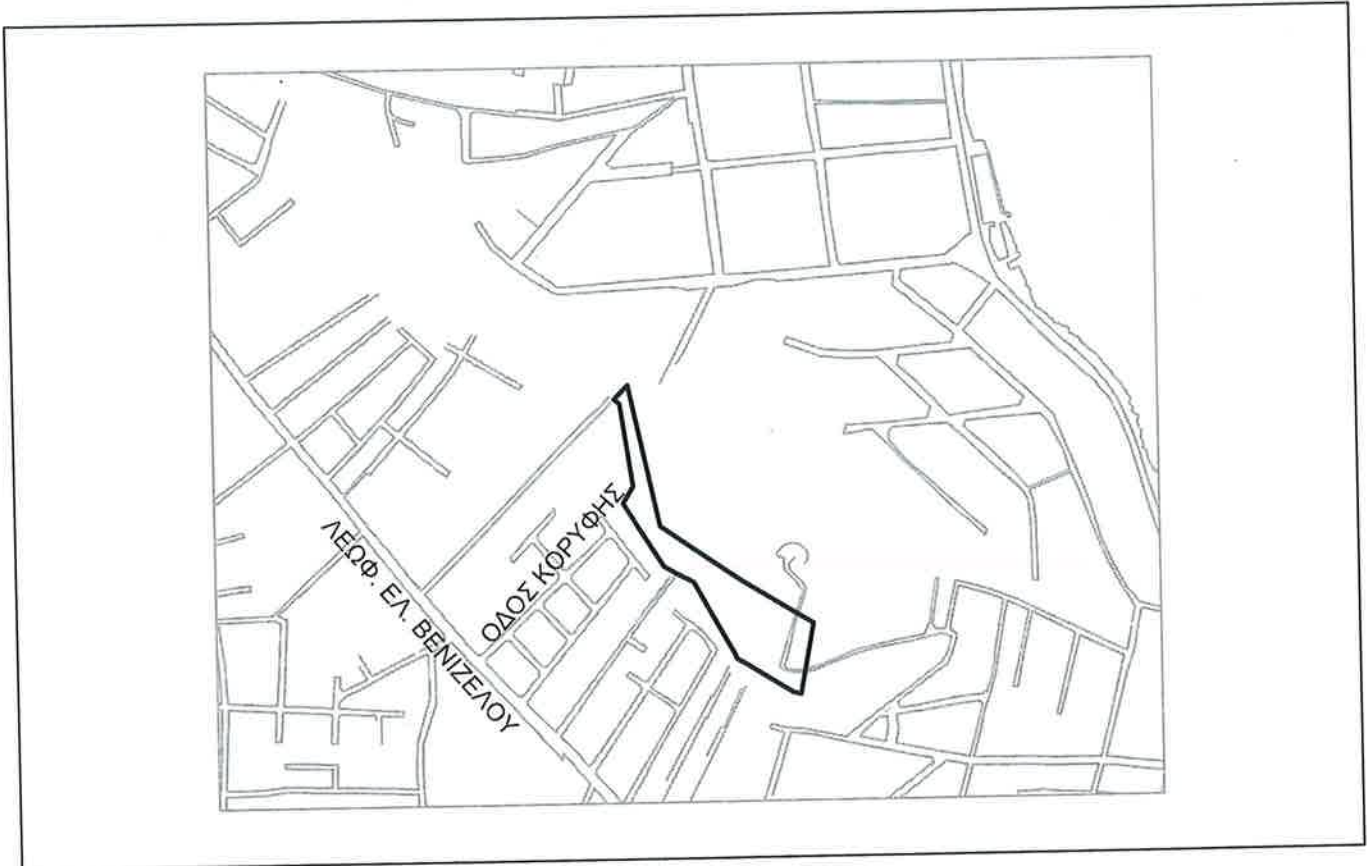




ΓΕΩΤΕΧΝΙΚΕΣ ΕΡΕΥΝΗΤΙΚΕΣ ΕΡΓΑΣΙΕΣ-ΜΕΛΕΤΕΣ ΓΙΑ ΤΟΝ ΚΙΝΔΥΝΟ ΑΠΟΚΟΛΛΗΣΗΣ ΚΑΙ ΚΑΤΑΠΤΩΣΕΩΝ  
 ΒΡΑΧΩΝ ΣΤΗΝ ΠΕΡΙΟΧΗ ΚΥΒΟΥΡΙ, ΠΟΡΤΟ ΡΑΦΤΗ ΤΟΥ ΔΗΜΟΥ ΜΑΡΚΟΠΟΥΛΟΥ

ΑΜΕΣΑ ΕΡΓΑ ΕΝΙΣΧΥΣΗΣ ΕΥΣΤΑΘΕΙΑΣ ΠΡΑΝΩΝ  
 ΓΕΩΛΟΓΙΚΗ - ΓΕΩΤΕΧΝΙΚΗ ΜΕΛΕΤΗ



Επικαιροποιημένα Παραρτήματα Γ3 - Γ8 - Γ9

Μαρκοπούλο 14/7/2020  
 Ήρθε από  
 Δημόσια  
 ΔΗΜΗΤΡΑ ΛΕΩΝΙΔΟΠΟΥΛΟΥ  
 Δρ. ΓΕΩΛΟΓΟΣ



Μαρκοπούλο 15-7-20  
 Ήρθε από  
 Δημόσια  
 5144

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### **ΠΑΡΑΡΤΗΜΑ Γ.3**

Ογκόλιθος "Ε". Υπολογισμοί διαστασιολόγησης συστήματος επένδυσής με περιμετρικώς αγκυρούμενο γαλβανισμένο συρματόπλεγμα.

Περίπτωση 1

# SPIDER® ONLINE-TOOL

SPIDER - The Dimensioning Online Tool for the rock protection system SPIDER® for individual rock boulders

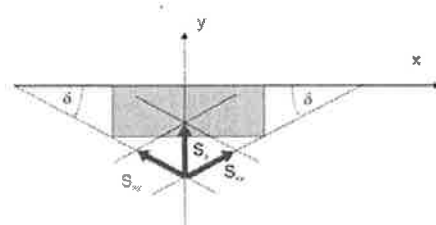
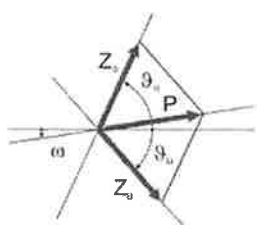
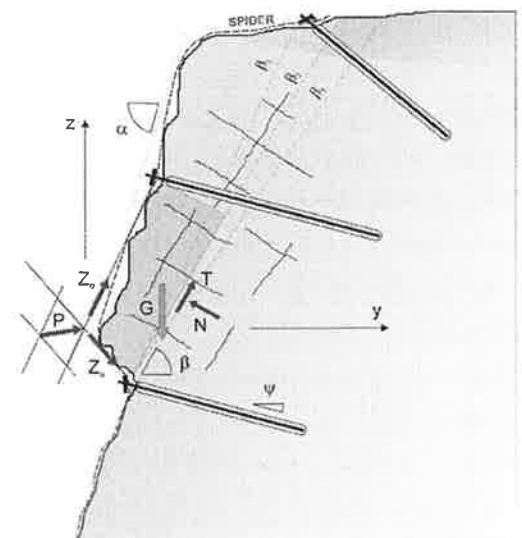
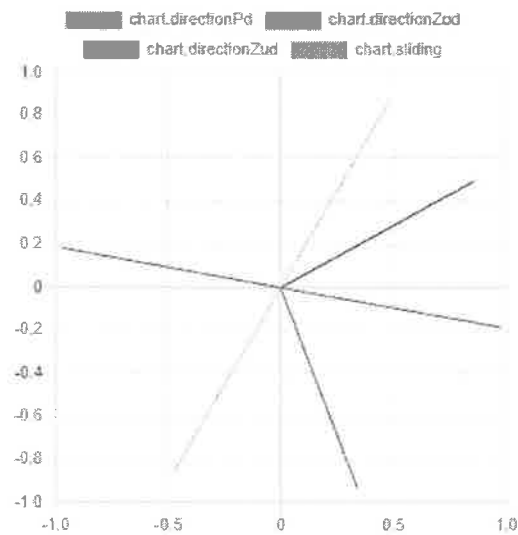
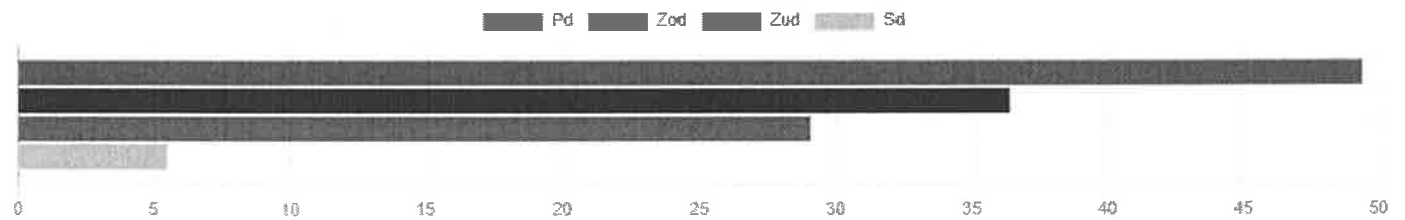
Project No.

Project name

Date/Author

Weight, Geometry		
Block weight (characteristic value)	$G =$	85 kN
Inclination of the sliding plane to horizontal	$\beta =$	61 degrees
Angle of the top restraint to horizontal	$\theta_0 =$	30 degrees
Angle of the bottom restraint to horizontal	$\theta_1 =$	70 degrees
Ratio $Z_u : Z_0$	$\eta =$	80 %

Lateral influence		
Angle of the lateral restraint to horizontal related to vertical plane	$\delta =$	40 degrees
Angle of the resultant, lateral restraint in line of slope	$\chi =$	0 degrees
Ratio $S : Z_0$	$\zeta =$	15 %



Geotechnical parameters			
Friction angle (characteristic value)	$\varphi_k =$	37	degrees
Cohesion (characteristic value)	$c_k =$	0	kN/m <sup>2</sup>
Cohesion related area	$A =$	0	m <sup>2</sup>

Safety factors for geotechnical parameters, arif model			
Partial safety factor for friction angle	$\gamma_\varphi =$	1	-
Partial safety factor for cohesion	$\gamma_c =$	1	-
Partial safety factor for volume weight	$\gamma_\gamma =$	1	-
Model uncertainty correction value	$\gamma_{mod} =$	1	-

Number of nails or anchors			
Number of participating nails or anchors at the top	$n_o =$	3	-
Number of participating nails or anchors at the bottom	$n_u =$	1	-
Number of participating nails or anchors lateral	$n_b =$	2	-

Earthquake			
Coefficient of horizontal acceleration due to earthquake	$\varepsilon_h =$	0.08	-
Coefficient of vertical acceleration due to earthquake	$\varepsilon_v =$	0.04	-

Water pressure acting onto the blocks			
Water pressure from behind, perpendicular to the sliding plane	$W_h =$	1	kN
Water pressure from above, parallel to the sliding plane	$W_a =$	0	kN

Elements of system			
Spiral rope net	SPIDER® S3-130		
Spike plate	System spike plate P33		
Bearing resistance of the spiral rope net to tensile stress	$Z_n$ [kN/m] =	220	
Bearing resistance of the spiral rope net to local force transmission longitudinal	$Z_{a1}$ [kN] =	60	
Bearing resistance of the spiral rope net to local force transmission transversal	$Z_{a2}$ [kN] =	45	
Spiral rope anchor (standard)	Spiral rope anchor, D = 14.5 mm		
Boundary rope (standard)	Steel wire rope, D = 14 mm		
Elements to connect the net panels between each other	Shackles 3/8"		
Nail type	GEWI D = 25 mm		
Taking into account rusting away (nail diameter reduced by 4 mm)	yes		
Nail inclination to horizontal	$\psi$ [degrees] =	10	
Maximum excentricity of the load to be transferred onto the nail at the top / bottom	$\xi$ [m] =	0.01	
Yield stress of the nail	$f_y$ [N/mm <sup>2</sup> ] =	500	
Cross-section with / without rusting away	$A_{res}$ [mm <sup>2</sup> ] =	346	
Plastic section modulus	$W_{pl, res}$ [mm <sup>3</sup> ] =	1544	
Bearing resistance of the nail to tensile stress	$T_{Res,t}$ [kN] =	173	
Bearing resistance of the nail to shear stress	$S_{Res,s}$ [kN] =	100	

**Calculated values**

Resultant stabilizing force P, on dimensioning level	$P_s$ [kN] =	52.0
Force in the net cover, to be transmitted to the top, on dimensioning level	$Z_{sd}$ [kN] =	38.4
Force in the net cover, to be transmitted to the bottom, on dimensioning level	$Z_{sb}$ [kN] =	30.7
Force in the net cover, to be transmitted laterally, on dimensioning level	$S_d$ [kN] =	5.8
Opening angle between the forces in the net cover to the top and to the bottom	$\vartheta = \vartheta_1 + \vartheta_2$ [degrees]=	100.0
Inclination of the resultant stabilizing force Pd to horizontal	$\omega$ [degrees]=	-10.7
Theoretical friction angle net - block (neglecting lateral influence)	$\varphi_a$ [degrees] =	9.3

**Proof of local force transmission to the top**

Maximum tensile force in the net cover to be transmitted to the top, on dim. level	$Z_{sd}$ [kN] =	38.4
Bearing resistance of the spiral rope net to local force transmission longitudinal	$Z_{R1}$ [kN] =	60.0
Resistance correction value for local force transmission	$\gamma_{R1}$ [-] =	1.5
Dim. value of the bearing res. of the spiral rope net to local force transmission longit.	$Z_{R1c} = Z_{R1} / \gamma_{R1}$ [kN] =	40.0
Number of nails or anchors at the top	$n_a$ =	3.0
Total bearing resistance of the spiral rope net to force transmission to the top	$Z_{R1tot} = Z_{R1c} \cdot n_a$ [kN] =	120.0
Proof of bearing safety	$Z_{sd} \leq Z_{R1tot}$ =	fulfilled!

**Proof of local force transmission to the bottom**

Proof of local force transmission to the bottom	$Z_{sb}$ [kN] =	30.7
Bearing resistance of the spiral rope net to local force transmission longitudinal	$Z_{R2}$ [kN] =	60.0
Resistance correction value for local force transmission	$\gamma_{R2}$ [-] =	1.5
Dim. value of the bearing res. of the spiral rope net to local force transmission longit.	$Z_{R2c} = Z_{R2} / \gamma_{R2}$ [kN] =	40.0
Number of nails or anchors at the bottom	$n_b$ =	1.0
Total bearing resistance of the spiral rope net to force transmission to the bottom	$Z_{R2tot} = Z_{R2c} \cdot n_b$ [kN] =	40.0
Proof of bearing safety	$Z_{sb} \leq Z_{R2tot}$ =	fulfilled!

**Proof of local force transmission laterally**

Maximum tensile force in the net cover to be transmitted laterally on dimensioning level	$S_d$ [kN] =	5.8
Bearing resistance of the spiral rope net to local force transmission transversal	$Z_{R3}$ [kN] =	45.0
Resistance correction value for local force transmission	$\gamma_{R3}$ [-] =	1.5
Dim. value of the bearing res. of the spiral rope net to local force transmission transv.	$Z_{R3c} = Z_{R3} / \gamma_{R3}$ [kN] =	30.0
Number of nails or anchors lateral	$n_l$ [-] =	2.0
Total bearing resistance of the spiral rope net to force transmission lateral	$Z_{R3tot} = Z_{R3c} \cdot n_l$ [kN] =	60.0
Proof of bearing safety	$S_d \leq Z_{R3tot}$ =	fulfilled!

