American code ANSI/AISC 360-10
June 22, 2010
INTRODUCTION

This verification manual contains numerical examples for elements of steel structures prepared and originally calculated by Autodesk Robot Structural Analysis Professional version 2015.

All examples have been taken from AISC Design Examples version 14.1, handbooks that include benchmark tests covering fundamental types of behaviour encountered in structural analysis. Benchmark results (signed as "Handbook") are recalled, and compared with results of Robot (signed further as "Robot").

Each problem contains the following parts:
- title of the problem
- specification of the problem
- Robot solution of the problem
- outputs with calculation results and calculation notes
- comparison between Robot results and exact solution
- conclusions
GENERAL REMARKS

If you make first step in Robot program you should select preferences corresponding to your example using “Preferences…” or “Job Preferences…” (click Tools).

A. Preferences

To specify your regional preferences click Tools / [Preferences...] and in default opened Preferences dialog box select in combo boxes a needed country (region) and working/printout language.

B. Job Preferences

To specify your job preferences click Tools / [Job Preferences...] and in default opened Job Preferences dialog box select preferences corresponding to your example at the option of the left list and appropriate combo boxes. Below a screenshot shown for the selection [Design codes]:
You can create a new Job Preferences with arbitrarily chosen options (standards, materials, databases, load codes etc.) under a new name to make it easier for future work, e.g., under the name LRFD or ASD for verification both ASD and LRFD requirements, respectively. In that case, first of all, make selection of all documents and parameters appropriate for USA condition choosing “United States” from regional setting in [Preferences…] dialog box. Than from [Job Preferences…] dialog box which looks like:

![Job Preferences dialog box](image)

Click Loads tab from the left list view and choose proper load codes from combo box or from [Configuration of Code List] dialog box which is opened after pressing [More codes…] button.
Pick *Load combinations* from *Codes* combo box. The new list view appears:

Set ASD ASCE 7-10 and LRFD ASCE 7-10 on the right list of the box using arrows than set LRFD ASCE 7-10 code as the *current* code.

Press OK.

After the job preferences decisions are set, type a new name in combo box, e.g. “LRFD _2010” and save it pressing *Save Job Preferences* icon placed on the top of *[Job Preferences]* dialog box. It opens *Save Job Preferences* dialog box.
After saving the new name appears in [Job Preferences...] upper combo-box. Press OK button. Do the same for ASD ASCE 7-10 code combination naming it “ASD_2010”.

You can check load combination regulations by pressing right button next to Code combinations combo-box in Loads tab [Job Preference] dialog box. It opens proper [Editor of code combination regulation] dialog box.
C. Calculation method

American code ANSI /AISC 360-10 gives two verification options: LRFD and ASD. In Robot program you always have to manually adjust:

1. calculation method,
2. load code combination → appropriate for calculation method

ad.1 calculation method

Calculation method (LRFD or ASD) can be chosen on Steel /Aluminum Design layout. Press the Configuration button in [Calculations] dialog box.

Here you can choose only calculation method, NOT load combination which is selected in [Job Preferences].

ad.2a load code combinations – basic approach

To select load code combination (LRFD or ASD) appropriate for calculation method, click Menu / Tools / Job Preferences. [Job Preferences] dialog box opens. Now, you can proceed either of two ways as was described in Chapter B:

- 1st way – expand Design codes, click on Loads tab from the left list view and choose proper load codes from combo box or from [Configuration of Code List] dialog box which is opened after pressing [More codes…] button

- 2nd way -- select earlier prepared job preferences by clicking its name from combo-box. In following dialog box "LRFD_2010" named job preferences is chosen from among several other possibilities previously defined.
By pressing OK button you accept chosen job preferences for a current task.

ad.2b  load code combinations  -  alternative (tricky-easy) approach

Start in Loads layout. Here, you can prepare load combination for both calculation method for further using (for member verification). Create manually LRFD load combinations and ASD load combinations in [Load Types] dialog box.

In this case, you can choose for LRFD and ASD verification respectively prepared load combinations corresponding to calculation method.
VERIFICATION PROBLEM 1
design of members for compression

Example taken from AISC Steel Construction Manual v14.0
AISC Design Examples
File: MAN_ex_E1d.rtd

TITLE:
Example E.1d – W-Shape Available Strength Calculation

SPECIFICATION:
Select an ASTM A992 (Fy = 50 ksi) W14x90 bar to carry an axial dead load of 140 kips and live load of 420 kips. Assume the design member is 30 feet long, is pinned top and bottom in both axes and is laterally braced about the z-z axis at the midpoint.
Verify the strength of a defined compression member.
You can choose ASD or LFRD calculation method.

SOLUTION:
You must remember to specify appropriate (LRSD or ASD) load code combination in JOB PREFERENCES dialog box (click Menu/Tools/Job Preferences) for considered verification method in a current task or define it manually.

In DEFINITIONS dialog box define a new type of member, laterally braced about the z-z axis at the midpoint. It can be set in Member type combo-box.
Pre-defined type of member “simple bar” may be initially opened.
For a chosen member type (here “simple bar”), press the Parameters button on Members tab, which opens MEMBER DEFINITION–PARAMETERS dialog box.

Type a new name in the Member type editable field. Change parameters to meet initial data requirements of the structure. In this particular compression case define buckling z-z parameters. Press Buckling length coefficient Z icon which opens BUCKLING DIAGRAMS dialog box.

Click second to last icon.

