GeniE User Manual
Code checking of beams
Implementation of API-WSD 22nd edition

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1. IMPLEMENTATION OF API RP 2A-WSD 22ND EDITION

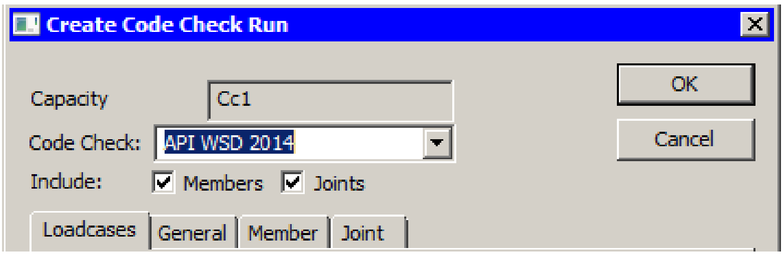
This implementation of API WSD is according to “**Recommended Practice for Planning, Designing and Constructing Fixed Offshore Platforms - Working Stress Design**”.

API RECOMMENDED PRACTICE 2A-WSD TWENTY-SECOND EDITION, NOVEMBER 2014

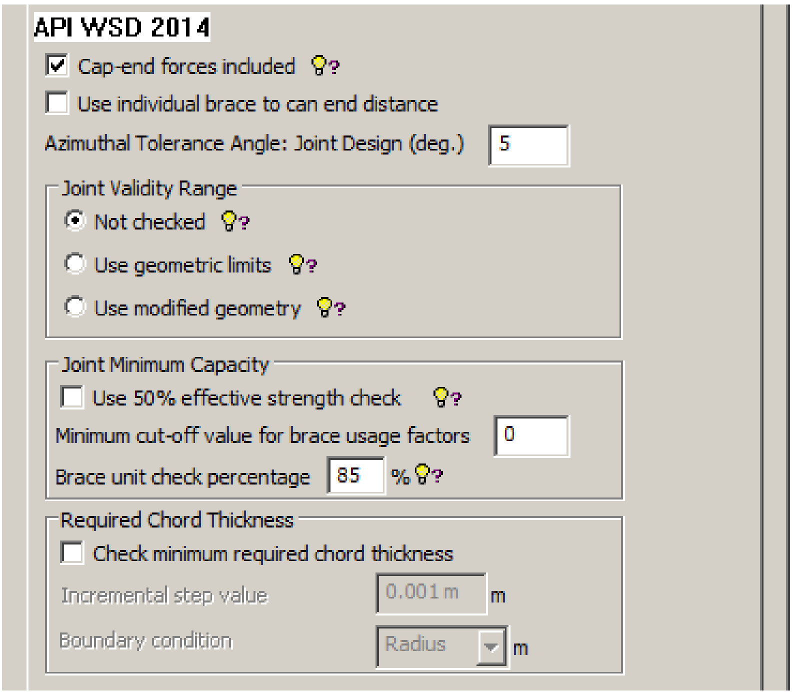
1.1 Implementation notes

The code checks implemented in GeniE cover capacity check of cylindrical members, conical transitions and tubular joints according to chapter 6 “Structural Steel Design” and chapter 7 “Connections”.

Select API WSD 2014 from the Create Code Check Run dialog



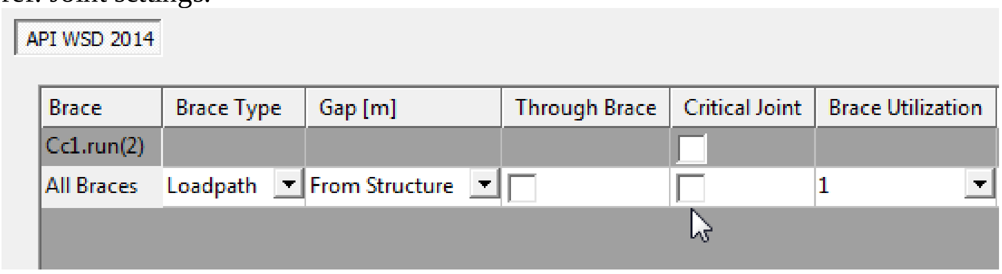
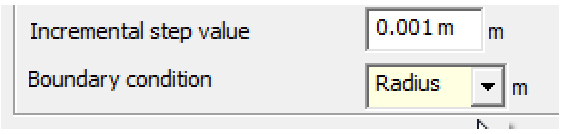
Define the global (General) parameters which will be assigned to the run. All settings are explained on the following pages.



Options:

Cap-end forces included	Select when Capped-end forces are included, i.e. the calculated axial stress includes the effect of the hydrostatic capped-end forces. This corresponds to an analysis where Wajac has been used.
Individual brace to can end distance	In previous versions only the minimum distance from brace to can end was used. GeniE’s new option allows choose between joint’s minimum or individual brace to can end distance. Ref. Figure 7.5
Tolerance	User can define azimuthal tolerance angle for joint design. Previous versions used 5 degrees as

<table>
<tr><td>Angle</td><td>default value. This provides the possibility to define different sets of braces to be used on Joint Punch Check Analysis. The subdivision in Y-, K- and X- joint axial force patterns normally considers all members in one plane at a joint. Brace planes within (±α°) of each other may be considered as being in the same plane.</td></tr>
<tr><td>Joint validity range</td><td>Use geometric limits: taking the usable strength as the lesser of the capacities calculated on the basis of a) actual geometric parameters, and b) imposed limiting parameters for the validity range, where these limits are infringed.
Use modified geometry: taking the usable strength as the lesser of the capacities calculated on the basis of a) actual geometric parameters, and b) modified geometry to satisfy limiting values for the validity range.</td></tr>
<tr><td>Joint Minimum Capacity</td><td>Regarding section 7.2.3 (and B7.2.3):
Two alternatives are available:
1) The joint capacity shall not be less than 50% of the strength of the incoming brace.
2) The unit check of the joint shall be limited to 85% of the unit check of the brace (ref. B7.2.3). Two user defined options are available:
- Define a cut-off value; if the brace usage factor is less than the cut-off value the actual usage factor for the brace for the investigated load case is neglected, i.e. 1.0 is used as brace usage factor. (Hence, when set to zero the actual brace usage factor will always be used.)
- Possibility to modify the 85% limit

