EVALUATION OF COLD-FORMED STEEL MEMBERS
IN THE
MICROSOFT WINDOWS ENVIRONMENT

BY

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APPROVED

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(ABSTRACT)

A user-friendly program for the design of cold-formed steel members has been developed. The Cold-Formed Steel Design program has the capacity to evaluate a variety of cold-formed steel shapes according to the American Iron and Steel Institute Load and Resistance Factor Design Specification of March 16, 1991. The program can calculate the member capacity in terms of nominal moment, deflection, shear, web crippling strength, and compression. It also has a user-friendly interface to accept input from the user, and also show the output. The program also features a graphical display for various elements of a member section.

The program is written in the Visual Basic programming language which runs in the Microsoft Windows graphical environment. Visual Basic is an object-oriented programming language and is ideal for developing small or medium sized programs in the Windows environment.

Acknowledgement

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CHAPTER ONE

1.1   Role of Computers in Cold-Formed Steel Design

Computers have been used in the analysis and design of cold-formed steel structures

for the past twenty-five years (Yu 1991). The research on cold-formed steel structures

usually involves the study of structural behaviour and instability of plate elements, as

well as the behaviour of individual members. Calculations are lengthy and iterative.

However, the use of computers considerably reduces the time of calculation, as well as

increases the reliability of the results. Hence, computers are widely used in the design

of cold-formed steel members.

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Computers are used in cold-formed steel design for various purposes. There are

computer programs for calculating the cross-sectional properties of different member

sections, for the optimum design of members and for the analysis and design of special

types of structures.

An example of a computer program used for the optimum design of cold-formed steel

members is DOLGAS (Yu 1991). This program was developed by Klippstein for

designing cold-formed steel trusses. DOLGAS can select the minimum-weight

members according to the American Iron and Steel Institute (AISI) Load and

Resistance Factor Design (LRFD) Specification of March 16, 1991. DOLGAS uses

the program STRESS for calculating the member forces, and then checks the design

of the member as per the AISI LRFD Specification.

Computers have also been used for designing special cold-formed steel structures (Yu 1991). Tezcan et al. (1971), developed a computer program to calculate the stresses and deflections at any point in a hyperbolic paraboloid shell.

Cold-formed steel is widely used for designing industrial buildings. For an optimum design, repeated modification and analysis of the structural systems is required. The use of computers has greatly reduced the time and cost of repeated analysis and modification of the structural systems. This has resulted in a minimum weight and minimum cost design.

1.2   Objectives

The objective of the project described in this report is to expand a user-friendly cold-formed steel design program, specifically for use as a teaching aid. This program was initially developed by Clint Rex, Rod Simon and Angella Terry, as part of the course requirement for CE 5474 (Fall Semester, 1992). The Cold-Formed Steel Design program can accept various dimensions of a member as the input and calculate the member capacity in terms of flexure, lateral buckling, compression, shear, etc., according to the AISI LRFD Cold-Formed Steel Design Specification (*Load and Resistance Factor Design, 1991*). It also has a graphical user interface for displaying information about the individual elements of a member.

1.3   Overview

Chapter Two gives a brief introduction to the role of Visual Basic in teaching cold-formed steel design. A detailed description of the Cold-Formed Steel Design program is also given in this chapter. It provides an explanation of all the menu items and dialog boxes that are used in the program. Chapter Three summarises the work done in the project. It also contains a comparison of design results, that are obtained by hand-calculation, and those obtained using Cold-Formed steel Design program. Possible extensions and modifications of this program are also given in Chapter Three. Appendix 1 shows results of hand-calculation on some cold-formed steel members and the computer output results. Appendix 2 consists of a user's guide for using Cold-Formed Steel Design program.

No attempt is made to cover the details of cold-formed steel design, Microsoft Windows or Visual Basic.

CHAPTER TWO

2.1   Introduction to Cold-Formed Steel Design program

The Cold-Formed Steel Design program has been developed in the Visual Basic programming environment.   Visual Basic, with its mathematical and graphical capabilities, is ideally suited for many kinds of calculations and for giving a visual structure to an application.   Hence, it makes an excellent programming language for cold-formed steel design, where visualisation of member geometry and effective widths of member elements are important aspects for understanding the structural behaviour.

The member sections that may be evaluated are stiffened and unstiffened C, Z, I, angle and hat sections.   A deck section has also been included in the program.   The different calculations, made according to the AISI LRFD Specification include, calculation of nominal flexural strength (Sec. C3.1.1), lateral buckling strength (Sec. C3.1.2), deflection capacity, shear strength (Sec. C3.2), combined bending and shear strength (Sec. C3.3), web crippling strength (Sec. C3.4), combined bending and web crippling strength (Sec. C3.5), and compressive strength (Sec. C4).

2.2   Member Evaluation

When the ' run ' button in the Visual Basic Toolbar is clicked, Cold-Formed Steel
Design program loads a startup form on the screen. The user chooses the member
section to be evaluated. Once the user chooses the member section, the startup form
is replaced by a form showing the member section. On this new form, the user
specifies whether the member is stiffened or unstiffened. According to the user's
choice, the shape of the member is displayed on the screen. A typical screen showing
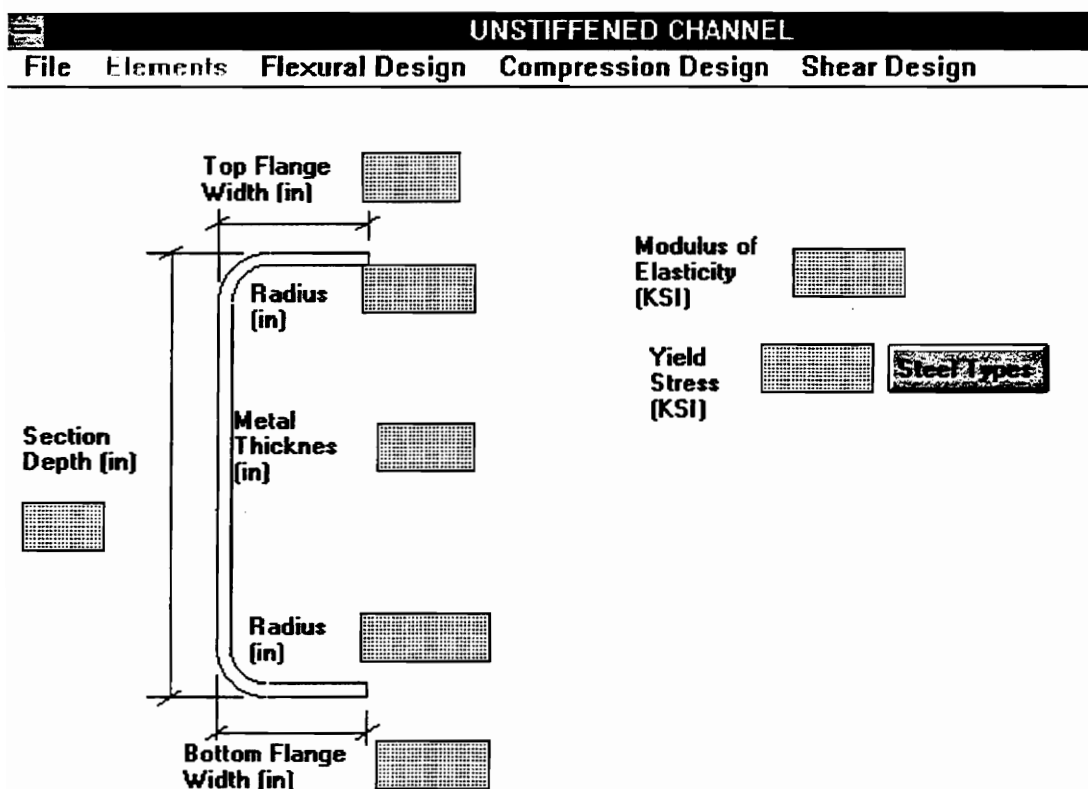an unstiffened channel section is shown in Figure 2.1 below.

Figure 2.1   An Unstiffened Channel Section

2.3   User Input

The user fills in blank input boxes with the dimensions of the member section, the yield stress and modulus of elasticity of steel. Clicking on the STEEL TYPES button displays information about the various kinds of steel used in cold-formed steel manufacturing.

2.4   File Processing Menu

The file processing function allows the user to save the current data in a file, open a file containing the dimensional data for a member shape, print design calculation results, and also exit to the startup form.

The ' Open File ' option allows the user to load an existing section model that has been saved on a disk. The user can select the drive from the ' drive listbox ', the filename from the ' file listbox ', and then click the O.K. button to open a file. The ' Open File ' ' picture box ' is closed automatically once the file has been loaded. The ' picture box ' can also be closed without loading any file by clicking the ' Cancel ' button.

The ' save ' file option is used for saving the dimensional data on to a disk file. This menu allows the user to choose the filename and the drive name in which the file is to be saved. This ' picture box ' also closes automatically once the file has been saved. It also closes without saving the file if the ' Cancel ' option is chosen.

The ' Print ' option allows the user to print the input data, as well as the design calculation results. Information about each element of a member section is also printed.

The ' Return To Main Menu ' option returns the user to the startup form to start a fresh design.

2.5   Flexural Design Menu

When the ' Flexural Design ' menu is clicked, the various items contained in it ' drop down '. It contains items such as, moment capacity, deflection capacity, lateral buckling strength, web crippling strength, and combined bending and web crippling strength.

The nominal moment capacity of a cold-formed steel member can be obtained by clicking on the ' Design Moment ' item. The user can choose whether or not to consider the effect of cold-working when calculating the nominal moment capacity. According to the user's choice, the program calculates the nominal moment of the section, moment of inertia of the section, and the effective section modulus. This information is then displayed in a ' picture box '. The program can also take into consideration, the shear lag effect when calculating the nominal moment of an I-section (AISI LRFD Specification, Sec. B1.1 (c)).

