GeniE User Manual
Code checking of beams and tubular joints
Implementation of NORSOK N-004 rev.3, 2013

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1. IMPLEMENTATION OF NORSOK N-004, 2013

This implementation of Norsok N-004 is according to:

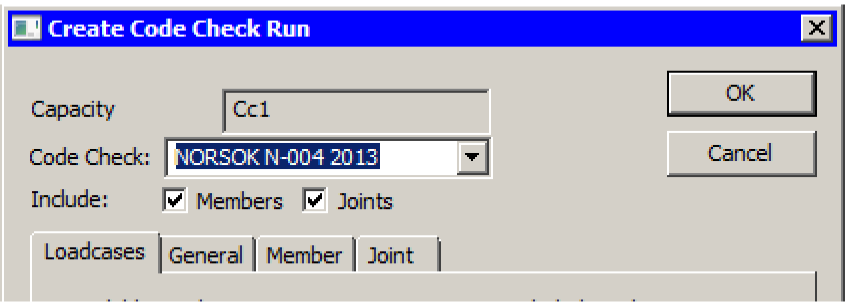
NORSOK STANDARD N-004, Rev. 3, February 2013, Design of steel structures

1.1 Revision supported

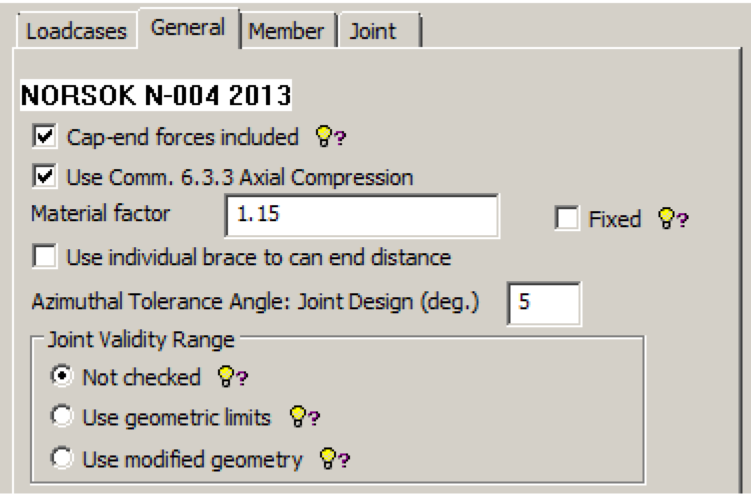
The implementation is according to revision 3 from February 2013, inclusive the Corrigendum issued May 2013 (Corrigendum re-printed March 2014, AC:2014).

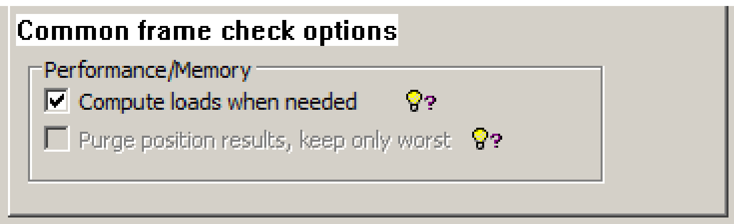
The check covers capacity check of tubular members, tubular joints and conical transitions according to chapter 6.3 “Tubular members”, chapter 6.4 “Tubular joints” and chapter 6.5 “Strength of conical transitions”.

Select NORSOK from the Create Code Check Run dialog

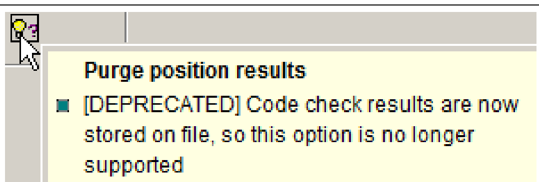


Define the global (General) parameters regarding member and joint capacity check options





Options:

Cap-end forces included	Cap-end forced included corresponds to Method B, i.e. the calculated axial stress includes the effect of the hydrostatic capped-end forces. This corresponds to analysis where default buoyancy option in Wajac has been used. (If not, Method A shall be used.)
Use Comm. 6.3.3 Axial Compression	The method described in the commentary part "Comm. 6.3.3. Axial compression" is used, i.e. equations (12.1) and (12.2) are taken into account.
Material factor	When the "Fixed" option is selected the material factor will be used "as is", i.e. calculating according to section 6.3.7 "Material factor" will be skipped. Hence, when not selected, the given material factor will be regarded as a "minimum factor" when used in section 6.3.7 equation (6.22). Examples : γ_m given as 1.15: γ_m according to (6.22) will be in range 1.15 to 1.45 γ_m given as 1.0: γ_m according to (6.22) will be in range 1.0 to 1.45/1.15 = 1.26
Use individual brace to can end distance	In previous versions only the minimum distance from brace to can end was used. GeniE's new option allows choose between joint's minimum or individual brace to can end distance. Ref. N-004 Figure 6-7.
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.
Joint validity range	**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.
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 code check