The new dialog box INTERNAL BRACING will appear with active Buckling Z tab.
In **Buckling Z** tab define internal support in the middle of the member by typing relative value 0.5 for marked *Define manually coordinates of the existing bracings* field.

Press OK.

Save the newly-created member type, e.g. “test”: 
Number of the member must be assigned to appropriate name of Member type.

( It is very important when you verify different member types.)

In the CALCULATIONS dialog box set for this task:

- **Verification option** → Member Verification
- **Loads cases** → for LRFD design (defined as n° 3)
- **Limit state** → only Ultimate Limit state will be analyzed so switch off Limit stat Serviceability.
- **Calculation method** → switch on LRFD radio button in CONFIGURATION box, opened by [Configuration] button.

Now, start calculations by pressing Calculations button.

MEMBER VERIFICATION dialog box with most significant results data will appear on screen.
Pressing the line with results for the member 1 opens the RESULTS dialog box with detailed results for the analyzed member. The view of the RESULTS windows are presented below.

**Simplified results tab**

![Simplified results tab](image)

**Detailed results tab**

![Detailed results tab](image)

Pressing the `[Calc.Note]` button in “RESULTS –Code” dialog box opens the printout note for the analyzed member. You can obtain *Simplified results printout* or *Detailed results printout*. It depends on which tab is active.
The printout note view of Simplified results is presented below.

**RESULTS for LRFD method:**

a) In the first calculation step W14x90 section was considered. The results are presented below.

---

<table>
<thead>
<tr>
<th>SECTION PARAMETERS: W14x90</th>
</tr>
</thead>
<tbody>
<tr>
<td>d=14.00 in</td>
</tr>
<tr>
<td>bf=14.50 in</td>
</tr>
<tr>
<td>tw=0.44 in</td>
</tr>
<tr>
<td>tf=0.71 in</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>MEMBER PARAMETERS:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ly = 30.00 ft</td>
</tr>
<tr>
<td>Ky = 1.00</td>
</tr>
<tr>
<td>KL/ry = 38.63</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>INTERNAL FORCES:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pr = 810.00 kip</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>DESIGN STRENGTHS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fic*Pn = 927.45 kip</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>SAFETY FACTORS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fic = 0.90</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>SECTION ELEMENTS:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flange = Nonslender</td>
</tr>
<tr>
<td>Web = Nonslender</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>VERIFICATION FORMULAS:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pr/(Fic*Pn)=0.91 &lt; 1.00 LRFD (H1.1a) Verified</td>
</tr>
<tr>
<td>Ky<em>Ly/ry = 58.63 &lt; (K</em>L/z)max = 200.00</td>
</tr>
<tr>
<td>Kz<em>L/z = 48.70 &lt; (K</em>L/r)max = 200.00</td>
</tr>
</tbody>
</table>

*Section OK !!!*
b) From economical reason try to check a lighter W section.

Being still in RESULTS- CODE dialog box, type W 12x87 in the editable field below drawing of a section and press ENTER. Calculations (and results) are refreshed instantly.

The results (Calcul.Note) for the new selected section are presented below.
RESULTS for ASD method (selecting in CONFIGURATION dialog box):

A section W14x90 was considered. The results are presented below.

Simplified results tab

![Simplified results tab](image1)

Detailed results tab

![Detailed results tab](image2)
The printout note view of Simplified results for ASD is presented below.

---

**STEEL DESIGN**

**CODE:** ANSI/AISC 360-10 An American National Standard, June 22, 2010

**ANALYSIS TYPE:** Member Verification

**CODE GROUP:**

**MEMBER:** 1

**POINT:** 1

**COORDINATE:** x = 0.00 L = 0.00 ft

**LOADS:**

*Governing Load Case:* 4 KOMB_ASD (1-2)*1.00

**MATERIAL:**

STEEL A992-50  
Fy = 50.00 ksi  
Fu = 65.00 ksi  
E = 29000.00 ksi

**SECTION PARAMETERS:** W 14x90

<table>
<thead>
<tr>
<th>d</th>
<th>A</th>
<th>Ax</th>
<th>A</th>
</tr>
</thead>
<tbody>
<tr>
<td>14.00 in</td>
<td>20.590 in²</td>
<td>6.160 in²</td>
<td>26.500 in²</td>
</tr>
<tr>
<td>14.50 in</td>
<td>999.000 in⁴</td>
<td>362.000 in⁴</td>
<td>4.060 in⁴</td>
</tr>
<tr>
<td>0.44 in</td>
<td>142.714 in³</td>
<td>49.931 in³</td>
<td></td>
</tr>
<tr>
<td>0.71 in</td>
<td>157.000 in³</td>
<td>75.600 in³</td>
<td></td>
</tr>
</tbody>
</table>

**MEMBER PARAMETERS:**

<table>
<thead>
<tr>
<th>Ly</th>
<th>Lz</th>
</tr>
</thead>
<tbody>
<tr>
<td>30.00 ft</td>
<td>15.00 ft</td>
</tr>
<tr>
<td>Ky</td>
<td>Kz</td>
</tr>
<tr>
<td>1.00</td>
<td>1.00</td>
</tr>
<tr>
<td>KLz/ry = 58.63</td>
<td>KLz/rz = 48.70</td>
</tr>
</tbody>
</table>

