

The Circular Concrete Viaduct

Development of Concept Demountable Footing to Foundation (F2F) Dowel Connection for the Application in Multiple Life-Cycles

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CIE5060-09 MSc Thesis

SCIA Engineering Report - Demountable F2F Dowel Model

December 24, 2020



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The Circular Concrete Viaduct Development of Concept Demountable Footing to Foundation (F2F) Dowel Connection for the Application in Multiple Life-Cycles

by

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Faculty of Civil Engineering and Geosciences
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Specialisation "Concrete Structures"

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An electronic version of this thesis is available at: <http://repository.tudelft.nl/>

Introduction

This report contains the Engineering Report of the concept demountable footing to foundation (F2F) dowel connection, developed in SCIA Engineer 19.1.3030 (student version), which belongs to the thesis report “The Circular Concrete Viaduct – Development of a Concept Demountable Footing to Foundation (F2F) Dowel Connection for the Application in Multiple Life-Cycles”. The report provides detailed information about the properties and input of the model as well as the main relevant results, which are the deformation of the dowel end (in SLS) and the contact stresses between the dowel and the surrounding concrete (in ULS).

Project Thesis "The Circular Concrete Viaduct"

1. Project

Licence name	TU Delft
Project	Thesis "The Circular Concrete Viaduct"
Part	Demountable dowel footing to foundation connection
Description	Checking of contact stresses and deformations
Author	JWB
Date	11.11. 2020
Structure	General XYZ
No. of nodes :	14
No. of beams :	0
No. of slabs :	5
No. of solids :	0
No. of used profiles :	0
No. of load cases :	12
No. of used materials :	1
Acceleration of gravity [m/s ²]	9,810
National code	EC - EN

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Student version

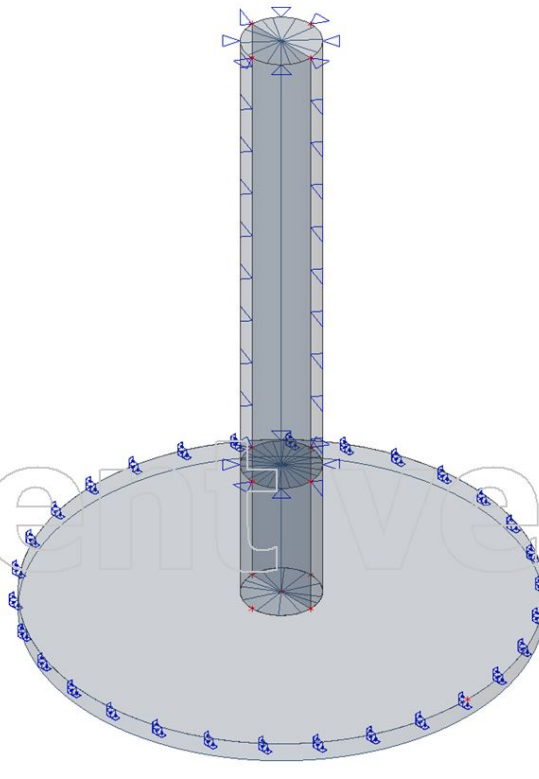
Student version

3. Materials

Steel EC3

Name	ρ [kg/m ³]	E_{mod} [MPa] G_{mod} [MPa]	μ α [m/mK]	Lower limit [mm]	Upper limit [mm]	F_y [MPa]	F_u [MPa]	Colour
S 355	7850,0	2,1000e+05 8,0769e+04	0,3 0,00	0 40	40 80	355,0 335,0	490,0 470,0	

4. Analysis model



5. Nodes

Name	Coord X [mm]	Coord Y [mm]	Coord Z [mm]
N227	1210,000	1250,000	0,000
N228	1290,000	1250,000	0,000
N229	1250,000	1210,000	0,000
N230	1290,000	1250,000	150,000
N231	1210,000	1250,000	150,000

Name	Coord X [mm]	Coord Y [mm]	Coord Z [mm]
N232	1250,000	1210,000	150,000
N233	1250,000	1290,000	0,000
N234	1250,000	1290,000	150,000
N235	1290,000	1250,000	650,000
N236	1210,000	1250,000	650,000

Name	Coord X [mm]	Coord Y [mm]	Coord Z [mm]
N237	1250,000	1210,000	650,000
N238	1250,000	1290,000	650,000
N239	1250,000	1250,000	0,000
N240	1504,000	1250,000	0,000

6. 2D member standard FEM

Name	Element type	Element behaviour	Layer	Type	Material	Thickness type	Th. [mm]
S74	Standard	Standard FEM	d=80mm	wall (80)	S 355	constant	40
S75	Standard	Standard FEM	d=80mm	wall (80)	S 355	constant	40
S76	Standard	Standard FEM	d=80mm	wall (80)	S 355	constant	40
S77	Standard	Standard FEM	d=80mm	wall (80)	S 355	constant	40
S78	Standard	Standard FEM	d=80mm	plate (90)	S 355	constant	20

7. Supports on 2D member edge

Sle35		
2D member, Edge	S78	1
Orig, Coor	From start	Rela
Pos x1, Pos x2	0.000	1.000
X, Stiffness X [N/mm ²]	Flexible	1,0000e+00
Y, Stiffness Y [N/mm ²]	Flexible	1,0000e+00
Z, Stiffness Z [N/mm ²]	Flexible	1,3125e+02
Rx, Stiffness Rx [Nmm/mm/rad]	Rigid	
Ry, Stiffness Ry [Nmm/mm/rad]	Rigid	
Rz, Stiffness Rz [Nmm/mm/rad]	Rigid	

8. 2D member supports

Name	Type	Subsoil	2D member
SS32	Individual	C30/37	S76
SS33	Individual	C30/37	S77

9. Concrete foundation modulus (subsoil)

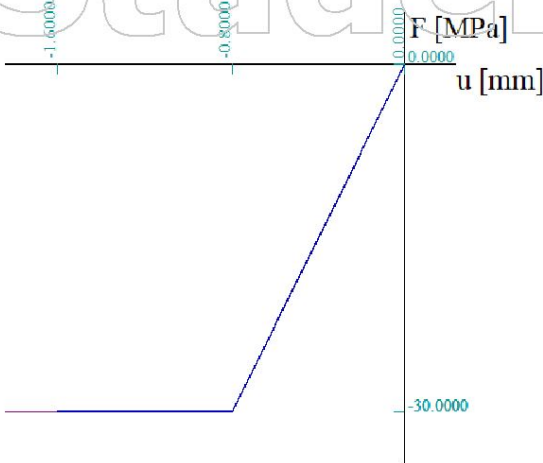
9.1. Concrete foundation modulus (subsoil) - C30/37

