DEVELOPMENT OF PERFORMANCE SECTIONS FOR COLD-FORMED STEEL RESIDENTIAL CONSTRUCTION

by

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(ABSTRACT)

The wider use of cold-formed steel framing is hindered by the lack of generic sections. This study puts forth an effort to develop a performance section designation code without specifying the geometry of the sections. A PC-based program to analyze C-section was developed and used to produce typical *Performance Section Tables* for both wall studs and joists.

For curtain walls the *Uniform Lateral Load Capacity Tables* and for bearing walls the *Axial Load with Specified Lateral Load Tables*, the *Strong Axis Axial Load Capacity Charts*, and the *Weak Axis and Torsional Axial Load Capacity Charts* were developed. The typical design aids for roof/floor joists include the *Uniform Load Capacity Tables* for single and two continuous spans, the *Moment-Shear Interaction Capacity Charts*, and the *Web Crippling Capacity Tables*. Design examples are provided to illustrate the usage of the above tables and charts.

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Finally, I would like to acknowledge my parents, Cecilia Szalay and Zoltán Némedi for their love, support and encouragement.

This work is dedicated to my father, Zoltán Némedi, who is no longer with us to share my joy and pride upon the successful completion of my Master of Science degree.

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CHAPTER I

INTRODUCTION

1.1 Purpose of Study

The use of light gauge steel framing (LSF) is growing in popularity in the residential construction market especially for multi-family housing and nursery homes (Steel Framing and Roofing Opportunities 1992). In 1987, LSF only covered two percent of the market but it has a potential for much more (Walls and Ceilings, 1987).

Fire resistance and low maintenance cost of steel walls provide substantial advantages over both wood framing and masonry. Pre-punched holes allow easier installation of pipes and conduits and placing insulation in stud cavities makes thermal performance excellent. In price, LSF can be competitive with wood or masonry construction; in areas with expensive labor costs it might even be cheaper. Cold-formed steel wall studs - especially in the southern states - can also benefit from problems associated with lumber like termite infestation, rot decay, and shrinkage.

Steel roofing and floor systems - despite their relatively higher cost - also have their advantages. Similar to metal framing, they possess good maintenance and fire resistance characteristics and their better performance makes them favorable in areas with bad environmental conditions like snow build up, high wind and, intense sun exposure. Cold-formed metal roofing also has lighter weight and in certain areas regional aesthetic preferences can be beneficial also (Steel Framing and Roofing Opportunities 1992).

Light gauge metal sections are adaptable to numerous different structural systems. Floor joists can rest on concrete or masonry walls; load bearing studs can support steel joists, wood trusses or concrete slabs.

To further increase cold-formed steel popularity and usability, generic guidelines should be developed, minimizing engineering analysis, making design more uniform and increasing the number of off-the-shelf components which would be available all over the country. Today each manufacturer has optimized cross-sections available for various purposes. The number of different, specifically developed, innovative and highly optimized cross-sections on the market is extremely high[*]. On one hand the ability to do this is a very positive feature of cold-formed steel. On the other hand, it does not allow the designer to specify generic sections with required structural properties and makes pre-engineered design impossible.

There are two basic ways to overcome this hindrance. First, one could specify generic sections with prescribed geometry such as thickness, radii, lip length, etc. This approach would certainly make the market more uniform but its drawbacks are far larger then the advantages. The construction industry could no longer use its optimized sections and existing tooling and machinery might become obsolete.

A second, more promising approach is to develop performance section designations, similarly to what is already used in the open-web steel joist industry. No geometry, only certain performance requirements would be specified and published. Existing sections can simply be renamed in accordance with the new designation code, or manufacturers can develop new sections in any number of ways to make their products more competitive. Designers then can specify desired performances using the new designation system.

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[*] A survey of 17 companies found that over 410 different studs and 280 different joists are produced.

The intent of this research is to provide the above outlined performance section tables and a set of design aids for wall studs and roof/floor joists.

1.2 Description of Wall Stud and Floor/Roof Joist Systems

Light gauge steel sections can be used in many different ways. Figure 1.1 shows how studs, joists, tracks, channels and angels are utilized in an all-metal building.

1.2.1 Wall Studs

Vertical framing elements are commonly referred to as wall studs. They can be used in curtain-walls on exterior of buildings to resist lateral (wind) loads or as axial load bearing studs on the inside or outside of the structure to support floor and roof loads. The thickness of these sections generally ranges from 20 to 12 gauge (0.030 in. to 0.105 in.). The 25 gauge drywall studs systems are used for interior walls to withstand small lateral loads, usually without axial loads. In Figure 1.1 one can see exterior axial load bearing studs which are also subjected to lateral loads.

Wall studs frame into tracks which restrain rotation and horizontal displacement of the stud ends. All wall studs subjected to lateral loads require horizontal bridging. The purpose of bridging is multi-fold; it keeps the studs straight, helps resisting various forces and impacts under construction, and provides added stability against weak axis and torsional buckling. The most common type of bridging is a channel inserted through the knock-outs of the stud webs (Fig. 1.2a), but X-bridging (Fig. 1.2b), or straps are also acceptable.

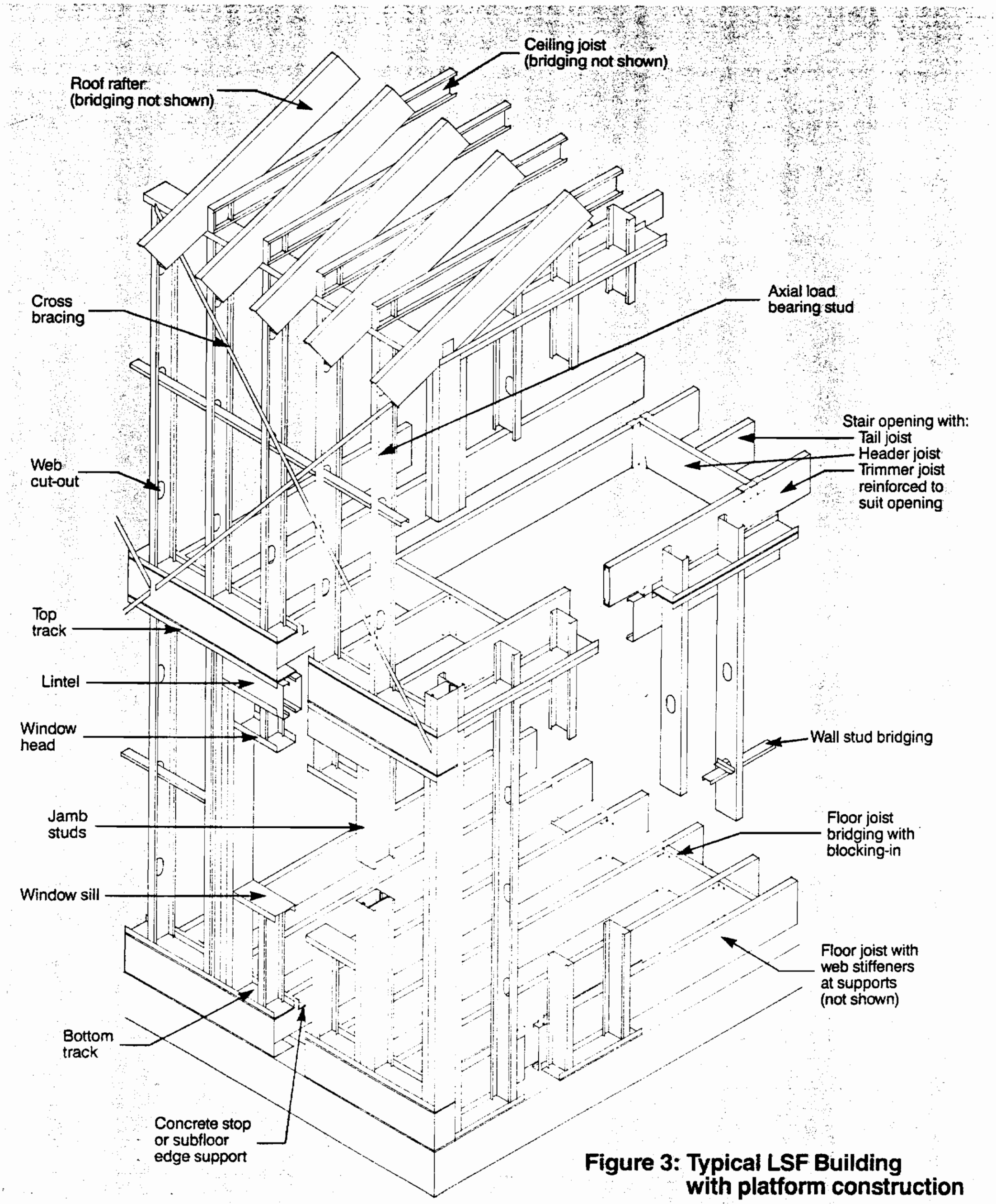
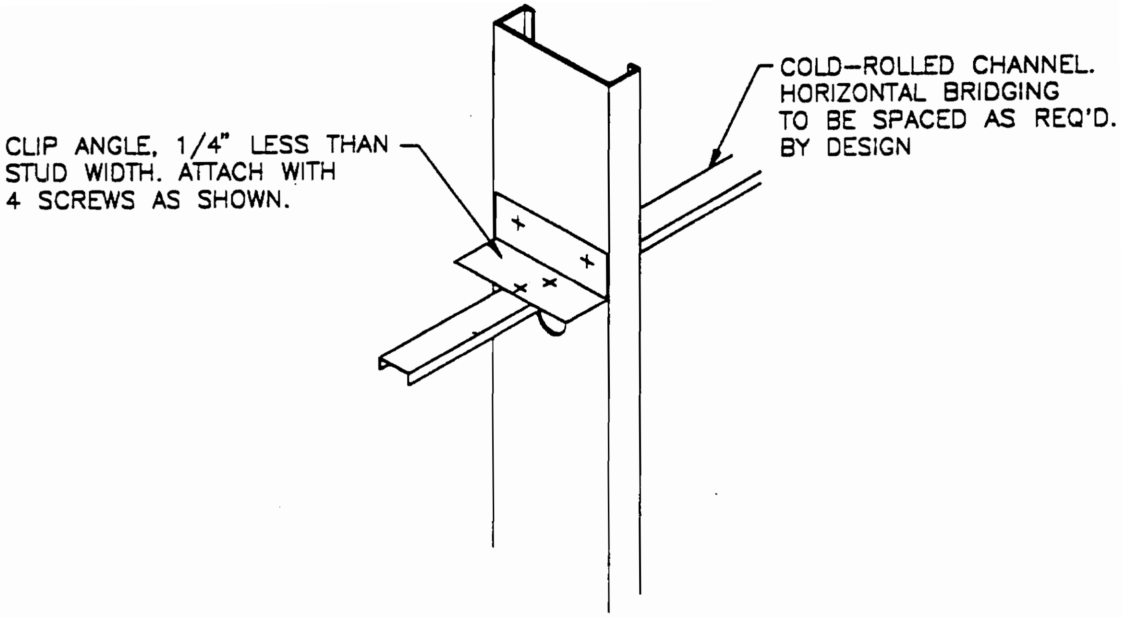
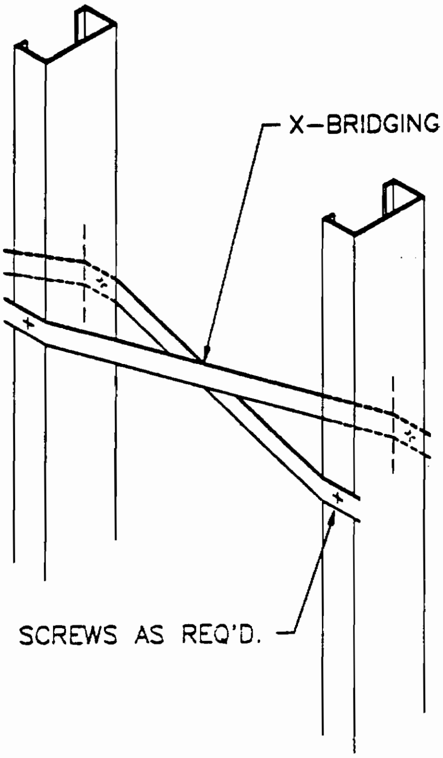


Figure 1.1 Typical Light Gauge Steel Building (from CSSBI, 1988)



a Bridging with Channel



b X-bridging

Figure 1.2 Typical Wall Stud Bridgings
(from AISI Construction Details)

To withstand forces parallel to the plane of the wall, which may result from wind or seismic loading, adequate bracing is required. The most effective way to provide this in-plane stiffness is by means of diagonal straps welded to the flanges of the studs and anchored at the ends. Since these straps carry tension loads only, they are normally used in both diagonals (Fig. 1.1).

Light gauge steel walls may be covered with various types of sheathing providing adequate to less then adequate lateral support. For interior, walls usually 3/8 to 5/8 inch thick gypsum boards are applied, which restrain studs against weak axis or torsional buckling giving additional axial strength. In the case of exterior walls, sheathing boards, cement stucco, bricks, plaster, etc. may also be attached to the studs.

1.2.2 Joists

Cold-formed joists are horizontal or inclined structural elements resisting floor and roof loads. The usual range of thickness range is the same as for wall studs 20 - 12 gauge, but their flange width is larger; 2 - 3 in. as opposed to 1 1/4 - 1 3/4 in. for studs.

Floor joists are supported by the top track and usually aligned with the wall studs (Fig. 1.1). Rafters can be attached to the joists (Fig. 1.3), or to clip angels resting on the top track. For bridging, channels (Fig. 1.3), or X-bracing can be used.

In case of large spans and/or high web height/thickness ratios web crippling may be a problem. Track or wall stud along the whole depth of the joist can be used to increase strength (Fig. 1.4b).

Joists can be covered with metal deck, concrete floor or plywood. At the stud-joist connection, angles prevent concrete from pouring into the stud cavities (Fig 1.1). For single spans the concrete floor provides continuous support all along the top (tension)

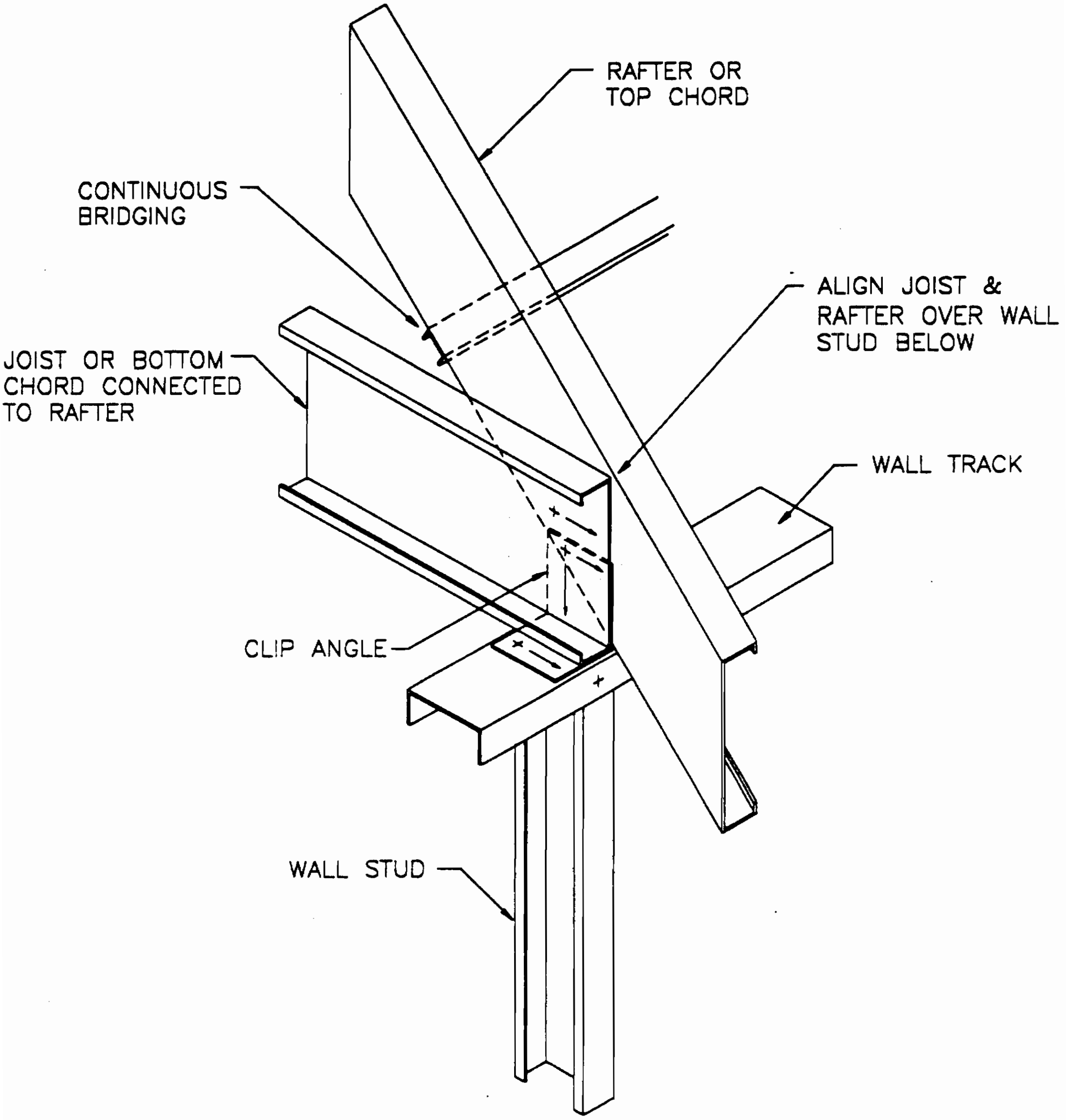
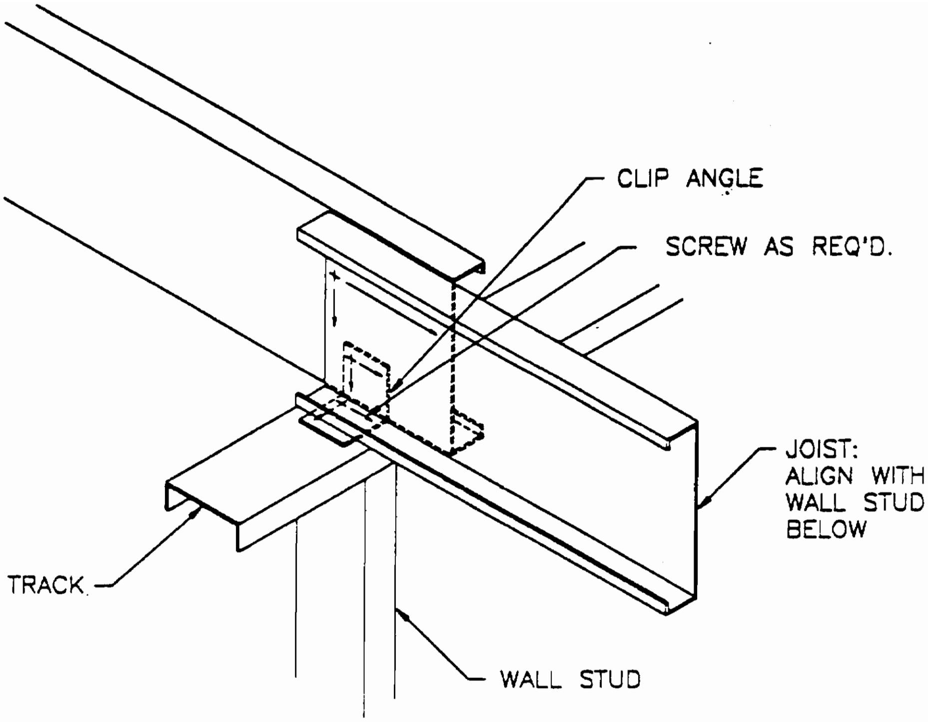
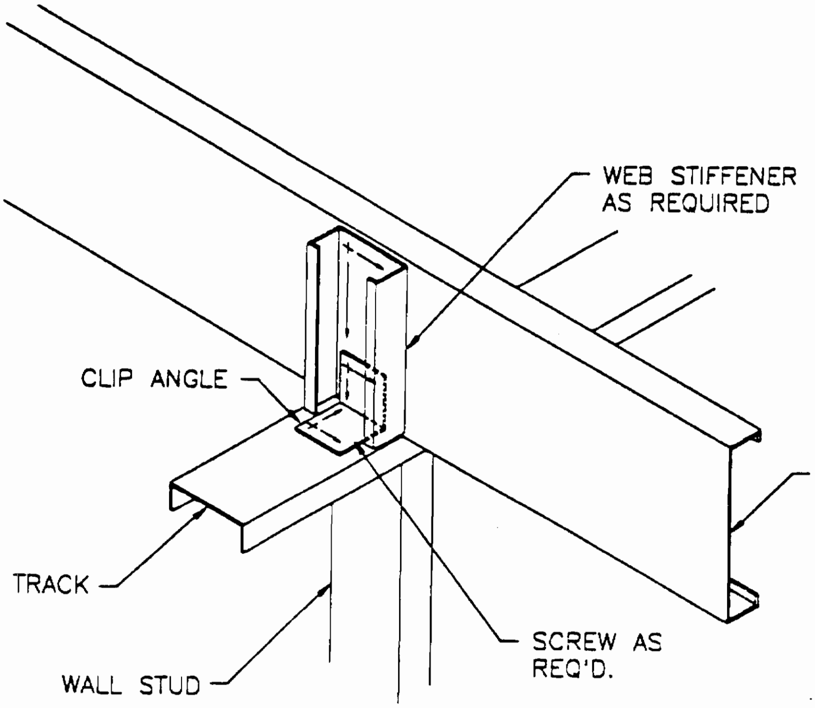


Figure 1.3 Roof Eave
(from AISI Construction Details)



a Support of Two Adjacent Single Spans



b Support of Continuous Span

Figure 1.4 Two Examples for Joists Supported on Studs (from AISI Construction Details) flange. Figure 1.4a shows details of support of two adjacent single spans. For the negative moment zones of continuous spans (Fig 1.4b), however, additional bridging is required to prevent joists from lateral torsional buckling. If the joists are not long enough to bridge two or more spans, lapping can be used to provide adequate continuity.

1.2.3 Scope of Study

Through the next five chapters this study will describe the development of performance sections and related tables. The computer program written for the purpose of analyzing cold-formed C-sections is dealt with in detail in Chapter II. The performance section tables for wall studs and joists are included in Chapter III. The next chapter contains the developed design aids for wall studs:

- uniform lateral load capacity tables,
- axial loads capacity with specified lateral loads tables,
- strong axis axial load capacity charts, and
- weak axis and torsional axial load capacity charts.

Chapter V provides further information about joists such as;

- uniform load capacities for single span,
- uniform load capacities for two continuous spans,
- moment-shear interaction capacity charts,
- web crippling capacity tables.

The last chapter gives a short summary of the work done.

CHAPTER II

PROGRAM FOR ANALYZING COLD-FORMED C-SECTIONS

2.1 General

The initial effort in this study was to develop a computer program for analyzing cold-formed sections. The program computes various properties and capacities of a cold-formed C-section with or without lips (Fig. 2.2), without taking the effects of cold forming into account. The program is written in QuickBasic, based on the 1986 Allowable Stress Design Edition of Cold-Formed Steel Design Specification (AISI Cold-Formed Steel Design Manual, 1986). It has a modular structure, each distinct set of calculations being performed by different subroutines. The main and sub-functions of the code are the following:

- input
- computation
  - section properties
  - flexural capacity
  - shear capacity
  - compression capacity
- output
  - screen
    - graphics
    - numerical data
  - printer

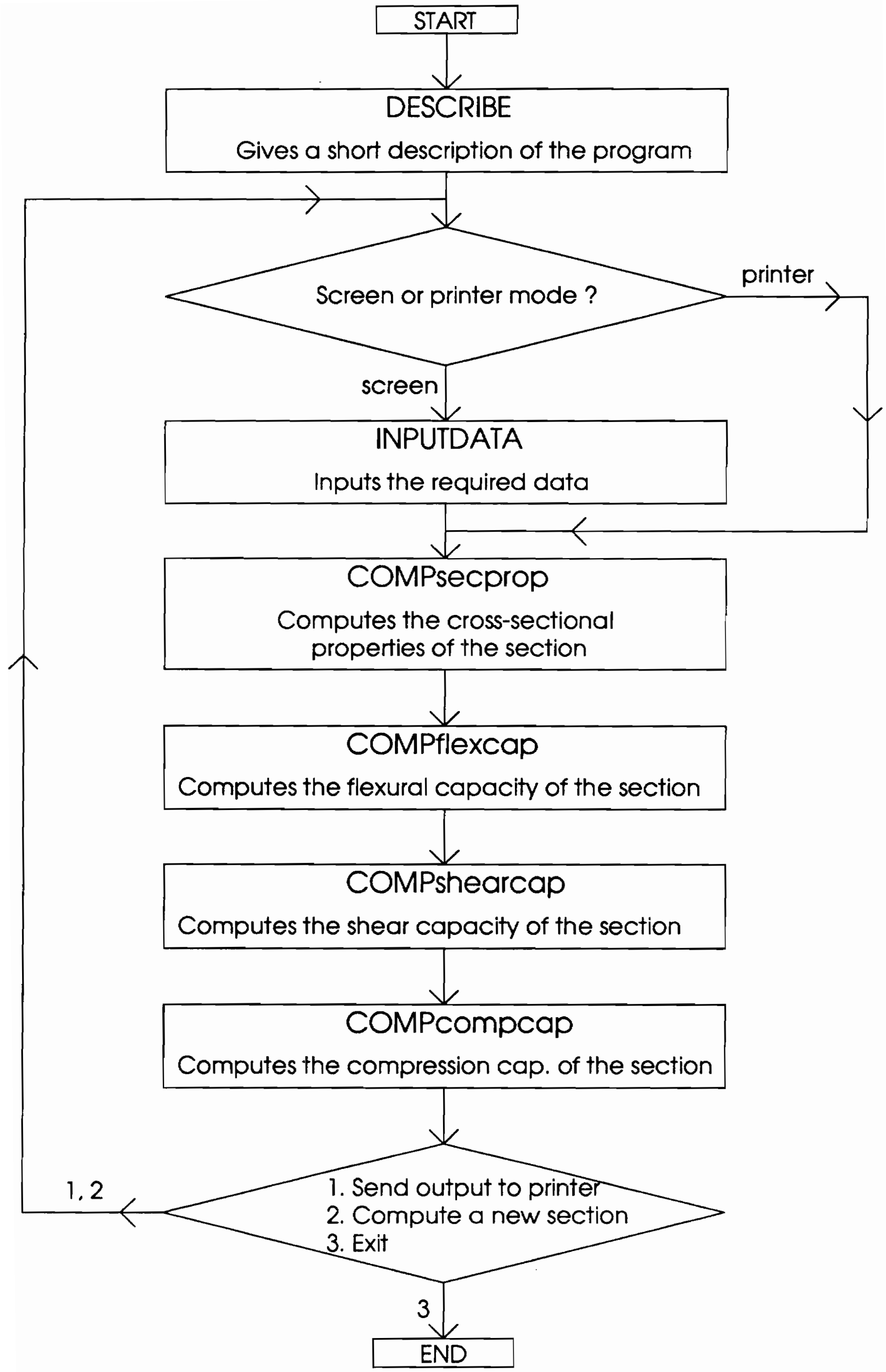


Figure 2.1 Flow Chart Of The Program

Inputting the required data is carried out solely by one subroutine. Usually the same applies to the output, but that would require passing too many variables. Another approach is when each computing module displays the just determined relevant data on the screen or printer, and this way only those variables have to be passed (i.e. included in the parameter list of the subroutine) which will be used later on.

Figure 2.1 shows the flowchart of the main routine. If at the end, the 'Send output to printer' option is selected, the program, since for the above outlined reasons it does not store and pass every variable, goes back to the beginning and recomputes everything but this time it uses the printer and not the screen for the output. In that case, the same data is used as previously and the INPUTDATA subroutine is be skipped.

The complete program listing is enclosed in Appendix A. A Load and Resistance Factor Design version, which for the most part requires only minor changes, was also developed.

2.2 Description Of The Subroutines

The structured program format and the large number of comments provided makes the code clear and easy to comprehend. An additional feature of each subroutine is that at the beginning a brief description and a complete list of the variables used is given.

2.2.1 Inputting The Data

This function is performed by the INPUTDATA subroutine. The information needed for the further computation is the following:

- yield strength of steel
- depth of section (A')
- width of flange (B')
- length of lip (C')
- radius of corners (R)
- material thickness (t)
- buckling length

As it is illustrated on Figure 2.2 these are outside dimensions with the exception of the radius of the corners.

2.2.2 Computing The Sectional Properties

Subroutine COMPsecprop computes the sectional properties based on the Supplementary Information Section 1.2.2 of the 1986 Cold-Formed Steel Design Manual. In the second part the program plots the section on the screen and marks the relevant data with dimension lines. It displays the computed properties on the right side of the screen or sends it to the printer depending on the active output mode.

2.2.3 Determining The Flexural Capacity

Before discussing subroutine COMPflexcap - the longest and most complex part of the program - one must have a look at its auxiliary routines.

2.2.3.1 Subroutine COMPeffwidth

This routine (Fig. 2.3) is used for computing the effective width of elements under the following conditions:

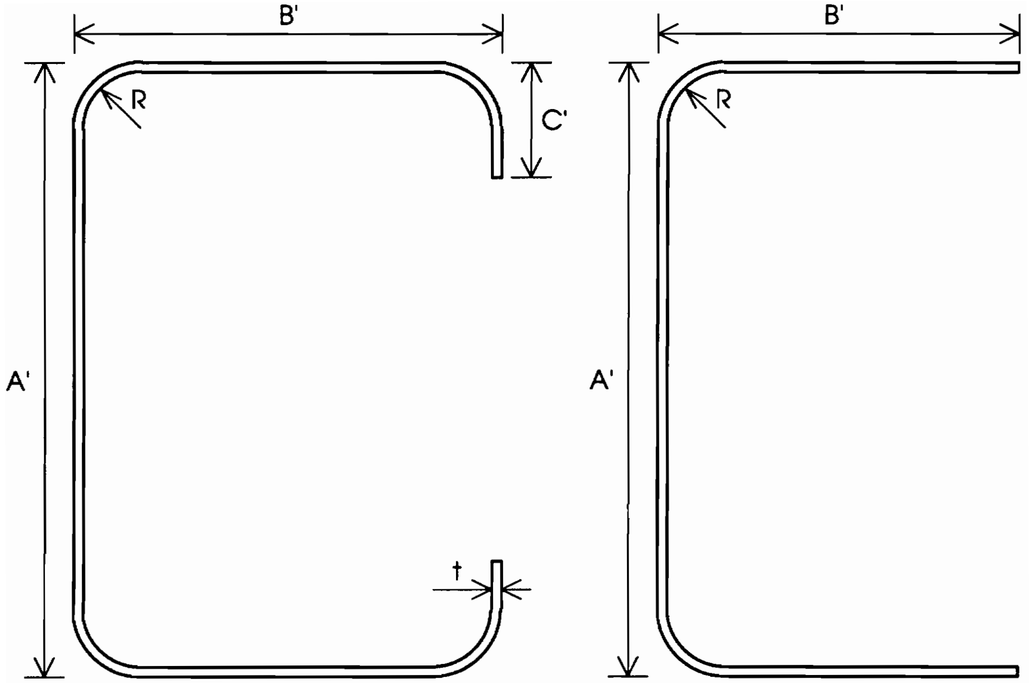


Figure 2.2 C-section With And Without Lips

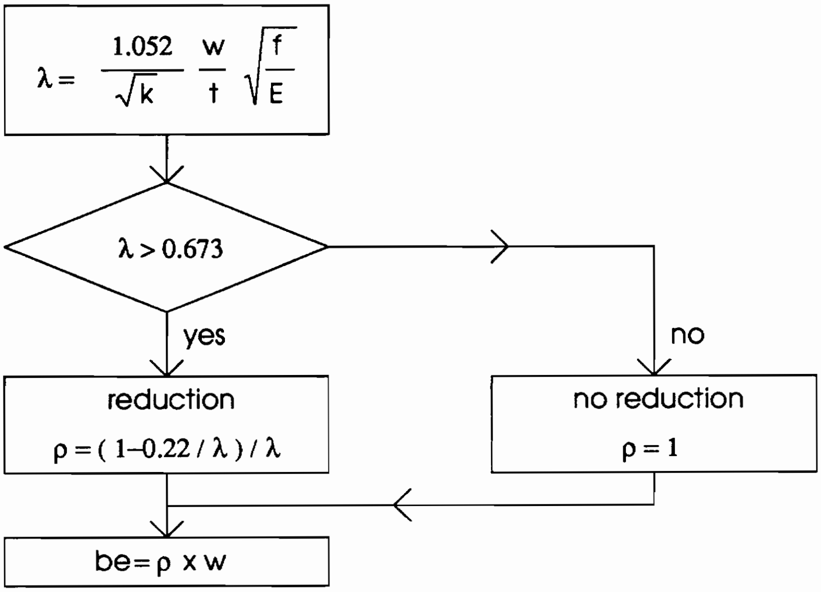


Figure 2.3 Flow Chart Of Subroutine COMPeffwidth
(See page 94 for explanation of variables)

- uniformly compressed stiffened elements (Sect. B2.1)
  e.g. web, if section is subjected to compression
- uniformly compressed unstiffened elements (Sect. B3.1)
  e.g. flange if there is no lip and section is in bending or compression,
  lip if section is in compression
- edge stiffeners with stress gradient (Sect. B3.2)
  e.g. lip if section is subjected to bending
- uniformly compressed elements with edge stiffeners (Sect. B4.2)
  called from subroutine COMPflange after the calculation of the plate buckling coefficient (k)
  e.g. flange in bending or compression
- stiffened element with stress gradient (Sect. B2.3)
  called from COMPweb after the computation of k and the appropriate stress level (f)
  e.g. web in bending

2.2.3.2 Subroutine COMPflange

This routine (Fig 2.4) computes the effective width of a uniformly compressed stiffened element based on Section B4.2.

