT
C N       REAL      RADIUS
C R       REAL      DENSITY
C S       REAL      RADIUS
C SFRQ(20) REAL      STARTING FREQUENCY
C SLOPE(20) REAL      SLOPE
C SFLG(40) REAL      SOUND PRESSURE LEVEL
C STIFF    LOG       TRUE IS STIFFNESS REDUCTION REQUIRED
C SUBNUM  INT       SUB-ELEMENT NUMBER
C T       REAL      THICKNESS
C TPE      CHAR      TYPE OF SUB-ELEMENT
C UNTS    CHAR      PI: IT'S METRIC, OTHERWISE ENGLISH UNITS
C V       REAL      VOLUME

C THE FOLLOWING COMMON BLOCKS ARE USED:

C OTHER PROGRAM UNITS USING THE COMMON BLOCK

C CR1: MAIN,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,REP,RE
<table>
<thead>
<tr>
<th>Line</th>
<th>Statement</th>
</tr>
</thead>
<tbody>
<tr>
<td>116</td>
<td>C</td>
</tr>
<tr>
<td>117</td>
<td>C</td>
</tr>
<tr>
<td>118</td>
<td>CHARACTER TYPE,ETYPE,MTYPE=7,UNITS=OTYPE=7</td>
</tr>
<tr>
<td>119</td>
<td>INTEGER FNAM,NUNAM</td>
</tr>
<tr>
<td>120</td>
<td>REAL MEX=MEL=MN</td>
</tr>
<tr>
<td>121</td>
<td>LOGICAL ERROR,STIFF,MAIN</td>
</tr>
<tr>
<td>122</td>
<td>COMMON /CE1/ ETAH(40),NUMAF,FREC</td>
</tr>
<tr>
<td>123</td>
<td>COMMON /CR2/ ERROR</td>
</tr>
<tr>
<td>124</td>
<td>COMMON /CR7/ ELMNUM,TGAMMAL,AMM,MSTIFF,LAV,VCR,R,M,MAIN</td>
</tr>
<tr>
<td>125</td>
<td>COMMON /CB5/ THICK(20),AREA(20),DENSE(20),VOL(20),EE(20)</td>
</tr>
<tr>
<td>126</td>
<td>* EAMMA(40),R(20)</td>
</tr>
<tr>
<td>127</td>
<td>COPPER /CB2/ SFL(20),401,MECH(20),401,AMM(20),ETY(20),MTE(20)</td>
</tr>
<tr>
<td>128</td>
<td>COPPER /CB7/ ML(50)</td>
</tr>
<tr>
<td>129</td>
<td>COPPER /CB8/ SLOPE(20),SFREQ(20),ETA(20),O TYPE</td>
</tr>
<tr>
<td>130</td>
<td>COMMON /CB5/ N(20),401</td>
</tr>
<tr>
<td>131</td>
<td>COMMON /CR1/ INPUT</td>
</tr>
<tr>
<td>132</td>
<td>DATA 01 01</td>
</tr>
<tr>
<td>133</td>
<td>300 FORMAT (212,F10.2,A1,A3)</td>
</tr>
<tr>
<td>134</td>
<td>310 FORMAT (212,A1,A3,F10.2)</td>
</tr>
<tr>
<td>135</td>
<td>310 FORMAT (F10.2,A1,A3,F10.2)</td>
</tr>
<tr>
<td>136</td>
<td>330 FORMAT (10*** ERROR *** TYPE = I, A1, t ON INPUT RECORD t)</td>
</tr>
<tr>
<td>137</td>
<td>1 I4,t IS AN INVALID TYPE, I t TYPE MUST BE B, M, P, C OR R t</td>
</tr>
<tr>
<td>138</td>
<td>S I THIS ERROR WAS DISCOVERED BY SUBROUTINE EPROP t</td>
</tr>
<tr>
<td>139</td>
<td>1 THIS ERROR WAS DISCOVERED BY SUBROUTINE EPROP t</td>
</tr>
<tr>
<td>140</td>
<td>2 I4,t AND I4,t</td>
</tr>
<tr>
<td>141</td>
<td>2 I THIS ERROR WAS DISCOVERED BY SUBROUTINE EPROP t</td>
</tr>
<tr>
<td>142</td>
<td>300 FORMAT (10*** ERROR *** A FORTRAN ERROR OCCURRED WHILE t)</td>
</tr>
<tr>
<td>143</td>
<td>300 FORMAT (10*** ERROR *** A FORTRAN ERROR OCCURRED WHILE t)</td>
</tr>
<tr>
<td>144</td>
<td>300 FORMAT (10*** ERROR *** A FORTRAN ERROR OCCURRED WHILE t)</td>
</tr>
<tr>
<td>145</td>
<td>300 FORMAT (10*** ERROR *** A FORTRAN ERROR OCCURRED WHILE t)</td>
</tr>
<tr>
<td>146</td>
<td>300 FORMAT (10*** ERROR *** A FORTRAN ERROR OCCURRED WHILE t)</td>
</tr>
<tr>
<td>147</td>
<td>300 FORMAT (10*** ERROR *** A FORTRAN ERROR OCCURRED WHILE t)</td>
</tr>
<tr>
<td>148</td>
<td>300 FORMAT (10*** ERROR *** A FORTRAN ERROR OCCURRED WHILE t)</td>
</tr>
<tr>
<td>149</td>
<td>300 FORMAT (10*** ERROR *** A FORTRAN ERROR OCCURRED WHILE t)</td>
</tr>
<tr>
<td>150</td>
<td>300 FORMAT (10*** ERROR *** A FORTRAN ERROR OCCURRED WHILE t)</td>
</tr>
<tr>
<td>151</td>
<td>300 FORMAT (10*** ERROR *** A FORTRAN ERROR OCCURRED WHILE t)</td>
</tr>
<tr>
<td>152</td>
<td>300 FORMAT (10*** ERROR *** A FORTRAN ERROR OCCURRED WHILE t)</td>
</tr>
<tr>
<td>153</td>
<td>300 FORMAT (10*** ERROR *** A FORTRAN ERROR OCCURRED WHILE t)</td>
</tr>
<tr>
<td>154</td>
<td>300 FORMAT (10*** ERROR *** A FORTRAN ERROR OCCURRED WHILE t)</td>
</tr>
<tr>
<td>155</td>
<td>300 FORMAT (10*** ERROR *** A FORTRAN ERROR OCCURRED WHILE t)</td>
</tr>
<tr>
<td>156</td>
<td>300 FORMAT (10*** ERROR *** A FORTRAN ERROR OCCURRED WHILE t)</td>
</tr>
<tr>
<td>157</td>
<td>300 FORMAT (10*** ERROR *** A FORTRAN ERROR OCCURRED WHILE t)</td>
</tr>
<tr>
<td>158</td>
<td>300 FORMAT (10*** ERROR *** A FORTRAN ERROR OCCURRED WHILE t)</td>
</tr>
<tr>
<td>159</td>
<td>300 FORMAT (10*** ERROR *** A FORTRAN ERROR OCCURRED WHILE t)</td>
</tr>
<tr>
<td>160</td>
<td>300 FORMAT (10*** ERROR *** A FORTRAN ERROR OCCURRED WHILE t)</td>
</tr>
<tr>
<td>161</td>
<td>300 FORMAT (10*** ERROR *** A FORTRAN ERROR OCCURRED WHILE t)</td>
</tr>
<tr>
<td>162</td>
<td>300 FORMAT (10*** ERROR *** A FORTRAN ERROR OCCURRED WHILE t)</td>
</tr>
<tr>
<td>163</td>
<td>300 FORMAT (10*** ERROR *** A FORTRAN ERROR OCCURRED WHILE t)</td>
</tr>
<tr>
<td>164</td>
<td>300 FORMAT (10*** ERROR *** A FORTRAN ERROR OCCURRED WHILE t)</td>
</tr>
<tr>
<td>165</td>
<td>300 FORMAT (10*** ERROR *** A FORTRAN ERROR OCCURRED WHILE t)</td>
</tr>
<tr>
<td>166</td>
<td>300 FORMAT (10*** ERROR *** A FORTRAN ERROR OCCURRED WHILE t)</td>
</tr>
<tr>
<td>167</td>
<td>300 FORMAT (10*** ERROR *** A FORTRAN ERROR OCCURRED WHILE t)</td>
</tr>
<tr>
<td>168</td>
<td>300 FORMAT (10*** ERROR *** A FORTRAN ERROR OCCURRED WHILE t)</td>
</tr>
<tr>
<td>169</td>
<td>300 FORMAT (10*** ERROR *** A FORTRAN ERROR OCCURRED WHILE t)</td>
</tr>
<tr>
<td>170</td>
<td>300 FORMAT (10*** ERROR *** A FORTRAN ERROR OCCURRED WHILE t)</td>
</tr>
<tr>
<td>171</td>
<td>300 FORMAT (10*** ERROR *** A FORTRAN ERROR OCCURRED WHILE t)</td>
</tr>
<tr>
<td>172</td>
<td>300 FORMAT (10*** ERROR *** A FORTRAN ERROR OCCURRED WHILE t)</td>
</tr>
<tr>
<td>173</td>
<td>300 FORMAT (10*** ERROR *** A FORTRAN ERROR OCCURRED WHILE t)</td>
</tr>
<tr>
<td>174</td>
<td>300 FORMAT (10*** ERROR *** A FORTRAN ERROR OCCURRED WHILE t)</td>
</tr>
<tr>
<td>175</td>
<td>300 FORMAT (10*** ERROR *** A FORTRAN ERROR OCCURRED WHILE t)</td>
</tr>
<tr>
<td>176</td>
<td>300 FORMAT (10*** ERROR *** A FORTRAN ERROR OCCURRED WHILE t)</td>
</tr>
<tr>
<td>177</td>
<td>300 FORMAT (10*** ERROR *** A FORTRAN ERROR OCCURRED WHILE t)</td>
</tr>
<tr>
<td>178</td>
<td>300 FORMAT (10*** ERROR *** A FORTRAN ERROR OCCURRED WHILE t)</td>
</tr>
<tr>
<td>179</td>
<td>300 FORMAT (10*** ERROR *** A FORTRAN ERROR OCCURRED WHILE t)</td>
</tr>
<tr>
<td>180</td>
<td>300 FORMAT (10*** ERROR *** A FORTRAN ERROR OCCURRED WHILE t)</td>
</tr>
<tr>
<td>181</td>
<td>300 FORMAT (10*** ERROR *** A FORTRAN ERROR OCCURRED WHILE t)</td>
</tr>
<tr>
<td>182</td>
<td>300 FORMAT (10*** ERROR *** A FORTRAN ERROR OCCURRED WHILE t)</td>
</tr>
<tr>
<td>183</td>
<td>300 FORMAT (10*** ERROR *** A FORTRAN ERROR OCCURRED WHILE t)</td>
</tr>
<tr>
<td>184</td>
<td>300 FORMAT (10*** ERROR *** A FORTRAN ERROR OCCURRED WHILE t)</td>
</tr>
<tr>
<td>185</td>
<td>300 FORMAT (10*** ERROR *** A FORTRAN ERROR OCCURRED WHILE t)</td>
</tr>
<tr>
<td>186</td>
<td>300 FORMAT (10*** ERROR *** A FORTRAN ERROR OCCURRED WHILE t)</td>
</tr>
<tr>
<td>187</td>
<td>300 FORMAT (10*** ERROR *** A FORTRAN ERROR OCCURRED WHILE t)</td>
</tr>
<tr>
<td>188</td>
<td>300 FORMAT (10*** ERROR *** A FORTRAN ERROR OCCURRED WHILE t)</td>
</tr>
<tr>
<td>189</td>
<td>300 FORMAT (10*** ERROR *** A FORTRAN ERROR OCCURRED WHILE t)</td>
</tr>
<tr>
<td>190</td>
<td>300 FORMAT (10*** ERROR *** A FORTRAN ERROR OCCURRED WHILE t)</td>
</tr>
<tr>
<td>191</td>
<td>300 FORMAT (10*** ERROR *** A FORTRAN ERROR OCCURRED WHILE t)</td>
</tr>
<tr>
<td>192</td>
<td>300 FORMAT (10*** ERROR *** A FORTRAN ERROR OCCURRED WHILE t)</td>
</tr>
<tr>
<td>193</td>
<td>300 FORMAT (10*** ERROR *** A FORTRAN ERROR OCCURRED WHILE t)</td>
</tr>
<tr>
<td>194</td>
<td>300 FORMAT (10*** ERROR *** A FORTRAN ERROR OCCURRED WHILE t)</td>
</tr>
<tr>
<td>195</td>
<td>300 FORMAT (10*** ERROR *** A FORTRAN ERROR OCCURRED WHILE t)</td>
</tr>
<tr>
<td>196</td>
<td>300 FORMAT (10*** ERROR *** A FORTRAN ERROR OCCURRED WHILE t)</td>
</tr>
<tr>
<td>197</td>
<td>300 FORMAT (10*** ERROR *** A FORTRAN ERROR OCCURRED WHILE t)</td>
</tr>
<tr>
<td>198</td>
<td>300 FORMAT (10*** ERROR *** A FORTRAN ERROR OCCURRED WHILE t)</td>
</tr>
<tr>
<td>199</td>
<td>300 FORMAT (10*** ERROR *** A FORTRAN ERROR OCCURRED WHILE t)</td>
</tr>
<tr>
<td>200</td>
<td>300 FORMAT (10*** ERROR *** A FORTRAN ERROR OCCURRED WHILE t)</td>
</tr>
<tr>
<td>201</td>
<td>300 FORMAT (10*** ERROR *** A FORTRAN ERROR OCCURRED WHILE t)</td>
</tr>
<tr>
<td>202</td>
<td>300 FORMAT (10*** ERROR *** A FORTRAN ERROR OCCURRED WHILE t)</td>
</tr>
<tr>
<td>203</td>
<td>300 FORMAT (10*** ERROR *** A FORTRAN ERROR OCCURRED WHILE t)</td>
</tr>
<tr>
<td>204</td>
<td>300 FORMAT (10*** ERROR *** A FORTRAN ERROR OCCURRED WHILE t)</td>
</tr>
<tr>
<td>205</td>
<td>300 FORMAT (10*** ERROR *** A FORTRAN ERROR OCCURRED WHILE t)</td>
</tr>
<tr>
<td>206</td>
<td>300 FORMAT (10*** ERROR *** A FORTRAN ERROR OCCURRED WHILE t)</td>
</tr>
<tr>
<td>207</td>
<td>300 FORMAT (10*** ERROR *** A FORTRAN ERROR OCCURRED WHILE t)</td>
</tr>
<tr>
<td>208</td>
<td>300 FORMAT (10*** ERROR *** A FORTRAN ERROR OCCURRED WHILE t)</td>
</tr>
<tr>
<td>209</td>
<td>300 FORMAT (10*** ERROR *** A FORTRAN ERROR OCCURRED WHILE t)</td>
</tr>
<tr>
<td>210</td>
<td>300 FORMAT (10*** ERROR *** A FORTRAN ERROR OCCURRED WHILE t)</td>
</tr>
<tr>
<td>211</td>
<td>300 FORMAT (10*** ERROR *** A FORTRAN ERROR OCCURRED WHILE t)</td>
</tr>
</tbody>
</table>
C WRITE THE HEADING FOR THE OUTPUT
   WRITE (6,520)

C READ HOW MANY ELEMENTS AND ANALYSIS FREQUENCIES THERE ARE, THE
C FIRST FREQUENCY, THE SYSTEM OF UNITS, AND THE TYPE OF OUTPUT
   READ (1,350,ERR=210) NNUM, NNUMAF, FREGL, UNITS, OTYPE

C WRITE THE FIRST RECORD TO OUTPUT
   WRITE (6,550) NNUM, NNUMAF, FREGL, UNITS, OTYPE

C CHECK TO SEE THAT THE NUMBER OF ELEMENTS AND ANALYSIS
C FREQUENCIES IS WITHIN RANGE
   IF (NUMEL .LT. 2 .OR. NUMEL .GT. 200) GO TO 260
   IF (NUMAF .LT. 1 .OR. NUMAF .GT. 40) GO TO 270