**Proof of shear stress in the nails at the top**

Shear load in the nail at the top as a result of the force (Zsd / no)	$V_{sd}$ [kN] =	9.2
Shear stress in the nail at the top	$\tau_{sd}$ [N/mm <sup>2</sup> ] = $V_{sd} / A_{n,eff}$ =	23.8
Resistance correction value for shear stress	$\gamma_v$ [-] =	1.1
Maximum permissible shear stress	$\tau_{sd} = f_y / (\sqrt{3} \cdot \gamma_v)$ =	262.4
Proof of bearing safety	$\tau_{sd} \leq \tau_a$	fulfilled!

Proof of combined stress in the nails at the top		
Tensile load in the nail at the top as a result of the force (Z <sub>od</sub> / n <sub>o</sub> )	$N_{od}$ [kN] =	9,8
Moment as a result of the eccentric acting force (Z <sub>od</sub> / n <sub>o</sub> )	$M_{od}$ [kNm] =	0,1
Normal stress in the nail at the top	$\sigma_{Nd}$ [N/mm <sup>2</sup> ] = $N_{od} / A_{nred} + M_{od} / W_{nred}$ =	81,5
Combined stress in the nail at the top	$\sigma_d$ [N/mm <sup>2</sup> ] = $(\sigma_{Nd}^2 + 3 \tau_d^2)^{0,5}$ =	91,3
Resistance correction value for combined stress	$\gamma_{Nd}$ [-] =	1,1
Maximum permissible yield stress	$\sigma_{Nd} = f_y / \gamma_{Nd}$ =	454,5
Proof of bearing safety	$\sigma_{Nd} \geq \sigma_d$ =	fulfilled

Proof of shear stress in the nails at the bottom		
Shear load in the nail at the bottom as a result of the force (Z <sub>ud</sub> / n <sub>u</sub> )	$V_{ud}$ [kN] =	26,6
Shear stress in the nail at the bottom	$\tau_d$ [N/mm <sup>2</sup> ] = $V_{ud} / A_{nred}$ =	76,8
Resistance correction value for shear stress	$\gamma_{Vd}$ [-] =	1,1
Maximum permissible shear stress	$\tau_{sd} = f_y / (\sqrt{3} \cdot \gamma_{Vd})$ =	262,4
Proof of bearing safety	$\tau_{sd} \geq \tau_d$ =	fulfilled

Proof of combined stress in the nails at the bottom		
Tensile load in the nail at the bottom as a result of the force (Z <sub>ud</sub> / n <sub>u</sub> )	$N_{ud}$ [kN] =	15,3
Moment as a result of the eccentric acting force (Z <sub>ud</sub> / n <sub>u</sub> )	$M_{ud}$ [kNm] =	0,3
Normal stress in the nail at the bottom	$\sigma_{Nd}$ [N/mm <sup>2</sup> ] = $N_{ud} / A_{nred} + M_{ud} / W_{nred}$ =	216,5
Combined stress in the nail at the bottom	$\sigma_d$ [N/mm <sup>2</sup> ] = $(\sigma_{Nd}^2 + 3 \tau_d^2)^{0,5}$ =	254,1
Resistance correction value for combined stress	$\gamma_{Nd}$ [-] =	1,1
Maximum permissible yield stress	$\sigma_{Nd} = f_y / \gamma_{Nd}$ =	454,5
Proof of bearing safety	$\sigma_{Nd} \geq \sigma_d$ =	fulfilled



Περίπτωση 2

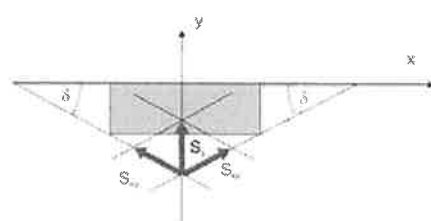
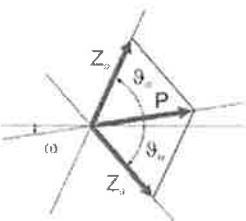
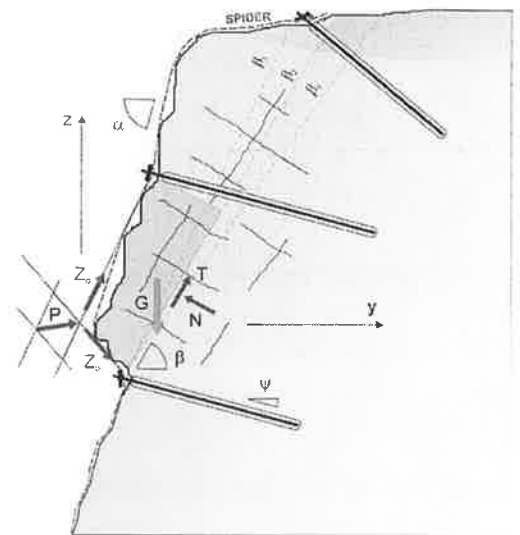
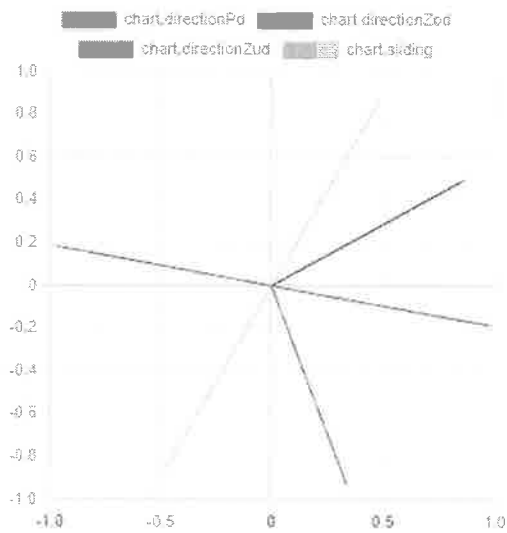
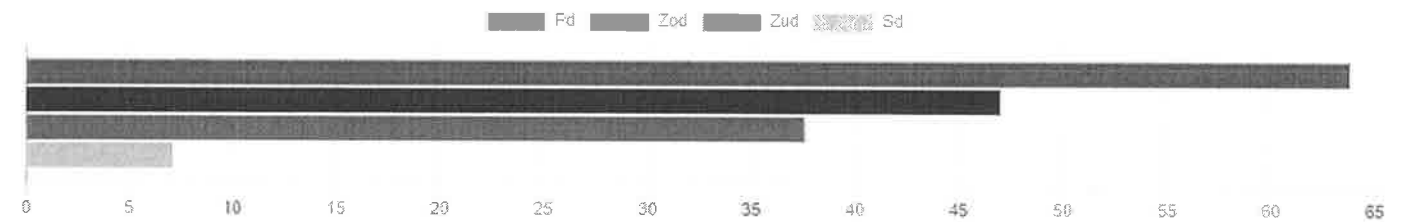
# SPIDER® ONLINE-TOOL

SPIDER - The Dimensioning Online Tool for the rock protection system SPIDER® for individual rock boulders

Project No.  
Project name  
Date/Author

Weight Geometry		
Block weight (characteristic value)	$G =$	85 kN
Inclination of the sliding plane to horizontal	$\beta =$	61 degrees
Angle of the top restraint to horizontal	$\delta_0 =$	30 degrees
Angle of the bottom restraint to horizontal	$\delta_1 =$	70 degrees
Ratio $Z_u : Z_0$	$\eta =$	80 %

Lateral Influence		
Angle of the lateral restraint to horizontal related to vertical plane	$\delta =$	40 degrees
Angle of the resultant, lateral restraint in line of slope	$\chi =$	0 degrees
Ratio $S : Z_0$	$\zeta =$	15 %



Geotechnical parameters			
Friction angle (characteristic value)	$\varphi_k =$	37	degrees
Cohesion (characteristic value)	$c_k =$	0	kN/m <sup>2</sup>
Cohesion related area	$A =$	0	m <sup>2</sup>

Safety factors for geotechnical parameters and model			
Partial safety factor for friction angle	$\gamma_\varphi =$	1	-
Partial safety factor for cohesion	$\gamma_c =$	1	-
Partial safety factor for volume weight	$\gamma_\gamma =$	1	-
Model uncertainty correction value	$\gamma_{mod} =$	1.2	-

Number of nails or anchors			
Number of participating nails or anchors at the top	$n_o =$	3	-
Number of participating nails or anchors at the bottom	$n_u =$	1	-
Number of participating nails or anchors lateral	$n_k =$	2	-

Earthquake			
Coefficient of horizontal acceleration due to earthquake	$E_h =$	0	-
Coefficient of vertical acceleration due to earthquake	$E_v =$	0	-

Water pressure acting onto the block			
Water pressure from behind, perpendicular to the sliding plane	$W_h =$	4	kN
Water pressure from above, parallel to the sliding plane	$W_v =$	0	kN

Elements of system			
Spiral rope net	SPIDER® S3-130		
Spike plate	System spike plate P33		
Bearing resistance of the spiral rope net to tensile stress	$Z_n$ [kN/m] =	220	
Bearing resistance of the spiral rope net to local force transmission longitudinal	$Z_{n1}$ [kN] =	60	
Bearing resistance of the spiral rope net to local force transmission transversal	$Z_{n2}$ [kN] =	45	
Spiral rope anchor (standard)	Spiral rope anchor, D = 14.5 mm		
Boundary rope (standard)	Steel wire rope, D = 14 mm		
Elements to connect the net panels between each other	Shackles 3/8"		
Nail type	GEWI D = 25 mm		
Taking into account rusting away (nail diameter reduced by 4 mm)	yes		
Nail inclination to horizontal	$\psi$ [degrees] =	10	
Maximum excentricity of the load to be transferred onto the nail at the top / bottom	$\xi$ [m] =	0.01	
Yield stress of the nail	$f_y$ [N/mm <sup>2</sup> ] =	500	
Cross-section with / without rusting away	$A_{net,n}$ [mm <sup>2</sup> ] =	346	
Plastic section modulus	$W_{pl,net}$ [mm <sup>3</sup> ] =	1544	
Bearing resistance of the nail to tensile stress	$T_{R_{tens}}$ [kN] =	173	
Bearing resistance of the nail to shear stress	$S_{R_{shear}}$ [kN] =	100	

Calculated values		
Resultant stabilizing force P, on dimensioning level	$P_s$ [kN] =	56.0
Force in the net cover, to be transmitted to the top, on dimensioning level	$Z_{so}$ [kN] =	41.3
Force in the net cover, to be transmitted to the bottom, on dimensioning level	$Z_{sb}$ [kN] =	33.0
Force in the net cover, to be transmitted laterally, on dimensioning level	$S_d$ [kN] =	6.2
Opening angle between the forces in the net cover to the top and to the bottom	$\theta = \theta_t + \theta_b$ [degrees]=	100.0
Inclination of the resultant stabilizing force Pd to horizontal	$\omega$ [degrees]=	-10.7
Theoretical friction angle net - block (neglecting lateral influence)	$\varphi_n$ [degrees] =	9.3

Proof of local force transmission to the top		
Maximum tensile force in the net cover to be transmitted to the top, on dim. level	$Z_{so}$ [kN] =	41.3
Bearing resistance of the spiral rope net to local force transmission longitudinal	$Z_{R1}$ [kN] =	60.0
Resistance correction value for local force transmission	$\gamma_{2P}$ [-] =	1.5
Dim. value of the bearing res. of the spiral rope net to local force transmission longit.	$Z_{R1d} = Z_{R1} / \gamma_{2P}$ [kN] =	40.0
Number of nails or anchors at the top	$n_o$ =	3.0
Total bearing resistance of the spiral rope net to force transmission to the top	$Z_{R1d,tot} = Z_{R1d} \cdot n_o$ [kN] =	120.0
Proof of bearing safety	$Z_{so} \leq Z_{R1d,tot}$ =	fulfilled!

Proof of local force transmission to the bottom		
Proof of local force transmission to the bottom	$Z_{sb}$ [kN] =	33.0
Bearing resistance of the spiral rope net to local force transmission longitudinal	$Z_{R1}$ [kN] =	60.0
Resistance correction value for local force transmission	$\gamma_{2P}$ [-] =	1.5
Dim. value of the bearing res. of the spiral rope net to local force transmission longit.	$Z_{R1d} = Z_{R1} / \gamma_{2P}$ [kN] =	40.0
Number of nails or anchors at the bottom	$n_u$ =	1.0
Total bearing resistance of the spiral rope net to force transmission to the bottom	$Z_{R1d,tot} = Z_{R1d} \cdot n_u$ [kN] =	40.0
Proof of bearing safety	$Z_{sb} \leq Z_{R1d,tot}$ =	fulfilled!

Proof of local force transmission laterally		
Maximum tensile force in the net cover to be transmitted laterally on dimensioning level	$S_d$ [kN] =	6.2
Bearing resistance of the spiral rope net to local force transmission transversal	$Z_{R2}$ [kN] =	45.0
Resistance correction value for local force transmission	$\gamma_{2P}$ [-] =	1.5
Dim. value of the bearing res. of the spiral rope net to local force transmission transv.	$Z_{R2d} = Z_{R2} / \gamma_{2P}$ [kN] =	30.0
Number of nails or anchors lateral	$n_s$ [-] =	2.0
Total bearing resistance of the spiral rope net to force transmission lateral	$Z_{R2d,tot} = Z_{R2d} \cdot n_s$ [kN] =	60.0
Proof of bearing safety	$S_d \leq Z_{R2d,tot}$ =	fulfilled!

Proof of shear stress in the nails at the top		
Shear load in the nail at the top as a result of the force (Zod / no)	$V_{ot}$ [kN] =	8.8
Shear stress in the nail at the top	$\tau_d$ [N/mm <sup>2</sup> ] = $V_{ot} / A_{top}$ =	25.6
Resistance correction value for shear stress	$\gamma_{Vs}$ [-] =	1.1
Maximum permissible shear stress	$\tau_{90} = f_s / (\sqrt{3} \cdot \gamma_{Vs})$ =	262.4
Proof of bearing safety	$\tau_{90} \geq \tau_d$	fulfilled!

Proof of combined stress in the nails at the top		
Tensile load in the nail at the top as a result of the force (Z <sub>0d</sub> / n <sub>0</sub> )	N <sub>0d</sub> [kN] =	10.5
Moment as a result of the eccentric acting force (Z <sub>0d</sub> / n <sub>0</sub> )	M <sub>0d</sub> [kNm] =	0.1
Normal stress in the nail at the top	$\sigma_{0d}$ [N/mm <sup>2</sup> ] = N <sub>0d</sub> / A <sub>0dcp</sub> + M <sub>0d</sub> / W <sub>0dtop</sub> =	87.8
Combined stress in the nail at the top	$\sigma_{0d}$ [N/mm <sup>2</sup> ] = ( $\sigma_{0d}^2 + 3 \tau_{0d}^2$ ) <sup>0.5</sup> =	98.3
Resistance correction value for combined stress	γ <sub>M</sub> [-] =	1.1
Maximum permissible yield stress	σ <sub>Rd</sub> = f <sub>y</sub> / γ <sub>M</sub> =	454.5
Proof of bearing safety	σ <sub>Rd</sub> ≥ σ <sub>d</sub> =	fulfilled!

Proof of shear stress in the nails at the bottom		
Shear load in the nail at the bottom as a result of the force (Z <sub>0d</sub> / n <sub>0</sub> )	V <sub>0d</sub> [kN] =	28.6
Shear stress in the nail at the bottom	τ <sub>0d</sub> [N/mm <sup>2</sup> ] = V <sub>0d</sub> / A <sub>0dcp</sub> =	82.7
Resistance correction value for shear stress	γ <sub>M</sub> [-] =	1.1
Maximum permissible shear stress	τ <sub>Rd</sub> = f <sub>v</sub> / (√3 · γ <sub>M</sub> ) =	262.4
Proof of bearing safety	τ <sub>Rd</sub> ≥ τ <sub>d</sub> =	fulfilled!