Deflection capacity has been calculated for the load case 1.2D + 1.6L. When the deflection capacity item is clicked, a ' message box ' appears on the screen and the user is asked to input the value of live to dead load ratio. Once this value is specified, the program calculates the service moment and the moment of inertia of the section at the service moment. The output for the deflection capacity calculation consists of the value of the service moment, stress at the service moment, and the moment of inertia at the service moment. All these are displayed in a ' picture box ' that appears on the screen at the end of the calculation. In case of the hat section, the user can also use Procedure II (AISI LRFD Specification, March 1991) for determining the moment of inertia for deflection capacity calculation.

When the ' Lateral Buckling Strength ' item is clicked, an ' input box ' pops up on the screen and prompts the user for the value of KL. This program assumes that the effective length for bending about y-axis, $K_y L_y$, and the effective length for twisting, $K_t L_t$, are same. Once the value of KL is given, the program prompts for the values of M_1 and M_2, the smaller and the larger moments at the ends of the unbraced length of the flexural member. The user is then prompted to specify whether or not the two end moments are of the same sign. Based on the user's input, the program calculates the lateral buckling strength of the member. The result of the calculation is shown in a ' message box ' window. Note that the lateral buckling strength may only be calculated for unbraced I, C, and Z sections.

To calculate the web crippling capacity of a member section, the user needs to click on the ' Web Crippling ' item. As soon as it is clicked, a form appears on the screen prompting the user to input the value of the bearing length of the support. On this

same form, the user has to specify whether the support distance is greater than 1.5h, and whether or not it is an interior support. This information is given using 'checkboxes '. After all the information has been provided, the user has to click the O.K. button to get the value of the nominal load per web. This value is displayed on the screen inside a ' message box ' window.

The combined and web crippling strength is calculated according to AISI LRFD Specification, Sec. 3.5. When the user clicks on this item, a ' message box ' appears on the screen asking if the web is a single unreinforced web. According to the input given by the user, the program calculates the value of the interaction equation and compares it with the standard value in the Specification. A ' message box ' appears on the screen, at the end of the calculation, to tell the user whether or not the section satisfies the specification.

2.6   Compression Design Menu

The ' Compression Strength ' item is contained within the ' Compression Design ' menu. When this item is clicked, an ' input box ' appears on the screen and the user has to specify the effective length of the compression member. After assigning a value for the effective length, the user has to choose the O.K. button for the program to calculate the design compressive strength of the member. The ' Cancel ' option in the

' input box ' allows the user to terminate the compressive strength calculation. The results of the calculation are printed in a ' picture box ' window, which appears on the screen automatically at the end of the calculation.

2.7   Shear Design Menu

The shear design menu contains the shear strength calculation, and the combined bending and shear strength calculation items. The only information that the user has to supply, for the program to calculate the shear strength of a member, is whether or not the web is reinforced. This information is given using a ' message box '. The ' message box ' has two options, YES and NO. The shear strength of the member is calculated by the program according to the web reinforcement condition. The results are displayed in a ' picture box ' window.

The combined bending and shear item works in a similar way as the shear strength calculation item. Here also, the user has to indicate the web reinforcement condition before the program can calculate the value of the interaction equation for combined bending and shear. A ' message box ' appears on the screen at the end of the calculation to let the user know whether the given section is safe or not.

2.8   Element Menu

This menu contains information about the individual elements of a member section. For example, in the case of a stiffened channel section, it provides information about the top and bottom flanges, the top and bottom stiffeners, the web, and the top and bottom corner elements.   Each item in this menu gives the user all the relevant information about a particular element.   For example, in the case of a top flange, it gives the length of the flat width, the length of the effective width, as well as the distance of the neutral axis of the top flange from the topmost fiber of the section.   It also shows pictorially the lengths of the flat width and the effective width of the element.   Because the effective widths of the elements are calculated based on the moment capacity of the section, the ' Element ' menu is ' enabled ' only after the ' Moment Capacity ' item has been clicked. A typical element showing the flat width and the effective width (shown shaded), along with their numerical values is shown in Figure 2.2.
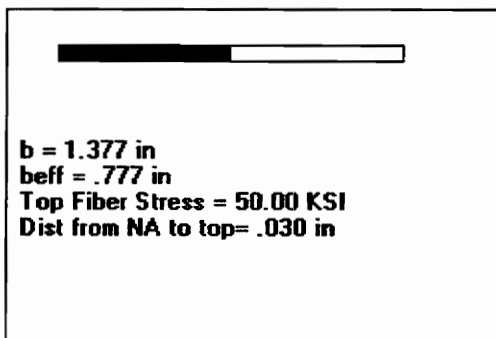
b = 1.377 in
beff = .777 in
Top Fiber Stress = 50.00 KSI
Dist from NA to top= .030 in

Figure 2.2   Picture of a Top Flange

CHAPTER THREE

3.1   Summary

This project involved the extension of a computer program for determining the capacity of cold-formed steel members according to the AISI LRFD Specification (1991). The program has been developed in the Microsoft Visual Basic programming language, which runs in the Microsoft Windows environment.

The Cold-Formed Steel design program can evaluate a wide variety of cold-formed steel members. The program can calculate the member strength with respect to a wide range capacities, as discussed earlier. The program can also read and write files containing information about the member dimensions. A comprehensive printout gives the results of the strength calculation, as well the properties of the individual elements.

The Cold-Formed Steel Design program is completely event-driven. Thus, the user has full control over the order in which the tasks can be performed. The program is also very user-friendly. It makes use of the standard Windows graphical user interface, and anyone with a knowledge of using Windows application can easily use the program.

The file menu in this program allows the user to save the current data on a disk drive and modify existing data for member evaluation. The program also features a print item for printing the calculation results.

The program can be started by clicking on the ' run ' icon in the Visual Basic Toolbar, or by selecting the ' run ' menu. A startup form loads automatically, and asks the user to choose a member section. A form showing the section chosen is shown on the screen. This form contains ' textboxes ' for the user to fill in the dimensions of the member elements, and the properties of steel.

Apart from the textboxes, the program uses the other Windows features to provide information to the computer. These include ' input boxes ', ' check boxes ' and the message boxes with the YES-NO options. Most of the input that are provided, while the program is executing, is given using one these tools.

The Cold-Formed Steel Design program has a number of ways to display the results of the calculation. The graphics display shows the element properties, such as the flat width and the effective width of the flanges and the length of the web. It also shows the corner element properties, and the properties of the edge and the intermediate stiffeners.

3.3 Modifications and Extensions

This program, though complete in its own capabilities, can be further extended to become a more comprehensive teaching tool.

Additions that would enhance the program include, the analysis of tension members, beams having one flange through-fastened to the deck or sheathing and members subjected to combined bending and axial load.

Because the program is developed for use as a teaching aid to cold-formed steel design, calculation of nominal moment using the concept of Inelastic Reserve Capacity can also be included.

Another improvement in the capability of the program would be to evaluate angle sections subjected to axial loading and a moment $P_uL/1000$, applied about the minor principaL axis.

This program can be extended to include other kinds of members, such as tubular members and wall studs, etc.

In the current form, only the values of the various dimensions of a member section, along with the design calculation results and the element properties are included in the output. An enhancement would be to include a graphical output of the section.

The deflection capacity is calculated assuming the load case 1.2D + 1.6L governs the design. The service moment for deflection capacity is calculated based on this criteria. The program can be made more flexible by providing service moment calculation for other load conditions.

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APPENDIX

A.1   Example Problems and Computer Results

Three examples from the AISI LRFD Manual are shown for the user's convenience. The same problems have also been solved using Cold-Formed Steel Design program. The computer output is given at the end of each example.

Example One :   A Channel section with unstiffened flange
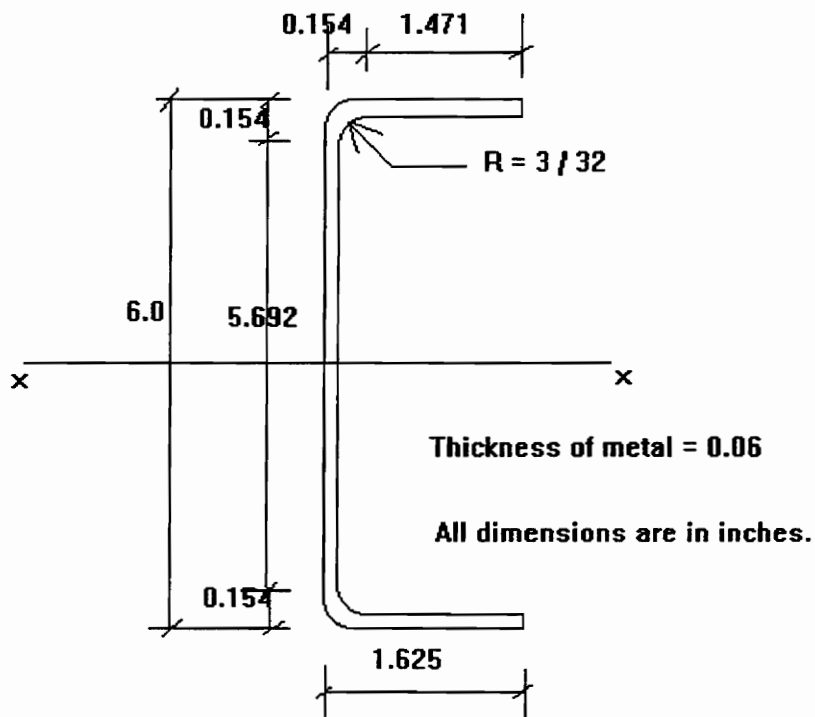
Given : 1. F_y of steel is 50 ksi., and E of steel is 29500 ksi.