C IF THE SYSTEM OF UNITS IS METRIC, CONVERT THE GRavitATIONAL
C CONSTANT TO METRIC UNITS
   IF (UNITS .EQ. 1 .AND. OTYPE .EQ. 61)
   GO TO 241
   C PUT THE VALUES OF THE ANALYSIS FREQUENCIES IN THE FREQUENCY TABLE
   CO 10 I = 1,NUMAF
   FTA(I) = FTAF(I) + FREGL
   10 CONTINUE
   C DB FOR EACH ELEMENT
   CO 20 I = 1,NUMEL
   C INCREMENT INPUT
   CO 240 I = INPUT + 1
   C READ THE ELEMENT PROPERTIES
   C     READ (1,510) EM(K), EM(K)EQ.230) ELNUM,NUMSH,ETYPE(K),MYPE(K),
   C     ETAPIK,SLOPEI(K),SFREIG(K)
   C WRITE THE ELEMENT PROPERTIES TO OUTPUT
   C     WRITE(6,540) INPUT, ELNUM, NUMSH, ETYPE(K), MYPE(K),
   C     ETAPIK,SLOPEI(K),SFREIG(K)
   C IF THE ELEMENT NUMBER IS OUT OF ORDER, WRITE A WARNING
   C MESSAGE
   IF (ELNUM .LE. 1) GO TO 12
   WRITE (6,535) INPUT, ELNUM, I
   120 ELNUM = I
   C IF THE TYPE OF ELEMENT IS MECHANICAL BUT THE TYPE OF MECHANICAL
   C INPUT IS NEITHER RMS NOR PSD, WRITE A MESSAGE AND SET THE
   C ERROR FLAG
   IF (ETYPE(K) .NE. PRT .OR. MYPE(K) .NE. RMS .OR.
   C     MYPE(K) .NE. PRT .OR. PRT .LT. 1 .OR.
   C       ERROR = .TRUE.
   C IF THE TYPE OF EXCITATION IS ACOUSTIC
   C     IF (ETYPE(K) .NE. CAT) GO TO 15
   C THE INCREMENT INPUT
   C     INPUT = INPUT + 1
   C READ THE SOUND PRESSURE LEVEL FOR EACH FREQUENCY
   C     READ (1,450) ERR=200,END=203) SPL(K), J=1,NUMAF
   C WRITE THE SOUND PRESSURE LEVELS TO OUTPUT
   C     WRITE (6,550) INPUT, K, (SPL(J), J=1,NUMAF)
   C ELSE IF THE TYPE OF EXCITATION IS MECHANICAL
   C     IF (ETYPE(K) .NE. PMK) GO TO 28
   C THE INCREMENT INPUT
   C     INPUT1 = INPUT
   C LINES = (NUMAF + 1) / 8
   270 C ERROR FLAG
   280 C READ THE SOUND PRESSURE LEVELS TO OUTPUT
   C     WRITE (6,550) INPUT, K, (SPL(J), J=1,LINES)
   290 C ELSE IF THE TYPE OF EXCITATION IS MECHANICAL
C READ THE MECHANICAL INPUTS FOR EACH FREQUENCY
READ (2,400,ERR=140,END=260) (MECH(1:J),J=1,NUMF)
C WRITE THE MECHANICAL INPUTS TO OUTPUT
WRITE (6,550) (INPUT1 + K, (MECH(1, K = (K - 1) + J),
                   J = 1:8), K = 1:4, LINE(1)
C END IF
C INITIALIZE MAIN TO SIGNIFY THAT THE FIRST SUB-ELEMENT IS THE
C MAIN SUB-ELEMENT
20
C DC FOR EACH SUB-ELEMENT
DO 100 4 = 1, NUMSUB
C INCREMENT INPUT
INPUT = INPUT + 2
C READ THE SUB-ELEMENT PROPERTIES
READ (5,320,ERR=80,END=240) SUBNUM, TYPE, RHO, E,
                   T, A, GAMMA, L, S, INPUT, STIFF, P, W, C, M
C WRITE THE SUB-ELEMENT PROPERTIES TO OUTPUT
WRITE (6,570) INPUT - 1, SUBNUM, TYPE, RHO, E, T, A,
                   GAMMA, L, S, INPUT, STIFF, P, W, C, M
C CHANGE ALL PLATE, BEAM, CYLINDER, AND MEMBRANE TYPE SUB-
C ELEMENTS TO THE SAME MODULUS OF ELASTICITY AS THE ELEMENT 1
C MAIN ELEMENT AND SET THEIR THICKNESS TO THAT:
C T = T * (E / E(1)) ** (1. / 3.)
C CHECK ELEMENT NUMBER IS OUT OF ORDER, WRITE A WARNING
C MESSAGE
IF 4 < SUBNUM <= 48, GO TO 22
WRITE (6,440) INPUT-1, SUBNUM, 4
C IF THE SUB-ELEMENT NUMBER IS A REAP, CALL BEAM
25 IF TYPE NE. FRA) GO TO 20
CALL BEAM
20 GO TO 100
C IF THE SUB-ELEMENT IS A MEMBRANE, CALL MEMBR
30 IF TYPE = MTH = 0) GO TO 40
CALL MEMBR
40 GO TO 100
C IF THE SUB-ELEMENT IS A PLATE, CALL PLATE
50 IF TYPE = MTH = PTH) GO TO 50
CALL PLATE
50 GO TO 100
C IF THE SUB-ELEMENT IS A ROOM, CALL ROOM
60 IF TYPE = MTH = PTH) GO TO 60
CALL ROOM
60 GO TO 100
C IF THE SUB-ELEMENT IS A CYLINDER, CALL CYLIN
70 IF TYPE = MTH = 0) GO TO 70
CALL CYLIN
70
GO TO 100
ELSE IF THE TYPE OF SUB-ELEMENT IS NONE OF THE ABOVE, WRITE AN ERROR MESSAGE AND SET THE ERROR FLAG TO TERMINATE THE PROGRAM.
GO TO 100
C IF AN ERROR WAS ENCOUNTERED WHILE READING SUB-ELEMENT PROPERTIES, WRITE A MESSAGE AND SET THE ERROR FLAG.
GO TO 100
C IF AN ERROR WAS ENCOUNTERED WHILE READING ELEMENT PROPERTIES, WRITE A MESSAGE AND SET THE ERROR FLAG.
GO TO 100
C IF AN ERROR WAS ENCOUNTERED WHILE READING SOUND PRESSURE LEVELS, WRITE A MESSAGE AND SET THE ERROR FLAG.
GO TO 100
C IF AN ERROR WAS ENCOUNTERED WHILE READING MECHANICAL INPUTS, WRITE A MESSAGE AND SET THE ERROR FLAG.
GO TO 100
DO 207 K = 1, NUMEL, 4
   KPLUS1 = MIN(K, K + 3)
   WRITE (6,1500) KPLUS1
DO 207 J2 = 1, NUMAF
   WRITE(4,510) KJP(K, KPLUS1)
207 CONTINUE
C IF AN ERROR OCCURRED WHILE READING THE FIRST INPUT RECORD, WRITE A MESSAGE AND SET THE ERROR FLAG.
C IF AN ERROR OCCURRED WHILE TRYING TO READ THE FIRST INPUT RECORD, WRITE A MESSAGE AND SET THE ERROR FLAG.
GO TO 205
C IF AN ERROR WAS ENCOUNTERED WHILE READING SUB-ELEMENT PROPERTIES, WRITE A MESSAGE AND SET THE ERROR FLAG.
GO TO 205
C IF AN ERROR WAS ENCOUNTERED WHILE READING ELEMENT PROPERTIES, WRITE A MESSAGE AND SET THE ERROR FLAG.
GO TO 205
C IF AN ERROR WAS ENCOUNTERED WHILE READING SUB-ELEMENT PROPERTIES, WRITE A MESSAGE AND SET THE ERROR FLAG.
C IF AN ERROR WAS ENCOUNTERED WHILE READING SOUND PRESSURE LEVELS, WRITE A MESSAGE AND SET THE ERROR FLAG.
C IF AN ERROR WAS ENCOUNTERED WHILE READING MECHANICAL INPUTS, WRITE A MESSAGE AND SET THE ERROR FLAG.
GO TO 285
C IF THE NUMBER OF ELEMENTS IS OUT OF RANGE, WRITE A
C MESSAGE AND SET THE ERROR FLAG
260 WRITE (6,450) NUMEL
GO TO 285
C IF THE NUMBER OF ANALYSIS FREQUENCIES IS OUT OF RANGE, WRITE A
C MESSAGE AND SET THE ERROR FLAG
210 WRITE (6,460) NUMAF
GO TO 285
C IF AN END OF FILE WAS ENCOUNTERED WHILE READING MECHANICAL
C INPUT, WRITE A MESSAGE AND SET THE ERROR FLAG
285 WRITE (6,480) INPUT
285 ERROR = .TRUE.
RETURN 1
ENC
**SCLRFCLINE FEM**

This subroutine calculates the modal density for a sub-element, which is a real and sums this value to the element modal density. The following variables are used in this program unit:

<table>
<thead>
<tr>
<th>Name</th>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>REAL</td>
<td>Sub-element area</td>
</tr>
<tr>
<td>AREA(20)</td>
<td>REAL</td>
<td>Element area</td>
</tr>
<tr>
<td>C</td>
<td>REAL</td>
<td>Speed of sound in sub-element room medium</td>
</tr>
<tr>
<td>DENSE(20)</td>
<td>REAL</td>
<td>Element density</td>
</tr>
<tr>
<td>C</td>
<td>REAL</td>
<td>Sub-element modulus of elasticity</td>
</tr>
<tr>
<td>FC(20)</td>
<td>REAL</td>
<td>Speed of sound in element room medium</td>
</tr>
<tr>
<td>FE(20)</td>
<td>REAL</td>
<td>Element modulus of elasticity</td>
</tr>
<tr>
<td>EGAPPA(20)</td>
<td>REAL</td>
<td>Poisson's ratio for element</td>
</tr>
<tr>
<td>ELNUP</td>
<td>INT</td>
<td>Element number</td>
</tr>
<tr>
<td>FTAB(40)</td>
<td>REAL</td>
<td>Table of analysis frequencies</td>
</tr>
<tr>
<td>GAMMA</td>
<td>REAL</td>
<td>Poisson's ratio for sub-element</td>
</tr>
<tr>
<td>L</td>
<td>REAL</td>
<td>Length</td>
</tr>
<tr>
<td>M</td>
<td>REAL</td>
<td>Sub-element added mass (non-structural)</td>
</tr>
<tr>
<td>MASS(20)</td>
<td>REAL</td>
<td>Element mass</td>
</tr>
<tr>
<td>N120, N120</td>
<td>REAL</td>
<td>Sub-element total mass</td>
</tr>
<tr>
<td>N120, N120</td>
<td>REAL</td>
<td>Element modal density</td>
</tr>
<tr>
<td>NUMAF</td>
<td>INT</td>
<td>Number of analysis frequencies</td>
</tr>
<tr>
<td>OMEGA</td>
<td>REAL</td>
<td>2<em>pi</em>frequency</td>
</tr>
<tr>
<td>PSUBD</td>
<td>REAL</td>
<td>Partial sub-element modal density</td>
</tr>
<tr>
<td>P</td>
<td>REAL</td>
<td>Radius</td>
</tr>
<tr>
<td>Q</td>
<td>REAL</td>
<td>Sub-element density</td>
</tr>
<tr>
<td>REAL</td>
<td>REAL</td>
<td>Pressure</td>
</tr>
<tr>
<td>Q</td>
<td>REAL</td>
<td>Sub-element modal density</td>
</tr>
<tr>
<td>T</td>
<td>REAL</td>
<td>Sub-element thickness</td>
</tr>
<tr>
<td>THICK(20)</td>
<td>REAL</td>
<td>Element thickness</td>
</tr>
<tr>
<td>V</td>
<td>REAL</td>
<td>Sub-element volume</td>
</tr>
<tr>
<td>VOL(20)</td>
<td>REAL</td>
<td>Element volume</td>
</tr>
<tr>
<td>NUM</td>
<td>INT</td>
<td>Other program units using this common block</td>
</tr>
<tr>
<td>CP1</td>
<td>MAIN</td>
<td>EPROP, MEPAR, PLATE, ROOM, CYLIN, RITER, BLOCK DATA</td>
</tr>
<tr>
<td>CP4</td>
<td>EPROP, MEPAR, PLATE, GCM, CYLIN</td>
<td></td>
</tr>
<tr>
<td>CP5</td>
<td>EPROP, MEPAR, PLATE, CYLIN, VPROP, EXCITE, ANSWER</td>
<td></td>
</tr>
<tr>
<td>CP7</td>
<td>EPROP, MEPAR, PLATE, CYLIN, VPROP, EXCITE, BLOCK DATA</td>
<td></td>
</tr>
<tr>
<td>CP11</td>
<td>MEPA, PLATE, ROOM, CYLIN, ANSWER, BLOCK DATA</td>
<td></td>
</tr>
</tbody>
</table>

The following common blocks are used:

- | Name | Type | Description |
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>CP1</td>
<td>MAIN</td>
<td>EPROP, MEPAR, PLATE, ROOM, CYLIN, RITER, BLOCK DATA</td>
</tr>
<tr>
<td>CP4</td>
<td>EPROP, MEPAR, PLATE, GCM, CYLIN</td>
<td></td>
</tr>
<tr>
<td>CP5</td>
<td>EPROP, MEPAR, PLATE, CYLIN, VPROP, EXCITE, ANSWER</td>
<td></td>
</tr>
<tr>
<td>CP7</td>
<td>EPROP, MEPAR, PLATE, CYLIN, VPROP, EXCITE, BLOCK DATA</td>
<td></td>
</tr>
<tr>
<td>CP11</td>
<td>MEPA, PLATE, ROOM, CYLIN, ANSWER, BLOCK DATA</td>
<td></td>
</tr>
</tbody>
</table>

**integer elnum**

<table>
<thead>
<tr>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>REAL</td>
<td>MAIN, PASS, PSUR</td>
</tr>
<tr>
<td>LOGICAL</td>
<td>STIFF, MAIN</td>
</tr>
<tr>
<td>COMMON /CB1/</td>
<td>FTAR(40), NUMAF, FREQL</td>
</tr>
<tr>
<td>COMMON /CB8/</td>
<td>ELNUP, YF, GAPP, PHO, WSTIFF, LAVV, CS, MAIN</td>
</tr>
<tr>
<td>COMMON /CB5/</td>
<td>THICK(20), AREA(20), DENSE(20), VOL(20), FE(20)</td>
</tr>
<tr>
<td>COMMON /CB11/</td>
<td>MA(5,20)</td>
</tr>
</tbody>
</table>

**Beam**

- Beam 2
- Beam 3
- Beam 4
- Beam 5
- Beam 6
- Beam 7
- Beam 8
- Beam 9
- Beam 10
- Beam 11
- Beam 12
- Beam 13
- Beam 14
- Beam 15
- Beam 16
- Beam 17
- Beam 18
- Beam 19
- Beam 20
- Beam 21
- Beam 22
- Beam 23
- Beam 24
- Beam 25
- Beam 26
- Beam 27
- Beam 28
- Beam 29
- Beam 30
- Beam 31
- Beam 32
- Beam 33
- Beam 34
- Beam 35
- Beam 36
- Beam 37
- Beam 38
- Beam 39
- Beam 40
- Beam 41
- Beam 42
- Beam 43
- Beam 44
- Beam 45
- Beam 46
- Beam 47
- Beam 48
- Beam 49
- Beam 50
- Beam 51
- Beam 52
- Beam 53
- Beam 54
- Beam 55
- Beam 56


SUBROUTINE READ

467  DATA PI /3.141592/
469  C CALCULATE THE PART OF THE SUB-ELEMENT MODAL DENSITY THAT IS
470  C NOT FREQUENCY DEPENDENT
471  FSLHND = L / (2. * PI) * SQRT(SCR(12) * RHO / E) / T
472  IF (STIFF) PSURMO = SQRT(5.) * PSURMO
473  DO FOR EACH ANALYSIS FREQUENCY
474  CM 20 I = 1,NUMAF
475     OMEGA = 2. * PI * FIAB(I)
476  C CALCULATE THE SUB-ELEMENT MODAL DENSITY
477      SUBMO = PSURMO / SQRT(OMEGA)
478  C SUM THE SUB-ELEMENT MODAL DENSITY TO THE ELEMENT MODAL DENSITY
479      N(EIUM,N) = N(EIUM,N) + SUBMO
480  20 CONTINUE
481  C SUM THE SUB-ELEMENT MASS TO THE ELEMENT MASS
482      PSLA = RHO * A + L + M
483      PSLA(EIUM') = M + N(EIUM) * PSUE
484  C IF THIS IS NOT THE MAIN SUB-ELEMENT, RETURN TO EPROP
485  IF (.NOT. PAIN) RETURN
486  C ELSE PLOT THE VALUES OF THE FOLLOWING SUB-ELEMENT VARIABLES INTO
487  C THE CORRESPONDING ELEMENT ARRAYS
488      EE(EIUM) = E
489      THICK(EIUM) = T
490      DESEQ(EIUM') = RHO
491      DESEQ(EIUM') = A
492      WCL(EIUM) = V
493      EGAMMA(EIUM) = GAMMA
494      EGAM(EIUM) = C
495  C SET PAIN TO INDICATE THAT ANY FOLLOWING SUB-ELEMENTS ARE NOT
496  C THE MAIN SUB-ELEMENT
497      PAIN = .FALSE.
498      RETURN
499  ENO
SUBROUTINE MFMAR

C THIS SUBROUTINE CALCULATES THE MODAL DENSITY FOR A SUB-ELEMENT
C WHICH IS A MEMBRANE AND SUMS THIS VALUE TO THE ELEMENT MODAL
C DENSITY.  MFMAR IS CALLED FROM EPROF.