Proof of combined stress in the nails at the bottom		
Tensile load in the nail at the bottom as a result of the force (Z <sub>0d</sub> / n <sub>0</sub> )	N <sub>0d</sub> [kN] =	16.5
Moment as a result of the eccentric acting force (Z <sub>0d</sub> / n <sub>0</sub> )	M <sub>0d</sub> [kNm] =	0.3
Normal stress in the nail at the bottom	$\sigma_{0d}$ [N/mm <sup>2</sup> ] = N <sub>0d</sub> / A <sub>0dcp</sub> + M <sub>0d</sub> / W <sub>0dbot</sub> =	233.1
Combined stress in the nail at the bottom	$\sigma_{0d}$ [N/mm <sup>2</sup> ] = ( $\sigma_{0d}^2 + 3 \tau_{0d}^2$ ) <sup>0.5</sup> =	273.6
Resistance correction value for combined stress	γ <sub>M</sub> [-] =	1.1
Maximum permissible yield stress	σ <sub>Rd</sub> = f <sub>y</sub> / γ <sub>M</sub> =	454.5
Proof of bearing safety	σ <sub>Rd</sub> ≥ σ <sub>d</sub> =	fulfilled!

Περίπτωση 3

# SPIDER® ONLINE-TOOL

SPIDER - The Dimensioning Online Tool for the rock protection system SPIDER® for individual rock boulders

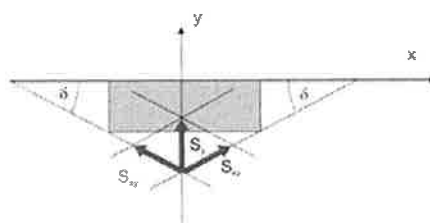
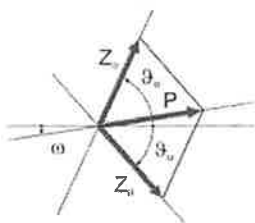
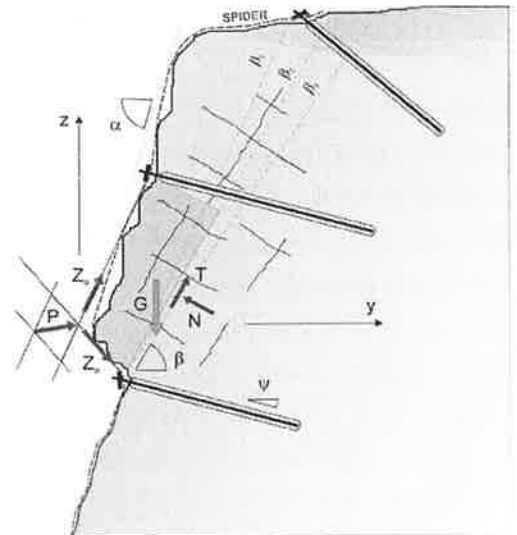
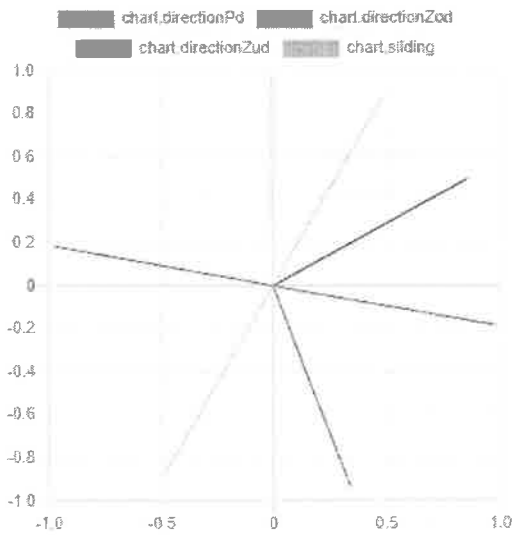
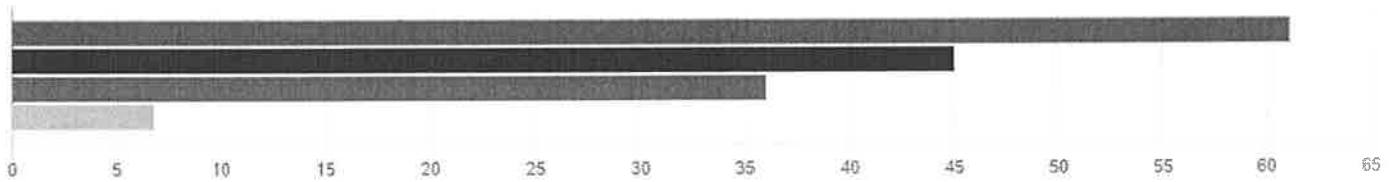
Project No.

Project name

Date/Author

Weight, Geometry		
Block weight (characteristic value)	G =	85 kN
Inclination of the sliding plane to horizontal	$\beta =$	61 degrees
Angle of the top restraint to horizontal	$\theta_u =$	30 degrees
Angle of the bottom restraint to horizontal	$\theta_u =$	70 degrees
Ratio $Z_u : Z_o$	$\eta =$	80 %
Lateral influence		
Angle of the lateral restraint to horizontal related to vertical plane	$\delta =$	40 degrees
Angle of the resultant, lateral restraint in line of slope	$\chi =$	0 degrees
Ratio $S : Z_o$	$\zeta =$	15 %

■ Pd ■ Zed ■ Zud ■ Sd



Geotechnical parameters		
Friction angle (characteristic value)	$\varphi_k =$	37 degrees
Cohesion (characteristic value)	$c_k =$	0 kN/m <sup>2</sup>
Cohesion related area	$A =$	0 m <sup>2</sup>
Safety factors for geotechnical parameters and model		
Partial safety factor for friction angle	$\gamma_\varphi =$	1 -
Partial safety factor for cohesion	$\gamma_c =$	1 -
Partial safety factor for volume weight	$\gamma_v =$	1 -
Model uncertainty correction value	$\gamma_{mod} =$	1.3 -
Number of nails or anchors		
Number of participating nails or anchors at the top	$\eta_o =$	3 -
Number of participating nails or anchors at the bottom	$\eta_u =$	1 -
Number of participating nails or anchors lateral	$\eta_n =$	2 -
Earthquake		
Coefficient of horizontal acceleration due to earthquake	$\ddot{e}_h =$	0 -
Coefficient of vertical acceleration due to earthquake	$\ddot{e}_v =$	0 -
Water pressure acting onto the block		
Water pressure from behind, perpendicular to the sliding plane	$W_h =$	1 kN
Water pressure from above, parallel to the sliding plane	$W_n =$	0 kN
Elements of system		
Spiral rope net	SPIDER® S3-130	
Spike plate	System spike plate P33	
Bearing resistance of the spiral rope net to tensile stress	$Z_n$ [kN/m] =	220
Bearing resistance of the spiral rope net to local force transmission longitudinal	$Z_{n1}$ [kN] =	60
Bearing resistance of the spiral rope net to local force transmission transversal	$Z_{n2}$ [kN] =	45
Spiral rope anchor (standard)	Spiral rope anchor, D = 14,5 mm	
Boundary rope (standard)	Steel wire rope, D = 14 mm	
Elements to connect the net panels between each other	Shackles 3/8"	
Nail type	GEWI D = 25 mm	
Taking into account rusting away (nail diameter reduced by 4 mm)	yes	
Nail inclination to horizontal	$\psi$ [degrees] =	10
Maximum eccentricity of the load to be transferred onto the nail at the top / bottom	$\xi$ [m] =	0,01
Yield stress of the nail	$f_y$ [N/mm <sup>2</sup> ] =	500
Cross-section with / without rusting away	$A_{gross}$ [mm <sup>2</sup> ] =	346
Plastic section modulus	$W_{pl,net}$ [mm <sup>3</sup> ] =	1544
Bearing resistance of the nail to tensile stress	$T_{tension}$ [kN] =	173
Bearing resistance of the nail to shear stress	$S_{shear}$ [kN] =	100



Calculated values		
Resultant stabilizing force $P_d$ on dimensioning level	$P_d$ [kN] =	59.0
Force in the net cover, to be transmitted to the top, on dimensioning level	$Z_{d1}$ [kN] =	43.5
Force in the net cover, to be transmitted to the bottom, on dimensioning level	$Z_{d2}$ [kN] =	34.8
Force in the net cover, to be transmitted laterally, on dimensioning level	$S_d$ [kN] =	6.5
Opening angle between the forces in the net cover to the top and to the bottom	$\theta = \theta_1 + \theta_2$ [degrees] =	100.0
Inclination of the resultant stabilizing force $P_d$ to horizontal	$\omega$ [degrees] =	-10.7
Theoretical friction angle net - block (neglecting lateral influence)	$\varphi_n$ [degrees] =	9.3

Proof of local force transmission to the top		
Maximum tensile force in the net cover to be transmitted to the top, on dim. level	$Z_{d1}$ [kN] =	43.5
Bearing resistance of the spiral rope net to local force transmission longitudinal	$Z_{R1}$ [kN] =	60.0
Resistance correction value for local force transmission	$\gamma_{R1}$ [-] =	1.5
Dim. value of the bearing res. of the spiral rope net to local force transmission longit.	$Z_{R1d} = Z_{R1} / \gamma_{R1}$ [kN] =	40.0
Number of nails or anchors at the top	$n_{d1}$ =	3.0
Total bearing resistance of the spiral rope net to force transmission to the top	$Z_{R1tot} = Z_{R1d} \cdot n_{d1}$ [kN] =	120.0
Proof of bearing safety	$Z_{d1} \leq Z_{R1tot}$ =	fulfilled

Proof of local force transmission to the bottom		
Proof of local force transmission to the bottom	$Z_{d2}$ [kN] =	34.8
Bearing resistance of the spiral rope net to local force transmission longitudinal	$Z_{R2}$ [kN] =	60.0
Resistance correction value for local force transmission	$\gamma_{R2}$ [-] =	1.5
Dim. value of the bearing res. of the spiral rope net to local force transmission longit.	$Z_{R2d} = Z_{R2} / \gamma_{R2}$ [kN] =	40.0
Number of nails or anchors at the bottom	$n_{d2}$ =	1.0
Total bearing resistance of the spiral rope net to force transmission to the bottom	$Z_{R2tot} = Z_{R2d} \cdot n_{d2}$ [kN] =	40.0
Proof of bearing safety	$Z_{d2} \leq Z_{R2tot}$ =	fulfilled

Proof of local force transmission laterally		
Maximum tensile force in the net cover to be transmitted laterally on dimensioning level	$S_d$ [kN] =	6.5
Bearing resistance of the spiral rope net to local force transmission transversal	$Z_{R3}$ [kN] =	45.0
Resistance correction value for local force transmission	$\gamma_{R3}$ [-] =	1.5
Dim. value of the bearing res. of the spiral rope net to local force transmission transv.	$Z_{R3d} = Z_{R3} / \gamma_{R3}$ [kN] =	30.0
Number of nails or anchors lateral	$n_{d3}$ [-] =	2.0
Total bearing resistance of the spiral rope net to force transmission lateral	$Z_{R3tot} = Z_{R3d} \cdot n_{d3}$ [kN] =	60.0
Proof of bearing safety	$S_d \leq Z_{R3tot}$ =	fulfilled

Proof of shear stress in the nail at the top		
Shear load in the nail at the top as a result of the force ( $Z_{d1}$ / no)	$V_{d1}$ [kN] =	9.3
Shear stress in the nail at the top	$\tau_{d1}$ [N/mm <sup>2</sup> ] = $V_{d1} / A_{N,d1}$ =	27.0
Resistance correction value for shear stress	$\gamma_w$ [-] =	1.1
Maximum permissible shear stress	$\tau_{d1} \leq f_v / (\sqrt{3} \cdot \gamma_w)$ =	262.4
Proof of bearing safety	$\tau_{d1} \leq \tau_c$	fulfilled

Proof of combined stress in the nails at the top		
Tensile load in the nail at the top as a result of the force (Z <sub>od</sub> / n <sub>o</sub> )	$N_{od}$ [kN] =	11.1
Moment as a result of the eccentric acting force (Z <sub>od</sub> / n <sub>o</sub> )	$M_{od}$ [kNm] =	0.1
Normal stress in the nail at the top	$\sigma_{no}$ [N/mm <sup>2</sup> ] = $N_{od} / A_{nre,0} + M_{od} / W_{pl,nre,0}$ =	92.6
Combined stress in the nail at the top	$\sigma_d$ [N/mm <sup>2</sup> ] = $(\sigma_{no}^2 + 3 \tau_c^2)^{0.5}$ =	103.7
Resistance correction value for combined stress	$\gamma_M$ [-] =	1.1
Maximum permissible yield stress	$\sigma_{Rd} = f_y / \gamma_M$ =	454.5
Proof of bearing safety	$\sigma_{Rd} \geq \sigma_d$ =	fulfilled

Proof of shear stress in the nails at the bottom		
Shear load in the nail at the bottom as a result of the force (Z <sub>ud</sub> / n <sub>u</sub> )	$V_{ud}$ [kN] =	30.2
Shear stress in the nail at the bottom	$\tau_c$ [N/mm <sup>2</sup> ] = $V_{ud} / A_{nre,0}$ =	87.2
Resistance correction value for shear stress	$\gamma_M$ [-] =	1.1
Maximum permissible shear stress	$\tau_{Rd} = f_t / (\sqrt{3} \cdot \gamma_M)$ =	262.4
Proof of bearing safety	$\tau_{Rd} \geq \tau_c$ =	fulfilled

Proof of combined stress in the nails at the bottom		
Tensile load in the nail at the bottom as a result of the force (Z <sub>ud</sub> / n <sub>u</sub> )	$N_{ud}$ [kN] =	17.4
Moment as a result of the eccentric acting force (Z <sub>ud</sub> / n <sub>u</sub> )	$M_{ud}$ [kNm] =	0.3
Normal stress in the nail at the bottom	$\sigma_{ud}$ [N/mm <sup>2</sup> ] = $N_{ud} / A_{nre,0} + M_{ud} / W_{pl,nre,0}$ =	245.7
Combined stress in the nail at the bottom	$\sigma_d$ [N/mm <sup>2</sup> ] = $(\sigma_{ud}^2 + 3 \tau_c^2)^{0.5}$ =	288.4
Resistance correction value for combined stress	$\gamma_M$ [-] =	1.1
Maximum permissible yield stress	$\sigma_{Rd} = f_y / \gamma_M$ =	454.5
Proof of bearing safety	$\sigma_{Rd} \geq \sigma_d$ =	fulfilled

### **ΠΑΡΑΡΤΗΜΑ Γ8**

Ογκόλιθος "Γ". Υπολογισμοί διαστασιολόγησης συστήματος επένδυσής με περιμετρικώς αγκυρούμενο γαλβανισμένο συρματοπλέγμα.

Περίπτωση 1

# SPIDER® ONLINE-TOOL

SPIDER - The Dimensioning Online Tool for the rock protection system SPIDER® for individual rock boulders

Project No.

