GeniE User Manual
Code checking of beams and joints
Implementation of ISO 19902 1st and 2nd edition

Table of Contents

1. IMPLEMENTATION OF ISO 19902 EDITION 2007

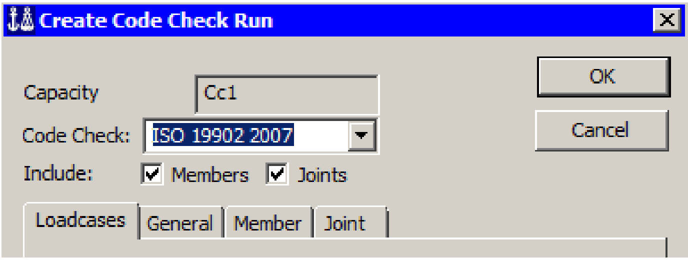
The implementation of ISO is according to "**International Standard ISO 19902, Petroleum and natural gas industries – fixed offshore structures".**

1.1 Revisions supported

1st Edition, 1 December 2007, inclusive Amendment 1, 2013-08-01.

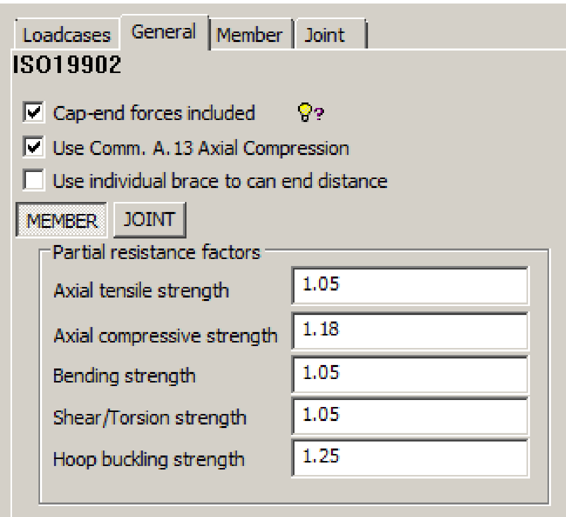
The check covers capacity check of tubular members, conical transitions and tubular joints according to chapter **13 "Strength of tubular members"** and chapter **14 "Strength of tubular joints"**.

Select ISO 19902 from the Create Code Check Run dialog. Note that this code check includes Eurocode 3 EN 1993-1-1 2005 for non-tubular members. (See comments in table below regarding resistance factors.)

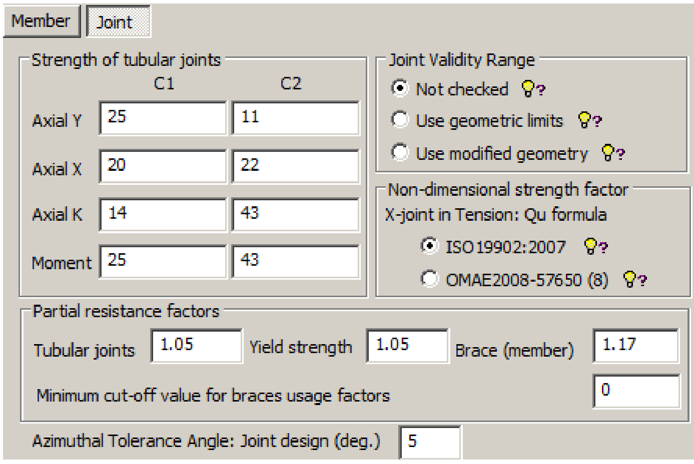


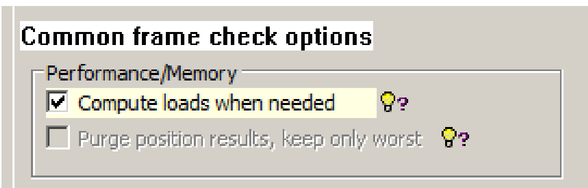
Define the global (General) parameters regarding capped-end forces and resistance factors. The C1 and C2 factors used in the joint strength calculations may also be modified.

Genral options, member:



General options, joint:





Options:

<table>
<tr><td>Cap-end forces included</td><td>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.</td></tr>
<tr><td>Use Comm. A.13
Axial Compression</td><td>The method described in the commentary part “A.13.2.3.2. Column buckling” is used, i.e. equations (A.13.2-1) and (A.13.2-2) are taken into account.</td></tr>
<tr><td>Individual brace to can end distance</td><td>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. ISO 19902 Figure 14.3-1.</td></tr>
<tr><td>Partial resistance factors</td><td>Give the partial resistance factors to be used, defaults given according to the standard.

- For member check five resistance factors are used.

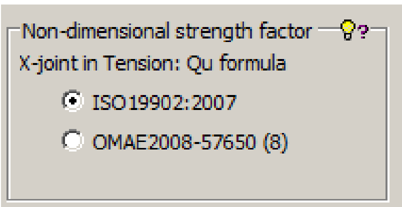
For structural shapes other than circular tubulars the resistance factors in the national or regional building code shall be modified by the application of a building standard correspondence factor, ref. ISO 19901-3. This must be handled manually.

- For joint capacity check three resistance factors are used.

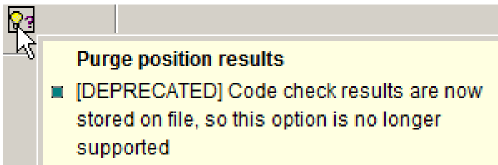
Minimum cut-off value for braces usage factor: This value is the lower limit brace members usage factor when to be used in the joint code check in equation (14.3-13). The default value is 0, i.e use actual Ub for all braces. This option is valid only for critical joints. U_b = 1 is used for braces with usage factors less than selected limit.</td></tr>
<tr><td>Strength of tubular joints</td><td>Give the factors C_1 and C_2, ref. Table 14.3-2, default values are according to the standard

<table>
<tr><th>Joint type</th><th>C_1</th><th>C_2</th></tr>
<tr><td>Y-joints for calculating strength against brace axial forces</td><td>25</td><td>11</td></tr>
<tr><td>X-joints for calculating strength against brace axial forces</td><td>20</td><td>22</td></tr>
<tr><td>K-joints for calculating strength against balanced brace axial forces</td><td>14</td><td>43</td></tr>
<tr><td>All joints for calculating strength against brace moments</td><td>25</td><td>43</td></tr>
</table></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>Non-dimensional strength factor</td><td>X-joint in tension: Qu formula



If the joint is classified as X and tension it is possible to select two options in order to compute the non-dimensional Qu factor:
ISO19902:2007 – This option selects the formulation presented on ISO19902:2007.</td></tr>
</table>

	OMAE2008-57650 (8) – This option uses the proposal presented in formula (8) in the paper: New data on the Capacity of X-joints Under Tension and Implication for Codes Proceedings of ASME 27th International conference on Offshore Mechanics and Artic Engineering. $Qu = 6.4\gamma^{(0.6\beta^2)}$ is used.
Tolerance Angle	User can define azimuthal tolerance angle for joint design. Previous versions used 5 degrees as 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 ($\pm\alpha^o$) of each other may be considered as being in the same plane.
Common frame check options	**Compute loads when needed** • To reduce use of database memory, you can compute temporary loads (during code check execution). These loads will be deleted immediately when no longer needed. • 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. **Purge position results, keep only worst** 

1.2 Member and cone design check – ISO 19902

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
13	Strength of tubular members	**13.1** General [1)] **13.2** Tubular members subjected to tension, compression, bending, shear or hydrostatic pressure - 13.2.2 Axial tension - 13.2.3 Axial compression - 13.2.3.1 General - 13.2.3.2 Column buckling - 13.2.3.3 Local buckling - 13.2.4 Bending - 13.2.5 Shear - 13.2.5.1 Beam shear - 13.2.5.2 Torsional shear - 13.2.6 Hydrostatic pressure - 13.2.6.1 Calculation of hydrostatic pressure [2)] - 13.2.6.2 Hoop buckling **13.3** Tubular members subjected to combined forces without hydrostatic pressure - 13.3.2 Axial tension and bending - 13.3.3 Axial compression and bending **13.4** Tubular members subjected to combined forces with hydrostatic pressure - 13.4.2 Axial tension, bending, and hydrostatic pressure - 13.4.3 Axial compression, bending, and hydrostatic pressure **13.5** Effective lengths and moment reduction factors [3)]
	Conical transition	**13.6** Conical transitions - 13.6.1 General - 13.6.2 Design stresses - 13.6.2.1 Equivalent axial stress in conical section - 13.6.2.2 Local bending stress at unstiffened junctions - 13.6.2.3 Hoop stress at unstiffened junctions - 13.6.3 Strength requirements without external hydrostatic pressure - 13.6.3.1 General Conical transition is checked against 13.3 as the equivalent tubular segment. - 13.6.3.2 Local buckling within conical transition - 13.6.3.3 Junction yielding

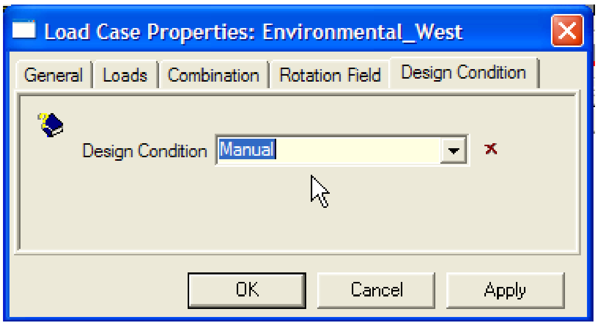
		- 13.6.3.4 Junction buckling - 13.6.4 Strength requirements with external hydrostatic pressure - 13.6.4.1 Hoop buckling Conical transition is checked against 13.4 as the equivalent tubular segment. - 13.6.4.2 Junction yielding and buckling

Note 1) to 13.1:

Limits with respect to yield strength is not checked.

Note 2) to 13.2.6.1:

The partial action factor $\gamma_{f,G1}$ is defined through the "Design condition factor" connected to the load case / load combination. Replace "Manual" with a user-defined value or set to Operating → $\gamma = 1.3$, Storm → $\gamma = 1.1$ or Earthquake → $\gamma = 1.1$



Note 3) to 13.5:

Reference is made to Table 13.5-1 with respect to selecting the moment reduction factor Cm. When selecting moment reduction factor option "ISO 2 or 3" the following criteria is used to determine if the beam is exposed to transverse loading or not. Note that the effect from self weight is included in this evaluation:

1. Calculate bending moment at midspan (point closest to midspan from check positions investigated) based on moment at start and end of beam, i.e. a linear distribution "Mlin"
2. Calculate difference "Δmom" between acting moment and "Mlin"
3. If "Δmom" is less than 1% of acting moment at the investigated point a linear distribution is assumed, i.e. no transverse loading

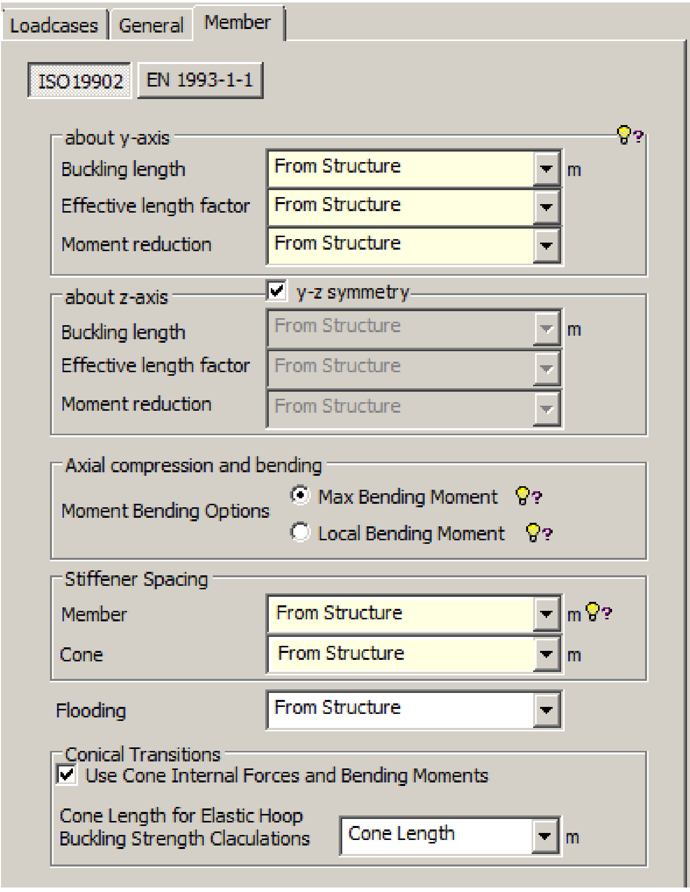
Note that for segmented beams with tubular cross sections of different sizes, the Euler buckling strength for the member is based on the cross section with the smallest radius of gyration. However, from V7.9 the "Energy method" is used, see User Documentation section 2.1.4.8 Compatibility Options: "**Energy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

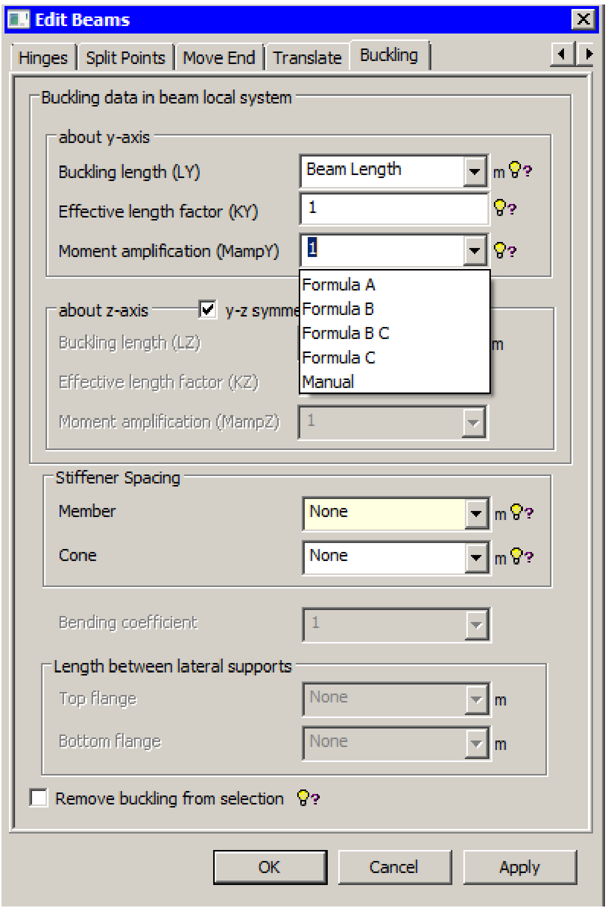
Definition of member specific parameters:

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 EN 1993-1-1). GeniE will automatically detect which profiles are present in the capacity model.