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

	Design consideration	Sections covered
6.3	Tubular members	**6.3.1** General **6.3.2** Axial tension **6.3.3** Axial compression **6.3.4** Bending **6.3.5** Shear **6.3.6** Hydrostatic pressure 6.3.6.1 Hoop buckling **6.3.7** Material factor **6.3.8** Tubular members subjected to combined loads without hydrostatic pressure 6.3.8.1 Axial tension and bending 6.3.8.2 Axial compression and bending [1)] 6.3.8.3 Interaction shear and bending moment 6.3.8.4 Interaction shear, bending moment and torsional moment **6.3.9** Tubular members subjected to combined loads with hydrostatic pressure 6.3.9.1 Axial tension, bending, and hydrostatic pressure - Method A - Method B 6.3.9.2 Axial compression, bending, and hydrostatic pressure - Method A - Method B
6.5	Strength of conical Transitions	**6.5.1** General **6.5.2** Design stresses

		6.5.2.1 Equivalent design axial stress in the cone section 6.5.2.2 Local bending stress at unstiffened junctions 6.5.2.3 Hoop stress at unstiffened junctions **6.5.3** Strength requirements without external hydrostatic pressure 6.5.3.1 Local buckling under axial compression 6.5.3.2 Junction yielding 6.5.3.3 Junction buckling **6.5.4** Strength requirements with external hydrostatic pressure 6.5.4.1 Hoop buckling (updated acc. to Corrigendum May 2013) 6.5.4.2 Junction yielding and buckling

Note 1) to 6.3.8.2:

Reference is made to Table 6-2 with respect to selecting the moment reduction factor Cm. When selecting moment reduction factor option “Norsok B or C” the following criteria is used to determine if the beam is exposed to transverse loading or not:

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**”.

Comments regarding implementation of conical transitions:

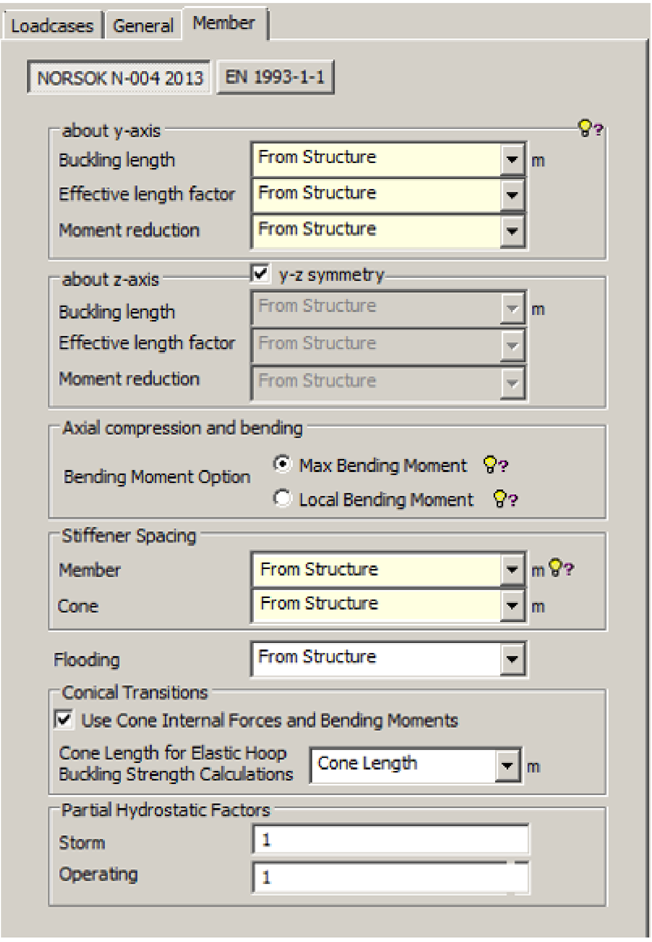
- The formulas given for conical transitions in axial compression and bending are also used for axial tension and that the checks are always performed both for positive and negative resulting bending stress.
- Actual Ds at transition/position investigated is used, ref. (6.64).
- γ_M is calculated for both tubular side and conical side of the transition. Max value is used for all calculations for the transition investigated.
- separate γ_M is calculated for the hoop buckling check in 6.5.4.1
- All calculations for hoop buckling check of equivalent tubular (section 6.5.4.1) are based on tubular with D = D_larger_end/cos(α) and thk = thickness of cone. Actual bending moments at the transitions are used in global stability calculations (6.43) and (6.50), i.e. Cmy = Cmz = 1.0 is used.

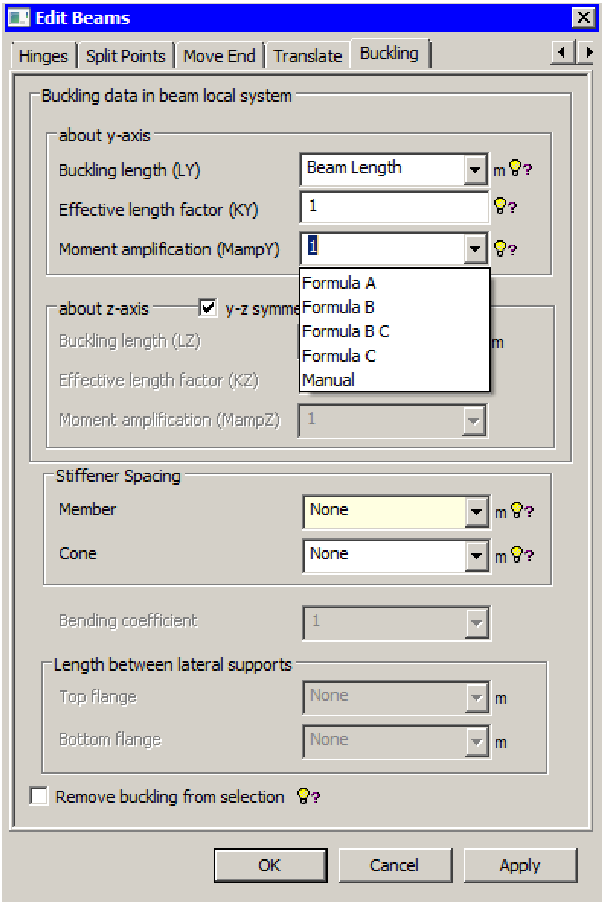
Definition of member specific parameters:

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.