**INTERNAL FORCES:**

Pr = 560.00 kip

**ALLOWABLE STRENGTHS**

Pn/Omc = 617.07 kip

**RESISTANCE FACTORS**

Omc = 1.67

**SECTION ELEMENTS:**

Flange = Nonslender  
Web = Nonslender

**VERIFICATION FORMULAS:**

Pr/(Pn/Omc) = 0.91 < 1.00  
ASD (H1-1a) Verified

Ky*Ly/ry = 58.63 < (K*L/r)max = 200.00  
Kz*Lz/rz = 48.70 < (K*L/r)max = 200.00  
STABLE

*Section OK !!!*
COMPARISON:

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>$F_{cr}$ – Critical flexural buckling stress</td>
<td>38,89</td>
<td>38,9</td>
</tr>
<tr>
<td>$P_n$ - Nominal compressive strength</td>
<td>1030,5</td>
<td>1030</td>
</tr>
</tbody>
</table>

For W14x90, LRFD $Fic=0.90$
1. $P_r$ - Required compressive strength | 840,0 | 840 |
2. $Fic*P_n$ - Design compressive strength | 927,45 | 927 |
$P_r < (Fic*P_n)$ | 840 < 927,5 | 840 < 927 |

For W14x90, ASD $Omc=1.67$
1. $P_r$ - Required compressive strength | 560,0 | 560 |
2. $P_n/Omc$ - Allowable compressive strength | 617,1 | 617 |
$P_r < (P_n/Omc))$ | 560 < 617,1 | 560 < 617 |

CONCLUSIONS:

Calculations compatibility are good.

The small differences are caused by different accuracy of parameters in calculations.
VERIFICATION PROBLEM 2
Lateral-torsional buckling of beams

Example taken from AISC Steel Construction Manual v.14.0
AISC Design Examples
File: MAN_EX_F1_3B.rtd

TITLE:
Example F.1-3b -- W-Shape Flexural Member Design in Strong-Axis Bending, Braced at Midspan

SPECIFICATION:
Verify the strength of the ASTM A992 W18×50 beam with a simple span of 35 feet. The beam is braced at the ends and center point. The nominal loads are a uniform dead load of 0.45 kip/ft and a uniform live load of 0.75 kip/ft. You can choose ASD or LFRD calculation method.

SOLUTION:
You must remember to specify appropriate (LRSD or ASD) load code combination in JOB PREFERENCES dialog box (click Menu/Tools/Job Preferences) for considered verification method in a current task or define it manually.

In DEFINITIONS dialog box define a new type of member, laterally braced upper flange about the z-z axis and torsional braced at the midpoint. It can be set in Member type combo-box. Pre-defined type of member “simple bar” may be initially opened.
For chosen member type, press the Parameters button on Members tab. It opens MEMBER DEFINITION – PARAMETERS dialog box.

Type a new name in the Member type editable field. Then, change parameters to meet initial data requirements of the structure. In this particular bending case set the following lateral-buckling parameters:

- switch on Flexural-torsional buckling;
- switch on Lateral buckling
- define appropriate value of parameter Cb by manually entering in editable field or pressing Cb icon which opens PARAMETER Cb dialog box:

For this task the second icon Cb=f(Mi) was selected.

- define bracings for Lateral buckling and Buckling Z.

To define Lateral buckling length coefficient for this structure, press Upper flange button. It opens LATERAL BUCKLING LENGTH COEFFICIENTS dialog box.
Click the last icon *Intermediate bracings*. The new dialog box *INTERNAL BRACINGS* will appear with automatically active *Lateral buckling - Upper flange* tab. 
In *INTERNAL BRACINGS* dialog box there are possibilities of defining independent bracings for buckling and lateral buckling of the marked *member type*. 
In *Lateral buckling-upper flange* tab define internal support in the middle of the member by typing relative value 0.5 for marked *Define manually coordinates of the existing bracings* field.

Press OK.
Save the newly-created member type, e.g. as “LB 0.5l up”

Number of the member must be assigned to the appropriate name of Member type.

( It is very important when you verify different member types.)
In the CALCULATIONS dialog box set for this task:

- **Verification option** → Member Verification
- **Loads cases** → for LRFD design (defined as n° 3)
- **Limit state** → only Ultimate Limit state will be analyzed so switch off **Limit stat Serviceability**.
- **Calculation method** → switch on LRFD radio button in CONFIGURATION dialog box, opened by [Configuration] button.

Now, start verifications by pressing [Calculations] button.

MEMBER VERIFICATION dialog box with most significant results data will appear on screen.
Pressing the line with general results for the member 1 opens the RESULTS dialog box with detailed results for the analyzed member. The view of the RESULTS windows are presented below.

**Simplified results tab**

![Simplified results tab](image)

**Detailed results tab**

![Detailed results tab](image)

Pressing the [Calc.Note] button in “RESULTS — Code” dialog box opens the printout note for the analyzed member. You can obtain Simplified results printout or Detailed results printout. It depends on which tab is active.
The printout note view of *Simplified results* is presented below.