Name	C1x [N/mm ³]	C1z	C1y [N/mm ³]	Stiffness [N/mm ³]	C2x [N/mm]	C2y [N/mm]
C30/37	0,0000e+00	Nonlinear function	0,0000e+00	3,7500e+01	0,0000e+00	0,0000e+00

9.1.1. Nonlinear functions

Name	Type	Positive end	Negative end
C30/37	Nonlinear subsoil	Free	Free

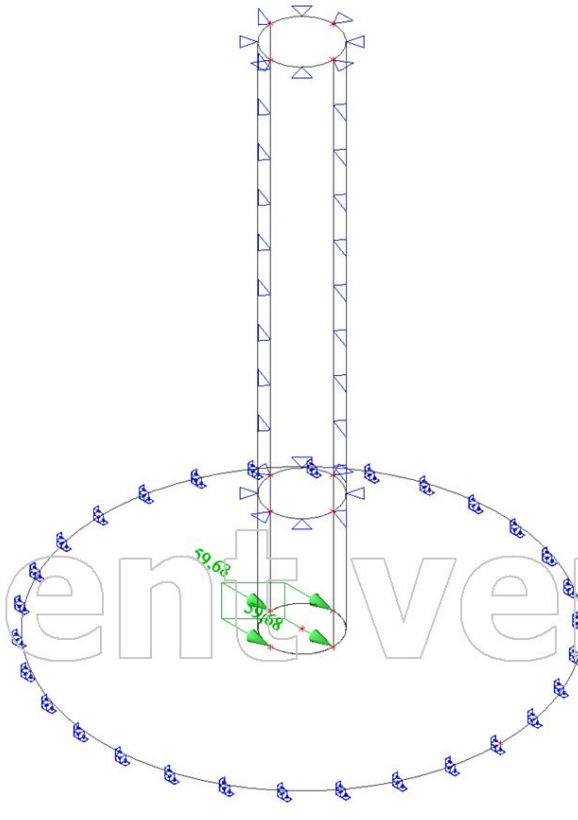
Drawing



10. Load cases

10.1. Load cases - V_Nmax_ULS

Name	Description Spec	Action type Load type	Load group
V_Nmax_ULS		Permanent Standard	LG1

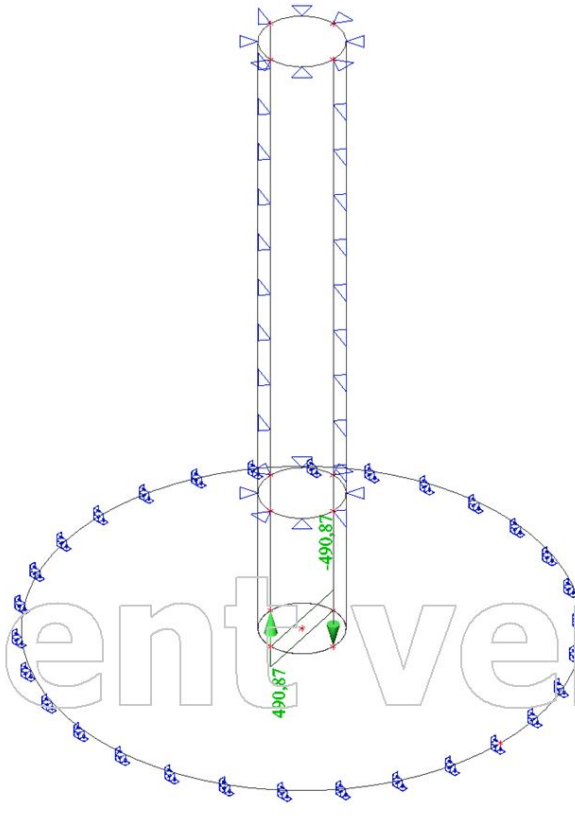


10.1.1. Line force on 2D member edge

Name	2D member	Type	Dir	Value - P ₁ [kN/m]	Pos x ₁	Loc	Edge
	Load case	System	Distribution	Value - P ₂ [kN/m]	Pos x ₂	Coor	Orig
LFS1050	S74 V_Nmax_ULS	Force GCS	X Uniform	59,68	0.000 1.000	Length Rela	1 From start
LFS1051	S75 V_Nmax_ULS	Force GCS	X Uniform	59,68	0.000 1.000	Length Rela	1 From start

10.2. Load cases - M_Nmax_ULS

Name	Description Spec	Action type Load type	Load group
M_Nmax_ULS		Permanent Standard	LG1

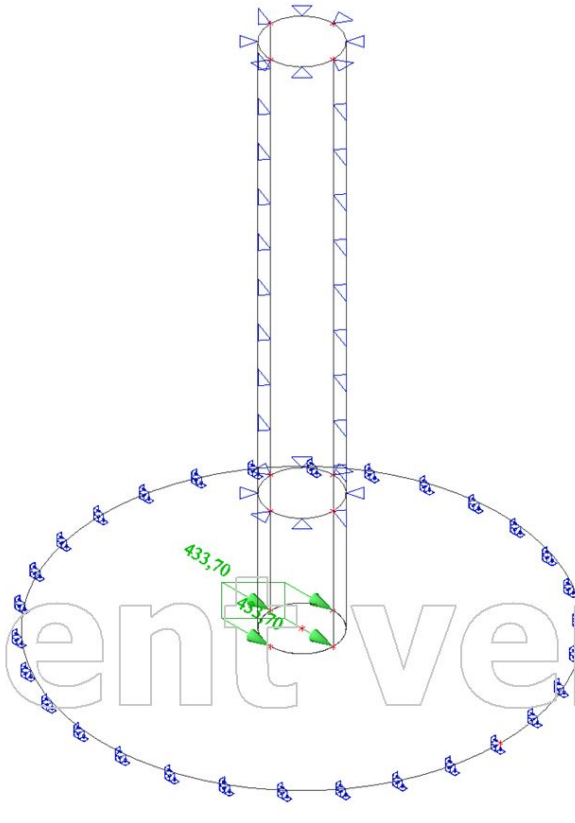


10.2.1. Line force on 2D member edge

Name	2D member	Type	Dir	Value - P ₁ [kN/m]	Pos x ₁	Loc	Edge
	Load case	System	Distribution	Value - P ₂ [kN/m]	Pos x ₂	Coor	Orig
LFS1052	S74	Force	Z	490,87	0.000	Length	1
	M_Nmax_ULS	GCS	Trapez	-490,87	1.000	Rela	From start
LFS1053	S75	Force	Z	490,87	0.000	Length	1
	M_Nmax_ULS	GCS	Trapez	-490,87	1.000	Rela	From start

10.3. Load cases - V_Vmax_ULS

Name	Description Spec	Action type Load type	Load group
V_Vmax_ULS		Permanent Standard	LG1