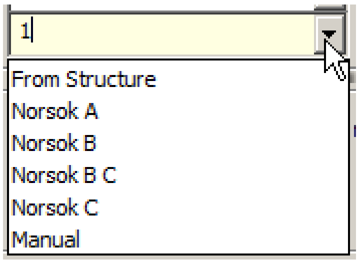
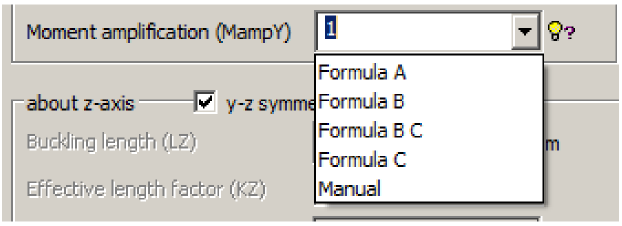
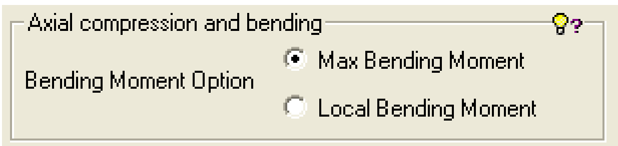
The From Structure alternative is only accepted in cases with one-to-one mapping between modelled beam and member, else the default value/option will be used.

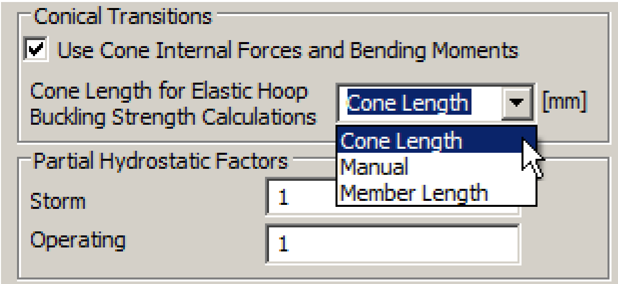
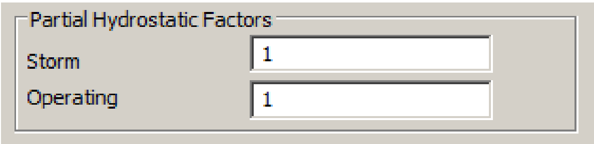




Options:

Buckling length	**From Structure** = use value/option assigned to the beam concept, ref. Edit Beam dialog **Member Length** = use the geometric length of the member (capacity model) **Manual** = specify the length to be used

Effective length factor	**From Structure** = use value/option assigned to the beam concept, ref. Edit Beam dialog **Manual** = specify the factor to be used
Moment amplification	Specify rule according to the standard, ref. Table 6-2, i.e. alternatives (a), (b), (b) or (c), (c)  or select: **From Structure** = use value/option assigned to the beam concept, ref. Edit Beam dialog  The moment amplification definitions are mapped as follows: Formula A → Norsok A , Formula B → Norsok B, Formula B C → Norsok B or C, Formula C → Norsok C **Manual** = specify the factor to be used
Axial compression and bending.	 **Max Bending Moment** This option selects the maximum bending moments along a capacity member derived by the effect of moment gradient, Cm. This method is considered to be best practise. **Local Bending Moment** This option uses the local bending moments at every code check positions. Use of local bending moment could be non-conservative.
Stiffener spacing, Member and Cone	**None** = no ring stiffeners given (For member: stiffener spacing = member length, for cone: stiffener spacing = cone length) **From Structure** = option will use the assignment given to the Beam concept, ref. Edit Beam dialog **Manual** = specify the length between stiffeners.

Flooding	**From Structure** = use the properties assigned to the beam concepts using the properties defined from the “Create/Edit Hydro Property” dialog **Flooded** = Manually set to flooded **Not Flooded** = Manually set to not flooded
Conical Transitions	GeniE allows users to choose between internal forces on cone structures or adjacent forces on tubulars close to transitions points for Cone Code Check Analysis. Analysis, where the cap end forces are computed, present internal axial force values bounded by the axial forces at the transitions. Use of internal forces is coherent and recommended but the use of external forces provides conservative results. 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 
Partial Hydrostatic Factors	These partial hydrostatic factors can be defined on the member code check tab. The design conditions "Operating" and "Storm" may be used to represent action combinations "ULS a" and "ULS b" respectively to give the partial action factors to be used when calculating the design external hydrostatic pressure. The action factor is selected based on the design condition assigned to the load combination. 

