RUVOLUM®

Software Manual

Dimensioning tool for the TECCO® / SPIDER® slope and rock stabilization system

Date: 11.03.2024

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Safety is our nature

PREFACE

Geobrugg AG, Geohazard Solutions, is grateful to you for using the RUVOLUM® Online Tool software. Every effort is made to give you the best possible support in the dimensioning of the TECCO® / SPIDER® slope and rock stabilization system.

RUVOLUM® offers the possibility of considering streaming pressure and accelerations due to earthquake in horizontal as well as in vertical direction. The calculations can be done based on International as well as American Units in English and several other languages.

This manual provides you with the most important references and function descriptions to enable you to use the program correctly. The aim has been to develop a program which, despite its complexity of structure and application, is as clear and straightforward as possible as far as aspects of graphic presentation and user-friendliness are concerned.

Numerous parameters need to be entered for the dimensioning operations. It is the responsibility of the user of this program to select and enter these parameters correctly.

Armin Roduner
Geobrugg AG
March 2024

PRODUCT LIABILITY CLAUSE OF GEOBRUGG AG, GEOHARD SOLUTIONS

Rockfall, landslides, debris flows or avalanches are sporadic and unpredictable. Causes can be e.g. human (construction, etc.) or environmental (weather, earthquakes, etc.). Due to the multiplicity of factors affecting such events it is not and cannot be an exact science that guarantees the safety of individuals and property.

However, by the application of sound engineering principles to a predictable range of parameters and by the implementation of correctly designed protection measures in identified risk areas the risks of injury and loss of property can be reduced substantially.

Inspection and maintenance of such systems are an absolute requirement to ensure the desired protection level. The system safety can also be impaired by events such as natural disasters, inadequate dimensioning parameters or failure to use the prescribed standard components, systems and original parts; and/or corrosion (caused by pollution of the environment or other man-made factors as well as other external influences).

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1. INTRODUCTION

The software RUVOLUM® Online Tool serves to dimension the TECCO® slope stabilization system consisting of the high-tensile steel wire mesh TECCO® G45/2, TECCO® G65/3 and TECCO® G65/4 with a wire diameter of 2.0, 3.0, respectively 4.0 mm and a mesh width of 45 respectively 65 mm, system spike plates P25, P33 and P66 and adequate nailing.

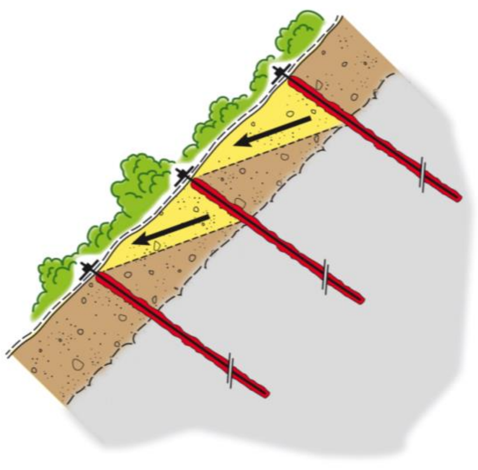
Furthermore, with software the SPIDER® rock protection system consisting of the high-tensile spiral rope net SPIDER® S3-130 with a strand diameter of 6.5 mm and a mesh width of 130 mm, system spike plates P33 and P66, can be dimensioned.

The software is based on the homonymous RUVOLUM® concept. This concept is basically applicable to all slope stabilization systems which are commonly available on the market and which allow for a flexible application of the nails both horizontally and in the line of the slope.

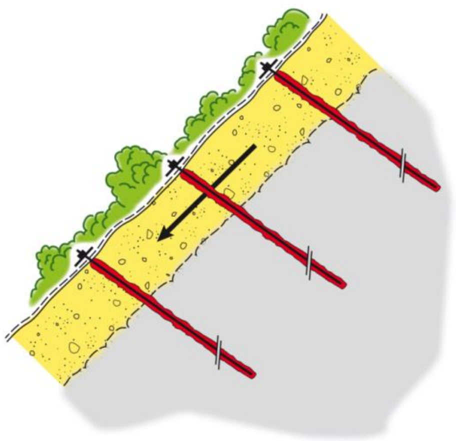
The RUVOLUM® concept investigates both simple wedge-shaped and composite mechanisms liable to break out from the area close to the surface between the individual nails down to a depth of approximately 1.5 to 2.0 m maximum. It can be applied to soil slopes as well as superficially and heavily disintegrated, loosened or weathered rock slopes.

If, depending on the prevailing geological circumstances, potential sliding surfaces exist at deeper levels, the overall stability of the slope must be analyzed in addition to the investigation of the instabilities close to the surface, and the protection measures must be dimensioned accordingly.

In-depth information about the dimensioning concept (model approach, sliding mechanisms, equilibrium relationships and equations) and about the application of flexible slope stabilization systems in soil as well as strongly weathered, loosened rock slopes is provided in the *Summary of Published Technical Papers in the Period of 1998 – 2019*.



Investigation of local, simple, wedge-shaped as well as composite instabilities between the individual nails in the RUVOLUM® concept



Investigation of slope-parallel instabilities near the surface in the RUVOLUM® concept

2. PURPOSE OF THE SLOPE STABILIZATION SYSTEM

The purpose of the TECCO® and SPIDER® slope stabilization system is to stabilize instabilities close to the surface and, depending on the prevailing subsoil circumstances and where applicable, also fault mechanisms with deeper sliding surfaces. Within the framework of the present explanations the investigations are limited to the area near the surface.

For the individual proofs of bearing safety, it is necessary to determine the maximum stress on the system. These stresses are established by the investigation of the equilibriums of simple wedge-shaped as well as composite faults. By a concept adapted to the case on hand and correct dimensioning it must be guaranteed that the slope stabilization system is able to absorb the occurring stresses and that, with the appropriate safety factors considered; it can pass them on to the stable subsoil outside the instability under examination.

If the slope stabilization system is planned as a permanent solution (which is normally the case), it must be guaranteed that the system can absorb the determined maximum stresses during the construction's entire life span. Reference is made in the technical literature on the TECCO® and SPIDER® system concerning protection against corrosion.

If the subsoil is prone to weathering, additional measures may have to be taken to oppose further loosening and erosion. One possible measure is to cover the surface with an erosion protection mat before the steel wire mesh is laid out and to suitably green the protected slope after completion of the installation work.

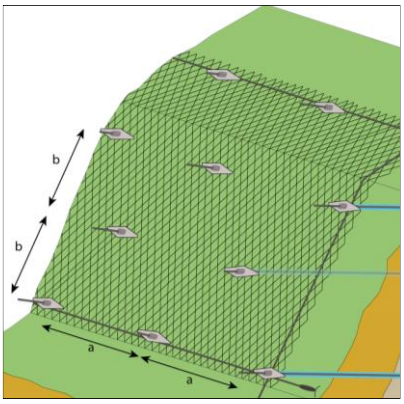
3. FUNDAMENTALS

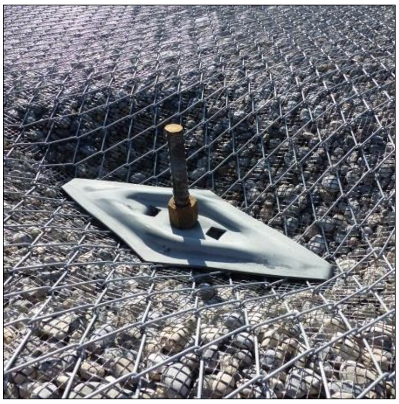
The TECCO® and SPIDER® slope stabilization system is a flexible system with a static function. Corresponding deformations of the subsoil are required before the system can display its maximum stabilizing effect. This must be kept in mind especially in the case of constructions which do not allow any or only a minor deformation such as e.g. in the area of the road edge on the downslope side. Under certain circumstances additional measures with a stiffening effect may be required, for example a concrete bar in combination with infiltration dowelling.

With the TECCO® respectively SPIDER® slope stabilization system each row of nails must be offset by half a horizontal distance between nails in relation to the next row. In this way, the maximum possible bodies liable to break out between the individual nails are clearly defined. This forms the basis for the RUVOLUM® concept. The horizontal distance between nails is denoted by parameter 'a' and the one in the direction of fall by 'b'. With older protection systems, the type of nail arrangement was often influenced by the actual type of mesh or rope net cover. The nails were usually positioned in a staggered pattern.

The concept underlying the TECCO® and SPIDER® system is such that the system can be tensioned actively with a certain force V against the subsoil to be stabilized. This is affected by tightening of the nuts with the aid of a torque spanner or by means of a suitable feed press, i.e. by pressing the spike plates firmly onto or slightly into the ground. Optimal tensioning of the slope stabilizing system can be achieved if the area around the nail head is slightly recessed. If the mortar reaches too far up the nail, with the result that the system cannot be tensioned at all or only insufficiently, it must be chipped away to the appropriate level right around the nail. In the RUVOLUM® concept the force V is considered in the investigation of slope-parallel instabilities as an outer force with a stabilizing effect and can be selected variably.