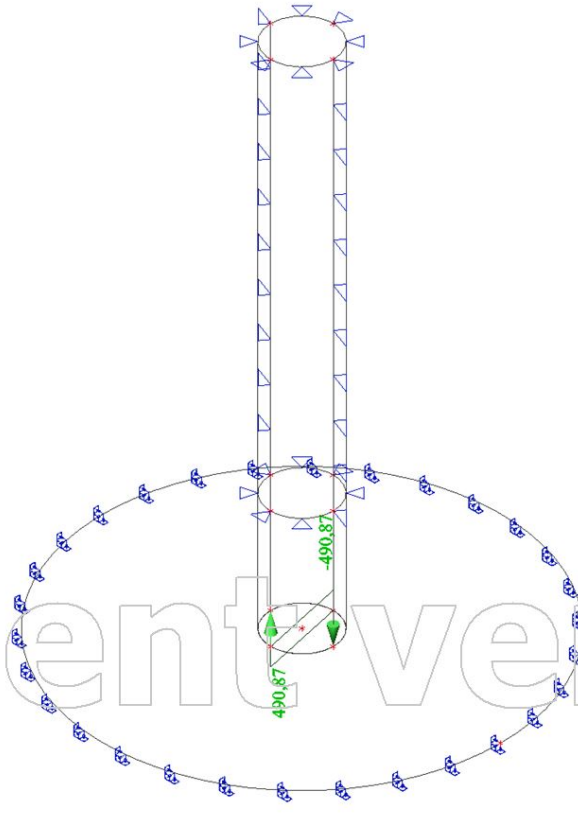


10.3.1. Line force on 2D member edge

Name	2D member	Type	Dir	Value - P ₁ [kN/m]	Pos x ₁	Loc	Edge
	Load case	System	Distribution	Value - P ₂ [kN/m]	Pos x ₂	Coor	Orig
LFS1034	S74 V_Vmax_ULS	Force GCS	X Uniform	433,70	0.000 1.000	Length Rela	1 From start
LFS1035	S75 V_Vmax_ULS	Force GCS	X Uniform	433,70	0.000 1.000	Length Rela	1 From start

10.4. Load cases - M_Vmax_ULS

Name	Description Spec	Action type Load type	Load group
M_Vmax_ULS		Permanent Standard	LG1

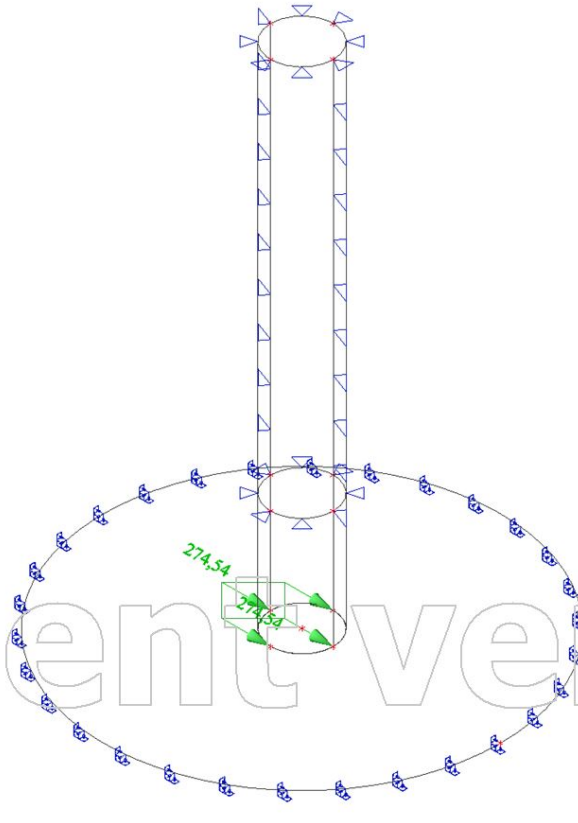


10.4.1. Line force on 2D member edge

Name	2D member	Type	Dir	Value - P ₁ [kN/m]	Pos x ₁	Loc	Edge
	Load case	System	Distribution	Value - P ₂ [kN/m]	Pos x ₂	Coor	Orig
LFS1042	S74	Force	Z	490,87	0.000	Length	1
	M_Vmax_ULS	GCS	Trapez	-490,87	1.000	Rela	From start
LFS1043	S75	Force	Z	490,87	0.000	Length	1
	M_Vmax_ULS	GCS	Trapez	-490,87	1.000	Rela	From start

10.5. Load cases - V_Mmax_ULS

Name	Description Spec	Action type Load type	Load group
V_Mmax_ULS		Permanent Standard	LG1

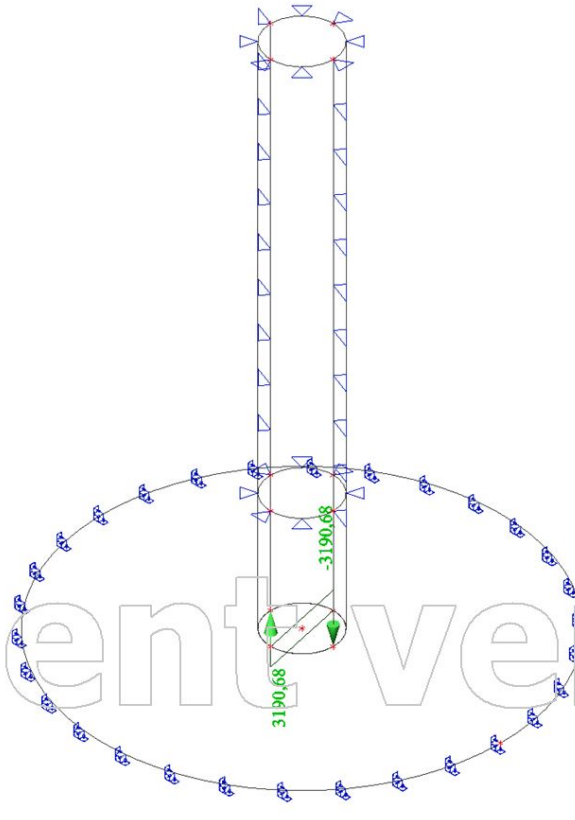


10.5.1. Line force on 2D member edge

Name	2D member	Type	Dir	Value - P ₁ [kN/m]	Pos x ₁	Loc	Edge
	Load case	System	Distribution	Value - P ₂ [kN/m]	Pos x ₂	Coor	Orig
LFS1036	S74 V_Mmax_ULS	Force GCS	X Uniform	274,54	0.000 1.000	Length Rela	1 From start
LFS1037	S75 V_Mmax_ULS	Force GCS	X Uniform	274,54	0.000 1.000	Length Rela	1 From start

