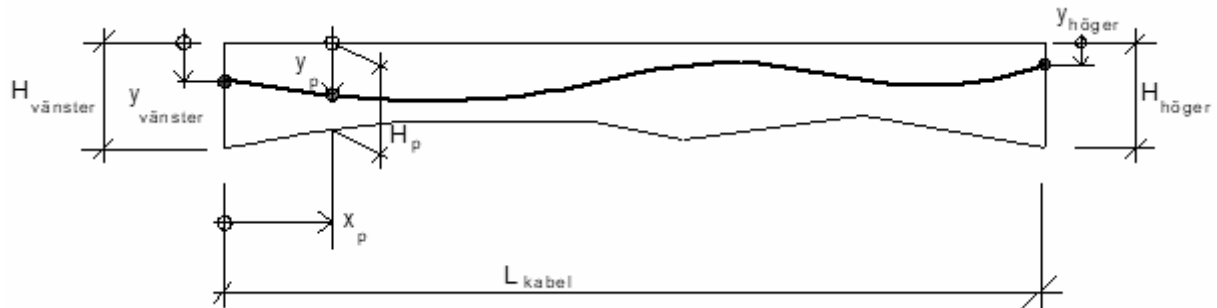


Object: Cable V1**PRINCIPLE SKETCH****INPUT**

Total cable length: $L_{kabel} := 2.2 \cdot m + 26 \cdot m + 32 \cdot m + 26 \cdot m + 2.2 \cdot m = 88.4 \text{ m}$

Number of definition points: $N := 17 \cdot st$

Friction coefficients: $\mu := 0.18$ $k := 0.005 \cdot \frac{rad}{m}$

Resistance cable: $f_{p0.1k} := 1640 \cdot MPa$

$$f_{pk} := 1860 \cdot MPa$$

E-modulus cable: $E_s := 195 \cdot GPa$

Tendon area: $A_s := 2250 \cdot mm^2$

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Maximum permissible tensile force before locking according to SS-EN 1992-1-1 section 5.10.2.1:

$$\min(0.8 \cdot f_{pk}, 0.9 \cdot f_{p0.1k}) \cdot A_s = 3321 \text{ kN}$$

Selected prestressing force:

$$V_{\sigma} := 3320 \cdot \text{kN}$$

Maximum permissible tensile force after locking according to SS-EN 1992-1-1 section 5.10.3:

$$\min(0.75 \cdot f_{pk}, 0.85 \cdot f_{p0.1k}) \cdot A_s = 3137 \text{ kN}$$

Type of anchorage ("Passiv" or "Aktiv") / chosen maximum tendon force after locking:

Section	Type	V_{max} [kN]
Left	Aktiv	3130
Right	Passiv	3130

Defined points along cable:

Snitt	x_p (m)	y_p (mm)	H_p (mm)
1	0	440	1500
2	1,00	600	1500
3	2,20	800	1500
4	7,20	1250	1500
5	12,20	1300	1500
6	21,20	600	1500
7	28,20	200	1500
8	34,20	500	1500
9	44,20	1400	1500
10	54,20	600	1500
11	60,20	200	1500
12	67,20	600	1500
13	76,20	1300	1500
14	81,20	1250	1500
15	86,20	800	1500
16	87,40	600	1500
17	88,40	440	1500

STEP 2

⇒

x	w
0	0,31
1,00	0,15
2,20	-0,05
7,20	-0,50
12,20	-0,55
21,20	0,15
28,20	0,55
34,20	0,25
44,20	-0,65
54,20	0,15
60,20	0,55
67,20	0,15
76,20	-0,55
81,20	-0,50
86,20	-0,05
87,40	0,15
88,40	0,31
m	m

LUSAS

⇒

x(+)	z(+)
0	0,31
1,00	0,15
2,20	-0,05
7,20	-0,50
12,20	-0,55
21,20	0,15
28,20	0,55
34,20	0,25
44,20	-0,65
54,20	0,15
60,20	0,55
67,20	0,15
76,20	-0,55
81,20	-0,50
86,20	-0,05
87,40	0,15
88,40	0,31
m	m

CALCULATION**Create mathematical functions for a beam and a cable**

$C := \text{pspline}(x_p, y_p)$: determination of coefficients for parabolic spline functions

$y(x) := \text{interp}(C, x_p, y_p, x)$: cable routing (= spline functions)

$y'(x) := \frac{d}{dx}y(x)$: slope of cable routing

$y''(x) := \frac{d^2}{dx^2}y(x)$: curvature change of cable routing

$R_{min} := \frac{1}{\max(y''(x))}$: lowest curvature radius of cable routing

Friction loss function measured from the "left" side

$\alpha_v := \text{if}\left(i > 1, \sum_{j=2}^i |y'(x_j) - y'(x_{j-1})|, 0\right)$: accumulated change in angle