1.3 Tubular joint design code check

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

	Design consideration	Sections covered
6.4	Tubular joints	**6.4.1** General **6.4.2** Joint classification **6.4.3** Strength of simple joints 6.4.3.1 General 6.4.3.2 Basic resistance 6.4.3.3 Strength factor Q_u 6.4.3.4 Chord action factor Q_f 6.4.3.5 Design axial resistance for X and Y joints with joint cans [1)] 6.4.3.6 Strength check **6.4.4** Overlap joints [2)]
N-004, Rev 2, Section 10.8.3	Grouted joints	Grouted joints are removed from revision 3 of N-004. (To be implemented in N-006.) The formulas given in N-004 rev. 2 have been implemented here. Notes to implementation wrt. Qu and Qf factors; *Fully grouted, tension:* Qu according to Table 12-1. Leg (outer member) wall thickness is used in formulas for Qu and Qf. Axial tension and moment resistance shall not exceed the brace resistance. Qu factors are set to 1.0 when this limitation occur. *Fully grouted, compression:* No specific formula is given for compression. The compression capacity of the brace itself will be governing. Hence, to report a low usage factor 5 times the brace axial and bending cross section yield resistances are used in the interaction equation (6-57). Qu factors are set to 1.0 when reporting results. *Double-skin, tension:* Must be checked both for condition with shear pullout and ovalisation. Report the largest usage factor for the two conditions. Shear pullout: Qu according to Table 12-1. Leg wall thickness is used in formulas for Qu and Qf. Axial tension and moment resistances shall not exceed the brace

		resistances. Qu factors are set to 1.0 when this limitation occur. Ovalisation: Qu according to Table 6-3 using effective thickness $t_{eff} = (t^2 + t_p^2)^{0.5}$ where t = wall thickness of chord and t_p = wall thickness of inner member. Leg wall thickness is used in Qf calculations. *Double-skin, compression:* Qu according to Table 6-3 using effective thickness t_{eff}. Leg wall thickness is used in Qf calculations. Also note: For joints defined as fully grouted or double-skin the four additional checks defined in 6.4.4 “Overlap joints” are NOT checked.

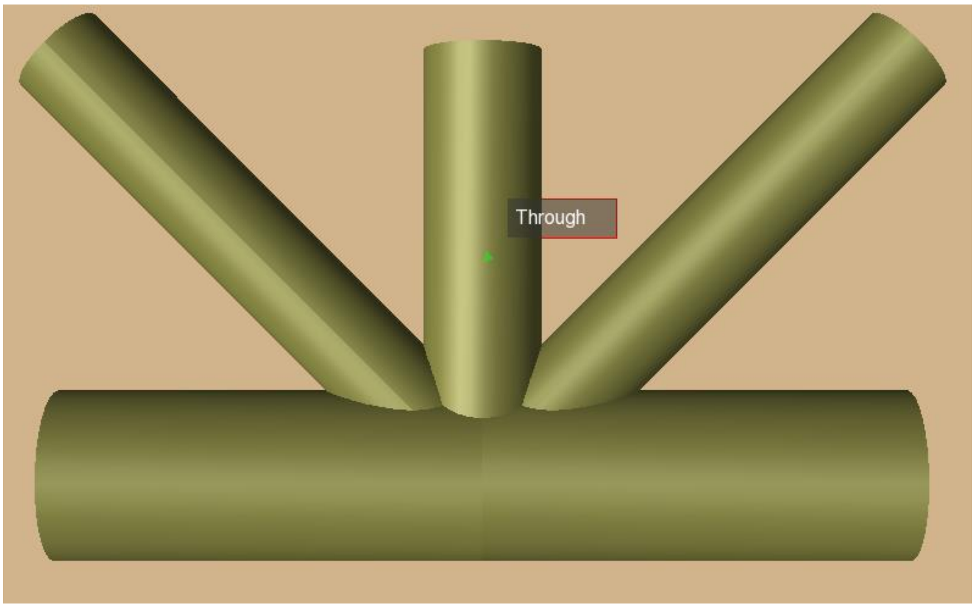
Note 1) to 6.4.3.5:

The reduction factor $\{r+(1-r)(Tn/Tc)^2\}$ is modified to also adjust for different yield strength in can section and nominal member, i.e. the implementation uses $\{r + (1-r)(Tn/Tc)^2(fyn/fyc)\}$.

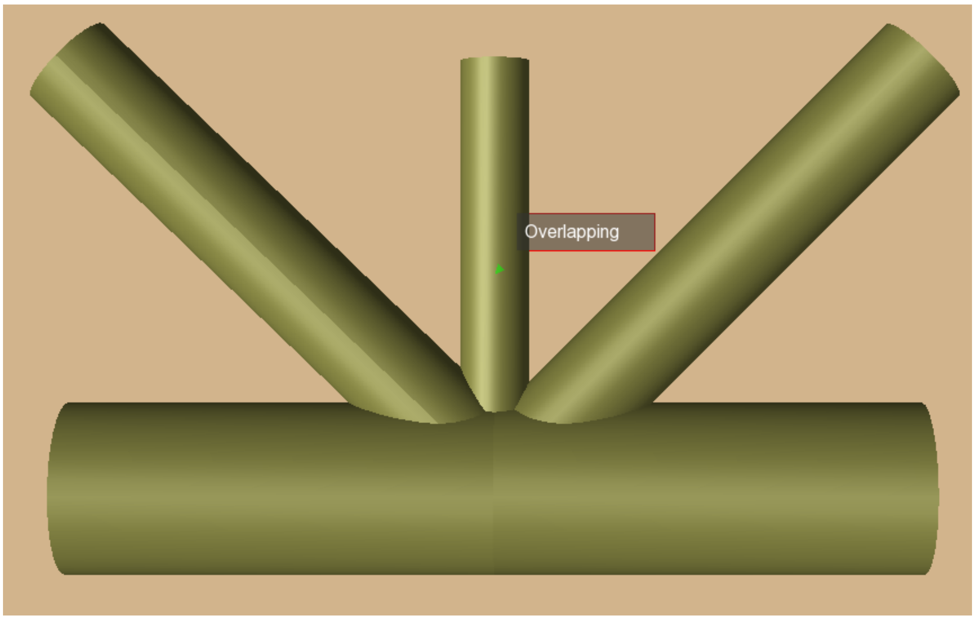
Note 2) to 6.4.4 Overlap joints:

For KT joints with double overlap the two geometric configurations shown below are handled with respect to calculating the additional checks described in section 6.4.4 Overlap joints items a. b. c. and d. Note that when using load path classification the two KTKs may get a positive “weighed gap” when the axial force in the middle brace is small compared to the axial force in the diagonal braces. For such conditions the checks described in section 6.4.4 are not assessed for the KTKs.

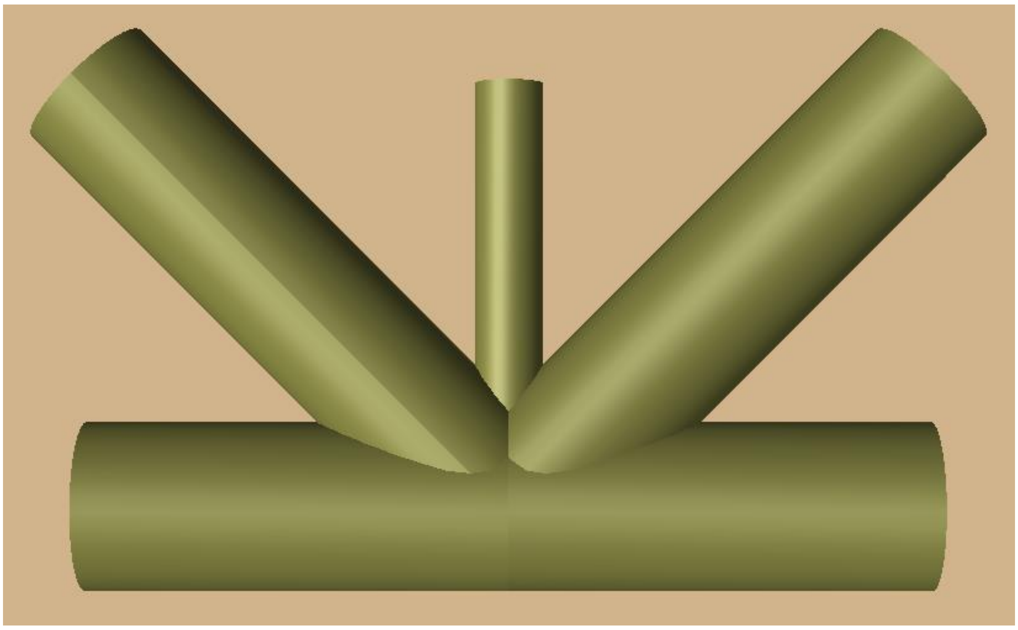
The KTT is the through brace and both KTKs overlap the KTT as shown below:



The KTT is overlapping both the KTKs as shown below:

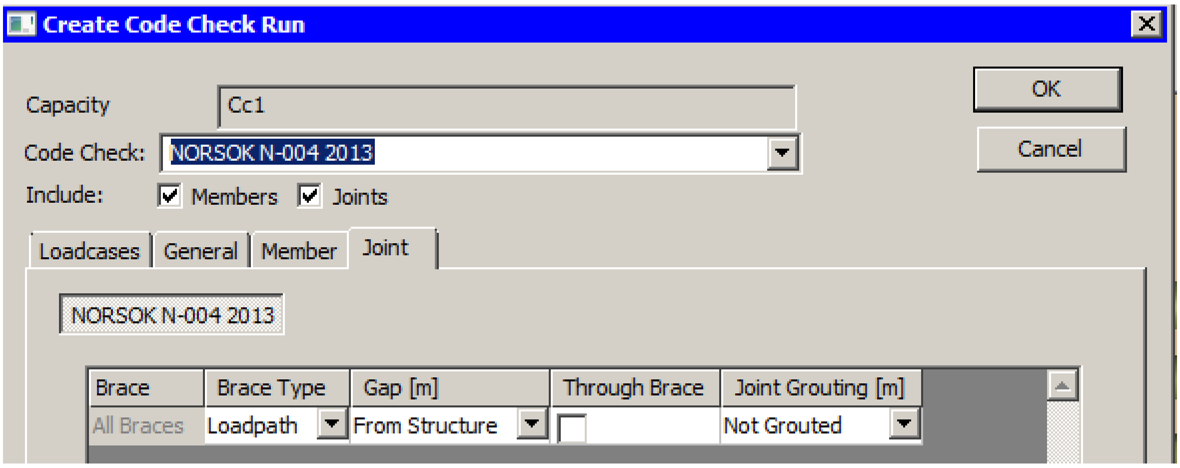


Also note that the configuration shown below is not supported, i.e. when the KTT does not touch the chord (KTKs are overlapping).



