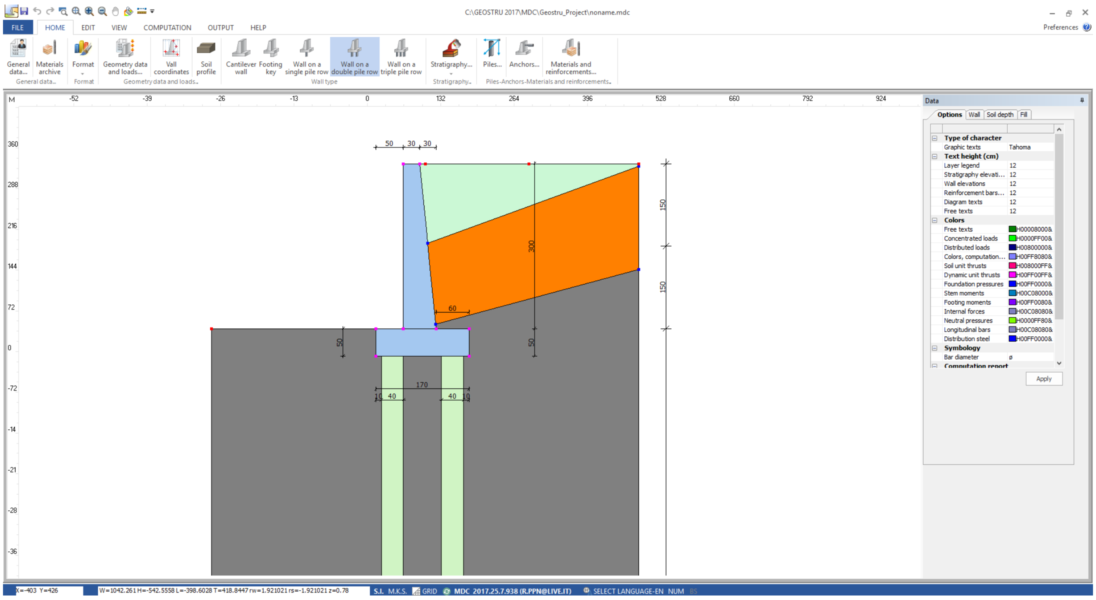
MDC

1 MDC

MDC is a software product for the design and analysis of reinforced concrete retaining walls either resting on their own foundation or on piles, optionally supported by tiebacks.
The geotechnical computation employs the standard geotechnical methods subject to user choice and carries out the verifications prescribed by the selected standard, amongst which global stability even in seismic conditions. Structural evaluations performs reinforcements sizing and verification with **Ultimate Limit State or Allowable Tensions**.

MDC is simple and intuitive but with amazing features including: pre-design work, easy management of the combinations: GEO, STR, GLOBAL STABILITY , localization and automatic import of seismic parameters, displacements analysis in dynamicfield, reinforcements editor. Import and export of works that should fall in stabilization operations.



Software for the design and analysis of reinforced concrete retaining walls either resting on their own foundation or on piles, optionally supported by tiebacks. Thanks to the manifold options available, the program permits treatment of Reinforced Concrete and Gravity walls in an ample range of cases:

- Reinforced concrete walls;
- Gravity walls;
- Walls supported on piles or minipiles;
- Walls with tiebacks/anchors;

- Walls with a shelf on the uphill side;
- Footing keys;
- Stepped wall on uphill side;
- Tapered profile (stem and footing) on both sides;
- Forces acting on wall: FX, FY, MZ on n points;
- Layered terrain;
- Backfill;
- Loads on backfill;
- Inclined terrain on uphill and downhill sides;
- Ground water or confined water layers;
- Drainage insertion on uphill side;
- Fixed head walls;
- Stress diagrams;
- Reinforcements Editor;
- Global stability analysis using several methods: *Fellenius, Bishop, Janbu, Bell, Sarma, Morgenstern & Price, D.E.M., Zeng Liang.*

Supported computation standards:

- Eurocod 7/8
- NTC 2018
- STAS
- British Codes BS8004/BS8110
- SR EN 1997-1 Anexa RO / EC2: SR EN 1992-1-1 / Normativul pentru proiectarea lucrarilor de sustinere (Anexa A)

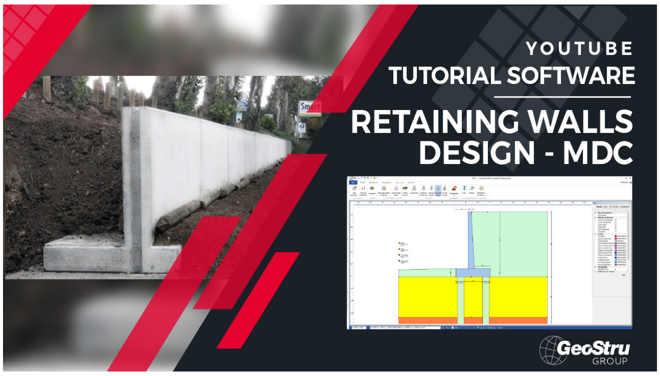
The unique feature of this software is the simplicity with which you can manage various combinations of loads summarizing in a single phase both load conditions and computation.

Stratigraphy

Simple layer declaration allow any series of layers to be modelled on uphill and downhill sides of the wall with individual inclination. Mouse click and drag allow layer boundaries to be moved or inclined. To each layer are assigned the geotechnic parameters required for computation and to each may be associated a colour and/or texture. An internal soils database, expandable and amendable by the user, simplifies these choices.

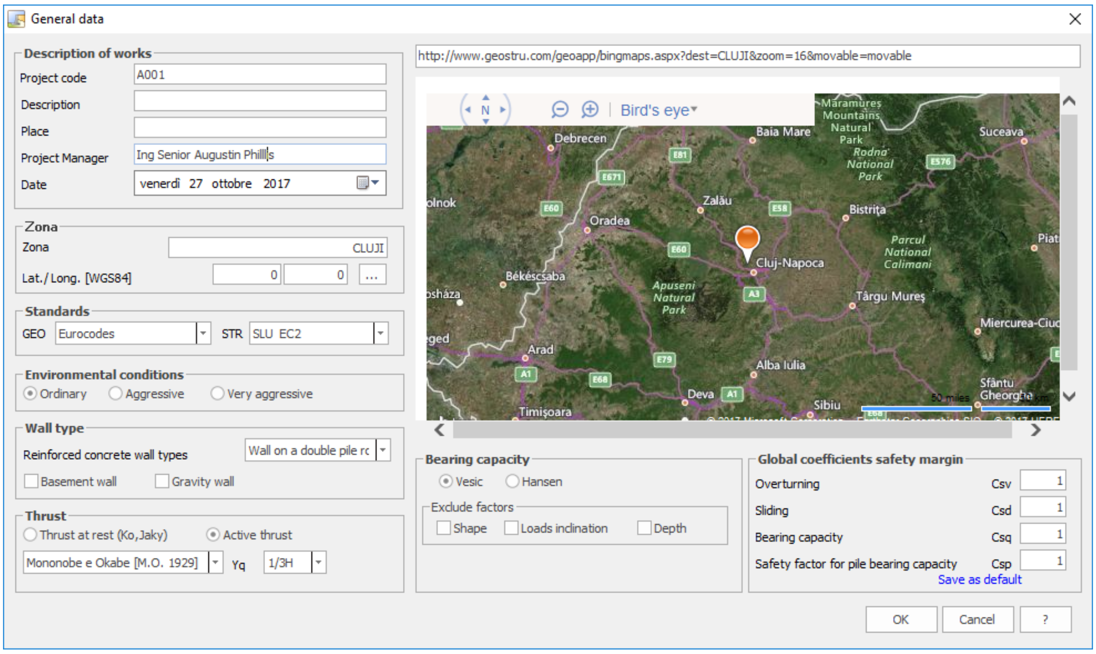
Computation

The user can choose one of the following methods for the computation of thrust: Coulomb, Rankine or Mononobe & Okabe. It is also possible to perform the computation considering the thrust at rest and, for the elemets subject to passive thrust, to impose the percentage of mobilized thrust. The structural computatin and analysis can be performed, at user's choice, with the Limit States or Allowable Tensions methods.



