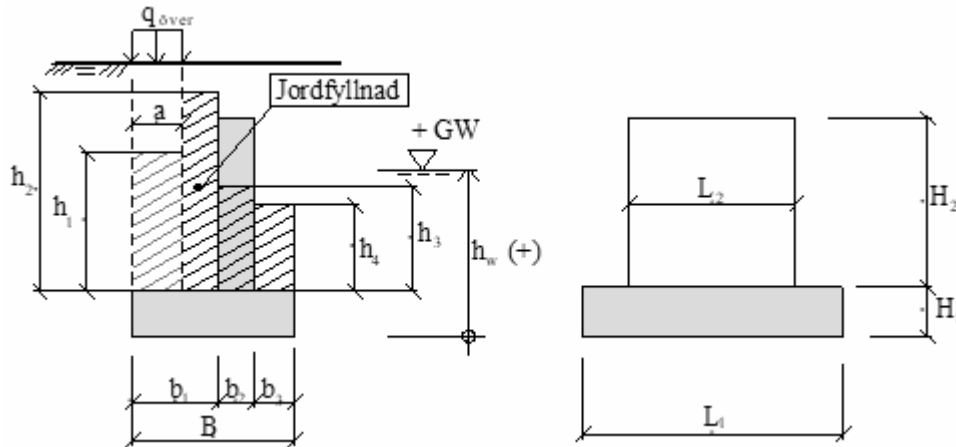


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Object: Support 2**PRINCIPLE SKETCH****INPUT - internal loads against abutment****Level GW**

$$h_w \equiv 209.31 \cdot m - 200.2 \cdot m = 9.11 \text{ m}$$

Density concrete above GW

$$\gamma_{big} \equiv 25 \cdot \frac{kN}{m^3}$$

$$\gamma'_{big} \equiv 15 \cdot \frac{kN}{m^3}$$

Density filling

$$\gamma_{jord} \equiv 20 \cdot \frac{kN}{m^3}$$

$$\gamma'_{jord} \equiv 13 \cdot \frac{kN}{m^3}$$

Surcharge

$$q_{\text{över}} \equiv 0 \cdot kPa$$

$$a \equiv 0 \cdot m$$

Height filling

$$h_1 \equiv 0.3 \cdot m$$

$$h_2 \equiv 0.3 \cdot m$$

$$h_3 \equiv 0.3 \cdot m$$

$$h_4 \equiv 0.3 \cdot m$$

Geometry bottom slab

$$b_1 \equiv 1.85 \cdot m$$

$$b_2 \equiv 2.30 \cdot m$$

$$b_3 \equiv 1.85 \cdot m$$

$$H_1 \equiv 1.50 \cdot m$$

$$L_1 \equiv 10.0 \cdot m$$

Geometry abutment

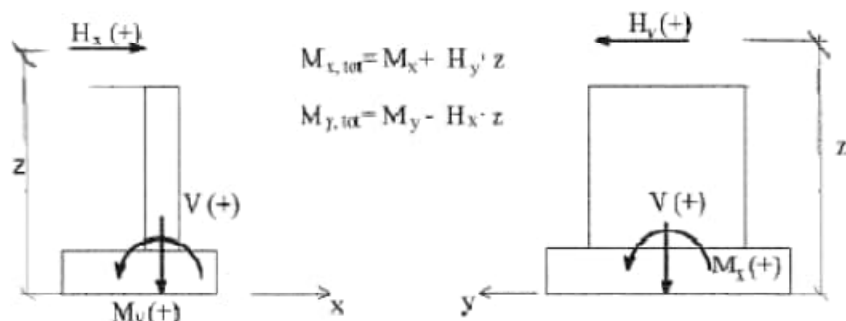
$$H_2 \equiv 1 \cdot m$$

$$L_2 \equiv 6.58 \cdot m$$

..