10.6. Load cases - M_Mmax_ULS

Name	Description Spec	Action type Load type	Load group
M_Mmax_ULS		Permanent Standard	LG1

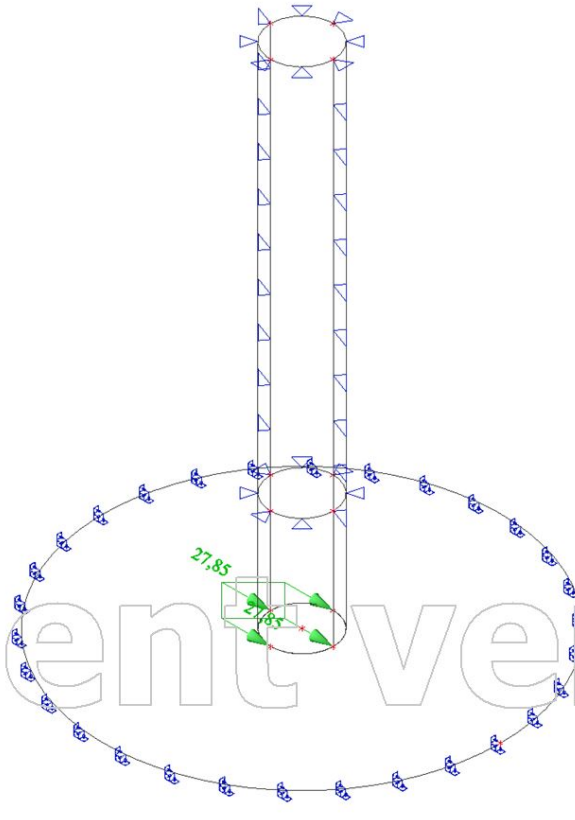


10.6.1. Line force on 2D member edge

Name	2D member	Type	Dir	Value - P ₁ [kN/m]	Pos x ₁	Loc	Edge
	Load case	System	Distribution	Value - P ₂ [kN/m]	Pos x ₂	Coor	Orig
LFS1044	S74 M_Mmax_ULS	Force GCS	Z Trapez	3190,68 -3190,68	0.000 1.000	Length Rela	1 From start
LFS1045	S75 M_Mmax_ULS	Force GCS	Z Trapez	3190,68 -3190,68	0.000 1.000	Length Rela	1 From start

10.7. Load cases - V_Nmax_SLS

Name	Description Spec	Action type Load type	Load group
V_Nmax_SLS		Permanent Standard	LG1

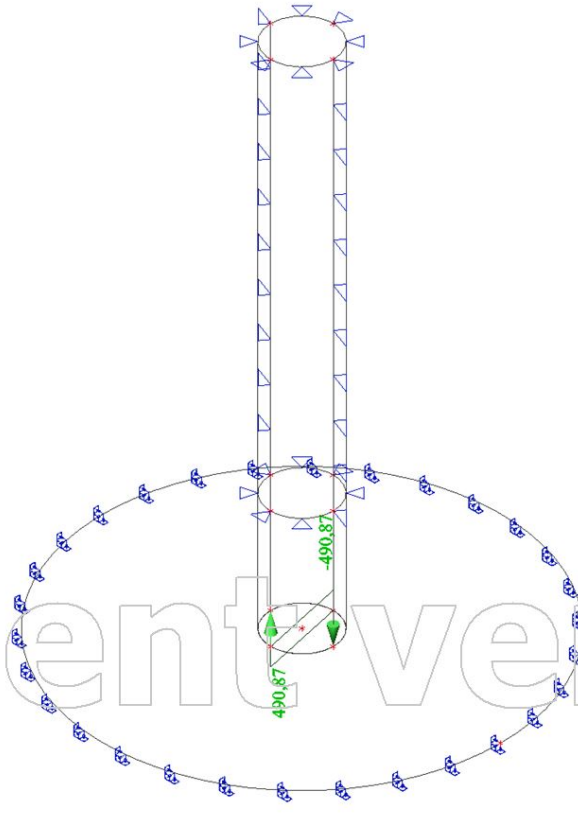


10.7.1. Line force on 2D member edge

Name	2D member	Type	Dir	Value - P ₁ [kN/m]	Pos x ₁	Loc	Edge
	Load case	System	Distribution	Value - P ₂ [kN/m]	Pos x ₂	Coor	Orig
LFS1054	S74 V_Nmax_SLS	Force GCS	X Uniform	27,85	0.000 1.000	Length Rela	1 From start
LFS1055	S75 V_Nmax_SLS	Force GCS	X Uniform	27,85	0.000 1.000	Length Rela	1 From start

10.8. Load cases - M_Nmax_SLS

Name	Description Spec	Action type Load type	Load group
M_Nmax_SLS		Permanent Standard	LG1

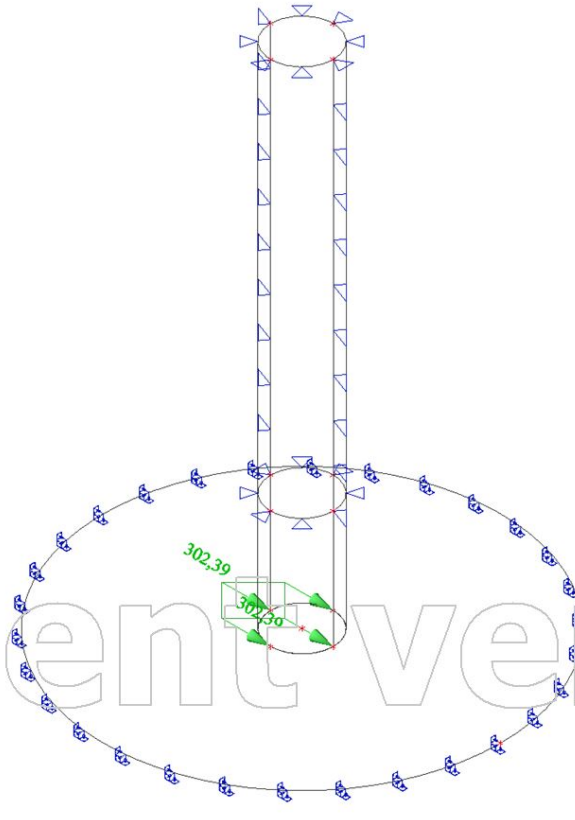


10.8.1. Line force on 2D member edge

Name	2D member	Type	Dir	Value - P ₁ [kN/m]	Pos x ₁	Loc	Edge
	Load case	System	Distribution	Value - P ₂ [kN/m]	Pos x ₂	Coor	Orig
LFS1056	S74	Force	Z	490,87	0.000	Length	1
	M_Nmax_SLS	GCS	Trapez	-490,87	1.000	Rela	From start
LFS1057	S75	Force	Z	490,87	0.000	Length	1
	M_Nmax_SLS	GCS	Trapez	-490,87	1.000	Rela	From start