2.   Compression flange is braced against lateral buckling.

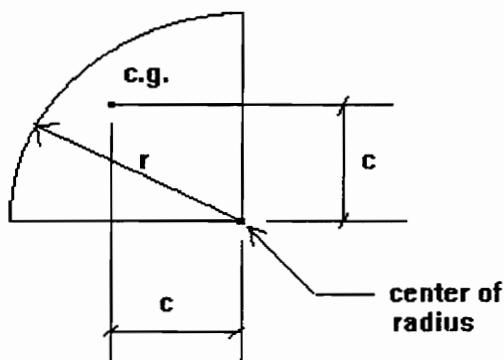3.   Dead Load to live load ratio is 1:5, and 1.2D + 1.6L governs the design.

<u>Find</u> :   1.   Design flexural strength, $\phi_b M_n$, based on initiation of yielding.

2.   Effective moment of inertia based on procedure I for deflection

determination at the service moment.

<u>Solution</u> :

<u>1.</u>   <u>Determination of the flexural design strength</u>

<u>A.</u>   <u>Calculation of element properties</u>

(i)   <u>90 degree corner</u> :

A 90 degree corner element

$r = R + t / 2 = 0.124$ in.

Length of arc, $u = 1.57 * r = 0.195$ in.

Distance of c.g. from the center of radius, $c = 0.637 * r = 0.079$ in.

(ii)   <u>Tension and Compression Flanges:</u>

Flat width, $w = 1.625 - (0.124 + 0.06 / 2) = 1.471$ in.

(iii)　Web :

Flat width, h = 6.0 - 2 * (0.124 + 0.03) = 5.692　in.

B.　Computation of Ix :

Assume :　　(a) Compressive stress f = Fy = 50 ksi in the top fibers of the section.

　　　　(b)　The web is fully effective.

(i)　Calculation of the effective of the compression flange :

　　k = 0.43　　for unstiffened compression elements　　(Sec. B3.1)

　　w / t = 24.52 < 60　　Hence, OK.　　(Sec. B1.1-(a)-(3))

　　λ = (1.052 / Sqr (k)) * (w / t) * Sqr (f / E)= 1.619　　(Eq. B2.1-4)

Since,　λ > 0.673,　　ρ = (1 - 0.22 / λ) / λ = 0.534　　(Eq. B2.1-3)

Therefore, effective width, b = ρ * w = 0.786　in.　　(Eq. B2.1-2)

(ii)   Effective section properties about x - axis :

Element	L Effective Length (in.)	y Distance from top fiber (in.)	Ly (in.^2)	Ly^2 (in.^3)	I_1' About own axis (in.^3)
Web	5.692	3.000	17.076	51.228	15.368
Upper corner	0.195	0.075	0.015	0.001	----
Lower corner	0.195	5.925	1.155	6.846	----
Compression flange	0.786	0.030	0.024	0.001	----
Tension flange	1.471	5.970	8.782	52.428	----
Sum	8.339		27.052	110.504	15.368

(iii)   Distance of the top fiber from the neutral axis, y_{cg} = 27.052 / 8.339 = 3.244 in. Since, y_{cg} > d /2, assumption (i) is valid.

(iv) To check if web is fully effective (Sec. B2.3) :
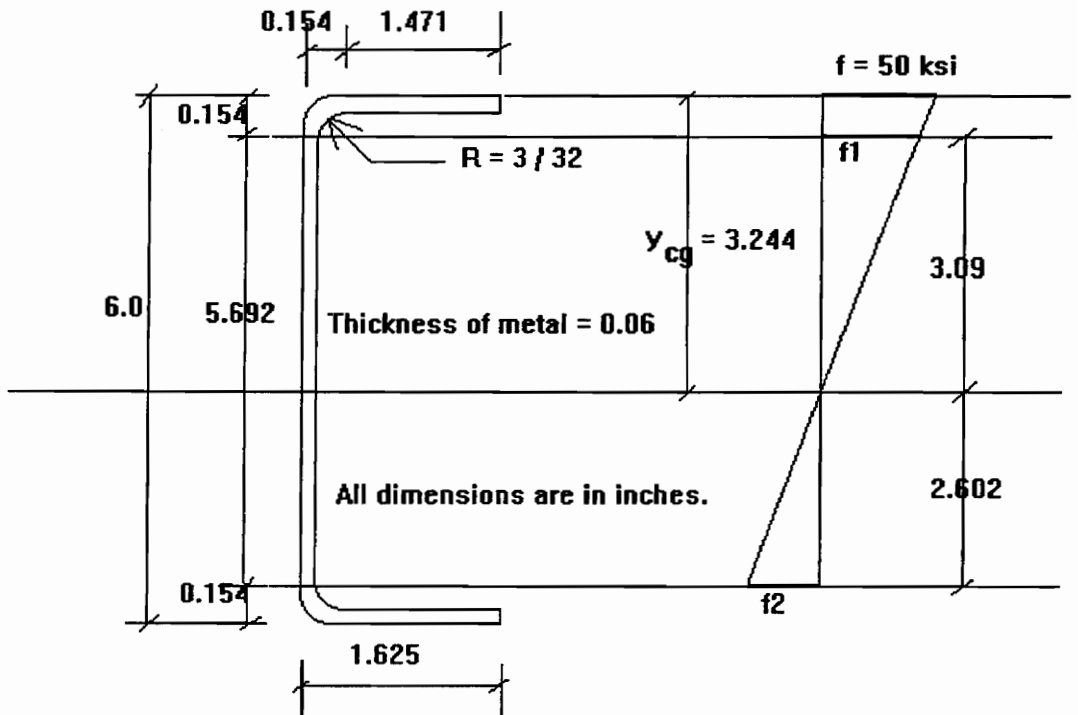
$f_1 = (3.09 / 3.244) * 50 = 47.63$ ksi   (compression)

$f_2 = - (2.602 / 3.244) = - 40.10$ ksi   (tension)

$\psi = f_2 / f_1 = - 0.842$

$k = 4 + 2 * (1 - \psi)^3 + 2 * (1 - \psi) = 20.184$ (Eq. B2.3 - 4)

$h = 5.692$ in. ; $h / t = 94.87 < 200$ OK.   (Sec. B1.2 - (a))

$\lambda = 1.052 / Sqr (20.184) * (94.87) * Sqr (47.63 / 29500) = 0.893$

Since, $\lambda > 0.673$, $\rho = (1 - 0.22 / \lambda) / \lambda = 0.844$

$b_e = \rho * h = 4.804$ in.

$b_2 = b_e / 2 = 2.402$ in.   (Eq. B2.3 - 2)

$b_1 = b_e / (3 - \psi) = 1.250$ in. $\hspace{2cm}$ (Eq. B2.3 - 1)

$b_1 + b_2 = 3.652$ in.

Compression portion the web, calculated on the basis of the effective section, is

$y_{cg} - 0.154 = 3.09$ in.

Since, $(b_1 + b_2) > 3.09$ in. , $(b_1 + b_2)$ is taken as 3.09 in. Thus, the second

assumption is also valid, i. e., the web is fully effective.

(v) $\quad I_x' = \Sigma (Ly^2) + \Sigma (I_1') - y_{cg} {}^\wedge 2 * \Sigma (L)$

$\quad = 110.504 + 15.368 - 8.339 * (3.244) {}^\wedge 2$

$\quad = 38.116$ in.$^\wedge 3$

Actual $I_x = I_x' * t = 2.287$ in.$^\wedge 4$

C. $\quad$ <u>Calculation of Factored Moment :</u>

$S_e = I_x / y_{cg} = 0.705$ in.$^\wedge 3$

$M_n = F_y * S_e = 35.25$ k-in. $\hspace{2cm}$ (Eq. C3.1.1 - 1)

$\phi_b = 0.90$ $\hspace{3cm}$ (Sec. C3.1.1)

$\phi_b M_n = 31.73$ k-in. (positive bending).

2. $\quad$ <u>Calculation of the effective moment of inertia based on procedure I for</u>

$\quad$ <u>deflection determination at the service moment</u>

A. $\quad$ <u>Calculation of the service moment:</u>

$\phi_b M_n = 1.2 M_{DL} + 1.6 M_{LL}$

$\quad = [1.2(M_{DL} / M_{LL}) + 1.6] M_{LL} = 1.84 M_{LL}$

Therefore, $M_{LL} = \phi_b M_n / 1.84 = 17.24$ kips

$M_s = M_{DL} + M_{LL} = 20.69$ kips

where, M_{DL} = moment determined on the basis of the nominal dead load

and M_{LL} = moment determined on the basis of the nominal live load.

(i)   For the first iteration, assume,

(a)   A compressive stress of $f = 25$ ksi in the top fibers of the section.

(b)   The web is fully effective.

Calculation of the effective width of the compression flange:

$\lambda = (1.052 / Sqr (0.43) * (24.52) * Sqr (25 / 29500) = 1.145 > 0.673$

Hence, $\rho = [1 - 0.22 / 1.145)] / 1.145 = 0.706$

Therefore, $b_d = 0.706 * 1.471 = 1.039$ in.

(ii) <u>Effective section properties about x - axis :</u>

Element	L Effective Length (in.)	y Distance from top fiber (in.)	Ly (in.^2)	Ly^2 (in.^3)	I_1' About own axis (in.^3)
Web	5.692	3.000	17.076	51.228	15.368
Upper corner	0.195	0.075	0.015	0.001	----
Lower corner	0.195	5.925	1.155	6.846	----
Compression flange	1.039	0.030	0.031	0.001	----
Tension flange	1.471	5.970	8.782	52.428	----
	--------		--------	---------	---------
Sum	8.592		27.059	110.504	15.368

(iii) Distance of the top fiber from the neutral axis, y_{cg} = 27.059 / 8.592 = 3.149 in.

Since, y_{cg} > d /2, the top fiber controls in the determination of S_e.

