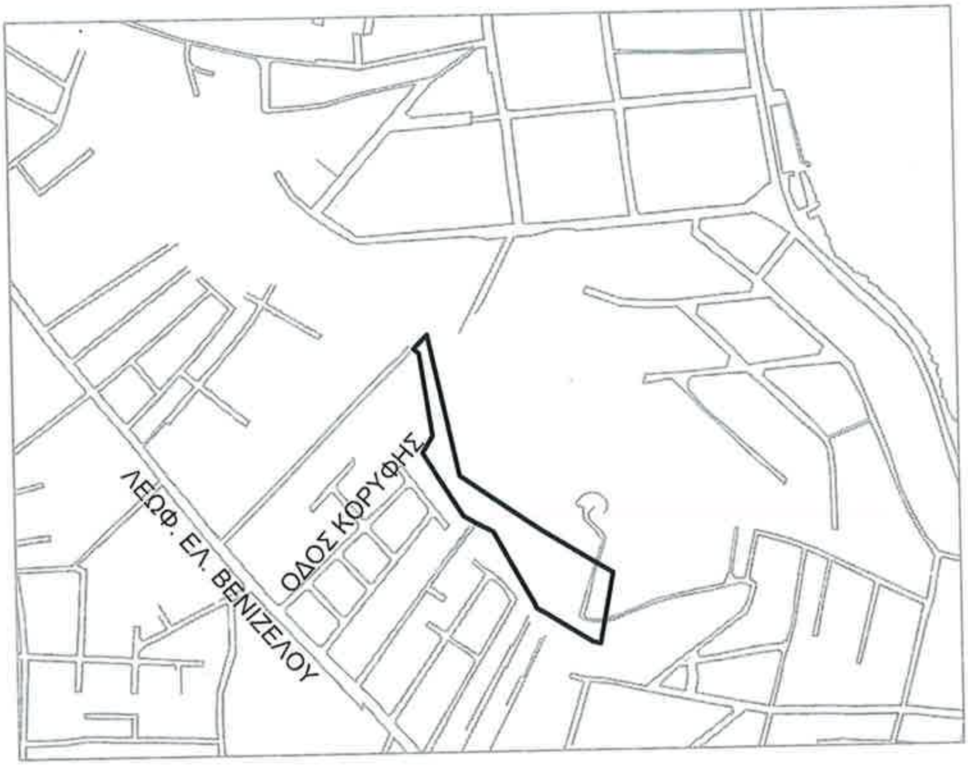
ΕΛΛΗΝΙΚΗ ΔΗΜΟΚΡΑΤΙΑ - ΠΕΡΙΦΕΡΕΙΑ ΑΤΤΙΚΗΣ
ΝΟΜΟΣ ΑΤΤΙΚΗΣ
ΔΗΜΟΣ ΜΑΡΚΟΠΟΥΛΟΥ ΜΕΣΟΓΑΙΑΣ

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

Μαρκόπουλο 14/7/2020
Ελέγχθηκε από
ΔΗΜΗΤΡΑ ΛΕΩΝΙΔΟΠΟΥΛΟΥ
Δρ. ΓΕΩΛΟΓΟΣ

Μαρκόπουλο 15-7-20
Ελέγχθηκε από η αυτή προϊσταμένη ΔΤΥ
Κατερίνα Σκοπελίτη
Π.Ε. Πολιτικός Μηχανικός
Βαθμός Α'

Ψηφιακά υπογεγραμμένο από
AIKATERINI SKOPELITI

Δρ. ΑΝΕΣΤΗΣ ΑΒΡΑΜΙΔΗΣ
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Επιβλέπουσα Μελέτης:
ΔΗΜΗΤΡΑ ΛΕΩΝΙΔΟΠΟΥΛΟΥ, Δρ Γεωλόγος (Δήμος Μαρκοπούλου)

* Κατόπιν του υπ'αριθμ. 8941/23/06/20 εγγράφου του Δήμου Μαρκοπούλου

Ημερομηνία : Ιούνιος 2020 *

Εγκρίθηκε κατόπιν της υπ' αριθμ. 140/2020 απόφασης Οικονομικής Επιτροπής

## ΠΑΡΑΡΤΗΜΑ Γ.3

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

Περίπτωση 1

GEOBRUGG BRUGG
Safety is our nature

# SPIDER® ONLINE-TOOL

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

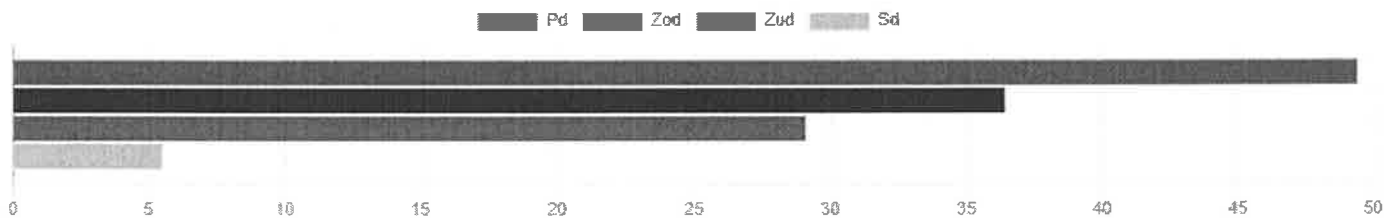
Project No.

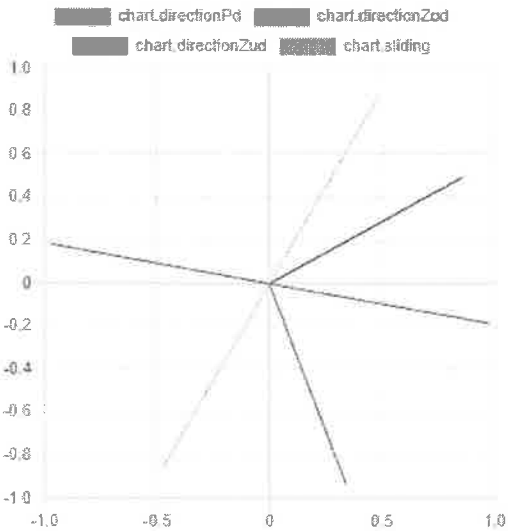
Project name

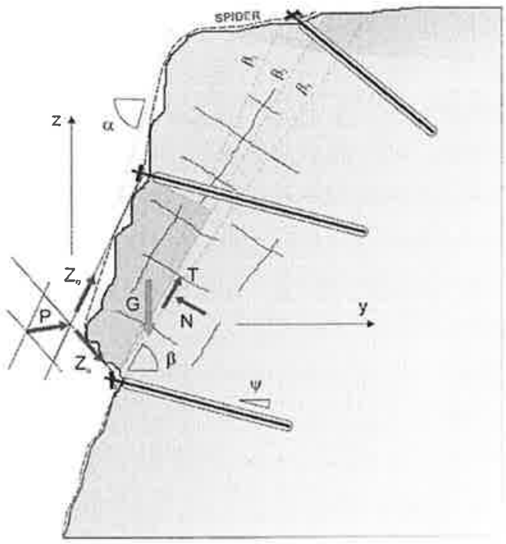
Date/Author

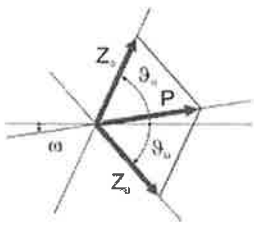
| Weight,Geometry | | | |
|---|---|---|---|
| Block weight (characteristic value) | G = | 85 | kN |
| Inclination of the sliding plane to horizontal | $\beta$ = | 61 | degrees |
| Angle of the top restraint to horizontal | $\vartheta_o$ = | 30 | degrees |
| Angle of the bottom restraint to horizontal | $\vartheta_u$ = | 70 | degrees |
| Ratio Zu : Zo | $\eta$ = | 80 | % |

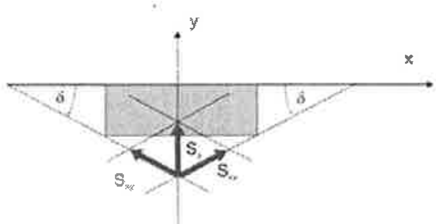
| Lateral influence | | | |
|---|---|---|---|
| Angle of the lateral restraint to horizontal related to vertical plane | $\delta$ = | 40 | degrees |
| Angle of the resultant, lateral restraint in line of slope | $\chi$ = | 0 | degrees |
| Ratio S : Zo | $\zeta$ = | 15 | % |



| Geotechnical parameters | | | |
|---|---|---|---|
| Friction angle (characteristic value) | $\varphi_k$ = | 37 | degrees |
| Cohesion (characteristic value) | $c_k$ = | 0 | kN/m² |
| Cohesion related area | A = | 0 | m² |

| 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 | $\eta_o$ = | 3 | - |
| 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 | $\varepsilon_h$ = | 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 | $W_h$ = | 1 | 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/mm²]= | 500 |
| Cross-section with / without rusting away | $A_{(red)}$ [mm²]= | 346 |
| Plastic section modulus | $W_{pl(red)}$ [mm³]= | 1544 |
| Bearing resistance of the nail to tensile stress | $T_{R(red)}$ [kN]= | 173 |
| Bearing resistance of the nail to shear stress | $S_{R(red)}$ [kN]= | 100 |