10.9. Load cases - V_Vmax_SLS

Name	Description Spec	Action type Load type	Load group
V_Vmax_SLS		Permanent Standard	LG1

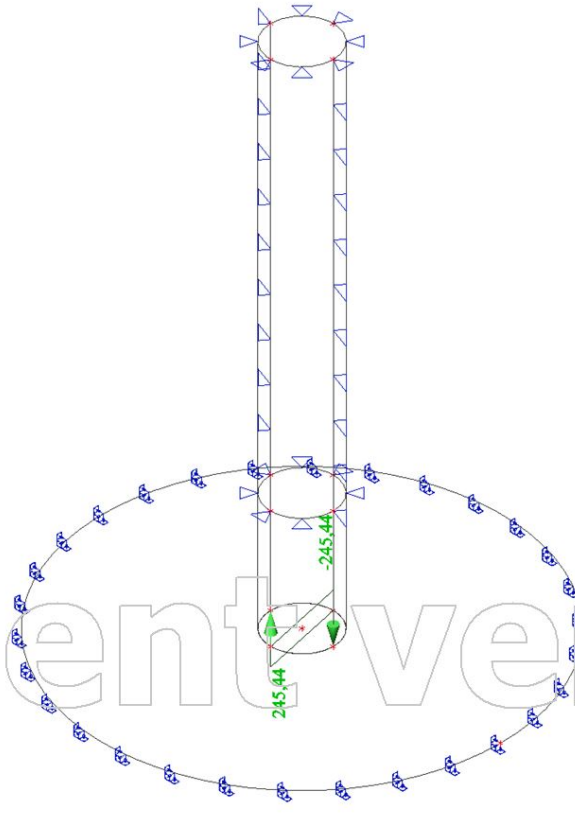


10.9.1. Line force on 2D member edge

Name	2D member	Type	Dir	Value - P ₁ [kN/m]	Pos x ₁	Loc	Edge
	Load case	System	Distribution	Value - P ₂ [kN/m]	Pos x ₂	Coor	Orig
LFS1038	S74 V_Vmax_SLS	Force GCS	X Uniform	302,39	0.000 1.000	Length Rela	1 From start
LFS1039	S75 V_Vmax_SLS	Force GCS	X Uniform	302,39	0.000 1.000	Length Rela	1 From start

10.10. Load cases - M_Vmax_SLS

Name	Description Spec	Action type Load type	Load group
M_Vmax_SLS		Permanent Standard	LG1

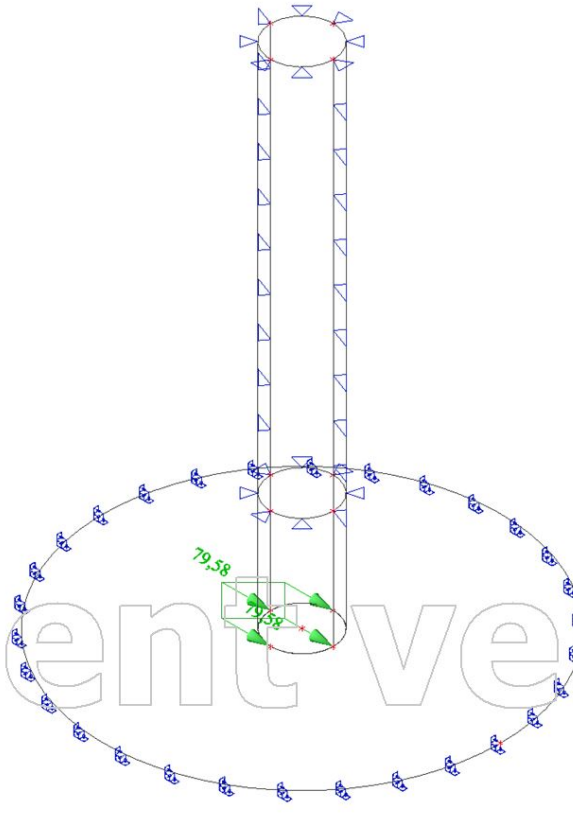


10.10.1. Line force on 2D member edge

Name	2D member	Type	Dir	Value - P ₁ [kN/m]	Pos x ₁	Loc	Edge
	Load case	System	Distribution	Value - P ₂ [kN/m]	Pos x ₂	Coor	Orig
LFS1048	S74	Force	Z	245,44	0.000	Length	1
	M_Vmax_SLS	GCS	Trapez	-245,44	1.000	Rela	From start
LFS1049	S75	Force	Z	245,44	0.000	Length	1
	M_Vmax_SLS	GCS	Trapez	-245,44	1.000	Rela	From start

10.11. Load cases - V_Mmax_SLS

Name	Description Spec	Action type Load type	Load group
V_Mmax_SLS		Permanent Standard	LG1

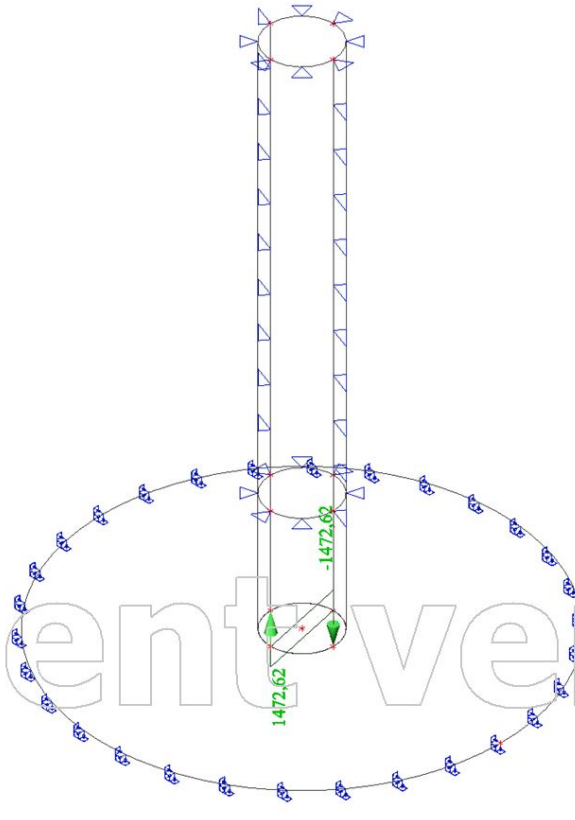


10.11.1. Line force on 2D member edge

Name	2D member	Type	Dir	Value - P ₁ [kN/m]	Pos x ₁	Loc	Edge
	Load case	System	Distribution	Value - P ₂ [kN/m]	Pos x ₂	Coor	Orig
LFS1040	S74 V_Mmax_SLS	Force GCS	X Uniform	79,58	0.000 1.000	Length Rela	1 From start
LFS1041	S75 V_Mmax_SLS	Force GCS	X Uniform	79,58	0.000 1.000	Length Rela	1 From start