If w/t, the ratio of the flat width to the thickness, is small enough (Case I) there is no reduction to either the flange or to the lip. On the other hand if w/t exceeds a certain number (Case II and III), the plate buckling coefficient (k) and then the slenderness (λ) must be calculated (by calling the previously described subroutine COMPeffwidth) to determine if the flange and lip are fully effective or not.

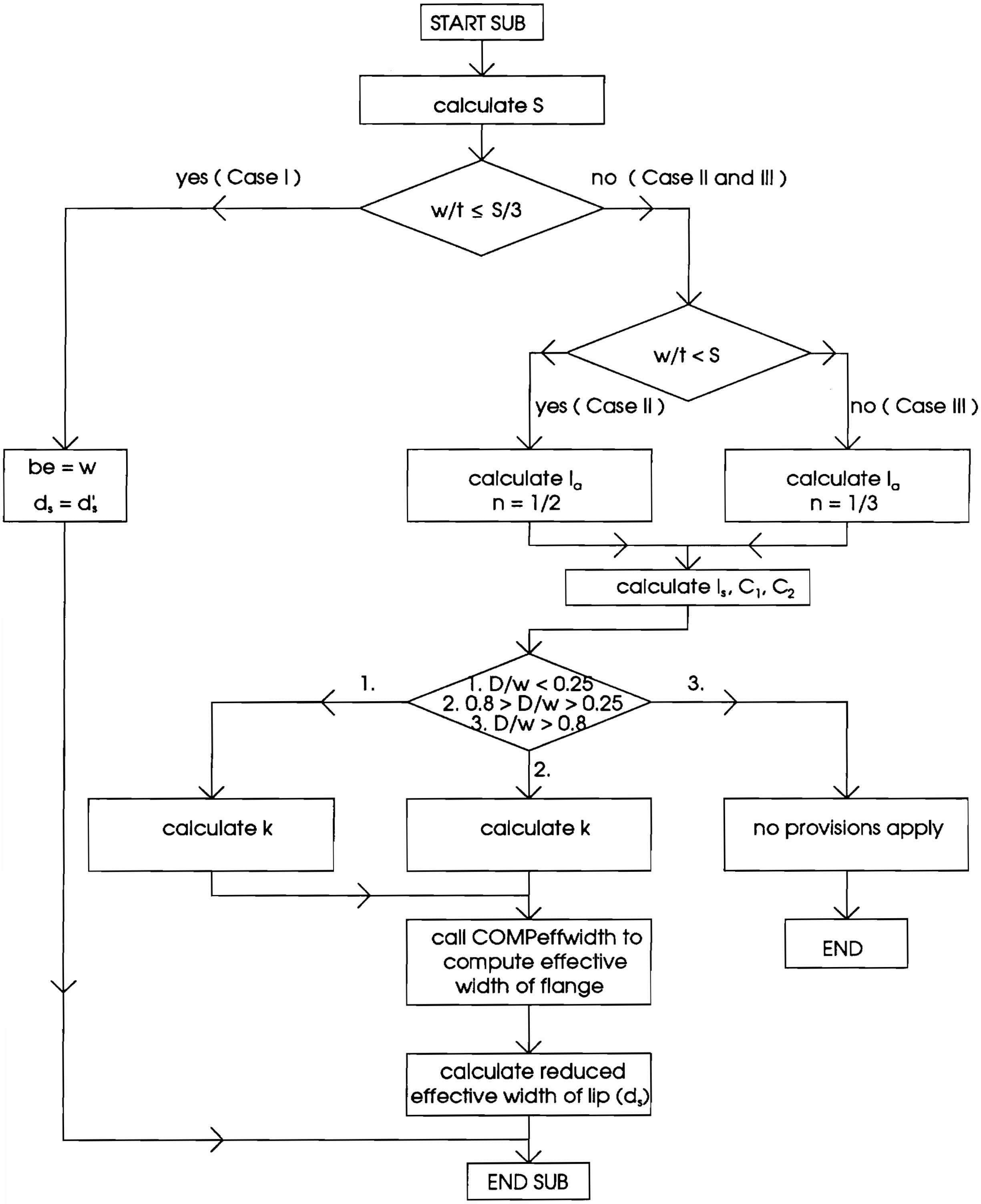


Figure 2.4 Flow Chart Of Subroutine COMPflange (See page 95 for explanation of variables)

2.2.3.3 Subroutine COMPweb

This routine (Fig. 2.5) computes the location of the neutral axis and the effective portions of the web based on Section B2.3.

The program assumes that the web is fully effective. If the assumption is correct the program returns to the main routine, if not iteration is needed to find the effective portions of the web. The approximation continues until the difference between two consecutive values of $b_1 + b_2$ is less the one percent.

2.2.3.4 Subroutine COMPflexcap

The previously described smaller routines are controlled by this subroutine (Fig. 2.6).

After plotting the section on the screen, the effective width of the flange (b_e) and the reduced effective width of the lip (d_s) is computed. By comparing these values to the flat widths (b, c), it can be determined whether they are fully effective or not. The appropriate message is then printed on the screen or printer. Next, the program determines the neutral axis and the effectiveness of the web. After analyzing every element of the section, the effective moment of inertia (I_{xe}), the section modulus (S_{xe}), the nominal and the allowable moment capacities (M_n, M_a) are computed.

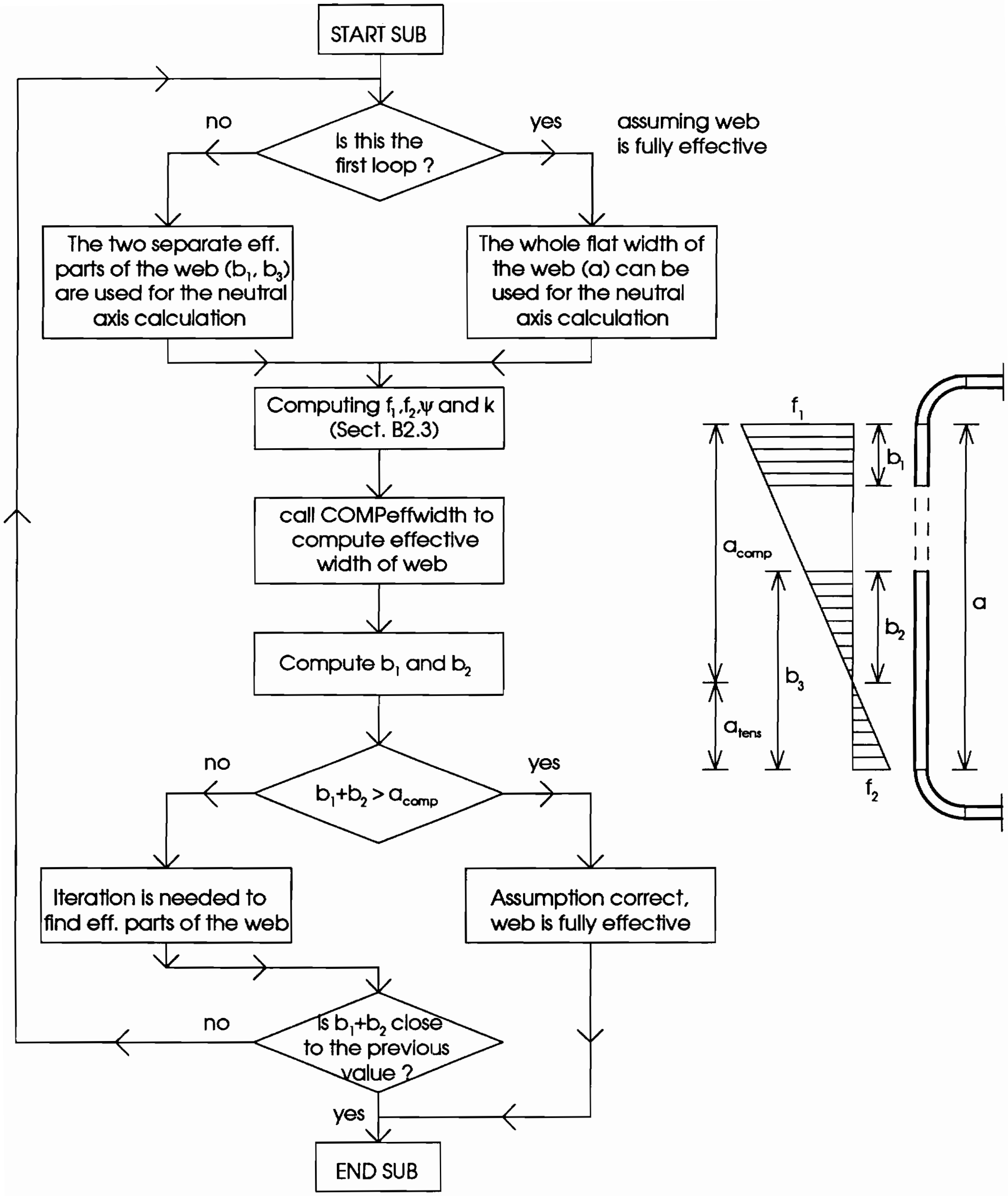


Figure 2.5 Flow Chart Of Subroutine COMPweb
(See page 98 for explanation of variables)

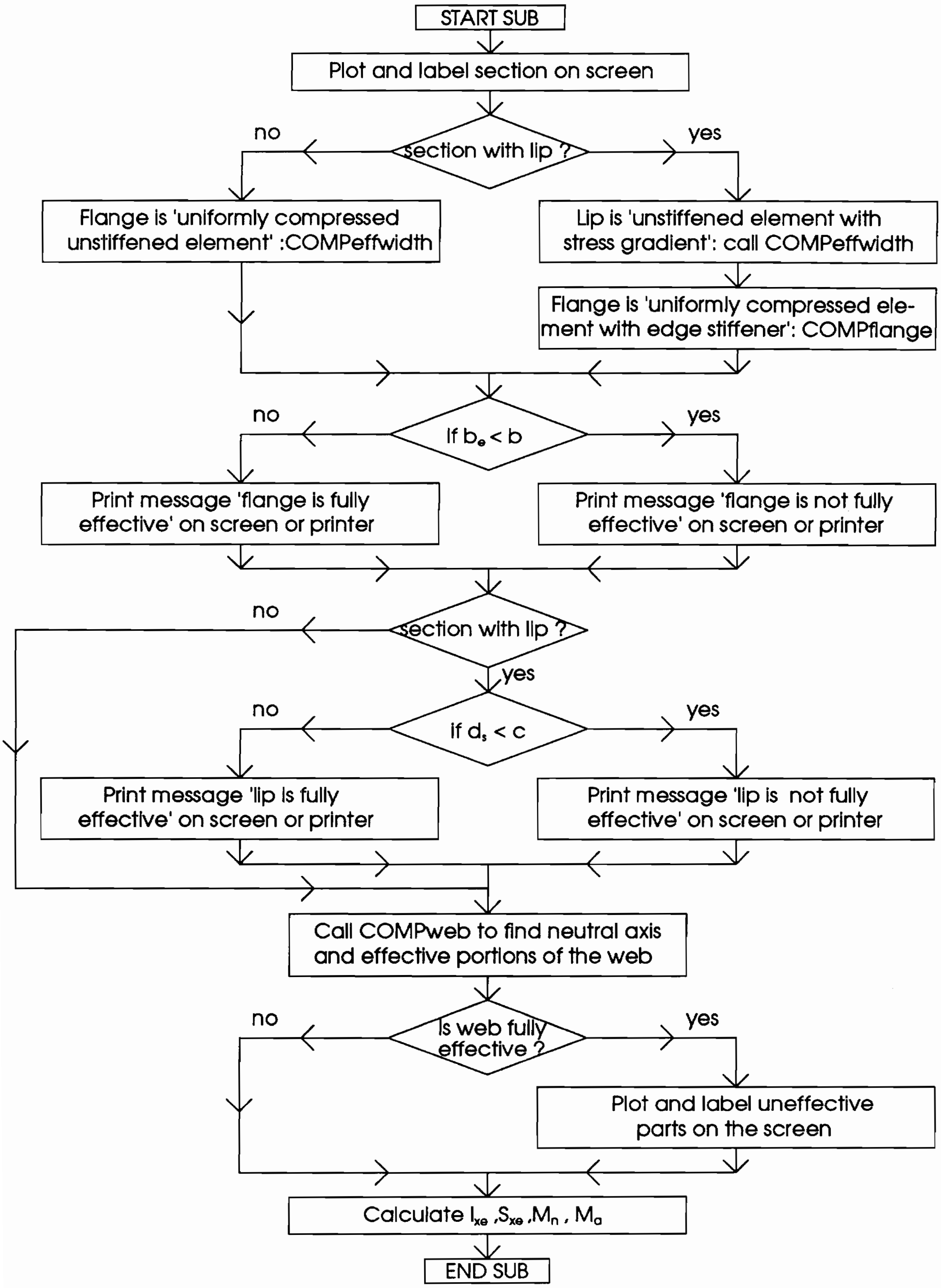


Figure 2.6 Flow Chart Of Subroutine COMPflexcap

2.2.4 Determining The Shear Capacity

Subroutine COMPshearcap (Fig. 2.8) calculates the shear capacity (V_a) of the section based on Section C3.2 of the 1986 Cold-Formed Steel Design Specification.

Depending on h/t (flat width to thickness ratio) either elastic or inelastic buckling governs. After yielding, the web can not carry any more shear therefore this value is the upper limit of the inelastic equation.

It is interesting to note - looking at the three equations - how the contribution of the thickness becomes more significant and that of the yield stress less significant as the h/t ratio increases.

	Equation	thickness	yield stress
yield:	$V_a = 0.4F_y ht$	t	F_y
inelastic buckling:	$V_a = 0.38t^2\sqrt{k_v F_y E}$	t^2	$\sqrt{F_y}$
elastic buckling:	$V_a = 0.53Ek_v t^3 / h$	t^3	-

2.2.5 Computing The Compression Capacity

Subroutine COMPcompcap (Fig. 2.7) computes the maximum allowable load the given section can carry based on Section C4 of the 1986 Cold-Formed Steel Design Specification.

The structure of this routine is very similar to the structure of subroutine COMPflexcap. First the elastic buckling stress (F_e) - the least of flexural, torsional and torsional-flexural buckling stresses - is determined, followed by the nominal buckling stress (F_n), which is used for the effective area calculations.

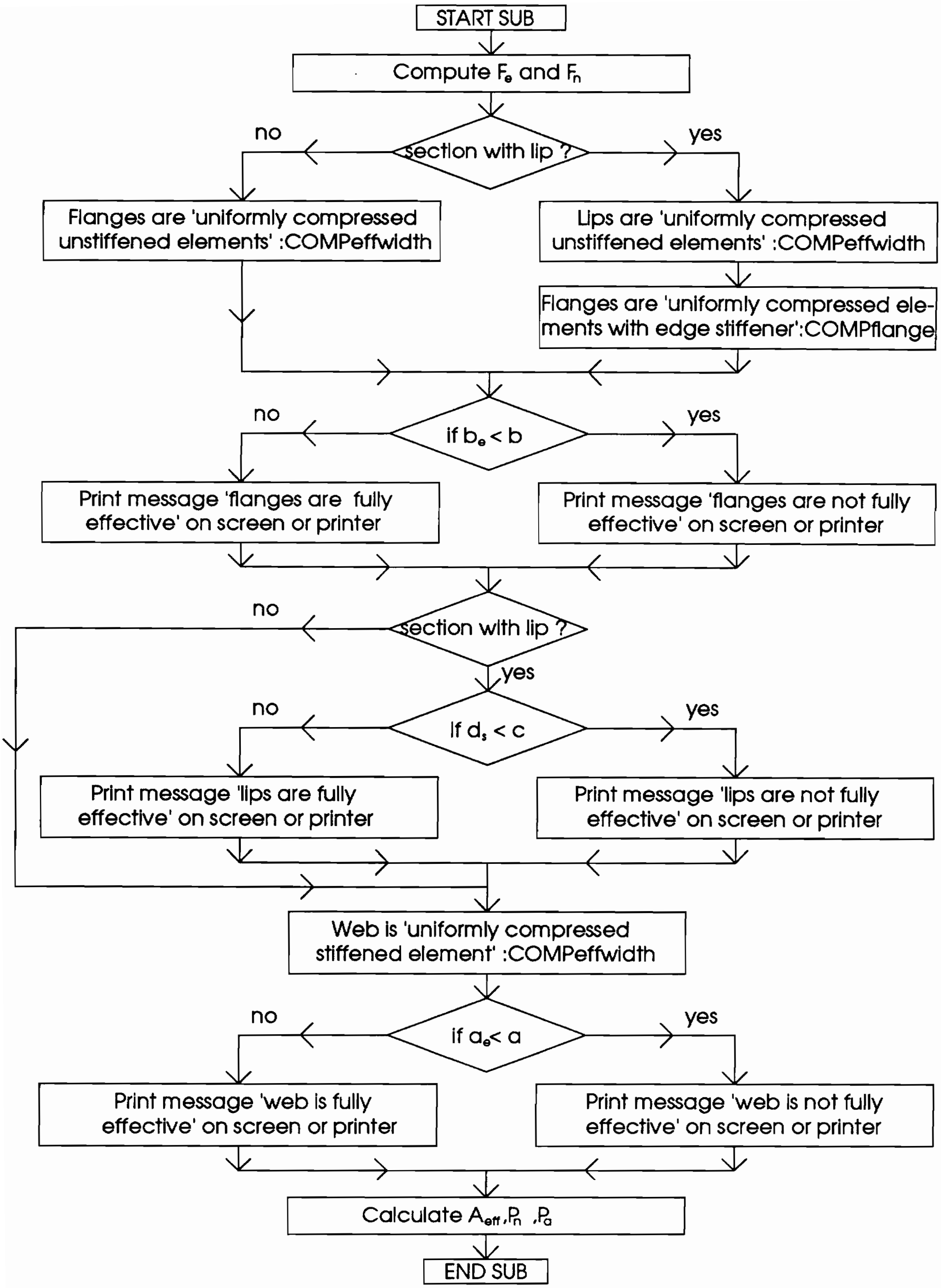


Figure 2.7 Flow Chart Of Subroutine COMPcompcap

The lips and the flanges are handled the same way as for the flexural capacity determination with two differences. First the lips are uniformly compressed elements as opposed to elements with stress gradient. This does not change anything, since both Section B3.1 and B3.2 prescribe $k = 0.43$. The other, more significant change, is that in this case F_n is used instead of the yield stress F_y, and because $F_n < F_y$ the section will now be more effective.

The web is a uniformly compressed element, therefore its effective width can be determined simply by calling COMPeffwidth. The final step is to compute the effective area (A_{eff}) and the compression capacities (P_n, P_a).

2.2.6 Graphical Subroutines

Subroutine PLOTSEC plots the section proportionally on the left side of the screen, leaving enough room on the other side for numerical data.

Subroutines SHOWSIZE and SHOWSIZE2 draw dimension lines and label them.

2.3 Example

Example 4.2 on page 128 of Cold Formed Steel Design by Wei-Wen Yu was solved by the program. Figures 2.9 through 2.11 show the screen output. The uneffective portions of the section shaded are. The printer output can be found on pages 25-27.

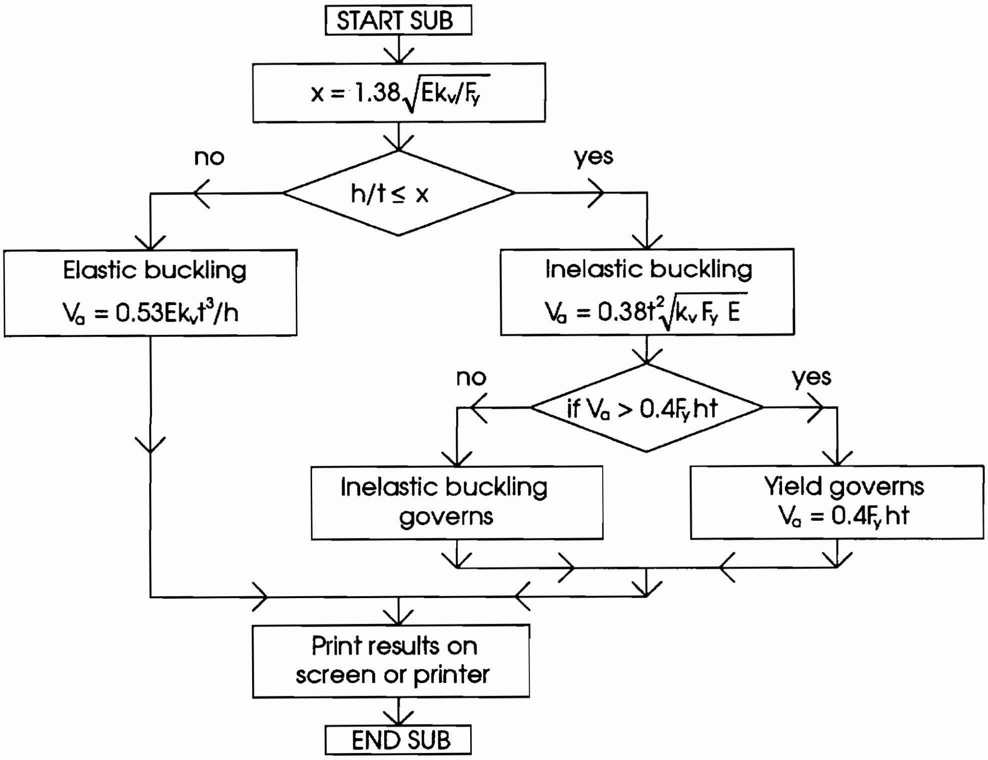
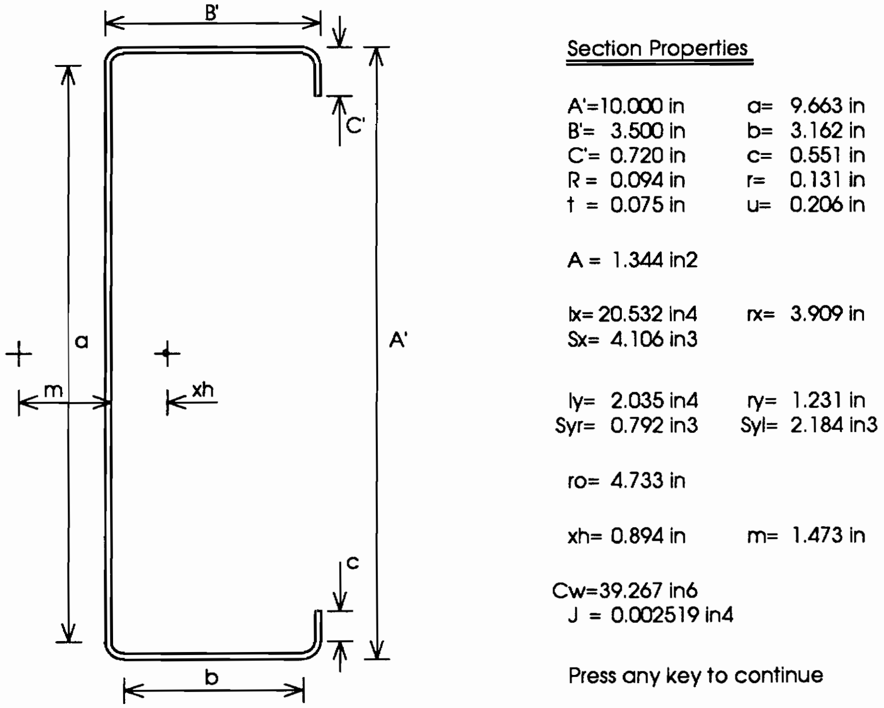
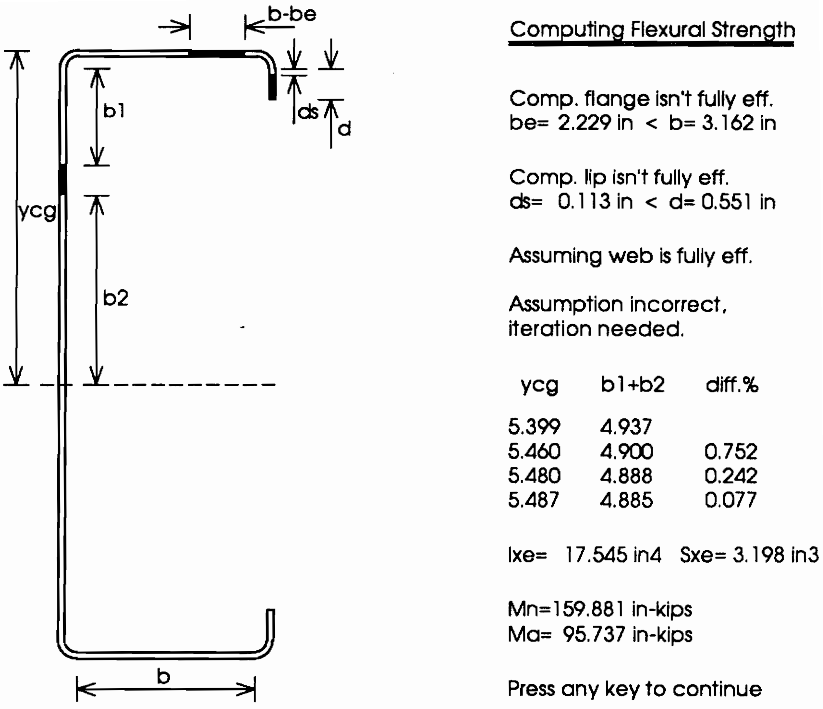


Figure 2.8 Flow Chart Of Subroutine COMPshearcap



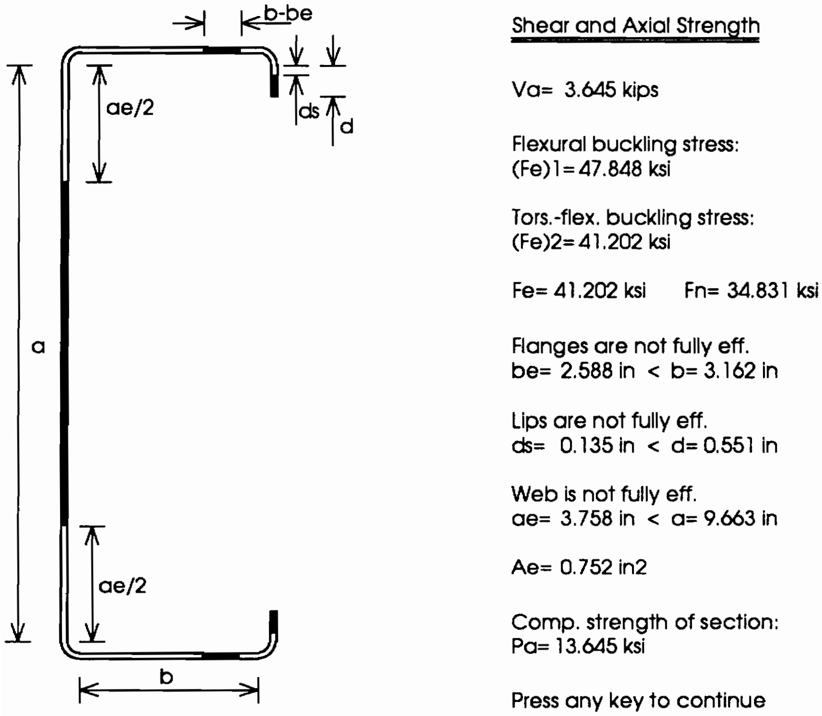
```
Section Properties

A'=10.000 in        a=  9.663 in
B'=  3.500 in       b=  3.162 in
C'=  0.720 in       c=  0.551 in
R =  0.094 in       r=  0.131 in
t  =  0.075 in      u=  0.206 in

A =  1.344 in2

Ix= 20.532 in4      rx=  3.909 in
Sx=  4.106 in3

Iy=  2.035 in4      ry=  1.231 in
Syr=  0.792 in3     Syl=  2.184 in3

ro=  4.733 in

xh=  0.894 in       m=  1.473 in

Cw=39.267 in6
J  =  0.002519 in4

Press any key to continue
```

Figure 2.9 Computing Section Properties



```
Computing Flexural Strength

Comp. flange isn't fully eff.
be= 2.229 in  <  b= 3.162 in

Comp. lip isn't fully eff.
ds=  0.113 in  <  d= 0.551 in

Assuming web is fully eff.

Assumption incorrect,
iteration needed.

  ycg      b1+b2     diff.%

5.399     4.937
5.460     4.900      0.752
5.480     4.888      0.242
5.487     4.885      0.077

Ixe=  17.545 in4   Sxe= 3.198 in3

Mn=159.881 in-kips
Ma=  95.737 in-kips

Press any key to continue
```

Figure 2.10 Computing Flexural Strength



```
Shear and Axial Strength

Va=  3.645 kips

Flexural buckling stress:
(Fe)1=47.848 ksi

Tors.-flex. buckling stress:
(Fe)2=41.202 ksi

Fe= 41.202 ksi      Fn= 34.831 ksi

Flanges are not fully eff.
be=  2.588 in  <  b= 3.162 in

Lips are not fully eff.
ds=  0.135 in  <  d= 0.551 in

Web is not fully eff.
ae=  3.758 in  <  a= 9.663 in

Ae= 0.752 in2

Comp. strength of section:
Pa= 13.645 ksi

Press any key to continue
```

Figure 2.11 Computing Shear And Axial Strength

```
****************************************************************************
*                                                                          *
*      Program for computing the flexural, shear and axial capacity       *
*      of  a  C  section  based  on  the  Allowable  Stress  Design       *
*                                                                          *
****************************************************************************


    Material and Section Properties
    ===============================


         Yield strength of steel               Fy = 50.000  ksi

         Effective length                      KL =  8.000 ft

         Depth of section                      A' = 10.000 in
         Width of section                      B' =  3.500 in
         Length of lip                         C' =  0.720 in
         Inner radius of corners               R  =  0.0938 in
         Thickness                             t  =  0.0750 in

         Flat portion of web                   a  =  9.663 in
         Flat portion of flanges               b  =  3.162 in
         Flat portion of lips                  c  =  0.551 in
         Midplane radius of corners            r  =  0.131 in
         Length of arc                         u  =  0.206 in

         Area of cross section                 A  =  1.344 in2

         Moment of inertia about x             Ix = 20.532 in4
         Moment of inertia about y             Iy =  2.035 in4

         Radius of gyration about x            rx =  3.909 in
         Radius of gyration about y            ry =  1.231 in
         Polar radius of gyration              ro =  4.733 in

         Section modulus about x               Sx =  4.106 in3
         Section mod. about y (right)          Sy =  0.792 in3
         Section mod. about x (left)           Sy =  2.184 in3

         Dist. bw cent. and web centerline     xh =  0.894 in
         Dist. bw shear cent. and web cl.      m  =  1.473 in

         Warping constant                      Cw = 39.267 in6
         St. Venant constant                   J  =  0.002519 in4
```

```
Computing flexural strength
===========================


     Effective width of edge stiffener      Section B3.2 of Spec.

          Buckling coefficient                k  =  0.430
          Slenderness ratio                   la =  0.485
          Reduction factor                    ro =  1.000
          Effective width                     b  =  0.551 in


     Effective width of compression flange  Section B4.2 of Spec.

          w/t = 42.167 > S = 31.091   case III
          Req'd  moment of inertia of stiffener Ia = 0.005093 in4
          Actual moment of inertia of stiffener Is = 0.001047 in4
          D/w =  0.228 < 0.25
          Buckling coefficient                k  =  2.537
          Slenderness ratio                   la =  1.147
          Reduction factor                    ro =  0.705
          Effective width                     b  =  2.229 in
          Reduced eff. width of stiffener     ds =  0.113 in
          be= 2.229 in < b = 3.162 in   Comp.  flange   is not fully eff.
          ds= 0.113 in < d = 0.551 in   Comp. stiffener is not fully eff.


     Computing the location of neutral axis and effective width of web

          Assuming web is fully effective

          Location of neutral axis          ycg =  5.399 in
          Compression portion of web      acomp =  5.230 in    f1 = 48.437 ksi
          Tension     portion of web       aten =  4.432 in    f2 =-41.045 ksi
          Buckling coefficient                k  = 20.304
          Slenderness ratio                   la =  1.219
          Reduction factor                    ro =  0.672
          Effective width                     b  =  6.497 in
          fi = -0.847     b1 =  1.689 in      b2 =  3.248 in
          b1+b2 = 4.937 in > acomp = 5.230 in   Assumption incorrect
          Iteration needed to find effective portion of web

          iter     ycg        fi         k         la        b1+b2      diff
           1      5.399     -0.847     20.304     1.219     4.937
           2      5.460     -0.826     19.828     1.234     4.900      0.752
           3      5.480     -0.819     19.678     1.238     4.888      0.242
           4      5.487     -0.817     19.630     1.240     4.885      0.077

          Difference is less then .1 percent, close enough


     Computation of Ixe and Sxe

          Effective moment of inertia       Ixe = 17.545 in4
          Effective section modulus         Sxe =  3.198 in3
          Nominal   moment capacity         Mn  =159.881 kip-in
          Allowable moment capacity         Ma  = 95.737 kip-in
```

```
Computing shear capacity   (Section C 3.2 of Spec.)
==================================================

         h/t = 128.833 > 1.38 * (E kv/Fy) ^ .5 =  77.460   case B
         Elastic buckling governs

         Shear capacity                   Va =  3.645 kips


Computing axial strength
========================

    Determining Fn

         Flexural buckling stress      (Fe)1 = 47.848 ksi
                                    sigma ex =482.782 ksi
                                     sigma t = 42.164 ksi
         Tors.-flex. buckling stress   (Fe)2 = 41.202 ksi

                                          Fe = 41.202 ksi
                                          Fn = 34.831 ksi

    Effective width of edge stiffeners      Section B3.2 of Spec.

         Buckling coefficient             k  =  0.430
         Slenderness ratio                la =  0.405
         Reduction factor                 ro =  1.000
         Effective width                  b  =  0.551 in

    Effective width of flanges              Section B4.2 of Spec.

         w/t = 42.167 > S = 37.251   case III
         Req'd  moment of inertia of stiffener Ia = 0.004277 in4
         Actual moment of inertia of stiffener Is = 0.001047 in4
         D/w =  0.228 < 0.25
         Buckling coefficient             k  =  2.663
         Slenderness ratio                la =  0.934
         Reduction factor                 ro =  0.818
         Effective width                  b  =  2.588 in
         Reduced eff. width of stiffener  ds =  0.135 in
         be= 2.588 in < b = 3.162 in     Flanges  are not fully effective
         ds= 0.135 in < d = 0.551 in   Stiffeners are not fully effective

    Effective width of web

         Buckling coefficient             k  =  4.000
         Slenderness ratio                la =  2.329
         Reduction factor                 ro =  0.389
         Effective width                  b  =  3.758 in
         ae= 3.758 in < a = 9.663 in   Web is not fully effective

    Computing effective cross-sectional area and axial strengths

         Effective cross-sectional area   Ae =  0.752 in2
         Nominal axial strength           Pn = 26.197 kip
         Allowable axial strength         Pa = 13.645 kip
```

CHAPTER III

PERFORMANCE SECTION TABLES FOR WALL STUDS AND JOISTS

3.1 Performance Section Properties And Capacities

This chapter of the study provides performance section properties for wall studs and floor/roof joists. Performance section descriptions consist of depth, type and relative strength indicators:

x.x a yy

Relative strength indicator 00 to 17

Section type: Stud or Joist

Depth in inches except x.6 represents x 5/8 in.