INPUT - external reactions

Sign conventions



Laster

Nr	Namn	V	H _x	H _y	z	M _x	M _y	Bearing
1	-							
2	Weight abutment	1350	0	0	0	0	0	No
3	Weight filling	175	0	0	0	0	0	No
4	-							
5	Reaction forces ULS:							
6	Max FX	3816	643	0	0	0	-1311	Yes
7	Min FX	5089	1192	155	0	478	-2149	Yes
8	Max FY	4914	698	-454	0	-2435	-1540	Yes
9	Min FY	4221	1083	454	0	2435	-1886	Yes
10	Max FZ	7700	1257	109	0	-1352	-2611	Yes
11	Min FZ	3361	620	-247	0	-1061	-1216	Yes
12	Max MX	6100	1177	353	0	3310	-2278	Yes
13	Min MX	5151	710	-353	0	-3310	-1589	Yes
14	Max MY	3816	643	0	0	0	-1311	Yes
15	Min MY	5089	1192	155	0	478	-2149	Yes
16	-							
17	-							
18	Vertical surcharge	0	0	0	0	0	0	No
19	-							
20	-							
21	-							
22	-							
23	-							
24	-							
25	-							
26	-							
-	-	kN	kN	kN	m	kNm	kNm	Yes/No

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Load coefficients ψ

Nr	Namn	ULS a	ULS b	ULS c	ULS d	ULS e	ULS f	ULS g	ULS h	ULS i	ULS j
1	-										
2	Weight abutment	1,33	1,00	1,00	1,00	1,00	1,33	1,33	1,00	1,00	1,33
3	Weight filling	1,33	0,90	0,90	0,90	0,90	1,33	1,33	1,00	1,00	1,33
4	-										
5	Reaction forces ULS:										
6	Max FX	1,00									
7	Min FX		1,00								
8	Max FY			1,00							
9	Min FY				1,00						
10	Max FZ					1,00					
11	Min FZ						1,00				
12	Max MX							1,00			
13	Min MX								1,00		
14	Max MY									1,00	
15	Min MY										1,00
16	-										
17	-										
18	Vertical surcharge	0	0	0	0	0	0	0	0	0	0
19	-										
20	-										
21	-										
22	-										
23	-										
24	-										
25	-										
26	-										

Second order effects

$$P_{cr.x} := 1000 \cdot MN$$

$$P_{cr.y} := 1000 \cdot MN$$

$$e_{xd} := 100 \cdot mm$$

$$e_{yd} := 100 \cdot mm$$

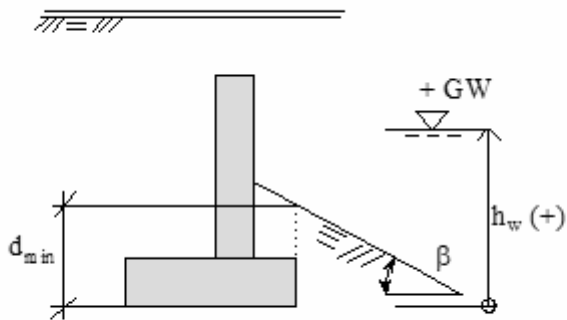
Number of loadcombinations

$$N \equiv 10 \cdot pcs$$

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INPUT - geotechnical resistisabce according to "allmänna bärlighets ekvationen"

(Calculation according to SS-EN 1997-1 attachment D)

Charateristic friction angle:

$$\phi_k := 39 \cdot ^\circ$$

Level GW :

$$h_w = 9.11 \text{ m}$$

Slope inclination :

$$\beta := 0 \cdot ^\circ$$

Lowest foundation depth (= d₁ + d₂):

$$d_{min} := 1.8 \cdot \text{m}$$

Dry density :

$$\gamma := 20 \cdot \frac{\text{kN}}{\text{m}^3}$$

Wet densitet :

$$\gamma' := 12 \cdot \frac{\text{kN}}{\text{m}^3}$$

Partial material coefficient (M2 och Geo PM):

$$\gamma_M := 1.30$$

Partial safety coefficient:

$$\gamma_d := 0.91$$

Partial vertical resistance coefficient (R3):

$$\gamma_{R,v} := 1.0$$

Partial horizontal resistance coefficient (R3):

$$\gamma_{R,h} := 1.0$$

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CALCULATON**Dead weight bottom slab**

