Piled design using Swedish P-y curves

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Appendix

1. GENERAL

A steel pile is evaluated using a non-linear analysis.

The pile pinned a bottom and is unrestrained at top.

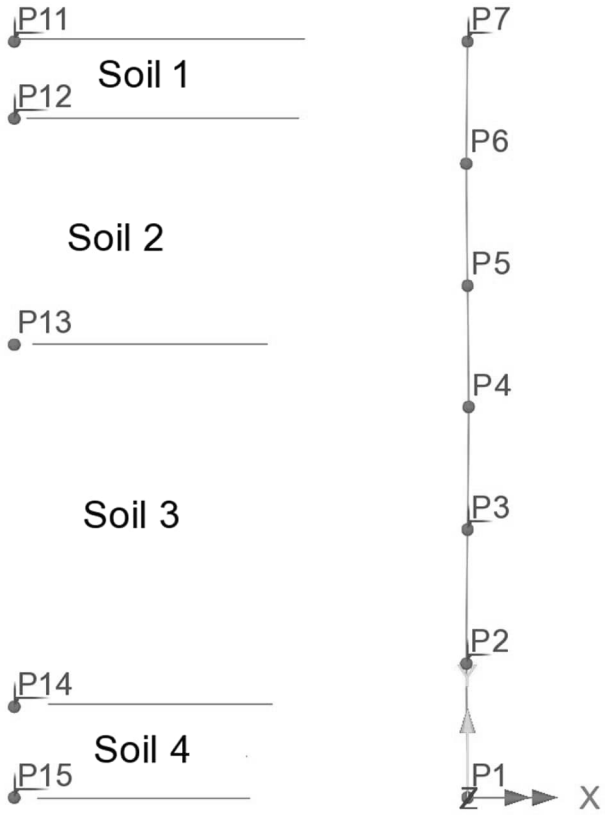
The movement of superstructure due to movements results in forced translation (δ_H).

An eccentric imperfection (e_{exc}) when installing bearings relative to piles is considered.

Also imperfection of piles (δ_0) is considered.

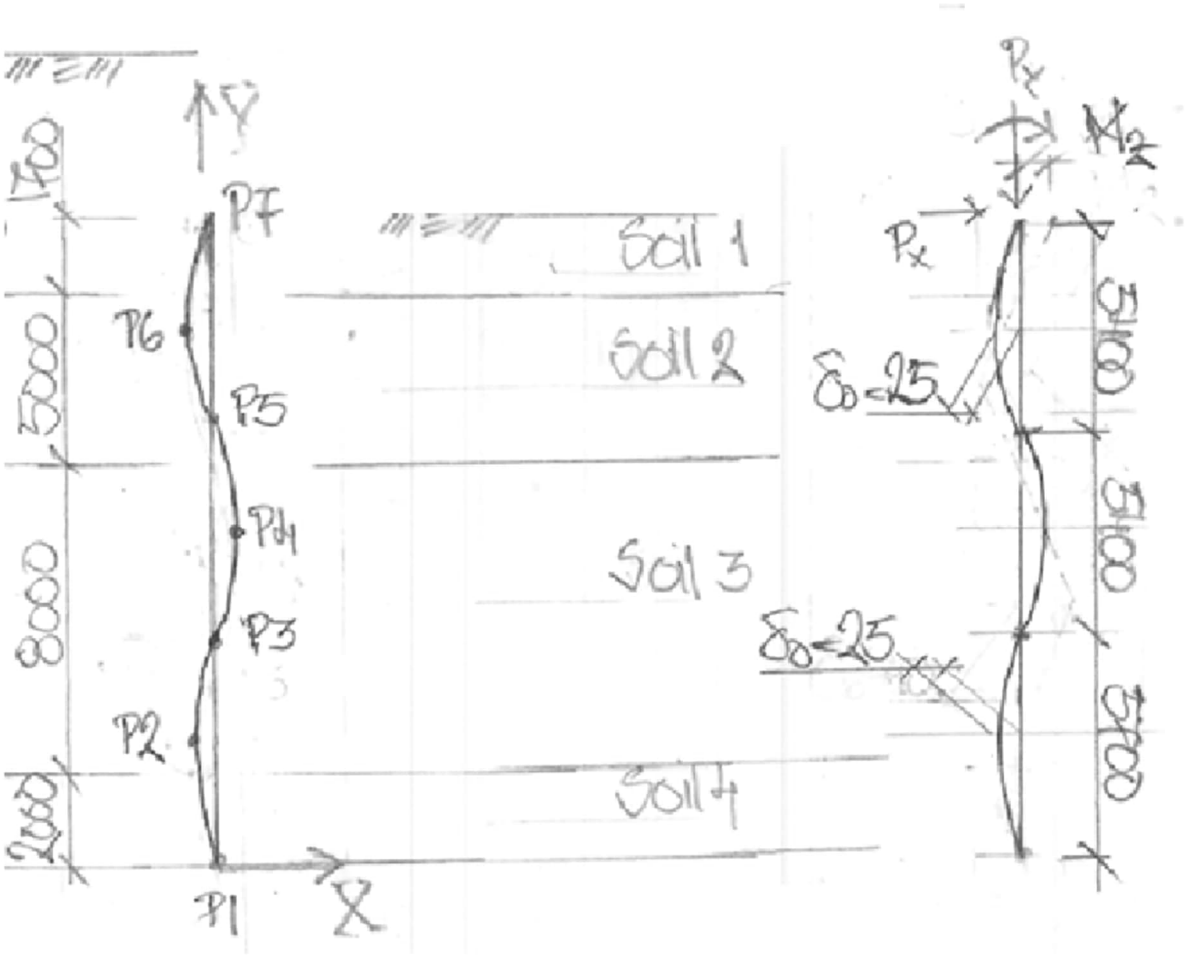
1.1 OVERVIEW

Soil	H	γ	γ´	Stiffness	Material
1	1.7	18	10	”Mycket låg”	”Sand”
2	5.0	20	13	”Medelhög”	”Sandig morän”
3	8.0	20	13	”Medelhög”	”Grusig morän”
4	2.0	20	13	”Hög”	”Blockig morän”
-	m	kN/m^3	kN/m^2	-	-


P11
Soil 1
P12
Soil 2
P13
Soil 3
P14
Soil 4
P15
P7
P6
P5
P4
P3
P2
P1
Z
X

1.3 PILE IMPERFECTIONS

Assumed pile imperfections.

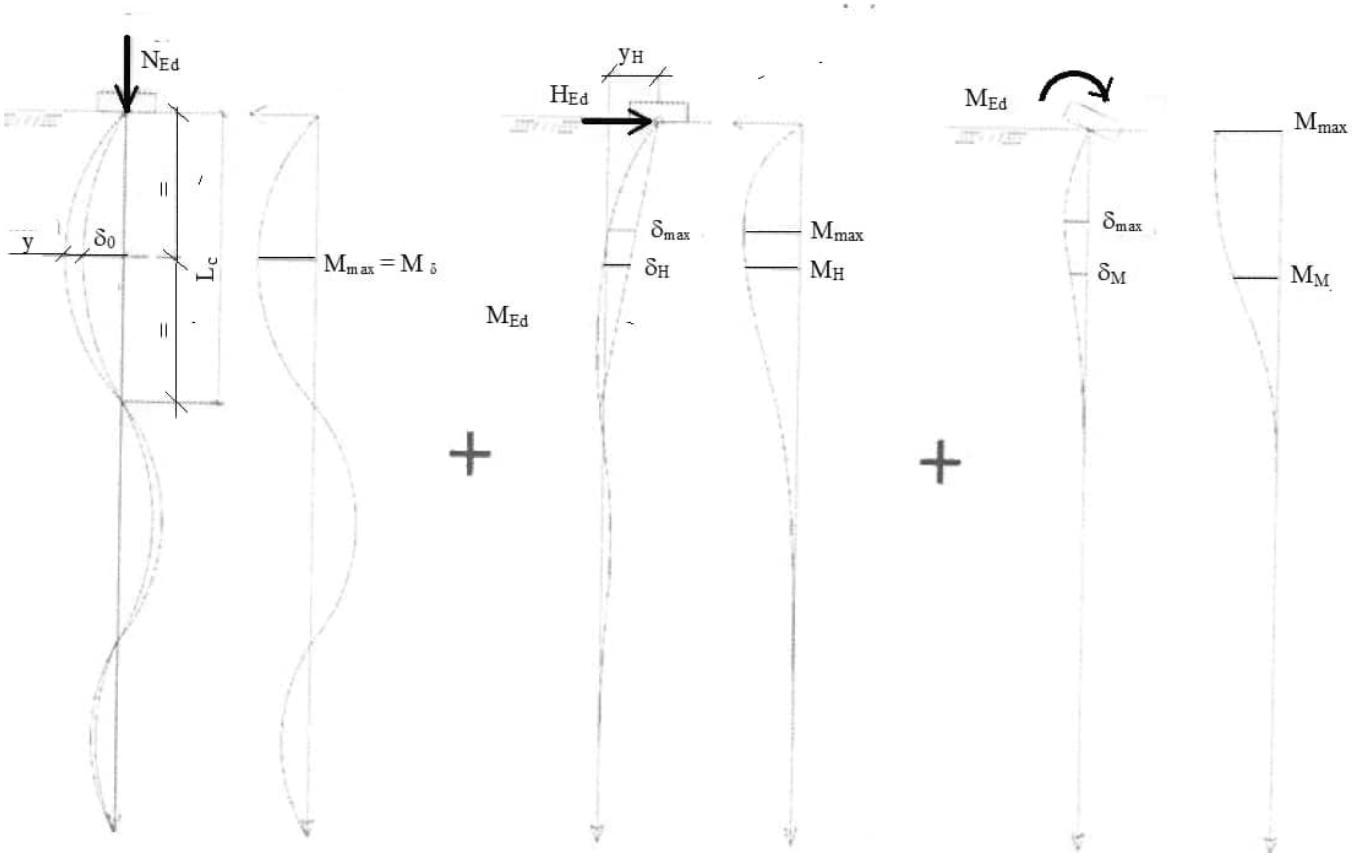


1.4 GEOTECHNICAL THEORY

Below are the effects of initial imperfections (δ_0), horizontal force (H_{Ed}) and moment (M_{Ed}). What is seen is that M_{max} do not act a same location.