**RESULTS for LRFD method:**

---

**STEEL DESIGN**

---

**CODE:** ANSI/AISC 360-10 An American National Standard, June 22, 2010

**ANALYSIS TYPE:** Member Verification

---

**CODE GROUP:**

**MEMBER:** beam_1  
**POINT:** 2  
**COORDINATE:** x = 0.50 L = 17.50 ft

---

**LOADS:**

*Governing Load Case:* 3 KOMB_LRFD 1*1.200+2*1.600

---

**MATERIAL:**

STEEL A992-50  
Fy = 50.00 ksi  
Fu = 65.00 ksi  
E = 290000.00 ksi

---

**SECTION PARAMETERS: W18X50**

<table>
<thead>
<tr>
<th>d</th>
<th>AY</th>
<th>AZ</th>
<th>Ax</th>
<th>Ay</th>
<th>Iy</th>
<th>IZ</th>
<th>J</th>
</tr>
</thead>
<tbody>
<tr>
<td>17.99 in</td>
<td>8.544 in²</td>
<td>6.386 in²</td>
<td>14.700 in²</td>
<td>800.000 in⁴</td>
<td>40.100 in⁴</td>
<td>1.240 in⁴</td>
<td></td>
</tr>
</tbody>
</table>

---

**MEMBER PARAMETERS:**

<table>
<thead>
<tr>
<th>Ly</th>
<th>Lz</th>
<th>Cb</th>
</tr>
</thead>
<tbody>
<tr>
<td>35.00 ft</td>
<td>35.00 ft</td>
<td>17.50 ft</td>
</tr>
</tbody>
</table>

---

**INTERNAL FORCES:**

Mr = 266.44 kip*ft  
Mr = 287.97 kip*ft

---

**SAFETY FACTORS**

Fib = 0.900

---

**SECTION ELEMENTS:**

Plange = Compact  
Web = Compact

---

**VERIFICATION FORMULAS:**

Mr/(Fib*Mry) = 0.925 < 1.000 LRFD (H1-1b) Verified

---

*Section OK !!!*
RESULTS for ASD method:

Simplified results tab

Detailed results tab
Pressing the [Calc.Note] button in “RESULTS – Code” dialog box opens the printout note for the analyzed member. You can obtain Simplified results printout or Detailed results printout. It depends on which tab is active.

The printout note view of Simplified results for ASD is presented below.

---

STEEL DESIGN

ANALYSIS TYPE: Member Verification

CODE GROUP:
MEMBER: 1 beam_1
POINT: 2
COORDINATE: x = 0.50 L = 17.50 ft

LOADS:
Governing Load Case: 4 KOMB_ASD (1+2)*1.000

MATERIAL:
STEEL A992-50  Fy = 50.00 ksi  Fu = 65.00 ksi  E = 29000.00 ksi

SECTION PARAMETERS: W18x50
\( c = 17.99 \) in  \( A_1 = 8.544 \) in\(^2\)  \( A_z = 6.386 \) in\(^2\)  \( A_x = 14.700 \) in\(^2\)
\( t_f = 7.50 \) in  \( I_y = 800.000 \) in\(^4\)  \( I_z = 40.100 \) in\(^4\)  \( J = 1.240 \) in\(^4\)
\( t_w = 0.35 \) in  \( S_y = 88.938 \) in\(^3\)  \( S_z = 10.700 \) in\(^3\)  
\( t_l = 0.57 \) in  \( Z_y = 101.000 \) in\(^3\)  \( Z_z = 17.000 \) in\(^3\)

MEMBER PARAMETERS:

\( L_y = 35.00 \) ft  \( L_z = 35.00 \) ft  \( L_b = 17.50 \) ft
\( K_{ly} = 1.000 \)  \( K_z = 1.000 \)  \( C_b = 1.299 \)

INTERNAL FORCES:
\( M_{ry} = 183.75 \) kip*ft

ALLOWABLE STRENGTHS:
\( M_{ry}/O_{mb} = 191.60 \) kip*ft

RESISTANCE FACTORS
\( O_{mb} = 1.670 \)

SECTION ELEMENTS:
Flange = Compact  Web = Compact

VERIFICATION FORMULAS:
\( M_{ry}/(M_{ry}/O_{mb}) = 0.939 < 1.000 \)  ASD (H1-1b) Verified

Section OK !!!
COMPARISON:

<table>
<thead>
<tr>
<th>verifications parameters, interaction expression</th>
<th>Robot</th>
<th>Handbook</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cb - Lateral-torsional buckling modification factor</td>
<td>1,3</td>
<td>1,3</td>
</tr>
<tr>
<td>Lpy - Limiting laterally unbraced length for the limit state of yielding [ ft ]</td>
<td>5,83</td>
<td>5,83</td>
</tr>
<tr>
<td>Lry - Literally unbraced length for the limit state of inelastic lateral- torsional buckling [ ft ]</td>
<td>16,96</td>
<td>17,0</td>
</tr>
<tr>
<td>FcrLtb - Critical stress (lateral-torsional buckling) [ksi]</td>
<td>43,17</td>
<td>43,2</td>
</tr>
<tr>
<td>Mny - Nominal flexural strength [kip*ft]</td>
<td>319,97</td>
<td>320</td>
</tr>
</tbody>
</table>

**LRFD**, Fib=0.90
1. Mry - Required flexural strength [kip*ft] | 266,44 | 266
2. Fib* Mny - Design compressive strength [kip*ft] | 287,97 | 288

Mry < (Fib* Mny) | 266,44< 287,97 | 266< 288

**ASD**, Omc =1.67
1. Mry - Required flexural strength [kip*ft] | 183,75 | 184
2. Mny /Omc - Allowable flexural strength [kip*ft] | 191,6  | 192

Mry < (Mny /Omc)) | 183,75< 191,60 | 184<192

CONCLUSIONS:

Consistency of results.
The small differences are caused by different accuracy of parameters in calculations.
VERIFICATION PROBLEM 3
combined compression and bending about both axes

Example taken from AISC Steel Construction Manual v14.0
AISC Design Examples
File: MAN_ex_H1b.rtd

TITLE:
Example H.1 b -- W-shape Subjected to Combined Compression and Bending About Both Axes (braced frame).