$$B \equiv (b_1 + b_2 + b_3) = 6.0 \text{ m}$$

$$V_{bpl} \equiv \begin{cases} \text{if } h_w \leq 0 \cdot m & V_{bpl} = 1350 \text{ kN} \\ \quad \parallel \\ \quad \parallel B \cdot H_1 \cdot L_1 \cdot \gamma_{btg} \\ \text{also if } h_w \geq H_1 \\ \quad \parallel \\ \quad \parallel B \cdot H_1 \cdot L_1 \cdot \gamma'_{btg} \\ \text{else} \\ \quad \parallel \\ \quad \parallel B \cdot L_1 \cdot (h_w \cdot \gamma'_{btg} + (H_1 - h_w) \cdot \gamma_{btg}) \end{cases}$$

$$M_{y.bpl} \equiv V_{bpl} \cdot \frac{B - b_2 - 2 \cdot b_3}{2} \quad M_{y.bpl} = 0 \text{ kNm}$$

Dead weight abutment

$$V_{skiva} \equiv \begin{cases} \text{if } h_w \leq H_1 & V_{skiva} = 0 \text{ kN} \\ \quad \parallel \\ \quad \parallel b_2 \cdot H_2 \cdot L_2 \cdot \gamma_{btg} \\ \text{also if } h_w \geq (H_1 + H_2) \\ \quad \parallel \\ \quad \parallel b_2 \cdot H_2 \cdot L_2 \cdot \gamma'_{btg} \\ \text{else} \\ \quad \parallel \\ \quad \parallel b_2 \cdot L_2 \cdot ((H_1 + H_2 - h_w) \cdot \gamma_{btg} + (h_w - H_1) \cdot \gamma'_{btg}) \end{cases}$$

Dead weight filling

$$V_{jord}(b, h, l) \equiv \begin{cases} \text{if } b > 0 \cdot m \\ \quad \parallel \\ \quad \parallel \text{if } h_w \leq H_1 \\ \quad \parallel \parallel \\ \quad \parallel \parallel b \cdot h \cdot l \cdot \gamma_{jord} \\ \quad \parallel \text{also if } h_w \geq (H_1 + h) \\ \quad \parallel \parallel \\ \quad \parallel \parallel b \cdot h \cdot l \cdot \gamma'_{jord} \\ \quad \parallel \text{else} \\ \quad \parallel \parallel \\ \quad \parallel \parallel b \cdot l \cdot ((H_1 + h - h_w) \cdot \gamma_{jord} + (h_w - H_1) \cdot \gamma'_{jord}) \\ \quad \parallel \text{else} \\ \quad \parallel \parallel \\ \quad \parallel \parallel 0 \cdot kN \end{cases}$$

$$V_{jord.1} \equiv V_{jord}(a, h_1, L_1) = 0 \text{ kN} \quad x_{tp1} \equiv 0.5 \cdot (2 \cdot b_1 - a + b_2) = 3 \text{ m}$$

$$V_{jord.2} \equiv V_{jord}(b_1 - a, h_2, L_1) = 72 \text{ kN} \quad x_{tp2} \equiv 0.5 \cdot (b_1 - a + b_2) = 2.075 \text{ m}$$

$$V_{jord.3} \equiv V_{jord}(b_2, h_3, L_1 - L_2) = 31 \text{ kN}$$

$$V_{jord.4} \equiv V_{jord}(b_3, h_4, L_1) = 72 \text{ kN} \quad x_{tp4} \equiv -0.5 \cdot (b_2 + b_3) = -2.075 \text{ m}$$

$$V_{jord.tot} \equiv (V_{jord.1} + V_{jord.2} + V_{jord.3} + V_{jord.4}) = 175 \text{ kN}$$

$$M_{y.jord} \equiv V_{jord.1} \cdot x_{tp1} + V_{jord.2} \cdot x_{tp2} + V_{jord.4} \cdot x_{tp4} = 0 \text{ kNm}$$

Date: 12-03-2025

File : PROG G3_007.mcdx

Vertical surcharge on bottom slab

$$V_{\text{over}} \equiv \begin{cases} \text{if } a \leq 0 \cdot m \\ 0 \cdot kN \\ a \cdot L_1 \cdot q_{\text{over}} \end{cases}$$

$$V_{\text{over}} = 0 \text{ kN}$$

$$x_{\text{over}} \equiv 0.5 \cdot (2 \cdot b_1 - a + b_2) = 3 \text{ m}$$

$$M_{y,\text{over}} \equiv x_{\text{over}} \cdot V_{\text{over}} = 0 \text{ kNm}$$