Nine wall stud depths (2 1/2, 3 1/2, 3 5/8, 4, 5 1/2, 6, 7, 8, and 9 in.) and ten joist depths (2 1/2, 3 5/8, 4, 6, 7, 8, 9, 10, 12, and 14 in.) were selected with between eight and eighteen section sizes per depth. Three performance properties are listed for each section: allowable moment, allowable shear and minimum strong axis moment of inertia. Other performance properties were developed as design aids, these are found in Chapter IV and V, respectively. All properties and capacities correspond to values calculated using the AISI Specification for Cold-Formed Steel, August 19, 1986 (Allowable Stress Design).

3.2 Development Of Performance Sections

As a first step, a large number of manufacturers' catalogs were obtained and available sections were tabulated to make sure that the proposed tables encompass the current market. Over 410 different studs and 280 different joists were identified and the above stud and joist depths selected. The previously described analysis program was then used to calculate feasible values for the allowable moment, shear, and moment of inertia for each performance section. The base material was 33 ksi for wall studs and 50 ksi for joists, with thicknesses ranging from 22 to 6 gauge (Table 3.1). The flange and lip dimensions were selected to obtain fully or almost fully effective sections for flexure. Table 3.2 shows the results for 4 in. studs and for 3 5/8 in. joists. The horizontal line denotes the level below which the sections are fully effective. The lower yield stress studs are almost all fully effective for flexure, for joists this was not always possible to achieve. For axial compression, the studs are less effective than in flexure, because in that case the whole web is subjected to uniform compression. Plotting the computed values quickly reveals that these curves are not very smooth (Table 3.3 and 3.4 solid lines). The main reason for that is the uneven increments between the thicknesses (Table 3.1). To overcome this, the computed values were replaced by functions with gradually increasing increments. (dashed lines). Since shear capacity rarely controls the design, 80% of the original values were taken as the base of the approximation. Similarly the calculated values of the minimum moment of inertia were multiplied by a factor of 0.9. These modifications will result in more economical design.

Next the intervals were halved ensuring that an already existing section will not be very far from a proposed performance section.

Table 3.1 Initial Performance Section Designations And Gauge Thicknesses

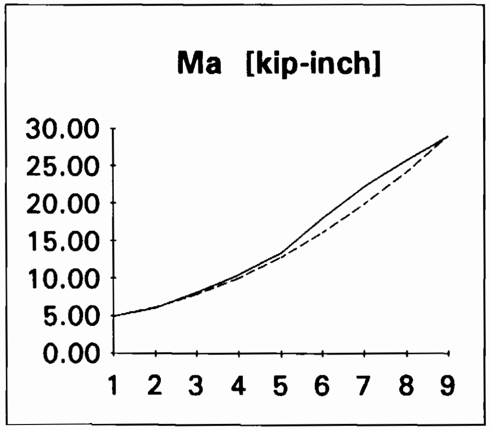
Designation	Gauge	Thickness [in]	Difference [in]
S01	22	0.0299	
S02	20	0.0359	0.0060
S03	18	0.0478	0.0119
S04	16	0.0598	0.0120
S05	14	0.0747	0.0149
S06	12	0.1046	0.0299
S07	10	0.1345	0.0299
S08	8	0.1644	0.0299
S09	6	0.1943	0.0299

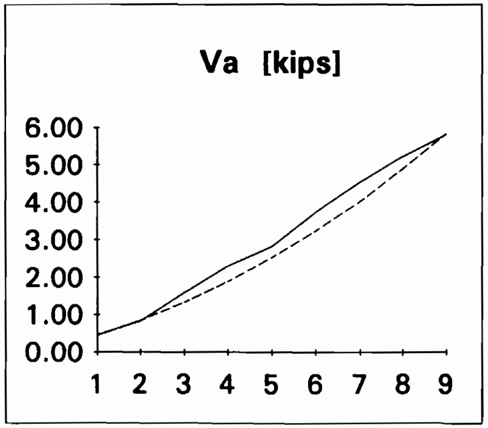
Table 3.2 Section Properties For 4 in. Studs And 3 5/8 in Joists

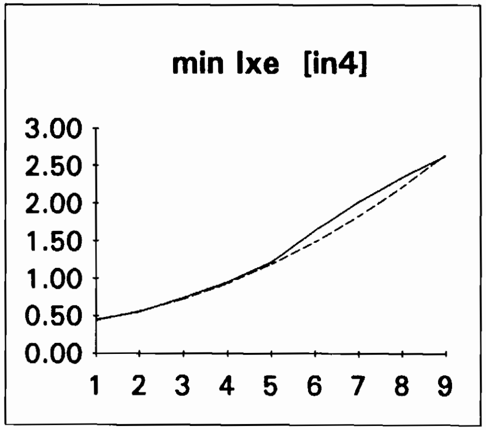
Section	Fy [ksi]	Flange [in]	Lip [in]	Ma [kip-in]	Va [kip]	Ixeff [in4]	Ix [in4]	Aeff [in2]	A [in2]	rx [in]	ry [in]
4.0S01	33	1.250	0.40	4.965	0.590	0.503	0.504	0.186	0.212	1.543	0.458
4.0S02	33	1.300	0.40	6.034	1.029	0.611	0.611	0.238	0.256	1.546	0.472
4.0S03	33	1.375	0.40	8.108	1.996	0.821	0.821	0.343	0.343	1.546	0.492
4.0S04	33	1.500	0.40	10.441	2.883	1.057	1.057	0.438	0.438	1.553	0.530
4.0S05	33	1.625	0.40	13.340	3.515	1.350	1.350	0.557	0.557	1.557	0.566
4.0S06	33	1.625	0.50	17.981	4.671	1.820	1.821	0.775	0.775	1.533	0.565
4.0S07	33	1.625	0.60	22.157	5.685	2.243	2.246	0.989	0.989	1.507	0.564
4.0S08	33	1.625	0.70	25.774	6.540	2.609	2.615	1.198	1.198	1.478	0.561
4.0S09	33	1.625	0.80	28.913	7.269	2.926	2.940	1.406	1.406	1.446	0.556
3.6J01	50	2.000	0.50	7.140	0.648	0.475	0.555	0.224	0.250	1.488	0.755
3.6J02	50	2.000	0.60	9.249	1.133	0.600	0.670	0.285	0.285	1.479	0.768
3.6J03	50	2.000	0.70	13.469	2.437	0.843	0.886	0.408	0.408	1.465	0.775
3.6J04	50	2.000	0.80	17.884	3.814	1.089	1.097	0.522	0.522	1.450	0.781
3.6J05	50	2.300	0.80	24.258	4.746	1.472	1.475	0.688	0.688	1.464	0.881
3.6J06	50	2.500	0.80	34.476	6.271	2.087	2.088	0.979	0.979	1.460	0.934
3.6J07	50	2.500	0.80	42.024	7.580	2.544	2.547	1.225	1.225	1.442	0.915

Table 3.3 Computing Performance Section Table For 4 in. Studs

	Exact values based on computation									Proposed values					
Section	Ma	diff.	Va	0.8*V	diff.	Ixeff	.9*Ix	diff.	Ma	diff.	Va	diff.	min Ixe	diff.
4.0S01	4.97		0.59	0.47		0.50	0.45		4.90		0.450		0.440	
4.0S02	6.03	1.07	1.03	0.82	0.35	0.61	0.55	0.10	6.10	1.20	0.850	0.400	0.560	0.120
4.0S03	8.11	2.07	2.00	1.60	0.77	0.82	0.74	0.19	7.82	1.72	1.329	0.479	0.725	0.165
4.0S04	10.44	2.33	2.88	2.31	0.71	1.06	0.95	0.21	10.05	2.24	1.886	0.557	0.934	0.209
4.0S05	13.34	2.90	3.52	2.81	0.51	1.35	1.22	0.26	12.81	2.75	2.521	0.636	1.188	0.254
4.0S06	17.98	4.64	4.67	3.74	0.92	1.82	1.64	0.42	16.08	3.27	3.236	0.714	1.486	0.299
4.0S07	22.16	4.18	5.69	4.55	0.81	2.24	2.02	0.38	19.87	3.79	4.029	0.793	1.830	0.343
4.0S08	25.77	3.62	6.54	5.23	0.68	2.61	2.35	0.33	24.18	4.31	4.900	0.871	2.218	0.388
4.0S09	28.91	3.14	7.27	5.82	0.58	2.93	2.63	0.29	29.00	4.83	5.850	0.950	2.650	0.433
									dd =	0.52		0.079		0.045





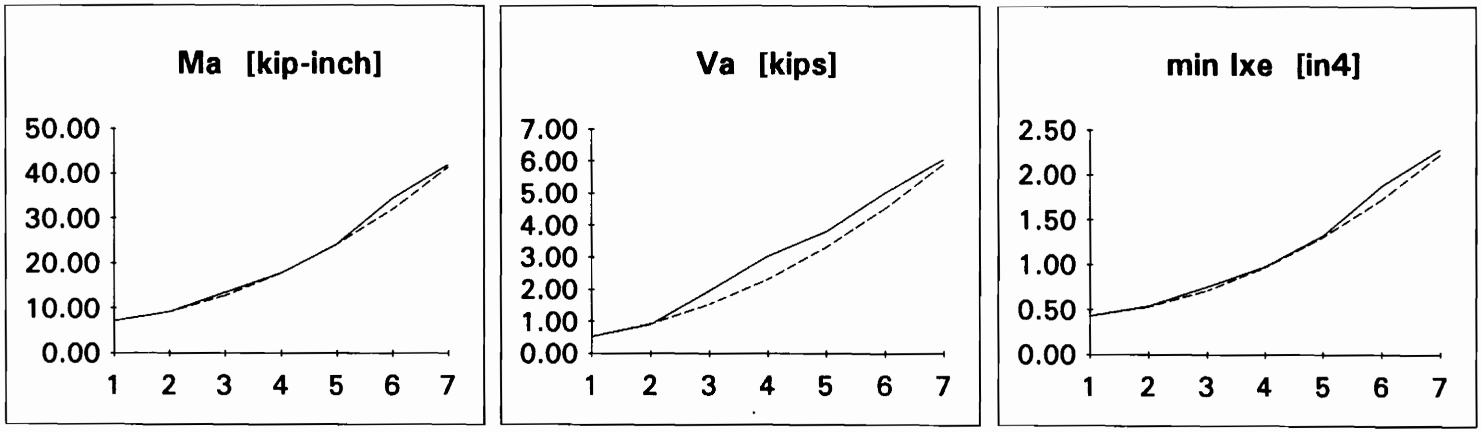


solid line: computed values

dashed line: proposed values

Table 3.4 Computing Performance Section Table For 3 5/8 in. Joists

	Exact values based on computation								Proposed values					
Section	Ma	diff.	Va	0.8*V	diff.	Ixeff	.9*Ix	diff.	Ma	diff.	Va	diff.	min Ixe	diff.
3.6J01	7.14		0.65	0.52		0.48	0.43		7.15		0.525		0.430	
3.6J02	9.25	2.11	1.13	0.91	0.39	0.60	0.54	0.11	9.25	2.10	0.925	0.400	0.530	0.100
3.6J03	13.47	4.22	2.44	1.95	1.04	0.84	0.76	0.22	12.80	3.55	1.525	0.600	0.710	0.180
3.6J04	17.88	4.42	3.81	3.05	1.10	1.09	0.98	0.22	17.80	5.00	2.325	0.800	0.970	0.260
3.6J05	24.26	6.37	4.75	3.80	0.75	1.47	1.32	0.34	24.25	6.45	3.325	1.000	1.310	0.340
3.6J06	34.48	10.22	6.27	5.02	1.22	2.09	1.88	0.55	32.15	7.90	4.525	1.200	1.730	0.420
3.6J07	42.02	7.55	7.58	6.06	1.05	2.54	2.29	0.41	41.50	9.35	5.925	1.400	2.230	0.500
									dd =	1.45		0.200		0.080



solid line: computed values

dashed line: proposed values

Table 3.5 and 3.6 illustrates the final tables for the performance section properties of the above two examples, and Figure 3.1 and 3.2 shows how the sections of 12 suppliers meet the requirements. The horizontal lines indicate the proposed moment capacities, whereas the dots represent the moment capacities of the existing sections of various suppliers.

Table 3.5 4 in. Wall Studs Performance Properties

Section	Ma [k-in.]	Va [kips]	min Ixe [in4]
4.0S00	4.3	0.25	0.38
4.0S01	4.9	0.45	0.44
4.0S02	5.5	0.65	0.50
4.0S03	6.1	0.85	0.56
4.0S04	7.0	1.09	0.64
4.0S05	7.8	1.33	0.73
4.0S06	8.9	1.61	0.83
4.0S07	10.1	1.89	0.93
4.0S08	11.4	2.20	1.06
4.0S09	12.8	2.52	1.19
4.0S10	14.4	2.88	1.34
4.0S11	16.1	3.24	1.49
4.0S12	18.0	3.63	1.66
4.0S13	19.9	4.03	1.83
4.0S14	22.0	4.46	2.02
4.0S15	24.2	4.90	2.22
4.0S16	26.6	5.38	2.43
4.0S17	29.0	5.85	2.65

Table 3.6 3 5/8 in. Joists Performance Properties

Section	Ma [k-in.]	Va [kips]	min Ixe [in4]
3.6J00	6.1	0.33	0.38
3.6J01	7.2	0.53	0.43
3.6J02	8.2	0.73	0.48
3.6J03	9.3	0.93	0.53
3.6J04	11.0	1.23	0.62
3.6J05	12.8	1.53	0.71
3.6J06	15.3	1.93	0.84
3.6J07	17.8	2.33	0.97
3.6J08	21.0	2.83	1.14
3.6J09	24.3	3.33	1.31
3.6J10	28.2	3.93	1.52
3.6J11	32.2	4.53	1.73
3.6J12	36.8	5.23	1.98
3.6J13	41.5	5.93	2.23

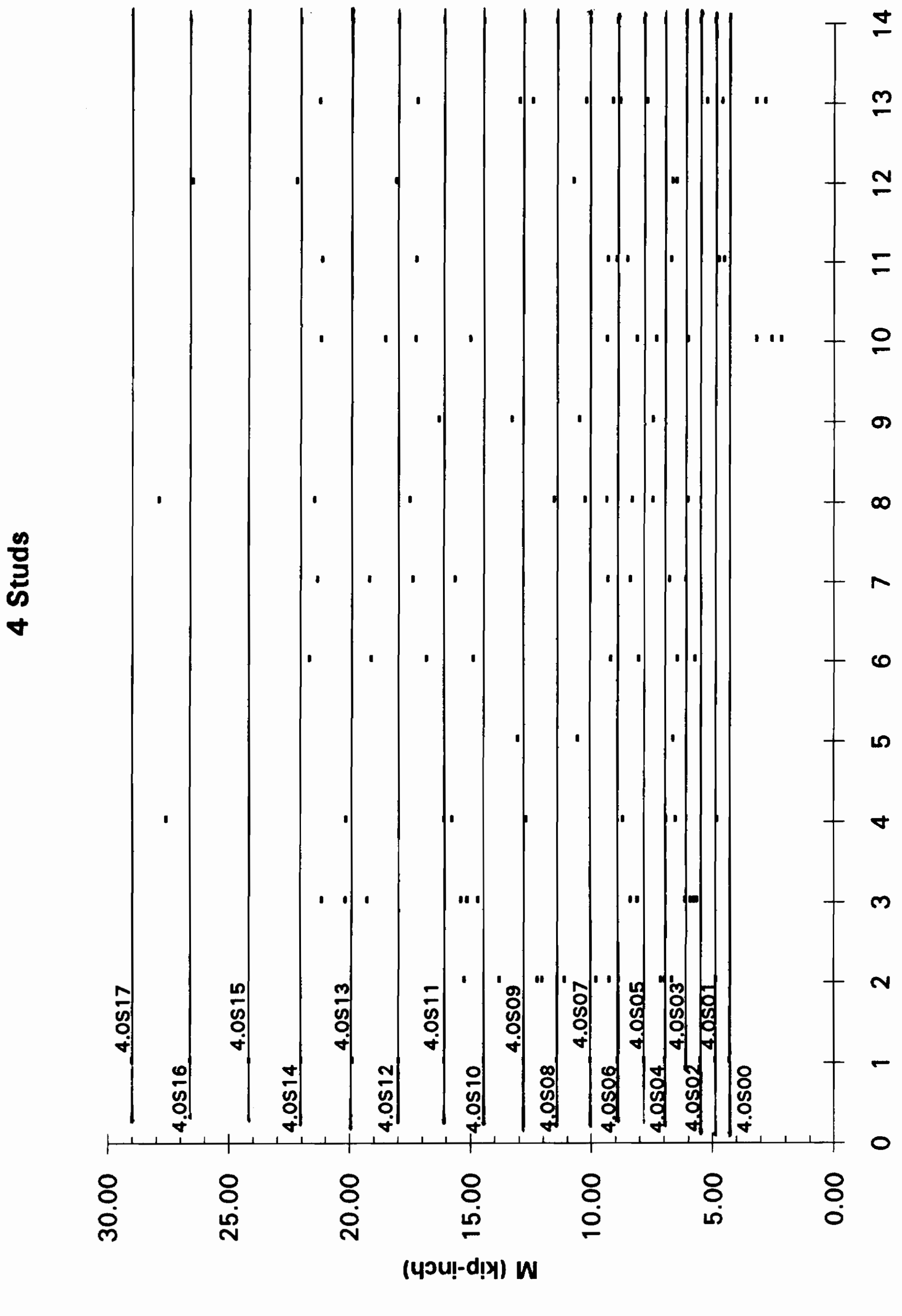


Figure 3.1 Comparison Of Performance Capacities With Available Sections For 4 in. Studs

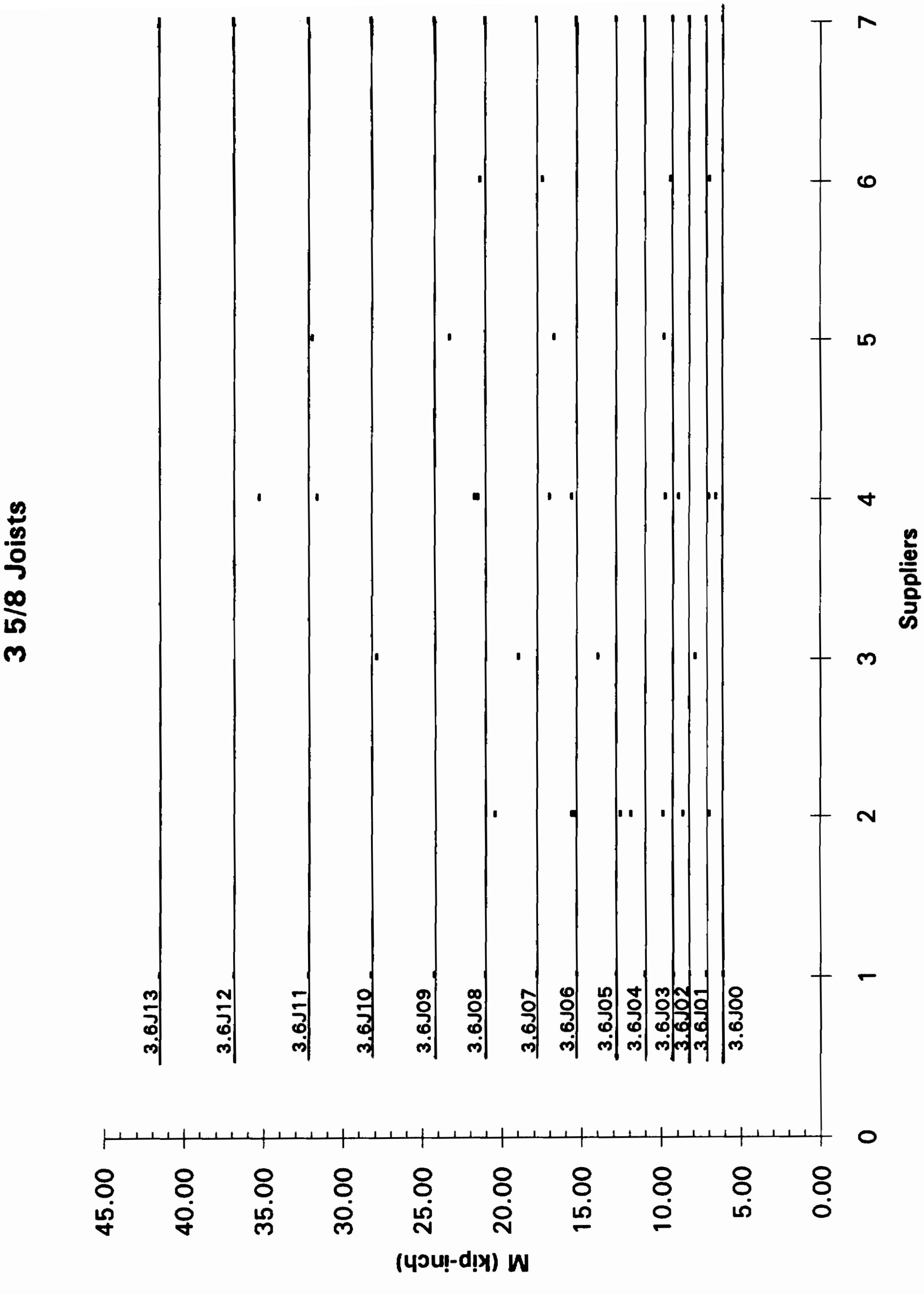


Figure 3.2 Comparison Of Performance Capacities With Available Sections For 3 5/8 in. Joists

CHAPTER IV

DESIGN AIDS FOR WALL STUDS

4.1 Development Of Design Aids

To further assist designers the following aids were developed. If the performance section concept is implemented, suppliers of wall studs and joists will be required to meet or exceed both the performance properties capacities and the values given in the design aids.

4.2 Uniform Lateral Load Capacity Of Wall Studs

In curtain wall applications the members resist wind loads only. Table 4.1 is an example of the type of performance section load table that can be developed. The table shows the maximum uniformly distributed load a section can withstand over a certain span. The considered limit states were flexure, shear, and excessive deflection.

For a simply supported beam the moment at midspan is calculated from

$$M = \frac{wl^2}{8} \ ,. \tag{4.1}$$

which gives

$$w[plf] = \frac{8}{l[ft]^2} M_a[k-in] \frac{10^3}{12} \ , \tag{4.2}$$

where M_a is the moment capacity of the section from the performance capacities tables,

l is the clear span and,

w is the uniform lateral load capacity.

For deep sections with small material thickness, shear can be the controlling factor. From

$$V = \frac{lw}{2}, \tag{4.3}$$

we get

$$w[plf] = \frac{2V_a[kips]10^3}{l[ft]}, \tag{4.4}$$

where V_a is the shear capacity of the section from the performance capacities tables.

The values computed from Equations 4.2 and 4.4 (labelled as total loads) are tabulated in the first column for each span length in Table 4.1. Shaded cells indicate that shear controls over flexure.

The deflection of a single span is

$$\Delta = \frac{5}{384}\frac{wl^4}{EI}, \tag{4.5}$$

which for the two considered limits L/360 and L/240 gives

$$w_{L/360}[plf] = \frac{l[ft]}{360}\frac{384}{5}\frac{E[ksi](10^3)(12^2)}{l[ft]^4}\frac{\min I_{xe}[in^4]}{12^4}, \tag{4.6}$$

$$w_{L/240}[plf] = \frac{l[ft]}{240}\frac{384}{5}\frac{E[ksi](10^3)(12^2)}{l[ft]^4}\frac{\min I_{xe}[in^4]}{12^4}, \tag{4.7}$$

where $E = 29500$ ksi is the modulus of elasticity for cold-formed steel, and

$\min I_{xe}$ is the minimum moment of inertia of the section from the performance capacities tables.

Table 4.1 Uniform Lateral Load Capacity Of Wall Studs in plf

Height	8 ft.			10 ft.			12 ft.			14 ft.			16 ft.			18 ft.		
	Total	L/360	L/240	Total	L/360	L/240	Total	L/360	L/240	Total	L/360	L/240	Total	L/360	L/240	Total	L/360	L/240
4.0S00	44.8	32.4	44.8	28.7	16.6	24.9	19.9	9.6	14.4	14.6	6.1	9.1	11.2	4.1	6.1			
4.0S01	51.0	37.6	51.0	32.7	19.2	28.8	22.7	11.1	16.7	16.7	7.0	10.5	12.8	4.7	7.0			
4.0S02	57.3	42.7	57.3	36.7	21.9	32.8	25.5	12.6	19.0	18.7	8.0	11.9	14.3	5.3	8.0			
4.0S03	63.5	47.8	63.5	40.7	24.5	36.7	28.2	14.2	21.2	20.7	8.9	13.4	15.9	6.0	9.0			
4.0S04	72.5	54.8	72.5	46.4	28.1	42.1	32.2	16.2	24.4	23.7	10.2	15.3	18.1	6.9	10.3			
4.0S05	81.5	61.9	81.5	52.1	31.7	47.5	36.2	18.3	27.5	26.6	11.5	17.3	20.4	7.7	11.6			
4.0S06	93.1	70.8	93.1	59.6	36.3	54.4	41.4	21.0	31.5	30.4	13.2	19.8	23.3	8.9	13.3			
4.0S07	104.7	79.7	104.7	67.0	40.8	61.2	46.5	23.6	35.4	34.2	14.9	22.3	26.2	10.0	14.9			
4.0S08	119.1	90.6	119.1	76.2	46.4	69.6	52.9	26.8	40.3	38.9	16.9	25.3	29.8	11.3	17.0			
4.0S09	133.4	101.4	133.4	85.4	51.9	77.9	59.3	30.0	45.1	43.6	18.9	28.4	33.4	12.7	19.0			
4.0S10	150.5	114.1	150.5	96.3	58.4	87.6	66.9	33.8	50.7	49.1	21.3	31.9	37.6	14.3	21.4			
4.0S11	167.5	126.8	167.5	107.2	64.9	97.4	74.4	37.6	56.4	54.7	23.7	35.5	41.9	15.9	23.8			
4.0S12	187.2	141.5	187.2	119.8	72.5	108.7	83.2	41.9	62.9	61.1	26.4	39.6	46.8	17.7	26.5			
4.0S13	207.0	156.2	207.0	132.5	80.0	120.0	92.0	46.3	69.4	67.6	29.1	43.7	51.7	19.5	29.3			
4.0S14	229.4	172.8	229.4	146.8	88.5	132.7	102.0	51.2	76.8	74.9	32.2	48.4	57.4	21.6	32.4			
4.0S15	251.9	189.3	251.9	161.2	96.9	145.4	111.9	56.1	84.1	82.2	35.3	53.0	63.0	23.7	35.5			
4.0S16	277.0	207.8	277.0	177.3	106.4	159.6	123.1	61.6	92.3	90.4	38.8	58.1	69.2	26.0	39.0			
4.0S17	302.1	226.2	302.1	193.3	115.8	173.7	134.3	67.0	100.5	98.6	42.2	63.3	75.5	28.3	42.4			
6.0S00	22.5	22.5	22.5	18.0	18.0	18.0	15.0	15.0	15.0	12.9	12.9	12.9	11.3	10.0	11.3	10.0	7.0	10.0
6.0S01	62.5	62.5	62.5	50.0	48.1	50.0	38.0	27.8	38.0	27.9	17.5	26.3	21.4	11.7	17.6	16.9	8.2	12.4
6.0S02	97.9	97.9	97.9	62.7	55.1	62.7	43.5	31.9	43.5	32.0	20.1	30.1	24.5	13.4	20.2	19.3	9.4	14.2
6.0S03	110.4	110.4	110.4	70.7	62.1	70.7	49.1	35.9	49.1	36.1	22.6	33.9	27.6	15.2	22.7	21.8	10.6	16.0
6.0S04	127.9	127.9	127.9	81.8	72.0	81.8	56.8	41.7	56.8	41.8	26.2	39.3	32.0	17.6	26.4	25.3	12.3	18.5
6.0S05	145.3	145.3	145.3	93.0	81.9	93.0	64.6	47.4	64.6	47.4	29.8	44.8	36.3	20.0	30.0	28.7	14.0	21.1
6.0S06	167.7	167.7	167.7	107.3	94.7	107.3	74.5	54.8	74.5	54.8	34.5	51.8	41.9	23.1	34.7	33.1	16.2	24.4
6.0S07	190.1	190.1	190.1	121.7	107.6	121.7	84.5	62.2	84.5	62.1	39.2	58.8	47.5	26.3	39.4	37.6	18.4	27.7
6.0S08	217.4	217.4	217.4	139.2	123.3	139.2	96.6	71.3	96.6	71.0	44.9	67.4	54.4	30.1	45.1	43.0	21.1	31.7
6.0S09	244.8	244.8	244.8	156.7	139.0	156.7	108.8	80.5	108.8	79.9	50.7	76.0	61.2	33.9	50.9	48.4	23.8	35.8
6.0S10	277.1	277.1	277.1	177.3	157.7	177.3	123.1	91.3	123.1	90.5	57.5	86.2	69.3	38.5	57.8	54.7	27.0	40.6
6.0S11	309.4	309.4	309.4	198.0	176.4	198.0	137.5	102.1	137.5	101.0	64.3	96.4	77.3	43.1	64.6	61.1	30.2	45.4
6.0S12	346.6	346.6	346.6	221.8	198.0	221.8	154.1	114.6	154.1	113.2	72.1	108.2	86.7	48.3	72.5	68.5	33.9	50.9
6.0S13	383.9	383.9	383.9	245.7	219.6	245.7	170.6	127.1	170.6	125.3	80.0	120.0	96.0	53.6	80.4	75.8	37.6	56.5
6.0S14	426.0	426.0	426.0	272.7	244.1	272.7	189.4	141.2	189.4	139.1	88.9	133.4	106.5	59.6	89.4	84.2	41.8	62.8
6.0S15	468.2	468.2	468.2	299.7	268.6	299.7	208.1	155.4	208.1	152.9	97.9	146.8	117.1	65.6	98.3	92.5	46.0	69.1
6.0S16	515.4	515.4	515.4	329.8	296.0	329.8	229.1	171.3	229.1	168.3	107.9	161.8	128.8	72.3	108.4	101.8	50.8	76.1
6.0S17	562.5	562.5	562.5	360.0	323.4	360.0	250.0	187.2	250.0	183.7	117.9	176.8	140.6	79.0	118.4	111.1	55.5	83.2

Shaded cells indicate that shear controls over flexure

The total loads are based on strength, i.e. this is the maximum a member can carry without failure. If the loads from the deflection equation exceed the total loads then of course the total load is shown.