C THE FOLLOWING VARIABLES ARE USED IN THIS PROGRAM UNIT:

C NAME TYPE DESCRIPTION

C A REAL SUB-ELEMENT AREA
C AREA(20) REAL ELEMENT AREA
C C REAL SPEED OF SOUND IN SUB-ELEMENT ROOM MEDIUM
C DENSE(20) REAL ELEMENT DENSITY
C E REAL SUB-ELEMENT MODULUS OF ELASTICITY
C FC(20) REAL SPEED OF SOUND IN ELEMENT ROOM MEDIUM
C EE(20) REAL ELEMENT MODULUS OF ELASTICITY
C CGAMMA(20) REAL HETT'S RATIO FOR ELEMENT...
C CM(40) REAL TABLE OF ANALYSIS FREQUENCIES
C GAMMA REAL PCISSON'S RATIO FOR SUB-ELEMENT
C L REAL ELEMENT LENGTH
C M REAL SUB-ELEMENT ADDED MASS (NON-STRUCTURAL)
C MASS(20) REAL ELEMENT MASS
C MSUB REAL SUB-ELEMENT TOTAL MASS
C N(20,40) REAL ELEMENT MODAL DENSITY
C NUMAF INT NUMBER OF ANALYSIS FREQUENCIES
C OMEGA REAL 2*PI*FREQUENCY
C PSLAPB REAL PARTIAL SUB-ELEMENT MODAL DENSITY
C R REAL RADIUS
C RHQ REAL SUB-ELEMENT DENSITY
C S REAL PRESSURE
C SPMDO REAL SUB-ELEMENT MODAL DENSITY
C THICK(20) REAL ELEMENT THICKNESS
C V REAL SUB-ELEMENT VOLUME
C VOL(20) REAL ELEMENT VOLUME

C THE FOLLOWING COMMON BLOCKS ARE USED:

C BLCK OTHER PROGRAM UNITS USING THIS COMMON BLOCK

C INTEGER ELMNUM
C REAL NLM, NMASS, NMSUB

C COMMON /CB1/ EPROF, BEAM, PLATE, ROOM, CYLIN, RITEP, BLOCK DATA
C COMMON /CB4/ EPROF, BEAM, PLATE, ROOM, CYLIN
C COMMON /CB8/ EPROF, BEAM, PLATE, ROOM, CYLIN, JPROF, EXCITE, ANSWER
C COMMON /CB11/ BEAM, PLATE, ROOM, CYLIN, ANSWER, BLOCK DATA

INTEGER ELMNUM
REAL NLM, NMASS, NMSUB
LOGICAL STIFF, MAIN
COMMON /CB1/ EPROF, BEAM, PLATE, ROOM, CYLIN, RITEP, BLOCK DATA
COMMON /CB4/ EPROF, BEAM, PLATE, ROOM, CYLIN
COMMON /CB8/ EPROF, BEAM, PLATE, ROOM, CYLIN, JPROF, EXCITE, ANSWER
COMMON /CB11/ BEAM, PLATE, ROOM, CYLIN, ANSWER, BLOCK DATA
DATA FILE 3.14.15926

C CALCULATE THE PART OF THE SUB-ELEMENT MODAL DENSITY THAT IS
C AT FREQUENCY DEPENDENT

FSUMO = A * RHO * T / (2 * PI * S)

C IF STIFFNESS REDUCTION IS REQUIRED, MULTIPLY BY SORT(*)

IF (STIFF) FSUMO = SORT(*) * FSUMO

C DO FOR EACH ANALYSIS FREQUENCY

DO 20 I = 1, NUMAF

OMEGA = 2 * PI * FILEI

C CALCULATE THE SUB-ELEMENT MODAL DENSITY

SUBKO = FSUMO * OMEGA

SUBKO = PSUMO * OMEGA

C SUM THE SUB-ELEMENT MODAL DENSITY TO THE ELEMENT MODAL DENSITY

NELNUM(I) = NELNUM(I) + SUBKO

20 CONTINUE

C SUM THE SUB-ELEMENT MASS TO THE ELEMENT MASS

MSUM(A) = RHO + A + T + M

MSUM(A) = MSAF + MSUB

C IF THIS IS NOT THE MAIN SUB-ELEMENT, RETURN TO EPROP

IF (.NOT. MAIN) RETURN

C ELSE PUT THE VALUES OF THE FOLLOWING SUB-ELEMENT VARIABLES INTO

C THE CORRESPONDING ELEMENT ARRAYS

ESEC(EK) = T

THICK(EK) = T

DENSEK(EK) = RHO

AREA(EK) = A

VOL(EK) = V

EGAMMA(EK) = GAMMA

EQDEL(EK) = C

C SET PAIN TO INDICATE THAT ANY FOLLOWING SUB-ELEMENTS ARE NOT

C THE MAIN SUB-ELEMENT

PAIN = .FALSE.

RETURN

END
SUBROUTINE PLATE

C THIS SUBROUTINE CALCULATES THE MODAL DENSITY FOR A SUB-ELEMENT
C WHICH IS A PLATE AND SUMS THIS VALUE TO THE ELEMENT MODAL
C DENSITY. PLATE IS CALLED FROM EPDENSITY.

C THE FOLLOWING VARIABLES ARE USED IN THIS PROGRAM UNIT:
C NAME TYPE DESCRIPTION
C ---- --- ---------------
C A REAL SUB-ELEMENT AREA
C ANP(20) REAL (AREA x MODES / MASS) OF SURFACE EXCITED AT
C ACOUSTIC FIELD
C AREA(20) REAL ELEMENT AREA
C C REAL SPEED OF SOUN IN SUB-ELEMENT ROOM MEDIUM
C DENSITY(20) REAL ELEMENT DENSITY
C E REAL ELEMENT MODULUS OF ELASTICITY
C F REAL ELEMENT MODULUS OF ELASTICITY
C E(GAMMA)(20) REAL POISSON'S RATIO FOR ELEMENT
C F(LAM) INT ELEMENT NUMBER
C F(LAM)(40) REAL TABLE OF ANALYSIS FREQUENCIES
C GAMMA REAL POISSON'S RATIO FOR SUB-ELEMENT
C H REAL LENGTH
C I REAL LENGTH
C M REAL ELEMENT ADDPD MASS (NON-STRUCTURAL)
C MASS(20) REAL ELEMENT MASS
C MSUR REAL SUB-ELEMENT TOTAL MASS
C N(20)(40) REAL ELEMENT MODAL DENSITY
C NUMF INT NUMBER OF ANALYSIS FREQUENCIES
C OMEGA REAL 2*PI*FREQUENCY
C PSURPD REAL PARTIAL SUB-ELEMENT MODAL DENSITY
C R REAL RADIUS
C RPC REAL SUB-ELEMENT DENSITY
C S REAL PRESSURE
C SUBMD REAL ELEMENT MODAL DENSITY
C SUBTH REAL SUB-ELEMENT THICKNESS
C THICK(20) REAL ELEMENT THICKNESS
C V REAL SUB-ELEMENT VOLUME
C VOL(20) REAL ELEMENT VOLUME

C THE FOLLOWING COMMON BLOCKS ARE USED:
C BLOCK OTHER PROGRAM UNITS USING THIS COMMON BLOCK
C ---- ----------------------------------------
C CPI MAIN,EPDENSITY,ROCK,RODCYL,CIP,ANP,R,REACH,LIST,BLOCK DATA
C CPA EPDENSITY,ROOC,RODCYL,CIP,ANP,R,REACH,LIST,BLOCK DATA
C CHS EPDENSITY,ROOC,RODCYL,CIP,ANP,R,REACH,LIST,BLOCK DATA
C CPE EPDENSITY,ROOC,RODCYL,CIP,ANP,R,REACH,LIST,BLOCK DATA
C CPH EPDENSITY,ROOC,RODCYL,CIP,ANP,R,REACH,LIST,BLOCK DATA
C CPO EPDENSITY,ROOC,RODCYL,CIP,ANP,R,REACH,LIST,BLOCK DATA
C CPII MAIN,EPDENSITY,ROOC,RODCYL,CIP,ANP,R,REACH,LIST,BLOCK DATA

C CHARACTER ETYP,TYPETO
C REAL PC,R,MASS,MSUR
C LOGICAL STIFF,MAIN
C COMMON /CPI,CHS,CPA,CPH,CPO,CPII/CIP,ANP,R,REACH,LIST,BLOCK DATA
C COMMON /CPI,CHS,CPA,CPH,CPO,CPII/CIP,ANP,R,REACH,LIST,BLOCK DATA
C COMMON /CPI,CHANP,R,REACH,LIST,BLOCK DATA
C COMMON /CPI,CHANP,R,REACH,LIST,BLOCK DATA
C COMMON /CPI,CHANP,R,REACH,LIST,BLOCK DATA
C COMMON /CPI,CHANP,R,REACH,LIST,BLOCK DATA
SUBROUTINE PLATE

 COMMON /CH/E, THICK(20), AREA(20), ENSF(20), VOL(20), FE(20),
 COMMON /CH/E, SML(20, 40), MECH(20, 40), ANN(20), ETYP(20),#TYPE(20)
 COMMON /CH/E, N(20, 40)
 COMMON /CH/E, N(100)/MASS(20)
 DATA PI, 3.1415927

 C CALCULATE THE SUB-ELEMENT MODAL DENSITY
 SUPMD = A / (E * T ** 2) * SORT(12, * RHO * (1. - GAMMA ** 2)
 + / (E * T ** 2))

 C IF STIFFNESS REDUCTION IS REUDED, MULTIPLY BY SORT(5)
 IF (STIFF) SUPMD = SORT(5) * SUPMD

 C DO FOR EACH ANALYSIS FREQUENCY
 DO 20 I = 1, NUMAF

 C SUM THE SUB-ELEMENT MODAL DENSITY TO THE ELEMENT MODAL DENSITY
 N(ELNUP, I) = N(ELNUP, I) * SUPMD

 20 CONTINUE

 C SUM THE SUB-ELEMENT MASS TO THE ELEMENT MASS
 MSUN = RHO * A * T * M
 PASS(ELNUP) = PASS(ELNUP) * MSUN
 IF (TYPE(ELNUP), EQ, TAF AND MAIN) ANM(ELNUP) =
   + (E * SUPMD) / MSUN * 2. * PI

 C IF THIS IS NOT THE MAIN SUB-ELEMENT, RETURN TO EPREP
 IF (.NOT. MAIN) RETURN

 C ELSE PUT THE VALUES OF THE FOLLOWING SUB-ELEMENT VARIABLES INTO
 C THE CORRESPONDING ELEMENT ARRAYS
 E(ELNUP) = E
 TMCE(ELNUP) = T
 DEASF(ELNUP) = RHO
 AREA(ELNUP) = A
 VOL(ELNUP) = V
 EPP(PLNUM) = GAMMA
 EPP(PLNUM) = C

 C SET MAIN TO INDICATE THAT ANY FOLLOWING SUB-ELEMENTS ARE NOT
 C THE MAIN SUB-ELEMENT
 MAIN = .FALSE.
 REILRA
 END
C THIS SUBROUTINE CALCULATES THE MODAL DENSITY FOR A SUB-ELEMENT
C WHICH IS A RING AND SUMS THIS VALUE TO THE ELEMENT MODAL
C DENSITY. ROOM IS CALLED LOCH EREON.
C
C THE FOLLOWING VARIABLES ARE USED IN THIS PROGRAM UNIT:

C REAL TYPE DESCRIPTION

C A REAL SUB-ELEMENT AREA
C AREA(20) REAL ELEMENT AREA
C C REAL SPEED OF SOUND IN SUB-ELEMENT ROOM MEDIUM
C DENSE(20) REAL ELEMENT DENSITY
C E REAL SUB-ELEMENT MODULUS OF ELASTICITY
C FC(20) REAL SPEED OF SOUND IN ELEMENT ROOM MEDIUM
C EE(20) REAL ELEMENT MODULUS OF ELASTICITY
C FGAPP(20) REAL POISSON'S RATIO FOR ELEMENT
C ELNIP INT ELEMENT NUMBER
C FNTAB(40) REAL TABLE OF ANALYSIS FREQUENCIES
C GAPP REAL POISSON'S RATIO FOR SUB-ELEMENT
C L REAL LENGTH
C P REAL SUB-ELEMENT ADDED MASS (NON-STRUCTURAL)
C MASS(20) REAL ELEMENT MASS
C MSLD REAL SUB-ELEMENT TOTAL MASS
C N(26,40) REAL ELEMENT MODAL DENSITY
C NUMAF INT NUMBER OF ANALYSIS FREQUENCIES
C OMEGA REAL 2*PI*FREQUENCY
C PSCLPD REAL PARTIAL SUB-ELEMENT MODAL DENSITY
C R REAL RADIUS
C RMC REAL SUB-ELEMENT DENSITY
C S REAL PRESSURE
C SUBC REAL SUB-ELEMENT MODAL DENSITY
C T REAL SUB-ELEMENT THICKNESS
C TRICK(20) REAL ELEMENT THICKNESS
C V REAL SUB-ELEMENT VOLUME
C VOL(20) REAL ELEMENT VOLUME
C
C THE FOLLOWING COMMON BLOCKS ARE USED:
C BLOCK OTHER PROGRAM UNITS USING THIS COMMON BLOCK
C
C ------
C CR1,MAIN,EPROP,BEAR,PERBA,PLATE,XYLIP,TER,ROKLDATA
C CR2,EPROP,BEAR,PERBA,PLATE,XYLIP
C CR3,EPROP,BEAR,PERBA,PLATE,XYLIP,PROP,EXCITE,ANSWER
C CR4,EPROP,BEAR,PERBA,PLATE,XYLIP,PROP,EXCITE
C CR11,BFAN,EPROP,PLATE,XYLIP,ANSWER,ROKLDATA
C
C INTEGER FOR
C NFAI NFAI,MFAI,MSUR,MSUR
C LOGICAL STIFF,MAIN
C COMMON /CR1/ FIAH401,NUMAF,FREG
C COMMON /CR2/ FIU401,SPM
C COMMON /CR3/ A20,MAPPA,REF,STIFF,LA,VEG,CRM,MAIN
C COMMON /CR4/ MPAH,PROP,EXCITE,ANSWER
C COMMON /CR11/ PROP,EXCITE,ROKLDATA
C COMMON /CR11/ MFAI,MFAI,MSUR
C
C CREAT PI /3.1415927/
C CALCULATE THE PART OF THE SUB-ELEMENT MODAL DENSITY THAT IS
C NOT FREQUENCY DEPENDENT
FS.RPD = V / (2.* PI ** 2 * C ** 2)
C DC PER EACH ANALYSIS FREQUENCY
DO 2C I = 1,NUMAF
   240
   OMEGA = 2.* PI + FIA[I]
C CALCULATE THE SUB-ELEMENT MODAL DENSITY
   SUBR = OMEGA ** 2 * FS.RPD
C SUM THE SUB-ELEMENT MODAL DENSITY TO THE ELEMENT MODAL DENSITY
   NEELNUM[I] = NEELNUM[I] + SUBR
240 CONTINUE
C SUM THE SUB-ELEMENT MASS TO THE ELEMENT PASS
   MSUH = RHU * V
   MASELNUM[I] = MASELNUM[I] + MSUH
C IF THIS IS NOT THE MAIN SUB-ELEMENT, RETURN
C IF ( .NOT. PAIH ) RETURN
C ELSE PUT THE VALUES OF THE FOLLOWING SUB-ELEMENT VARIABLES INTO
C THE CORRESPONDING ELEMENT ARRAYS
   EE(LNUM) = F
   TMIC(ELENP) = T
   DENG(ELENP) = RHO
   MCH(ELENP) = A
   VCL(ELENP) = V
   FGAMPA(ELENP) = GAMMA
   FCFL(ELENP) = L
C SET PAIH TO INDICATE THAT ANY FOLLOWING SUB-ELEMENTS ARE NOT
C THE MAIN SUB-ELEMENT
   PAIH = .FALSE.
   RETURN
   ENC
SUBROUTINE CYLIN

C THIS SUBROUTINE CALCULATES THE MODAL DENSITY FOR A SUB-ELEMENT
C WHICH IS A CYLINDER AND SUFFS THIS VALUE TO THE ELEMENT MODAL
C DENSITY. CYLIN IS CALLED FROM EPORP.