(iv)   To check if web is fully effective (Sec. B2.3 - (a), (b)) :
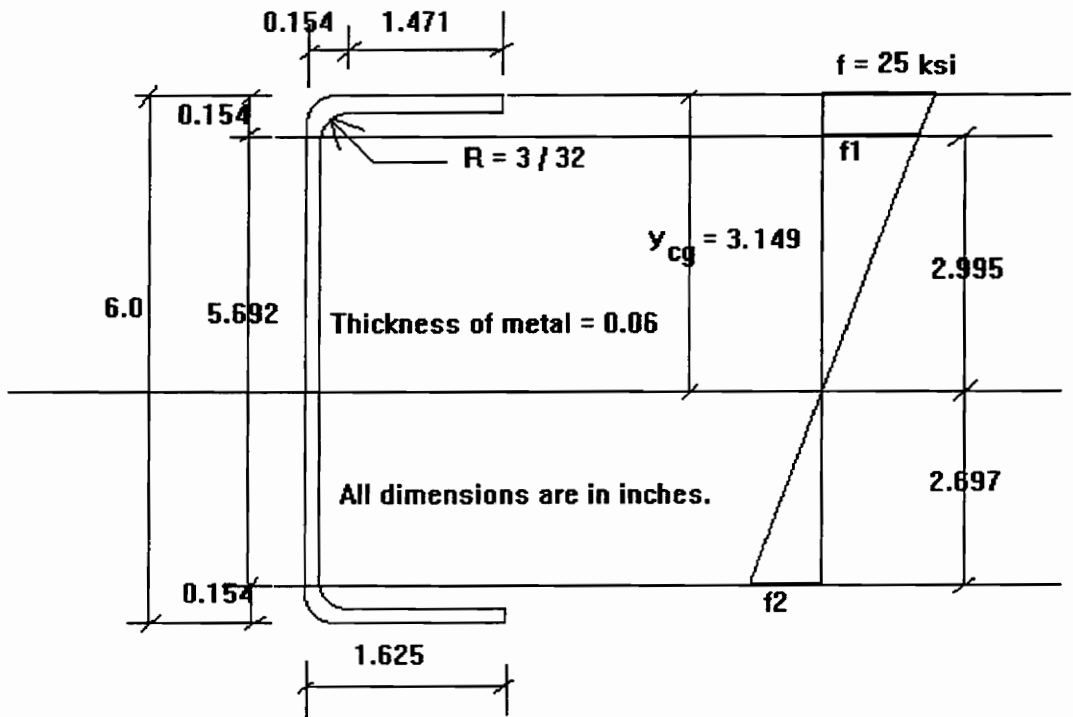
f_1= (2.995 / 3.149) * 25 = 23.78 ksi   (compression)

f_2 = - (2.697 / 3.149) = - 21.41 ksi   (tension)

$\psi = f_2 / f_1 = - 0.900$

$k = 4 + 2 * (1 - \psi)^3 + 2 * (1 - \psi)$ (Eq. B2.3 - 4)

$\quad = 21.518$

$h = 5.692$ in. ; $h / t = 94.87 < 200$ OK.   (Sec. B1.2 - (a))

$\lambda = 1.052 / Sqr (k) * (h / t) * Sqr (f / E) = 0.611$

Since, $\lambda < 0.673$

$b_e = h = 5.692$ in.

$b_2 = b_e / 2 = 2.846$ in.   (Eq. B2.3 - 2)

$b_1 = b_e / (3 - \psi) = 1.459$ in.   (Eq. B2.3 - 1)

$b_1 + b_2 = 4.305$ in.

Compression portion the web, calculated on the basis of the effective section, is

$y_{cg} - 0.154 = 2.995$ in.

Since, $(b_1 + b_2) > 2.995$ in. , $(b_1 + b_2)$ is taken as 2.995 in. Thus, the second

assumption is also valid, i. e., the web is fully effective.

(v) $I_x' = \Sigma (Ly^2) + \Sigma (I_1') - y_{cg} \wedge 2 * \Sigma (L)$

$= 40.672$ in.^{3}

Actual $I_x = I_x' * t = 2.440$ in.^{4}

$S_e = I_x / y_{cg} = 0.775$ in.^{3}

$M = f * S_e = 19.38$ k-in. $< M_s$.

Hence, we need to increase f, and do another iteration.

Second iteration:

Assume (i) f = 27.01 ksi, in the top fibers of the section.

(ii) The web is fully effective.

Calculation of the effective width of the compression flange:

$\lambda = (1.052 / Sqr (0.43) * (24.52) * Sqr (27.1 / 29500) = 1.190 > 0.673$

Hence, $\rho = [1 - 0.22 / 1.190)] / 1.190 = 0.685$

Therefore, $b_d = 0.685 * 1.471 = 1.008$ in.

(ii)   Effective section properties about x - axis :

Element	L Effective Length (in.)	y Distance from top fiber (in.)	Ly (in.^2)	Ly^2 (in.^3)	I_1' About own axis (in.^3)
Web	5.692	3.000	17.076	51.228	15.368
Upper corner	0.195	0.075	0.015	0.001	----
Lower corner	0.195	5.925	1.155	6.846	----
Compression flange	1.008	0.030	0.030	0.001	----
Tension flange	1.471	5.970	8.782	52.428	----
	--------		---------	---------	---------
Sum	8.561		27.058	110.504	15.368

(iii)   Distance of the top fiber from the neutral axis, y_{cg} = 27.058 / 8.561 = 3.161 in.
Since, y_{cg} > d /2, the top fiber controls the determination of S_e.

(iv) <u>To check if web is fully effective (Sec. B2.3 - (a), (b)) :</u>
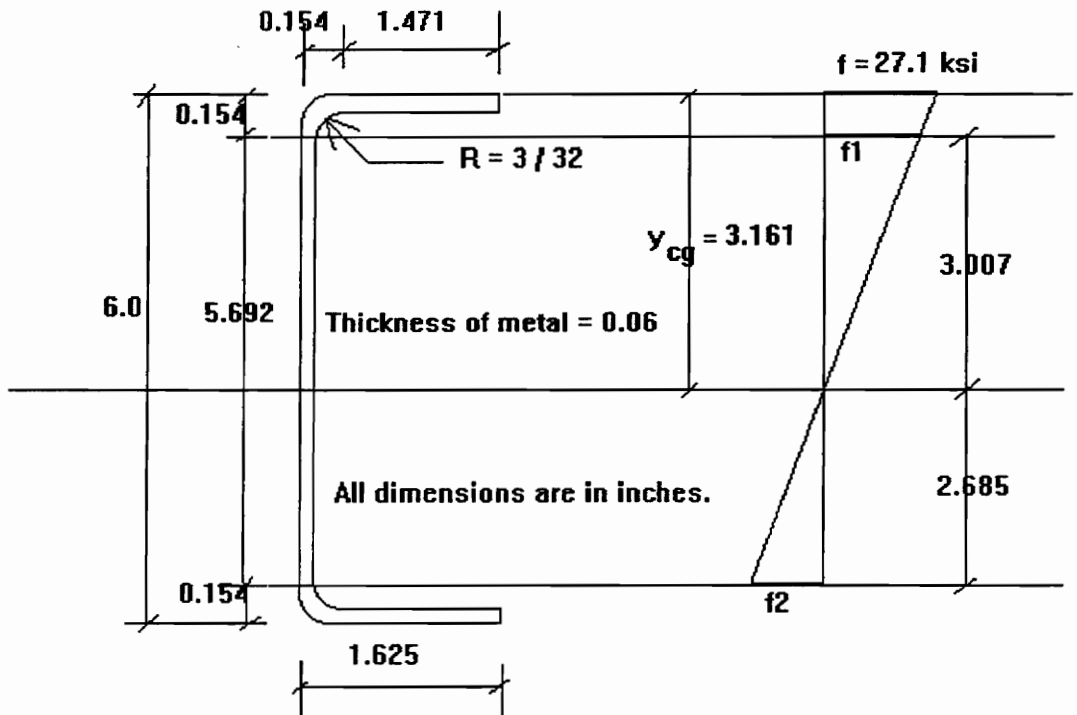
$f_1 = (3.007 / 3.161) * 27.1 = 23.78$ ksi   (compression)

$f_2 = - (3.007 / 3.161) = - 22.94$ ksi   (tension)

$\psi = f_2 / f_1 = - 0.893$

$k = 4 + 2 * (1 - \psi)^3 + 2 * (1 - \psi)$ (Eq. B2.3 - 4)

  $= 21.353$

$h = 5.692$ in. ; $h / t = 94.87 < 200$ OK.   (Sec. B1.2 - (a))

$\lambda = 1.052 / Sqr (k) * (h / t) * Sqr (f_1 / E) = 0.637$

Since, $\lambda < 0.673$

$b_e = h = 5.692$ in.

$b_2 = b_e / 2 = 2.846$ in.   (Eq. B2.3 - 2)

$b_1 = b_e / (3 - \psi) = 1.462$ in.   (Eq. B2.3 - 1)

$b_1 + b_2 = 4.308$ in.

Compression portion the web, calculated on the basis of the effective section, is

$y_{cg} - 0.154 = 3.007$ in.

Since, $(b_1 + b_2) > 3.007$ in. , $(b_1 + b_2)$ is taken as 3.007 in. Thus, the second

assumption is also valid, i. e., the web is fully effective.

(v) $I_x' = \Sigma (Ly^2) + \Sigma (I_1') - y_{cg} ^ 2 * \Sigma (L)$

= 40.331 in.^3

Actual $I_x = I_x' * t = 2.420$ in.^4

$S_e = I_x / y_{cg} = 0.766$ in.^3

$M = f * S_e = 20.68$ k-in. $= M_s$.

Thus, $I_x = 2.420$ in.^4.

Note: The results of this problem solved with Cold-Formed Steel Design program is

given on the next two pages.

