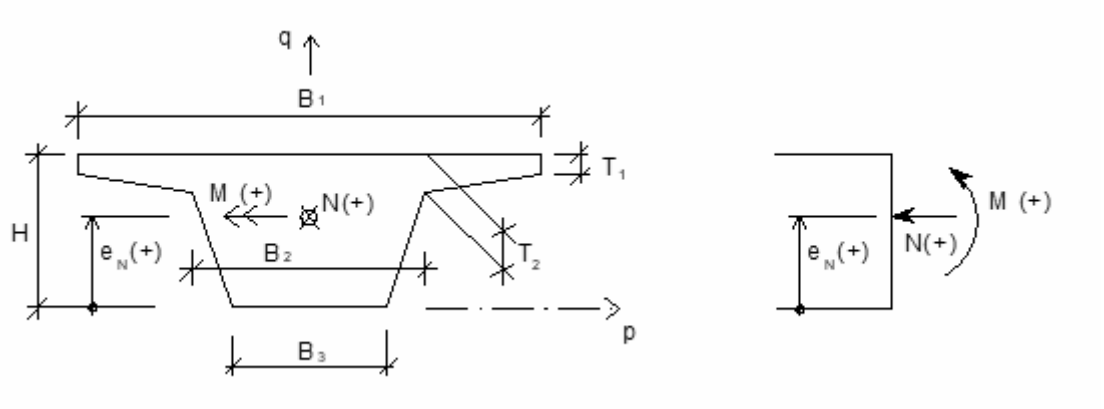
Moment capacity: trapezoid cross section

PROG B1_002/ 2002-03-06 (T004)

Object: Beam L1 - moment at bottom M(T)

PRINCIPLE SKETCH



INPUT

Concrete (C30/37, C35/45, C40/50 , C45/55 och C50/60)

$BTG := \text{“C35/45”}$

Dimension rebars (ϕ10, ϕ12, ϕ16, ϕ20, ϕ25 och ϕ32)

$\phi := 16 \cdot mm$

Quality rebars (B500 och Ks60)

$TYP := \text{“B500”}$

Calculation rebars "bottom" reinforcement (K = -1) or "top" reinforcement (K = -1)

$K := -1$

Concrete cover

$TB := 40 \cdot mm$

Permissible crack width

$w_{k.till} := 0.40 \cdot mm$

Size largest ballast

$stenmax := 32 \cdot mm$

Minimal distance c/c rebars

$s_{min} := 100 \cdot mm$

Location of centroid "compressed rebars" (measured from compressed edge concrete):

$d_{tryck} := 50 \cdot mm$

Material concrete coefficients

$\gamma_{c.U} := 1.50$: ultimate state / ULS see EC2-1-1 table 2.1N

$\gamma_{c.S} := 1.00$: service state / SLS

Material rebar coefficients

$\gamma_{s.U} := 1.15$: ultimate state / ULS see EC2-1-1 table 3.1

$\gamma_{s.S} := 1.00$: service state / SLS

Correction factors concrete resistance

$\alpha_{cc} := 1.00$

$\alpha_{ct} := 1.00$

Factors for tension-elongation determination of concrete resistance

$\lambda := 0.80$: see EC2-1 equation 3.19

$\eta := 1.00$: see EC2-1 equation 3.20

Factors for detemination of crack width

$k_1 := 0.80$: see EC2-1 section 7.3.4

$k_2 := 0.50$: see EC2-1 section 7.3.4

$k_3 := 7 \cdot \frac{\phi}{TB} = 2.8$: see VVFS section 21.13

$k_4 := 0.425$

$k_t := 0.40$: see EC2-1 section 7.3.4

$\phi_{ef} := 1.7$: effective creep

Number of sections

$N := 9$

Spann length

$L := 12.0 \cdot m$

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Geometry

x / L	B_1	B_2	B_3	H	T_1	T_2
0	1700	1500	1300	1200	240	250
0,125	1700	1500	1300	1200	240	250
0,250	1700	1500	1300	1200	240	250
0,375	1700	1500	1300	1200	240	250
0,500	1700	1500	1300	1200	240	250
0,625	1700	1500	1300	1200	240	250
0,750	1700	1500	1300	1200	240	250
0,875	1700	1500	1300	1200	240	250
1,000	1700	1500	1300	1200	240	250
-	mm	mm	mm	mm	mm	mm