C THE FOLLOWING VARIABLES ARE USED IN THIS PROGRAM UNIT:
C NAME TYPE DESCRIPTION
C A REAL SUB-ELEMENT AREA
C AREA(20) REAL ELEMENT AREA
C C REAL SPEED OF SOUND IN SUB-ELEMENT ROOM MEDIUM
C DENSITY(20) REAL ELEMENT DENSITY
C C REAL SUB-ELEMENT MODULUS OF ELASTICITY
C C(20) REAL SPEED OF SOUND IN ELEMENT ROOM MEDIUM
C C(20) REAL ELEMENT MODULUS OF ELASTICITY
C C(20) REAL POISSON'S RATIO FOR ELEMENT
C C ELNUM INT ELEMENT NUMBER
C C FTAR(40) REAL TABLE OF ANALYSIS FREQUENCIES
C C GRAPPA REAL POISSON'S RATIO FOR SUB-ELEMENT
C C L REAL LENGTH
C W REAL SUB-ELEMENT ADDED MASS (NON-STRUCTURAL)
C W(20) REAL ELEMENT MASS
C PSUB REAL SUB-ELEMENT TOTAL MASS
C NICE(20) REAL ELEMENT MODAL DENSITY
C NUMAF INT NUMBER OF ANALYSIS FREQUENCIES
C OMEGA REAL 2*PI*FREQUENCY
C PSUEPO REAL PARTIAL SUB-ELEMENT MODAL DENSITY
C R REAL RADIUS
C RHO REAL SUB-ELEMENT DENSITY
C S REAL PRESSURE
C SUBPE REAL SUB-ELEMENT MODAL DENSITY
C T REAL ELEMENT THICKNESS
C THICK(20) REAL ELEMENT THICKNESS
C V REAL SUB-ELEMENT VOLUME
C WCL(20) REAL ELEMENT VOLUME

C THE FOLLOWING COMMON BLOCKS ARE USED:
C CN(8) COMMON PROGRAM UNIT USING THIS COMMON BLOCK
C CB1 MAIN, EPROP, BEAM, MEMBR, PLATE, ROOM, RITER, BLOCK DATA
C CB5 EPROP, BEAM, MEMBR, PLATE, ROOM, JPROP, EXCITE, ANSWER
C CHP1 EPROP, BEAM, MEMBR, PLATE, ROOM, JPROP, EXCITE, BLOCK DATA
C CS11 BEAM, MEMBR, PLATE, ROOM, ANSWER, BLOCK DATA
C INTEFA CLAMP
C ICR1 REAL M, W, MASS, MSUR
C ICR4 LOGICAL STIFF, MAIN
C COMMON /CB1/ FTAR(40), NUMAF, FREQL
C COMMON /CB5/ THICK(20), AREA(20), DENSF(20), WCL(20), E(20)
C COMMON /CS11/ WCL(20)
C COMMON /CB1/ ICR1
DATA PI /3.1415927/
C CALCULATE THE PART OF THE SUB-ELEMENT MODAL DENSITY THAT IS
C NOT FREQUENCY DEPENDENT
FSUBD = R / L / 2. * SQRT(12. * R * C *
* (1. - GAMMA ** 2) / (E * T ** 2))
C IF STIFFNESS REDUCTION IS REQUIRED, MULTIPLY BY SQRT(4.)
IF (STIFF) PSUBMD = SQRT(4.) * FSUBD
C DO FOR EACH ANALYSIS FREQUENCY
DO 20 I = 1, NUMAF
SUBMD = FSUBMD
OPPA = 2. * PI * FTGAF(I)
C CALCULATE THE CRITERION FOR THE FREQUENCY DEPENDENT PART
E37  C OF THE SUB-ELEMENT MODAL DENSITY
CRIT = OMEGA / R * SQRT(PSUMD / E)
C IF THE CRITERION IS GREATER THAN 1, ALTER THE MODAL DENSITY
APPROPRIATELY
IF (CRIT > 1. * SUBMD = SUBMD * CRIT ** (2./3.))
C SLAP THE SUB-ELEMENT MODAL DENSITY TO THE ELEMENT MODAL DENSITY
NZELNUM(I) = N(FNLNUM(I)) * SUBMD
20 CONTINUE
C SUM THE SUB-ELEMENT MASS TO THE ELEMENT MASS
A = 2. * PI * R * L
MSLB = A * T * RHO * M
MASS(ELNUM) = MASS(ELNUM) + MSLB
C IF THIS IS NOT THE MAIN SUB-ELEMENT, RETURN TO EPROP
IF (N.OT. MAIN) RETURN
C ELSE PUT THE VALUES OF THE FOLLOWING SUB-ELEMENT VARIABLES INTO
C THE CORRESPONDING ELEMENT ARRAYS
EE(ELNUM) = E
THICK(ELNUM) = T
CENS(ELNUM) = RHO
AREA(ELNUM) = A
VOL(ELNUM) = V
ESAMMAC(ELNUM) = GAMMA
ECELLNUM = C
C SET MAIN TO INDICATE THAT ANY FOLLOWING SUB-ELEMENTS ARE NOT
C THE MAIN SUB-ELEMENT
MAIN = .FALSE.
RETURN
END
SUBROUTINE JINPUT

C THIS SUBROUTINE READS JOINT PROPERTIES FROM UNIT 3 AND CHECKS
C THAT ELEMENT PAIRS ARE NOT INPUT MORE THAN ONCE. JINPUT IS
C CALLED FROM THE MAIN PROGRAM.

C THE FOLLOWING VARIABLES ARE USED IN THIS PROGRAM UNIT:

C NAME TYPE DESCRIPTION
C ----- ------ ------------
C U(150) REAL ACOUSTIC SPACE DENSITY
C BL(150) REAL BEAM LENGTH
C INPUT INT NUMBER OF INPUT RECORDS READ
C JL(190) REAL JOINT LENGTH
C JTYPE(190) CHAR TYPE OF JOINT
C NE1(150) INT FIRST ELEMENT
C NE2(190) INT SECOND ELEMENT
C NS(190) INT NUMBER OF SIDES
C NUMEL INT NUMBER OF ELEMENTS
C SP(190) REAL POINT SPACING
C TL(190) REAL THICKNESS OF FIRST ELEMENT OF PAIR
C T2(190) REAL THICKNESS OF SECOND ELEMENT OF PAIR
C TOTAL INT NUMBER OF ELEMENT PAIRS INPUT

C THE FOLLOWING COMMON BLOCKS ARE USED:

C BLOCK OTHER PROGRAM UNITS USING THIS COMMON BLOCK

C CB2 MAIN, EPROP, BLOCK DATA
C CH7 EPROP, APROP, EXCIT, ANSWER, SOLVE, RITER, BLOCK DATA
C CB10 EPROP, BLOCK DATA
C C12 JPROP
C
C CHARACTER#2 JTYPE
C INTEGER TOTAL
C REAL JL

LOGICAL ERROR
C COPM(4) /CB2/ ERROR
C COPM(4) /CB7/ NUMEL,G
C COPM(4) /CB10/ INPUT
C COPM(12)/ NC11(190),NE2(190),JL(190),BL(190)
C
C T11(190),T2(190),A5D(190),NS(190),SP(190),JPUT(190),TOTAL

180 FORMAT (12,14,12,6F10.2)

110 FORMAT (100*** WARNING *** ON INPUT RECORD 1,14,1, ONE OR
C 1 BOTH MEMBERS OF THE/1 ELEMENT PAIR 1,12,1 AND 1,12
C 2 THIS ERROR WAS DISCOVERED BY SUBROUTINE JINPUT.
C 3 THIS ERROR WAS DISCOVERED BY SUBROUTINE JINPUT.
C 4 THIS ERROR IS IGNORED.
C 5 THIS ERROR WILL BE IGNORED.
C 6 THIS ERROR WILL BE IGNORED.
C 7 THIS ERROR WILL BE IGNORED.
C 8 THIS ERROR WILL BE IGNORED.
C 9 THIS ERROR WILL BE IGNORED.
C 10 THIS ERROR WILL BE IGNORED.

120 FORMAT (100*** WARNING *** THE ELEMENT PAIR 1,12,1 AND 1,
C 12,1 ON INPUT RECORD 1,14,1 WAS/1 PREVIOUSLY READ ON 1,
C 2 INPUT RECORD 1,14,1 WILL BE USED.

130 FORMAT (100*** ERROR *** WHILE ATTEMPTING TO READ JOINT 1,
C 1 1,14,1 A FORTRAN ERROR OCCURRED ON INPUT RECORD 1,
C 2 1,14,1
C 3 THIS ERROR WAS DISCOVERED BY SUBROUTINE JINPUT.

MAY 13 49
140 FORMAT (10*** ERROR *** THE END OF FILE WAS REACHED BEFORE 1.
1 TYPING INFORMATION/ ANU JOINT PROPERTIES WAS READ/1/
1 IF THIS ERROR WAS DISCOVERED BY SUBROUTINE JINPUT, 1.
19 FORMAT (10*** WARNING *** ON INPUT RECORD 1.
1 10TH ELEMENT NUMBERS WERE ALL GIVEN AS 1.
1 2. THEY MUST BE DIFFERENT. THIS RECORD WILL BE IGNORED/1/
1 IF THIS ERROR WAS DISCOVERED BY SUBROUTINE JINPUT, 1.
17C FORMAT (12,4X), FIRST ELEMENT = 1, I2 / 10X, SECOND = 1.
1 1. ELEMENT = 1, I2 / 10X, TYPE OF JOINT = 1, A12 / 10X.
1 2. NUMBER OF SIDES = 1, I2 / 10X, JOINT LENGTH = 1.
1 3. 1PE12-SE2 / 10X, THICKNESS OF FIRST ELEMENT = 1.
1 4. 1PE12-SE2 / 10X, THICKNESS OF SECOND ELEMENT = 1.
1 5. 1PE12-SE2 / 10X, AEOSTRUC SPACE DENSITY = 1, IPE12-SE2 /
1 6. 1PE12-SE2 / 10X, INSERTION LOSS = 1.
1 7. FACTOR = 1, IPE12-SE2)
180 FORMAT (### T RECORDS / INPUT DATA 1.
2 7 FROM W-153 / 1X, 6(4H-), 1X, 21(4H-) /)
C WRITE A HEADING TO CONTINUE PRINTING INPUT DATA
401 WRITE (6,'(A,180)')
402 C INITIALIZE TOTAL
403 TOTAL = 0
404 C INITIALIZE I
405 I = 0
406 C INCREMENT I
407 5 I = I + 1
408 C INCREMENT INPUT
409 10 INPUT = INPUT + 1
410 C READ THE JOINT PROPERTIES
411 READ (3,100,ERR=60,END=7) NE1(I),NE2(I),JTYPE(I),NS(I),JL(I),
412 T1(I),T2(I),ASD,I,SI,SP(I)
413 C WRITE THE JOINT PROPER TO OUTPUT
414 WRITE (6,'(A,70)') 'NE1(I),NE2(I),JTYPE(I),NS(I),JL(I),
415 T1(I),T2(I),ASD(I),SI,SP(I)
416 C PUT THE INPUT RECORD NUMBER IN JPUT
417 JPUT(I) = INPUT
418 C IF FILTER ELEMENT NUMBER IS OUT OF RANGE,
419 IF (NE1(I) .GE. 1 .AND. NE1(I) .LE. NUMEL .AND. NE2(I) .GE. 1.
420 .AND. NE2(I) .LE. NUMEL) GO TO 15
421 C THEN WRITE A WARNING MESSAGE
422 WRITE (6,110) INPUT,NE1(I),NE2(I),NUMEL
423 GO TO 10
424 C END IF
425 C IF PCP ELEMENTS IN THE PAIR ARE THE SAME,
426 IF (NE1(I) = NE2(I)) GO TO 20
427 C THEN WRITE A WARNING MESSAGE
428 WRITE (6,160) INPUT,NE1(I)
429 GO TO 10
430 C END IF
431 C IF THIS IS THE FIRST ELEMENT PAIR, SKIP THE FOLLOWING TEST
432 20 IF (I .LE. 1) GO TO 90
433 C OB FOR EACH PAIR OF ELEMENTS PREVIOUSLY INPUT
434 GO TO 5 = 1, TOTAL
435 C IF THE CURRENT PAIR OF ELEMENTS MATCHES A PREVIOUS PAIR,
436 IF (NE1(I) = NE1(J) .AND. NE2(I) = NE2(J)) .AND.
SUPPORT  LINE INPUT

977  * (NF1(I), NF, NF2(I), OP, NF3(I), NF, NF4(I), NF5(I)) GO TO 30

978  C THEN WRITE A WARNING MESSAGE

979  WRITE (6,120) NE1(I),NE2(I),INPUT,INPUT(I)

980  GO TO 10

981  C END IF

982  10 CONTINUE

983  C INCREMENT TOTAL

984  50 TOTAL = I

985  GO TO 5

986  C IF AN ERROR OCCURRED ON READING, WRITE AN ERROR MESSAGE

987  60 WRITE (6,130) INPUT

988  ERROR = *TRUE*

989  GO TO 10

990  C IF THE END OF FILE WAS ENCOUNTERED, PUT NO RECORDS

991  C WERE READ, WRITE A MESSAGE AND SET THE ERROR FLAG

992  70 IF (TOTAL < 60) GO TO 90

993  ERROR = *TRUE*

994  WRITE (6,140)

995  C IF THERE WERE NO ERRORS, RETURN

996  80 IF (.NOT. ERROR) RETURN

997  C ELSE WRITE A MESSAGE AND TERMINATE THE PROGRAM

998  WRITF (6,150)

999  CALL FERR

1000  END
SUBROUTINE JPROP

C THIS SUBROUTINE CALCULATES THE ELEMENT-TO-ELEMENT STRUCTURAL COUPLING COEFFICIENT (PHI). JPROP IS CALLED FROM THE MAIN PROGRAM.

C THE FOLLOWING VARIABLES ARE USED IN THIS PROGRAM UNIT:

C NAME TYPE DESCRIPTION
C ---- ----- -----------
C A REAL PSEUDO AREA
C AFR REAL ANALYSIS FREQUENCY ORIGINAL
C AREA REAL SURFACE AREA
C ASC REAL ACOUSTIC SPACE DENSITY
C BLM REAL BEAM LENGTH
C CFREE REAL CRITICAL FREQUENCY
C CMODE REAL DENSITY
C CEC REAL SPEED OF SOUND IN PCC MEDIUM
C CEE REAL MODULUS OF ELASTICITY
C CFEM الذ REAL POISSON'S RATIO
C E1 REAL FIRST ELEMENT
C E2 REAL SECOND ELEMENT
C FREQ REAL FREQUENCY
C JN REAL JOINT LENGTH
C JTYPE INTEGER TYPE OF JOINT
C M REAL NUMBER OF MODES IN BANDWIDTH
C M2 REAL MODAL DENSITY
C M1 REAL FIRST ELEMENT
C M2 REAL SECOND ELEMENT
C M3 REAL NUMBER OF SIDES
C M4 REAL 2*PI*FREQUENCY
C PMI REAL COUPLING COEFFICIENT
C SAM REAL RADIATION EFFICIENCY
C SPM REAL BOLT SPACING REDUCTION
C TAU REAL THICKNESS RATIO
C THM5 REAL THICKNESS
C C TOTAL INT NUMBER OF ELEMENT PAIRS (I.E., JOINTS)
C V5 REAL VOLUME

C THE FOLLOWING COMMON BLOCKS ARE USED:

C BLOCK OTHER PROGRAMS USING THIS COMMON BLOCK

C MAIN,EXCITE,ANSWER
C EPROP,Beam,Mem,Plate,Room,Cylin,Excite,Prop,Plate,Room,Cylin,Excite,Answer
C EREP,Input,Excite,Answer,Solve,Prep,Block
C EREP,Beam,Mem,Plate,Room,Cylin,Excite,Block
C CH12,Jinput
C CB14,Excite,Answer
C
C CHARACTER*10 JTYPE
C INTEGER A1,A2,TOTAL
C REAL JL,A1,MODES
C LOGICAL ERROR
C COMMON /CB3,FREQ,OMEGA
C COMMON /CB5/THICK,AREA,DENS
C COMMON /CB6/VOL,FF