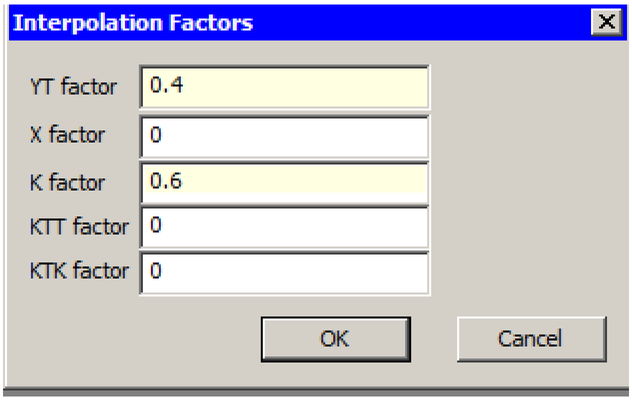
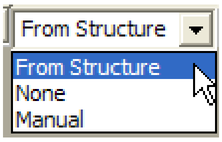
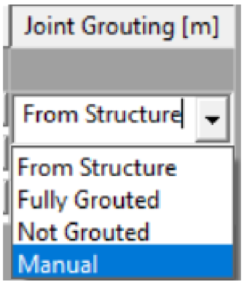
For a geometric configuration shown above the middle brace must be modelled with one of the diagonal braces as chord.

Joint specific parameters:



Options:

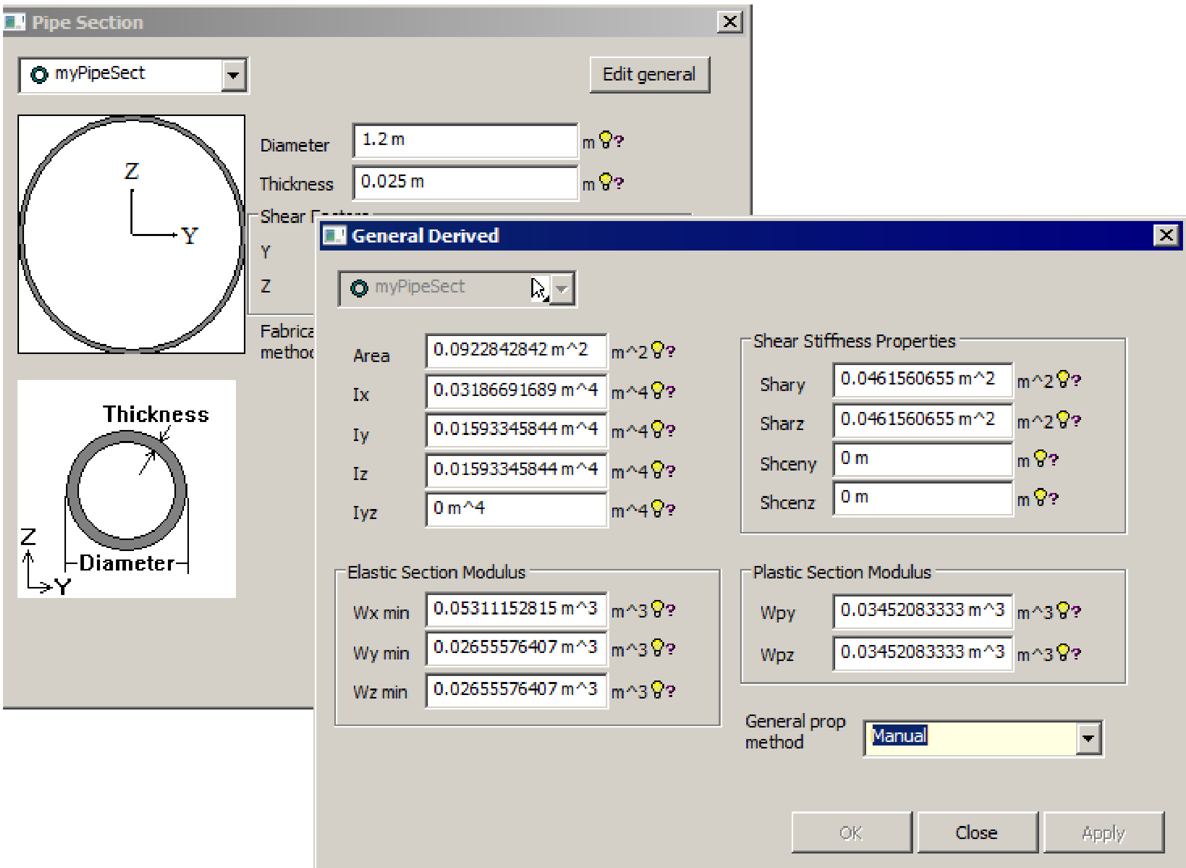
Brace Type	Select how to classify the brace type regarding geometry. Alternatives are: - manually set to YT, X, K, KTT, KTK - classify according to geometry - classify according to loadpath (and geometry) - interpolate using manual input

	
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.
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.