## Calculated values

| | | |
|---|---|---|
| Resultant stabilizing force P, on dimensioning level | $P_d$ [kN] = | 52.0 |
| Force in the net cover, to be transmitted to the top, on dimensioning level | $Z_{od}$ [kN] = | 38.4 |
| Force in the net cover, to be transmitted to the bottom, on dimensioning level | $Z_{ud}$ [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 | $\vartheta = \vartheta_u + \vartheta_o$ [degrees]= | 100.0 |
| Inclination of the resultant stabilizing force Pd to horizontal | $\omega$ [degrees]= | -10.7 |
| Theoretical friction angle net - block (neglecting lateral influence) | $\varphi_G$ [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 | $Z_{od}$ [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 | $\gamma_{ZR}$ [-] = | 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 | $n_o$ = | 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 | $Z_{od} <= Z_{R1d,tot}$ = | fulfilled! |

## Proof of local force transmission to the bottom

| | | |
|---|---|---|
| Proof of local force transmission to the bottom | $Z_{ud}$ [kN] = | 30.7 |
| Bearing resistance of the spiral rope net to local force transmission longitudinal | $Z_{R1}$ [kN] = | 60.0 |
| Resistance correction value for local force transmission | $\gamma_{ZR}$ [-] = | 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 | $n_u$ = | 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 | $Z_{ud} <= Z_{R1d,tot}$ = | fulfilled! |

## Proof of local force transmission laterally

| | | |
|---|---|---|
| Maximum tensile force in the net cover to be transmitted laterally on dimensioning level | $S_d$ [kN] = | 5.8 |
| 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 | $S_d <= Z_{R2d,tot}$ = | 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] = | 8.2 |
| Shear stress in the nail at the top | $\tau_d$ [N/mm²] = $V_{od} / A_{rest}$ = | 23.8 |
| Resistance correction value for shear stress | $\gamma_M$ [-] = | 1.1 |
| Maximum permissible shear stress | $\tau_{Rd} = f_y / (\sqrt{3} \cdot \gamma_M)$ = | 262.4 |
| Proof of bearing safety | $\tau_{Rd} \geq \tau_d$ | fulfilled! |

| Proof of combined stress in the nails at the top | | |
|---|---|---|
| Tensile load in the nail at the top as a result of the force (Zod / no) | $N_{od}$ [kN] = | 9.8 |
| Moment as a result of the eccentric acting force (Zod / no) | $M_{od}$ [kNm] = | 0.1 |
| Normal stress in the nail at the top | $\sigma_{Nd}$ [N/mm²] = $N_{od} / A_{(red)} + M_{od} / W_{pl(red)}$ = | 81.5 |
| Combined stress in the nail at the top | $\sigma_d$ [N/mm²] = $(\sigma_{Nd}^2 + 3\,\tau_d^2)^{0.5}$ = | 91.3 |
| 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 (Zud / nu) | $V_{ud}$ [kN] = | 26.6 |
| Shear stress in the nail at the bottom | $\tau_d$ [N/mm²] = $V_{ud} / A_{(red)}$ = | 76.8 |
| Resistance correction value for shear stress | $\gamma_M$ [-] = | 1.1 |
| Maximum permissible shear stress | $\tau_{Rd} = f_y / (\sqrt{3} \cdot \gamma_M)$ = | 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 (Zud / nu) | $N_{ud}$ [kN] = | 15.3 |
| Moment as a result of the eccentric acting force (Zud / nu) | $M_{ud}$ [kNm] = | 0.3 |
| Normal stress in the nail at the bottom | $\sigma_{Nd}$ [N/mm²] = $N_{ud} / A_{(red)} + M_{ud} / W_{pl(red)}$ = | 216.5 |
| Combined stress in the nail at the bottom | $\sigma_d$ [N/mm²] = $(\sigma_{Nd}^2 + 3\,\tau_d^2)^{0.5}$ = | 254.1 |
| 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

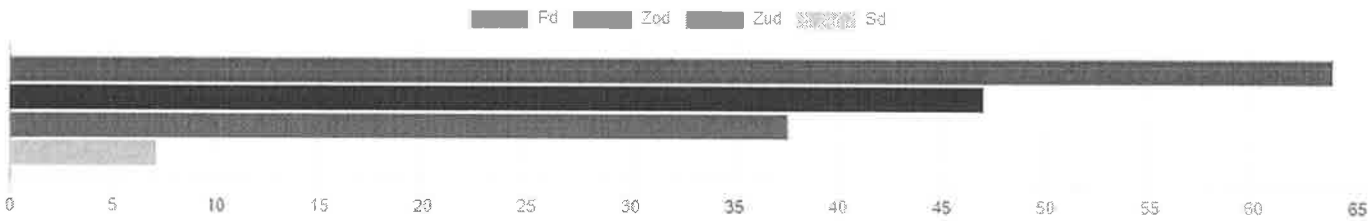
Project No.

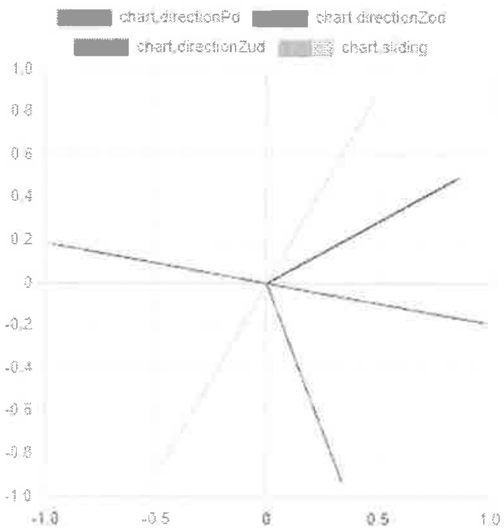
Project name

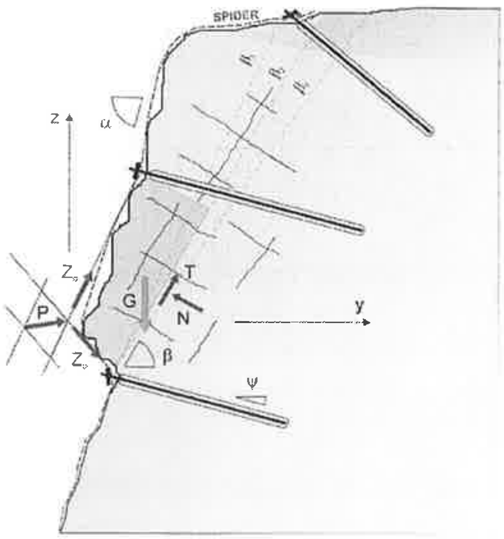
Date/Author

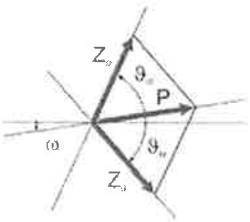
| Weight Geometry | | | |
|---|---|---|---|
| Block weight (characteristic value) | G = | 85 | kN |
| Inclination of the sliding plane to horizontal | β = | 61 | degrees |
| Angle of the top restraint to horizontal | $\vartheta_o$ = | 30 | degrees |
| Angle of the bottom restraint to horizontal | $\vartheta_u$ = | 70 | degrees |
| Ratio Zu : Zo | η = | 80 | % |

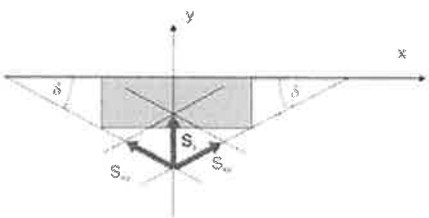
| Lateral influence | | | |
|---|---|---|---|
| Angle of the lateral restraint to horizontal related to vertical plane | δ = | 40 | degrees |
| Angle of the resultant, lateral restraint in line of slope | χ = | 0 | degrees |
| Ratio S : Zo | ζ = | 15 | % |



| Geotechnical parameters | | | |
|---|---|---|---|
| Friction angle (characteristic value) | $\varphi_k$ = | 37 | degrees |
| Cohesion (characteristic value) | $c_k$ = | 0 | kN/m² |
| Cohesion related area | A = | 0 | m² |

| 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 | $\eta_o$ = | 3 | - |
| 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 | $\varepsilon_h$ = | 0 | - |
| Coefficient of vertical acceleration due to earthquake | $\varepsilon_v$ = | 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 | $W_o$ = | 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/mm²]= | 500 |
| Cross-section with / without rusting away | $A_{(red)}$ [mm²]= | 346 |
| Plastic section modulus | $W_{pl(red)}$ [mm³]= | 1544 |
| Bearing resistance of the nail to tensile stress | $T_{R(red)}$ [kN]= | 173 |
| Bearing resistance of the nail to shear stress | $S_{R(red)}$ [kN]= | 100 |

| Calculated values | | |
|---|---|---|
| Resultant stabilizing force P, on dimensioning level | $P_d$ [kN] = | 56.0 |
| Force in the net cover, to be transmitted to the top, on dimensioning level | $Z_{od}$ [kN] = | 41.3 |
| Force in the net cover, to be transmitted to the bottom, on dimensioning level | $Z_{ud}$ [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 | $\vartheta = \vartheta_L + \vartheta_o$ [degrees]= | 100.0 |
| Inclination of the resultant stabilizing force Pd to horizontal | $\omega$ [degrees]= | -10.7 |
| Theoretical friction angle net - block (neglecting lateral influence) | $\varphi_G$ [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 | $Z_{od}$ [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 | $\gamma_{ZR}$ [-] = | 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 | $n_o$ = | 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 | $Z_{od} <= Z_{R1d,tot}$ = | fulfilled! |

