GeniE User Manual
Code checking of beams
Implementation of AISC 9th

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1. IMPLEMENTATION OF AISC 9TH EDITION

This implementation of AISC is according to **AISC 9th edition (AISC 335-89): "Specification for Structural Steel Buildings, Allowable Stress Design and Plastic Design”**, June 1, 1989

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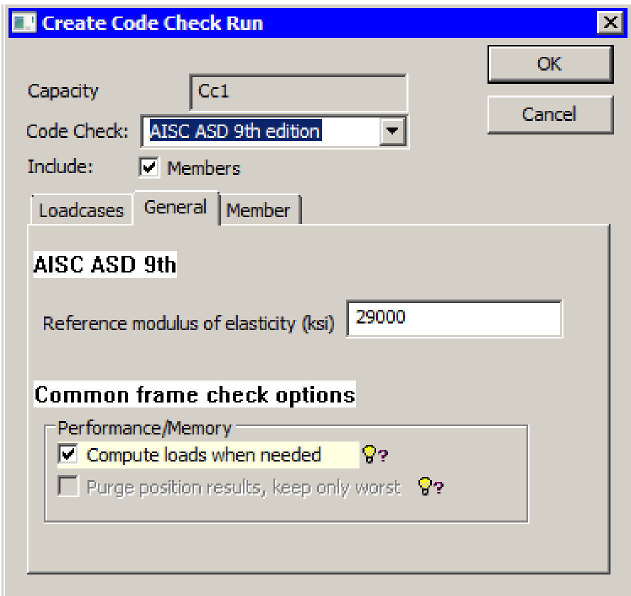
1.1 Revision supported

The implementation of AISC is according to the revision June 1, 1989.

The check covers design/utilisation of members according to the provisions for Allowable Stress Design and Plastic Design. Notice:

- Design is based on the principle that no applicable strength limit state shall be exceeded when the structure is subjected to all appropriate load combinations. The check covers checking of isolated members.
- Design of connections is not covered.
- Design for serviceability is not covered.
- Cross sections are classified according to TABLE B5.1, Limiting Width-Thickness Ratios for Compression Elements.

Select AISC ASD 9th edition from the Create Code Check Run Dialog:



General parameter:

Give the modulus of elasticity (E-modulus) in **ksi** corresponding to the E-modulus used in the analysis. This value is used for models having other units than ksi. Fy_{ksi} is used in many of the equations/expressions and calculated as follows: $\mathbf{Fy_{ksi} = Fy_{model} * (E_{reference} / E_{model})}$

For model E-modulus given in the range 28000 to 31000, ksi is assumed and Fy is used “as is”.

Example values:

E=29000 ksi equals 2.0x10^5 MPa

E=30458 ksi equals 2.1x10^5 Mpa

Common frame check options:

Compute loads when needed

- To reduce use of database memory, you can compute loads temporarily during code check execution only.
- This option can affect performance on redesign, as loads must be recalculated locally every time you change member/joint settings.
- With this option checked, you will always use the latest FEM loads. When unchecked, you will use the FEM loads retrieved the last time you used “Generate Code Check Loads”.
- Note that with option checked member loads will not be available in the report nor in object properties.

1.2 Member code check

Member design is performed according to the chapters and sections referred to in the table below:

	Design consideration	Sections covered
B	DESIGN REQUIREMENTS	B5. LOCAL BUCKLING B5.1 Classification of Steel Sections B5.2 Slender Compression Elements Inclusive APPENDIX B: B5.2 Slender Compression elements B5.2.a Unstiffened Compression Elements B5.2.b Stiffened Compression Elements B5.2.c Design Properties B5.2.d Combined Axial and Flexural Stress
D	TENSION MEMBERS	D1. ALLOWABLE STRESS
E	COLUMNS AND OTHER COMPRESSION MEMBERS	E1. EFFECTIVE LENGTH OF SLENDERNESS RATION E2. ALLOWABLE STRESS
F	BEAMS AND OTHER FLEXURAL MEMBERS 1)	F1. ALLOWABLE STRESS: STRONG AXIS BENDING OF I-SHAPED MEMBERS AND CHANNELS F1.1 Members with Compact Sections F1.2 Members with Noncompact Sections F1.3 Members with Compact or Noncompact Sections with Unbraced Length Greater than Lc F2. ALLOWABLE STRESS: WEAK AXIS BENDING OF I-SHAPED MEMBERS, SOLID BARS AND RECTANGULAR PLATES F2.1 Members with Compact Sections F2.2 Members with Noncompact Sections F3. ALLOWABLE STRESS: BENDING OF BOX MEMBERS, RECTANGULAR TUBES AND CIRCULAR TUBES F3.1 Members with Compact Sections F3.2 Members with Noncompact Sections F4. ALLOWAVLE SHEAR STRESS F5. TRANSVERSE STIFFENERS
G	PLATE GIRDERS	G1. WEB SLENDERNESS LIMITATION