Section forces

s / L	M_{ULS}	N_{ULS}	M_{SLS}	N_{SLS}	e_N
0	1	0	1	0	730
0,125	200	0	100	0	730
0,250	500	0	200	0	730
0,375	1500	0	700	0	730
0,500	2700	0	1700	0	730
0,625	1500	0	700	0	730
0,750	500	0	200	0	730
0,875	200	0	100	0	730
1,000	1	0	1	0	730
-	kNm	kN	kNm	kN	mm

Input material properties

$f_{ck} = 35.0\ MPa$ $f_{ctk\_0.05} = 2.2\ MPa$ $f_{ctk\_0.95} = 4.2\ MPa$ $\varepsilon_{cu} = 0.0035$ $E_{cm} = 34.1\ GPa$

$\phi = 16\ mm$ $f_{yk} = 500\ MPa$ $E_{sk} = 200\ GPa$

CALCULATION

Resistance properties concrete

Ultimate state / ULS

$f_{cd.U} := \alpha_{cc} \cdot \frac{f_{ck}}{\gamma_{c.U}} = 23.3\ MPa$: see EC2-1-1 equation 3.15

$f_{ctd} := \alpha_{ct} \cdot \frac{f_{ctk\_0.05}}{\gamma_{c.U}} = 1.5\ MPa$: see EC2-1-1 equation 3.16

Service state / SLS

$f_{cd.S} := \alpha_{cc} \cdot \frac{f_{ck}}{\gamma_{c.S}} = 35.0\ MPa$: see EC2-1-1 equation 3.15

$f_{ctd} := \alpha_{ct} \cdot \frac{f_{ctk\_0.05}}{\gamma_{c.S}} = 2.25\ MPa$: see EC2-1-1 equation 3.16

Design values reinforcement:

Ultimate state / ULS

$f_{yd.U} := \frac{f_{yk}}{\gamma_{s.U}} = 435\ MPa$

$E_{s.U} := E_{sk} = 200\ GPa$

Service state / SLS

$f_{yd.S} := \frac{f_{yk}}{\gamma_{s.S}} = 500\ MPa$

$E_{s.S} := E_{sk} = 200\ GPa$

RESULTS

Partial results ULS

x	M_u	A_{st}	d_{st}	A_{sc}	d_{sc}	ε_{st}	ε_{sc}	ε_{sy}	X
0	83	201	1152	0	1102	176,90	0	0,22	2
1,500	206	603	1152	0	1102	71,10	0	0,22	6
3,000	694	1407	1152	0	1102	20,74	0	0,22	19
4,500	2483	5228	1126	0	1076	5,17	0	0,22	71
6,000	4385	10053	1076	0	1026	2,43	0	0,22	135
7,500	2483	5228	1126	0	1076	5,17	0	0,22	71
9,000	694	1407	1152	0	1102	20,74	0	0,22	19
10,500	206	603	1152	0	1102	71,10	0	0,22	6
12,000	83	201	1152	0	1102	176,90	0	0,22	2
m	kNm	mm^2	mm	mm^2	mm	%	%	%	mm

Partial results SLS

s	A_s	w_k	d	$\Delta\varepsilon$	$s_{r,max}$	$\rho_{p,eff}$	σ_s	x	h_{ef}
0	402	0,01	1152	0,0000	1177	0,00	2	89	120
1,500	603	0,37	1152	0,0004	822	0,00	149	108	120
3,000	1005	0,29	1152	0,0005	538	0,01	180	138	120
4,500	2011	0,34	1152	0,0011	325	0,01	320	189	120
6,000	4222	0,40	1132	0,0015	257	0,02	385	261	170
7,500	2011	0,34	1152	0,0011	325	0,01	320	189	120
9,000	1005	0,29	1152	0,0005	538	0,01	180	138	120
10,500	603	0,37	1152	0,0004	822	0,00	149	108	120
12,000	402	0,01	1152	0,0000	1177	0,00	2	89	120
m	mm^2	mm	mm	%	mm	-	MPa	mm	mm