For deflection calculations a different I value should be used, which is the one corresponding to the stress level in the extreme fibers, if the section is subject to the allowable moment (M_a). This moment of inertia is between the full-section moment of inertia and the effective section moment of inertia.

$$I_x \geq I_{xedef} \geq I_{xe}$$

For studs, however, as it was pointed out earlier, the sections are almost all fully effective, in which case the above three values are equal, i.e. using I_{xe} instead of I_{xedef} does not make any difference for most cases.

4.3 Axial Load Capacity With Specified Lateral Loads

Load bearing wall studs, especially in exterior walls, are subjected both to axial and lateral loads. Section C5 of the 1986 Cold-Formed Steel Specification deals with combined axial load and bending. It's provisions for single axis bending are the following:

$$\frac{P}{P_a}+\frac{C_{mx}M_x}{\alpha_x M_{ax}} \leq 1.0\ , \tag{4.8}$$

$$\frac{P}{P_{ao}}+\frac{M_x}{M_{axo}} \leq 1.0 \tag{4.9}$$

When $P/P_a \leq 0.15$ then

$$\frac{P}{P_a}+\frac{M_x}{M_{ax}} \leq 1.0\ , \tag{4.10}$$

where P is the applied axial load ,

M_x is the applied moment,

P_a is the allowable axial load,

P_{ao} is the allowable axial load with $F_n=F_y$,

M_{ax} is the allowable moment, lateral-torsional buckling taken into account,

M_{axo} is the allowable moment excluding lateral-torsional buckling,

$1/\alpha_x$ $=1/[1-(\Omega_c P/P_{cr})]$ magnification factor, (4.11)

Ω_c factor of safety used for determining P_a, now 1.92,

P_{cr} $=\frac{\pi^2 E \min I_{xe}}{KL^2}$, (4.12)

KL is the buckling length, now height of the wall since K=1,

C_{mx} =1 because the frame is assumed to be braced in the plane of loading, the members are subjected to transverse loading between their support, and the ends are unrestrained (pinned).

The tabulated values were computed with a modified version of the program described in Chapter II. Figure 4.1 illustrates the flowchart, and Appendix B contains the program listing. The equations and assumptions used are the following:

$$M_x[k-in]=\frac{KL[in]^2}{8}\frac{s[in]w[psf]}{(10^3)(12^2)} \tag{4.13}$$

where w is the lateral load (i.e. wind load),

s is the spacing of studs: 12, 16, and 24 in. on center respectively,

P_a is computed with a modified version of subroutine COMPcompcap (see Chapter 2.2.5 and page 104 of Appendix B) assumed that:

- the sections are braced by the sheathing material therefore the flexural-torsional buckling mode is not considered,
- the studs are subjected to strong axis bending therefore r_y is replaced by r_x in the first equation of the subroutine.

P_{ao} is calculated the same way as P_a except that F_y is used instead of F_n (Eq. 4.20). Since $F_y > F_n$ the corresponding effective area will be smaller and therefore $P_{ao} < P_a$ (Table 4.2). $M_{ax}=M_{axo}=M_a$, since lateral-torsional buckling is prevented.

Expressing P from Equations 4.9 and 4.10 and substituting M_a for M_{ax} and M_{axo} gives the following:

$$P_{max} = (1 - \frac{M_x}{M_a})P_{ao} \tag{4.14}$$

$$P_{max} = (1 - \frac{M_x}{M_a})P_a \tag{4.15}$$

Since in Equation 4.8 α_x is a function of P (Eq. 4.11) expressing P will result in a second order equation where the smaller root is P_{max}:

$$\frac{P}{P_a} + \frac{M_x}{(1 - \frac{1.92P}{P_{cr}})M_a} \leq 1.0 \tag{4.16}$$

$$-\frac{1.92M_{ax}}{P_{cr}}P^2 + (1 + \frac{1.92P_a}{P_{cr}})P + P_a(M_x - M_{ax}) = 0 \tag{4.17}$$

Table 4.2 shows typical output from the program. These values are tabulated to a typical *Axial Load Capacity With Specified Lateral Loads Table,* Table 4.3.

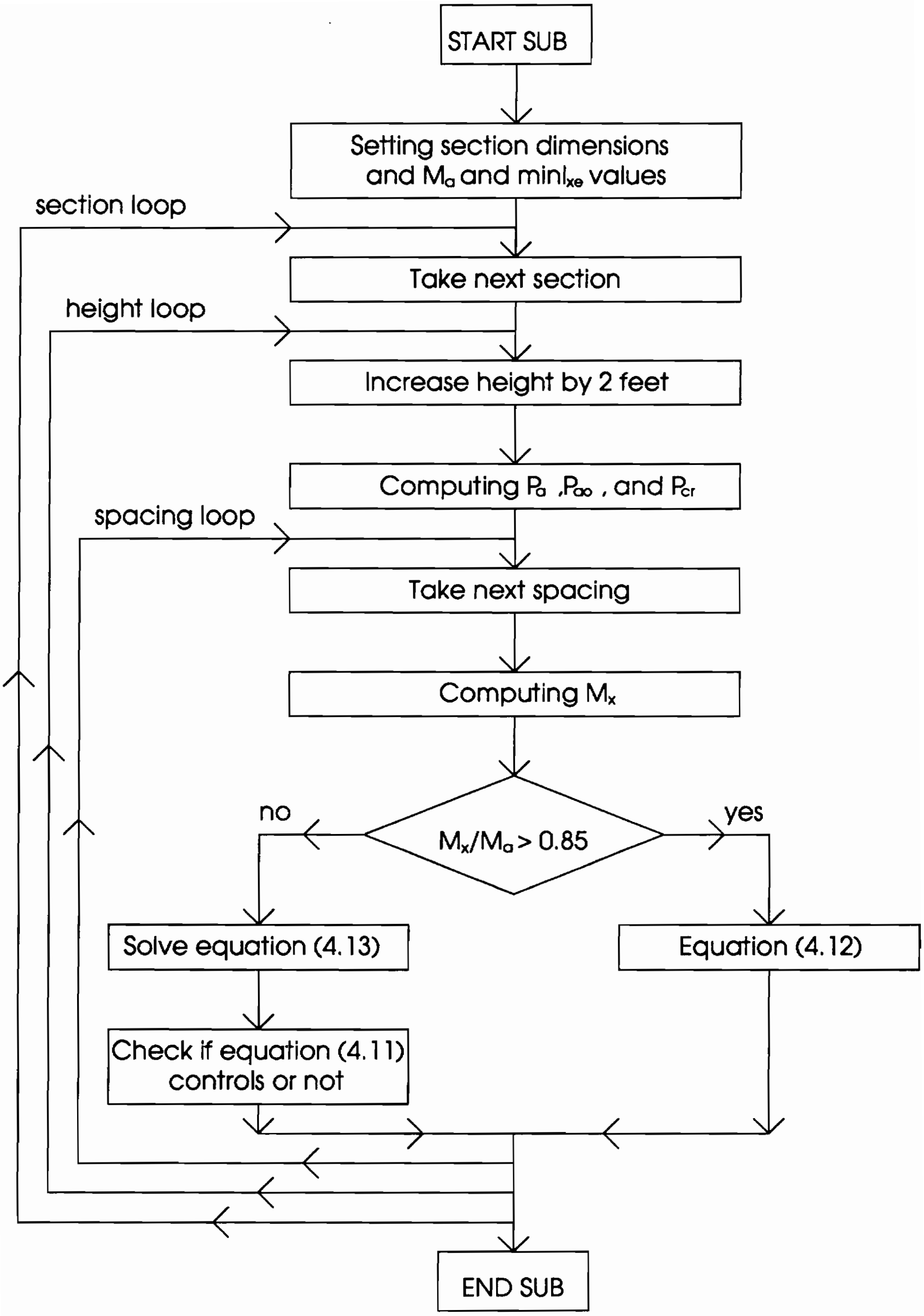


Figure 4.1 Flow Chart Of The Program For Computing Axial Loads

Table 4.2 Output Of The Program Computing The Axial Loads For 6 in. Studs

```
lateral load : w= 25 psf
6.000S06    Ma= 29.7 kip-inch    Ix= 4.036 in4
                                      s=  12''           16''             24''
   H       Pa      Pao     Pcr      Mx      P        Mx      P        Mx      P
  [ft]   [kip]   [kip]   [kip]    [k-i]  [kip]     [k-i]  [kip]     [k-i]  [kip]
  8.00   14.70   14.55  127.51     2.40  13.21      3.20  12.74      4.80  11.81
 10.00   14.31   14.10   81.60     3.75  11.81      5.00  11.06      7.50   9.64
 12.00   13.84   13.53   56.67     5.40  10.03      7.20   9.01     10.80   7.19
 14.00   13.28   12.87   41.63     7.35   8.05      9.80   6.87     14.70   4.83
 16.00   12.62   12.11   31.88     9.60   6.14     12.80   4.90     19.20   2.80
 18.00   11.86   11.24   25.19    12.15   4.49     16.20   3.26     24.30   1.19
 20.00   11.00   10.27   20.40    15.00   3.13     20.00   1.94     30.00  -0.11
 22.00   10.03    9.20   16.86    18.15   2.04     24.20   0.91     36.30  -2.23
 24.00    8.83    8.02   14.17    21.60   1.18     28.80   0.27     43.20  -4.02
6.000S07    Ma= 36.85 kip-inch    Ix= 5.024 in4
                                      s=  12''           16''             24''
   H       Pa      Pao     Pcr      Mx      P        Mx      P        Mx      P
  [ft]   [kip]   [kip]   [kip]    [k-i]  [kip]     [k-i]  [kip]     [k-i]  [kip]
  8.00   20.47   20.44  158.72     2.40  18.75      3.20  18.19      4.80  17.11
 10.00   19.81   19.78  101.58     3.75  16.85      5.00  15.96      7.50  14.29
 12.00   19.00   18.98   70.54     5.40  14.42      7.20  13.21     10.80  11.04
 14.00   18.05   18.02   51.83     7.35  11.70      9.80  10.29     14.70   7.88
 16.00   16.94   16.92   39.68     9.60   9.07     12.80   7.62     19.20   5.17
 18.00   15.70   15.67   31.35    12.15   6.81     16.20   5.39     24.30   3.01
 20.00   14.30   14.28   25.40    15.00   4.97     20.00   3.62     30.00   1.34
 22.00   12.76   12.74   20.99    18.15   3.51     24.20   2.23     36.30   0.19
 24.00   11.07   11.05   17.64    21.60   2.35     28.80   1.16     43.20  -1.91
6.000S08    Ma= 44.95 kip-inch    Ix= 6.145 in4
                                      s=  12''           16''             24''
   H       Pa      Pao     Pcr      Mx      P        Mx      P        Mx      P
  [ft]   [kip]   [kip]   [kip]    [k-i]  [kip]     [k-i]  [kip]     [k-i]  [kip]
  8.00   24.78   24.78  194.13     2.40  23.06      3.20  22.51      4.80  21.42
 10.00   23.96   23.96  124.25     3.75  21.00      5.00  20.09      7.50  18.37
 12.00   22.95   22.95   86.28     5.40  18.30      7.20  17.03     10.80  14.75
 14.00   21.77   21.77   63.39     7.35  15.18      9.80  13.67     14.70  11.06
 16.00   20.40   20.40   48.53     9.60  12.06     12.80  10.48     19.20   7.80
 18.00   18.85   18.85   38.35    12.15   9.31     16.20   7.75     24.30   5.13
 20.00   17.12   17.12   31.06    15.00   7.02     20.00   5.54     30.00   3.04
 22.00   15.20   15.20   25.67    18.15   5.18     24.20   3.79     36.30   1.44
 24.00   13.10   13.10   21.57    21.60   3.71     28.80   2.41     43.20   0.51
6.000S09    Ma= 54  kip-inch    Ix= 7.4 in4
                                      s=  12''           16''             24''
   H       Pa      Pao     Pcr      Mx      P        Mx      P        Mx      P
  [ft]   [kip]   [kip]   [kip]    [k-i]  [kip]     [k-i]  [kip]     [k-i]  [kip]
  8.00   29.09   29.09  233.78     2.40  27.42      3.20  26.87      4.80  25.80
 10.00   28.09   28.09  149.62     3.75  25.21      5.00  24.31      7.50  22.60
 12.00   26.88   26.88  103.90     5.40  22.31      7.20  21.02     10.80  18.67
 14.00   25.45   25.45   76.34     7.35  18.86      9.80  17.28     14.70  14.53
 16.00   23.80   23.80   58.45     9.60  15.29     12.80  13.60     19.20  10.73
 18.00   21.92   21.92   46.18    12.15  12.04     16.20  10.37     24.30   7.55
 20.00   19.83   19.83   37.41    15.00   9.30     20.00   7.69     30.00   5.00
 22.00   17.52   17.52   30.91    18.15   7.05     24.20   5.54     36.30   3.02
 24.00   15.00   15.00   25.98    21.60   5.22     28.80   3.83     43.20   1.50
```

Table 4.3 Axial Load Capacity With Specified Lateral Load Of Wall Studs in kips

25 psf Lateral Load

Height	8 ft.			10 ft.			12 ft.			14 ft.			16 ft.			18 ft.			20 ft.		
Spacing	12	16	24	12	16	24	12	16	24	12	16	24	12	16	24	12	16	24	12	16	24
4.0S00	0.7	0.4		0.1																	
4.0S01	1.0	0.6	0.1	0.4																	
4.0S02	1.2	0.9	0.3	0.6																	
4.0S03	1.5	1.2	0.5	0.8	0.4		0.3														
4.0S04	2.1	1.7	0.9	1.2	0.7		0.5														
4.0S05	2.6	2.2	1.3	1.6	1.1	0.2	0.7	0.3		0.2											
4.0S06	3.3	2.8	1.9	2.2	1.6	0.6	1.2	0.6		0.5											
4.0S07	4.0	3.5	2.6	2.7	2.1	1.0	1.6	0.9		0.7	0.1		0.2								
4.0S08	5.0	4.4	3.4	3.5	2.8	1.6	2.2	1.4		1.1	0.5		0.4								
4.0S09	6.0	5.4	4.3	4.3	3.5	2.2	2.7	2.0	0.6	1.6	0.8		0.7			0.2					
4.0S10	7.5	6.8	5.6	5.4	4.6	3.1	3.6	2.7	1.3	2.1	1.3		1.1			0.5					
4.0S11	9.0	8.3	6.9	6.6	5.7	4.1	4.4	3.4	1.9	2.7	1.8	0.8	1.5	0.7		0.7			0.3		
4.0S12	10.5	9.7	8.3	7.8	6.8	5.1	5.3	4.3	2.6	3.4	2.5	1.1	2.0	1.2		1.1			0.5		
4.0S13	12.0	11.2	9.7	9.0	8.0	6.2	6.2	5.2	3.4	4.1	3.1	1.5	2.5	1.6	0.3	1.4	0.6		0.7		
4.0S14	13.5	12.7	11.2	10.3	9.2	7.4	7.2	6.1	4.3	4.8	3.8	2.1	3.1	2.2	0.7	1.9	1.0		1.0		
4.0S15	15.1	14.2	12.6	11.6	10.5	8.6	8.2	7.1	5.2	5.6	4.5	2.7	3.6	2.7	1.1	2.3	1.4		1.3	0.6	
4.0S16	16.6	15.7	14.2	12.9	11.8	9.8	9.3	8.1	6.2	6.4	5.3	3.5	4.3	3.3	1.6	2.7	1.9		1.7	0.9	
4.0S17	18.2	17.3	15.7	14.3	13.1	11.1	10.4	9.2	7.1	7.2	6.1	4.2	4.9	3.9	2.1	3.2	2.3	0.8	2.1	1.2	
6.0S00	1.3	1.0	0.6	0.8	0.5		0.4														
6.0S01	1.6	1.4	0.9	1.1	0.8	0.2	0.6	0.3		0.2											
6.0S02	2.0	1.7	1.2	1.5	1.1	0.5	0.9	0.5		0.4											
6.0S03	2.3	2.1	1.6	1.8	1.4	0.8	1.2	0.8		0.7	0.2		0.3								
6.0S04	3.0	2.8	2.2	2.4	2.0	1.3	1.8	1.3		1.1	0.6		0.6								
6.0S05	3.7	3.4	2.9	3.1	2.7	1.8	2.3	1.8	0.8	1.6	0.9		0.9	0.3		0.5					
6.0S06	4.6	4.3	3.7	3.9	3.5	2.6	3.1	2.5	1.4	2.2	1.5		1.4	0.8		0.8					
6.0S07	5.5	5.2	4.6	4.8	4.3	3.4	3.9	3.2	2.1	2.9	2.1	0.8	2.0	1.2		1.2	0.6		0.5		
6.0S08	6.8	6.5	5.8	5.9	5.4	4.4	4.9	4.2	3.0	3.8	3.0	1.6	2.7	1.9		1.8	1.0		1.0		
6.0S09	8.1	7.7	7.0	7.1	6.6	5.5	6.0	5.2	3.9	4.7	3.8	2.3	3.5	2.6	1.0	2.4	1.5		1.5	1.0	
6.0S10	10.6	10.2	9.4	9.5	8.8	7.6	8.0	7.1	5.5	6.4	5.4	3.6	4.8	3.7	1.9	3.5	2.4		2.3	1.5	
6.0S11	13.2	12.7	11.8	11.8	11.1	9.6	10.0	9.0	7.2	8.1	6.9	4.8	6.1	4.9	2.8	4.5	3.3	1.2	3.1	1.9	
6.0S12	16.0	15.5	14.5	14.3	13.5	12.0	12.2	11.1	9.1	9.9	8.6	6.4	7.6	6.3	4.0	5.7	4.3	2.1	4.1	2.8	
6.0S13	18.8	18.2	17.1	16.9	16.0	14.3	14.4	13.2	11.0	11.7	10.3	7.9	9.1	7.6	5.2	6.8	5.4	3.0	5.0	3.6	1.3
6.0S14	20.9	20.4	19.3	18.9	18.0	16.3	16.4	15.1	12.9	13.4	12.0	9.5	10.6	9.1	6.5	8.1	6.6	4.1	6.0	4.6	2.2
6.0S15	23.1	22.5	21.4	21.0	20.1	18.4	18.3	17.0	14.8	15.2	13.7	11.1	12.1	10.5	7.8	9.3	7.8	5.1	7.0	5.5	3.0
6.0S16	25.2	24.7	23.6	23.1	22.2	20.5	20.3	19.0	16.7	17.0	15.5	12.8	13.7	12.0	9.3	10.7	9.1	6.3	8.2	6.6	4.0
6.0S17	27.4	26.9	25.8	25.2	24.3	22.6	22.3	21.0	18.7	18.9	17.3	14.5	15.3	13.6	10.7	12.0	10.4	7.6	9.3	7.7	5.0

4.4 Strong Axis Axial Load Capacity Charts

Interior bearing walls are generally not subject to lateral loads; they only carry the axial loads transmitted from the supported slab. In a wall assembly, the bracing and sheathing prevents weak axis (in the plane of the wall) or lateral torsional buckling, so that the only controlling mode is strong axis buckling.

Section C4 of the *1986 Cold-Formed Steel Specification* contains the provisions for compression members. The allowable axial load is determined the following way:

$$P_a = P_n / \Omega_c \tag{4.18}$$

where Ω_c is the factor of safety, now 1.92,

P_n $= A_e F_n$, (4.19)

A_e Effective area at the stress F_n. This was computed for each section with the C-section analysis program.

$$F_n = F_y(1 - F_y / 4F_e) \quad \text{if} \quad F_e > F_y / 2 ,$$
$$= F_e \quad \text{if} \quad F_e \le F_y / 2 , \tag{4.20}$$

F_e $= \dfrac{\pi^2 E}{(KL / r_x)^2}$ since the section is not subject to torsional-flexural buckling (Section C4.1).

Table 4.4 illustrates a portion of the table used for calculating the axial load capacities, and Figure 4.2 shows typical buckling curves for 6 inch studs.

Table 4.4 Computing Strong Axis Axial Load Capacities For 6 in. Studs

	Section 0		Section 1	Section 2	Section 3
E =	29500	ksi	29500	29500	29500
rx =	2.211	in	2.213	2.215	2.217
Fy =	33	ksi	33	33	33
Ae =	0.178	in2	0.201	0.230	0.259

KLx[ft]	Fe [k]	Fn [k]	Pa [k]	Fe [k]	Fn [k]	Pa [k]	Fe [k]	Fn [k]	Pa [k]	Fe [k]	Fn [k]	Pa [k]
0	######	33.00	3.06	######	33.00	3.45	######	33.00	3.95	######	33.00	4.45
1	9884.09	32.97	3.06	9901.98	32.97	3.45	9919.89	32.97	3.95	9937.81	32.97	4.45
2	2471.02	32.89	3.05	2475.50	32.89	3.44	2479.97	32.89	3.94	2484.45	32.89	4.44
3	1098.23	32.75	3.04	1100.22	32.75	3.43	1102.21	32.75	3.92	1104.20	32.75	4.42
4	617.76	32.56	3.02	618.87	32.56	3.41	619.99	32.56	3.90	621.11	32.56	4.39
5	395.36	32.31	3.00	396.08	32.31	3.38	396.80	32.31	3.87	397.51	32.32	4.36
6	274.56	32.01	2.97	275.06	32.01	3.35	275.55	32.01	3.83	276.05	32.01	4.32
7	201.72	31.65	2.93	202.08	31.65	3.31	202.45	31.66	3.79	202.81	31.66	4.27
8	154.44	31.24	2.90	154.72	31.24	3.27	155.00	31.24	3.74	155.28	31.25	4.22
9	122.03	30.77	2.85	122.25	30.77	3.22	122.47	30.78	3.69	122.69	30.78	4.15
10	98.84	30.25	2.80	99.02	30.25	3.17	99.20	30.26	3.62	99.38	30.26	4.08
11	81.69	29.67	2.75	81.83	29.67	3.11	81.98	29.68	3.56	82.13	29.69	4.00
12	68.64	29.03	2.69	68.76	29.04	3.04	68.89	29.05	3.48	69.01	29.06	3.92
13	58.49	28.35	2.63	58.59	28.35	2.97	58.70	28.36	3.40	58.80	28.37	3.83
14	50.43	27.60	2.56	50.52	27.61	2.89	50.61	27.62	3.31	50.70	27.63	3.73
15	43.93	26.80	2.48	44.01	26.81	2.81	44.09	26.82	3.21	44.17	26.84	3.62
16	38.61	25.95	2.41	38.68	25.96	2.72	38.75	25.97	3.11	38.82	25.99	3.51

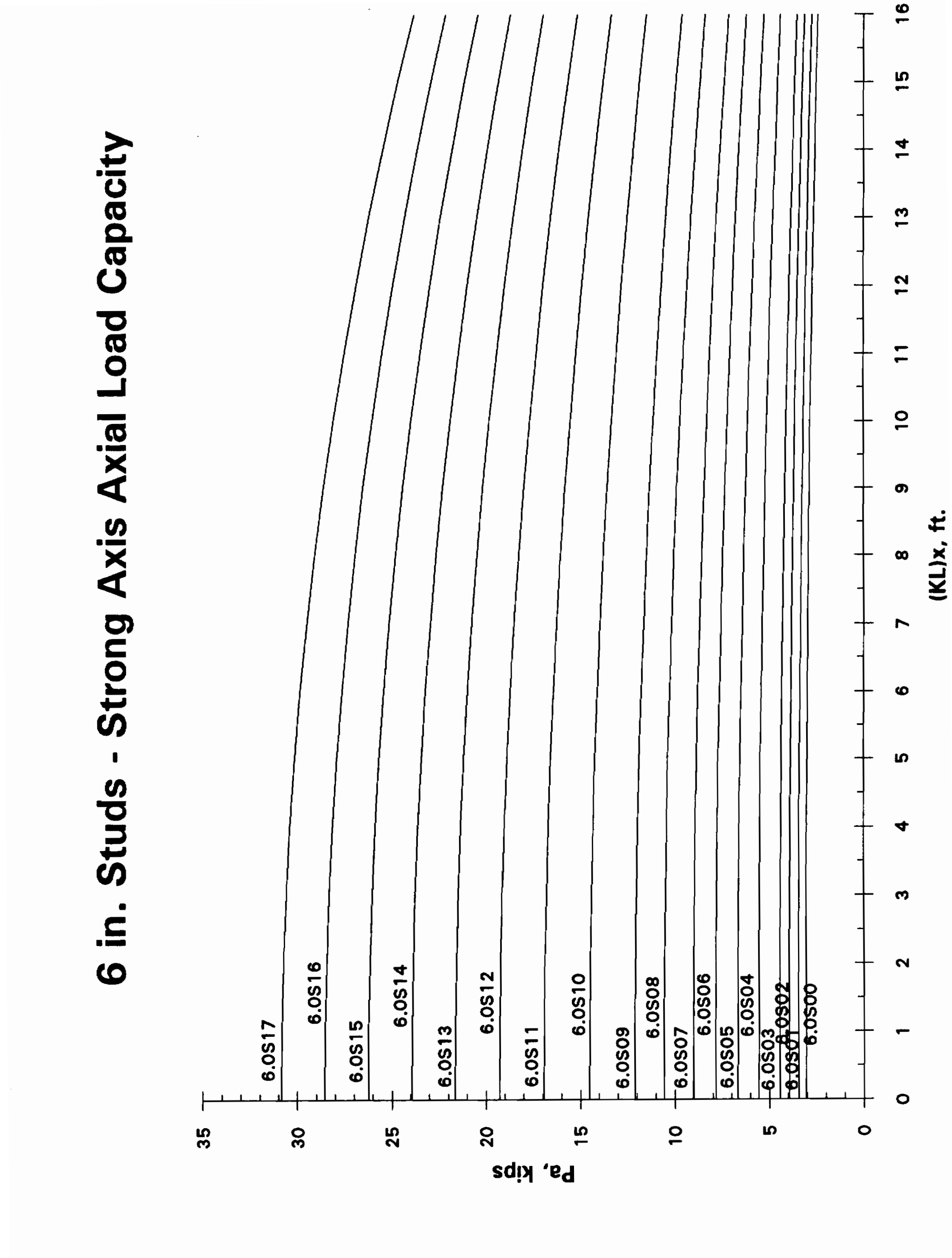


Figure 4.2 Typical Strong Axis Axial Load Capacity Chart

4.5 Weak Axis And Torsional Axial Load Capacity Charts

If the sheathing material does not provide sufficient support, or the member is used as a single column, either weak axis or flexural-torsional buckling modes can control.

Determination of P_a, P_n and F_y is the same as previously described (Eq. 4.18 through 4.20), but the procedure to find F_e, in Section C4.2 of the *1986 Cold-Formed Steel Specification*, is more complex and is as follows:

$$F_e = \min \left| \begin{array}{l} \dfrac{\pi^2 E}{(KL/r_y)^2} \\ \dfrac{1}{2\beta}\left[(\delta_{ex}+\delta_t)-\sqrt{(\delta_{ex}+\delta_t)^2-4\beta\delta_{ex}\delta_t}\right] \end{array} \right. \tag{4.21}$$

where β is a cross sectional property, computed with the C-section analysis program for each section,

$$\delta_{ex} = \frac{\pi^2 E}{(KL/r_x)^2}, \tag{4.22}$$

$$\delta_t = \frac{1}{Ar_o^2}\left[GJ + \frac{\pi^2 EC_w}{(KL)^2}\right]. \tag{4.23}$$

See page 104 of Appendix A for more detailed explanation of variables. Table 4.5 illustrates a portion of the table used for calculating the axial capacities. As we can see the weak axis buckling mode (F_{e1}) controls over the torsional one (F_{e2}). Figure 4.3 shows typical buckling curves for 6 inch studs.

Table 4.5 Computing Weak Axial And Torsional Load Capacities For 6 in. Wall Studs

	Section 1		Section 3
E =	29500	ksi	29500
G =	11300	ksi	11300
ry =	0.427	in	0.441
rx =	2.213	in	2.217
ro =	2.374	in	2.391
beta =	0.901		0.894
Cw =	0.360	in6	0.464
J =	0.00008	in4	0.00014
Fy =	33	ksi	33
A =	0.272	in2	0.378
Ae =	0.201	in2	0.259

KLx[ft]	sigex[ksi]	sigt[ksi]	Fe1	Fe2	Fe [k]	Fn [k]	Pa [k]	sigex[ksi]	sigt[ksi]	Fe1	Fe2	Fe [k]	Fn [k]	Pa [k]
0	######	#####	#####	######	#####	33.00	3.45	######	#####	#####	######	#####	33.00	4.45
1	9901.98	475.42	368.65	473.07	368.65	32.26	3.38	9937.81	434.88	393.22	432.79	393.22	32.31	4.36
2	2475.50	119.30	92.16	118.71	92.16	30.05	3.15	2484.45	109.28	98.31	108.75	98.31	30.23	4.08
3	1100.22	53.36	40.96	53.09	40.96	26.35	2.76	1104.20	48.98	43.69	48.74	43.69	26.77	3.61
4	618.87	30.27	23.04	30.12	23.04	21.18	2.22	621.11	27.88	24.58	27.74	24.58	21.92	2.96
5	396.08	19.59	14.75	19.49	14.75	14.75	1.54	397.51	18.11	15.73	18.02	15.73	15.73	2.12
6	275.06	13.79	10.24	13.72	10.24	10.24	1.07	276.05	12.80	10.92	12.74	10.92	10.92	1.47
7	202.08	10.29	7.52	10.23	7.52	7.52	0.79	202.81	9.60	8.02	9.55	8.02	8.02	1.08
8	154.72	8.02	5.76	7.97	5.76	5.76	0.60	155.28	7.53	6.14	7.49	6.14	6.14	0.83
9	122.25	6.46	4.55	6.42	4.55	4.55	0.48	122.69	6.10	4.85	6.07	4.85	4.85	0.65
10	99.02	5.35	3.69	5.32	3.69	3.69	0.39	99.38	5.08	3.93	5.06	3.93	3.93	0.53
11	81.83	4.52	3.05	4.50	3.05	3.05	0.32	82.13	4.33	3.25	4.31	3.25	3.25	0.44
12	68.76	3.89	2.56	3.87	2.56	2.56	0.27	69.01	3.76	2.73	3.73	2.73	2.73	0.37
13	58.59	3.41	2.18	3.39	2.18	2.18	0.23	58.80	3.31	2.33	3.29	2.33	2.33	0.31
14	50.52	3.02	1.88	3.00	1.88	1.88	0.20	50.70	2.96	2.01	2.94	2.01	2.01	0.27
15	44.01	2.71	1.64	2.69	1.64	1.64	0.17	44.17	2.67	1.75	2.65	1.75	1.75	0.24
16	38.68	2.45	1.44	2.44	1.44	1.44	0.15	38.82	2.44	1.54	2.42	1.54	1.54	0.21

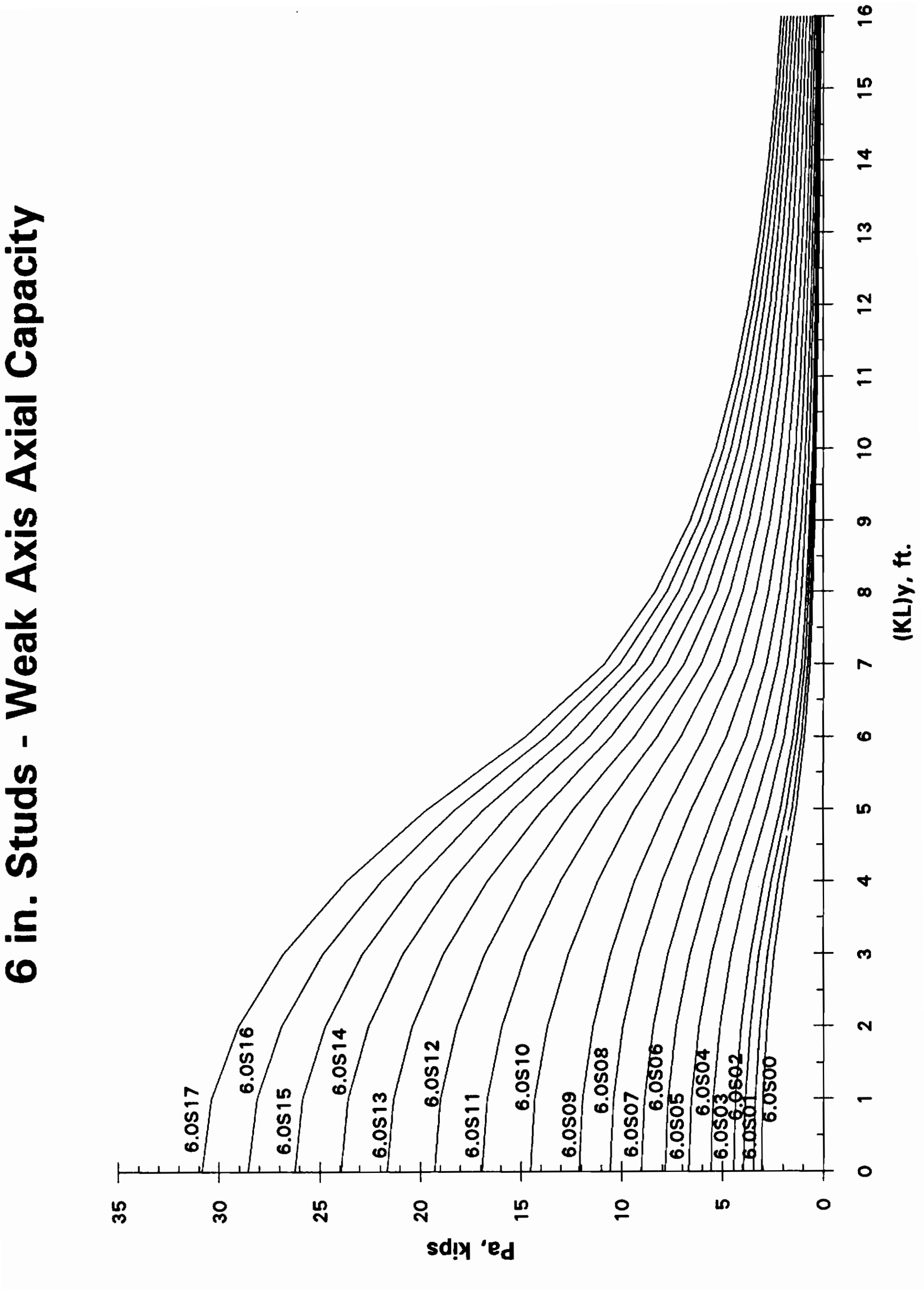


Figure 4.3 Typical Weak Axis-Torsional Axial Load Capacity Chart

CHAPTER V

DESIGN AIDS FOR JOISTS

5.1 Uniform Load Capacity Of Single Span Joists

Joists in slabs or roofs are subject to the uniformly distributed load of the floor or the live loads (snow etc.).