* EPROP(A1),C(F1,2)
COMMON /C/ NUMFL.G
COMMON /C/69 / N(20*40)
COMMON /C/72 / JTOPF(190)
COMMON /C/1Z2 / NE(190), NL(190), JL(190), RL(190),
* TI(190), T(190), A(190), NS(190), SP(190), JTOPF(190), TOTAL
COMMON /C/84 / PHI(20*20), MODES(20)
DATA PI, ERRPRI, /3.1415926, .10,
C FORMAT (3F10.0) ERROR LS: THE TYPE OF JOINT GIVEN FOR I,
C ELEMENT PAIR 1,1? , AND 1,12? ON INPUT RECORD 1,14,6, IS?
C THIS IS NOT A VALID TYPE. THE TYPE MUST?
C REPEATED, BLD, OR PADD?
C THIS ERROR WAS DISCOVERED BY SUBROUTINE JPROP.L.
C 720 FORMAT (BECAUSE OF THE ERRORS LISTED ABOVE, THE SEA PROGRAM,
C WILL ABORT.)
C INITIALIZE THE COUPLING COEFFICIENTS TO C AND CALCULATE MODES
C 60 DC D = 1, 20
C MODES(6) = N(4,AF) * OMEGA / 2,33
C DO 10 I = 1, 20
C PHI(I,J) = 0.
C 10 CONTINUE
C DO 20 CONTINUE
C DO 100 I = 1, TOTAL
C C PUT THE ELEMENT NUMBERS IN SIMPLE VARIABLES TO AVOID
C DOUBLE SUBSCRIPTS
C 90 I = NE(1)
C 98 J = NE(1)
C IF THE TYPE OF JOINT IS PLATE TO PLATE,
C IF JTOPF(I) NE. TYPPI) GO TO 30
C THEN SET TAU TO A/27
C ELSE SET TAU TO 27.,
C UNLESS THE RATIO OF THICKNESS IS LESS THAN .5, IN WHICH CASE
C SET TAU TO THE RATIO
C IF TII(I) / TII(I) .LT. .5,
C TAU = TII(I) / TII(I)
C CALCULATE THE PSEUDO AREA
A = 2 * PI * N(4,AF) * 2. * TII(I) * SORT(JEE(EE) / 2)
+ N(4, AEEC) * (1. - EGMMAEE) * II)
C CALCULATE THE COUPLING COEFFICIENT FOR PLATE TO PLATE COUPLING
PHI(EE,EE) = 1.07 * JLI(EE) / (PI * A * MODES(2))
E = SORT(JOMAE * THICKNESS) * SORT(JEE(EE) / EGMMAEE) * II)
+ 1. - (EGMMAEE * 2)) * TAU
GO TO 90
C ELSE IF TYPE OF JOINT IS REAM TO PLATE,
C IF JTOPF(I) NE. TYPPI) GO TO 40
C CALCULATE THE COUPLING COEFFICIENT FOR THAT TYPE
PHI(EE,EE) = 2. * PI * FREG * JLI(EE) / (MODES(2))
* 0. * RL(II)
GO TO 90
C ELSE IF TYPE OF JOINT IS BOLTED OR RIVETED JOINT,
C IF JTOPF(I) NE. TYPPI) GO TO 50
C THEN SET TAU TO A/27
C TAU = A/27
C UNLESS THE RATIO OF THICKNESS IS LESS THAN .5, IN WHICH CASE
C SET TAU TO THE RATIO
SUBROUTINE JPROP

1113  IF (PI1(I) .LT. T2(I)) THEN
1114     TAU = T1(I) / T2(I)
1115  END IF
1116
1117  C CALCULATE THE PSEUDO AREA
1118  A = 2. * PI * (10. + .01) .times. T2(I) .times. T1(I) .times. SQRT(TAU) / TAU
1119  END IF
1120
1121  C CALCULATE THE COUPLING COEFFICIENT FOR THAT TYPE
1122  PHIE1(E2) = 1 + J(I) / (J + A .times. MODES(E2))
1123  END IF
1124
1125  C IF THE TYPE OF JOINT IS PLATE TO ACOUSTIC SPACE,
1126      5G IF (JTYPE(I) .NE. 0) GO TO 60
1127
1128  C CALCULATE THE CRITICAL FREQUENCY
1129  CFREQ = FC(E2) .times. 2 / (J + A .times. THICK(E1))
1130  END IF
1131
1132  C CALCULATE THE RADIATION EFFICIENCY USING THE SIGF FUNCTION
1133  SIGMA = 10. .times. SIGF(CFREQ .times. CFREQ)
1134  END IF
1135
1136  C CALCULATE THE COUPLING COEFFICIENT FOR THAT TYPE
1137  PHIE1(E2) = 4.33 .times. PI .times. FC(E2) .times. 4 / (FREQ .times. OMEGA .times. 2)
1138  END IF
1139
1140  C ELSE IF THE TYPE OF JOINT IS NONE OF THE ABOVE, SET THE ERROR
1141  C FAIL AND WRITE AN ERROR MESSAGE
1142  60 ERROR = .TRUE.
1143  200 E1, E2, JPUT(I), JTYPE(I)
1144  ENC IF
1145  ENC
1146  100 CONTINUE
1147  C IF NO ERRORS IN JOINT TYPE WERE ENCOUNTERED, RETURN
1148  IF (.NOT. ERROR) RETURN
1149
1150  C ELSE WRITE A MESSAGE AND TERMINATE THE PROGRAM
1151  WRITE (*, 220) JTYPE(I)
1152  CALL FERR
1153  ENC
FUNCTION SIGF(x)

C THIS FUNCTION SUBPROGRAM RETURNS A VALUE FOR THE RADIATION
C EFFICIENCY OF A PANEL BASED ON THE FOLLOWING TABLE:
C
C X SIGF // X SIGF // X SIGF // X SIGF
C
C 0.0 -1.2 // 0.1 -1.0 // 0.17 -0.2 // 1.0 0.0
C 0.11 -1.5 // 0.50 -0.8 // 0.82 0.0 // 1.5 0.4
C 0.22 -1.9 // 0.60 -0.6 // 0.96 0.2 // 2.0 0.4
C 0.32 -2.3 // 0.80 -0.4 // 0.92 0.4 // 0.0
C
C THE ENTRY IN THE X COLUMN IS THE MAXIMUM VALUE OF X FOR WHICH
C SIGF WAS THE INDICATED VALUE. SIGF IS CALLED FROM JPROP AND
C EXCITE.
C
C THE FOLLOWING VARIABLES ARE USED IN THIS PROGRAM UNIT:
C
NAME TYPE DESCRIPTION
C
C D(I1) REAL A TABLE OF VALUES TO COMPARE WITH X
C I INTEGER THE ORDINAL OF THE LEAST VALUE OF D GREATER THAN X
C X REAL THE RATIO OF THE ANALYSIS FREQUENCY TO THE
C CRITICAL FREQUENCY
C
DIMENSION D(16)
DATA D /0.0,0.1,0.2,0.3,0.4,0.5,0.6,0.7,0.8,0.9,1.0,1.5,1.9,2.0,2.5,3.0/
C DETERMINE WHERE X LIES IN THE TABLE
DO 20 I = 2, 15
IF (X .LE. D(I)) GO TO 30
20 CONTINUE
I = 16
C SIGF REACHES A MAXIMUM AT I = 15. A DIFFERENT ALGORITHM
C FOR COMPUTING SIGF IS REQUIRED DEPENDING ON WHETHER I IS
C GREATER OR LESS THAN 15.
C
C IF (I .LT. 15) GO TO 50
SIF = -2.0 + .2 * FLOAT(I)
C INTERPOLATE
SIF = .2 / (D(I) - D(I - 1)) + D(I - 1) + SIGF
RETURN
C
C INTERPOLATE IF X IS LESS THAN 4
C IF (X .GE. D(I)) RETURN
SIF = .2 / (D(I) - D(I - 1)) + (C(I) - X) + SIGF
RETURN
ENC
C INITIALIZE THE ACOUSTIC ENERGY INPUT AND ELEMENT ENERGY LEVELS

S(I) = 0.
E(I) = 0.

C IF(1) THE TYPE OF EXCITATION IS ACOUSTIC,

IF (TYPE(I) .NE. 1.0) GO TO 20

C CALCULATE THE CRITICAL FREQUENCY

CRFREQ = ECI(I) ** 2 / (L-9 * THICK(I))

SRTFREQ(I) / ECI(I)

C CALCULATE THE RADIATION EFFICIENCY USING THE SIGF FUNCTION

SIGMA = 10. ** SIGF(FREQ / CRFREQ)

C THEN calculate the acoustic energy input

S(I) = 4.33 * PI * ECI(I) ** 2 * 8.91 * 10. **

(SFL(I, AF) / 10. - 1.0) / SIGMA / ANG(I) / (OMEGA ** 2)

GO TO 100

C ELSE IF(1) THE TYPE OF EXCITATION IS MECHANICAL,

20 IF (TYPE(I) .NE. 1.0) GO TO 100

C THEN IF(2) THE TYPE OF MECHANICAL INPUT IS RPS,

IF (TYPE(I) .NE. TMECH(I)) GO TO 30

C THEN calculate the element energy level

E(I) = PASS(I) / OMEGA ** 2 * (MECH(I, AF) * G) ** 2

GC TO 100

C ELSE IF(2) THE TYPE OF MECHANICAL INPUT IS PSB,

30 ETMP = PASS(I) / (OMEGA**2)

E(I) = ETMP * MECH(I, AF) * (G**2) * (FREQ/9.33)

C EN IF(2)

C EN IF(1)

100 CONTINUE

RETURN

ENC
SUBROUTINE ANSWER

C THIS SUBROUTINE SOLVES THE SEA SYSTEM OF EQUATIONS FOR
C ELEMENT ENERGY LEVELS AND STORES THE SOLUTION IN ARRAY
C ARRAY TO BE PRINTED OUT BY RITER. ANSWER IS CALLED FROM
C THE MAIN PROGRAM.

C THE FOLLOWING VARIABLES ARE USED IN THIS PROGRAM UNIT:
C
C NAME TYPE DESCRIPTION
C ---- ------ -------------
C ARKEE REAL AVERAGE ACCELERATION
C ALPHAI REAL MATRIX OF COEFFICIENTS
C E(20) REAL ELEMENT ENERGY LEVELS
C ETA(20) REAL DAMPING
C FRE(20) REAL FREQUENCY
C MAS(20) REAL MASS
C MODES(20) REAL NUMBER OF MODES IN BANDWIDTH
C NPEL INT MEMBER OF ELEMENTS
C OMEGA REAL 2*PI*FREQUENCY
C CTYPE CHAR TYPE OF OUTPUT
C PHII(20,20) REAL COUPLING COEFFICIENT
C SI(20) REAL ACOUSTIC ENERGY INPUT
C SFB(20) REAL STARTING FREQUENCY
C SIZE INT SIZE OF REDUCED ALPHA ARRAY
C SLOPE(20) REAL SLOPE

C THE FOLLOWING COMMON BLOCKS ARE USED:
C
C BLOCK OTHER PROGRAM UNITS USING THIS COMMON BLOCK

C

C CP2 MAIN,JRITER,EXCITE
C CP3 EPROP,REAL,PMEM,PLATE,ROOM,SYLIN,JRITER,EXCITE
C CP7 EPROP,UINT,MODE,PROP,EXCITE,RESULT,ITRITER,BLOCK DATA
C CP9 EPROP,JRITER,BLOCK DATA
C CP11 PMEM,REAL,PLATE,PROP,SFB,SYLIN,EXCITE,BLOCK DATA
C CP14 JRITER,EXCITE
C CP16 EXCITE
C CP17 JRITER

C CHARACTER*1 CTYPE
C INTEGER AP,SIZE
C REAL MAS(20)
C
C DIMENSION AMAN(20),SMAT(20)
C C0,M,C2/CM/,FRE(20),OMEGA
C COMC/CM/,THICK(20),AREA(20),DENST(20),VOL(20),EC(20)
C ECMAM(20),EC20
C COMC/CM/,NPEL,ES(20)
C COP1/CP1/,SLOPE(20),SFB(20),ETA(20),CITY
C COP2/CP2/,MASS(20)
C
C COP3/CP3/,PHII(20,20),PQDF(20)
C COP4/CP4/,SI(20),F20
C COP5/CP5/,ALPHA(20,20)

C CC FOR EACH ELEMENT

C

C

C

C

C

C

C

C

C

C

C

C

C

C

C

C

C

C

C

C

C

C

C

C

C

C

C

C

C

C
1337   DO 150 I = 1, NUMEL
1339   C SET THE CAMPING FACTOR EQUAL TO THE INPUT VALUE
1340   ETA = ETA(I)
1342   SLOPE = SLOPE(I)
1344   C IF DABING IS FREQUENCY DEPENDENT AND THE ANALYSIS FREQUENCY
1346   C IS GREATER THAN THE STARTING FREQUENCY OF THE DEPENDENCY
1348   C CALCULATE THE DAMPING FACTOR
1350   IF (SLOPE(I) .NE. 0.0 .AND. FREQ .GT. SFREQ(I))
1352   ETA = ETA(I) / (FREQ / SFREQ(I) ** SLOPE(I))
1354   C IF THIS IS NOT THE LAST ELEMENT
1356   C THEN FOR EACH SUCCESSING ELEMENT
1358   TPLUS = I + 1
1360   DC 40 J = TPLUS * NUMEL
1362   C CALCULATE THE I-TH ROW OF ALPHA TO THE RIGHT OF THE MAIN
1364   C DIAGONAL
1366   ALPHA(I,J) = -MODES(I) * PHI(I,J)
1368   C CALCULATE THE I-TH COLUMN OF ALPHA BELOW THE MAIN DIAGONAL
1370   ALPHA(I,J) = -MODES(J) * PHI(I,J)
1372   40  CONTINUE
1374   C END IF
1376   C CALCULATE ALPHA ON THE MAIN DIAGONAL
1378   30  ALPHA(I,I) = OMEGA * ETA(I)
1380   DC 80 J = I + NUMEL
1382   ALPHA(I,J) = I(J) = ALPHA(I,I) * MODES(J) * PHI(I,J)
1384   80  CONTINUE
1386   100 CONTINUE
1388   C INITIALIZE SIZE
1390   SIZE = NUMEL
1392   C DO FOR EACH ELEMENT
1394   ED 150 I = 1, NUMEL
1396   C IF THE ENERGY LEVEL IS ALREADY KNOWN,
1398   IF E(I) .EQ. 0.0) GO TO 150
1400   C THEN BE FOR EACH ELEMENT
1402   DC 150 J = I + NUMEL
1404   C SUBTRACT FROM THE ACOSIC ENERGY ARRAY S THAT PORTION OF
1406   C THE VALUE WHICH CAME FROM THE PRODUCT OF THE ALPHA ARRAY
1408   C AND THE KNOWN ENERGY LEVEL
1410   SIZF = SIZE - 1
1412   130 CONTINUE
1414   C DECREMENT SIZE TO SHOW THAT THE I-TH ROW AND COLUMN WILL BE
1416   C ELIMINATED FROM THE ALPHA ARRAY WHEN IT BECOMES AMAT AND THE
1418   C I-TH ELEMENT FROM THE S ARRAY WHEN IT BECOMES SMAT
1420   C SIZE = SIZE - 1
1422   C END IF
1424   150 CONTINUE
1426   C CALL SOLVE TO CREATE THE REDUCED ARRAYS AND SOLVE THE MATRIX
1428   CALL SOLVE
1430   C FILL IN
1432   C PLUG IN
1434   C IF THE DEFAULT OUTPUT TYPE PSD IS SELECTED, PUT ARAR IN THAT FORM
1436   IF (TYPF .EQ. 1.0) GO TO 140
1438   ANARR(AF) = ANARR(AF) / (6.0 ** 2 * FREQ ** 2 ** 55)
GO TO 200
C ELSE IF THE OUTPUT TYPE IS ARB, PUT ARAB IN THAT FORM
L0C ARAB(:I,AF) = SQRT(ARAB(:I,AF)) / G
C END IF
200 CONTINUE
RETURN
ENC
SUBROUTINE SOLVE (AMAT, SMAT)

C THIS SUBROUTINE CREATES MATRIX A*T F. OM ALPHA BY ELIMINATING
C THOSE ROWS AND COLUMNS REPRESENTING ELEMENTS FOR WHICH THE
C ENERGY LEVELS ARE ALREADY KNOWN. IN TH SAME WAY, SMAT IS
C CREATED FROM SM. SURROUTE GASEM F. J. T. RARY SYS*MATHS.AT.
C IS THEN CALLED TO SOLVE THE M.T. X = B ON AMAT*X = SMAT F. FOR X.
C GASEM PUTS THE SOLUTION IN SMAT, SO THIS SUBROUTINE PUTS
C THE RESULTS IN E:, LEAVING INTACT THOSE ELEMENTS OF E
C WHICH WERE ALREADY KNOWN. SOLVE IS CALLED BY ANSWER.

