Modification 'NEN 3650' module in PLE-micro-CAD

1. **Input data and conditions**
2. **Processing data**
3. **Result data**
4. **User documentation**

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1. Input data and conditions

The input data that has been changed are mainly default values as stored in the table definitions. Besides the checking on the correctness or the likelihood of input data by the function(s) has been adapted.

a. The columns SIGEPS and CHKEPS from table ISTROP have been moved to the new table SIGEPS for specification of the stress-strain relation. The new layout of table ISTROP shows as follows:

MATREF	Emod	Gmod	Nu	ALPHA	Re	ReT
	F/L**2	F/L**2		1/DEGC	F/L**2	F/L**2
title	value	value	value	value	value	value

Re : yield stress at 20 °C
ReT : yield stress at T °C (= T-abs in table TEMP)
Info : the pipeline is loaded in DF5 by f_T (T-abs – T-ref) °C. (f_T = load factor)

b. In DF3.2 some values of the uncertainty factors of the soil mechanical parameters change (see table B.3 of NEN 3650-1:2003, quire 3) and are indicated as bold in next overview. The low and high values for sand (*italics*) - the default values – remain unchanged.

Soil mechanical parameters	Partial factors (uncertainty factors)					
	sand			clay / peat		
	low (*)	low(L)/high(H) (**)	high (***)	low (*)	low(L)/high(H) (**)	high (***)
KLH	*1.7*	1.7 H	*1.7*	**1.7**	**1.7** H	**1.7**
KLS	*2.0*	2.0 H	*2.0*	**1.6**	**1.6** H	**1.6**
KLT	*1.4*	1.4 H	*1.4*	1.9	1.9 H	1.9
F	*1.375*	1.136 L	*1.375*	**2.355**	**1.047** L	**2.355**
UF	*1.6*	1.6 H	*1.6*	1.5	1.5 H	1.5
RVS	*2.0*	2.0 H	*2.0*	**1.6**	**1.6** H	**1.6**
RVT	*1.5*	1.5 H	*1.5*	1.5	1.5 H	1.5
RH	*1.6*	1.6 H	*1.6*	2.0	2.0 H	2.0
SOILNB	*1.1*	1.1 H	*1.1*	1.1	1.1 H	1.1

(*) applicable for hot pipelines in a 'bad' (= poorly compacted) soil
(**) applicable for hot pipelines in a 'good' (= well compacted) soil
(***) applicable for 'cold' pipelines (= pipelines at an ambient operational temperature)
low (L) : average value is divided by the uncertainty factor
high (H) : average value is multiplied by the uncertainty factor

c. The new NEN 3650 states frequently that the path of most of the soil mechanical parameters is approximated well by trilinear springs; use of bilinear springs is explicitly allowed, however. Because incorporation of trilinear springs in PLE is rather time consuming, this action is dropped for the time being. It is assumed as yet that the tangent hyperbolic (TANH in module C) represents the trilinear path well enough.

2. Processing data

Flexible cross-sections

In the 'Flexible' option the stiffness of the soil counteracting the ovalisation of a cross-section is taken into account resulting in lower ovalisation and stresses, especially of importance for buried pressureless flexible plastic pipes and/or thinwalled steel pipes. Horizontal soil support springs are applied at the points of the cross-section that move outward. The use of this option can be compared to the application of the so-called IOWA contribution to the horizontal soil support pressure. See article C.4.2.5 of NEN 3650-1:2003. However, modelling the soil support through soil **springs** is more in line with the real soil behaviour than the application of extra soil support **pressure.**
In PLE version 3.10 the "Flexible' option can be applied within the NEN 3650 module as well, if the Flexible cross-section module (U) is available.

Stress check

The stress check is performed according to table D.3 of NEN 3650-2:2003/A1:2006 (quire 5). The replacing stress σ_v:pm (the primary membrane stress) has been removed from this table, but the check has been explained sub "Pipeline on pile foundation". Only when the pipeline is loaded as a spanning beam mainly and the occurring stresses are primary membrane stresses for the greater part making equilibrium with the loadings directly, this check stress has to be performed. The stress check is **not** applicable for buried continuous pipelines without (pile) supports even if a free span develops below ground. The stress checking in PLE version 3.10 has been adapted accordingly.
The σ_v stress from table D.3 is calculated and reported always.