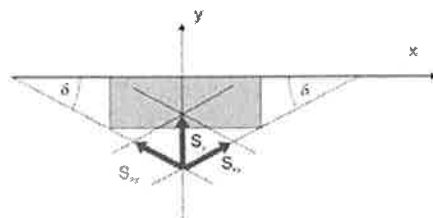
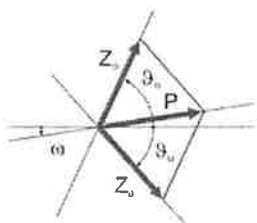
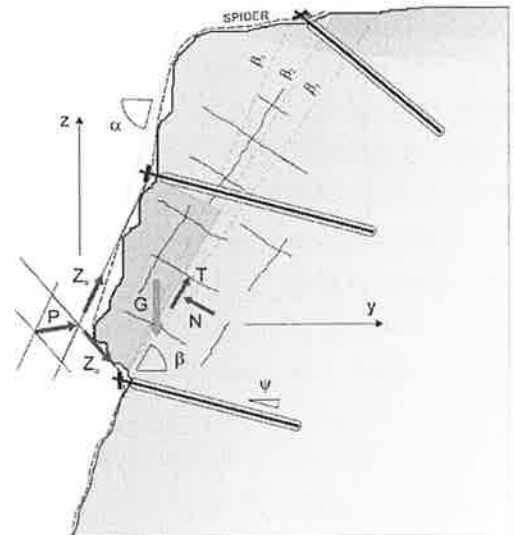
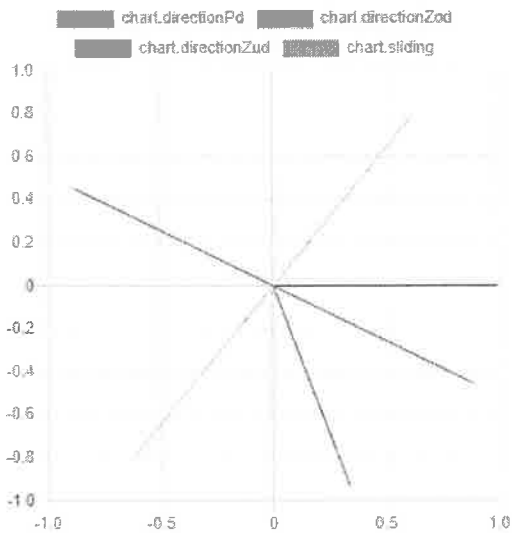
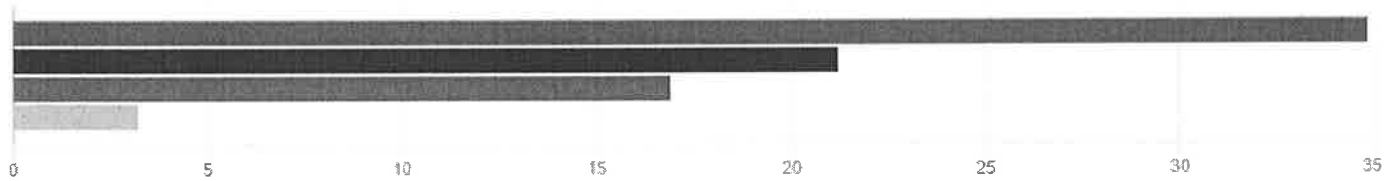
Project name

Date/Author

Weight/Geometry		
Block weight (characteristic value)	$G =$	100 kN
Inclination of the sliding plane to horizontal	$\beta =$	52 degrees
Angle of the top restraint to horizontal	$\vartheta_u =$	0 degrees
Angle of the bottom restraint to horizontal	$\vartheta_o =$	70 degrees
Ratio $Z_u : Z_o$	$\eta =$	80 %

Lateral Influence		
Angle of the lateral restraint to horizontal related to vertical plane	$\delta =$	40 degrees
Angle of the resultant, lateral restraint in line of slope	$\chi =$	0 degrees
Ratio $S : Z_o$	$\zeta =$	15 %

█ Pd █ Zod █ Zud █ Sd



Geotechnical parameters			
Friction angle (characteristic value)	$\varphi_k =$	37	degrees
Cohesion (characteristic value)	$c_k =$	0	kN/m <sup>2</sup>
Cohesion related area	$A =$	0	m <sup>2</sup>
Safety factors for geotechnical parameters and model			
Partial safety factor for friction angle	$\gamma_\varphi =$	1	-
Partial safety factor for cohesion	$\gamma_c =$	1	-
Partial safety factor for volume weight	$\gamma_\gamma =$	1	-
Model uncertainty correction value	$\gamma_{mod} =$	1	-
Number of nails or anchors			
Number of participating nails or anchors at the top	$\eta_o =$	2	-
Number of participating nails or anchors at the bottom	$\eta_u =$	1	-
Number of participating nails or anchors lateral	$\eta_b =$	1	-
Earthquake			
Coefficient of horizontal acceleration due to earthquake	$E_h =$	0.08	-
Coefficient of vertical acceleration due to earthquake	$E_v =$	0.04	-
Water pressure acting onto the block			
Water pressure from behind, perpendicular to the sliding plane	$W_h =$	10	kN
Water pressure from above, parallel to the sliding plane	$W_v =$	0	kN
Elements of system			
Spiral rope net	SPIDER® S3-130		
Spike plate	System spike plate P33		
Bearing resistance of the spiral rope net to tensile stress	$Z_n$ [kN/m] =	220	
Bearing resistance of the spiral rope net to local force transmission longitudinal	$Z_{n1}$ [kN] =	60	
Bearing resistance of the spiral rope net to local force transmission transversal	$Z_{n2}$ [kN] =	45	
Spiral rope anchor (standard)	Spiral rope anchor, D = 14.5 mm		
Boundary rope (standard)	Steel wire rope, D = 14 mm		
Elements to connect the net panels between each other	Shackles 3/8"		
Nail type	GEWI D = 25 mm		
Taking into account rusting away (nail diameter reduced by 4 mm)	yes		
Nail inclination to horizontal	$\psi$ [degrees] =	10	
Maximum eccentricity of the load to be transferred onto the nail at the top / bottom	$\xi$ [m] =	0,01	
Yield stress of the nail	$f_y$ [N/mm <sup>2</sup> ] =	500	
Cross-section with / without rusting away	$A_{red}$ [mm <sup>2</sup> ] =	346	
Plastic-section modulus	$W_{pl,red}$ [mm <sup>3</sup> ] =	1544	
Bearing resistance of the nail to tensile stress	$T_{B,red}$ [kN] =	173	
Bearing resistance of the nail to shear stress	$S_{B,red}$ [kN] =	100	

Calculated values		
Resultant stabilizing force P, on dimensioning level	$P_o$ [kN] =	54,8
Force in the net cover, to be transmitted to the top, on dimensioning level	$Z_{od}$ [kN] =	33,3
Force in the net cover, to be transmitted to the bottom, on dimensioning level	$Z_{ob}$ [kN] =	26,6
Force in the net cover, to be transmitted laterally, on dimensioning level	$S_o$ [kN] =	5,0
Opening angle between the forces in the net cover to the top and to the bottom	$\vartheta = \vartheta_1 + \vartheta_2$ [degrees]=	70,0
Inclination of the resultant stabilizing force Pd to horizontal	$\omega$ [degrees]=	-27,1
Theoretical friction angle net - block (neglecting lateral influence)	$\varphi_o$ [degrees] =	7,9

Proof of local force transmission to the top		
Maximum tensile force in the net cover to be transmitted to the top, on dim. level	$Z_{ot}$ [kN] =	33,3
Bearing resistance of the spiral rope net to local force transmission longitudinal	$Z_{Rt}$ [kN] =	60,0
Resistance correction value for local force transmission	$\gamma_{Rt}$ [-] =	1,5
Dim. value of the bearing res. of the spiral rope net to local force transmission longit.	$Z_{Rt} \cdot \gamma_{Rt}$ [kN] =	40,0
Number of nails or anchors at the top	$n_o$ =	2,0
Total bearing resistance of the spiral rope net to force transmission to the top	$Z_{Rt,tot} = Z_{Rt} \cdot n_o$ [kN] =	80,0
Proof of bearing safety	$Z_{ot} \leq Z_{Rt,tot}$ =	fulfilled

Proof of local force transmission to the bottom		
Proof of local force transmission to the bottom	$Z_{ob}$ [kN] =	26,6
Bearing resistance of the spiral rope net to local force transmission longitudinal	$Z_{Rb}$ [kN] =	60,0
Resistance correction value for local force transmission	$\gamma_{Rb}$ [-] =	1,5
Dim. value of the bearing res. of the spiral rope net to local force transmission longit.	$Z_{Rb} \cdot \gamma_{Rb}$ [kN] =	40,0
Number of nails or anchors at the bottom	$n_o$ =	1,0
Total bearing resistance of the spiral rope net to force transmission to the bottom	$Z_{Rb,tot} = Z_{Rb} \cdot n_o$ [kN] =	40,0
Proof of bearing safety	$Z_{ob} \leq Z_{Rb,tot}$ =	fulfilled

Proof of local force transmission laterally		
Maximum tensile force in the net cover to be transmitted laterally on dimensioning level	$S_o$ [kN] =	5,0
Bearing resistance of the spiral rope net to local force transmission transversal	$Z_{Rl}$ [kN] =	45,0
Resistance correction value for local force transmission	$\gamma_{Rl}$ [-] =	1,5
Dim. value of the bearing res. of the spiral rope net to local force transmission transv.	$Z_{Rl} \cdot \gamma_{Rl}$ [kN] =	30,0
Number of nails or anchors lateral	$n_l$ [-] =	1,0
Total bearing resistance of the spiral rope net to force transmission lateral	$Z_{Rl,tot} = Z_{Rl} \cdot n_l$ [kN] =	30,0
Proof of bearing safety	$S_o \leq Z_{Rl,tot}$ =	fulfilled

Proof of shear stress in the nails at the top		
Shear load in the nail at the top as a result of the force (Zod / no)	$V_{ot}$ [kN] =	2,9
Shear stress in the nail at the top	$\tau_o$ [N/mm <sup>2</sup> ] = $V_{ot} / A_{nvd}$ =	8,4
Resistance correction value for shear stress	$\gamma_{Vt}$ [-] =	1,1
Maximum permissible shear stress	$\tau_{nd} = f_t / (\sqrt{3} \cdot \gamma_{Vt})$ =	262,4
Proof of bearing safety	$\tau_{nd} \geq \tau_o$	fulfilled

Proof of combined stress in the nails at the top		
Tensile load in the nail at the top as a result of the force (Z <sub>0d</sub> / n <sub>0</sub> )	$N_{0d}$ [kN] =	16.4
Moment as a result of the eccentric acting force (Z <sub>0d</sub> / n <sub>0</sub> )	$M_{0d}$ [kNm] =	0.0
Normal stress in the nail at the top	$\sigma_{0d}$ [N/mm <sup>2</sup> ] = $N_{0d} / A_{n0top} + M_{0d} / W_{pln0top}$ =	66.1
Combined stress in the nail at the top	$\sigma_{0d}$ [N/mm <sup>2</sup> ] = $(\sigma_{0d}^2 + 3 \tau_{0d}^2)^{0.5}$ =	67.6
Resistance correction value for combined stress	$\gamma_{M}$ [-] =	1.1
Maximum permissible yield stress	$\sigma_{0d} = f_y / \gamma_{M}$ =	454.5
Proof of bearing safety	$\sigma_{0d} \geq \sigma_y$ =	fulfilled!

Proof of shear stress in the nails at the bottom		
Shear load in the nail at the bottom as a result of the force (Z <sub>0d</sub> / n <sub>0</sub> )	$V_{0d}$ [kN] =	23.1
Shear stress in the nail at the bottom	$\tau_{0d}$ [N/mm <sup>2</sup> ] = $V_{0d} / A_{n0bot}$ =	66.6
Resistance correction value for shear stress	$\gamma_{M}$ [-] =	1.1
Maximum permissible shear stress	$\tau_{0d} = f_v / (\sqrt{3} \cdot \gamma_{M})$ =	262.4
Proof of bearing safety	$\tau_{0d} \geq \tau_d$ =	fulfilled!

Proof of combined stress in the nails at the bottom		
Tensile load in the nail at the bottom as a result of the force (Z <sub>0d</sub> / n <sub>0</sub> )	$N_{0d}$ [kN] =	13.3
Moment as a result of the eccentric acting force (Z <sub>0d</sub> / n <sub>0</sub> )	$M_{0d}$ [kNm] =	0.2
Normal stress in the nail at the bottom	$\sigma_{0d}$ [N/mm <sup>2</sup> ] = $N_{0d} / A_{n0bot} + M_{0d} / W_{pln0bot}$ =	187.8
Combined stress in the nail at the bottom	$\sigma_{0d}$ [N/mm <sup>2</sup> ] = $(\sigma_{0d}^2 + 3 \tau_{0d}^2)^{0.5}$ =	220.4
Resistance correction value for combined stress	$\gamma_{M}$ [-] =	1.1
Maximum permissible yield stress	$\sigma_{0d} = f_y / \gamma_{M}$ =	454.5
Proof of bearing safety	$\sigma_{0d} \geq \sigma_y$ =	fulfilled!



Περίπτωση 2

# SPIDER® ONLINE-TOOL

SPIDER - The Dimensioning Online Tool for the rock protection system SPIDER® for individual rock boulders

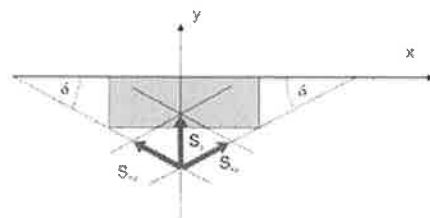
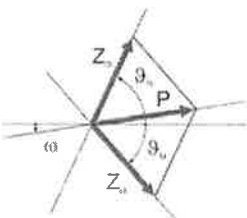
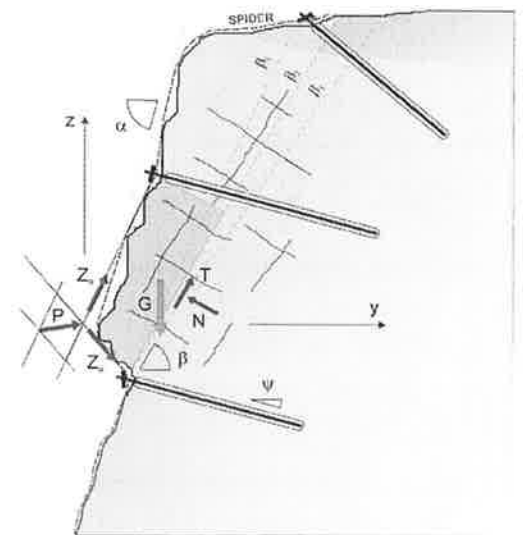
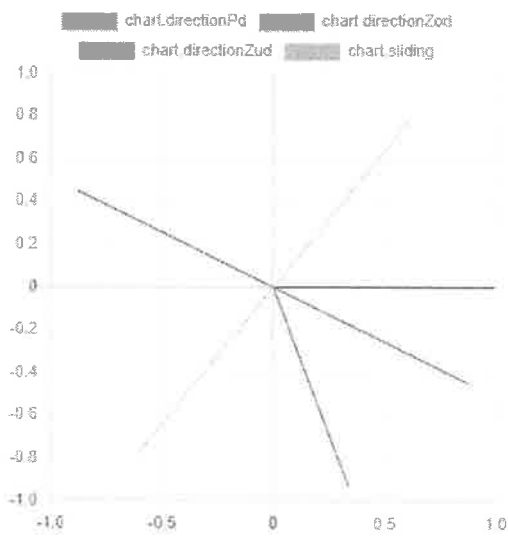
Project No.