Note that both alternatives require that the joints (or individual braces) are defined as critical, ref. Joint settings:

</td></tr>
<tr><td>Required Chord Thickness</td><td>Select if the required chord/can thickness shall be calculated when the usage factor is > 1 for actual thickness.
Two user defined options are available:
- Incremental step value: give the step value to be used to increase the thickness until the usage factor is < 1.
- Boundary condition: the maximum thickness (Tmax) where the thickness iteration process is stopped without obtaining a usage factor < 1. As default the Radius is the limit. Alternatively give the maximum thickness manually.


Note the following:
- If used in combination with “Use geometric limits” the required thickness calculation will not use the required thickness in the D/2T limitation check.
- If reaching the “Tmax” due to the defined boundary condition before the calculation gives a usage factor < 1, the text “Tmax” will be reported.
- If the user given “Tmax” is less than actual/original thickness the text “Tmax < T” will be reported.
- For braces with negative gap: If the governing usage factor is caused by the check of the overlapping brace onto the through brace as chord the calculations will run until “Tmax”</td></tr>
</table>

	is reached. - DO NOT use this option in connection with Grouted Joints.

1.2 Member and cone design check

The member and cone design code check is performed according to the chapters and sections referred to in the table below:

	Design consideration	Sections covered
6.2	Allowable Stress for Cylindrical Members	**6.2.1** Axial tension **6.2.2** Axial compression 6.2.2.1 Column Buckling 6.2.2.2 Local Buckling 6.2.2.2.1 General 6.2.2.2.2 Elastic Local Buckling Stress 6.2.2.2.3 Inelastic Local Buckling Stress **6.2.3** Bending **6.2.4** Shear 6.2.4.1 Beam Shear 6.2.4.2 Torsional Shear **6.2.5** Hydrostatic Pressure 6.2.5.1 General 6.2.5.2 Design Hydrostatic Head 6.2.5.3 Hoop Buckling Stress 6.2.5.3.1 General 6.2.5.3.2 Elastic Hoop Buckling Stress 6.2.5.3.3 Critical Hoop Buckling Stress
6.3	Combined Stresses for Cylindrical Members	**6.3.2** Combined Axial Compression and Bending 6.3.2.1 Cylindrical Members 6.3.2.2 Cylindrical Piles 6.3.2.3 Pile Overload Analysis 6.3.2.4 Member Slenderness

		6.3.2.5 Reduction Factor **6.3.3** Combined Axial Tension and Bending **6.3.4** Axial Tension and Hydrostatic Pressure **6.3.5** Axial Compression and Hydrostatic Pressure **6.3.6** Safety Factors
6.4	Conical Transitions 1)	**6.4.1** Axial compression and Bending 6.4.1.2 Cone Section Properties 6.4.1.3 Local buckling 6.4.1.4 Unstiffened Cone-cylinder Junctions 6.4.1.4.1 General 6.4.1.4.2 Longitudinal Stress 6.4.1.4.3 Hoop Stress **6.4.2** Hydrostatic Pressure 6.4.2.2 Cone Design

Note 1) to 6.4:

The formulas given for conical transitions in axial compression and bending are also used for axial tension and that the checks are always performed both for positive and negative resulting bending stress. With respect to the hoop stress the following approach is used: At the smaller-diameter junction, the hoop stress is tensile (or compressive) when (fa + fb) is tensile (or compressive). Similarly, the hoop stress at the larger-diameter junction is tensile (or compressive) when (fa + fb) is compressive (or tensile).

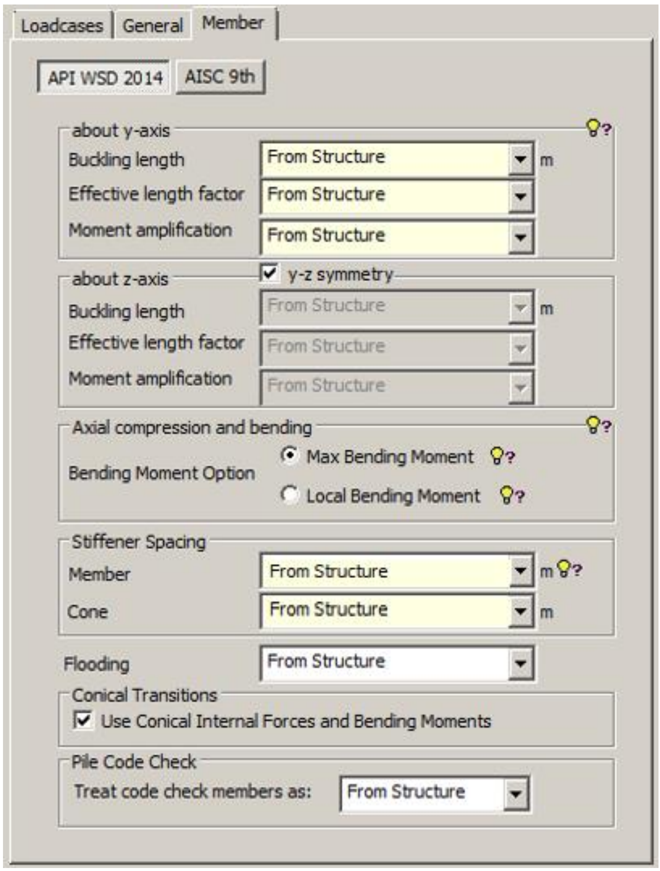
Note that for segmented beams with tubular cross sections of different sizes, the Euler buckling strength for the member is based on the cross section with the smallest radius of gyration. However, from V7.9 the "Energy method" is used, see User Documentation section 2.1.4.8 Compatibility Options: "**Energy method for column buckling of segmented members**".