| Proof of local force transmission to the bottom | | |
|---|---|---|
| Proof of local force transmission to the bottom | $Z_{ud}$ [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 | $\gamma_{ZR}$ [-] = | 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 | $n_u$ = | 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 | $Z_{ud} <= Z_{R1d,tot}$ = | 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 | $\gamma_{ZR}$ [-] = | 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 | $S_d <= Z_{R2d,tot}$ = | 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] = | 8.8 |
| Shear stress in the nail at the top | $\tau_d$ [N/mm²] = $V_{od} / A_{(red)}$ = | 25.6 |
| Resistance correction value for shear stress | $\gamma_M$ [-] = | 1.1 |
| Maximum permissible shear stress | $\tau_{Rd} = f_y / (\sqrt{3} \cdot \gamma_M)$ = | 262.4 |
| Proof of bearing safety | $\tau_{Rd} \geq \tau_d$ | fulfilled! |

| Proof of combined stress in the nails at the top | | |
|---|---|---|
| Tensile load in the nail at the top as a result of the force (Zod / no) | $N_{od}$ [kN] = | 10.5 |
| Moment as a result of the eccentric acting force (Zod / no) | $M_{od}$ [kNm] = | 0.1 |
| Normal stress in the nail at the top | $\sigma_{Nd}$ [N/mm²] = $N_{od} / A_{(red)} + M_{od} / W_{pl(red)}$ = | 87.8 |
| Combined stress in the nail at the top | $\sigma_d$ [N/mm²] = $(\sigma_{Nd}^2 + 3\ \tau_d^2)^{0.5}$ = | 98.3 |
| 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 (Zud / nu) | $V_{ud}$ [kN] = | 28.6 |
| Shear stress in the nail at the bottom | $\tau_d$ [N/mm²] = $V_{ud} / A_{(red)}$ = | 82.7 |
| Resistance correction value for shear stress | $\gamma_M$ [-] = | 1.1 |
| Maximum permissible shear stress | $\tau_{Rd} = f_y / (\sqrt{3} \cdot \gamma_M)$ = | 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 (Zud / nu) | $N_{ud}$ [kN] = | 16.5 |
| Moment as a result of the eccentric acting force (Zud / nu) | $M_{ud}$ [kNm] = | 0.3 |
| Normal stress in the nail at the bottom | $\sigma_{Nd}$ [N/mm²] = $N_{ud} / A_{(red)} + M_{ud} / W_{pl(red)}$ = | 233.1 |
| Combined stress in the nail at the bottom | $\sigma_d$ [N/mm²] = $(\sigma_{Nd}^2 + 3\ \tau_d^2)^{0.5}$ = | 273.6 |
| 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 3

GEOBRUGG BRUGG
Safety is our nature

# SPIDER® ONLINE-TOOL

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

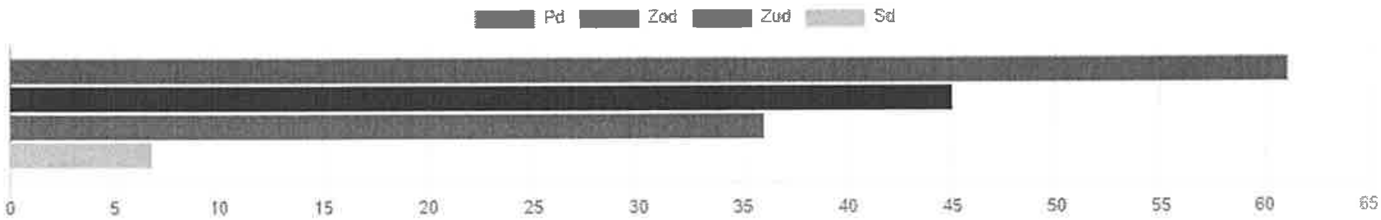
Project No.

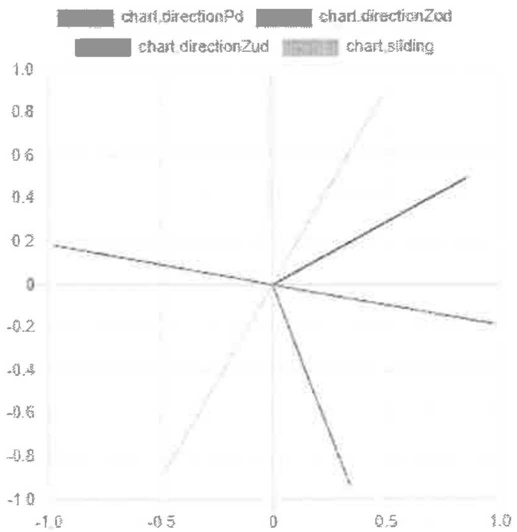
Project name

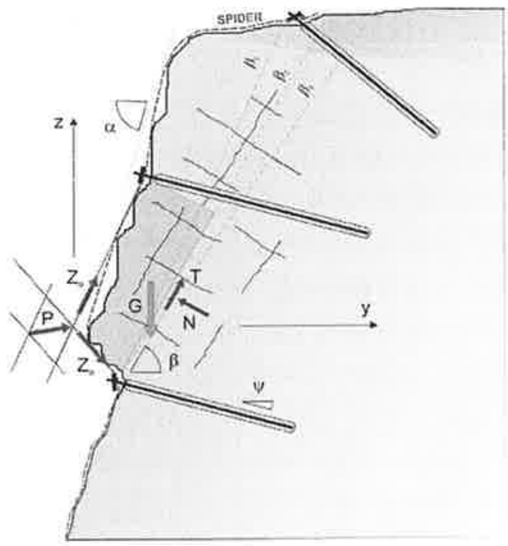
Date/Author

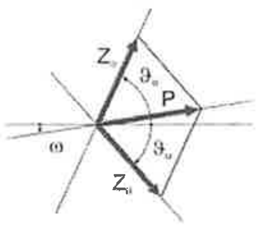
| Weight,Geometry | | | |
|---|---|---|---|
| Block weight (characteristic value) | G = | 85 | kN |
| Inclination of the sliding plane to horizontal | $\beta$ = | 61 | degrees |
| Angle of the top restraint to horizontal | $\vartheta_o$ = | 30 | degrees |
| Angle of the bottom restraint to horizontal | $\vartheta_u$ = | 70 | degrees |
| Ratio Zu : Zo | $\eta$ = | 80 | % |

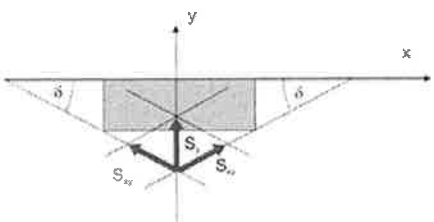
| Lateral influence | | | |
|---|---|---|---|
| Angle of the lateral restraint to horizontal related to vertical plane | $\delta$ = | 40 | degrees |
| Angle of the resultant, lateral restraint in line of slope | $\chi$ = | 0 | degrees |
| Ratio S : Zo | $\zeta$ = | 15 | % |



## Geotechnical parameters

| | | | |
|---|---|---|---|
| Friction angle (characteristic value) | $\varphi_k$ = | 37 | degrees |
| Cohesion (characteristic value) | $c_k$ = | 0 | kN/m² |
| Cohesion related area | A = | 0 | m² |

## 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 | $\eta_o$ = | 3 | - |
| 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 | $\varepsilon_h$ = | 0 | - |
| Coefficient of vertical acceleration due to earthquake | $\varepsilon_v$ = | 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 | $Z_{R1}$ [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/mm²]= | 500 |
| Cross-section with / without rusting away | $A_{(red)}$ [mm²]= | 346 |
| Plastic section modulus | $W_{pl(red)}$ [mm³]= | 1544 |
| Bearing resistance of the nail to tensile stress | $T_{R(red)}$ [kN]= | 173 |
| Bearing resistance of the nail to shear stress | $S_{R(red)}$ [kN]= | 100 |

## Calculated values

| | | |
|---|---|---|
| Resultant stabilizing force P, on dimensioning level | $P_d$ [kN] = | 59.0 |
| Force in the net cover, to be transmitted to the top, on dimensioning level | $Z_{od}$ [kN] = | 43,5 |
| Force in the net cover, to be transmitted to the bottom, on dimensioning level | $Z_{ud}$ [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 | $\vartheta = \vartheta_o + \vartheta_u$ [degrees]= | 100,0 |
| Inclination of the resultant stabilizing force Pd to horizontal | ω [degrees]= | -10,7 |
| Theoretical friction angle net - block (neglecting lateral influence) | $\varphi_G$ [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 | $Z_{od}$ [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 | $\gamma_{ZR}$ [-] = | 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 | $n_o$ = | 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 | $Z_{od} <= Z_{R1d,tot}$ = | fulfilled! |

## Proof of local force transmission to the bottom

| | | |
|---|---|---|
| Proof of local force transmission to the bottom | $Z_{ud}$ [kN] = | 34,8 |
| 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 | $n_u$ = | 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 | $Z_{ud} <= Z_{R1d,tot}$ = | fulfilled! |

