CALIFORNIA STATE UNIVERSITY, NORTHRIDGE

A USER'S MANUAL

FOR

THE TIMBER ENGINEERING COMPUTER PROGRAM

A graduate project submitted in partial satisfaction of the requirements for the degree of Master of Science in

Engineering

by

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May 1986
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CALIFORNIA STATE UNIVERSITY, NORTHRIDGE
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ABSTRACT

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FOR

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by

Robert Charles Neal

Master of Science in Engineering

This graduate project consists of developing a computer program that performs the design wooden members, putting the program in the system 50 computer library at CSUN, and preparing a user's manual for the program. The program is intended to be used in the design of (1) sawn lumber beams, (2) glued laminated beams, and (3) general sawn lumber members.

The program is menu driven. From an initial menu the user selects one of the three principal design types indicated above. The program has, as part of its internal code, data tables containing standard structural and member data extracted from timber and building code manuals. The program printout includes all design calculations used in the selection of the member.

The user's manual contains four sections. Section one is general information. Section two describes the sawn beam portion of the
program. Section three describes glued laminated beam design. The last section, section four, describes general sawn lumber design subroutines.

In the appendix of the manual are the source file listings. All source files are in BASIC. The appendix also contains the principal design equations used in each section of the program.
DISCLAIMER

The user of this manual and of the Timber Engineering Design Program is solely responsible for the design of all structures and engineering plans prepared through the use of this program. While every precaution has been taken to insure that all data and information set forth in this manual and the program are complete and accurate, the author shall not be held liable for any errors or oversights that may be contained. It is the user’s responsibility to review and verify all information resulting from the use of the program or contained within this manual. The author assumes no liability for any damages that may occur through the use of this program.
USER'S MANUAL

FOR

THE TIMBER ENGINEERING COMPUTER PROGRAM

CALIFORNIA STATE UNIVERSITY, NORTHridge

MAY 1986
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</tr>
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Section 1

General Information

INTRODUCTION

What The Program Does

Lumber Design is a comprehensive member design program written for both the student and the experienced structural design engineer. It allows the user to select wooden members based upon structural stresses and other appropriate information entered during program execution. Once the member has been selected, analysis and design conclusions are displayed along with the analysis and design formulae. This allows the student to view the selection criteria and how they were determined as well as verify calculations.

The program has, as part of its internal code, data tables containing standard structure and member data extracted from timber and building code manuals. As the program executes, these data, from the appropriate tables, are used for processing.

For cases requiring user defined data, which are not part of the standard tables, the program allows the data to be specified and entered by the user.

Getting Started

NOTE

It is assumed that the user is familiar with the operation (logging on, the proper password, and correct usage of the keyboard and other function keys) of the
computer in which the program runs. If this is not so, consult the computer's user manual for information.

The program is nearly totally menu-driven. During program execution the terminal screen displays selection menus from which the desired data are selected. The only portion of the program that is not menu driven is the initiating sequence. To begin program execution, type the following (the word RETURN in angle brackets <> indicates that the RETURN key is pressed at this point):

OLD,TIMBER <RETURN>
TIMBER <RETURN>
The program Main Menu is then displayed.

NOTE
See DISCLAIMER at the beginning of this manual. The author assumes no liability for any damages or design errors that may occur through the use of this program.
The Timber Engineering Library consists of several files as explained in Program Structure in this section.

SAWN LUMBER DESIGN is for beam designs that are not glued-laminated.

Enter the number corresponding with the desired selection and press the RETURN key. The selection causes the appropriate menu to be displayed for the desired member design. See, in this manual, Section 2 for Sawn Lumber Beam Design, Section 3 for Glued-Laminated Design, or Section 4 for General Sawn Lumber Design. Selection number 4, RETURN TO SYSTEM, causes the computer to leave this lumber design program and return to the operating system.
If error codes are encountered during program execution, refer to the
BASIC reference guide. If the program stops execution, type RUN and
press RETURN to begin the program.

SCOPE OF THIS MANUAL

This manual supplies all information to use the Lumber Design program
in four sections. Section 1, this section, contains general
information about the program and how to begin program execution.
Section 2 contains operating information for Sawn Lumber (Beam)
Design. Section 3 provides operating information on Glued-Laminated
Beam Design. Section 4 provides operating information on General Sawn
Lumber Design. Sections 2 through 4 contain Sample Problems and
figures of most menus.

PROGRAM STRUCTURE

This brief explanation of the program structure is provided for future
modifications to the Lumber Design program to enhance its operation,
to update the standard data files, and for the interest of the user
familiar with the BASIC programming language. For a more detailed
analysis of the program, see the program listing in the Appendix.

NOTE

This brief explanation of program structure is written
for the user familiar with the BASIC programming
language. Technical terms are used in this explanation.
The Lumber Design program consists of 21 files in three file-types: (1) source programs written in BASIC, (2) data files containing standard timber data, and (3) a procedural file that initiates and concludes program execution. The procedural file creates temporary files, which are erased upon completion of program execution, and starts the initial source program (SRT). Source programs are linked together by the "chain" command, and execution is passed, as necessary, from one program to another.

Formulae used in the source files of the program are standard in the industry and can be found in most text books covering the design of wood structures. The order the formulae are used, or the procedure used in the design, roughly corresponds to the design procedures as they are presented in Design of Wood Structures by Donald Breyer, copyright 1980.
Section 2
Sawn Beam Design

INTRODUCTION

This section provides all necessary operating information for the Sawn Beam Design program. A brief description of the capabilities of the program and the program constraints, assumptions, and restrictions are provided in this introduction. The operating procedure, with appropriate figures, is explained in the section entitled Operation. A Sample Problem section contains a step-by-step procedure of a typical design problem.

What Sawn Beam Design Does

The Sawn Beam Design program performs all necessary analysis and provides all essential design information to specify an appropriate size of a simply supported, uniformly loaded, prismatic sawn wood beam. Standard design values for graded structural lumber are provided in the program, or the user may choose to specify them. Appropriate member sizes are specified based upon the given design condition and design values for the sawn lumber. The engineer or engineering student selects the desired member size from one of the appropriate sizes.

Constraints, Assumptions, & Restrictions

The analysis and selection are subject to the following constraints, assumptions, and restrictions. This program assumes a linearly elastic system. Only small deflections are considered.

Shear deformations are neglected.
Beam is assumed prismatic throughout.

Shear is taken at the face of the support. The allowable reduction, taking maximum shear at a distance "d" away, is not taken.

Net sizes of members are used in the calculations, therefore this is not a design program for rough-sawn lumber. However, rough-sawn lumber may be conservatively substituted for the nominal sizes shown.

The program uses a "k" factor equal to 1 in computing total loads. For other than simply supported conditions, a smaller "k" factor could be used. The use of "k" equal to 1 is conservative for all other span conditions.

Selection of members is limited to those listed in Appendix M, Properties of Structural Lumber, from the 1982 edition of the National Design Specifications, Recommended Practice by National Forest Products Association.


Notches are not taken into account by the program.

Bridging is a detailing requirement not considered by the program. It is the responsibility of the engineer.
OPERATION

Overview

After entering the Sawn Beam Design program, condition data and, if necessary, the user-specified lumber design values are entered through display menus similar to the one used to select the Sawn Beam Design program. After the data are entered, the program displays an appropriate member size selected from standard tables using the design criteria specified. This selection may be accepted or rejected. If rejected, the next appropriate size is displayed, which may also be accepted or rejected. Once a member size has been accepted, the results of the analysis, design condition, and member parameters, are displayed with appropriate equations.

In the following paragraphs, operating menus are shown and described. It is assumed that the user is familiar with terms used in the civil engineering industry pertaining to design of members. Terms that are considered, by the author of this program, unclear are defined or explained in the menu descriptions below.

Refer to Section 1, Getting Started, for instructions on starting the Lumber Design program. If you haven't read this section, be sure to do so before using the program.
Operating Menus

After entering the startup sequence (see Section 1), Timber Engineering Library menu is displayed from which is selected the design program for the desired member type. Since this section explains and instructs in the usage of sawn beam design, it is assumed that number 1 was selected and entered, followed by pressing the RETURN key. This causes the Lumber Species menu to be displayed. See Figure 1.

<table>
<thead>
<tr>
<th>LUMBER SPECIES</th>
<th>INPUT ###</th>
</tr>
</thead>
<tbody>
<tr>
<td>DOUGLAS-FIR LARCH</td>
<td>1</td>
</tr>
<tr>
<td>SOUTHERN PINE</td>
<td>2</td>
</tr>
<tr>
<td>CALIFORNIA REDWOOD</td>
<td>3</td>
</tr>
<tr>
<td>USER DEFINED VALUES</td>
<td>4</td>
</tr>
<tr>
<td>END PROGRAM</td>
<td>5</td>
</tr>
</tbody>
</table>

YOUR SELECTION?

Figure 1. Lumber Species Menu

The Lumber Species menu allows selection of Douglas-Fir Larch (1), Southern Pine (2), or California Redwood (3) lumber. Standard structure and member data for these lumber species are stored in the program for processing; therefore, the data does not need to be entered by the user.
Structure and member data may be defined by the user by selecting option four, USER DEFINED VALUES, in the menu. If this is selected, the following information must be entered as it is requested, followed by pressing the RETURN key: bending strength (Fb), shear strength (Fv), compressive strength perpendicular to the grain (Fcl), and the modulus of elasticity (E). The program makes all necessary value adjustments during processing; therefore, no preadjustment is necessary.

The last option in this menu, END PROGRAM (5), stops Lumber Design and returns to the system.

Once the lumber species has been selected, the Size Classification menu is displayed. Though similar, the actual contents of this menu depends on the lumber species selected. Figure 2 below shows a Size Classification menu for Douglas-Fir Larch.

If USER DEFINED VALUES is selected, the next two menus are skipped. The data entered through these two menus are used to determine the stress values found in standard data tables (which are already part of the program) for the selected lumber species and selected usage. However, since the USER DEFINED VALUES requests this data directly, the next two menus are not required.
<table>
<thead>
<tr>
<th>SIZE CLASSIFICATION</th>
<th>INPUT</th>
</tr>
</thead>
<tbody>
<tr>
<td>LIGHT FRAMING - UP TO 4 INCHES WIDE</td>
<td>1</td>
</tr>
<tr>
<td>LIGHT FRAMING - 4 INCHES WIDE</td>
<td>2</td>
</tr>
<tr>
<td>LIGHT FRAMING - 5 INCHES AND WIDER</td>
<td>3</td>
</tr>
<tr>
<td>BEAMS AND STRINGERS</td>
<td>4</td>
</tr>
<tr>
<td>POSTS AND TIMBERS</td>
<td>5</td>
</tr>
<tr>
<td>DECKING</td>
<td>6</td>
</tr>
</tbody>
</table>

Usage Description Selection?

Figure 2. Size Classification Menu

Size classification, and thus the contents of this menu, depends on the lumber species selected. Size classification is not always known when the program is first run. If the size classification is incorrect, the tabulated stresses may also be wrong. If necessary, rerun the program after it is finished to correct the classification.

Enter the desired size classification by typing the corresponding number and pushing the return key.

After the size is classified, the Lumber Grade menu is displayed. See Figure 3. (This is the second menu that is skipped if the USER DEFINED VALUES option was selected.)
The contents of the Lumber Grade menu depends on the selected lumber species and the size classification. Figure 3 shows available lumber grades for Douglas-Fir Larch with size classification of light framing - 5 inches and wider (selection number three on the Size Classification menu of Figure 2).

Select grade by typing in the suitable input number and pushing the return key.

This menu allows the member to be classified as a repetitive member. By definition, repetitive members are three or more parallel beams spaced not more than 24 inches on centers and are joined together by

<table>
<thead>
<tr>
<th>LUMBER GRADE</th>
<th>INPUT</th>
</tr>
</thead>
<tbody>
<tr>
<td>DENSE SELECT STRUCTURAL</td>
<td>1</td>
</tr>
<tr>
<td>SELECT STRUCTURAL</td>
<td>2</td>
</tr>
<tr>
<td>DENSE NO.1</td>
<td>3</td>
</tr>
<tr>
<td>NO.1</td>
<td>4</td>
</tr>
<tr>
<td>DENSE NO.2</td>
<td>5</td>
</tr>
<tr>
<td>NO.2</td>
<td>6</td>
</tr>
<tr>
<td>NO.3</td>
<td>7</td>
</tr>
<tr>
<td>APPEARANCE</td>
<td>8</td>
</tr>
<tr>
<td>STUD</td>
<td>9</td>
</tr>
</tbody>
</table>
floor, roof, or other load distributing elements. Allowable bending stresses for repetitive members are approximately 15 percent greater than allowable bending stresses for single-used members. If the member is to be a repetitive member, simply type Y followed by pressing the RETURN key.

With the lumber grade selected and the member classified for repetitive or single use, the program prompts for design criteria. See Figure 4.

**INPUT DESIGN PARAMETERS:**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>LENGTH, FEET</td>
<td>?</td>
</tr>
<tr>
<td>MAXIMUM UNBRACED LENGTH</td>
<td>?</td>
</tr>
<tr>
<td>CONDITION OF USE FACTOR</td>
<td>?</td>
</tr>
<tr>
<td>DISTRIBUTED LIVE LOAD, LBS/FT</td>
<td>?</td>
</tr>
<tr>
<td>DISTRIBUTED DEAD LOAD, LBS/FT</td>
<td>?</td>
</tr>
</tbody>
</table>

Figure 4. Input Design Parameters

In this menu, each design parameter is displayed with the question mark. The parameter value is entered followed by pressing RETURN. The next parameter is then displayed with the question mark prompt. The appropriate value is entered, again followed by RETURN. This process is repeated until the parameters have been defined.

LENGTH. Length is beam span length in feet.
MAXIMUM UNBRACED LENGTH. Maximum unbraced length is the largest distance between blocking that occurs. This distance is used to determine the allowable bending stress considering lateral stability. For blocking to be effective it must brace the compression zone of a beam against lateral movement. With proper nailing, a roof or floor diaphragm can provide full lateral support, which equals an unbraced length of zero feet. Blocking may be either solid blocking or bridging.

Bridging is cross-bracing made from wood or light gauge metal. Solid blocking is wood blocking the same depth as the beam. The Uniform Building Code (UBC) states that if the width to thickness ratio of a beam is greater than or equal to 6, then solid blocking or bridging is required at intervals not to exceed 8 feet. The effective unbraced length, and therefore the lateral stability, of a beam depends upon the maximum unbraced length, the type of supports, and the configuration of the loads. The Lumber Design program conservatively assumes simple span (pinned supports) beam with a uniformly distributed load. Designers should be conscious of the fact that lateral stability considerations may control the selection of a beam.

CONDITION OF USE FACTOR. The condition of use factor is an adjustment for possible moisture content conditions that can occur during the life of the member. Changes in moisture content affect the strength of the lumber and can vary in a member depending upon its environment. Design values (tabulated stresses) for sawn lumber used in this
program have been taken from Table 4A of the National Design Specifications (NDS) Supplement. For most species of wood, the tabulated stresses are given assuming surfaced dry or surfaced green lumber used in conditions where the moisture content of the lumber does not exceed 19 percent. A notable exception to this is Southern Pine. The user is referred to the footnotes of Table 4A in order to determine the appropriate condition of use factor to be used.

DISTRIBUTED LIVE LOAD. Uniform distributed live load, in lbs. per linear foot along the beam, is vertical gravity loads not permanently applied to the structure. Table 23A of the UBC specifies floor live loads in pounds per square foot. Table 23C of the UBC specifies roof live loads in pounds per square foot. Loads given in these tables may be adjusted depending on such factors as tributary area and roof slope. Uniform live load along the beam may be computed by multiplying the unit load (in pounds per square foot) by the width of the area that is contributing loads to the beam.

DISTRIBUTED DEAD LOAD. Similar to the live load, the distributed dead load, in lbs. per linear foot along the beam, is vertical gravity loads constituting the weights of all materials permanently attached to the structure including the weight of the beam itself. Because this is not normally known at the onset of design, it should be estimated. A fairly complete table of material weights can be found in American National Standards Institute (ANSI) Standard A58.1985
After the input design parameters have been entered, the Live Load Deflection Criteria menu is displayed. See Figure 5.

**LIVE LOAD DEFLECTION CRITERIA**

<table>
<thead>
<tr>
<th>LIVE LOAD DEFORMATION CRITERIA</th>
<th>INPUT</th>
</tr>
</thead>
<tbody>
<tr>
<td>L/180</td>
<td>1</td>
</tr>
<tr>
<td>L/240</td>
<td>2</td>
</tr>
<tr>
<td>L/360</td>
<td>3</td>
</tr>
<tr>
<td>USER DEFINED MAX. LIVE LOAD DEFL.</td>
<td>4</td>
</tr>
</tbody>
</table>

**LIVE LOAD DEFORMATION CRITERIA SELECTED ?**

Figure 5. Live Load Deflection Criteria Menu

The Live Load Deflection Criteria Menu displays three commonly used deflection criteria and an option to define maximum live load deflection. Tables 23D and 23E of the UBC define deflection limitations to be used under certain gravity loads. The UBC requires that deflection under live load be calculated and should be less than or equal to L/360, where L is the span length. The *Timber Construction Manual*, published by the American Institute of Timber Construction, recommends a less stringent standard limited to L/240.

The user may wish to limit deflections depending on the code requirements governing the design and the design conditions being faced. The user's deflection limitations may be more stringent than permitted by code in order to prevent ponding on roofs or excessive cracking in plastered ceilings or to accommodate some other design
requirement. This program allows the user to define the maximum deflection permitted. If this option is selected, enter the permitted maximum live load deflection in inches.

Enter the desired criteria by entering the corresponding number and pressing RETURN.

With this information entered, the Total Load Deflection Criteria menu is displayed. See Figure 6.

TOTAL LOAD DEFLECTION CRITERIA

<table>
<thead>
<tr>
<th>INPUT DEFLECTION CRITERIA</th>
<th>TOTAL LOAD</th>
</tr>
</thead>
<tbody>
<tr>
<td>L/180</td>
<td>1</td>
</tr>
<tr>
<td>L/240</td>
<td>2</td>
</tr>
<tr>
<td>L/360</td>
<td>3</td>
</tr>
<tr>
<td>USER DEFINED MAX. TOTAL LOAD DEFL.</td>
<td>4</td>
</tr>
</tbody>
</table>

TOTAL LOAD DEFLECTION CRITERIA SELECTED?

Figure 6. Total Load Deflection Criteria Menu

Similar to the Live Load Deflection Criteria menu, this menu displays three commonly used deflection criteria and an option to define maximum total load deflection. Tables 23D and 23E of the UBC define deflection limitations to be used under certain gravity loads. The UBC requires that deflection under total load be less than or equal to
L/240, where L is the span length. The Timber Construction Manual published by the American Institute of Timber Construction recommends a less stringent standard limited to L/180.

The user may specify maximum total deflection. If this option is selected, enter the permitted maximum live load deflection in inches. No adjustments are made in the program for creep.

The UBC allows total deflection to be calculated using full live load and half dead load for seasoned lumber having a moisture content of less than 16 percent at the time of construction and subject to dry conditions of use. Conservatively, this program uses full live load and dead to determine deflections.
-- LOAD DURATION FACTOR --

<table>
<thead>
<tr>
<th>SHORTEST DURATION LOAD IN COMBINATION</th>
<th>(APPROXIMATE DURATION)</th>
<th>LDF</th>
</tr>
</thead>
<tbody>
<tr>
<td>DEAD LOAD</td>
<td>(PERMANENT)</td>
<td>0.9</td>
</tr>
<tr>
<td>FLOOR LIVE LOAD</td>
<td>(10 YEARS)</td>
<td>1.0</td>
</tr>
<tr>
<td>SNOW LOAD</td>
<td>(2 MONTHS)</td>
<td>1.15</td>
</tr>
<tr>
<td>ROOF LIVE LOAD</td>
<td>(7 DAYS)</td>
<td>1.25</td>
</tr>
<tr>
<td>WIND OR SEISMIC</td>
<td>(1 DAY)</td>
<td>1.33</td>
</tr>
<tr>
<td>IMPACT</td>
<td>(2 SECONDS)</td>
<td>2.0</td>
</tr>
</tbody>
</table>

NOTES:
A. CHECK ALL CODE REQUIRED LOAD COMBINATIONS.
B. SELECT LDF ASSOCIATED WITH THE SHORTEST DURATION IN THE COMBINATION OF LOADS.
C. THE CRITICAL COMBINATION OF LOADS IS THE ONE THAT REQUIRES THE LARGEST SIZE STRUCTURAL MEMBER.

LOAD DURATION FACTOR TO BE USED?

Figure 7. Load Duration Factor Menu

The load duration factor takes into account wood's ability to support greater stresses that are applied for a short period of time. The total accumulated length of time that a load is applied to a structure is known as the the duration of loading. The load duration factor applies to the entire combination of loads and not just to that portion of the stress caused by a load of a particular duration. The load duration to be used is the one associated with the shortest duration load in the combination.

Enter the desired load duration factor (LDF) shown in the menu.
This concludes the data that is entered by the user. The next displays identify the member selection (which may be rejected or accepted) and design analysis.

MEMBER SELECTED : 1 X 10
DO YOU WANT TO SELECT ANOTHER MEMBER ? (Y/N)
? [ Y ]

MEMBER SELECTED : 1 X 12
DO YOU WANT TO SELECT ANOTHER MEMBER ? (Y/N)
? [ Y ]

MEMBER SELECTED : 2 X 8
DO YOU WANT TO SELECT ANOTHER MEMBER ? (Y/N)
? [ N ]

Figure 8. Member Selection Display

The Lumber Design program selects an appropriate member size from a table of sectional properties of standard dressed (S4S) sizes of structural lumber. The selection is based on the data that was entered and the tabulated stresses that are part of the program. The selection may be rejected by typing N and pressing RETURN. A new member is then selected and displayed. It too may be rejected or accepted. Once a member is selected, the program displays all data concerning the design and the member.
Analysis & Design Displays

------------------- INPUT DATA -------------------

SPAN LENGTH = 14 ft
MAX. UNBRACED LENGTH = 0 ft
LOAD DURATION FACTOR = 1.25
CONDITION OF USE FACTOR = 1
UNIFORM DIST. LIVE LOAD = 20 lbs/ft
UNIFORM DIST. DEAD LOAD = 27 lbs/ft
DEFLECTION LIMITATION (LIVE LOAD) = L/240
DEFLECTION LIMITATION (TOTAL LOAD) = L/180

LUMBER SPECIES: DOUGFIR
COMMERCIAL GRADE: NO.1
SIZE CLASSIFICATION: LIGHT FRAMING -5 INCHES AND WIDER
REPETITIVE MEMBER ?: YES
TYPE 'R' WHEN READY TO CONTINUE ?

Figure 9. Input Data Display

The first analysis and design display repeats the "input" data so that the user may verify that the program received the input data correctly. This sample menu identifies a species of Douglas-Fir Larch, commercial grade no. 1, size classification of light framing - 5 inches and wider, and classifies the member as repetitive.

If user defined deflection limitations were entered, they are now expressed as a fraction of the length (L/XXX).
The Stresses Display (Figure 10.) shows the tabulated stresses that correspond with the lumber species, grade, and size classification selected. (Figure 10 is only an example of a display.) It also displays the adjusted bending stresses for size factor and lateral stability. The symbol CS in the display is the slenderness factor computed in the lateral stability analysis. The symbol CK defines the dividing line between intermediate and long unbraced beams. The lateral stability classification identifies the portion of the lateral stability bending curve that was used. The slenderness factor is not allowed to exceed a maximum value of 50. If the lateral stability classification has been designated as a long unbraced beam, the user should consider additional blocking along the beam. Two adjusted bend
stresses (FB) are calculated: one for size and one for stability. The smaller figure is used for the selection of the member.

\[
\begin{align*}
FV &= (\text{TAB FV}) \times \text{LDF} \times \text{CUF} \\
FV &= 95 \times 1.25 \times 1 = 118.75 \text{ PSI} \\
FCL &= (\text{TAB FCL}) \times \text{LDF} \times \text{CUF} \\
FCL &= 625 \times 1.25 \times 1 = 781.25 \text{ PSI}
\end{align*}
\]

**DESIGN LOADS:**

\[
\begin{align*}
\text{WTL} &= \text{WLL} + \text{WDL} \\
\text{WTL} &= 27 + 20 = 47 \text{ lbs/ft}
\end{align*}
\]

\[
\begin{align*}
\text{M(\text{MAX})} &= \text{WTL} \times (\text{L})^2 / 8 \\
\text{M(\text{MAX})} &= 47 \times (14)^2 / 8 = 1151.5 \text{ ft-lbs}
\end{align*}
\]

\[
\begin{align*}
\text{V(\text{MAX})} &= \text{WTL} \times \text{L} / 2 \\
\text{V(\text{MAX})} &= 47 \times 14 / 2 = 329
\end{align*}
\]

(TYPE 'R' WHEN READY TO CONTINUE ?

*Figure 11. Adjusted Shear and Bearing Stresses Display*

The adjusted shear and bearing stresses are shown on the next display (Figure 11).
REQUIRED SELECTION MODULUS = M(MAX)/Fb(adj.)
SREQ. = 1151.5 / 2187.5 X 12 = 6.3168 inches 3

MAX DEFLECTION (for live load) = L/ 240
DEF(live load) = 14 / 240 X 12 = .7 inches

MAX DEFLECTION (for total load) = L/ 180
DEF(total load) = 14 / 180 X 12 = .9333 inches

REQUIRED INERTIA (for live load) = 5xWLLx(L)^4 / (384xExDEF(live load))
IREQ(for live load) = 5 X 20 X (14)^4 X 1728 / 384 X 1800000 X .7 ) = 24.1815 INCHES 4

REQUIRED INERTIA (FOR TOTAL LOAD) = 5xWLLx(L)^4 / (384xExDEF(TOTAL LOAD))
IREQ(for live load) = 5 X 47 X (14)^4 X 1728 / 384 X 1800000 X .9333 ) = 24.1815 INCHES 4

REQUIRED AREA = 1.5 X V(MAX) / FV(ADJUSTED)
AREQ = 1.5 X 329 / 118.75 = 4.15579 INCHES 2

TYPE 'R' WHEN READY TO CONTINUE
?

Figure 12. Required Section Modulus, Moment of Inertia, Area Calculations

Figure 12 is an example display of the calculations for the required section modulus, moment of inertia, and area. The maximum permitted deflections, in inches, for the live loading and the total loading are also shown. The values from these calculations are used directly in the selection of a member.
MEMBER SELECTED 2 X 8

MEMBER PROPERTIES:
ACTUAL DIMENSIONS 1.5 INCHES X 7.25 INCHES
SECTION MODULUS = 13.14063
AREA = 10.875 INCHES 2
INERTIA = 47.63477 INCHES 4
WEIGHT = 3.0208 LBS/FT
BOARD FEET OF LUMBER PER LINEAR FOOT: 1.33333 BOARD-FEET/LIN. FT

TYPE 'R' WHEN READY TO CONTINUE?