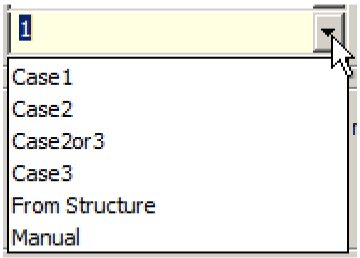
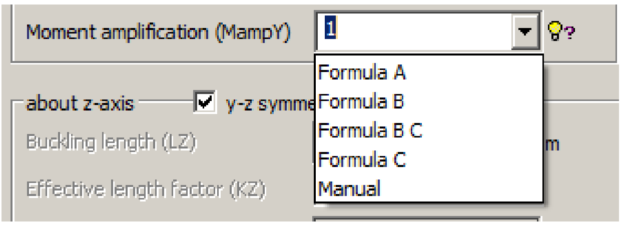
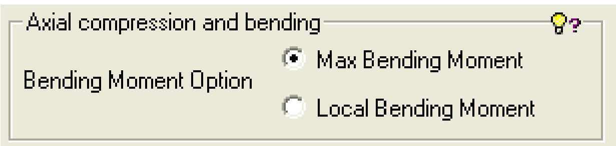
The From Structure alternative is only accepted in cases with one-to-one mapping between modelled beam and member

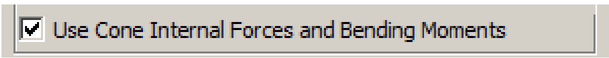
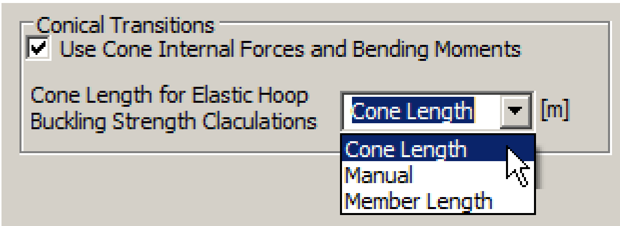




Options:

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. Table 13.5-1, i.e. alternatives (1), (2), (2) or (3), (3)  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 → Case 1 , Formula B → Case 2, Formula B C → Case 2 or 3, Formula C → Case 3 **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. **Local Bending Moment** This option uses the local bending moments at every code check positions.
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	Prior to V8.2, GeniE focuses on the strength check of the conical-tubular junctions and allows users to choose between the internal forces on the cone

	itself or the adjacent forces on tubulars close to the junctions. The analysis, where the capped-end forces are computed, present the internal axial force values bounded by the axial forces at the transitions. If necessary, the use of external forces may be chosen to provide the conservative results at certain junction. In V8.3, GeniE supports checking the position inside the conical segment in addition to the junction positions. "**Use Cone Internal Forces** …" is default and recommended.  Prior to V8.2 GeniE checks the local buckling according to Clause **13.6.3.2** and the hoop buckling according to Clause **13.6.4.1**. As an enhancement, GeniE V8.3 checks the conical transition as **the equivalent tubular segment.** The Elastic Hoop Buckling Strength fhe is required in the hoop buckling and the equivalent tubular check. Select option for the Cone Length for Elastic Hoop Buckling Strength Calculations (for calculating μ → Ch → fhe): - When set to Cone Length (default) the minimum length of actual cone length and any given cone stiffener spacing is used - When set to Member Length the total concept/member length is used (stiffener spacing for member is not considered). - Alternatively, give the length to be used manually  The capped-end force is considered in both the junction checks and the equivalent tubular check.
Conical Transition checked as equivalent tubular segment	In V8.3, the conical transition is checked as the equivalent tubular segment to assure the conical transition does not fail by the combined axial force/bending moments with hydrostatic pressure or by shear forces. The code check positions can locate on the junctions and inside the cone segment. The equivalent diameter is De=Ds/cos(α), according to Equation (13.6-9). The tubular thickness is the wall thickness of the cone. • The strength requirements without and with external hydrostatic pressure are checked according to 13.3 and 13.4 respectively. • The bending moment reduction factor Cm is a constant 0.85 for both major and minor bending axis. The option of moment amplification on the capacity member is not effective. • "Energy method" of column buckling of segmented member is supported. • Shear strength requirement is checked according to 13.2.5. • If the code check position locates inside the conical transition the junction yielding check and buckling check are skipped. • The method described in the commentary part "A.13.2.3.2. Column buckling" is supported. • The Geometric Check Failed will be reported if the ratio of equivalent diameter over cone thickness, De/tc > 120.

1.3 Member with D/t > 120 design check – DNVGL-RP-C202

The code check for a member with diameter over thickness ratio D/t > 120 is performed according to DNVGL-RP-C202 Edition September 2019. The standard DNVGL-ST-0126 recommends the strength and stability of shell structures may be checked according to DNVGL-RP-C202. The RP-C202 strength check of unstiffened cylinder is combined with the existing ISO 19902 tubular member check for the member with D/t>120. The amendment to ISO 19902 is particularly designed for the application of offshore wind turbine.

The chapters and sections referred to are listed in the table below.

Section 3. Buckling Resistance of Cylindrical Shells	3.1 Stability requirement 3.2 Characteristic buckling strength of shells 3.4 Elastic buckling strength of unstiffened circular cylinders 3.4.1 General 3.4.2 Shell buckling 3.8 Column buckling 3.8.1 Stability requirement 3.8.2 Column buckling strength

Note: 1) The column buckling assessment requirement, Equation (3.8.1), is ignored.

The following options are not considered in code checks for beams with D/t > 120:

- Cap end force
- “Local moment” or “Max moment”
- User define Design Condition for each load case.

1.4 Tubular joint design code check – ISO 19902

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

	Design consideration	Sections covered
14	Strength of tubular joints	**14.2** Design considerations - 14.2.4. Joint classification **14.3** Simple circular tubular joints - 14.3.1 General - 14.3.2 Basic joint strength [1)] - 14.3.3 Strength factor Q_u - 14.3.4 Chord force factor Q_f - 14.3.5 Y- and X- joints with chord cans - 14.3.6 Strength check **14.4** Overlapping circular tubular joints [2)] **A.14.3.1.1** Usable strength taken as the lesser of the strengths calculated based on actual geometrical parameters and the limiting value parameter for the validity range. **14.5** Grouted circular tubular joints Notes to implementation wrt. Qu and Qf factors; Enhancement has been made with the release version of 8.3. *Fully grouted, tension:* Qu factors are computed according to Table A.14.5-1 and not less than those for simple joint in Table 14.3-1. The leg (outer member) wall thickness is used in formulas for Qu and Qf. The axial capacity is interpolated for mixed joint classifications. The thickened can reduction factor is ignored. The interaction equations (14.3-12/ 14.3-13) are applied for the utilization factors. *Fully grouted, compression:* The utilization factors are calculated by the interaction equations (14.3-12/ 14.3-13) with the axial brace load being set to zero. The factors Qu/Qf and the strength capacities are calculated by the same method as those in axial tension. *Double-skin:* Must be checked both for condition with shear pullout and ovalisation. Report the largest usage factor for the two conditions.

		- Shear pullout in both tension and compression: The same method as the fully grouted joint is applied with the leg (outer-member) wall thickness is used in Qu and Qf calculations. - Ovalisation in both tension and compression: The simple joint formula are applied with the leg wall thickness replaced by the effective thickness Te, i.e. $Te = (T^2 + Tp^2)^{0.5}$ where T = wall thickness of chord and Tp = wall thickness of inner member, e.g. Qu according to Table 14.3-1 and factor ϒ = ChordDiameter/(2*Te). The axial capacity is interpolated for mixed joint classifications. The thickened can reduction factor is computed according to Te and the effective nominal thickness $Tne = (Tn^2 + Tp^2)^{0.5}$ The leg (outer-member) wall thickness is used in Qf calculations. Also note: For joints defined as fully grouted or double-skin the additional checks defined in 14.4 “Overlapping circular tubular joints” are NOT checked.

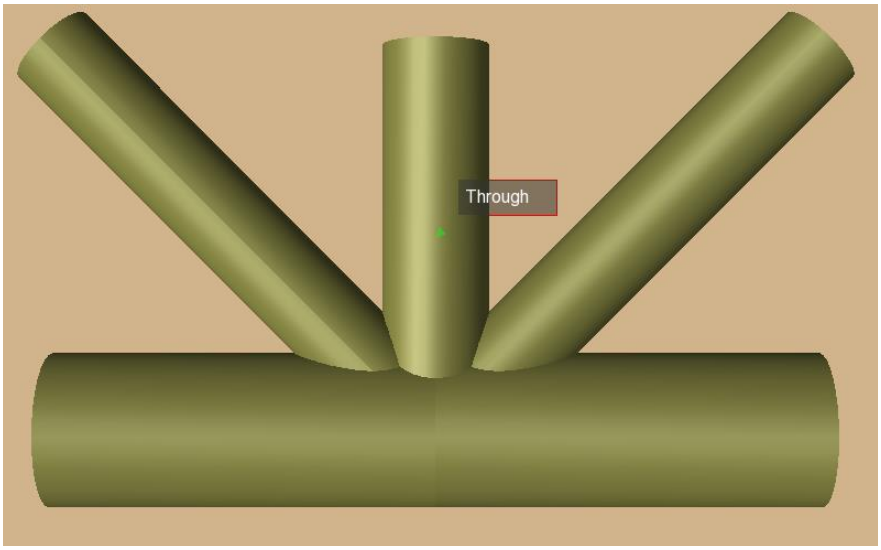
Note 1) to 14.3.2:

The default tensile strength for the joint capacity model is defined to 1.11 times the material yield strength (SMYS). Hence, the yield strength fy used when calculating the representative strengths will be 1.11*0.8 = 0.89 times the material yield strength when no specific tensile strength is defined.

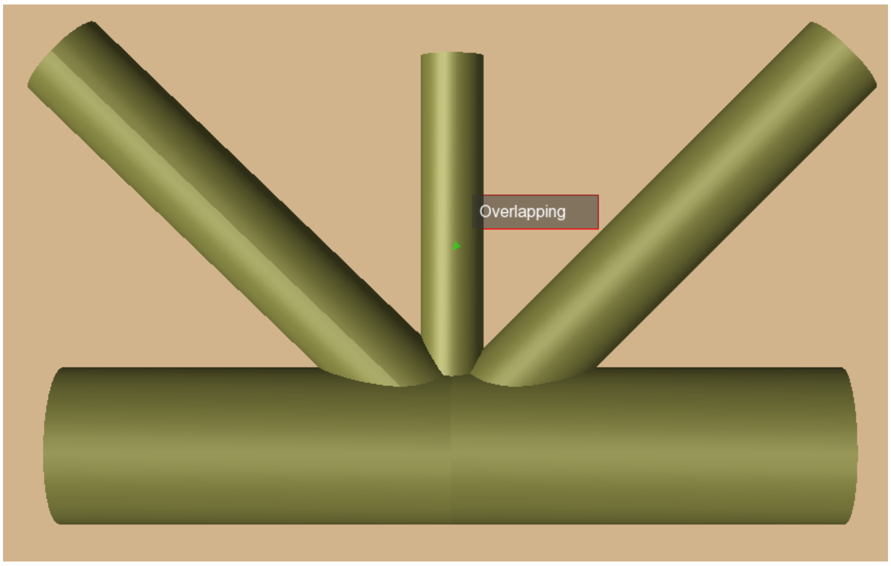
Note 2) to 14.4 Overlapping circular tubular joints:

For KT joints with double overlap the two geometric configurations shown below are handled with respect to calculating the additional checks described in section 14.4 Overlapping circular tubular joints items a) through e). 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 14.4 are not assessed for the KTKs.