Resulting moments

$$M_{x,\text{tot}} = M_x + H_y \cdot z$$

$$M_{y,\text{tot}} = M_y - H_x \cdot z$$

Design reactions without second order effects

$$V_d = V \cdot \psi_T$$

$$H_{xd} = H_x \cdot \psi_T$$

$$H_{yd} = H_y \cdot \psi_T$$

$$M_{xd,0} = M_{x,\text{tot}} \cdot \psi_T$$

$$M_{yd,0} = M_{y,\text{tot}} \cdot \psi_T$$

Design vertical bearing load

$$V_{d,\text{lager}} := V \cdot \psi_T \text{ if Bearing} = \text{"Yes"}$$

Design moment incl. second order effect and geometrical imperfections

$$M_{xd} = \begin{cases} (M_{xd,0} + V_{d,\text{lager}} \cdot e_{yd}) \cdot \frac{1}{1 - \frac{V_{d,\text{lager}}}{P_{cr,x}}} & \text{if } M_{xd,0} > 0 \text{ kNm} \\ (M_{xd,0} - V_{d,\text{lager}} \cdot e_{yd}) \cdot \frac{1}{1 - \frac{V_{d,\text{lager}}}{P_{cr,x}}} & \text{if } M_{xd,0} \leq 0 \text{ kNm} \end{cases}$$

$$M_{yd} = \begin{cases} (M_{yd,0} + V_{d,\text{lager}} \cdot e_{xd}) \cdot \frac{1}{1 - \frac{V_{d,\text{lager}}}{P_{cr,y}}} & \text{if } M_{yd,0} > 0 \text{ kNm} \\ (M_{yd,0} - V_{d,\text{lager}} \cdot e_{xd}) \cdot \frac{1}{1 - \frac{V_{d,\text{lager}}}{P_{cr,y}}} & \text{if } M_{yd,0} \leq 0 \text{ kNm} \end{cases}$$

Load excentricity

$$e_x = -\frac{M_{yd}}{V_d}$$

$$e_y = \frac{M_{xd}}{V_d}$$

Effective width and length

$$B_{ef} = \begin{cases} b_2 + 2b_3 - 2e_x & \text{if } (0.5b_2 + b_3 - e_x) < (b_1 + 0.5b_2 + e_x) \\ 2b_1 + b_2 + 2e_x & \text{otherwise} \end{cases}$$

$$L_{ef} = L_1 - 2|e_y$$

Verify if bottom slab is standing on at front edge (= "toe") or edge towards bank filling

$$Toe := \begin{cases} \text{if } (0.5 \cdot b_2 + b_3 - e_{x1}) < (b_1 + 0.5 \cdot b_2 + e_{x1}) \\ \quad \text{"Yes"} \\ \text{else} \\ \quad \text{"No"} \end{cases}$$

Verify friction

$$H_d = \sqrt{H_{xd}^2 + H_{yd}^2}$$

$$\mu_d = \frac{H_d}{V_d}$$

Calculate ground pressure

$$\sigma_d = \frac{V_d}{B_{ef} \cdot L_{ef}}$$

Design friction angle

$$\phi_d = \text{atan} \left(\frac{\tan(\phi_k)}{\gamma M \cdot \gamma_d} \right)$$

$$\phi_d = 34^\circ$$

Overlay pressure

$$d_1 = \text{if}(h_w \geq 0 \text{ m}, \text{if}(h_w \geq d_{\min} \cdot 0 \text{ m}, d_{\min} - h_w), d_{\min})$$

$$d_1 = 0 \text{ m}$$

$$d_2 = d_{\min} - d_1$$

$$d_2 = 1.8 \text{ m}$$

$$q = \gamma \cdot d_1 + \gamma' \cdot d_2$$

$$q = 22 \text{ kPa}$$

Calculate θ

$$\theta = \text{asin} \left(\frac{H_{xd}}{H_d} \right)$$

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Calculate m_θ

$$m_b = \frac{2 + \frac{B_{ef}}{L_{ef}}}{1 + \frac{B_{ef}}{L_{ef}}} \quad m_l = \frac{2 + \frac{L_{ef}}{B_{ef}}}{1 + \frac{L_{ef}}{B_{ef}}}$$