For further application-technical information reference is made here to the system manual of the TECCO® and SPIDER® system.





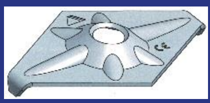

4. ELEMENTS OF THE SLOPE STABILIZATION SYSTEM

The slope stabilization system consists of the high-tensile steel wire mesh TECCO® / SPIDER®, the system spike plate and a corresponding nailing.

The high-tensile steel wire mesh TECCO® and the high-tensile spiral rope net SPIDER®

	TECCO® G45/2	TECCO® G45/2 STAIN-LESS	TECCO® G65/3	TECCO® G65/3 STAIN-LESS	TECCO® G65/4	SPIDER® S3-130
Diagonal [mm] [in]	62 x 95 2.44 x 3.74	62 x 95 2.44 x 3.74	83 x 143 3.27 x 5.63	83 x 143 3.27 x 5.63	83 x 138 3.27 x 5.44	164 x 270 6.46 x 10.64
Mesh width [mm] [in]	48 1.89	48 1.89	65 2.56	65 2.56	63 2.48	130 5.12
Wire diameter [mm] [in]	2 0.079	2 0.079	3 0.118	3 0.118	4 0.158	3 0.118
Tensile strength of the steel wire [N/mm²] [ksi]	≥ 1‘770 ≥ 256	≥ 1‘650 ≥ 239	≥ 1‘770 ≥ 256	≥ 1‘650 ≥ 239	≥ 1‘770 ≥ 256	≥ 1‘770 ≥ 256
Tensile strength of the mesh [kN/m] [kips/ft]	≥ 85 ≥ 5.7	≥ 75 ≥ 5.7	≥ 150 ≥ 10.2	≥ 140 ≥ 9.5	≥ 250 ≥ 17.1	≥ 220 ≥ 15.1
Bearing re-sistances	Spike plate P25 / P33	Spike plate P33	Spike plate P33 / P66	Spike plate P33	Spike plate P33 / P66	Spike plate P33 / P66
Bearing resistance of the mesh against puncturing D_R [kN] [kips]	80 / 110 18.0 / 24.7	100 22.5	180 / 240 40.5 / 54.0	170 38.2	280 / 370 62.9 / 83.2	230 / 300 51.7 / 67.4
Bearing resistance of the mesh against shearing-off at the upslope edge of the spike plate P_R [kN] [kips]	40 / 55 9.0 / 12.4	50 11.2	90 / 120 20.2 / 27.0	85 19.1	140 / 185 31.5 / 41.6	115 / 150 25.9 / 33.7
Bearing resistance of the mesh against slope-parallel ten-sile stress Z_R [kN] [kips]	10 / 10 2.2 / 2.2	10 2.2	30 / 45 6.7 / 10.1	25 5.6	50 / 75 11.2 / 16.9	45 / 70 10.1 / 15.7

The system spike plate

	Spike plate P25 	Spike plate P33 	Spike plate P66 
Basic shape	diamond-shaped	diamond-shaped	diamond-shaped
Length [mm] [in]	250 9.9	330 13.0	667 26.3
Width [mm] [in]	155 6.1	205 8.1	300 11.8
Thickness [mm] [in]	5 0.2	7 0.3	7 0.3
Hole diameter [mm] [in]	34 1.3	40 / 50 1.6 / 2.0	50 2.0

Two lengthwise bridges in the spike plate serve to increase the plate's bending resistance and to guide the optional boundary ropes. Ball-type nuts should be used to secure the spike plates.

Soil or rock nails

The following nail types can be used as soil or rock nails:

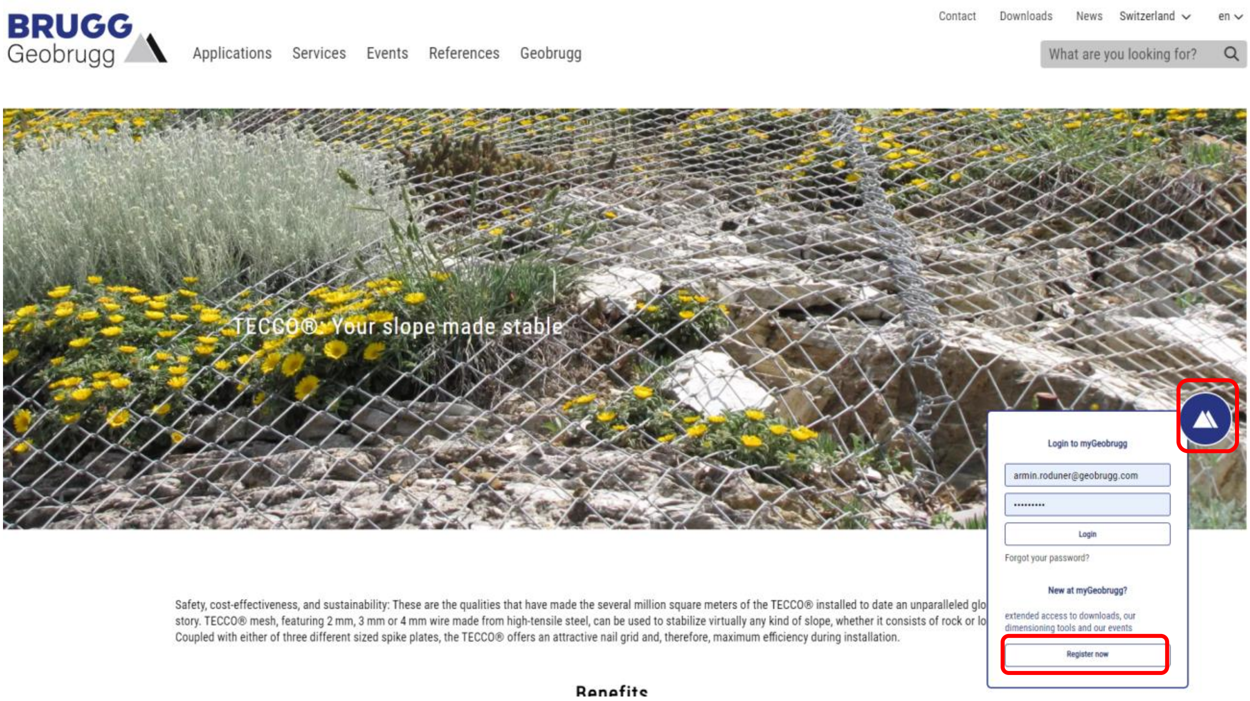
- GEWI D = 20 mm, DYWIDAG D = 20 mm (Grade 75)
- GEWI D = 25 mm, DYWIDAG D = 25 mm (Grade 75)
- GEWI D = 28 mm, DYWIDAG D = 28 mm (Grade 75)
- GEWI D = 32 mm, DYWIDAG D = 32 mm (Grade 75)
- GEWI D = 40 mm, DYWIDAG D = 40 mm (Grade 75)
- TITAN 30/11, TITAN 40/16, IBO R32, IBO R38, IBO R51

Alternatively, other nail types can be used if suited. In principle, each nail must satisfy the static proofs. Additionally, the nail diameter and the corresponding (ball) nut must be matched to the whole diameter of the system spike plate. A suitable corrosion protection must be envisaged for the nail as a permanent measure, unless rusting away of usually 4.0 mm (= 0.158 in) with reference to the nail's diameter is considered.

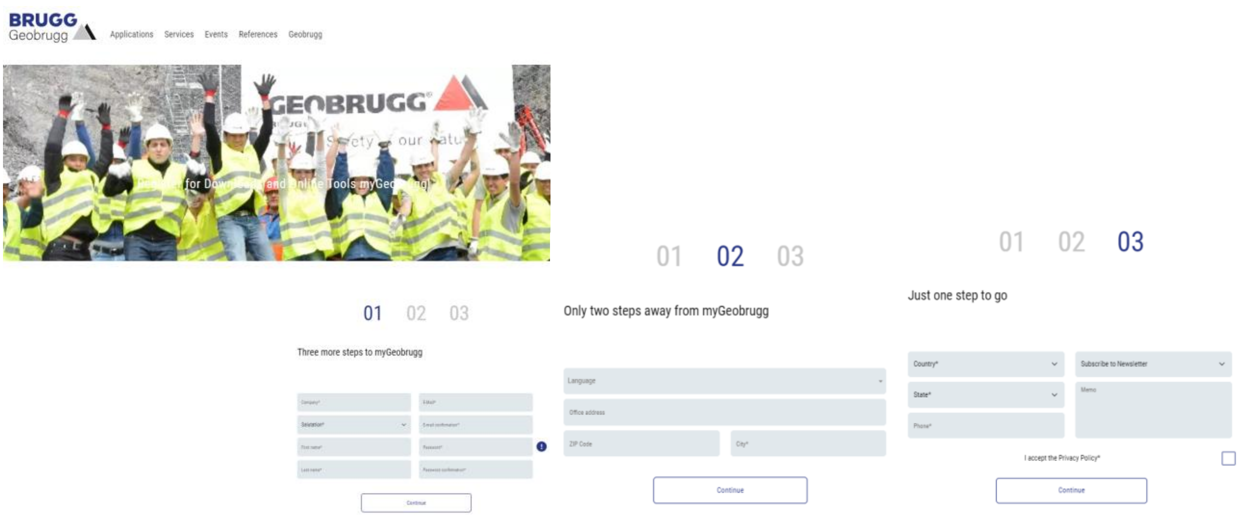
5. ACCESS TO THE ONLINE-TOOL

Our homepage www.geobrugg.com offers the access to the online software.