1.1 Main Parameters

This command opens a window in which the main parameters of the project can be given.



Works description

This field is intended for a synthetic description of the project.

Wall Type

In this pane it is possible to specify the type of wall by selecting from the drop down list and check boxes.

⚠

Gravity walls

For Gravity walls, the program reports the results of thrust calculation and verifies slide, overturning, and limit load. Moreover it performs verification of cohesion of stem to footing joint. The latter is performed to check that the section under consideration does not generate traction but only compression tension. Such verification is presented in the report.

Head wall

For for fixed head wall calculation, it is advisable to select thrust at rest (Ko) and to apply a low value for passive thrust contribution (min. 1%). The program reports soil pressure, that will have a nearly constant value.
Such walls are considered fixed in downwards and downhill directions.
For this type of wall, stem head movement is inhibited, so that the program only performs verification of limit load of foundation on its base, and omits slide and overturning verification.

Thrust

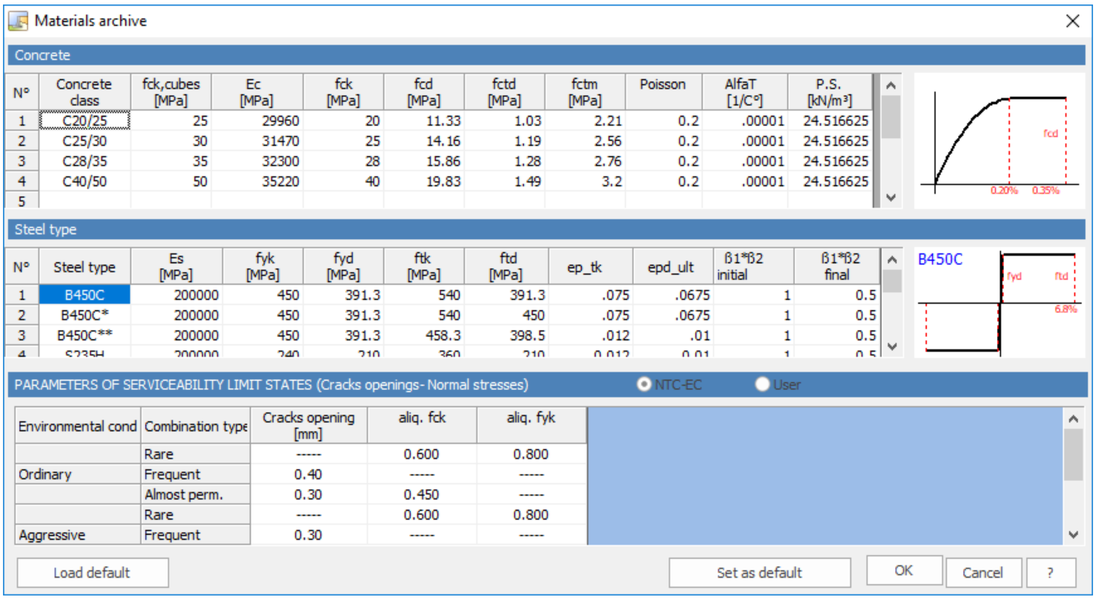
This pane is used to determine a number of factors and methods in the calculation of soil thrust either at rest (i.e. for fixed head supports) or active.
For Active thrust it is possible to opt either for Rankine's method - valid for horizontal backfill with no soil/wall friction (δ=0), or Mononobe & Okabe' s method - valid for seismic condition - based on Coulomb's non seismic condition theory. For passive thrust on downhill terrain the actually applied percentage thrust can be specified. The program only calculates passive thrust on terrain downhill of the wall footing and not on the soil covering it (See Fill pane).
In the evaluation of increase in thrust due to seismic action, the user is requested to specify the point of applicatin of such increment on the stem either at 1/3,or 2/3 of H, considering seismic thrust diagram as a triangle or as a constant on stem height at 1/2 H.

Global safety margin coefficients

Safety factor coefficients for slide, overturn and limit load can be specified here and can if required be saved as predefined in other projects.

1.2 Materials Archive

When opening the program or a new calculation, the starting fixed archive is displayed in which it is possible to add new types of conglomerate and steel or modify the values present. When the calculated section data is saved, the entire modified archive is also stored with it.The nomenclature used to define the strength of concrete is modified by the program depending on whether the operator chooses the S.I. (international) or M.K.S. (technical) system from the Preferences menu or from the initial settings in the Wizard.



Environment for material management

Concrete

Concrete class: Naming of the strength class of the conglomerate by means of an alphanumeric definition of no more than 10 characters. The new NTC (Chapter 4) require the use of standardized designations such as: C20/25; C25/30; C28/35; C35/45 etc. defined according to the characteristic resistance respectively cylindrical f_{ck} and on cubes f_{ck},cubes (=R_{ck}).

fck, cubes: Characteristic compressive strength on conglomerate cubes.

Ec: Elastic modulus.

fck: Compressive characteristic cylindrical resistance, $f_{ck} = 0,83\ R_{ck}$ [point 11.2.10.1 NTC].

fcd: Ultimate compressive calculation resistance, $f_{cd} = \alpha_{cc} f_{ck} / 1,5$ [point 4.1.2.1.1.1 NTC] where α_{cc} =0,85 = coeff. reductive of long-lasting resistances and 1.5 is the coeff. partial safety of concrete.
fctd: Tensile calculation resistance, f_{ctd} = 0,7 fctm / 1,5.
fctm:Average tensile strength, $f_{ctm} = 3 (f_{ck}/10)2/3$ by classes ≤ C50/60 [11.2.10.2 NTC], $f_{ctm} = 21,2 \ln[1+ (f_{cm}/100)]$ by classes > C50/60.
Poisson: Transverse coefficient of contraction (Poisson) varying between 0 and 0,2.
AlfaT: Coefficient of thermal expansion [1/°C].
P.S.: Specific gravity of reinforced concrete.