## Proof of local force transmission laterally

| | | |
|---|---|---|
| Maximum tensile force in the net cover to be transmitted laterally on dimensioning level | $S_d$ [kN] = | 6,5 |
| Bearing resistance of the spiral rope net to local force transmission transversal | $Z_{R2}$ [kN] = | 45,0 |
| Resistance correction value for local force transmission | $\gamma_{ZR}$ [-] = | 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 | $S_d <= Z_{R2d,tot}$ = | 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] = | 9,3 |
| Shear stress in the nail at the top | $\tau_d$ [N/mm²] = $V_{od} / A_{(net)}$ = | 27,0 |
| Resistance correction value for shear stress | $\gamma_M$ [-] = | 1,1 |
| Maximum permissible shear stress | $\tau_{Rd} = f_y / (\sqrt{3} \cdot \gamma_M)$ = | 262,4 |
| Proof of bearing safety | $\tau_{Rd} \geq \tau_d$ | fulfilled! |

| Proof of combined stress in the nails at the top | | |
|---|---|---|
| Tensile load in the nail at the top as a result of the force (Zod / no) | $N_{od}$ [kN] = | 11.1 |
| Moment as a result of the eccentric acting force (Zod / no) | $M_{od}$ [kNm] = | 0.1 |
| Normal stress in the nail at the top | $\sigma_{Nd}$ [N/mm²] = $N_{od} / A_{(red)} + M_{od} / W_{p(red)}$ = | 92.6 |
| Combined stress in the nail at the top | $\sigma_d$ [N/mm²] = $(\sigma_{Nd}^2 + 3\ \tau_d^2)^{0.5}$ = | 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 (Zud / nu) | $V_{ud}$ [kN] = | 30.2 |
| Shear stress in the nail at the bottom | $\tau_d$ [N/mm²] = $V_{ud} / A_{(red)}$ = | 87.2 |
| Resistance correction value for shear stress | $\gamma_M$ [-] = | 1.1 |
| Maximum permissible shear stress | $\tau_{Rd} = f_y / (\sqrt{3} \cdot \gamma_M)$ = | 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 (Zud / nu) | $N_{ud}$ [kN] = | 17.4 |
| Moment as a result of the eccentric acting force (Zud / nu) | $M_{ud}$ [kNm] = | 0.3 |
| Normal stress in the nail at the bottom | $\sigma_{Nd}$ [N/mm²] = $N_{ud} / A_{(red)} + M_{ud} / W_{p(red)}$ = | 245.7 |
| Combined stress in the nail at the bottom | $\sigma_d$ [N/mm²] = $(\sigma_{Nd}^2 + 3\ \tau_d^2)^{0.5}$ = | 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 συρματόπλεγμα.

Περίπτωση 1

GEOBRUGG BRUGG Safety is our nature

# SPIDER® ONLINE-TOOL

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

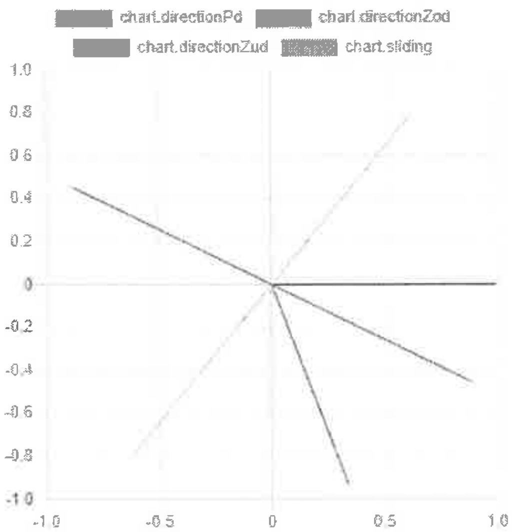
Project No.

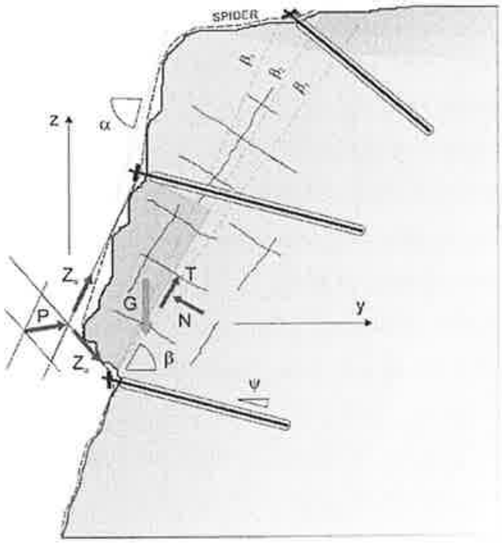
Project name

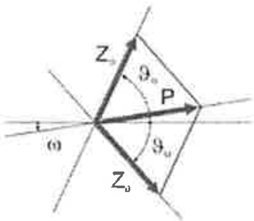
Date/Author

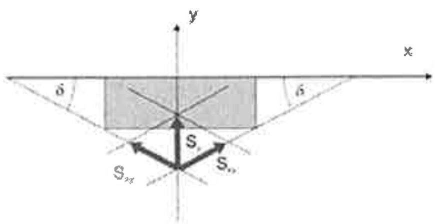
| Weight,Geometry | | | |
|---|---|---|---|
| Block weight (characteristic value) | G = | 100 | kN |
| Inclination of the sliding plane to horizontal | β = | 52 | degrees |
| Angle of the top restraint to horizontal | $\vartheta_o$ = | 0 | degrees |
| Angle of the bottom restraint to horizontal | $\vartheta_u$ = | 70 | degrees |
| Ratio Zu : Zo | η = | 80 | % |

| Lateral influence | | | |
|---|---|---|---|
| Angle of the lateral restraint to horizontal related to vertical plane | δ = | 40 | degrees |
| Angle of the resultant, lateral restraint in line of slope | χ = | 0 | degrees |
| Ratio S : Zo | ζ = | 15 | % |

| Geotechnical parameters | | | |
|---|---|---|---|
| Friction angle (characteristic value) | $\varphi_k$ = | 37 | degrees |
| Cohesion (characteristic value) | $c_k$ = | 0 | kN/m² |
| Cohesion related area | A = | 0 | m² |

| 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 | $\eta_s$ = | 1 | - |

| 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 | $W_h$ = | 10 | kN |
| Water pressure from above, parallel to the sliding plane | $W_p$ = | 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 | $Z_R$ [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/mm²]= | 500 |
| Cross-section with / without rusting away | $A_{(red)}$ [mm²]= | 346 |
| Plastic section modulus | $W_{pl(red)}$ [mm³]= | 1544 |
| Bearing resistance of the nail to tensile stress | $T_{R(red)}$ [kN]= | 173 |
| Bearing resistance of the nail to shear stress | $S_{R(red)}$ [kN]= | 100 |

| Calculated values | | |
|---|---|---|
| Resultant stabilizing force P, on dimensioning level | $P_d$ [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 | $Z_{ud}$ [kN] = | 26.6 |
| Force in the net cover, to be transmitted laterally, on dimensioning level | $S_d$ [kN] = | 5.0 |
| Opening angle between the forces in the net cover to the top and to the bottom | $\vartheta = \vartheta_u + \vartheta_o$ [degrees]= | 70.0 |
| Inclination of the resultant stabilizing force Pd to horizontal | ω [degrees]= | -27.1 |
| Theoretical friction angle net - block (neglecting lateral influence) | $\varphi_G$ [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] = | 33.3 |
| Bearing resistance of the spiral rope net to local force transmission longitudinal | $Z_{R1}$ [kN] = | 60.0 |
| Resistance correction value for local force transmission | $\gamma_{ZR}$ [-] = | 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 | $n_o$ = | 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 | $Z_{od} <= Z_{R1d,tot}$ = | fulfilled! |

| Proof of local force transmission to the bottom | | |
|---|---|---|
| Proof of local force transmission to the bottom | $Z_{ud}$ [kN] = | 26.6 |
| 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 | $n_u$ = | 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 | $Z_{ud} <= Z_{R1d,tot}$ = | fulfilled! |

| Proof of local force transmission laterally | | |
|---|---|---|
| Maximum tensile force in the net cover to be transmitted laterally on dimensioning level | $S_d$ [kN] = | 5.0 |
| 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 | $n_s$ [-] = | 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 | $S_d <= Z_{R2d,tot}$ = | 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] = | 2.9 |
| Shear stress in the nail at the top | $\tau_d$ [N/mm²] = $V_{od} / A_{(red)}$ = | 8.4 |
| Resistance correction value for shear stress | $\gamma_M$ [-] = | 1.1 |
| Maximum permissible shear stress | $\tau_{Rd} = f_y / (\sqrt{3} \cdot \gamma_M)$ = | 262.4 |
| Proof of bearing safety | $\tau_{Rd} \geq \tau_d$ | fulfilled! |

| Proof of combined stress in the nails at the top | | |
|---|---|---|
| Tensile load in the nail at the top as a result of the force (Zod / no) | $N_{od}$ [kN] = | 16.4 |
| Moment as a result of the eccentric acting force (Zod / no) | $M_{od}$ [kNm] = | 0.0 |
| Normal stress in the nail at the top | $\sigma_{Nd}$ [N/mm²] = $N_{od} / A_{(red)} + M_{od} / W_{pl(red)}$ = | 66.1 |
| Combined stress in the nail at the top | $\sigma_d$ [N/mm²] = $(\sigma_{Nd}^2 + 3\ \tau_d^2)^{0.5}$ = | 67.6 |
| 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 (Zud / nu) | $V_{ud}$ [kN] = | 23.1 |
| Shear stress in the nail at the bottom | $\tau_d$ [N/mm²] = $V_{ud} / A_{(red)}$ = | 66.6 |
| Resistance correction value for shear stress | $\gamma_M$ [-] = | 1.1 |
| Maximum permissible shear stress | $\tau_{Rd} = f_y / (\sqrt{3} \cdot \gamma_M)$ = | 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 (Zud / nu) | $N_{ud}$ [kN] = | 13.3 |
| Moment as a result of the eccentric acting force (Zud / nu) | $M_{ud}$ [kNm] = | 0.2 |
| Normal stress in the nail at the bottom | $\sigma_{Nd}$ [N/mm²] = $N_{ud} / A_{(red)} + M_{ud} / W_{pl(red)}$ = | 187.8 |
| Combined stress in the nail at the bottom | $\sigma_d$ [N/mm²] = $(\sigma_{Nd}^2 + 3\ \tau_d^2)^{0.5}$ = | 220.4 |
| 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! |

Περίπτωση 2

GEOBRUGG BRUGG
Safety is our nature

# SPIDER® ONLINE-TOOL

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

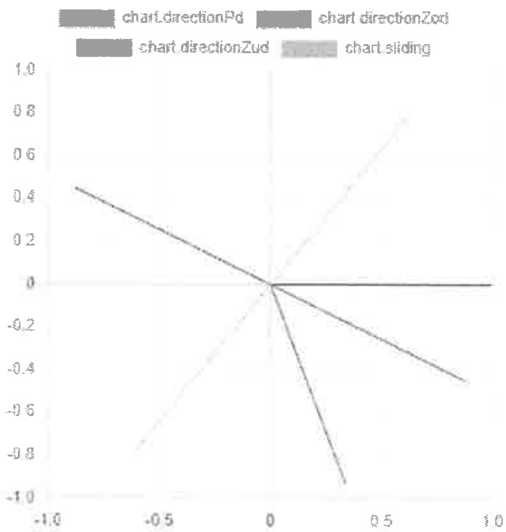
Project No.