Figure 13. Member Selection Data Display

The Member Selection Data display (Figure 13) shows the properties of the selected member's: actual dimensions, section modulus, area, moment of inertia, weight, and board feet of lumber. Board feet of lumber is provided for cost estimation. The estimated weight per foot of beam is provided to verify the dead load weight. The estimated weight is based upon a unit weight of lumber of 40 lbs per cubic foot. (Seasoned Douglas Fir typically weights approximately 35 lbs per cubic foot; other seasoned lumber may weigh slightly more or less. Forty pounds per cubic foot is a conservative value.) Actual lumber dimensions (as compared to the nominal dimensions) are provided to assist the designer in detailing connections, computing actual field dimensions, etc.
DEFLECTION UNDER LIVE LOAD = 5 x WLL x (L)^4 / (384 x E x I)
DEF(UNDER LIVE LOAD) = 5 x 20 x ( 14 )^4 / (384 x 1800000 x 47.63477 =
.2016174 INCHES

DEFLECTION UNDER TOTAL LOAD = 5 x WTL x (L)^4 / (384 x E x I)
DEF(UNDER TOTAL LOAD) = 5 x 47 x ( 14 )^4 / (384 x 1800000 x 47.63477 =
.473801 inches

REQUIRED BEARING LENGTH = V(max)/(FCL(adj.) x b)
REQUIRED BEARING LENGTH = 329 X / ( 781.25 X 1.5 ) = .2807647 inches

MEMBER STRESSES:
FB = 1051.548 PSI
FV = 45.37931 PSI

TYPE 'R' WHEN READY TO CONTINUE?

Figure 14. Deflections, Bearing Length, Computed Stresses Under Full Load

Figure 14 shows a sample of the final data display which contains the following: the computed deflection of the member selected under live load and under total load, the required bearing length, and the computed member stresses under full load.

DO YOU WANT A HARD COPY ?, (Y OR N); IF 'Y' TURN PRINTER ON ?

Figure 15. Print Request Display

Finally, the program offers the opportunity to print the analysis and design data just displayed. If a copy of the data is desired, turn on the printer, type Y, and press RETURN. The data is redisplayed (scrolled) as it is printed.
DO YOU WANT TO RECYCLE THROUGH THE PROGRAM AGAIN?, (Y OR N)
?

Figure 16. Recycle Request Display

After the data is printed or after the print request is denied, the
opportunity is given to rerun the program. An affirmative answer
causes another menu to be displayed, which allows starting the program
from the beginning, or returns to the Input Design Parameters menu
(Figure 4 above). If the latter is selected, the same lumber type is
assumed.

SAMPLE PROBLEM

This part of Section 2 provides a problem sample to show how efficient
using this program can be. Data entered from the keyboard is shown in
square brackets.

Problem

Design a roof beam spanning 14 feet for 20 lbs/ft dead load and 27
lbs/ft live load. It is laterally supported along it's entire length.
Assume beam qualifies as a repetitive member. Use a condition of use
factor equal to 1. Use Joist & Plank (J&P), No. 1 grade Douglas Fir.
Limit live load deflection to L/240 and total load deflection to
L/180. The roof live load will be for no longer than seven days.
Calculate minimum bearing length.
First, the Lumber Design program is entered.

[ OLD,TIMBER ]
READY.
[ TIMBER. ]

The Timber Engineering Library menu is displayed.

TIMBER ENGINEERING LIBRARY
---------------------------------
SAWN LUMBER BEAM DESIGN 1
GLU-LAM BEAM DESIGN 2
GENERAL SAWN LUMBER DESIGN 3
RETURN TO SYSTEM 4
---------------------------------

YOUR SELECTION ?
? [ 1 ]

Sawn Lumber Beam Design is selected.

The Lumber Species menu is displayed.

LUMBER SPECIES
------------------
DOUGLAS-FIR LARCH 1
SOUTHERN PINE 2
CALIFORNIA REDWOOD 3
END PROGRAM 4

YOUR SELECTION ? [ 1 ]

Since Douglas-Fir Larch is the specified species, (1) is entered.

The Size Classification Selection menu for Douglas-Fir Larch is displayed.
-- SIZE CLASSIFICATION SELECTION MENU --

<table>
<thead>
<tr>
<th>SIZE CLASSIFICATION</th>
<th>INPUT</th>
</tr>
</thead>
<tbody>
<tr>
<td>LIGHT FRAMING - UPTO 4 INCHES WIDE</td>
<td>1</td>
</tr>
<tr>
<td>LIGHT FRAMING - 4 INCHES WIDE</td>
<td>2</td>
</tr>
<tr>
<td>LIGHT FRAMING - 5 INCHES AND WIDER</td>
<td>3</td>
</tr>
<tr>
<td>BEAMS AND STRINGERS</td>
<td>4</td>
</tr>
<tr>
<td>POSTS AND TIMBERS</td>
<td>5</td>
</tr>
<tr>
<td>DECKING</td>
<td>6</td>
</tr>
</tbody>
</table>

USAGE DESCRIPTION SELECTION
? [ 3 ]

Joist and plank (J&P) size classification is the same as light framing. Light framing - 5 inches and wider is selected because, from experience, it appears to be a reasonable choice.

The Commercial Grade Selection menu for Douglas-Fir Larch used for light framing - 5 inches and wider is displayed.
-- COMMERCIAL GRADE SELECTION MENU --

<table>
<thead>
<tr>
<th>LUMBER GRADE</th>
<th>INPUT ###</th>
</tr>
</thead>
<tbody>
<tr>
<td>DENSE SELECT STRUCTURAL</td>
<td>1</td>
</tr>
<tr>
<td>SELECT STRUCTURAL</td>
<td>2</td>
</tr>
<tr>
<td>DENSE NO.1</td>
<td>3</td>
</tr>
<tr>
<td>NO.1</td>
<td>4</td>
</tr>
<tr>
<td>DENSE NO.2</td>
<td>5</td>
</tr>
<tr>
<td>NO.2</td>
<td>6</td>
</tr>
<tr>
<td>NO.3</td>
<td>7</td>
</tr>
<tr>
<td>APPEARANCE</td>
<td>8</td>
</tr>
<tr>
<td>STUD</td>
<td>9</td>
</tr>
</tbody>
</table>

LUMBER GRADE SELECTION
?

DOES THIS MEMBER QUALIFY AS A REPETITIVE MEMBER, (Y/N) ?
?

We are using No. 1 grade lumber, therefore, number one is selected.
The member qualifies as a repetitive member.
The Input Design Parameters are requested.

INPUT DESIGN PARAMETERS:

LENGTH, FEET      ? [ 14 ]
MAXIMUM UNBRACED LENGTH  ? [ 0 ]
CONDITION OF USE FACTOR  ? [ 1 ]
DISTRIBUTED LIVE LOAD, LBS/FT  ? [ 20 ]
DISTRIBUTED DEAD LOAD, LBS/FT  ? [ 27 ]
Input design parameters are given as 14 foot span length, laterally supported the entire length (maximum unbraced length equals zero), condition of use factor of 1, distributed dead load of 20 lbs/ft, and distributed live load of 27 lbs/ft. Remember, this display is shown one line at a time. Each time the input data is entered, the next line is displayed.

The Live Load Deflection Criteria menu is displayed

**LIVE LOAD DEFLECTION CRITERIA**

<table>
<thead>
<tr>
<th>LIVE LOAD DEFLECTION CRITERIA</th>
<th>INPUT</th>
</tr>
</thead>
<tbody>
<tr>
<td>L/180</td>
<td>1</td>
</tr>
<tr>
<td>L/240</td>
<td>2</td>
</tr>
<tr>
<td>L/360</td>
<td>3</td>
</tr>
<tr>
<td>USER DEFINED MAX. LIVE LOAD DEFL.</td>
<td>4</td>
</tr>
</tbody>
</table>

LIVE LOAD DEFLECTION CRITERIA SELECTED
? [ 2 ]

Since the live load deflection of L/240 is specified, number two is selected.

The Total Load Deflection Criteria menu is displayed.

TOTAL LOAD DEFLECTION CRITERIA
Because the total load deflection of L/180 was given, number one is selected.

The Load Duration Factor menu is displayed.
-- LOAD DURATION FACTOR --

<table>
<thead>
<tr>
<th>SHORTEST DURATION LOAD IN COMBINATION</th>
<th>(APPROXIMATE DURATION)</th>
<th>LDF</th>
</tr>
</thead>
<tbody>
<tr>
<td>DEAD LOAD</td>
<td>(PERMANENT)</td>
<td>0.9</td>
</tr>
<tr>
<td>FLOOR LIVE LOAD</td>
<td>(10 YEARS)</td>
<td>1.0</td>
</tr>
<tr>
<td>SNOW LOAD</td>
<td>(2 MONTHS)</td>
<td>1.15</td>
</tr>
<tr>
<td>ROOF LIVE LOAD</td>
<td>(7 DAYS)</td>
<td>1.25</td>
</tr>
<tr>
<td>WIND OR SEISMIC</td>
<td>(1 DAY)</td>
<td>1.33</td>
</tr>
<tr>
<td>IMPACT</td>
<td>(2 SECONDS)</td>
<td>2.0</td>
</tr>
</tbody>
</table>

NOTES:
A. CHECK ALL CODE REQUIRED LOAD COMBINATIONS.
B. SELECT LDF ASSOCIATED WITH THE SHORTEST DURATION IN THE COMBINATION OF LOADS.
C. THE CRITICAL COMBINATION OF LOADS IS THE ONE THAT REQUIRES THE LARGEST SIZE STRUCTURAL MEMBER.

LOAD DURATION FACTOR TO BE USED?
? [ 1.25 ]

It was given that the roof live load would be for a maximum of seven days, therefore the menu indicates a load duration factor of 1.25.

Now that all the input data is entered, the program performs the analyses, searches for the smallest appropriate member, and displays this choice. Another size can be requested. The program then searches for the next largest appropriate size. This continues until a member size is selected.
MEMBER SELECTED : 1 X 10
DO YOU WANT TO SELECT ANOTHER MEMBER ? (Y/N) ? [ Y ]

MEMBER SELECTED : 1 X 12
DO YOU WANT TO SELECT ANOTHER MEMBER ? (Y/N) ? [ Y ]

MEMBER SELECTED : 2 X 8
DO YOU WANT TO SELECT ANOTHER MEMBER ? (Y/N) ? [ N ]

Finally, the analysis data is displayed, starting with the input data and ending with the Print Request and Recycle Request displays.

-------------------------  I N P U T   D A T A  -------------------------

SPAN LENGTH = 14 ft
MAX. UNBRACED LENGTH = 0 ft
LOAD DURATION FACTOR = 1.25
CONDITION OF USE FACTOR = 1
UNIFORM DIST. LIVE LOAD = 20 lbs/ft
UNIFORM DIST. DEAD LOAD = 27 lbs/ft
DEFLECTION LIMITATION (LIVE LOAD) = L/ 240
DEFLECTION LIMITATION (TOTAL LOAD) = L/ 180
LUMBER SPECIES: DOUGFIR
COMMERCIAL GRADE: NO.1
SIZE CLASSIFICATION: LIGHT FRAMING -5 INCHES AND WIDER
REPETITIVE MEMBER ?: YES
TYPE 'R' WHEN READY TO CONTINUE ? R
TABULATED STRESSES:

FB = 1750 PSI  
FCL = 625 PSI  
FV = 95 PSI  
E = 1800000 PSI

ALLOWABLE DESIGN STRESSES:

\[ Fb = (\text{tab} \ FB) \times LDF \times CUF \times CF \]
\[ Fb(\text{adjusted for size factor}) = 1750 \times 1.25 \times 1.00 \times 1.000 = 2188 \]
\[ Fb(\text{ADJUSTED FOR LATERAL STABILITY}) = 2187.5 \text{ PSI} \]

LATERNAL STABILITY FACTORS:

CS = 0  
CK = 24.842

LATERNAL STABILITY CLASSIFICATION: SHORT UNBRACED BEAM

TYPE 'R' WHEN READY TO CONTINUE

WTL = WLL + WDL  
WTL = 27 + 20 = 47 lbs/ft

\[ M(\text{MAX}) = WTL \times (L)^2 /8 \]
\[ M(\text{MAX}) = 47 \times (14)^2 /8 = 1151.5 \text{ ft-lbs} \]

\[ V(\text{MAX}) = WTL \times L/2 \]
\[ V(\text{MAX}) = 47 \times 14 / 2 = 329 \]

TYPE 'R' WHEN READY TO CONTINUE

? [ R ]
REQUIRED SELECTION MODULUS = M(MAX)/Fb(adj.)
SREQ. = 1151.5 / 2187.5 X 12 = 6.3168 inches

MAX DEFLECTION (for live load) = L/ 240
DEF(live load) = 14 / 240 X 12 = .7 inches

MAX DEFLECTION (for total load) = L/ 180
DEF(total load) = 14 / 180 X 12 = .9333 inches

REQUIRED INERTIA (for live load) = 5xWLLx(L) / (384xExDEF(live load))
IREQ(for live load) = 5 X 20 X ( 14 )4 X 1728 / 384 X
1800000 X
.7 ) = 24.1815 inches

REQUIRED INERTIA (FOR TOTAL LOAD) = 5xWLLx(L) / (384xExDEF(TOTAL LOAD))
IREQ(for live load) = 5 X 47 X ( 14 )4 X 1728 / 384 X
1800000 X
.9333 ) = 24.1815 INCHES

REQUIRED AREA = 1.5 X V(MAX) / FV(ADJUSTED)
AREQ = 1.5 X 329 / 118.75 = 4.15579 INCHES

TYPE 'R' WHEN READY TO CONTINUE
? [ R ]

MEMBER SELECTED 2 X 8

MEMBER PROPERTIES:
ACTUAL DIMENSIONS 1.5 INCHES X 7.25 INCHES
SECTION MODULUS = 13.14063
AREA = 10.875 INCHES
INERTIA = 47.63477 INCHES
WEIGHT = 3.0208 LBS/FT
BOARD FEET OF LUMBER PER LINEAR FOOT: 1.333333 BOARD-FEET/LIN. FT

TYPE 'R' WHEN READY TO CONTINUE
? [ R ]
DEFLECTION UNDER LIVE LOAD = 5 x WLL x (L)^4 / (384 x E x I)
DEF(UNDER LIVE LOAD) = 5 x 20 x (14) 4 / (384 x 1800000 x 47.63477
= .2016174 INCHES

DEFLECTION UNDER TOTAL LOAD = 5 x WTL x (L)^4 / (384 x E x I)
DEF(UNDER TOTAL LOAD) = 5 x 47 x (14) 4 / (384 x 1800000 x 47.63477
= .473801 inches

REQUIRED BEARING LENGTH = V(max)/(FCL(adj.) x b)
REQUIRED BEARING LENGTH = 329 x (781.25 x 1.5) = .2807647 inches

MEMBER STRESSES:
FB = 1051.548 PSI
FV = 45.37931 PSI

TYPE 'R' WHEN READY TO CONTINUE
? [ R ]

DO YOU WANT A HARD COPY ?, (Y OR N); IF 'Y' TURN PRINTER ON
? [ N ]

DO YOU WANT TO RECYCLE THROUGH THE PROGRAM AGAIN ?, (Y OR N)
? [ N ]

This concludes the sample problem.
Section 3
Sawn Beam Design

INTRODUCTION

This section provides all necessary operating information for the Glued-Laminated Beam design program. A brief description of the capabilities of the program and the program constraints, assumptions, and restrictions are provided in this introduction. The operating procedure, with appropriate figures, is explained in the section entitled Operation. The section entitled Sample Problem contains a step-by-step procedure of a typical design problem.

What Glued-Laminated Beam Design Does

The Glued-Laminated Beam Design program performs all necessary analysis and provides all essential design information to specify an appropriate size of a simply supported, uniformly loaded, prismatic glued-laminated beam. Standard design values for glued-laminated lumber are provided in the program, or the user may choose to specify them. Appropriate member sizes are specified by the computer based upon the given design condition and design values for the glued-laminated lumber. The engineer or engineering student selects the desired member size from one of the appropriate sizes.

Constraints, Assumptions, & Restrictions

The analysis and selection are subject to the following constraints, assumptions, and restrictions.
This program assumes a linearly elastic system. Only small deflections are considered.

Shear deformations are neglected.

Beam is assumed prismatic throughout.

Shear is taken at the face of the support. The allowable reduction, taking maximum shear at a distance "d" away, is not taken.

The program uses a "k" factor equal to 1 in computing total loads. For other than simply supported conditions, a smaller "k" factor could be used. The use of "k" equal to 1 is conservative for all other span conditions.

Selection of members is limited to those listed in Appendix C, Section Properties of Glulam Members, from Design of Wood Structures by Donald E. Breyer, Copyright 1980.


Notches are not taken into account by the program.
Bridging is a detailing requirement not considered by the program. It is the responsibility of the engineer.

OPERATION

Overview

After entering the Glued-Laminated Beam Design program, condition data and, if necessary, the user-specified lumber design values are entered through display menus similar to the one used to select the Glued-Laminated Beam Design program. After the data are entered, the program displays an appropriate member size selected from standard tables using the design criteria specified. This selection may be accepted or rejected. If rejected, the next appropriate size is displayed, which may also be accepted or rejected. Once a member size has been accepted, the results of the analysis, design condition, and member parameters, are displayed with appropriate equations.

In the following paragraphs, operating menus are shown and described. It is assumed that the user is familiar with terms used in the civil engineering industry pertaining to design of members. Terms that are considered, by the author of this program, unclear are defined or explained in the menu descriptions below.

Refer to Section 1, Getting Started, for instructions on starting the Lumber Design program. If you haven’t read this section, be sure to do so before using the program.
Operating Menus

After entering the startup sequence (see Section 1), Timber Engineering Library menu is displayed from which is selected the design program for the desired member type. Since this section explains and instructs in the usage of glued-laminated beam design, it is assumed that number 2 was selected and entered, followed by pressing the RETURN key. This causes the Glued- Laminated Lumber Usage menu to be displayed. See Figure 1.

-- GLULAM LUMBER SELECTION MENU --

GLULAM LUMBER USAGE

PRIMARILY BENDING 1
PRIMARILY IN AXIAL TENSION
OR COMPRESSION 2
USER DEFINED ALLOWABLE STRESSES 3
END PROGRAM 4

YOUR SELECTION ?

Figure 1. GluLam Lumber Usage Menu
The lumber usage menu allows selection of primarily bending (1) or primarily in axial tension or compression (2) usages.

The user may define structure and member data by selecting option three USER DEFINED ALLOWABLE STRESSES, in the menu. If this is selected, the following information must be entered as it is requested, followed by pressing the RETURN key: bending strength (Fb), shear strength (Fv), compressive strength perpendicular to the grain (Fcl), and the modulus of elasticity (E). The program makes all necessary value adjustments during processing; therefore, no preadjustment is necessary.

The last option in this menu, END PROGRAM (5), stops the program and returns to the system.

Once the lumber usage has been selected, the Lumber Grade menu is displayed. Though similar to other glu-lam lumber grade menus, the actual contents of this menu depends on the usage selected. Figure 2 below shows a Lumber Grade menu for Primarily Bending usage.

If USER DEFINED VALUES is selected, the next three menus are skipped. The data entered through these three menus are used to determine the stress values found in standard data tables (which are already part of the program) for the selected lumber species and selected usage. However, since the USER DEFINED VALUES requests this data directly, the next three menus are not required.
The lumber grade, and thus the contents of this menu, depends on the usage selected.

Enter the desired lumber grade by typing the corresponding number and pushing the return key.

After the grade is specified, the Stress Grade (Usage Description) menu is displayed. See Figure 3.
The contents of the Stress Grade menu depends on the selected lumber grade and the selected lumber usage. Figure 3 shows available stress grades for visually graded western species (selection #1 of Lumber Grade menu, Figure 2) in primarily bending usages (selection #1 of the Lumber Usage menu, Figure 1).

Select stress grade by typing in the suitable input number and pushing the return key.

With the stress grade selected, the program prompts for the lamination species. See Figure 4.
## Lamination Species Selection Menu

<table>
<thead>
<tr>
<th>SYMBOL</th>
<th>SPECIES OUTER /INNER LAM</th>
<th>INPUT</th>
</tr>
</thead>
<tbody>
<tr>
<td>-V1</td>
<td>DF/WW</td>
<td>1</td>
</tr>
<tr>
<td>-V2</td>
<td>HF/HF</td>
<td>2</td>
</tr>
<tr>
<td>-V3</td>
<td>DF/DF</td>
<td>3</td>
</tr>
<tr>
<td>-V4</td>
<td>DF/DF</td>
<td>4</td>
</tr>
<tr>
<td>-V5</td>
<td>DF/N3WW</td>
<td>5</td>
</tr>
<tr>
<td>-V6</td>
<td>DF/N3DF</td>
<td>6</td>
</tr>
<tr>
<td>-V7</td>
<td>DF/DF</td>
<td>7</td>
</tr>
<tr>
<td>-V8</td>
<td>DF/DF</td>
<td>8</td>
</tr>
<tr>
<td>-V9</td>
<td>HF/HF</td>
<td>9</td>
</tr>
</tbody>
</table>

Lamination Species Selection

Figure 4. Lamination Species Selection Menu

The Lamination Species Menu allows selection of the species of the outer and inner laminations. To select the desired species, enter the number corresponding to that combination and press ENTER.
INPUT DESIGN PARAMETERS:

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>LENGTH, FEET</td>
<td>?</td>
</tr>
<tr>
<td>MAXIMUM UNBRACED LENGTH</td>
<td>?</td>
</tr>
<tr>
<td>CONDITION OF USE FACTOR</td>
<td>?</td>
</tr>
<tr>
<td>DISTRIBUTED LIVE LOAD, LBS/FT</td>
<td>?</td>
</tr>
<tr>
<td>DISTRIBUTED DEAD LOAD, LBS/FT</td>
<td>?</td>
</tr>
</tbody>
</table>

Figure 5. Input Design Parameters

In this menu, each design parameter is displayed with the question mark. The parameter value is entered followed by pressing RETURN. The next parameter is then displayed with the question mark prompt. The appropriate value is entered, again followed by RETURN. This process is repeated until the parameters have been defined.

LENGTH. Length is beam span length in feet.

MAXIMUM UNBRACED LENGTH. Maximum unbraced length is the largest distance between blocking that occurs. This distance is used to determine the allowable bending stress considering lateral stability. For blocking to be effective it must brace the compression zone of a beam against lateral movement. With proper nailing, a roof or floor diaphragm can provide full lateral support, which equals an unbraced
length of zero feet. Blocking may be either solid blocking or bridging.

Bridging is cross-bracing made from wood or light gauge metal. Solid blocking is wood blocking the same depth as the beam. The Uniform Building Code (UBC) states that if the width to thickness ratio of a beam is greater than or equal to 6, then solid blocking or bridging is required at intervals not to exceed 8 feet. This will be the case in most glued-laminated beams. The effective unbraced length, and therefore the lateral stability, of a beam depends upon the maximum unbraced length, the type of supports, and the configuration of the loads. The Lumber Design program conservatively assumes simple span (pinned supports) beam with a uniformly distributed load. Designers should be conscious of the fact that lateral stability considerations may control the selection of a beam.

CONDITION OF USE FACTOR. The condition of use factor is an adjustment for possible moisture content conditions that can occur during the life of the member. Changes in moisture content affect the strength of the lumber. Design values (tabulated stresses) for glued-laminated lumber used in this program have been taken from Table 5A of the National Design Specifications (NDS) Supplement. The tabulated stresses are given assuming dry condition of use where the moisture content of the lumber does not exceed 16 percent. The user is referred to the footnotes of Table 5A in order to determine the appropriate condition of use factor to be used where the moisture content of the lumber in use will exceed 16 percent limitation.
DISTRIBUTED LIVE LOAD. Uniform distributed live load, in lbs. per linear foot along the beam, is vertical gravity loads not permanently applied to the structure. Table 23A of the UBC specifies floor live loads in pounds per square foot. Table 23C of the UBC specifies roof live loads in pounds per square foot. Loads given in these tables may be adjusted depending on such factors as tributary area and roof slope. Uniform live load along the beam may be computed by multiplying the unit load (in pounds per square foot) by the width of the area that is contributing loads to the beam.

DISTRIBUTED DEAD LOAD. Similar to the live load, the distributed dead load, in lbs. per linear foot along the beam, is vertical gravity loads constituting the weights of all materials permanently attached to the structure including the weight of the beam itself. Because this is not normally known at the onset of design, it should be estimated. A fairly complete table of material weights can be found in American National Standards Institute (ANSI) Standard A58.1985

After the input design parameters have been entered, the Live Load Deflection Criteria menu is displayed. See Figure 6.
LIVE LOAD DEFLECTION CRITERIA

<table>
<thead>
<tr>
<th>LIVE LOAD DEFLECTION CRITERIA</th>
<th>INPUT</th>
</tr>
</thead>
<tbody>
<tr>
<td>L/180</td>
<td>1</td>
</tr>
<tr>
<td>L/240</td>
<td>2</td>
</tr>
<tr>
<td>L/360</td>
<td>3</td>
</tr>
<tr>
<td>USER DEFINED MAX. LIVE LOAD DEFL.</td>
<td>4</td>
</tr>
</tbody>
</table>

LIVE LOAD DEFLECTION CRITERIA SELECTED

? 

Figure 6. Live Load Deflection Criteria Menu

The Live Load Deflection Criteria Menu displays three commonly used deflection criteria and an option to define maximum live load deflection. Tables 23D and 23E of the UBC define deflection limitations to be used under certain gravity loads. The UBC requires that deflection under live load be calculated and should be less than or equal to L/360, where L is the span length. The Timber Construction Manual, published by the American Institute of Timber Construction, recommends a less stringent standard limited to L/240.
The user may wish to limit deflections depending on the code requirements governing the design and the design conditions being faced. The user's deflection limitations may be more stringent than permitted by code in order to prevent ponding on roofs or excessive cracking in plastered ceilings or to accommodate some other design requirement. This program allows the user to define the maximum deflection permitted. If this option is selected, enter the permitted maximum live load deflection in inches.

Enter the desired criteria by entering the corresponding number and pressing RETURN.

With this information entered, the Total Load Deflection Criteria menu is displayed. See Figure 7.
TOTAL LOAD DEFLECTION CRITERIA

<table>
<thead>
<tr>
<th>TOTAL LOAD DEFLECTION CRITERIA</th>
<th>INPUT</th>
</tr>
</thead>
<tbody>
<tr>
<td>L/180</td>
<td>1</td>
</tr>
<tr>
<td>L/240</td>
<td>2</td>
</tr>
<tr>
<td>L/360</td>
<td>3</td>
</tr>
<tr>
<td>USER DEFINED MAX. TOTAL LOAD DEFL.</td>
<td>4</td>
</tr>
</tbody>
</table>

TOTAL LOAD DEFLECTION CRITERIA SELECTED

Figure 7. Total Load Deflection Criteria Menu

Similar to the Live Load Deflection Criteria menu, this menu displays three commonly used deflection criteria and an option to define maximum total load deflection. Tables 23D and 23E of the UBC define deflection limitations to be used under certain gravity loads. The UBC requires that deflection under total load be less than or equal to L/240, where L is the span length. The Timber Construction Manual published by the American Institute of Timber Construction recommends a less stringent standard limited to L/180.
The user may specify maximum total deflection. If this option is selected, enter the permitted maximum live load deflection in inches. No adjustments are made in the program for creep.