Steel type

Steel Type: Name of the steel grade by means of a free alphanumeric definition of no more than 10 characters.
Es: Instantaneous elastic modulus.
fyk: Nominal yield strength characteristic stress.
fyd: Calculation yield stress = f_{yk} / 1.15 [1.15 = partial safety coefficient].
ftk: Nominal characteristic breaking voltage.
ftd: Calculation breaking voltage. It is the voltage reduced by the coeff. 1.15. at the computational break-down unit deformation equal to 90% of the characteristic break deformation.
ep_tk: Unit deformation εuk at break in the idealized steel diagram equal to 0.01.
epd_ult: ultimate computational deformation equal to $\varepsilon_{ud} = 0.9\ \varepsilon_{uk}$.
β1,*β2 (start..): coeff. adhesion steel concrete at the first application of the load. It is used by the program in checking the opening of cracks in rare combinations of exercise (SLE).
β1,*β2 (final): coeff. adhesion steel concrete for long-lasting loads. It is used by the program in the verification of crack opening in frequent and quasi-permanent combinations of exercise (SLE).

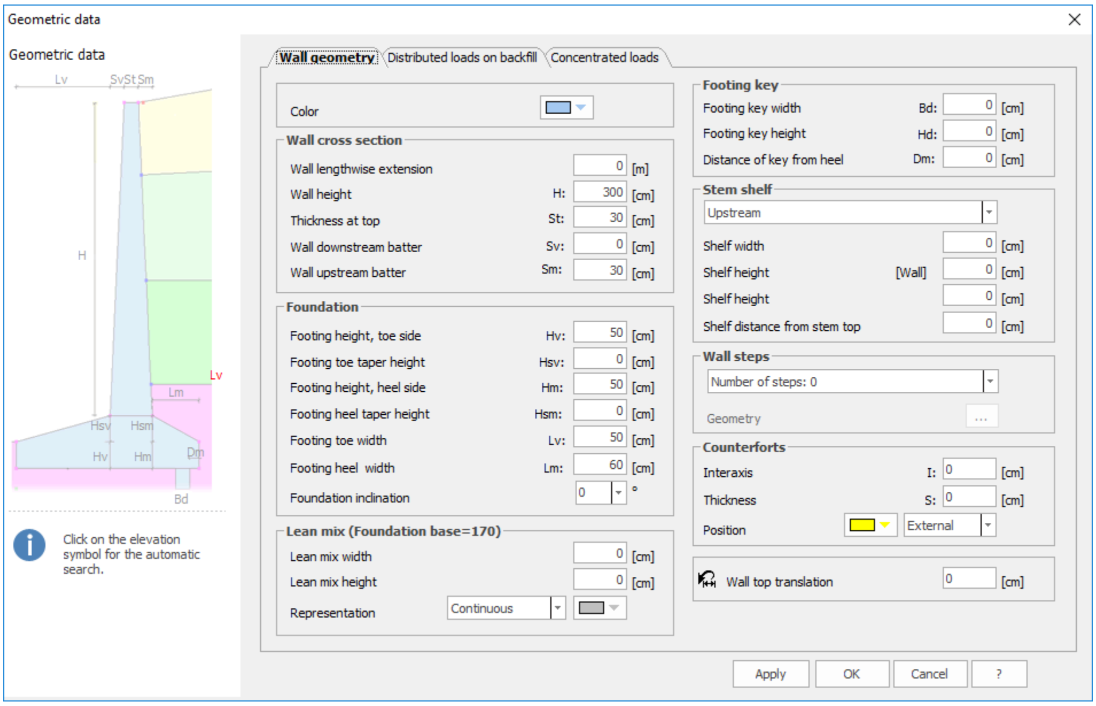
Operating limit state parameters (Apert. fess. - Normal voltages)

Apert. fess.: this column shows the limit values of the crack opening set out in clause 4.1.2.2.4.5 of the NTC depending on the limit state and the environmental conditions set (the latter must be indicated in the General Data window).
S.cls [aliq. fck]: limit stress of the concrete in operation expressed as an aliquot of the characteristic tension of concrete rupture.

S.fe [aliq. fyk]: limiting voltage of the steel in operation expressed as an aliquot of the characteristic tension of rupture of the steel.By default the parameters are set equal to those provided by the NTC.

1.3 Wall Geometry and Loads

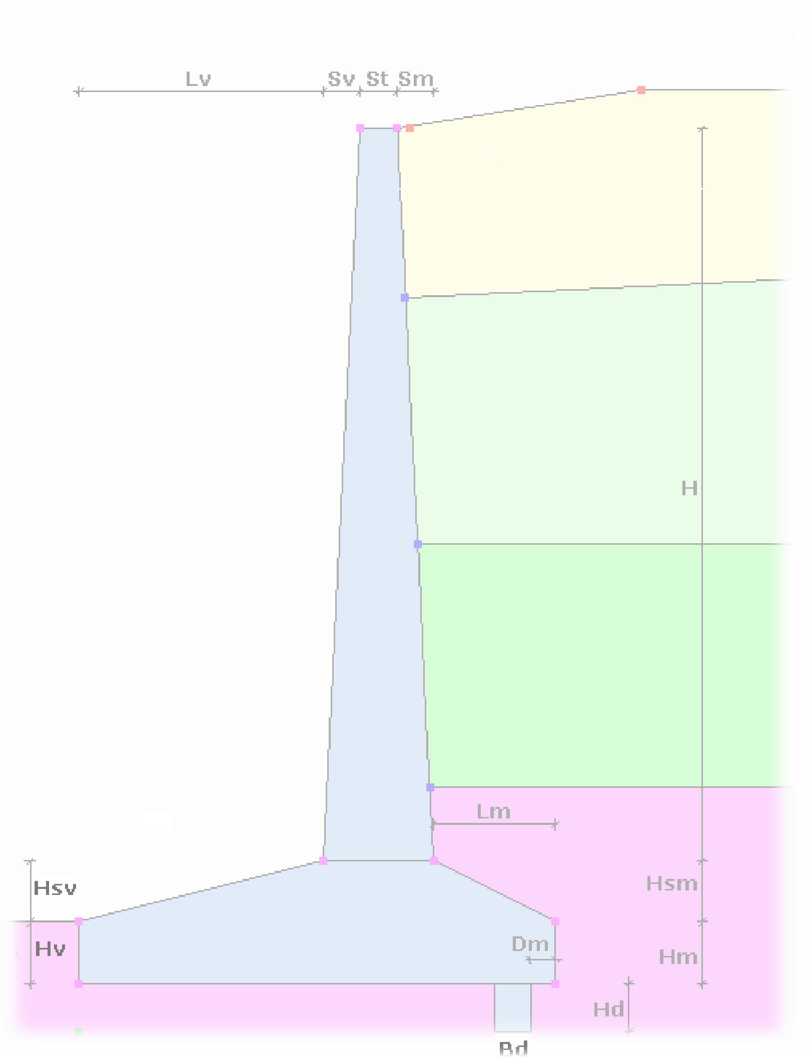
This option opens a tab window in which definition of wall geometry, loads on the wall or on the backfill can be entered. This option opens a tab window in which definition of wall geometry, loads on the wall or on the backfill can be entered.



Wall Geometry

Wall geometry is entered by wall element. Thus a pane each is devoted to wall stem, wall footing, footing key, and flying shelf. It is also possible to define the uphill side of the wall as a number of steps, whose individual geometry is then declared.

Within the same window, there where no supporting piles are present, a pane enables the presence of a lean mix base below the footing to be specified, that is taken into consideration for slide limit state verification.