USER INPUT

Fy = 50.00 ksi
E = 29500.00 ksi
t = 0.060 in
Width of top flange = 1.625 in
Radius of top corner = 0.094 in
Depth of section = 6.000 in
Radius of bottom corner = 0.094 in
Width of bottom flange = 1.625 in

MOMENT CAPACITY RESULTS

Ycg = 3.244 in
Ix = 2.286 in^4
St = 0.705 in^3
Sb = 0.830 in^3
Mn = 35.234 in-K
PhiMn = 31.710 in-K
f top fiber = 50.000 ksi

DEFLECTION CAPACITY RESULTS

Ms = 20.681 in-K
Ix at Ms = 2.421 in^4
St at Ms= 0.766 in^3
f top fiber at Ms= 27.010 ksi

GROSS SECTION PROPERTIES OF ELEMENTS

Top Flange

Flat width = 1.471 in
Effective width = 0.785 in
Distance from NA to top fiber = 0.030 in

Top Corner
----
u = 0.195 in
C1 = 0.079 in
Ix = 0.000 in^3
Distance from NA to top fiber = 0.075 in

Web

Flat width = 5.692 in
Fully Effective
Ix = 15.3679 in^3
f1 = 47.63 KSI
f2 = -40.09 KSI

Bottom Corner
----
u = 0.195 in
C1 = 0.079 in
Ix = 0.000 in^3
Distance from NA to top fiber = 5.925 in

Bottom Flange

Flat width = 1.471 in
Distance from NA to top fiber = 5.970 in

Example Two: A Hat Section with an intermediate stiffener
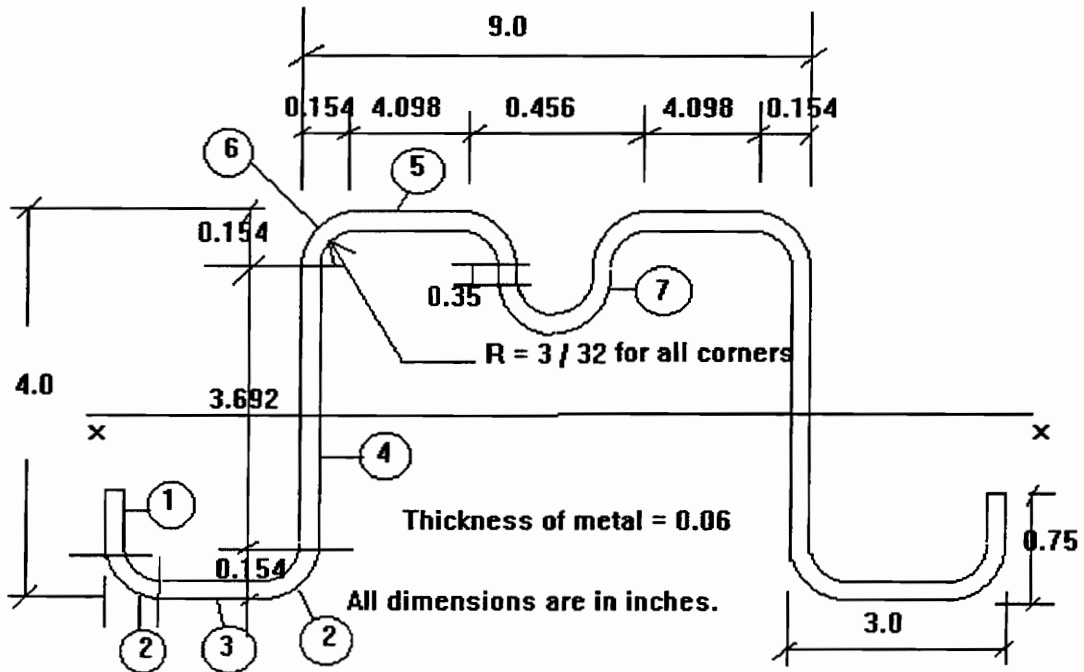
Given : 1.   Yield Stress of steel is 50 ksi., and the modulus of elasticity of steel is 29500 ksi.

2.   Dead Load to live load ratio is 1:5, and 1.2D + 1.6L governs the design.

Find :   1.   Design flexural strength, $\phi_b M_n$, based on initiation of yielding.

Solution :

1. Determination of the flexural design strength

A. Calculation of element properties

(i) 90 degree corner :

$r = R + t / 2 = 0.124$ in.

Length of arc, $u = 1.57 * r = 0.195$ in.

Distance of c.g. from the center of radius, $c = 0.637 * r = 0.079$ in.

(ii) Element 5 :

$b_0 = 9.000 - 0.154 * 2 = 8.692$ in.

Flat width, $w = 4.098$ in.

(iii) Web :

Flat width, $h = 4.0 - 2 * (0.124 + 0.03) = 3.692$ in.

(iv) Bottom flange (Element 3) :

Flat width, $w = 3.0 - 2 * 0.154 = 2.692$ in.

(v) Edge stiffeners (Element 1) :

Straight length, $d = 0.75 - 0.154 = 0.596$ in.

B. Computation of Ix :

Assume :　　(a)　Compressive stress $f = Fy = 50$ ksi in the top fibers of the section.

(b)   The web is fully effective.

Element 4 :

$h / t = 61.53 < 200$ OK.   (Sec. B1.2 - (a))

Element 5 :

$S = 1.28 * Sqr (E / f) = 31.09$ (Eq. B4.1-9)

$b_0 / t = 144.9 < 500$ OK.   (Sec. B1.1 - (a)-(2))

$3S = 93.27$ Hence, Case III.   (Sec. B4.1)

$I_a = t \wedge 4 * \{ [128 * (b_0 / t) / S] - 285 \} = 0.004038$ in.^4   (Eq. B4.1-9)

Determine the full section properties of the intermediate stiffener (Element 7):

0.154

0.35

0.154
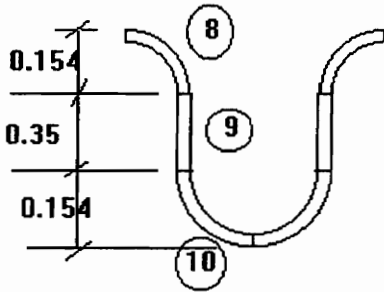
All dimensions are in inches.

Element	L	y	Ly	Ly^2	I1'
	Effective	Distance			About
	Length	from top			own
		fiber			axis
	(in.)	(in.)	(in.^2)	(in.^3)	(in.^3)
8	2 * 0.195 = 0.390	3.000	0.0293	0.0022	----
9	2 * 0.35 = 0.700	0.329	0.2303	0.0758	----
10	2 * 0.195 = 0.390	0.583	0.2274	0.1326	----
Sum	1.480		0.4870	0.2106	0.0071

Distance of the top fiber from the neutral axis, y_{cg} = 0.4870 / 1.480 = 0.329 in.

Total area of the section is = Σ(L) * t = 0.0888 in.^2

I_s' = 0.2106 + 0.0071 - 1.480 * (0.329) ^2 = 0.0575 in.^3

Actual I_s = 0.0575 * 0.06 = 0.00345 in.^4

Reduced Area of stiffener :

Element 9 :

   k = 4   for stiffened element

   $w / t = 0.35 / 0.06 = 5.83 < 500$ OK.   (Sec. B1.1 - (a) - (2))

   $\lambda = 1.052 / \text{Sqr} (k) * (w / t) * \text{Sqr} (f / E) = 0.126 < 0.673$

Hence, $b = w = 0.35$ in.

   $A_s' = \Sigma(L) * t = 0.0888$ in.^2

   $A_s = A_s' * (I_s / I_a)$, less or equal to A_s'.

      $= 0.0759$ in.^2 $< A_s'$ OK.

   $L_s = A_s * t = 1.265$ in.

Continuing with element 5 :

   $k = 3 * (I_s / I_a) \wedge 1/3 + 1$, should be less or equal to 4   (Eq. B4.1-10)

   $w / t = 68.30$

   $\lambda = 1.052 / \text{Sqr} (k) * (w / t) * \text{Sqr} (f / E) = 1.508 > 0.673$

   $\rho = (1 - 0.22 / \lambda) / \lambda = 0.566$

   $b = \rho * w = 2.320$ in.

Effective section properties about the x-axis:

Element	L Effective Length	y Distance from top fiber	Ly	Ly^2	I1' About own axis
	(in.)	(in.)	(in.^2)	(in.^3)	(in.^3)
1	2 * 0.596 = 1.192	3.548	4.229	15.005	----
2	4 * 0.195 = 0.780	3.925	3.062	12.016	----
3	2 * 2.692 = 5.384	3.970	21.375	84.857	----
4	2 * 3.692 = 7.384	2.000	14.768	29.536	8.388
5	2 * 2.320 = 4.640	0.030	0.139	0.004	----
6	2 * 0.195 = 0.390	0.075	0.029	0.002	----
7	1.265	0.329	0.416	0.137	0.058
Sum	21.035		44.018	141.557	8.481

Distance of neutral axis from the top fiber is, y_{cg} = 44.018 / 21.035 = 2.093 in.

Since, y_{cg} > d /2 , assumption (a) is valid.

(iv) To check if web is fully effective (Sec. B2.3) :

f = 50 ksi

0.154

f1

2.093

1.939

3.692

N.A.

1.753

f2

All dimensions are in inches.
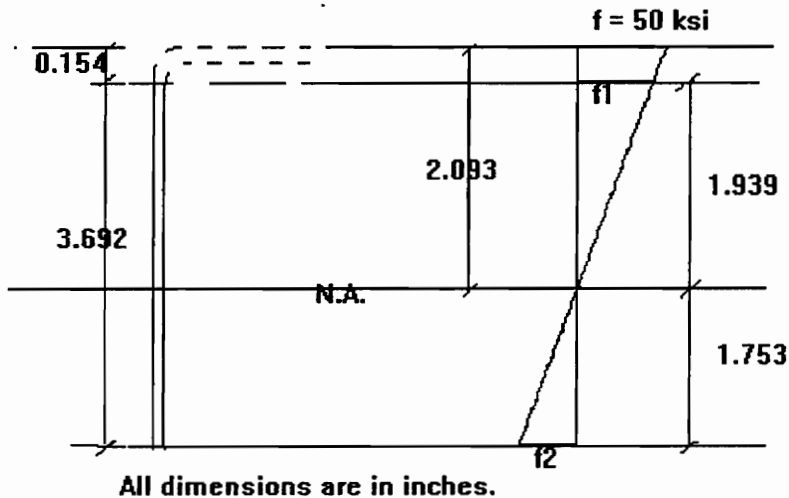
$f_1 = (1.939 / 2.093) * 50 = 46.32$ ksi   (compression)

$f_2 = - (1.753 / 2.093) * 50 = - 41.88$ ksi   (tension)

$\psi = f_2 / f_1 = - 0.904$

$k = 4 + 2 * (1 - \psi)^3 + 2 * (1 - \psi)$ (Eq. B2.3 - 4)

    $= 21.61$

$h = 3.692$ in. ; $h / t = 61.53 < 200$ OK.   (Sec. B1.2 - (a))

$\rho = 1.052 / Sqr (21.61) * (61.53) * Sqr (46.32 / 29500) = 0.552$

Since, $\rho < 0.673$

    $be = w = 3.692$ in.