It can also be seen that soil resistance is lowest at top of pile where H_{Ed} and M_{Ed} are acting. Generally, soil reaches maximal pressure (yield strength) near top of pile since load effect is highest and soil strength is often weakest. Once the load effect reaches yield strength no additional lateral soil force will act, thus initial imperfections will give less contribution to design load effect since M_{max} is located lower than for horizontal force and moment.

Two analyses will be performed to verify this assumption. The first analysis is without initial imperfections and the second including.



Initial imperfection

Horizonal force
($y_H \rightarrow H_{Ed}$)

Moment
($M_{Ed} = N_{Ed} \cdot e_{exc}$)

1.5 Swedish P-y curves

P-y curves are determined using TRVINFRA-00227 appendix 3.

Since soil height varies on either side of pile due to embankment both are considered.

1.5.1 Lateral stiffness

$$K = \min(k_k \cdot d; K_{max}) = \min(n_h \cdot z; K_{max}) \left[\frac{kN}{m^2}\right]$$

Excluding embankment

Soil	z	n_h	K_{max}	$n_h \cdot z$	K
1	0	1500	2.40	0	0
-"-	1.7	1500	2.40	2.55	2,40
2	1.7	4500	18.00	7.65	4,50
-"-	4.0	4500	18.00	18.00	18,00
-"-	4.2	4500	18.00	18.90	18.00
-"-	6.7	4500	18.00	30.15	18,00
3	6.7	4500	18.00	30.15	18,00
-"-	10.7	4500	18.00	48.15	18,00
-"-	14.7	4500	18.00	66.15	18,00
4	14.7	7500	30.00	66.15	30,00
-"-	16.7	7500	30.00	125.25	30,00
-	m	kN/m^3	kN/m^2	MN/m^2	MN/m^2

Including embankment (h = 3.8 m)

Soil	z	n_h	K_{max}	$n_h \cdot z$	K
1	3.8	1500	2.40	5.70	2,40
-"-	5.5	1500	2.40	8.25	2,40
2	5.5	4500	18.00	24.75	18,00
-"-	8.0	4500	18.00	36.00	18,00
-"-	10.5	4500	18.00	47.25	18,00
3	10.5	4500	18.00	47.25	18,00
-"-	15.5	4500	18.00	69.75	18,00
-"-	18.5	4500	18.00	83.25	18,00
4	18.5	7500	30.00	138.75	30,00
-"-	20.5	7500	30.00	153.75	30,00
-	m	kN/m^3	kN/m^2	MN/m^2	kN/m^2

1.5.2 Maximum soil pressure

$$q_k = 3K_p \cdot \sigma_v' \left[\frac{kN}{m^2}\right]$$

Excluding embankment

Soil	z	ϕ_κ	K_p	σ'_v	q_k	$F = d \cdot q_k$
1	0	26.7	2.63	0	0	0
-"-	1.7	26.7	2.63	17	134	43
2	1.7	29.1	2.89	17	147	47
-"-	4.2	29.1	2.89	50	429	136
-"-	6.7	29.1	2.89	82	710	226
3	6.7	28.5	2.82	82	693	221
-"-	10.7	28.5	2.82	134	1133	362
-"-	14.7	28.5	2.82	186	1573	502
4	14.7	42.0	5.05	186	2817	899
-"-	16.7	42.0	5.05	212	3212	1025
-	m	deg	kN/m²	kN/m²	kN/m²	kN/m

Including embankment (h = 3.8 m)

Soil	z	ϕ_κ	K_p	σ'_v	q_k	$F = d \cdot q_k$
1	3.8	26.7	2.63	76*	599	191
-"-	5.5	26.7	2.63	93	733	234
2	5.5	29.1	2.89	93	806	257
-"-	8.0	29.1	2.89	75	1088	347
-"-	10.5	29.1	2.89	158	1369	437
3	10.5	28.5	2.82	158	1337	427
-"-	14.5	28.5	2.82	210	1777	567
-"-	18.5	28.5	2.82	262	2216	707
4	18.5	42.0	5.05	262	3969	1266
-"-	20.5	42.0	5.05	288	4363	1392
-	m	deg	kN/m²	kN/m²	kN/m²	kN/m

$$* = 3.8\,m \cdot 20\,\frac{kN}{m^3} = 76kPa$$

2. SYSTEM ANALYSIS

2.1 GENERAL

The pile structure is modelled in 2D using FEM-program.

The pile is modelled using 2D beam elements (BMI2).

Soil is modelled using non-linear springs (JNT3).

The pile is considered pinned at bottom and free at top.

Two models are studied as seen below.

Modell	Imperfections
Pile_straight	No
Pile_spline	Yes

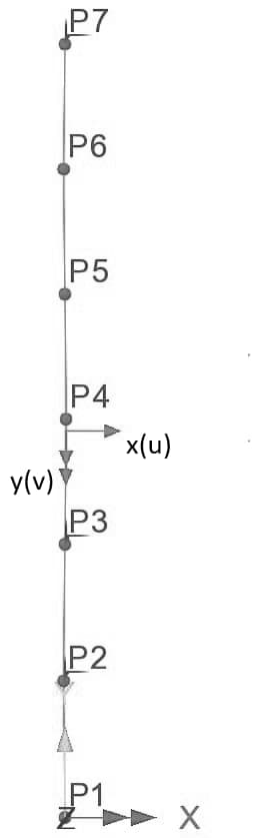
2.2 SKETCH SYSTEM ANALYSIS

2.2.1 Geometry

Points (P1-P7) and line (L1-L6) including coordinate systems.

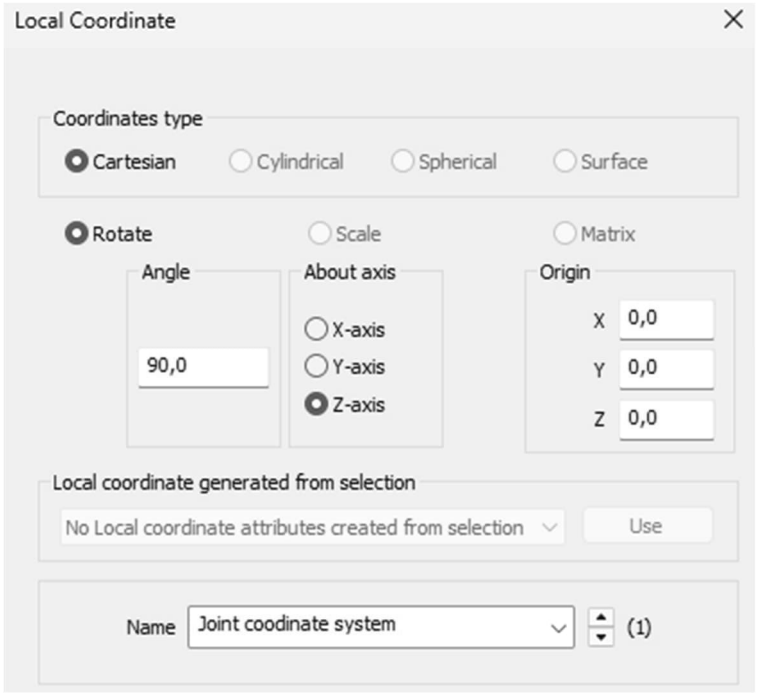
Global: X-Y-Z

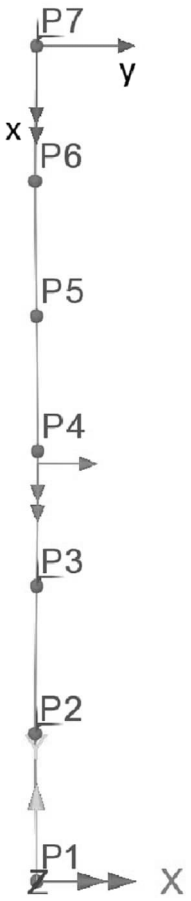
Local line coordinate system: x-y



2.2.2 Local coordinate system

Due to imperfections the *Local line coordinate system*: x-y can not be used for definition joint elements, thus coordinate system Joint coordinate system is createad.





2.2.3 Cross section properties

The properties include the effect of concrete (C35/45) and corrosion (t_r) of pile (ϕ323.9 x 12.5).

d = D – $2t_{rm}$ = 323.9 – 2 x 2.4 mm = 319 mm

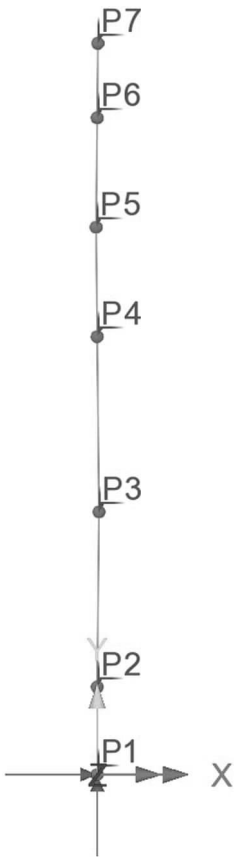
$$A = 9.805 \cdot 10^{-3}\ m^2$$

$$I = 1.406 \cdot 10^{-4}\ m^4$$

$$E_{sk} = 210GPa \qquad \rightarrow E = \frac{\alpha_s \cdot \mu_s \cdot E_{sk}}{\gamma_{M0}} = \frac{0.9 \cdot 1.0 \cdot 210GPa}{1.0} = 189Ga$$

2.2.4 Boundary

Pile is pinned at bottom (P1).



2.2.5 MESH: Beam element (BMI2)

Pile is modelled as thick beam as seen below.