	2)	G2. ALLOWABLE BENDING STRESS
H	COMBINES STRESSES 3) & 4)	H1. AXIAL COMPRESSION AND BENDING H2. AXIAL TENSION AND BENDING

Notes to table above:

1) If assigned material has yield strength F_y > 65 ksi the calculations are based on actual F_y. However, this is reported as a “geometric warning”. Message text in the GeomCheck column: FyLim65ksi.

2) Limiting web slenderness ratio h/t_w used to distinguish between beam and plate-girder is $970/\sqrt{F_y}$. Allowable shear stress with tension field action is **not supported.**

3) Cross section type Angle profile is **not supported.** Usage equal to 998 is reported. (Also see note below regarding limitation regarding Tees.)

4) Implementation of warping effect is according to theory description and expressions given in: AISC, Steel Design Guide Series 9, Torsional Analysis of Structural Steel Members, Seaburg and Carter, 1997 (2nd print 2003).

   Implemented for double symmetric I/H shaped profiles and channel profiles.

   Maximum torsional moment reported along the member is regarded as the design torsional moment (applied torque) to be used in connection with the selected warping calculation method (Case 3 with α=0.5, Case 4 or Case 7).

   Shear stress from pure torsion, in-plane shear stress and normal (longitudinal) stress due to warping are calculated. These shear stresses are added to the shear stresses from acting shear forces when calculating the governing shear utilization factor.

   The effect from warping normal stress is added to bending about weak axis when calculating the utilization factor.

   Reported warping normal stress, fnw:

   - for I/H: normal (bending) stress in flange tip
   - for channel: maximum normal (bending) stress from flange tip and transition flange/web

   Reported warping shear stress, fvw:

   - for I/H: shear stress in flange
   - for channel: maximum shear stress from flange and web

Also note the following:

- **AISC member check in context of API run**

When the AISC ASD member code check is executed in context of an API WSD 22nd edition run the safety factors are automatically modified based on the load case condition definition (or a manually defined stress increase factor).

- **Profile type rolled vs. built-up**

Note that all cross sections are as default set to fabrication status “Unknown”. Status “Unkown” is in the code check treated as Built-up (Welded). Note that sections read from the section libraries are also set to status “Unknown”.

- **Un-symmetric I cross section profiles**

Un-symmetric I sections are in current implementation treated as single symmetric. Upper and lower flange thicknesses and width are kept, but symmetry about local Z axis is assumed.

- **Torsion**

Warping effect can be included for double-symmetric I/H sections and channel profiles. The effect (shear flow/stress in webs and flanges) from warping and pure torsion is added to the shear stresses caused by shear forces in member local y and z directions. Hence, the reported usage factor from shear includes effect from torsion.

- **Channel cross section profiles**

Channel sections are always treated as rolled.

- **T cross section profiles, LIMITATION**

Tees are always treated as compact sections. The allowable bending stress is for both local y and z axes set to Fb = 0.60Fy.

- **Cross section types Bar and General**

For rectangular bar and general section the areas used for shear check includes the effect of the “Shear factors” given when defining the cross section (default shear factor = 1.0). The allowable bending stress is for both local y and z axes set to Fb = 0.60Fy.

- **Double web plate girder cross section type**

Double web plate girder is a built-up cross section. Only “Welded” fabrication type is permitted for this cross section. It is a mix of box section and I shape section. Thus, the compression elements of the section are checked based on both I-shaped (the outer flanges) and Box-shaped section (the box part) types. So is the lateral torsional buckling. The warping effect is ignored for this section type. The reduction to the slender compression elements will be ignored if the User Defined Section properties are used to the section. The effective width of the stiffened element "be" calculation is always based on the local bending moment regardless the "MAX Bending Moment" or "LOCAL Bending Moment" options.