After clicking on the top right corner to “myGeobrugg” the below shown window appears, which offers the possibilities of the first-time personal registration, the Login and the function of the delivery of the forgotten password per e-mail.



If the program is used the first time one must click on “register here" and the registration form with the 3 steps should be filled out once. Afterwards one will get the personal username and password automatically sent per e-mail.



With the so gotten personal login it can be logged in to “myGeobrugg”.

One can choose between the following dimensioning software packages:

ATTERO

The dimensioning program for flexible attenuator systems in German and English.

RUVOLUM® Online Tool

The dimensioning tool for the TECCO® and SPIDER® slope stabilization system, in German, English, Spanish, Polish, Portuguese, Romanic, Russian, Chinese, Turkish, French and Italian.

DEBFLOW

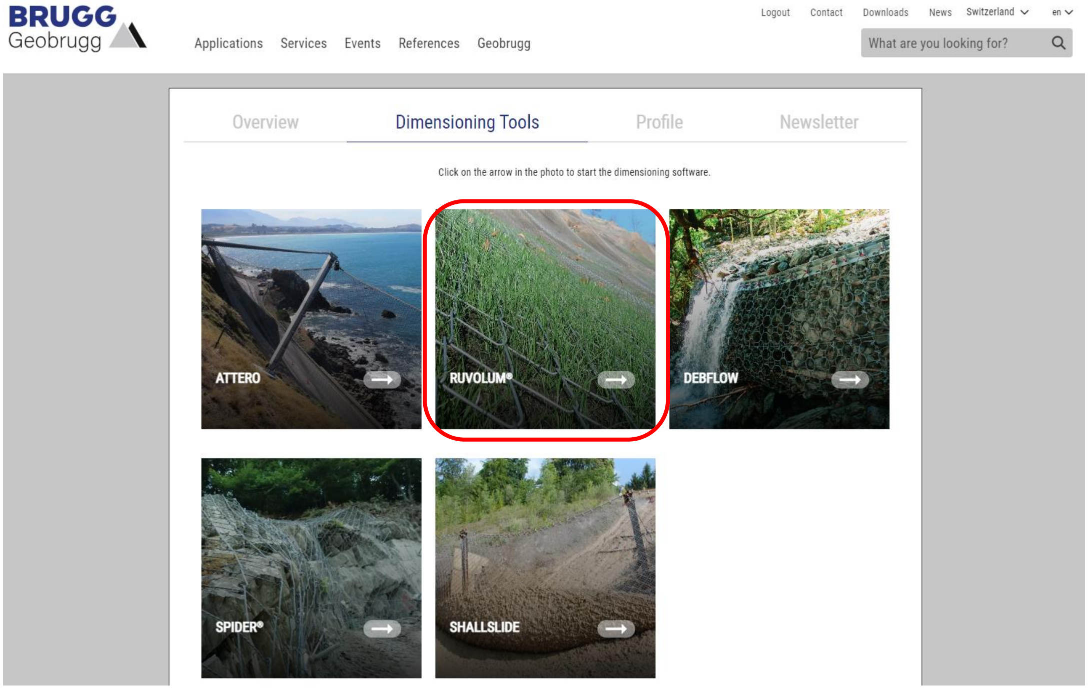
The dimensioning tool for flexible ring net barriers against debris flows, in German, English, Spanish, French, Russian, Chinese and Italian.

SPIDER®

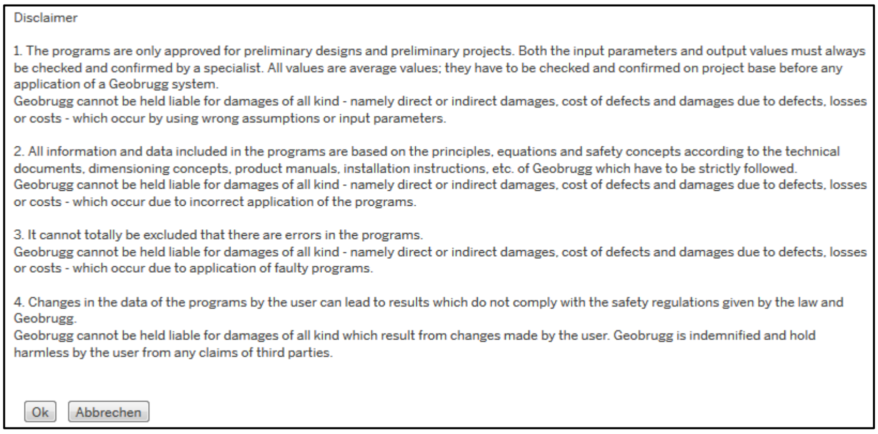
The dimensioning tool for the SPIDER® rock protection system in German and English.

SHALLSLIDE

The dimensioning tool for flexible barriers against shallow landslides in German and English.



When starting the online tool, there is first a disclaimer to be accepted:



Disclaimer

1. The programs are only approved for preliminary designs and preliminary projects. Both the input parameters and output values must always be checked and confirmed by a specialist. All values are average values; they have to be checked and confirmed on project base before any application of a Geobrugg system.
Geobrugg cannot be held liable for damages of all kind - namely direct or indirect damages, cost of defects and damages due to defects, losses or costs - which occur by using wrong assumptions or input parameters.

2. All information and data included in the programs are based on the principles, equations and safety concepts according to the technical documents, dimensioning concepts, product manuals, installation instructions, etc. of Geobrugg which have to be strictly followed.
Geobrugg cannot be held liable for damages of all kind - namely direct or indirect damages, cost of defects and damages due to defects, losses or costs - which occur due to incorrect application of the programs.

3. It cannot totally be excluded that there are errors in the programs.
Geobrugg cannot be held liable for damages of all kind - namely direct or indirect damages, cost of defects and damages due to defects, losses or costs - which occur due to application of faulty programs.

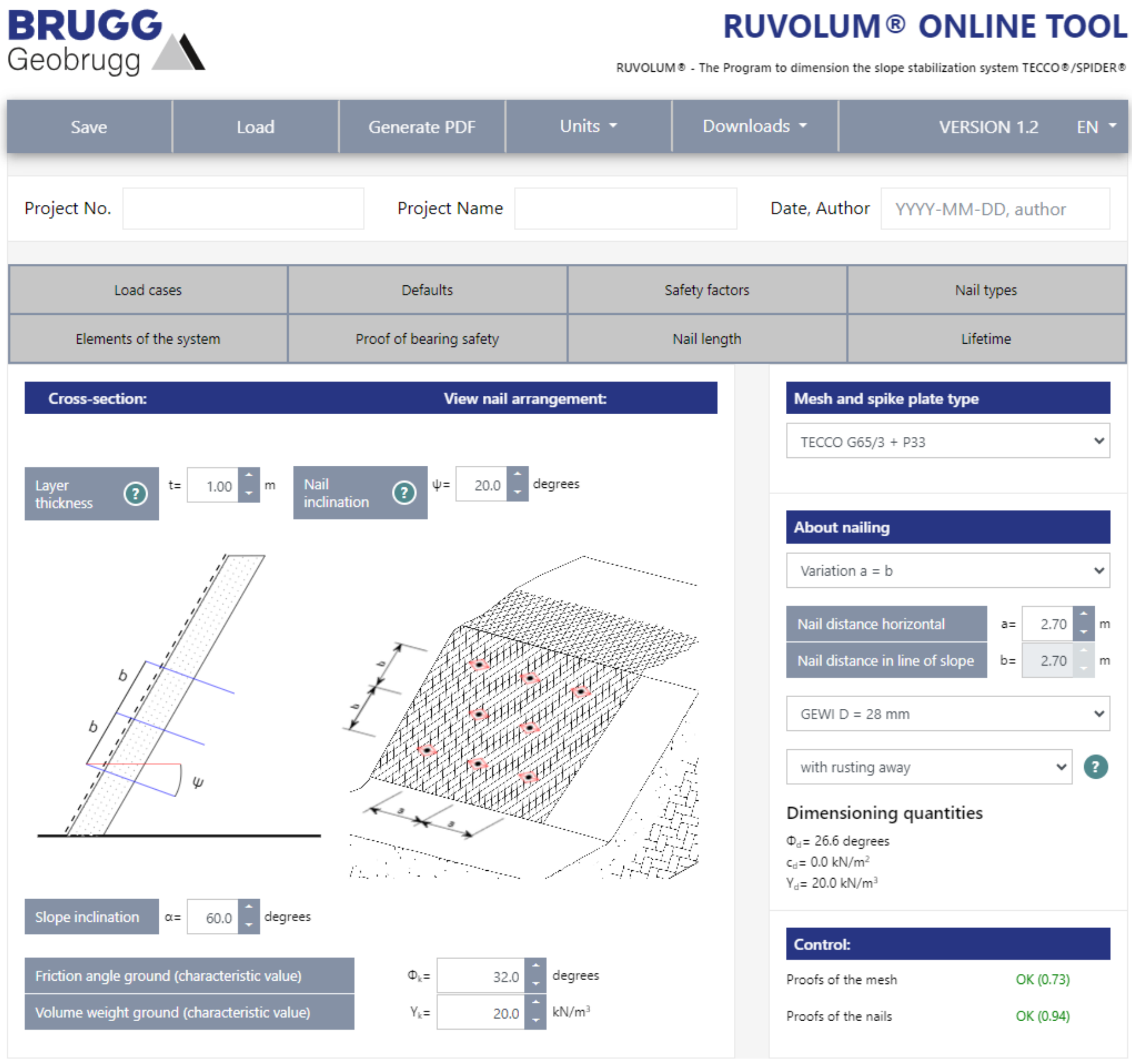
4. Changes in the data of the programs by the user can lead to results which do not comply with the safety regulations given by the law and Geobrugg.
Geobrugg cannot be held liable for damages of all kind which result from changes made by the user. Geobrugg is indemnified and hold harmless by the user from any claims of third parties.