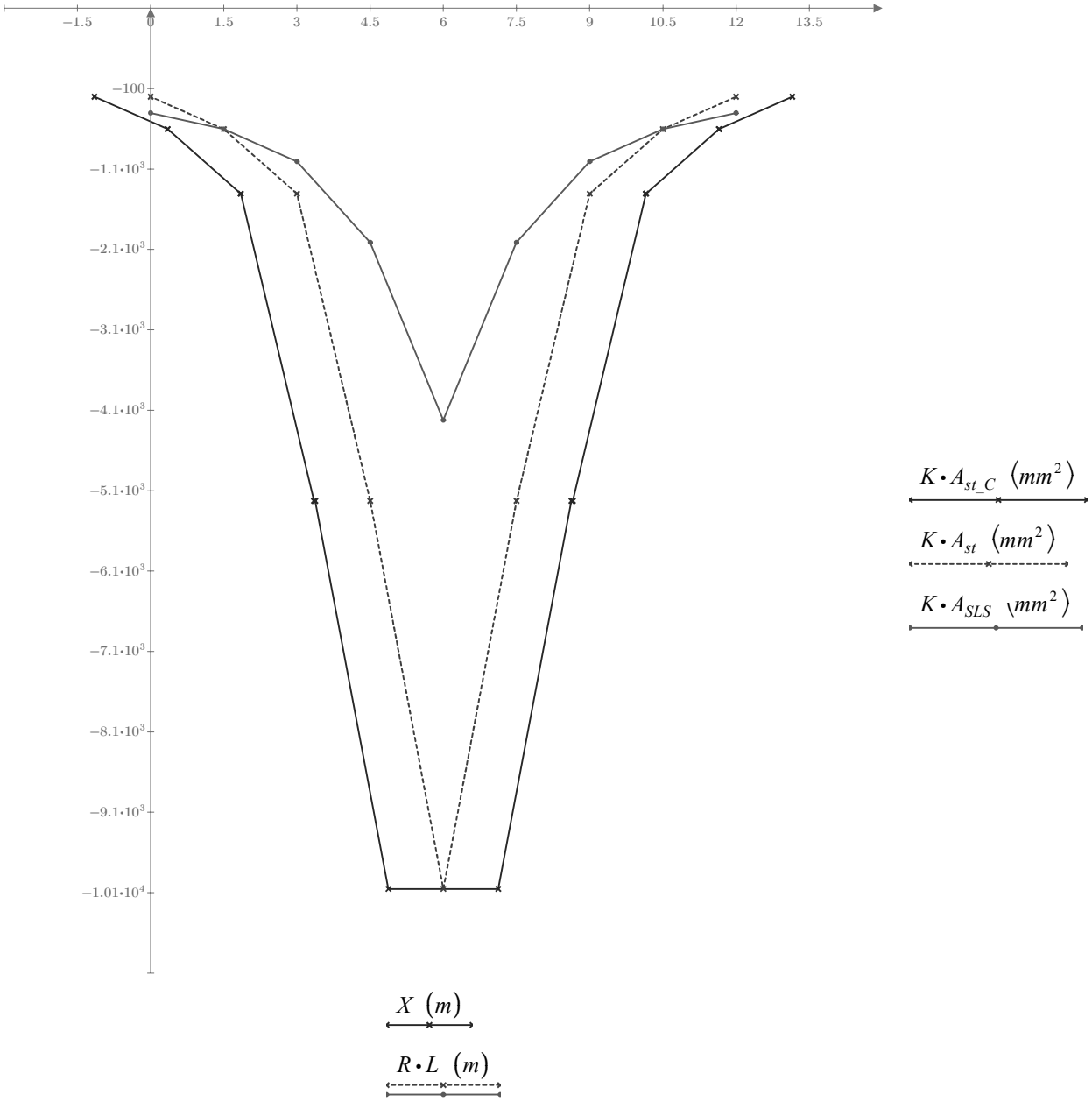
Reinforcement ULS

	Tension rebars					Compression rebars	
x	A_{st}	Layer 1	Layer 2	Layer 3	Layer 4	A_{sc}	Layer 1
0	201	1	0	0	0	0	0
1,500	603	3	0	0	0	0	0
3,000	1407	7	0	0	0	0	0
4,500	5228	13	13	0	0	0	0
6,000	10053	13	13	13	11	0	0
7,500	5228	13	13	0	0	0	0
9,000	1407	7	0	0	0	0	0
10,500	603	3	0	0	0	0	0
12,000	201	1	0	0	0	0	0
m	mm^2	pcs	pcs	pcs	pcs	mm^2	pcs