SPECIFICATION:
Verify if an ASTM A992 W14×99 has sufficient available strength to support the axial forces and moments listed below, obtained from a second order analysis that includes second-order effects. The unbraced length is 14 ft and the member has pinned ends. \( KL_x = KL_y = L_b = 14.0 \) ft

<table>
<thead>
<tr>
<th>LRFD</th>
<th>ASD</th>
</tr>
</thead>
<tbody>
<tr>
<td>( Pu = 400 ) kips</td>
<td>( Pa = 267 ) kips</td>
</tr>
<tr>
<td>( Mux = 250 ) kip-ft</td>
<td>( Max = 167 ) kip-ft</td>
</tr>
<tr>
<td>( Muy = 80.0 ) kip-ft</td>
<td>( May = 53.3 ) kip-ft</td>
</tr>
</tbody>
</table>

Material Properties:
ASTM A992 \( F_y = 50 \) ksi \( F_u = 65 \) ksi

SOLUTION:
You must remember to specify appropriate (LRSD or ASD) load code combination in JOB PREFERENCES dialog box (click Menu/Tools/Job Preferences) for considered verification method in a current task or define it manually.

In DEFINITIONS dialog box define a new type of member. It can be set in Member type combo-box. Pre-defined type of member "simple bar" may be initially opened.
For chosen member type click the [Parameters] button on Members tab. It opens MEMBER DEFINITION–PARAMETERS dialog box.

Type a new name in the Member type editable field. Then change parameters to meet initial data requirements of the structure. For this particular task switch off Flexural-torsional buckling.

Save the newly-created member type under a new name, e.g. “H.1b 1”.

MEMBER DEFINITION–PARAMETERS dialog box defined for this verifications looks like:

In DEFINITIONS dialog box number of the member must be assigned to the appropriate name of Member type.

( It is very important when you verify different member types).

In the CALCULATIONS dialog box set for this task :
Verification option → Member Verification

Loads cases → for LRFD design (defined as n° 1)

Limit state → only Ultimate Limit state will be analyzed, so switch off Limit stat Serviceability.

Calculation method → switch on LRFD radio button in CONFIGURATION dialog box, opened by [Configuration] button.

Now, start verifications by pressing [Calculations] button.

MEMBER VERIFICATION dialog box with most significant results data will appear on screen.

Pressing a line with results for the member opens the RESULTS dialog box with detailed results for the analyzed member. The view of the RESULTS windows are presented below.
Pressing the [Calc.Note] button in “RESULTS –Code” dialog box opens the printout note for the analyzed member. You can obtain Simplified results printout or Detailed results printout. It depends on which tab is active.
The printout note view of *Simplified results* is presented below.

**RESULTS for LRFD method:**

---

### STEEL DESIGN

**CODE:** ANSI/AISC 360-10 An American National Standard, June 22, 2010

**ANALYSIS TYPE:** Member Verification

---

**CODE GROUP:**

**MEMBER:** beam_1  
**POINT:** 3  
**COORDINATE:** x = 1.00 L = 14.00 ft

---

**LOADS:**

*Governing Load Case:* 1 LRFD

---

**MATERIAL:**

STEEL A992-50  
Fy = 50.0 ksi  
Fu = 65.0 ksi  
E = 29000.0 ksi

---

**SECTION PARAMETERS:** W 14x99

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>d</td>
<td>14.200 in</td>
</tr>
<tr>
<td>bf</td>
<td>14.600 in</td>
</tr>
<tr>
<td>tw</td>
<td>0.485 in</td>
</tr>
<tr>
<td>tf</td>
<td>0.780 in</td>
</tr>
<tr>
<td>Ay</td>
<td>22.78 in^2</td>
</tr>
<tr>
<td>Iy</td>
<td>1110.0 in^4</td>
</tr>
<tr>
<td>Sy</td>
<td>156.34 in^2</td>
</tr>
<tr>
<td>Zy</td>
<td>173.90 in^3</td>
</tr>
<tr>
<td>Az</td>
<td>6.89 in^2</td>
</tr>
<tr>
<td>Iz</td>
<td>402.00 in^4</td>
</tr>
<tr>
<td>Sx</td>
<td>55.07 in^3</td>
</tr>
<tr>
<td>Zx</td>
<td>83.60 in^3</td>
</tr>
<tr>
<td>A</td>
<td>29.10 in^2</td>
</tr>
<tr>
<td>J</td>
<td>5.37 in^4</td>
</tr>
</tbody>
</table>

---

**MEMBER PARAMETERS:**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ly</td>
<td>14.00 ft</td>
</tr>
<tr>
<td>Lz</td>
<td>14.00 ft</td>
</tr>
<tr>
<td>Ky</td>
<td>1.000</td>
</tr>
<tr>
<td>Kz</td>
<td>1.000</td>
</tr>
<tr>
<td>Kly/ry</td>
<td>27.202</td>
</tr>
<tr>
<td>KLz/rz</td>
<td>45.200</td>
</tr>
</tbody>
</table>

---

**INTERNAL FORCES:**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>P</td>
<td>400.00 kip</td>
</tr>
<tr>
<td>Mry</td>
<td>-230.0 kip*ft</td>
</tr>
<tr>
<td>Mz</td>
<td>-80.0 kip*ft</td>
</tr>
</tbody>
</table>

**DESIGN STRENGTHS**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vry*</td>
<td>5.1 kip</td>
</tr>
<tr>
<td>Vrz*</td>
<td>-17.9 kip</td>
</tr>
<tr>
<td>Fv*</td>
<td>615.0 kip</td>
</tr>
</tbody>
</table>