3. Result data

Flexible cross-sections

The result tables RMAXNEN and RDPLNEN are extended with 2 columns containing data on the applied soil springs. The new layout of table RMAXNEN is as follows:

ELEM	WGROUND-M	WBEND-M	W+WD/D-M	WTOTAL-M	R-IND	RG/KLG-M	KLG-M
	L	L	%	L		L	F/L**3
num	value	value	value	value	title	value	value

ELEM : element number
WGROUND-M : radial deformation of pipe wall due to soil reactions (maximum over cross-section)
WBEND-M : radial deformation of pipe wall due to bend ovalisation (maximum over cross-section)
W+WD/D-M : change of diameter (in %) due to loads on cross-section (maximum over cross-section)
WTOTAL-M : total radial deformation of pipe wall due to all loads on cross-section (maximum over cross-section)
R-IND : deformation indicator
RG/KLG-M : elastic impression of the soil at 50% of the 'horizontal' bearing capacity
KLG-M : 'horizontal' bedding constant (soil stiffness)

The new layout of table RDPLNEN is as follows:

ELEM	WGROUND	WBEND-M	W+WD/D-M	WTOTAL-M	R-IND	RG/KLG-M	KLG-M
	L	L	%	L		L	F/L**3
num	value	value	value	value	title	value	value

ANGLE : location at circumference running from 0º to 360º
WGROUND : radial deformation of pipe wall due to soil reactions
WBEND : radial deformation of pipe wall due to bend ovalisation
W+WD/D : change of diameter (in %) due to loads on cross-section
WTOTAL : total radial deformation of pipe wall due to all loads on cross-section
R-IND : deformation indicator
RG/KLG : elastic impression of the soil at 50% of the 'horizontal' bearing capacity
KLG : 'horizontal' bedding constant (soil stiffness)

Stress check

The stress check result tables NENSMAX and NENSTRS keep the same layout, but the content is different possibly in accordance with above mentioned modifications. See appendix D.3.1 of NEN 3650-2:2003/A1:2006 (quire 5).

Implosion check

An implosion check has been added according to appendix D.3.3.4 of NEN 3650-2:2003 due to external pressure, bending moments and a combination of both loads. If the allowable external pressure or bending moment is exceeded, a warning is given.

4. User documentation

Overview of modified Help Screens for NEN 3650 module in PLE-micro-CAD version 3.10.01

(screens at numerical order)
O = operation
m = modification of screen
a = addition of screen
M = module
K = Kernel module
S = Stress module
T0 = NEN 3650 check module

Ident.	*O*	*M*	*date*	*short description of modification*
H000/1.3	m	K	24nov06	Short description module T0
H310-14/1.2	m	K	24nov06	Description input data table ISTROP
H310-51/1	m	K	01feb06	Description result data table PIPEMAT
H500-57/1.1	m	K	01feb06	Adding description KLG in table BENDFAC
H610/4.6	m	S	28feb07	Function conditions cross-section data model
H610-57/1	m	S	24nov06	Description result data table PRIMSEL
H630/3.3	m	T0	24nov06	Function description NEN stress check
H630-54/1.1	m	T0	01feb06	Description result data table RMAXNEN
H630-54/1.2	m	T0	01feb06	Description result data table RMAXNEN
H630-54/1.3	m	T0	01feb06	Description result data table RMAXNEN
H630-551.1	m	T0	01feb06	Description result data table RDPLNEN
H630-55/1.2	m	T0	01feb06	Description result data table RDPLNEN
H630-55/1.3	m	T0	01feb06	Description result data table RDPLNEN

Total of 8 screens dated 01feb06 and 4 screens dated 24nov06 and 1 screen dated 28feb07.