1.4 Cross section properties for manually updated profiles

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



Member code checks will utilize updated/modified:

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

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

No specific update for cone or joint code check has been made to utilize modified values. However, modified area and elastic section modulus will be used when calculating stress in chord member. (Stress in chord for calculation of parameter A used in chord load factor Qf.)

1.5 Nomenclature

When printing/reporting stresses representing σ, o is used in the nomenclature, e.g. oaSd = σa,Sd.

1.5.1 Member check

The print of all available results inclusive intermediate data from the member 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 NORSOK N-004 member check
Run	Reference to run reported
uf6_1	Usage factor according to (6.1)
uf6_13	Usage factor according to (6.13)
uf6_14	Usage factor according to (6.14)
uf6_15	Usage factor according to (6.15)
uf6_41	Usage factor according to (6.41)
uf6_26	Usage factor according to (6.26)
uf6_26ax	Axial contribution to usage factor according to (6.26)
uf6_26mo	Moment contribution to usage factor according to (6.26)
uf6_27	Usage factor according to (6.27)
uf6_27ax	Axial contribution to usage factor according to (6.27)
uf6_27mo	Moment contribution to usage factor according to (6.27)
uf6_28	Usage factor according to (6.28)
uf6_28ax	Axial contribution to usage factor according to (6.28)
uf6_28mo	Moment contribution to usage factor according to (6.28)
uf6_31	Usage factor according to (6.31)
uf6_33	Usage factor according to (6.33)
uf6_34	Usage factor according to (6.34)
uf6_34ax	Axial contribution to usage factor according to (6.34)
uf6_34mo	Moment contribution to usage factor according to (6.34)
uf6_39	Usage factor according to (6.39)
uf6_39ax	Axial contribution to usage factor according to (6.39)
uf6_39mo	Moment contribution to usage factor according to (6.39)
uf6_42	Usage factor according to (6.42)
uf6_42ax	Axial contribution to usage factor according to (6.42)
uf6_42mo	Moment contribution to usage factor according to (6.42)

uf6_43	Usage factor according to (6.43)
uf6_43ax	Axial contribution to usage factor according to (6.43)
uf6_43mo	Moment contribution to usage factor according to (6.43)
uf6_44	Usage factor according to (6.44)
uf6_44ax	Axial contribution to usage factor according to (6.44)
uf6_44mo	Moment contribution to usage factor according to (6.44)
uf6_50	Usage factor according to (6.50)
uf6_50ax	Axial contribution to usage factor according to (6.50)
uf6_50mo	Moment contribution to usage factor according to (6.50)
uf6_51	Usage factor according to (6.51)
uf6_51ax	Axial contribution to usage factor according to (6.51)
uf6_51mo	Moment contribution to usage factor according to (6.51)
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
NSd	Design axial force
NtRd	Design axial tensile resistance
NEy	Euler buckling strength about y-axis
NEz	Euler buckling strength about z-axis
NcRd	Design axial compressive resistance
NclRd	Design axial local buckling resistance
MySd	Design bending moment about member y-axis
MzSd	Design bending moment about member z-axis
MySdMax	Design bending moment about member y-axis, for use in (6.27)
MzSdMax	Design bending moment about member z-axis, for use in (6.27)
Mrd	Design bending moment resistance
oaSd	Design axial stress
oacSd	Design axial stress that includes the effect of capped-end axial compression
fthRd	Design bending resistance in the presence of external hydrostatic pressure
fEy	Euler buckling stress about y-axis
fEz	Euler buckling stress about z-axis
fclRd	Design axial local buckling strength
fchRd	Design axial compression strength in the presence of external hydrostatic pressure
omySd	Design bending stress about member y-axis
omzSd	Design bending stress about member z-axis
omySdMax	Design bending stress about member y-axis, for use in (6.43)

omzSdMax	Design bending stress about member z-axis, for use in (6.43)
fmhRd	Design bending resistance in the presence of external hydrostatic pressure
yM	The material factor
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
Cmy	Reduction factor corresponding to member y-axis
Cmz	Reduction factor corresponding to member z-axis
stfspace	Length between ring stiffeners
slendery	Member slenderness about y-axis
slenderz	Member slenderness about z-axis
fcle	Characteristic elastic local buckling strength
fcl	Characteristic local buckling strength
fc	Characteristic axial compressive strength
fm	Characteristic bending strength
fhe	Elastic hoop buckling strength
fh	Characteristic hoop buckling strength
pSd	Design hydrostatic pressure
opSd	Design hoop stress due to hydrostatic pressure
oqSd	Capped-end design axial compression stress due to external hydrostatic pressure
VSd	Design shear force
VRd	Design shear resistance
MTSd	Design torsional moment
MTRd	Design torsional moment resistance