$\beta_v := \mu \cdot (\alpha_v + k \cdot x)$: friction loss exponent

$\eta_{vf} := e^{-\beta_v}$: friction loss before locking

$\eta_{ve} := e^{\beta_v}$: friction loss after locking

Location of maximal cable force on "left" side after locking of cable

$$X_{mv} = \begin{cases} x_{skär} \leftarrow 0m & \text{if Typ = "Passiv"} \\ \text{if Typ = "Aktiv"} \\ \quad \begin{cases} x_{start} \leftarrow 2m \\ x_{skär} \leftarrow \text{root}(V_{max} - V_{\delta} \cdot \text{interp}(X, \eta_{vf}, x_{start}), x_{start}) \end{cases} \end{cases}$$

Friction loss function measured from the "right" side

$$\alpha_h := \text{if} \left(i > 1, \sum_{j=i+1}^n |y'(x_j) - y'(x_{j-1})|, 0 \right) \quad : \text{accumulated change in angle}$$

$$\beta_h := \mu \cdot (\alpha_h + k \cdot (L_{\text{kabel}} - x)) \quad : \text{friction loss exponent}$$

$$\eta_{hf} := e^{-\beta_h} \quad : \text{friction loss before locking}$$

$$\eta_{he} := e^{\beta_h} \quad : \text{friction loss after locking}$$

Location of maximal cable force on "right" side after locking of cable

$$X_{mh} = \begin{cases} x_{\text{skär}} \leftarrow L_{\text{kabel}} & \text{if Typ} = \text{"Passiv"} \\ \text{if Typ} = \text{"Aktiv"} \\ \quad \begin{cases} x_{\text{start}} \leftarrow L_{\text{kabel}} - 2\text{m} \\ x_{\text{skär}} \leftarrow \text{root}(V_{\text{max}} - V_{\delta} \cdot \text{linterp}(X, \eta_{hf}, x_{\text{start}}), x_{\text{start}}) \end{cases} \end{cases}$$

Location where curve of cable force "right" side intersects curve of cable force "left"

$$X_m = \begin{cases} x_{\text{skär}} \leftarrow L_{\text{kabel}} & \text{if Typ} = \text{"Aktiv"} \wedge \text{Typ} = \text{"Passiv"} \\ x_{\text{skär}} \leftarrow 0\text{m} & \text{if Typ} = \text{"Passiv"} \wedge \text{Typ} = \text{"Aktiv"} \\ \text{if Typ} = \text{"Aktiv"} \wedge \text{Typ} = \text{"Aktiv"} \\ \quad \begin{cases} x_{\text{start}} \leftarrow 0.5 \cdot L_{\text{kabel}} \\ x_{\text{skär}} \leftarrow \text{root}(V_{\delta} \cdot \text{linterp}(X, \eta_{vf}, x_{\text{start}}) - V_{\delta} \cdot \text{linterp}(X, \eta_{hf}, x_{\text{start}}), x_{\text{start}}) \end{cases} \end{cases}$$

Determine cable force at each end of cable after locking

Cable force at "left" side :

$$P_{ve} = \begin{cases} V_{\text{max}} \cdot \text{linterp}(X, \eta_{hf}, 0\text{m}) & \text{if Typ} = \text{"Passiv"} \\ \frac{V_{\text{max}}}{\text{linterp}(X, \eta_{ve}, X_{mv})} & \text{if Typ} = \text{"Aktiv"} \end{cases}$$

Cable force at "right" side :

$$P_{he} = \begin{cases} V_{\text{max}} \cdot \text{linterp}(X, \eta_{vf}, L_{\text{kabel}}) & \text{if Typ} = \text{"Passiv"} \\ \frac{V_{\text{max}}}{\text{linterp}(X, \eta_{he}, X_{mh})} & \text{if Typ} = \text{"Aktiv"} \end{cases}$$

Determine post slip / "lock sliding" at each end of cableLeft side :

$$\Delta L_v := \text{if} \left(\text{Typ} = \text{"Aktiv"}, \frac{1}{A_s \cdot E_s} \cdot \int_0^{X_{mv}} (V_{\delta} \cdot \text{linterp}(X, \eta_{vf}, x) - P_{ve} \cdot \text{linterp}(X, \eta_{ve}, x)) dx, 0 \right)$$

Right side :

$$\Delta L_h := \text{if} \left(\text{Typ} = \text{"Aktiv"}, \frac{1}{A_s \cdot E_s} \cdot \int_{X_{mh}}^{L_{kabel}} (V_{\delta} \cdot \text{linterp}(X, \eta_{hf}, x) - P_{ve} \cdot \text{linterp}(X, \eta_{he}, x)) dx, 0 \right)$$