$$m_\theta = m_l \cdot \cos(\theta)^2 + m_b \cdot \sin(\theta)^2$$

Density of soil under foundation level

$$\gamma_{ef} = \text{if} \left(h_w \geq 0 \text{m}, \gamma', \text{if} \left(-h_w \geq B_{ef} \cdot \gamma \cdot \gamma' \cdot \frac{B_{ef} + h_w}{B_{ef}} - \gamma \cdot \frac{h_w}{B_{ef}} \right) \right)$$

Calculate R_q

$$N_q = \frac{1 + \sin(\phi_d)}{1 - \sin(\phi_d)} \cdot e^{\pi \cdot \tan(\phi_d)}$$

$$d_q = \text{if} \left(1 + 0.35 \cdot \frac{d_{min}}{B_{ef}} \geq 1.7, 1.7, 1 + 0.35 \cdot \frac{d_{min}}{B_{ef}} \right)$$

$$s_q = 1 + \frac{B_{ef}}{L_{ef}} \cdot \tan(\phi_d)$$

$$i_q = \left(1 - \frac{H_d}{V_d} \right)^{m_\theta}$$

$$g_q = 1 - \sin(2 \cdot \beta)$$

$$b_q = 1$$

$$R_q = q \cdot N_q \cdot d_q \cdot s_q \cdot i_q \cdot g_q \cdot b_q \cdot \frac{B_{ef} \cdot L_{ef}}{\gamma R_v}$$

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Calculate R_γ

$$F_\phi = 0.08705 + 0.3231 \cdot \sin(2 \cdot \phi_d) - 0.04836 \cdot \sin(2 \cdot \phi_d)^2$$

$$N_\gamma = F_\phi \cdot \left(\frac{1 + \sin(\phi_d)}{1 - \sin(\phi_d)} \right)^{1.5 \cdot \tan(\phi_d) - 1}$$

$$d_\gamma = 1$$

$$s_\gamma = 1 - 0.4 \cdot \frac{B_{ef}}{L_{ef}}$$

$$i_\gamma = \left(1 - \frac{H_d}{V_d} \right)^{m_b + 1}$$

$$g_\gamma = g_q$$

$$b_\gamma = 1$$

$$R_\gamma = 0.5 \cdot \gamma_{ef} \cdot B_{ef} \cdot N_\gamma \cdot d_\gamma \cdot s_\gamma \cdot i_\gamma \cdot g_\gamma \cdot b_\gamma \cdot \frac{B_{ef} \cdot L_{ef}}{\gamma R_v}$$

Calculate geotechnical resistance R_d

$$R_d = R_q + R_\gamma$$

Calculate permissible ground pressure

$$\sigma_{d,till} = \frac{R_d}{B_{ef} \cdot L_{ef}}$$

Calculate permissible design frictional coefficient

$$\mu_{d,till} = \frac{\tan(\phi_d)}{\gamma R_h}$$

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RESULTS**Bearing loads**

Refers to load from the superstructure that is supplemented by second-order effects.

	ULS a	ULS b	ULS c	ULS d	ULS e	ULS f	ULS g	ULS h	ULS i	ULS j	Enhet
$V_{d.lager}$	3816	5089	4914	4221	7700	3361	6100	5151	3816	5089	kN

First-order reactions excl. second-order effects

	ULS a	ULS b	ULS c	ULS d	ULS e	ULS f	ULS g	ULS h	ULS i	ULS j	Enhet
V_d	5845	6597	6422	5729	9208	5390	8129	6676	5341	7118	kN
H_{xd}	643	1192	698	1083	1257	620	1177	710	643	1192	kN
H_{yd}	0	155	-454	454	109	-247	353	-353	0	155	kN
$M_{xd.0}$	0	478	-2435	2435	-1352	-1061	3310	-3310	0	478	kNm
$M_{yd.0}$	-1311	-2149	-1540	-1886	-2611	-1216	-2278	-1589	-1311	-2149	kNm