Reinforcement SLS

x	A_s	Layer 1	Layer 2	Layer 3	Layer 4
0	402	2	0	0	0
1,500	603	3	0	0	0
3,000	1005	5	0	0	0
4,500	2011	10	0	0	0
6,000	4222	13	8	0	0
7,500	2011	10	0	0	0
9,000	1005	5	0	0	0
10,500	603	3	0	0	0
12,000	402	2	0	0	0
m	mm^2	pcs	pcs	pcs	pcs

Diagram over required reinforcement



Chosen reinforcement

Table format:

Pos	K_{rebar}	Layer	x_{start}	x_{end}	ϕ	n_{rebar}	c_c	l_b
1	-1	1	-1,0	13,0	16	7	200	800
2	-1	1	0	12,0	16	6	200	800
3	-1	2	1,0	11,0	16	7	200	800
4	-1	2	2,0	10,0	16	6	200	800
5	-1	3	2,0	10,0	16	7	200	800
6	-1	3	3,0	9,0	16	6	200	800
7	-1	4	3,0	9,0	16	13	100	800
8	-1	x	0	0	0	0	0	0
9	-1	x	0	0	0	0	0	0
10	-1	x	0	0	0	0	0	0
-	-	-	m	m	mm	pcs	mm	mm

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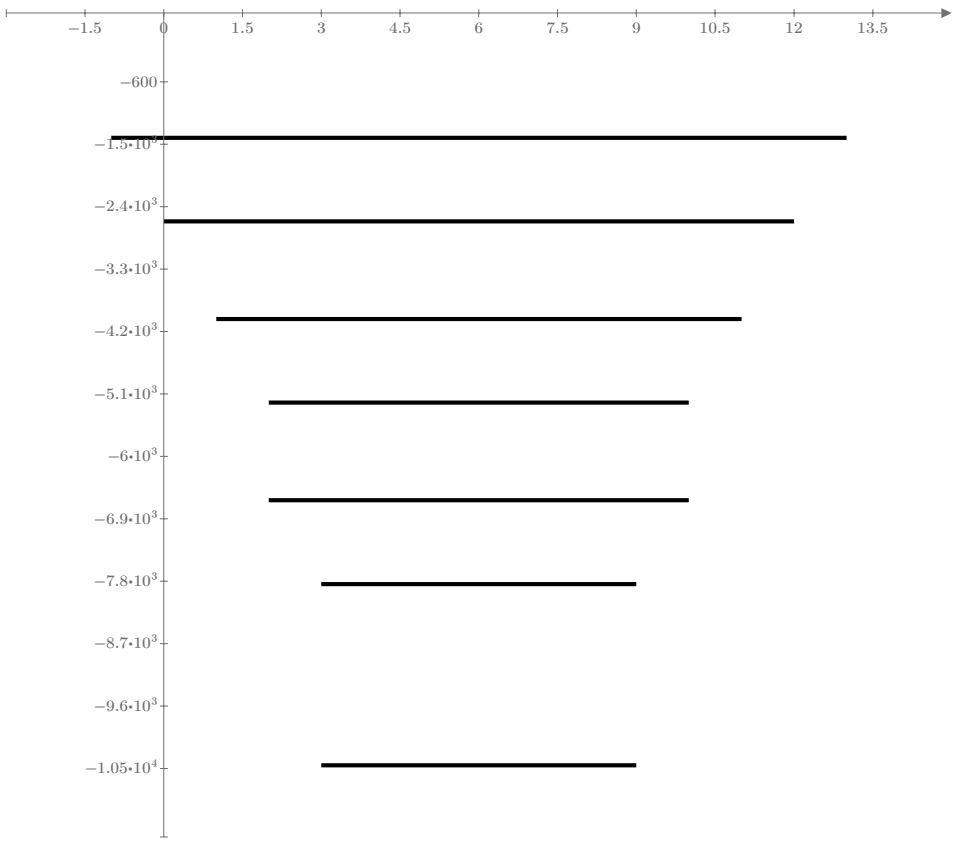
Diagram for graphic visualization:



$RebarArea(1)\ \langle mm^2 \rangle$

$RebarArea(2)\ \langle mm^2 \rangle$

$RebarArea(3)\ \langle mm^2 \rangle$

$RebarArea(4)\ \langle mm^2 \rangle$

$RebarArea(5)\ \langle mm^2 \rangle$

$RebarArea(6)\ \langle mm^2 \rangle$

$RebarArea(7)\ \langle mm^2 \rangle$

$RebarX(1)\ (m)$

$RebarX(2)\ (m)$

$RebarX(3)\ (m)$

$RebarX(4)\ (m)$

$RebarX(5)\ (m)$

$RebarX(6)\ (m)$

$RebarX(7)\ (m)$

Diagram over required reinforcement

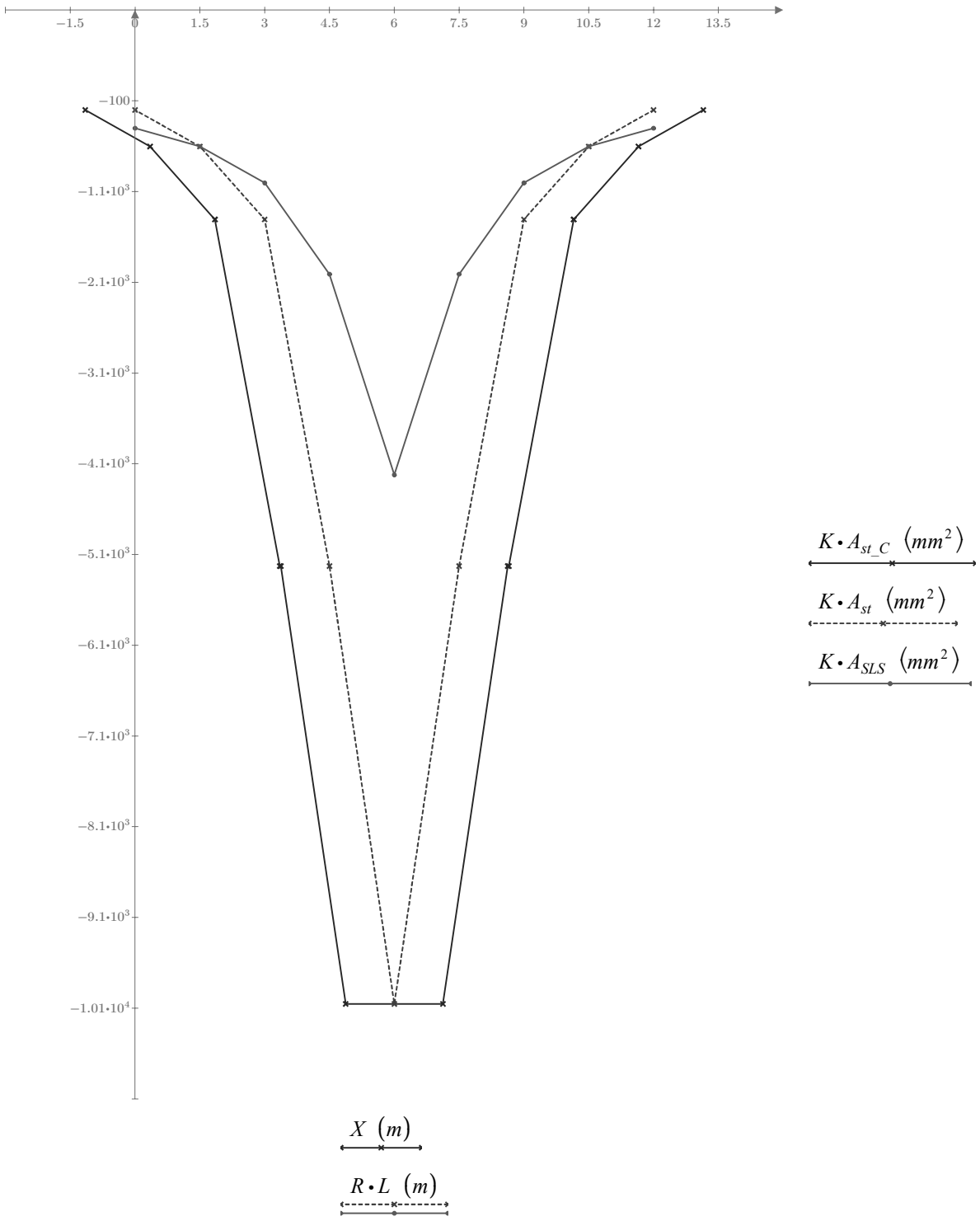


Diagram over resistance of chosen reinforcement