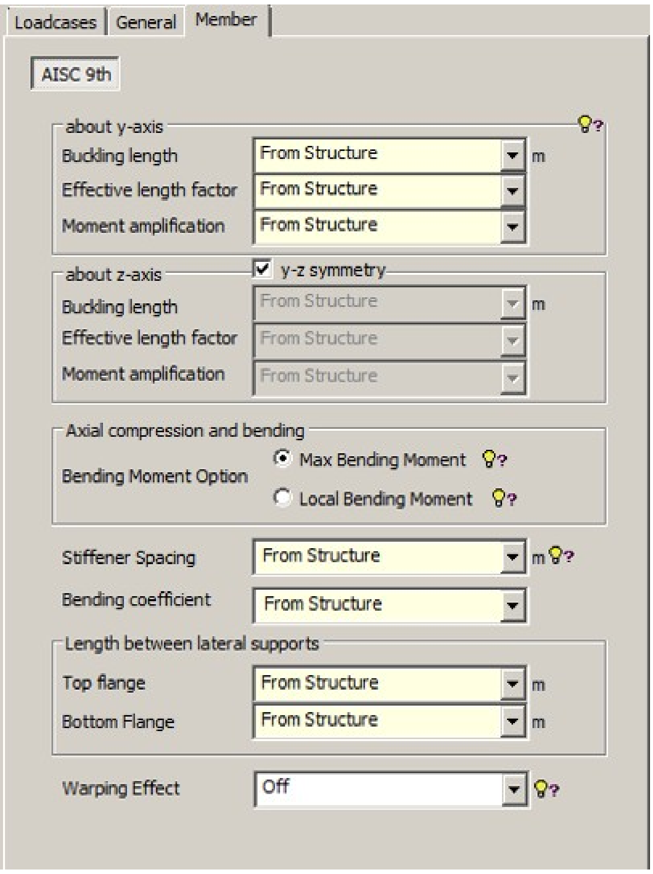
- **Boxed plate girder cross section type**

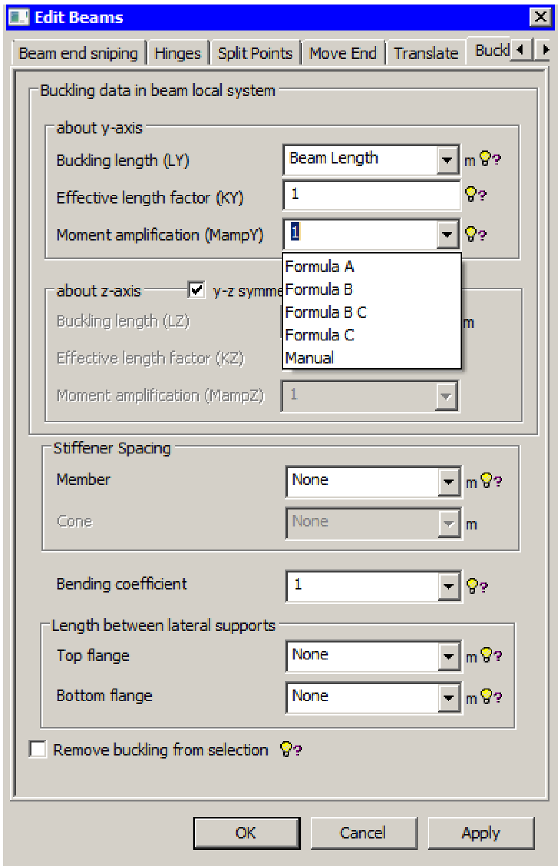
The section is checked according to the Box cross section. Only “welded” fabrication type is permitted. The shear in major axis is checked separately for each web. The warping effect is ignored. The reduction to the slender compression elements will be ignored if the User Defined Section properties are used to the section. The effective width of the stiffened element "be" calculation is always based on the local bending moment regardless the "MAX Bending Moment" or "LOCAL Bending Moment" options.

1.3 Definition of member specific parameters

For the Member specific parameters shown below (to the left) set to From Structure the values will be inherited from the assignments done to the Beam concept (dialog to the right).