10.12. Load cases - M_Mmax_SLS

Name	Description Spec	Action type Load type	Load group
M_Mmax_SLS		Permanent Standard	LG1



10.12.1. Line force on 2D member edge

Name	2D member	Type	Dir	Value - P ₁ [kN/m]	Pos x ₁	Loc	Edge
	Load case	System	Distribution	Value - P ₂ [kN/m]	Pos x ₂	Coor	Orig
LFS1046	S74	Force	Z	1472,62	0.000	Length	1
	M_Mmax_SLS	GCS	Trapez	-1472,62	1.000	Rela	From start
LFS1047	S75	Force	Z	1472,62	0.000	Length	1
	M_Mmax_SLS	GCS	Trapez	-1472,62	1.000	Rela	From start

11. Nonlinear combinations

Name	Type	Load cases	Coeff. [-]
Nmax_ULS	Ultimate	V_Nmax_ULS	1,00
		M_Nmax_ULS	1,00
Vmax_ULS	Ultimate	V_Vmax_ULS	1,00
		M_Vmax_ULS	1,00
Mmax_ULS	Ultimate	V_Mmax_ULS	1,00
		M_Mmax_ULS	1,00
Nmax_SLS	Serviceability	V_Nmax_SLS	1,00
		M_Nmax_SLS	1,00
Vmax_SLS	Serviceability	V_Vmax_SLS	1,00
		M_Vmax_SLS	1,00
Mmax_SLS	Serviceability	V_Mmax_SLS	1,00
		M_Mmax_SLS	1,00

Student version

Student version

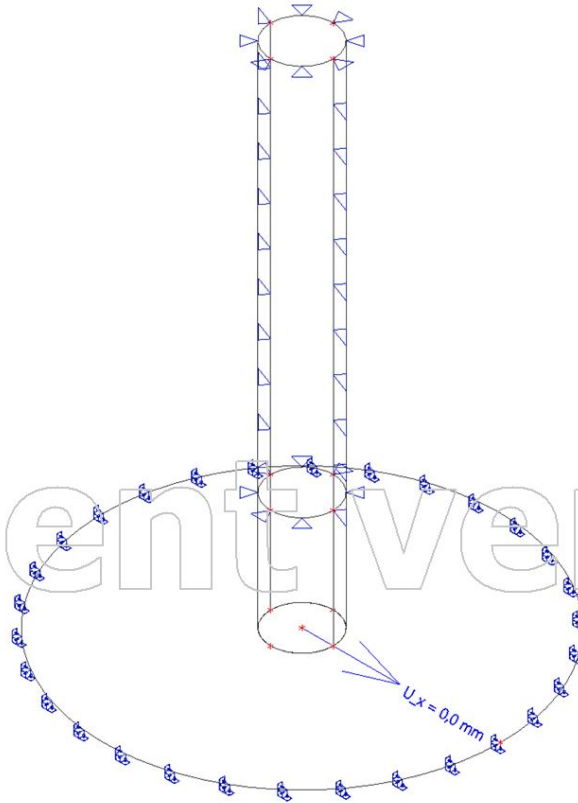
12. Displacement at dowel end

12.1. Combination 1: Nmax (SLS)

Nonlinear calculation, Extreme : Node
 Selection : Named selection - x=-a
 Nonlinear combinations : Nmax_SLS

Node	Case	Ux [mm]	Uy [mm]	Uz [mm]	Fix [mrad]	Fiy [mrad]	Fiz [mrad]
N239	Nmax_SLS	0,0	0,0	0,0	0,0	0,3	0,0

Values: **U_x**
 Nonlinear calculation
 NonLinear Combi: Nmax_SLS
 Extreme: Node
 Selection: Named selection - x=-a

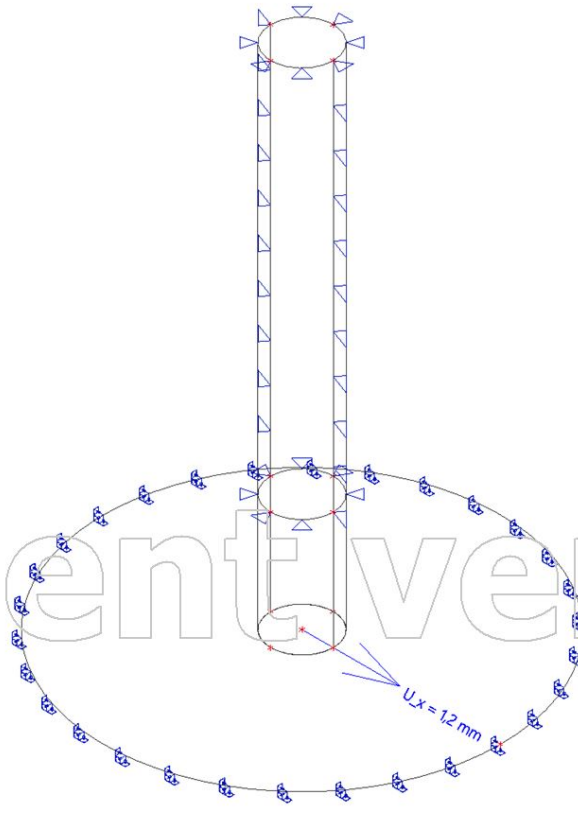


12.2. Combination 2: Vmax (SLS)

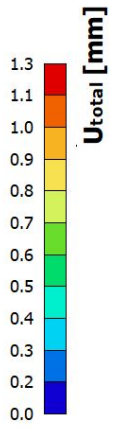
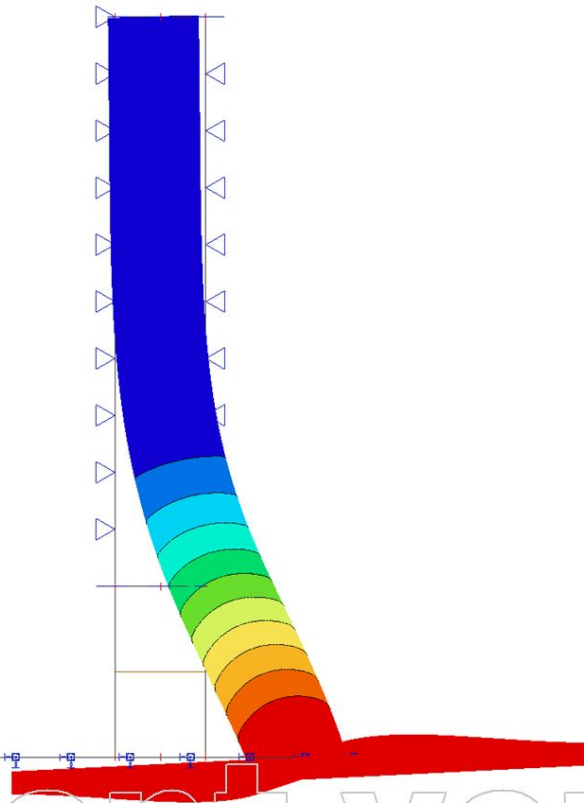
Nonlinear calculation, Extreme : Node
Selection : Named selection - x=-a
Nonlinear combinations : Vmax_SLS