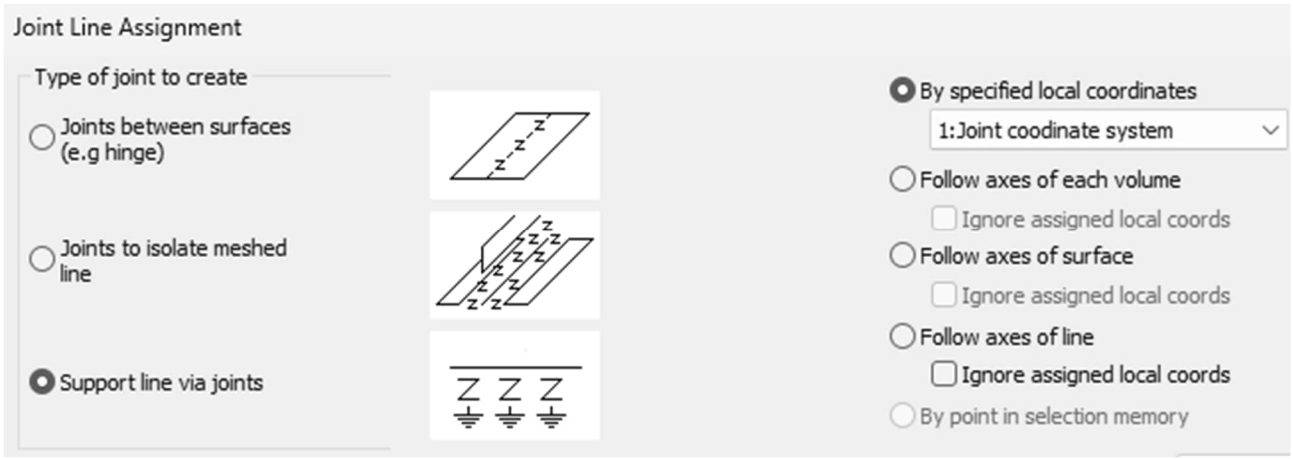
Name	Element length	End release: Start	End release: End
Pile	0.5 m	None	None

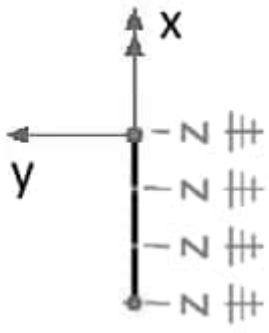
2.2.6 Joint element between lines (JNT3)

Connection between soil and pile is of type joint element, see presentation below. The joint has no rotational stiffness in order achieve a hinge.

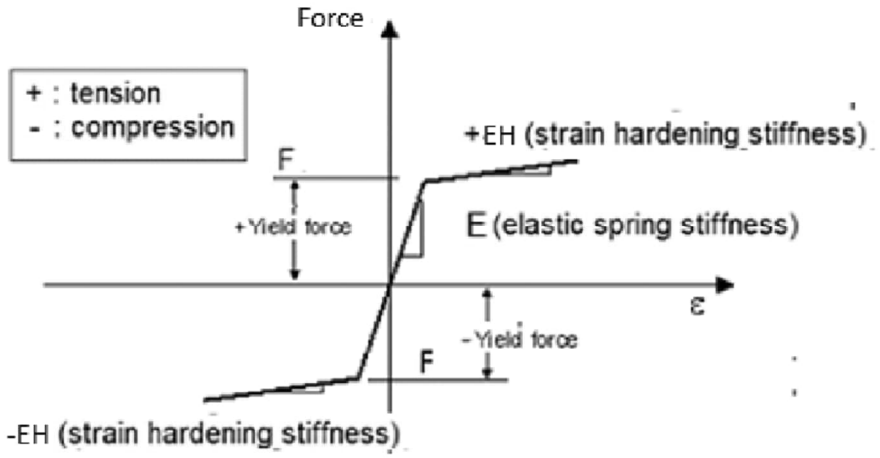
The joint uses nonlinear material termed *Elasto-Plastic (Tension and Compression Equal).* They vary along pile. This is handled using *Line Variation.*

The joint are introduced as same location as nodes along beam element.





Principle sketch



The properties “E” and “F” are vary over distance. This is handled by introducing a line variation.

Remark

Since lateral resistance is higher excluding embankment, this is used in system analysis since weaker soil material generates more load effect in pile.

2.2.6.1 Elastic spring stiffness (Elastic spring stiffness ∴ E)

See page 7 (excluding embankment).

Line Variation

Type: Interpolation

Specify order

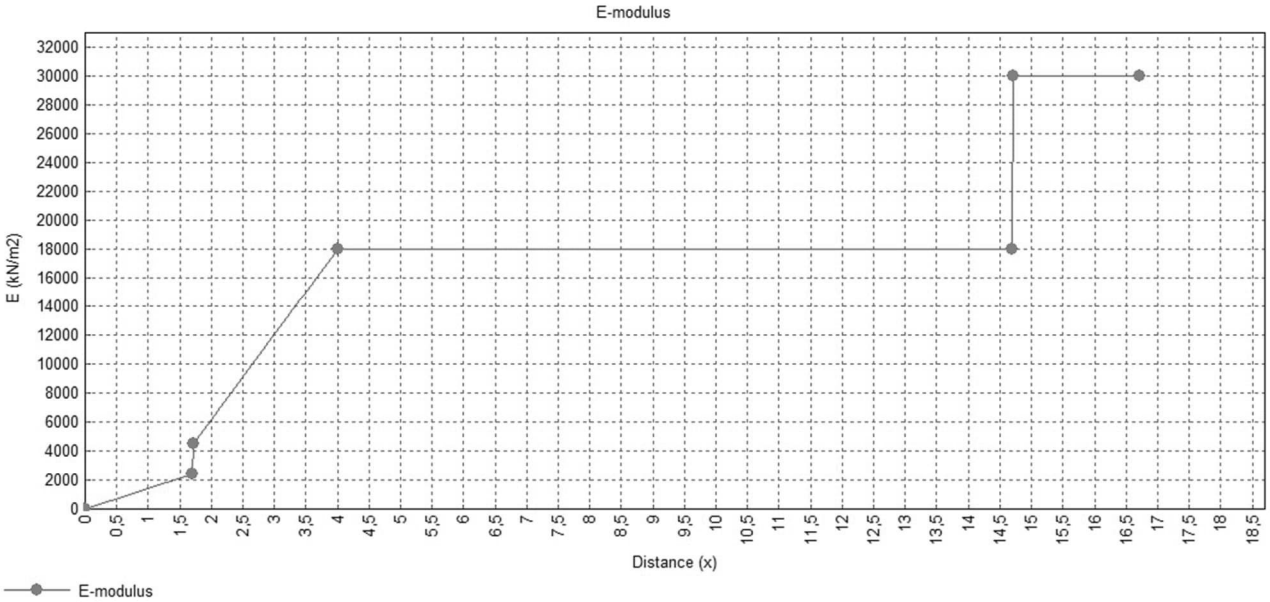
Order: Linear

Equal spacing assumed

Distance type: Actual

	Distance (x)	Value (y)
1	0	0,0
2	1,7	2,4E3
3	1,71	4,5E3
4	4	18,0E3
5	4,2	18,0E3
6	6,7	18,0E3
7	6,71	18,0E3
8	10,7	18,0E3
9	14,7	18,0E3
10	14,71	30,0E3
11	16,71	30,0E3

Name: E (1)



2.2.6.2 Maximum soil pressure (Yield force ∴ F)

See page 8 (excluding embankment).

Line Variation

Type: Interpolation

Specify order

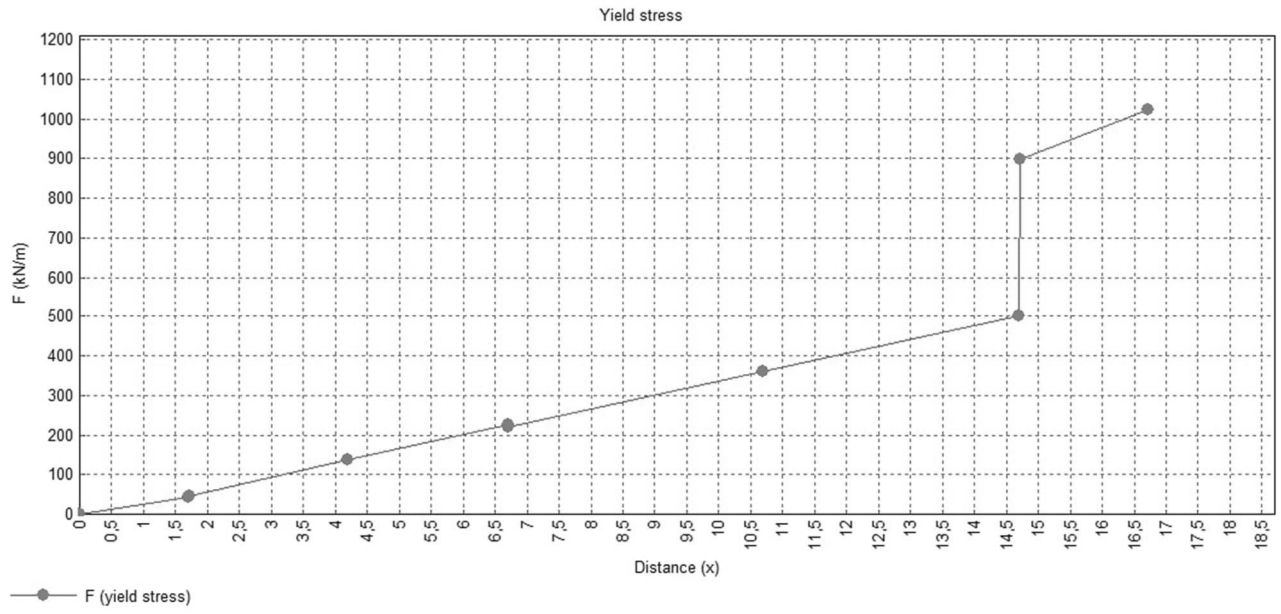
Order: Linear

Equal spacing assumed

Distance type: Actual

	Distance (x)	Value (y)
1	0	0,0
2	1,7	43,0
3	1,71	47,0
4	4,2	136,0
5	6,7	226,0
6	6,71	221,0
7	10,7	362,0
8	14,7	502,0
9	14,71	899,0
10	16,71	1,025E3

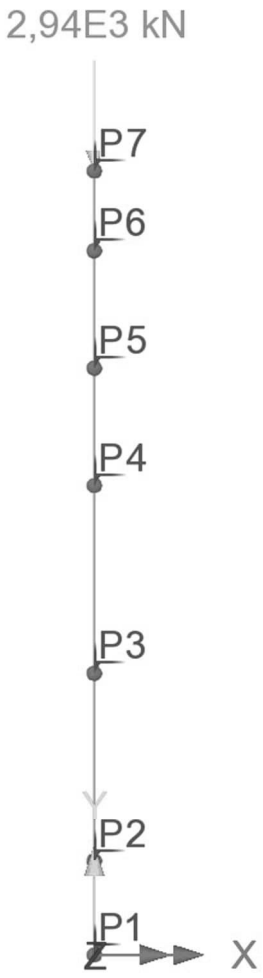
Name: F (14)