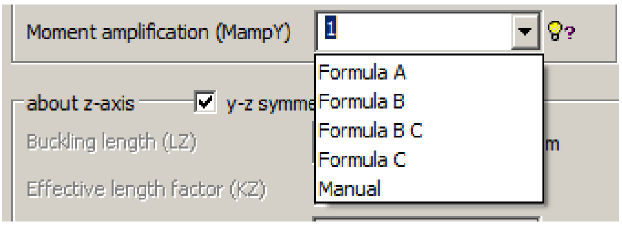
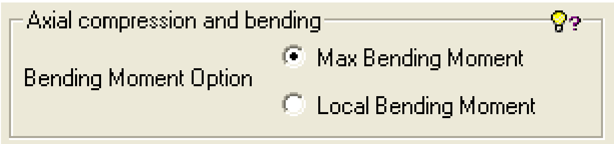
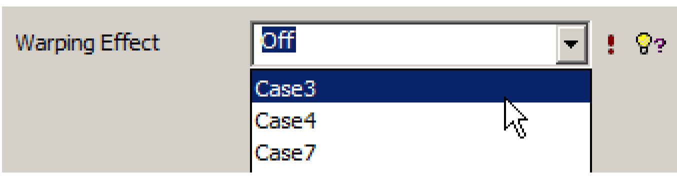
The From Structure alternative is only accepted in cases with one-to-one mapping between modelled beam and member, else the default value/option will be used.





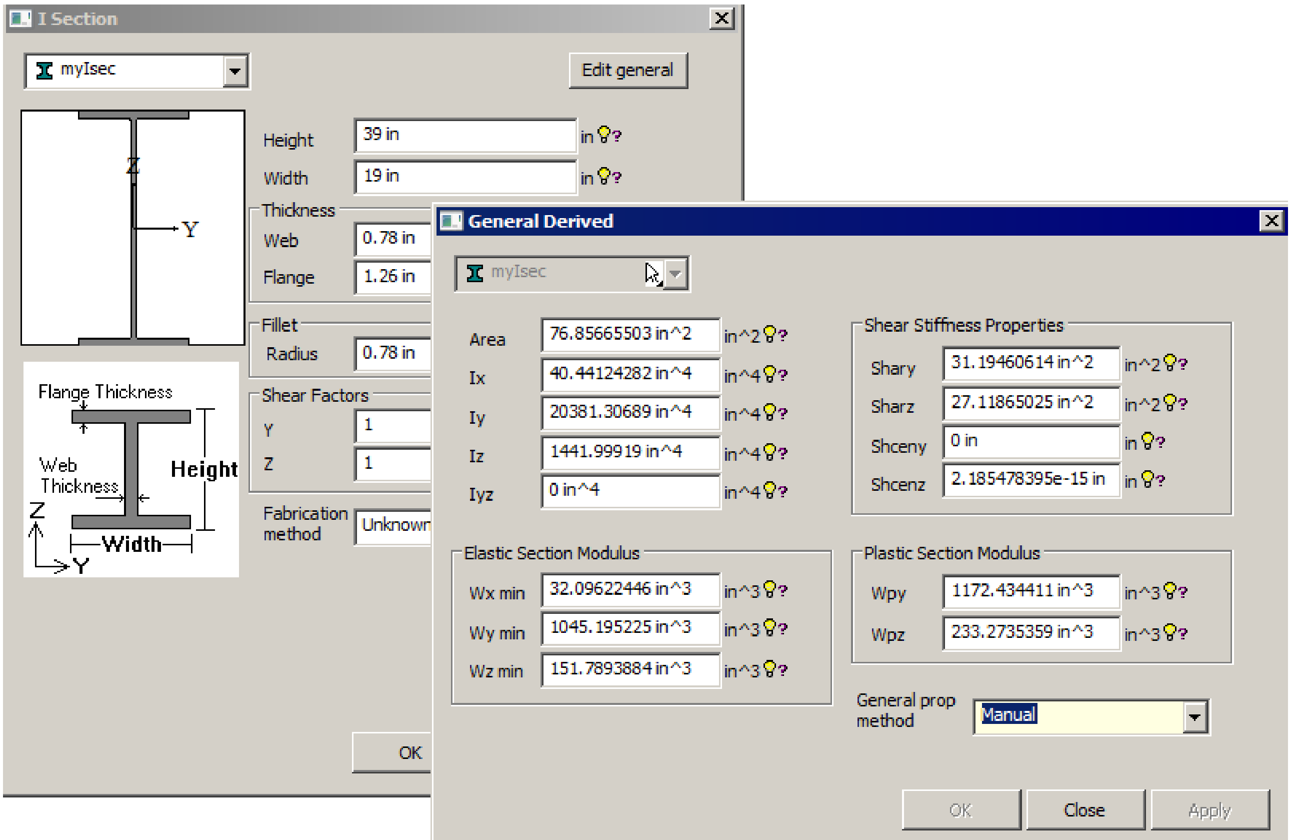
Options:

Buckling length	**From Structure** = use value/option assigned to the beam concept, ref. Edit Beam dialog **Member Length** = use the geometric length of the member (capacity model) **Manual** = specify the length to be used
Effective length factor	**From Structure** = use value/option assigned to the beam concept, ref. Edit Beam dialog **Manual** = specify the factor to be used
Moment amplification	**Aisc** = use rule/expression given in the standard **From Structure** = use value/option assigned to the beam concept, ref.

	Edit Beam dialog  For this code check all dialog Formula options are mapped to **Aisc** rulebased. **Manual** = specify the factor to be used
Axial compression and bending.	 **Max Bending Moment** This option selects the maximum bending moments along a capacity member when beam in compression. **Local Bending Moment** This option uses the local bending moments at every code check positions.
Stiffener spacing	**None** = no web stiffeners given (stiffener spacing = member length) **From Structure** = option will use the assignment given to the Beam concept, ref. Edit Beam dialog **Manual** = specify the length between stiffeners. (The spacing given may be larger than the length of the member concept)
Bending coefficient	**Aisc** = use rule/expression given in the standard **From Structure** = use the assignment given to the Beam concept, ref. Edit Beam dialog **Manual** = specify the value to be used
Length between lateral supports, top and bottom flange	**None** = no lateral supports given **From Structure** = use the assignment given to the Beam concept, ref. Edit Beam dialog **Manual** = specify the length between lateral supports (unbraced length)
Warping effect	Select how to handle warping: **Off**, or according to **Case**3, 4 or 7 (see note 4) on page 4) 

1.4 Cross section properties for manually updated profiles

From GeniE v7.5 it is possible to manually modify/update the computed cross section properties.



When any of the stiffness properties have been modified by use of “Edit general”, the values sent to the code check routines will be used as is. Dependent of profile type and check different stiffness properties are in use. It is strongly recommended to always update related values, e.g. if modifying Iy also update Wymin and Wpy accordingly.

Also note that when the code check routines get information that something has been modified the slenderness classification (width/thickness ratios) will still be determined, but no cross section reduction will be calculated even if flange or web are defined as slender. Shear capacity (area) will also be re-calculated according to specific formulas given in the standard.

1.5 Nomenclature AISC 9th

The print of all available results inclusive intermediate data from the AISC check will report the following:

Member	Capacity model name (name of Beam(s) or part of beam representing the member)
Loadcase	Name of load case/combination under consideration
Position	Relative position along member longitudinal axis (start = 0, end = 1)
Status	Status regarding outcome of code check (OK or Failed)
UfTot	Value of governing usage factor
Formula	Reference to formula/check type causing the governing usage factor
SubCheck	Which check causes this result, here AISC 9th member check
GeomCheck	Status regarding any violation of geometric/material limitations: - slenderness L/r < 300 (member in tension) - slenderness L/r < 200 (member in compression) - transverse stiffeners required (according to F5.) - plate girder web slenderness limitation exceeded (according to G1.) - Fy > 65 ksi - Section type not handled in current code check release
ufShear	Usage factor caused by shear force
ufEuler	"Usage factor" caused by Euler buckling failure Note: when bending is negligible in direction of Euler buckling it will not be checked (i.e. reported to zero). For Euler buckling failure the usage factor according to H1-1 will be 100 + the remaining usage components. When Euler buckling occur for both strong and weak axis the final usage factor will be "Axial component + 100 +100".
ufH1-1	Usage factor according to section H1-1
ufH1-1ax	Axial contribution to usage factor according to section H1-1
ufH1-1mo	Moment contribution to usage factor according to section H1-1
ufH1-2	Usage factor according to section H2-1
ufH1-2ax	Axial contribution to usage factor according to section H2-1
ufH1-2mo	Moment contribution to usage factor according to section H2-1
ufH1-3	Usage factor according to section H1-3
ufH1-3ax	Axial contribution to usage factor according to section H1-3
ufH1-3mo	Moment contribution to usage factor according to section H1-3
ufH2-1	Usage factor according to section H2-1
ufH2-1ax	Axial contribution to usage factor according to section H2-1
ufH2-1mo	Moment contribution to usage factor according to section H2-1
ufH3	Usage factor according to section H3
sldTens	Member slenderness, member in tension
sldComp	Member slenderness, member in compression
stfReqLimit	Limiting a/h ratio (F5-1) if transverse stiffeners are required acc. to F5
PGwebSldLimit	Limiting h/tw ratio if plate girder web slenderness exceeds (G1-1) or (G1-2)