Ok Abbrechen

There is no installation of the software on the user's computer neither necessary nor possible. The software has to be used online only.

Every calculation can be stored as a json or pdf file with all information included.

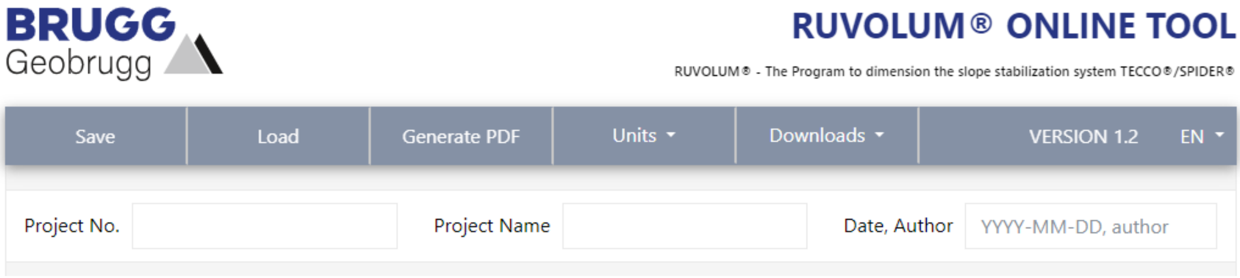
6. STRUCTURE OF THE PROGRAM



Window after entering the software

Starting window:

Main tabs on top:



Save: For saving the project on your computer.

Load: It allows you to load the saved projects.

Generate pdf: To generate a PDF and print it out.

Units: You can choose between the International Units or the American Units.

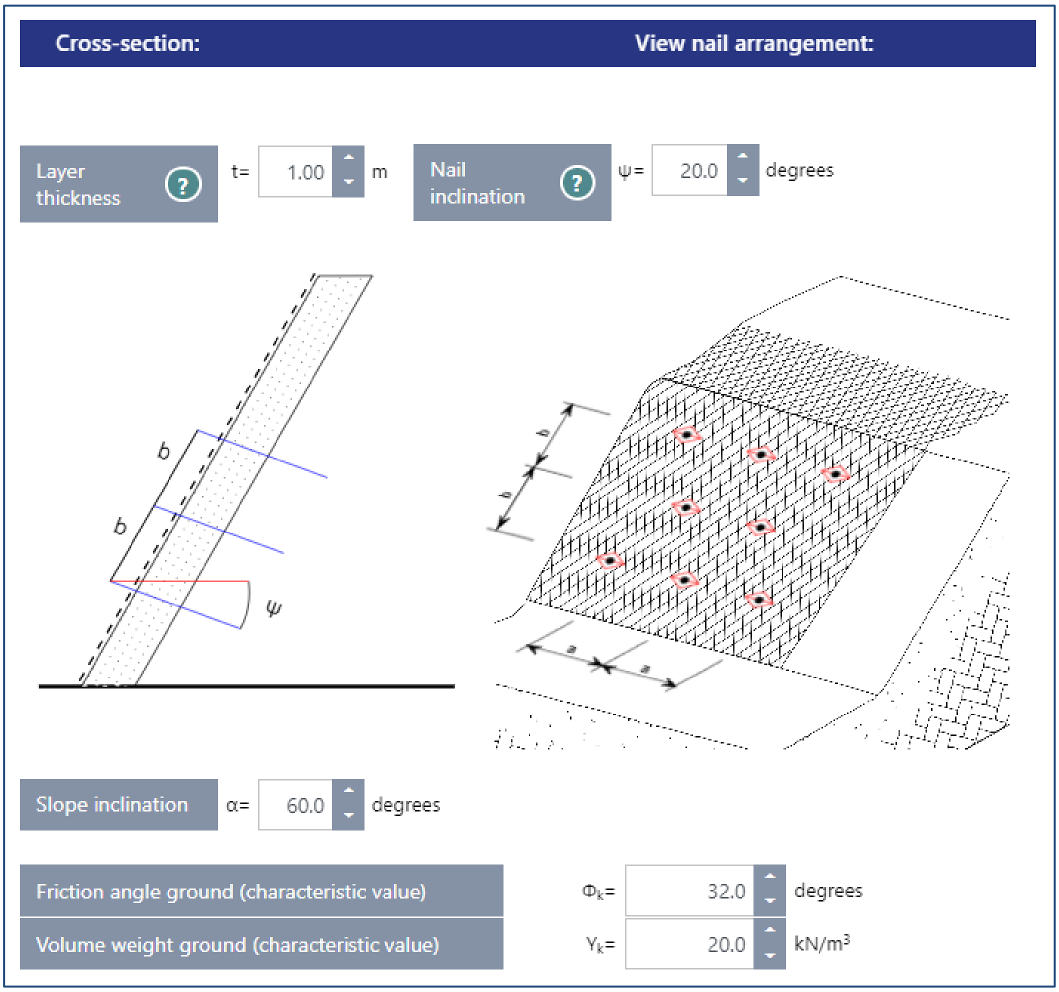
Language: Choose between German, English, Spanish, Polish, Portuguese, Romanic, Russian, Chinese, Turkish, Italian and French languages.

In the area below information about the project and the author can be put in which are than on the printout in the head area visible afterwards.

Area at left of the starting window

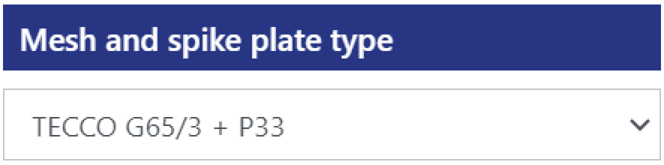
The main parameters for a calculation are directly visual in the starting window and can be adapted there.

These are the following parameters: Layer thickness „t“, slope inclination α, nail inclination to horizontal ψ, as well as the characteristic values for the friction angle and the volume weight for the ground. They can be overwritten in the field or adjusted by clicking with the mouse.

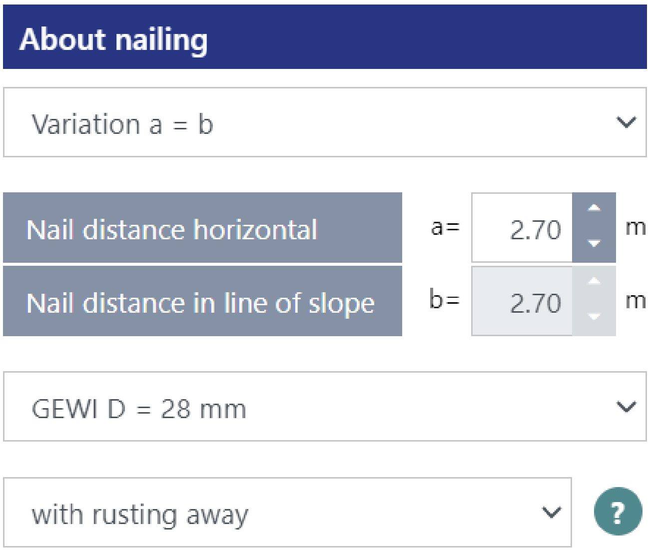


Area at right of the starting window:

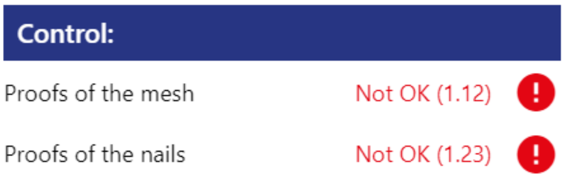
At first the mesh and spike plate can be chosen:



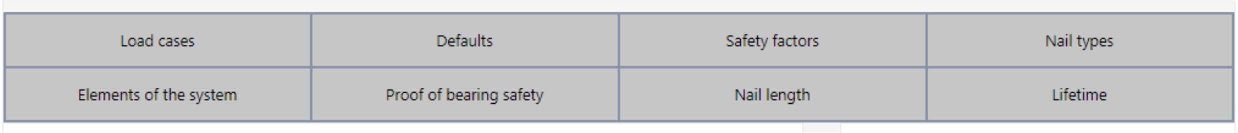
At the right side on the screen the nail distance „a“ and “b“, the nail and the rusting away can be selected.