Determine cable elongation before locking of cableLeft side:

$$L_v := \frac{1}{A_s \cdot E_s} \cdot \int_0^{X_m} (V_{\delta} \cdot \text{linterp}(X, \eta_{vf}, x)) dx$$

Right side :

$$L_h := \frac{1}{A_s \cdot E_s} \cdot \int_{X_m}^{L_{kabel}} (V_{\delta} \cdot \text{linterp}(X, \eta_{hf}, x)) dx$$

Function - determine cable force at arbitrary location along cable before locking

$$P_{\text{fore}} = \begin{cases} V_{\delta} \cdot \text{linterp}(X, \eta_{vf}, x) & \text{if } x \leq X_m \\ V_{\delta} \cdot \text{linterp}(X, \eta_{hf}, x) & \text{if } x > X_m \end{cases}$$

Function - determine cable force at arbitrary location along cable after locking

$$P_{\text{efter}} := \begin{cases} \text{if } x \leq X_{mv} \\ \quad \parallel P_{ve} \cdot \text{linterp}(X, \eta_{ve}, x) \\ \text{if } X_{mv} < x < X_m \\ \quad \parallel V_{\delta} \cdot \text{linterp}(X, \eta_{vf}, x) \\ \text{if } X_m \leq x \leq X_{mh} \\ \quad \parallel V_{\delta} \cdot \text{linterp}(X, \eta_{hf}, x) \\ \text{if } x > X_{mh} \\ \quad \parallel P_{he} \cdot \text{linterp}(X, \eta_{he}, x) \end{cases}$$

Staking-out data for cable location in table form

Arbitrary sections :

Sections	x' (m)	Remark
1	0,00	-
2	1,00	-
3	8,70	-
4	12,00	-
5	15,20	-
6	18,50	-
6	21,70	-
8	25,00	-
9	28,20	-
10	32,20	-
11	36,20	-
12	40,20	-
13	44,20	-

Cable locations :

Sections	y' (m)	Remark.
1	0,440	Anchors
2	0,600	-
3	1,302	-
4	1,306	-
5	1,140	-
6	0,856	-
7	0,555	-
8	0,305	-
9	0,200	-
10	0,334	-
11	0,714	-
12	1,162	-
13	1,400	-