---

**SAFETY FACTORS**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fyb</td>
<td>0.900</td>
</tr>
<tr>
<td>Fiv</td>
<td>0.900</td>
</tr>
</tbody>
</table>

---

**SECTION ELEMENTS:**

Flange = Non-compact  
Web = Compact

---

**VERIFICATION FORMULAS:**

- \( P/(Fic*Fm) = 8.9^*(Mry/(Fib*Miny)) + Mz/(Fib*Minz) = 0.928 < 1.000 \) LRFD (H1-1a) Verified
- \( Vry/(Fiv*Vny) = 0.009 < 1.000 \) LRFD (G2-1) Verified
- \( Vrz/(1.000*Vnz) = 0.086 < 1.000 \) LRFD (G2-1) Verified
- \( Ky*Ly/rz = 27.202 < (K*L/r).max = 200.000 \)  
  \( Kz*Lz/rz = 45.200 < (K*L/r).max = 200.000 \)  
  \( \text{STABLE} \)

---

*Section OK !!!*
RESULTS for ASD method:

Simplified results tab

Detailed results tab
Pressing the \([\text{Calc.Note}]\) button in “RESULTS – Code” dialog box opens the printout note for the analyzed member. You can obtain **Simplified results printout** or **Detailed results printout**. It depends on which tab is active. The printout note view of **Simplified results** for ASD is presented below.

---

### STEEL DESIGN

**CODE:** ANSI/ACI 360-10 An American National Standard, June 22, 2010  
**ANALYSIS TYPE:** Member Verification

**CODE GROUP:**  
**MEMBER:** 2 _2  
**POINT:** 3  
**COORDINATE:** \( x = 1.00 \text{ ft}, L = 14.00 \text{ ft} \)

**LOADS:**  
**Governing Load Case:** 2 ASD

**MATERIAL:**  
STEEL A992-50 \( F_y = 50.0 \text{kpsi} \)  \( F_u = 65.0 \text{kpsi} \)  \( E = 29000.0 \text{kpsi} \)

**SECTION PARAMETERS:** \( W \) 14x99

| \( d \) 14.200 in | \( A_y \) 22.78 in
| \( b_f \) 14.600 in | \( I_y \) 1110.00 in
| \( r_w \) 0.485 in | \( S_y \) 156.34 in
| \( t_f \) 0.780 in | \( Z_y \) 173.00 in

**MEMBER PARAMETERS:**  
\( L_y = 14.00 \text{ ft} \)  \( L_z = 14.00 \text{ ft} \)  
\( K_y = 1.000 \)  \( K_z = 1.000 \)  
\( K_{Ly/ry} = 27.202 \)  \( K_{Lz/rz} = 45.200 \)

**INTERNAL FORCES:**  
\( P_r = 257.0 \text{ kip} \)  
\( M_{ry} = -167.0 \text{ kip*ft} \)  \( V_{ry} = 3.8 \text{kip} \)  
\( M_{rz} = -53.3 \text{ kip*ft} \)  \( V_{rz} = 11.9 \text{kip} \)

**ALLOWABLE STRENGTHS:**  
\( P_{r,\text{Omc}} = 750.4 \text{ kip} \)  
\( M_{ry,\text{Omb}} = 429.4 \text{ kip*ft} \)  \( V_{ry,\text{Omv}} = 409.1 \text{kip} \)  
\( M_{rz,\text{Omb}} = 207.0 \text{ kip*ft} \)  \( V_{rz,\text{Omv}} = 137.7 \text{kip} \)

**RESISTANCE FACTORS:**  
\( O_{mb} = 1.670 \)  \( O_{mc} = 1.670 \)  \( O_{mv} = 1.670 \)

**SECTION ELEMENTS:**  
**Flange:** Non-compact  
**Web:** Compact

**VERIFICATION FORMULAS:**  
\( P_r / (P_{r,\text{Omc}}) + 8.9 * (M_{ry} / (M_{ry,\text{Omb}}) + M_{rz} / (M_{rz,\text{Omb}})) < 0.930 < 1.000 \)  
ASD (H1-1a) Verified  
\( V_{ry} / (V_{ry,\text{Omv}}) = 0.009 < 1.000 \)  
ASD (G2-1) Verified  
\( V_{rz} / (V_{rz,\text{Omv}}) = 0.087 < 1.000 \)  
ASD (G2-1) Verified  
\( K_y * L_y / r_y = 27.202 < (K * L / r)_{max} = 200.000 \)  
\( K_z * L_z / r_z = 45.200 < (K * L / r)_{max} = 200.000 \)  
STABLE

*Section OK !!!*
Comparisons:

<table>
<thead>
<tr>
<th>verifications parameters, interaction expression</th>
<th>Robot</th>
<th>Handbook</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>LRFD Fib=0.90</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Required compressive strength [kips]</td>
<td>$P_r$</td>
<td>$400$</td>
</tr>
<tr>
<td>- Design compressive strength [kips]</td>
<td>$Fic*P_n$</td>
<td>$1127.8$</td>
</tr>
<tr>
<td>$Pr &lt; Fic*P_n$</td>
<td>$400&lt; 1127.8$</td>
<td>$400&lt; 1130$</td>
</tr>
<tr>
<td>- Required flexural strength [kip*ft]</td>
<td>$M_{ry}$; $M_{rz}$</td>
<td>$250$; $80$</td>
</tr>
<tr>
<td>- Design compressive strength [kip*ft]</td>
<td>$Fic<em>M_{ny}$; $Fic</em>M_{nz}$</td>
<td>$645.4$; $311.2$</td>
</tr>
<tr>
<td>$M_{ry} &lt; Fib*M_{ny}$</td>
<td>$250 &lt; 645.4$</td>
<td>$250 &lt; 642$</td>
</tr>
<tr>
<td>$M_{rz} &lt; Fib*M_{nz}$</td>
<td>$80 &lt; 311.2$</td>
<td>$80 &lt; 311$</td>
</tr>
<tr>
<td>Interaction expression for $Pr/(Fic*P_n)&gt;0.2$</td>
<td>$0.355$</td>
<td>$0.354$</td>
</tr>
<tr>
<td>$M_{ry}/(Fib*M_{ny})$</td>
<td>$0.387$</td>
<td>$0.389$</td>
</tr>
<tr>
<td>$M_{rz}/(Fib*M_{nz})$</td>
<td>$0.257$</td>
<td>$0.257$</td>
</tr>
<tr>
<td>$Pr/(Fic<em>P_n) + 8/9</em>(M_{ry}/(Fib<em>M_{ny}) + M_{rz}/(Fib</em>M_{nz})) = &lt; 1.0$ (H1-1a)</td>
<td>$0.9275$</td>
<td>$0.9280$</td>
</tr>
<tr>
<td><strong>ASD Omc =1.67</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Required compressive strength [kips]</td>
<td>$P_r$</td>
<td>$267$</td>
</tr>
<tr>
<td>- Design compressive strength [kips]</td>
<td>$Pr/Omc$</td>
<td>$750.4$</td>
</tr>
<tr>
<td>$Pr &lt; Pr/Omc$</td>
<td>$267 &lt; 750.4$</td>
<td>$267 &lt; 750$</td>
</tr>
<tr>
<td>- Required flexural strength [kip*ft]</td>
<td>$M_{ry}$; $M_{rz}$</td>
<td>$167$; $53.3$</td>
</tr>
<tr>
<td>- Design compressive strength [kip*ft]</td>
<td>$M_{ny}/Omc$; $M_{nz}/Omc$</td>
<td>$429.4$; $207.0$</td>
</tr>
<tr>
<td>$M_{ry} &lt; M_{ny}/Omc$</td>
<td>$167 &lt; 429.4$</td>
<td>$167 &lt; 428$</td>
</tr>
<tr>
<td>$M_{rz} &lt; M_{nz}/Omc$</td>
<td>$53.3 &lt; 207.0$</td>
<td>$53.3 &lt; 207$</td>
</tr>
<tr>
<td>Interaction expression for $Pr/(Pr/Omc)&gt;0.2$</td>
<td>$0.356$</td>
<td>$0.356$</td>
</tr>
<tr>
<td>$M_{ry}/(M_{ny}/Omc)$</td>
<td>$0.389$</td>
<td>$0.390$</td>
</tr>
<tr>
<td>$M_{rz}/(M_{nz}/Omc)$</td>
<td>$0.257$</td>
<td>$0.257$</td>
</tr>
<tr>
<td>$Pr/(Fic<em>P_n) + 8/9</em>(M_{ry}/(Fib<em>M_{ny}) + M_{rz}/(Fib</em>M_{nz})) = &lt; 1.0$ (H1-1a)</td>
<td>$0.9306$</td>
<td>$0.9310$</td>
</tr>
</tbody>
</table>

Conclusions:
Agreement of results.
The small differences are caused by different accuracy of parameters in calculations.