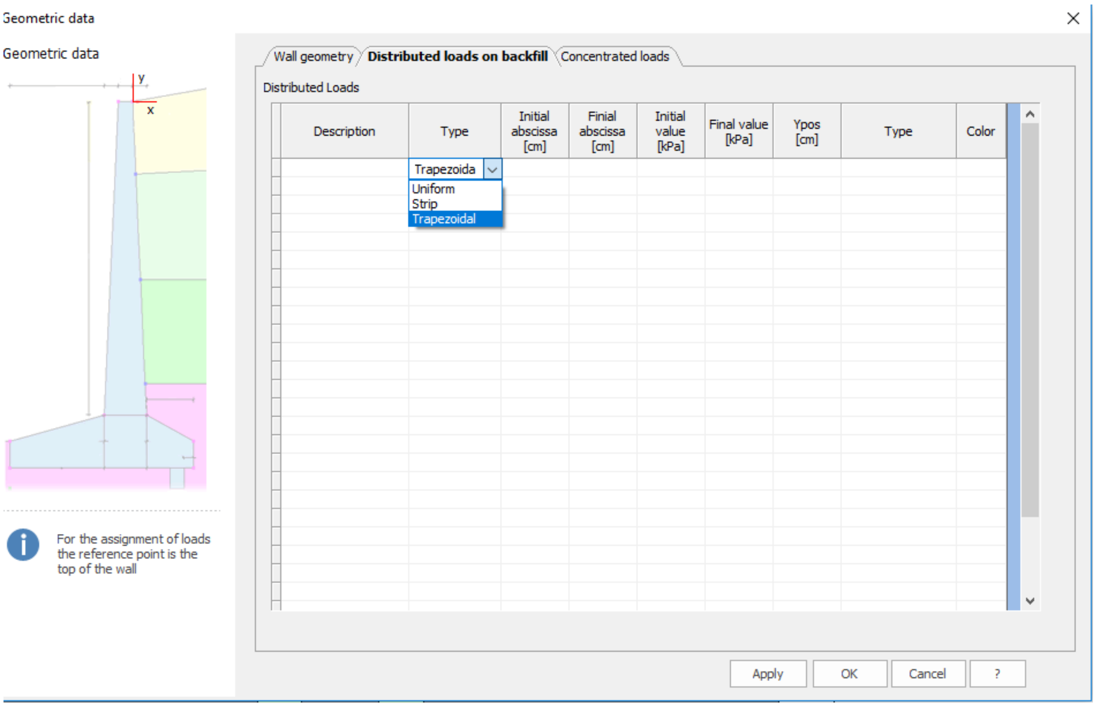
Loads may be modeled on the project as:

1. Loads distributed on backfill;
2. Loads on the wall structure.

Loads may be specified either by acting on the respective tool bar icon or by invoking "Wall Geometry and loads" from the Data Menu.

Distributed loads

The extent of the load is defined by the start and end abscissa values; the load value can be constant or variable. The depth indicates its placement in relation to the stem head.
Even multiple loads can be defined and their action combined during the calculation according to specified permutation factors.
The effect of loads on the active thrust is only considered if this is located within the failure wedge.

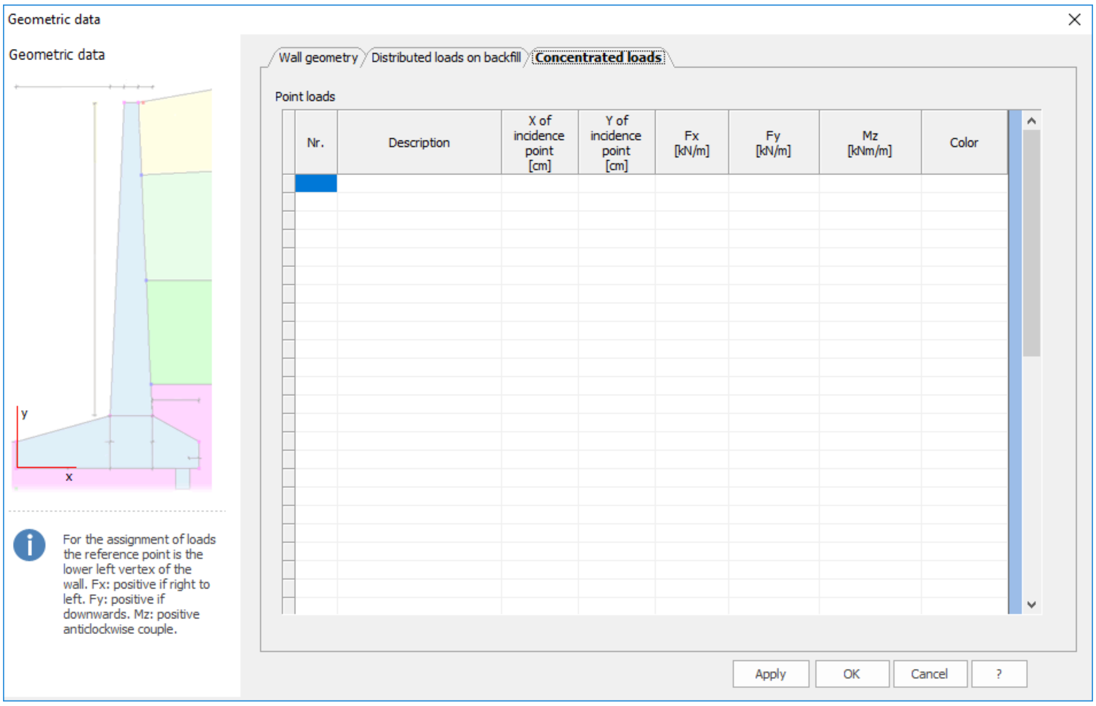


Point loads

Such loads can be modeled according to the following conventions below:

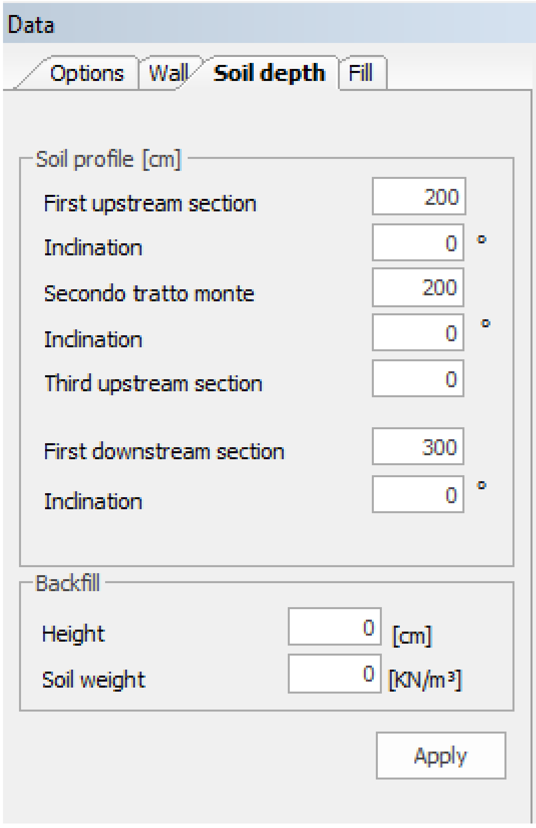
- Horizontal forces (Fx) defined as a positive value when directed right to left;
- Vertical forces (Fy) defined as a positive value when directed top downwards;
- Moments (Mz) positive when anticlockwise.