Typical design aid tables were developed the same way, using the same formulas as the Uniform Lateral Load Capacity of Wall Studs Tables described in Chapter 4.1.1. For the joists, however, because of the higher yield stress, only the sections with higher relative thicknesses are fully effective. In case of the thinner sections I_{xedef} could be as much as 10-15% larger then I_{xe}, so for sections with a relative thickness of 00 to 07 I_{xedef} is used in Equations 4.6 and 4.7, as opposed to the I_{xe} values tabulated in the performance section tables. Table 5.1 shows the typical values for 3 5/8 and 10 in. joists.

5.2 Uniform Load Capacity Of Two Continuous Spans Joists

Another common way to use joists is to bridge two spans with one continuous member (Fig. 1.4b). The controlling limit state in this case is the combined moment and shear over the support.

$$M = \frac{wl^2}{8}, \qquad V = \frac{5}{8}wl \qquad (5.1)$$

Substituting into the interaction equation in Section C3.3 of the 1986 Cold-Formed Steel Specification gives

$$\left(\frac{\frac{wl^2}{8}}{M_a}\right)^2 + \left(\frac{\frac{5}{8}wl}{V_a}\right)^2 \leq 1.0 . \tag{5.2}$$

Expressing w results in

$$w[plf] = \frac{8(10^3)}{l[ft]}\sqrt{\frac{1}{\left(\frac{l[ft](12)}{M_a[k-in]}\right)^2 + \left(\frac{5}{V_a[k]}\right)^2}} , \tag{5.3}$$

where M_a, V_a, l, and w are as described in Chapter IV.

The uniform loads which produce deflections of 1/360 of the span are also shown unless that loading exceeds the total capacity. The L/240 values were always greater then the total load capacity therefore they were omitted. The deflection formula for double span is

$$\Delta = \frac{1}{185}\frac{wl^4}{EI} , \tag{5.4}$$

which for L/360 gives

$$w_{L/360}[plf] = \frac{l[ft]}{360}185\frac{E[ksi](10^3)(12^2)}{l[ft]^4}\frac{\min I_{xe}[in^4]}{12^4} , \tag{5.5}$$

where E and ***min*** I_{xe} are as before, except that for the lighter sections, I_{xedef} is used. The typical uniform load capacities of two continuous spans are shown in Table 5.2 .

5.3 Moment-Shear Interaction Capacity Charts

The total load column of the previous tables are based the combined moment and shear capacity of the section. There might be a need to check this limit state at other locations of the member (e.g. fixed end of a cantilever or end of laps). In this case the

Table 5.1 Uniform Load Capacity of Single Span Joists in plf

Span	8 ft.			10 ft.			12 ft.			14 ft.			16 ft.			18 ft.			20 ft.		
	Total	L/360	L/240	Total	L/360	L/240	Total	L/360	L/240	Total	L/360	L/240	Total	L/360	L/240	Total	L/360	L/240	Total	L/360	L/240
3.6J00	63.5	35.6	53.4	40.7	18.2	27.3	28.2	10.5	15.8	20.7	6.6	10.0									
3.6J01	74.5	39.9	59.9	47.7	20.5	30.7	33.1	11.8	17.8	24.3	7.5	11.2									
3.6J02	85.4	44.3	66.5	54.7	22.7	34.0	38.0	13.1	19.7	27.9	8.3	12.4									
3.6J03	96.4	48.7	73.0	61.7	24.9	37.4	42.8	14.4	21.6	31.5	9.1	13.6									
3.6J04	114.8	56.2	84.2	73.5	28.8	43.1	51.0	16.6	25.0	37.5	10.5	15.7									
3.6J05	133.3	63.7	95.5	85.3	32.6	48.9	59.3	18.9	28.3	43.5	11.9	17.8									
3.6J06	159.4	73.2	109.9	102.0	37.5	56.2	70.8	21.7	32.6	52.0	13.7	20.5									
3.6J07	185.4	82.8	124.2	118.7	42.4	63.6	82.4	24.5	36.8	60.5	15.4	23.2									
3.6J08	219.0	97.3	146.0	140.2	49.8	74.7	97.3	28.8	43.2	71.5	18.2	27.2									
3.6J09	252.6	111.8	167.7	161.7	57.3	85.9	112.3	33.1	49.7	82.5	20.9	31.3									
3.6J10	293.8	129.7	194.6	188.0	66.4	99.6	130.6	38.4	57.7	95.9	24.2	36.3									
3.6J11	334.9	147.7	221.5	214.3	75.6	113.4	148.8	43.8	65.6	109.4	27.6	41.3									
3.6J12	383.6	169.0	253.5	245.5	86.5	129.8	170.5	50.1	75.1	125.3	31.5	47.3									
3.6J13	432.3	190.4	285.5	276.7	97.5	146.2	192.1	56.4	84.6	141.2	35.5	53.3									

Span	12 ft.			14 ft.			16 ft.			18 ft.			20 ft.			22 ft.			24 ft.		
	Total	L/360	L/240	Total	L/360	L/240	Total	L/360	L/240	Total	L/360	L/240	Total	L/360	L/240	Total	L/360	L/240	Total	L/360	L/240
10.0J04	100.0	100.0	100.0	85.7	85.7	85.7	75.0	75.0	75.0	66.7	56.8	66.7	56.7	41.4	56.7	46.8	31.1	46.7			
10.0J05	133.3	133.3	133.3	114.3	114.3	114.3	100.0	92.5	100.0	88.9	65.0	88.9	75.0	47.4	71.0	62.0	35.6	53.4			
10.0J06	166.7	166.7	166.7	142.9	142.9	142.9	125.0	104.2	125.0	111.1	73.2	109.8	93.3	53.3	80.0	77.1	40.1	60.1			
10.0J07	200.0	200.0	200.0	171.4	171.4	171.4	150.0	115.9	150.0	133.3	81.4	122.1	111.7	59.3	89.0	92.3	44.6	66.9			
10.0J08	384.3	326.4	384.3	282.3	205.5	282.3	216.1	137.7	206.5	170.8	96.7	145.1	138.3	70.5	105.7	114.3	53.0	79.5			
10.0J09	458.3	378.1	458.3	336.7	238.1	336.7	257.8	159.5	239.3	203.7	112.0	168.0	165.0	81.7	122.5	136.4	61.4	92.0			
10.0J10	555.6	456.5	555.6	408.2	287.5	408.2	312.5	192.6	288.9	246.9	135.3	202.9	200.0	98.6	147.9	165.3	74.1	111.1			
10.0J11	652.8	534.9	652.8	479.6	336.9	479.6	367.2	225.7	338.5	290.1	158.5	237.7	235.0	115.5	173.3	194.2	86.8	130.2			
10.0J12	773.1	634.2	773.1	568.0	399.4	568.0	434.9	267.5	401.3	343.6	187.9	281.9	278.3	137.0	205.5	230.0	102.9	154.4			
10.0J13	893.5	733.5	893.5	656.5	461.9	656.5	502.6	309.4	464.1	397.1	217.3	326.0	321.7	158.4	237.6	265.8	119.0	178.5			

Table 5.2 Uniform Load Capacity of Two Continuous Span Joists in plf

Span	2@ 10 ft.		2@ 12 ft.		2@ 14 ft.		2@ 16 ft.		2@ 18 ft.		2@ 20 ft.		2@ 22 ft.	
	Total	L/360	Total	L/360	Total	L/360	Total	L/360	Total	L/360	Total	L/360	Total	L/360
7.0J02	23.1	23.1	18.9	18.9	15.9	15.9	13.6	13.6	11.8	11.8	10.4	10.4		
7.0J03	56.8	56.8	45.3	45.3	37.0	37.0	30.8	30.8	26.0	26.0	22.2	22.2		
7.0J04	87.7	87.7	68.9	68.9	55.5	55.5	45.5	45.5	38.0	38.0	32.1	32.1		
7.0J05	117.5	117.5	91.4	91.4	73.0	73.0	59.6	59.6	49.4	49.4	41.5	41.5		
7.0J06	183.5	183.5	138.1	138.1	107.2	107.2	85.4	85.4	69.4	69.4	57.5	54.5		
7.0J07	239.9	239.9	177.6	177.6	136.1	136.1	107.4	107.4	86.7	86.6	71.3	63.2		
7.0J08	313.4	313.4	227.9	227.9	172.5	172.5	134.8	134.8	108.1	104.7	88.5	76.3		
7.0J09	380.6	380.6	274.4	274.4	206.5	206.5	160.7	160.7	128.4	122.7	104.9	89.5		
7.0J10	460.9	460.9	329.6	329.6	246.8	246.8	191.3	191.3	152.5	145.3	124.3	105.9		
7.0J11	538.2	538.2	383.2	383.2	286.0	286.0	221.3	221.3	176.2	167.9	143.4	122.4		
7.0J12	627.8	627.8	445.3	445.3	331.5	331.5	256.1	256.1	203.6	195.0	165.6	142.1		
7.0J13	715.9	715.9	506.6	506.6	376.5	376.5	290.5	290.5	230.8	222.0	187.7	161.9		

Span	2@ 12 ft.		2@ 14 ft.		2@ 16 ft.		2@ 18 ft.		2@ 20 ft.		2@ 22 ft.		2@ 24 ft.	
	Total	L/360	Total	L/360	Total	L/360	Total	L/360	Total	L/360	Total	L/360	Total	L/360
10.0J04	71.3	71.3	59.0	59.0	49.7	49.7	42.4	42.4	36.6	36.6	31.9	31.9		
10.0J05	94.9	94.9	78.5	78.5	66.1	66.1	56.4	56.4	48.7	48.7	42.4	42.4		
10.0J06	118.6	118.6	98.0	98.0	82.5	82.5	70.4	70.4	60.7	60.7	52.9	52.9		
10.0J07	142.2	142.2	117.5	117.5	98.9	98.9	84.4	84.4	72.8	72.8	63.4	63.4		
10.0J08	245.9	245.9	196.7	196.7	160.6	160.6	133.3	133.3	112.2	112.2	95.6	95.6		
10.0J09	331.5	331.5	260.6	260.6	209.6	209.6	171.8	171.8	143.2	143.2	120.9	120.9		
10.0J10	451.2	451.2	347.6	347.6	275.1	275.1	222.7	222.7	183.7	183.7	153.9	153.9		
10.0J11	556.8	556.8	424.7	424.7	333.7	333.7	268.6	268.6	220.6	220.6	184.2	184.2		
10.0J12	686.6	686.6	519.2	519.2	405.4	405.4	324.8	324.8	265.8	265.8	221.4	221.4		
10.0J13	810.1	810.1	609.7	609.7	474.5	474.5	379.3	379.3	309.8	309.8	257.7	257.7		

provisions of Section C3.3 of the 1986 Cold-Formed Steel Specification should be applied:

$$\left(\frac{M}{M_a}\right)^2 + \left(\frac{V}{V_a}\right)^2 \le 1.0 \tag{5.6}$$

Figure 5.1 shows a typical interaction chart for 7 in. Joists.

5.4 Web Crippling Capacity Tables

For deep section with relatively small thicknesses web crippling can be a problem. Section C3.4 of the 1986 AISI Specification for Cold-Formed Steel gives equations for four different conditions as follows:

Condition 1: End Reaction, Opposing Loads Spaced > 1.5h
Condition 2: Interior Reaction, Opposing Loads Spaced > 1.5h
Condition 3: End Reaction, Opposing Loads Spaced < 1.5h
Condition 4: Interior Reaction, Opposing Loads Spaced < 1.5h

where h is the depth of the flat portion of the web.

Web crippling capacities are tabulated for a basic bearing length of 3.5 in. and for +/- 0.5 in. increment. The web crippling capacity for any length is then determined from

$$P_a = (P_a)_{3.5} + \left(\frac{L_a - 3.5}{0.5}\right)(P_a)_{0.5} \tag{5.7}$$

where

P_a	web crippling capacity for bearing length L_a, kips
$(P_a)_{3.5}$	web crippling capacity for 3.5 in bearing length (from table), kips
$(P_a)_{0.5}$	web crippling capacity for 0.5 in bearing length increment (from table), kips
L_a	actual bearing length, in

Table 5.3 shows typical web crippling capacities for 7 and 10 in. joists.

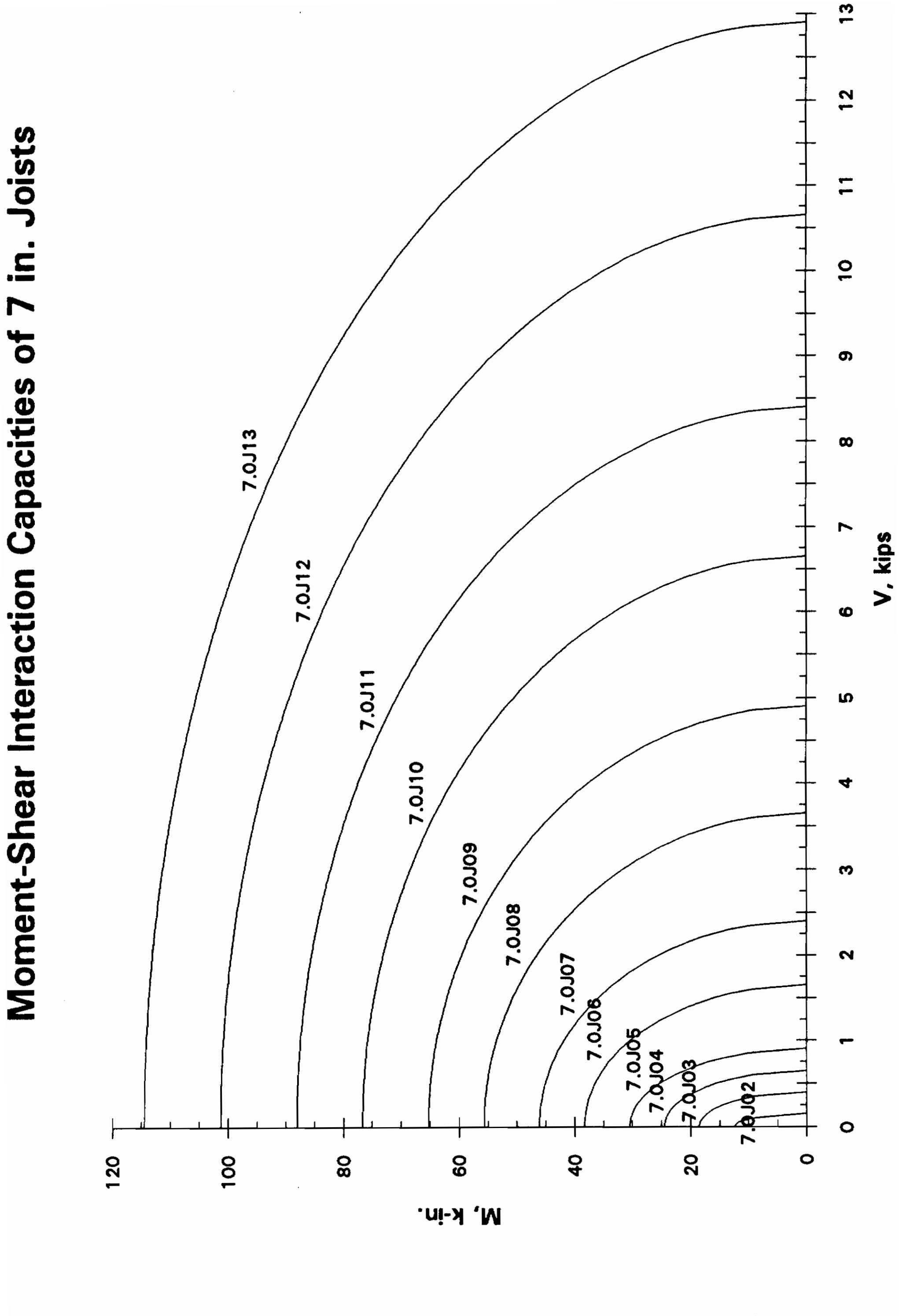


Figure 5.1 Typical Moment-Shear Interaction Capacity Chart

Table 5.3 Web Crippling Capacities of 7 and 10 in. Joists in kips

Condition	1		2		3		4	
Bearing Length	3.5 in.	+/- 0.5 in.	3.5 in.	+/- 0.5 in.	3.5 in.	+/- 0.5 in.	3.5 in.	+/- 0.5 in.
7.0J02	0.19	0.017	0.37	0.026	0.11	0.010	0.12	0.003
7.0J03	0.32	0.022	0.59	0.034	0.20	0.014	0.34	0.005
7.0J04	0.44	0.028	0.81	0.042	0.29	0.018	0.56	0.008
7.0J05	0.56	0.034	1.03	0.050	0.37	0.023	0.78	0.010
7.0J06	0.71	0.040	1.30	0.057	0.48	0.027	1.07	0.012
7.0J07	0.86	0.045	1.57	0.065	0.59	0.031	1.37	0.014
7.0J08	1.08	0.053	1.98	0.075	0.75	0.036	1.84	0.016
7.0J09	1.31	0.060	2.40	0.085	0.91	0.042	2.32	0.019
7.0J10	1.89	0.074	3.47	0.104	1.34	0.052	3.63	0.024
7.0J11	2.47	0.089	4.55	0.123	1.76	0.063	4.94	0.029
7.0J12	3.23	0.103	5.96	0.143	2.31	0.074	6.73	0.035
7.0J13	3.98	0.117	7.36	0.162	2.86	0.084	8.52	0.040

Condition	1		2		3		4	
Bearing Length	3.5 in.	+/- 0.5 in.	3.5 in.	+/- 0.5 in.	3.5 in.	+/- 0.5 in.	3.5 in.	+/- 0.5 in.
10.0J04	0.33	0.023	0.65	0.037	0.19	0.013	0.27	0.005
10.0J05	0.47	0.029	0.92	0.044	0.29	0.018	0.53	0.007
10.0J06	0.62	0.034	1.18	0.052	0.39	0.022	0.80	0.009
10.0J07	0.76	0.040	1.44	0.060	0.50	0.026	1.07	0.011
10.0J08	0.98	0.047	1.84	0.070	0.65	0.031	1.51	0.013
10.0J09	1.19	0.054	2.25	0.079	0.81	0.037	1.95	0.016
10.0J10	1.76	0.069	3.30	0.099	1.21	0.047	3.19	0.021
10.0J11	2.32	0.083	4.35	0.118	1.62	0.058	4.44	0.026
10.0J12	3.06	0.098	5.74	0.137	2.16	0.069	6.16	0.032
10.0J13	3.80	0.112	7.12	0.157	2.69	0.079	7.88	0.037

CHAPTER VI

SUMMARY AND APPLICATION

6.1 Summary

The wider use of cold-formed steel framing is hindered by the lack of generic sections. This study puts forth an effort to develop a performance section designation code without specifying the geometry of the sections. A PC-based program to analyze C-section was developed and used to produce typical *Performance Section Tables* for both wall studs and joists. For curtain walls the *Uniform Lateral Load Capacity Tables* and for bearing walls the *Axial Load with Specified Lateral Load Tables*, the *Strong Axis Axial Load Capacity Charts*, and the *Weak Axis and Torsional Axial Load Capacity Charts* were developed. The typical design aids for roof/floor joists include the *Uniform Load Capacity Tables* for single and two continuous spans, the *Moment-Shear Interaction Capacity Charts*, and the *Web Crippling Capacity Tables*.

6.2 Application

In this chapter design examples are provided for the better understanding of the concept and usage of this study.

6.2.1 Design Examples For Wall Studs

Design Example 1. Non-load Bearing Wall Stud with Continuous Lateral Support

1. Given

Depth	3 5/8 in.
Height:	14 ft
Spacing:	24 in. o.c.
Load:	25 psf lateral
Deflection:	< L/240

2. Required

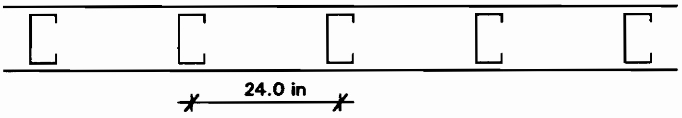
Choose and check a section using the design aids.

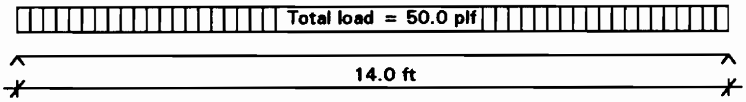
3. Solution

3.1 Assumption

The wall studs are prevented from weak axis lateral and lateral-torsional buckling by sheathing.

3.2 Maximum Moment and Shear





w = 25.0 x 2 = 50 plf

V_{max} = 0.35 kips

M_{max} = 14.7 k-in

3.3 Section Selection

From *Uniform Lateral Load Capacity of Wall Studs Table*, select 6.0S06. Total load capacity is 54.8 plf; L/240 deflection limit is 51.8 plf.

51.8 plf > 50.0 plf OK

3.4 Check Shear Capacity

Since the total load column in the *Uniform Lateral Load Capacity of Wall Studs Table* already includes the shear capacity, choosing the section based on that table inherently satisfies this criterion.

4. Final Selection

Use 6.0S06 Stud

Design Example 2. Load Bearing Wall Stud with Continuous Lateral Support

1. Given

Depth:	3 1/2 in.
Height:	14 ft
Spacing:	24 in. o.c.
Loadings:	25 psf lateral
	2.0 kips axial
Deflection:	< L/360

2. Required

Choose and check a section using the design aids.

3. Solution

3.1 Assumptions

a. The wall studs are prevented from weak axis lateral and lateral-torsional buckling by sheathing.

b. The strong axis effective length factor is 1.0.

3.2 Maximum Moment and Shear

The same as for Example 1.

3.3 Section Selection

From *Axial Load Capacity with Specified Lateral Load of Wall Stud Tables* choose 6.0S09 (height = 14 ft, spacing = 24 in), $P_a = 2.3$ kips

$P_a = 2.3$ kips $> P = 2.0$ kips OK

3.4 Check Deflection

From *Uniform Lateral Load Capacity of Wall Studs Table*, the limiting uniform load for L/360 deflection is 50.7 plf

50.7 plf $>$ 2 x 25 = 50 plf OK

3.5 Check Shear Capacity

Since the *Uniform Lateral Load Capacity of Wall Studs Tables* were developed with the shear capacities taken into consideration, satisfying the previous check also means that the section is adequate for shear.

4. Final Selection

Use 6.0S09 Stud

Design Example 3. Load Bearing Wall Stud without Continuous Lateral Support

1. Given

Depth:	6 in.
Height:	12 ft
Load:	5 kips axial
Bracing Spacing:	4 ft (weak axis lateral and lateral-torsional)

2. Required

Choose and check a section using the design aids.

3. Solution

3.1 Assumptions

The weak axis lateral and lateral-torsional effective length factors are 1.0.

3.2 Section Selection

From *Weak Axis Axial Load Capacity Charts for Wall Studs* choose 6.0S06 (height = 4 ft) $P_a = 5.6$ kips.

$P_a = 5.6$ kips $> P = 5.0$ kips OK

3.3 Check Strong Axis Buckling

From *Strong Axis Axial Load Capacity Charts for Wall Studs,* $P_a = 6.8$ kips (height = 12 ft)

$P_a = 6.8$ kips $> P = 5.0$ kips OK

4. Final Selection

Use 6.0S06 Stud

6.2.2 Design Examples For Joists

Design Example 1. Single Span C-Joist

1. Given

Single span C-joist system
Span: 20 ft
Spacing: 24 in. o.c.
Loads: 15 psf dead
50 psf live
Deflection: < L/240 for Live Load
Bearing Length: 6 in.

2. Required

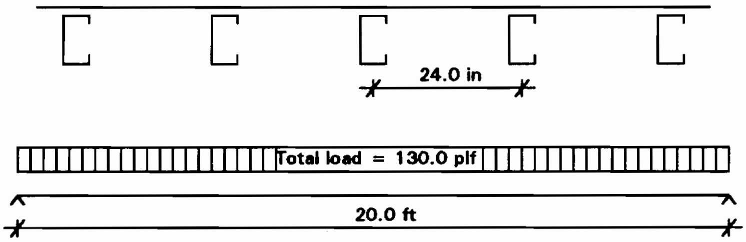
Choose and check a C-Joist section using the design aids.

3. Solution

3.1 Assumptions

The sheathing provides continuous lateral support to the top flange.

3.2 Moment and Shear Diagrams



$w_D = 15 \times 2 = 30$ plf
$w_L = 50 \times 2 = 100$ plf
$w_T = 130$ plf
$V_{max} = 1.30$ kips
$M_{max} = 78.0$ k-in

3.3 Section Selection

Using the *Uniform Load Capacity of Single Span Joists Table*, possible choices are

Joist	Total Load Capacity, plf	L/240 Live Load Deflection, plf
7.0J13	190.8	100.8
8.0J12	175.0	101.6
9.0J10	174.6	117.0
10.0J08	138.3	105.7
12.0J08	170.8	165.0
14.0J08	155.0	155.0

Try 10.0J08

3.4 Check Shear Capacity

This criterion is automatically satisfied if the *Uniform Load Capacity of Single Span Joists Tables* are used for section selection.

3.5 Web Crippling Strength

From the *Web Crippling Capacity of 10 in. Joists Table* for Condition 1, the web crippling capacity is

$$P_a = 0.98 + [(6-3.5)/0.5](0.047) = 1.10 \text{ kips} < 1.3 \text{ kips} \quad \text{NG}$$

Either a bearing stiffener could be used or the section increased to a 10.0J09, where

$$P_a = 1.19 + [(6-3.5)/0.5](0.054) = 1.33 \text{ kips} > 1.3 \text{ kips} \quad \text{OK}$$

4. Final Selection

Use 10.0J08 with bearing stiffener at supports or 10.0J09 without bearing stiffener at supports.

Design Example 2. Two Span Continuous C-Joist

1. Given

Two span C-joist system

Spans:	2 x 16 ft
Spacing:	24 in. o.c.
Loads:	10 psf dead
	40 psf live
Deflection:	< L/360 for Live Load
Bearing Length:	6 in.

2. Required

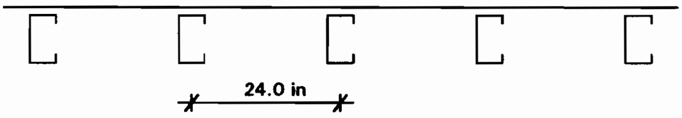
Choose and check a C-joist section using the design aids.

3. Solution

3.1 Assumptions

a. The joist is prismatic, e.g. laps are not used.
b. The sheathing provides a continuous lateral support to the top flange.
c. The compression (bottom) flange near the interior support is fully braced.

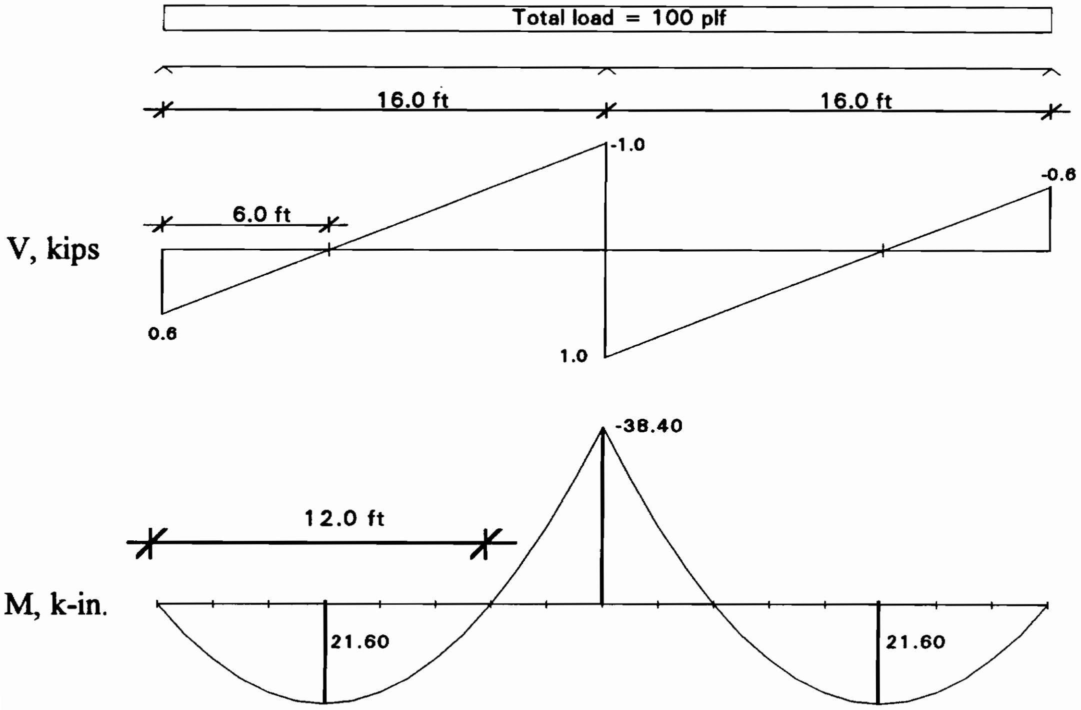
3.2 Moment and Shear Diagrams



$w_D = 10 \times 2 = 20$ plf

$w_L = 40 \times 2 = 80$ plf

$w_T = 100$ plf



3.3 Section Selection

Using the *Uniform Load Capacity of Two Continuous Span Joists Table*, possible choices are

Joist	Total Load Capacity, plf	L/360 Live Load Deflection, plf
6.0J08	109.8	104.1
7.0J07	107.4	107.4
8.0J07	105.9	105.9
9.0J07	101.8	101.8
10.0J08	160.6	160.6
12.0J07	104.0	104.0

Try 7.0J07

3.4 Check Web Crippling Capacity

From the *Web Crippling Capacity of 7 in. Joists Table*:

At exterior support, Condition 1

$P_a = 0.86 + [(6.0-3.5)/0.5](0.045) = 1.09 \text{ kips} > 0.60 \text{ kips}$ OK

At interior support, Condition 2

$P_a = 2\{1.57 + [(6.0\text{-}3.5)/0.5](0.065)\} = 3.79 \text{ kips} > 2.0 \text{ kips}$ OK

3.5 Check Combined Bending and Web Crippling Capacity

Using AISI Specification Equation 3.5.2-1:

$$1.2\left(\frac{P}{P_a}\right)+\left(\frac{M}{M_a}\right)\leq 1.5$$

At the interior support with M_a = 46.10 k-in. from *7 in. Joist Performance Properties Table*:

$$1.2\left(\frac{2.0}{3.79}\right)+\left(\frac{38.40}{2x46.1}\right)=1.05<1.50 \quad \text{OK}$$

4. Final Selection

Use 7.0J07

Design Example 3. Two Span Lapped C-Joist Non-Prismatic Member

1. Given

Two span C-joist system using laps to create continuity.