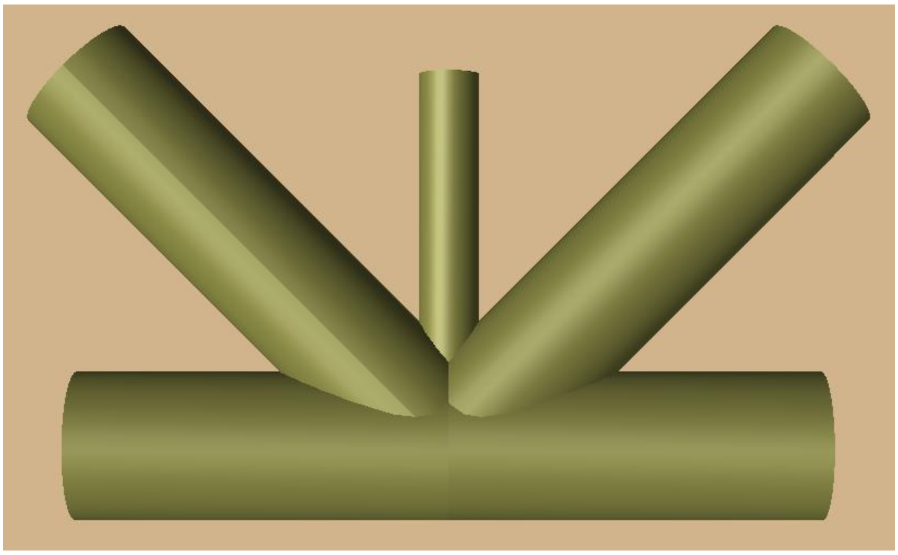
The KTT is the through brace and both KTKs overlap the KTT as shown below:



The KTT is overlapping both the KTKs as shown below:

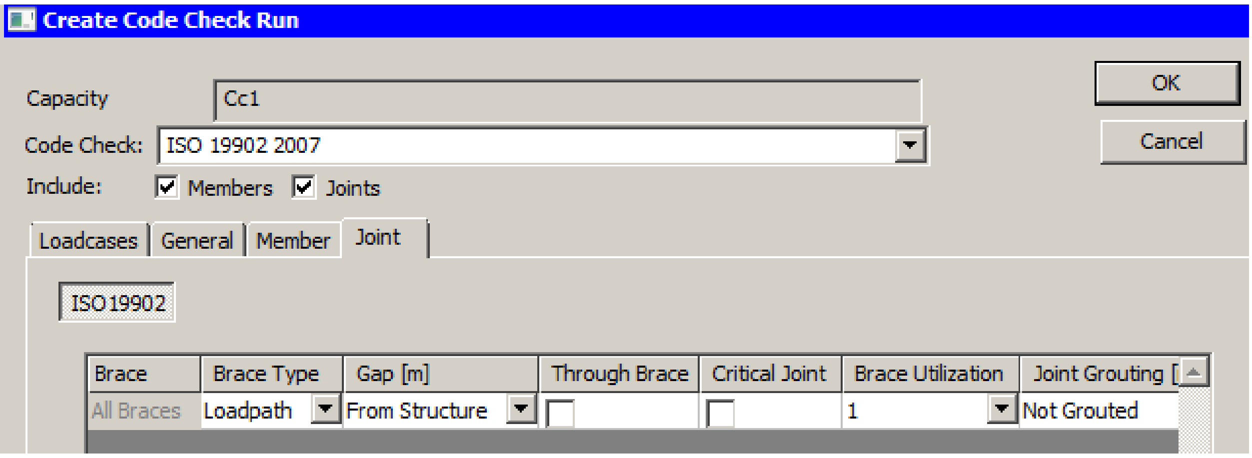


Also note that the configuration shown below is not supported, i.e. when the KTT does not touch the chord (KTKs are overlapping).

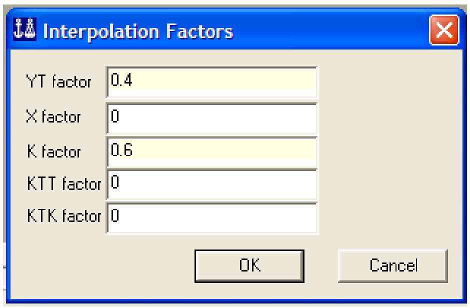
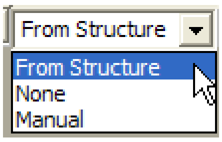


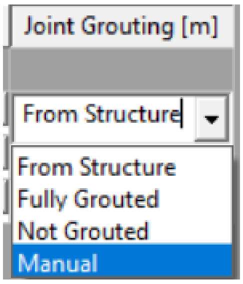
For a geometric configuration shown above the middle brace must be modelled with one of the diagonal braces as chord.

Joint specific parameters:



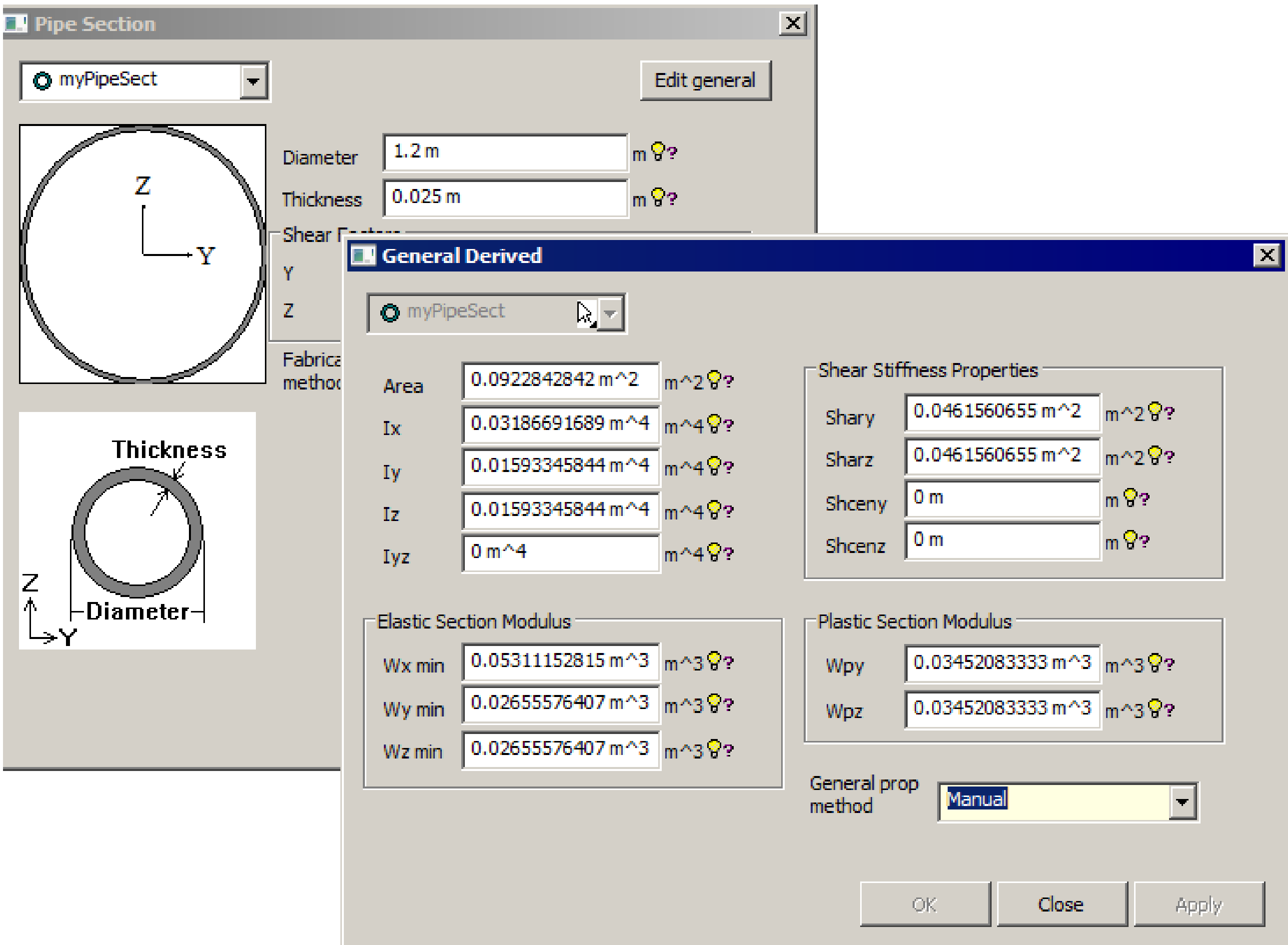
Options:

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) - interpolate using manual input 
Gap	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
Through Brace	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.
Critical joint Brace Utilization	Select if the joint shall be classified as critical. If critical: For each brace select if the brace utilization Ub shall be automatically read from the member check or alternatively give a manually defined usage factor. A value of 1.0 is used when: - Ub is < 0.001 - Ub is > 1.0
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 modelled.

1.5 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.

1.6 Nomenclature

1.6.1 Member check ISO 19902

The print of all available results inclusive intermediate data from the member check will report the following data. In the print o is used to represent σ (sigma).

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 ISO 19902 member check
GeomCheck	Status regarding any violation of geometric limitations
(13.2-2)	Usage factor according to (13.2-2), axial tension
(13.2-4)	Usage factor according to (13.2-4), axial compression
Euler	Usage factor with respect to Euler load capacity
(13.2-12)	Usage factor according to (13.2-12), bending moment
(13.2-17)	Usage factor according to (13.2-17), beam shear
(13.2-19)	Usage factor according to (13.2-19), torsional shear
(13.3-2)	Usage factor according to (13.3-2), axial tension and bending
(13.3-2ax)	Axial contribution to usage factor according to (13.3-2)
(13.3-2mo)	Moment contribution to usage factor according to (13.3-2)
(13.3-7)	Usage factor according to (13.3-7), axial compression and bending
(13.3-7ax)	Axial contribution to usage factor according to (13.3-7)
(13.3-7mo)	Moment contribution to usage factor according to (13.3-7)
(13.3-8)	Usage factor according to (13.3-8) , axial compression and bending
(13.3-8ax)	Axial contribution to usage factor according to (13.3-8)
(13.3-8mo)	Moment contribution to usage factor according to (13.3-8)
(13.2-31)	Usage factor according to (13.2-31), external pressure
(13.4-12)	Usage factor according to (13.4-12), axial tension, bending and hydrostatic pressure
(13.4-12ax)	Axial contribution to usage factor according to (13.4-12)
(13.4-12mo)	Moment contribution to usage factor according to (13.4-12)
(13.4-19)	Usage factor according to (13.4-19), axial compression, bending and hydrostatic pressure
(13.4-19ax)	Axial contribution to usage factor according to (13.4-19)
(13.4-19mo)	Moment contribution to usage factor according to (13.4-19)
(13.4-20)	Usage factor according to (13.4-20) , axial compression, bending and hydrostatic pressure
(13.4-20ax)	Axial contribution to usage factor according to (13.4-20)
(13.4-20mo)	Moment contribution to usage factor according to (13.4-20)
(13.4-21)	Usage factor according to (13.4-21), axial compression, bending and hydrostatic

	pressure
(C202-3.1.1)	Usage factor according to the stability requirement of local buckling Eqn(3.1.1)
(C202-3.8.2)	Usage factor according to the stability requirement for a column buckling, Eqn(3.8.2)
(C202-3.8.2ax)	Axial contribution to the usage factor of (C202-3.8.2)
(C202-3.8.2mo)	Moment contribution to the usage factor of (C202-3.8.2)
D/t	The D/t ratio (outer diamter / wall thickness)
thk(m)	Tubular wall thickness in meter
relpos	Relative position along member longitudinal axis (start = 0, end = 1)
D	Tubular outside diameter
thk	Tubular wall thickness
fy	Yield strength
E	Young's modulus of elasticity
Nx	Axial force (negative when compression)
My	Bending moment about local y axis
Mz	Bending moment about local z axis
V	Beam shear force
Mv,t	Torsional moment
oa	Axial stress (negative when compression)
ot	Axial tensile stress
ft	Representative axial tensile strength, Ft = Fy
oc	Axial compressive stress
fc	Representative axial compressive strength
fyc	Representative local buckling strength
fxe	Representative elastic local buckling strength
ob,y	Bending stress with respect to bending moment about local y axis
ob,z	Bending stress with respect to bending moment about local z axis
ob,yS	Design bending stress about local y axis for use in Stability calculations, ref equations (13.3-7) and (13.4-20)
ob,zS	Design bending stress about local z axis for use in Stability calculations, ref equations (13.3-7) and (13.4-20)
fb	Representative bending strength
taub	Beam shear stress
taut	Torsional shear stress
p	Water pressure (exclusive partial action factor)
oh	Hoop stress from factored hydrostatic pressure
fh	Representative hoop buckling strength
fhe	Elastic hoop buckling strength
KLy	Effective length factor times unbraced length for buckling about member y-axis
KLz	Effective length factor times unbraced length for buckling about member z-axis
Cm,y	Reduction factor corresponding to member y-axis

Cm,z	Reduction factor corresponding to member z-axis
Lr	Length between ring stiffeners
fe,y	Euler buckling strength with respect to buckling about local y axis
fe,z	Euler buckling strength with respect to buckling about local z axis
ot,c	Axial tensile stress due to forces from factored actions (incl. capped-end action)
oc,c	Axial compressive stress due to forces from factored actions (incl. capped-end action)
ox	Maximum combined compressive stress
ft,h	Representative axial tensile strength in the presence of external hydrostatic pressure
fb,h	Representative bending strength in the presence of external hydrostatic pressure,
fc,h	Representative axial compressive strength in the presence of external hydrostatic pressure,
	The following symbols are for DNVGL RP-C202 Edition 2019.
stjsd	Design equivalent von Mises' stress
gmm_Loc	Material factor of Eqn(3.1.1)
fEa	Elastic buckling strength for axial force
fEm	Elastic buckling strength for bending moment
fEh	Elastic buckling strength for hydrostatic pressure
fEt	Elastic buckling strength for shear stress
gmm_Col	Material factor of Eqn(3.8.2)
faka	Reduced characteristic buckling strength under axial compression
fakm	Reduced characteristic buckling strength under bending moment

1.6.2 Cone check ISO 19902

The print of all available results inclusive intermediate data from the cone check will report the following data. In the print o is used to represent σ (sigma).