C THE FOLLOWING VARIABLES ARE USED IN THIS PROGRAM UNIT:

C NAME TYPE DESCRIPTION
C -------- ---- ---------------
C ALPHA(20,20) REAL MATRIX OF COEFFICIENTS
C SMAT(SIZE) REAL REDUCED ALPH ARRAY
C DET REAL DETERMINANT OF AMAT
C E(20) REAL ELEMENT ENERGY LEVELS
C NUMEL INT NUMBER OF ELEMENTS
C S(20) REAL ACOUSTIC ENERGY INPUT
C SIZE INT SIZE OF AMAT AND SMAT
C SMAT(SIZE) REAL REDUCED S ARRAY

C THE FOLLOWING COMMON BLOCKS ARE USED:

C BLOCK OTHER PROGRAM UNITS USING THIS COMMON BLOCK
C ----- --------------------------------------------------
C C87 EPROM INPUT, JPROP, EXITE, ANSWER, TEMPERATURE,BLOCK DATA
C C815 EXITE, ANSWER
C C816 ANSWER
C C817
C C818
C
C INTEGER SIZE
C DIMENSION AMAT(SIZE,SIZE), SMAT(SIZE)
C CPMRN /C817/ NUMEL=6
C CPMRN /C815/ SIZE1,E(20)
C CPMRN /C816/ ALPHA(20,20)
C 350 FORMAT (19*** ERROR *** THE DETERMINANT OF THE SEA T1
C 1 \تقيزЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦИЦI

C INITIALIZE I1
C D6 FOR EACH ELEMENT FOR WHICH ENERGY LEVELS ARE UNKNOWN
C D0 100 I = 1, SIZE
C INCREMENT I1
C 10 I1 = I1 + 1
C IF THE ENERGY LEVEL FOR ELEMENT I1 IS KNOWN, GO TO NEXT ELEMENT
C ELSE INITIALIZE J1
C 0 FOR EACH ELEMENT FOR WHICH ENERGY LEVELS ARE UNKNOWN
C D5 J1 = J1 + 1
C 30 I1 = I1 + 1
C IF ENERGY LEVEL FOR ELEMENT J1 IS KNOWN, GO TO NEXT ELEMENT
IF (E(I,J) .NE. 0.) GO TO 30  
C ELSE PUT THE VALUE OF ALPHA FOR ELEMENT PAIR I1,J1 IN AMAT    
AMAT(I,J) = ALPHA(I,J)  
C END IF  
C PUT THE VALUE OF S FOR ELEMENT I1 IN SMAT        
SMAT(I) = S(I)  
180 CONTINUE  
C SOLVE THE MATRIX EQUATION    
CALL GASSPE (AMAT,SIZE,1,DET,SMAT)    
C IF THE DETERMINANT OF AMAT IS 0    
IF (DET .NE. 0.) GO TO 180    
C THEN WRITE AN ERROR MESSAGE AND TERMINATE THE PROGRAM    
WRITE (6,380)    
C RETURNED BY GASSPE TO ARRAY SMAT    
150 I1 = 1    
C ELSE INITIALIZE I1 TO 1, REPRESENTING THE FIRST VALUE    
C RETURNED BY GASSEM TO ARRAY SMAT    
1473 I1 = 1    
C END FOR EACH ELEMENT    
CO 200 I = 1, NUPEL    
C IF THE ELEMENT ENERGY LEVEL WAS UNKNOWN    
C IF (E(I) .NE. 0.) GO TO 200    
C THEN PLACE ITS VALUE IN THE ARRAY E    
E(I) = SMAT(I)  
C INCREMENT I1    
1480 I1 = I1 + 1    
C END IF  
1482 200 CONTINUE    
1484 RETURN    
1485 END
SUBROUTINE RITER

C THIS SUBROUTINE WRITES OUT THE RESULTS THAT ARE STORED IN
C ARRAY ARR. RITER IS CALLED FROM THE MAIN PROGRAM.

C

C THE FOLLOWING VARIABLES ARE USED IN THIS PROGRAM UNIT:

C NAME    TYPE    DESCRIPTION
C ------    ------    ------------
C ABAR    REAL    AVERAGE ACCELERATION
C FTABLE(10) REAL    TABLE OF ANALYSIS FREQUENCIES
C NUMAF   INT     NUMBER OF ANALYSIS FREQUENCIES
C SEMPL   INT     NUMBER OF ELEMENTS
C OTYPE   CHAR    TYPE OF OUTPUT

C

THE FOLLOWING COMMON BLOCKS ARE USED:

C BLOCK    OTHER PROGRAM UNITS USING THIS COMMON BLOCK
C -------    ---------------------------------
C ELLOW     -------------------------------
C MK          -------------------------------
C CP7         -------------------------------
C CP8         -------------------------------
C CB17        -------------------------------

C

C CHARACTER#20 TITLE / PSD LEVELS (G**2/H2)** /
C ***** / RMS 1 / OTYPE 3
C
C COMMON /CB1/ FTA(B40),NUMAF,FREQ
C COMMON /CB7/ NUMEL,6
C COMMON /CB9/ SLOPE(20),SFREQ(20),ETA(20),OTYPE
C COMMON /CB17/ ABAR(20,40)

C 100 FORMAT (///5X,TENTFR1,24X,A20/)
C 1 4X,FREQ(H21),45X,ELEMENT I,J,K)
C 110 FORMAT (F12.2,4(IPE15.5E2))

C IF THE TYPE OF OUTPUT IS RMS, CHANGE THE HEADING ACCORDINGLY
C IF (OTYPE * EQ. RMS) TITLE = RMS
C DO FOR EACH ELEMENT IN GROUPS OF 4
C DO 20 I = 1, NUMEL, 4
C IPLUS3 WILL BE THE TERMINAL VARIABLE FOR IMPLIED DO LOOPS TO
C PRECEDE 4 COLUMNS UNLESS THERE ARE FEWER THAN 4 ELEMENTS
C REMAINING TO BE LISTED
C IPLUS3 = MIN(NUMEL, I + 3)
C WRITE THE HEADING FOR THESE 4 ELEMENTS
C WRITE (6,100) TITLE,J,J,J,J,1(IPLE3)
C DC FOR EACH ANALYSIS FREQUENCY
C DO 10 J = 1, NUMAF
C WRITE THE RESULTS
C WRITE (6,110) FTABLE(J),THERE(J),K=1,1(IPLE3)
C CONTINUE
C CONTINUE (6,110) FTABLE(J),THERE(J),K=1,1(IPLE3)
C 20 CONTINUE
C RETURN
C END
PLCK DATA

THE FOLLOWING VARIABLES ARE USED IN THIS PROGRAM UNIT:

NAME   TYPE   DESCRIPTION
-----   -----   ---------

ERROR   LOG   TRUE IF A FATAL ERROR HAS OCCURRED

FREQ(40)   REAL   TABLE OF ANALYSIS FREQUENCIES

G   REAL   GRAVITATIONAL CONSTANT

INPT   INT   NUMBER OF INPUT RECORDS READ

MASS(20)   REAL   MASS

M(20,40)   REAL   MOBIL DENSITY

SLOPE   REAL   SLOPE

THE FOLLOWING COMMON RECORDS ARE USED:

BLOCK   OTHER PROGRAM UNITS USING THIS COMMON BLOCK

--------------   ---------------

CB1   MAIN,EPROP,BEAM,-,KER,PLATE,ROCK,CYLIN,RITER

CB2   MAIN,EPROP,INPUT

CB7   EPROP,INPUT,PROP,EXCITE,ANSWER,SOLVE,RITER

CB9   EPROP,ANSWER,LIER

CB9   EPROP,BEAM,HERB,PLATE,ROCK,CYLIN,PROP,EXCITE

CB10   EPROP,INPUT

CB11   BEAM,HERB,PLATE,ROCK,CYLIN,ANSWER

REAL M,MASS

LOGICAL ERROR

COMMON /CB1/ FREQ(40),NUMB,FREQ

COMMON /CB2/ ERROR

COMMON /CB7/ NUMEL,G

COMMON /CB8/ SLOPE(20),FREQ(20),ETA(20),OTYPE

COMMON /CB9/ M(20,40)

COMMON /CB10/ INPUT

COMMON /CB11/ MASS(20)

DATA M,SLORF,MASS,INPUT,ERROR /840.0, 386.4, 1.0, .FALSE./

DATA FREQ /3.0, 25.1, 62.0, 125, 250, 500.0, 1000.0, 2000.0, 3000.0, 5000.0, 7500.0, 10000.0, 15000.0, 25000.0/

END
<table>
<thead>
<tr>
<th>LL</th>
<th>CCCCCC</th>
<th>AA</th>
<th>00</th>
<th>33333</th>
<th>55555555</th>
<th>44</th>
<th>11</th>
</tr>
</thead>
<tbody>
<tr>
<td>LL</td>
<td>CC</td>
<td>AA</td>
<td>00</td>
<td>33333</td>
<td>55555555</td>
<td>444111</td>
<td></td>
</tr>
<tr>
<td>LL</td>
<td>CC</td>
<td>AAAA</td>
<td>00</td>
<td>33333</td>
<td>55555555</td>
<td>444111</td>
<td></td>
</tr>
<tr>
<td>LL</td>
<td>CC</td>
<td>AA</td>
<td>00</td>
<td>33333</td>
<td>55555555</td>
<td>444111</td>
<td></td>
</tr>
<tr>
<td>LLLL</td>
<td>CCCCCC</td>
<td>AA</td>
<td>00</td>
<td>33333</td>
<td>55555555</td>
<td>44411111</td>
<td></td>
</tr>
<tr>
<td>LLLLLL</td>
<td>CCCCCC</td>
<td>AA</td>
<td>00</td>
<td>33333</td>
<td>55555555</td>
<td>44411111</td>
<td></td>
</tr>
<tr>
<td>EEEE EEEE</td>
<td>NN</td>
<td>NN</td>
<td>CDCC</td>
<td>00000000</td>
<td>FFFFFFFFFFF</td>
<td>JJJJJJ</td>
<td>000000</td>
</tr>
<tr>
<td>EEEEEE</td>
<td>NN</td>
<td>NN</td>
<td>CDDDDC</td>
<td>00000000</td>
<td>FFFFFFFFFFF</td>
<td>JJJJJJ</td>
<td>00000000</td>
</tr>
<tr>
<td>EEE</td>
<td>NN</td>
<td>NN</td>
<td>CD</td>
<td>00</td>
<td>00</td>
<td>FF</td>
<td>J</td>
</tr>
<tr>
<td>EEEE-T</td>
<td>NN</td>
<td>NNNA</td>
<td>CD</td>
<td>00</td>
<td>00</td>
<td>FF</td>
<td>J</td>
</tr>
<tr>
<td>EE</td>
<td>NN</td>
<td>NNA</td>
<td>CD</td>
<td>00</td>
<td>00</td>
<td>FF</td>
<td>J</td>
</tr>
<tr>
<td>EEEEEE</td>
<td>NN</td>
<td>NN</td>
<td>CDCCDD</td>
<td>00000000</td>
<td>FF</td>
<td>JJJJJJ</td>
<td>00000000</td>
</tr>
<tr>
<td>EEEE EEEE</td>
<td>NN</td>
<td>NN</td>
<td>DDDDD</td>
<td>00000000</td>
<td>FF</td>
<td>JJJJJJ</td>
<td>00000000</td>
</tr>
</tbody>
</table>

**Table:**

<table>
<thead>
<tr>
<th>LL</th>
<th>CCCCCC</th>
<th>AA</th>
<th>00</th>
<th>33333</th>
<th>55555555</th>
<th>44</th>
<th>11</th>
</tr>
</thead>
<tbody>
<tr>
<td>LL</td>
<td>CC</td>
<td>AA</td>
<td>00</td>
<td>33333</td>
<td>55555555</td>
<td>444111</td>
<td></td>
</tr>
<tr>
<td>LL</td>
<td>CC</td>
<td>AAAA</td>
<td>00</td>
<td>33333</td>
<td>55555555</td>
<td>444111</td>
<td></td>
</tr>
<tr>
<td>LL</td>
<td>CC</td>
<td>AA</td>
<td>00</td>
<td>33333</td>
<td>55555555</td>
<td>444111</td>
<td></td>
</tr>
<tr>
<td>LLLL</td>
<td>CCCCCC</td>
<td>AA</td>
<td>00</td>
<td>33333</td>
<td>55555555</td>
<td>44411111</td>
<td></td>
</tr>
<tr>
<td>LLLLLL</td>
<td>CCCCCC</td>
<td>AA</td>
<td>00</td>
<td>33333</td>
<td>55555555</td>
<td>44411111</td>
<td></td>
</tr>
<tr>
<td>EEEE EEEE</td>
<td>AA</td>
<td>FF</td>
<td>IIIIII</td>
<td>LL</td>
<td>EEEE EEEE</td>
<td>LL</td>
<td>EEEE EEEE</td>
</tr>
<tr>
<td>SS SSSS</td>
<td>EEEE EEEE</td>
<td>AAAA</td>
<td>FF</td>
<td>IIIIII</td>
<td>LL</td>
<td>EEEE EEEE</td>
<td>LL</td>
</tr>
<tr>
<td>SS SSSS</td>
<td>EEEE EEEE</td>
<td>AA</td>
<td>FF</td>
<td>II</td>
<td>LL</td>
<td>EE</td>
<td>EE</td>
</tr>
<tr>
<td>SSSSSS</td>
<td>EEEE EEEE</td>
<td>AA</td>
<td>FF</td>
<td>II</td>
<td>LL</td>
<td>EEEE EEEE</td>
<td>LL</td>
</tr>
<tr>
<td>SSSSSS</td>
<td>EEEE EEEE</td>
<td>AA</td>
<td>FF</td>
<td>II</td>
<td>LL</td>
<td>LLLLLLLL</td>
<td>EEEE EEEE</td>
</tr>
<tr>
<td>SSSSSS</td>
<td>EEEE EEEE</td>
<td>AA</td>
<td>FF</td>
<td>II</td>
<td>LL</td>
<td>LLLLLLLL</td>
<td>EEEE EEEE</td>
</tr>
</tbody>
</table>

**Table:**

<table>
<thead>
<tr>
<th>LL</th>
<th>CCCCCC</th>
<th>AA</th>
<th>00</th>
<th>33333</th>
<th>55555555</th>
<th>44</th>
<th>11</th>
</tr>
</thead>
<tbody>
<tr>
<td>LL</td>
<td>CC</td>
<td>AA</td>
<td>00</td>
<td>33333</td>
<td>55555555</td>
<td>444111</td>
<td></td>
</tr>
<tr>
<td>LL</td>
<td>CC</td>
<td>AAAA</td>
<td>00</td>
<td>33333</td>
<td>55555555</td>
<td>444111</td>
<td></td>
</tr>
<tr>
<td>LL</td>
<td>CC</td>
<td>AA</td>
<td>00</td>
<td>33333</td>
<td>55555555</td>
<td>444111</td>
<td></td>
</tr>
<tr>
<td>LLLL</td>
<td>CCCCCC</td>
<td>AA</td>
<td>00</td>
<td>33333</td>
<td>55555555</td>
<td>44411111</td>
<td></td>
</tr>
<tr>
<td>LLLLLL</td>
<td>CCCCCC</td>
<td>AA</td>
<td>00</td>
<td>33333</td>
<td>55555555</td>
<td>44411111</td>
<td></td>
</tr>
<tr>
<td>EEEE EEEE</td>
<td>AA</td>
<td>FF</td>
<td>IIIIII</td>
<td>LL</td>
<td>EEEE EEEE</td>
<td>LL</td>
<td>EEEE EEEE</td>
</tr>
<tr>
<td>SS SSSS</td>
<td>EEEE EEEE</td>
<td>AAAA</td>
<td>FF</td>
<td>IIIIII</td>
<td>LL</td>
<td>EEEE EEEE</td>
<td>LL</td>
</tr>
<tr>
<td>SSSSSS</td>
<td>EEEE EEEE</td>
<td>AA</td>
<td>FF</td>
<td>II</td>
<td>LL</td>
<td>EE</td>
<td>EE</td>
</tr>
<tr>
<td>SSSSSS</td>
<td>EEEE EEEE</td>
<td>AA</td>
<td>FF</td>
<td>II</td>
<td>LL</td>
<td>EEEE EEEE</td>
<td>LL</td>
</tr>
<tr>
<td>SSSSSS</td>
<td>EEEE EEEE</td>
<td>AA</td>
<td>FF</td>
<td>II</td>
<td>LL</td>
<td>LLLLLLLL</td>
<td>EEEE EEEE</td>
</tr>
<tr>
<td>SSSSSS</td>
<td>EEEE EEEE</td>
<td>AA</td>
<td>FF</td>
<td>II</td>
<td>LL</td>
<td>LLLLLLLL</td>
<td>EEEE EEEE</td>
</tr>
</tbody>
</table>
Appendix II

SEA PROGRAM LOGIC AND FLOW
1. EPROP

READ INITIAL INFORMATION

WRITE ERROR MESSAGE

WRITE ERROR MESSAGE

WRITE ERROR MESSAGE

WRITE ERROR MESSAGE

SET ERROR FLAG

METRIC VALUE TAKEN OUT

NO

READ NUMBER OF ANALYSIS FREQUENCIES IN RANGE

NO

WRITE ERROR MESSAGE

YES

CHANGE GRAVITATIONAL CONSTANT TO METRIC UNITS

YES

METRIC VALUE TAKEN OUT

NO

NO

LOOP FOR EACH ANALYSIS FREQUENCY

MULTIPLY FREQUENCY FACTOR BY FIRST FREQUENCY

EXIT

3

EPROP2

RETURN

GENERAL PAGE IS 1/4 QUALITY
BEAM

CALCULATE THE PARTIAL SUB-ELEMENT MODAL DENSITY

IS STIFFNESS REDUCTION REQUIRED?

REDUCE BY \( \frac{1}{\sqrt{2}} \)

LOOP FOR EACH ANALYSIS FREQUENCY

SUM MASS TO THE ELEMENT MASS

RETURN

CALCULATE ANGULAR VELOCITY

CALCULATE SUB-ELEMENT MODAL DENSITY

SUM TO THE ELEMENT MODAL DENSITY

SET ELEMENT VALUES TO SUB-ELEMENT VALUES

SET PLC TO INDICATE THAT FOLLOWING SUB-ELEMENTS ARE NOT MAIN

RETURN
MEMBR

CALCULATE THE PARTIAL SUB-ELEMENT MODAL DENSITY

YES

REDUCE BY \( \frac{1}{\sqrt{2}} \)

NO

LOOP FOR EACH ANALYSIS FREQUENCY

SUM MASS TO THE ELEMENT MASS

YES

RETURN

CALCULATE ANGULAR VELOCITY

CALCULATE SUB-ELEMENT MODAL DENSITY

SUM TO THE ELEMENT MODAL DENSITY

RETURN

IS THE ELEMENT SUB-ELEMENT?