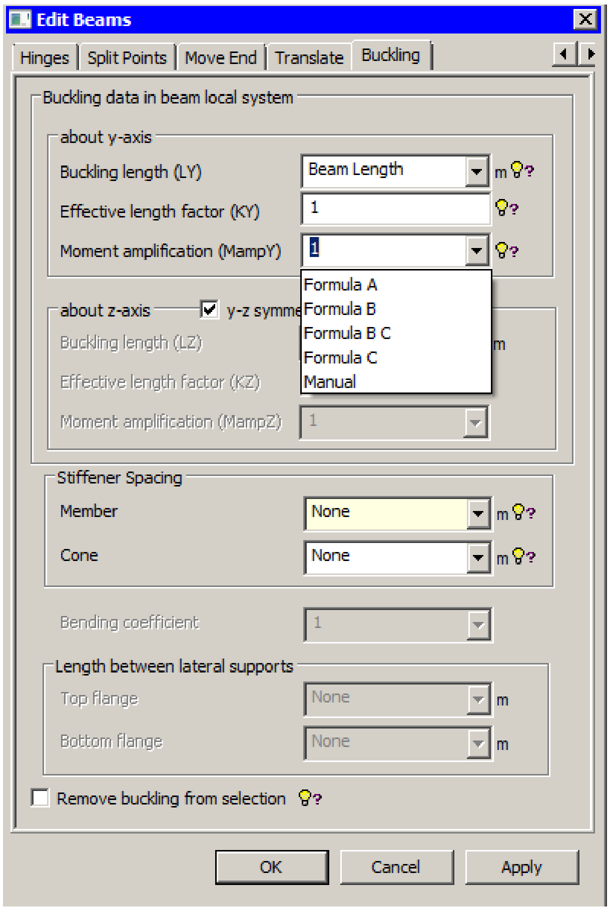
Definition of member specific parameters:

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 default member data for tubular members are shown. Notice that there are different properties for tubular members and non-tubular members (using AISC ASD 9th). GeniE will automatically detect which profiles are present in the capacity model.

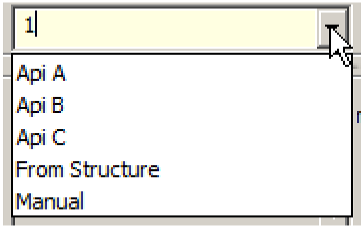
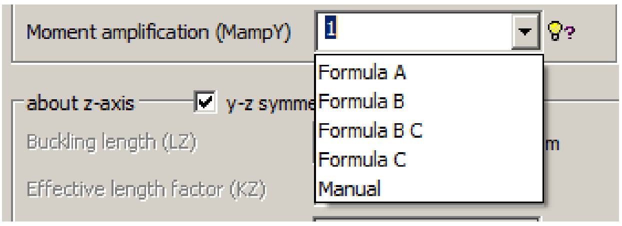
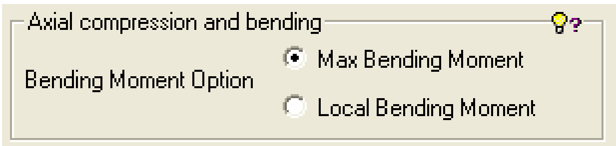
The From Structure alternative is only accepted in cases with one-to-one mapping between modelled beam and member, else the default value/option will be used.

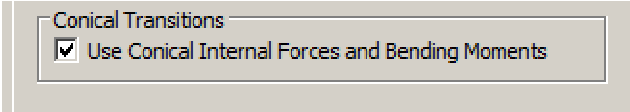
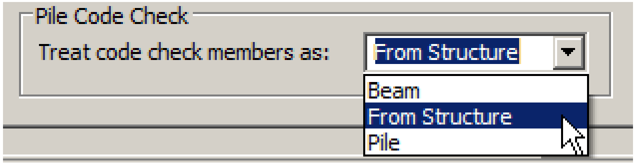




Options:

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	Specify **Rule** according to the standard, ref. section 6.3.2.5 “Reduction

	Factor" alternatives (a), (b) or (c)  or select: **From Structure** = use value/option assigned to the beam concept, ref. Edit Beam dialog  The moment amplification definitions are mapped as follows: Formula A → Api A, Formula B → Api B, Formula B C → Api C , Formula C → Api C **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 derived by the effect of moment gradient, Cm. This method is considered to be best practise. **Local Bending Moment** This option uses the local bending moments at every code check positions. Use of local bending moment could be non-conservative.
Stiffener spacing, Member and Cone	**None** = no ring stiffeners given (For member: stiffener spacing = member length, for cone: stiffener spacing = cone length) **From Structure** = option will use the assignment given to the Beam concept, ref. Edit Beam dialog **Manual** = specify the length between stiffeners.
Flooding	**From Structure** = use the properties assigned to the beam concepts using the properties defined from the "Create/Edit Hydro Property" dialog **Flooded** = Manually set to flooded **Not Flooded** = Manually set to not flooded
Conical Transitions	GeniE allows users to choose between internal forces on cone structures or adjacent forces on tubulars close to transitions points for Cone Code Check Analysis. Analysis, where the cap end forces are computed, present internal

	axial force values bounded by the axial forces at the transitions. Use of internal forces is coherent and recommended but the use of external forces provides conservative results. 
Pile Code Check	Options for how to treat the capacity members with respect to section 6.3.2.2 "Cylindrical Piles" equations (6.24) and (6.25). - From Structure: The capacity members are treated as piles when defined as a pile concept, beams are treated as ordinary members. - Beam: Pile concepts are treated/code checked as ordinary beams only - Pile: May be used to force ordinary beams to be checked according to (6.24) and (6.25). 