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 ISO 19902 cone check
GeomCheck	Status regarding any violation of geometric limitations
(13.6-10)	Usage factor according to (13.6-10)
(13.6-13)	Usage factor according to (13.6-13)
(13.6-14)	Usage factor according to (13.6-14)
(13.6-18)	Usage factor according to (13.6-18)
(13.6-21)	Usage factor according to (13.6-21)
(13.6-22)	Usage factor according to (13.6-22)

HoopBuckl	Usage factor with respect to Hoop Buckling of cone
EqTubShea	Governing shear usage factor of Equation (13.2-17) and Equation (13.2-19).
EqTubComb	Governing usage factor of Equation (13.3-2), (13.3-7) and (13.3-8) for the combined axial force and bending moments without hydrostatic pressure, or Equation (13.4-12), (13.4-19, 20, 21) for the combined axial force and bending moments with hydrostatic pressure.
Alpha	The slope angle of the cone
D/t	Ratio of diameter over thickness of the equivalent tubular of current position in cone
relpos	Relative position along member longitudinal axis (start = 0, end = 1)
Ds	Outer cone diameter at the section of current position in cone
tc	Cone thickness
Dj	Cylinder diameter at the closest junction
t	Cylinder wall thickness at the closest junction
De	Equivalent tubular diameter of current position in cone
Ps	Axial force at section
Ms	Bending moment at section
p	Water pressure at the current position (exclusive partial action factor)
pLFac	Partial action factor applied on hydrostatic pressure
flood	Indicator of Flooded member (=0 for non-flooded; =1 for flooded)
oa,eq	Equivalent axial stress at section
oa,c	Axial stress at section due to global axial force
ob,c	Bending stress at section due to bending moments
ob,jt	Local bending stress at the tubular side of the junction
ob,jc	Local bending stress at the cone side of the junction
oa,t	Axial stress in the tubular section at the junction due to global axial force
ob,t	Bending stress in the tubular section at the junction due to global bending moments
oh,t	Hoop stress at the tubular side of the junction due to the global axial force and bending
oh,c	Hoop stress at the cone side of the junction due to the global axial force and bending
ohq,t	Hoop stress oh,t including the capped-end effect from the hydrostatic pressure
ohq,c	Hoop stress oh,c including the capped-end effect from the hydrostatic pressure
omaxt	Maximum axial tensile stress at the junction, tubular side
omaxc	Maximum axial tensile stress at the junction, cone side
oh,jt	Net hoop stress at the junction of the tubular side
oh,jc	Net hoop stress at the junction of the cone side
fy_t	Yield strength of the tubular
fxe_t	Representative elastic local buckling strength of the tubular side at the junction
fhe_t	Elastic hoop buckling strength of the tubular side at the junction
fh_t	Representative hoop buckling strength of the tubular side at the junction
fyc_t	Representative local buckling strength of the tubular side at the junction
fy_c	Yield strength of the cone
fxe_c	Representative elastic local buckling strength of the cone side at the junction

fhe_c	Elastic hoop buckling strength of the cone side at the junction
fh_c	Representative hoop buckling strength of the cone side at the junction
fyc_c	Representative local buckling strength of the cone side at the junction
fxc	Representative local buckling strength of the cone with equivalent diameter at the current position
Pey	Critical column buckling force w.r.t. the major bending axis
Pez	Critical column buckling force w.r.t. the minor bending axis
ften	Axial tensile strength of the equivalent tubular (hydrostatic pressure included if any)
fcom	Axial compressive strength of the equivalent tubular (hydrostatic pressure included if any)
fbcap	Bending strength of the equivalent tubular (hydrostatic pressure included if any)

Note: If the code check position locates inside the cone segment, the tubular side stresses and the local stresses at the junctions are reported as 0; and the junctions checks are skipped. The associated stresses, strengths, and usage factors are shown as 0.

1.6.3 Tubular joint check ISO 19902

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

Member	Capacity model name (brace name)
Loadcase	Name of load case/combination under consideration
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 ISO 19902 joint capacity check
GeomCheck	Status regarding any violation of geometric limitations
Uj	Usage factor according to equation (14.3-11)
Ujax	Axial contribution to usage factor according to equation (14.3-11)
Ujmo	Moment contribution to usage factor according to equation (14.3-11)
Ujmod	Usage factor from through brace in overlapping joint, modified loads
Ujaxmod	Axial contribution in Ujmod
Ujmomod	Moment contribution in Ujmod
Ujove	Usage factor from overlap brace in overlapping joint, through brace as chord
Ujaxove	Axial contribution in Ujove
Ujmoove	Moment contribution in Ujove
Ujshear	Shear utilisation, overlapping joint
beta	Value of β (= d/D), geometric limitation; $0.2 < \beta < 1$.
gamma	Value of γ (= D/2T)
theta	Angle between brace and chord
tau	The ratio t/T
gap_D	The gap/D ratio

Uj,ipb	usage factor, contribution from in-plane bending
Uj,opb	usage factor, contribution from out-of-plane bending
PB	Axial for in brace
Pd	Design value of joint axial strength
MB,ipb	Bending moment in brace, in-plane-bending
Md,ipb	Design value of joint bending moment strength, in-plane-bending
MB,opb	Bending moment in brace, out-of-plane-bending
Md,opb	Design value of joint bending moment strength, out-of-plane-bending
Qu,ax	Strength factor dependant of joint and load type, axial
Qu,ipb	Strength factor dependant of joint and load type, in-plane bending
Qu,opb	Strength factor dependant of joint and load type, out-of-plane bending
Qf,ax	Factor to account for forces in chord, axial
Qf,ipb	Factor to account for forces in chord, in-plane bending
Qf,opb	Factor to account for forces 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
CanRFac	reduction factor r in section 14.3.5
fy	Yield strength of chord
Ub	The calculated brace utilization from the applicable brace interaction equation checks from Clause 13. (For braces connected to non-critical joints this value is not relevant and a value of -1.0 is reported.)
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
Tp	Wall thickness of inner member (inner pile)

Note that the joint utilization Uj is always scaled with respect to unity, hence for braces connected to a critical joint the utilization factor Uj is multiplied by (γ_{zj}/Ub). For a given value of Ub > 1.0 and Ub close to zero the check uses Ub = 1.0.

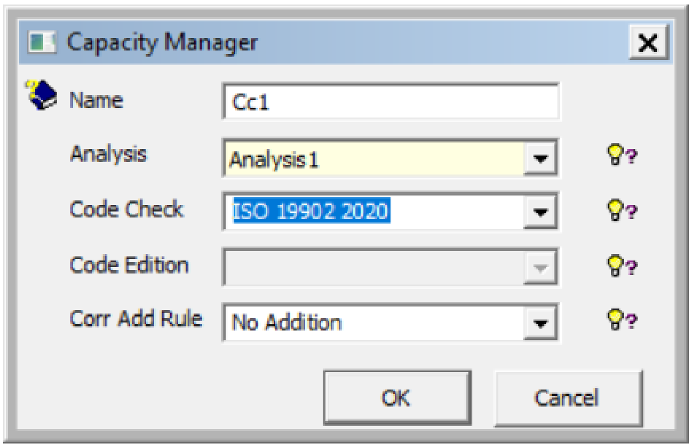
2. IMPLEMENTATION OF ISO 19902 EDITION 2020

The implementation of ISO 19902 is according to "**International Standard ISO 19902, Petroleum and natural gas industries – fixed offshore structures, Second edition, 2020".** The N 1304 Note on ISO 19902-2020 Typographical Errors R3 received on May 23, 2022 has been included.

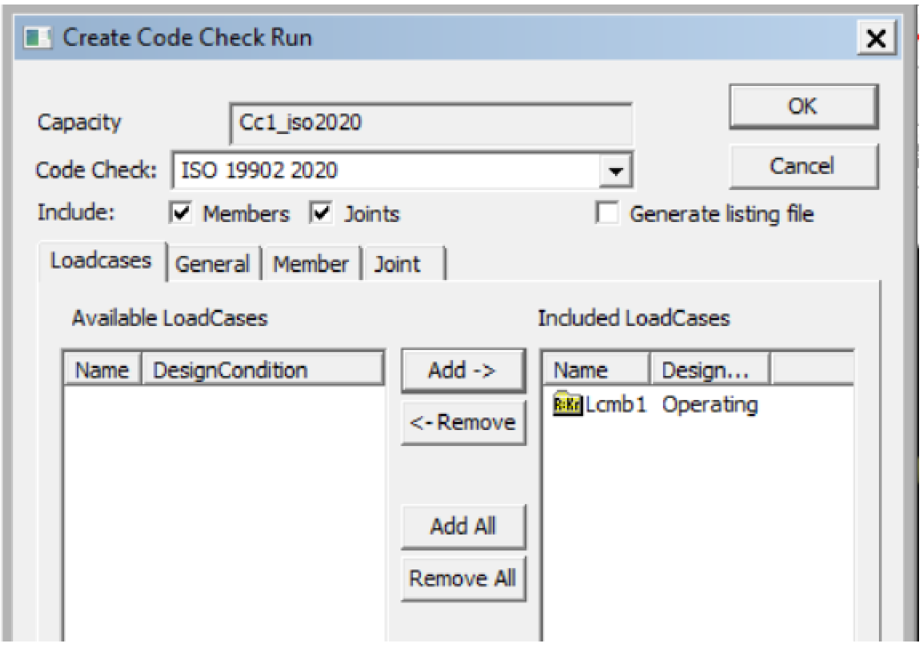
The implementation in the latest GeniE release covers the code check of tubular members and tubular joints according to chapter **13 "Strength of tubular members"** and chapter **14 "Strength of tubular joints"**. The clause **13.6 Conical Transitions** has been included for conical segments strength code check.

2.1 New Code Check Run option

Select ISO 19902 2020 from the **Code Check** box in the **Capacity Manager** dialog. Note that this code check includes Eurocode 3 EN 1993-1-1 2005 for non-tubular members. (See comments in table below regarding resistance factors.)

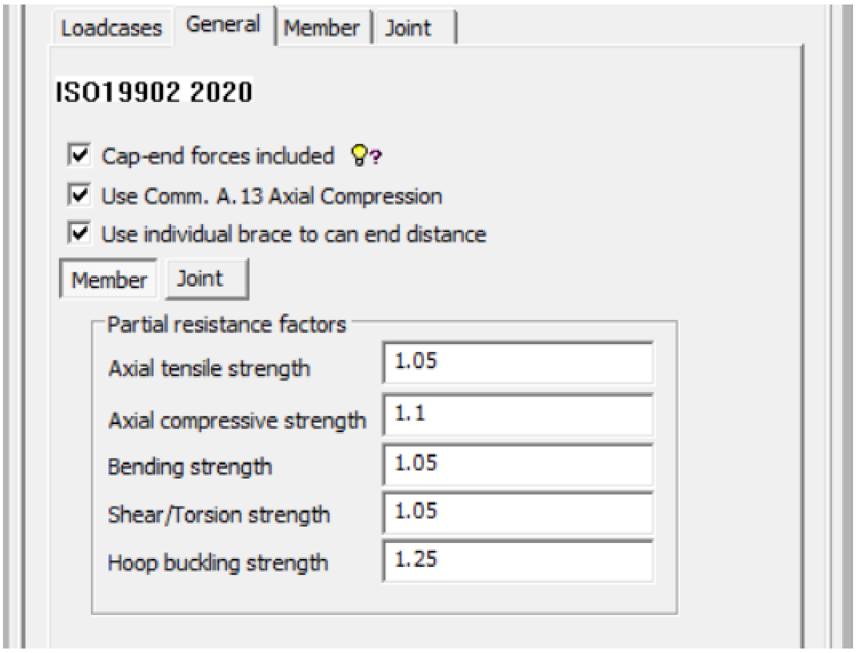


The load case or load combination for the code check can be specified at **Loadcases** Tab of **Create Code Check Run** dialog,

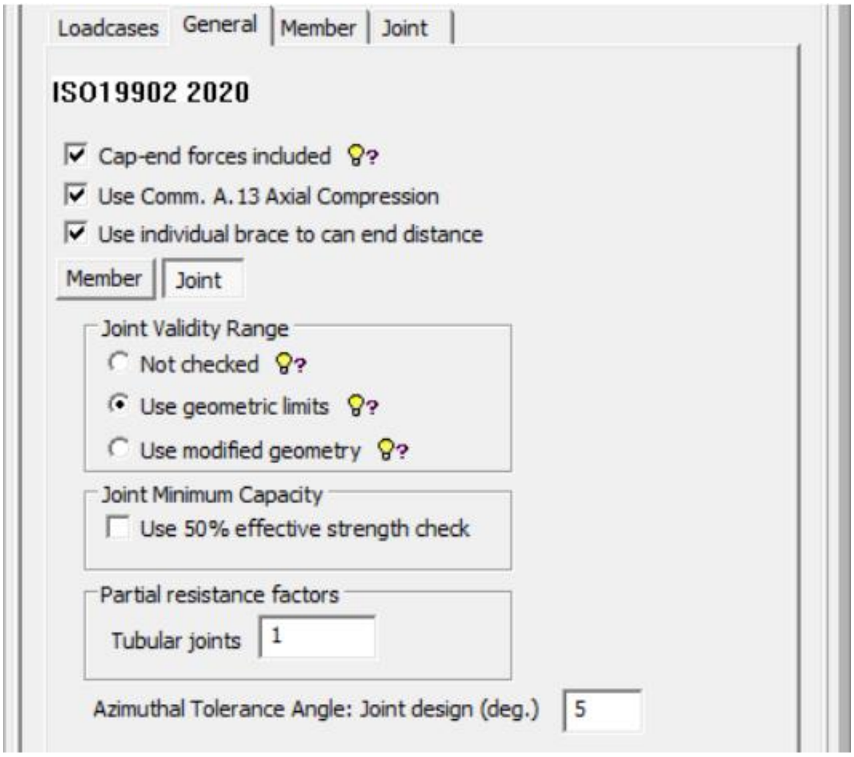


Define the global (General) parameters regarding capped-end forces and resistance factors. The coefficients C1, C2 and C3 used in the joint strength calculations are NOT allowed to change for ISO 19902 2020.