    $b_2 = be / 2 = 1.846$ in.   (Eq. B2.3 - 2)

    $b_1 = be / (3 - \psi) = 0.946$ in.   (Eq. B2.3 - 1)

    $b_1 + b_2 = 2.792$ in.

Compression portion the web, calculated on the basis of the effective section, is

    $y_{cg} - 0.154 = 1.939$ in.

Since, $(b_1 + b_2) > 1.939$ in. , $(b_1 + b_2)$ is taken as 1.939 in. Thus, the second assumption is also valid, i. e., the web is fully effective.

(v) $I_x' = \Sigma (L_y{}^\wedge 2) + \Sigma (I_1') - y_{cg}{}^\wedge 2 * \Sigma (L)$

        $= 57.89$ in.^3

        Actual $I_x = I_x' * t = 3.47$ in.^4

C.   Calculation of Factored Moment :

        $S_e = I_x / y_{cg} = 1.66$ in.^3

        $M_n = F_y * S_e = 83.0$ k-in.   (Eq. C3.1.1 - 1)

        $\phi_b = 0.95$ (Sec. C3.1)

        $\phi_b M_n = 78.85$ k-in.   (positive bending).

Note: The results of this problem solved with Cold-Formed Steel Design program is given on the next two pages.

```
*****COLD-FORMED STEEL DESIGN*****
  Edge Stiffened Hat with Intermediate Stiffene:

USER INPUT
==========
Fy = 50.00 ksi
E = 29500.00 ksi
t = 0.060 in
D edge stiffener = 0.750 in
Angle of edge stiffener = 90.000 degrees
Radius of bottom corners = 0.094 in
Width of bottom flange = 3.000 in
Width of top flange = 9.000 in
Radius of top corners = 0.094 in
Depth of section = 4.000 in
Flat width of intermediate stiffener web = 0.350 in
Radius of intermediate stiffener = 0.094 in

MOMENT CAPACITY RESULTS
===========================
Ycg = 2.092 in
Ix = 3.469 in^4
St = 1.658 in^3
Sb = 1.818 in^3
Mn = 82.905 in-K
PhiMn = 78.759 in-K
f top fiber = 50.000 ksi
```

*****COLD-FORMED STEEL DESIGN*****
Edge Stiffened Hat with Intermediate Stiffener

GROSS SECTION PROPERTIES OF ELEMENTS

Edge Stiffener
----
d = 0.596 in
Ix = 0.018 in^4
Distance from NA to top fiber = 3.548 in

Bottom Corner
----
u = 0.195 in
C1 = 0.079 in
Ix = 0.000 in^4
Distance from NA to top fiber = 3.925 in

Top Flange

Flat width w = 4.098 in
Effective width b= 2.320 in
Distance from NA to top fiber = 0.030 in

Top Corners
----
u = 0.195 in
C1 = 0.079 in
Ix = 0.000 in^4
Distance from NA to top fiber = 0.075 in

Web

Flat width = 3.692 in
Fully Effective
Ix = 4.1938 in^4
f1 = 46.32 ksi
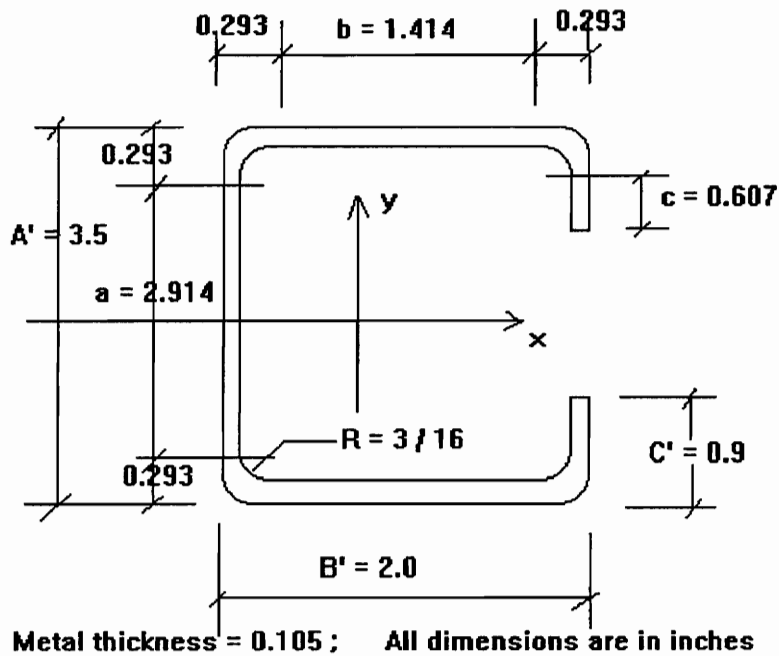f2 = -41.92 ksi

Intermediate Stiffener

Actual Length of Stiffener = 1.479 in
Reduced Length of Stiffener= 1.262 in.
Area of Stiffener = 0.076 in^2
Ix = 0.003 in^4
Distance from NA to top fiber = 0.329 in

Bottom Flange

Flat width = 2.692 in
Distance from NA to top fiber = 3.970 in

Example Three: Channel section under axial loading :

Metal thickness = 0.105 ;   All dimensions are in inches

Given : F_y = 50 ksi., and E for steel is 29500 ksi.

$$K_x L_x = K_y L_y = K_t L_t = 6 \text{ ft.}$$

Find :   The design axial strength, $\phi_c P_n$.

Solution :

1.   Basic parameters:

        r = R + t /2 = 0.240 in. and α = 1.0 for stiffened sections.

        abar = A' - t = 3.395 in.

        bbar = B' - t = 1.895 in.

cbar = C' - t / 2 = 0.848 in.

u = 1.57 * r = 0.377 in.

2.   Total Area, A = t * [a + 2b +2c + 4u] = 0.889 in.^2

3.   Moment of inertia about x - axis,

I_x = 1.657 in.^4

4.   Distance from the centroid of the section to the centerline of web is,

xbar = 0.757 in.

.5.   Moment of inertia about y - axis,

I_y = 0.524 in.^4

6.   Distance from shear center to centerline of web,

m = 1.194 in.

7.   Distance from centroid to shear center,

x_0 = - (xbar + m) = -1.951 in.

8.   St. Venant torsion constant,

J = 0.003266 in.^4

9.   Warping constant,

C_w = 2.05 in.^6

10. Radii of gyration,

$$r_x = Sqr (I_x / A) = 1.365 \text{ in.}$$

$$r_y = Sqr (I_y / A) = 0.768 \text{ in.}$$

$$r_0 = Sqr (r_x \char94 2 + r_y \char94 2 + x_0 \char94 2)$$

$K_y L_y / r_y = 93.75 < 200$ OK.

11. Torsional-flexural constant,

$$\beta = 1 - (x_0 / r_0) \char94 2 = 0.392$$

12. Determination of Fe:

$$(F_e)_1 = \pi \char94 2 * E / (K_y L_y / r_y) \char94 2 \qquad \text{(Eq. C4.1 - 1)}$$

$$= 33.13 \text{ ksi.}$$

$$\sigma_{ex} = \pi \char94 2 * E / (K_x L_x / r_x) \char94 2 \qquad \text{(Eq. C3.1.2 - 7)}$$

$$= 104.65 \text{ ksi.}$$

$$\sigma_t = 1 / (A * r_0 \char94 2)[GJ + (\pi \char94 2 * E * C_w) / (K_t L_t \char94 2) \qquad \text{(Eq. C3.1.2 - 9)}$$

$$= 27.23 \text{ ksi.}$$

$$(F_e)_2 = (1 / 2\beta)[\sigma_{ex} + \sigma_t) - Sqr ((\sigma_{ex} + \sigma_t)\char94 2 - 4\beta\sigma_{ex}\sigma_t]$$

$$= 23.27 \text{ ksi.}$$

Therefore, $F_e = 23.27$ ksi.

Determination of F_n :

$$F_y / 2 = 25.0 \text{ ksi}$$

For $F_e < F_y / 2$

$$F_n = F_e = 23.27 \text{ ksi.} \qquad \text{(Eq. C4-3)}$$

<u>Determination of A_e :</u>

<u>Flanges:</u>

      d = 0.607 in.

      Is = d ^ 3 * t / 12 = 0.001957 in.^4

      D = 0.9 in.,   w = 1.414 in.,   D / w = 0.636 < 0.80

      S = 1.28 * Sqr (E / f) = 45.57,   where, f = 23.27 ksi.

      w / t = 13.47 < S / 3 = 15.19; hence Ia = 0 and b = w = 1.141 in.

Hence, flanges are fully effective.

<u>Web :</u>

      w = 2.914 in.;   k = 4

      λ = 0.41 < 0.673

Hence, b = w = 2.914 in.   The web is fully effective.

<u>Lips :</u>

      d = 0.607 in.

      k = 0.43,   for unstiffened element.

      ds = ds'

      λ = 0.26 < 0.673

Therefore, ds' = d = 0.607 in.

      d / t = 5.78 < 14   OK.