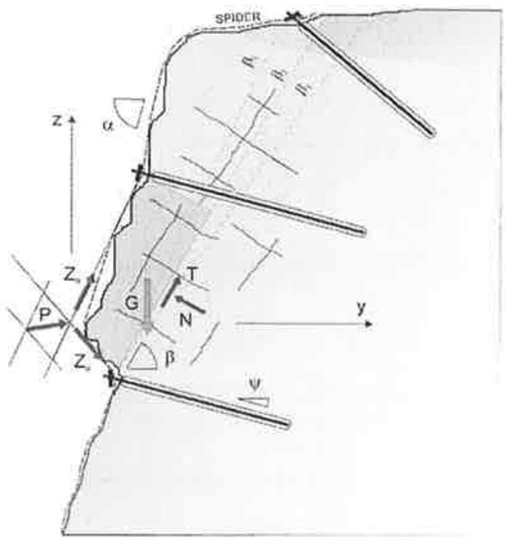
Project name

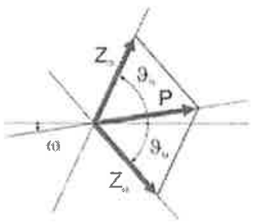
Date/Author

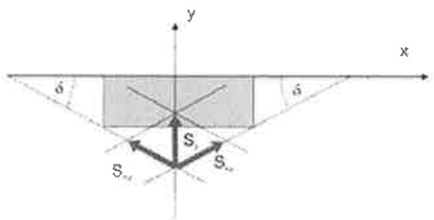
| Weight Geometry | | | |
|---|---|---|---|
| Block weight (characteristic value) | G = | 100 | kN |
| Inclination of the sliding plane to horizontal | $\beta$ = | 52 | degrees |
| Angle of the top restraint to horizontal | $\vartheta_o$ = | 0 | degrees |
| Angle of the bottom restraint to horizontal | $\vartheta_u$ = | 70 | degrees |
| Ratio Zu : Zo | $\eta$ = | 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 : Zo | $\zeta$ = | 15 | % |

| Geotechnical parameters | | | |
|---|---|---|---|
| Friction angle (characteristic value) | $\varphi_k =$ | 37 | degrees |
| Cohesion (characteristic value) | $c_k =$ | 0 | kN/m² |
| Cohesion related area | A = | 0 | m² |

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

| Earthquake | | | |
|---|---|---|---|
| Coefficient of horizontal acceleration due to earthquake | $\varepsilon_h =$ | 0 | - |
| Coefficient of vertical acceleration due to earthquake | $\varepsilon_v =$ | 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 | $Z_R$ [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/mm²]= | 500 |
| Cross-section with / without rusting away | $A_{(red)}$ [mm²]= | 346 |
| Plastic section modulus | $W_{pl(red)}$ [mm³]= | 1544 |
| Bearing resistance of the nail to tensile stress | $T_{R(red)}$ [kN]= | 173 |
| Bearing resistance of the nail to shear stress | $S_{R(red)}$ [kN]= | 100 |

| Calculated values | | |
|---|---|---|
| Resultant stabilizing force P, on dimensioning level | $P_d$ [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 | $Z_{ud}$ [kN] = | 34.4 |
| 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 | $\vartheta = \vartheta_o + \vartheta_u$ [degrees]= | 70.0 |
| Inclination of the resultant stabilizing force Pd to horizontal | $\omega$ [degrees]= | -27.1 |
| Theoretical friction angle net - block (neglecting lateral influence) | $\varphi_G$ [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 | $\gamma_{ZR}$ [-] = | 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 | $n_o$ = | 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 | $Z_{od} <= Z_{R1d,tot}$ = | fulfilled! |

| Proof of local force transmission to the bottom | | |
|---|---|---|
| Proof of local force transmission to the bottom | $Z_{ud}$ [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 | $\gamma_{ZR}$ [-] = | 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 | $n_u$ = | 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 | $Z_{ud} <= Z_{R1d,tot}$ = | fulfilled! |

| Proof of local force transmission laterally | | |
|---|---|---|
| Maximum tensile force in the net cover to be transmitted laterally on dimensioning level | $S_d$ [kN] = | 6.5 |
| Bearing resistance of the spiral rope net to local force transmission transversal | $Z_{R2}$ [kN] = | 45.0 |
| Resistance correction value for local force transmission | $\gamma_{ZR}$ [-] = | 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 | $n_s$ [-] = | 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 | $S_d <= Z_{R2d,tot}$ = | 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/mm²] = $V_{od} / A_{(red)}$ = | 10.8 |
| Resistance correction value for shear stress | $\gamma_M$ [-] = | 1.1 |
| Maximum permissible shear stress | $\tau_{Rd} = f_y / (\sqrt{3} \cdot \gamma_M)$ = | 262.4 |
| Proof of bearing safety | $\tau_{Rd} \geq \tau_d$ | fulfilled! |

| Proof of combined stress in the nails at the top | | |
|---|---|---|
| Tensile load in the nail at the top as a result of the force (Zod / no) | $N_{od}$ [kN] = | 21.2 |
| Moment as a result of the eccentric acting force (Zod / no) | $M_{od}$ [kNm] = | 0.0 |
| Normal stress in the nail at the top | $\sigma_{Nd}$ [N/mm²] = $N_{od} / A_{(red)} + M_{od} / W_{pl(red)}$ = | 85.4 |
| Combined stress in the nail at the top | $\sigma_d$ [N/mm²] = $(\sigma_{Nd}^2 + 3\ \tau_d^2)^{0.5}$ = | 87.5 |
| 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! |

| 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] = | 29.8 |
| Shear stress in the nail at the bottom | $\tau_d$ [N/mm²] = $V_{ud} / A_{(red)}$ = | 86.2 |
| Resistance correction value for shear stress | $\gamma_M$ [-] = | 1.1 |
| Maximum permissible shear stress | $\tau_{Rd} = f_y / (\sqrt{3} \cdot \gamma_M)$ = | 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 (Zud / nu) | $N_{ud}$ [kN] = | 17.2 |
| Moment as a result of the eccentric acting force (Zud / nu) | $M_{ud}$ [kNm] = | 0.3 |
| Normal stress in the nail at the bottom | $\sigma_{Nd}$ [N/mm²] = $N_{ud} / A_{(red)} + M_{ud} / W_{pl(red)}$ = | 242.9 |
| Combined stress in the nail at the bottom | $\sigma_d$ [N/mm²] = $(\sigma_{Nd}^2 + 3\ \tau_d^2)^{0.5}$ = | 285.0 |
| 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 3

# SPIDER® ONLINE-TOOL

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

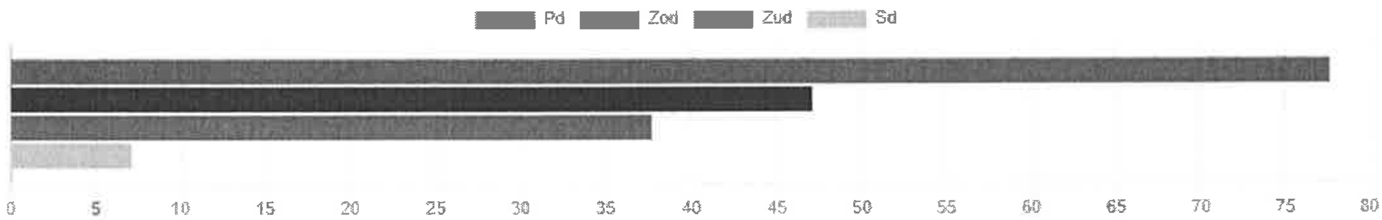
Project No.