The UBC allows total deflection to be calculated using full live load and half dead load for seasoned lumber having a moisture content of less than 16 percent at the time of construction and subject to dry conditions of use. Conservatively, this program uses full live load and dead to determine deflections.
-- LOAD DURATION FACTOR --

<table>
<thead>
<tr>
<th>SHORTEST DURATION LOAD</th>
<th>(APPROXIMATE DURATION)</th>
<th>LDF</th>
</tr>
</thead>
<tbody>
<tr>
<td>DEAD LOAD</td>
<td>(PERMANENT)</td>
<td>0.9</td>
</tr>
<tr>
<td>FLOOR LIVE LOAD</td>
<td>(10 YEARS)</td>
<td>1.0</td>
</tr>
<tr>
<td>SNOW LOAD</td>
<td>(2 MONTHS)</td>
<td>1.15</td>
</tr>
<tr>
<td>ROOF LIVE LOAD</td>
<td>(7 DAYS)</td>
<td>1.25</td>
</tr>
<tr>
<td>WIND OR SEISMIC</td>
<td>(1 DAY)</td>
<td>1.33</td>
</tr>
<tr>
<td>IMPACT</td>
<td>(2 SECONDS)</td>
<td>2.0</td>
</tr>
</tbody>
</table>

NOTES:
A. CHECK ALL CODE REQUIRED LOAD COMBINATIONS.
B. SELECT LDF ASSOCIATED WITH THE SHORTEST DURATION IN THE COMBINATION OF LOADS.
C. THE CRITICAL COMBINATION OF LOADS IS THE ONE THAT REQUIRES THE LARGEST SIZE STRUCTURAL MEMBER.

LOAD DURATION FACTOR TO BE USED?

Figure 8. Load Duration Factor Menu

The load duration factor takes into account wood's ability to support greater stresses that are applied for a short period of time. The
total accumulated length of time that a load is applied to a structure is known as the duration of loading. The load duration factor applies to the entire combination of loads and not just to that portion of the stress caused by a load of a particular duration. The load duration to be used is the one associated with the shortest duration load in the combination.

Enter the desired load duration factor (LDF) shown in the menu.

This concludes the data that is entered by the user. The following displays identify the member selection (which may be rejected or accepted) and design analysis.

MEMBER SELECTED : 5.125 X 31.5
NUMBER OF 3/4 INCH LAMIANTIONS: 42
DO YOU WANT TO SELECT ANOTHER MEMBER ? (Y/N)
? [ N ]

Figure 9. Member Selection Display

The Lumber Design program selects an appropriate member size from a table of sectional properties of glued-laminated lumber. The selection may be rejected by typing N and pressing RETURN. A new member is then selected and displayed. It too may be rejected or
accepted. Once a member is selected, the program displays all data concerning the design and the member.
Analysis & Design Displays

------------------------------- INPUT DATA -----------------------------

SPAN LENGTH = 25 ft
MAX. UNBRACED LENGTH = 8 ft
LOAD DURATION FACTOR = 1.0
CONDITION OF USE FACTOR = 1
UNIFORM DIST. LIVE LOAD = 1000 lbs/ft
UNIFORM DIST. DEAD LOAD = 400 lbs/ft
DEFLECTION LIMITATION (LIVE LOAD) = L/360
DEFLECTION LIMITATION (TOTAL LOAD) = L/240

PRIMARY USAGE BENDING

GRADE VGWS

STRESS CLASSIFICATION 20F-V4

SPECIES: OUTER/INNER LAMINATIONS DF/DF

TYPE 'R' WHEN READY TO CONTINUE

Figure 10. Input Data Display
The first analysis and design display repeats the "input" data so that the user may verify that the program received the input data correctly. This sample menu identifies a primary bending usage, visually graded western species, stress classification of 20F-V4, and lamination species DF/DF.

If user defined deflection limitations were entered, they are now expressed as a fraction of the length (L/XXX).
TABULATED STRESSES:

FB = 2200 PSI   FV = 165 PSI
FCL = 410 PSI   E = 1600000 PSI

ALLOWABLE DESIGN STRESSES:

Fb = (tab FB) X LDF X CUF X CF
Fb(adjusted for size factor) = 2200 X 1 X 1 X .8983179 = 1976.3
FB(ADJUSTED FOR LATERAL STABILITY) = 2011.83 PSI

LATERAL STABILITY FACTORS:
CS = 14.87   CK = 20.89

LATERAL STABILITY CLASSIFICATION: INTERMEDIATE UNBRACED BEAM

TYPE 'R' WHEN READY TO CONTINUE

Figure 11. Stresses Display

The Stresses Display (Figure 11) shows the tabulated stresses that correspond with the primary usage, grade, and laminate species selected. (Figure 11 is only an example of a display.) It also displays the adjusted bending stresses for size factor and lateral stability. The symbol CS in the display is the slenderness factor
computed in the lateral stability analysis. The symbol CK defines the dividing line between intermediate and long unbraced beams. The lateral stability classification identifies the portion of the lateral stability bending curve that was used. The slenderness factor is not allowed to exceed a maximum value of 50. If the lateral stability classification has been designated as a long unbraced beam, the user should consider additional blocking along the beam. Two adjusted bend stresses (FB) are calculated: one for size and one for stability. The smaller figure is used for the selection of the member.

The adjusted shear and bearing stresses are shown on the next display (Figure 12).
\[ FV = (TAB \ FV) \times LDF \times CUF \]
\[ FV = 165 \times 1 \times 1 = 165 \text{ PSI} \]

\[ FCL = (TAB \ FCL) \times LDF \times CUF \]
\[ FCL = 410 \times 1 \times 1 = 410 \text{ PSI} \]

DESIGN LOADS:

\[ WTL = WLL + WDL \]
\[ WTL = 1000 + 400 = 1400 \text{ lbs/ft} \]

\[ M(\text{max}) = WTL \times (L)^2 /8 \]
\[ M(\text{max}) = 1400 \times (25)^2 /8 = 109375 \text{ FT-LBS} \]

\[ V(\text{max}) = WTL \times L/2 \]
\[ V(\text{max}) = 1400 \times 25 /2 = 17500 \text{ LBS} \]

TYPE 'R' WHEN READY TO CONTINUE

? 

Figure 12. Adjusted Shear and Bearing Stresses Display
REQUIRED SELECTION MODULUS = M(MAX)/Fb(adj.)
SREQ. = 109375 / 1976.3 X 12 = 664.12 inches
MAX DEFLECTION (for live load) = L/360
DEF(live load) = 25 / 360 X 12 = .8333333 inches
MAX DEFLECTION (for total load) = L/240
DEF(total load) = 25 / 240 X 12 = 1.25 inches
REQUIRED INERTIA (for live load) = 5xWLLx(L)^4 / (384xExDEF(live load))
IREQ(for live load) = 5 X 1000 X (25)^4 X 1728 / 384 X 1600000 X .8333333 = 6591.797 INCHES
REQUIRED INERTIA (FOR TOTAL LOAD) = 5xWLLx(L)^4 / (384xExDEF(TOTAL LOAD))
IREQ(FOR TOTAL LOAD) = 5 X 1400 X (25)^4 X 1728 / 384 X 1600000 X 1.25 = 6152.344 INCHES
REQUIRED AREA = 1.5 X V(MAX) / FV(ADJUSTED)
AREQ = 1.5 X 17500 / 165 = 159.0909 INCHES

TYPE 'R' WHEN READY TO CONTINUE
?

Figure 13. Required Section Modulus, Moment of Inertia, Area Calculations
Figure 13 is an example display of the calculations for the required section modulus, moment of inertia, and area. The maximum permitted deflections, in inches, for the live loading and the total loading are also shown. The values from these calculations are used directly in the selection of a member.

MEMBER SELECTED 5.125 X 31.5

MEMBER PROPERTIES:
NUMBER OF 3/4 LAMINATIONS: 42
SECTION MODULUS = 847.5469
AREA = 161.4375 INCHES 2
INERTIA = 13348.86 INCHES 4
WEIGHT = 38.2293 LBS/FT
BOARD FEET OF LUMBER PER LINEAR FOOT: 13.45313 BOARD-FEET/LIN. FT

TYPE 'R' WHEN READY TO CONTINUE

Figure 14. Member Selection Data Display

The Member Selection Data display (Figure 14) shows the properties of the selected member’s: number of 3/4 inch laminations, section modulus, area, moment of inertia, weight, and board feet of lumber.
The Member Selection Data display (Figure 14) shows the properties of the selected member's: number of 3/4 inch laminations, section modulus, area, moment of inertia, weight, and board feet of lumber. Board feet of lumber is provided for cost estimation. The estimated weight per foot of beam is provided to verify the dead load weight. The estimated weight is based upon a unit weight of lumber of 40 lbs per cubic foot. (Seasoned Douglas Fir typically weights approximately 35 lbs per cubic foot; other seasoned lumber may weigh slightly more or less. Forty pounds per cubic foot is a conservative value.) Actual lumber dimensions (as compared to the nominal dimensions) are provided to assist the designer in detailing connections, computing actual field dimensions, etc.
DEFLECTION UNDER LIVE LOAD = 5 x WLL x (L)^4 / (384 x E x I)
DEF(UNDER LIVE LOAD) = 5 x 1000 x (25)^4 / (384 x 1600000 x 13348.86) = .4115081 INCHES

DEFLECTION UNDER TOTAL LOAD = 5 x WTL x (L)^4 / (384 x E x I)
DEF(UNDER TOTAL LOAD) = 5 x 1400 x (25)^4 / (384 x 1600000 x 13348.86) = .5761113 INCHES

REQUIRED BEARING LENGTH = V(max)/(FCL(adj.) x b)
REQUIRED BEARING LENGTH = 17500 x (410 x 1.5) = 8.328376 inches

MEMBER STRESSES:
FB = 1548.587 PSI
FV = 162.6016 PSI

TYPE 'R' WHEN READY TO CONTINUE
?

Figure 15. Deflections, Bearing Length, Computed Stresses Under Full Load

Figure 15 shows a sample of the final data display which contains the following: the computed deflection of the member selected under live
load and under total load, the required bearing length, and the computed member stresses under full load.

**DO YOU WANT A HARD COPY ?, (Y OR N); IF 'Y' TURN PRINTER ON ?**

Figure 16. Print Request Display

Finally, the program offers the opportunity to print the analysis and design data just displayed. If a copy of the data is desired, turn on the printer, type Y, and press RETURN. The data is redisplayed (scrolled) as it is printed.

**DO YOU WANT TO RECYCLE THROUGH THE PROGRAM AGAIN ?, (Y OR N) ?**

Figure 17. Recycle Request Display

After the data is printed or after the print request is denied, the opportunity is given to rerun the program. An affirmative answer causes another menu to be displayed, which allows starting the program from the beginning, or returns to the Input Design Parameters menu.
(Figure 5 above). If the latter is selected, the same lumber type is assumed.

SAMPLE PROBLEM

This part of Section 2 provides a problem sample to show how efficient using this program can be. Data entered from the keyboard is shown in square brackets.

Problem

Design a glulam floor girder spanning 25 feet for 400 lbs/ft dead load and 1000 lbs/ft live load. Lateral support is provided every 8 feet. Use a condition of use factor equal to 1. Use visually graded western species glued laminated lumber having the designation 22F-V4. Limit live load deflection to L/360 and total load deflection to L/240. Calculate minimum bearing length.

First, the Lumber Design program is entered.

[ OLD,TIMBER ]

READY.

[ TIMBER. ]
The Timber Engineering Library menu is displayed.

TIMBER ENGINEERING LIBRARY

SAWN LUMBER BEAM DESIGN

GLU-LAM BEAM DESIGN

GENERAL SAWN LUMBER DESIGN

RETURN TO SYSTEM

YOUR SELECTION?

? [ 2 ]

Glued-Laminated Beam Design is selected.

The Glued-Laminated Lumber Usage menu is displayed.
GLULAM LUMBER SELECTION MENU

GLULAM LUMBER USAGE

---------------------------
PRIMARILY BENDING 1
PRIMARILY IN AXIAL TENSION
OR COMPRESSION 2
USER DEFINED ALLOWABLE STRESSES 3
END PROGRAM 4

YOUR SELECTION? [1]

Primarily bending lumber usage category is selected because the problem as stated requires the design of a beam.

The Lumber Grade menu is displayed.
It was given that the grade be visually graded western species, therefore, #1 was entered, followed by pressing RETURN.

The Stress Grade menu is displayed.
We are using stress grade 22F lumber. Selection #3 was entered.

The program prompts for the lamination species next.
**-- LAMINATION SPECIES SELECTION MENU --**

<table>
<thead>
<tr>
<th>SYMBOL</th>
<th>SPECIES OUTER /INNER LAM</th>
<th>INPUT ###</th>
</tr>
</thead>
<tbody>
<tr>
<td>-V1</td>
<td>DF/WW</td>
<td>1</td>
</tr>
<tr>
<td>-V2</td>
<td>HF/HF</td>
<td>2</td>
</tr>
<tr>
<td>-V3</td>
<td>DF/DF</td>
<td>3</td>
</tr>
<tr>
<td>-V4</td>
<td>DF/DF</td>
<td>4</td>
</tr>
<tr>
<td>-V5</td>
<td>DF/N3WW</td>
<td>5</td>
</tr>
<tr>
<td>-V6</td>
<td>DF/N3DF</td>
<td>6</td>
</tr>
<tr>
<td>-V7</td>
<td>DF/DF</td>
<td>7</td>
</tr>
<tr>
<td>-V8</td>
<td>DF/DF</td>
<td>8</td>
</tr>
<tr>
<td>-V9</td>
<td>HF/HF</td>
<td>9</td>
</tr>
</tbody>
</table>

LAMINATION SPECIES SELECTION

? [ 4 ]

Our lamination species are V4, or DF/DF, therefore, selection #4 was entered.

The Input Design Parameter menu is displayed.
--- GLU-LAM BEAM DESIGN PROGRAM---

INPUT DESIGN PARAMETERS:

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>LENGTH, FEET</td>
<td>25</td>
</tr>
<tr>
<td>MAXIMUM UNBRACED LENGTH</td>
<td>8</td>
</tr>
<tr>
<td>CONDITION OF USE FACTOR</td>
<td>1</td>
</tr>
<tr>
<td>DISTRIBUTED LIVE LOAD, LBS/FT</td>
<td>1000</td>
</tr>
<tr>
<td>DISTRIBUTED DEAD LOAD, LBS/FT</td>
<td>400</td>
</tr>
</tbody>
</table>

Input design parameters were given as 25 foot length, laterally supported every 8 feet, condition of use factor of 1, distributed live load of 1000 lbs/ft, and distributed dead load of 400 lbs/ft.

The Live Load Deflection Criteria is requested.
LIVE LOAD DEFLECTION CRITERIA

<table>
<thead>
<tr>
<th>LIVE LOAD</th>
<th>INPUT</th>
</tr>
</thead>
<tbody>
<tr>
<td>DEFLECTION CRITERIA</td>
<td></td>
</tr>
</tbody>
</table>

| L/180              | 1     |
| L/240              | 2     |
| L/360              | 3     |
| USER DEFINED MAX. LIVE LOAD DEFL. | 4 |
TOTAL LOAD DEFLECTION CRITERIA

<table>
<thead>
<tr>
<th>TOTAL LOAD DEFLECTION CRITERIA</th>
<th>INPUT</th>
</tr>
</thead>
<tbody>
<tr>
<td>L/180</td>
<td>1</td>
</tr>
<tr>
<td>L/240</td>
<td>2</td>
</tr>
<tr>
<td>L/360</td>
<td>3</td>
</tr>
<tr>
<td>USER DEFINED MAX. TOTAL LOAD DEFL.</td>
<td>4</td>
</tr>
</tbody>
</table>

TOTAL LOAD DEFLECTION CRITERIA SELECTED

? [ 2 ]

The design limits total load deflection to L/240. Selection #2 is entered.

Load duration factor is then requested.
-- LOAD DURATION FACTOR --

<table>
<thead>
<tr>
<th>SHORTEST DURATION LOAD IN COMBINATION</th>
<th>(APPROXIMATE DURATION)</th>
<th>LDF</th>
</tr>
</thead>
<tbody>
<tr>
<td>DEAD LOAD</td>
<td>(PERMANENT)</td>
<td>0.9</td>
</tr>
<tr>
<td>FLOOR LIVE LOAD</td>
<td>(10 YEARS)</td>
<td>1.0</td>
</tr>
<tr>
<td>SNOW LOAD</td>
<td>(2 MONTHS)</td>
<td>1.15</td>
</tr>
<tr>
<td>ROOF LIVE LOAD</td>
<td>(7 DAYS)</td>
<td>1.25</td>
</tr>
<tr>
<td>WIND OR SEISMIC</td>
<td>(1 DAY)</td>
<td>1.33</td>
</tr>
<tr>
<td>IMPACT</td>
<td>(2 SECONDS)</td>
<td>2.0</td>
</tr>
</tbody>
</table>

NOTES:

A. CHECK ALL CODE REQUIRED LOAD COMBINATIONS.

B. SELECT LDF ASSOCIATED WITH THE SHORTEST DURATION IN THE COMBINATION OF LOADS.

C. THE CRITICAL COMBINATION OF LOADS IS THE ONE THAT REQUIRES THE LARGEST SIZE STRUCTURAL MEMBER.

LOAD DURATION FACTOR TO BE USED?

? [ 1.0 ]

The load duration factor is entered as the actual factor displayed in the menu. The first appropriate member is selected.
MEMBER SELECTED : 5.125 X 31.5

NUMBER OF 3/4 INCH LAMINATIONS: 42

DO YOU WANT TO SELECT ANOTHER MEMBER ? (Y/N)

? [ N ]

Since this is the desired member size, N is entered.

The program now begins to display the analysis and design data, beginning with the data entered at the keyboard.
--- INPUT DATA ---

SPAN LENGTH = 25 ft
MAX. UNBRACED LENGTH = 8 ft
LOAD DURATION FACTOR = 1.0
CONDITION OF USE FACTOR = 1
UNIFORM DIST. LIVE LOAD = 1000 lbs/ft
UNIFORM DIST. DEAD LOAD = 400 lbs/ft
DEFLECTION LIMITATION (LIVE LOAD) = L/360
DEFLECTION LIMITATION (TOTAL LOAD) = L/240

PRIMARY USAGE BENDING
GRADE VGWS
STRESS CLASSIFICATION 20F-V4
SPECIES: OUTER/INNER LAMINATIONS DF/DF

TYPE 'R' WHEN READY TO CONTINUE
? [ R ]
TABULATED STRESSES:

FB = 2200 PSI  FV = 165 PSI
FCL = 410 PSI  E = 1600000 PSI

ALLOWABLE DESIGN STRESSES:

Fb = (tab FB) X LDF X CUF X CF
Fb(adjusted for size factor) = 2200 X 1 X 1 X .8983179 = 1976.3
FB(ADJUSTED FOR LATERAL STABILITY) = 2011.83 PSI

LATERAL STABILITY FACTORS:
CS = 14.87  CK = 20.89

LATERAL STABILITY CLASSIFICATION: INTERMEDIATE UNBRACED BEAM

TYPE 'R' WHEN READY TO CONTINUE
? [ R ]
\[ FV = (\text{TAB FV}) \times \text{LDF} \times \text{CUF} \]
\[ FV = 165 \times 1 \times 1 = 165 \text{ PSI} \]

\[ \text{FCL} = (\text{TAB FCL}) \times \text{LDF} \times \text{CUF} \]
\[ \text{FCL} = 410 \times 1 \times 1 = 410 \text{ PSI} \]

**DESIGN LOADS:**

\[ \text{WTL} = \text{WLL} + \text{WDL} \]
\[ \text{WTL} = 1000 + 400 = 1400 \text{ lbs/ft} \]

\[ \text{M}(\text{max}) = \text{WTL} \times (\text{L})^2 / 8 \]
\[ \text{M}(\text{max}) = 1400 \times (25)^2 / 8 = 109375 \text{ FT-LBS} \]

\[ \text{V}(\text{max}) = \text{WTL} \times \text{L}/2 \]
\[ \text{V}(\text{max}) = 1400 \times 25 / 2 = 17500 \text{ LBS} \]

*TYPE 'R' WHEN READY TO CONTINUE*

? [ R ]
REQUIRED SELECTION MODULUS = M(MAX)/Fb(adj.)
SREQ. = 109375 / 1976.3 x 12 = 664.12 inches

MAX DEFLECTION (for live load) = L/360
DEF(live load) = 25 / 360 x 12 = .833333 inches

MAX DEFLECTION (for total load) = L/240
DEF(total load) = 25 / 240 x 12 = 1.25 inches

REQUIRED INERTIA (for live load) = 5xWLLx(L)^4 / (384xExDEF(live load))
IREQ(for live load) = 5 x 1000 x (25)^4 x 1728 / 384 x 1600000 x
.833333 = 6591.797 INCHES

REQUIRED INERTIA (FOR TOTAL LOAD) = 5xWLLx(L)^4 / (384xExDEF(TOTAL LOAD))
IREQ(FOR TOTAL LOAD) = 5 x 1400 x (25)^4 x 1728 / 384 x 1600000 x
1.25 = 6152.344 INCHES

REQUIRED AREA = 1.5 x V(MAX) / FV(ADJUSTED)
AREQ = 1.5 x 17500 / 165 = 159.0909 INCHES

TYPE 'R' WHEN READY TO CONTINUE
? [ R ]
MEMBER SELECTED  5.125 X 31.5

MEMBER PROPERTIES:

NUMBER OF 3/4 LAMINATIONS: 42

SECTION MODULUS = 847.5469

AREA = 161.4375 INCHES 2

INERTIA = 13348.86 INCHES 4

WEIGHT = 38.2293 LBS/FT

BOARD FEET OF LUMBER PER LINEAR FOOT: 13.45313 BOARD-FEET/LIN. FT

TYPE 'R' WHEN READY TO CONTINUE

? [ R ]
DEFLECTION UNDER LIVE LOAD = 5 x WLL x (L)^4 / (384 x E x I)

DEF(UNDER LIVE LOAD) = 5 x 1000 x (25)^4 / (384 x 1600000) x 13348.86 = .4115081 INCHES

DEFLECTION UNDER TOTAL LOAD = 5 x WTL x (L)^4 / (384 x E x I)

DEF(UNDER TOTAL LOAD) = 5 x 1400 x (25)^4 / (384 x 1600000) x 13348.86 = .5761113 INCHES

REQUIRED BEARING LENGTH = V(max)/(FCL(adj.) x b)

REQUIRED BEARING LENGTH = 17500 x (410 x 1.5) = 8.328376 inches

MEMBER STRESSES:

FB = 1548.587 PSI

FV = 162.6016 PSI

TYPE 'R' WHEN READY TO CONTINUE

? [ R ]
DO YOU WANT A HARD COPY? (Y OR N); IF 'Y' TURN PRINTER ON
? [ N ]

DO YOU WANT TO RECYCLE THROUGH THE PROGRAM AGAIN? (Y OR N)
? [ N ]

This concludes the sample problem.
Section 4
General Sawn Lumber Design

INTRODUCTION

This section provides all necessary operating information for the General Sawn Lumber Design program. The General Sawn Lumber Design program is very similar to the Sawn Beam Design program explained in Section 2, however, the General Sawn Lumber program offers a number of type stresses that must be considered for the wood member selection. A brief description of the capabilites of the program and the program constraints, assumptions, and restrictions are provided in this introduction. The operating procedure, with appropriate figures, is explained in the section entitled Operation. The section entitled Sample Problem contains a step-by-step procedure of typical design problems using each of the options available in the program.

What General Sawn Lumber Design Does

The General Sawn Lumber Design program performs all necessary analysis and provides all essential design information to specify an appropriate size of a sawn wood beam under a specified stress condition. Standard design values for graded structural lumber are provided in the program, or the user may choose to specify them. Appropriate member sizes are specified based upon the given design condition and design values for the sawn lumber. The engineer or engineering student selects the desired member size from one of the appropriate sizes.
Constraints, Assumptions, & Restrictions

The analysis and selection are subject to the following constraints, assumptions, and restrictions.

This program assumes a linearly elastic system. Only small deflections are considered.

Shear deformations are neglected.

Member is assumed to be prismatic throughout.

Net sizes of members are used in the calculations, therefore this is not a design program for rough-sawn lumber. However, rough-sawn lumber may be conservatively substituted for the nominal sizes shown.

Selection of members is limited to those listed in Appendix M, Properties of Structural Lumber, from the 1982 edition of the National Design Specifications, Recommended Practice by National Forest Products Association.


Notches are not taken into account by the program.
Bridging is a detailing requirement not considered by the program. It is the responsibility of the engineer.

OPERATION

Overview

After entering the General Sawn Lumber Design program, condition data and, if necessary, the user-specified lumber design values are entered through display menus similar to the one used to select the General Sawn Lumber Design program. After the data are entered, the program displays an appropriate member size selected from standard tables using the design criteria specified. This selection may be accepted or rejected. If rejected, the next appropriate size is displayed, which may also be accepted or rejected. Once a member size has been accepted, the results of the analysis, design condition, and member parameters, are displayed with appropriate equations.

In the following paragraphs, operating menus are shown and described. It is assumed that the user is familiar with terms used in the civil engineering industry pertaining to design of members. Terms that are considered, by the author of this program, unclear are defined or explained in the menu descriptions below.
Refer to Section 1, Getting Started, for instructions on starting the Lumber Design program. If you haven't read this section, be sure to do so before using the program.

Operating Menus

After entering the startup sequence (see Section 1), Timber Engineering Library menu is displayed from which is selected the design program for the desired member type. Since this section explains and instructs in the usage of sawn beam design, it is assumed that number 3 was selected and entered, followed by pressing the RETURN key. This causes the Lumber Species menu to be displayed. See Figure 1.
The Lumber Species menu allows selection of Douglas-Fir Larch (1), Southern Pine (2), or California Redwood (3) lumber. Standard structure and member data for these lumber species are stored in the program for processing; therefore, the data does not need to be entered by the user.

Structure and member data may be defined by the user by selecting option four, USER DEFINED VALUES, in the menu. If this is selected, the following information must be entered as it is requested, followed by pressing the RETURN key: bending strength (FB), tensile strength parallel to the grain (Ft), horizontal shear strength (FV), compressive strength perpendicular to the grain (Fc1), compressive strength parallel to the grain (Fc), and the modulus of elasticity.
(E). The program makes all necessary value adjustments during processing; therefore, no preadjustment is necessary.

The last option in this menu, END PROGRAM (5), stops Lumber Design and returns to the system.

Once the lumber species has been selected, the Size Classification menu is displayed. Though similar, the actual contents of this menu depends on the lumber species selected. Figure 2 below shows a Size Classification menu for Douglas-fir Larch.

If USERDEFINED VALUES is selected, the next two menus are skipped. The data entered through these two menus are used to determine the structure values found in standard data tables (which are already part of the program) for the selected lumber species and selected usage. However, since the USERDEFINED VALUES requests this data directly, the next two menus are not required.
SIZE CLASSIFICATION

<table>
<thead>
<tr>
<th>Classification</th>
<th>Input</th>
</tr>
</thead>
<tbody>
<tr>
<td>LIGHT FRAMING - UP TO 4 INCHES WIDE</td>
<td>1</td>
</tr>
<tr>
<td>LIGHT FRAMING - 4 INCHES WIDE</td>
<td>2</td>
</tr>
<tr>
<td>LIGHT FRAMING - 5 INCHES AND WIDER</td>
<td>3</td>
</tr>
<tr>
<td>BEAMS AND STRINGERS</td>
<td>4</td>
</tr>
<tr>
<td>POSTS AND TIMBERS</td>
<td>5</td>
</tr>
<tr>
<td>DECKING</td>
<td>6</td>
</tr>
</tbody>
</table>

USAGE DESCRIPTION SELECTION

Figure 2. Size Classification Menu

Size classification, and thus the contents of this menu, depends on the lumber species selected. If size classification is not known when the program is first run, estimate it. Although the size classification may be incorrect, causing the tabulated stresses to be wrong, the program can be rerun after the calculations are finished to correct the classification.