Since flanges, web, and lips are fully effective,

      Ae = A = 0.889 in.^2

Determination of $\phi_c P_n$:

      $Pn = Ae * Fn = 20.69$ kips

      $\phi_c = 0.85$

      $\phi_c P_n = 17.58$ kips.

Note: The results of this problem solved with Cold-Formed Steel Design program is given on next page.

*****COLD-FORMED STEEL DESIGN*****
Stiffened C Channel

USER INPUT
====================

Fy = 50.00 ksi
E = 29500.00 ksi
t = 0.105 in
D top stiffener = 0.900 in
Angle of top stiffener = 0.000 degrees
Radius of top stiffener corner = 0.188 in
Width of top flange = 1.707 in
Radius of top corner = 0.188 in
Depth of section = 3.500 in
Radius of bottom corner = 0.188 in
Width of bottom flange = 1.707 in
Radius of bottom stiffener corner = 0.188 in
Angle of bottom stiffener = 0.000 degrees
D bottom stiffener = 0.900 in

COMPRESSION CAPACITY RESULTS
==================================

Area = 0.889 in^2
Effective area = 0.889 in^2
St. Venant torsion constant, J = 0.00327 in^4
Moment of inertia about the x-axis, Ix = 1.658 in^4
Radius of gyration about the x-axis, rx = 1.366 in
Moment of inertia about the y-axis, Iy = 0.524 in^4
Radius of gyration about the y-axis, ry = 0.768 in
Distance between shear center and center of gravity = -1.949 in
Polar radius of gyration, ro = 2.501 in^2
Beta = 0.392
Sigma ex = 104.74 ksi
Sigma t = 27.33 ksi
Elastic buckling stress, Fe = 23.28 ksi
Nominal buckling stress, Fn = 23.28 ksi
Unfactored compressive strength, Pn = 20.7 kips
Factored compressive strength, Pu = 17.59 kips

A.2   User's Guide to Cold-Formed Steel Design Program

A.2.1 Loading the Startup Form

1.   To start Cold-Formed Steel Design program, choose the menu ' Run ' from the
        Visual Basic ToolBar, or click the ' run ' icon. The startup form is loaded
        automatically. This form has a heading PROGRAM MANAGER. It shows six
        different kinds of cold-formed steel sections that the program can evaluate.

2.   To exit Cold-Formed Steel Design program, choose Exit from the file menu on
        the PROGRAM MANAGER, or click the ' stop ' icon on the Visual Basic
        Toolbar.

PROGRAM MANAGER

File   Help

COLD-FORMED STEEL DESIGN

This program accepts dimensional and material input from the user for six possible
cold-formed steel shapes, a channel section, a Z-section, a hat section, an angle
section, an I section and a deck section. Design moment and compressive strength
are computed according to the specifications of the 1991 LRFD Cold-Formed Steel
Design Manual. The program checks limit states specified in the 1991 Specification.
COLD-FORMED STEEL DESIGN was written by Clint Rex, Angela Terry, and Rodney
Simon and subsequently modified and extended by Sanjoy Chowdhury.

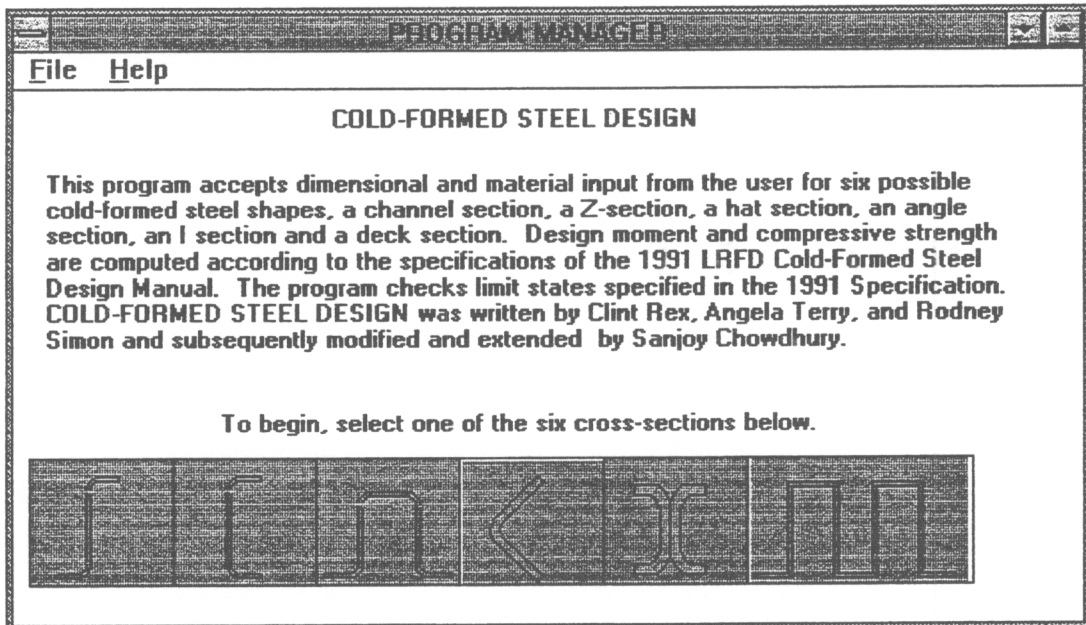To begin, select one of the six cross-sections below.

Figure A.1   The figure of the form PROGRAM MANAGER

A.2.2 <u>Choosing a Member Shape</u>

1.   To start the evaluation of a member shape, choose any one of the six member
        shapes, shown on the PROGRAM MANAGER, by clicking on the desired
        member shape. Once the member shape has been chosen from PROGRAM
        MANAGER, it automatically closes and a form showing the chosen member
        shape is loaded. This new form contains the name of the member chosen, for
        example, if a C-section is chosen, it will have a heading C - CHANNEL
        OPTIONS. A picture of the member shape is shown on the form. The user is
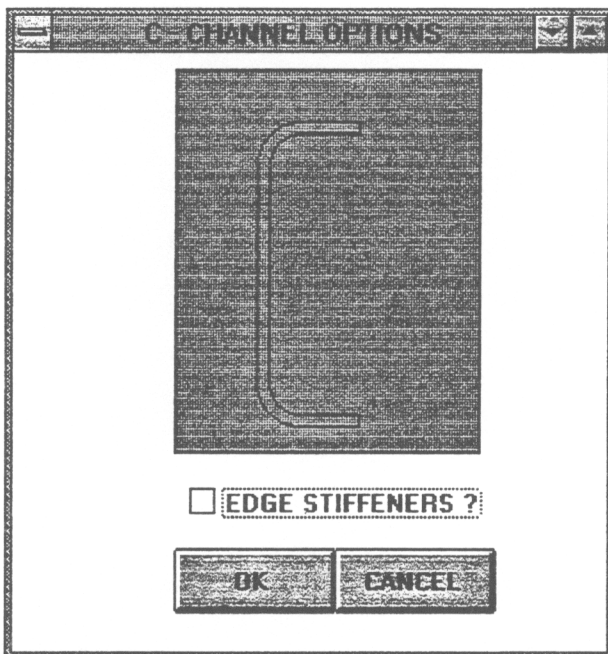   asked to specify whether the given section is stiffened or unstiffened.

Figure A.2   A Channel section option form

2.   If the section is stiffened ' check ' the checkbox, ' EDGE STIFFENERS ? ' with

a **X** mark. If it is an unstiffened section the checkbox is ' unchecked '.

3.   To start evaluation of the chosen member section, click the O. K. button.

4.   To exit and return to PROGRAM MANAGER, click the Cancel button.

A.2.3 Specifying the Dimensions and the Steel Properties of a Member Section

When the O.K. button is clicked, the form showing the chosen member shape

is displayed on the screen. The various text boxes are also shown on the

screen.

1.   To input the value of the dimensions of the section, and the properties of the

steel such as modulus of elasticity, and yield stress, go to the respective text

box and click the left button of the mouse. The cursor will start blinking on the

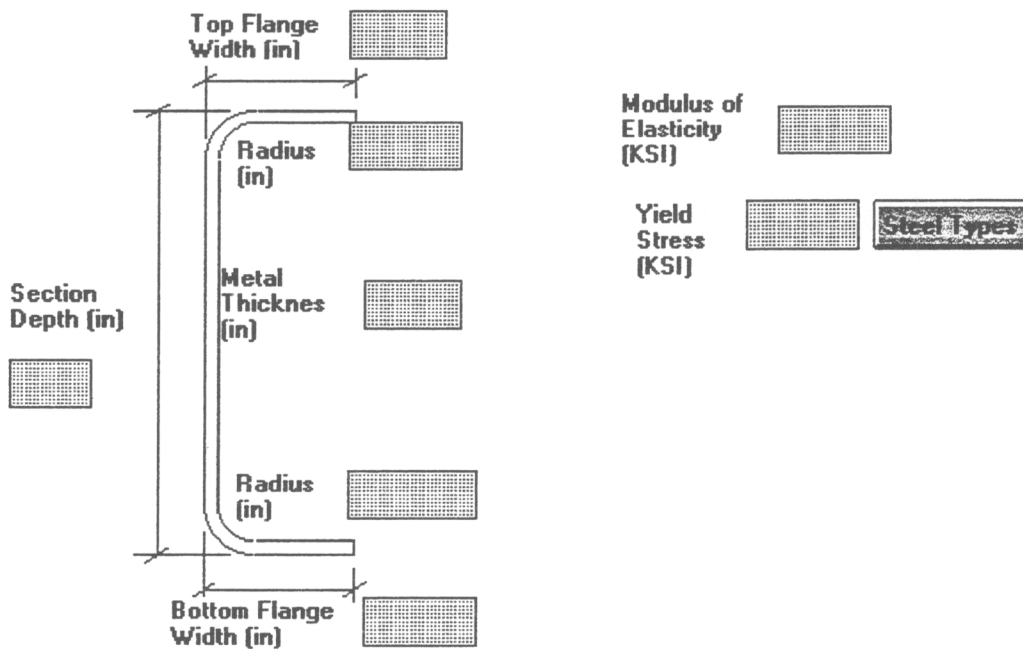selected text box. Type in the required value and go to the next text box.