3. LOADS

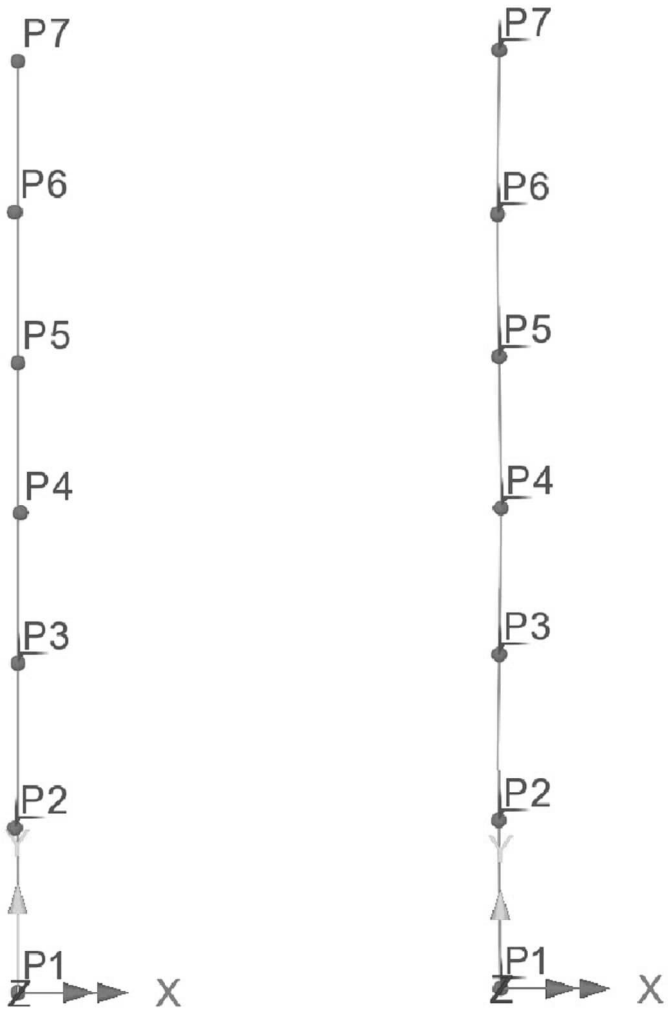
3.1 VERTICAL LOAD

N_{Ed} = 2940 kN



3.2 INITIAL IMPERFECTIONS

Two models are studied. Either with or without imperfections, see page 3.

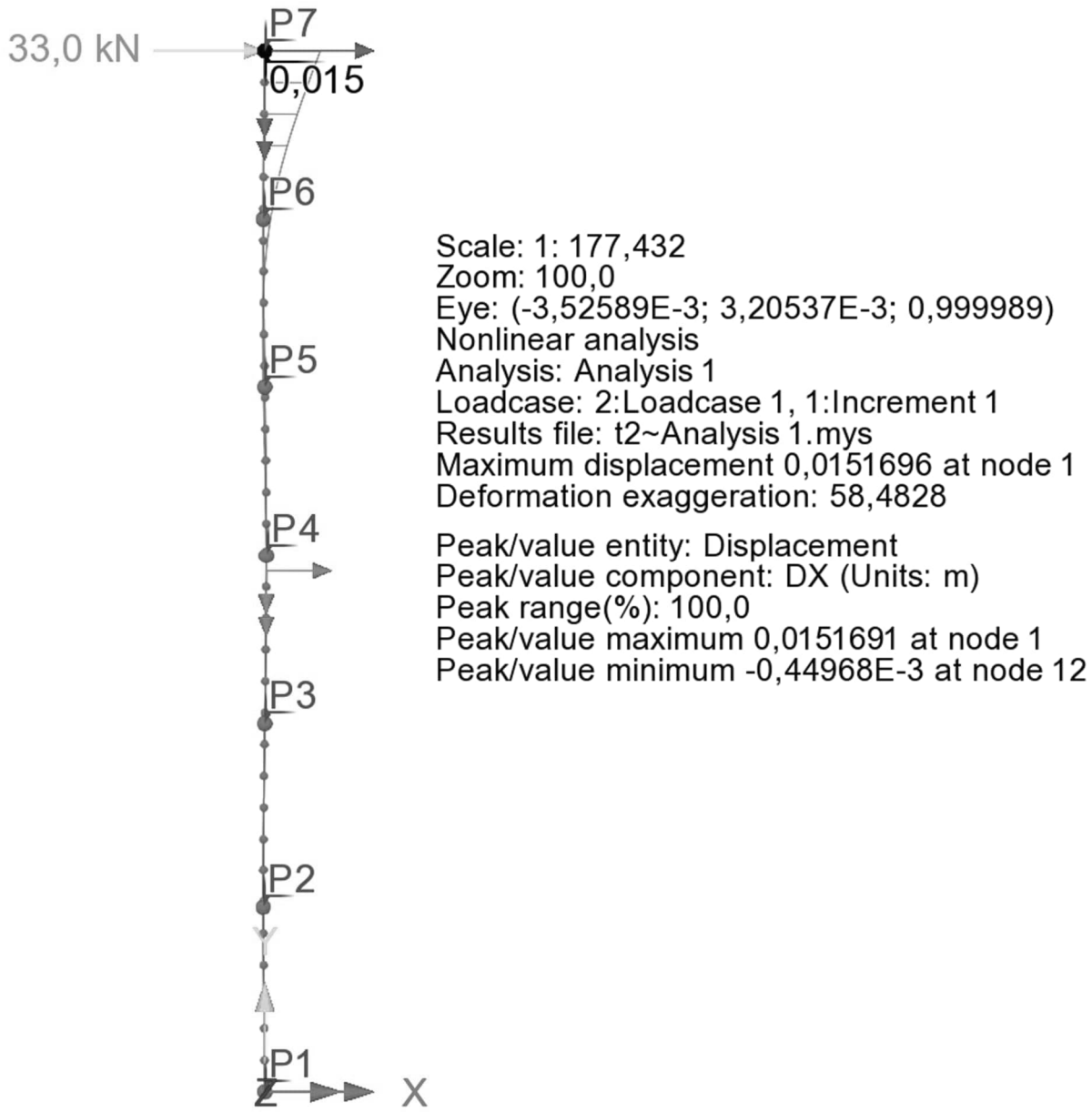


Straight pile Spline pile

3.3 HORIZONTAL LOAD

The horizontal load acts due to movement (y_H) of superstructure.

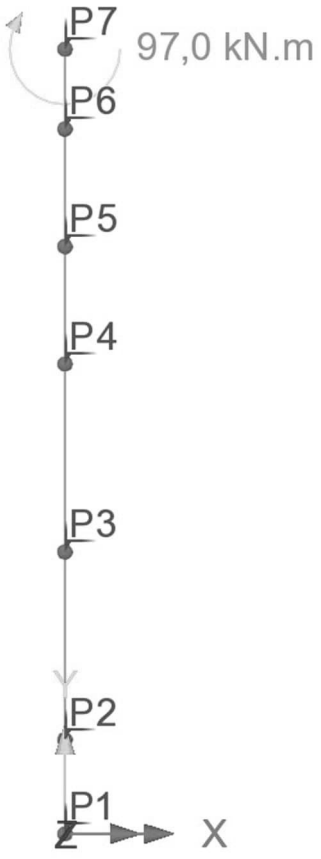
y_H = 15 mm → H_{Ed} = 33 kN



3.4 MOMENT LOAD

The moment load arises due to excentric bearing load.

$e_{exc} = 33\ mm \quad \rightarrow M_{Ed} = e_{exc} \cdot N_{Ed} = 0.033\ m \cdot 2940\ kN = \ 97\ kMm$