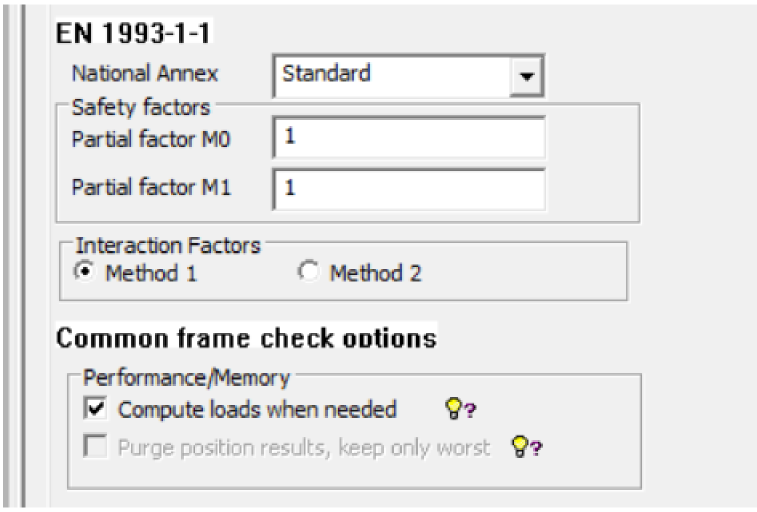
Genral options, member:



General options, joint:



The non-tubular members are checked against Eurocode 3 EN 1993-1-1



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.
Use Comm. A.13 Axial Compression	The method described in the commentary part “A.13.2.3.2. Column buckling” is used, i.e. equations (A.13.2-1) and (A.13.2-2) are taken into account. Pcr, the representative axial compressive strength is applied on the calculation of fc The “Energy method of column bcukling” is recommended when using this option.
Use Individual brace to can end distance	This option is recommended and set to the default. The individual brace to can end distance defines the can extension length (*a*,*b*,*c* in ISO 19902 Figure 14.3-1) in the reinforced chord effect, i.e. the reduction factor in Formula (14.3-11). The can extension length is relevant to the effective total chord length, Lc.
Partial resistance factors	Give the partial resistance factors to be used, defaults given according to the standard. - For member check five resistance factors are used. For structural shapes other than circular tubulars the resistance factors in the national or regional building code shall be modified by the application of a *building standard correspondence factor*, ref. ISO 19901-3. This must be handled manually. - For joint capacity check, only one resistance factor is used. Minimum cut-off value for braces usage factor in version 2007 is removed.
Joint validity range	**Use geometric limits (default)**: 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. Note: in practice, the program will run the first utilization calculation for (a) and run for the second time to get the utilizations for (b). The final utilization is sorted out from both sets of utilizations. **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.

<table>
<tr><td>Joint Minimum Capacity</td><td>The minimum joint strength will be checked if this option is turned on. Ref. 14.2.3 ISO 19902 2020.</td></tr>
<tr><td>Non-dimensional strength factor (removed)</td><td>The Qu formula for X-joint in tension of ISO 19902 2020 has taken the proposed formula (8) in the paper: New data on the Capacity of X-joints Under Tension and Implication for Codes Proceedings of ASME 27th International conference on Offshore Mechanics and Artic Engineering.

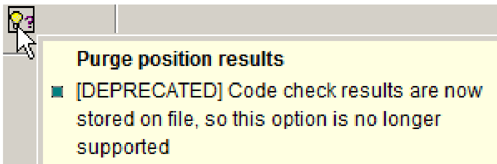
$$Qu = 6.4\gamma^{(0.6\beta^2)}$$

The option in version 2007 is removed for version 2020.</td></tr>
<tr><td>Tolerance Angle</td><td>User can define azimuthal tolerance angle for joint design. Previous versions used 5 degrees as 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>Common frame check options</td><td>

Compute loads when needed

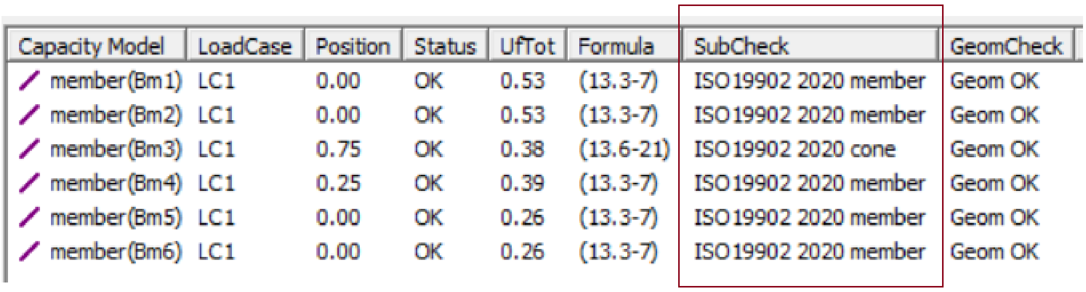
- To reduce use of database memory, you can compute temporary loads (during code check execution). These loads will be deleted immediately when no longer needed.
- This option can affect performance on redesign, as loads must be recalculated locally every time you change member/joint settings.
- With 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.

Purge position results, keep only worst



</td></tr>
</table>

The SubCheck shows ISO 19902 2020 member or cone in the Capacity Manager and the listing reports.



Capacity Model	LoadCase	Position	Status	UfTot	Formula	SubCheck	GeomCheck
member(Bm1)	LC1	0.00	OK	0.53	(13.3-7)	ISO19902 2020 member	Geom OK
member(Bm2)	LC1	0.00	OK	0.53	(13.3-7)	ISO19902 2020 member	Geom OK
member(Bm3)	LC1	0.75	OK	0.38	(13.6-21)	ISO19902 2020 cone	Geom OK
member(Bm4)	LC1	0.25	OK	0.39	(13.3-7)	ISO19902 2020 member	Geom OK
member(Bm5)	LC1	0.00	OK	0.26	(13.3-7)	ISO19902 2020 member	Geom OK
member(Bm6)	LC1	0.00	OK	0.26	(13.3-7)	ISO19902 2020 member	Geom OK

2.2 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
13	Strength of tubular members	**13.1** General [1)] **13.2** Tubular members subjected to tension, compression, bending, shear or hydrostatic pressure - 13.2.2 Axial tension - 13.2.3 Axial compression - 13.2.3.1 General - 13.2.3.2 Column buckling - 13.2.3.3 Local buckling - 13.2.4 Bending - 13.2.5 Shear - 13.2.5.1 Beam shear - 13.2.5.2 Torsional shear - *13.2.5.3 Combined beam shear and torsion shear* - 13.2.6 Hydrostatic pressure - 13.2.6.1 Calculation of hydrostatic pressure [2)] - 13.2.6.2 Hoop buckling **13.3** Tubular members subjected to combined forces without hydrostatic pressure - 13.3.2 Axial tension and bending - 13.3.3 Axial compression and bending - *13.3.4 Axial tension or compression, bending, shear and torsion* **13.4** Tubular members subjected to combined forces with hydrostatic pressure - 13.4.2 Axial tension, bending, and hydrostatic pressure - 13.4.3 Axial compression, bending, and hydrostatic pressure - *13.4.4 Axial tension or compression, bending, hydrostatic pressure, shear and torsion* **13.5** Effective lengths and moment reduction factors [3)]
	Conical transition	**13.6** Conical transitions - 13.6.1 General - 13.6.2 Design stresses - 13.6.2.1 Equivalent axial stress in conical section - 13.6.2.2 Local stresses at unstiffened junctions - 13.6.3 Strength requirements without external hydrostatic pressure - 13.6.3.1 General

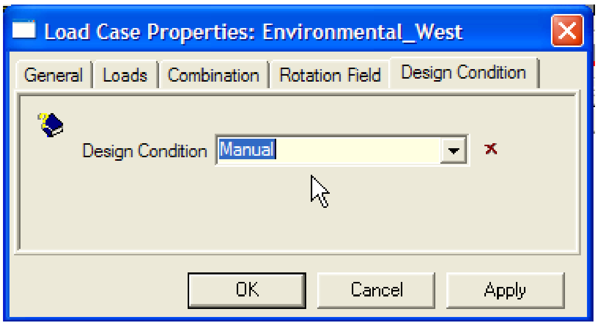
		Conical transition is checked as per 13.3 as the equivalent tubular segment. - 13.6.3.2 Local buckling within conical transition - 13.6.3.3 Junction yielding - 13.6.3.4 Junction buckling - 13.6.4 Strength requirements with external hydrostatic pressure - 13.6.4.1 Hoop buckling *Conical transition is checked as per 13.4 as the equivalent tubular segment.* - 13.6.4.2 Junction yielding and buckling

Note 1) to 13.1:

Limits with respect to yield strength is not checked.

Note 2) to 13.2.6.1:

The partial action factor $\gamma_{f,G1}$ is defined through the "Design condition factor" connected to the load case / load combination. Replace "Manual" with a user-defined value or set to Operating → $\gamma = 1.3$, Storm → $\gamma = 1.1$ or Earthquake → $\gamma = 1.1$



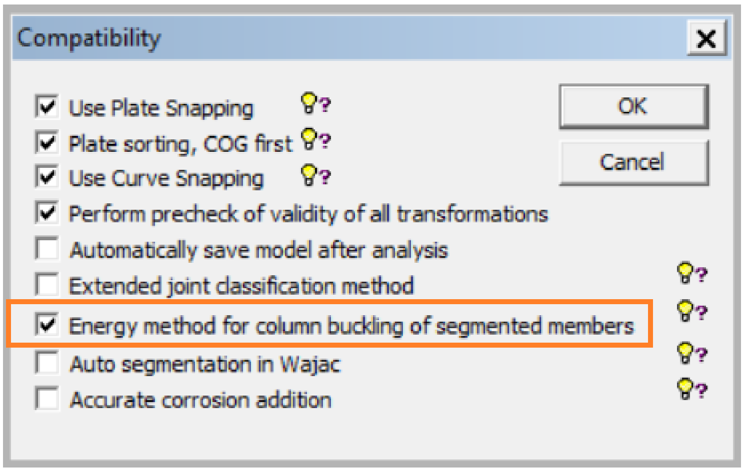
Note 3) to 13.5:

Reference is made to Table 13.5-1 with respect to selecting the moment reduction factor Cm. When selecting moment reduction factor option "ISO 2 or 3" the following criteria is used to determine if the beam is exposed to transverse loading or not. Note that the effect from self weight is included in this evaluation:

4. Calculate bending moment at midspan (point closest to midspan from check positions investigated) based on moment at start and end of beam, i.e. a linear distribution "Mlin"
5. Calculate difference "Δmom" between acting moment and "Mlin"
6. If "Δmom" is less than 1% of acting moment at the investigated point a linear distribution is assumed, i.e. no transverse loading

Note on Column Buckling

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 recommended. See User Documentation section 2.1.4.8 Compatibility Options: "**Energy method for column buckling of segmented members**". The option can be selected at Edit->Rules->Compatibility of GeniE's menu.



Note on strength reduction due to high shear stresses

The design standard ISO 19902 2020 highlights the influence of shear stresses on the strength of the member due to high torsional shear and bending shear. The high torsional shear stress equivalently reduces the yielding strength, i.e. Eqn(13.3-9) and Eqn(13.3-10). Consequently, the local buckling strength fyc, axial tensile strength ft, and compressive strength fc, and bending strength fb will be modified. Further modification will be made on the strengths when the bending shear stress is over the limit of Eqn(13.3-11), i.e. Eqn(13.3-12) and Eqn(13.3-17). The strength reduction due to shear stress is made for the member subjected to combined forces with hydrostatic pressure and is also considered in calculating the representative axial compressive strength of Commentary A.13.2.3.2. For conical transition check, the shear stress reduction on strength has been considered at the relevant utilization calculation.

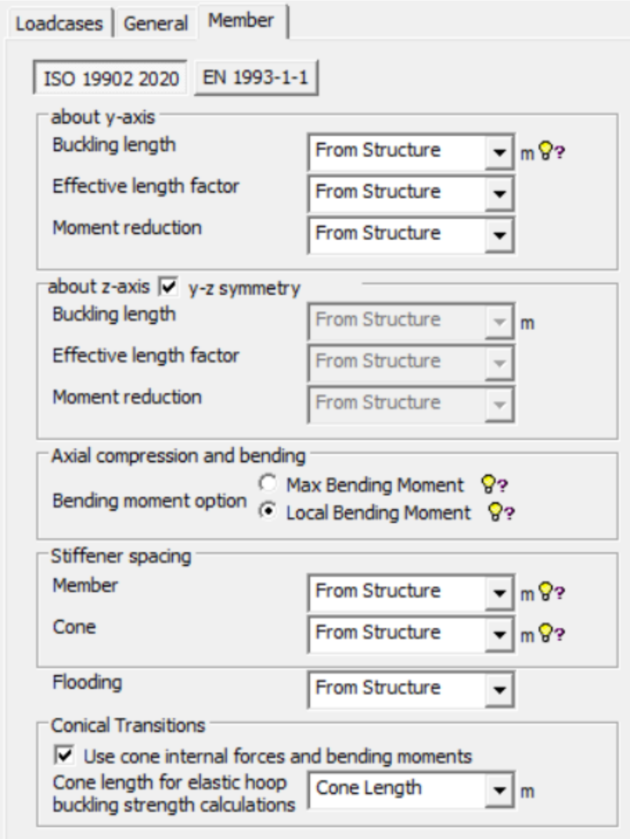
Note on potential invalid values in formula:

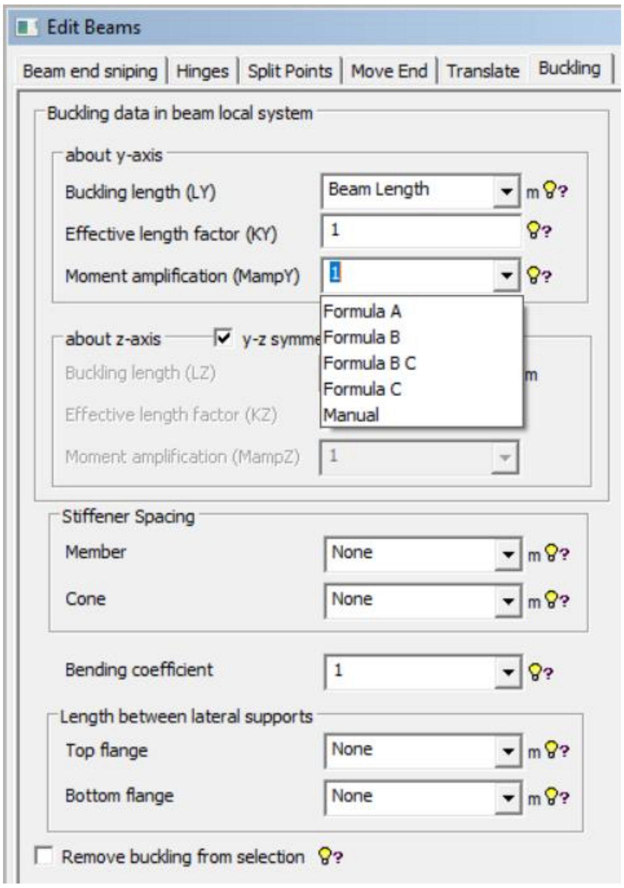
In Eqn(13.2-8,9), the value of representative local buckling strength fyc can become invalid when the ratio of D/t is large, which results in a very small elastic local buckling stregnth. The program refers to the relevant part of Norsok N-004 2021 to avoid the numerical problem.