Project name

Date/Author

Weight Geometry		
Block weight (characteristic value)	$G =$	100 kN
Inclination of the sliding plane to horizontal	$\beta =$	52 degrees
Angle of the top restraint to horizontal	$\theta_u =$	0 degrees
Angle of the bottom restraint to horizontal	$\theta_n =$	70 degrees
Ratio $Z_u : Z_o$	$\eta =$	80 %

Lateral Influence		
Angle of the lateral restraint to horizontal related to vertical plane	$\delta =$	40 degrees
Angle of the resultant, lateral restraint in line of slope	$\chi =$	0 degrees
Ratio $S : Z_o$	$\zeta =$	15 %



Geotechnical parameters		
Friction angle (characteristic value)	$\varphi_k =$	37 degrees
Cohesion (characteristic value)	$c_k =$	0 kN/m <sup>2</sup>
Cohesion related area	$A =$	0 m <sup>2</sup>

Safety factors for geotechnical parameters and model		
Partial safety factor for friction angle	$\gamma_\varphi =$	1 -
Partial safety factor for cohesion	$\gamma_c =$	1 -
Partial safety factor for volume weight	$\gamma_s =$	1 -
Model uncertainty correction value	$\gamma_{mod} =$	1,2 -

Number of nails or anchors		
Number of participating nails or anchors at the top	$n_t =$	2 -
Number of participating nails or anchors at the bottom	$n_b =$	1 -
Number of participating nails or anchors lateral	$n_l =$	1 -

Earthquake		
Coefficient of horizontal acceleration due to earthquake	$\alpha_h =$	0 -
Coefficient of vertical acceleration due to earthquake	$\alpha_v =$	0 -

Water pressure acting onto the block		
Water pressure from behind, perpendicular to the sliding plane	$W_h =$	27 kN
Water pressure from above, parallel to the sliding plane	$W_v =$	0 kN

Elements of system		
Spiral rope net	SPIDER® S3-130	
Spike plate	System spike plate P33	
Bearing resistance of the spiral rope net to tensile stress	$Z_t$ [kN/m] =	220
Bearing resistance of the spiral rope net to local force transmission longitudinal	$Z_{  }$ [kN] =	60
Bearing resistance of the spiral rope net to local force transmission transversal	$Z_{\perp}$ [kN] =	45
Spiral rope anchor (standard)	Spiral rope anchor, D = 14.5 mm	
Boundary rope (standard)	Steel wire rope, D = 14 mm	
Elements to connect the net panels between each other	Shackles 3/8"	
Nail type	GEWI D = 25 mm	
Taking into account rusting away (nail diameter reduced by 4 mm)	yes	
Nail inclination to horizontal	$\psi$ [degrees] =	10
Maximum excentricity of the load to be transferred onto the nail at the top / bottom	$\xi$ [m] =	0.01
Yield stress of the nail	$f_t$ [N/mm <sup>2</sup> ] =	500
Cross-section with / without rusting away	$A_{n,nail}$ [mm <sup>2</sup> ] =	346
Plastic section modulus	$W_{pl,nail}$ [mm <sup>3</sup> ] =	1544
Bearing resistance of the nail to tensile stress	$T_{R,nail}$ [kN] =	173
Bearing resistance of the nail to shear stress	$S_{R,nail}$ [kN] =	100

Calculated values		
Resultant stabilizing force P, on dimensioning level	$P_o$ [kN] =	70.9
Force in the net cover, to be transmitted to the top, on dimensioning level	$Z_{od}$ [kN] =	43.0
Force in the net cover, to be transmitted to the bottom, on dimensioning level	$Z_{ob}$ [kN] =	34.4
Force in the net cover, to be transmitted laterally, on dimensioning level	$S_o$ [kN] =	6.5
Opening angle between the forces in the net cover to the top and to the bottom	$\theta = \theta_t + \theta_b$ [degrees]=	70.0
Inclination of the resultant stabilizing force Pd to horizontal	$\omega$ [degrees]=	-27.1
Theoretical friction angle net - block (neglecting lateral influence)	$\varphi_o$ [degrees] =	7.9

Proof of local force transmission to the top		
Maximum tensile force in the net cover to be transmitted to the top, on dim. level	$Z_{od}$ [kN] =	43.0
Bearing resistance of the spiral rope net to local force transmission longitudinal	$Z_{R1}$ [kN] =	60.0
Resistance correction value for local force transmission	$\gamma_{ZF}$ [-] =	1.5
Dim. value of the bearing res. of the spiral rope net to local force transmission longit.	$Z_{R1d} = Z_{R1} / \gamma_{ZF}$ [kN] =	40.0
Number of nails or anchors at the top	$n_o$ =	2.0
Total bearing resistance of the spiral rope net to force transmission to the top	$Z_{R1d,tot} = Z_{R1d} \cdot n_o$ [kN] =	80.0
Proof of bearing safety	$Z_{od} \leq Z_{R1d,tot}$ =	fulfilled!

Proof of local force transmission to the bottom		
Proof of local force transmission to the bottom	$Z_{ob}$ [kN] =	34.4
Bearing resistance of the spiral rope net to local force transmission longitudinal	$Z_{R1}$ [kN] =	60.0
Resistance correction value for local force transmission	$\gamma_{ZF}$ [-] =	1.5
Dim. value of the bearing res. of the spiral rope net to local force transmission longit.	$Z_{R1d} = Z_{R1} / \gamma_{ZF}$ [kN] =	40.0
Number of nails or anchors at the bottom	$n_b$ =	1.0
Total bearing resistance of the spiral rope net to force transmission to the bottom	$Z_{R1d,tot} = Z_{R1d} \cdot n_b$ [kN] =	40.0
Proof of bearing safety	$Z_{ob} \leq Z_{R1d,tot}$ =	fulfilled!

Proof of local force transmission laterally		
Maximum tensile force in the net cover to be transmitted laterally on dimensioning level	$S_o$ [kN] =	6.5
Bearing resistance of the spiral rope net to local force transmission transversal	$Z_{R2}$ [kN] =	45.0
Resistance correction value for local force transmission	$\gamma_{ZF}$ [-] =	1.5
Dim. value of the bearing res. of the spiral rope net to local force transmission transv.	$Z_{R2d} = Z_{R2} / \gamma_{ZF}$ [kN] =	30.0
Number of nails or anchors lateral	$n_s$ [-] =	1.0
Total bearing resistance of the spiral rope net to force transmission lateral	$Z_{R2d,tot} = Z_{R2d} \cdot n_s$ [kN] =	30.0
Proof of bearing safety	$S_o \leq Z_{R2d,tot}$ =	fulfilled!

Proof of shear stress in the nails at the top		
Shear load in the nail at the top as a result of the force (Zod / no)	$V_{od}$ [kN] =	3.7
Shear stress in the nail at the top	$\tau_d$ [N/mm <sup>2</sup> ] = $V_{od} / A_{n(s)}$ =	10.8
Resistance correction value for shear stress	$\gamma_{s}$ [-] =	1.1
Maximum permissible shear stress	$\tau_{sd} = f_y / (\sqrt{3} \cdot \gamma_{s})$ =	262.4
Proof of bearing safety	$\tau_{sd} \geq \tau_d$	fulfilled!

Proof of combined stress in the nails at the top		
Tensile load in the nail at the top as a result of the force (Z <sub>od</sub> / n <sub>o</sub> )	$N_{od}$ [kN] =	21.2
Moment as a result of the eccentric acting force (Z <sub>od</sub> / n <sub>o</sub> )	$M_{od}$ [kNm] =	0.0
Normal stress in the nail at the top	$\sigma_{Nd}$ [N/mm <sup>2</sup> ] = $N_{od} / A_{nred} + M_{od} / W_{skred}$ =	85.4
Combined stress in the nail at the top	$\sigma_d$ [N/mm <sup>2</sup> ] = $(\sigma_{Nd}^2 + 3 \tau_c^2)^{0.5}$ =	87.5
Resistance correction value for combined stress	$\gamma_M$ [-] =	1.1
Maximum permissible yield stress	$\sigma_{Nd} = f_y / \gamma_M$ =	454.5
Proof of bearing safety	$\sigma_{Nd} \geq \sigma_d$ =	fulfilled

Proof of shear stress in the nails at the bottom		
Shear load in the nail at the bottom as a result of the force (Z <sub>ud</sub> / n <sub>u</sub> )	$V_{ud}$ [kN] =	29.8
Shear stress in the nail at the bottom	$\tau_c$ [N/mm <sup>2</sup> ] = $V_{ud} / A_{nred}$ =	36.2
Resistance correction value for shear stress	$\gamma_M$ [-] =	1.1
Maximum permissible shear stress	$\tau_{sd} = f_t / (\sqrt{3} \cdot \gamma_M)$ =	262.4
Proof of bearing safety	$\tau_{sd} \geq \tau_c$ =	fulfilled

Proof of combined stress in the nails at the bottom		
Tensile load in the nail at the bottom as a result of the force (Z <sub>ud</sub> / n <sub>u</sub> )	$N_{ud}$ [kN] =	17.2
Moment as a result of the eccentric acting force (Z <sub>ud</sub> / n <sub>u</sub> )	$M_{ud}$ [kNm] =	0.3
Normal stress in the nail at the bottom	$\sigma_{Nd}$ [N/mm <sup>2</sup> ] = $N_{ud} / A_{nred} + M_{ud} / W_{skred}$ =	242.9
Combined stress in the nail at the bottom	$\sigma_d$ [N/mm <sup>2</sup> ] = $(\sigma_{Nd}^2 + 3 \tau_c^2)^{0.5}$ =	285.0
Resistance correction value for combined stress	$\gamma_M$ [-] =	1.1
Maximum permissible yield stress	$\sigma_{Nd} = f_y / \gamma_M$ =	454.5
Proof of bearing safety	$\sigma_{Nd} \geq \sigma_d$ =	fulfilled

Περίπτωση 3

# SPIDER® ONLINE-TOOL

SPIDER - The Dimensioning Online Tool for the rock protection system SPIDER® for individual rock boulders

Project No.

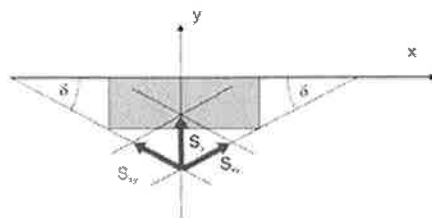
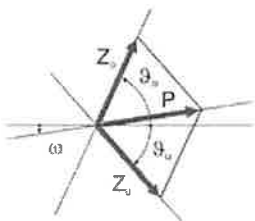
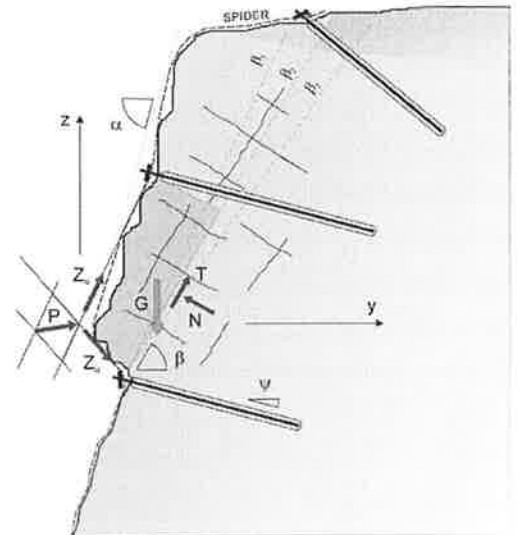
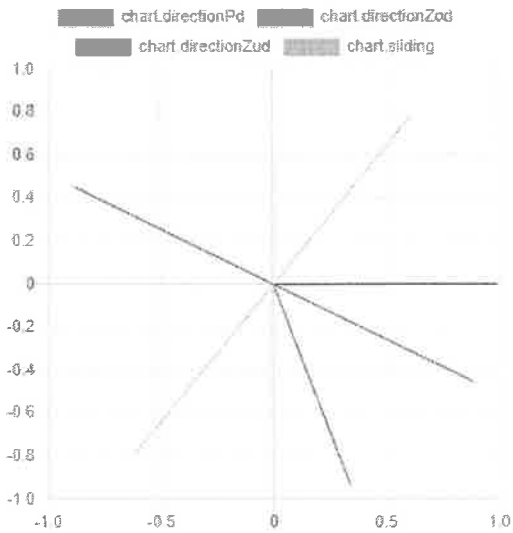
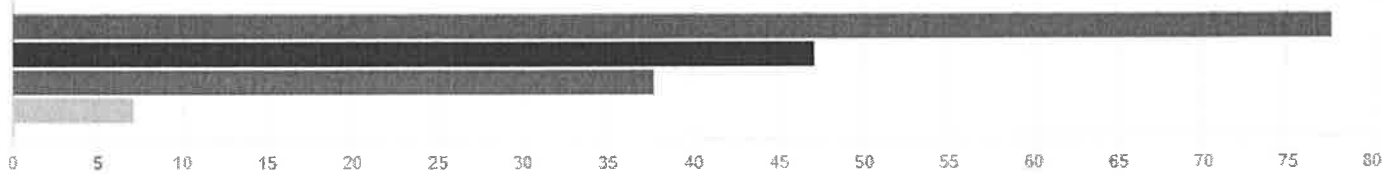
Project name

Date/Author

Weight/Geometry		
Block weight (characteristic value)	$G =$	100 kN
Inclination of the sliding plane to horizontal	$\beta =$	52 degrees
Angle of the top restraint to horizontal	$\vartheta_u =$	0 degrees
Angle of the bottom restraint to horizontal	$\vartheta_u =$	70 degrees
Ratio $Z_u : Z_o$	$\eta =$	80 %

Lateral influence		
Angle of the lateral restraint to horizontal related to vertical plane	$\delta =$	40 degrees
Angle of the resultant, lateral restraint in line of slope	$\chi =$	0 degrees
Ratio $S : Z_o$	$\zeta =$	15 %

█ Pd █ Zod █ Zud █ Sd



Geotechnical parameters			
Friction angle (characteristic value)	$\varphi_c =$	37	degrees
Cohesion (characteristic value)	$c_c =$	0	kN/m <sup>2</sup>
Cohesion related area	$A =$	0	m <sup>2</sup>
Safety factors for geotechnical parameters and model			
Partial safety factor for friction angle	$\gamma_\varphi =$	1	-
Partial safety factor for cohesion	$\gamma_c =$	1	-
Partial safety factor for volume weight	$\gamma_\gamma =$	1	-
Model uncertainty correction value	$\gamma_{mod} =$	1.3	-
Number of nails or anchors			
Number of participating nails or anchors at the top	$\eta_t =$	2	-
Number of participating nails or anchors at the bottom	$\eta_b =$	1	-
Number of participating nails or anchors lateral	$\eta_l =$	1	-
Earthquake			
Coefficient of horizontal acceleration due to earthquake	$E_h =$	0	-
Coefficient of vertical acceleration due to earthquake	$E_v =$	0	-
Water pressure acting onto the block			
Water pressure from behind, perpendicular to the sliding plane	$W_h =$	10	kN
Water pressure from above, parallel to the sliding plane	$W_a =$	0	kN
Elements of system			
Spiral rope net	SPIDER® S3-130		
Spike plate	System spike plate P33		
Bearing resistance of the spiral rope net to tensile stress	$Z_n$ [kN/m] =	220	
Bearing resistance of the spiral rope net to local force transmission longitudinal	$Z_{A1}$ [kN] =	60	
Bearing resistance of the spiral rope net to local force transmission transversal	$Z_{A2}$ [kN] =	45	
Spiral rope anchor (standard)	Spiral rope anchor, D = 14.5 mm		
Boundary rope (standard)	Steel wire rope, D = 14 mm		
Elements to connect the net panels between each other	Shackles 3/8"		
Nail type	GEWI D = 25 mm		
Taking into account rusting away (nail diameter reduced by 4 mm)	yes		
Nail inclination to horizontal	$\psi$ [degrees] =	10	
Maximum eccentricity of the load to be transferred onto the nail at the top / bottom	$\xi$ [m] =	0.01	
Yield stress of the nail	$f_y$ [N/mm <sup>2</sup> ] =	500	
Cross-section with / without rusting away	$A_{red}$ [mm <sup>2</sup> ] =	346	
Plastic section modulus	$W_{pl,red}$ [mm <sup>3</sup> ] =	1544	
Bearing resistance of the nail to tensile stress	$T_{Res}$ [kN] =	173	
Bearing resistance of the nail to shear stress	$S_{Res}$ [kN] =	100	



Calculated values		
Resultant stabilizing force P <sub>d</sub> on dimensioning level	P <sub>d</sub> [kN] =	64.6
Force in the net cover, to be transmitted to the top, on dimensioning level	Z <sub>sd</sub> [kN] =	39.2
Force in the net cover, to be transmitted to the bottom, on dimensioning level	Z <sub>sb</sub> [kN] =	31.3
Force in the net cover, to be transmitted laterally, on dimensioning level	S <sub>d</sub> [kN] =	5.9
Opening angle between the forces in the net cover to the top and to the bottom	θ = θ <sub>1</sub> + θ <sub>2</sub> [degrees]=	70.0
Inclination of the resultant stabilizing force P <sub>d</sub> to horizontal	ω [degrees]=	-27.1
Theoretical friction angle net - block (neglecting lateral influence)	φ <sub>0</sub> [degrees] =	7.9

Proof of local force transmission to the top		
Maximum tensile force in the net cover to be transmitted to the top, on dim. level	Z <sub>sd</sub> [kN] =	39.2
Bearing resistance of the spiral rope net to local force transmission longitudinal	Z <sub>rs</sub> [kN] =	60.0
Resistance correction value for local force transmission	γ <sub>2R</sub> [-] =	1.5
Dim. value of the bearing res. of the spiral rope net to local force transmission longit.	Z <sub>rs1d</sub> = Z <sub>rs</sub> / γ <sub>2R</sub> [kN] =	40.0
Number of nails or anchors at the top	n <sub>0</sub> =	2.0
Total bearing resistance of the spiral rope net to force transmission to the top	Z <sub>rs1d,tot</sub> = Z <sub>rs1d</sub> · n <sub>0</sub> [kN] =	80.0
Proof of bearing safety	Z <sub>sd</sub> <= Z <sub>rs1d,tot</sub> =	fulfilled!