Top Flange
Width (in)

Modulus of
Elasticity
(KSI)

Radius
(in)

Yield
Stress
(KSI)

Steel Types

Section
Depth (in)

Metal
Thicknes
(in)

Radius
(in)

Bottom Flange
Width (in)

Figure A.3   Form showing an Unstiffened Channel section with the input boxes.

A.2.3.1   Choosing Yield Stress of Steel from the ' STEEL TYPE ' Item

The yield stress of steel can also be selected from the Steel Type item.

1.   Click on ' Steel Type ' button, to give a list of the types of steel used in the cold-formed industry. A window appears on the screen, showing the various types of steel.

2.   On the right side of the window there are three options, Select Steel, Get Info, and Cancel. Click the Get Info option, to get information about the type of steel chosen.

3.   Click on Select Steel to show a window with various grades of steel. On this window choose the grade of steel desired, using the mouse and the cursor.

4.   Go to Select Grade option, by clicking on it with the mouse, to fill in the text box with the yield stress of steel.

5.   The Cancel option takes the user back to the input form.

A.2.4 Calculating the Design Moment

The Design Moment is included as an item, within the Flexural Design menu.

1.   Click the Flexural Design menu, on the main menu bar.

2.   To calculate the nominal moment of a member section, click Design Moment item. A window will appear on the screen and ask the user, whether or not to consider the increase of stresses due to cold-working.

3.   To consider the effects of cold-working click YES, and to neglect the effect of cold-working, click NO.

The program will calculate the values of the nominal moment, and the factored nominal moment, according to the user's choice. At the end of the calculation the values of the nominal moment, design moment, moment of inertia, etc., are shown on the screen.

A.2.5 Calculating the Lateral Buckling Strength

1. To calculate the lateral buckling of the chosen member section, click on the Lateral Buckling Strength item, in the Flexural Design menu. A window will appear on the screen and prompt the user to type in the value of the effective lengths, KxLx, KyLy and KtLt, which have been assumed to be the same in this program.

2. Type in this value, and click O.K.

3. Another window appears on the screen, prompting for the value of moment, M_1. Type in this value and click O.K.

4. Repeat the above procedure for the value of moment, M_2.

5. A third window will pop up, and prompt the user to specify whether or not the moments have the same sign. Click YES or No as the case may be.

6.   To terminate lateral buckling strength calculation, choose Cancel in steps 2, 3, or 4.

A.2.6 Calculating Deflection Properties

1.   Click on the Deflection Properties item in the Flexural Design menu. A window will appear prompting the user to give the value of the live load to dead load ratio.

2.   Type this value, and click O.K.

The values of the service moment, stress at the extreme fiber, effective section modulus, and the moment of inertia for deflection calculation, will appear on the screen inside a window.

3.   If the user does not want to continue with the deflection properties calculation clicking the Cancel button will terminate it.

A.2.7 Calculating the Web Crippling Strength

1.   Click the Web Crippling item, in the Flexural Design menu. A window will appear on the screen.

2. Type the bearing length of the support in the text box shown.

3. Check for the condition whether the support distance is greater than 1.5h or not, by putting a **X** mark in the appropiate box.

4. Repeat step 3 for the other support condition.

5. Click the O.K. button to get the value of the nominal load per web.

6. The Cancel button provided allows the user to quit web crippling calculation.

Figure A.4   A Web Crippling input form

A.2.8 Combined Bending and Web Crippling Strength Calculation

This item, within the Flexural Design menu, is activated after the Design Moment item and the Web Crippling item has been selected.

1.   To calculate the combined bending and web crippling strength of a member section, click on this item. A window will pop up prompting for the value of Pu.

2.   Type in this value and click O. K. or press Enter.

3.   Another window shows up prompting for the value of Mu. Repeat the previous procedure.

4.   A third window pops up and prompts the user whether the web is a single unreinforced web. Choose YES or NO as the case may be using the the mouse and the cursor.

    A message appears on the screen telling the user whether the section is safe or not.

5.   Use the Cancel button in steps 2 or 3 to terminate the calculation.

A.2.9 <u>Compression Design</u>

1. To calculate the compressive strength of the member section click the Compression Design menu. It will show the Compressive Strength item.

2. Click on this item to start compressive strength calculation. A window will appear prompting for the value of the effective length of the member.

3. Type in this value and click O.K.
   The results of the compression strength calculation will appear inside a window on the screen.

4. Click the Cancel button to terminate compressive strength calculation.

A.2.10   <u>Shear Design</u>

1. Click the Shear Design menu on the main menu bar. It will show the Shear Strength item, and the Combined Bending and Shear Strength item

2. Click the Shear Strength item. A window appears on the screen prompting the user whether the web is reinforced or unreinforced.

3. Click YES or the NO as the case may be.

The program then calculates the values of the shear strength and the factored shear strength which are displayed on the screen along with the ' kv ' value and the h/t ratio.

A.2.11   <u>Calculation for Combined Bending and Shear</u>

This item comes within the Shear Design menu. This can be calculated only after calculating the nominal moment and shear strength of the section.

1.   Choose this item by clicking on it with the mouse. A window will pop up and prompt the user for the value of Mu.

2.   Type in this value and click O. K. or press Enter. Another window will pop up prompting for the value of Vu.

3.   Repeat the above procedure. Again a window comes up on the screen and asks the user whether the web of the section is reinforced.

4.   Choose YES or No as reqiured.
A window will be displyed on the monitor saying whether the section is safe or not.

5.   Click Cancel in steps 2 or 3 to terminate the calculation.

A.2.12　　　Saving the Dimensional Data as an Input File

The dimensions of the various elements of a section, along with the steel properties, such as the modulus of elasticity and yield strength, can be saved as an input file.

1.　　　Choose the Save As item in the file menu. A window comes up on the screen.

2.　　　On this window choose the drive in which the file is to be saved from the drive list box.

3.　　　Type in the name of the file in which the data is to be saved. All files are saved with the .CFS extension.

4.　　　Choose the directory in which the file is to be saved.

5.　　　Then click the O. K. button to save the file.

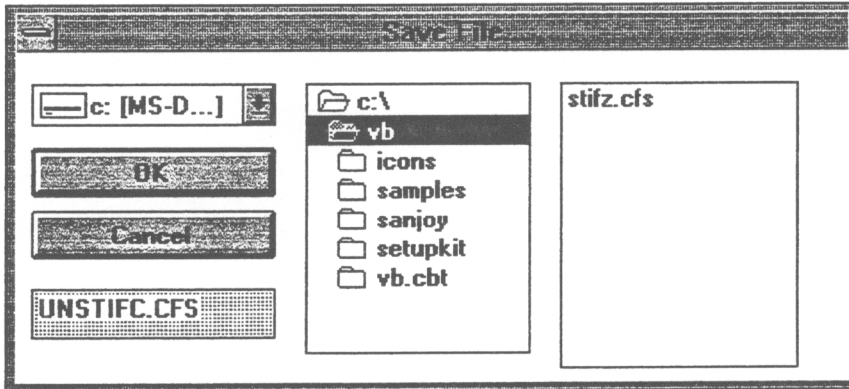6.　　　To go out of this menu click the Cancel button.

Figure A.5   A typical " Save File " picture box

A.2.13   Opening an Input File

1.   Click on the file menu in the main menu bar.

2.   Choose Open File item from the file menu. A window appears on the screen
       showing the drive list box, directory list box and the file list box.

3.   Use the mouse to choose the required drive, directory and the file. Once the file
       is chosen its name appears on the text box below the Cancel button.

4.   Click the O.K. button to load the file.

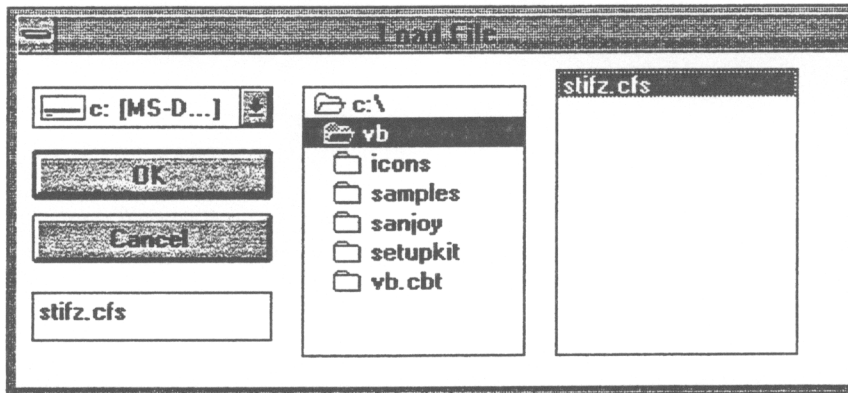5.   To exit without loading the file click Cancel.

Figure A.6   A typical " Load File... " picture box

A.2.14   Printing the Results

To get a hard copy of the member evaluation results, choose Print item from the
File menu. If the computer is connected to a printer, it starts printing the results
immediately.

A.2.15   Quitting Evaluation of a Member Section

To quit the evaluation of a particular section the user needs to click on the File
menu from the main menu bar. Then choose Return to Main Menu from the
File menu. The program will reload the startup form for the user to start
evaluating a new section.

A.2.16   <u>Graphics Display</u>

The Element menu in the main menu bar provides a graphics display of the various individual elements of a member section. This menu is activated only when the Design Moment menu is clicked.

1.   To activate this menu, click Design Moment item in the Flexural Design menu first. On completion of the nominal moment calculation, the Element menu will turn black from gray, indicating that it is active.

2.   Click on it to see a list of items available.

3.   Choose the item whose properties need to be seen by clicking on it. A picture will appear on the screen showing the selected item and giving all relevant information about it.

4.   To get rid of the picture use the mouse to position the cursor on the picture and click.

VITA

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