1.3 Tubular joint design code check

The code check is performed according to chapter 7 "Strength of Tubular Joints" and sections referred to in the table below:

	Design consideration	Sections covered
7.2	Design Considerations	**7.2.3** Minimum Capacity [1)] **7.2.4** Joint Classification
7.3	Simple joints	**7.3.1** Validity Range, (B**7.3.1** Usable strength taken as the lesser of the strengths calculated based on actual geometrical parameters and the limiting value parameter for the validity range.) **7.3.2** Basic Capacity [3)] **7.3.3** Strength Factor Qu **7.3.4** Chord Load Factor Qf **7.3.5** Joints with Thickened Cans **7.3.6** Strength Check

7.4	Overlapping Joints	2)
7.5	Grouted Joints	**Double-skin** joints are checked according to condition a) and b) and largest usage factor is reported. For condition a) the maximum Qu factors from Table 7.2 and 7.3 are used. Table 7.3 gives Qu axial for axial tension force only. Hence, the usage factor calculation for condition a) excludes contribution from axial force when the brace is in compression. Thickened can reduction factor (based on equivalent thicknesses) is included in condition b), i.e. ovalization check. **Fully grouted** joints are checked according to condition a) only. The maximum Qu factors from Table 7.2 and 7.3 are used. Table 7.2 gives Qu axial for axial tension force only. Hence, the usage factor calculation excludes contribution from axial force when the brace is in compression. Also note: - For joints defined as fully grouted or double-skin the four additional checks (a. through d.) defined in 7.4 “Overlapping joints” are NOT checked. - DO NOT use the “Calculate required thickness” option in connection with Grouted Joints.

Note 1) to 7.2.3:

Effective strength of the brace member is calculated as follows:

- Fy*A when in tension (minimum value from member segments)
- Fa*A when in compression (minimum value from member segments)

When the “Use 50% effective strength check” is selected the relevant braces must be defined as member capacity models in the capacity manager. If no data found the effective strength is set to zero, hence the usage factor for this check will be zero.

This check is a pure axial utilization check, i.e. Uf = 0.5*effStrength / Pa. (For load cases defined as earthquake 100% of effective strength is used.)

The effective strength and Pa used in this usage factor calculation do not include any factor of safety or stress increase factor.

Also note support for the minimum capacity check approach explained in B7.2.3: “The unit check of the joint shall be limited to 85% of the unit check of the brace”.

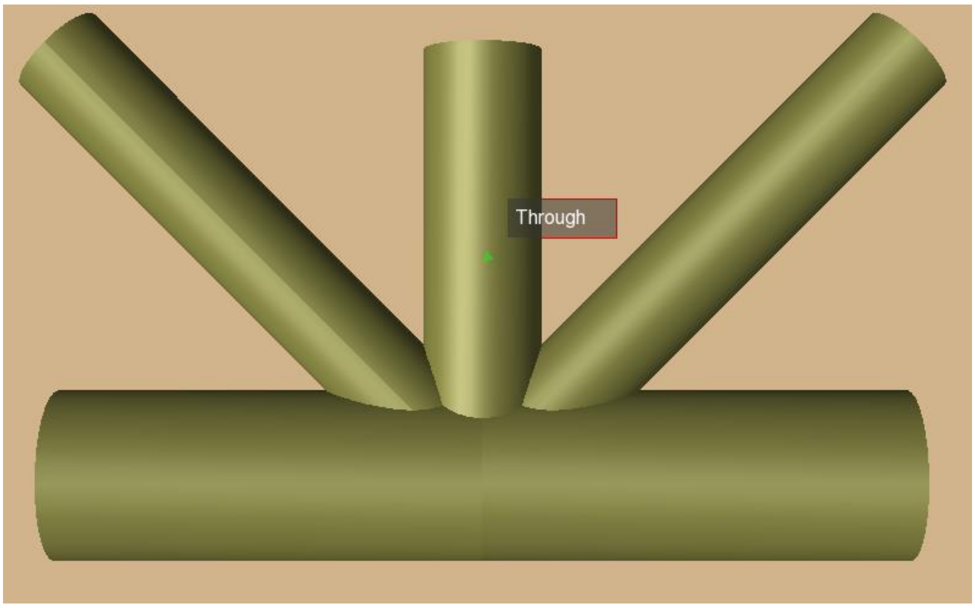
Note 2) to 7.4 Overlapping joints:

For KT joints with double overlap the two geometric configurations shown below are handled with respect to calculating the additional checks described in section 7.4 “Overlapping Joints” items a. b. c. and d. Note that when using load path classification the two KTKs may get a positive “weighed gap” when the axial force in the middle brace is small compared to the axial force in the diagonal braces. For such conditions the checks described in section 7.4 are not assessed for the KTKs.