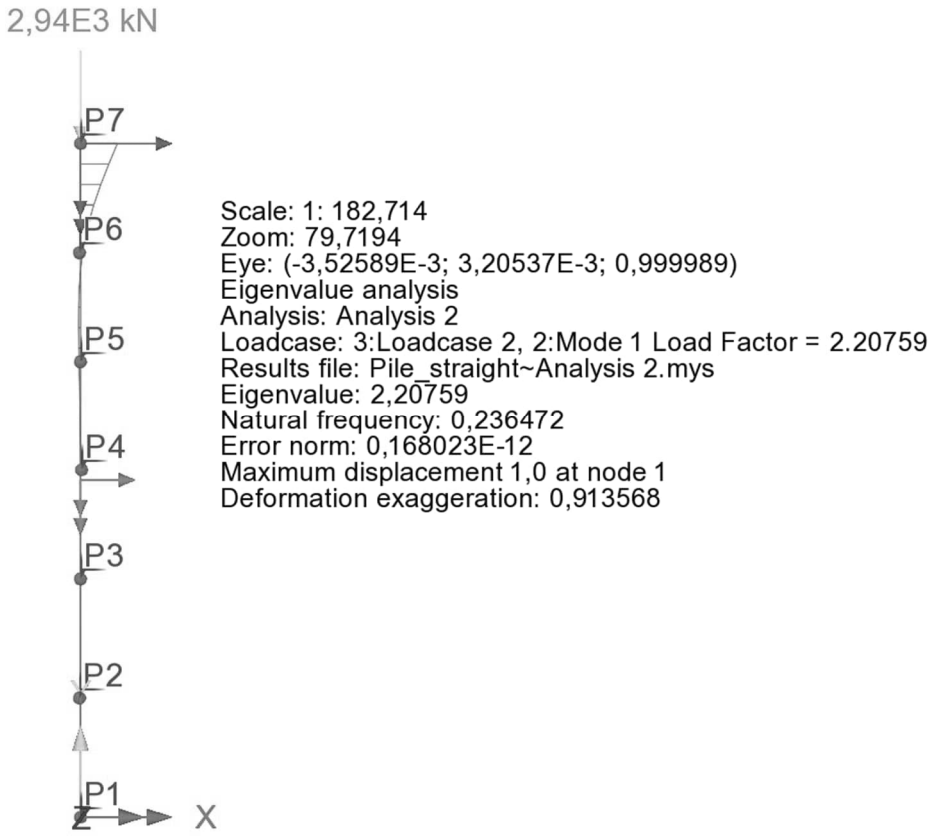
4. SUMMARY RESULTS

4.1 STRAIGHT PILE

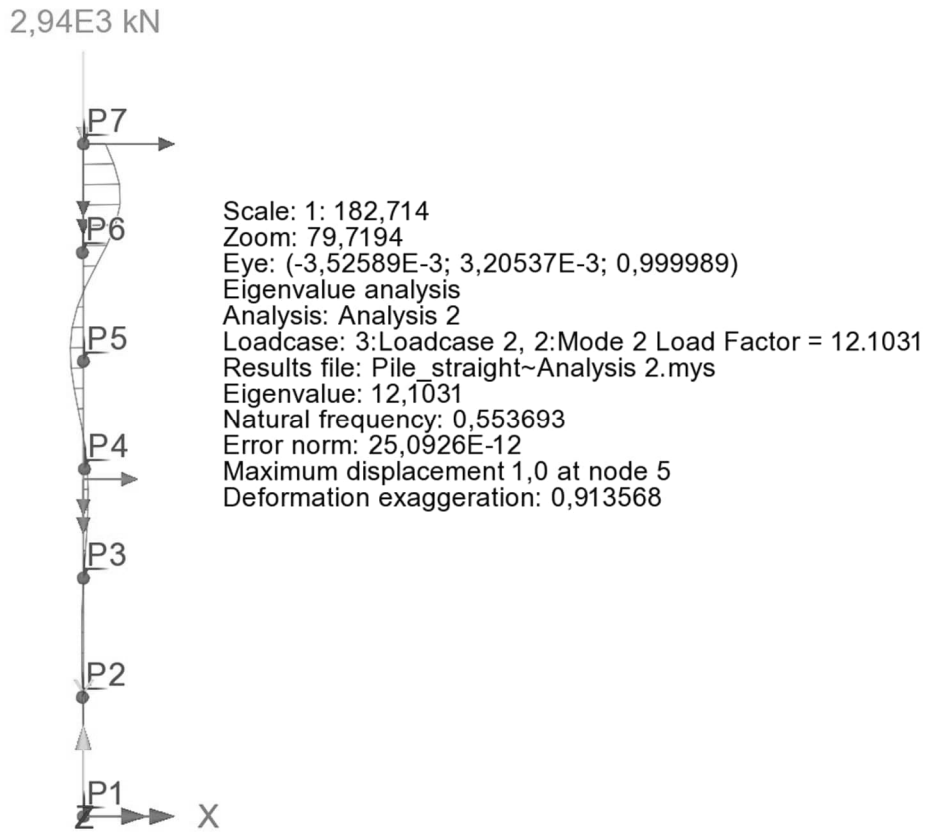
See appendix 1 (∴ Pile_straight).

4.1.1 Buckling load

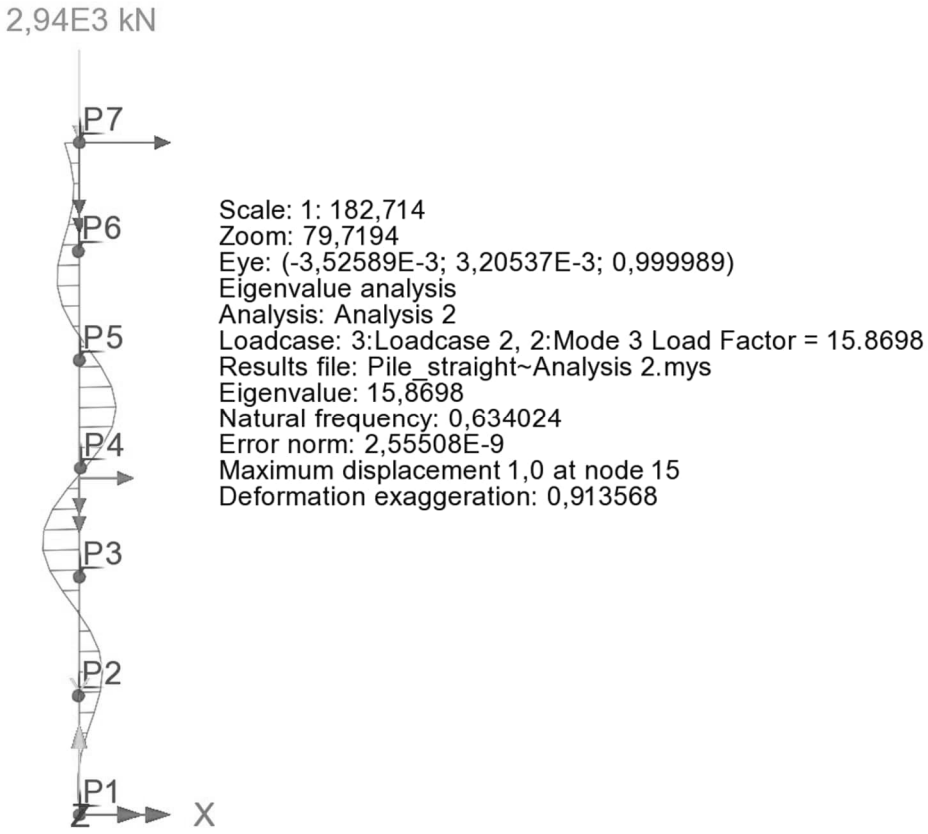
$$N_{cr} = s \cdot N_{Ed} = 2.208 \cdot 2940\ kN = 6491 kN$$