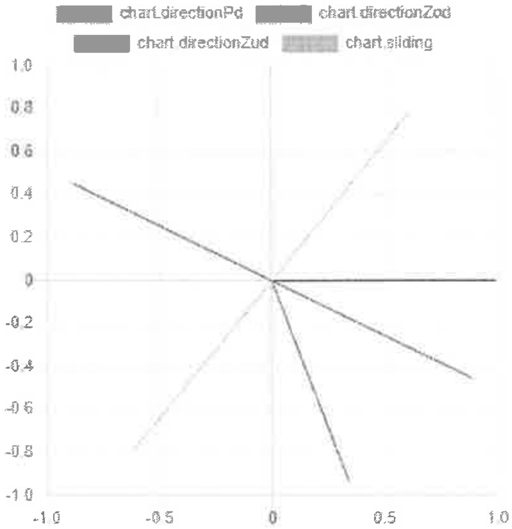
Project name

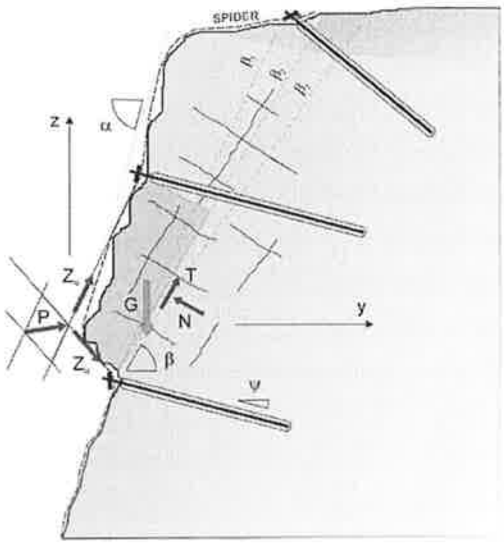
Date/Author

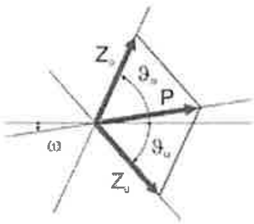
| Weight Geometry | | | |
|---|---|---|---|
| Block weight (characteristic value) | G = | 100 | kN |
| Inclination of the sliding plane to horizontal | $\beta$ = | 52 | degrees |
| Angle of the top restraint to horizontal | $\vartheta_o$ = | 0 | degrees |
| Angle of the bottom restraint to horizontal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

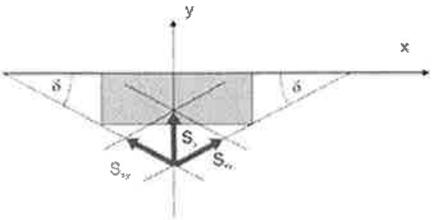
| Lateral influence | | | |
|---|---|---|---|
| Angle of the lateral restraint to horizontal related to vertical plane | $\delta$ = | 40 | degrees |
| Angle of the resultant, lateral restraint in line of slope | $\chi$ = | 0 | degrees |
| Ratio S : Zo | $\zeta$ = | 15 | % |



| Geotechnical parameters | | | |
|---|---|---|---|
| Friction angle (characteristic value) | $\varphi_k$ = | 37 | degrees |
| Cohesion (characteristic value) | $c_k$ = | 0 | kN/m² |
| Cohesion related area | A = | 0 | m² |

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

| Earthquake | | | |
|---|---|---|---|
| Coefficient of horizontal acceleration due to earthquake | $\varepsilon_h$ = | 0 | - |
| Coefficient of vertical acceleration due to earthquake | $\varepsilon_v$ = | 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 | $W_o$ = | 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/mm²]= | 500 |
| Cross-section with / without rusting away | $A_{(red)}$ [mm²]= | 346 |
| Plastic section modulus | $W_{pl(red)}$ [mm³]= | 1544 |
| Bearing resistance of the nail to tensile stress | $T_{R(red)}$ [kN]= | 173 |
| Bearing resistance of the nail to shear stress | $S_{R(red)}$ [kN]= | 100 |

| Calculated values | | |
|---|---|---|
| Resultant stabilizing force P, on dimensioning level | $P_d$ [kN] = | 64.6 |
| Force in the net cover, to be transmitted to the top, on dimensioning level | $Z_{od}$ [kN] = | 39.2 |
| Force in the net cover, to be transmitted to the bottom, on dimensioning level | $Z_{ud}$ [kN] = | 31.3 |
| Force in the net cover, to be transmitted laterally, on dimensioning level | $S_d$ [kN] = | 5.9 |
| Opening angle between the forces in the net cover to the top and to the bottom | $\vartheta = \vartheta_L + \vartheta_a$ [degrees]= | 70.0 |
| Inclination of the resultant stabilizing force Pd to horizontal | ω [degrees]= | -27.1 |
| Theoretical friction angle net - block (neglecting lateral influence) | $\varphi_G$ [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] = | 39.2 |
| 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 | $n_o$ = | 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 | $Z_{od} <= Z_{R1d,tot}$ = | fulfilled! |

| Proof of local force transmission to the bottom | | |
|---|---|---|
| Proof of local force transmission to the bottom | $Z_{ud}$ [kN] = | 31.3 |
| Bearing resistance of the spiral rope net to local force transmission longitudinal | $Z_{R1}$ [kN] = | 60.0 |
| Resistance correction value for local force transmission | $\gamma_{ZR}$ [-] = | 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 | $n_u$ = | 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 | $Z_{ud} <= Z_{R1d,tot}$ = | fulfilled! |

| Proof of local force transmission laterally | | |
|---|---|---|
| Maximum tensile force in the net cover to be transmitted laterally on dimensioning level | $S_d$ [kN] = | 5.9 |
| 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 | $n_S$ [-] = | 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 | $S_d <= Z_{R2d,tot}$ = | 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] = | 3.4 |
| Shear stress in the nail at the top | $\tau_d$ [N/mm²] = $V_{od} / A_{(red)}$ = | 9.8 |
| Resistance correction value for shear stress | $\gamma_M$ [-] = | 1.1 |
| Maximum permissible shear stress | $\tau_{Rd} = f_y / (\sqrt{3} \cdot \gamma_M)$ = | 262.4 |
| Proof of bearing safety | $\tau_{Rd} \geq \tau_d$ | fulfilled! |

| Proof of combined stress in the nails at the 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 | $\sigma_{Nd}$ [N/mm²] = $N_{od} / A_{red} + M_{od} / W_{pl(red)}$ = | 77.8 |
| Combined stress in the nail at the top | $\sigma_d$ [N/mm²] = $(\sigma_{Nd}^2 + 3\ \tau_d^2)^{0.5}$ = | 79.6 |
| 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 (Zud / nu) | $V_{ud}$ [kN] = | 27.1 |
| Shear stress in the nail at the bottom | $\tau_d$ [N/mm²] = $V_{ud} / A_{(red)}$ = | 78.4 |
| Resistance correction value for shear stress | $\gamma_M$ [-] = | 1.1 |
| Maximum permissible shear stress | $\tau_{Rd} = f_y / (\sqrt{3} \cdot \gamma_M)$ = | 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 (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 | $\sigma_{Nd}$ [N/mm²] = $N_{ud} / A_{red} + M_{ud} / W_{pl(red)}$ = | 221.1 |
| Combined stress in the nail at the bottom | $\sigma_d$ [N/mm²] = $(\sigma_{Nd}^2 + 3\ \tau_d^2)^{0.5}$ = | 259.5 |
| 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! |

## ΠΑΡΑΡΤΗΜΑ Γ9

Ογκόλιθος "Χ23". 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

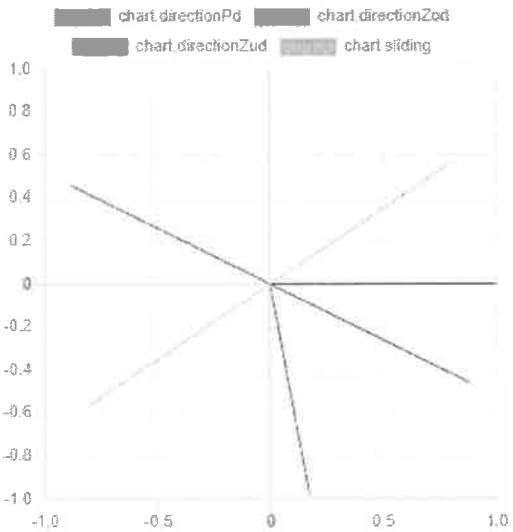
Project No.

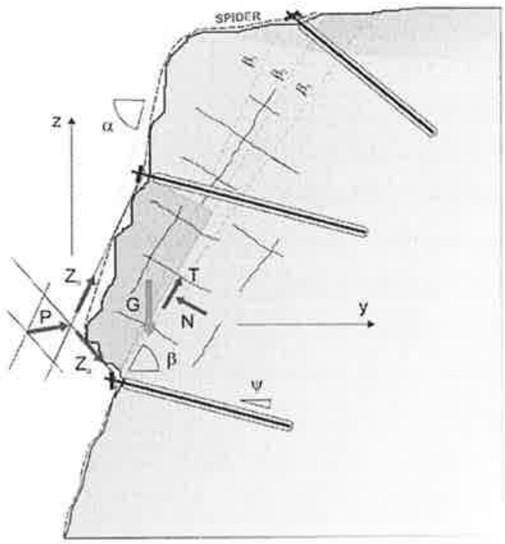
Project name

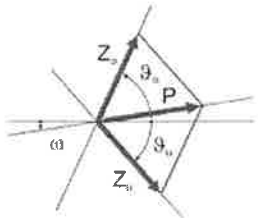
Date/Author

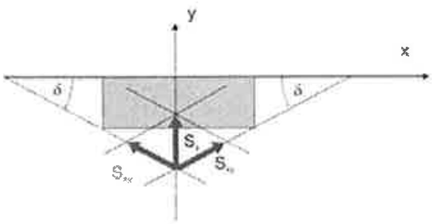
| Weight Geometry | | | |
|---|---|---|---|
| Block weight (characteristic value) | G = | 155 | kN |
| Inclination of the sliding plane to horizontal | $\beta$ = | 35 | degrees |
| Angle of the top restraint to horizontal | $\vartheta_o$ = | 0 | degrees |
| Angle of the bottom restraint to horizontal | $\vartheta_u$ = | 80 | degrees |
| Ratio Zu : Zo | $\eta$ = | 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 : Zo | $\zeta$ = | 20 | % |

| Geotechnical parameters | | | |
|---|---|---|---|
| Friction angle (characteristic value) | $\varphi_k$ = | 37 | degrees |
| Cohesion (characteristic value) | $c_k$ = | 0 | kN/m² |
| Cohesion related area | A = | 0 | m² |

| 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 | $\eta_o$ = | 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 | $\varepsilon_h$ = | 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 | $W_h$ = | 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 | $Z_{R1}$ [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/mm²]= | 500 |
| Cross-section with / without rusting away | $A_{(red)}$ [mm²]= | 346 |
| Plastic section modulus | $W_{pl(red)}$ [mm³]= | 1544 |
| Bearing resistance of the nail to tensile stress | $T_{R(red)}$ [kN]= | 173 |
| Bearing resistance of the nail to shear stress | $S_{R(red)}$ [kN]= | 100 |