Enter the desired size classification by typing the corresponding number and pushing the return key.
After the size is classified, the Lumber Grade menu is displayed. See Figure 3. (This is the second menu that is skipped if the USER DEFINED VALUES option was selected.

---

<table>
<thead>
<tr>
<th>LUMBER GRADE</th>
<th>INPUT #1</th>
</tr>
</thead>
<tbody>
<tr>
<td>DENSE SELECT STRUCTURAL</td>
<td>1</td>
</tr>
<tr>
<td>SELECT STRUCTURAL</td>
<td>2</td>
</tr>
<tr>
<td>DENSE NO.1</td>
<td>3</td>
</tr>
<tr>
<td>NO.1</td>
<td>4</td>
</tr>
<tr>
<td>DENSE NO.2</td>
<td>5</td>
</tr>
<tr>
<td>NO.2</td>
<td>6</td>
</tr>
<tr>
<td>NO.3</td>
<td>7</td>
</tr>
<tr>
<td>APPEARANCE</td>
<td>8</td>
</tr>
<tr>
<td>STUD</td>
<td>9</td>
</tr>
</tbody>
</table>

LUMBER GRADE SELECTION

? DOES THIS MEMBER QUALIFY AS A REPETITIVE MEMBER, (Y/N)?

?

Figure 3. Lumber Grade Menu
The contents of the Lumber Grade menu depends on the selected lumber species and the size classification. Figure 3 shows available lumber grades for Douglas-Fir Larch with size classification of light framing - 5 inches and wider (selection number three on the Size Classification menu of Figure 2).

Select grade by typing in the suitable input number and pushing the return key.

This menu allows the member to be classified as a repetitive member. By definition, repetitive members are three or more parallel beams spaced not more than 24 inches on centers and are joined together by floor, roof, or other load distributing elements. Allowable bending stresses for repetitive members are approximately 15 percent greater than allowable bending stresses for single-used members. If the member is to be a repetitive member, simply type Y followed by pressing the RETURN key.

With the lumber grade selected and the member classified for repetitive or single use, the program prompts for design criteria. See Figure 4.

INPUT DESIGN PARAMETERS:

CONDITION OF USE FACTOR ?

Figure 4. Enter Design Parameters
The parameter value is entered followed by pressing RETURN.

CONDITION OF USE FACTOR. The condition of use factor is an adjustment for possible moisture content conditions that can occur during the life of the member. Changes in moisture content affect the strength of the lumber and can vary in a member depending upon its environment. Design values (tabulated stresses) for sawn lumber used in this program have been taken from Table 4A of the National Design Specifications (NDS) Supplement. For most species of wood, the tabulated stresses are given assuming surfaced dry or surfaced green lumber used in conditions where the moisture content of the lumber does not exceed 19 percent. A notable exception to this is Southern Pine. The user is referred to the footnotes of Table 4A in order to determine the appropriate condition of use factor to be used.

After the condition of use factor is entered, the Load Duration Factor menu is displayed.
-- LOAD DURATION FACTOR --

<table>
<thead>
<tr>
<th>SHORTEST DURATION LOAD IN COMBINATION</th>
<th>(APPROXIMATE DURATION)</th>
<th>LDF</th>
</tr>
</thead>
<tbody>
<tr>
<td>DEAD LOAD</td>
<td>(PERMANENT)</td>
<td>0.9</td>
</tr>
<tr>
<td>FLOOR LIVE LOAD</td>
<td>(10 YEARS)</td>
<td>1.0</td>
</tr>
<tr>
<td>SNOW LOAD</td>
<td>(2 MONTHS)</td>
<td>1.15</td>
</tr>
<tr>
<td>ROOF LIVE LOAD</td>
<td>(7 DAYS)</td>
<td>1.25</td>
</tr>
<tr>
<td>WIND OR SEISMIC</td>
<td>(1 DAY)</td>
<td>1.33</td>
</tr>
<tr>
<td>IMPACT</td>
<td>(2 SECONDS)</td>
<td>2.0</td>
</tr>
</tbody>
</table>

NOTES:
A. CHECK ALL CODE REQUIRED LOAD COMBINATIONS.
B. SELECT LDF ASSOCIATED WITH THE SHORTEST DURATION IN THE COMBINATION OF LOADS.
C. THE CRITICAL COMBINATION OF LOADS IS THE ONE THAT REQUIRES THE LARGEST SIZE STRUCTURAL MEMBER.

LOAD DURATION FACTOR TO BE USED?

Figure 5. Load Duration Factor Menu

The load duration factor takes into account wood's ability to support greater stresses that are applied for a short period of time. The total accumulated length of time that a load is applied to a structure is known as the duration of loading. The load duration factor
applies to the entire combination of loads and not just to that portion of the stress caused by a load of a particular duration. The load duration to be used is the one associated with the shortest duration load in the combination.

Enter the desired load duration factor (LDF) shown in the menu.

Once the load duration factor is entered, the Selection Menu is displayed. See Figure 6.

SELECTION MENU

AXIAL TENSION MEMBER DESIGN 1
COLUMN DESIGN 2
COMBINED BENDING AND TENSION MEMBER DESIGN 3
COMBINED BENDING AND COMPRESSION DESIGN 4
BEAM DESIGN (USER DEFINED STRESSES) 5
RETURN TO SYSTEM 6

YOUR SELECTION?
?

Figure 6. Selection Menu

This menu allows the user a variety of design conditions. Each selection causes other menus to be displayed that request design data for the final selection of an appropriate sized member. The selected
member size is displayed, which may be accepted or rejected. If rejected, another appropriate member size is offered, which also may be accepted or rejected. Once the member size has been accepted, analysis and design data are displayed with the design calculations.

The analysis and design data that are displayed vary depending on the selection made from this menu. In previous sections of this manual, the menus requesting data that must be entered by the user (input data) were explained first and then all analysis and design data (output data) were shown. However, since the output data varies depending on this Selection Menu, all menus and output data for a particular selection from this Selection Menu are displayed together. All items in the Selection menu are explained below after brief descriptions of the selections in this menu.

AXIAL TENSION MEMBER DESIGN (#1). This selection allows the user to perform tension member design. Provisions are made for bolt holes in the member if the user indicates the size of bolt used.

COLUMN DESIGN (#2). This selection allows the user to perform design of a member under compression loads. A number of end support conditions are accommodated by the program.

COMBINED BENDING AND TENSION DESIGN (#3). This selection allows the user to perform combined bending and tension design. This combination
of stresses is typical in the design world. Combined bending and tension often occurs in trusses.

COMBINED BENDING AND COMPRESSION DESIGN (#4). This selection allows the user to perform combined bending and compression design. As is the case with the previous option, the combination of bending and compression stresses is a typical occurrence in the design world. Combined bending and compression often occurs in trusses and beam columns.

BEAM DESIGN, USER DEFINED SHEAR AND MOMENT (#5). This selection is very similar to the program of Section 2 in this manual (uniformly loaded sawn beam program) in analysis and output data. However, in the uniformly loaded program, the user entered the uniform loads and let the computer solve for the maximum moment and shear; in this program, the user enters the maximum moment and shear directly.

Analysis & Design Displays

AXIAL TENSION. If #1 is selected the following menus and data are displayed.
TENSION MEMBER SELECTION SUBROUTINE

INPUT DESIGN PARAMETERS:

AXIAL LOAD, LBS : ? [ 16000 ]

IS THERE A BOLT HOLE? (Y/N): ? [ Y ]

WHAT IS THE DIAMETER OF THE BOLT HOLE?, INCHES

? [ .75 ]

DOES THIS INCLUDE 1/8 INCH OVERSIZE? (Y/N) ? [ N ]

Figure 6. Input Parameters Menu

The first screen to appear in this subroutine requests the input parameters. These are the axial load (in pounds), whether or not there is a bolt hole, and if so the size of the bolt hole, and if the size stated includes oversizing for drilling damage.

MEMBER SELECTED : 2 X 10

DO YOU WANT TO SELECT ANOTHER MEMBER? (Y/N) ?

Figure 7. Member Selection

The computer displays the appropriate sized member selected. The user is given the option of reselecting another member. If the size is rejected, the program will select the next largest suitable member and display it. It too, may be rejected.
Once a member size has been accepted, the analysis data is displayed, beginning with the data entered by the user to verify its accuracy. See Figure 8.

--- INPUT DATA ---

AXIAL LOAD = 16000 lbs
LOAD DURATION FACTOR = 1.33
CONDITION OF USE FACTOR = 1
BOLT HOLE DIAMETER, (including 1/8 inch oversize) = .875 inches

LUMBER SPECIES DOUGFIR
COMMERCIAL GRADE NO.1
SIZE CLASSIFICATION LIGHT FRAMING -5 INCHES AND WIDER
REPEITIVE MEMBER? NO

TYPE 'R' AND HIT RETURN KEY WHEN READY TO CONTINUE.
?

Figure 8. The Input Data Display
TABULATED STRESS:

FT = 1000 psi

ALLOWABLE DESIGN STRESS:

FT = (tab FT) X LDF X CUF

FT(adjusted) = 1000 X 1.33 X 1 = 1330 PSI

REQUIRED AREA = AXIAL LOAD / FT(adjusted)

AREQ = 16000 / 1330 = 12.03008 inches^2

GROSS AREA REQUIRED = AREQ + (B x DIA(including 1/8 inch oversize))

GROSS AREA REQUIRED = 12.03008 + (2 X .875) = 13.34258 inches^2

TYPE 'R' AND HIT RETURN KEY WHEN READY TO CONTINUE.

Figure 9. Tabulated and Design Stresses

The calculation of the adjusted adjusted tensile stress and the computations of the gross required area are shown.

The last display of design and analysis data shows member information (Figure 10).
MEMBER SELECTED 2 X 10

MEMBER PROPERTIES:
ACTUAL DIMENSIONS 1.5 INCHES X 9.25 inches
AREA = 13.875 inches^2
WEIGHT = 3.854167 lbs/ft
BOARD FEET OF LUMBER PER LINEAR FOOT: 1.666667 board-feet/lin. ft

MEMBER STRESS:
FT = 1153.153 PSI

TYPE 'R' AND HIT RETURN KEY WHEN READY TO CONTINUE.
?

Figure 10. Member Information

Once all data are displayed, the program allows the user to make a
hard copy of the analysis and design data and then allows the user to
return to the beginning of the program or exit the program. See Figure
11.
DO YOU WANT A HARD COPY ?, (Y OR N); IF 'Y' TURN PRINTER ON

DO YOU WANT TO RECYCLE THROUGH THE PROGRAM AGAIN ?, (Y OR N)

Figure 11. Final Display

COLUMN DESIGN. Entering the number '2' into the selection menu causes the program to enter the column design program.

COLUMN MEMBER SELECTION SUBROUTINE

INPUT DESIGN PARAMETERS :

AXIAL LOAD, LBS :

UNBRACED LENGTH (ABOUT X AXIS), FEET :

UNBRACED LENGTH (ABOUT Y AXIS), FEET :

IS SIDESWAY PREVENTED IN THE X-X DIRECTION ? (Y/N)

IS SIDESWAY PREVENTED IN THE Y-Y DIRECTION ? (Y/N)

Figure 12. Input Design Parameters Menu

The first screen displayed upon entering the column design subroutine requests the input of design parameters. In order of appearance they
are the axial load on the column is pounds, the unbraced length about the x axis, the unbraced length about the y axis, whether sidesway is prevented in the x direction, and whether sidesway sway is prevent in the y direction.

Design parameters are displayed one at a time. Once the design parameter is entered, the next one is requested.

X - X DIRECTION, SIDESWAY PREVENTED
SELECT COLUMN END CONDITIONS
---------------------------------------------
TOP      - BOTTOM END CONDITION
FIXED - FIXED ..................... 1
PINNED- FIXED ..................... 2
PINNED- PINNED ..................... 3
---------------------------------------------
YOUR SELECTION ?

Figure 13. Possible End Conditions Menu (X-X direction)

The next screen will display the possible end conditions of the column in the x and y direction depending whether or not sidesway is prevented. Select the proper end conditions by entering in the corresponding input number.
Y - Y DIRECTION, SIDESWAY PREVENTED

SELECT COLUMN END CONDITIONS

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

TOP - BOTTOM END CONDITION

FIXED - FIXED .................... 1
PINNED- FIXED .................... 2
PINNED- PINNED .................... 3

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

YOUR SELECTION ?

Figure 14. Possible End Conditions Menu (Y-Y direction)

Having defined the design problem, the computer will now compute and display the effective lengths of the column in both the x and y direction. Following this, a member is selected and displayed. The user has the option of reselection.
EFF. LENGTH X DIR. = 10
EFF. LENGTH Y DIR. = 10

MEMBER SELECTED IS 4 X 10
DO YOU WANT TO SELECT ANOTHER MEMBER ? (Y/N)
? [ Y ]

MEMBER SELECTED IS 4 X 12
DO YOU WANT TO SELECT ANOTHER MEMBER ? (Y/N)
? [ N ]

Figure 15. Member Selection

Upon final selection of a member the computer will display a summary of the input data. Following the summary are the calculations showing the adjusted allowable bending stress. The output data of the subroutine is concluded with the display of member properties, realized member stresses, and maximum allowable column capacity.
INPUT DATA

AXIAL LOAD = 14000 lbs
LOAD DURATION FACTOR = 1
CONDITION OF USE FACTOR = 1
SIDESWAY PREVENTED IN X DIRECTION?: Y
SIDESWAY PREVENTED IN Y DIRECTION?: Y
UNBRACED LENGTH IN THE X -DIRECTION: 10 FEET
UNBRACED LENGTH IN THE Y -DIRECTION: 10 FEET

LUMBER SPECIES DOUGFIR
COMMERCIAL GRADE NO.1
SIZE CLASSIFICATION LIGHT FRAMING -5 INCHES AND WIDER
TYPE 'R' AND HIT RETURN KEY WHEN READY TO CONTINUE.
?

Figure 16. Input Data
TABULATED STRESS:
FC = 125 PSI
E = 1.80000E+6 PSI

ALLOWABLE DESIGN STRESS:
EFFECTIVE LENGTH, X DIR. = 10 FEET
EFFECTIVE LENGTH, Y DIR. = 10 FEET

MAXIMUM L/D RATIO = 34.2857
K = 25.4627

SLENDERNESS CLASSIFICATION: LONG COLUMN
FC(ADJUSTED) = 459.375

TYPE 'R' AND HIT RETURN KEY WHEN READY TO CONTINUE.
?

Figure 17. Adjusted and Allowable Bending Stresses
MEMBER SELECTED 4 X 12

MEMBER PROPERTIES:

ACTUAL DIMENSIONS 3.5 INCHES X 11.25 inches

AREA = 39.375 inches^2

WEIGHT = 10.9375 lbs/ft

BOARD FEET OF LUMBER PER LINEAR FOOT: 4 board-feet/lin. ft

MEMBER STRESS:

FC = AXIAL LOAD / AREA

FC = 14000 / 39.375 PSI

MAXIMUM AXIAL LOAD = FC(ADJUSTED) X AREA

MAXIMUM AXIAL LOAD = 459.375 X 39.375 = 18087.9 LBS

TYPE 'R' AND HIT RETURN KEY WHEN READY TO CONTINUE.

Figure 18. The Member Properties

Once all data are displayed, the program allows the user to make a hard copy of the analysis and design data and then allows the user to return to the beginning of the program or exit the program. See Figure 19.
DO YOU WANT A HARD COPY?, (Y OR N); IF 'Y' TURN PRINTER ON
?

DO YOU WANT TO RECYCLE THROUGH THE PROGRAM AGAIN?, (Y OR N)
?

Figure 19. Final Display

COMBINED BENDING AND TENSION. Selection of option #3 causes the
program to enter the COMBINED BENDING AND TENSION subroutine.

COMBINED BENDING & TENSION MEMBER SELECTION SUBROUTINE

INPUT DESIGN PARAMETERS:

AXIAL LOAD, LBS :
?

MAXIMUM MOMENT, FT-LBS :
?

IS THERE A BOLT HOLE? (Y):
?

WHAT IS THE DIAMETER OF THE BOLT HOLE?, INCHES
?

DOES THIS INCLUDE 1/8 INCH OVERSIZE? (Y/N)
?

Figure 20. Input Design Parameters Menu

The design parameters that are requested by the program are axial
load, maximum moment and whether or not there is a bolt hole to
consider. Parameters are requested one at a time. When a parameter has been entered, the next request is displayed.

The program then selects the first appropriate sized member. See Figure 21.

**MEMBER SELECTED IS 2 X 12**

\[ FB/\text{FB} + FT/\text{FT} \leq 1.0 \]
\[ 0.316049 + 0.592593 = 0.908642 \leq 1 \]

**DO YOU WANT TO SELECT ANOTHER MEMBER? (Y/N)**

? [ Y ]

**MEMBER SELECTED IS 2 X 14**

\[ FB/\text{FB} + FT/\text{FT} \leq 1.0 \]
\[ 0.227839 + 0.503145 = 0.730984 \leq 1 \]

**DO YOU WANT TO SELECT ANOTHER MEMBER? (Y/N)**

? [ N ]

Figure 21. Member Selection Menu

The selection can be accepted or rejected. If rejected, another appropriate member size is offered. It too can be accepted or rejected.

Once a member is selected, the interaction formula will be displayed. The interaction formula defines how efficiently the member is used and to what extent bending and tension effect the design. The user has the option of reselecting a member.
The analysis and design data includes the calculations for adjusted stresses, member properties, and member stresses under full load.

--- INPUT DATA ---

AXIAL LOAD = 10000 lbs
MAXIMUM MOMENT = 1250 FT-LBS
LOAD DURATION FACTOR = 1
CONDITION OF USE FACTOR = 1
BOLT HOLE DIAMETER, (INCLUDING 1/8 INCH OVERSIZE) = .75 INCHES

LUMBER SPECIES DOUGFIR
COMMERCIAL GRADE NO.1
SIZE CLASSIFICATION LIGHT FRAMING -5 INCHES AND WIDER
REPETITIVE MEMBER ? NO

TYPE 'R' AND HIT RETURN KEY WHEN READY TO CONTINUE.

Figure 22. Input Data
--- OUTPUT DATA ---

TABULATED STRESS:

FT = 1000 PSI
FB = 1500 PSI

ALLOWABLE DESIGN STRESS:

FT = (tab FT) X LDF X CUF
FT(adjusted) = 1500 X 1 X 1 = 150 PSI

REQUIRED AREA = AXIAL LOAD / FT(adjusted)
AREQ = 10000 / 1000 = 10 inches^2

GROSS AREA REQUIRED = AREQ + (B x DIA(including 1/8 inch oversize))
GROSS AREA REQUIRED = 10 + ( 2 x .75 ) = 11.125 inches^2

TYPE 'R' AND HIT RETURN KEY WHEN READY TO CONTINUE.
?

Figure 23. Tabulated and Design Stresses
MEMBER SELECTED 2 X 14

MEMBER PROPERTIES:
ACTUAL DIMENSIONS 1.5 INCHES X 13.25 inches
AREA = 43.8906 inches^2
WEIGHT = 5.52083 lbs/ft
BOARD FEET OF LUMBER PER LINEAR FOOT: 2.333333 board-feet/lin. ft

MEMBER STRESS:
FT = 503.145 PSI
FB = 341.759 PSI

TYPE 'R' AND HIT RETURN KEY WHEN READY TO CONTINUE.
?

Figure 24. Member Properties

Once all data are displayed, the program allows the user to make a hard copy of the analysis and design data and then allows the user to return to the beginning of the program or exit the program. See Figure 25.
DO YOU WANT A HARD COPY?, (Y OR N); IF 'Y' TURN PRINTER ON?

DO YOU WANT TO RECYCLE THROUGH THE PROGRAM AGAIN?, (Y OR N)?

Figure 25. Final Display

COMBINED BENDING AND COMPRESSION. Selection of option #4 causes the program to enter the COMBINED BENDING AND COMPRESSION subroutine.

COMBINED BENDING AND COMPRESSION DESIGN

INPUT MAXIMUM MOMENT (FT-LBS) ?
INPUT MAXIMUM SHEAR (LBS) ?
AXIAL LOAD, LBS :

UNBRACED LENGTH (ABOUT X AXIS), FEET :
UNBRACED LENGTH (ABOUT Y AXIS), FEET :
IS SIDESWAY PREVENTED IN THE X-X DIRECTION? (Y/N) ?
IS SIDESWAY PREVENTED IN THE Y-Y DIRECTION? (Y/N) ?

Figure 26. Input Design Parameters Menu
Input design parameters requested by the program are maximum moment, maximum shear, axial load, and a description of the support conditions. Parameters are requested one at a time. After a parameter is entered, the next request is displayed.

**X - X DIRECTION, SIDESWAY PREVENTED**

**SELECT COLUMN END CONDITIONS**

<table>
<thead>
<tr>
<th>Top</th>
<th>Bottom</th>
<th>End Condition</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fixed - Fixed</td>
<td></td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Pinned - Fixed</td>
<td></td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Pinned - Pinned</td>
<td></td>
<td>3</td>
<td></td>
</tr>
</tbody>
</table>

---

**YOUR SELECTION?**

Figure 27. X-X Direction End Support Conditions Menu

Select the appropriate X-X direction end condition and enter the associated number.
Y - Y DIRECTION, SIDESWAY PREVENTED

SELECT COLUMN END CONDITIONS

-------------------------------
TOP - BOTTOM END CONDITION

FIXED - FIXED .................... 1
PINNED- FIXED .................... 2
PINNED- PINNED .................... 3

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

YOUR SELECTION ?

?

Figure 28. Y-Y Direction End Support Conditions Menu

Select the appropriate Y-Y direction end condition and enter the associated number.
EFF. LENGTH X DIR. = 20
EFF. LENGTH Y DIR. = 20
MEMBER SELECTED IS 6 X 16
FB/(FB-J*FC) + FC/FC <= 1.0
.45869 + .413627 = .872317 <= 1
DO YOU WANT TO SELECT ANOTHER MEMBER? (Y/N)
? [Y]

MEMBER SELECTED IS 6 X 18
FB/(FB-J*FC) + FC/FC <= 1.0
.360812 + .366355 = .727167 <= 1
DO YOU WANT TO SELECT ANOTHER MEMBER? (Y/N)
? [N]

Figure 29. Member Selection Menu

Once the input parameters and end conditions are defined, an appropriate member size is selected and displayed along with the interaction formula. The interaction formula indicates how efficiently the member is used and the effect of bending or tension on the design. The member may be accepted or rejected. If rejected, the next appropriate size is offered, which may also be accepted or rejected.

After a member size has been selected, the program displays the analysis and design data, beginning with the data entered by the user. The rest of the analysis and design data includes calculations
for adjusted stresses, member properties, and member stresses under full load. The interaction equation and the stresses used in the equation are also displayed. The 'J' factor in the equation indicates how much the design is controlled by the P-Delta effect.

"------------------ INPUT DATA ------------------"

LOAD DURATION FACTOR = 1
CONDITION OF USE FACTOR = 1
MAXIMUM MOMENT = 12000 FT-LBS
MAXIMUM SHEAR = 5000 LBS
AXIAL LOAD = 10000 LBS

LUMBER SPECIES DOUGFIR
COMMERCIAL GRADE NO.1
SIZE CLASSIFICATION LIGHT FRAMING -5 INCHES AND WIDER

TYPE 'R' AND HIT RETURN KEY WHEN READY TO CONTINUE.
?

Figure 30. Input Data
TABULATED STRESS:

FB = 1500 PSI  FV = 95 PSI
FCL = 625 PSI  E = 1.8000E+6 PSI
FC = 1250 PSI

SIDESWAY PREVENTED IN X DIRECTION ?: Y
SIDESWAY PREVENTED IN Y DIRECTION ?: Y
UNBRACED LENGTH IN THE X -DIRECTION ?: 20 FEET
UNBRACED LENGTH IN THE Y -DIRECTION ?: 20 FEET

ALLOWABLE DESIGN STRESS:

FB = (TAB FB) X LDF X CUF X CF

FB(ADJUSTED FOR SIZE FACTOR) = 1500 X 1 X 1 X .958945 = 1438.42

EFFECTIVE LENGTH, X DIR. = 20 FEET
EFFECTIVE LENGTH, Y DIR. = 20 FEET

MAXIMUM L/D RATIO = 43.6364
K = 25.4627

SLENDERNESS CLASSIFICATION: LONG COLUMN

FC(ADJUSTED) = 283.594

TYPE 'R' AND HIT RETURN KEY WHEN READY TO CONTINUE.

Figure 31a. Tabulated and Design Stresses
FV = (TAB FV) X LDF
FV = 95 X 1 = 95 PSI

FCL = (TAB FCL) X LDF
FCL = 625 X 1 = 625 PSI

TYPE 'R' AND HIT RETURN KEY WHEN READY TO CONTINUE.

? Figure 31b. Tabulated Stresses
DESIGN LOADS:

MAXIMUM MOMENT = 12000 FT-LBS

SHEAR = 5000 LBS

AXIAL LOAD = 10000 LBS

REQUIRED SECTION MODULUS = M(MAX)/FB(ADJ.)

SREQ. = 12000 / 1438.42 X 12 = 100.11 INCHES^3

REQUIRED AREA = 1.5 V(MAX) / FV(ADJUSTED)

AREQ = 1.5 X 5000 / 95 = 78.9474

FB/(FB-J*FC) + FC/FC <= 1.0

512.95 / (1438.42 - .161335 * 103.896) + 103.896 / 283.594 =

.727167

<= 1.0

.360812 + .366355 = .727167 <= 1.0

TYPE 'R' AND HIT RETURN KEY WHEN READY TO CONTINUE.

Figure 32. Design Loads
MEMBER SELECTED 6 X 18

MEMBER PROPERTIES:

ACTUAL DIMENSIONS 5.5 INCHES X 17.5 inches

SECTION MODULUS = 280.729

AREA = 96.25 inches²

WEIGHT = 26.7361 lbs/ft

BOARD FEET OF LUMBER PER LINEAR FOOT: 9 board-feet/lin. ft

REQUIRED BEARING LENGTH = V(MAX)/(FCL(ADJ.) X B)

REQUIRED BEARING LENGTH = 5000 / ( 625 X 5.5 ) = 1.45455 INCHES

MEMBER STRESS:

FB = 512.95 PSI

FV = 77.9221 PSI

FC = 103.896 PSI

TYPE 'R' AND HIT RETURN KEY WHEN READY TO CONTINUE.

?

Figure 33. Member Properties

Once all data are displayed, the program allows the user to make a hard copy of the analysis and design data and then allows the user to return to the beginning of the program or exit the program. See Figure 34.
DO YOU WANT A HARD COPY ?, (Y OR N); IF 'Y' TURN PRINTER ON ?

DO YOU WANT TO RECYCLE THROUGH THE PROGRAM AGAIN ?, (Y OR N) ?

Figure 34. Final Display

BEAM DESIGN (USER DEFINED STRESSES). Selection of option #5 causes the program to enter the BEAM DESIGN (USER DEFINED STRESSES) subroutine.