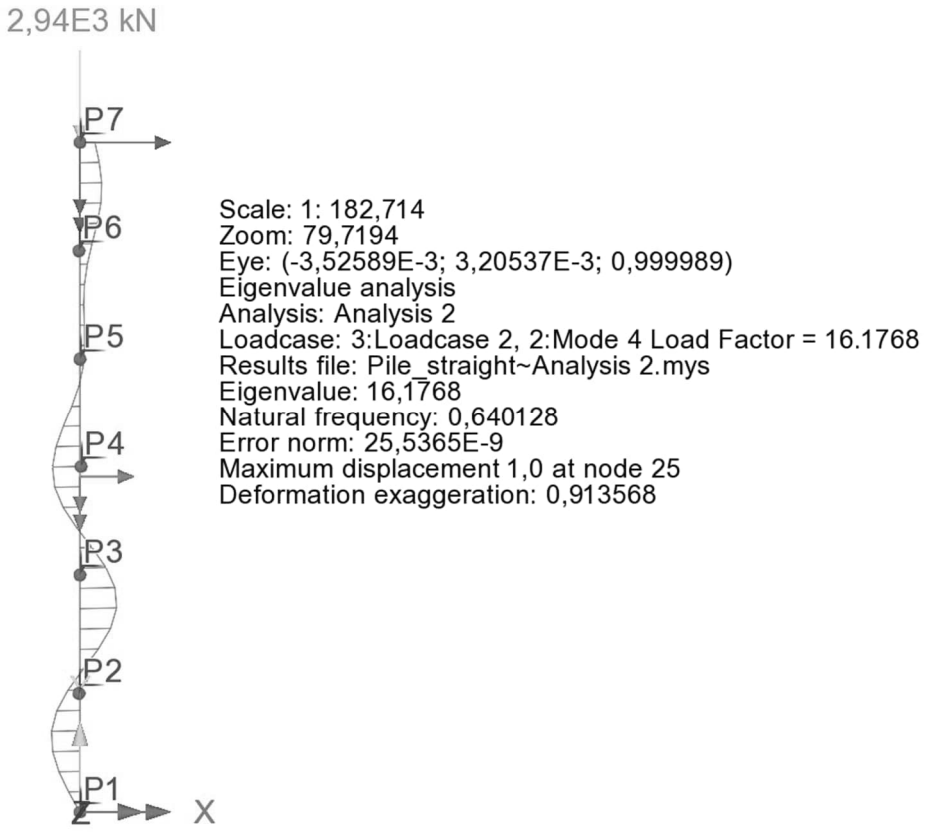
Mode 1
Load factor 2.208



Mode 2
Load factor 12.103



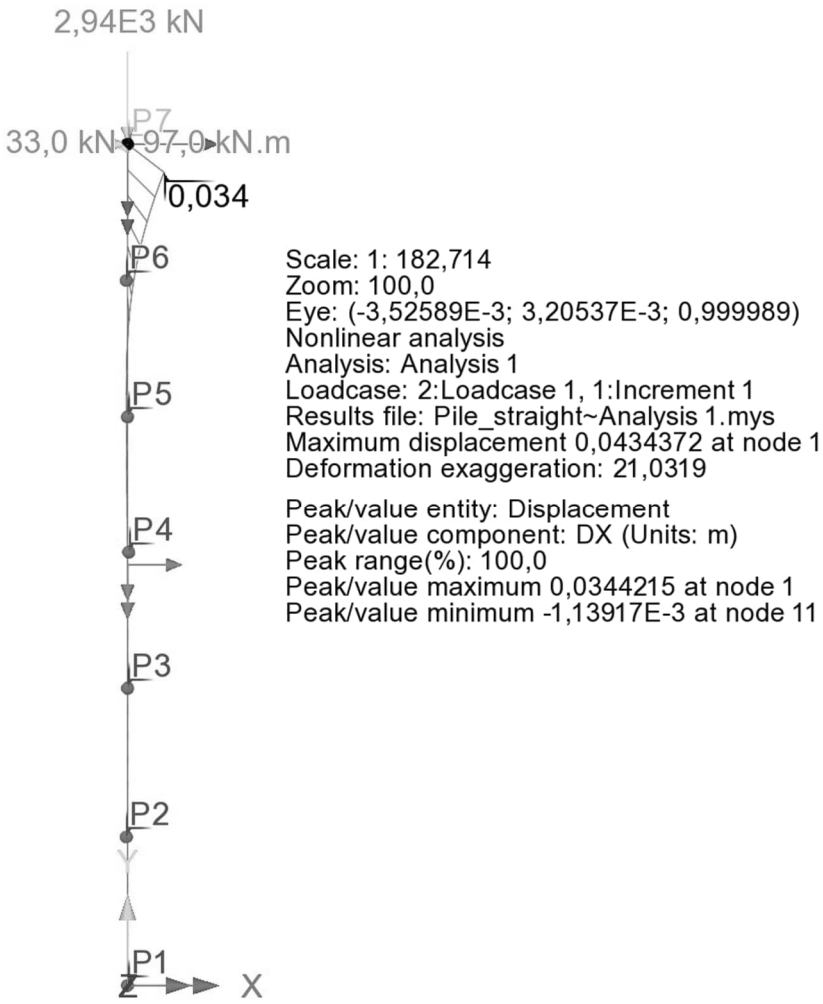
Mode 3
Load factor 15.870



Mode 4
Load factor 16.177

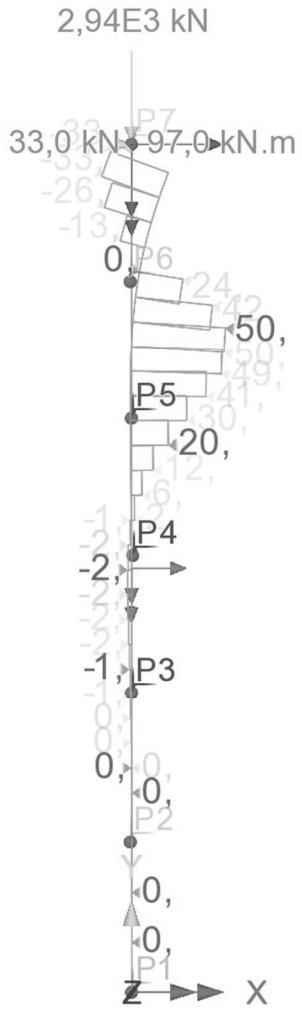
4.1.2 Deformations

$N_{Ed} = 2940kN, H_{Ed} = 33kN \;\&\; M_{Ed} = 97kNm \quad \rightarrow max\ Dx = 34\ mm$



4.1.3 Shear forces: Fy

$N_{Ed} = 2940kN, H_{Ed} = 33kN \;\&\; M_{Ed} = 97kNm \quad \rightarrow max\ Fy = 50\ kN$

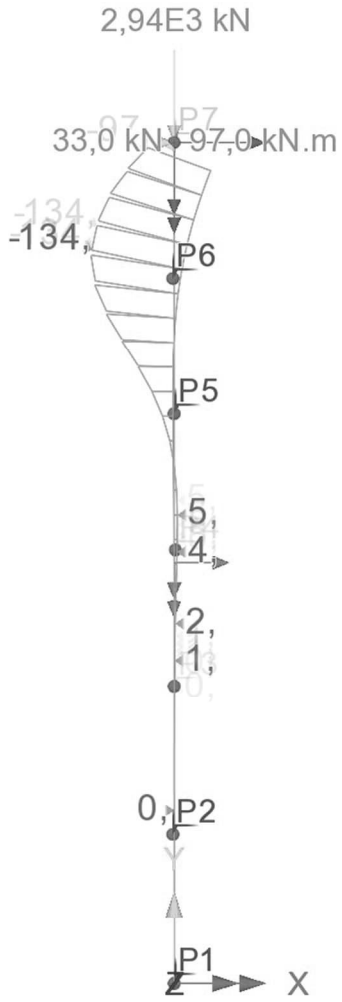


Scale: 1: 182,714
Zoom: 100,0
Eye: (-3,52589E-3; 3,20537E-3; 0,999989)
Nonlinear analysis
Analysis: Analysis 1
Loadcase: 2:Loadcase 1, 1:Increment 1
Results file: Pile_straight~Analysis 1.mys
Maximum displacement 0,0434372 at node 1
Deformation exaggeration: 21,0319

Diagram entity: Force/Moment - Thick 2D Beam
Diagram component: Fy (Units: kN)
Diagram maximum 49,8239 at node 8 of element 7
Diagram minimum -32,9129 at node 1 of element 1
Diagram scale: 1: 0,200707
Peak/value entity: Displacement
Peak/value component: DX (Units: m)
Peak range(%): 100,0
Peak/value maximum 0,0344215 at node 1
Peak/value minimum -1,13917E-3 at node 11

4.1.4 Moment: Mz

$N_{Ed} = 2940kN, H_{Ed} = 33kN$ & $M_{Ed} = 97kNm \quad \rightarrow max\ Mz = 134\ kNm$



Scale: 1: 182,714
Zoom: 100,0
Eye: (-3,52589E-3; 3,20537E-3; 0,999989)
Nonlinear analysis
Analysis: Analysis 1
Loadcase: 2:Loadcase 1, 1:Increment 1
Results file: Pile_straight~Analysis 1.mys
Maximum displacement 0,0434372 at node 1
Deformation exaggeration: 21,0319

Diagram entity: Force/Moment - Thick 2D Beam
Diagram component: Mz (Units: kN.m)
Diagram maximum 5,00919 at Internal point 10 of element
Diagram minimum -133,813 at node 5 of element 3
Diagram scale: 1: 0,0747313
Peak/value entity: Force/Moment - Thick 2D Beam
Peak/value component: Mz (Units: kN.m)
Peak range(%): 100,0
Peak/value maximum 5,0999 at node 16 of element 14
Peak/value minimum -133,861 at node 6 of element 4

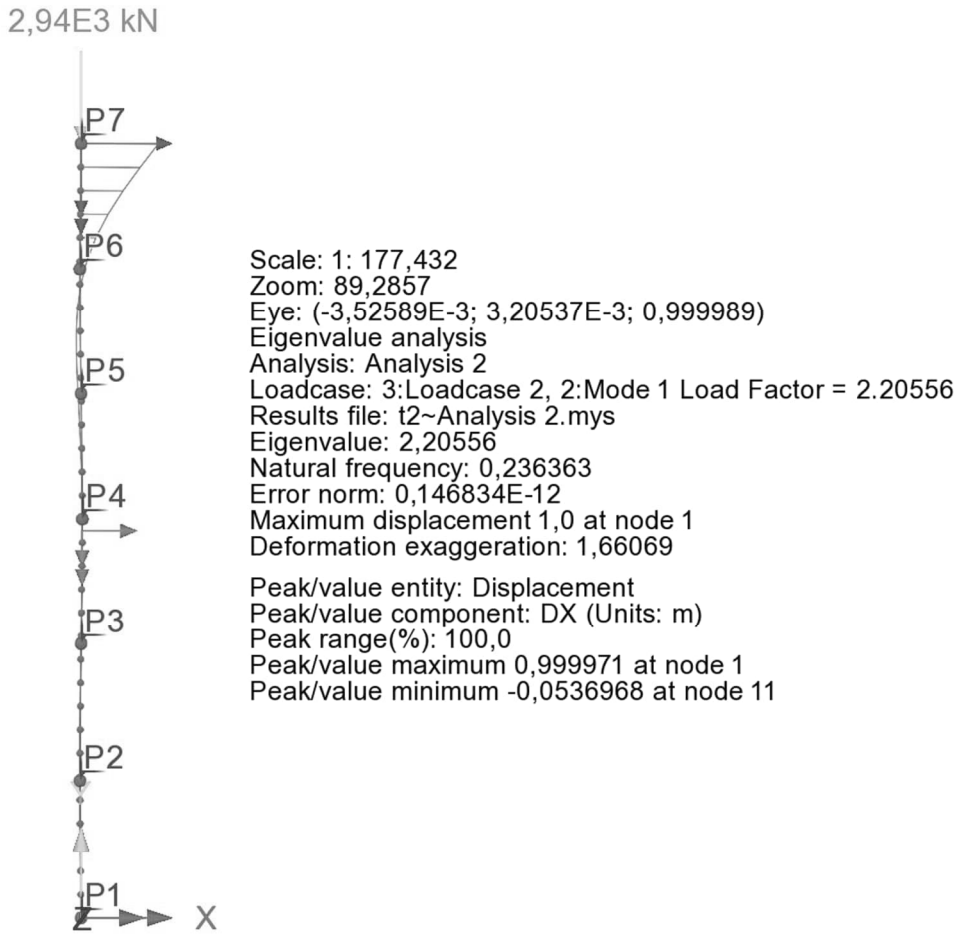
4.2 INITIALLY IMPERFECT PILE

See appendix 2 (∴ Pile_spline).

4.2.1 Buckling load

The buckling load is almost the same as straight pile, see value inside parenthesis.

$$N_{cr} = s \cdot N_{Ed} = 2.206 \cdot 2940\ kN = 6485kN\ (6491kN)$$

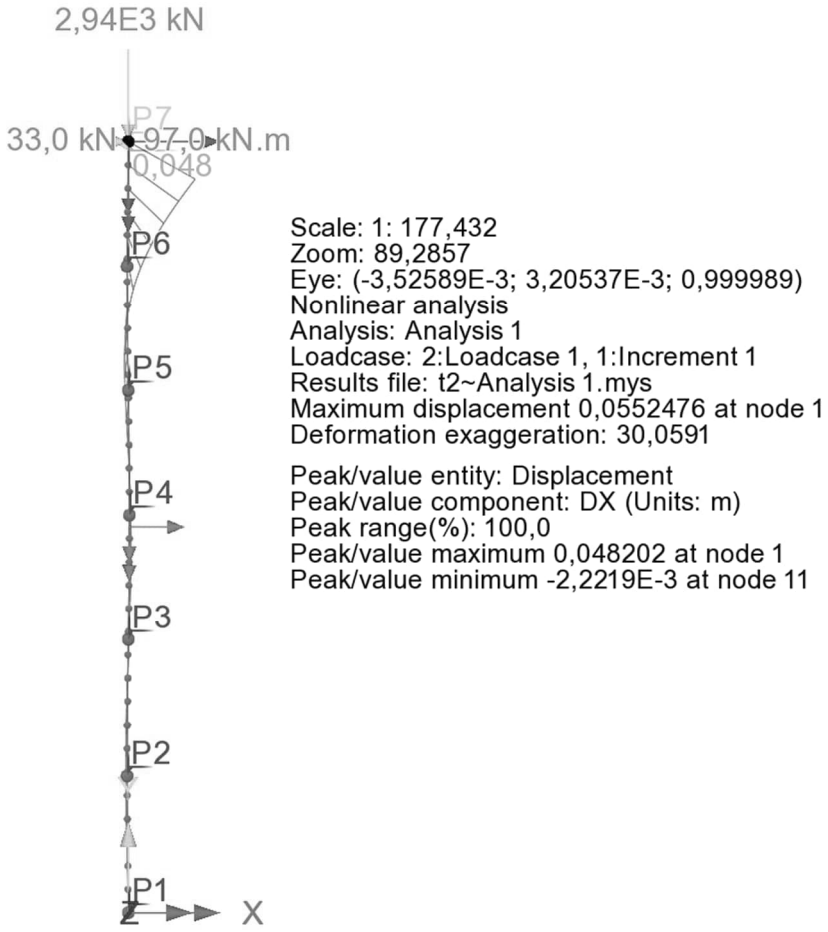


Mode 1
Load factor 2.206

4.2.2 Deformations

The deformation is almost twice as straight pile, see value inside parenthesis.