NO

SET ELEMENT VALUES TO SUB-ELEMENT VALUES

SET FLAG TO INDICATE THAT FOLLOWING SUB-ELEMENTS ARE NOT MAIN

RETURN
PLATE

CALCULATE THE SUB-ELEMENT MODAL DENSITY

IS STIFFNESS REDUCTION REQUIRED?

YES

REDUCE BY \( \frac{1}{12} \)

LOOP FOR EACH ANALYSIS FREQUENCY

NO

SUM MASS TO THE ELEMENT MASS

SUM TO THE ELEMENT MODAL DENSITY

IS THIS THE MAIN SUB-ELEMENT?

NO

RETURN

SET ELEMENT VALUES TO SUB-ELEMENT VALUES

SET FLAG TO INDICATE THAT FOLLOWING SUB-ELEMENTS ARE NOT MAIN

RETURN
ROOM

CALCULATE THE PARTIAL SUB-ELEMENT MODAL DENSITY

IS STIFFNESS REDUCTION REQUIRED?

YES

REDUCE BY \( \frac{1}{\sqrt{2}} \)

NO

LOOP FOR EACH ANALYSIS FREQUENCY

SUM MASS TO THE ELEMENT MASS

CALCULATE ANGULAR VELOCITY

IS THIS THE LAST SUB-ELEMENT?

YES

RETURN

NO

SET ELEMENT VALUES TO SUB-ELEMENT VALUES

SET FLAG TO INDICATE THAT FOLLOWING SUB-ELEMENTS ARE NOT MASS

RETURN

SUM TO THE ELEMENT MODAL DENSITY
SIGF

LOOP
FOR EACH ELEMENT OF THE TABLE BETWEEN FIRST AND LAST

X IS THIS ELEMENT OF THE TABLE?

SET INDEX TO 16 (= NUMBER OF ELEMENTS IN THE TABLE)

LOOP NEXT ELEMENT OF THE TABLE?

YES

CALCULATE SIGF AS DECREASING FUNCTION

INTERPOLATE

RETURN

NO

CALCULATE SIGF AS INCREASING FUNCTION

INTERPOLATE

RETURN

EXIT

THE TABLE CONSISTS OF 16 VALUES; THE FIRST AND LAST ARE USED FOR INTERPOLATION
Appendix III

SEA PROGRAM INPUT LIST

MATERIALS EXPERIMENT ASSEMBLY - EXAMPLE 2
<table>
<thead>
<tr>
<th>RECORD NUMBER</th>
<th>DATA READ FROM UNIT 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>NUMBER OF ELEMENTS = 6</td>
</tr>
<tr>
<td></td>
<td>NUMBER OF ANALYSIS FREQUENCIES = 23</td>
</tr>
<tr>
<td></td>
<td>FIRST ANALYSIS FREQUENCY = 3.16000E+01</td>
</tr>
<tr>
<td>2</td>
<td>TYPE OF UNITS =</td>
</tr>
<tr>
<td></td>
<td>TYPE OF OUTPUT = PSD</td>
</tr>
<tr>
<td></td>
<td>ELEMENT NUMBER = 1</td>
</tr>
<tr>
<td></td>
<td>NUMBER OF SUB-ELEMENTS = 20</td>
</tr>
<tr>
<td></td>
<td>TYPE OF EXCITATION = A</td>
</tr>
<tr>
<td></td>
<td>TYPE OF MECHANICAL INPUT =</td>
</tr>
<tr>
<td></td>
<td>DAMPING = 1.00000E-02</td>
</tr>
<tr>
<td></td>
<td>SLOPE = 0</td>
</tr>
<tr>
<td></td>
<td>STARTING FREQUENCY = 0</td>
</tr>
<tr>
<td></td>
<td>SOUN D PRESSURE LEVELS</td>
</tr>
<tr>
<td>3</td>
<td>1.24000E+02 1.24000E+02 1.24000E+02 1.24000E+02</td>
</tr>
<tr>
<td>4</td>
<td>1.24000E+02 1.30000E+02 1.30000E+02 1.30000E+02</td>
</tr>
<tr>
<td>5</td>
<td>1.35000E+02 1.35000E+02 1.35000E+02 1.35000E+02</td>
</tr>
<tr>
<td>6</td>
<td>1.35000E+02 1.35000E+02 1.35000E+02 1.35000E+02</td>
</tr>
<tr>
<td></td>
<td>SUB-ELEMENT NUMBER = 1</td>
</tr>
<tr>
<td></td>
<td>TYPE OF SUB-ELEMENT = P</td>
</tr>
<tr>
<td></td>
<td>DENSITY = 2.61700E-04</td>
</tr>
<tr>
<td></td>
<td>MODULUS OF ELASTICITY = 1.00000E+07</td>
</tr>
<tr>
<td></td>
<td>THICKNESS = 6.37000E-02</td>
</tr>
<tr>
<td></td>
<td>AREA = 2.35670E+00</td>
</tr>
<tr>
<td></td>
<td>POISSONS RATIO = 3.30000E-01</td>
</tr>
<tr>
<td></td>
<td>LENGTH = 0</td>
</tr>
<tr>
<td></td>
<td>PRESSURE = 0</td>
</tr>
<tr>
<td></td>
<td>STIFFNESS REDUCTION REQUIRED = F</td>
</tr>
<tr>
<td></td>
<td>RADIUS = 0</td>
</tr>
<tr>
<td></td>
<td>VOLUME = 0</td>
</tr>
<tr>
<td></td>
<td>SPEED OF SOUND IN ROOM MEDIUM = 1.34800E+04</td>
</tr>
<tr>
<td></td>
<td>ADDED MASS = 6.49000E-01</td>
</tr>
<tr>
<td>7</td>
<td>SUB-ELEMENT NUMBER = 2</td>
</tr>
<tr>
<td></td>
<td>TYPE OF SUB-ELEMENT = P</td>
</tr>
<tr>
<td></td>
<td>DENSITY = 2.61700E-04</td>
</tr>
<tr>
<td></td>
<td>MODULUS OF ELASTICITY = 1.00000E+07</td>
</tr>
<tr>
<td></td>
<td>THICKNESS = 1.98000E-01</td>
</tr>
<tr>
<td></td>
<td>AREA = 2.14500E+02</td>
</tr>
<tr>
<td></td>
<td>POISSONS RATIO = 3.30000E-01</td>
</tr>
<tr>
<td></td>
<td>LENGTH = 0</td>
</tr>
<tr>
<td></td>
<td>PRESSURE = 0</td>
</tr>
<tr>
<td></td>
<td>STIFFNESS REDUCTION REQUIRED = F</td>
</tr>
<tr>
<td></td>
<td>RADIUS = 0</td>
</tr>
<tr>
<td></td>
<td>VOLUME = 0</td>
</tr>
<tr>
<td></td>
<td>SPEED OF SOUND IN ROOM MEDIUM = C.</td>
</tr>
<tr>
<td></td>
<td>ADDED MASS = 0</td>
</tr>
<tr>
<td>8</td>
<td>SUB-ELEMENT NUMBER = 3</td>
</tr>
<tr>
<td></td>
<td>TYPE OF SUB-ELEMENT = P</td>
</tr>
<tr>
<td></td>
<td>DENSITY = 2.61700E-04</td>
</tr>
<tr>
<td></td>
<td>MODULUS OF ELASTICITY = 1.00000E+07</td>
</tr>
<tr>
<td></td>
<td>THICKNESS = 9.59000E-02</td>
</tr>
<tr>
<td></td>
<td>AREA = 3.31200E+03</td>
</tr>
<tr>
<td></td>
<td>POISSONS RATIO = 3.30000E-01</td>
</tr>
</tbody>
</table>
LENGTH = 0.
PRESSURE = 0.
STIFFNESS REDUCTION REQUIRED = F
RADIUS = 0.
VOLUME = 0.
SPEED OF SOUND IN ROOM MEDIUM = C.
ADDED MASS = 0.
11
SUB-ELEMENT NUMBER = 4
TYPE OF SUB-ELEMENT = P
DENSITY = 2.61700E-04
MODULUS OF ELASTICITY = 1.00000E+07
THICKNESS = 2.50000E-01
AREA = 6.90000E+02
POISSON'S RATIO = 3.30000E-01
LENGTH = 0.
PRESSURE = 0.
STIFFNESS REDUCTION REQUIRED = F
RADIUS = 0.
VOLUME = 0.
SPEED OF SOUND IN ROOM MEDIUM = C.
ADDED MASS = 0.
12
SUB-ELEMENT NUMBER = 5
TYPE OF SUB-ELEMENT = P
DENSITY = 2.61700E-04
MODULUS OF ELASTICITY = 1.00000E+07
THICKNESS = 9.50000E-02
AREA = 3.93000E+03
POISSON'S RATIO = 3.30000E-01
LENGTH = 0.
PRESSURE = 0.
STIFFNESS REDUCTION REQUIRED = F
RADIUS = 0.
VOLUME = 0.
SPEED OF SOUND IN ROOM MEDIUM = C.
ADDED MASS = 0.
13
SUB-ELEMENT NUMBER = 6
TYPE OF SUB-ELEMENT = P
DENSITY = 2.61700E-04
MODULUS OF ELASTICITY = 1.00000E+07
THICKNESS = 2.50000E-01
AREA = 1.22013E+03
POISSON'S RATIO = 3.30000E-01
LENGTH = 0.
PRESSURE = 0.
STIFFNESS REDUCTION REQUIRED = F
RADIUS = 0.
VOLUME = 0.
SPEED OF SOUND IN ROOM MEDIUM = C.
ADDED MASS = 0.
14
SUB-ELEMENT NUMBER = 7
TYPE OF SUB-ELEMENT = P
DENSITY = 2.61700E-04
MODULUS OF ELASTICITY = 1.00000E+07
THICKNESS = 2.00000E-01
AREA = 1.74720E+03
POISSON'S RATIO = 3.30000E-01
LENGTH = 0.
PRESSURE = 0.
STIFFNESS REDUCTION REQUIRED = F
RADIUS = 0.
VOLUME = 0.
SPEED OF SOUND IN ROOM MEDIUM = C.
ADDED MASS = 0.
15
SUB-ELEMENT NUMBER = 8
TYPE OF SUB-ELEMENT = P
DENSITY = 2.61700E-04
MODULUS OF ELASTICITY = 1.00000E+07
THICKNESS = 2.00000E-01
AREA = 1.74720E+03
POISSON'S RATIO = 3.30000E-01
LENGTH = 0.
PRESSURE = 0.
MODULUS OF ELASTICITY = 1.00000E+07
THICKNESS = 4.64000E-02
AREA = 2.04637E+03
POISSONS RATIO = 3.30000E-01
LENGTH = 0.
PRESSURE = 0.
STIFFNESS REDUCTION REQUIRED = F
RADIUS = 0.
VOLUME = 0.
SPEED OF SOUND IN ROOM MEDIUM = 0.
ADDED MASS = 0.
SUB-ELEMENT NUMBER = 9
TYPE OF SUB-ELEMENT = P
DENSITY = 2.61700E-04
MODULUS OF ELASTICITY = 1.00000E+07
THICKNESS = 1.23000E-01
AREA = 7.47320E+02
POISSONS RATIO = 3.30000E-01
LENGTH = 0.
PRESSURE = 0.
STIFFNESS REDUCTION REQUIRED = F
RADIUS = 0.
VOLUME = 0.
SPEED OF SOUND IN ROOM MEDIUM = 0.
ADDED MASS = 0.
SUB-ELEMENT NUMBER = 10
TYPE OF SUB-ELEMENT = P
DENSITY = 2.61700E-04
MODULUS OF ELASTICITY = 1.00000E+07
THICKNESS = 3.62000E-01
AREA = 6.00000E+01
POISSONS RATIO = 3.30000E-01
LENGTH = 0.
PRESSURE = 0.
STIFFNESS REDUCTION REQUIRED = F
RADIUS = 0.
VOLUME = 0.
SPEED OF SOUND IN ROOM MEDIUM = 0.
ADDED MASS = 0.
SUB-ELEMENT NUMBER = 11
TYPE OF SUB-ELEMENT = P
DENSITY = 2.61700E-04
MODULUS OF ELASTICITY = 1.00000E+07
THICKNESS = 1.30000E-01
AREA = 1.65920E+03
POISSONS RATIO = 3.30000E-01
LENGTH = 0.
PRESSURE = 0.
STIFFNESS REDUCTION REQUIRED = F
RADIUS = 0.
VOLUME = 0.
SPEED OF SOUND IN ROOM MEDIUM = 0.
ADDED MASS = 0.
SUB-ELEMENT NUMBER = 12
TYPE OF SUB-ELEMENT = P
DENSITY = 2.61700E-04
MODULUS OF ELASTICITY = 1.00000E+07
THICKNESS = 2.75000E-01
AREA = 5.03000E+01
POISSONS RATIO = 3.30000E-01
LENGTH = 0.
PRESSURE = 0.
STIFFNESS REDUCTION REQUIRED = F
RADIUS = 0.
VOLUME = 0.
SPEED OF SOUND IN ROOM MEDIUM = 0.
<table>
<thead>
<tr>
<th>Element</th>
<th>Added Mass</th>
<th>Sub-Element Number</th>
<th>Type of Sub-Element</th>
<th>Density</th>
<th>Modulus of Elasticity</th>
<th>Thickness</th>
<th>Area</th>
<th>Poisson's Ratio</th>
<th>Length</th>
<th>Pressure</th>
</tr>
</thead>
<tbody>
<tr>
<td>30</td>
<td>0</td>
<td>13</td>
<td>P</td>
<td>2.61700E-04</td>
<td>1.00000E+07</td>
<td>1.90000E-01</td>
<td>3.54160E-02</td>
<td>3.30000E-01</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>31</td>
<td>0</td>
<td>14</td>
<td>P</td>
<td>2.61700E-04</td>
<td>1.00000E+07</td>
<td>1.50000E-01</td>
<td>7.36200E-02</td>
<td>3.30000E-01</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>32</td>
<td>0</td>
<td>15</td>
<td>P</td>
<td>2.61700E-04</td>
<td>1.00000E+07</td>
<td>2.00000E-01</td>
<td>1.90000E-02</td>
<td>3.30000E-01</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>33</td>
<td>0</td>
<td>16</td>
<td>P</td>
<td>2.61700E-04</td>
<td>1.00000E+07</td>
<td>2.50000E-01</td>
<td>1.07100E-02</td>
<td>3.30000E-01</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>34</td>
<td>0</td>
<td>17</td>
<td>P</td>
<td>2.61700E-04</td>
<td>1.00000E+07</td>
<td>3.00000E-01</td>
<td>7.91500E-01</td>
<td>3.30000E-01</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>
SPEED OF SOUND IN ROOM MEDIUM = C.
ADDED MASS = 8.60000E-03
SUB-ELEMENT NUMBER = 2
TYPE OF SUB-ELEMENT = P
DENSITY = 2.61700E-04
MODULUS OF ELASTICITY = 1.00000E+07
THICKNESS = 1.50000E-01
AREA = 7.36000E+02
POISSONS RATIO = 3.30000E-01
LENGTH = 0.
PRESSURE = 0.
STIFFNESS REDUCTION REQUIRED = F
RADIUS = 0.
VOLUME = 0.
SPEED OF SOUND IN ROOM MEDIUM = C.
ADDED MASS = 0.
SUB-ELEMENT NUMBER = 3
TYPE OF SUB-ELEMENT = P
DENSITY = 2.61700E-04
MODULUS OF ELASTICITY = 1.00000E+07
THICKNESS = 2.00000E-01
AREA = 1.98000E+02
POISSONS RATIO = 3.30000E-01
LENGTH = 0.
PRESSURE = 0.
STIFFNESS REDUCTION REQUIRED = F
RADIUS = 0.
VOLUME = 0.
SPEED OF SOUND IN ROOM MEDIUM = C.
ADDED MASS = 0.
SUB-ELEMENT NUMBER = 4
TYPE OF SUB-ELEMENT = P
DENSITY = 2.61700E-04
MODULUS OF ELASTICITY = 1.00000E+07
THICKNESS = 2.50000E-01
AREA = 1.807100E+02
POISSONS RATIO = 3.30000E-01
LENGTH = 0.
PRESSURE = 0.
STIFFNESS REDUCTION REQUIRED = F
RADIUS = 0.
VOLUME = 0.
SPEED OF SOUND IN ROOM MEDIUM = C.
ADDED MASS = 0.
SUB-ELEMENT NUMBER = 3
NUMBER OF SUB-ELEMENTS = 3
TYPE OF EXCITATION =
TYPE OF MECHANICAL INPUT =
DAMPING = 1.00000E-02
SLOPE = -0.30480E-01
STARTING FREQUENCY = 2.50000E+02

SPEED OF SOUND IN ROOM MEDIUM = C.
ADDED MASS = 1.44900E-01
SUB-ELEMENT NUMBER = 1
TYPE OF SUB-ELEMENT = P
DENSITY = 2.61700E-04
MODULUS OF ELASTICITY = 1.00000E+07
THICKNESS = 6.50000E-01
AREA = 0.76300E+01
POISSONS RATIO = 3.30000E-01
LENGTH = 0.
PRESSURE = 0.
STIFFNESS REDUCTION REQUIRED = T
RADIUS = 0.
VOLUME = 0.
SPEED OF SOUND IN ROOM MEDIUM = C.
ADDED MASS = 1.44900E-01
SUB-ELEMENT NUMBER = 2
TYPE OF SUB-ELEMENT = P
DENSITY = 2.61700E-04
MODULUS OF ELASTICITY = 1.00000E+07
THICKNESS = 6.50000E-01
AREA = 0.76300E+01
POISSONS RATIO = 3.30000E-01
LENGTH = 0.
PRESSURE = 0.
STIFFNESS REDUCTION REQUIRED = T
RADIUS = 0.
VOLUME = 0.
SPEED OF SOUND IN ROOM MEDIUM = C.
ADDED MASS = 1.44900E-01
SUB-ELEMENT NUMBER = 3
TYPE OF SUB-ELEMENT = P
DENSITY = 2.61700E-04
MODULUS OF ELASTICITY = 1.00000E+07
THICKNESS = 6.50000E-01
AREA = 0.76300E+01
POISSONS RATIO = 3.30000E-01
LENGTH = 0.
PRESSURE = 0.
STIFFNESS REDUCTION REQUIRED = T
RADIUS = 0.
VOLUME = 0.
TYPE OF SUB-ELEMENT = P
DENSITY = 2.61700E-04
MODULUS OF ELASTICITY = 1.000000E+07
THICKNESS = 2.500000E-01
AREA = 9.16700E+01
POISSONS RATIO = 3.300000E-01
LENGTH = 0.
PRESSURE = 0.
STIFFNESS REDUCTION REQUIRED = T
RADIUS = 0.
VOLUME = 0.
SPEED OF SOUND IN ROOM MEDIUM = C.
ADDED MASS = 0.