Dead weight abutment

$$V_{bpl} = 1350 \text{ kN}$$

$$V_{egen.tot} \equiv V_{bpl} + V_{skiva}$$

$$M_{y.egen} \equiv M_{y.bpl}$$

$$V_{skiva} = 0 \text{ kN}$$

$$V_{egen.tot} = 1350 \text{ kN}$$

$$M_{y.egen} = 0 \text{ kNm}$$

Load of earth filling on bottom slab

$$V_{jord.tot} = 175 \text{ kN}$$

$$M_{y.jord} = 0 \text{ kNm}$$

Vertical load effect on bottom slab

$$V_{over} = 0 \text{ kN}$$

$$M_{y.over} = 0 \text{ kNm}$$

Design friction angle

$$\phi_d = 34^\circ$$

Overlay pressure

$$q = 22 \text{ kPa}$$

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Resultat inkl. geometriska imperfektioner och 2:a ordningens moment

	ULS a	ULS b	ULS c	ULS d	ULS e	ULS f	ULS g	ULS h	ULS i	ULS j	Unit
V_d	5845	6597	6422	5729	9208	5390	8129	6676	5341	7118	kN
H_{xd}	643	1192	698	1083	1257	620	1177	710	643	1192	kN
H_{yd}	0	155	-454	454	109	-247	353	-353	0	155	kN
M_{xd}	-383	992	-2941	2869	-2138	-1402	3944	-3845	-383	992	kNm
M_{yd}	-1699	-2671	-2041	-2318	-3407	-1557	-2906	-2115	-1699	-2671	kNm
e_x	0,29	0,40	0,32	0,40	0,37	0,29	0,36	0,32	0,32	0,38	m
e_y	-0,07	0,15	-0,46	0,50	-0,23	-0,26	0,49	-0,58	-0,07	0,14	m
B_{ef}	5,42	5,19	5,36	5,19	5,26	5,42	5,29	5,37	5,36	5,25	m
L_{ef}	9,87	9,70	9,08	9,00	9,54	9,48	9,03	8,85	9,86	9,72	m
σ_d	109	131	132	123	184	105	170	141	101	139	kPa
$\sigma_{d, till}$	1424	1179	1378	1133	1324	1390	1294	1411	1384	1224	kPa
μ_d	0,11	0,18	0,13	0,20	0,14	0,12	0,15	0,12	0,12	0,17	-
$\mu_{d, till}$	0,68	0,68	0,68	0,68	0,68	0,68	0,68	0,68	0,68	0,68	-
"Toe"	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes/No
θ	90	83	57	67	85	68	73	64	90	83	deg
m	1,65	1,65	1,55	1,59	1,64	1,60	1,61	1,57	1,65	1,64	-
N_q	30,9	30,9	30,9	30,9	30,9	30,9	30,9	30,9	30,9	30,9	-
d_q	1,12	1,12	1,12	1,12	1,12	1,12	1,12	1,12	1,12	1,12	-
s_q	1,38	1,37	1,40	1,39	1,38	1,39	1,40	1,42	1,37	1,37	-
i_q	0,83	0,72	0,81	0,69	0,79	0,81	0,77	0,82	0,81	0,74	-
g_q	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	-
b_q	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	-
R_q	45230	36950	41121	33814	40522	43116	38340	41055	43792	38528	kN
γ_{ef}	12,0	12,0	12,0	12,0	12,0	12,0	12,0	12,0	12,0	12,0	kN/m ³
F_ϕ	0,35	0,35	0,35	0,35	0,35	0,35	0,35	0,35	0,35	0,35	-
N_γ	30,99	30,99	30,99	30,99	30,99	30,99	30,99	30,99	30,99	30,99	-
d_γ	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	-
s_γ	0,78	0,79	0,76	0,77	0,78	0,77	0,77	0,76	0,78	0,78	-
i_γ	0,73	0,59	0,70	0,55	0,68	0,71	0,65	0,72	0,71	0,61	-
g_γ	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	-
b_γ	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	-
R_γ	30893	22425	26048	19129	25903	28349	23423	25921	29377	23946	kN
R_d	76124	59374	67169	52944	66425	71465	61763	66976	73168	62475	kN