Proof of local force transmission to the bottom		
Proof of local force transmission to the bottom	Z <sub>sb</sub> [kN] =	31.3
Bearing resistance of the spiral rope net to local force transmission longitudinal	Z <sub>rs</sub> [kN] =	60.0
Resistance correction value for local force transmission	γ <sub>2R</sub> [-] =	1.5
Dim. value of the bearing res. of the spiral rope net to local force transmission longit.	Z <sub>rs1b</sub> = Z <sub>rs</sub> / γ <sub>2R</sub> [kN] =	40.0
Number of nails or anchors at the bottom	n <sub>0</sub> =	1.0
Total bearing resistance of the spiral rope net to force transmission to the bottom	Z <sub>rs1b,tot</sub> = Z <sub>rs1b</sub> · n <sub>0</sub> [kN] =	40.0
Proof of bearing safety	Z <sub>sb</sub> <= Z <sub>rs1b,tot</sub> =	fulfilled!

Proof of local force transmission laterally		
Maximum tensile force in the net cover to be transmitted laterally on dimensioning level	S <sub>d</sub> [kN] =	5.9
Bearing resistance of the spiral rope net to local force transmission transversal	Z <sub>rs</sub> [kN] =	45.0
Resistance correction value for local force transmission	γ <sub>2R</sub> [-] =	1.5
Dim. value of the bearing res. of the spiral rope net to local force transmission transv.	Z <sub>rs2d</sub> = Z <sub>rs</sub> / γ <sub>2R</sub> [kN] =	30.0
Number of nails or anchors lateral	n <sub>s</sub> [-] =	1.0
Total bearing resistance of the spiral rope net to force transmission lateral	Z <sub>rs2d,tot</sub> = Z <sub>rs2d</sub> · n <sub>s</sub> [kN] =	30.0
Proof of bearing safety	S <sub>d</sub> <= Z <sub>rs2d,tot</sub> =	fulfilled!

Proof of shear stresses in the nails at the top		
Shear load in the nail at the top as a result of the force (Z <sub>sd</sub> / n <sub>0</sub> )	V <sub>sd</sub> [kN] =	3.4
Shear stress in the nail at the top	τ <sub>sd</sub> [N/mm <sup>2</sup> ] = V <sub>sd</sub> / A <sub>V,nail</sub> =	9.8
Resistance correction value for shear stress	γ <sub>vd</sub> [-] =	1.1
Maximum permissible shear stress	τ <sub>sd0</sub> = f <sub>y</sub> / (√3 · γ <sub>vd</sub> ) =	262.4
Proof of bearing safety	τ <sub>sd</sub> <= τ <sub>sd0</sub>	fulfilled!

Proof of combined stress in the nails at the top		
Tensile load in the nail at the top as a result of the force (Zod / no)	$N_{od}$ [kN] =	19,3
Moment as a result of the eccentric acting force (Zod / no)	$M_{od}$ [kNm] =	0,0
Normal stress in the nail at the top	$\sigma_{od}$ [N/mm <sup>2</sup> ] = $N_{od} / A_{nec} + M_{od} / W_{p,red}$ =	77,8
Combined stress in the nail at the top	$\sigma_d$ [N/mm <sup>2</sup> ] = $(\sigma_{od}^2 + 3 \tau_d^2)^{0,5}$ =	79,6
Resistance correction value for combined stress	$\gamma_{vs}$ [-] =	1,1
Maximum permissible yield stress	$\sigma_{sd} = f_y / \gamma_{vs}$ =	454,5
Proof of bearing safety	$\sigma_{sd} \geq \sigma_d$ =	fulfilled

Proof of shear stress in the nails at the bottom		
Shear load in the nail at the bottom as a result of the force (Zud / nu)	$V_{ud}$ [kN] =	27,1
Shear stress in the nail at the bottom	$\tau_d$ [N/mm <sup>2</sup> ] = $V_{ud} / A_{v,red}$ =	78,4
Resistance correction value for shear stress	$\gamma_{vs}$ [-] =	1,1
Maximum permissible shear stress	$\tau_{sd} = f_t / (\sqrt{3} \cdot \gamma_{vs})$ =	262,4
Proof of bearing safety	$\tau_{sd} \geq \tau_d$ =	fulfilled

Proof of combined stress in the nails at the bottom		
Tensile load in the nail at the bottom as a result of the force (Zud / nu)	$N_{ud}$ [kN] =	15,7
Moment as a result of the eccentric acting force (Zud / nu)	$M_{ud}$ [kNm] =	0,3
Normal stress in the nail at the bottom	$\sigma_{ud}$ [N/mm <sup>2</sup> ] = $N_{ud} / A_{nec} + M_{ud} / W_{p,red}$ =	221,1
Combined stress in the nail at the bottom	$\sigma_d$ [N/mm <sup>2</sup> ] = $(\sigma_{ud}^2 + 3 \tau_d^2)^{0,5}$ =	259,5
Resistance correction value for combined stress	$\gamma_{vs}$ [-] =	1,1
Maximum permissible yield stress	$\sigma_{sd} = f_y / \gamma_{vs}$ =	454,5
Proof of bearing safety	$\sigma_{sd} \geq \sigma_d$ =	fulfilled

### **ΠΑΡΑΡΤΗΜΑ Γ9**

Ογκόλιθος "X23". Υπολογισμοί διαστασιολόγησης συστήματος επένδυσής με περιμετρικώς αγκυρούμενο γαλβανισμένο συρματόπλεγμα.

Περίπτωση 1

# SPIDER® ONLINE-TOOL

SPIDER - The Dimensioning Online Tool for the rock protection system SPIDER® for individual rock boulders

Project No.

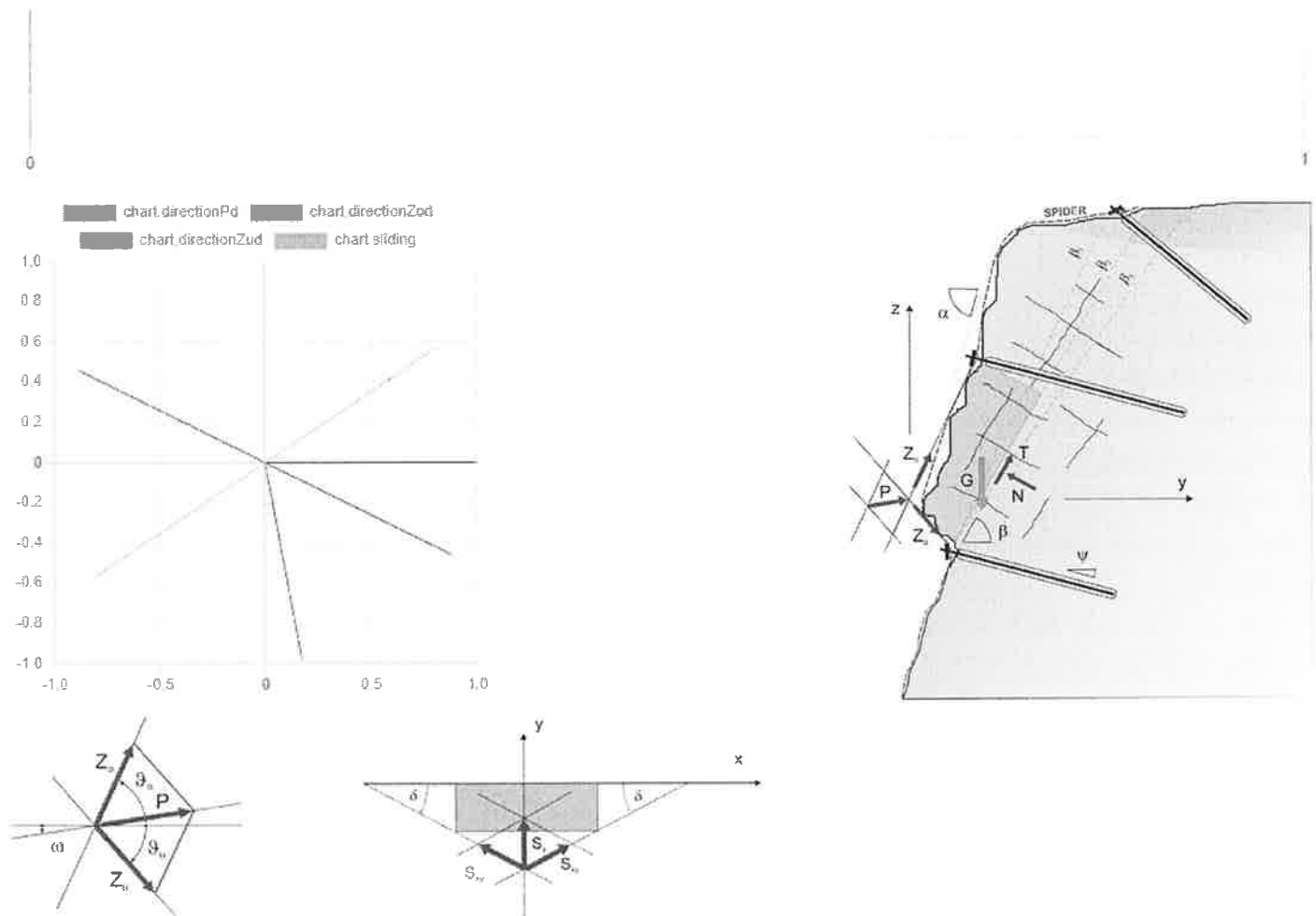
Project name

Date/Author

Weight Geometry		
Block weight (characteristic value)	$G =$	155 kN
Inclination of the sliding plane to horizontal	$\beta =$	35 degrees
Angle of the top restraint to horizontal	$\theta_a =$	0 degrees
Angle of the bottom restraint to horizontal	$\theta_b =$	80 degrees
Ratio $Z_u : Z_o$	$\eta =$	80 %

Lateral influence		
Angle of the lateral restraint to horizontal related to vertical plane	$\delta =$	70 degrees
Angle of the resultant, lateral restraint in line of slope	$\chi =$	0 degrees
Ratio $S : Z_o$	$\zeta =$	20 %

■ Pd ■ Z<sub>od</sub> ■ Z<sub>ud</sub> ■ S<sub>d</sub>



Geotechnical parameters			
Friction angle (characteristic value)	$\varphi_k =$	37	degrees
Cohesion (characteristic value)	$c_k =$	0	kN/m <sup>2</sup>
Cohesion related area	$A =$	0	m <sup>2</sup>
Safety factors for geotechnical parameters and model			
Partial safety factor for friction angle	$\gamma_\varphi =$	1	-
Partial safety factor for cohesion	$\gamma_c =$	1	-
Partial safety factor for volume weight	$\gamma_\gamma =$	1	-
Model uncertainty correction value	$\gamma_{mod} =$	1	-
Number of nails or anchors			
Number of participating nails or anchors at the top	$n_o =$	1	-
Number of participating nails or anchors at the bottom	$n_u =$	1	-
Number of participating nails or anchors lateral	$n_s =$	2	-
Earthquake			
Coefficient of horizontal acceleration due to earthquake	$\varepsilon_h =$	0.08	-
Coefficient of vertical acceleration due to earthquake	$\varepsilon_v =$	0.04	-
Water pressure acting onto the block			
Water pressure from behind, perpendicular to the sliding plane	$W_b =$	1	kN
Water pressure from above, parallel to the sliding plane	$W_a =$	0	kN
Elements of system			
Spiral rope net	SPIDER® S3-130		
Spike plate	System spike plate P33		
Bearing resistance of the spiral rope net to tensile stress	$Z_n$ [kN/m] =	220	
Bearing resistance of the spiral rope net to local force transmission longitudinal	$Z_{n1}$ [kN] =	60	
Bearing resistance of the spiral rope net to local force transmission transversal	$Z_{n2}$ [kN] =	45	
Spiral rope anchor (standard)	Spiral rope anchor, D = 14.5 mm		
Boundary rope (standard)	Steel wire rope, D = 14 mm		
Elements to connect the net panels between each other	Shackles 3/8"		
Nail type	GEWI D = 25 mm		
Taking into account rusting away (nail diameter reduced by 4 mm)	yes		
Nail inclination to horizontal	$\psi$ [degrees] =	10	
Maximum eccentricity of the load to be transferred onto the nail at the top / bottom	$\xi$ [m] =	0.01	
Yield stress of the nail	$f_y$ [N/mm <sup>2</sup> ] =	500	
Cross-section with / without rusting away	$A_{red}$ [mm <sup>2</sup> ] =	346	
Plastic section modulus	$W_{pl,red}$ [mm <sup>3</sup> ] =	1544	
Bearing resistance of the nail to tensile stress	$T_{Red}$ [kN] =	173	
Bearing resistance of the nail to shear stress	$S_{Red}$ [kN] =	100	

Calculated values		
Resultant stabilizing force P, on dimensioning level	$P_d$ [kN] =	8,2
Force in the net cover, to be transmitted to the top, on dimensioning level	$Z_{d1}$ [kN] =	4,8
Force in the net cover, to be transmitted to the bottom, on dimensioning level	$Z_{d2}$ [kN] =	3,8
Force in the net cover, to be transmitted laterally, on dimensioning level	$S_d$ [kN] =	1,0
Opening angle between the forces in the net cover to the top and to the bottom	$\hat{\theta} = \theta_1 + \theta_2$ [degrees]=	80,0
Inclination of the resultant stabilizing force Pd to horizontal	$\omega$ [degrees]=	-27,5
Theoretical friction angle net - block (neglecting lateral influence)	$\varphi_n$ [degrees] =	12,5

Proof of local force transmission to the top		
Maximum tensile force in the net cover to be transmitted to the top, on dim. level	$Z_{d1}$ [kN] =	4,8
Bearing resistance of the spiral rope net to local force transmission longitudinal	$Z_{n1}$ [kN] =	60,0
Resistance correction value for local force transmission	$\gamma_{2P}$ [-] =	1,5
Dim. value of the bearing res. of the spiral rope net to local force transmission longit.	$Z_{n1d} = Z_{n1} / \gamma_{2P}$ [kN] =	40,0
Number of nails or anchors at the top	$n_1$ =	1,0
Total bearing resistance of the spiral rope net to force transmission to the top	$Z_{n1tot} = Z_{n1d} \cdot n_1$ [kN] =	40,0
Proof of bearing safety	$Z_{d1} \leq Z_{n1tot}$ =	fulfilled!