Spans: 2 x 16 ft with 1.0 ft lap each side of interior support.
Spacing: 24 in. o.c.
Loads: 10 psf dead
40 psf live
Bearing Length: 6 in.

2. Required

Choose and check a C-joist section using the design aids.

3. Solution

Increased stiffness within the lapped portion of each span is considered when determining design moments, shears and reactions.

3.1 Assumptions

a. Full continuity is achieved through the laps.

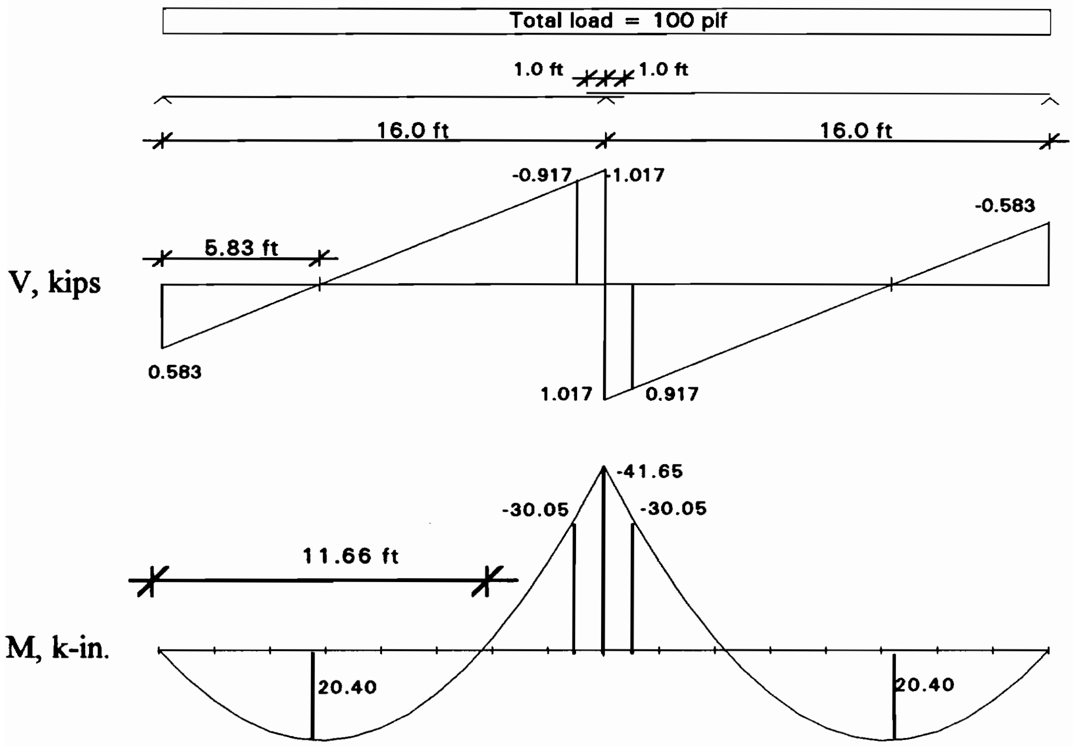
b. The continuous beam analysis to establish the shear and moment diagrams assumes continuous members in which the I_x value within the lapped portions is the sum of the individual members.

c. The capacity within the lap portion of each span is equal to the sum of the individual purlin capacities.

d. The sheathing provides a continuous lateral support to the top flange.

e. The compression (bottom) flange near the interior support is fully braced.

3.2 Moment and Shear Diagrams



3.3 Section Selection

The required moment capacity for each purlin is 30.05 k-in. (moment at start of lap). Using the *Joist Performance Properties Tables*, possible choices are

Joist	M_a k-in.	V_a kips
6.0J06	30.20	1.90
7.0J05	30.50	0.90
8.0J05	36.00	0.90
9.0J05	40.00	0.85

Try 7.0J05

3.4 Check Shear Capacity

From the *7 in. Joist Performance Properties Table*, $V_a = 0.90$ kips

At start of lap

$V_a = 0.90$ kips $< V = 0.92$ kips NG

Try 7.0 J06 $V_a = 1.650$ kips

$V_a = 1.650$ kips $> V = 0.92$ kips OK

At interior support

$V_a = 2 \times 1.650 = 3.30$ kips $> V = 1.0$ kips OK

3.5 Check Combined Moment and Shear Capacity

Using the *Moment-Shear Inaction Capacities of 7 in. Joists Chart*, at start of lap:

$M = 30.05$ k-in.
$V = 0.92$ kips

which plots below the interaction curve for the 7.0J06 section. OK

3.6 Check Web Crippling Capacity

From the *Web Crippling Capacity of 7 in. Joists Table*:

At exterior support, Condition 1

$P_a = 0.71 + [(6.0-3.5)/0.5](0.040) = 0.91$ kips > 0.583 kips OK

At interior support, Condition 2

$P_a = 2\{1.30 + [(6.0\text{-}3.5)/0.5](0.057)\} = 3.17$ kips $> 2 \times 1.017 =$ 2.034 kips OK

3.7 Check Combined Bending and Web Crippling Capacity

Using AISI Specification Equation 3.5.2-1:

$$1.2\left(\frac{P}{P_a}\right)+\left(\frac{M}{M_a}\right)\leq 1.5$$

At the interior support with M_a = 38.30 k-in. from *7 in. Joist Performance Properties Table*:

$$1.2\left(\frac{2.034}{3.17}\right)+\left(\frac{41.65}{2x38.3}\right)=1.31<1.50\text{ OK}$$

4. Final Selection

Use 7.0J06

REFERENCES

1. *Steel Framing and Roofing Opportunities in Residential Buildings*, A report prepared for the AISI by Steven Winter Associates, Inc., New York, NY, January 1992

2. *Walls and Ceilings*, Angeles Metal Systems, August, 1987

3. *Steel Framing Systems*, Steel Benders Inc., April, 1992

4. CSSBI (Aug. 1988) *Lightweight Steel Framing Manual*, Canadian Sheet Steel Building Institute

5. *American Iron and Steel Institute Low-rise Residential Construction Details Index*, AISI

6. AISI (1986), *Cold-Formed Steel Design Manual*, American Iron and Steel Institute, Washington, DC

7. AISI (1991), *LRFD Cold-Formed Steel Design Manual*, American Iron and Steel Institute, Washington, DC

8. Miller, T. H., and Pekoz, T: *Behavior of Cold Formed Steel Wall Stud Assemblies*, Journal of Structural Engineering, vol. 119, no. February, 1993.