## Calculated values

| | | |
|---|---|---|
| Resultant stabilizing force P, on dimensioning level | $P_d$ [kN] = | 8.2 |
| Force in the net cover, to be transmitted to the top, on dimensioning level | $Z_{od}$ [kN] = | 4.8 |
| Force in the net cover, to be transmitted to the bottom, on dimensioning level | $Z_{ud}$ [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 | $\vartheta = \vartheta_o + \vartheta_u$ [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] = | 4.8 |
| 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 | $Z_{od} <= Z_{R1d,tot}$ = | fulfilled! |

## Proof of local force transmission to the bottom

| | | |
|---|---|---|
| Proof of local force transmission to the bottom | $Z_{ud}$ [kN] = | 3.8 |
| 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 | $n_u$ = | 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 | $Z_{ud} <= Z_{R1d,tot}$ = | fulfilled! |

## Proof of local force transmission laterally

| | | |
|---|---|---|
| Maximum tensile force in the net cover to be transmitted laterally on dimensioning level | $S_d$ [kN] = | 1.0 |
| 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 | $S_d <= Z_{R2d,tot}$ = | 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] = | 0.8 |
| Shear stress in the nail at the top | $\tau_d$ [N/mm$^2$] = $V_{od}$ / $A_{Nett}$ = | 2.4 |
| Resistance correction value for shear stress | $\gamma_M$ [-] = | 1.1 |
| Maximum permissible shear stress | $\tau_{Rd} = f_y / (\sqrt{3} \cdot \gamma_M)$ = | 262.4 |
| Proof of bearing safety | $\tau_{Rd} \geq \tau_d$ | fulfilled! |

| Proof of combined stress in the nails at the top | | |
|---|---|---|
| Tensile load in the nail at the top as a result of the force (Zod / no) | $N_{od}$ [kN] = | 4.7 |
| Moment as a result of the eccentric acting force (Zod / no) | $M_{od}$ [kNm] = | 0.0 |
| Normal stress in the nail at the top | $\sigma_{Nd}$ [N/mm²] = $N_{od} / A_{(red)} + M_{od} / W_{pl(red)}$ = | 19.0 |
| Combined stress in the nail at the top | $\sigma_d$ [N/mm²] = $(\sigma_{Nd}^2 + 3\,\tau_d^2)^{0.5}$ = | 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 (Zud / nu) | $V_{ud}$ [kN] = | 3.6 |
| Shear stress in the nail at the bottom | $\tau_d$ [N/mm²] = $V_{ud} / A_{(red)}$ = | 10.4 |
| Resistance correction value for shear stress | $\gamma_M$ [-] = | 1.1 |
| Maximum permissible shear stress | $\tau_{Rd} = f_y / (\sqrt{3} \cdot \gamma_M)$ = | 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 (Zud / nu) | $N_{ud}$ [kN] = | 1.3 |
| Moment as a result of the eccentric acting force (Zud / nu) | $M_{ud}$ [kNm] = | 0.0 |
| Normal stress in the nail at the bottom | $\sigma_{Nd}$ [N/mm²] = $N_{ud} / A_{(red)} + M_{ud} / W_{pl(red)}$ = | 27.1 |
| Combined stress in the nail at the bottom | $\sigma_d$ [N/mm²] = $(\sigma_{Nd}^2 + 3\,\tau_d^2)^{0.5}$ = | 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

GEOBRUGG BRUGG
Safety is our nature

# SPIDER® ONLINE-TOOL

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

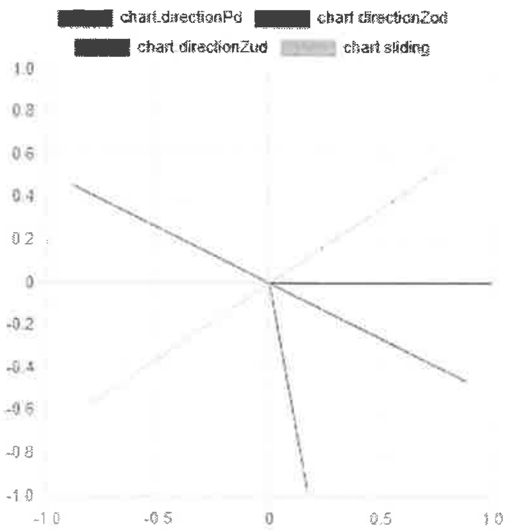
Project No.

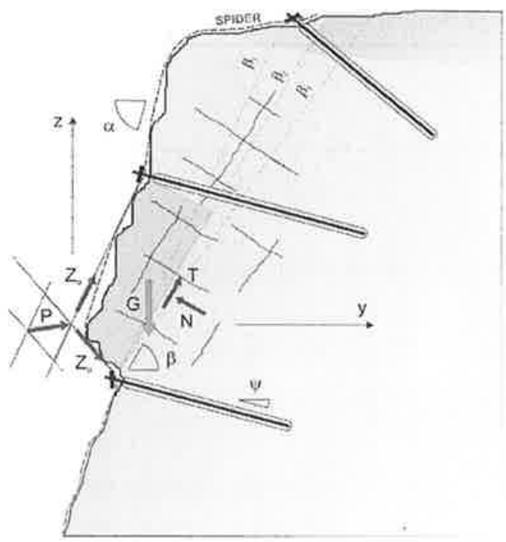
Project name

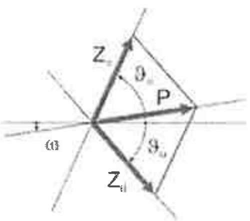
Date/Author

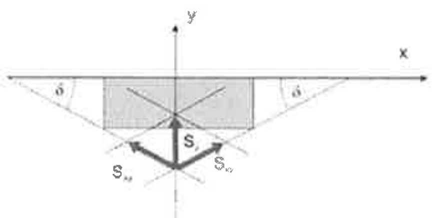
| Weight Geometry | | | |
|---|---|---|---|
| Block weight (characteristic value) | G = | 155 | kN |
| Inclination of the sliding plane to horizontal | β = | 35 | degrees |
| Angle of the top restraint to horizontal | $\vartheta_o$ = | 0 | degrees |
| Angle of the bottom restraint to horizontal | $\vartheta_u$ = | 80 | degrees |
| Ratio Zu : Zo | η = | 80 | % |

| Lateral influence | | | |
|---|---|---|---|
| Angle of the lateral restraint to horizontal related to vertical plane | δ = | 70 | degrees |
| Angle of the resultant, lateral restraint in line of slope | χ = | 0 | degrees |
| Ratio S : Zo | ζ = | 20 | % |

| Geotechnical parameters | | | |
|---|---|---|---|
| Friction angle (characteristic value) | $\varphi_k$ = | 37 | degrees |
| Cohesion (characteristic value) | $c_k$ = | 0 | kN/m² |
| Cohesion related area | A = | 0 | m² |

| 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 | $\varepsilon_h$ = | 0 | - |
| Coefficient of vertical acceleration due to earthquake | $\varepsilon_v$ = | 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/mm²]= | 500 |
| Cross-section with / without rusting away | $A_{(red)}$ [mm²]= | 346 |
| Plastic section modulus | $W_{pl(red)}$ [mm³]= | 1544 |
| Bearing resistance of the nail to tensile stress | $T_{R(red)}$ [kN]= | 173 |
| Bearing resistance of the nail to shear stress | $S_{R(red)}$ [kN]= | 100 |

| Calculated values | | |
|---|---|---|
| Resultant stabilizing force P, on dimensioning level | $P_d$ [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 | $Z_{ud}$ [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 | $\vartheta = \vartheta_u + \vartheta_o$ [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 | $\gamma_{ZR}$ [-] = | 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 | $Z_{od} <= Z_{R1d,tot}$ = | fulfilled! |

| Proof of local force transmission to the bottom | | |
|---|---|---|
| Proof of local force transmission to the bottom | $Z_{ud}$ [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 | $\gamma_{ZR}$ [-] = | 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 | $n_u$ = | 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 | $Z_{ud} <= Z_{R1d,tot}$ = | fulfilled! |

| Proof of local force transmission laterally | | |
|---|---|---|
| Maximum tensile force in the net cover to be transmitted laterally on dimensioning level | $S_d$ [kN] = | 1.4 |
| Bearing resistance of the spiral rope net to local force transmission transversal | $Z_{R2}$ [kN] = | 45.0 |
| Resistance correction value for local force transmission | $\gamma_{ZR}$ [-] = | 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 | $S_d <= Z_{R2d,tot}$ = | 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] = | 1.2 |
| Shear stress in the nail at the top | $\tau_d$ [N/mm²] = $V_{od} / A_{(red)}$ = | 3.6 |
| Resistance correction value for shear stress | $\gamma_M$ [-] = | 1.1 |
| Maximum permissible shear stress | $\tau_{Rd} = f_y / (\sqrt{3} \cdot \gamma_M)$ = | 262.4 |
| Proof of bearing safety | $\tau_{Rd} \geq \tau_d$ | fulfilled! |