General Conclusions
More examples from “AISC Design Examples v. 14.0, Steel Construction Manual” were made using Robot program. In the last column of the following table it was shown the comparison between Robot results and “AISC Design Examples” results.
<table>
<thead>
<tr>
<th>Examples</th>
<th>Description</th>
<th>Section</th>
<th>ok?</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>TENSION</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 MAN_ex_D1.rdt</td>
<td>W-Shape Tension Member - shear lag effect</td>
<td>W 8x21</td>
<td>100</td>
</tr>
<tr>
<td>2 MAN_ex_D2.rdt</td>
<td>Single-Angle Tension Member - shear lag effect</td>
<td>L 4x8x0.5</td>
<td>100</td>
</tr>
<tr>
<td>3 MAN_ex_D3.rdt</td>
<td>WT-Shape Tension Member - shear lag effect</td>
<td>WT 6x20</td>
<td>100</td>
</tr>
<tr>
<td>4 MAN_ex_D4.rdt</td>
<td>Rectangular HSS Tension Member</td>
<td>HSS 6x4x0.375</td>
<td>100</td>
</tr>
<tr>
<td>5 MAN_ex_D5.rdt</td>
<td>Round HSS Tension Member</td>
<td>HSS 6x500</td>
<td>100</td>
</tr>
<tr>
<td>6 MAN_ex_D6.rdt</td>
<td>Double-Angle Tension Member - shear lag effect</td>
<td>2L 4x6x0.5</td>
<td>100</td>
</tr>
<tr>
<td><strong>COMPRESSION</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7 MAN_ex_E1.rdt</td>
<td>W-Shape</td>
<td>W 14x90</td>
<td>100</td>
</tr>
<tr>
<td>8 MAN_ex_E2.rdt</td>
<td>Built-up Column with Slender Web</td>
<td>J 15x8x1x0.25</td>
<td>100</td>
</tr>
<tr>
<td>9 MAN_ex_E3.rdt</td>
<td>Built-up Column with Slender Flanges</td>
<td>110,5x7,25x0,375x0,25</td>
<td>100</td>
</tr>
<tr>
<td>10 MAN_ex_E6.rdt</td>
<td>WT Compression Member without Slender Elements</td>
<td>WT 7x34</td>
<td>100</td>
</tr>
<tr>
<td>11 MAN_ex_E6.rdt</td>
<td>WT Compression Member with Slender Elements + LTB</td>
<td>WT 7x15</td>
<td>100</td>
</tr>
<tr>
<td>12 MAN_ex_E9.rdt</td>
<td>Rect HSS Compression Member without Slender Elements Ky=Kz=0.8</td>
<td>HSFE 12x10x0.375</td>
<td>100</td>
</tr>
<tr>
<td>13 MAN_ex_E11.rdt</td>
<td>Pipe Compression Member Ky=1, Kz=1</td>
<td>Pipe P10</td>
<td>100</td>
</tr>
<tr>
<td>14 MAN_ex_E12.rdt</td>
<td>Built-up I-Shaped Member with Different Flange Sizes Ky=Kz=1, + LTB</td>
<td>I-ASYM 10,5x8x5x3/8x3/4</td>
<td>100</td>
</tr>
<tr>
<td><strong>BENDING</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>15 MAN_ex_F1.rdt</td>
<td>W- Flexural el. Design in Strong-Axis Bending. Braced at Midspan, LTB, CB=auto</td>
<td>W16x50</td>
<td>100</td>
</tr>
<tr>
<td>16 MAN_ex_F2.rdt</td>
<td>Compact Channel Flexural el. with Bracing at End and Fifth Points LTB, CB=1.0</td>
<td>C 15x33,9</td>
<td>100</td>
</tr>
<tr>
<td>17 MAN_ex_F3.rdt</td>
<td>W-Shape Flexural braced member with NC Flanges in Strong-Axis Bending, no LTB</td>
<td>W 21x48</td>
<td>100</td>
</tr>
<tr>
<td>18 MAN_ex_F7.rdt</td>
<td>Rect HSS Flexural Member with Noncompact Flanges</td>
<td>HSS 10x6x3/15</td>
<td>100</td>
</tr>
<tr>
<td>19 MAN_ex_F10.rdt</td>
<td>WT Shape Flexural Members el.1</td>
<td>WT 5x6</td>
<td>100</td>
</tr>
<tr>
<td>20 MAN_ex_F11.rdt</td>
<td>Single Angle Flexural Member</td>
<td>L 4x4x1/4</td>
<td>100</td>
</tr>
<tr>
<td>21 MAN_ex_F12.rdt</td>
<td>Rectangular Bar in Strong-Axis Bending</td>
<td>RECT 5x3</td>
<td>100</td>
</tr>
<tr>
<td>22 MAN_ex_F13.rdt</td>
<td>Round Bar in Bending</td>
<td>RB 1</td>
<td>100</td>
</tr>
<tr>
<td><strong>SHEARING</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>23 MAN_ex_G1.rdt</td>
<td>W-Shape in Strong-Axis Shear</td>
<td>W 24x62</td>
<td>100</td>
</tr>
<tr>
<td>24 MAN_ex_G2.rdt</td>
<td>C-Shape in Strong-Axis Shear</td>
<td>C 15x33,9</td>
<td>100</td>
</tr>
<tr>
<td>25 MAN_ex_G3.rdt</td>
<td>Angle in Shear</td>
<td>L 5x3x1/4</td>
<td>100</td>
</tr>
<tr>
<td>26 MAN_ex_G5.rdt</td>
<td>Round HSS in Shear</td>
<td>HSS0 16x0,375</td>
<td>100</td>
</tr>
<tr>
<td>27 MAN_ex_G6.rdt</td>
<td>Doubly-Symmetric Shape W in Weak-Axis Shear</td>
<td>W 21x48</td>
<td>100</td>
</tr>
<tr>
<td>28 MAN_ex_G7.rdt</td>
<td>Singly-Symmetric Shape C in Weak-Axis Shear (both directions)</td>
<td>C9x20</td>
<td>100</td>
</tr>
<tr>
<td>29 MAN_ex_G8.rdt</td>
<td>Built-up I-Shaped Member without &amp; with stiffeners (tension field action)</td>
<td>I-SYM_2.33/0.31 x 12/1.5</td>
<td>100</td>
</tr>
<tr>
<td><strong>INTERACTION</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>30 MAN_ex_H1.rdt</td>
<td>Nc+MY+Mz - W shape - &amp;H1</td>
<td>W 14x99</td>
<td>100</td>
</tr>
<tr>
<td>31 MAN_ex_H2.rdt</td>
<td>Nc+MY+Mz - W shape - &amp;H2</td>
<td>W 14x99</td>
<td>100</td>
</tr>
<tr>
<td>32 MAN_ex_H3.rdt</td>
<td>Nt+MY+Mz - W shape - &amp;H1 (exemp. for Nt+M H1 2 - [a cB])</td>
<td>W 14x82</td>
<td>100</td>
</tr>
<tr>
<td>33 MAN_ex_H5.rdt</td>
<td>Torsional Strength HSS rect</td>
<td>HSS 6x4x1/4</td>
<td>100</td>
</tr>
<tr>
<td>34 MAN_ex_H6.rdt</td>
<td>Torsional Strength HSS0 tube</td>
<td>HSS0 5x0,25</td>
<td>100</td>
</tr>
</tbody>
</table>