In Eqn(13.3-13) to Eqn(13.3-17), the reduction ratio can become un-realisitic (i.e. negative) if the bending shear stress is too large w.r.t. the shear strength. The program will avoid this occurring in utilization calculation.

The ratio of σ_q/fyc can make Eqn(13.4-15,16) become invalid mathematically. It usually occurs when the representative local buckling strength is reduced by high shear stresses and the hydrostatic pressure is high. The program will take the cut-off value of fch to avoid numerical problem in calculation.

In Eqn(13.6-14a,b), the local bending plasticification utilization ratio can become numerically wrong when σ_{max}/fy≥1. In this case, the program will report Um=σ_{max}/fy.





Definition of member specific parameters:

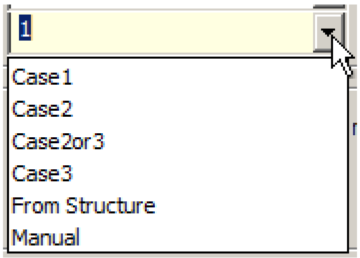
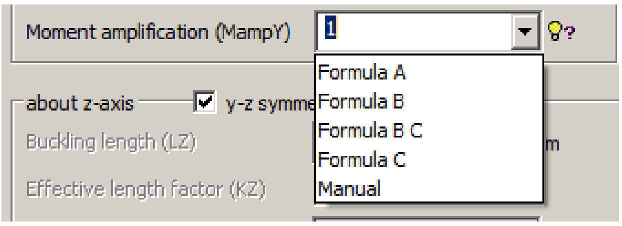
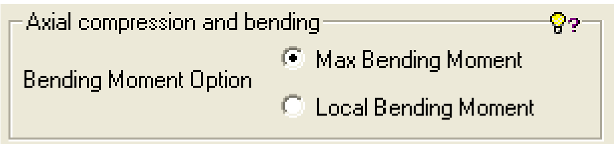
For the Member specific parameters shown above (to the left) set to From Structure the values will be inherited from the assignments done to the Beam concept (dialog to the right).

The default member data for tubular members are shown. Notice that there are different properties for tubular members and non-tubular members (using EN 1993-1-1). 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

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. Table 13.5-1, i.e. alternatives (1), (2), (2) or (3), (3)

	 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 → Case 1 , Formula B → Case 2, Formula B C → Case 2 or 3, Formula C → Case 3 **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. **Local Bending Moment** This option uses the local bending moments at every code check positions.
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	The strength check in clause 13.6 has been implemented in GeniE. The strength checks on local buckling, junction yielding, junction buckling and hoop buckling are performed. The conical segment is additionally checked as the equivalent tubular segment to assure not to fail by the combined axial force/bending moments/shear forces with or without hydrostatic pressure. The equivalent diameter is De=Ds/cos(α), according to Equation (13.6-9). The

	tubular thickness is the actual wall thickness of the cone. The code check position can locate on the junctions and inside the cone. • The strength requirements without and with external hydrostatic pressure are checked according to 13.3 and 13.4 respectively. • The bending moment reduction factor Cm is a constant 0.85 for both major and minor bending axis. The option of moment amplification on the capacity member is not effective. • “Energy method” of column buckling of segmented member is supported. • The strength reduction due to high shear stresses is considered. • The check on the equivalent tubular section is performed on every code check position. If the position locates inside the conical transition the junction yielding check and buckling check are skipped. • The alternative method to calculate axial compressive strength described in the commentary part “A.13.2.3.2. Column buckling” is supported. • Geometric Check Failed will be reported if the ratio of equivalent diameter over cone thickness De/tc is greater than 0.2E/fy of the conical side material. No checking as per RP-C202 will be made.

2.3 Member with D/t > 0.2E/fy design check – DNVGL-RP-C202

If the diameter over thickness ratio D/t > 0.2E/*fy*, the check against Geometric requirement of ISO 19902 2020 will show failed. Then, the strength check according to DNVGL RP C202 will be triggered. The utilizations will be included in sorting out the final governing usage factor. The calculation is the same as the implementation for ISO 19902 2007.

2.4 Tubular joint design code check – ISO 19902 2020

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

	Design consideration	Sections covered
14	Strength of tubular joints	**14.2** Design considerations - 14.2.3 Minimum joint strength[1)] - 14.2.5 Joint classification **14.3** Simple circular tubular joints - 14.3.1 General - 14.3.2 Basic joint strength [2)] - 14.3.3 Strength factor Q_u - 14.3.4 Chord force factor Q_f - 14.3.5 Effect of chord can length on joint strength - 14.3.6 Strength check **A.14.3.1.1** Usable strength taken as the lesser of the strengths calculated based on actual geometrical parameters and the limiting value parameter for

		the validity range. **14.4** Overlapping circular tubular joints [3)] **14.5** Grouted circular tubular joints Enhancement has been made with the GeniE release version of 8.3. The same method in ISO 19902 2007 is applied for ISO 19902 2020. Notes to implementation wrt. Qu and Qf factors; *Fully grouted joint, tension:* Qu factors are computed according to Table A.14.5-1 and not less than those for simple joint in Table 14.3-1. The leg (outer member) wall thickness is used in formulas for Qu and Qf. The axial capacity is interpolated for mixed joint classifications. The thickened can reduction factor is ignored. The interaction equation (14.3-12) is applied for the utilization factors. *Fully grouted, compression:* The utilization factors are calculated by the interaction equations (14.3-12) with the axial brace load being set to zero. The factors Qu/Qf and the strength capacities are calculated by the same method as those in axial tension. The utilization UjGJ is reported while Uj is skipped for fully grouted joint. *Double-skin joint:* Must be checked both for condition with shear pullout and ovalisation. Report the largest usage factor for the two conditions. - Shear pullout in both tension and compression, reported by UjGJ: The same method as the fully grouted joint is applied with the leg (outer-member) wall thickness is used in Qu and Qf calculations. - Ovalisation in both tension and compression, reported by Uj: The simple joint formula are applied with the leg wall thickness replaced by the effective thickness Te, i.e. $Te = (T^2 + Tp^2)^{0.5}$ where T = wall thickness of chord and Tp = wall thickness of inner member, e.g. Qu according to Table 14.3-1 and factor ϒ = ChordDiameter/(2*Te). The axial capacity is interpolated for mixed joint classifications. The thickened can reduction factor is computed according to Te and the effective nominal thickness $Tne = (Tn^2 + Tp^2)^{0.5}$ The leg (outer-member) wall thickness is used in Qf calculations. Uj and UjGJ are compared and the larger is sorted out in UfTot.

Note 1) to 14.2.3 Minimum joint strength:

If the following 3 conditions are met, i.e. (1) the joint is specified “Critical” and (2) the capacity model of brace members are available, and (3) the option of “Use 50% effective strength check” is chosen, the minimum strength check will be performed. The chord shall have a minimum axial capacity of at least 50% of the effective strength of the incoming brace, which is

- the representative yield strength if the axial force on the brace is tensile, Formula (13.2-1). The program takes the smallest axial tensile force making the brace member yield at a cross section;
- or the compression buckling strength if the axial force on the brace is compressive, Formula (13.2-5), or (13.2-6). The program takes the smallest compressive axial force magnitude that makes a cross section fail by axial compression.

Note:
  - The Energy Method for column buckling is recommended. The alternative method for column buckling in Commentary A.13.2.3.2 is not considered in minimum joint strength check.
  - The same effective buckling length of the capacity brace member is applied. The Euler buckling force is estimated by using the size of the current cross section.
  - The effective strength of axial compression is primarily decided by the geometric size and restraint conditions, reflecting an estimated axial compression load that causes failing.
  - It shall be independent to the various loadcases except for the axial tensile or compressive condition. Therefore, the shear effect and the hydrostatic pressure effect are not considered.
  - The minimum joint strength check is skipped (Uf showing 0) for the fully grouted joint if the brace is under axial compression.
  - For the double-skin grouted joint, the chord axial capacity only considers the strength calculated with the effective thickness if the brace is under axial compression because the strength for grouted joint under axial compression is assumed larger.

Note 2) to 14.3.2:

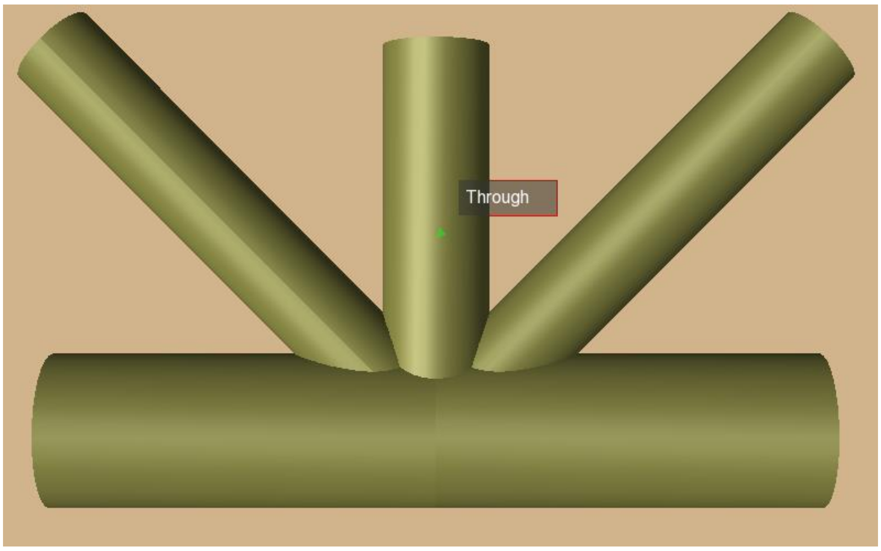
The default tensile strength for the joint capacity model is defined to 1.11 times the material yield strength (SMYS). Hence, the yield strength fy used when calculating the representative strengths will be 1.11*0.8 = 0.89 times the material yield strength when no specific tensile strength is defined.

Note 3) to 14.4 Overlapping circular tubular joints:

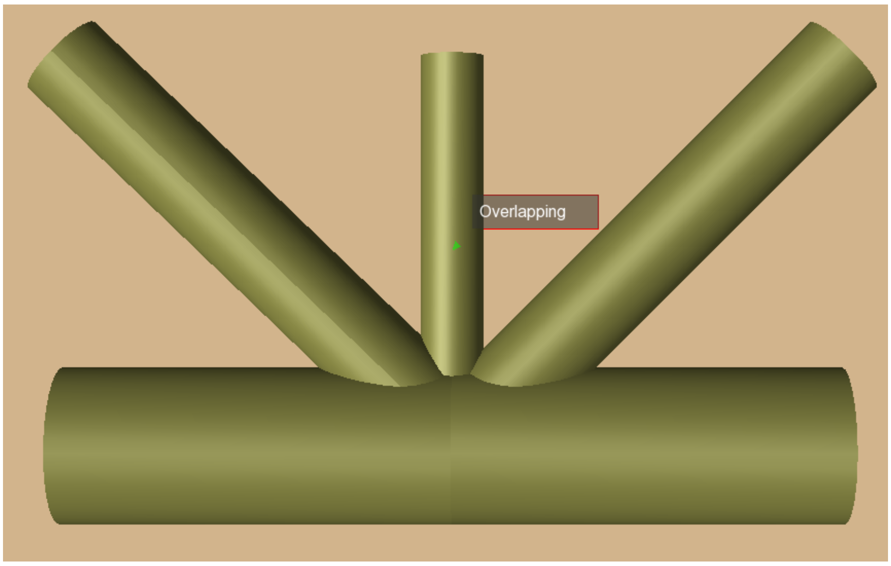
- Shearing of the brace parallel to the chord is checked and reported as Ujshear. This part has been enhanced from ISO 19902 2007.
- For Through brace, the combined axial force and bending moments are considered; the associated utilization is reported as Ujmod.
- For Overlapping brace, the strength check is done by using the Through brace as the chord, assuming Y/T type joint only. The utilization is recorded as Ujove. The joint minimum strength check is ignored for the connection of Through brace and overlapping brace.
- When determining the Through brace, the program firstly takes the brace with larger thickness, or the brace with larger outer diameter as the Through brace. The program does not check the 10% difference as the ISO standard advises. GeniE considers the Through brace is a manufacturing practice and provides a user specified option for Through brace.
- Support the case of "grouted and overlapped" joint. In ISO 19902 2007 code check of GeniE, for the grouted joints, the additional checks defined in 14.4 “Overlapping tubular joints” are NOT checked. In ISO 19902 2020 of GeniE, the grouted joints will be checked as per clause 14.4 if the brace is overlapping with the other braces. The utilization is reported in Ujmod for Through brace.