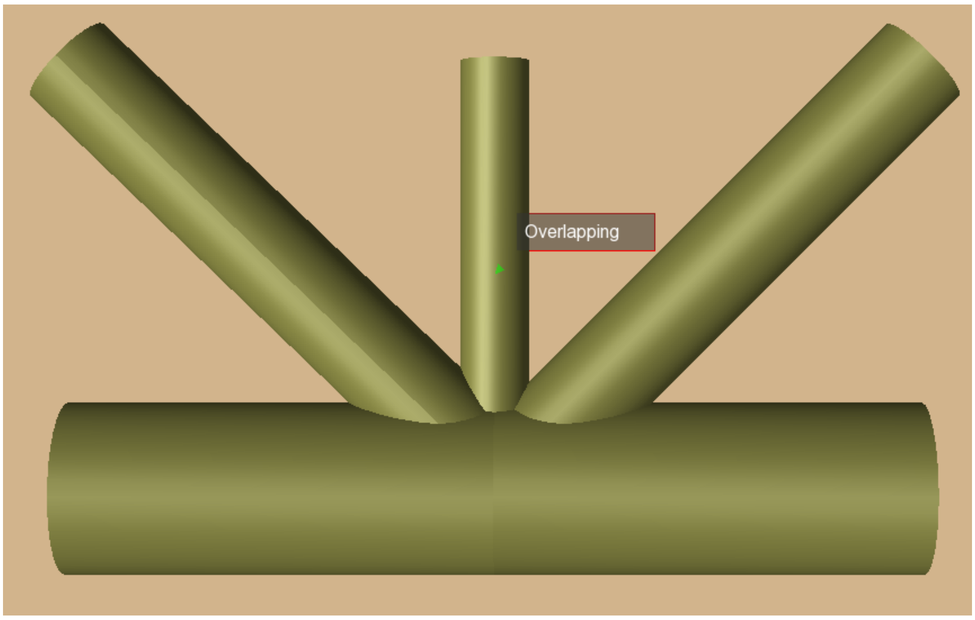
Note 3) to 7.3.2 Basic Capacity

The joint capacity check requires that the tensile strength of the chord material is defined. If the tensile strength has not been defined, a tensile strength equal to Yield strength * 1.11 will be used. Hence, the yield strength **Fyc** used when calculating the basic capacities will be 1.11*0.8 = 0.89 times the material yield strength when no specific tensile strength is defined.

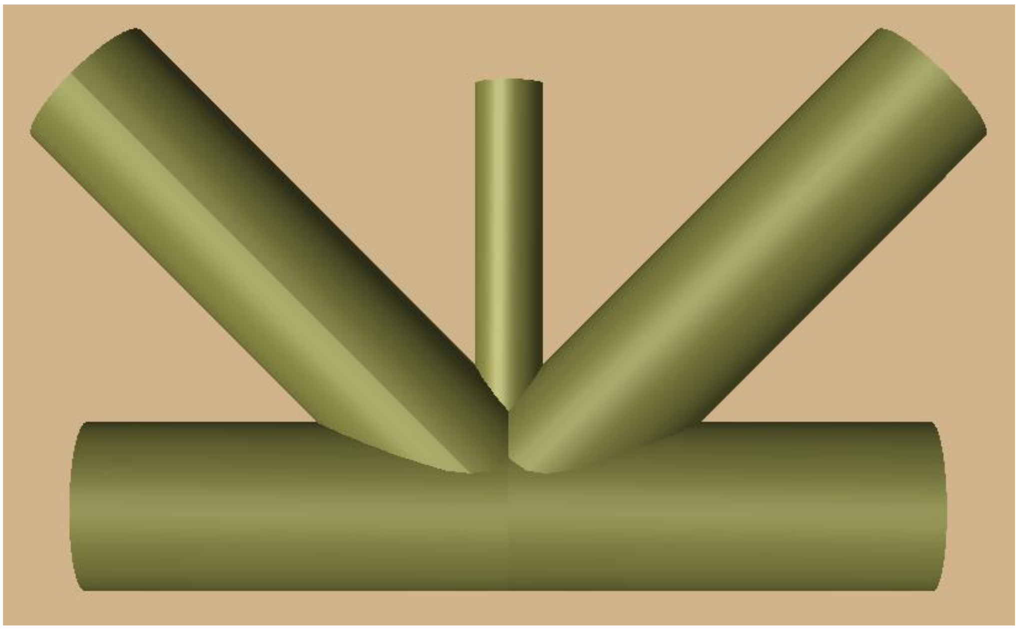
The KTT is the through brace and both KTKs overlap the KTT as shown below:



The KTT is overlapping both the KTKs as shown below:



Also note that the configuration shown below is not supported, i.e. when the KTT does not touch the chord (KTKs are overlapping).

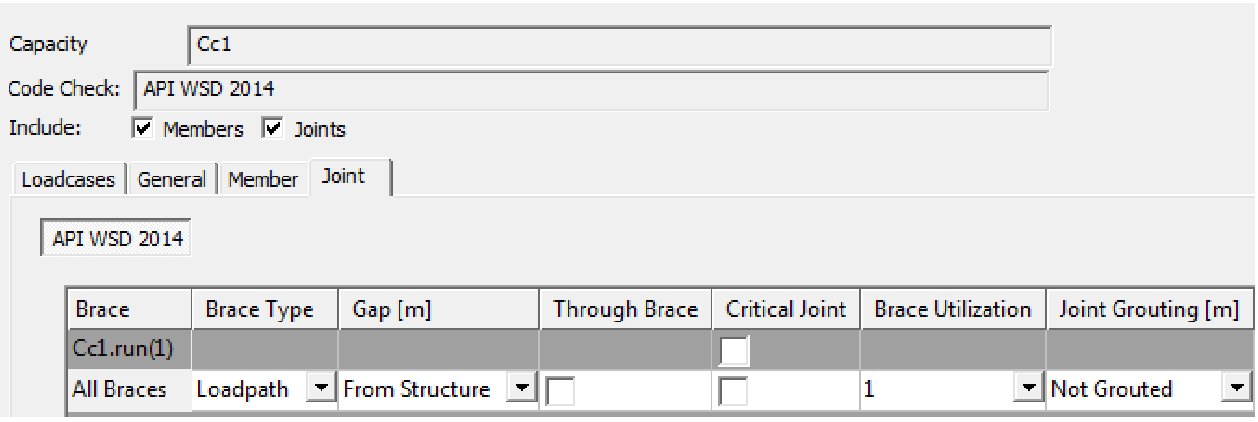


For a geometric configuration shown above the middle brace must be modelled with one of the diagonal braces as chord.