Node	Case	Ux [mm]	Uy [mm]	Uz [mm]	Fix [mrad]	Fiy [mrad]	Fiz [mrad]
N239	Vmax_SLS	1,2	0,0	0,0	0,0	-3,4	0,0

Values: **U_x**
Nonlinear calculation
NonLinear Combi: Vmax_SLS
Extreme: Node
Selection: Named selection - x=-a



Values: U_{total}
Nonlinear calculation
NonLinear Combi: Vmax_SLS
Selection: All
Location: In nodes avg. on macro.
System: LCS mesh element



Student version

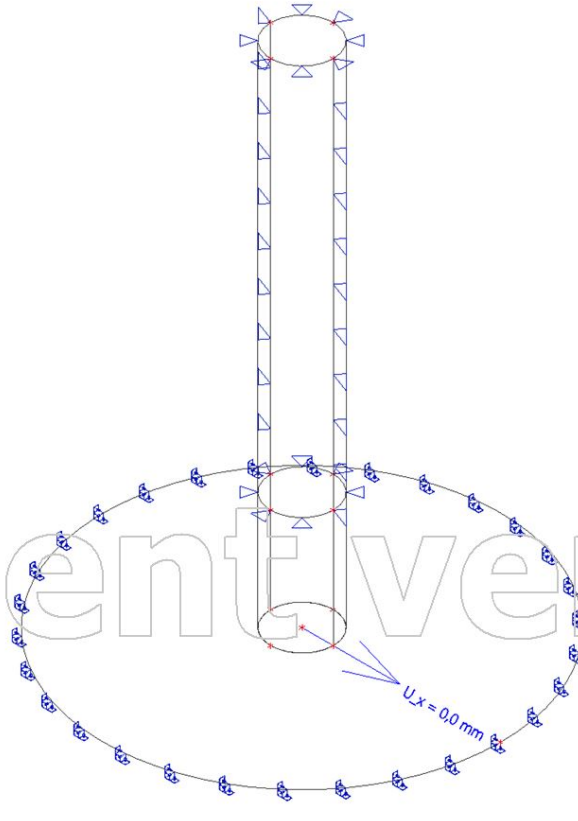
Student version

12.3. Combination 3: Mmax (SLS)

Nonlinear calculation, Extreme : Node
 Selection : Named selection - x=-a
 Nonlinear combinations : Mmax_SLS

Node	Case	Ux [mm]	Uy [mm]	Uz [mm]	Fix [mrad]	Fiy [mrad]	Fiz [mrad]
N239	Mmax_SLS	0,0	0,0	0,0	0,0	0,9	0,0

Values: **U_x**
 Nonlinear calculation
 NonLinear Combi: Mmax_SLS
 Extreme: Node
 Selection: Named selection - x=-a



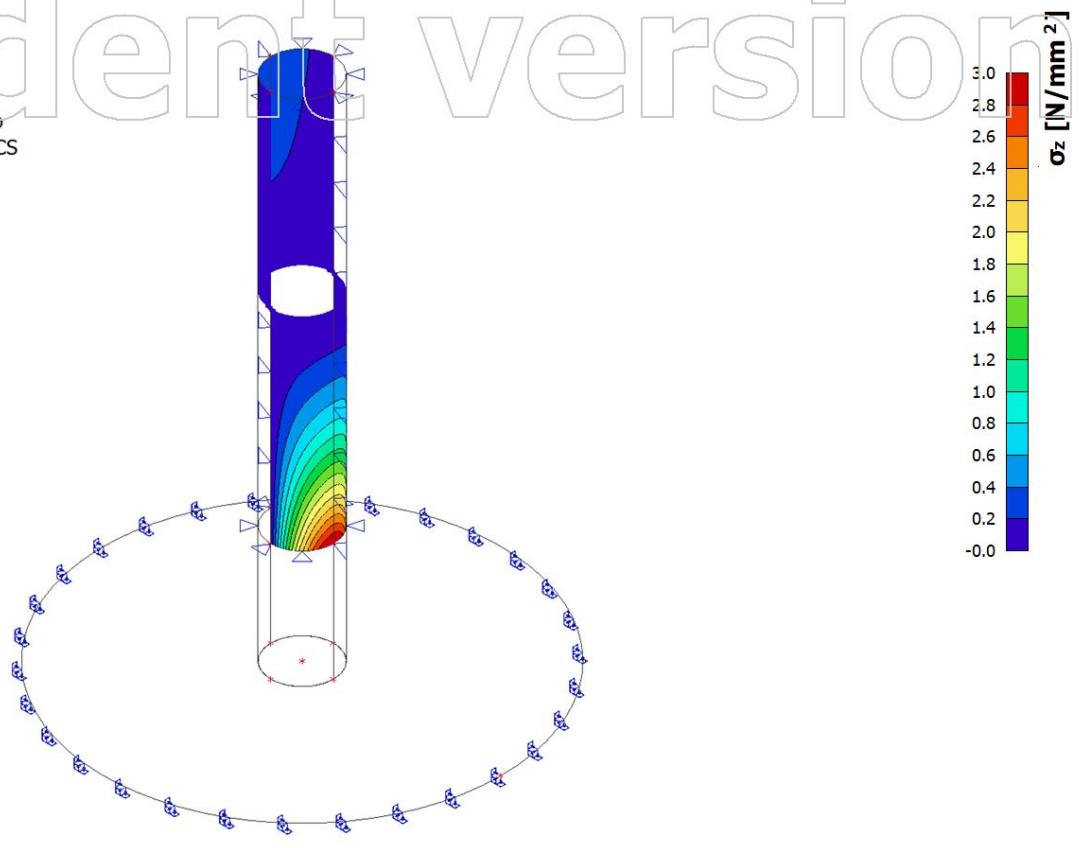
13. 2D contact stress between steel dowel and concrete interface

13.1. Combination 1: Nmax (ULS)

Nonlinear calculation
 NonLinear Combi: Nmax_ULS
 Extreme: Global
 Selection: Named selection - 0<x<b
 Location: In nodes avg.. System: LCS mesh element