55

60

STIFFNESS REDUCTION REQUIRED = T
RADIUS = 0.
VOLUME = 0.
SPEED OF SOUND IN ROOM MEDIUM = C.
ADDED MASS = 0.

62

ELEMENT NUMBER = 4
NUMBER OF SUB-ELEMENTS = 1
TYPE OF EXCITATION =
TYPE OF MECHANICAL INPUT =
DAMPING = 1.000000E+02
SLOPE = -8.30480E-01
STARTING FREQUENCY = 2.500000E+02

63

SUB-ELEMENT NUMBER = 1
TYPE OF SUB-ELEMENT = P
DENSITY = 2.61700E-04
MODULUS OF ELASTICITY = 1.000000E+07
THICKNESS = 2.500000E-01
AREA = 9.167000E+01
POISSONS RATIO = 3.300000E-01
LENGTH = 0.
PRESSURE = 0.

64

STIFFNESS REDUCTION REQUIRED = T
RADIUS = 0.
VOLUME = 0.
SPEED OF SOUND IN ROOM MEDIUM = C.
ADDED MASS = 2.270000E+02

65

ELEMENT NUMBER = 5
NUMBER OF SUB-ELEMENTS = 3
TYPE OF EXCITATION =
TYPE OF MECHANICAL INPUT =
DAMPING = 1.000000E+02
SLOPE = -8.30480E-01
STARTING FREQUENCY = 2.500000E+02

66

SUB-ELEMENT NUMBER = 1
TYPE OF SUB-ELEMENT = P
DENSITY = 2.61700E-04
MODULUS OF ELASTICITY = 1.000000E+07
THICKNESS = 2.500000E-01
AREA = 9.167000E+01
POISSONS RATIO = 3.300000E-01
LENGTH = 0.
PRESSURE = 0.

67

STIFFNESS REDUCTION REQUIRED = T
RADIUS = 0.
VOLUME = 0.
SPEED OF SOUND IN ROOM MEDIUM = 0.
ADDED MASS = 1.38790E+00
SUB-ELEMENT NUMBER = 2
TYPE OF SUB-ELEMENT = P
DENSITY = 2.61700E-04
MODULUS OF ELASTICITY = 1.00000E+07
THICKNESS = 3.50000E-01
AREA = 1.09960E+02
POISSONS RATIO = 3.30000E-01
LENGTH = 0.
PRESSURE = 0.
STIFFNESS REDUCTION REQUIRED = T
RADIUS = 0.
VOLUME = 0.
SPEED OF SOUND IN ROOM MEDIUM = 0.
ADDED MASS = 0.
SUB-ELEMENT NUMBER = 3
TYPE OF SUB-ELEMENT = P
DENSITY = 2.61700E-04
MODULUS OF ELASTICITY = 1.00000E+07
THICKNESS = 3.50000E-01
AREA = 6.71110E+02
POISSONS RATIO = 3.30000E-01
LENGTH = 0.
PRESSURE = 0.
STIFFNESS REDUCTION REQUIRED = T
RADIUS = 0.
VOLUME = 0.
SPEED OF SOUND IN ROOM MEDIUM = 0.
ADDED MASS = 0.

ELEMENT NUMBER = 6
NUMBER OF SUB-ELEMENTS = 2
TYPE OF EXCITATION =
TYPE OF MECHANICAL INPUT = DAMPING = 1.00000E-02
SLOPE = -9.30400E-01
STARTING FREQUENCY = 2.50000E+02
SUB-ELEMENT NUMBER = 1
TYPE OF SUB-ELEMENT = P
DENSITY = 2.61700E-04
MODULUS OF ELASTICITY = 1.00000E+07
THICKNESS = 5.00000E-01
AREA = 7.26900E+02
POISSONS RATIO = 3.30000E-01
LENGTH = 0.
PRESSURE = 0.
STIFFNESS REDUCTION REQUIRED = T
RADIUS = 0.
VOLUME = 0.
SPEED OF SOUND IN ROOM MEDIUM = 0.
ADDED MASS = 1.38320E+00
SUB-ELEMENT NUMBER = 2
TYPE OF SUB-ELEMENT = P
DENSITY = 2.61700E-04
MODULUS OF ELASTICITY = 1.00000E+07
THICKNESS = 3.75000E-01
AREA = 7.26900E+02
POISSONS RATIO = 3.30000E-01
LENGTH = 0.
PRESSURE = 0.
STIFFNESS REDUCTION REQUIRED = T
RADIUS = 0.
VOLUME = 0.
SPEED OF SOUND IN ROOM MEDIUM = 0.
ADDED MASS = 0.
<table>
<thead>
<tr>
<th>CENTER FREQ (Hz)</th>
<th>ELEMENT 1</th>
<th>ELEMENT 2</th>
<th>ELEMENT 3</th>
<th>ELEMENT 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>31.50</td>
<td>1.00892E+00</td>
<td>1.09014E-02</td>
<td>1.20975E-02</td>
<td>2.65614E-03</td>
</tr>
<tr>
<td>39.38</td>
<td>1.00892E+00</td>
<td>1.09014E-02</td>
<td>1.20975E-02</td>
<td>2.65614E-03</td>
</tr>
<tr>
<td>50.40</td>
<td>1.00892E+00</td>
<td>1.09014E-02</td>
<td>1.20975E-02</td>
<td>2.65614E-03</td>
</tr>
<tr>
<td>63.00</td>
<td>1.00892E+00</td>
<td>1.09014E-02</td>
<td>1.20975E-02</td>
<td>2.65614E-03</td>
</tr>
<tr>
<td>76.75</td>
<td>1.00892E+00</td>
<td>1.09014E-02</td>
<td>1.20975E-02</td>
<td>2.65614E-03</td>
</tr>
<tr>
<td>99.23</td>
<td>1.00892E+00</td>
<td>1.09014E-02</td>
<td>1.20975E-02</td>
<td>2.65614E-03</td>
</tr>
<tr>
<td>126.40</td>
<td>1.00892E+00</td>
<td>1.09014E-02</td>
<td>1.20975E-02</td>
<td>2.65614E-03</td>
</tr>
<tr>
<td>157.50</td>
<td>1.00892E+00</td>
<td>1.09014E-02</td>
<td>1.20975E-02</td>
<td>2.65614E-03</td>
</tr>
<tr>
<td>196.45</td>
<td>1.00892E+00</td>
<td>1.09014E-02</td>
<td>1.20975E-02</td>
<td>2.65614E-03</td>
</tr>
<tr>
<td>252.00</td>
<td>1.00892E+00</td>
<td>1.09014E-02</td>
<td>1.20975E-02</td>
<td>2.65614E-03</td>
</tr>
<tr>
<td>315.40</td>
<td>1.00892E+00</td>
<td>1.09014E-02</td>
<td>1.20975E-02</td>
<td>2.65614E-03</td>
</tr>
<tr>
<td>393.75</td>
<td>1.00892E+00</td>
<td>1.09014E-02</td>
<td>1.20975E-02</td>
<td>2.65614E-03</td>
</tr>
<tr>
<td>504.00</td>
<td>1.00892E+00</td>
<td>1.09014E-02</td>
<td>1.20975E-02</td>
<td>2.65614E-03</td>
</tr>
<tr>
<td>630.00</td>
<td>1.00892E+00</td>
<td>1.09014E-02</td>
<td>1.20975E-02</td>
<td>2.65614E-03</td>
</tr>
<tr>
<td>767.50</td>
<td>1.00892E+00</td>
<td>1.09014E-02</td>
<td>1.20975E-02</td>
<td>2.65614E-03</td>
</tr>
<tr>
<td>992.25</td>
<td>1.00892E+00</td>
<td>1.09014E-02</td>
<td>1.20975E-02</td>
<td>2.65614E-03</td>
</tr>
<tr>
<td>1260.00</td>
<td>1.00892E+00</td>
<td>1.09014E-02</td>
<td>1.20975E-02</td>
<td>2.65614E-03</td>
</tr>
<tr>
<td>1575.00</td>
<td>1.00892E+00</td>
<td>1.09014E-02</td>
<td>1.20975E-02</td>
<td>2.65614E-03</td>
</tr>
<tr>
<td>1984.50</td>
<td>1.00892E+00</td>
<td>1.09014E-02</td>
<td>1.20975E-02</td>
<td>2.65614E-03</td>
</tr>
<tr>
<td>2520.00</td>
<td>1.00892E+00</td>
<td>1.09014E-02</td>
<td>1.20975E-02</td>
<td>2.65614E-03</td>
</tr>
<tr>
<td>3150.00</td>
<td>1.00892E+00</td>
<td>1.09014E-02</td>
<td>1.20975E-02</td>
<td>2.65614E-03</td>
</tr>
<tr>
<td>3937.50</td>
<td>1.00892E+00</td>
<td>1.09014E-02</td>
<td>1.20975E-02</td>
<td>2.65614E-03</td>
</tr>
<tr>
<td>5640.00</td>
<td>1.00892E+00</td>
<td>1.09014E-02</td>
<td>1.20975E-02</td>
<td>2.65614E-03</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>CENTER FREQ (Hz)</th>
<th>ELEMENT 5</th>
<th>ELEMENT 6</th>
</tr>
</thead>
<tbody>
<tr>
<td>31.50</td>
<td>1.32509E-03</td>
<td>3.19266E-03</td>
</tr>
<tr>
<td>39.38</td>
<td>1.32509E-03</td>
<td>3.19266E-03</td>
</tr>
<tr>
<td>50.40</td>
<td>1.32509E-03</td>
<td>3.19266E-03</td>
</tr>
<tr>
<td>63.00</td>
<td>1.32509E-03</td>
<td>3.19266E-03</td>
</tr>
<tr>
<td>76.75</td>
<td>1.32509E-03</td>
<td>3.19266E-03</td>
</tr>
<tr>
<td>99.23</td>
<td>1.32509E-03</td>
<td>3.19266E-03</td>
</tr>
<tr>
<td>126.40</td>
<td>1.32509E-03</td>
<td>3.19266E-03</td>
</tr>
<tr>
<td>157.50</td>
<td>1.32509E-03</td>
<td>3.19266E-03</td>
</tr>
<tr>
<td>198.45</td>
<td>1.32509E-03</td>
<td>3.19266E-03</td>
</tr>
<tr>
<td>252.00</td>
<td>1.32509E-03</td>
<td>3.19266E-03</td>
</tr>
<tr>
<td>315.40</td>
<td>1.32509E-03</td>
<td>3.19266E-03</td>
</tr>
<tr>
<td>393.75</td>
<td>1.32509E-03</td>
<td>3.19266E-03</td>
</tr>
<tr>
<td>463.00</td>
<td>1.32509E-03</td>
<td>3.19266E-03</td>
</tr>
<tr>
<td>767.50</td>
<td>1.32509E-03</td>
<td>3.19266E-03</td>
</tr>
<tr>
<td>992.25</td>
<td>1.32509E-03</td>
<td>3.19266E-03</td>
</tr>
<tr>
<td>1260.00</td>
<td>1.32509E-03</td>
<td>3.19266E-03</td>
</tr>
<tr>
<td>1575.00</td>
<td>1.32509E-03</td>
<td>3.19266E-03</td>
</tr>
<tr>
<td>1984.50</td>
<td>1.32509E-03</td>
<td>3.19266E-03</td>
</tr>
<tr>
<td>2520.00</td>
<td>1.32509E-03</td>
<td>3.19266E-03</td>
</tr>
<tr>
<td>3150.00</td>
<td>1.32509E-03</td>
<td>3.19266E-03</td>
</tr>
<tr>
<td>3937.50</td>
<td>1.32509E-03</td>
<td>3.19266E-03</td>
</tr>
<tr>
<td>5640.00</td>
<td>1.32509E-03</td>
<td>3.19266E-03</td>
</tr>
</tbody>
</table>

**Data Read From Unit 3**

**First Element = 1**
**Second Element = 2**
**Type of Joint = B9**
**Number of Staps = 9**
JOINT LENGTH = 7.06700E+01
THICKNESS OF FIRST ELEMENT = 2.95000E+01
THICKNESS OF SECOND ELEMENT = 1.90000E-01
ACOUSTIC SPACE DENSITY = 0.
BEAM LENGTH = 0.
INSERTION LOSS FACTOR = 1.000000E+02
FIRST ELEMENT = 1
SECOND ELEMENT = 3
TYPE OF JOINT = BJ
NUMBER OF SIDES = 0
JOINT LENGTH = 1.23840E+02
THICKNESS OF FIRST ELEMENT = 2.50000E-01
THICKNESS OF SECOND ELEMENT = 7.00000E-01
ACOUSTIC SPACE DENSITY = 0.
BEAM LENGTH = 0.
INSERTION LOSS FACTOR = 1.000000E+02
FIRST ELEMENT = 1
SECOND ELEMENT = 4
TYPE OF JOINT = BJ
NUMBER OF SIDES = 0
JOINT LENGTH = 4.00000E+00
THICKNESS OF FIRST ELEMENT = 2.50000E-01
THICKNESS OF SECOND ELEMENT = 2.50000E-01
ACOUSTIC SPACE DENSITY = 0.
BEAM LENGTH = 0.
INSERTION LOSS FACTOR = 1.000000E+02
FIRST ELEMENT = 4
SECOND ELEMENT = 3
TYPE OF JOINT = PP
NUMBER OF SIDES = 0
JOINT LENGTH = 1.07600E+01
THICKNESS OF FIRST ELEMENT = 7.00000E-01
THICKNESS OF SECOND ELEMENT = 2.50000E-01
ACOUSTIC SPACE DENSITY = 0.
BEAM LENGTH = 0.
INSERTION LOSS FACTOR = 0.
FIRST ELEMENT = 1
SECOND ELEMENT = 5
TYPE OF JOINT = BJ
NUMBER OF SIDES = 0
JOINT LENGTH = 1.08840E+02
THICKNESS OF FIRST ELEMENT = 2.50000E-01
THICKNESS OF SECOND ELEMENT = 7.00000E-01
ACOUSTIC SPACE DENSITY = 0.
BEAM LENGTH = 0.
INSERTION LOSS FACTOR = 1.000000E+02
FIRST ELEMENT = 1
SECOND ELEMENT = 6
TYPE OF JOINT = BJ
NUMBER OF SIDES = 0
JOINT LENGTH = 2.67500E+02
THICKNESS OF FIRST ELEMENT = 2.50000E-01
THICKNESS OF SECOND ELEMENT = 3.45000E-01
ACOUSTIC SPACE DENSITY = 0.
BEAM LENGTH = 0.
INSERTION LOSS FACTOR = 1.000000E+02