General note with respect to Factor of Safety:

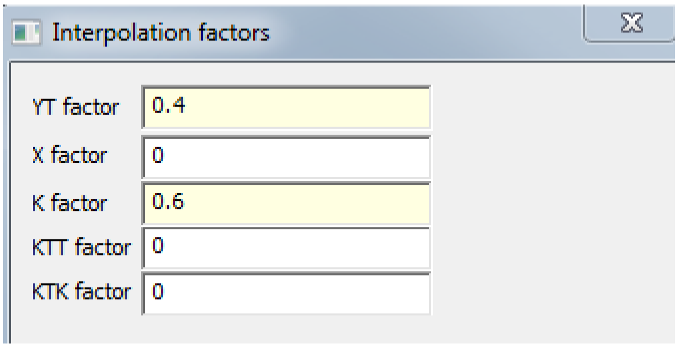
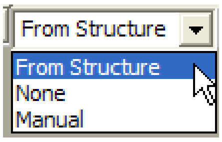
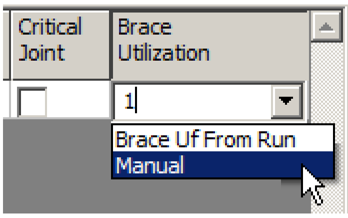
The safety factor *FS* is as default set to 1.6 according to the standard. The actual safety factor used is 1.6/(increase factor), where the increase factor is based on the load case/combination design condition.

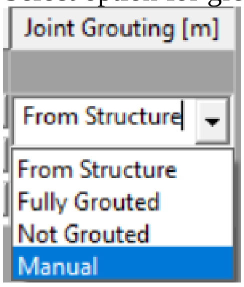
Joint specific parameters:



Options:

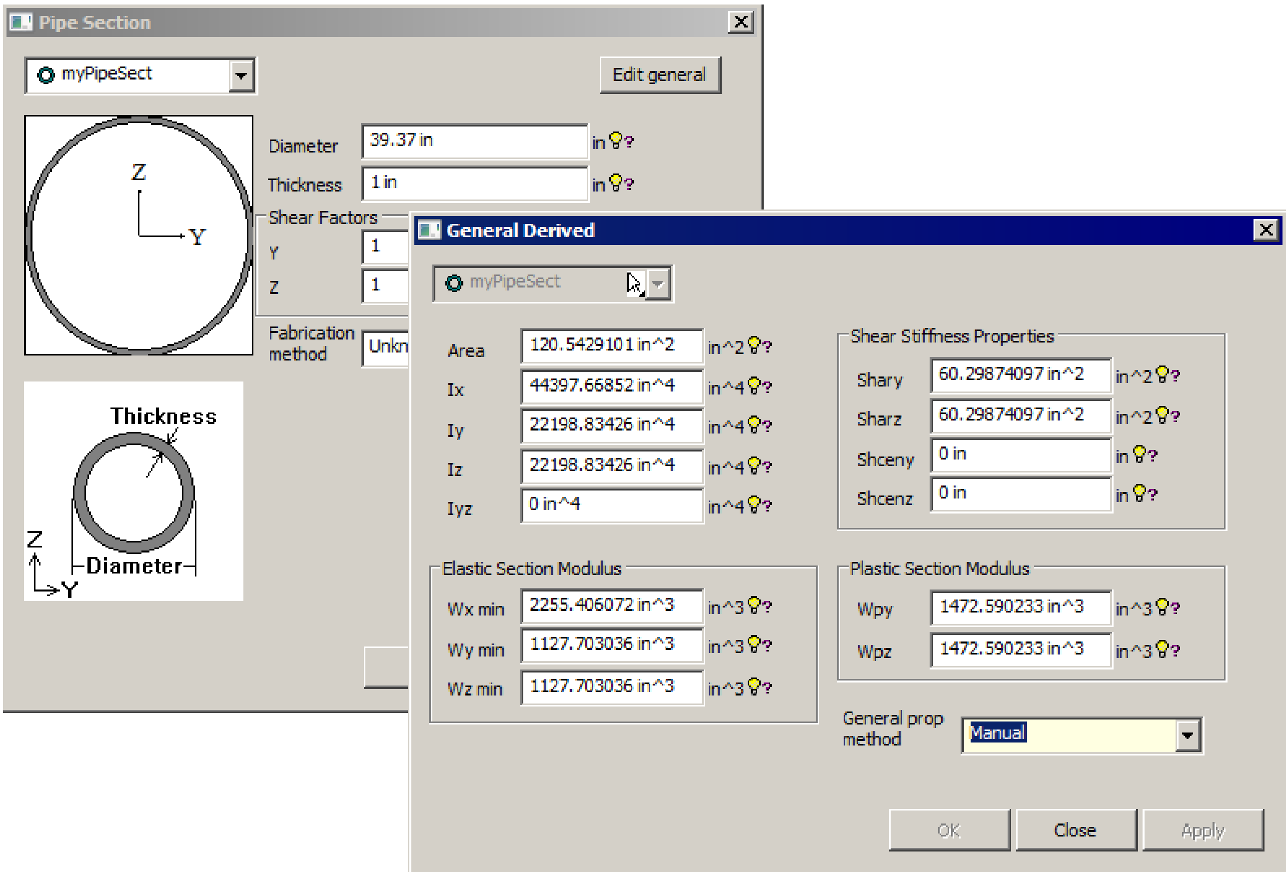
Brace Type	Select how to classify the brace type regarding geometry. Alternatives are: -manually set to YT, X, K, KTT, KTK -classify according to geometry -classify according to loadpath (and geometry)

<table>
<tr><td></td><td>-interpolate using manual input
</td></tr>
<tr><td>Gap</td><td>From Structure = use the geometry as defined in the model and calculate gap values.

None = do not include gap => set gap to zero
Manual = specify the gap value to be used towards neighbour braces</td></tr>
<tr><td>Through Brace</td><td>The program will propose the through brace in an overlapping joint based on:
1. Max. thickness is through-brace
2. Max. diameter is through, when 1. equal
3. Minimum angle with chord is through brace
The user may change this if the situation is different from the proposal.</td></tr>
<tr><td>Critical joint</td><td>Select if the joint shall be classified as critical, i.e. if the selected alternative for Minimum Capacity requirement shall be checked/used.</td></tr>
<tr><td>Brace Utilization</td><td>If the joint is defined as Critical and “Use 50% effective strength check” is not selected, decide if the brace utilization factor shall be automatically read from the member check or a user given usage factor (0 < uf < 1). When “Brace Uf From Run” is selected the relevant braces must be defined as member capacity models in the capacity manager. If no data found, usage factor = 1.0 is used. A value of 1.0 is also used when the actual brace usage factor is less than 0.001 or greater than 1.0.