Proof of local force transmission to the bottom		
Proof of local force transmission to the bottom	$Z_{d2}$ [kN] =	3,8
Bearing resistance of the spiral rope net to local force transmission longitudinal	$Z_{n2}$ [kN] =	60,0
Resistance correction value for local force transmission	$\gamma_{2B}$ [-] =	1,5
Dim. value of the bearing res. of the spiral rope net to local force transmission longit.	$Z_{n2d} = Z_{n2} / \gamma_{2B}$ [kN] =	40,0
Number of nails or anchors at the bottom	$n_2$ =	1,0
Total bearing resistance of the spiral rope net to force transmission to the bottom	$Z_{n2tot} = Z_{n2d} \cdot n_2$ [kN] =	40,0
Proof of bearing safety	$Z_{d2} \leq Z_{n2tot}$ =	fulfilled!

Proof of local force transmission laterally		
Maximum tensile force in the net cover to be transmitted laterally on dimensioning level	$S_d$ [kN] =	1,0
Bearing resistance of the spiral rope net to local force transmission transversal	$Z_{n3}$ [kN] =	45,0
Resistance correction value for local force transmission	$\gamma_{2L}$ [-] =	1,5
Dim. value of the bearing res. of the spiral rope net to local force transmission transv.	$Z_{n3d} = Z_{n3} / \gamma_{2L}$ [kN] =	30,0
Number of nails or anchors lateral	$n_3$ [-] =	2,0
Total bearing resistance of the spiral rope net to force transmission lateral	$Z_{n3tot} = Z_{n3d} \cdot n_3$ [kN] =	60,0
Proof of bearing safety	$S_d \leq Z_{n3tot}$ =	fulfilled!

Proof of shear stress in the nails at the top		
Shear load in the nail at the top as a result of the force (Zod / no)	$V_{d1}$ [kN] =	0,8
Shear stress in the nail at the top	$\tau_{d1}$ [N/mm <sup>2</sup> ] = $V_{d1} / A_{n1}$ =	2,4
Resistance correction value for shear stress	$\gamma_{d1}$ [-] =	1,1
Maximum permissible shear stress	$\tau_{d1} = f_y / (\sqrt{3} \cdot \gamma_{d1})$ =	262,4
Proof of bearing safety	$\tau_{d1} \geq \tau_c$	fulfilled!

Proof of combined stress in the nails at the top		
Tensile load in the nail at the top as a result of the force (Z <sub>0d</sub> / n <sub>0</sub> )	$N_{0d}$ [kN] =	4.7
Moment as a result of the eccentric acting force (Z <sub>0d</sub> / n <sub>0</sub> )	$M_{0d}$ [kNm] =	0.0
Normal stress in the nail at the top	$\sigma_{0d}$ [N/mm <sup>2</sup> ] = $N_{0d} / A_{0d} + M_{0d} / W_{pl,y0d}$ =	19.0
Combined stress in the nail at the top	$\sigma_d$ [N/mm <sup>2</sup> ] = $(\sigma_{0d}^2 + 3 \tau_d^2)^{0.5}$ =	19.4
Resistance correction value for combined stress	$\gamma_M$ [-] =	1.1
Maximum permissible yield stress	$\sigma_{Rd} = f_y / \gamma_M$ =	454.5
Proof of bearing safety	$\sigma_{Rd} \geq \sigma_d$ =	fulfilled!

Proof of shear stress in the nails at the bottom		
Shear load in the nail at the bottom as a result of the force (Z <sub>0d</sub> / n <sub>0</sub> )	$V_{0d}$ [kN] =	3.6
Shear stress in the nail at the bottom	$\tau_d$ [N/mm <sup>2</sup> ] = $V_{0d} / A_{0d}$ =	10.4
Resistance correction value for shear stress	$\gamma_M$ [-] =	1.1
Maximum permissible shear stress	$\tau_{Rd} = f_t / (\sqrt{3} \cdot \gamma_M)$ =	262.4
Proof of bearing safety	$\tau_{Rd} \geq \tau_d$ =	fulfilled!

Proof of combined stress in the nails at the bottom		
Tensile load in the nail at the bottom as a result of the force (Z <sub>0d</sub> / n <sub>0</sub> )	$N_{0d}$ [kN] =	1.3
Moment as a result of the eccentric acting force (Z <sub>0d</sub> / n <sub>0</sub> )	$M_{0d}$ [kNm] =	0.0
Normal stress in the nail at the bottom	$\sigma_{0d}$ [N/mm <sup>2</sup> ] = $N_{0d} / A_{0d} + M_{0d} / W_{pl,y0d}$ =	27.1
Combined stress in the nail at the bottom	$\sigma_d$ [N/mm <sup>2</sup> ] = $(\sigma_{0d}^2 + 3 \tau_d^2)^{0.5}$ =	32.5
Resistance correction value for combined stress	$\gamma_M$ [-] =	1.1
Maximum permissible yield stress	$\sigma_{Rd} = f_y / \gamma_M$ =	454.5
Proof of bearing safety	$\sigma_{Rd} \geq \sigma_d$ =	fulfilled!



Περίπτωση 2

# SPIDER® ONLINE-TOOL

SPIDER - The Dimensioning Online Tool for the rock protection system SPIDER® for individual rock boulders

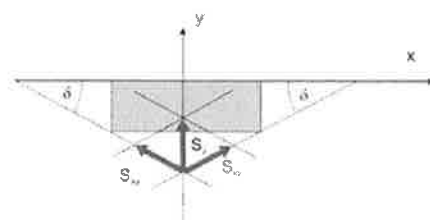
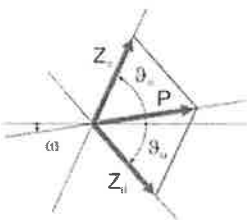
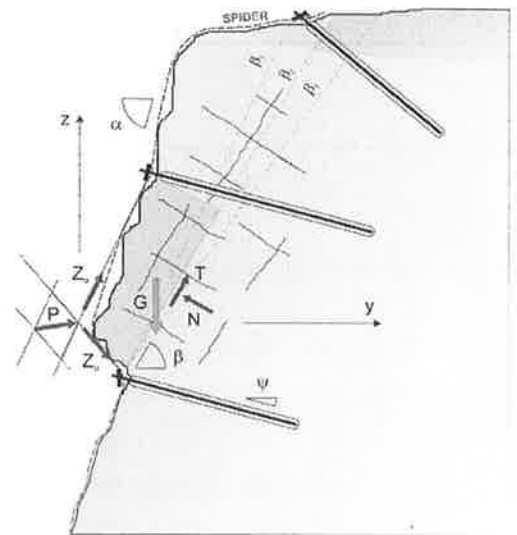
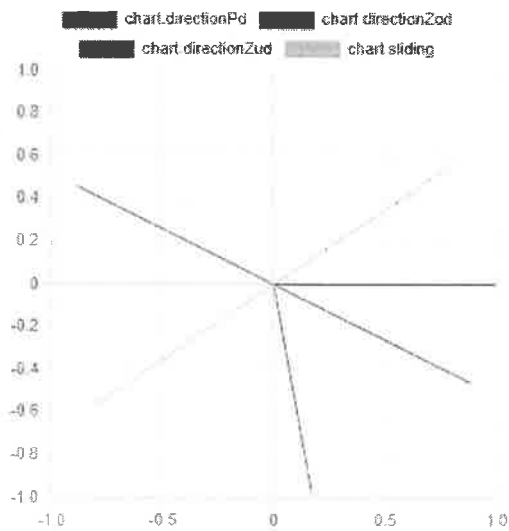
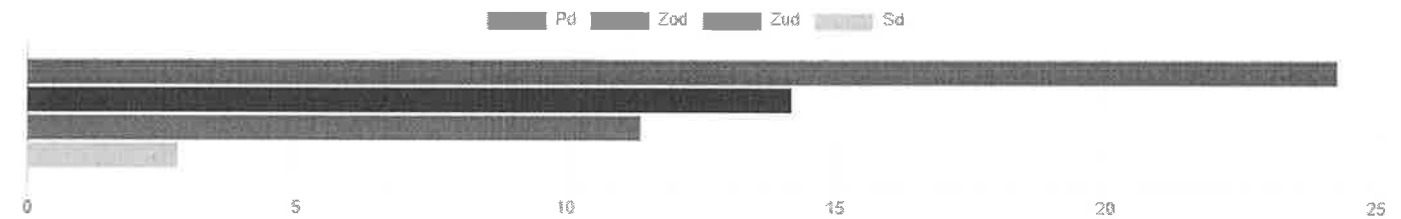
Project No.

Project name

Date/Author

Weight Geometry		
Block weight (characteristic value)	$G =$	155 kN
Inclination of the sliding plane to horizontal	$\beta =$	35 degrees
Angle of the top restraint to horizontal	$\vartheta_u =$	0 degrees
Angle of the bottom restraint to horizontal	$\vartheta_u =$	80 degrees
Ratio $Z_u : Z_o$	$\eta =$	80 %

Lateral influence		
Angle of the lateral restraint to horizontal related to vertical plane	$\delta =$	70 degrees
Angle of the resultant, lateral restraint in line of slope	$\chi =$	0 degrees
Ratio $S : Z_o$	$\zeta =$	20 %



Geotechnical parameters			
Friction angle (characteristic value)	$\varphi_c =$	37	degrees
Cohesion (characteristic value)	$c_c =$	0	kN/m <sup>2</sup>
Cohesion related area	$A =$	0	m <sup>2</sup>

Safety factors for geotechnical parameters and model			
Partial safety factor for friction angle	$\gamma_\varphi =$	1	-
Partial safety factor for cohesion	$\gamma_c =$	1	-
Partial safety factor for volume weight	$\gamma_\gamma =$	1	-
Model uncertainty correction value	$\gamma_{mod} =$	1.2	-

Number of nails or anchors			
Number of participating nails or anchors at the top	$\eta_o =$	1	-
Number of participating nails or anchors at the bottom	$\eta_u =$	1	-
Number of participating nails or anchors lateral	$\eta_s =$	2	-

Earthquake			
Coefficient of horizontal acceleration due to earthquake	$\epsilon_h =$	0	-
Coefficient of vertical acceleration due to earthquake	$\epsilon_v =$	0	-

Water pressure acting onto the block			
Water pressure from behind, perpendicular to the sliding plane	$W_h =$	5	kN
Water pressure from above, parallel to the sliding plane	$W_o =$	0	kN

Elements of system			
Spiral rope net	SPIDER® S3-130		
Spike plate	System spike plate P33		
Bearing resistance of the spiral rope net to tensile stress	$Z_n$ [kN/m] =	220	
Bearing resistance of the spiral rope net to local force transmission longitudinal	$Z_{R1}$ [kN] =	60	
Bearing resistance of the spiral rope net to local force transmission transversal	$Z_{R2}$ [kN] =	45	
Spiral rope anchor (standard)	Spiral rope anchor, D = 14,5 mm		
Boundary rope (standard)	Steel wire rope, D = 14 mm		
Elements to connect the net panels between each other	Shackles 3/8"		
Nail type	GEWI D = 25 mm		
Taking into account rusting away (nail diameter reduced by 4 mm)	yes		
Nail inclination to horizontal	$\psi$ [degrees] =	10	
Maximum excentricity of the load to be transferred onto the nail at the top / bottom	$\xi$ [m] =	0.01	
Yield stress of the nail	$f_y$ [N/mm <sup>2</sup> ] =	500	
Cross-section with / without rusting away	$A_{R1000}$ [mm <sup>2</sup> ] =	346	
Plastic section modulus	$W_{pl,R1000}$ [mm <sup>3</sup> ] =	1544	
Bearing resistance of the nail to tensile stress	$T_{R1000}$ [kN] =	173	
Bearing resistance of the nail to shear stress	$S_{R1000}$ [kN] =	100	

Calculated values		
Resultant stabilizing force P, on dimensioning level	$P_d$ [kN] =	12.1
Force in the net cover, to be transmitted to the top, on dimensioning level	$Z_{od}$ [kN] =	7.1
Force in the net cover, to be transmitted to the bottom, on dimensioning level	$Z_{od}$ [kN] =	5.7
Force in the net cover, to be transmitted laterally, on dimensioning level	$S_d$ [kN] =	1.4
Opening angle between the forces in the net cover to the top and to the bottom	$\vartheta = \vartheta_t + \vartheta_b$ [degrees]=	80.0
Inclination of the resultant stabilizing force Pd to horizontal	$\omega$ [degrees]=	-27.5
Theoretical friction angle net - block (neglecting lateral influence)	$\varphi_G$ [degrees] =	12.5

Proof of local force transmission to the top		
Maximum tensile force in the net cover to be transmitted to the top, on dim. level	$Z_{od}$ [kN] =	7.1
Bearing resistance of the spiral rope net to local force transmission longitudinal	$Z_{R1}$ [kN] =	60.0
Resistance correction value for local force transmission	$\gamma_{2B}$ [-] =	1.5
Dim. value of the bearing res. of the spiral rope net to local force transmission longit.	$Z_{R1B} = Z_{R1} / \gamma_{2B}$ [kN] =	40.0
Number of nails or anchors at the top	$n_s$ =	1.0
Total bearing resistance of the spiral rope net to force transmission to the top	$Z_{R1Btot} = Z_{R1B} \cdot n_s$ [kN] =	40.0
Proof of bearing safety	$Z_{od} \leq Z_{R1Btot}$ =	fulfilled!

Proof of local force transmission to the bottom		
Proof of local force transmission to the bottom	$Z_{ob}$ [kN] =	5.7
Bearing resistance of the spiral rope net to local force transmission longitudinal	$Z_{R1}$ [kN] =	60.0
Resistance correction value for local force transmission	$\gamma_{2B}$ [-] =	1.5
Dim. value of the bearing res. of the spiral rope net to local force transmission longit.	$Z_{R1B} = Z_{R1} / \gamma_{2B}$ [kN] =	40.0
Number of nails or anchors at the bottom	$n_b$ =	1.0
Total bearing resistance of the spiral rope net to force transmission to the bottom	$Z_{R1Btot} = Z_{R1B} \cdot n_b$ [kN] =	40.0
Proof of bearing safety	$Z_{ob} \leq Z_{R1Btot}$ =	fulfilled!

Proof of local force transmission laterally		
Maximum tensile force in the net cover to be transmitted laterally on dimensioning level	$S_d$ [kN] =	1.4
Bearing resistance of the spiral rope net to local force transmission transversal	$Z_{R2}$ [kN] =	45.0
Resistance correction value for local force transmission	$\gamma_{2B}$ [-] =	1.5
Dim. value of the bearing res. of the spiral rope net to local force transmission transv.	$Z_{R2B} = Z_{R2} / \gamma_{2B}$ [kN] =	30.0
Number of nails or anchors lateral	$n_s$ [-] =	2.0
Total bearing resistance of the spiral rope net to force transmission lateral	$Z_{R2Btot} = Z_{R2B} \cdot n_s$ [kN] =	60.0
Proof of bearing safety	$S_d \leq Z_{R2Btot}$ =	fulfilled!

Proof of shear stress in the nails at the top		
Shear load in the nail at the top as a result of the force (Zod / no)	$V_{od}$ [kN] =	1.2
Shear stress in the nail at the top	$\tau_d$ [N/mm <sup>2</sup> ] = $V_{od} / A_{nail}$ =	3.6
Resistance correction value for shear stress	$\gamma_{3d}$ [-] =	1.1
Maximum permissible shear stress	$\tau_{ad} = f_y / (\sqrt{3} \cdot \gamma_{3d})$ =	262.4
Proof of bearing safety	$\tau_{ad} \geq \tau_d$	fulfilled!