1.5.2 Cone check

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 NORSOK N-004 cone check
Run	Reference to run reported
uf6_63	Usage factor according to (6.63)
uf6_65	Usage factor according to (6.65)

uf6_66	Usage factor according to (6.66)
uf6_67	Usage factor according to (6.67)
uf6_68	Usage factor according to (6.68)
uf6_71	Usage factor according to (6.71)
uf6_72	Usage factor according to (6.72)
uf6_73	Usage factor according to (6.73)
uf6_34	Usage factor according to (6.34), Hoop buckling of equivalent tubular
uf6_39	Usage factor according to (6.39) , Hoop buckling of equivalent tubular
uf6_41	Usage factor according to (6.41) , Hoop buckling of equivalent tubular
uf6_42	Usage factor according to (6.42) , Hoop buckling of equivalent tubular
uf6_43	Usage factor according to (6.43) , Hoop buckling of equivalent tubular
uf6_44	Usage factor according to (6.44) , Hoop buckling of equivalent tubular
uf6_50	Usage factor according to (6.50) , Hoop buckling of equivalent tubular
uf6_51	Usage factor according to (6.51) , Hoop buckling of equivalent tubular
Alpha	The slope angle of the cone
t/tc	Ratio wall thickness tubular and cone
relpos	Relative position along member longitudinal axis (start = 0, end = 1)
Ds	Outer cone diameter at the section under consideration
tc	Cone thickness
fyc	Yield strength of cone
Dj	Cylinder diameter at junction
t	Tubular member wall thickness
fy	Yield strength of tubular
yM	Material factor
NSd	Design axial force
MSd	Design axial tensile resistance
oacSd	Design axial stress at the section within the cone due to global actions
omcSd	Design bending stress at the section within the cone due to global actions
oequSd	Equivalent design axial stress within the conical transition
oatSd	Design axial stress in tubular section at junction due to global actions
omtSd	Design bending stress in tubular section at junction due to global actions
omlSd	Local design bending stress at unstiffened tubular-cone junction
ohcSd	The design hoop stress at unstiffened tubular-cone junctions due to unbalanced radial line forces
fclc	Local buckling strength of conical transition
oequSdT	Total stress for checking stresses on the tubular side of the junction
fheT	Elastic hoop buckling strength, tubular side
fhjT	Characteristic hoop buckling strength, tubular side
fcljT	Characteristic axial local compressive strength, tubular side
fheC	Elastic hoop buckling strength, cone side

fhjC	Characteristic hoop buckling strength, cone side
fcljC	Characteristic axial local compressive strength, cone side
pSd	Design hydrostatic pressure
opSd	Design hoop stress due to hydrostatic pressure
opSd6541	Design hydrostatic pressure for use in 6.5.4.1
fhe6541	Elastic hoop buckling strength for use in 6.5.4.1
fh6541	Characteristic hoop buckling strength for use in 6.5.4.1
fm	Characteristic bending strength
fmhRd	Design bending resistance in the presence of external hydrostatic pressure
fclRd	Design axial local buckling strength
fthRd	Design axial tensile resistance in the presence of external hydrostatic pressure
fchRd	Design axial compression strength in the presence of external hydrostatic pressure
ohjSd	Net design hoop stress at a tubular-cone junction

1.5.3 Tubular joint check

The print of all available results inclusive intermediate data from the tubular joint check will report the following data. Note that the usage factors uf6_57 to ufshear are also reported for the case with respect to limit geometrical values. The nomenclature is then similar to the "original", but with _lim added.

Joint	Capacity model name (joint name)
Loadcase	Name of load case/combination under consideration
Member	Brace name regarding presented results
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 NORSOK N-004 joint capacity check
uf6_57	Usage factor according to equation (6.57)
uf6_57ax	Axial contribution to usage factor according to equation (6.57)
uf6_57mo	Moment contribution to usage factor according to equation (6.57)
uf6_57mod	Usage factor from through brace in overlapping joint, modified loads
uf6_57axmod	Axial contribution in uf6_57mod
uf6_57momod	Moment contribution in uf6_57mod
uf6_57ove	Usage factor from overlap brace in overlapping joint, through brace as chord
uf6_57axove	Axial contribution in uf6_57ove
uf6_57moove	Moment contribution in uf6_57ove
ufshear	Shear utilisation when overlapping braces
beta	Value of geometric parameter β (= d/D), geometric limitation; $0.2 < \beta < 1$.
gamma	Value of geometric parameter γ (= D/2T)

theta	Angle between brace and chord
gap_D	The gap/D ratio
Tn/Tc	Ratio of chord nominal thickness and reinforcement can thickness
ufIPB	Usage factor, contribution from in-plane bending
ufOPB	Usage factor, contribution from out-of-plane bending
NSd	Design axial force in the brace member
NRd	The joint design axial resistance
MySd	Design in-plane bending moment in the brace member
MyRd	Design in-plane bending resistance
MzSd	Design out-of-plane bending moment in the brace member
MzRd	Design out-of-plane bending resistance
Qbeta	Geometric factor dependent of β
Qg	Gap factor
Quaxial	Ultimate strength factor dependant of joint and load type, axial
QuIPB	Ultimate strength factor dependant of joint and load type, in-plane bending
QuOPB	Ultimate strength factor dependant of joint and load type, out-of-plane bending
A	Parameter representing the stress level in the chord
Qfaxial	Factor to account for nominal longitudinal stress in chord, axial
QfIPB	Factor to account for nominal longitudinal stress in chord, in-plane bending
QfOPB	Factor to account for nominal longitudinal stress in chord, out-of-plane bending
Ytfact	Brace classification, fraction as type YT behaviour
Xfact	Brace classification, fraction as type X behaviour
Kfact	Brace classification, fraction as type K behaviour
KTTfact	Brace classification, fraction as type KTT behaviour
KTKfact	Brace classification, fraction as type KTK behaviour
CanFact	reduction factor r in section 6.4.3.5
fy	Yield strength of chord
gammaM	Material factor γ_M
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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