FyLim65ksi	Actual yield stress (in ksi) when Fy > 65ksi
OutOfBounds	Warning flag indicating that the cross section is outside what is covered in the current implementation. For profile type Angle a value of 2 is used.
relpos	Relative position along member longitudinal axis (start = 0, end = 1)
Fy	Yield strength
E	Young's modulus of elasticity
KLy	Buckling length for buckling about major axis
KLz	Buckling length for buckling about minor axis
a	Distance between vertical web stiffeners
L	Length of capacity model
Lc	Maximum unbraced length of compression flange
Lb	Length between point for lateral support of flange
h/tw	Web slenderness ratio
b/tf	Width-thickness ratio for most slender flange
Cmy	Bending moment amplification coefficient for bending about major axis
Cmz	Bending moment amplification coefficient for bending about minor axis
P	Acting axial force, negative sign is compression
Vy	Acting shear force in y direction (giving shear in flanges)
Vz	Acting shear force in z direction (giving shear in web(s))
My	Acting bending moment about major axis, negative sign means compression in bottom flange (flange at negative z-axis)
Mz	Acting bending moment about minor axis, negative sign means compression at negative y-axis, e.g. for box profile: compression in right web when looking in positive member x-axis
Mymax	Maximum acting bending moment about major axis in case of compression. If tension then Mymax is not used when calculating usage factor.
Mzmax	Maximum acting bending moment about minor axis in case of compression. If tension then Mzmax is not used when calculating usage factor.
FlaClass	Slenderness classification of flange (0=compact, 1=non-compact, 2=slender)
WebClass	Slenderness classification of web (0=compact, 1=non-compact, 2=slender)
FlaAsWeb	Slenderness classification of flange when acting as webs (webs in flexural compression / webs in combined flexural and axial compression), i.e. when bending about weak axis (0=compact, 1=non-compact, 2=slender). Valid for **Box profile only**
WebAsFla	Slenderness classification of web for uniform compression, i.e. when bending about weak axis (0=compact, 1=non-compact, 2=slender) . Valid for **Box profile only**
Cb	Bending coefficient dependent upon moment gradient
Cv	Ratio of “critical” web stress
fa	Acting axial stress
fvy	Acting shear stress in y direction (giving shear in flanges)
fvz	Acting shear stress in z direction (giving shear in web(s))

fby	Acting bending stress about strong axis
fbz	Acting bending stress about weak axis
Qs	Axial stress reduction factor for unstiffened elements
Qa	Ratio of effective profile area of an axially loaded member to its total profile area
Fa	Axial compressive stress permitted
Ft	Allowable axial tensile stress
Fvy	Allowable shear stress for shear in y direction (shear in flanges)
Fvz	Allowable shear stress for shear in z direction (shear in web(s))
Fby	Bending stress permitted about strong axis
Fbz	Bending stress permitted about weak axis
Fey	Euler stress (divided by factor of safety) for buckling about strong axis
Fez	Euler stress (divided by factor of safety) for buckling about weak axis
J	Torsional constant
Cw	Warping constant
fnw	Calculated normal stress (maximum) due to warping
fvw	Calculated shear stress (maximum) due to warping

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