BEAM SELECTION SUBROUTINE

INPUT MAXIMUM MOMENT, FT-LBS ?
INPUT MAXIMUM SHEAR, LBS ?

Figure 35. Maximum Moment/Shear Menu

The only input required by this subroutine other than the lumber stresses are the maximum moment and maximum shear.

The program then displays the first appropriate member size. The member may be accepted or rejected. If it is rejected, the next appropriate member size is displayed, which may also be accepted or rejected.
MEMBER SELECTED IS 12 X 20

DO YOU WANT TO SELECT ANOTHER MEMBER ? (Y/N)

? [ Y ]

MEMBER SELECTED IS 12 X 22

DO YOU WANT TO SELECT ANOTHER MEMBER ? (Y/N)

? [ N ]

Figure 36. Member Selection Menu

When the desired member has been accepted, the design and analysis data are displayed beginning with the input data.

The beam has been analyzed assuming full lateral support. In order to give the user a program that allows for a wider range of support conditions and loadings, this program has left off the lateral stability considerations. The user should provide full lateral support or verify that lateral stability does not control the design.
"LOAD DURATION FACTOR = 1
CONDITION OF USE FACTOR = 1
MAXIMUM MOMENT = 30000 FT-LBS
MAXIMUM SHEAR = 15000 LBS
LUMBER SPECIES DOUGFIR
COMMERCIAL GRADE NO.1
SIZE CLASSIFICATION LIGHT FRAMING -5 INCHES AND WIDER
REPETITIVE MEMBER? NO
TYPE 'R' AND HIT RETURN KEY WHEN READY TO CONTINUE.
?

Figure 37. Input Data
OUTPUT DATA

TABULATED STRESS:
FB = 1500 PSI  FV = 95 PSI
FCL = 625 PSI  E = 1.80000E+6 PSI

ALLOWABLE DESIGN STRESS:
FB = (TAB FB) X LDF X CUF X CF
FB(ADJUSTED FOR SIZE FACTOR) = 1500 X 1 X 1 X .93726 = 1405.89
FB(ADJUSTED FOR LATERAL STABILITY) = 1500 PSI

LATERAL STABILITY FACTORS:
CS = 0  CK = 0

LATERAL STABILITY CLASSIFICATION : SHORT UNBRACED BEAM

TYPE 'R' AND HIT RETURN KEY WHEN READY TO CONTINUE.
?

Figure 38a. Tabulated and Design Stresses Display
FV = (TAB FV) X LDF
FV = 95 X 1 = 95 PSI

FCL = (TAB FCL) X LDF
FCL = 625 X 1 = 625 PSI

TYPE 'R' AND HIT RETURN KEY WHEN READY TO CONTINUE.

Figure 38b. Tabulated Stresses Display

DESIGN LOADS:
M(MAX) = 30000 FT-LBS
V(MAX) = 15000 LBS

REQUIRED SECTION MODULUS = M(MAX)/FB(ADJ.)
SREQ. = 30000 / 1405.89 X 12 = 256.065 INCHES^3

REQUIRED AREA = 1.5 V(MAX) / FV(ADJUSTED)
AREQ = 1.5 X 15000 / 95 = 236.842 INCHES^2

TYPE 'R' AND HIT RETURN KEY WHEN READY TO CONTINUE.

Figure 39. Design Loads Display
MEMBER SELECTED 12 X 22

MEMBER PROPERTIES:

ACTUAL DIMENSIONS 11.5 INCHES X 21.5 inches

SECTION MODULUS = 885.979

AREA = 247.25 inches^2

INERTIA = 9524.28 INCHES^4

WEIGHT = 68.6806 lbs/ft

BOARD FEET OF LUMBER PER LINEAR FOOT: 22 board-feet/lin. ft

REQUIRED BEARING LENGTH = V(MAX)/(FCL(ADJ.) X B)

REQUIRED BEARING LENGTH = 15000 / (625 X 11.5) = 2.08696 INCHES

MEMBER STRESS:

FB = 406.33 PSI

FV = 91.001 PSI

TYPE 'R' AND HIT RETURN KEY WHEN READY TO CONTINUE.

Figure 40. Member Properties Display

Once all data are displayed, the program allows the user to make a hard copy of the analysis and design data and then allows the user to return to the beginning of the program or exit the program. See Figure 31.
DO YOU WANT A HARD COPY?, (Y OR N); IF 'Y' TURN PRINTER ON?

DO YOU WANT TO RECYCLE THROUGH THE PROGRAM AGAIN?, (Y OR N)?

Figure 31. Final Display

SAMPLE PROBLEMS

In the following sample problems, a sample of each of the five selections has been included. In the sample problems the following steps are identical, therefore they are not repeated in sample problems two through five: entering the Lumber Design program, selecting the General Sawn Lumber Design program, selecting the lumber species (Douglas-Fir Larch is used in all sample problems), selecting the size classification (light framing - 5 inches and wider is used in all sample problems), selecting lumber grade (No. 1, non-repetative member is used in all problems), designating a condition of use factor of 1. Refer to Sample Problem No. 1 for examples of entering these data.
Problem No. 1 Axial Tension Member Design

Design a tension member of a truss that carries 16,000 lbs resulting from wind or seismic loading. It is pinned at each end by a 3/4 inch diameter bolt. Use Douglas Fir, light framing -5 inches and wider, No.1 lumber.

First, the Lumber Design program is entered. (User input will be designated in brackets.)

[ OLD,TIMBER ]
READY.
[ TIMBER. ]

The Timber Engineering Library menu is displayed.

TIMBER ENGINEERING LIBRARY

SAWN LUMBER BEAM DESIGN 1
GLU-LAM BEAM DESIGN 2
GENERAL SAWN LUMBER DESIGN 3
RETURN TO SYSTEM 4

YOUR SELECTION ?

? [ 3 ]

The General Sawn Lumber Design program is selected.
The Lumber Species menu is displayed.

LUMBER SPECIES                      INPUT ###
--------------------------------------
DOUGLAS-FIR LARCH                     1
SOUTHERN PINE                        2
CALIFORNIA REDWOOD                   3
END PROGRAM                          4

YOUR SELECTION? [ 1 ]

The problem required the use of Douglas-Fir Larch. Selection #1 is entered.

The Size Classification Selection menu for Douglas-Fir Larch is displayed.
-- SIZE CLASSIFICATION SELECTION MENU --

<table>
<thead>
<tr>
<th>SIZE CLASSIFICATION</th>
<th>INPUT ###</th>
</tr>
</thead>
<tbody>
<tr>
<td>LIGHT FRAMING -UPTO 4 INCHES WIDE</td>
<td>1</td>
</tr>
<tr>
<td>LIGHT FRAMING -4 INCHES WIDE</td>
<td>2</td>
</tr>
<tr>
<td>LIGHT FRAMING -5 INCHES AND WIDER</td>
<td>3</td>
</tr>
<tr>
<td>BEAMS AND STRINGERS</td>
<td>4</td>
</tr>
<tr>
<td>POSTS AND TIMBERS</td>
<td>5</td>
</tr>
<tr>
<td>DECKING</td>
<td>6</td>
</tr>
</tbody>
</table>

USAGE DESCRIPTION SELECTION
?

[ 3 ]

It was given that we use light framing of 5 inches or wider, therefore (3) entered.

The Lumber Grade Selection menu is displayed.
COMMERCIAL GRADE SELECTION MENU

<table>
<thead>
<tr>
<th>LUMBER GRADE</th>
<th>INPUT ###</th>
</tr>
</thead>
<tbody>
<tr>
<td>DENSE SELECT STRUCTURAL</td>
<td>1</td>
</tr>
<tr>
<td>SELECT STRUCTURAL</td>
<td>2</td>
</tr>
<tr>
<td>DENSE NO.1</td>
<td>3</td>
</tr>
<tr>
<td>NO.1</td>
<td>4</td>
</tr>
<tr>
<td>DENSE NO.2</td>
<td>5</td>
</tr>
<tr>
<td>NO.2</td>
<td>6</td>
</tr>
<tr>
<td>NO.3</td>
<td>7</td>
</tr>
<tr>
<td>APPEARANCE</td>
<td>8</td>
</tr>
<tr>
<td>STUD</td>
<td>9</td>
</tr>
</tbody>
</table>

? [ 4 ]

DOES THIS MEMBER QUALIFY AS A REPETITIVE MEMBER, (Y/N) ?
? [ N ]

Grade #1 was given in the problem. Therefore (4) is entered. This does not qualify as a repetative member.

The program then requests the condition of use factor.

--LUMBER DESIGN PROGRAM

CONDITION OF USE FACTOR ? 1.0
The condition of use factor is 1.

The Load Duration Factor menu is displayed.

--- LOAD DURATION FACTOR ---

<table>
<thead>
<tr>
<th>SHORTEST DURATION LOAD IN COMBINATION</th>
<th>(APPROXIMATE DURATION)</th>
<th>LDF</th>
</tr>
</thead>
<tbody>
<tr>
<td>DEAD LOAD</td>
<td>(PERMANENT)</td>
<td>0.9</td>
</tr>
<tr>
<td>FLOOR LIVE LOAD</td>
<td>(10 YEARS)</td>
<td>1.0</td>
</tr>
<tr>
<td>SNOW LOAD</td>
<td>(2 MONTHS)</td>
<td>1.15</td>
</tr>
<tr>
<td>ROOF LIVE LOAD</td>
<td>(7 DAYS)</td>
<td>1.25</td>
</tr>
<tr>
<td>WIND OR SEISMIC</td>
<td>(1 DAY)</td>
<td>1.33</td>
</tr>
<tr>
<td>IMPACT</td>
<td>(2 SECONDS)</td>
<td>2.0</td>
</tr>
</tbody>
</table>

NOTES:

A. CHECK ALL CODE REQUIRED LOAD COMBINATIONS.

B. SELECT LDF ASSOCIATED WITH THE SHORTEST DURATION IN THE COMBINATION OF LOADS.

C. THE CRITICAL COMBINATION OF LOADS IS THE ONE THAT REQUIRES THE LARGEST SIZE STRUCTURAL MEMBER.

LOAD DURATION FACTOR TO BE USED?

? [ 1.33 ]
The problem defined the loading to be wind or seismic. The corresponding value is 1.33, which is entered.

The Selection Menu is displayed.

SELECTION MENU

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

AXIAL TENSION MEMBER DESIGN   1
COLUMN DESIGN                 2
COMBINED BENDING AND TENSION MEMBER DESIGN   3
COMBINED BENDING AND COMPRESSION DESIGN      4
BEAM-COLUMN DESIGN            5
BEAM DESIGN (USER DEFINED STRESSES    6
RETURN TO SYSTEM              7

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

YOUR SELECTION?

? [ 1 ]

Since this is an axial tension member design problem, (1) is selected.

The Tension Member Selection subroutine is entered.
TENSION MEMBER SELECTION SUBROUTINE

INPUT DESIGN PARAMETERS:

AXIAL LOAD, LBS: ? [16000]

IS THERE A BOLT HOLE? (Y/N): ? [Y]

WHAT IS THE DIAMETER OF THE BOLT HOLE?, INCHES

? [.75]

DOES THIS INCLUDE 1/8 INCH OVERSIZE? (Y/N) ? [N]

The design parameters were specified in the problem as 16000 pounds load with a 3/4 inch diameter bolt hole. The hole is not oversized.

The program now displays the first appropriate member size.

MEMBER SELECTED: 2 X 10

DO YOU WANT TO SELECT ANOTHER MEMBER? (Y/N) ? [N]

This size is acceptable. The design and analysis data is now displayed.
INPUT DATA

AXIAL LOAD = 16000 lbs
LOAD DURATION FACTOR = 1.33
CONDITION OF USE FACTOR = 1
BOLT HOLE DIAMETER, (including 1/8 inch oversize) = .875 inches

LUMBER SPECIES DOUGFIR
COMMERCIAL GRADE NO.1
SIZE CLASSIFICATION LIGHT FRAMING -5 INCHES AND WIDER
REPETITIVE MEMBER? NO

TYPE 'R' AND HIT RETURN KEY WHEN READY TO CONTINUE.

? [ R ]
TABULATED STRESS:
FT = 1000 psi

ALLOWABLE DESIGN STRESS:
FT = (tab FT) X LDF X CUF
FT(adjusted) = 1000 X 1.33 X 1 = 1330 PSI

REQUIRED AREA = AXIAL LOAD / FT(adjusted)
AREQ = 16000 / 1330 = 12.03008 inches^2

GROSS AREA REQUIRED = AREQ + (B x DIA(including 1/8 inch oversize))
GROSS AREA REQUIRED = 12.03008 + ( 2 X .875 ) = 13.34258 inches^2

TYPE 'R' AND HIT RETURN KEY WHEN READY TO CONTINUE.
? [ R ]
MEMBER SELECTED 2 X 10

MEMBER PROPERTIES:

ACTUAL DIMENSIONS 1.5 INCHES X 9.25 inches

AREA = 13.875 inches^2

WEIGHT = 3.854167 lbs/ft

BOARD FEET OF LUMBER PER LINEAR FOOT: 1.666667 board-feet/lin. ft

MEMBER STRESS:

FT = 1153.153 PSI

TYPE 'R' AND HIT RETURN KEY WHEN READY TO CONTINUE.

? [ R ]

Problem No. 2 Column Design

Design a compression member that carries 14,000 lbs. Use a condition of use factor and a load duration factor of 1.0. The member is 10 feet long and its pinned at each end. Sideway movement is prevented in both directions. Use Douglas Fir, light framing -5 inches and wider, No.1 lumber.

Since the first steps are identical to Problem No. 1, they are not duplicated here. See the introductory paragraph of Sample Problems.

The Load Duration Factor is the first menu after the Condition Of Use Factor menu.
--- LOAD DURATION FACTOR ---

<table>
<thead>
<tr>
<th>SHORTEST DURATION LOAD IN COMBINATION</th>
<th>(APPROXIMATE DURATION)</th>
<th>LDF</th>
</tr>
</thead>
<tbody>
<tr>
<td>DEAD LOAD</td>
<td>(PERMANENT)</td>
<td>0.9</td>
</tr>
<tr>
<td>FLOOR LIVE LOAD</td>
<td>(10 YEARS)</td>
<td>1.0</td>
</tr>
<tr>
<td>SNOW LOAD</td>
<td>(2 MONTHS)</td>
<td>1.15</td>
</tr>
<tr>
<td>ROOF LIVE LOAD</td>
<td>(7 DAYS)</td>
<td>1.25</td>
</tr>
<tr>
<td>WIND OR SEISMIC</td>
<td>(1 DAY)</td>
<td>1.33</td>
</tr>
<tr>
<td>IMPACT</td>
<td>(2 SECONDS)</td>
<td>2.0</td>
</tr>
</tbody>
</table>

NOTES:

A. CHECK ALL CODE REQUIRED LOAD COMBINATIONS.

B. SELECT LDF ASSOCIATED WITH THE SHORTEST DURATION IN THE COMBINATION OF LOADS.

C. THE CRITICAL COMBINATION OF LOADS IS THE ONE THAT REQUIRES THE LARGEST SIZE STRUCTURAL MEMBER.

LOAD DURATION FACTOR TO BE USED?

? [ 1 ]

The load duration factor was given as 1.0. Therefore, 1 is entered.

The Selection Menu is displayed.
SELECTION MENU
----------------------------------------
AXIAL TENSION MEMBER DESIGN 1
COLUMN DESIGN 2
COMBINED BENDING AND TENSION MEMBER DESIGN 3
COMBINED BENDING AND COMPRESSION DESIGN 4
BEAM-COLUMN DESIGN 5
BEAM DESIGN (USER DEFINED STRESSES 6
RETURN TO SYSTEM 7
----------------------------------------
YOUR SELECTION ?
? [ 2 ]

Since this is a column design, 2 is entered.

The Column Member Selection subroutine is entered. The Input Design Parameters menu is displayed.

COLUMN MEMBER SELECTION SUBROUTINE
INPUT DESIGN PARAMETERS :
AXIAL LOAD, LBS : ? [ 14000 ]
UNBRACED LENGTH (ABOUT X AXIS), FEET : ? [ 10 ]
UNBRACED LENGTH (ABOUT Y AXIS), FEET : ? [ 10 ]
IS SIDESWAY PREVENTED IN THE X-X DIRECTION ? (Y/N) ? [ Y ]
IS SIDESWAY PREVENTED IN THE Y-Y DIRECTION ? (Y/N) ? [ Y ]
Input design parameters were given as 14000 pounds load, unbraced length of 10 feet, and is sideway pinned in both X-X and Y-Y directions.

The X-X direction menu is displayed.

X - X DIRECTION, SIDESWAY PREVENTED
SELECT COLUMN END CONDITIONS
-----------------------------------------
TOP - BOTTOM END CONDITION
FIXED - FIXED .................... 1
PINNED- FIXED .................... 2
PINNED- PINNED .................... 3
-----------------------------------------
YOUR SELECTION ?  ? [ 3 ]

Selection #3 is entered. The Y-Y direction menu is then displayed.
Y - Y DIRECTION, SIDESWAY PREVENTED
SELECT COLUMN END CONDITIONS
----------------------------------------

TOP - BOTTOM END CONDITION

FIXED - FIXED .................... 1
PINNED- FIXED ..................... 2
PINNED- PINNED ..................... 3

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

YOUR SELECTION ?  ? [ 3 ]

Selection #3 is entered. The first appropriate member size is selected and displayed.

EFF. LENGTH X DIR. = 10
EFF. LENGTH Y DIR. = 10

MEMBER SELECTED IS 4 X 10

DO YOU WANT TO SELECT ANOTHER MEMBER ? (Y/N)
? [ Y ]

MEMBER SELECTED IS 4 X 12

DO YOU WANT TO SELECT ANOTHER MEMBER ? (Y/N)
? [ N ]

The first member size was rejected. The second size was selected.

With the acceptance of a member size, the analysis and design data are displayed.
AXIAL LOAD = 14000 lbs
LOAD DURATION FACTOR = 1
CONDITION OF USE FACTOR = 1
SIDESWAY PREVENTED IN X DIRECTION ?: Y
SIDESWAY PREVENTED IN Y DIRECTION ?: Y
UNBRACED LENGTH IN THE X-DIRECTION: 10 FEET
UNBRACED LENGTH IN THE Y-DIRECTION: 10 FEET
LUMBER SPECIES DOUGFIR
COMMERCIAL GRADE NO. 1
SIZE CLASSIFICATION LIGHT FRAMING -5 INCHES AND WIDER
TYPE 'R' AND HIT RETURN KEY WHEN READY TO CONTINUE.
? [ R ]
TABULATED STRESS:
FC = 125 PSI
E = 1.80000E+6 PSI

ALLOWABLE DESIGN STRESS:
EFFECTIVE LENGTH, X DIR. = 10 FEET
EFFECTIVE LENGTH, Y DIR. = 10 FEET
MAXIMUM L/D RATIO = 34.2857
K = 25.4627
SLENDERNESS CLASSIFICATION: LONG COLUMN
FC(ADJUSTED) = 459.375

TYPE 'R' AND HIT RETURN KEY WHEN READY TO CONTINUE.
? [ R ]
MEMBER SELECTED 4 X 12

MEMBER PROPERTIES:

ACTUAL DIMENSIONS 3.5 INCHES X 11.25 inches

AREA = 39.375 inches^2

WEIGHT = 10.9375 lbs/ft

BOARD FEET OF LUMBER PER LINEAR FOOT: 4 board-feet/lin. ft

MEMBER STRESS:

FC = AXIAL LOAD / AREA

FC = 14000 / 39.375 PSI

MAXIMUM AXIAL LOAD = FC(ADJUSTED) X AREA

MAXIMUM AXIAL LOAD = 459.375 X 39.375 = 18087.9 LBS

TYPE 'R' AND HIT RETURN KEY WHEN READY TO CONTINUE.

? [ R ]

The printing request is displayed.

DO YOU WANT A HARD COPY ?, (Y OR N); IF 'Y' TURN PRINTER ON

?

DO YOU WANT TO RECYCLE THROUGH THE PROGRAM AGAIN ?, (Y OR N)

?
Sample No. 3 Combined Bending and Tension Design

Design a bending tension member that has an axial load of 10,000 lbs and a maximum bending moment of 1250 ft-lbs. There is a line of 3/4 inch bolts at each end of the beam column. Use a condition of use factor and a load duration factor of 1.0. Use Douglas Fir, light framing -5 inches and wider, No.1 lumber.

Since the first steps are identical to Problem No. 1, they are not duplicated here. See the introductory paragraph of Sample Problems.

The Selection Menu menu is displayed.

SELECTION MENU

------------------------------------------
AXIAL TENSION MEMBER DESIGN 1
COLUMN DESIGN 2
COMBINED BENDING AND TENSION MEMBER DESIGN 3
COMBINED BENDING AND COMPRESSION DESIGN 4
BEAM DESIGN (USER DEFINED STRESSES) 5
RETURN TO SYSTEM 6
------------------------------------------

YOUR SELECTION ?
? [ 3 ]

Since this sample uses the Combined Bending and Tension Member Design, (3) is entered.
The Combined Bending & Tension Member Selection subroutine is entered. The Input Design Parameters is the first menu of this subroutine.

COMBINED BENDING & TENSION MEMBER SELECTION SUBROUTINE

INPUT DESIGN PARAMETERS:

AXIAL LOAD, LBS: ? [10000]

MAXIMUM MOMENT, FT-LBS: ? [1250]

IS THERE A BOLT HOLE? (Y): ? [Y]

WHAT IS THE DIAMETER OF THE BOLT HOLE?, INCHES

? [.75]

DOES THIS INCLUDE 1/8 INCH OVERSIZE? (Y/N)? [Y]

The input design parameters were defined as 10000 pounds load, maximum bending moment of 1250 ft-lbs., and a 3/4 inch bolt hole that is oversized.

The first appropriate member size is selected and displayed along with the interaction formula.

MEMBER SELECTED IS 2 X 12

FB/FB + FT/FT <= 1.0

.316049 + .592593 = .908642 <= 1

DO YOU WANT TO SELECT ANOTHER MEMBER? (Y/N)
MEMBER SELECTED IS 2 X 14

FB/FB + FT/FT <= 1.0

.227839 + .503145 = .730984 <= 1

DO YOU WANT TO SELECT ANOTHER MEMBER? (Y/N)

? [ N ]

The member is first rejected. The second size is accepted.

With the selection of a member size, the analysis and design data is displayed.

-------------------------------- INPUT DATA --------------------------------

AXIAL LOAD = 10000 lbs
MAXIMUM MOMENT = 1250 FT-LBS
LOAD DURATION FACTOR = 1
CONDITION OF USE FACTOR = 1
BOLT HOLE DIAMETER, (INCLUDING 1/8 INCH OVERSIZE) = .75 INCHES
LUMBER SPECIES DOUGFIR
COMMERCIAL GRADE NO.1
SIZE CLASSIFICATION LIGHT FRAMING -5 INCHES AND WIDER
REPETITIVE MEMBER? NO

TYPE 'R' AND HIT RETURN KEY WHEN READY TO CONTINUE.

? [ R ]
TABULATED STRESS:
FT = 1000 PSI
FB = 1500 PSI

ALLOWABLE DESIGN STRESS:
FT = (tab FT) \times \text{LDF} \times \text{CUF}
FT(adjusted) = 1500 \times 1 \times 1 = 150 PSI
REQUID AREA = AXIAL LOAD / FT(adjusted)
AREQ = 10000 / 1000 = 10 \text{ inches}^2
GROSS AREA REQUIRED = AREQ + (B \times \text{DIA(including 1/8 inch oversize)})
GROSS AREA REQUIRED = 10 + (2 \times .75) = 11.125 \text{ inches}^2

TYPE 'R' AND HIT RETURN KEY WHEN READY TO CONTINUE.

? [ R ]
MEMBER SELECTED 2 X 14

MEMBER PROPERTIES:

ACTUAL DIMENSIONS 1.5 INCHES X 13.25 inches

AREA = 43.8906 inches^2

WEIGHT = 5.52083 lbs/ft

BOARD FEET OF LUMBER PER LINEAR FOOT: 2.333333 board-feet/lin. ft

MEMBER STRESS:

FT = 503.145 PSI

FB = 341.759 PSI

TYPE 'R' AND HIT RETURN KEY WHEN READY TO CONTINUE.

? [ R ]

Finally, the user is allowed to make a hard copy of the analysis and design data.

DO YOU WANT A HARD COPY ?, (Y OR N); IF 'Y' TURN PRINTER ON

?

DO YOU WANT TO RECYCLE THROUGH THE PROGRAM AGAIN ?, (Y OR N)

?
Sample No. 4 Combined Bending And Compression Design

Design a beam column that has an axial load of 5,000 lbs and a maximum bending moment of 12000 ft-lbs. This member has a maximum shear of 10000 lbs. It is 20 feet long and is pinned at both ends. Sidesway is prevented in both directions. Use a condition of use factor and a load duration factor of 1.0. Use Douglas Fir, light framing -5 inches and wider, No.1 lumber for initial sizing.

Since the first steps are identical to Problem No. 1, they are not duplicated here. See the introductory paragraph of Sample Problems.

The Selection Menu menu is displayed.

SELECTION MENU

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

1  AXIAL TENSION MEMBER DESIGN
2  COLUMN DESIGN
3  COMBINED BENDING AND TENSION MEMBER DESIGN
4  COMBINED BENDING AND COMPRESSION DESIGN
5  BEAM DESIGN (USER DEFINED STRESSES
6  RETURN TO SYSTEM

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

YOUR SELECTION ?

? [ 4 ]
The problem is a combined bending and compression design problem, therefore 4 is entered.

The Combined Bending and Compression Design subroutine is entered.

COMBINED BENDING AND COMPRESSION DESIGN

INPUT MAXIMUM MOMENT (FT-LBS) ? [ 12000 ]
INPUT MAXIMUM SHEAR (LBS) ? [ 10000 ]
AXIAL LOAD, LBS : ? [ 5000 ]

UNBRACED LENGTH (ABOUT X AXIS), FEET : ? [ 20 ]
UNBRACED LENGTH (ABOUT Y AXIS), FEET : ? [ 20 ]
IS SIDESWAY PREVENTED IN THE X-X DIRECTION ? (Y/N) ? [ Y ]
IS SIDESWAY PREVENTED IN THE Y-Y DIRECTION ? (Y/N) ? [ Y ]

The input parameters were defined as maximum bending moment of 12000 pounds, maximum load of 5000 pounds, maximum shear of 10000 pounds, length of 20 feet, pinned at both ends, and sidesway prevented in both X-X and Y-Y directions.
The first appropriate member size is displayed next.
EFF. LENGTH X DIR. = 20
EFF. LENGTH Y DIR. = 20
MEMBER SELECTED IS 6 X 16
FB/(FB-J*FC) + FC/FC <= 1.0
.45869 + .413627 = .872317 <= 1
DO YOU WANT TO SELECT ANOTHER MEMBER ? (Y/N)
? [ Y ]
MEMBER SELECTED IS 6 X 18
FB/(FB-J*FC) + FC/FC <= 1.0
.360812 + .366355 = .727167 <= 1
DO YOU WANT TO SELECT ANOTHER MEMBER ? (Y/N)
? [ N ]

The first member size is rejected. The second size offered is accepted.