| Proof of combined stress in the nails at the top | | |
|---|---|---|
| Tensile load in the nail at the top as a result of the force (Zod / no) | $N_{ud}$ [kN] = | 7.0 |
| Moment as a result of the eccentric acting force (Zod / no) | $M_{ud}$ [kNm] = | 0.0 |
| Normal stress in the nail at the top | $\sigma_{Nd}$ [N/mm²] = $N_{ud} / A_{red} + M_{ud} / W_{pl(red)}$ = | 28.1 |
| Combined stress in the nail at the top | $\sigma_d$ [N/mm²] = $(\sigma_{Nd}^2 + 3\,\tau_d^2)^{0.5}$ = | 28.8 |
| 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 (Zud / nu) | $V_{ud}$ [kN] = | 5.3 |
| Shear stress in the nail at the bottom | $\tau_d$ [N/mm²] = $V_{ud} / A_{red}$ = | 15.4 |
| Resistance correction value for shear stress | $\gamma_M$ [-] = | 1.1 |
| Maximum permissible shear stress | $\tau_{Rd} = f_y / (\sqrt{3} \cdot \gamma_M)$ = | 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 (Zud / nu) | $N_{ud}$ [kN] = | 1.9 |
| Moment as a result of the eccentric acting force (Zud / nu) | $M_{ud}$ [kNm] = | 0.1 |
| Normal stress in the nail at the bottom | $\sigma_{Nd}$ [N/mm²] = $N_{ud} / A_{red} + M_{ud} / W_{pl(red)}$ = | 40.1 |
| Combined stress in the nail at the bottom | $\sigma_d$ [N/mm²] = $(\sigma_{Nd}^2 + 3\,\tau_d^2)^{0.5}$ = | 48.1 |
| 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 3

# SPIDER® ONLINE-TOOL

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

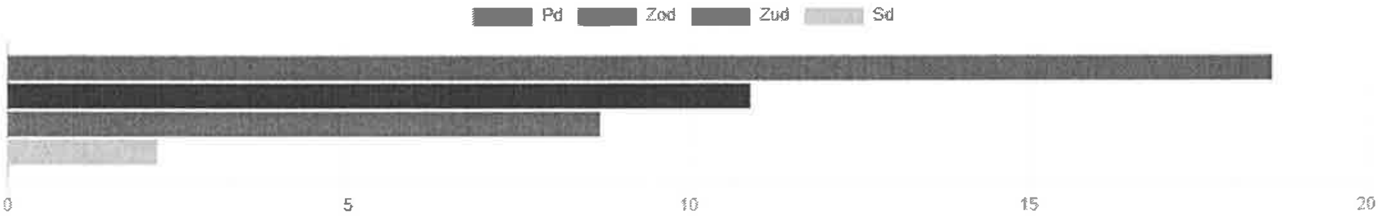
Project No.

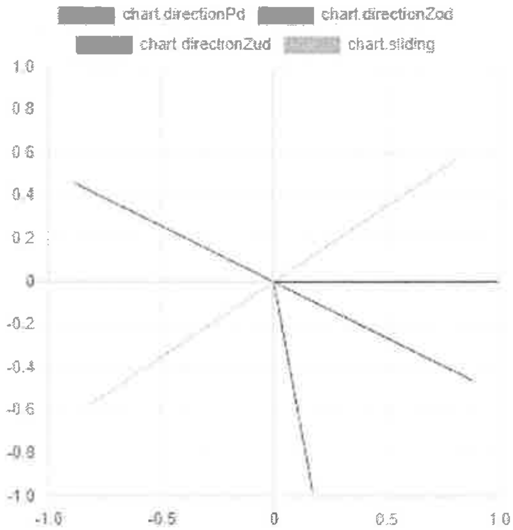
Project name

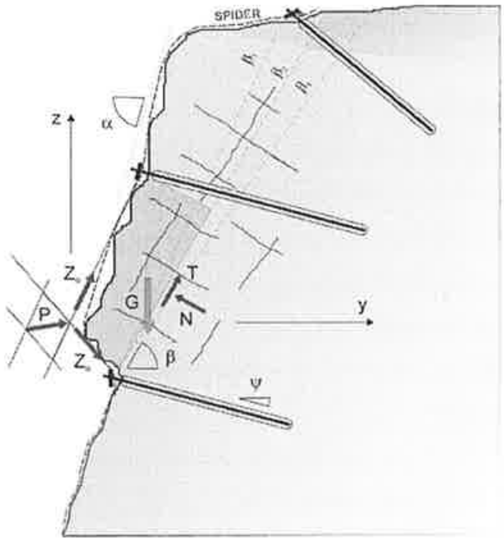
Date/Author

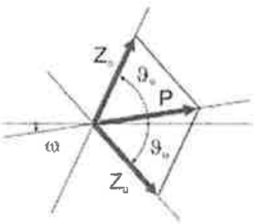
| Weight.Geometry | | | |
|---|---|---|---|
| Block weight (characteristic value) | G = | 155 | kN |
| Inclination of the sliding plane to horizontal | $\beta$ = | 35 | degrees |
| Angle of the top restraint to horizontal | $\vartheta_o$ = | 0 | degrees |
| Angle of the bottom restraint to horizontal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

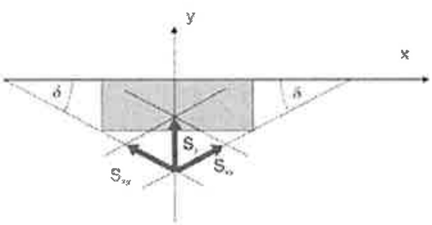
| Lateral influence | | | |
|---|---|---|---|
| Angle of the lateral restraint to horizontal related to vertical plane | $\delta$ = | 70 | degrees |
| Angle of the resultant, lateral restraint in line of slope | $\chi$ = | 0 | degrees |
| Ratio S : Zo | $\zeta$ = | 20 | % |



GEOBRUGG BRUGG
Safety is our nature

| Geotechnical parameters | | | |
|---|---|---|---|
| Friction angle (characteristic value) | $\varphi_k$ = | 37 | degrees |
| Cohesion (characteristic value) | $c_k$ = | 0 | kN/m² |
| Cohesion related area | A = | 0 | m² |

| 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 | $\eta_o$ = | 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 | $\varepsilon_h$ = | 0 | - |
| Coefficient of vertical acceleration due to earthquake | $\varepsilon_v$ = | 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 | $Z_{R1}$ [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 | ψ [degrees] = | 10 |
| Maximum excentricity of the load to be transferred onto the nail at the top / bottom | ξ [m] = | 0.01 |
| Yield stress of the nail | $f_y$ [N/mm²]= | 500 |
| Cross-section with / without rusting away | $A_{(red)}$ [mm²]= | 346 |
| Plastic section modulus | $W_{pl(red)}$ [mm³]= | 1544 |
| Bearing resistance of the nail to tensile stress | $T_{R(red)}$ [kN]= | 173 |
| Bearing resistance of the nail to shear stress | $S_{R(red)}$ [kN]= | 100 |

| Calculated values | | |
|---|---|---|
| Resultant stabilizing force $P_d$ on dimensioning level | $P_d$ [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 | $Z_{ud}$ [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 | $\vartheta = \vartheta_u + \vartheta_o$ [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] = | 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 | $Z_{od} <= Z_{R1d,tot}$ = | fulfilled! |

| Proof of local force transmission to the bottom | | |
|---|---|---|
| Proof of local force transmission to the bottom | $Z_{ud}$ [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 | $n_u$ = | 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 | $Z_{ud} <= Z_{R1d,tot}$ = | 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 | $S_d <= Z_{R2d,tot}$ = | 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/mm²] = $V_{od} / A_{(red)}$ = | 4.8 |
| Resistance correction value for shear stress | $\gamma_M$ [-] = | 1.1 |
| Maximum permissible shear stress | $\tau_{Rd} = f_y / (\sqrt{3} \cdot \gamma_M)$ = | 262.4 |
| Proof of bearing safety | $\tau_{Rd} \geq \tau_d$ | fulfilled! |

| Proof of combined stress in the nails at the 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 | $\sigma_{No}$ [N/mm²] = $N_{od} / A_{(red)} + M_{od} / W_{pl(red)}$ = | 37.8 |
| Combined stress in the nail at the top | $\sigma_d$ [N/mm²] = $(\sigma_{No}^2 + 3\,\tau_d^2)^{0.5}$ = | 38.7 |
| 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 (Zud / nu) | $V_{ud}$ [kN] = | 7.2 |
| Shear stress in the nail at the bottom | $\tau_d$ [N/mm²] = $V_{ud} / A_{(red)}$ = | 20.7 |
| Resistance correction value for shear stress | $\gamma_M$ [-] = | 1.1 |
| Maximum permissible shear stress | $\tau_{Rd} = f_y / (\sqrt{3} \cdot \gamma_M)$ = | 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 (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 | $\sigma_{Nu}$ [N/mm²] = $N_{ud} / A_{(red)} + M_{ud} / W_{pl(red)}$ = | 53.9 |
| Combined stress in the nail at the bottom | $\sigma_d$ [N/mm²] = $(\sigma_{Nd}^2 + 3\,\tau_d^2)^{0.5}$ = | 64.8 |
| 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! |