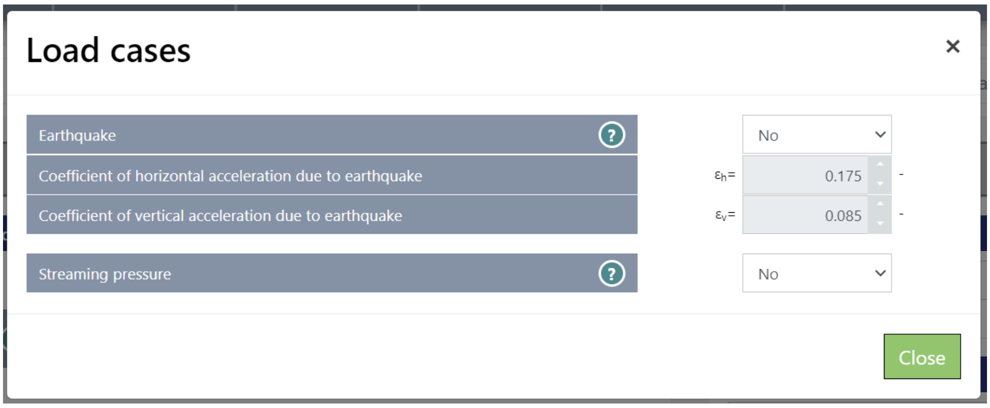
On the basis of the selected input quantities, if at least one proof of bearing safety is not established, a corresponding message will display.
The input quantities must be selected in such a manner that all proofs of bearing safety concerning both the nail and the mesh are established.



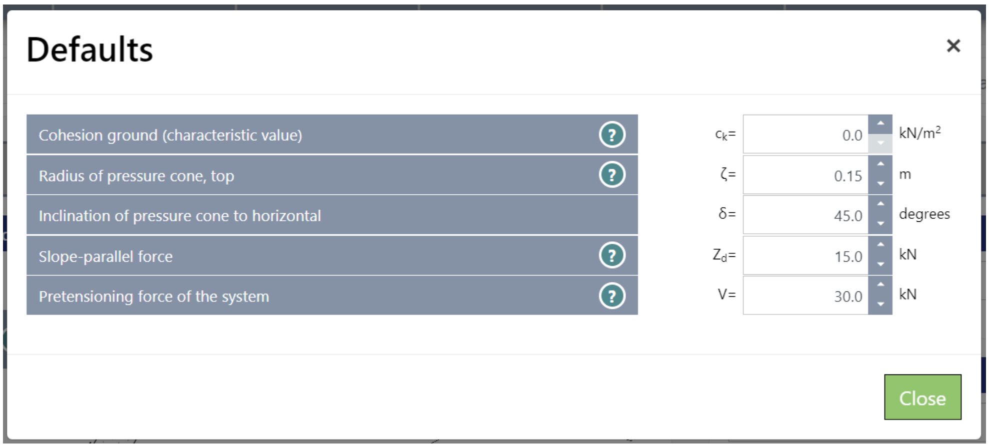
In the middle part of the starting window are eight sub-windows selectable:



Load cases:
In this sub-window the two load cases earthquake and streaming pressure can be activated.



Defaults:
All standard values can be adjusted in this window:

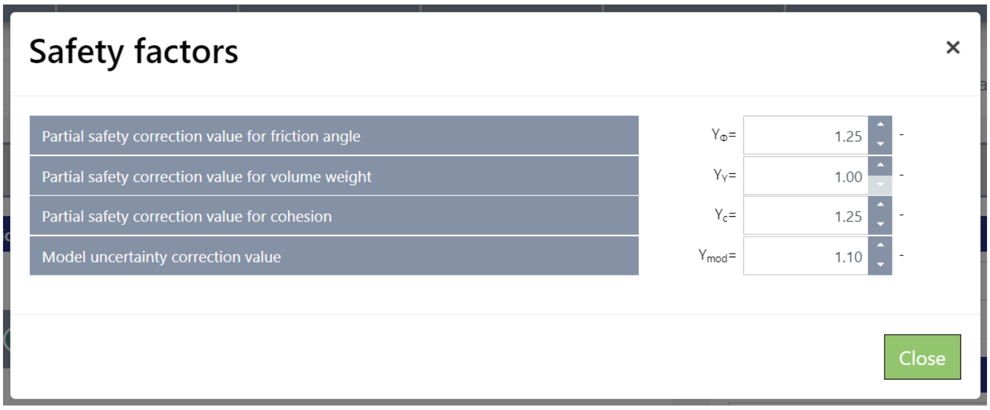


The Z_d value varies and is defined for each mesh+spike plate separately. For the TECCO® G45/2 the maximum pretensioning force V is reduced automatically to 20 kN.

Default values Z_d and V	TECCO® G45/2	TECCO® G45/2 STAIN-LESS	TECCO® G65/3	TECCO® G65/3 STAIN-LESS	TECCO® G65/4	SPIDER® S3-130
	Spike plate P25 / P33	Spike plate P33	Spike plate P33 / P66	Spike plate P33	Spike plate P33 / P66	Spike plate P33 / P66
Slope-parallel force Z_d [kN] [kips]	5 / 5 1.1 / 1.1	5 1.1	15 / 25 3.4 / 5.6	15 3.4	30 / 45 6.7 / 10.1	25 / 40 5.6 / 9
Pretensioning force V [kN] [kips]	20 / 20 4.5 / 4.5	20 4.5	30 / 30 6.7 / 6.7	30 6.7	30 / 30 6.7 / 6.7	30 / 30 6.7 / 6.7

Safety factors:

The following safety factors are given as a standard and can be adapted according to the project:

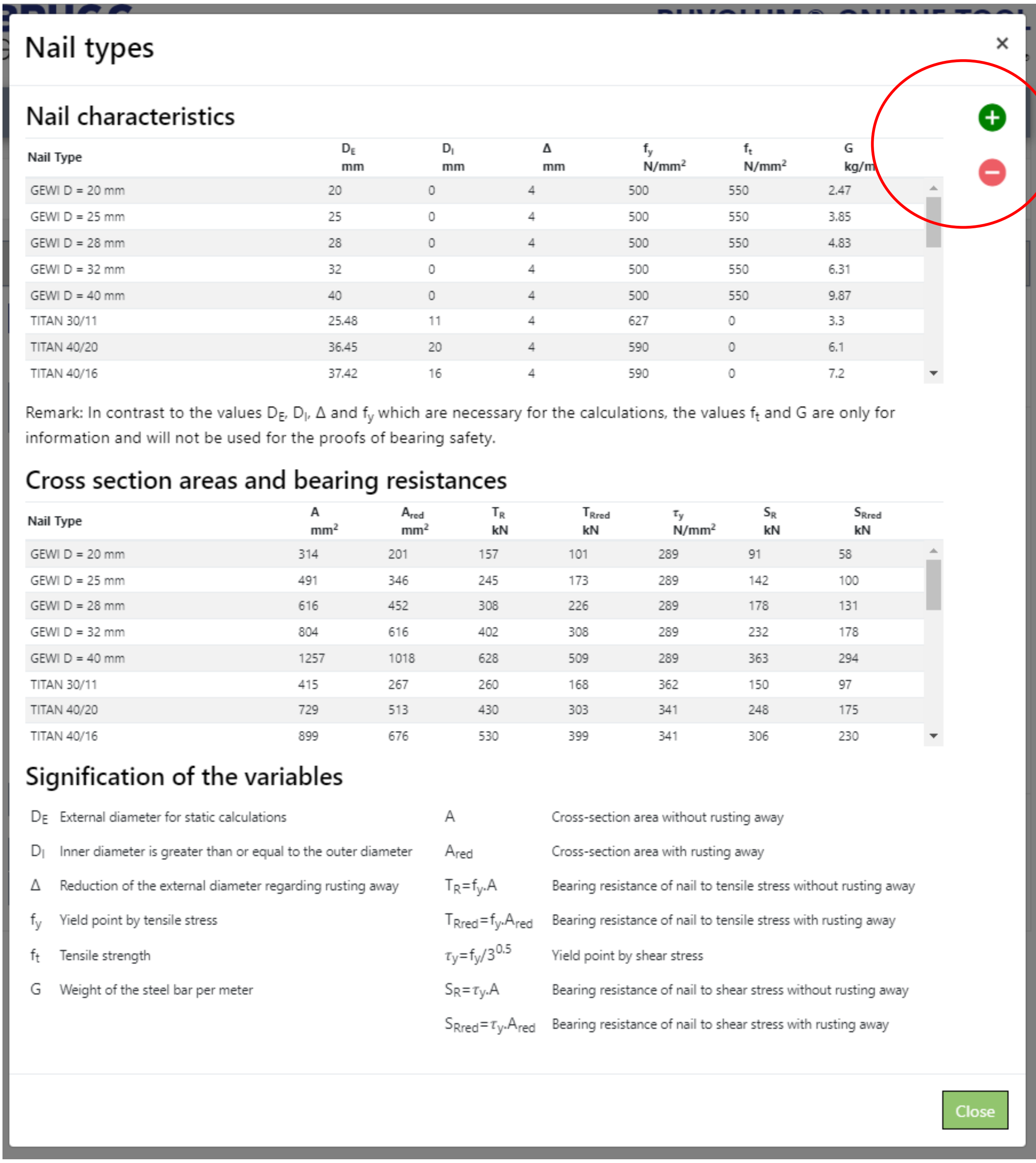


Nail types:

To alter the specifications of an existing nail type it is possible to overwrite the values. To define a new, additional nail type, a new line can be inserted by clicking button ⊕ .