The analysis and design data is now displayed.
LOAD DURATION FACTOR = 1
CONDITION OF USE FACTOR = 1
MAXIMUM MOMENT = 12000 FT-LBS
MAXIMUM SHEAR = 5000 LBS
AXIAL LOAD = 10000 LBS
LUMBER SPECIES DOUGFIR
COMMERCIAL GRADE NO.1
SIZE CLASSIFICATION LIGHT FRAMING -5 INCHES AND WIDER

TYPE 'R' AND HIT RETURN KEY WHEN READY TO CONTINUE.
--- OUTPUT DATA ---

TABULATED STRESS:
FB = 1500 PSI  FV = 95 PSI
FCL = 625 PSI  E = 1.80000E+6 PSI
FC = 1250 PSI

SIDESWAY PREVENTED IN X DIRECTION ?: y
SIDESWAY PREVENTED IN Y DIRECTION ?: y
UNBRACED LENGTH IN THE X -DIRECTION ?: 20 FEET
UNBRACED LENGTH IN THE Y -DIRECTION ?: 20 FEET

ALLOWABLE DESIGN STRESS:
FB = (TAB FB) X LDF X CUF X CF
FB(ADJUSTED FOR SIZE FACTOR) = 1500 X 1 X 1 X .958945 = 1438.42

EFFECTIVE LENGTH, X DIR. = 20 FEET
EFFECTIVE LENGTH, Y DIR. = 20 FEET
MAXIMUM L/D RATIO = 43.6364
K = 25.4627

SLENDERNESS CLASSIFICATION: LONG COLUMN
FC(ADJUSTED) = 283.594

TYPE 'R' AND HIT RETURN KEY WHEN READY TO CONTINUE.
? [ R ]
\[ FV = (\text{TAB FV}) \times \text{LDF} \]
\[ FV = 95 \times 1 = 95 \text{ PSI} \]

\[ FCL = (\text{TAB FCL}) \times \text{LDF} \]
\[ FCL = 625 \times 1 = 625 \text{ PSI} \]

*TYPE 'R' AND HIT RETURN KEY WHEN READY TO CONTINUE.*

? [ R ]
DESIGN LOADS:

MAXIMUM MOMENT = 12000 FT-LBS

SHEAR = 5000 LBS

AXIAL LOAD = 10000 LBS

REQUIRED SECTION MODULUS = M(MAX)/FB(ADJ.)

SREQ. = 12000 / 1438.42 X 12 = 100.11 INCHES^3

REQUIRED AREA = 1.5 V(MAX) / FV(ADJUSTED)

AREQ = 1.5 X 5000 / 95 = 78.9474

FB/(FB-J*FC) + FC/FC <= 1.0

512.95 / (1438.42 - .161335 * 103.896) + 103.896 / 283.594 =

.727167

<= 1.0

.360812 + .366355 = .727167 <= 1.0

TYPE 'R' AND HIT RETURN KEY WHEN READY TO CONTINUE.

? [ R ]
MEMBER SELECTED 6 X 18

MEMBER PROPERTIES:

ACTUAL DIMENSIONS 5.5 INCHES X 17.5 inches

SECTION MODULUS = 280.729

AREA = 96.25 inches^2

WEIGHT = 26.7361 lbs/ft

BOARD FEET OF LUMBER PER LINEAR FOOT: 9 board-feet/lin. ft

REQUIRED BEARING LENGTH = V(MAX)/(FCL(ADJ.) X B)

REQUIRED BEARING LENGTH = 5000 / ( 625 X 5.5 ) = 1.45455 INCHES

MEMBER STRESS:

FB = 512.95 PSI

FV = 77.9221 PSI

FC = 103.896 PSI

TYPE 'R' AND HIT RETURN KEY WHEN READY TO CONTINUE.

? [ R ]

Finally, the program allows the user to make a hardcopy of the design and analysis data.
Problem No. 5  Beam Design (User Defined Stresses)

Design a beam having a maximum shear of 15,000 lbs and a maximum bending moment of 30000 ft-lbs. Use a condition of use factor and a load duration factor of 1.0. Use Douglas Fir, light framing -5 inches and wider, No.1 lumber stresses.

Since the first steps are identical to Problem No. 1, they are not duplicated here. See the introductory paragraph of Sample Problems.

The Selection Menu menu is displayed.
Option 5 is selected.

The Beam Selection subroutine is entered. The Input Data menu is displayed.

BEAM SELECTION SUBROUTINE

INPUT MAXIMUM MOMENT, FT-LBS
? [ 30000 ]

INPUT MAXIMUM SHEAR, LBS
? [ 15000 ]

Maximum moment was given as 30000 ft-lbs.; maximum shear was given as 15000 pounds. The first appropriate member size is displayed.
MEMBER SELECTED IS 12 X 20

DO YOU WANT TO SELECT ANOTHER MEMBER? (Y/N)

? [ Y ]

MEMBER SELECTED IS 12 X 22

DO YOU WANT TO SELECT ANOTHER MEMBER? (Y/N)

? [ N ]

The first appropriate member size was rejected. The next size is accepted.

The analysis and design data is displayed.

------------------------ INPUT DATA ------------------------

LOAD DURATION FACTOR = 1
CONDITION OF USE FACTOR = 1
MAXIMUM MOMENT = 30000 FT-LBS
MAXIMUM SHEAR = 15000 LBS
LUMBER SPECIES DOUGFIR
COMMERCIAL GRADE NO.1
SIZE CLASSIFICATION LIGHT FRAMING -5 INCHES AND WIDER
REPETITIVE MEMBER? NO

TYPE 'R' AND HIT RETURN KEY WHEN READY TO CONTINUE.

? [ R ]
TABULATED STRESS:

FB = 1500 PSI  \quad FV = 95 PSI
FCL = 625 PSI  \quad E = 1.80000E+6 PSI

ALLOWABLE DESIGN STRESS:

FB = (TAB FB) X LDF X CUF X CF

FB(ADJUSTED FOR SIZE FACTOR) = 1500 X 1 X 1 X .93726 = 1405.89

FB(ADJUSTED FOR LATERAL STABILITY) = 1500 PSI

LATERAL STABILITY FACTORS:

CS = 0  \quad CK = 0

LATERAL STABILITY CLASSIFICATION: SHORT UNBRACED BEAM

TYPE 'R' AND HIT RETURN KEY WHEN READY TO CONTINUE.

? [ R ]

FV = (TAB FV) X LDF

FV = 95 X 1 = 95 PSI

FCL = (TAB FCL) X LDF

FCL = 625 X 1 = 625 PSI

TYPE 'R' AND HIT RETURN KEY WHEN READY TO CONTINUE.
DESIGN LOADS:
M(MAX) = 30000 FT-LBS
V(MAX) = 15000 LBS

REQUIRED SECTION MODULUS = M(MAX)/FB(ADJ.)
SREQ. = 30000 / 1405.89 X 12 = 256.065 INCHES^3

REQUIRED AREA = 1.5 V(MAX) / FV(ADJUSTED)
AREQ = 1.5 X 15000 / 95 = 236.842 INCHES^2

TYPE 'R' AND HIT RETURN KEY WHEN READY TO CONTINUE.

? [ R ]
MEMBER SELECTED 12 X 22

MEMBER PROPERTIES:

ACTUAL DIMENSIONS 11.5 INCHES X 21.5 inches

SECTION MODULUS = 885.979

AREA = 247.25 inches^2

INERTIA = 9524.28 INCHES^4

WEIGHT = 68.6806 lbs/ft

BOARD FEET OF LUMBER PER LINEAR FOOT: 22 board-feet/lin. ft

REQUIRED BEARING LENGTH = \( \frac{V(\text{MAX})}{(\text{FCL}(\text{ADJ.}) \times B)} \)

REQUIRED BEARING LENGTH = \( \frac{15000}{(625 \times 11.5)} \) = 2.08696 INCHES

MEMBER STRESS:

FB = 406.33 PSI

FV = 91.001 PSI

TYPE 'R' AND HIT RETURN KEY WHEN READY TO CONTINUE.

? [ R ]

Finally, the program allows the user to make a hardcopy of the design and analysis data.
DO YOU WANT A HARD COPY?, (Y OR N); IF 'Y' TURN PRINTER ON

?

DO YOU WANT TO RECYCLE THROUGH THE PROGRAM AGAIN?, (Y OR N)

?

This concludes the sample problems.
BIBLIOGRAPHY


INTRODUCTION

The following equations are used by the Lumber Design program. The equations are listed according to the type of member that is being designed: Sawn Lumber, Glued-Laminated, or General Sawn Lumber.

SAWN LUMBER EQUATIONS

1. \( Le = 1.92 \times Lu \)
   - Le-effective length
   - Lu - maximum unbraced length

2. \( Ck = \sqrt{0.6 \times \frac{E}{Fb}} \)
   - Ck - division point between long and intermediate unbraced beam lengths.
   - E - modulus of elasticity
   - Fb - tabulated bending stress

3. \( Wtl = Wll + Wdl \)
   - Wtl - total uniform distributed load
   - Wll - uniform live load
   - Wdl - uniform dead load

4. \( Mmax = \frac{Wtl \times L^2}{8} \)
   - Mmax - maximum moment
   - L - span length

5. \( Vmax = \frac{Wtl \times L}{2} \)
   - Vmax - maximum shear

6. \( Fbadj = Fb \times LDF \times CUF \times Cf \)
   - Fbadj - adjusted bending stress (for size factor)
7. \[ Cf = \left( \frac{12}{d} \right)^{1/9} \]

Cf - size factor
d - actual width of beam

8. \[ F_{v \text{adj}} = F_v \times LDF \times CUF \times CF \]

Fv - tabulated shear stress

9. \[ F_{c \text{adj}} = F_{c1} \times LDF \times CUF \times CF \]

Fc1 - tabulated bearing stress

10. \[ S_{req} = \frac{M_{max}}{F_{b \text{adj}}} \]

Sreq - required section modulus

11. \[ I_{req(\text{ll})} = \frac{(5 \times W_{ll} \times L^4)}{384 \times E \times \text{DEF(\text{ll})}} \]

Ireq(\text{ll}) - inertia required for live load deflection
I - inertia provided by member
DEF(\text{ll}) - maximum allowable live deflection

12. \[ I_{req(\text{tl})} = \frac{(5 \times W_{tl} \times L^4)}{384 \times E \times \text{DEF(\text{tl})}} \]

Ireq(\text{tl}) - inertia required for total load deflection
DEF(\text{tl}) - maximum allowable live deflection

13. \[ \text{BEARING} = \frac{V_{\text{max}}}{(F_{c \text{adj}} \times b)} \]

BEARING - required bearing length
b - actual thickness of member

14. \[ \text{Defl(\text{ll})} = \frac{(5 \times W_{ll} \times L^4)}{384 \times E \times I} \]

Defl(\text{ll}) - deflection of member under live load
I - inertia of member

15. \[ \text{Defl(\text{tl})} = \frac{(5 \times W_{tl} \times L^4)}{384 \times E \times I} \]

Defl(\text{tl}) - deflection of member under total load

LDF - load duration factor
CUF - condition of use factor
CF - size factor
GLUED-LAMINATED EQUATIONS

1. $Le = 1.92 \times Lu$
   
   Le - effective length
   Lu - maximum unbraced length

2. $Ck = \text{SQR}(0.6 \times E/ Fb)$
   
   Ck - division point between long and intermediate unbraced beam lengths.
   E - modulus of elasticity
   Fb - tabulated bending stress

3. $Wtl = Wll + Wdl$
   
   Wtl - total uniform distributed load
   Wll - uniform live load
   Wdl - uniform dead load

4. $M_{\text{max}} = (Wtl \times L^2)/8$
   
   $M_{\text{max}}$ - maximum moment
   L - span length

5. $V_{\text{max}} = (Wtl \times L)/2$
   
   $V_{\text{max}}$ - maximum shear

6. $F_{\text{badj}} = Fb \times \text{LDF} \times \text{CUF} \times \text{Cf}$
   
   $F_{\text{badj}}$ - adjusted bending stress (for size factor)
   LDF - load duration factor
   CUF - condition of use factor
   Cf - size factor

7. $Cf = (12 / d)(1/9)$
   
   Cf - size factor
   d - actual width of beam

8. $F_{\text{vadj}} = Fv \times \text{LDF} \times \text{CUF} \times \text{CF}$
   
   $Fv$ - tabulated shear stress

9. $F_{\text{cadj}} = Fc1 \times \text{LDF} \times \text{CUF} \times \text{CF}$
   
   $Fc1$ - tabulated bearing stress

10. $S_{\text{req}} = M_{\text{max}} / F_{\text{badj}}$

   $S_{\text{req}}$ - required section modulus
11. \( I_{\text{req}}(11) = \left( \frac{5 \times W_{11} \times L_4}{384 \times E \times \text{DEF}(11)} \right) \)  
   \( I_{\text{req}}(11) \) - inertia required for live load deflection  
   \( I \) - inertia provided by member  
   \( \text{DEF}(11) \) - maximum allowable live deflection

12. \( I_{\text{req}}(t1) = \left( \frac{5 \times W_{t1} \times L_4}{384 \times E \times \text{DEF}(t1)} \right) \)  
   \( I_{\text{req}}(t1) \) - inertia required for total load deflection  
   \( \text{DEF}(t1) \) - maximum allowable live deflection

13. \( \text{BEARING} = \frac{V_{\text{max}}}{(F_{\text{cladj}} \times b)} \)  
   \( \text{BEARING} \) - required bearing length  
   \( b \) - actual thickness of member

14. \( \text{Defl}(11) = \left( \frac{5 \times W_{11} \times L_4}{384 \times E \times I} \right) \)  
   \( \text{Defl}(11) \) - deflection of member under live load  
   \( I \) - inertia of member

15. \( \text{Defl}(t1) = \left( \frac{5 \times W_{t1} \times L_4}{384 \times E \times I} \right) \)  
   \( \text{Defl}(t1) \) - deflection of member under total load

GENERAL SAWN LUMBER EQUATIONS

TENSION MEMBER DESIGN

1. \( FT_{\text{adj}} = FT \times LDF \times CUF \)  
   \( FT_{\text{adj}} \) - adjusted tensile stress  
   \( LDF \) - load duration factor  
   \( CUF \) - condition of use factor

2. \( A_{\text{req}} = \frac{P}{FT_{\text{adj}}} \)  
   \( A_{\text{req}} \) - required area  
   \( P \) - axial load

3. Gross \( A_{\text{req}} = A_{\text{req}} + (b \times ba) \)  
   Gross \( A_{\text{req}} \) - Gross area required
b - thickness of member
ba - bolt hole area including oversizing

COLUMN DESIGN

1. $F_{cs} = FC \times LDF$
   - $F_{cs}$ - short column compression allowable stress
   - FC - tabulated compression stress

2. $F_{ci} = FC \times LDF \times (1-0.3333 \times (L/d)^4)$
   - $F_{ci}$ - intermediate column compression allowable stress
   - $L/d$ - length/ member width

3. $F_{cl} = 0.3 \times 0.3 \times E/(L/d)^2$  
   - $F_{cl}$ - long column compression allowable stress
   - E - modulus of elasticity

4. $K = 0.671 \times \sqrt{E/(FC \times LDF)}$
   - K - division point between intermediate and long column range.

COMBINED BENDING AND TENSION

1. $F_{Tadj} = FT \times LDF \times CUF$
   - $F_{Tadj}$ - adjusted tensile stress

2. $F_{Badj} = FB \times LDF \times CUF$
   - $F_{Badj}$ - adjusted bending stress

3. $fb = M / S$
   - $fb$ - bending stress of member
   - M - maximum moment
   - S - section modulus of member
4. \( ft = \frac{T}{A} \)  

\( ft \) - tensile stress of member  
\( T \) - tensile force  
\( A \) - area of member

5. \( (fb / FBadj) + (ft / FTadj) \leq 1.0 \)  

Interaction Formula

COMBINED BENDING AND COMPRESSION DESIGN

1. \( FBadj = FB \times LDF \times \text{CUR} \)  

\( FBadj \) - adjusted bending stress

2. \( fb = M / S \)  

\( fb \) - bending stress of member

3. \( Fcs = FC \times LDF \)  

\( Fcs \) - short column compression allowable stress

4. \( Fci = FC \times LDF \times (1 - 0.3333 \times (L/d)^4) \)  

\( Fci \) - intermediate column compression allowable stress

5. \( Fcl = 0.3 \times 0.3 \times E/(L/d)^2 \)  

\( Fcl \) - long column compression allowable stress

6. \( K = 0.671 \times \text{SQR}(E/ (FC \times LDF)) \)  

\( K \) - division point between intermediate and long column range.

7. \( fC = P / A \)  

\( fC \) - compressive stress of member  
\( P \) - compressive force  
\( A \) - area of member

8. \( Js = 0 \)  

\( Js \) = p-delta adjustment factor for short column

9. \( Ji = ((L/d)-11) / (K - 11) \)  

\( Ji \) = p-delta adjustment factor for intermediate column

10. \( Jl = 1 \)  

\( Jl \) = p-delta adjustment factor for long column

11. \( (fb / FBadj - (J \times fc)) + (fc / FAdj) \leq 1.0 \)  

Interaction Formula
BEAM DESIGN, USER DEFINED SHEAR AND MOMENT

1. \( F_{badj} = F_b \times \text{LDF} \times \text{CUF} \times \text{Cf} \)
   - \( F_{badj} \) - adjusted bending stress (for size factor)
   - \( \text{Cf} \) - size factor

2. \( \text{Cf} = \left( \frac{12}{d} \right) \left( \frac{1}{9} \right) \)
   - \( \text{Cf} \) - size factor
   - \( d \) - actual width of beam

3. \( F_{vadj} = F_v \times \text{LDF} \times \text{CUF} \times \text{CF} \)
   - \( F_v \) - tabulated shear stress

4. \( F_{cadj} = F_{cl} \times \text{LDF} \times \text{CUF} \times \text{CF} \)
   - \( F_{cl} \) - tabulated bearing stress

5. \( S_{req} = M_{max} / F_{adj} \)
   - \( S_{req} \) - required section modulus

6. \( \text{BEARING} = V_{max} / (F_{cadj} \times b) \)
   - \( \text{BEARING} \) - required bearing length
   - \( b \) - actual thickness of member

7. \( f_b = M / S \)
   - \( f_b \) - bending stress of member
   - \( M \) - maximum moment
   - \( S \) - section modulus of member

8. \( S_{req} = 1.5 \times V / F_{vadj} \)
   - \( S_{req} \) - required area
   - \( V \) - maximum shear
Program Listing

.PROC,TIMBER*I.
GET,SRT,DOUGFIR,REDWOOD,STHPINE.
GET,GLULAM,GLUBEA1.
GET,SPROP.
BASIC,I=SRT.
REVERT,NOLIST.
00090 GOSUB 00300
00100
00110 PRINT " TIMBER ENGINEERING LIBRARY"
00120 PRINT " BEAM DESIGN MENU"
00130 PRINT "LUMBER MEMBER DESIGN

00140 PRINT "GLU-LAM MEMBER DESIGN

00150 PRINT "RETURN TO SYSTEM"

00160 PRINT "YOUR SELECTION ? "
00170 INPUT S2
00180 FOR Q=1 TO 25
00190 NEXT Q
00200 RETURN
00210 GOSUB 00300
00220 PRINT " TIMBER ENGINEERING LIBRARY"
00230 PRINT " MASTER MENU "
00240 PRINT "LUMBER MEMBER DESIGN

00250 PRINT "GLU-LAM MEMBER DESIGN

00260 STOP
00270 REM CLEAR SCREEN
00280 FOR Q=1 TO 25
00290 PRINT
00300 NEXT Q
00310 RETURN
00320 GOSUB 00300
"00170 PRINT
00180 PRINT "RETURN TO SYSTEM
------------------------------------------------------------------"

00210 PRINT "YOUR SELECTION ?"
00220 INPUT S2
00230 ON S2 GOTO 00240,00250,00260
00240 CHAIN"MENU99"
00250 CHAIN"GMENU99"
00260 STOP
00300 REM CLEAR SCREEN
00310 FOR Q=1 TO 25
00320 PRINT
00330 NEXT Q
00340 RETURN
00090 GOSUB 01000
00100 REM -- TIMBER ENGINEERING MENU --
00110 REM LABEL MENU
00115 FILE#1="DUMMY1"
00120 PRINT "-- LUMBER SELECTION MENU --"
00130 PRINT"
00140 PRINT "LUMBER SPECIES INPUT ###"
00150 PRINT "------------------------------------------------------------------"
00160 PRINT "DOUGLAS-FIR  LARCH  SOUTHERN PINE  CALIFORNIA REDWOOD  USER DEFINED ALLOWABLE STRESSES  END PROGRAM"
00170 PRINT "------------------------------------------------------------------"

00180 PRINT"DOUGLAS-FIR LARCH  1  "
00190 PRINT"SOUTHERN PINE  2  "
00200 PRINT"CALIFORNIA REDWOOD  3  "
00205 PRINT"USER DEFINED ALLOWABLE STRESSES  4  "
00210 PRINT"END PROGRAM  5  "
00220 PRINT"
00230 PRINT
00240 PRINT "YOUR SELECTION 
00250 INPUT G
00260 ON G GOTO 00280,00340,00400,00800,00460
00280 REM -- DOUGLAS-FIR LARCH SUBROUTINE --
00290 L1$="DOUGFIR"
00300 WRITE#1,L1$
00310 CLOSE#1
00320 CHAIN "LSEL"
00330 GOTO 00460
00340 REM -- SOUTHERN PINE SUBROUTINE --
00350 L1$="STHPINE"
00360 WRITE#1,L1$
00370 CLOSE#1
00380 CHAIN "LSEL"
00390 GOTO 00460
00400 REM -- CALIFORNIA REDWOOD SUBROUTINE --
00410 L1$="REDWOOD"
00420 WRITE#1,L1$
00430 CLOSE#1
00440 CHAIN "LSEL"
00450 GOTO 00460
00460 STOP
00800 REM USER DEFINED ALLOWABLE STRESSES
00810 CLOSE#1
00820 FILE#1="DUMMY"
00830 L1$="USER DEFINED ALLOWABLE STRESSES"
00840 G1$="USER DEFINED"
00850 C2$="USER DEFINED"
00855 A3$="USER DEFINED"
00860 GOSUB 1000
00870 PRINT"INPUT ALLOWABLE STRESSES FOR THE FOLLOWING: "
00880 PRINT
00890 PRINT
00900 PRINT"INPUT ALLOWABLE BENDING STRESS: ",TAB(50);
00910 INPUT F8
00920 PRINT"INPUT ALLOWABLE SHEAR STRESS: ",TAB(50);
00930 INPUT F5
00940 PRINT"INPUT ALLOWABLE BEARING STRESS: ",TAB(50);
00950 INPUT F4
00960 PRINT"INPUT MODULUS OF ELASTICITY: ",TAB(50);
00970 INPUT E
00975 Z1=0
00980 Z2=0
00981 WRITE#1,L1$
00982 WRITE#1,G1$
00983 WRITE#1,C2$
00984 WRITE#1,F8
00985 WRITE#1,Z1
00986 WRITE#1,F5.
00987 WRITE#1,F4
00988 WRITE#1,Z2
00989 WRITE#1,E
00990 WRITE#1,A3$
00991 CLOSE#1
00995 STOP
01000 REM CLEAR SCREEN
01010 FOR Q = 1 TO 25
01020 PRINT
01030 NEXT Q
01040 RETURN
00990 GOSUB 01000
00100 REM -- TIMBER ENGINEERING MENU --
00110 REM LABEL MENU
00115 FILE#1="DUMMY99"
00120 PRINT "-- LUMBER SELECTION MENU --"
00130 PRINT
00140 PRINT"LUMBER SPECIES INPUT ###
00150 PRINT"---------------------------------------------------------
00160 PRINT
00170 PRINT"DOUGLAS-FIR LARCH
00180 PRINT"...
PRINT "SOUTHERN PINE"
PRINT "CALIFORNIA REDWOOD"
PRINT "END PROGRAM"
PRINT "YOUR SELECTION "
INPUT G
ON G GOTO 00280,00340,00400,00460
REM -- DOUGLAS-FIR LARCH SUBROUTINE --
L1$="DOUGFIR"
WRITE#1,L1$
CLOSE#1
CHAIN "LSEL99"
GOTO 00460
REM -- SOUTHERN PINE SUBROUTINE --
L1$="STHPINE"
WRITE#1,L1$
CLOSE#1
CHAIN "LSEL99"
GOTO 00460
REM -- CALIFORNIA REDWOOD SUBROUTINE --
L1$="REDWOOD"
WRITE#1,L1$
CLOSE#1
CHAIN "LSEL99"
GOTO 00460
STOP
REM CLEAR SCREEN
FOR Q = 1 TO 25
PRINT NEXT Q
RETURN
FILE#1="DUMMY1"
READ#1,L1$
CLOSE#1
REM -- THIS IS THE LUMBER SELECTION ROUTINE --
REM -- THIS IS A FILE CALLED LSEL --
FILE#1=L1$
RESTORE #1
DIM A$(99),B$(99),C(99),D(99),E1(99),F(99),G(99),H(99),I(99)
FOR J=1 TO 99
INPUT#1,A$(J)
IF A$(J)="END" THEN 00280
INPUT#1,B$(J)
INPUT#1,C(J)
INPUT#1,D(J)
INPUT#1,E1(J)
INPUT#1,F(J)
INPUT#1,G(J)
INPUT#1,H(J)
INPUT#1,I(J)
NEXT J
E9=J-1
GOSUB 00980
00290 PRINT " -- SIZE CLASSIFICATION SELECTION MENU -- "
00300 PRINT
00310 K=1
00320 PRINT
""
00330 PRINT "SIZE CLASSIFICATION INPUT ###"
"
00340 PRINT "----------------------------------------------"
00350 PRINT
00360 FOR J=1 TO E9
00370 IF B$(J) <> B$(J-1) THEN 00860
00380 NEXT J
00390 PRINT "USAGE DECRPTION SELECTION"
00400 INPUT A7
00410 GOSUB 00980
00420 PRINT "-- COMMERCIAL GRADE SELECTION MENU --"
00430 PRINT
00440 K=1
00450 PRINT
""
00460 PRINT "LUMBER GRADE INPUT ###"
"
00470 PRINT "----------------------------------------------"
00480 PRINT
00490 FOR J=1 TO E9
00500 IF B$(J) = S4$(A7) THEN 00900
00510 NEXT J
00520 PRINT "LUMBER GRADE SELECTION"
00530 INPUT A5
00540 X=S3(A5)
00550 G1$=A$(X)
00560 C2$=B$(X)
00570 H2=C(X)
00580 H1=D(X)
00590 Z1=E1(X)
00600 F5=F(X)
00610 F4=G(X)
00620 Z2=H(X)
00630 E=I(X)
00640 IF H1=0 THEN FS=H2
00650 IF H1=0 THEN 00720
00660 PRINT"DOES THIS MEMBER QUALIFY AS A REPETITIVE MEMBER, (Y/N)? "
00670 INPUT A3$
00680 IF A3$="Y" THEN FS=H1
00690 IF A3$="Y" THEN A3$="YES"
00700 IF A3$="N" THEN FS=H2
00710 IF A3$="N" THEN A3$="NO"
00720 IF A3$="" THEN 00950
00730 CLOSE #1
00740 FILE#1="DUMMY"
00742 WRITE#1,L1$
00745 WRITE#1,G1$
00760 WRITE#1,C2$
00770 WRITE#1,F8$
00780 WRITE#1,Z1$
00790 WRITE#1,F5$
00800 WRITE#1,F4$
00810 WRITE#1,Z2$
00820 WRITE#1,E$
00830 WRITE#1,A3$
00840 CLOSE#1
00850 CHAIN "BEAM"
00860 S4$(K)=B$(J)
00870 PRINT B$(J),TAB(59);K
00880 K=K + 1
00890 GOTO 00380
00900 PRINT A$(J),TAB(59);K
00910 S3(K)=J
00920 K=K+1
00930 GOTO 00510
00940 STOP
00950 A3$="NOT ELIGIBLE AS A REPETITIVE MEMBER"
00960 GOTO 00730
00970 STOP
00980 REM CLEAR SCREEN
00990 FOR Q=1 TO 25
01000 PRINT
01010 NEXT Q
01020 RETURN
01030 FILE#1="DUMMY99"
01040 CLOSE#1
01050 REM -- THIS IS THE LUMBER SELECTION ROUTINE --
01060 REM -- THIS IS A FILE CALLED LSEL --
01070 FILE#1=L1$
01080 RESTORE #1
01090 DIM A$(99),B$(99),C(99),D(99),E1(99),F(99),G(99),H(99),I(99)
01100 FOR J=1 TO 99
01110 INPUT#1,A$(J)
01115 IF A$(J)="END" THEN 00280
01120 INPUT#1,B$(J)
01125 INPUT#1,C(J)
01130 INPUT#1,D(J)
01135 INPUT#1,E1(J)
01140 INPUT#1,F(J)
01145 INPUT#1,G(J)
01150 INPUT#1,H(J)
01155 INPUT#1,I(J)
01160 NEXT J
01165 E9=J-1
01170 GOSUB 00980
01175 IF A$(J)="END" THEN 00280
01180 INPUT#1,A$(J)
01190 INPUT#1,B$(J)
01200 INPUT#1,C(J)
01210 INPUT#1,D(J)
01215 INPUT#1,E1(J)
01220 INPUT#1,F(J)
01225 INPUT#1,G(J)
01230 INPUT#1,H(J)
01235 INPUT#1,I(J)
01240 NEXT J
01245 E9=J-1
01250 GOSUB 00980
01255 PRINT " -- SIZE CLASSIFICATION SELECTION MENU -- "
01260 PRINT
01270 K=1
00320 PRINT
" "
00330 PRINT "SIZE CLASSIFICATION INPUT"
###
""
00340 PRINT
""-------------------------------------------------------------------"
00350 PRINT
00360 FOR J=1 TO E9
00370 IF BS(J) < > BS(J-1) THEN 00860
00380 NEXT J
00390 PRINT "USAGE DESCRIPTION SELECTION "
00400 INPUT A7
00410 GOSUB 00980
00420 PRINT " -- COMMERCIAL GRADE SELECTION MENU -- "
00430 PRINT
00440 K=1
00450 PRINT
K=1
00460 PRINT "LUMBER GRADE SELECTION "
00470 INPUT A5
00480 PRINT
00490 FOR J=1 TO E9
00500 IF BS(J) = S4$(A7) THEN 00900
00510 NEXT J
00520 PRINT "LUMBER GRADE SELECTION "
00530 INPUT A5
00540 X=S3(A5)
00550 G1$=A$2(X)
00560 C2$=B$(X)
00570 H2=C(X)
00580 H1=D(X)
00590 Z1=E1(X)
00600 F5=F(X)
00610 F4=G(X)
00620 Z2=H(X)
00630 E=I(X)
00640 IF H1=0 THEN F8=H2
00650 IF H1=0 THEN 00720
00660 PRINT"DOES THIS MEMBER QUALIFY AS A REPETITIVE MEMBER, (Y/N)? "
00670 INPUT A3$
00680 IF A3$="Y" THEN F8=H1
00690 IF A3$="Y" THEN A3$="YES"
00700 IF A3$="N" THEN F8=H2
00710 IF A3$="N" THEN A3$="NO"
00720 IF A3$="" THEN 00950
00730 CLOSE #1
00740 FILE#1="DUMMY9"
00750 WRITE#1,L1$
00760 WRITE#1,G1$
00770 WRITE#1,C2$
00770 WRITE#1,F8
00780 WRITE#1,F5
00790 WRITE#1,F4
00800 WRITE#1,Z2
00810 WRITE#1,Z1
00820 WRITE#1,F5
00830 WRITE#1,E
00840 CLOSE#1
00850 CHAIN "LDESIGN"
00860 S4$(K)=B$(J)
00870 PRINT B$(J),TAB(59);K
00880 K=K+1
00890 GOTO 00380
00900 PRINT A$(J),TAB(59);K
00910 S3(K)=J
00920 K=K+1
00930 GOTO 00510
00940 STOP
00950 A3$="NOT ELIGIBLE AS A REPETITIVE MEMBER"
00960 GOTO 00730
00970 STOP
00980 REM CLEAR SCREEN
00990 FOR Q=1 TO 25
01000 PRINT
01010 NEXT Q
01020 RETURN
40 GOSUB 1000
50 FILE#1="DUMMYA"
60 READ#1,G1$,U1$,U2$
70 CLOSE#1
100 REM -- THIS IS THE GLU-LAM LUMBER SELECTION ROUTINE --
110 REM -- THIS IS A FILE CALLED GSEL--
120 DIM G1$(150,4), M(150,13), S3(15)
130 FILE#1="GLUBEA1"
135 RESTORE #1
140 FOR J=1 TO 101
150 INPUT#1,G1$(J,1),G1$(J,2),G1$(J,3),G1$(J,4)
160 INPUT#1,M(J,1),M(J,2),M(J,3),M(J,4),M(J,5),M(J,6),M(J,7),M(J,8)
170 INPUT#1,M(J,9),M(J,10),M(J,11),M(J,12),M(J,13)
180 NEXT J
185 CLOSE#1
190 PRINT " -- GLU-LAM STRESS GRADE SELECTION MENU -- "
200 PRINT
210 K=1
220 PRINT