For critical joints the joint check usage factor IR is scaled with respect to the Brace Utilization * (Brace unit check percentage /100), and not 1.0 as for non-critical joints.</td></tr>
</table>

	Ref. equation (7.6): - Non-critical: IR ≤ 1.0 - Critical: IR/(Ubrace*0.85) ≤ 1.0 (for default 85%)
Joint Grouting	Select option for grouting condition.  - Default is "From Structure". For joints with inner piles (double-skin), the capacity model will automatically detect the connection type based on the concept model as follows: • The inner beam type is "Disconnected". The joint will be treated as "Not Grouted". The joint is checked as a simple joint. • The inner beam type is "Fully Coupled". The joint will be treated as "Double Skin Grouted", and the according wall thickness Tp of the inner member/pile will be assigned automatically. • The inner beam type is "Beam spring". The joint will be treated as "Double Skin Grouted". • If no inner beam exists, the joint will be treated as "Not Grouted". - Select "Fully grouted" for joints with chords filled up with grout. The joint capacity for the fully grouted joint will be applied as the design code requires. - "Manual" can be used to manually define the wall thickness Tp to be used in the calculations for a "Double-skin Grouted" joint. May be used both where inner pile is modeled and when not modeled. Tp should be entered in the box. - "Not grouted". The joint is checked as a simple joint. Note that for double-skin configurations the Inner Beam must be assigned one of the three available beam types, i.e. how to connect to the Outer Beam (e.g. Fully coupled, Beam spring or Disconnected) when modeled.

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.



Member code checks will utilize updated/modified:

- Area
- Moment of inertia, Ix, Iy and Iz
- Elastic section modulus, Wy and Wz
- Plastic section modulus, Wpy and Wpz

No attempt to calculate any equivalent diameter or wall thickness. It is strongly recommended to always update related values, e.g. if modifying Iy also update Wymin and Wpy accordingly.

No specific update for cone or joint code check has been made to utilize modified values.

1.5 Nomenclature

1.5.1 Member check

The print of all available results inclusive intermediate data from the member 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 API WSD member check
GeomCheck	Status regarding any violation of geometric limitations:
	- D/thk < 300
	- Thk ≥ 0.25 inch (6 mm)
ufShear	Usage factor due to shear action
ufTorsion	Usage factor due to torsional action
uf6.13	Usage factor according to equation (6.13), i.e. hydrostatic pressure
uf6.22	Usage factor according to equation (6.22), i.e. axial compression and bending
uf6.22ax	Axial contribution to usage factor according to equation (6.22)
uf6.22mo	Moment contribution to usage factor according to equation (6.22)
uf6.21	Usage factor according to equation (6.21), i.e. axial compression or tension and bending
uf6.21ax	Axial contribution to usage factor according to equation (6.21)
uf6.21mo	Moment contribution to usage factor according to equation (6.21)
Uf6.23	Usage factor according to equation (6.23), i.e. axial compression and bending
uf6.23ax	Axial contribution to usage factor according to equation (6.23)
uf6.23mo	Moment contribution to usage factor according to equation (6.23)
uf6.27	Usage factor according to equation (6.27), i.e. axial compression and hydrostatic pressure
uf6.27ax	Axial contribution to usage factor according to equation (6.27)
uf6.27mo	Moment contribution to usage factor according to equation (6.27)
uf6.28	Usage factor according to equation (6.28), i.e. axial compression and hydrostatic pressure
uf6.29	Usage factor according to equation (6.29), i.e. axial compression and hydrostatic pressure
uf6.26	Usage factor according to equation (6.26), i.e. axial tension and hydrostatic pressure
uf6.24	Usage factor according to pile capacity equation (6.24)
uf6.25	Usage factor according to pile capacity equation (6.25)

D/t	The D/t ratio
thk	Tubular wall thickness in meter
relpos	Relative position along member longitudinal axis (start = 0, end = 1)
D	Tubular outside diameter
t	Tubular wall thickness
Fy	Yield strength
E	Young's modulus of elasticity
P	Acting axial force, negative when compression
My	Acting bending moment about local y-axis
Mz	Acting bending moment about local z-axis
Mt	Acting torsional moment
V	Acting transverse shear force (vector sum for local y and z directions)
p	Hydrostatic pressure according to section 6.2.5.2 "Design Hydrostatic Head"
Kly	Buckling length for buckling about local y-axis
Klz	Buckling length for buckling about local z-axis
stfspace	Length between ring stiffeners
Fey'	Euler stress appropriate for bending about local y-axis
Fez'	Euler stress appropriate for bending about local z-axis
fa	Acting axial stress, negative when compression
fby	Acting bending stress about local y-axis
fbz	Acting bending stress about local z-axis
fv	Acting torsional shear stress
fvt	Acting transverse shear stress
fbymax	Bending stress about local y axis caused by maximum bending moment along the capacity member
fbzmax	Bending stress about local z axis caused by maximum bending moment along the capacity member
Cmy	Bending moment amplification coefficient for bending about local y-axis
Cmz	Bending moment amplification coefficient for bending about local z-axis
Fxc	Inelastic local buckling stress (reported value does not include stress increase factor when applicable)
Fa	Allowable axial compressive stress
Fb	Allowable bending stress
Fv	Allowable beam shear stress
Fvt	Allowable torsional shear stress
fh	Hoop stress due to hydrostatic pressure
Fhe	Elastic hoop buckling stress
Fhc	Critical hoop buckling stress

SFh	Safety factor against hydrostatic collapse
SFxt	Safety factor for axial tension used within section 6.3.3 and 6.3.4
SFxc	Safety factor for axial compression used within section 6.3.3 and 6.3.4
SFb	Safety factor for bending used within section 6.3.3 and 6.3.4
sFac	Stress increase factor according to load design condition