Name	Mesh	Position [mm]	Case	T _{ZX} [N/mm ²]	T _{YZ} [N/mm ²]	σ _z [N/mm ²]
S77	Node: 9698	1251,963 1289,952 150,000	Nmax_ULS	0,0	0,0	0,2
S76	Node: 4909	1251,963 1210,048 150,000	Nmax_ULS	0,0	0,0	0,2
S77	Node: 9727	1289,807 1253,921 150,000	Nmax_ULS	0,0	0,0	3,0
S77	Node: 9728	1289,952 1251,963 150,000	Nmax_ULS	0,0	0,0	3,0
S76	Node: 6	1210,000 1250,000 150,000	Nmax_ULS	0,0	0,0	0,0
S76	Node: 4	1290,000 1250,000 150,000	Nmax_ULS	0,0	0,0	3,0

Values: σ_z
 Nonlinear calculation
 NonLinear Combi: Nmax_ULS
 Extreme: Global
 Selection: Named selection - 0<x<b
 Location: In nodes avg.. System: LCS mesh element

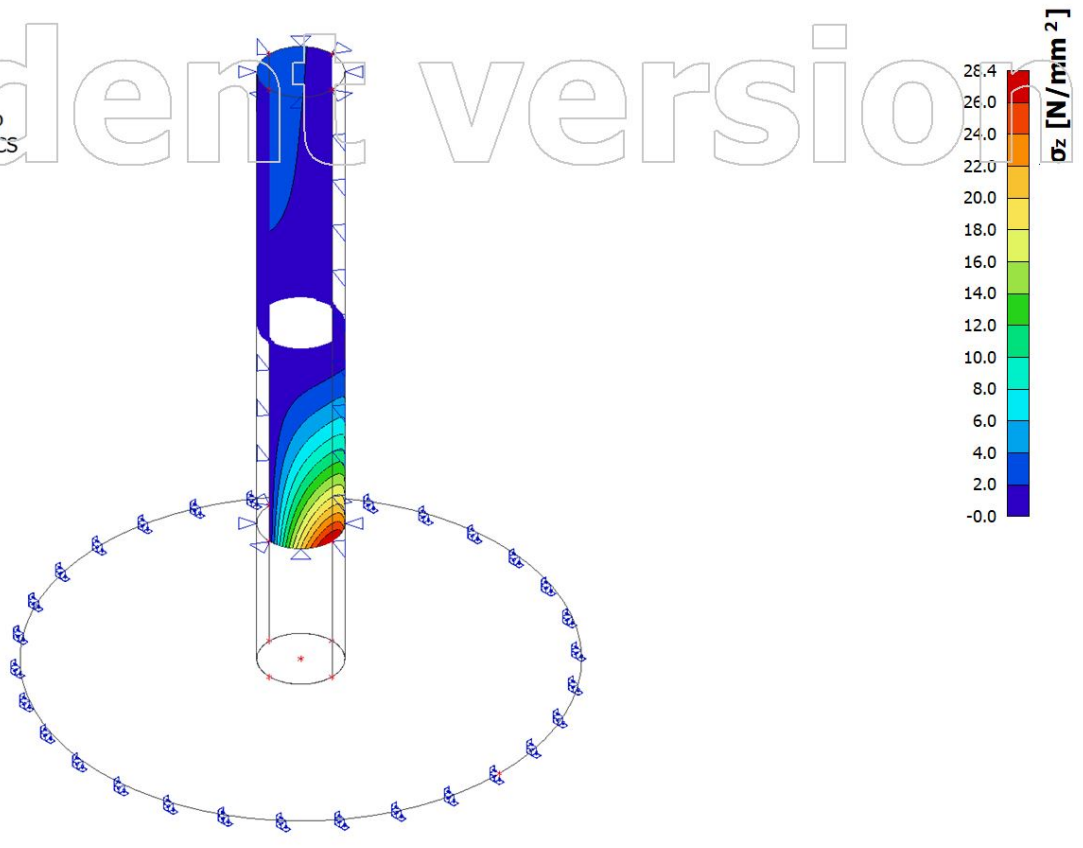


13.2. Combination 2: Vmax (ULS)

Nonlinear calculation
 NonLinear Combi: Vmax_ULS
 Extreme: Global
 Selection: Named selection - 0<x<b
 Location: In nodes avg.. System: LCS mesh element

Name	Mesh	Position [mm]	Case	T _{ZX} [N/mm ²]	T _{YZ} [N/mm ²]	σ _Z [N/mm ²]
S77	Node: 9698	1251,963 1289,952 150,000	Vmax_ULS	0,0	0,0	1,4
S76	Node: 4909	1251,963 1210,048 150,000	Vmax_ULS	0,0	0,0	1,4
S77	Node: 9727	1289,807 1253,921 150,000	Vmax_ULS	0,0	0,0	28,3
S77	Node: 9728	1289,952 1251,963 150,000	Vmax_ULS	0,0	0,0	28,4
S76	Node: 6	1210,000 1250,000 150,000	Vmax_ULS	0,0	0,0	0,0
S76	Node: 4	1290,000 1250,000 150,000	Vmax_ULS	0,0	0,0	28,4

Values: σ_Z
 Nonlinear calculation
 NonLinear Combi: Vmax_ULS
 Extreme: Global
 Selection: Named selection - 0<x<b
 Location: In nodes avg.. System: LCS mesh element



13.3. Combination 3: Mmax (ULS)

Nonlinear calculation
 NonLinear Combi: Mmax_ULS
 Extreme: Global
 Selection: Named selection - 0<x<b
 Location: In nodes avg.. System: LCS mesh element

Name	Mesh	Position [mm]	Case	T _{zx} [N/mm ²]	T _{yz} [N/mm ²]	σ _z [N/mm ²]
S77	Node: 9698	1251,963 1289,952 150,000	Mmax_ULS	0,0	0,0	0,6
S76	Node: 4909	1251,963 1210,048 150,000	Mmax_ULS	0,0	0,0	0,6
S77	Node: 9727	1289,807 1253,921 150,000	Mmax_ULS	0,0	0,0	12,0
S77	Node: 9728	1289,952 1251,963 150,000	Mmax_ULS	0,0	0,0	12,1
S76	Node: 6	1210,000 1250,000 150,000	Mmax_ULS	0,0	0,0	0,0
S76	Node: 4	1290,000 1250,000 150,000	Mmax_ULS	0,0	0,0	12,1

Values: σ_z
 Nonlinear calculation
 NonLinear Combi: Mmax_ULS
 Extreme: Global
 Selection: Named selection - 0<x<b
 Location: In nodes avg.. System: LCS mesh element