"-------------------------------------------------------------------"  INPUT
230 PRINT "USAGE DESCRIPTION
###
240 PRINT
"-------------------------------------------------------------------"
250 PRINT
260 FOR J=1 TO 101
270 IF G1$(J,1)=G1$ THEN 480
280 NEXT J
PRINT "GLU-LAM STRESS GRADE SELECTION"
INPUT A7
GOSUB 1000
PRINT " -- LAMINATION SPECIES SELECTION MENU -- "
PRINT
K=1
PRINT
PRINT "SYMBOL SPECIES OUTER /INNER LAM INPUT"

FOR J=1 TO 101
    IF G1$(J,1) < > G1$ THEN 390
    IF G1$(J,2) = S4$(A7) THEN 530
    NEXT J
PRINT "LAMINATION SPECIES SELECTION"
INPUT A5
X=S3(A5)
X1=M(X,1)
X3=M(X,2)
F9=M(X,3)
X4=M(X,4)
X2=M(X,5)
X5=M(X,6)
X6=M(X,7)
X7=M(X,8)
X8=M(X,9)
X9=M(X,10)
Z1=M(X,11)
Z2=M(X,12)
E=M(X,13)
G1$=G1$(X,1)
G2$=G1$(X,2)
G3$=G1$(X,3)
G4$=G1$(X,4)
FILE#1="DUMMYB"
WRITE#1,X1
WRITE#1,X3
WRITE#1,F9
WRITE#1,X4
WRITE#1,X2
WRITE#1,X5
WRITE#1,X6
WRITE#1,X7
WRITE#1,X8
WRITE#1,X9
WRITE#1,Z1
WRITE#1,Z2
WRITE#1,E
WRITE#1,G1$
WRITE#1,G2$
466 WRITE#1,G3$
467 WRITE#1,G4$
468 WRITE#1,U1$
469 WRITE#1,U2$
470 CLOSE#1
471 CHAIN "GLUBEAM"
480 IF G1$(J,2)=G1$(J-1,2) THEN 280
490 S4$(K)=G1$(J,2)
500 PRINT G1$(J,2),TAB(59);K
510 K=K + 1
520 GOTO 280
530 PRINT G1$(J,3),G1$(J,4),TAB(60);K
540 S3(K)=J
550 K=K+1
560 GOTO 390
570 STOP
1000 REM CLEAR SCREEN
1010 FOR Q=1 TO 25
1020 PRINT
1030 NEXT Q
1040 RETURN
00100 FILE#1="DUMMY"
00105 READ#1,L1$
00110 READ#1,G1$,C2$,F8,Z1,F5,F4,Z2,E,A3$
00200 CLOSE#1
00210 REM -- WOOD BEAM DESIGN PROGRAM --
00220 GOSUB 04950
00230 PRINT "--WOOD BEAM DESIGN PROGRAM--"
00240 GOSUB 05010
00250 OPTION BASE 1
00260 DIM B(160), D(160), B1(160), D1(160)
00270 DIM A(160), I(160), S(160), W(160)
00280 FILE#1="SPROP"
00290 RESTORE #1
00300 FOR J=1 TO 160
00310 INPUT #1,B(J),D(J),B1(J),D1(J),A(J),I(J),S(J),W(J)
00320 NEXT J
00330 close #1
00340 PRINT" INPUT DESIGN PARAMETERS : ":
00350 PRINT
00360 N=1
00370 I3=1
00380 PRINT
00390 PRINT "LENGTH, FEET ",TAB(59);"L
00400 INPUT L
00410 PRINT "MAXIMUM UNBRACED LENGTH, FEET ",TAB(59);"L2
00420 INPUT L2
00430 L3=1.92*L2
00440 C4=SQR(.6*E/F8)
00450 F7=F8*2
00460 J=1
00470 Y=1
00480 Z=1
00490 PRINT "CONDITION OF USE FACTOR ",TAB(59);"
00500 INPUT C5
00510 PRINT "DISTRIBUTED LIVE LOAD, LBS/FT ",TAB(59);  
00520 INPUT W1
00530 PRINT "DISTRIBUTED DEAD LOAD, LBS/FT ",TAB(59);  
00540 INPUT W2
00550 GOSUB 04950
00560 W3=W1+W2
00570 GOSUB 04070
00580 GOSUB 04950
00590 GOSUB 04360
00600 GOSUB 04950
00610 GOSUB 03820
00620 GOSUB 04950
00630 REM -- CALCULATIONS --
00640 M=W3*L)/8
00650 V1=W3*L/2
00660 C6=1
00670 REM -- ADJUSTED ALLOWABLE STRESSES --
00680 F3=F8*L1*C5*C6
00690 REM --ASSUME C6 =1 (INITALLY)  
00700 IF F3>F7 THEN F3=F7
00710 F2=F5*L1*C5
00720 F1=F4*L1*C5
00730 REM -- COMPUTE REQUIRED SECTION PROPERTIES --
00740 S1=M/F3*12
00750 A3=1.5*V1/F2
00760 I1=5*W1*(L )*1728/(384*E*D6)
00770 I2=5*W3*(L )*1728/(384*E*D3)
00780 IO=I1
00790 IF IO<I2 THEN IO=I2
00800 REM -- MEMBER SELECTION ROUTINE --
00810 FOR J=I3 TO 160
00820 IF S1 < S(J) THEN 00870
00830 NEXT J
00840 PRINT "MEMBERS IN TABLE ARE NOT ADEQUATE"
00850 PRINT "MEMBERS CANNOT MEET REQUIRED SECTION MODULUS"
00860 STOP
00870 FOR Z=J TO 160
00880 IF A3<=A(Z) THEN 00930
00890 NEXT Z
00900 PRINT "MEMBERS IN TABLE ARE NOT ADEQUATE"
00910 PRINT "MEMBERS CANNOT MEET REQUIRED AREA"
00920 STOP
00930 FOR Y=Z TO 160
00940 IF IO < I(Y) GOTO 01010
00950 NEXT Y
00960 PRINT "MEMBERS IN TABLE ARE NOT ADEQUATE"
00970 PRINT "MEMBERS CANNOT MEET REQUIRED INERTIA"
00980 STOP
00990 IF F7=F6 THEN 01020
01000 PRINT "N=",N
01010 IF N< 3 THEN GOSUB 04660
01020 IF D1(Y)<12 THEN 01070
01030 C2=(12/D1(Y)) 1/9)
01040 IF C2=C6 THEN 01070
01050 C6=C2
01060 GOTO 00680
01070 B0=V1/(F1*B1(Y))
01080 D0=5*W1*(L )*1728/(384*E*I(Y))
01090 D2=5*W3*(L )*1728/(384*E*I(Y))
01100 GOSUB 04900
01110 REM --PRINT RESULTS --
01120 PRINT "MEMBER SELECTED : ";B(Y);" X ";D(Y)
01130 PRINT"DO YOU WANT TO SELECT ANOTHER MEMBER ? (Y/N) "
01140 INPUT IO$
01150 GOSUB 05010
01160 IF IO$="Y" THEN I3=Y+1
01170 IF IO$="Y" THEN N=1
01180 IF IO$="Y" THEN 00810
01190 GOSUB 04950
01200 PRINT
01210 PRINT "-------------------------
-------------------------
01220 PRINT
01230 PRINT "SPAN LENGTH = ";L;" FT"
01240 PRINT "MAX. UNBRACED LENGTH = ";L2;" FT"
01250 PRINT "LOAD DURATION FACTOR = ";L1
01260 PRINT "CONDITION OF USE FACTOR = ";C5
01270 PRINT "UNIFORM DIST. LIVE LOAD = ";W1;" LBS/FT"
01280 PRINT "UNIFORM DIST. DEAD LOAD = ";W2;" LBS/FT"
01290 PRINT "DEFLECTION LIMITATION (LIVE LOAD) = L/";D5
01300 PRINT "DEFLECTION LIMITATION (TOTAL LOAD) = L/";D4
01310 PRINT
01320 PRINT
01330 PRINT "LUMBER SPECIES: ";L1$
01340 PRINT "COMMERICAL GRADE: ";G1$
01350 PRINT "SIZE CLASSIFICATION: ";C2$
01360 PRINT "REPETITIVE MEMBER ?: ";A3$
01370 PRINT
01380 PRINT "TYPE 'R' WHEN READY TO CONTINUE "
01390 INPUT AO$
01400 GOSUB 04950
01410 PRINT "-------------------------
-------------------------
01420 PRINT
01430 PRINT
01440 PRINT
01450 PRINT "TABULATED STRESSES: 
01460 PRINT
01470 PRINT USING 01480,"FB = ";F8;" PSI FV = ";F5;" PSI
01480 :<##### ##### ############## ### ##########
01490 PRINT USING 01500,"FCL = ";F4;" PSI E = ";E;" PSI
01500 :<##### ### ##############
01520 PRINT
01530 PRINT "ALLOWABLE DESIGN STRESSES:"
01540 PRINT
01550 PRINT "FB = (TAB FB) X LDF X CUF X CF"
01560 PRINT USING 01570,"FB(ADJUSTED FOR SIZE FACTOR) = ";F8;" X "
";L1;" X ";C5;" X";C6;" = ";F8*L1*C5*C6
01570 :<#--------------------------------------#--------------------------------------#
#--------------------------------------#--------------------------------------#
01580 PRINT
01590 PRINT "FB(ADJUSTED FOR LATERAL STABILITY) = ";ROF(F7,2);" PSI"
01600 PRINT "LATERAL STABILITY FACTORS: 
01610 PRINT "CS = ";ROF(C3,3),"CK = ";ROF(C4,3)
01620 PRINT "LATERAL STABILITY CLASSIFICATION : ";C1$
01630 PRINT
01640 PRINT "TYPE 'R' WHEN READY TO CONTINUE 
01650 INPUT AO$ 01660 GOSUB 04950
01670 PRINT
01680 PRINT "FV = (TAB FV) X LDF X CUF"
01690 PRINT "FV = ";F5;" X ";L1;" X ";C5;" = ";F2;" PSI 
01700 PRINT
01710 PRINT "FCL = (TAB FCL) X LDF X CUF"
01720 PRINT "FCL = ";F4;" X ";L1;" X ";C5;" = ";F1;" PSI
01730 PRINT
01740 PRINT "DESIGN LOADS: 
01750 PRINT
01760 PRINT "WTL = WLL + WDL 
01770 PRINT "WTL = ";W1;" + ";W2;" = ";W3;" LBS/FT 
01780 PRINT
01790 PRINT "M(MAX) = WTL X (L)) /8 
01800 PRINT "M(MAX) = ";W3;" X (";L;") /8 = ";M;" FT-LBS 
01810 PRINT
01820 PRINT "V(MAX) = WTL X L/2 
01830 PRINT "V(MAX) = ";W3;" X ";L;"/2 = ";V1
01840 PRINT
01850 PRINT "TYPE 'R' WHEN READY TO CONTINUE 
01860 INPUT AO$ 01870 GOSUB 04950
01880 PRINT
01890 PRINT "REQUIRED SELECTION MODULUS = M(MAX)/FB(ADJ.)"
01900 PRINT "SREQ. = (";M;" / ";F3;") X 12 = ";ROF(S1,3);" INCHES•
01910 PRINT
01920 PRINT "MAX DEFLECTION (FOR LIVE LOAD) = L/";D5
01930 PRINT "DEF(LIVE LOAD) = (";L;" / ";D5;") X 12 = ";ROF(D6,3);" INCHES
01940 PRINT
01950 PRINT "MAX DEFLECTION (FOR TOTAL LOAD) = L/";D4
01960 PRINT"DEF(TOTAL LOAD) = (";L;" / ";D4;") X 12 = ";ROF(D3,3);" INCHES
01970 PRINT
01980 PRINT "REQUIRED INERTIA (FOR LIVE LOAD) = 5XWLLX(L) / (384*EXDEFL(LIVE LOAD))"
01990 PRINT "IREQ(FOR LIVE LOAD) = ";F5;" X ";W1;" X (";L;") X 1728 / (384 X
REQUIRED INERTIA (FOR TOTAL LOAD) = \( 5 \times WTL \times L \) / (384 X E X DEF(TOTAL LOAD))

IREQ (FOR TOTAL LOAD) = \( 5 \times \frac{W3 \times L}{1728} \) INCHES

REQUIRED AREA = 1.5 X \( V_{MAX} \) / FV(ADJUSTED) INCHES

AREQ = 1.5 \( \frac{V1}{F2} \) = ROF(A3,3) INCHES

DEFLECTION UNDER LIVE LOAD = \( 5 \times WLL \times L \) / (384 X E X I) INCHES

DEF(UNDER LIVE LOAD) = \( 5 \times \frac{W1 \times L}{1728} \) INCHES

DEFLECTION UNDER TOTAL LOAD = \( 5 \times WTL \times L \) / (384 X E X I) INCHES

DEF(UNDER TOTAL LOAD) = \( 5 \times \frac{W3 \times L}{1728} \) INCHES

REQUIRED BEARING LENGTH = \( \frac{V_{MAX}}{FCL(ADJ.) \times B} \) INCHES

MEMBER SELECTED: \( B(Y), X, D(Y) \)

MEMBER PROPERTIES:

ACTUAL DIMENSIONS: \( B1(Y), X, D1(Y) \) INCHES

SECTION MODULUS = \( S(Y) \) INCHES

INERTIA = \( I(Y) \) INCHES

WEIGHT = \( W(Y) \) LBS/FT

BOARD FEET OF LUMBER PER LINEAR FOOT: \( B(Y) \times D(Y) / 12 \)

DEFLECTION UNDER TOTAL LOAD = \( 5 \times \frac{WTL \times L}{1728} \) INCHES

REQUIRED BEARING LENGTH = \( \frac{V1}{F1 \times B1(Y)} \) INCHES

MEMBER STRESSES:

FB = \( \frac{A9}{PSI} \)

FV = \( \frac{A8}{PSI} \)

TYPE 'R' WHEN READY TO CONTINUE
02400 PRINT
02410 PRINT
02420 PRINT
02430 PRINT "DO YOU WANT A HARD COPY ?, (Y OR N); IF 'Y' TURN PRINTER ON.
"
02440 INPUT A1$
02450 IF A1$="Y" THEN GOSUB 02770
02460 PRINT
02470 PRINT "DO YOU WANT TO RECYCLE THROUGH THE PROGRAM AGAIN ?, (Y OR N)
"
02480 INPUT A1$
02490 IF A1$="Y" THEN GOSUB 02600
02500 STOP
02560 GOSUB 04950
02570 PRINT "--SELECT OPTION--"
02580 PRINT
02590 PRINT "-------------------------------
"
02600 PRINT "INPUT NEW LOADING REQUIREMENTS ........................................ 1"
02640 PRINT "START NEW DESIGN ...................................................... 2"
02650 PRINT
02660 PRINT
02670 PRINT "-------------------------------"
02680 PRINT
02690 PRINT "SELECTION ",
02700 INPUT S2
02710 ON S2 GOTO 02720,02740
02720 GOSUB 04950
02730 GOTO 00340
02740 CHAIN "SRT"
02750 RETURN
02760 STOP
02770 PRINT
02780 PRINT
02790 PRINT "---------------------------
"
02800 PRINT
02810 PRINT
02820 PRINT "SPAN LENGTH = ";L;" FT"
02830 PRINT "MAX. UNBRACED LENGTH = ";L2;" FT"
02840 PRINT "LOAD DURATION FACTOR = ";L1
02850 PRINT "CONDITION OF USE FACTOR = ";C5
02860 PRINT "UNIFORM DIST. LIVE LOAD = ";W1;" LBS/FT"
02870 PRINT "UNIFORM DIST. DEAD LOAD = ";W2;" LBS/FT"
02880 PRINT "DEFLECTION LIMITATION (LIVE LOAD) = L/";D5
02890 PRINT "DEFLECTION LIMITATION (TOTAL LOAD) = L/";D4
02900 PRINT
02910 PRINT "LUMBER SPECIES : ";L1$
02920 PRINT "COMMERICAL GRADE : ";G1$
02930 PRINT "SIZE CLASSIFICATION : ";C2$
02940 PRINT "REPETITIVE MEMBER ? : ";A3$
02950 PRINT
TABULATED STRESSES:

FB = \( F_8 \) PSI,

FCL = \( F_4 \) PSI,

ALLOWABLE DESIGN STRESSES:

\[ FB = (TAB \ FB) \times LDF \times CUF \times CF \]

\[ FV = (TAB \ FV) \times LDF \times CUF \]

\[ FCL = (TAB \ FCL) \times LDF \times CUF \]

DESIGN LOADS:

\[ WTL = WLL + WDL \]

\[ WTL = \left( \frac{W_1}{L} + \frac{W_2}{L} \right) \text{ LBS/FT} \]

\[ M(MAX) = \frac{WTL \times (L)}{8} \]

\[ M(MAX) = \frac{W_3}{(L;\;)} \times (\;L;\;) / 8 = \;M; \text{ FT-LBS} \]

\[ V(MAX) = \frac{W_3 \times L}{2} \]

\[ V(MAX) = \frac{W_3}{(L;\;)/2 = \;V_1; \text{ LBS} \]

\[ SREQ. = \frac{M(MAX)}{FB(ADJ.)} \]

\[ SREQ. = \frac{M; \;F3; \times 12 = \;S1; \text{ INCHES•} \]

\[ \text{MAX DEFLECTION (FOR LIVE LOAD)} = \frac{L}{D_5} \]

\[ \text{MAX DEFLECTION (FOR TOTAL LOAD)} = \frac{L}{D_4} \]

\[ \text{REQUIRED INERTIA (FOR LIVE LOAD)} = \frac{5XWLLX(L)}{(384XEXDEF(LIVE LOAD))} \]
PRINT "IREQ(FOR LIVE LOAD) = \";5;\" X \";W1;\" X (\";L;\") X 1728 / (384 X \";E;\" X \";D6;\") = \";I1;\" INCHES "
03470 PRINT
03480 PRINT "REQUIRED INERTIA (FOR TOTAL LOAD) = 5XWTLX(L) / (384XEEXDEF(TOTAL LOAD))"
03490 PRINT "IREQ(FOR TOTAL LOAD) = \";5;\" X \";W3;\" X (\";L;\") X 1728 / (384 X \";E;\" X \";D3;\") = \";I2;\" INCHES "
03500 PRINT
03510 PRINT "REQUIRED AREA = 1.5 X V(MAX) / FV(ADJUSTED) "
03520 PRINT "AREQ = 1.5 X \";V1;\" / \";F2;\" = \";ROF(A3,3);\" INCHES)"
03530 PRINT
03540 PRINT "MEMBER SELECTED: \";B(Y);\" X \";D(Y)"
03550 PRINT "ACTUAL DIMENSIONS \";B1(Y);\" INCHES X \";D1(Y);\" INCHES"
03560 PRINT "SECTION MODULUS = \";S(Y)"
03570 PRINT "AREA = \";A(Y);\" INCHES"
03580 PRINT "INERTIA = \";I(Y);\" INCHES"
03590 PRINT "WEIGHT = \";W(Y);\" LBS/FT"
03600 PRINT "BOARD FEET OF LUMBER PER LINEAR FOOT: \";B(Y)*D(Y)/12;\"
BOARD-FEET/LIN. FT "
03620 PRINT "DEFLECTION UNDER LIVE LOAD = 5 X WLL X (L) / (384 X E X I) "
03630 PRINT "DEF(UNDER LIVE LOAD) = 5 X \";W1;\" X (\";L;\") X 1728/ (384 X \";E;\" X \";I(Y);\") = \";D0;\" INCHES"
03640 PRINT
03650 PRINT "DEFLECTION UNDER TOTAL LOAD = 5 X WTL X (L) / (384 X E X I) "
03660 PRINT "DEF(UNDER TOTAL LOAD) = 5 X \";W3;\" X (\";L;\") X 1728/ (384 X \";E;\" X \";I(Y);\") = \";D2;\" INCHES"
03670 PRINT
03680 PRINT "REQUIRED BEARING LENGTH = V(MAX)/(FCL(ADJ.) X B)"
03690 PRINT "REQUIRED BEARING LENGTH = \";V1;\" / (\";F1;\" X \";B1(Y);\") = \";B0;\" INCHES"
03700 PRINT
03710 PRINT
03720 PRINT "MEMBER STRESSES: "
03730 PRINT
03740 PRINT "FB = \";A9;\" PSI"
03750 PRINT "FV = \";A8;\" PSI"
03760 PRINT
03770 PRINT
03780 PRINT
03790 PRINT
03800 RETURN
03810 STOP
03820 REM -- LOAD DURATION FACTOR SUBROUTINE --
03830 PRINT"-- LOAD DURATION FACTOR -- "
PRINT "SHORTEST DURATION LOAD (APPROXIMATE DURATION)"

---

PRINT "DEAD LOAD (PERMANENT)"
0.9

PRINT "FLOOR LIVE LOAD (10 YEARS)"
1.0

PRINT "SNOW LOAD (2 MONTHS)"
1.15

PRINT "ROOF LIVE LOAD (7 DAYS)"
1.25

PRINT "WIND OR SEISMIC (1 DAY)"
1.33

PRINT "IMPACT (2 SECONDS)"
2.0

PRINT "NOTES:"

PRINT "A. CHECK ALL CODE REQUIRED LOAD COMBINATIONS."

PRINT "B. SELECT LDF ASSOCIATED WITH THE SHORTEST DURATION IN THE COMBINATION OF LOADS."