Multiple point loads can also be defined and their action combined during the calculation according to specified permutation factors.



1.4 Terrain profile- Enbankment

This screen enable the terrain profile on either side of the wall to be defined in one (downhill) or two (uphill) segments of which the first is the one abutting upon the wall and may be inclined to rise or fall as required.
It is further possible to model an embankment on the uphill side, that rises above the stem head, whose height and weight per unit volume is declared here.

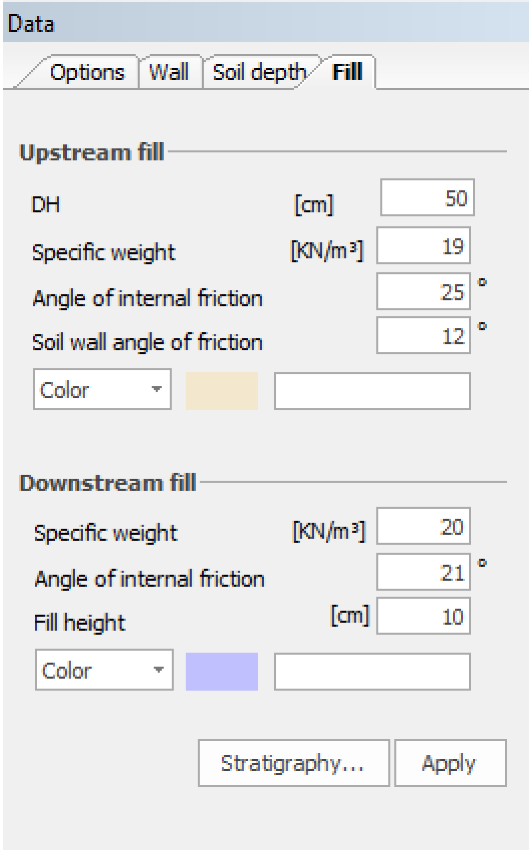


1.5 Filling

The presence of fillers on the back of the wall and in the foundation can be assigned from the Fill panel visible on the right of the work area.

- **Upstream filling:** To define the filling of the area behind the wall, it is necessary to assign the weight per unit volume, the angle of shear resistance that of earth-wall friction.
- **Valley filling:** To insert a fill on the valley side foundation, the weight per unit volume of the material, the shear resistance angle and the height must be assigned.

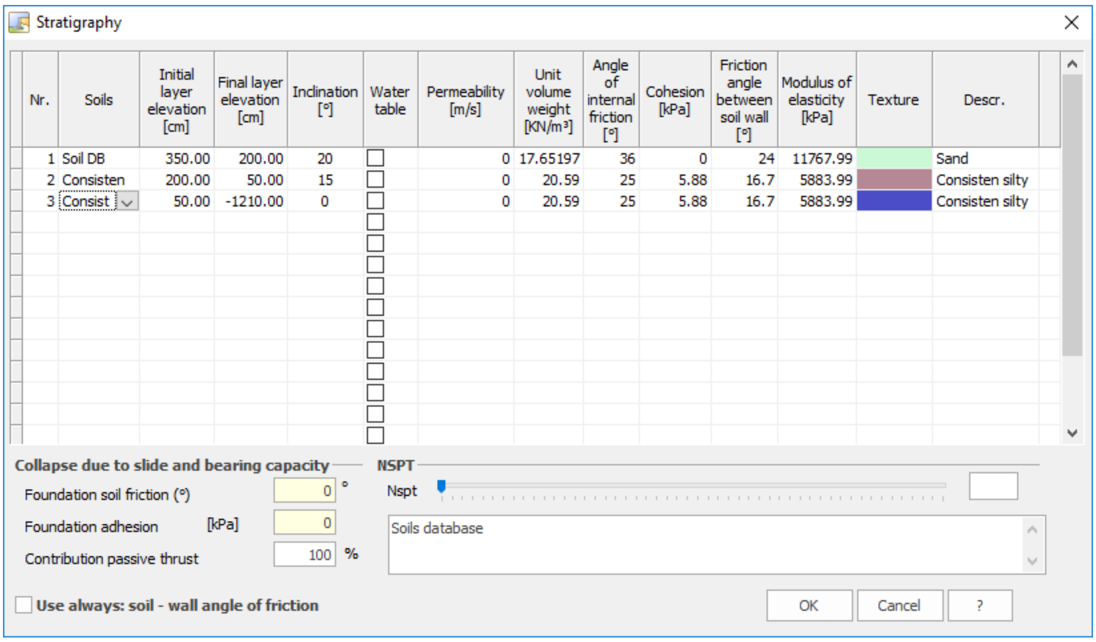
The geotechnical parameters of characterization of the two fillings are necessary for the evaluation of the stresses on the foundation and on the shelf in elevation.



Fill assignment environment

The downstream filling does not contribute to the passive thrust, but contributes to the determination of the limit load.

1.6 Stratigraphy



No.: Layer ordinal number.

N.B.: *Layers must be entered in sequence from the uppermost down.*

Soil DB: The user can take advantage of a database of more common soils that is included in the program. To expand the scope of this database refer to Resource files from the Introduction.

Initial layer elevation [cm]: Height of upper level of layer. This will coincide with the lower level height of the previous layer (if any).

Final layer elevation [cm]: Height of lower level of layer. This will coincide with the upper level height of the next layer (if any).

Inclination layer [°]: Inclination of layer in respect of the horizontal.

Water Table: Check to indicate that layer is in contact with the water table so as to consider the thrust effect of water and the analysis of effective pressures. In such a case, please enter the total weight per unit volume.

k [m/s]: Layer permeability.

Unit Volume weight: Soil weight per unit volume.

Shear resistance angle [°]: Soil shear resistance angle; where water table is present enter the effective parameter.

Cohesion : Soil cohesion; where water table is present enter the effective parameter.

Soil wall angle of friction [°]: Soil-wall angle of friction.

Elastic Modulus: Elastic modulus of the layer. This is required to evaluate settlement where piles are involved.

Colour: Use colour palette to select colour that will denote this layer.

Description: Identifying description of the layer.