9. Yu, Wei-Wen *Cold-Formed Steel Design*, John Wiley & Sons, Inc, 1991, New York, NY

APPENDIX A

PROGRAM LISTING

```
DECLARE SUB DESCRIBE ()
DECLARE SUB INPUTDATA (Fy!, aa!, bb!, cc!, rr!, t!, KL!, lip%)

DECLARE SUB COMPsecprop (Fy!, aa!, bb!, cc!, rr!, t!, KL!, lip%, grap%,
                    Area!, a!, b!, c!, r!, u!, xh!, !, rx!, ry!, ro!, beta!, Jstv!, Cw!, xwcl!)
DECLARE SUB COMPflexcap (Fy!, aa!, bb!, cc!, rr!, t!, a!, b!, c!, r!, u!,
                    lip%, xwcl!, grap%, be!, C1!, C2!, ds!)
DECLARE SUB COMPeffwidth (w!, t!, k!, f!, grap%, la!, b!)
DECLARE SUB COMPflange (w!, t!, f!, cc!, c!, dsp!, grap%, be!, C1!, C2!, ds!)
DECLARE SUB COMPweb (Fy!, aa!, t!, a!, b!, c!, r!, u!, be!, ds!, sumLy!, lip%,
                    grap%, b1!, b2!, b3!, le!, ycg!, yu!, yl!, I%)

DECLARE SUB COMPshearcap (Fy!, a!, t!, grap%)

DECLARE SUB COMPcompcap (Fy!, aa!, bb!, cc!, t!, KL!, Area!, a!, b!, c!, r!, u!,
                    rx!, ry!, ro!, beta!, Jstv!, Cw!, be!, C1!, C2!, ds!, gf!, vc!, hc!, lip%, xwcl!, grap%)

DECLARE SUB PLOTSECT (aa!, bb!, cc!, rr!, t!, a!, b!, c!, r!, lip%, gf!, vc!, hc!, xwcl!)
DECLARE SUB SHOWSIZE (value$, h!, x1!, y1!, x2!, y2!, po$)
DECLARE SUB SHOWSIZE2 (label$, u!, x1!, y1!, x2!, y2!, po$)

DECLARE SUB CORRECT (a$)
DECLARE SUB presskey (x!, y!)
'****************************************************************************
'*
'*    Program for computing the flexural, shear and axial capacities
'*    of cold-formed C-sections based on the Allowable Stress Design
'*
'*                   Version 1.0a
'****************************************************************************
'*
'* INPUT VARIABLES:
'* Fy    - yield stength of steel (ksi)
'*
'* aa    - depth of section (in)
'* bb    - width of flange (in)
'* cc    - length of lip (in)
'* rr    - radius of corners (in)
'* t     - thickness (in)
'* KL    - effective length (ft)
'* LOCAL VARIABLES:
'* grap%    = 1    print graphics and result on screen
'*          = 0    print results on paper
'* exitp%
'****************************************************************************

CALL DESCRIBE

grap% = 1
exitp% = 0
```

```
DO

        IF grap% = 1 THEN
                CALL INPUTDATA(Fy, aa, bb, cc, rr, t, KL, lip%)
        END IF

        CALL COMPsecprop(Fy, aa, bb, cc, rr, t, KL, lip%, grap%,
                        Area, a, b, c, r, u, xh, m, rx, ry, ro, beta, Jstv, Cw, xwcl)

        CALL COMPflexcap(Fy, aa, bb, cc, rr, t, a, b, c, r, u, lip%, xwcl, grap%, be, C2, C1, ds)

        IF grap% = 1 THEN
                CLS
                CALL PLOTSECT(aa, bb, cc, rr, t, a, b, c, r, lip%, gf, vc, hc, xwcl)
        END IF

        CALL COMPshearcap(Fy, a, t, grap%)

        CALL COMPcompcap(Fy, aa, bb, cc, t, KL, Area, a, b, c, r, u,
                        rx, ry, ro,beta, Jstv, Cw, be, C1, C2, ds, gf, vc, hc, lip%, xwcl, grap%)

        SCREEN 0
        CLS
        LOCATE 10, 15
        PRINT "Enter your choice:"
        LOCATE 12, 20
        PRINT "(1)  Send output to printer"
        LOCATE 14, 20
        PRINT "(2)  Compute another section"
        LOCATE 16, 20
        PRINT "(3)  Exit program"

        DO
                a$ = INKEY$
        LOOP UNTIL a$ = "1" OR a$ = "2" OR a$ = "3"

        LOCATE 10, 35
        PRINT a$

        SELECT CASE a$
                CASE "1"
                        grap% = 0
                CASE "2"
                        grap% = 1
                CASE "3"
                        exitp% = 1
        END SELECT

LOOP UNTIL exitp% = 1

END
```

```
SUB DESCRIBE

CLS
LOCATE 5
PRINT "  *****************************************************************"
PRINT "  *                                          *"
PRINT "  *        Program for analyzing cold-formed C-sections        *"
PRINT "  *                                          *"
PRINT "  *                  Version 1.0a                  *"
PRINT "  *                                          *" 10
PRINT "  *                by  Zsolt V. NEMEDI                 *"
PRINT "  *                                          *"
PRINT "  *****************************************************************"
LOCATE 16, 31
PRINT "(1) Description"
PRINT TAB(31); "(2) Start analysis"

DO
        a$ = INKEY$
LOOP UNTIL a$ = "1" OR a$ = "2"

IF a$ = "1" THEN

        CLS
        LOCATE 5

        PRINT TAB(17); "The program computes the flexural, shear and axial"
        PRINT TAB(17); "capacities  of  cold-formed  C-sections  (with  or"
        PRINT TAB(17); "without lips) based on the August 19, 1986 Edition"
        PRINT TAB(17); "of  the  Allowable  Stress  Design  Cold-Formed"
        PRINT TAB(17); "Specification.  It does  not take  the  effect  of"
        PRINT TAB(17); "cold-forming into account."
        PRINT TAB(22); "After inputing the yield strength (ksi), the"
        PRINT TAB(17); "dimensions  of  the  cross-section  (in)  and  the"
        PRINT TAB(17); "effective  length  (ft), it  prints  the  computed"
        PRINT TAB(17); "results on the  screen.  It also  plots the cross-"
        PRINT TAB(17); "section  proportionally, marking the relevant data"
        PRINT TAB(17); "with dimension  lines. For bending and compression"
        PRINT TAB(17); "the  uneffective   portions  of  the  section  are"
        PRINT TAB(17); "shaded.  The results  can also be printed out on a"
        PRINT TAB(17); "printer if requested."

        CALL presskey(23, 29)
        CLS

END IF

END SUB
```

```
SUB INPUTDATA (Fy, aa, bb, cc, rr, t, KL, lip%)
'***************************************************************************
'* SUBROUTINE INPUTDATA
'*
'* This routine reads in the required data.
'*
'* OUTPUT VARIABLES:
'* Fy     - yield stength of steel (ksi)
'*
'* aa     - depth of section (in)
'* bb     - width of flange (in)
'* cc     - length of lip (in)
'* rr     - inner radius of corners (in)
'* t      - thickness (in)
'* KL     - effective length (in)
'* lip%   = 0  if there is no lip
'*        = 1  if there is a lip
'*
'* LOCAL VARIABLES:
'* a$
'*
'* For further information see p III-10 of AISI  ASD COLD-FORMED
'* STEEL DESIGN MANUAL.
'* Capital letters are here double letters, ie. aa corresponds to A'.
'***************************************************************************

DO

        CLS
        LOCATE 2, 10
        PRINT "Defining geometry and material properties"
        PRINT TAB(10); "=========================================="
        PRINT
        PRINT
```

```
LOCATE 5, 10
PRINT "Select yield strength of section :"
PRINT
PRINT TAB(22); "(1)   50 ksi"
PRINT TAB(22); "(2)   33 ksi"
PRINT TAB(22); "(3)   other"
PRINT

DO
        a$ = INKEY$
LOOP UNTIL a$ = "1" OR a$ = "2" OR a$ = "3"

LOCATE 5, 58
PRINT a$

SELECT CASE a$
        CASE "1"
                Fy = 50!
        CASE "2"
                Fy = 33!
        CASE "3"
                DO
                        LOCATE 11, 10
                        INPUT "Enter yield strength   (ksi) "; Fy
                LOOP UNTIL Fy > 0!
END SELECT


DO
        LOCATE 13, 10
        INPUT "Enter depth of section  (in) "; aa
LOOP UNTIL aa > 0!

DO
        LOCATE 15, 10
        INPUT "Enter width of flange   (in) "; bb
LOOP UNTIL bb > 0!
```

```
        LOCATE 22, 10
        PRINT "(Press enter if there is no lip)"
        DO
                LOCATE 17, 10
                INPUT "Enter length of lip     (in) "; cc
        LOOP UNTIL cc >= 0!
        LOCATE 22, 10
        PRINT "                                  "

        IF cc = 0! THEN
                lip% = 0
        ELSE
                lip% = 1
        END IF


        DO
                LOCATE 19, 10
                INPUT "Enter radius of corners (in) "; rr
        LOOP UNTIL rr > 0!

        DO
                LOCATE 21, 10
                INPUT "Enter thickness         (in) "; t
        LOOP UNTIL t > 0!

        DO
                LOCATE 23, 10
                INPUT "Enter buckling length   (ft) "; KL
        LOOP UNTIL KL > 0!
        KL = KL * 12!

        LOCATE 25
        CALL CORRECT(a$)

        IF a$ = "y" OR a$ = "Y" THEN EXIT DO

LOOP WHILE a$ = "n" OR a$ = "N"

END SUB
```

```
SUB COMPsecprop (Fy, aa, bb, cc, rr, t, KL, lip%, grap%,
                  Area, a, b, c, r, u, xh, m, rx, ry, ro, beta, Jstv, Cw, xwcl)
'****************************************************************************
'*  SUBROUTINE COMPsecprop
'*
'*  This routine computes the cross-sectional properties of the section,
'*  based on the Supplementary Information 1.2.2. Section of the Manual.
'*
'*  INPUT VARIABLES:
'*  Fy     - yield stength of steel (ksi)
'*  aa     - A' depth of section (in)
'*  bb     - B' width of flange (in)
'*  cc     - C' length of lip (in)
'*  rr     - R  inner radius of corners (in)
'*  t      -   thickness (in)
'*  lip%    = 0  if there is no lip
'*          = 1  if there is a lip
'*  grap%   = 1  print graphics and result on screen
'*          = 0  print results on paper
'*
'*  OUTPUT VARIABLES:
'*  Area - cross-sectional area of the section (in2)
'*  a      - flat portion of web (in)
'*  b      - flat portion of flange (in)
'*  c      - flat portion of lip (in)
'*  r      - midplane radius of corners (in)
'*  u      - length of arc of 90 degree corners (in)
'*  xh     - distance between centroid and web centerline (in)
'*  m      - distance between shear center and web centerline (in)
'*  rx, ry - radii of giration (in)
'*  ro
'*  beta
'*  Jstv   - St. Venant torsion constant (in4)
'*  Cw     - warping constant (in6)
'*  xwcl  - x coordinate of the centerline of the web
'*
'*  LOCAL VARIABLES:
'*  l      - midplane length of the section (in)
'*  Ix, Iy - moments of inertia about the main axes (in4)
'*  Sx, Syr, Syl - section moduli (in3)
'*  ah, bh, ch    - section dimensions defiened on Fig.1.2.2-1
'*
'*  Cw1-Cw6      - helping variables for computing Cw
'*
'*  gf     - (graphical) factor for defining window
'*  vc     - vertical centerline
'*  hc     - horizontal centerline (center of flanges)
'*  xwcl  - coordinate of web center line
'*  xcgs, ycgs    - coordinates of center of gravity
'*  xsc , ysc     - coordinates of shear center
'****************************************************************************
```

```
'---------computing inner sizes

r = rr + t / 2!
a = aa - 2! * r - t
b = bb - (r + t / 2!) - lip% * (r + t / 2!)
c = lip% * (cc - r - t / 2!)
u = 1.57 * r

'---------computing area and moment of inertia

l = a + 2! * b + 2! * u + lip% * (2! * c + 2! * u)
Area = t * l

Ix1 = a ^ 3! / 24! + b * (a / 2! + r) ^ 2! + u * (a / 2! + .637 * r) ^ 2! + .149 * r ^ 3!
Ix2 = lip% * (c ^ 3! / 12! + c * (a - c) ^ 2! / 4! + u * (a / 2! + .637 * r) ^ 2! + .149 * r ^ 3!)
Ix = 2! * t * (Ix1 + Ix2)

Sx = 2! * Ix / aa

rx = (Ix / Area) ^ .5

'-------distances of centroid and shear center from web centerline

xh = 2! * t * (b * (b / 2! + r) + u * .363 * r + lip% * (u * (b + 1.637 * r) + c * (b + 2! * r))) / Area

ah = aa - t
bh = bb - t / 2! - lip% * t / 2!
ch = lip% * (cc - t / 2!)

m = bh * t * (6! * ch * ah ^ 2! + 3! * bh * ah ^ 2! - 8! * ch ^ 3!) / 12! / Ix

Iy = 2! * t * (b * (b / 2! + r) ^ 2! + b ^ 3! / 12! + .356 * r ^ 3! + lip% * (c * (b + 2! * r) ^ 2! + u * (b +
                    1.637 * r) ^ 2! + .149 * r ^ 3!)) - Area * xh ^ 2!

Syr = Iy / (bb - xh - t / 2!)
Syl = Iy / (xh + t / 2!)

ry = (Iy / Area) ^ .5
ro = (rx ^ 2! + ry ^ 2! + (xh + m) ^ 2!) ^ .5

beta = 1! - ((xh + m) / ro) ^ 2!
```

```
'---------St.Venant's and warping constants-------

Jstv = t ^ 3! * (a + 2! * b + 2! * u + lip% * (2! * c + 2! * u)) / 3

IF lip% = 1 THEN
        Cw1 = xh * Area * ah ^ 2! * (bh ^ 2! / 3! + m ^ 2! - m * bh) / t
        Cw2 = Area * (m ^ 2! * ah ^ 3! + bh ^ 2! * ch ^ 2! * (2! * ch + 3! * ah)) / 3! / t
        Cw3 = -Ix * m ^ 2! * (2! * ah + 4! * ch) / t
        Cw4 = m * ch ^ 2! * (8! * bh ^ 2! * ch + 2! * m * (2! * ch * (ch - ah) + bh * (2! * ch - 3! * ah))) / 3!
        Cw5 = bh ^ 2! * ah ^ 2! * ((3! * ch + bh) * (4! * ch + ah) - 6! * ch ^ 2!) / 6!
        Cw6 = -m ^ 2 * ah ^ 4! / 4!

        Cw = t ^ 2! * (Cw1 + Cw2 + Cw3 + Cw4 + Cw5 + Cw6) / Area
ELSE
        Cw = t * ah ^ 2! * bh ^ 3! * (3! * bh + 2! * ah) / 12! / (6! * bh + ah)
END IF

'==================================================================
'----------------graphical part------------------

IF grap% = 1 THEN

        CALL PLOTSECT(aa, bb, cc, rr, t, a, b, c, r, lip%, gf, vc, hc, xwcl)

        'ploting cgs of the section

        xcgs = xwcl + xh
        ycgs = vc

        LINE (xcgs - .015 * gf * aa, ycgs)-STEP(.03 * gf * aa, 0!)
        LINE (xcgs, ycgs + .015 * gf * aa)-STEP(0!, -.03 * gf * aa)
        CIRCLE (xcgs, ycgs), .007 * gf * aa

        'ploting shear center

        xsc = xwcl - m
        ysc = ycgs

        LINE (xsc - .015 * gf * aa, ysc)-STEP(.03 * gf * aa, 0!)
        LINE (xsc, ysc + .015 * gf * aa)-STEP(0!, -.03 * gf * aa)

        'labeling section with light cyan

        COLOR 11
```

```
IF lip% = 1 THEN
        x1 = hc + bb / 2! + .025 * gf * aa            'labeling cc on upper lip
        y1 = vc + aa / 2!
        CALL SHOWSIZE2("C'", gf * aa, x1, y1, x1, y1 - cc, "vb")
        x1 = hc + bb / 2! + .025 * gf * aa            'labeling c on lower lip
        y1 = vc - aa / 2! + cc
        CALL SHOWSIZE2("c", gf * aa, x1, y1, x1, y1 - c, "vt")
END IF

x1 = hc + bb / 2! + .07 * gf * aa                     'labeling aa
y1 = vc + aa / 2!
CALL SHOWSIZE("A'", gf * aa, x1, y1, x1, y1 - aa, "v")

x1 = xwcl - .04 * gf * aa                             'labeling a
y1 = vc + a / 2!
CALL SHOWSIZE("a", gf * aa, x1, y1, x1, y1 - a, "v")

x1 = xwcl - t / 2!                                    'labeling bb
y1 = vc + aa / 2 + .03 * gf * aa
CALL SHOWSIZE("B'", gf * aa, x1, y1, x1 + bb, y1, "h")

x1 = hc - b / 2!                                      'labeling b
y1 = vc - aa / 2 - .068 * gf * aa
CALL SHOWSIZE("b", gf * aa, x1, y1, x1 + b, y1, "h")

x1 = xwcl - m                                         'labeling m
y1 = .43 * gf * aa
CALL SHOWSIZE("m", gf * aa, x1, y1, x1 + m, y1, "h")

x1 = xwcl                                             'labeling xh
y1 = .43 * gf * aa
CALL SHOWSIZE2("xh", gf * aa, x1, y1, x1 + xh, y1, "hl")

'--------------printing section properties on screen

COLOR 7
l = 3
LOCATE l, 52
PRINT "Section Properties"
LOCATE l + 1, 52
PRINT "══════════════════"

LOCATE l + 3, 52
PRINT "A'="; USING "##.###"; aa; : PRINT " in    ";
PRINT "a= "; USING "##.###"; a; : PRINT " in";

LOCATE l + 4, 52
PRINT "B'="; USING "##.###"; bb; : PRINT " in    ";
PRINT "b= "; USING "##.###"; b; : PRINT " in"
```

```
LOCATE l + 5, 52
PRINT "C'="; USING "##.###"; cc; : PRINT " in    ";
PRINT "c= "; USING "##.###"; c; : PRINT " in"

LOCATE l + 6, 52
PRINT "R= "; USING "##.###"; rr; : PRINT " in    ";
PRINT "r= "; USING "##.###"; r; : PRINT " in"

LOCATE l + 7, 52
PRINT "t= "; USING "##.###"; t; : PRINT " in    ";
PRINT "u= "; USING "##.###"; u; : PRINT " in"

LOCATE l + 9, 52
PRINT "A= "; USING "##.###"; Area; : PRINT " in2"

LOCATE l + 11, 52
PRINT "Ix="; USING "##.###"; Ix; : PRINT " in4   ";
PRINT "rx="; USING "##.###"; rx; : PRINT " in"

LOCATE l + 12, 52
PRINT "Sx="; USING "##.###"; Sx; : PRINT " in3"

LOCATE l + 14, 52
PRINT "Iy="; USING "##.###"; Iy; : PRINT " in4   ";
PRINT "ry="; USING "##.###"; ry; : PRINT " in"

LOCATE l + 15, 51
PRINT "Syr="; USING "##.###"; Syr; : PRINT " in3  ";
PRINT "Syl="; USING "##.###"; Syl; : PRINT " in3"

LOCATE l + 17, 52
PRINT "ro="; USING "##.###"; ro; : PRINT " in"

LOCATE l + 19, 52
PRINT "xh="; USING "##.###"; xh; : PRINT " in    ";
PRINT "m= "; USING "##.###"; m; : PRINT " in"

LOCATE l + 21, 52
PRINT "Cw="; USING "##.###"; Cw; : PRINT " in6"

LOCATE l + 22, 52
PRINT "J= "; USING "##.######"; Jstv; : PRINT " in4"

CALL presskey(27, 52)

SCREEN 0
```

```
ELSE
        LPRINT"*******************************************************************"
        LPRINT "*                                               *"
        LPRINT "*     Program for computing the flexural, shear and axial capacity      *"
        LPRINT "*     of a C section based on the Allowable Stress Design      *"
        LPRINT "*                                               *"
        LPRINT"*******************************************************************"
        LPRINT
        LPRINT
        LPRINT
        LPRINT TAB(5); "Material and Section Properties"
        LPRINT TAB(5); "==============================="
        LPRINT
        LPRINT
        LPRINT TAB(10); "Yield strength of steel          Fy = "; USING "##.###"; Fy; : LPRINT "  ksi"
        LPRINT
        LPRINT TAB(10); "Effective length                KL = "; USING "##.###"; KL / 12!; : LPRINT " ft"
        LPRINT
        LPRINT TAB(10); "Depth of section                 A' = "; USING "##.###"; aa; : LPRINT " in"
        LPRINT TAB(10); "Width of section                 B' = "; USING "##.###"; bb; : LPRINT " in"
        LPRINT TAB(10); "Length of lip                   C' = "; USING "##.###"; cc; : LPRINT " in"
        LPRINT TAB(10); "Inner radius of corners          R  = "; USING "##.####"; rr; : LPRINT " in"
        LPRINT TAB(10); "Thickness                       t  = "; USING "##.####"; t; : LPRINT " in"
        LPRINT
        LPRINT TAB(10); "Flat portion of web              a  = "; USING "##.###"; a; : LPRINT " in"
        LPRINT TAB(10); "Flat portion of flanges          b  = "; USING "##.###"; b; : LPRINT " in"
        LPRINT TAB(10); "Flat portion of lips            c  = "; USING "##.###"; c; : LPRINT " in"
        LPRINT TAB(10); "Midplane radius of corners        r  = "; USING "##.###"; r; : LPRINT " in"
        LPRINT TAB(10); "Length of arc                   u  = "; USING "##.###"; u; : LPRINT " in"
        LPRINT
        LPRINT TAB(10); "Area of cross section            A  = "; USING "##.###"; Area; : LPRINT " in2"
        LPRINT
        LPRINT TAB(10); "Moment of inertia about x         Ix = "; USING "##.###"; Ix; : LPRINT " in4"
        LPRINT TAB(10); "Moment of inertia about y         Iy = "; USING "##.###"; Iy; : LPRINT " in4"
        LPRINT
        LPRINT TAB(10); "Radius of gyration about x        rx = "; USING "##.###"; rx; : LPRINT " in"
        LPRINT TAB(10); "Radius of gyration about y        ry = "; USING "##.###"; ry; : LPRINT " in"
        LPRINT TAB(10); "Polar radius of gyration         ro = "; USING "##.###"; ro; : LPRINT " in"
        LPRINT
        LPRINT TAB(10); "Section modulus about x           Sx = "; USING "##.###"; Sx; : LPRINT " in3"
        LPRINT TAB(10); "Section mod. about y (right)      Sy = "; USING "##.###"; Syr; : LPRINT " in3"
        LPRINT TAB(10); "Section mod. about x (left)       Sy = "; USING "##.###"; Syl; : LPRINT " in3"
        LPRINT
        LPRINT TAB(10); "Dist. bw cent. and web centerline  xh = "; USING "##.###"; xh; : LPRINT " in"
        LPRINT TAB(10); "Dist. bw shear cent. and web cl.   m  = "; USING "##.###"; m; : LPRINT " in"
        LPRINT
        LPRINT TAB(10); "Warping constant                 Cw = "; USING "##.###"; Cw; : LPRINT " in6"
        LPRINT TAB(10); "St. Venant constant              J  = "; USING "##.######"; Jstv; : LPRINT " in4"
        LPRINT CHR$(12)     'end of page
END IF
END SUB
```

```
SUB COMPflexcap (Fy, aa, bb, cc, rr, t, a, b, c, r, u, lip%, xwcl, grap%, be, C1, C2, ds)
'*************************************************************************
'* This routine computes the flexural capacity of the section
'*
'* INPUT VARIABLES:
'* Fy     - yield stength of steel (ksi)
'*
'* aa     - depth of section (in)
'* bb     - width of flange (in)
'* cc     - length of lip (in)
'* rr     - inner radius of corners (in)
'* t      - thickness (in)
'* a      - flat portion of web (in)
'* b      - flat portion of flange (in)
'* c      - flat portion of lip (in)
'* r      - midplane radius of corners (in)
'* u      - length of arc of 90 degree corners (in)
'* lip%    = 0  if there is no lip
'*         = 1  if there is a lip
'* xwcl - x coordinate of the centerline of the web
'* grap%  = 1  print graphics and result on screen
'*        = 0  print results on paper
'*
'* OUTPUT VARIABLES:
'* be     - effective width of flange
'* C1,C2 - coefficients of effective portions of flange
'* ds     - reduced effective width of stiffener
'*
'* LOCAL VARIABLES:
'* E      - modulus of elasticity
'* dsp  - effective width of stiffener
'* gf     - (graphical) factor for defining window
'* vc     - vertical centerline
'* hc     - horizontal centerline (center of flanges)
'* x1, y1 - coordinates of dimension lines
'* Ipxe  - linear effective moment of inertia (in3)
'* Ixe    - effective moment of inertia (in4)
'* Sxet  - effective section modulus (top)  (in3)
'* Sxeb  - effective section modulus (bottom) (in3)
'* Sxe    - smallest effective section modulus (in3)
'* Mn     - nominal moment capacity (kip-in)
'*************************************************************************
IF grap% = 1 THEN

        SCREEN 12
        CLS
        CALL PLOTSECT(aa, bb, cc, rr, t, a, b, c, r, lip%, gf, vc, hc, xwcl)
        COLOR 7
        LOCATE 1, 52
        PRINT "Computing flexural strength"
        LOCATE 2, 52
```

```
        PRINT "============================="
ELSE
        LPRINT TAB(5); "Computing flexural strength"
        LPRINT TAB(5); "============================="
        LPRINT
        LPRINT
        IF lip% = 1 THEN
                LPRINT TAB(10); "Effective width of edge stiffener     Section B3.2 of Spec."
                LPRINT
        END IF
END IF

E = 29500

'------------Computing the flange and the lip
'===================================

IF lip% = 1 THEN
        '--------------Effective width of lip (stiffener)
        '--------------Unstiffened Element with Stress Gradient:
        '--------------Sect. B3.2 of Spec.

        CALL COMPeffwidth(c, t, .43, Fy, grap%, la, dsp)          'dsp: ds prime: effective
                                                                  '      width of stiffener

        '--------------Effective width of compression flange
        '--------------Uniformly Compressed Element with Edge Stiffener:
        '--------------Sect. B4.2 of Spec.

        IF grap% = 0 THEN
                LPRINT
                LPRINT
                LPRINT TAB(10); "Effective width of compression flange  Section B4.2 of Spec."
                LPRINT
        END IF

        CALL COMPflange(b, t, Fy, cc, c, dsp, grap%, be, C1, C2, ds)
ELSE

        '--------------Uniformly Compressed Unstiffened Element:
        '--------------Sect. B3.1 of Spec.

        IF grap% = 0 THEN
                LPRINT
                LPRINT
                LPRINT TAB(10); "Effective width of compression flange  Section B3.1 of Spec."
                LPRINT
        END IF

        CALL COMPeffwidth(b, t, .43, Fy, grap%, la, be)
END IF
```

```
'-------writing message about effectiveness of comp.flange ---

IF be < b THEN

        IF grap% = 1 THEN
                LOCATE 4, 52
                PRINT "Comp. flange isn't fully eff.";
                LOCATE 5, 52
                PRINT "be="; USING "##.###"; be; : PRINT " in < ";
                PRINT "b="; USING "##.###"; b; : PRINT " in"

        '----------showing uneffective portion of flange-----
        COLOR 10

        IF lip% = 1 THEN
                LINE (hc + b / 2! - C2 * be / 2!, vc + aa / 2!)-STEP(0, -t)
                LINE (hc - b / 2! + C1 * be / 2!, vc + aa / 2!)-STEP(0, -t)
                PAINT (hc + b / 2! - C2 * be / 2! - (b - be) / 2!, vc + aa / 2! - t / 2!)

                COLOR 11
                x1 = hc - b / 2! + C1 * be / 2!                         'labeling b-be
                y1 = vc + aa / 2 + .03 * gf * aa
                CALL SHOWSIZE2("b-be", gf * aa, x1, y1, x1 + (b - be), y1, "hl")
        ELSE
                LINE (hc + b / 2!, vc + aa / 2!)-STEP(0, -t)
                LINE (hc + b / 2! - (b - be), vc + aa / 2!)-STEP(0, -t)
                PAINT (hc + b / 2! - (b - be) / 2!, vc + aa / 2! - t / 2!)

                COLOR 11
                x1 = hc - b / 2!                                        'labeling be
                y1 = vc + aa / 2 + .03 * gf * aa
                CALL SHOWSIZE("be", gf * aa, x1, y1, x1 + be, y1, "h")
        END IF

        ELSE
                LPRINT TAB(15); "be="; USING "##.###"; be; : LPRINT " in < b ="; USING "##.###"; b;
                LPRINT " in   Comp.  flange   is not fully eff."
        END IF

ELSE

        IF grap% = 1 THEN
                LOCATE 4, 52
                PRINT "Comp. flange is fully eff."
                LOCATE 5, 52
                PRINT TAB(52); "be = b ="; USING "##.###"; b; : PRINT " in"
        ELSE
                LPRINT TAB(15); "be = b ="; USING "##.###"; b;
                LPRINT " in  Comp.  flange   is fully effective"
        END IF
END IF
```

```
IF grap% = 1 THEN
        COLOR 11
        x1 = hc - b / 2!                                                  'labeling b
        y1 = vc - aa / 2 - .068 * gf * aa
        CALL SHOWSIZE("b", gf * aa, x1, y1, x1 + b, y1, "h")
END IF

IF lip% = 1 THEN

        '---------writing message about effectiveness of comp lip on screen---

        IF ds < c THEN

                IF grap% = 1 THEN
                        COLOR 7
                        LOCATE 7, 52
                        PRINT "Comp. lip isn't fully eff."
                        LOCATE 8, 52
                        PRINT "ds="; USING "##.###"; ds; : PRINT " in < ";
                        PRINT "d="; USING "##.###"; c; : PRINT " in"

                        '----------showing uneffective portion of lip-----
                        COLOR 10
                        LINE (hc + bb / 2!, vc + a / 2! - ds)-STEP(-t, 0)
                        PAINT (hc + bb / 2! - t / 2!, vc + a / 2! - ds - (c - ds) / 2!)

                        COLOR 11
                        x1 = hc + bb / 2! + .023 * gf * aa                'labeling ds
                        y1 = vc + a / 2!
                        CALL SHOWSIZE2("ds", gf * aa, x1, y1, x1, y1 - ds, "vb")
                ELSE
                        LPRINT TAB(15); "ds="; USING "##.###"; ds; : LPRINT " in < d =";
                                                                          USING "##.###"; c;
                        LPRINT " in   Comp. stiffener is not fully eff."
                END IF

ELSE

        IF grap% = 1 THEN
                COLOR 7
                LOCATE 7, 52
                PRINT "Comp. lip is fully eff."
                LOCATE 8, 52
                PRINT "ds = d ="; USING "##.###"; c; : PRINT " in"
        ELSE
                LPRINT TAB(15); "ds = d ="; USING "##.###"; c;
                LPRINT " in  Comp. stiffener is fully effective"
        END IF

        END IF
```

```
          IF grap% = 1 THEN
                    COLOR 11
                    x1 = hc + bb / 2! + .08 * gf * aa                              'labeling d on upper lip
                    y1 = vc + a / 2!
                    CALL SHOWSIZE2("d", gf * aa, x1, y1, x1, y1 - c, "vb")
          END IF

END IF

'------------Computing the location of neutral axis and effectiveness of web
'=====================================================================


'-----------distances from top fiber
y1 = (1! - .637) * r + t / 2!          'top corners
y2 = t / 2!                            'top flange
y3 = aa - t / 2!                       'bottom flange
y4 = aa - (1! - .637) * r - t / 2!     'bottom corners
y5 = t / 2! + r + ds / 2!              'top lip
y6 = aa - t / 2! - r - c / 2!          'bottom lip

'------------summa Ly
Ly1 = u * y1 + lip% * (u * y1)
Ly2 = be * y2
Ly3 = b * y3
Ly4 = u * y4 + lip% * (u * y4)
Ly5 = lip% * (ds * y5)
Ly6 = lip% * (c * y6)
sumLy = Ly1 + Ly2 + Ly3 + Ly4 + Ly5 + Ly6

'--------Computing ycg and effective width of web

IF grap% = 0 THEN
          LPRINT
          LPRINT
          LPRINT TAB(10); "Computing the location of neutral axis and effective width of web"
          LPRINT
END IF

CALL COMPweb(Fy, aa, t, a, b, c, r, u, be, ds, sumLy, lip%, grap%, b1, b2, b3, le, ycg, y7, y8, I%)

IF grap% = 1 THEN

          '---------dashline for ycg and labeling ycg

          length = 1.4 * bb                'length of the whole line
          lengthdash = length / 20!        'length of one segment
          COLOR 10

          FOR j% = 0 TO 19 STEP 2
                    LINE (hc - .7 * bb + j% * lengthdash, vc + aa / 2! - ycg)-STEP(lengthdash, 0)
          NEXT j%
```

```
        COLOR 11
        xx1 = hc - bb / 2! - .07 * gf * aa                              'labeling ycg
        yy1 = vc + aa / 2!
        CALL SHOWSIZE("ycg", gf * aa, xx1, yy1, xx1, yy1 - ycg, "v")

        '-----------showing uneffective portion of web, labelling b1 and b2------
        IF I% <> 1 THEN

              COLOR 10
              yy4 = vc + a / 2! - b1
              yy5 = vc + aa / 2! - ycg + b2
              LINE (xwcl - t / 2!, yy4)-STEP(t, 0)                'border lines of
              LINE (xwcl - t / 2!, yy5)-STEP(t, 0)                'uneffective portion

              PAINT (xwcl, (yy4 + yy5) / 2!)                      'painting by choosing
                                                                  'the midpoint
              COLOR 11
              xx2 = xwcl - t / 2! + .04 * gf * aa                       'labeling b1
              yy2 = vc + a / 2!
              CALL SHOWSIZE("b1", gf * aa, xx2, yy2, xx2, yy2 - b1, "v")

              xx3 = xwcl - t / 2! + .04 * gf * aa                       'labeling b2
              yy3 = vc + aa / 2! - ycg + b2
              CALL SHOWSIZE("b2", gf * aa, xx3, yy3, xx3, yy3 - b2, "v")

        END IF

END IF

'----------calculation of Ixe and Sxe
                                    'moment of inertia about own axis for
I1p = lip% * (ds ^ 3! / 12!)        'top lip
I6p = lip% * (c ^ 3! / 12!)         '+bottom lip

sumLy2 = u * y1 ^ 2! + be * y2 ^ 2! + b * y3 ^ 2! + u * y4 ^ 2! +
        lip% * (u * y1 ^ 2! + u * y4 ^ 2! + ds * y5 ^ 2! + c * y6 ^ 2!)

IF I% = 1 THEN                      'there was no iteration,
        I7p = 0!                    'the web is fully effective
        I8p = a ^ 3! / 12!
        sumLy2 = sumLy2 + a * y8 ^ 2
ELSE                                'the web is not fully eff.
        I7p = b1 ^ 3! / 12!
        I8p = b3 ^ 3! / 12!

        sumLy2 = sumLy2 + b1 * y7 ^ 2! + b3 * y8 ^ 2!
END IF
```

```
sumIp = I1p + I6p + I7p + I8p
Ipxe = sumLy2 - le * ycg ^ 2! + sumIp
Ixe = Ipxe * t
Sxet = Ixe / ycg
Sxeb = Ixe / (a - ycg)

Sxe = Sxet
IF Sxe > Sxeb THEN Sxe = Sxeb

Mn = Sxe * Fy

'----------printing results on the screen----------

IF grap% = 1 THEN

        COLOR 7
        LOCATE 18 + I%, 52
        PRINT "Ixe="; USING "##.###"; Ixe; : PRINT " in4 Sxe="; :
        PRINT USING "##.###"; Sxe; : PRINT " in3"

        LOCATE 20 + I%, 52
        PRINT "Mn="; USING "###.###"; Mn; : PRINT " in-kips"

        LOCATE 21 + I%, 52
        PRINT "Ma="; USING "###.###"; Mn / 1.67; : PRINT " in-kips"

        CALL presskey(28, 52)

ELSE

        LPRINT
        LPRINT
        LPRINT TAB(10); "Computation of Ixe and Sxe"
        LPRINT
        LPRINT TAB(15); "Effective moment of inertia    Ixe ="; USING "###.###"; Ixe; : LPRINT " in4"
        LPRINT TAB(15); "Effective section modulus      Sxe ="; USING "###.###"; Sxe; : LPRINT " in3"
        LPRINT TAB(15); "Nominal   moment capacity       Mn  ="; USING "###.###"; Mn; :
                                                                        LPRINT " kip-in"
        LPRINT TAB(15); "Allowable moment capacity       Ma  ="; USING "###.###"; Mn / 1.67; :
                                                                        LPRINT " kip-in"
        LPRINT CHR$(12)

END IF

END SUB
```

```
SUB COMPeffwidth (w, t, k, f, grap%, la, b)
'****************************************************************************
'* Subroutine COMPeffwidth
'*
'* This routine computes the effective width of an
'* element, based on section B2.1 of the Spec.
'*
'* INPUT VARIABLES:
'* w      - flat width of element
'* t      - thickness of element
'* k      - plate buckling coefficient
'* f      - specified stress in element
'* grap%     = 1    print graphics and result on screen
'*           = 0    print results on paper
'*
'* OUTPUT VARIABLE:
'* la     - slenderness factor
'* b      - effective width of element
'*
'* LOCAL VARIABLES:
'* ro     - reduction factor
'****************************************************************************

la = 1.052 / k ^ .5 * w / t * (f / 29500!) ^ .5


IF la <= .673 THEN                'no reduction

        ro = 1!

ELSE                              'reduction

        ro = (1 - .22 / la) / la

END IF


b = ro * w


IF grap% = 0 THEN

        LPRINT TAB(15); "Buckling coefficient      k  = "; USING "##.###"; k
        LPRINT TAB(15); "Slenderness ratio        la = "; USING "##.###"; la
        LPRINT TAB(15); "Reduction factor         ro = "; USING "##.###"; ro
        LPRINT TAB(15); "Effective width         b  = "; USING "##.###"; b; : LPRINT " in"

END IF

END SUB
```

```
SUB COMPflange (w, t, f, dd, d, dsp, grap%, be, C1, C2, ds)
'****************************************************************************
'* This routine computes the effective width of a uniformly compressed
'* stiffened element, based on sect. B4.2.
'*
'* INPUT VARIABLES:
'* w     - flat width of element
'* t     - thickness of element
'* f     - specified stress in element
'* dd    - D length of stiffener including bend (see Fig. B4-2)
'* d     - width of the flat portion of stiffener (lip)
'* dsp   - effectife width of stiffener
'* grap%        = 1    print graphics and result on screen
'*              = 0    print results on paper
'*
'* OUTPUT VARIABLES:
'* be    - effective width of element  ( compression flange )
'* C1,C2- coefficients of effective portions of flange
'* ds    - reduced effective width of stiffener (lip)
'*
'* LOCAL VARIABLES:
'* E     - modulus of elasticity (kip)
'* S     - quantity defined in sect. B4 of Spec.
'* Ia    - adequate moment of inertia of stiffener
'* n     - power for calculating k
'* Iss   - Is  moment of inertia of stiffener
'* k     - plate buckling coefficient
'****************************************************************************
E = 29500
S = 1.28 * (E / f) ^ .5

SELECT CASE w / t
        CASE IS <= S / 3!                               'Case I

                be = w
                ds = dsp

                IF grap% = 0 THEN
                        LPRINT TAB(15); "w/t = "; USING "##.###"; w / t;
                        LPRINT " < S/3 ="; USING "##.###"; S / 3!;
                        LPRINT "   case I"
                        LPRINT TAB(15); "Effective width of element  b="; be; "in"
                END IF
```

```
CASE IS > S / 3!                        'Case II and III (same procedure applies
                                        'only Ia and n are different)

     IF w / t < S THEN                  'Calculating Ia and n for Case II

          Ia = 399! * (w / t / S - .33) ^ 3! * t ^ 4!
          n = .5

          IF grap% = 0 THEN
               LPRINT TAB(15); "S/3 = "; USING "##.###"; S / 3;
               LPRINT " < w/t = "; USING "##.###"; w / t!;
               LPRINT " < S = "; USING "##.###"; S;
               LPRINT "   case II"
          END IF

     ELSE                               'Calculating Ia and n for Case III

          Ia = (115! * w / t / S + 5!) * t ^ 4
          n = 1! / 3!

          IF grap% = 0 THEN
               LPRINT TAB(15); "w/t = "; USING "##.###"; w / t!;
               LPRINT " > S = "; USING "##.###"; S;
               LPRINT "   case III"
          END IF

     END IF

     Iss = d ^ 3 * t / 12!
     C2 = Iss / Ia
     IF C2 > 1! THEN C2 = 1!
     C1 = 2! - C2

     IF grap% = 0 THEN
          LPRINT TAB(15); "Req'd  moment of inertia of stiffener Ia = ";
                                        USING "#.######"; Ia; : LPRINT " in4"
          LPRINT TAB(15); "Actual moment of inertia of stiffener Is = ";
                                        USING "#.######"; Iss; : LPRINT " in4"
     END IF
```

```
          SELECT CASE dd / w

                CASE IS <= .25
                      k = 3.57 * (Iss / Ia) ^ n + .43
                      IF k > 4! THEN k = 4!

                       IF grap% = 0 THEN
                            LPRINT TAB(15); "D/w = "; USING "##.###"; dd / w; :
                                                                          LPRINT " < 0.25"
                      END IF

                CASE IS > .8
                      PRINT "no provisions of the Spec. applies to D/w > .8 ratios"
                      END

                CASE ELSE
                      k = (4.82 - 5 * dd / w) * (Iss / Ia) ^ n + .43
                      IF k > 5.25 - 5 * dd / w THEN k = 5.25 - 5 * dd / w

                      IF grap% = 0 THEN
                            LPRINT TAB(15); "0.8 > D/w = "; USING "##.###"; dd / w; :
                                                                          LPRINT " > 0.25"
                      END IF

          END SELECT

          CALL COMPeffwidth(w, t, k, f, grap%, la, be) 'be: effective width of flange

          ds = dsp * (Iss / Ia)                      'reduced effective width of lip
          IF ds > dsp THEN ds = dsp

          IF grap% = 0 THEN LPRINT TAB(15); "Reduced eff. width of stiffener  ds = ";
                                                     USING "##.###"; ds; : LPRINT " in"

END SELECT

END SUB
```

```
SUB COMPweb (Fy, aa, t, a, b, c, r, u, be, ds, sumLy, lip%, grap%, b1, b2, b3, le, ycg, yu, yl, I%)
'*************************************************************************
'* This routine computes the location of neutral axis (ycg) and
'* the effective portions of the web, based on Sect. B2.3
'*
'* INPUT VARIABLES:
'* Fy    - yield stength of steel (ksi)
'* aa    - depth of section (in)
'* t     - thickness (in)
'* a     - flat portion of web (in)
'* b     - flat portion of flange (in)
'* c     - flat portion of lip (in)
'* r     - midplane radius of corners (in)
'* u     - length of arc of 90 degree corners (in)
'* be    - effective width of flange (in)
'* ds    - reduced effective width of stiffener (in)
'* sumLy- summation of the L*y terms of the other elements then web
'* lip%       = 0  if there is no lip
'*            = 1  if there is a lip
'* grap%      = 1  print graphics and result on screen
'*            = 0  print results on paper
'*
'* OUTPUT VARIABLES:          (Fig.  B2.3-1)
'* b1    - upper effective portion of web
'* b2    - lower effective portion of web (until ycg)
'* b3    - total lower effective portion of web ( b3 = b2 + aten )
'* le    - effective length of the section
'* ycg   - location of neutral axis
'* yu    - distance of the upper effective portion (b1) from top
'*         extreme fiber
'* yl    - same for the lower effective portion (b3)
'* I%    - loop counter (used in the LOCATE statements)
'*
'* LOCAL VARIABLES:
'* ssumLy        - summation of the L*y terms for all elements
'* b12prev       - variable for storing the value of b1+b2 for the next
'*                 iteration (so that we can compare them)
'* acomp         - compression part of the web
'* f1    - stress at upper end of the flat portion of the web
'* aten  - tension part of the web
'* f2    - stress at lower end of the flat portion of the web
'* fi    - = f2 / f1    coefficient for computing k
'* k     - plate buckling coefficient
'* ae    - effective width of web
'* diff  - difference between the last two b1+b2 values
'*************************************************************************
```

```
I% = 0

DO                                              'iteration loop to find effective portion of web
     I% = I% + 1

     IF I% = 1 THEN                                          'first loop, assuming web
                                                             'is fully effective
          IF grap% = 1 THEN
               COLOR 7
               LOCATE 10, 52
               PRINT "Assuming web is fully eff."
          ELSE
               LPRINT TAB(15); "Assuming web is fully effective"
               LPRINT
          END IF

          le = 2! * u + be + b + a + lip% * (2! * u + ds + c)     'effective length

          yl = aa / 2!
          ssumLy = sumLy + a * yl

     ELSE                                                    'iteration to find effective
                                                             'portions of web
          le = 2! * u + be + b + b1 + b3 + lip% * (2! * u + ds + c)
          yu = b1 / 2! + r + t / 2!
          ssumLy = sumLy + b1 * yu
          yl = aa - t / 2! - r - b3 / 2!
          ssumLy = ssumLy + b3 * yl

          b12prev = b1 + b2                                  'storing value for next iteration

     END IF

     ycg = ssumLy / le

     '--------------Effective width of web
     '--------------Stiffened Element with Stress Gradient:
     '--------------Sect. B2.3 on p. I-32 of Spec.

     acomp = ycg - r - t / 2!                                'compression portion of web
     f1 = Fy * acomp / ycg

     aten = aa - ycg - r - t / 2!                            'tension portion of web
     f2 = -Fy * aten / ycg

     fi = f2 / f1
     k = 4! + 2! * (1! - fi) ^ 3! + 2! * (1! - fi)
```

```
IF grap% = 0 AND I% = 1 THEN                              'this routine will only print
        prin% = 0                                         'to printer for the first loop
ELSE
        prin% = 1
END IF

IF prin%=0 THEN
        LPRINT TAB(15); "Location of neutral axis      ycg = "; USING "##.###"; ycg; : LPRINT " in"
        LPRINT TAB(15); "Compression portion of web    acomp = "; USING "##.###"; acomp;
        LPRINT " in   f1 ="; USING "###.###"; f1; : LPRINT " ksi"
        LPRINT TAB(15); "Tension     portion of web    aten = "; USING "##.###"; aten;
        LPRINT " in   f2 ="; USING "###.###"; f2; : LPRINT " ksi"
END IF

CALL COMPeffwidth(a, t, k, f1, prin%, la, ae)             'ae:  effective width of web

b1 = ae / (3! - fi)

IF fi <= -.236 THEN
        b2 = ae / 2!
ELSE
        b2 = ae - b1
END IF

IF prin%=0 THEN
        LPRINT TAB(15); "fi = "; USING "##.###"; fi;
        LPRINT ; "    b1 = "; USING "##.###"; b1;
        LPRINT " in    b2 = "; USING "##.###"; b2; : LPRINT " in"
END IF

'-----------deciding whether assumption was correct or not---

IF b1 + b2 > acomp THEN                                   'assumption is correct:web is fully
                                                          'effective, we can compute Ixe, Sxe
        IF grap% = 1 THEN
                COLOR 7
                LOCATE 12, 52
                PRINT "Assumption correct"
                LOCATE 14, 52
                PRINT "ycg="; USING "##.###"; ycg; : PRINT " in"
                LOCATE 16, 52
                PRINT "b1+b2="; USING "##.###"; b1 + b2; : PRINT " < acomp="; :
                PRINT USING "##.###"; acomp
        ELSE
                LPRINT TAB(15); "b1+b2 ="; USING "##.###"; b1 + b2; : LPRINT " in > acomp =";
                                                          USING "##.###"; acomp;
                LPRINT " in   Assumption correct"
        END IF

        EXIT DO
```

```
        ELSE                                                    'iteration needed to find effective
                                                                'portion of the web
                IF I% = 1 then

                        if grap% = 1 THEN
                                COLOR 7
                                LOCATE 12, 52
                                PRINT "Assumption incorrect,"
                                LOCATE 13, 52
                                PRINT "iteration needed."
                                LOCATE 15, 52
                                PRINT " ycg    b1+b2    diff.%"
                        ELSE
                                LPRINT TAB(15); "b1+b2 ="; USING "##.###"; b1 + b2; :
                                                LPRINT " in > acomp =";USING "##.###"; acomp;
                                LPRINT " in   Assumption incorrect"
                                LPRINT TAB(15); "Iteration needed to find effective portion of web"
                                LPRINT
                                LPRINT TAB(15); "iter   ycg     fi      k       la      b1+b2     diff"
                        END IF

                END IF

                b3 = aten + b2
        END IF

        diff = ABS(1 - b12prev / (b1 + b2)) * 100!

        IF grap% = 1 THEN
                COLOR 7
                LOCATE 16 + I%, 52
                PRINT USING "##.###"; ycg; : PRINT "    ";
                PRINT USING "##.###"; b1 + b2; : PRINT "    ";
                IF I% > 1 THEN PRINT USING "###.###"; diff
                PRINT
        ELSE
                LPRINT TAB(15); I%;
                LPRINT TAB(21); USING "##.###"; ycg; :
                LPRINT TAB(31); USING "##.###"; fi;
                LPRINT TAB(41); USING "##.###"; k;
                LPRINT TAB(50); USING "##.###"; la;
                LPRINT TAB(59); USING "##.###"; b1 + b2;
                IF I% > 1 THEN
                        LPRINT TAB(67); USING "###.###"; diff
                ELSE
                        LPRINT
                END IF
        END IF
LOOP UNTIL diff < .1
```

```
IF grap% = 0 AND I% > 1 THEN
        LPRINT
        LPRINT TAB(15); "Difference is less then .1 percent, close enough"
END IF
END SUB
```

```
SUB COMPshearcap (Fy, a, t, grap%)
'**************************************************************************
'* This routine computes the shear capacity of the section,
'* based on section C3.2 of Spec.
'*
'* INPUT VARIABLES:
'* Fy    - yield stength of steel (ksi)
'* a     - flat portion of web (in)
'* t     - thickness (in)
'* grap%      = 1    print graphics and result on screen
'*            = 0     print results on paper
'*
'* INPUT VARIABLES:
'* h     - height of element
'* kv    - plate buckling coefficient
'* E     - modulus of elasticity
'* x
'* Va    - shear capacity of the section (kip)
'**************************************************************************

IF grap% = 0 THEN
        LPRINT TAB(5); "Computing shear capacity   (Section C 3.2 of Spec.)"
        LPRINT TAB(5); "================================================="
        LPRINT
END IF

h = a
kv = 5.34
E = 29500!

x = (E * kv / Fy) ^ .5
```

```
IF h / t <= 1.38 * x THEN                                       'case a

        Va = .38 * t ^ 2! * (kv * Fy * E) ^ .5

        IF grap% = 0 THEN
                LPRINT TAB(15); "h/t = "; USING "###.###"; h / t;
                LPRINT " < 1.38 * (E kv/Fy) ^.5 = "; USING "###.###"; 1.38 * x;
                LPRINT "   case A"
                LPRINT TAB(15); "Shear capacity (inelastic)   (Va)1 ="; USING "###.###"; Va; :
                                                                                LPRINT " kips"
                LPRINT TAB(15); "Shear capacity (yield)       (Va)2 ="; USING "###.###"; .4 * Fy * h * t; :
                                                                                LPRINT " kips"
        END IF

        IF Va > .4 * Fy * h * t THEN

                Va = .4 * Fy * h * t

                IF grap% = 0 THEN LPRINT TAB(15); "Yield governs"
        ELSE
                IF grap% = 0 THEN LPRINT TAB(15); "Inelastic buckling governs"
        END IF
ELSE                                                            'case b

        IF grap% = 0 THEN
                LPRINT TAB(15); "h/t = "; USING "###.###"; h / t;
                LPRINT " > 1.38 * (E kv/Fy) ^ .5 = "; USING "###.###"; 1.38 * x;
                LPRINT "   case B"
                LPRINT TAB(15); "Elastic buckling governs"
         END IF

        Va = .53 * E * kv * t ^ 3! / h
END IF

IF grap% = 1 THEN

        COLOR 7

        LOCATE 2, 52
        PRINT "Shear and axial strength"
        LOCATE 3, 52
        PRINT "════════════════════════"

        LOCATE 5, 52
        PRINT "Va="; USING "###.###"; Va; : PRINT " kips"
ELSE
        LPRINT
        LPRINT TAB(15); "Shear capacity           Va ="; USING "###.###"; Va; : LPRINT " kips"
END IF

END SUB
```

```
SUB COMPcompcap (Fy, aa, bb, cc, t, KL, Area, a, b, c, r, u, rx, ry, ro, beta, Jstv, Cw, be, C1, C2, ds, gf,
                                                                                    vc, hc, lip%, xwcl, grap%)
'***************************************************************************
'*  This routine computes the compression capacity of the section based on Sect. C4
'*
'*  INPUT VARIABLES:
'*  Fy     - yield stength of steel (ksi)
'*  aa     - A' depth of section (in)
'*  bb     - B' width of flange (in)
'*  cc     - C' length of lip (in)
'*  t      - thickness (in)
'*  KL     - effective length (in)
'*  Area   - cross-sectional area of the section (in2)
'*  a      - flat portion of web (in)
'*  b      - flat portion of flange (in)
'*  c      - flat portion of lip (in)
'*  r      - midplane radius of corners (in)
'*  u      - length of arc of 90 degree corners (in)
'*  rx, ry - radii of giration (in)
'*  ro
'*  beta
'*  Jstv   - St. Venant torsion constant (in4)
'*  Cw     - warping constant (in6)
'*  be     - effective width of flange
'*  C1,C2- coefficients of effective portions of flange
'*  ds     - reduced effective width of stiffener
'*  gf     - (graphical) factor for defining window
'*  vc     - location of vertical centerline of section
'*  hc     - location of horizontal centerline of section
'*  lip%        = 0  if there is no lip
'*              = 1  if there is a lip
'*  xwcl  - x coordinate of the centerline of the web
'*  grap%       = 1    print graphics and result on screen
'*              = 0    print results on paper
'*
'*  LOCAL VARIABLES:
'*  pi
'*  E      - modulus of elasticity
'*  GG     - shear modulus
'*
'***************************************************************************

pi = 3.1415927#
E = 29500
GG = 11300
```

```
'----------------computing Fe--------------

Fe1 = pi ^ 2! * E / (KL / ry) ^ 2!

sigex = pi ^ 2! * E / (KL / rx) ^ 2!
sigt = (GG * Jstv + pi ^ 2! * E * Cw / KL ^ 2) / Area / ro ^ 2!
Fe2 = (sigex + sigt - ((sigex + sigt) ^ 2! - 4! * beta * sigex * sigt) ^ .5) / 2! / beta

Fe = Fe1
IF Fe > Fe2 THEN Fe = Fe2

'--------------determining Fn-----------------

IF Fe > Fy / 2! THEN
        FFn = Fy * (1! - Fy / 4! / Fe)
ELSE
        FFn = Fe
END IF

'----------printing relevant data on the screen-----

IF grap% = 1 THEN
        LOCATE 7, 52
        PRINT "Flexural buckling stress:"
        LOCATE 8, 52
        PRINT "(Fe)1="; USING "###.###"; Fe1; : PRINT " ksi"
        LOCATE 10, 52
        PRINT "Tors.-flex. buckling stress:"
        LOCATE 11, 52
        PRINT "(Fe)2="; USING "###.###"; Fe2; : PRINT " ksi"
        LOCATE 13, 52
        PRINT "Fe="; USING "###.###"; Fe; : PRINT " ksi ";
        PRINT "Fn="; USING "###.###"; FFn; : PRINT " ksi"
ELSE
        LPRINT
        LPRINT
        LPRINT TAB(5); "Computing axial strength"
        LPRINT TAB(5); "========================"
        LPRINT
        LPRINT TAB(10); "Determining Fn"
        LPRINT
        LPRINT TAB(15); "Flexural buckling stress      (Fe)1 ="; USING "###.###"; Fe1; : LPRINT " ksi"
        LPRINT TAB(42); "sigma ex ="; USING "###.###"; sigex; : LPRINT " ksi"
        LPRINT TAB(43); "sigma t ="; USING "###.###"; sigt; : LPRINT " ksi"
        LPRINT TAB(15); "Tors.-flex. buckling stress   (Fe)2 ="; USING "###.###"; Fe2; : LPRINT " ksi"
        LPRINT
        LPRINT TAB(48); "Fe ="; USING "###.###"; Fe; : LPRINT " ksi"
        LPRINT TAB(48); "Fn ="; USING "###.###"; FFn; : LPRINT " ksi"
        LPRINT
        IF lip% = 1 THEN
                LPRINT TAB(10); "Effective width of edge stiffeners Section      B3.2 of Spec."
```

```
            LPRINT
        END IF
END IF

'-------------Computing the flange and the lip
'=========================================

IF lip% = 1 THEN
        '--------------Effective width of lip (stiffener)
        '--------------Uniformly Compressed Unstiffened Element:
        '--------------Sect. B3.1

        CALL COMPeffwidth(c, t, .43, FFn, grap%, la, dsp)          'dsp: ds prime: effective
                                                                   '     width of stiffener

        '--------------Effective width of compression flange
        '--------------Uniformly Compressed Element with Edge Stiffener:
        '--------------Sect. B4.2 of Spec.

        IF grap% = 0 THEN
            LPRINT
            LPRINT TAB(10); "Effective width of flanges        Section B4.2 of Spec."
            LPRINT
        END IF

        CALL COMPflange(b, t, FFn, cc, c, dsp, grap%, be, C1, C2, ds)
ELSE

        '--------------Uniformly Compressed Unstiffened Element:
        '--------------Sect. B3.1 of Spec.

        IF grap% = 0 THEN
            LPRINT
            LPRINT TAB(10); "Effective width of flanges        Section B3.1 of Spec."
            LPRINT
        END IF

        CALL COMPeffwidth(b, t, .43, FFn, grap%, la, be)
END IF

'----------writing message about effectiveness of flanges on screen---

IF be < b THEN

        IF grap% = 1 THEN
            LOCATE 15, 52
            PRINT "Flanges are not fully eff.";
            LOCATE 16, 52
            PRINT "be="; USING "##.###"; be; : PRINT " in < ";
            PRINT "b="; USING "##.###"; b; : PRINT " in"
```

```
        '-----------showing uneffective portion of flanges-----
        COLOR 10

        IF lip% = 1 THEN
                LINE (hc + b / 2! - C2 * be / 2!, vc + aa / 2!)-STEP(0, -t)
                LINE (hc - b / 2! + C1 * be / 2!, vc + aa / 2!)-STEP(0, -t)
                PAINT (hc + b / 2! - C2 * be / 2! - (b - be) / 2!, vc + aa / 2! - t / 2!)
                LINE (hc + b / 2! - C2 * be / 2!, vc - aa / 2!)-STEP(0, t)
                LINE (hc - b / 2! + C1 * be / 2!, vc - aa / 2!)-STEP(0, t)
                PAINT (hc + b / 2! - C2 * be / 2! - (b - be) / 2!, vc - aa / 2! + t / 2!)

                COLOR 11
                x1 = hc - b / 2! + C1 * be / 2                      'labeling b-be
                y1 = vc + aa / 2 + .03 * gf * aa
                CALL SHOWSIZE2("b-be", gf * aa, x1, y1, x1 + (b - be), y1, "hl")
        ELSE
                LINE (hc + b / 2!, vc + aa / 2!)-STEP(0, -t)
                LINE (hc + b / 2! - (b - be), vc + aa / 2!)-STEP(0, -t)
                PAINT (hc + b / 2! - (b - be) / 2!, vc + aa / 2! - t / 2!)

                COLOR 11
                x1 = hc - b / 2                                     'labeling be
                y1 = vc + aa / 2 + .03 * gf * aa
                CALL SHOWSIZE("be", gf * aa, x1, y1, x1 + be, y1, "h")
        END IF

    ELSE
        LPRINT TAB(15); "be="; USING "##.###"; be; : LPRINT " in < b ="; USING "##.###"; b;
        LPRINT " in     Flanges  are not fully effective"
    END IF

ELSE

    IF grap% = 1 THEN
        LOCATE 15, 52
        PRINT "Flanges are fully eff."
        LOCATE 16, 52
        PRINT TAB(52); "be = b ="; USING "##.###"; be; : PRINT " in"
    ELSE
        LPRINT TAB(15); "be = b ="; USING "##.###"; b;
        LPRINT " in     Flanges  are fully effective"
    END IF

END IF

IF grap% = 1 THEN
    COLOR 11
    x1 = hc - b / 2!                                                'labeling b
    y1 = vc - aa / 2 - .068 * gf * aa
    CALL SHOWSIZE("b", gf * aa, x1, y1, x1 + b, y1, "h")
END IF
```

```
IF lip% = 1 THEN

        '---------writing message about effectiveness of lips on screen---

        IF ds < c THEN

                IF grap% = 1 THEN
                        COLOR 7
                        LOCATE 18, 52
                        PRINT "Lips are not fully eff."
                        LOCATE 19, 52
                        PRINT "ds="; USING "##.###"; ds; : PRINT " in < ";
                        PRINT "d="; USING "##.###"; c; : PRINT " in"

                        '----------showing uneffective portion of lip-----
                        COLOR 10
                        LINE (hc + bb / 2!, vc + a / 2! - ds)-STEP(-t, 0)
                        PAINT (hc + bb / 2! - t / 2!, vc + a / 2! - ds - (c - ds) / 2!)
                        LINE (hc + bb / 2!, vc - a / 2! + ds)-STEP(-t, 0)
                        PAINT (hc + bb / 2! - t / 2!, vc - a / 2! + ds + (c - ds) / 2!)

                        COLOR 11
                        x1 = hc + bb / 2! + .023 * gf * aa                'labeling ds
                        y1 = vc + a / 2!
                        CALL SHOWSIZE2("ds", gf * aa, x1, y1, x1, y1 - ds, "vb")
                ELSE
                        LPRINT TAB(15); "ds="; USING "##.###"; ds; : LPRINT " in < d =";
                                                                    USING "##.###"; c;
                        LPRINT " in   Stiffeners are not fully effective"
                END IF

        ELSE
                IF grap% = 1 THEN
                        COLOR 7
                        LOCATE 18, 52
                        PRINT "Lips are fully eff."
                        LOCATE 19, 52
                        PRINT "ds = d ="; USING "##.###"; c; : PRINT " in"
                ELSE
                        LPRINT TAB(15); "ds = d ="; USING "##.###"; c;
                        LPRINT " in   Stiffeners are fully effective"
                END IF
        END IF

        IF grap% = 1 THEN
                COLOR 11
                x1 = hc + bb / 2! + .08 * gf * aa                         'labeling d on upper lip
                y1 = vc + a / 2!
                CALL SHOWSIZE2("d", gf * aa, x1, y1, x1, y1 - c, "vb")
        END IF
END IF
```

```
'-------------Computing the web
'===========================


IF grap% = 0 THEN
        LPRINT
        LPRINT TAB(10); "Effective width of web"
        LPRINT
END IF

CALL COMPeffwidth(a, t, 4!, FFn, grap%, la, ae)  'ae effective width of web

'----------writing message about effectiveness of web on screen---

IF ae < a THEN

        IF grap% = 1 THEN
                COLOR 7
                LOCATE 21, 52
                PRINT "Web is not fully eff."
                LOCATE 22, 52
                PRINT "ae="; USING "##.###"; ae; : PRINT " in < ";
                PRINT "a="; USING "##.###"; a; : PRINT " in"

                '-----------showing uneffective portion of web-----
                COLOR 10
                LINE (xwcl - t / 2!, vc + a / 2! - ae / 2!)-STEP(t, 0)
                LINE (xwcl - t / 2!, vc - a / 2! + ae / 2!)-STEP(t, 0)
                PAINT (xwcl, vc)

                COLOR 11
                x1 = xwcl - t / 2! + .04 * gf * aa                          'labeling ae/2. upper
                y1 = vc + a / 2!
                CALL SHOWSIZE("ae/2", gf * aa, x1, y1, x1, y1 - ae / 2!, "v")
                y1 = vc - a / 2! + ae / 2!                                  'labeling ae/2. lower
                CALL SHOWSIZE("ae/2", gf * aa, x1, y1, x1, y1 - ae / 2!, "v")
        ELSE
                PRINT TAB(15); "ae="; USING "##.###"; ae; : LPRINT " in < a ="; USING "##.###"; a;
                LRINT " in   Web is not fully effective"
        END IF
```

```
ELSE

        IF grap% = 1 THEN
                COLOR 7
                LOCATE 21, 52
                PRINT "Web is fully eff."
                LOCATE 22, 52
                PRINT "ae = a ="; USING "##.###"; a; : PRINT " in"
        ELSE
                LPRINT TAB(15); "ae = a ="; USING "##.###"; a;
                LPRINT " in  Web is fully effective"
        END IF

END IF

IF grap% = 1 THEN
        COLOR 11
        x1 = xwcl - t / 2! - .03 * gf * aa                                      'labeling a
        y1 = vc + a / 2!
        CALL SHOWSIZE("a", gf * aa, x1, y1, x1, y1 - a, "v")
END IF

'-----------determining Aeff, Pn, & Pa----------

Aeff = Area - (lip% * 2! * (c - ds) + 2! * (b - be) + (a - ae)) * t
Pn = FFn * Aeff
Pa = Pn / 1.92

IF grap% = 1 THEN
        COLOR 7
        LOCATE 24, 52
        PRINT "Ae="; USING "###.###"; Aeff; : PRINT " in2"

        LOCATE 26, 52
        PRINT "Comp. strength of section:"
        LOCATE 27, 52
        PRINT "Pa="; USING "###.###"; Pa; : PRINT " ksi"

        CALL presskey(30, 52)
ELSE
        LPRINT
        LPRINT TAB(10); "Computing effective cross-sectional area and axial strengths"
        LPRINT
        LPRINT TAB(15); "Effective cross-sectional area  Ae ="; USING "###.###"; Aeff; : LPRINT " in2"
        LPRINT TAB(15); "Nominal axial strength          Pn ="; USING "###.###"; Pn; : LPRINT " kip"
        LPRINT TAB(15); "Allowable axial strength        Pa ="; USING "###.###"; Pa; : LPRINT " kip"
END IF

END SUB
```

```
SUB PLOTSECT (aa, bb, cc, rr, t, a, b, c, r, lip%, gf, vc, hc, xwcl)
'*****************************************************************************
'* SUBROUTINE PLOTSECT
'*
'* This routine plots and labels the given cross-section.
'*
'* INPUT VARIABLES:
'* aa     - A' depth of section (in)
'* bb     - B' width of flange (in)
'* cc     - C' length of lip (in)
'* rr     - R  inner radius of corners (in)
'* t      -   thickness (in)
'* a      - flat portion of web (in)
'* b      - flat portion of flange (in)
'* c      - flat portion of lip (in)
'* r      - midplane radius of corners (in)
'* lip%        = 0  if there is no lip
'*             = 1  if there is a lip
'*
'* OUTPUT VARIABLES:
'* gf     - (graphical) factor for defining window
'* vc     - location of vertical centerline of section
'* hc     - location of horizontal centerline of section
'* xwcl  - x coordinate of the centerline of the web
'*
'* LOCAL VARIABLES:
'* pi
'*****************************************************************************
SCREEN 12

IF .725 * aa > bb THEN                          'depth (aa) is the governing size
        gf = 1.5
ELSE                                            'width (bb) is the governing size
        gf = 1.5 * (bb / (.725 * aa))
END IF

'exact square is gain with 3.9 / 3 factor
WINDOW (0!, 0!)-(3.9 / 3! * gf * aa, gf * aa)

pi = 3.14159265#
vc = gf / 2! * aa                               'vertical centerline of section
hc = .6125 * aa * (gf / 1.5)                    'horizontal centerline of section
                                                '62% of the screen is for
                                                'drawing, the rest is for text

IF lip% = 1 THEN                                'web center line
        xwcl = hc - bb / 2! + t / 2!
ELSE                                            'note: for the no lip case b
        xwcl = hc - b / 2! - (bb - b) + t / 2!  'and bb will not be concentric
END IF                                          'anymore,hc will only be at the
                                                'center of b
```

```
'drawing the section with light green
COLOR 10

IF lip% = 1 THEN                                              'starting point at the outer corner of upper lip
        LINE (hc + bb / 2!, vc + aa / 2! - cc)-STEP(0, c)            'outer part of upper lip
        CIRCLE (hc + b / 2!, vc + a / 2), r + t / 2!, , 0, pi / 2!   'outer p. of top right circle
END IF

LINE (hc + b / 2!, vc + aa / 2!)-STEP(-b, 0)                         'outer p. of upper flange
CIRCLE (hc - b / 2!, vc + a / 2), r + t / 2!, , pi / 2!, pi          'outer p. of top left circle
LINE (xwcl - t / 2!, vc + a / 2!)-STEP(0, -a)                        'outer p. of web
CIRCLE (hc - b / 2!, vc - a / 2), r + t / 2!, , pi, 1.5 * pi         'outer p. of bottom left circle
LINE (hc - b / 2!, vc - aa / 2!)-STEP(b, 0)                          'outer p. of lower flange

IF lip% = 1 THEN
        CIRCLE (hc + b / 2!, vc - a / 2), r + t / 2!, , 1.5 * pi, 2! * pi   'outer p. of bottom right circle
        LINE (hc + bb / 2, vc - a / 2!)-STEP(0, c)                   'outer p. of lower lip
        'back to where we started
        LINE (hc + bb / 2!, vc + aa / 2! - cc)-STEP(-t, 0)           'end of upper lip
        LINE -STEP(0, c)                                             'inner p of upper lip
        CIRCLE (hc + b / 2!, vc + a / 2), r - t / 2!, , 0, pi / 2!   'inner p. of top right circle
ELSE
        LINE (hc + b / 2!, vc + aa / 2)-STEP(0, -t)                  'end of upper flange
END IF

LINE (hc + b / 2!, vc + aa / 2! - t)-STEP(-b, 0)                     'inner p. of upper flange
CIRCLE (hc - b / 2!, vc + a / 2), r - t / 2!, , pi / 2!, pi          'inner p. of top left circle
LINE (xwcl + t / 2!, vc + a / 2!)-STEP(0, -a)                        'inner p. of web
CIRCLE (hc - b / 2!, vc - a / 2), r - t / 2!, , pi, 1.5 * pi         'inner p. of bottom left circle
LINE (hc - b / 2!, vc - aa / 2! + t)-STEP(b, 0)                      'inner p. of lower flange

IF lip% = 1 THEN
        CIRCLE (hc + b / 2!, vc - a / 2), r - t / 2!, , 1.5 * pi, 2! * pi   'inner p. of bottom right circle
        LINE (hc + bb / 2 - t, vc - a / 2!)-STEP(0, c)               'inner p. of lower lip
        LINE -STEP(t, 0)                                             'end of lower lip
ELSE
        LINE -STEP(0, -t)                                            'end of lower flange
END IF

END SUB
```

```
SUB SHOWSIZE (label$, u, x1, y1, x2, y2, po$)
'*****************************************************************************
'* SUBROUTINE SHOWSIZE
'*
'* This routine draws a dimension line with arrows on the end and
'* labels it.          |<------->|
'*
'* INPUT VARIABLES:
'* label$  - label to be written on the line
'* u       - heigth of the window
'* x1, y1  - starting point of line (absolute)
'* x2, y2  - ending point of line   (absolute)
'*           point (x1, y1) must be to the left or above point (x2,y2)
'* po$     - indicates position of line:
'*           v vertical,  h horizontal
'* LOCAL VARIABLES:
'* larr    - length of the arrow : u/42.
'* warr    - width of the arrow : larr/2.
'*****************************************************************************

'drawing dimensionline
LINE (x1, y1)-(x2, y2)

'arrow dimensions
larr = u / 42!
warr = larr / 2!

SELECT CASE po$
        CASE "v"                                        'vertical line

                LINE -STEP(-warr / 2!, larr)            'lower arrow
                LINE (x2, y2)-STEP(warr / 2!, larr)
                LINE (x1, y1)-STEP(-warr / 2!, -larr)   'upper arrow
                LINE (x1, y1)-STEP(warr / 2!, -larr)
                LINE (x1 - .015 * u, y1)-STEP(.03 * u, 0!) 'perpendicular lines
                LINE (x1 - .015 * u, y2)-STEP(.03 * u, 0!) 'at the end

                'computing coordinates of LOCATE statement
                ' horizontal:
                '       No of columns:          80  horizontal size of sc. : 3.9 / 3 * u
                '       Label to be printed at : x                           x1 + .022* u
                ' vertical :
                '       No of rows :            30  vertical   size of sc. :     u
                '       Label to be printed at : y                           (y1 + y2) / 2.

                x = CINT((x1 + .022 * u) / (3.9 / 3! * u) * 80!)
                y = CINT((u - (y1 + y2) / 2!) / u * 30!)

                'locate statement:  row, column (y,x) !!!!
```

```
    CASE "h"                                            'horizontal line

        LINE -STEP(-larr, warr / 2!)                    'right arrow
        LINE (x2, y2)-STEP(-larr, -warr / 2!)
        LINE (x1, y1)-STEP(larr, warr / 2!)             'left  arrow
        LINE (x1, y1)-STEP(larr, -warr / 2!)
        LINE (x1, y1 - .015 * u)-STEP(0!, .03 * u)      'perpendicular lines
        LINE (x2, y1 - .015 * u)-STEP(0!, .03 * u)      'at the end

        'computing coordinates of LOCATE statement
        ' horizontal:
        '       No of columns :         80  horizontal size of sc. : 3.9 / 3.* u
        '       Label to be printed at : x                          (x1 + x2) / 2.
        ' vertical  :
        '       No of rows :            30  vertical   size of sc. : u
        '       Label to be printed at : y                          y1

        x = CINT(((x1 + x2) / 2!) / (3.9 / 3! * u) * 80!)
        y = CINT((u - y1) / u * 30!)

END SELECT

LOCATE y, x
PRINT label$

END SUB

SUB SHOWSIZE2 (label$, u, x1, y1, x2, y2, po$)
'***************************************************************************
'* SUBROUTINE SHOWSIZE2
'*
'* This routine draws a dimension line with arrows on the end and
'* labels it.      -->|  |<--
'*
'* INPUT VARIABLES:
'* label$   - label to be written on the line
'* u        - heigth of the window
'* x1, y1   - starting point of line (absolute)
'* x2, y2   - ending point of line   (absolute)
'*             point (x1, y1) must be to the left or above point (x2,y2)
'* po$      - indicates position of line:
'*                  vt:  vertical, label on top
'*                  vb:  vertical, label on bottom
'*                  hr:  horizontal, label on the right
'*                  hl:  horizontal, label on the left
'*
'* LOCAL VARIABLES:
'* larr     - length of the arrow : u/42.
'* warr     - width of the arrow : larr/2.
'***************************************************************************
```

```
'arrow dimensions
larr = u / 42!
warr = larr / 2!

SELECT CASE LEFT$(po$, 1)
        CASE "v"                                                        'vertical line

                LINE (x1, y1)-STEP(-warr / 2!, larr)                    'upper arrow
                LINE (x1, y1)-STEP(warr / 2!, larr)
                LINE (x2, y2)-STEP(-warr / 2!, -larr)                   'lower arrow
                LINE (x2, y2)-STEP(warr / 2!, -larr)
                LINE (x1 - .015 * u, y1)-STEP(.03 * u, 0!)              'perpendicular lines
                LINE (x1 - .015 * u, y2)-STEP(.03 * u, 0!)              'at the end

                ' computing coordinates of the LOCATE statement
                '  horizontal:
                '       No of columns :          80  horizontal size of sc. : 3.9 / 3 * u
                '       Label to be printed at :  x                           x1 + .022 * u

                x = CINT((x1 + .022 * u) / (3.9 / 3! * u) * 80!)

                IF po$ = "vt" THEN                                      'label at upper end

                        'upper portion of dimension line,   length:  3  * arrowlength
                        LINE (x1, y1 + 3! * larr)-(x1, y1)
                        'lower portion of dimension line,   length: 1.5 * arrowlength
                        LINE (x2, y2)-(x2, y2 - 1.5 * larr)

                        '  vertical  :
                        '       No of rows :             30  vertical size of sc. :        u
                        '       Label to be printed at :  y                        y1 + 1.5 * larr

                        y = CINT((u - (y1 + 1.5 * larr)) / u * 30!)

                ELSE                                                    'label at lower end

                        LINE (x1, y1 + 1.5 * larr)-(x1, y1)
                        LINE (x2, y2)-(x2, y2 - 3! * larr)

                        '  vertical  :
                        '       No of rows :             30  vertical size of sc. :        u
                        '       Label to be printed at :  y                        y2 - 1.5 * larr

                        y = CINT((u - (y2 - 1.5 * larr)) / u * 30!)

                END IF
```

```
    CASE "h"                                            'horizontal line

        LINE (x1, y1)-STEP(-larr, warr / 2!)            'left arrow
        LINE (x1, y1)-STEP(-larr, -warr / 2!)
        LINE (x2, y2)-STEP(larr, warr / 2!)             'right arrow
        LINE (x2, y2)-STEP(larr, -warr / 2!)
        LINE (x1, y1 - .015 * u)-STEP(0!, .03 * u)      'perpendicular lines
        LINE (x2, y1 - .015 * u)-STEP(0!, .03 * u)      'at the end

        ' vertical:
        '       No of rows :            30  vertical size of sc. :  u
        '       Label to be printed at : y                          y1

        y = CINT((u - y1) / u * 30!)

        IF po$ = "hr" THEN                              'label at right end

            'right portion of dimension line,    length:  3  * arrowlength
            LINE (x1 - 3! * larr, y1)-(x1, y1)
            'left  portion of dimension line,    length: 1.5 * arrowlength
            LINE (x2, y2)-(x2 + 1.5 * larr, y2)

            ' horizontal:
            '       No of columns :          80  horiz. size of sc. :    3.9 / 3 * u
            '       Label to be printed at :  x                          x1- 1.5 * larr

            x = CINT((x1 - 1.5 * larr) / (3.9 / 3! * u) * 80!)

        ELSE                                            'label at left end

            LINE (x1 - 1.5 * larr, y1)-(x1, y1)
            LINE (x2, y2)-(x2 + 3! * larr, y2)

            ' horizontal:
            '       No of columns:           80  horiz. size of sc. :    3.9 / 3 * u
            '       Label to be printed at :  x                          x2+ 1.5 * larr

            x = CINT((x2 + 1.5 * larr) / (3.9 / 3! * u) * 80!)

    END IF

END SELECT

LOCATE y, x
PRINT label$

END SUB
```

```
SUB CORRECT (a$)
'***********************************************************************
'*  SUBROUTINE: CORRECT
'*
'*  This routine asks you if the data you entered is correct or not.
'*
'*  OUTPUT VARIABLE: A$
'***********************************************************************

PRINT TAB(26); "Is this correct ? (y/n) ";

DO
        a$ = INKEY$
LOOP UNTIL a$ = "y" OR a$ = "Y" OR a$ = "n" OR a$ = "N"

PRINT a$;

END SUB
```

```
SUB presskey (x, y)
'***********************************************************************
'*  SUBROUTINE: PRESSKEY
'*
'*  This routine waits for pressing any key to continue the program,
'*  and writes the message to LOCATE x,y
'***********************************************************************
LOCATE x, y
PRINT "Press any key to continue";

DO
LOOP WHILE INKEY$ = ""

END SUB
```