PRINT "C. THE CRITICAL COMBINATION OF LOADS IS THE ONE THAT REQUIRES THE LARGEST-SIZE STRUCTURAL MEMBER."

PRINT "LOAD DURATION FACTOR TO BE USED?"

INPUT L1

RETURN

STOP

REM -- DEFLECTION SELECTION SUBROUTINE --

PRINT "LIVE LOAD DEFLECTION CRITERIA"

---

PRINT "LIVE LOAD"

PRINT "DEFLECTION CRITERIA"

---

PRINT "L/180" 1

PRINT "L/240" 2

PRINT "L/360" 3
04170 PRINT "USER DEFINED MAX. LIVE LOAD DEFL."
04180 PRINT
04190 PRINT "LIVE LOAD DEFLECTION CRITERIA SELECTED"
04200 INPUT A7
04210 ON A7 GOTO 04230,04260,04290,04320
04230 D5=L*12/180
04240 D6=L*12/180
04250 RETURN
04260 D5=L*240
04270 D6=L*12/240
04280 RETURN
04290 D5=L*360
04300 D6=L*12/360
04310 RETURN
04320 PRINT "INPUT MAXIMUM LIVE LOAD DEFLECTION IN INCHES"
04330 INPUT D6
04340 D5=L*12/D6
04350 RETURN
04360 REM -- TOTAL LOAD DEFLECTION SELECTION SUBROUTINE --
04370 PRINT "TOTAL LOAD DEFLECTION CRITERIA"
04380 PRINT
04390 PRINT "TOTAL LOAD INPUT"
04400 PRINT "DEFLECTION CRITERIA"
04410 PRINT "--"  
04420 PRINT "L/180"
04430 PRINT "L/240"
04440 PRINT "L/360"
04450 PRINT "USER DEFINED MAX. TOTAL LOAD DEFL."
04460 PRINT
04470 PRINT
04480 PRINT "TOTAL LOAD DEFLECTION CRITERIA SELECTED"
04490 INPUT A7
04510 ON A7 GOTO 04520,04550,04580,04610
04520 D4=180
04530 D3=L*12/180
04540 RETURN
04550 D4=240
04560 D3=L*12/240
04570 RETURN
04580 D4=360
04590 D3=L*12/360
04600 RETURN
04610 PRINT "INPUT MAXIMUM TOTAL LOAD DEFLECTION IN INCHES"
04620 INPUT D3
04630 D4=L*12/D3
04640 RETURN
04650 STOP
04660 REM -- SLENDERNESS FACTOR SUBROUTINE --
04670 C3=SQR(L3*D1(Y)*12/(B1(Y)))
04680 IF C3 >=0 AND C3 <= 10 THEN F6=F8*L1
04690 IF C3 > 10 AND C3 <= 10 THEN C1$="SHORT UNBRACED BEAM"
04700 IF C3 > 10 AND C3 <= 10 THEN F6=F8*L1*(1-.333*(C3/C4))
04710 IF C3 > 10 AND C3 <= 10 THEN C1$="INTERMEDIATE UNBRACED BEAM"
04720 IF C3 > C4 AND C3 <= 50 THEN F6=.4*E/C3
04730 IF C3 > C4 AND C3 <= 50 THEN C1$="LONG UNBRACED BEAM"
04740 N=N+1
04750 IF C3 > 50 THEN 04810
04760 F7=F6
04770 IF F3 > F7 THEN 04830
04780 I3=Y
04790 RETURN
04800 PRINT "I3=",I3
04810 I3=I3+1
04820 GOTO 00800
04830 F3=F7
04840 IF IO$="Y" THEN I3=I3+1
04850 IF IO$="Y" THEN 00800
04860 I3=Y
04870 GOTO 00730
04880 PRINT "F3= ";F3," F7=";F7
04890 STOP
04900 REM -- ACTUAL STRESSES SUBROUTINE --
04910 A9=M/S(Y)*12
04920 A8=1.5*V1/A(Y)
04930 RETURN
04940 STOP
04950 REM CLEAR SCREEN
04960 FOR Q=1 TO 25
04970 PRINT
04980 NEXT Q
04990 RETURN
05000 STOP
05010 REM 3/4 PAGE SCROLL
05020 FOR Q=1 TO 14
05030 PRINT
05040 NEXT Q
05050 RETURN
05060 STOP
10 REM -- GLU-LAM BEAM DESIGN PROGRAM --
11 FILE#1="DUMMYB"
12 READ#1,X1,X3,F9,X4,X2,X5,X6,X7,X8,X9,Z1,Z1,E,G1$,G2$,G3$,G4$,U1$,U2$
13 CLOSE#1
20 REM LABEL PROGRAM AS "GLUBEAM.PRG"
25 GOSUB 4000
30 PRINT "--GLU-LAM BEAM DESIGN PROGRAM--"
40 OPTION BASE 1
50 DIM B(290), N(290), D(290), C6(290)
60 DIM A(290), S(290), I(290), W(290)
70 FILE #1="GLULAM"
71 RESTORE #1
80 FOR J=1 TO 289
90 INPUT #1,N(J),B(J),D(J),A(J),S(J),I(J),W(J)
100 NEXT J
110 CLOSE #1
130 GOSUB 4100
140 PRINT "INPUT DESIGN PARAMETERS"
150 PRINT "LENGTH, FEET ",TAB(59);
151 INPUT L
160 PRINT "MAXIMUM UNBRACED LENGTH, FEET ",TAB(59);
161 INPUT L2
170 L3=1.92*L2
180 C4=SQRT(.6*E/X1)
190 F7=X1*2
191 J=1
192 Y=1
193 Z=1
195 I3=1
200 PRINT "CONDITION OF USE FACTOR ",TAB(59);
201 INPUT C5
210 PRINT "DISTRIBUTED LIVE LOAD, LBS/FT ",TAB(59);
211 INPUT W1
220 PRINT "DISTRIBUTED DEAD LOAD, LBS/FT ",TAB(59);
221 INPUT W2
230 W3=W2+W1
235 GOSUB 4000
260 GOSUB 3180
265 GOSUB 4000
270 GOSUB 3430
275 GOSUB 4000
280 GOSUB 2930
285 GOSUB 4000
290 REM -- CALCULATIONS --
300 M=W3*L}/8
310 V1=W3*L/2
320 C6=1
330 REM -- ADJUSTED ALLOWABLE STRESSES --
340 F3=X1*L1*C5*C6
341 REM --ASSUME CF=1 (INITIALLY)
350 F2=X2*L1*C5
360 F1=F9*L1*C5
370 REM -- COMPUTE REQUIRED SECTION PROPERTIES --
380 S1=M/F3*12
390 A3=1.5*V1/F2
400 I1=5*W1*(L )*1728/(384*E*D6)
410 I2=5*W3*(L )*1728/(384*E*D3)
420 IO=I1
430 IF IO>I2 THEN IO=I2
440 REM -- MEMBER SELECTION ROUTINE --
450 FOR J=I3 TO 289
460 IF S1 <= S(J) THEN 490
470 NEXT J
480 PRINT "MEMBERS IN TABLE ARE NOT ADEQUATE"
490 FOR Z=J TO 289
500 IF A3<=A(Z) THEN 530
510 NEXT Z
520 PRINT "MEMBERS IN TABLE ARE NOT ADEQUATE"
530 FOR Y=Z TO 289
540 IF IO<=I(Y) THEN 562
550 NEXT Y
560 PRINT "MEMBERS IN TABLE ARE NOT ADEQUATE"
562 IF F7=F6 THEN 570
564 GOSUB 3690
570 IF D(Y)<=12 THEN 620
580 C2=(12/D(Y)) 1/9)
590 IF C2=C6 THEN 620
600 C6=C2
610 GOTO 340
620 B0=V1/(F1*B(Y))
630 D0=5*W1*(L )*1728/(384*E*I(Y))
640 D2=5*W3*(L )*1728/(384*E*I(Y))
645 GOSUB 3860
650 REM --PRINT RESULTS --
660 PRINT "GLULAM MEMBER SELECTED : ";B(Y);" X ";D(Y)
661 PRINT "NO. OF 3/4 LAMINATIONS ";D(Y)/0.75
662 PRINT "DO YOU WISH TO SELECT ANOTHER MEMBER? (Y/N) 
663 INPUT IO$
664 GOSUB 4100
665 IF IO$="Y" THEN I3=Y+1
666 IF IO$="Y" THEN N=1
667 IF IO$="Y" THEN 450
668 GOSUB 4000
670 PRINT
680 PRINT
690 PRINT "------------------------ I N P U T   D A T A ------------------------
700 PRINT
710 PRINT
720 PRINT "SPAN LENGTH = ";L;" FT"
721 PRINT "MAX. UNBRACED LENGTH = ";L2;" FT"
730 PRINT "LOAD DURATION FACTOR = ";L1
740 PRINT "CONDITION OF USE FACTOR = ";C5
750 PRINT "UNIFORM DIST. LIVE LOAD = ";W1;" LBS/FT"
760 PRINT "UNIFORM DIST. DEAD LOAD = ";W2;" LBS/FT"
770 PRINT "DEFLECTION LIMITATION (LIVE LOAD) = L/ ";D5
780 PRINT "DEFLECTION LIMITATION (TOTAL LOAD) = L/ ";D4
790 PRINT
800 PRINT "PRIMARY USAGE ";U1$
810 PRINT "GRADE ";G1$
820 PRINT "STRESS CLASSIFICATION ";G2$;G3$
830 PRINT "SPECIES: OUTER/INNER LAMINATIONS ";G4$
840 PRINT
850 PRINT
PRINT "TYPE 'R' AND HIT RETURN WHEN READY TO CONTINUE."
INPUT Z$
GOSUB 4000
PRINT "------------------------------- OUTPUT DATA -------------------------------"
PRINT "TABULATED STRESSES:"
PRINT "FB = ";&X1;&" PSI", "FV = ";&X2;&" PSI"
PRINT "FCL = ";&F9;&" PSI", "E = ";&E;&" PSI"
PRINT "------------------------
_________________________
------------------------"
PRINT "ALLOWABLE DESIGN STRESSES:
PRINT "FB(ADJUSTED FOR SIZE FACTOR) = ";&X1;&" X ";&L1;&" X ";&C5;&" X ";&C6;& = ";&X1;&L1;&C5;&C6
PRINT "FB(ADJUSTED FOR LATERAL STABILITY) = ";&F7;&" PSI"
PRINT "LATERAL STABILITY FACTORS:"
PRINT "CS = ";&ROF(C3,3), "CK = ";&ROF(C4,3)
PRINT "LATERAL STABILITY CLASSIFICATION: ";&C1$
PRINT "TYPE 'R' AND HIT RETURN KEY WHEN READY TO CONTINUE"
INPUT A1$
GOSUB 4000
PRINT "FV = (TAB FV) X LDF X CUF "
PRINT "FCL = (TAB FCL) X LDF X CUF"
PRINT "M(MAX) = WTL X (L)) /8 "
PRINT "M(MAX) = ";&W3;&" X (";&L;") /8 = ";&M;&" FT-LBS"
PRINT "V(MAX) = WTL X L/2 "
PRINT "V(MAX) = ";&W3;&" X ";&L;&"/2 = ";&V1
PRINT "TYPE 'R' AND HIT RETURN WHEN READY TO CONTINUE."
INPUT A1$
GOSUB 4000
PRINT
1300 PRINT "REQUIRED SELECTION MODULUS = M(MAX)/FB(ADJ.)"
1310 PRINT "SREQ. = ";M," / ";F3," X 12 = ";S1," INCHES"
1320 PRINT "MAX DEFLECTION (FOR LIVE LOAD) = L/";D5
1330 PRINT "DEF(LIVE LOAD) = ";L," / ";D5," X 12 = ";D6," INCHES"
1340 PRINT "MAX DEFLECTION (FOR TOTAL LOAD) = L/";D4
1350 PRINT "DEF(TOTAL LOAD) = ";L," / ";D4," X 12 = ";D3," INCHES"
1360 PRINT "REQUIRED INERTIA (FOR LIVE LOAD) = 5XWLLX(L) / (384XEXDEF(LIVE LOAD))"
1370 PRINT "IREQ(FOR LIVE LOAD) = ";5," X ";W1," X (";L;") X 1728 / (384 X ";E;" X ";D6;") = ";I1," INCHES "
1380 PRINT "IREQ(FOR TOTAL LOAD) = ";5," X ";W3," X (";L;") X 1728 / (384 X ";E;" X ";D3;") = ";I2," INCHES "
1390 PRINT "REQUIRED AREA = 1.5 X V(MAX) / FV(ADJUSTED) "
1400 PRINT "AREQ = 1.5 X ";V1," / ";F2;" = ";A3," INCHES"
1410 PRINT "DEFLECTION UNDER LIVE LOAD = 5 X W1 X (L) / (384 X E X I)"
1420 PRINT "DEF(UNDER LIVE LOAD) = 5 X ";W1," X (";L;") / (384 X ";E;" X ";I(Y);" = ";D0;" INCHES"
1430 PRINT "DEFLECTION UNDER TOTAL LOAD = 5 X W3 X (L) / (384 X E X I)"
1440 PRINT "DEF(UNDER TOTAL LOAD) = 5 X ";W3," X (";L;") / (384 X ";E;" X ";I(Y);" = ";D2;" INCHES"
1450 PRINT "REQUIRED BEARING LENGTH = V(MAX)/(FCL(ADJ.) X B)"
1460 PRINT "REQUIRED BEARING LENGTH = ";V1," / (";F1;" X ";B(Y);" = ";B0;"
```
INCHES
1630 PRINT
1640 PRINT "MEMBER STRESSES: FB = ";A9;" PSI FV = ";A8;" PSI"
1652 PRINT
1660 PRINT "TYPE 'R' AND HIT RETURN WHEN READY TO CONTINUE."
1661 INPUT A1$
1665 GOSUB 4000
1670 PRINT
1680 PRINT
1690 PRINT "DO YOU WANT A HARD COPY?, (Y OR N); IF 'Y' TURN PRINTER ON"
1691 INPUT A6$
1700 IF A6$="Y" THEN GOSUB 1930
1705 GOSUB 4000
1710 PRINT "DO YOU WANT TO RECYCLE THROUGH THE PROGRAM AGAIN?, (Y OR N)"
1711 INPUT A6$
1720 IF A6$="Y" THEN GOSUB 1790
1730 STOP
1740 PRINT "ALLOWABLE BENDING STRESS, PSI"
1741 INPUT Y2
1750 PRINT "ALLOWABLE SHEAR STRESS, PSI"
1751 INPUT Y1
1760 PRINT "ALLOWABLE COMPRESSION STRESS, PSI"
1761 INPUT Y3
1770 PRINT "MODULUS OF ELASTICITY, PSI"
1771 INPUT E
1780 STOP
1790 GOSUB 4000
1800 PRINT "--SELECT OPTION--"
1810 INPUT S2
1820 ON S2 GOTO 130,1900
1900 CHAIN"SRT"
1910 RETURN
1920 STOP
1930 REM -- PRINTER SUBROUTINE --
1935 GOSUB 4000
1940 PRINT
1950 PRINT
1960 PRINT "I N P U T  D A T A "
1970 PRINT
```
1980 PRINT
1990 PRINT "SPAN LENGTH = ";L;" FT"
1991 PRINT "MAX. UNBRACED LENGTH = ";L2;" FT"
2000 PRINT "LOAD DURATION FACTOR = ";L1
2010 PRINT "CONDITION OF USE FACTOR = ";C5
2020 PRINT "UNIFORM DIST. LIVE LOAD = ";W1;" LBS/FT"
2030 PRINT "UNIFORM DIST. DEAD LOAD = ";W2;" LBS/FT"
2040 PRINT "DEFLECTION LIMITATION (LIVE LOAD) = L/";D5
2050 PRINT "DEFLECTION LIMITATION (TOTAL LOAD) = L/";D4
2060 PRINT
2070 PRINT "PRIMARY USAGE ";U1$
2080 PRINT "GRADE ";G1$
2090 PRINT "STRESS CLASSIFICATION ";G2$;G3$
2100 PRINT "SPECIES: OUTER/INNER LAMINATIONS ";G4$
2110 PRINT
2120 PRINT
2130 PRINT
2140 PRINT
2150 PRINT "---------------------- OUTPUT DATA ----------------------"
2160 PRINT
2170 PRINT
2180 PRINT
2190 PRINT "TABULATED STRESSES: "
2200 PRINT
2210 PRINT "FB = ";X1;" PSI","FV = ";X2;" PSI"
2220 PRINT "FCL = ";F9;" PSI","E = ";E;" PSI"
2230 PRINT
2240 PRINT
2250 PRINT "ALLOWABLE DESIGN STRESSES:"
2260 PRINT
2270 PRINT "FB = (TAB FB) X LDF X CUF X CF "
2280 PRINT "FB(ADJUSTED FOR SIZE FACTOR) = ";X1;" X ";L1;" X ";C5;" X ";C6;" = ";X1*L1*C5*C6
2290 PRINT
2300 PRINT "FB(ADJUSTED FOR LATERAL STABILITY) = ";F7;" PSI"
2310 PRINT "LATERAL STABILITY FACTORS: "
2320 PRINT "CS = ";ROF(C3,3),"CK = ";ROF(C4,3)
2330 PRINT "BEAM CLASSIFICATION ";C1$
2340 PRINT
2350 PRINT "FV = (TAB FV) X LDF X CUF"
2360 PRINT "FV = ";X2;" X ";L1;" X ";C5;" = ";F2;" PSI "
2370 PRINT
2380 PRINT "FCL = (TAB FCL) X LDF X CUF"
2390 PRINT "FCL = ";F9;" X ";L1;" X ";C5;" = ";F1;" PSI"
2400 PRINT
2410 PRINT
2420 PRINT "DESIGN LOADS : "
2430 PRINT
2440 PRINT "WTL = WLL + WDL "
2450 PRINT "WTL = ";W1;" + ";W2;" = ";W3;" LBS/FT "
2460 PRINT
2470 PRINT "M(MAX) = WTL X (L)) /8 "

PRINT "M(MAX) = ";W3;" X ";L:")) /S = ";M:" FT-LBS 
PRINT "V(MAX) = WTL X L/2 " 
PRINT "V(MAX) = ";W3;" X ";L:"/2 = ";V1:" LBS 
PRINT "REQUIRED SELECTION MODULUS = M(MAX)/FB(ADJ.)" 
PRINT "S1. = ";M;" / ";F3;" X 12 = ";S1;" INCHES* 
PRINT "MAX DEFORMATION (FOR LIVE LOAD) = L/";D5 
PRINT "DEF(LIVE LOAD) = ";L;" / ";D5;" X 12 = ";D6;" INCHES 
PRINT "MAX DEFORMATION (FOR TOTAL LOAD) = L/";D4 
PRINT "DEF(TOTAL LOAD) = ";L;" / ";D4;" X 12 = ";D3;" INCHES 
PRINT "REQUIRED INERTIA (FOR LIVE LOAD) = 5XWLLX(L) / 
(384XEXDEF(LIVE LOAD))" 
PRINT "IREQ(FOR LIVE LOAD) = ";5;" X ";W1;" X ";L:" X 1728 / 
(384 X ";E;" X ";D6;") = ";I1;" INCHES " 
PRINT "REQUIRED INERTIA (FOR TOTAL LOAD) = 5XWTLX(L) / 
(384XEXDEF(TOTAL LOAD))" 
PRINT "IREQ(FOR TOTAL LOAD) = ";5;" X ";W3;" X ";L:" X 1728 / 
(384 X ";E;" X ";D3;") = ";I2;" INCHES " 
PRINT "REQUIRED AREA = 1.5 X V(MAX) / FV(ADJUSTED) " 
PRINT "AREQ = 1.5 X ";V1;" / ";F2;" = ";A3;" INCHES" 
PRINT "MEMBER SELECTED: ";B(Y);" X ";D(Y) 
PRINT "NUMBER OF 3/4 INCH LAMINATIONS: ";D(Y)/.75 
PRINT "SECTION MODULUS = ";S(Y) 
PRINT "AREA = ";A(Y);" INCHES" 
PRINT "INERTIA = ";I(Y);" INCHES " 
PRINT "WEIGHT = ";W(Y);" LBS/FT" 
PRINT "BOARD FEET OF LUMBER PER LINEAR FOOT: ";B(Y)*D(Y)/12;" 
PRINT "BOARD-FEET/LIN. FT " 
PRINT "DEFLECTION UNDER LIVE LOAD = 5 X W1 X (L) / (384 X E X I) " 
PRINT "DEF(UNDER LIVE LOAD) = 5 X ";W1;" X ";L:" / (384 X ";E;" X ";I(Y);" = ";D0;" INCHES" 
PRINT "DEFLECTION UNDER TOTAL LOAD = 5 X W3 X (L) / (384 X E X I) " 
PRINT "DEF(UNDER TOTAL LOAD) = 5 X ";W3;" X ";L:" / (384 X ";E;" X ";I(Y);" = ";D2;" INCHES" 
PRINT "REQUIRED BEARING LENGTH = V(MAX)/(FCL(ADJ.) X B)"
2820 PRINT "REQUIRED BEARING LENGTH = ";V1;" / (";F1;" X ";B(Y);") = ";B0;"
2830 PRINT
2840 PRINT
2850 PRINT "MEMBER STRESSES: "
2860 PRINT
2870 PRINT "FB = ";A9;" PSI"
2871 PRINT "FV = ";AS;" PSI"
2872 PRINT
2880 PRINT
2890 PRINT
2900 PRINT
2910 RETURN
2920 STOP
2930 REM -- LOAD DURATION FACTOR SUBROUTINE --
2940 PRINT "-- LOAD DURATION FACTOR -- "
2950
def
2960 PRINT
2970 PRINT "SHORTEST DURATION LOAD (APPROXIMATE DURATION)
2980 PRINT "IN COMBINATION --"
2990 PRINT "DEAD LOAD (PERMANENT) 0.9"
3000 PRINT "FLOOR LIVE LOAD (10 YEARS) 1.0"
3010 PRINT "SNOW LOAD (2 MONTHS) 1.15"
3020 PRINT "ROOF LIVE LOAD (7 DAYS) 1.25"
3030 PRINT "WIND OR SEISMIC (1 DAY) 1.33"
3040 PRINT "IMPACT (2 SECONDS) 2.0"
3050 PRINT
3060 PRINT
3070 PRINT "NOTES: "
3080 PRINT "A. CHECK ALL CODE REQUIRED LOAD COMBINATIONS. "
3090 PRINT "B. SELECT LDF ASSOCIATED WITH THE SHORTEST DURATION IN THE "
3100 PRINT "COMBINATION OF LOADS. "
3110 PRINT "C. THE CRITICAL COMBINATION OF LOADS IS THE ONE THAT \"
3120 PRINT "REQUIRES "
3130 PRINT "THE LARGEST-SIZE STRUCTURAL MEMBER. "
3140 PRINT
3150 PRINT "LOAD DURATION FACTOR TO BE USED ? "
3151 INPUT L1
3160 RETURN
3170 STOP
3180 REM -- DEFLECTION SELECTION SUBROUTINE --
3190 PRINT "LIVE LOAD DEFLECTION CRITERIA"
3200
3210 PRINT "____________________________________" INPUT"
3220 PRINT "LIVE LOAD DEFLECTION CRITERIA ##
3230 PRINT ________________________________
3240 PRINT "LIVE LOAD DEFLECTION CRITERIA SELECTED "
3250 PRINT "____________________________________"
3260 PRINT "L/180 "
3270 PRINT "L/240 "
3280 PRINT "L/360 
3290 PRINT "USER DEFINED MAX. LIVE LOAD DEFL. 
3300 PRINT "____________________________________"
3310 PRINT "LIVE LOAD DEFORMATION CRITERIA SELECTED "
3320 PRINT "____________________________________"
3330 INPUT A7
3340 ON A7 GOTO 3340,3360,3380,3400
3350 D5=180
3360 D6=L*12/180
3370 RETURN
3360 D5=240
3370 D6=L*12/240
3380 RETURN
3360 D5=360
3370 D6=L*12/360
3390 RETURN
3400 PRINT "INPUT MAXIMUM LIVE LOAD DEFORMATION IN INCHES "
3410 INPUT D6
3420 RETURN
3430 REM -- TOTAL LOAD DEFLECTION SELECTION SUBROUTINE --
3440 PRINT "TOTAL LOAD DEFLECTION CRITERIA"
3450
3460 PRINT "____________________________________" INPUT"
3470 PRINT "TOTAL LOAD DEFLECTION CRITERIA ##
3480 PRINT ________________________________
3490 PRINT "TOTAL LOAD DEFLECTION SELECTED "
3500 PRINT "____________________________________"
3530 PRINT "L/360"
3540 PRINT "USER DEFINED MAX. TOTAL LOAD DEFL."
3550 PRINT "TOTAL LOAD DEFLECTION CRITERIA SELECTED"
3560 INPUT A7
3570 ON A7 GOTO 3590,3610,3630,3650
3590 D4=180
3591 D3=L*12/180
3600 RETURN
3610 D4=240
3611 D3=L*12/240
3620 RETURN
3630 D4=360
3631 D3=L*12/360
3640 RETURN
3650 PRINT "INPUT MAXIMUM TOTAL LOAD DEFLECTION IN INCHES"
3660 INPUT D3
3670 RETURN
3680 STOP
3690 REM -- SLENDERNESS FACTOR SUBROUTINE --
3700 C3=SQR(L3*D(Y)*12/(B(Y)))
3710 IF C3 >=0 AND C3 <= 10 THEN F6=X1*L1
3711 IF C3 >=0 AND C3 <= 10 THEN C1$="SHORT UNBRACED BEAM"
3720 IF C3 > 10 AND C3 <= C4 THEN F6=X1*L1*(1-.3333*(C3/C4))
3721 IF C3 > 10 AND C3 <= C4 THEN C1$="INTERMEDIATE UNBRACED BEAM"
3730 IF C3 > C4 AND C3 <= 50 THEN F6=.4*E/C3
3731 IF C3 > C4 AND C3 <= 50 THEN C1$="LONG UNBRACED BEAM"
3740 N=N+1
3760 IF C3 > 50 THEN 3810
3770 F7=F6
3780 IF F3>F7 THEN 3820
3790 I3=Y
3800 RETURN
3810 Y=Y+1
3811 GOTO 440
3820 F3=F7
3821 GOTO 370
3830 PRINT "F3= ";F3," F7=";F7
3840 PRINT "TYPE 'R' AND HIT RETURN WHEN READY TO CONTINUE."
3841 INPUT T$
3850 STOP
3860 REM -- ACTUAL STRESSES SUBROUTINE --
3870 A9=M/S(Y)*12
3880 A8=1.5*V1/A(Y)
3890 RETURN
3900 STOP
4000 REM CLEAR SCREEN
4010 FOR Q=1 TO 25
208

4020 PRINT
4030 NEXT Q
4040 RETURN
4100 REM 3/4 PAGE SCROLL
4110 FOR Q=1 TO 14
4120 PRINT
4130 NEXT Q
4140 RETURN

DATA FILES

DENSE SELECT STRUCTURAL
LIGHT FRAMING -UPTO 4 INCHES WIDE
2450
2800
1400
95
730
1850
1900000

SELECT STRUCTURAL
LIGHT FRAMING -UPTO 4 INCHES WIDE
2100
2400
1200
95
625
1600
1800000

DENSE NO.1
LIGHT FRAMING -UPTO 4 INCHES WIDE
2050
2400