The following lines must be filled in under all circumstances when altering an existing nail type and also when defining a new one: nail type, the external diameter D_E, the internal diameter D_I if $\neq 0$, rusting away Δ and the yielding point f_y. The tensile strength f_t and the nail's weight G per running meter or per foot, respectively, are only informative and do not necessarily have to be stated. If a cell is empty, this corresponds to the value 0.

To delete an existing nail type, place the cursor anywhere on the corresponding line and click button ⊖ . A window is then displayed asking whether or not this nail type should really be deleted.



Nail types

Nail characteristics

Nail Type	D_E mm	D_I mm	Δ mm	f_y N/mm²	f_t N/mm²	G kg/m
GEWI D = 20 mm	20	0	4	500	550	2.47
GEWI D = 25 mm	25	0	4	500	550	3.85
GEWI D = 28 mm	28	0	4	500	550	4.83
GEWI D = 32 mm	32	0	4	500	550	6.31
GEWI D = 40 mm	40	0	4	500	550	9.87
TITAN 30/11	25.48	11	4	627	0	3.3
TITAN 40/20	36.45	20	4	590	0	6.1
TITAN 40/16	37.42	16	4	590	0	7.2

Remark: In contrast to the values D_E, D_I, Δ and f_y which are necessary for the calculations, the values f_t and G are only for information and will not be used for the proofs of bearing safety.

Cross section areas and bearing resistances

Nail Type	A mm²	A_{red} mm²	T_R kN	T_{Rred} kN	τ_y N/mm²	S_R kN	S_{Rred} kN
GEWI D = 20 mm	314	201	157	101	289	91	58
GEWI D = 25 mm	491	346	245	173	289	142	100
GEWI D = 28 mm	616	452	308	226	289	178	131
GEWI D = 32 mm	804	616	402	308	289	232	178
GEWI D = 40 mm	1257	1018	628	509	289	363	294
TITAN 30/11	415	267	260	168	362	150	97
TITAN 40/20	729	513	430	303	341	248	175
TITAN 40/16	899	676	530	399	341	306	230

Signification of the variables

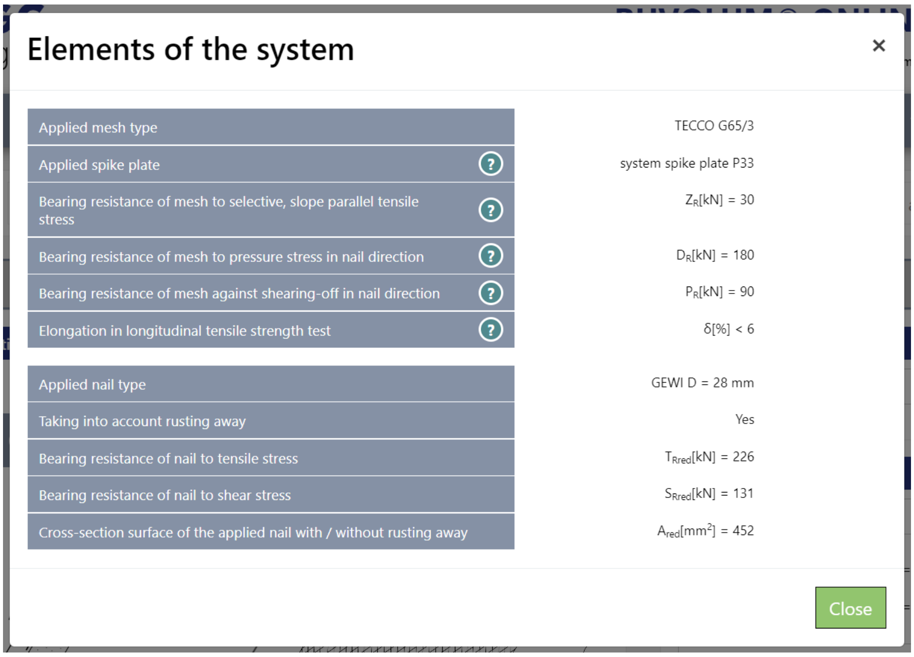
D_E	External diameter for static calculations	A	Cross-section area without rusting away
D_I	Inner diameter is greater than or equal to the outer diameter	A_{red}	Cross-section area with rusting away
Δ	Reduction of the external diameter regarding rusting away	$T_R=f_y.A$	Bearing resistance of nail to tensile stress without rusting away
f_y	Yield point by tensile stress	$T_{Rred}=f_y.A_{red}$	Bearing resistance of nail to tensile stress with rusting away
f_t	Tensile strength	$\tau_y=f_y/3^{0.5}$	Yield point by shear stress
G	Weight of the steel bar per meter	$S_R=\tau_y.A$	Bearing resistance of nail to shear stress without rusting away
		$S_{Rred}=\tau_y.A_{red}$	Bearing resistance of nail to shear stress with rusting away

Close

Elements of the system:

The third tab displays an overview of the bearing resistances of the individual system elements in International or American Units for the chosen mesh and spike plate.

The bottom part shows a summary of the bearing resistances and the cross-section surface of the applied nail type. Moreover, it is stated whether or not any rusting away of the nail is considered. If rusting away is taken into account, the nail diameter is in standard mode reduced by 4.0 mm (0.158 in) for the determination of the bearing resistances.



Elements of the system

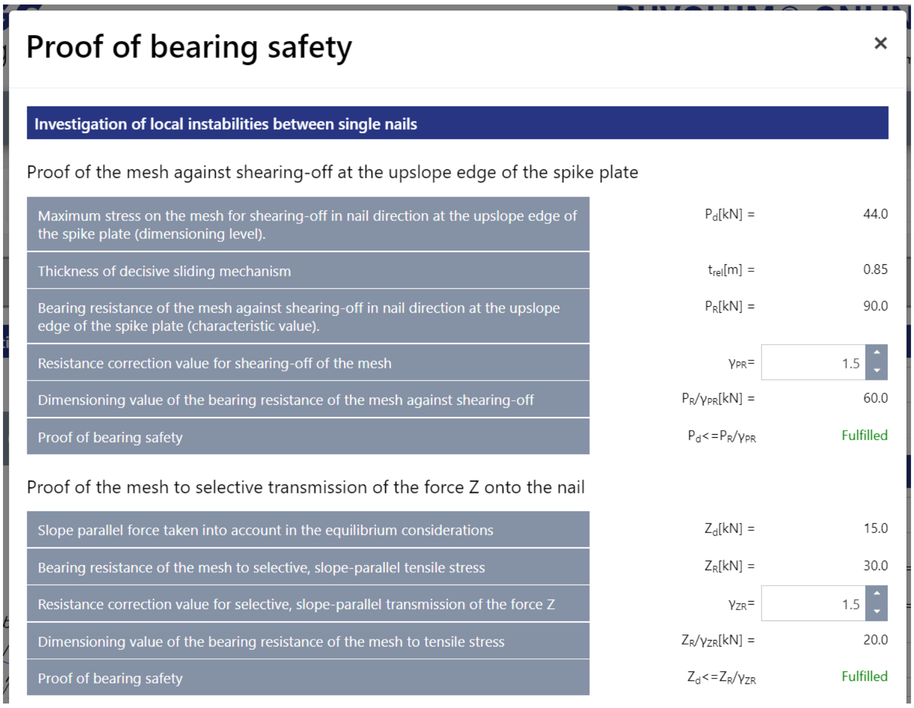
Applied mesh type	TECCO G65/3
Applied spike plate	system spike plate P33
Bearing resistance of mesh to selective, slope parallel tensile stress	Z_R[kN] = 30
Bearing resistance of mesh to pressure stress in nail direction	D_R[kN] = 180
Bearing resistance of mesh against shearing-off in nail direction	P_R[kN] = 90
Elongation in longitudinal tensile strength test	δ[%] < 6
Applied nail type	GEWI D = 28 mm
Taking into account rusting away	Yes
Bearing resistance of nail to tensile stress	T_{Rred}[kN] = 226
Bearing resistance of nail to shear stress	S_{Rred}[kN] = 131
Cross-section surface of the applied nail with / without rusting away	$A_{red}[mm^2]$ = 452

Close

Proof of bearing safety

Compiled in the second to last tab are the individual proofs of bearing safety concerning the investigation of local instabilities between the individual nails as well as the investigation concerning slope-parallel instabilities near the surface. Some safety and load factors are directly in these sub-windows adjustable.