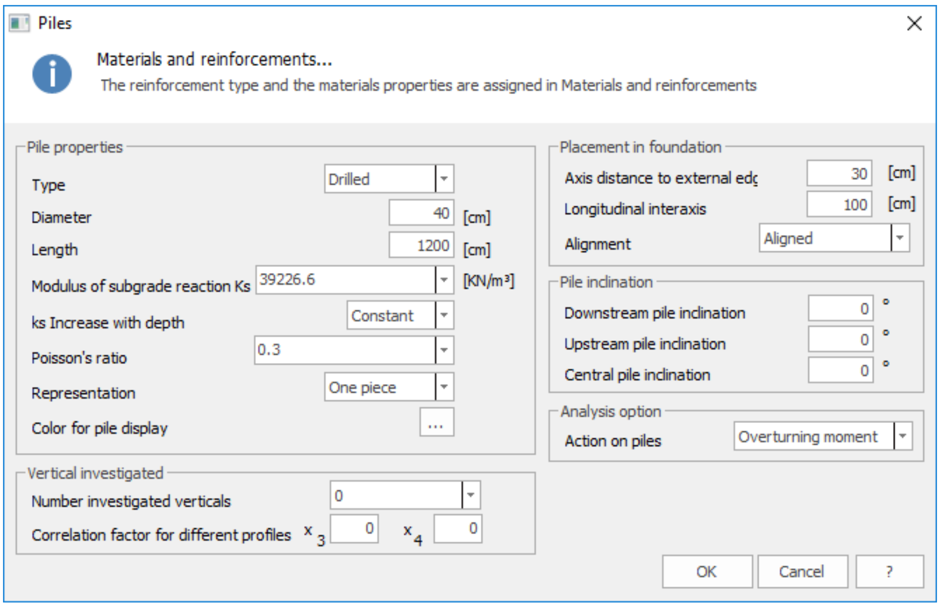
Fill: For fills on either side of the wall, it is required that: Soil weight per unit volume, Shear resistance angle, and Height be given in order to evaluate the stresses on the wall stem and foundation. The data is entered on a tab card at the right side of the screen.

note

In the global checks (load limits, overturning and sliding), the thrust is referred to a plane passing through the extrados of the founding upstream. Along this plane, the friction that develops in the presence of the shelf of founding is soil-soil friction and not soil-wall. Where, however, the foundation upstream is not present or is negligible, it is reasonable to assume that throughout the plan is to develop soil-wall friction, so the thrust evaluated with the theory of Coulomb is inclined the angle friction d of the soil-wall. In such cases it is possible to use the angle of soil-wall for global checks selecting this option down in the environment of definition of the stratigraphy.

1.7 Piles

When a wall resting on piles is specified (Main Parameters) the Pile command is made available in the Data Menu, within which the pile configuration can be specified.



Pile properties

Type and geometry as well as the coefficient of horizontal reaction, whether this is constant or varies with depth, and Poisson coefficient for the layer in which the pile tip is embeded for the calculation of settlement.

Foundation placement

To be able to locate the piles in the model the xxis distance from external edge is requested. In case of double pile row these are placed symmetrically, in case triple, threse are place in quincuncial format. Finally the distance of the longitudinal interaxis distance is requested.

Pile inclination

To each pile can be assigned a positive (anticlockwise) inclination.

Analysis options

For pile calculations, it is possible to choose either overturning moment or total moment of the action transmitted to the wall structure (Computation Process).

Shear check of circular sections, foundation piles

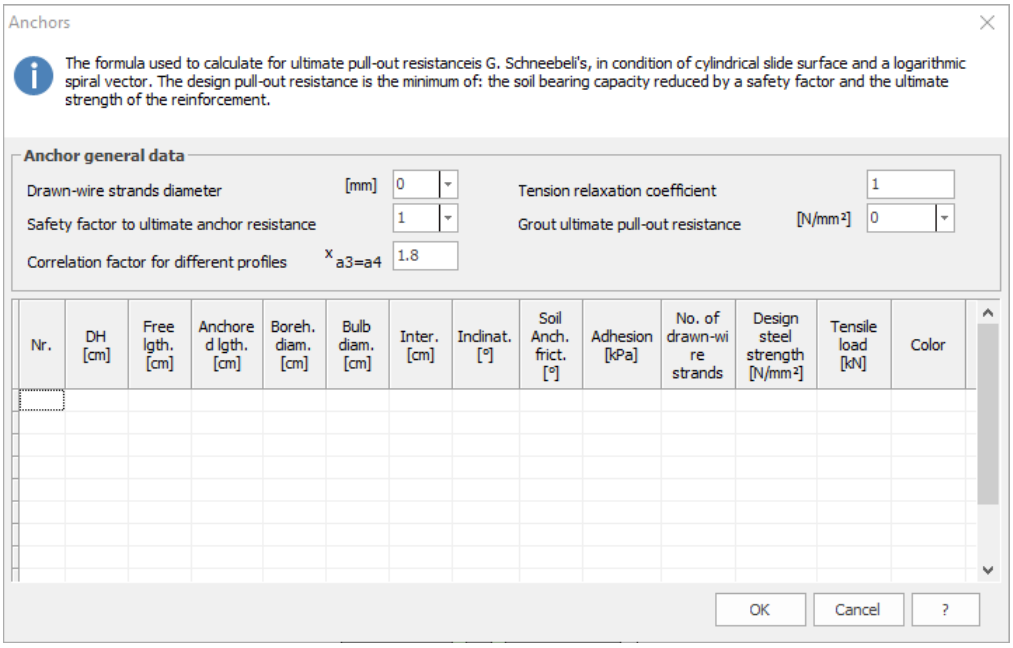
In a first phase, the program designs the shear reinforcement of the piles and then performs the verification.

The check is carried out between the design conditions and the data set by the user (in materials and reinforcements), for example the pitch of the stirrups.

If the step set by the user is less than the calculated step, the checks are carried out with the step assigned by the user, otherwise the program considers the design step.

1.8 Tiebacks

A tieback is considered by the program as a force of the same magnitude as the drag, applied to the wall. This force is taken into consideration in the calculation of global stability whenever any potential slide surface crosses the line of the tieback.



N°
Ordinal tieback no.

DH [cm]
Distance of tieback from wall stem head.

Li [cm]
Length of drag rod/cable of tieback.

La [cm]
Length of anchor part of tieback.

Df [cm]
Perforation diameter.

Db [cm]
Bulb diameter.

Inter. [cm]
Longitudinal spacing.

Incl. [°]
Angle to horizontal.

Soil-Tieback friction [°]
Soil/Tieback angle of friction.

Adhesion
Tieback/Soil adhesion.

No. of Strands
No. of strands in tieback cable.

Tieback drag
User choice for drag value for tieback that, when entered, overrules that calculated (and shown here) by the program.

Colour
Select colour that should denote the tieback.

Suggested path to applying tiebacks to wall:

1. Calculate wall without tiebacks.

2. Enter tieback geometry: as data is entered the program automatically calculates the tieback's drag. The user can override the calculated value by entering the preferred one.

3. Repeat wall calculation and check the foundation stress diagram. It is desirable that this diagram result roughly rectangular or at least with the major side on the uphill side. Further slide safety and overturning safety should verify.