1.5.2 Cone check

The print of all available results inclusive intermediate data from the cone 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 API WSD cone check
GeomCheck	Status regarding any violation of geometric limitations:
	- $\alpha \leq 30$ degrees
uffTotC	Usage factor based on total stress (ref. section 6.4.1.4.2), cone side of junction
uffTotT	Usage factor based on total stress (ref. section 6.4.1.4.2), tubular side of junction
ufnomiC	Usage factor based on nominal stresses (ref. section 6.4.1.2), cone side of junction
ufnomiT	Usage factor based on nominal stresses (ref. section 6.4.1.2), cone side of junction
ufHoop	Usage factor due to hoop stress
uf6.27	Usage factor according to equation (6.27), i.e. axial compression and hydrostatic pressure
uf6.28	Usage factor according to equation (6.28), i.e. axial compression and hydrostatic pressure
uf6.29	Usage factor according to equation (6.29), i.e. axial compression and hydrostatic pressure
uf6.26	Usage factor according to equation (6.26), i.e. axial tension and hydrostatic pressure
Alpha	One-half the projected apex angle of the cone
relpos	Relative position along member longitudinal axis (start = 0, end = 1)
D	Outside diameter of tubular (tubular side of junction)
t	Wall thickness of tubular (tubular side of junction)
Dc	Outside diameter of cone
tc	Wall thickness of cone
E	Young's modulus of elasticity of tubular section
Fy	Yield strength of tubular section

Tens	Tensile strength of tubular section
Ec	Young's modulus of elasticity of cone
Fyc	Yield strength of cone
Tensc	Tensile strength of cone
fa	Acting axial stress in the tubular section
fb	Acting resultant bending stress in the tubular section
fac	Acting axial stress in the cone
fbc	Acting resultant bending stress in the cone
fb'	The localized bending stress at the junction, tubular side
fb'c	The localized bending stress at the junction, cone side
fh'	The hoop stress caused by the unbalanced radial line load
p	Hydrostatic pressure according to section 6.2.5.2 "Design Hydrostatic Head"
fh	Hoop stress due to hydrostatic pressure
Fxe	Elastic local buckling stress
Fxc	Inelastic local buckling stress
Fhe	Elastic hoop buckling stress
Fhc	Critical hoop buckling stress
SFh	Safety factor against hydrostatic collapse
SFxt	Safety factor for axial tension used within section 6.3.3 and 6.3.4
SFxc	Safety factor for axial compression used within section 6.3.3 and 6.3.4
SFb	Safety factor for bending used within section 6.3.3 and 6.3.4
sFac	Stress increase factor according to load design condition

1.5.3 Tubular joint check

The print of all available results inclusive intermediate data from the joint check will report the following data. Note that the usage factors "uf7.6…" and "ufshear" are also reported for the case with respect to limit geometrical values. The nomenclature is then similar to the "original", but with _lim added.

Joint	Capacity model name (joint name)
Loadcase	Name of load case/combination under consideration
Member	Governing brace causing highest utilisation
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 API WSD 2005 joint capacity check
GeomCheck	Status regarding any violation of geometric limitations
uf7.6	Usage factor according to equation (7.6)
uf7.6ax	Axial contribution to usage factor according to equation (7.6)

uf7.6mo	Moment contribution to usage factor according to equation (7.6)
ufMinCapacity	Usage factor from the Minimum Capacity check when alternative “Use 50% effective strength check” is selected
uf7.6mod	Usage factor from through brace in overlapping joint, modified loads
uf7.6axmod	Axial contribution in uf7.6mod
uf7.6momod	Moment contribution in uf7.6mod
uf7.6ove	Usage factor from overlap brace in overlapping joint, through brace as chord
uf7.6axove	Axial contribution in uf7.6ove
uf7.6moove	Moment contribution in uf7.6ove
ufshear	Usage factor regarding shear capacity for overlapping joint
beta	Value of β (= d/D)
gamma	Value of γ (= D/2T)
theta	Angle between brace and chord
gap_D	The gap/D ratio
ufipb	usage factor, contribution from in-plane bending
ufopb	usage factor, contribution from out-of-plane bending
P	Design axial force in the brace member
Pa	The joint design axial resistance (capacity)
Mipb	Design in-plane bending moment in the brace member
Maipb	Design in-plane bending resistance (capacity)
Mopb	Design out-of-plane bending moment in the brace member
Maopb	Design out-of-plane bending resistance (capacity)
Quaxial	Ultimate strength factor dependant of joint and load type, axial
Quipb	Ultimate strength factor dependant of joint and load type, in-plane bending
Quopb	Ultimate strength factor dependant of joint and load type, out-of-plane bending
Pc	Nominal axial load in the chord
Mcipb	Nominal in-plane bending moment in the chord
Mcopb	Nominal out-of-plane bending moment in the chord
A	The A factor used for calculating Qf
Qfaxial	Factor to account for nominal longitudinal stress in chord, axial
Qfipb	Factor to account for nominal longitudinal stress in chord, in-plane bending
Qfopb	Factor to account for nominal longitudinal stress in chord, out-of-plane bending
Ytfact	Brace classification, fraction as type YT behaviour
Xfact	Brace classification, fraction as type X behaviour
Kfact	Brace classification, fraction as type K behaviour
KTTfact	Brace classification, fraction as type KTT behaviour
KTKfact	Brace classification, fraction as type KTK behaviour

CanFact	reduction factor according to section 7.3.5 “Joints with Thickened Cans”
Fyc	Yield strength of chord used in calculation
Fyb	Yield strength of brace used in calculation
FS	Factor of Safety
D	Outer diameter of chord
T	Wall thickness of chord
d	Outer diameter of brace
t	Wall thickness of brace
g	Gap value used in calculations
Ub	Usage factor for brace from member check (reported to -1 for braces connected to non-critical joints)
Tp	Wall thickness of inner member (inner pile)
effStrength	Brace member effective strength used in the Minimum Capacity check when alternative “Use 50% effective strength check” is selected

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