The two sections below show the proofs of bearing safety concerning the investigation of local instabilities between the nails:



Proof of bearing safety

Investigation of local instabilities between single nails

Proof of the mesh against shearing-off at the upslope edge of the spike plate

Maximum stress on the mesh for shearing-off in nail direction at the upslope edge of the spike plate (dimensioning level).	P_d[kN] =	44.0
Thickness of decisive sliding mechanism	t_{rel}[m] =	0.85
Bearing resistance of the mesh against shearing-off in nail direction at the upslope edge of the spike plate (characteristic value).	P_R[kN] =	90.0
Resistance correction value for shearing-off of the mesh	γ_{PR}=	1.5
Dimensioning value of the bearing resistance of the mesh against shearing-off	P_R/γ_{PR}[kN] =	60.0
Proof of bearing safety	$P_d <= P_R/\gamma_{PR}$	Fulfilled

Proof of the mesh to selective transmission of the force Z onto the nail

Slope parallel force taken into account in the equilibrium considerations	Z_d[kN] =	15.0
Bearing resistance of the mesh to selective, slope-parallel tensile stress	Z_R[kN] =	30.0
Resistance correction value for selective, slope-parallel transmission of the force Z	γ_{ZR}=	1.5
Dimensioning value of the bearing resistance of the mesh to tensile stress	Z_R/γ_{ZR}[kN] =	20.0
Proof of bearing safety	$Z_d <= Z_R/\gamma_{ZR}$	Fulfilled

The next three sections show the proofs of bearing safety concerning the investigation of slope-parallel instabilities close to the surface.

Investigation of slop-parallel instabilities

Proof of the nail against sliding-off of a superficial layer parallel to the slope

Pretensioning force effectively applied on nail	V[kN] =	30.0
Load factor for positive influence of pretension V	γ_{VI}=	0.8
Dimensioning value of the applied pretensioning force by positive influence of V	V_{dI}[kN] =	24.0
Calculatorily required shear force at dimensioning level in function of V_{dI}	S_d[kN] =	78.2
Bearing resistance of the nail to shear stress	S_{Rred}[kN] =	131.0
Resistance correction value for shearing-off of the nail	γ_{SR}=	1.5
Dimensioning value of the bearing resistance of the nail to shear stress	S_{Rred}/γ_{SR}[kN] =	87.3
Proof of bearing safety	$S_d <= S_{Rred}/\gamma_{SR}$	Fulfilled

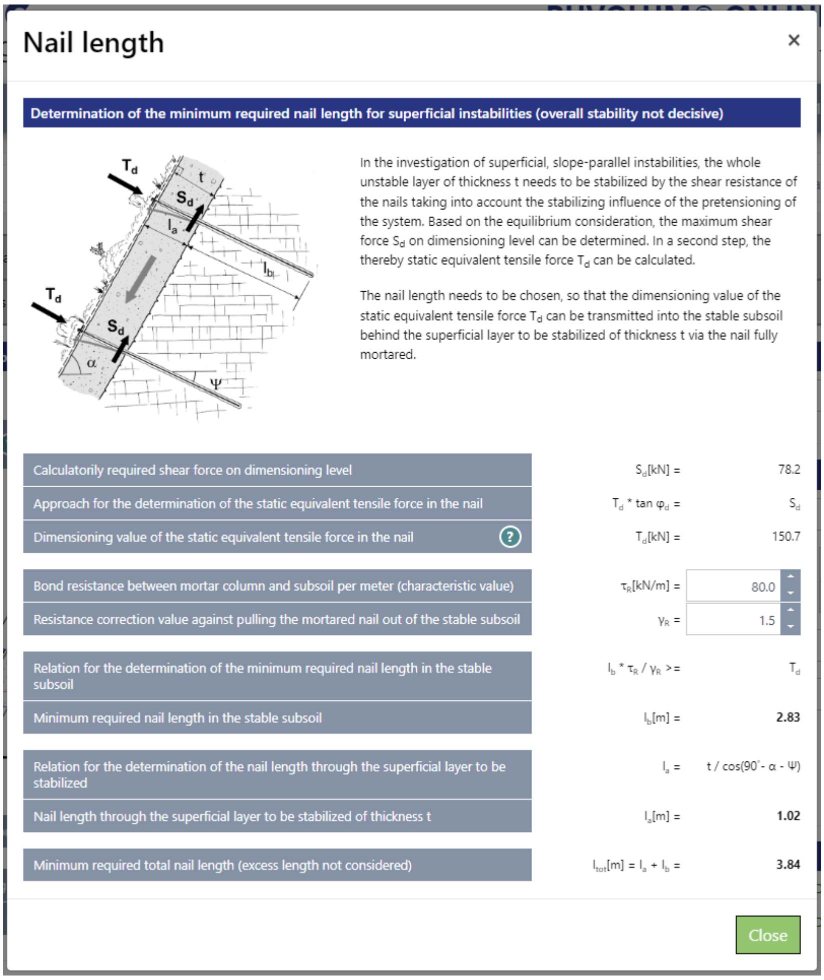
Proof of the mesh against puncturing

Pretensioning force effectively applied on nail	V[kN] =	30.0
Load factor for positive influence of pretension V	γ_{VII}=	1.5
Dimensioning value of the applied pretensioning force by positive influence of V	V_{dII}[kN] =	45.0
Bearing resistance of the mesh to pressure stress in nail direction	D_R[kN] =	180.0
Resistance correction value for puncturing	γ_{DR}=	1.5
Dimensioning value of the bearing resistance of the mesh to pressure stress	D_R/γ_{DR}[kN] =	120.0
Proof of bearing safety	$V_{dII} <= D_R/\gamma_{DR}$	Fulfilled

Proof of the nail to combined stress

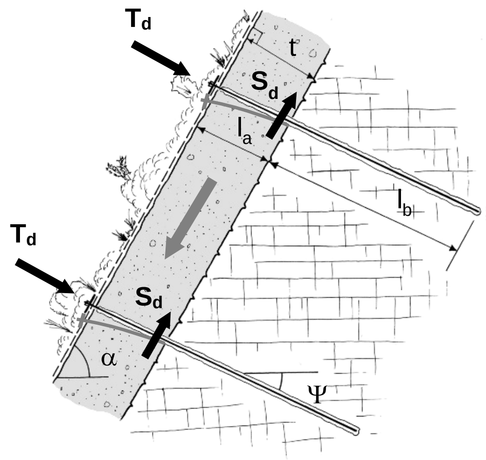
Pretensioning force effectively applied on nail	V[kN] =	30.0
Load factor for positive influence of pretension V	γ_{VI}=	0.8
Dimensioning value of the applied pretensioning force by positive influence of V	V_{dI}[kN] =	24.0
Load factor for negative influence of pretension V	γ_{VII}=	1.5
Dimensioning value of the applied pretensioning force by negative influence of V	V_{dII}[kN] =	45.0
Calculatorily required shear force at dimensioning level in function of V_{dII}	S_d[kN] =	78.2
Maximum stress on the mesh for shearing-off	P_d[kN] =	44.0
Bearing resistance of the nail to tensile stress	T_{Rred}[kN] =	226.0
Bearing resistance of the nail to shear stress	S_{Rred}[kN] =	131.0
Resistance correction value for tensile stress	γ_{TR}=	1.5
Resistance correction value for shear stress	γ_{SR}=	1.5
Proof of bearing safety	$\{[V_{dII}/(T_{Rred}/\gamma_{TR})]^2 + [S_d/(S_{Rred}/\gamma_{SR})]^2\}^{0.5} <= 1.0$	0.944 Fulfilled
Proof of bearing safety	$\{[P_d/(T_{Rred}/\gamma_{TR})]^2 + [S_d/(S_{Rred}/\gamma_{SR})]^2\}^{0.5} <= 1.0$	0.942 Fulfilled

Nail length (without considering global stability)



In the investigation of superficial, slope-parallel instabilities, the whole unstable layer of thickness t needs to be stabilized by the shear resistance of the nails taking into account the stabilizing influence of the pre-tensioning of the system. Based on the equilibrium consideration, the maximum shear force S_d on dimensioning level is determined. In a second step, the thereby static equivalent tensile force T_d can be calculated considering the tangent of the friction angle:

$T_d = S_d / \tan\phi_d$



The following requirements have to be fulfilled:

$T_{d,\,min} \geq V_d$

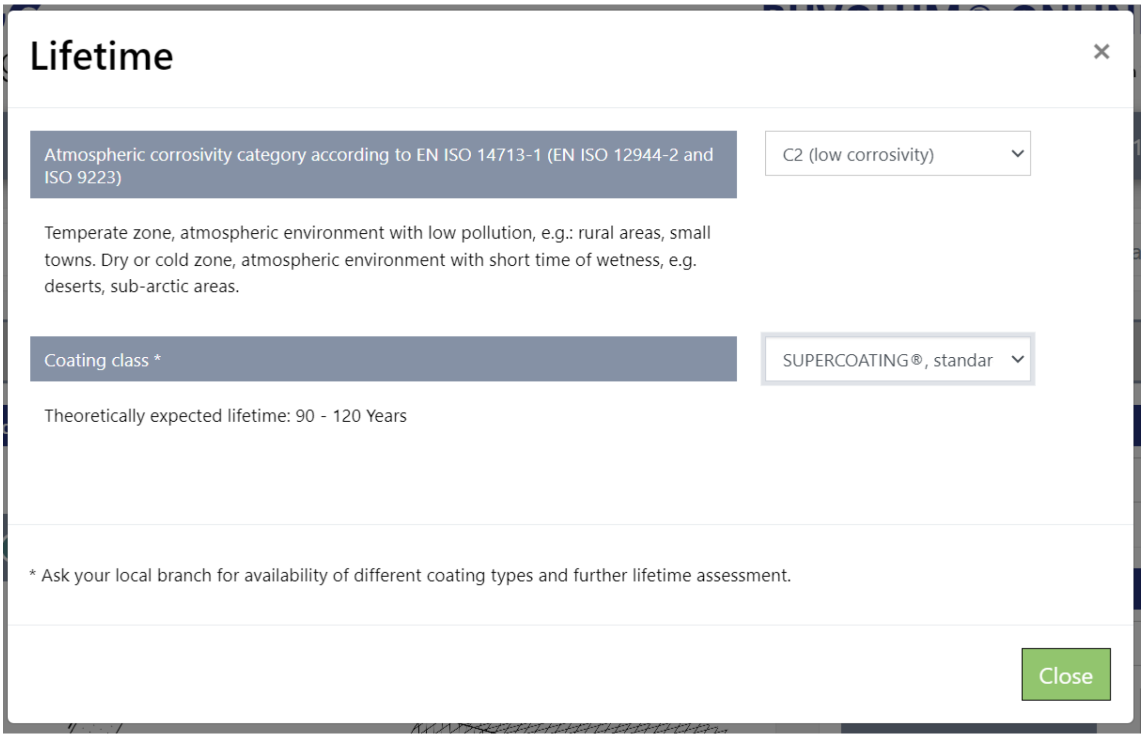
$T_{d,\,min} \geq P_d$

$T_{d,\,max} \leq T_{R,d}$ respectively $T_{R,red,d}$

The nail length needs to be chosen, so that the dimensioning value of the static equivalent tensile force T_d can be transmitted into the stable subsoil behind the superficial layer to be stabilized of thickness t via the nail fully mortared. This is for the case of superficial instabilities only, for global stability problems the nail length needs to be evaluated separately.

Lifetime

Based on the corrosivity category at the project site, the theoretical service life can be estimated:



7. RANGES OF VALUES

Ranges of values of the input quantities in International Units

The chart below shows an overview of the minimum, maximum and default values as well as of the increments in International Units. The default values are called up when a new project and thereby automatically a new calculation is established.

Input quantity	parameter	min.	max.	default	increment
Slope inclination	α [degrees]	0.0	90.0	60.0	1.0
Nail distance horizontal	a [m]	1.00	5.00	2.70	0.05
Nail distance in line of slope	b [m]	1.00	5.00	2.70	0.05
Layer thickness	t [m]	0.00	2.50	1.00	0.05
Radius of pressure cone, top	ζ [m]	0.00	1.00	0.15	0.05
Inclination of pressure cone to horizontal	δ [degrees]	30.0	90.0	45.0	1.0
Friction angle ground (charact. value)	φ_k [degrees]	0.0	60.0	32.0	0.5
Cohesion ground (characteristic value)	c_k [kN/m^2]	0.0	20.0	0.0	1.0
Volume weight ground (charact. value)	γ_k [kN/m^3]	0.0	35.0	20.0	0.5
Slope-parallel force	Z_d [kN]	0.0	50.0	15.0	5.0
Pretensioning force of the system	V [kN]	0.0	50.0	30.0	10.0
Nail inclination to horizontal	Ψ [degrees]	0.0	90.0	20.0	5.0
Partial safety corr. value for friction angle	γ_φ [-]	1.00	2.00	1.25	0.05
Partial safety correction value for cohesion	γ_c [-]	1.00	2.00	1.25	0.05
Partial safety corr. value for volume weight	γ_γ [-]	1.00	2.00	1.00	0.05
Model uncertainty correction value	γ_{mod} [-]	1.00	2.00	1.10	0.05
Coeffic. of vertical accel. due to earthquake	ε_v [-]	0.000	1.000	0.175	0.005
Coeffic. of horiz. accel. due to earthquake	ε_h [-]	0.000	1.000	0.085	0.005

Ranges of values of the input quantities in American Units

The chart below shows an overview of the minimum, maximum and default values as well as of the increments in American Units. The default values are called up when a new project and thereby automatically a new calculation is established.

Input quantity	parameter	min.	max.	default	increment
Slope inclination	α [degrees]	0.0	90.0	60.0	1.0
Nail distance horizontal	a [ft]	3.00	16.25	9.00	¼
Nail distance in line of slope	b [ft]	3.00	16.25	9.00	¼
Layer thickness	t [ft]	0.00	8.25	3.00	¼
Radius of pressure cone, top	ζ [in]	0.00	40.00	6.0	1.0
Inclination of pressure cone to horizontal	δ [degrees]	30.0	90.0	45.0	1.0
Friction angle ground (charact. value)	φ_k [degrees]	0.0	60.0	32.0	0.5
Cohesion ground (characteristic value)	c_k [lbs/ft^2]	0.0	420.0	0.0	10.0
Volume weight ground (charact. value)	γ_k [lbs/ft^3]	0.0	225.0	130.0	5.0
Slope-parallel force	Z_d [kips]	0.0	11.0	3.3	1.1
Pretensioning force of the system	V [kips]	0.0	11.0	7.0	1.0
Nail inclination to horizontal	Ψ [degrees]	0.0	90.0	20.0	5.0
Partial safety corr. value for friction angle	γ_φ [-]	1.00	2.00	1.25	0.05
Partial safety correction value for cohesion	γ_c [-]	1.00	2.00	1.25	0.05
Partial safety corr. value for volume weight	γ_γ [-]	1.00	2.00	1.00	0.05
Model uncertainty correction value	γ_{mod} [-]	1.00	2.00	1.10	0.05
Coeffic. of vertical accel. due to earthquake	ε_v [-]	0.000	1.000	0.175	0.005
Coeffic. of horiz. accel. due to earthquake	ε_h [-]	0.000	1.000	0.085	0.005

8. CONVERSION

Conversions

The following conversions are taken into account.

American – International Units			International – American Units		
1 ft	0.3048	m	1 m	3.281	ft
1 in	25.4	mm	1 mm	0.0394	in
1 in²	645.2	mm²	1 mm²	0.00155	in²
1 lb(s)	0.4536	kg	1 kg	2.20462	lbs
1 lb(s)	4.4482	N	1 N	0.22481	lbs
1 lb(s)	0.0044482	kN	1 kN	224.81	lbs
1 kip(s)	4.4482	kN	1 kN	0.22481	kips
1 lbs/ft	1.4882	kg/m	1 kg/m	0.6719	lbs/ft
1 lbs/ft	0.0149	kN/m	1 kN/m	68.519	lbs/ft
1 lbs/ft²	0.0479	kN/m²	1 kN/m²	20.88	lbs/ft²
1 lbs/ft³	0.1571	kN/m³	1 kN/m³	6.365	lbs/ft³
1 ksi	6.895	N/mm²	1 N/mm²	0.145	ksi

9. DIMENSIONING VALUES OF THE GEOTECHNICAL PARAMETERS

In the standard mode the TECCO® and SPIDER® slope stabilization system is dimensioned in line with the partial safety concept. Hereby the characteristic values of the ground are transformed into dimensioning values according to the relationships listed below, whereby the corresponding partial safety correction values are taken into account:

φ_d = arctan (tan φ_k / γ_φ)

c_d = c_k / γ_c

γ_d = $\gamma_k \cdot \gamma_\gamma$

φ_k = characteristic value of the friction angle

c_k = characteristic value of the cohesion

γ_k = characteristic value of the volume weight

γ_φ = partial safety correction value for friction angle

γ_c = partial safety correction value for cohesion

γ_γ = partial safety correction value for volume weight

φ_d = dimensioning value of the friction angle

c_d = dimensioning value of the cohesion

γ_d = dimensioning value of the volume weight

If the system is to be dimensioned in the traditional manner according to the global safety concept, all partial safeties can be put equal 1.00. In this case the model uncertainty correction factor γ_{mod} corresponds to the global safety.