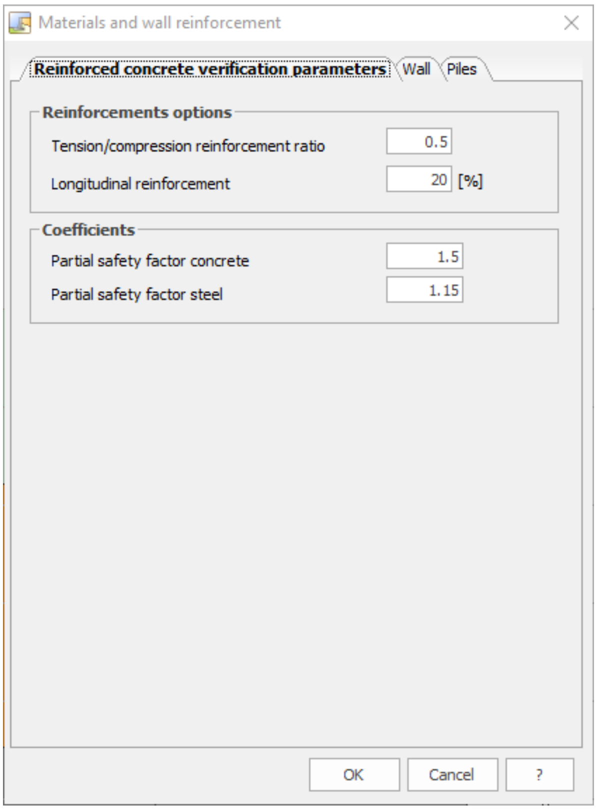
4. If the foundation stress diagram does not satisfy the above requirements, the drag should be reduced or increased as required.

5. If limit load verification fails, piles should be introduced.

6. The tieback rod(cable) length should be such as to place the anchor bulb outside the rupture zone identified by the program after tieback insertion.

1.9 Materials and Armatures

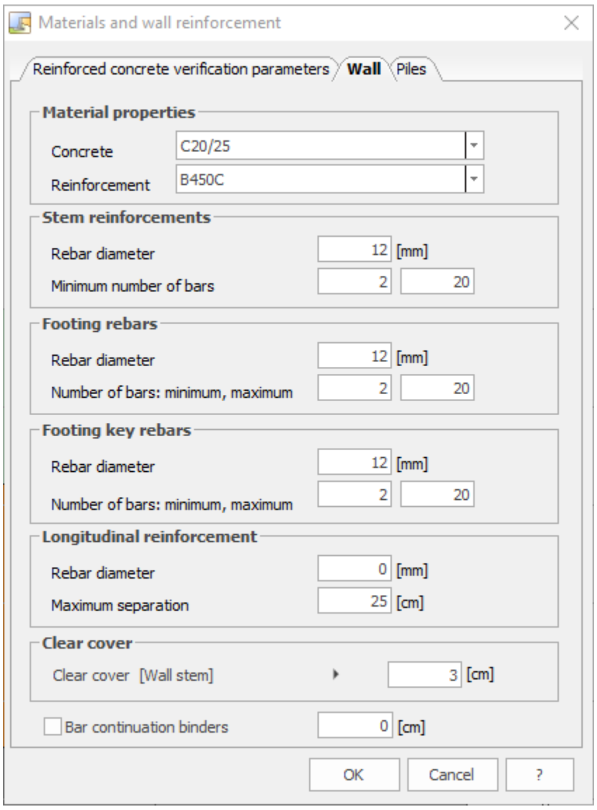
This window enables wall and pile materials and armatures to be determined and of their verification parameters.



Reinforced concrete verification parameters

Ratio between stretched and compressed reinforcement
The ratio between stretched and compressed reinforcement in each section is held to the value requested by the user.

Distribution steel
Distribution steel quantity is calculated as the user selected percentage of the stretched reinforcement of the most reinforced section.



Wall

Material properties

For concrete typical cubic resistance value and specific weight are required. For reinforcement steel the required values are typical yield strength (f_{yk}) permissible tension (for permissible tension verification), the elastic modulus the homogeneity ratio and the cover value.

Stem bars - Footing bars - Barre dente - Distribution steel

For each of these elements it is possible to specify differentiated bar diameter, and minimum and maximum number of bars.
Based upon these parameters the program attempts verification at various vertical levels, starting with the minimum and proceeding up to the maximum number of bars, and if these verifications fail, the diameter is increased until verification succeeds.

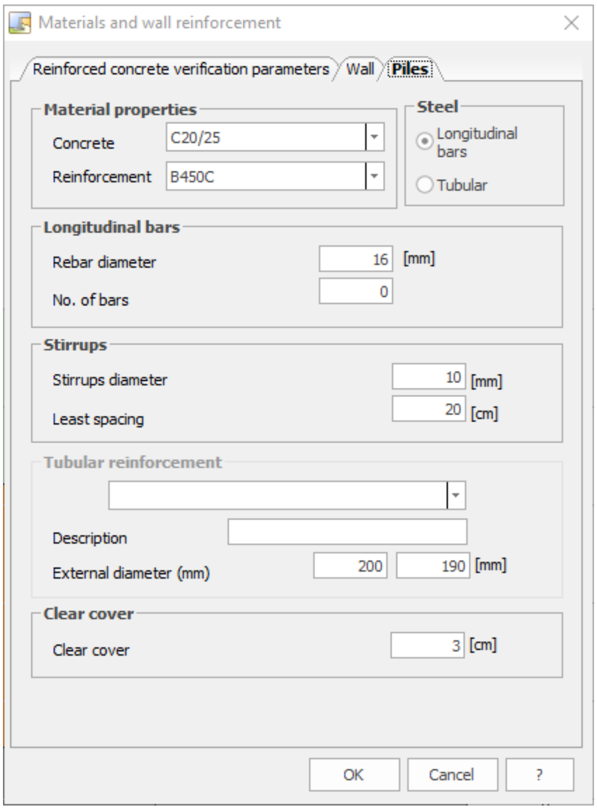
Lap splice bars

There where the reinforcement bars anchored in the footing, do not extend for the full height of the stem, additional bars extend to the full height these are spliced to the original ones. The user is requested to specify the anchorage length of the original bars extending above the footing.

Pile

Material properties
For concrete typical cubic resistance value and specific weight are required. For reinforcement steel the required values are typical yield strength (f_{yk}) permissible tension (for permissible tension verification), the elastic modulus, the homogeneity ratio, and the cover value.