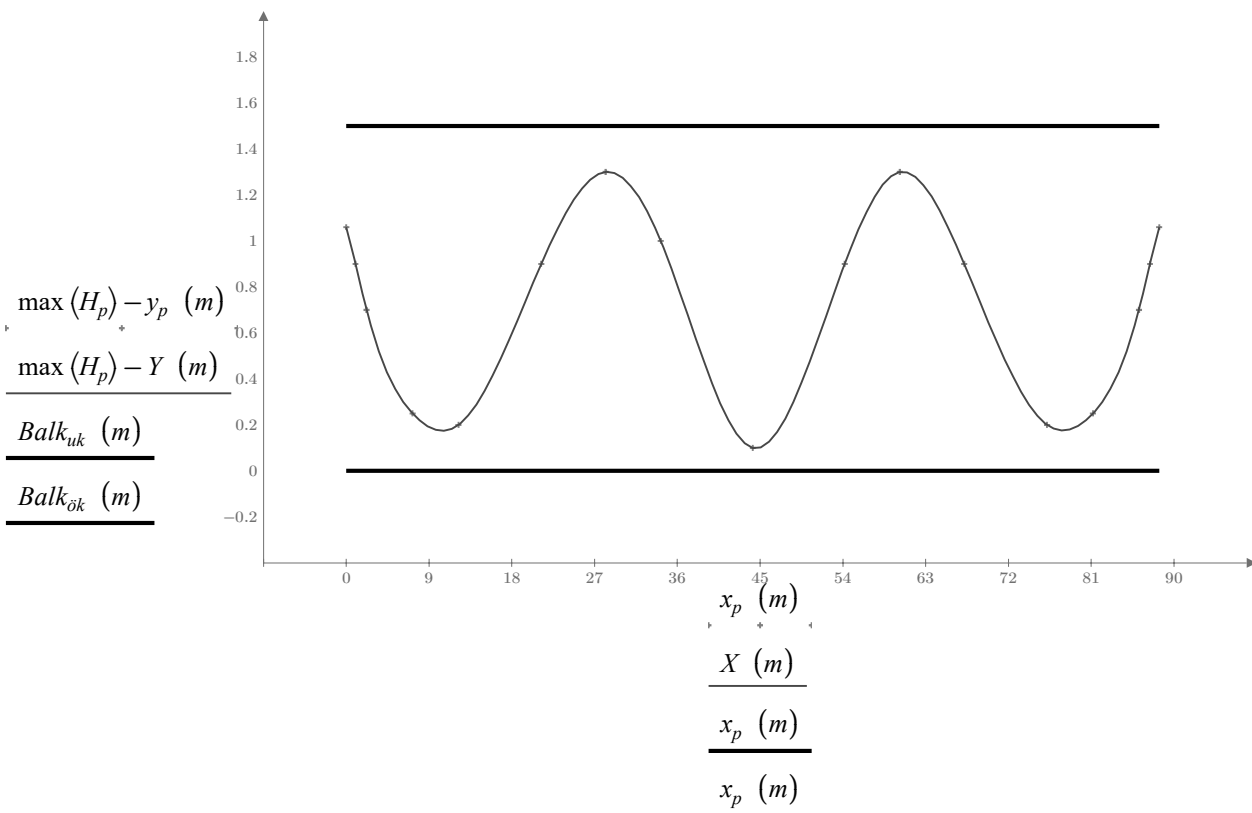
⇒

q _{sp} (m)
1,060
0,900
0,198
0,194
0,360
0,644
0,945
1,195
1,300
1,166
0,786
0,338
0,100

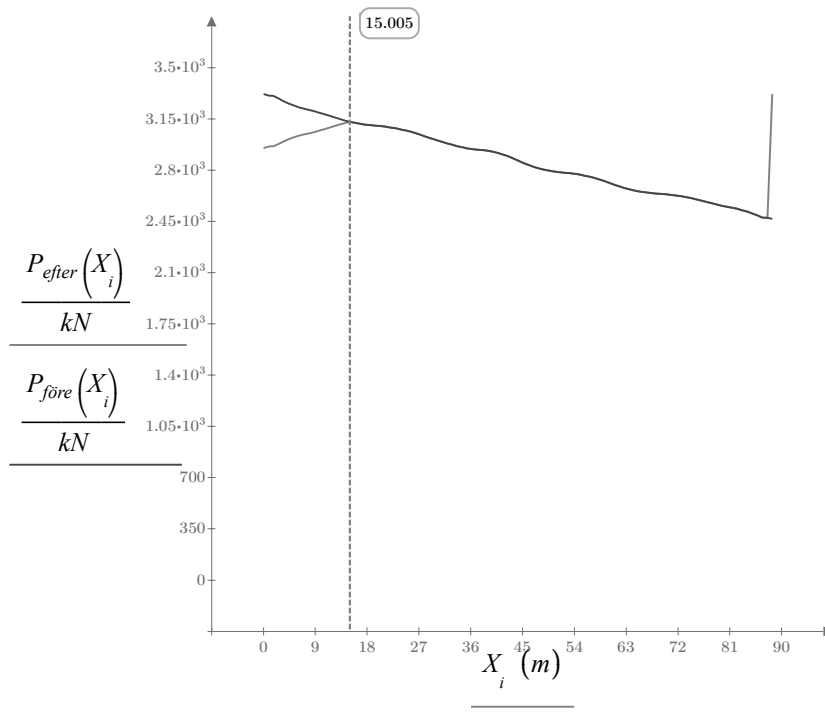
$$q_{sp} = H - y'$$

RESULTS

Beam and Cable routing — graphic presentation



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Graphical plotting of cable forces**Minimum curvature radius**

$$R_{min} = 38.8 \text{ m}$$

Cable elongation before locking

$$L_v = 579 \text{ mm}$$

: left side

$$L_h = 0 \text{ mm}$$

: right side

Post slip / "lock sliding" at each end of cable

$$\Delta L_v = 6 \text{ mm}$$

: left side

$$\Delta L_h = 0$$

: right side

Cable force at each end after locking

$$P_{ve} = 2951 \text{ kN}$$

: left side

$$P_{he} = 2325 \text{ kN}$$

: right side

Location of maximum cable force after locking

$$X_{mv} = 15.005 \text{ m}$$

: left side

$$X_{mh} = 88.4 \text{ m}$$

: right side

Location of minimum cable force after locking

$$X_m = 88.4 \text{ m}$$

Determination of cable force at an arbitrary point before locking

$$x_{test} := 0 \cdot m$$

$$P_{före}(x_{test}) = 3320 \text{ kN}$$

$$x_{test} := 4.6 \cdot m$$

$$P_{före}(x_{test}) = 3251 \text{ kN}$$

$$x_{test} := 8.5 \cdot m$$

$$P_{före}(x_{test}) = 3205 \text{ kN}$$

$$x_{test} := 10 \cdot m$$

$$P_{före}(x_{test}) = 3189 \text{ kN}$$

Determination of cable force at an arbitrary point after locking

$$x_{test} := 0 \cdot m$$

$$P_{efter}(x_{test}) = 2951 \text{ kN}$$

$$x_{test} := 10 \cdot m$$

$$P_{efter}(x_{test}) = 3073 \text{ kN}$$

$$x_{test} := 20 \cdot m$$

$$P_{efter}(x_{test}) = 3102 \text{ kN}$$