Proof of combined stress in the nails at the top		
Tensile load in the nail at the top as a result of the force (Z <sub>0d</sub> / n <sub>0</sub> )	$N_{0d}$ [kN] =	7.0
Moment as a result of the eccentric acting force (Z <sub>0d</sub> / n <sub>0</sub> )	$M_{0d}$ [kNm] =	0.0
Normal stress in the nail at the top	$\sigma_{0d}$ [N/mm <sup>2</sup> ] = $N_{0d} / A_{0d,n} + M_{0d} / W_{0d,n}$ =	29.1
Combined stress in the nail at the top	$\sigma_d$ [N/mm <sup>2</sup> ] = $(\sigma_{0d}^2 + 3 \tau_d^2)^{0.5}$ =	28.8
Resistance correction value for combined stress	$\gamma_M$ [-] =	1.1
Maximum permissible yield stress	$\sigma_{Rk} = f_y / \gamma_M$ =	454.5
Proof of bearing safety	$\sigma_{Rk} \geq \sigma_d$ =	fulfilled!

Proof of shear stress in the nails at the bottom		
Shear load in the nail at the bottom as a result of the force (Z <sub>1d</sub> / n <sub>1</sub> )	$V_{1d}$ [kN] =	5.3
Shear stress in the nail at the bottom	$\tau_d$ [N/mm <sup>2</sup> ] = $V_{1d} / A_{0d,n}$ =	15.4
Resistance correction value for shear stress	$\gamma_M$ [-] =	1.1
Maximum permissible shear stress	$\tau_{Rk} = f_t / (\sqrt{3} \cdot \gamma_M)$ =	262.4
Proof of bearing safety	$\tau_{Rk} \geq \tau_d$ =	fulfilled!

Proof of combined stress in the nails at the bottom		
Tensile load in the nail at the bottom as a result of the force (Z <sub>1d</sub> / n <sub>1</sub> )	$N_{1d}$ [kN] =	1.9
Moment as a result of the eccentric acting force (Z <sub>1d</sub> / n <sub>1</sub> )	$M_{1d}$ [kNm] =	0.1
Normal stress in the nail at the bottom	$\sigma_{1d}$ [N/mm <sup>2</sup> ] = $N_{1d} / A_{1d,n} + M_{1d} / W_{1d,n}$ =	40.1
Combined stress in the nail at the bottom	$\sigma_d$ [N/mm <sup>2</sup> ] = $(\sigma_{1d}^2 + 3 \tau_d^2)^{0.5}$ =	48.1
Resistance correction value for combined stress	$\gamma_M$ [-] =	1.1
Maximum permissible yield stress	$\sigma_{Rk} = f_y / \gamma_M$ =	454.5
Proof of bearing safety	$\sigma_{Rk} \geq \sigma_d$ =	fulfilled!

Περίπτωση 3

# SPIDER® ONLINE-TOOL

SPIDER - The Dimensioning Online Tool for the rock protection system SPIDER® for individual rock boulders

Project No.

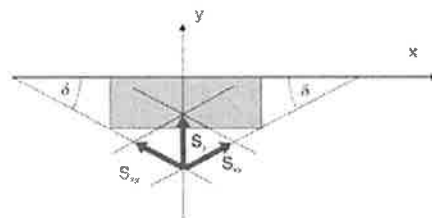
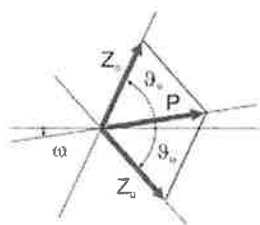
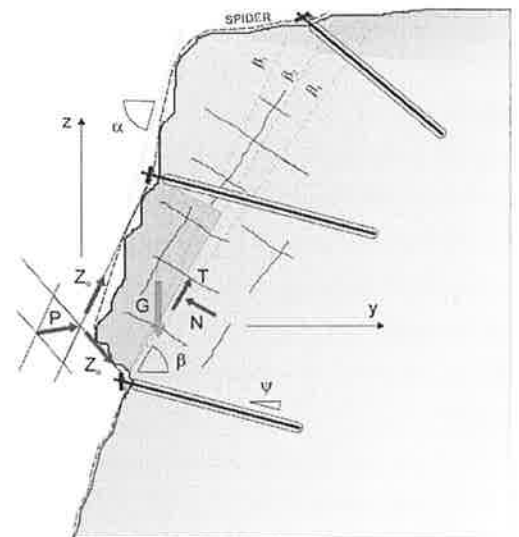
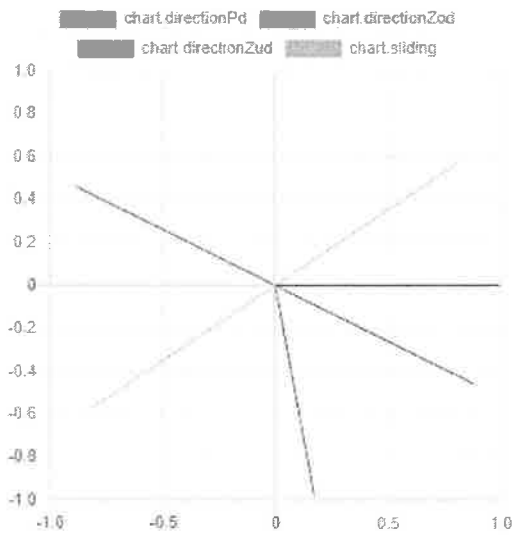
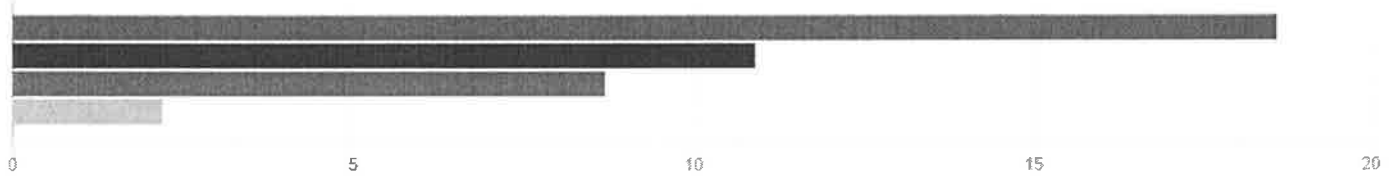
Project name

Date/Author

Weight/Geometry		
Block weight (characteristic value)	$G =$	155 kN
Inclination of the sliding plane to horizontal	$\beta =$	35 degrees
Angle of the top restraint to horizontal	$\theta_u =$	0 degrees
Angle of the bottom restraint to horizontal	$\theta_n =$	80 degrees
Ratio $Z_u : Z_n$	$\eta =$	80 %

Lateral influence		
Angle of the lateral restraint to horizontal related to vertical plane	$\delta =$	70 degrees
Angle of the resultant, lateral restraint in line of slope	$\chi =$	0 degrees
Ratio $S : Z_n$	$\zeta =$	20 %

■ Pd ■ Z<sub>od</sub> ■ Z<sub>ud</sub> ■ S<sub>d</sub>



Geotechnical parameters		
Friction angle (characteristic value)	$\varphi_c =$	37 degrees
Cohesion (characteristic value)	$c_c =$	0 kN/m <sup>2</sup>
Cohesion related area	$A_c =$	0 m <sup>2</sup>

Safety factors (on geotechnical parameters and model)		
Partial safety factor for friction angle	$\gamma_\varphi =$	1 -
Partial safety factor for cohesion	$\gamma_c =$	1 -
Partial safety factor for volume weight	$\gamma_\gamma =$	1 -
Model uncertainty correction value	$\gamma_{mod} =$	1.3 -

Number of nails or anchors		
Number of participating nails or anchors at the top	$n_o =$	1 -
Number of participating nails or anchors at the bottom	$n_u =$	1 -
Number of participating nails or anchors lateral	$n_s =$	2 -

Earthquake		
Coefficient of horizontal acceleration due to earthquake	$\xi_h =$	0 -
Coefficient of vertical acceleration due to earthquake	$\xi_v =$	0 -

Water pressure acting onto the block		
Water pressure from behind, perpendicular to the sliding plane	$W_h =$	1 kN
Water pressure from above, parallel to the sliding plane	$W_v =$	0 kN

Elements of system		
Spiral rope net	SPIDER® S3-130	
Spike plate	System spike plate P33	
Bearing resistance of the spiral rope net to tensile stress	$Z_n$ [kN/m] =	220
Bearing resistance of the spiral rope net to local force transmission longitudinal	$Z_{n1}$ [kN] =	60
Bearing resistance of the spiral rope net to local force transmission transversal	$Z_{n2}$ [kN] =	45
Spiral rope anchor (standard)	Spiral rope anchor, D = 14,5 mm	
Boundary rope (standard)	Steel wire rope, D = 14 mm	
Elements to connect the net panels between each other	Shackles 3/8"	
Nail type	GEWI D = 25 mm	
Taking into account rusting away (nail diameter reduced by 4 mm)	yes	
Nail inclination to horizontal	$\psi$ [degrees] =	10
Maximum eccentricity of the load to be transferred onto the nail at the top / bottom	$\xi$ [m] =	0,01
Yield stress of the nail	$f_y$ [N/mm <sup>2</sup> ] =	500
Cross-section with / without rusting away	$A_{n,red}$ [mm <sup>2</sup> ] =	346
Plastic section modulus	$W_{pl,red}$ [mm <sup>3</sup> ] =	1544
Bearing resistance of the nail to tensile stress	$T_{R,ten}$ [kN] =	173
Bearing resistance of the nail to shear stress	$S_{R,red}$ [kN] =	100



Calculated values		
Resultant stabilizing force P, on dimensioning level	$P_s$ [kN] =	16.3
Force in the net cover, to be transmitted to the top, on dimensioning level	$Z_{od}$ [kN] =	9.5
Force in the net cover, to be transmitted to the bottom, on dimensioning level	$Z_{ob}$ [kN] =	7.6
Force in the net cover, to be transmitted laterally, on dimensioning level	$S_d$ [kN] =	1.9
Opening angle between the forces in the net cover to the top and to the bottom	$\theta = \theta_t + \theta_b$ [degrees]=	80.0
Inclination of the resultant stabilizing force Pd to horizontal	$\omega$ [degrees]=	-27.5
Theoretical friction angle net - block (neglecting lateral influence)	$\varphi_c$ [degrees] =	12.5

Proof of local force transmission to the top		
Maximum tensile force in the net cover to be transmitted to the top, on dim. level	$Z_{od}$ [kN] =	9.5
Bearing resistance of the spiral rope net to local force transmission longitudinal	$Z_{R1}$ [kN] =	60.0
Resistance correction value for local force transmission	$\gamma_{ZR}$ [-] =	1.5
Dim. value of the bearing res. of the spiral rope net to local force transmission longit.	$Z_{R1d} = Z_{R1} / \gamma_{ZR}$ [kN] =	40.0
Number of nails or anchors at the top	$n_o$ =	1.0
Total bearing resistance of the spiral rope net to force transmission to the top	$Z_{R1d, tot} = Z_{R1d} \cdot n_o$ [kN] =	40.0
Proof of bearing safety	$Z_{od} \leq Z_{R1d, tot}$ =	fulfilled!

Proof of local force transmission to the bottom		
Proof of local force transmission to the bottom	$Z_{ob}$ [kN] =	7.6
Bearing resistance of the spiral rope net to local force transmission longitudinal	$Z_{R1}$ [kN] =	60.0
Resistance correction value for local force transmission	$\gamma_{ZR}$ [-] =	1.5
Dim. value of the bearing res. of the spiral rope net to local force transmission longit.	$Z_{R1d} = Z_{R1} / \gamma_{ZR}$ [kN] =	40.0
Number of nails or anchors at the bottom	$n_b$ =	1.0
Total bearing resistance of the spiral rope net to force transmission to the bottom	$Z_{R1d, tot} = Z_{R1d} \cdot n_b$ [kN] =	40.0
Proof of bearing safety	$Z_{ob} \leq Z_{R1d, tot}$ =	fulfilled!

Proof of local force transmission laterally		
Maximum tensile force in the net cover to be transmitted laterally on dimensioning level	$S_d$ [kN] =	1.9
Bearing resistance of the spiral rope net to local force transmission transversal	$Z_{R2}$ [kN] =	45.0
Resistance correction value for local force transmission	$\gamma_{ZR}$ [-] =	1.5
Dim. value of the bearing res. of the spiral rope net to local force transmission transv.	$Z_{R2d} = Z_{R2} / \gamma_{ZR}$ [kN] =	30.0
Number of nails or anchors lateral	$n_s$ [-] =	2.0
Total bearing resistance of the spiral rope net to force transmission lateral	$Z_{R2d, tot} = Z_{R2d} \cdot n_s$ [kN] =	60.0
Proof of bearing safety	$S_d \leq Z_{R2d, tot}$ =	fulfilled!

Proof of shear stress in the nails at the top		
Shear load in the nail at the top as a result of the force (Zod / no)	$V_{od}$ [kN] =	1.7
Shear stress in the nail at the top	$\tau_d$ [N/mm <sup>2</sup> ] = $V_{od} / A_{nec}$ =	4.8
Resistance correction value for shear stress	$\gamma_{Vd}$ [-] =	1.1
Maximum permissible shear stress	$\tau_{hd} = f_y / (\sqrt{3} \cdot \gamma_{Vd})$ =	262.4
Proof of bearing safety	$\tau_{hd} \geq \tau_d$ =	fulfilled!

Proof of combined stress in the nails at the top		
Tensile load in the nail at the top as a result of the force (Zod / no)	$N_{od}$ [kN] =	9,4
Moment as a result of the eccentric acting force (Zod / no)	$M_{od}$ [kNm] =	0,0
Normal stress in the nail at the top	$\sigma_{od}$ [N/mm <sup>2</sup> ] = $N_{od} / A_{nret} + M_{od} / W_{skret}$ =	37,8
Combined stress in the nail at the top	$\sigma_{ed}$ [N/mm <sup>2</sup> ] = $(\sigma_{od}^2 + 3 \tau_{ed}^2)^{0,5}$ =	38,7
Resistance correction value for combined stress	$\gamma_{ed}$ [-] =	1,1
Maximum permissible yield stress	$\sigma_{ed} = f_y / \gamma_{ed}$ =	454,5
Proof of bearing safety	$\sigma_{ed} \geq \sigma_d$ =	fulfilled

Proof of shear stress in the nails at the bottom		
Shear load in the nail at the bottom as a result of the force (Zud / nu)	$V_{ud}$ [kN] =	7,2
Shear stress in the nail at the bottom	$\tau_{ud}$ [N/mm <sup>2</sup> ] = $V_{ud} / A_{nret}$ =	20,7
Resistance correction value for shear stress	$\gamma_{vd}$ [-] =	1,1
Maximum permissible shear stress	$\tau_{sd} = f_t / (\sqrt{3} \cdot \gamma_{vd})$ =	262,4
Proof of bearing safety	$\tau_{ud} \geq \tau_d$ =	fulfilled

Proof of combined stress in the nails at the bottom		
Tensile load in the nail at the bottom as a result of the force (Zud / nu)	$N_{ud}$ [kN] =	2,6
Moment as a result of the eccentric acting force (Zud / nu)	$M_{ud}$ [kNm] =	0,1
Normal stress in the nail at the bottom	$\sigma_{ud}$ [N/mm <sup>2</sup> ] = $N_{ud} / A_{nret} + M_{ud} / W_{skret}$ =	53,9
Combined stress in the nail at the bottom	$\sigma_{ed}$ [N/mm <sup>2</sup> ] = $(\sigma_{ud}^2 + 3 \tau_{ed}^2)^{0,5}$ =	64,8
Resistance correction value for combined stress	$\gamma_{ed}$ [-] =	1,1
Maximum permissible yield stress	$\sigma_{ed} = f_y / \gamma_{ed}$ =	454,5
Proof of bearing safety	$\sigma_{ed} \geq \sigma_d$ =	fulfilled