For KT joints with double overlap the two geometric configurations shown below are handled with respect to calculating the additional checks described in section 14.4 Overlapping circular tubular joints items a) through e). 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 14.4 are not assessed for the KTKs.

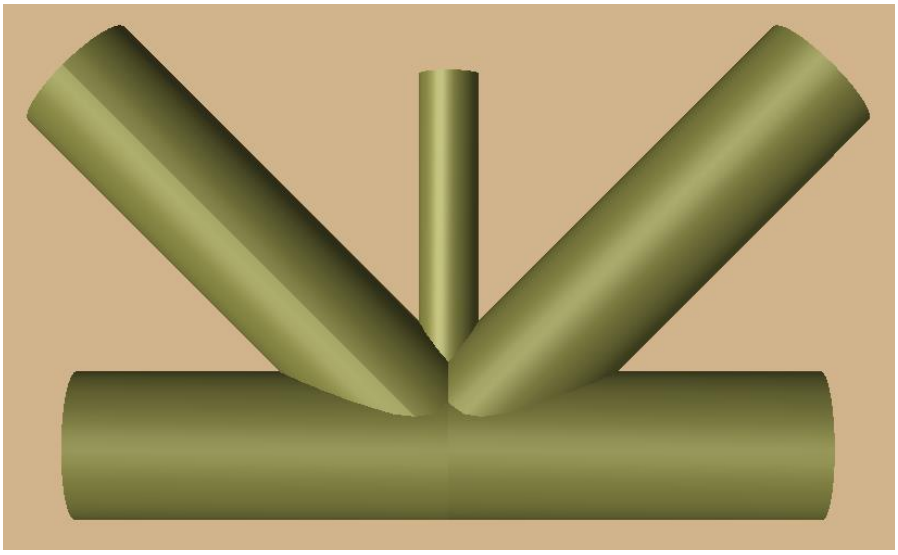
The KTT is the through brace and both KTKs overlap the KTT as shown below:



The KTT is overlapping both the KTKs as shown below:

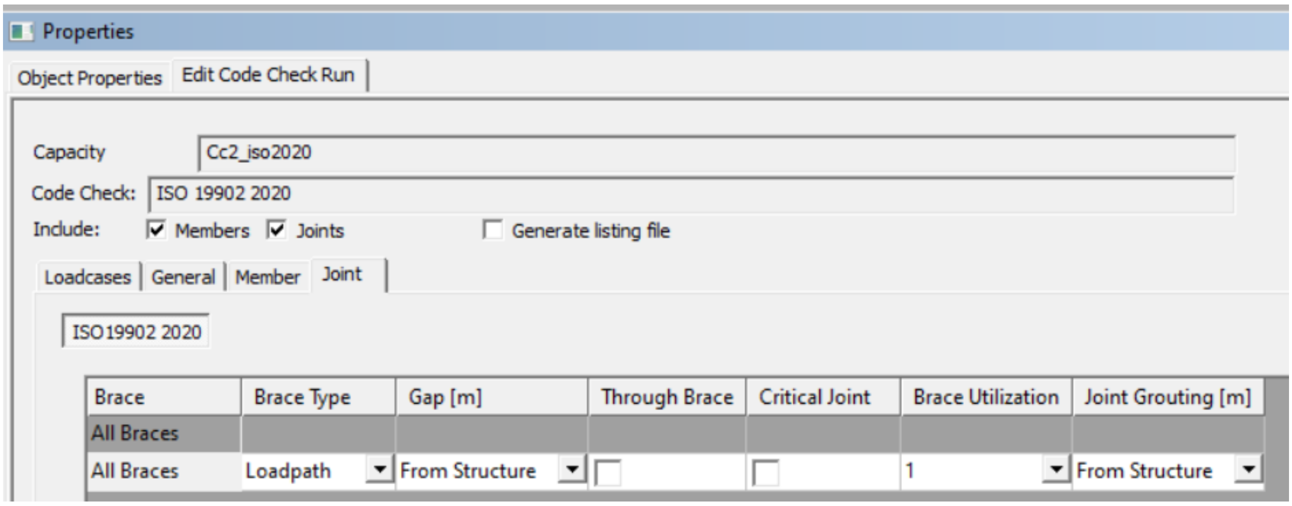


Also note that the configuration shown below is not supported, i.e. when the KTT does not touch the chord (KTKs are overlapping).

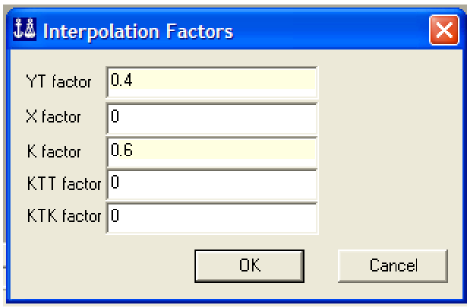


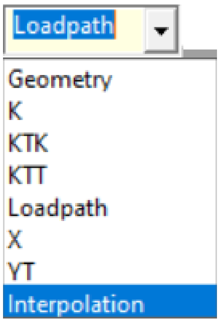
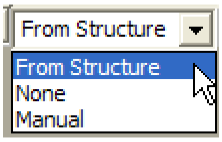
For a geometric configuration shown above the middle brace must be modelled with one of the diagonal braces as chord.

Joint specific parameters:



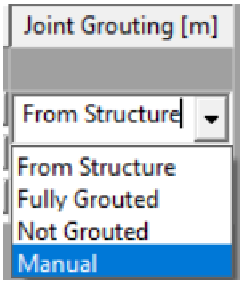
Options:

<table>
<tr><td>Brace Type</td><td>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)
- 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</td></tr>
</table>

	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.
Critical joint	Select if the joint shall be classified as critical. The Brace Utilization option is shared with ISO 19902 2007 but is ignored in the utilization calculation of ISO 19902 2020.

Joint Grouting	Select option for grouting condition. The same logic for ISO 19902 2007 is applied for ISO 19902 2020.
	
	
	- 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 modelled.

2.5 Nomenclature

2.5.1 Member check ISO 19902 2020

The nomenclature of results has been updated to address the shear stress reduction introduced in the new version of ISO 19902. The print of all available results inclusive intermediate data from the member check will report the following data. In the print, sigma represent σ, stress.

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 ISO 19902 2020 member check
GeomCheck	Status regarding any violation of geometric limitations
(13.2-2)	Usage factor according to (13.2-2), axial tension
(13.2-4)	Usage factor according to (13.2-4), axial compression
Euler	Usage factor with respect to Euler load capacity
(13.2-12)	Usage factor according to (13.2-12), bending moment
(Um_Tau_b)	Usage factor according to (13.2-17), beam shear
(Um_Tau_t)	Usage factor according to (13.2-19), torsional shear
(13.2-21)	Usage factor according to (13.2-21), combined beam shear and torsional shear
(13.3-2)	Usage factor according to (13.3-2), axial tension and bending
(13.3-2ax)	Axial contribution to usage factor according to (13.3-2)
(13.3-2mo)	Moment contribution to usage factor according to (13.3-2)
(13.3-7)	Usage factor according to (13.3-7), axial compression and bending
(13.3-7ax)	Axial contribution to usage factor according to (13.3-7)
(13.3-7mo)	Moment contribution to usage factor according to (13.3-7)
(13.3-8)	Usage factor according to (13.3-8), axial compression and bending
(13.3-8ax)	Axial contribution to usage factor according to (13.3-8)
(13.3-8mo)	Moment contribution to usage factor according to (13.3-8)
(13.3-19)	Usage factor according to (13.3-19), axial tension, bending, shear and torsion
(13.3-19ax)	Axial contribution to usage factor according to (13.3-19)
(13.3-19mo)	Moment contribution to usage factor according to (13.3-19)
(13.3-22)	Usage factor according to (13.3-22), axial compression, bending, shear and torsion
(13.3-22ax)	Axial contribution to usage factor according to (13.3-22)
(13.3-22mo)	Moment contribution to usage factor according to (13.3-22)
(13.3-23)	Usage factor according to (13.3-23), axial compression, bending, shear and torsion
(13.3-23ax)	Axial contribution to usage factor according to (13.3-23)
(13.3-23mo)	Moment contribution to usage factor according to (13.3-23)

(13.2-33)	Usage factor according to (13.2-33), external pressure
(13.4-12)	Usage factor according to (13.4-12), axial tension, bending and hydrostatic pressure
(13.4-12ax)	Axial contribution to usage factor according to (13.4-12)
(13.4-12mo)	Moment contribution to usage factor according to (13.4-12)
(13.4-19)	Usage factor according to (13.4-19), axial compression, bending and hydrostatic pressure
(13.4-19ax)	Axial contribution to usage factor according to (13.4-19)
(13.4-19mo)	Moment contribution to usage factor according to (13.4-19)
(13.4-20)	Usage factor according to (13.4-20), axial compression, bending and hydrostatic pressure
(13.4-20ax)	Axial contribution to usage factor according to (13.4-20)
(13.4-20mo)	Moment contribution to usage factor according to (13.4-20)
(13.4-12sh)	Usage factor according to (13.4-12), axial tension, bending and hydrostatic pressure with shear and torsion effect if necessary according to 13.4.4
(13.4-12shax)	Axial contribution to usage factor according to (13.4-12sh)
(13.4-12shmo)	Moment contribution to usage factor according to (13.4-12sh)
(13.4-19sh)	Usage factor according to (13.4-19), axial compression, bending and hydrostatic pressure, with shear and torsion effect if necessary according to 13.4.4
(13.4-19shax)	Axial contribution to usage factor according to (13.4-19sh)
(13.4-19shmo)	Moment contribution to usage factor according to (13.4-19sh)
(13.4-20sh)	Usage factor according to (13.4-20), axial compression, bending and hydrostatic pressure, with shear and torsion effect if necessary according to 13.4.4
(13.4-20shax)	Axial contribution to usage factor according to (13.4-20sh)
(13.4-20shmo)	Moment contribution to usage factor according to (13.4-20sh)
(13.4-21)	Usage factor according to (13.4-21), axial compression, bending and hydrostatic pressure
(C202-3.1.1)	Usage factor according to the stability requirement of local buckling Eqn(3.1.1)
(C202-3.8.2)	Usage factor according to the stability requirement for a column buckling, Eqn(3.8.2)
(C202-3.8.2ax)	Axial contribution to the usage factor of (C202-3.8.2)
(C202-3.8.2mo)	Moment contribution to the usage factor of (C202-3.8.2)
D/t	The D/t ratio (outer diameter / wall thickness)
thk(m)	Tubular wall thickness in meter
relpos	Relative position along member longitudinal axis (start = 0, end = 1)
D	Tubular outside diameter
thk	Tubular wall thickness
fy	Yield strength
E	Young's modulus of elasticity
Nx	Axial force (negative when compression)
My	Bending moment about local y axis
Mz	Bending moment about local z axis
V	Beam shear force
Mv,t	Torsional moment

UseCommA13	=1 to use CommA.13.2.3.2 Column buckling;
	=0, not to use.
EnergyColBuck	=1 to use Energy Method in column buckling of segmented member
	=0 not to use
sigma_a	Axial stress (negative when compression)
sigma_by	Bending stress with respect to bending moment about local y axis
sigma_bz	Bending stress with respect to bending moment about local z axis
sigma_byMax	Design bending stress about local y axis for use in Stability calculations, ref equations (13.3-7) and (13.4-20)
sigma_bzMax	Design bending stress about local z axis for use in Stability calculations, ref equations (13.3-7) and (13.4-20)
ft	Representative axial tensile strength, Ft = Fy
fc	Representative axial compressive strength
fyc	Representative local buckling strength
fxe	Representative elastic local buckling strength
fb	Representative bending strength
taub	Beam shear stress
taut	Torsional shear stress
p	Water pressure (exclusive partial action factor)
sigma_h	Hoop stress from factored hydrostatic pressure
flood	=1 member is flooded
	=0 member is non-flooded
fh	Representative hoop buckling strength
fhe	Elastic hoop buckling strength
KLy	Effective length factor times unbraced length for buckling about member y-axis
KLz	Effective length factor times unbraced length for buckling about member z-axis
Cm,y	Reduction factor corresponding to member y-axis
Cm,z	Reduction factor corresponding to member z-axis
Lr	Length between ring stiffeners
fe,y	Euler buckling strength with respect to buckling about local y axis
fe,z	Euler buckling strength with respect to buckling about local z axis
sigma_t	Axial tensile stress due to forces from factored actions (without capped-end action)
sigma_tc	Axial tensile stress due to forces from factored actions (reduced by capped-end actions if there is external pressure)
sigma_c	Axial compressive stress due to forces from factored actions (without capped-end action)
sigma_cc	Axial compressive stress due to forces from factored actions (including capped-end actions if there is external pressure)
sigma_x	Maximum combined compressive stress
ft,h	Representative axial tensile strength in the presence of external hydrostatic pressure
fb,h	Representative bending strength in the presence of external hydrostatic pressure,

fc,h	Representative axial compressive strength in the presence of external hydrostatic pressure,
ShearRedEffect	= 0 no shear reduction
	=1 reduction on fy due to large torsional shear stress is required as Eqn (13.3-9)
	= 2 reduction on strengths due to large bending shear stress is required
fy_t	Torsional shear reduced representative yield strength fy,t in Eqn(13.3-10)
ft_t	Representative axial tensile strength from torsional shear reduced yield strength fy,t
fb_t	Representative bending strength from torsional shear reduced yield strength fy,t
fh_t	Representative hoop buckling strength from torsional shear reduced yield strength fy,t
fyc_t	Representative local buckling strength from torsional shear reduced yield strength fy,t
ft_v	Representative axial tensile strength reduced by large torsional & bending shear
fb_v	Representative bending strength reduced by large torsional & bending shear
fyc_v	Representative local buckling strength reduced by large torsional & bending shear
fc_v	Representative axial compressive strength reduced by large torsional & bending shear
fth_v	Representative axial tensile strength in the presence of external hydrostatic pressure reduced by large torsional & bending shear
fbh_v	Representative bending strength in the presence of external hydrostatic pressure reduced by large torsional & bending shear
fch_v	Representative axial compressive strength in the presence of external hydrostatic pressure reduced by large torsional & bending shear
UseRPC202	= 1 to use DNV RPC202 if the diameter over thickness ratio D/t > 0.2E/fy
	= 0 not to use
	The following symbols are for DNVGL RP-C202 Edition 2019.
stjsd	Design equivalent von Mises' stress
gmm_Loc	Material factor of Eqn(3.1.1)
fEa	Elastic buckling strength for axial force
fEm	Elastic buckling strength for bending moment
fEh	Elastic buckling strength for hydrostatic pressure
fEt	Elastic buckling strength for shear stress
gmm_Col	Material factor of Eqn(3.8.2)
faka	Reduced characteristic buckling strength under axial compression
fakm	Reduced characteristic buckling strength under bending moment

2.5.1 Cone check ISO 19902 2020

The nomenclature of results has been updated to address the shear stress reduction introduced in the new version of ISO 19902 2020. The print of all available results inclusive intermediate data from the cone check will report the following data.