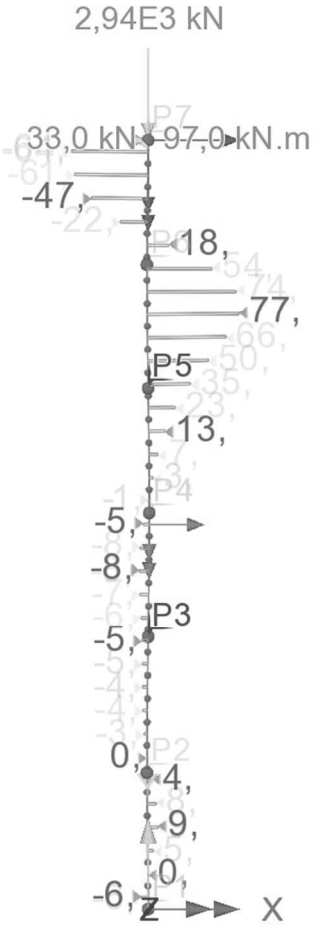
$N_{Ed} = 2940kN, H_{Ed} = 33kN\ \&\ M_{Ed} = 97kNm \quad \rightarrow max\ Dx = 48\ mm\ (34\ mm)$



4.2.3 Shear forces: Fy

The shear forces more than twice as straight pile, see value inside parenthesis.

$N_{Ed} = 2940kN, H_{Ed} = 33kN$ & $M_{Ed} = 97kNm \quad \rightarrow max\ Fy = 77\ kN\ (50\ kN)$

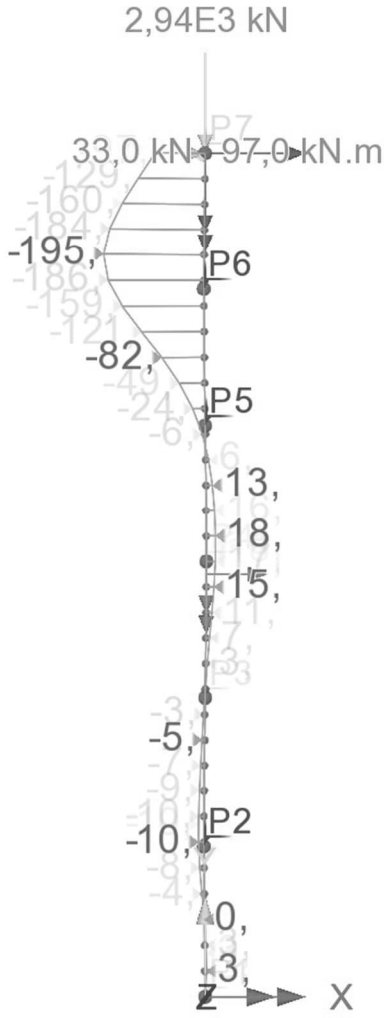


Scale: 1: 177,432
Zoom: 89,2857
Eye: (-3,52589E-3; 3,20537E-3; 0,999989)
Nonlinear analysis
Analysis: Analysis 1
Loadcase: 2:Loadcase 1, 1:Increment 1
Results file: t2~Analysis 1.mys

Diagram entity: Force/Moment - Thick 2D Beam
Diagram component: Fy (Units: kN)
Diagram maximum 76,5913 at node 9 of element 8
Diagram minimum -63,6881 at node 1 of element 1
Diagram scale: 1: 0,130563
Peak/value entity: Force/Moment - Thick 2D Beam
Peak/value component: Fy (Units: kN)
Peak range(%): 100,0
Peak/value maximum 75,495 at node 9 of element 7
Peak/value minimum -63,6881 at node 1 of element 1

4.2.4 Moment: Mz

$N_{Ed} = 2940kN, H_{Ed} = 33kN$ & $M_{Ed} = 97kNm \quad \rightarrow max\ Mz = 195kNm\ (134\ kNm)$



Scale: 1: 177,432
Zoom: 89,2857
Eye: (-3,52589E-3; 3,20537E-3; 0,999989)
Nonlinear analysis
Analysis: Analysis 1
Loadcase: 2:Loadcase 1, 1:Increment 1
Results file: t2~Analysis 1.mys

Diagram entity: Force/Moment - Thick 2D Beam
Diagram component: Mz (Units: kN.m)
Diagram maximum 17,7971 at node 17 of element 15
Diagram minimum -195,193 at node 6 of element 4
Diagram scale: 1: 0,0512313
Peak/value entity: Force/Moment - Thick 2D Beam
Peak/value component: Mz (Units: kN.m)
Peak range(%): 100,0
Peak/value maximum 17,7971 at node 17 of element 15
Peak/value minimum -195,193 at node 6 of element 4

Title: Input receipt

LUSAS version: 23.0-1c3
Model Units: kN,m,t,s,C
Report Units: kN,m,t,s,C

Model Title:
Model File: Pile straight

Table of Contents

Points

Point	X coordinate	Y coordinate	Z coordinate
1	0,000	0,000	0,000
2	-0,025	2,950	0,000
3	0,000	5,900	0,000
4	0,025	8,600	0,000
5	0,000	11,300	0,000
6	-0,025	14,000	0,000
7	0,000	16,700	0,000
11	-10,000	16,700	0,000
12	-10,000	15,000	0,000
13	-10,000	10,000	0,000
14	-10,000	2,000	0,000
15	-10,000	0,000	0,000

Lines

Line	Points	Line	Points
1	7;1		

Line Mesh (Elements showing results)

Attribute: 2 Title: Pile

Sub Type = Line Mesh **Element Type = BMI2**

Mesh spacing	Element size	Start node end releases:	End node end releases:
Irregular	0,5	None	None

Assignment to Lines:

1

Attribute: 4 Title: Joint element: soil

Sub Type = Line Mesh **Element Type = JNT3**

Mesh spacing	Start node end releases:	End node end releases:
Uniform	None	None

Assignment to Lines: Local Coordinates = Joint coodinate system (Local x is joint x), Single feature insertion type : grounded

1

Attribute: 1 Title: Pile

Sub Type = Line Geometric

Assigned in: Analysis 1

Property	Symbol	Value
Cross sectional area	A	0,010
Second moment of area about y axis	Iyy	0,000
Second moment of area about z axis	Izz	0,000
Product moment of area	Iyz	0,000
Torsional constant	J	0,000
Eccentricity in local z direction, relative to specified origin	ez0	0,000
Eccentricity in local y direction, relative to specified origin	ey0	0,000
Eccentricity in local z direction, relative to beam centroid	ez	0,000
Eccentricity in local y direction, relative to beam centroid	ey	0,000
Wagner constant 1st moment of square radius about y (Iyr)	Iyr	0,000
Wagner constant 1st moment of square radius about z (Izr)	Izr	0,000
Wagner constant 4th moment of area about origin (Irr)	Irr	0,000
Wagner constant 2nd moment of warping about origin (Iwr)	Iwr	0,000
Effective shear area in local z direction	Asz	0,000
Effective shear area in local y direction	Asy	0,010
Radius of gyration about y axis	ky	0,000
Radius of gyration about z axis	kz	0,120
y axis extreme fibre, top	yt	0,000
y axis extreme fibre, bottom	yb	0,000
z axis extreme fibre, top	zt	0,000
z axis extreme fibre, bottom	zb	0,000
Shape code identifier	Type	-1
Element type	elementType	"2D Thick Beam"
Reinforcement	reinforcement	None

Assignment to Lines:

1

Attribute: 1 Title: Steel

Sub Type = Isotropic Material
Assigned in: Analysis 1

Property	Symbol	Value
Young's modulus	E	189000000,000
Poisson's ratio	nu	0,300
Density	rho	0,000

Loadcase ID: 2 Title: Loadcase 1
Assignment to Lines:
1

Attribute: 2 Title: Joint material: Soil

Sub Type = Joint Material, Elasto-Plastic (Tension and Compression Equal)
Assigned in: Analysis 1

	u	v
Number of degrees of freedom	nDOF	2
Joint type	JointType	"Plane stress / plane strain / 2D axisymmetric membra
Assignment type	Assignment	"Line"
Yield force	F[0]	0,000
Yield force	F[1]	F
Hardening stiffness	H[0]	0,000
Hardening stiffness	H[1]	10,000
Elastic spring stiffness	K[0]	0,000
Elastic spring stiffness	K[1]	E
Mass	M[0]	0,000
Mass	M[1]	0,000
Mass position	MassPosition	"Between nodes"

Loadcase ID: 2 Title: Loadcase 1
Assignment to Lines:
1

Attribute: 1 Title: E

Sub Type = Interpolation Variation

Property	Symbol	Value
Interpolation order	type	"Linear"
Distance type	distType	"Actual"
Distance	distance	0,000
Distance	distance	1,700
Distance	distance	1,710
Distance	distance	4,000
Distance	distance	4,200
Distance	distance	6,700
Distance	distance	6,710
Distance	distance	10,700
Distance	distance	14,700
Distance	distance	14,710
Distance	distance	16,710
Function	expression	"0.0"
Function	expression	"2.4E3"
Function	expression	"4.5E3"
Function	expression	"18.0E3"
Function	expression	"18.0E3"
Function	expression	"18.0E3"
Function	expression	"18.0E3"
Function	expression	"18.0E3"
Function	expression	"18.0E3"
Function	expression	"30.0E3"
Function	expression	"30.0E3"