APPENDIX B

LISTING OF THE MODIFIED PROGRAM FOR COMPUTING AXIAL CAPACITIES WITH SPECIFIED LATERAL LOADS

```
DECLARE SUB COMPsecprop (Fy!, AA!, BB!, CC!, rr!, t!, KL!, lip%, grap%,
                  Area!, A!, b!, c!, r!, u!, xh!, M!, rx!, ry!, ro!, beta!, Jstv!, Cw!, xwcl!)
DECLARE SUB COMPeffwidth (w!, t!, k!, fl, grap%, la!, b!)
DECLARE SUB COMPflange (w!, t!, fl, CC!, c!, dsp!, grap%, be!, C1!, C2!, ds!)
DECLARE SUB COMPweb (Fy!, AA!, t!, A!, b!, c!, r!, u!, be!, ds!, sumLy!, lip%,
                  grap%, B1!, b2!, b3!, le!, ycg!, yu!, yl!, I%)

DECLARE SUB COMPcompcap (Fy!, AA!, BB!, CC!, t!, KL!, Area!, A!, b!, c!, r!, u!,
                  rx!, ry!, ro!, beta!, Jstv!, Cw!, be!, C1!, C2!, ds!, gfl, vc!, hc!, lip%, xwcl!, grap%, Pa!)
DECLARE SUB COMPcompcap2 (Fy!, AA!, BB!, CC!, t!, KL!, Area!, A!, b!, c!, r!, u!,
                  rx!, ry!, ro!, beta!, Jstv!, Cw!, be!, C1!, C2!, ds!, gfl, vc!, hc!, lip%, xwcl!, grap%, Pa!)

DECLARE SUB SECORDSOLV (AA!, BB!, CC!, x1!, x2!)
'**************************************************************************
'*
'*    Program for computing the flexural, shear and axial capacity
'*    of a C section based on the Allowable Stress Design
'*
'*    This modified version computes the max axial load for a
'*    given lateral load based on sect C5 of the Spec.
'*
'*    The bending moment Mx is computed from
'*      w (psf)    lateral load (eg. wind load)
'*      s (in)     spacing of the studs and
'*      KL(in)     height of the wall (length of studs)
'*
'*                    Kl [in]^2     s [in] * w [psf]
'*      Mx [k-in] = ----------- --------------------
'*                        8          1000 * 12^2
'*
'*    (Mx is to be recomputed for each case, ie in the innermost loop)
'*
'*    The Ma and Ix values are not computed from the section properties
'*    but taken from the performance section tables
'*    (varies for each section)
'*
'*    Mao = Ma for this case since flex.-tors. buckling is prevented
'*
'*    The Pa value is gain from a modified version of subroutine
'*    COMPcompcap
'*      -the sections are braced by the sheathing material
'*       therefore the torsional-flexural buckling mode is not
'*       considered
'*      -the studs are subject to strong axis bending
'*       therefore ry is replaced by rx in the first equation
'*    Pao is computed with the above mentioned modified COMPcompcap
'*    routine except that Fn is used instead of Fy
'*    Pcr :  eq C5-5
'*    (Pa, Pao and Pcr are function of the section and the height,
'*    must be recomputed in the second loop)
```

```
'*      Cm = 1    since joint translation is prevented, and
'*              the ends are unrestrained
'*
'*      Since alfa is a fuction of P, solving eq. C5-1 for P leads to
'*      a second order equation where the smaller root is P
'*      For the 8*9 studs this was usually the governing case as opposed
'*      to eq. C5-2 (in fact this was always the governing case for
'*      those cases I checked)
'*      If P/Pa <= .15 (or Mx/Ma > .85 i.e. the axial force is small
'*      then eq.C5-3 is used which gives larger values for P then the
'*      other two equations.
'******************************************************************************
grap% = 1

lip% = 1

SCREEN 0
CLS

Fy = 33
w = 35

LPRINT "lateral load : w="; w; "psf"

AA = 9.25
sect$(1) = "9.250S01": BB(1) = 1.25: CC(1) = .4: t(1) = .03: rr(1) = 2! * t(1)
sect$(2) = "9.250S02": BB(2) = 1.3: CC(2) = .4: t(2) = .036: rr(2) = 2! * t(2)
sect$(3) = "9.250S03": BB(3) = 1.375: CC(3) = .4: t(3) = .048: rr(3) = 2! * t(3)
sect$(4) = "9.250S04": BB(4) = 1.5: CC(4) = .4: t(4) = .06: rr(4) = 2! * t(4)
sect$(5) = "9.250S05": BB(5) = 1.625: CC(5) = .4: t(5) = .075: rr(5) = 2! * t(5)
sect$(6) = "9.250S06": BB(6) = 1.625: CC(6) = .5: t(6) = .105: rr(6) = 2! * t(6)
sect$(7) = "9.250S07": BB(7) = 1.625: CC(7) = .6: t(7) = .135: rr(7) = 2! * t(7)
sect$(8) = "9.250S08": BB(8) = 1.625: CC(8) = .7: t(8) = .1644: rr(8) = 2! * t(8)
sect$(9) = "9.250S09": BB(9) = 1.625: CC(9) = .8: t(9) = .1943: rr(9) = 2! * t(9)

Ma(1) = 0: Ix(1) = 0
Ma(2) = 16.4: Ix(2) = 3.8
Ma(3) = 25!: Ix(3) = 5.3
Ma(4) = 34.95: Ix(4) = 7.19
Ma(5) = 46.26: Ix(5) = 9.471
Ma(6) = 58.91: Ix(6) = 12.143
Ma(7) = 72.92: Ix(7) = 15.205
Ma(8) = 88.29: Ix(8) = 18.657
Ma(9) = 105!: Ix(9) = 22.5

s(1) = 12: s(2) = 16: s(3) = 24                    'spacings [in]
pi = 3.1415927#
```

```
FOR kk% = 2 TO 9                              'section loop

    LPRINT
    LPRINT sect$(kk%); "  Ma="; Ma(kk%); "kip-inch  Ix="; Ix(kk%); "in4"
    LPRINT

    'printing header

    LPRINT TAB(36); "s= 12""; TAB(56); "16""; TAB(72); "24""
    LPRINT "  H"; TAB(12); "Pa"; TAB(20); "Pao"; TAB(28); "Pcr";
    LPRINT TAB(36); "Mx"; TAB(44); "P";
    LPRINT TAB(52); "Mx"; TAB(60); "P";
    LPRINT TAB(68); "Mx"; TAB(76); "P"
    LPRINT "  [ft]"; TAB(11); "[kip]"; TAB(19); "[kip]"; TAB(27); "[kip]";
    LPRINT TAB(35); "[k-i]"; TAB(42); "[kip]";
    LPRINT TAB(51); "[k-i]"; TAB(58); "[kip]";
    LPRINT TAB(67); "[k-i]"; TAB(74); "[kip]"

    CALL COMPsecprop(Fy, AA, BB(kk%), CC(kk%), rr(kk%), t(kk%), KL, lip%, grap%,
                Area, A, b, c, r, u, xh, M, rx, ry, ro, beta, Jstv, Cw, xwcl)

    FOR II% = 1 TO 7                          'height routine, height varies with an increment of
                                              '2 ft from 8' to 20'

        KL = (6! + 2! * II%) * 12             '[in]

        CALL COMPcompcap(Fy, AA, BB(kk%), CC(kk%), t(kk%), KL, Area, A, b, c, r, u,
                rx, ry, ro, beta, Jstv, Cw, be, C1, C2, ds, gf, vc, hc, lip%, xwcl, 1, Pa)
        CALL COMPcompcap2(Fy, AA, BB(kk%), CC(kk%), t(kk%), KL, Area, A, b, c, r, u,
                rx, ry, ro, beta, Jstv, Cw, be, C1, C2, ds, gf, vc, hc, lip%, xwcl, 1, Pao)

        Pcr = (pi ^ 2 * 29500! * Ix(kk%)) / KL ^ 2
        LPRINT USING "###.##"; KL / 12;
        LPRINT TAB(10); USING "###.##"; Pa;
        LPRINT TAB(18); USING "###.##"; Pao;
        LPRINT TAB(26); USING "###.##"; Pcr;
```

```
            FOR JJ% = 1 TO 3                    'spacing loop

                    Mx = KL ^ 2! / 8! * s * w / (1000! * 12! ^ 2)

                    IF Mx / Ma(kk%) >= .85 THEN

                            P = (1 - Mx / Ma(kk%)) * Pa                     'Eq. C5-3

                    ELSE

                            A1 = -1.92 * Ma(kk%) / Pcr                      'Eq. C5-1
                            B1 = (1 + 1.92 * Pa / Pcr) * Ma(kk%)
                            C1 = Pa * (Mx - Ma(kk%))

                            CALL SECORDSOLV(A1, B1, C1, x1, x2) 'Eg. C5-2

                            P = x1

                            P2 = (1 - Mx / Ma(kk%)) * Pao

                            IF P2 < P THEN P = P2

                    END IF

                    LPRINT TAB(18 + JJ% * 16); USING "###.##"; Mx;
                    LPRINT TAB(25 + JJ% * 16); USING "###.##"; P;

            NEXT JJ%

            LPRINT

    NEXT II%

    IF kk% = 5 THEN
            LPRINT CHR$(12)
            LPRINT "lateral load : w="; w; "psf"
    END IF

NEXT kk%

LPRINT CHR$(12)

END
```

```
SUB COMPcompcap (Fy, AA, BB, CC, t, KL, Area, A, b, c, r, u,
                    rx, ry, ro, beta, Jstv, Cw, be, C1, C2, ds, gf, vc, hc, lip%, xwcl, grap%, Pa)

'----------------computing Fe--------------

Fe = pi ^ 2! * E / (KL / rx) ^ 2!                'strong axis buckling

'for this modified vers. the wall studs are braced against
'weak axis and flexural-torsional buckling
.
.
.
.
.
CALL COMPeffwidth(A, t, 4!, FFn, grap%, la, ae)   'ae effective width of web
.
.
.
.
.
END SUB



SUB COMPcompcap2 (Fy, AA, BB, CC, t, KL, Area, A, b, c, r, u,
                    rx, ry, ro, beta, Jstv, Cw, be, C1, C2, ds, gf, vc, hc, lip%, xwcl, grap%, Pa)

'this routine is the same as COMPcompcap exept that it calculates Pao
'i.e.  uses Fy instead of FFn when computing the effective area (Ae) of
'the section.  Since Fy > Fn the Ae value computed this way will be less than
'the usual one, and as a result of that the corresponding P value (Pao) too
.
.
.
.
.
CALL COMPeffwidth(A, t, 4!, Fy, grap%, la, ae)     'ae effective width of web
.
.
.
.
.
END SUB
```

VITA

Zsolt V. Némedi was born in Budapest, Hungary on April 1, 1968. After receiving his Civil Engineering Degree from the Technical University of Budapest in 1991, he worked as a Structural Engineer in Austria. He enrolled in the graduate program at Virginia Polytechnic Institute and State University in January, 1992.

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