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
GeomCheck	Status regarding any violation of geometric limitations
SubCheck	Which check causes this result, here ISO 19902 2020 cone check
Run	Run Name in the Capacity Manager of GeniE
(13.6-10)	Usage factor according to (13.6-10); Local buckling check if Sigma_aeq is compressive
(13.6-13)	Usage factor according to (13.6-13); Junction yielding check for tensile Sigma_max
(13.6-14)	Usage factor according to (13.6-14); Junction yielding check for compressive Sigma_max
(13.6-14ab)	Larger usage factor according to (13.6-14a,b); local bending plastification
(13.6-18)	Usage factor according to (13.6-18); Junction buckling check for tensile Sigma_max
(13.6-21)	Usage factor according to (13.6-21); Junction buckling check for compressive Sigma_max
(13.6-22)	Usage factor according to (13.6-22); Junction buckling check for compressive Sigma_max
HoopBuckl	Usage factor of Hoop Buckling of cone as equivalent tubular, Eqn(13.2-33)
EqTubShea	Governing shear usage factor of cone as equivalent tubular section, Eqn (13.2-17), Eqn (13.2-19), and Eqn(13.2-21).
EqTubComb	Governing usage factor cone as equivalent tubular section of Eqn (13.3-2), (13.3-7) and (13.3-8) for the combined axial force and bending moments without hydrostatic pressure, or Eqn (13.4-12), (13.4-19, 20, 21) for the combined axial force and bending moments with hydrostatic pressure.
Alpha	The slope angle of the cone
D/t	Ratio of diameter over thickness of the equivalent tubular of current position in cone
relpos	Relative position along member longitudinal axis (start = 0, end = 1)
Ds	Outer cone diameter at the section of current position in cone
tc	Cone thickness
Dj	Cylinder diameter at the closest junction
t	Cylinder wall thickness at the closest junction
De	Equivalent tubular diameter of current position in cone
Ps	Axial force at current position
Ms	Bending moment at current position
p	Water pressure at the current position (exclusive partial action factor)
pLFac	Partial action factor applied on hydrostatic pressure
flood	Indicator of Flooded member (=0 for non-flooded; =1 for flooded)
Sigma_aeq	Equivalent axial stress at section, Eqn(13.6-1)
Sigma_ac	Axial stress at section due to global axial force, Eqn(13.6-2)
Sigma_bc	Bending stress at section due to bending moments, Eqn(13.6-3)
Sigma_q	Compressive axials stress due to the capped end hydrostatic pressure, to be combined with Sigma_ac in local buckling check (13.6-10). The diameter Ds is applied.
Steqv_hp	Hoop stress on equivalent tubular section De/tc due to hydrostatic pressure, to be applied in Eqn(13.2-33).
Sigma_bjt	Local bending stress at the tubular side of the junction
Sigma_bjc	Local bending stress at the cone side of the junction

Sigma_at	Axial stress in the tubular section at the junction due to global axial force
Sigma_bt	Bending stress in the tubular section at the junction due to global bending moments
Sigma_ht	Hoop stress at the tubular side of the junction due to the global axial force and bending moments from the original analysis, Eqn(13.6-6), without the capped-end effect
Sigma_hc	Hoop stress at the cone side of the junction due to the global axial force and bending moments from the original analysis, Eqn(13.6-7), without the capped-end effect
Sigma_hqt	Hoop stress at the tubular side of the junction Eqn(13.6-6) including the capped-end effect from hydrostatic pressure acting on axial term of stresses
Sigma_hqc	Hoop stress at the cone side of the junction Eqn(13.6-7) including the capped-end effect from the hydrostatic pressure acting the axial term of stresses
Sigma_maxt	Maximum axial tensile stress at the junction, tubular side
Sigma_maxc	Maximum axial tensile stress at the junction, cone side
Sigma_hjt	Net hoop stress at the junction of tubular side Eqn(13.6-26), i.e. Sigma_hqt combined with the hoop stress from hydrostatic pressure at tubular side
Sigma_hjc	Net hoop stress at the junction of cone side Eqn(13.6-26), i.e. Sigma_hqc combined with the hoop stress from hydrostatic pressure at cone side
Um_JuncBKT	Junction buckling check Eqn(13.6-21 or 13.6-22) on Tubular side
Um_JuncBKC	Junction buckling check Eqn(13.6-21 or 13.6-22) on Cone side
Um_JuncYDT	Junction yielding check Eqn(13.6-13 or 13.6-14) on Tubular side
Um_JuncYDC	Junction yielding check Eqn(13.6-13 or 13.6-14) on Cone side
Um_LocBndT	Local bending plastification Eqn(13.6-14a) on Tubular side
Um_LocBndC	Local bending plastification Eqn(13.6-14b) on Cone side
ShearRdct	= 0 no shear reduction made in equivalent tubualr section check =1 reduction on yielding strength fy due to large torsional shear stress is required as Eqn (13.3-9) in equivalent tubualr section check = 2 reduction on strengths due to large bending shear stress is required in equivalent tubualr section check
UmTau_t_eqv	Torsional shear usage factor of cone as equivalent tubular, Eqn (13.2-19) at current position
UmTau_b_eqv	Beam shear usage factor of cone as equivalent tubular, Eqn (13.2-17) at current position
UmShCmb_eqv	Combined beam shear and torsional shear usage factor of cone as equivalent tubular section, Eqn (13.2-21), at current position
UmTau_t_tub	Torsional shear usage factor at the junction on tubular side, Eqn (13.2-19)
UmTau_b_tub	Beam shear usage factor at the junction on tubular side, Eqn (13.2-17)
fy_t	Yield strength of the tubular (with torsional shear stress reduction if necessary)
fxe_t	Representative elastic local buckling strength of the tubular side at the junction
fhe_t	Elastic hoop buckling strength of the tubular side at the junction
fh_t	Representative hoop buckling strength of the tubular side at the junction
fyc_t	Representative local buckling strength of the tubular side at the junction
fy_c	Yield strength of the cone (with torsional shear stress reduction if necessary)
fxe_c	Representative elastic local buckling strength of the cone side at the junction
fhe_c	Elastic hoop buckling strength of the cone side at the junction
fh_c	Representative hoop buckling strength of the cone side at the junction
fyc_c	Representative local buckling strength of the cone side at the junction

Pey	Critical column buckling force w.r.t. the major bending axis
Pez	Critical column buckling force w.r.t. the minor bending axis
ften	Axial tensile strength of the equivalent tubular (hydrostatic pressure included if there is and shear reduction considered if necessary)
fcom	Axial compressive strength of the equivalent tubular (hydrostatic pressure included if there is and shear reduction considered if necessary)
fbcap	Bending strength of the equivalent tubular (hydrostatic pressure included if there is and shear reduction considered if necessary)
fhc_hp	Hoop buckling strength (13.2-25,26,27) of cone using the equivalent diameter at the larger side
fhec_hp	Elastic critical hoop buckling strength (13.2-28) of cone using the equivalent diameter at the larger side
fhc_EqT	Hoop buckling strength (13.2-25,26,27) of cone using the equivalent diameter at current position
fhec_EqT	Elastic critical hoop buckling strength (13.2-28) of cone using the equivalent diameter at current position
fxec_EqT	Elastic local buckling strength (13.2-10) of cone using the equivalent diameter at current position
fxc	Local buckling strength (13.2-8,9) of cone using the equivalent diameter at current position piror to shear reduction

Note: If the code check position locates inside the cone segment, the tubular side stresses and the local stresses at the junctions are reported as 0; and the junctions checks are skipped. The associated stresses, strengths, and usage factors are shown as 0.

2.5.2 Tubular joint check ISO 19902 2020

The nomenclature of ISO 19902 2020 tubular joint has been modified, comparing to ISO 19902 2007. All available results inclusive intermediate data from the joint check will report the following data. Note that the meaning of usage factors Uj, Ujove can be different from the symbol in ISO 19902 2007. Also, the brace utilization Ub is ignored in the 2020 standard; instead, the minimum joint strength is reported as UfMinStrng. A new utilization ratio UjGJ is reported for grouted joints. In addition, the axial and bending components of combined utilization are not reported. The nomenclature for utilizations with respect to limiting geometrical values is then similar to the “original”, but with “_lim”. For a joint without violating geometric validity range, the largest utilization UfTot is sorted from Uj, UjGJ and UfMinStrng, including Ujmod, Ujove and Ujshear if overlapping. If the validity range is violated and the 2nd run of code checking is done, the final UfTot is determined from the utilizations above plus those utilizations with limiting parameters, “U***_lim”. Note that the parameter τ is not explicitly applied in the strength check. Thus, the validity range $\tau \leq 1$ is the recommended manufacturing practice and is not considered in the limiting utilizations.

Joint	Capacity Joint name
Member	Capacity brace name
Loadcase	Name of load case/combination under consideration
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 ISO 19902 2020 Joint capacity check
GeomCheck	Status regarding any violation of geometric limitations
Uj	Utilization factor according to equation (14.3-12) as the simple joint Equation (14.3-12) with effective thickness Teff, for double skin grouted joints. = 0 for fully grouted joint.
UjGJ	Utilization factor according to equation (14.3-12) with grouted joint Qu factors and original TC for double skin grouted and fully grouted joints.
UfMinStrng	Usage factor from joint minimum strength check = 0 if joint minimum strength check is not turned on
Ujmod	Utilization factor from through brace with modified loads, for overlapping joint only
Ujove	Utilization factor from overlapping brace with through brace as chord, for overlapping joint only
Ujshear	Parallel shear utilization for overlapping joint only
Uj_lim	Same as Uj, with the parameters at the limiting validity range
UjGJ_lim	Same as UjGJ, with the parameters at the limiting validity range
UfMinStrng_lim	Same as usage factor UfMinStrng with the parameters at the limiting validity range
Ujmod_lim	Same as Ujmod, with the parameters at the limiting validity range
Ujove_lim	Same as Ujove, with the parameters at the limiting validity range
Ujshear_lim	Same as Ujshear, with the parameters at the limiting validity range
beta	Value of β (= d/D)
gamma	Value of γ (= D/2T)
theta	Angle between brace and chord
tau	The ratio t/T
gap_D	The gap/D ratio
Tn/Tc	Ratio of nominal thickness over the thickened can thickness
PB	Axial for in brace
MB,ipb	Bending moment in brace, in-plane-bending
MB,opb	Bending moment in brace, out-of-plane-bending
Pd	Design value of joint axial strength in Uj calculation
Md,ipb	Design value of joint bending strength, in-plane-bending, in Uj calculation
Md,opb	Design value of joint bending strength, out-of-plane-bending, in Uj calculation
EffStrength	Effective strength of the incoming brace
isCritical	= 1 if the joint is specified as Critical Joint
isDoubleSkin	= 1 if the joint chord is double-skin grouted
isFullyGrouted	= 1 if the joint chord is specified as “Fully Grouted”
isThrough	= 1 if the brace is determined or user specified as Through
Qu,Yax	Strength factor, axial Y type
Qu,Xax	Strength factor, axial X type
Qu,Kax	Strength factor, axial K type

Qu,ipb	Strength factor, in-plane bending
Qu,opb	Strength factor, out-of-plane bending
Qf,Yax	Factor to account for forces in chord, axial Y type
Qf,Xax	Factor to account for forces in chord, axial X type
Qf,Kax	Factor to account for forces in chord, axial K type
Qf,ipb	Factor to account for forces in chord, in-plane bending
Qf,opb	Factor to account for forces in chord, out-of-plane bending
Qu,YaxGJ	Strength factor, axial Y type, larger of Table 14.3-1 and Table A.14.5-1, using original Tc
Qu,XaxGJ	Strength factor, axial X type, larger of Table 14.3-1 and Table A.14.5-1, using original Tc
Qu,KaxGJ	Strength factor, axial K type, larger of Table 14.3-1 and Table A.14.5-1, using original Tc
Qu,ipbGJ	Strength factor, in-plane bending, larger of Table 14.3-1 and Table A.14.5-1, using original Tc
Qu,opbGJ	Strength factor, out-of-plane bending, larger of Table 14.3-1 and Table A.14.5-1, using original Tc
PdGJ	Design value of joint axial strength for grouted joint, in UjGJ
MdipbGJ	Design value of joint bending strength, in-plane-bending, for grouted joint in in UjGJ
MdopbGJ	Design value of joint bending strength, out-of-plane-bending, for grouted joint in UjGJ
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
CanRFac	Reduction factor r in section 14.3.5
Tn	Nominal thickness
Lc	Effective can length
CanExten	Can extension length (Distance of brace to can end)
fyChord	Yield strength of chord
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
Tp	Wall thickness of inner member (inner pile)

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