Attribute: 4 Title: F

Sub Type = Interpolation Variation

Property	Symbol	Value
Interpolation order	type	"Linear"
Distance type	distType	"Actual"
Distance	distance	0,000
Distance	distance	1,700
Distance	distance	1,710
Distance	distance	4,200
Distance	distance	6,700
Distance	distance	6,710
Distance	distance	10,700
Distance	distance	14,700
Distance	distance	14,710
Distance	distance	16,710
Function	expression	"0.0"
Function	expression	"43.0"
Function	expression	"47.0"
Function	expression	"136.0"
Function	expression	"226.0"
Function	expression	"221.0"
Function	expression	"362.0"
Function	expression	"502.0"
Function	expression	"899.0"
Function	expression	"1.025E3"

Attribute: 1 Title: Pinned

Sub Type = Structural Support
Assigned in: Analysis 1

Property	Symbol	Value
Translation in X	U	"R"
Translation in Y	V	"R"
Rotation about Z	THZ	"F"
Pore pressure	pore	"C"

Loadcase ID: 2 Title: Loadcase 1
Assignment to Points:
1

Attribute: 3 Title: Lager krafter

Sub Type = Concentrated Load

Property	Symbol	Value
Concentrated load in X Dir	PX	2940,000
Concentrated load in Y Dir	PY	33,000
Concentrated load in Z Dir	PZ	0,000
Moment about X axis	MX	0,000
Moment about Y axis	MY	0,000
Moment about Z axis	MZ	-97,000
Moment about hinge nodes	L2	0,000
Pore pressure flux	PorePressure	0,000
Bi moment	Mb	0,000

Loadcase ID: 2 Title: Loadcase 1 Factor = 1.0

Assignment to Points:

7

Attribute: 9 Title: N = 2940 kN

Sub Type = Concentrated Load

Property	Symbol	Value
Concentrated load in X Dir	PX	2940,000
Concentrated load in Y Dir	PY	0,000
Concentrated load in Z Dir	PZ	0,000
Moment about X axis	MX	0,000
Moment about Y axis	MY	0,000
Moment about Z axis	MZ	0,000
Moment about hinge nodes	L2	0,000
Pore pressure flux	PorePressure	0,000
Bi moment	Mb	0,000

Loadcase ID: 3 Title: Loadcase 2 Factor = 1.0

Assignment to Points:

7

Attribute: 1 Title: Joint coodinate system

Sub Type = Local Coordinates

Property	Symbol	Value
Attribute type	type	"Cartesian"
Rotation angle	angle	270,000
Origin	originPos[0]	0,000
Origin	originPos[1]	0,000
Origin	originPos[2]	0,000
Type	plane	"XY_Angle"

Assignment to Points:

7

Loadcases

Loadcase	Gravity	Title	Analysis	Type
2		Loadcase 1	Analysis 1	
3		Loadcase 2	Analysis 2	

Gravity (when chosen) is applied as a body force of -9,81000m/s² in the Y direction

Title: Input receipt

LUSAS version: 23.0-1c3
Model Units: kN,m,t,s,C
Report Units: kN,m,t,s,C

Model Title:
Model File: Pile spline

Table of Contents

Points

Point	X coordinate	Y coordinate	Z coordinate
1	0,000	0,000	0,000
2	-0,025	2,950	0,000
3	0,000	5,900	0,000
4	0,025	8,600	0,000
5	0,000	11,300	0,000
6	-0,025	14,000	0,000
7	0,000	16,700	0,000
11	-10,000	16,700	0,000
12	-10,000	15,000	0,000
13	-10,000	10,000	0,000
14	-10,000	2,000	0,000
15	-10,000	0,000	0,000

Splines

Splines	Points	Splines	Points
1	1;2;3;4;5;6;7	-	-

Line Mesh (Elements showing results)

Attribute: 2 Title: Pile

Sub Type = Line Mesh **Element Type = BMI2**

Mesh spacing	Element size	Start node end releases:	End node end releases:
Irregular	0,5	None	None

Assignment to Lines:

1

Attribute: 4 Title: Joint element: soil

Sub Type = Line Mesh **Element Type = JNT3**

Mesh spacing	Start node end releases:	End node end releases:
Uniform	None	None

Assignment to Lines: Local Coordinates = Joint coodinate system (Local x is joint x), Single feature insertion type : grounded

1

Attribute: 1 Title: Pile

Sub Type = Line Geometric

Assigned in: Analysis 1

Property	Symbol	Value
Cross sectional area	A	0,010
Second moment of area about y axis	Iyy	0,000
Second moment of area about z axis	Izz	0,000
Product moment of area	Iyz	0,000
Torsional constant	J	0,000
Eccentricity in local z direction, relative to specified origin	ez0	0,000
Eccentricity in local y direction, relative to specified origin	ey0	0,000
Eccentricity in local z direction, relative to beam centroid	ez	0,000
Eccentricity in local y direction, relative to beam centroid	ey	0,000
Wagner constant 1st moment of square radius about y (Iyr)	Iyr	0,000
Wagner constant 1st moment of square radius about z (Izr)	Izr	0,000
Wagner constant 4th moment of area about origin (Irr)	Irr	0,000
Wagner constant 2nd moment of warping about origin (Iwr)	Iwr	0,000
Effective shear area in local z direction	Asz	0,000
Effective shear area in local y direction	Asy	0,010
Radius of gyration about y axis	ky	0,000
Radius of gyration about z axis	kz	0,120
y axis extreme fibre, top	yt	0,000
y axis extreme fibre, bottom	yb	0,000
z axis extreme fibre, top	zt	0,000
z axis extreme fibre, bottom	zb	0,000
Shape code identifier	Type	-1
Element type	elementType	"2D Thick Beam"
Reinforcement	reinforcement	None

Assignment to Lines:

1

Attribute: 1 Title: Steel

Sub Type = Isotropic Material
Assigned in: Analysis 1

Property	Symbol	Value
Young's modulus	E	189000000,000
Poisson's ratio	nu	0,300
Density	rho	0,000

Loadcase ID: 2 Title: Loadcase 1
Assignment to Lines:
1

Attribute: 2 Title: Joint material: Soil

Sub Type = Joint Material, Elasto-Plastic (Tension and Compression Equal)
Assigned in: Analysis 1

	u	v
Number of degrees of freedom	nDOF	2
Joint type	JointType	"Plane stress / plane strain / 2D axisymmetric membra
Assignment type	Assignment	"Line"
Yield force	F[0]	0,000
Yield force	F[1]	F
Hardening stiffness	H[0]	0,000
Hardening stiffness	H[1]	10,000
Elastic spring stiffness	K[0]	0,000
Elastic spring stiffness	K[1]	E
Mass	M[0]	0,000
Mass	M[1]	0,000
Mass position	MassPosition	"Between nodes"

Loadcase ID: 2 Title: Loadcase 1
Assignment to Lines:
1

Attribute: 1 Title: E

Sub Type = Interpolation Variation

Property	Symbol	Value
Interpolation order	type	"Linear"
Distance type	distType	"Actual"
Distance	distance	0,000
Distance	distance	1,700
Distance	distance	1,710
Distance	distance	4,000
Distance	distance	4,200
Distance	distance	6,700
Distance	distance	6,710
Distance	distance	10,700
Distance	distance	14,700
Distance	distance	14,710
Distance	distance	16,710
Function	expression	"0.0"
Function	expression	"2.4E3"
Function	expression	"4.5E3"
Function	expression	"18.0E3"
Function	expression	"18.0E3"
Function	expression	"18.0E3"
Function	expression	"18.0E3"
Function	expression	"18.0E3"
Function	expression	"18.0E3"
Function	expression	"30.0E3"
Function	expression	"30.0E3"

Attribute: 4 Title: F

Sub Type = Interpolation Variation

Property	Symbol	Value
Interpolation order	type	"Linear"
Distance type	distType	"Actual"
Distance	distance	0,000
Distance	distance	1,700
Distance	distance	1,710
Distance	distance	4,200
Distance	distance	6,700
Distance	distance	6,710
Distance	distance	10,700
Distance	distance	14,700
Distance	distance	14,710
Distance	distance	16,710
Function	expression	"0.0"
Function	expression	"43.0"
Function	expression	"47.0"
Function	expression	"136.0"
Function	expression	"226.0"
Function	expression	"221.0"
Function	expression	"362.0"
Function	expression	"502.0"
Function	expression	"899.0"
Function	expression	"1.025E3"

Attribute: 1 Title: Pinned

Sub Type = Structural Support
Assigned in: Analysis 1

Property	Symbol	Value
Translation in X	U	"R"
Translation in Y	V	"R"
Rotation about Z	THZ	"F"
Pore pressure	pore	"C"

Loadcase ID: 2 Title: Loadcase 1
Assignment to Points:
1

Attribute: 3 Title: Lager krafter

Sub Type = Concentrated Load

Property	Symbol	Value
Concentrated load in X Dir	PX	2940,000
Concentrated load in Y Dir	PY	33,000
Concentrated load in Z Dir	PZ	0,000
Moment about X axis	MX	0,000
Moment about Y axis	MY	0,000
Moment about Z axis	MZ	-97,000
Moment about hinge nodes	L2	0,000
Pore pressure flux	PorePressure	0,000
Bi moment	Mb	0,000

Loadcase ID: 2 Title: Loadcase 1 Factor = 1.0

Assignment to Points:

7

Attribute: 9 Title: N = 2940 kN

Sub Type = Concentrated Load

Property	Symbol	Value
Concentrated load in X Dir	PX	2940,000
Concentrated load in Y Dir	PY	0,000
Concentrated load in Z Dir	PZ	0,000
Moment about X axis	MX	0,000
Moment about Y axis	MY	0,000
Moment about Z axis	MZ	0,000
Moment about hinge nodes	L2	0,000
Pore pressure flux	PorePressure	0,000
Bi moment	Mb	0,000

Loadcase ID: 3 Title: Loadcase 2 Factor = 1.0

Assignment to Points:

7

Attribute: 1 Title: Joint coodinate system

Sub Type = Local Coordinates

Property	Symbol	Value
Attribute type	type	"Cartesian"
Rotation angle	angle	270,000
Origin	originPos[0]	0,000
Origin	originPos[1]	0,000
Origin	originPos[2]	0,000
Type	plane	"XY_Angle"

Assignment to Points:

7

Loadcases

Loadcase	Gravity	Title	Analysis	Type
2		Loadcase 1	Analysis 1	
3		Loadcase 2	Analysis 2	

Gravity (when chosen) is applied as a body force of -9,81000m/s² in the Y direction