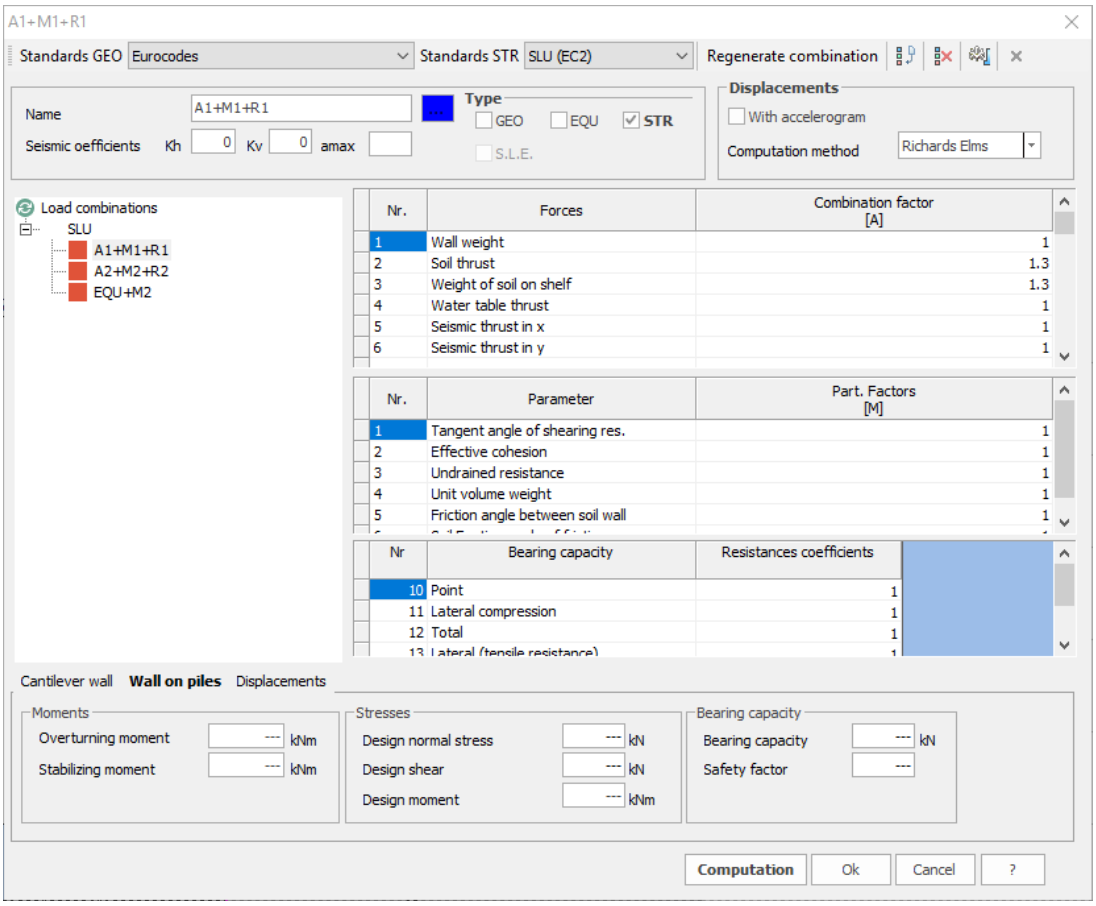
Longitudinal bars - Tie bars - Tubular armature
For reinforcement steel the required values are typical yield strength (f_{yk}) permissible tension (for permissible tension verification), the elastic modulus, the homogeneity ratio, and the cover value.
If the pile is also reinforced with tie bars and or longitudinal bars, diameter and number/separation are requested.
For tubular armature internal and external diameter are requested, however selecting from a drop down list of types these data are inserted automatically.



1.10 Computation

Computation
Performs geotechnical calculation on the wall and displays summary results.

When invoked the command presents the Combination screen where the user defined loads (backfill and wall loads) are shown along with those calculated by the program (i.e. weight, thrust, seism, water thrust etc.)
At this point the user may wish to define a number of combinations of actions and coefficients to verify the structural resistance of the wall, of the terrain specifying reductions in property values.



Load permutations

The program itself generates two combinations. One for wall structural capacity and the other for geotechnical dimensions:

- The first (A1 + M1) aimed at determining the structural capacity of the wall, uses actions amplified by specific coefficients (A1), shown below, and the given geotechnical parameters (M1);

- The second (A2 + M2), aimed at geotechnical sizing of the structure, uses actions as defined (A2) and reduces the defined geotechnical values by specific coefficients (M2).

Resistance parameter	Specific coefficient gm	
	M1	M2
Shear resistance angle tangent: $\tan\varphi'_k$	1,00	1,25
Effective cohesion c'_k	1,00	1,25
Undrained cohesion cu_k	1,00	1,40
Unit volume weight γ	1,00	1,00

Action	Specific coefficient	
	A1	A2
Constant unfavourable	1,40	1,00
Constant favourable	1,00	1,00
Variable unfavourable	1,50	1,30
Variable favourable	0,00	0,00

These defaults may be varied by the user by selecting the relevant one and altering the specific coefficients.

The program performs a complete calculation for each combination (i.e. Computation model) and returns a summary of the more notable verification results (overturning, sliding an bearing capacity). When one of the combinations fails verification in one or more respects this is highlighted.
Combinations may be removed with the mouse or using the tool bar buttons:

New combinations
New combinations may be added (check the new combination button or right click on the 'Combinations' column header).
This displays the all calculated loads (structure weight, soil weight, thrust, seism) and those defined by the user (Distributed and point loads) as well as resistance parameters (Shear resistance angle, cohesion etc.) all with specific factors set at one which the user can change to reflect requirements.

Delete combination
Combinations can be deleted either by right click on the combination name in the list or by selecting and pressing the delete button.

Rename combination

The name of combinations are assigned when inserted and can be altered at any time by selecting it on the list and typing the new name in the list box (top right).

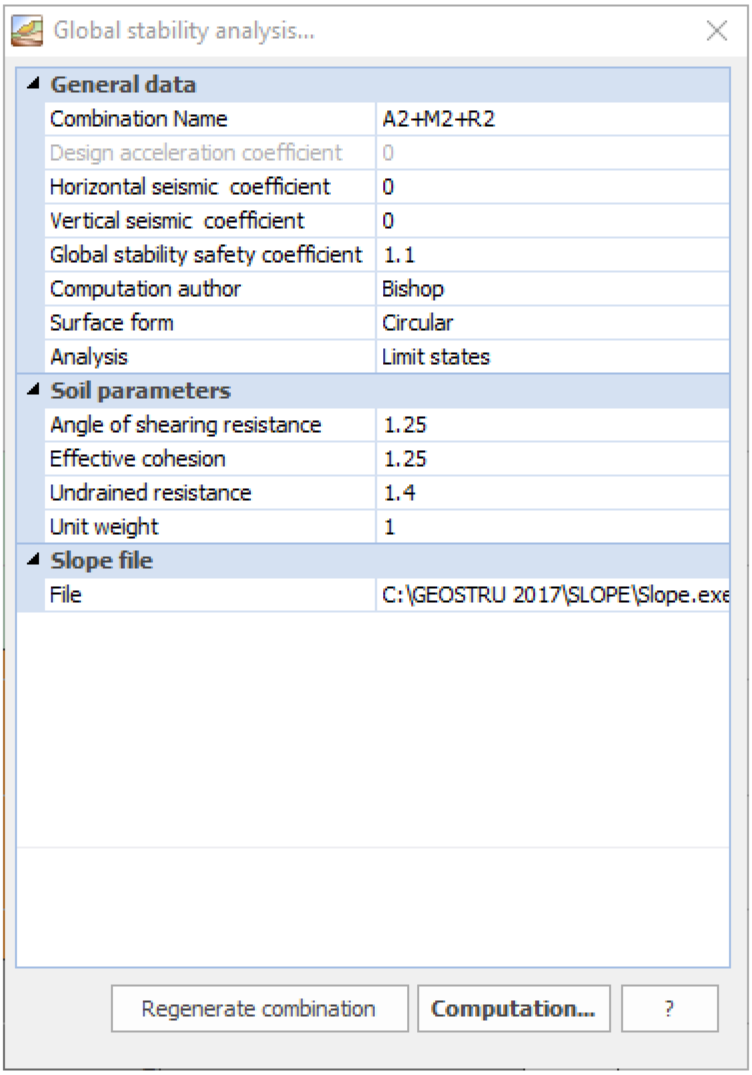
Verify combination

The user may run a verification of all combinations by pressing the computation button. The program shows with a yellow triangle those that totally or partially failed to verify (Overturn, slide and limit weight verification). By clicking on the combination name on the list the results of that combination are shown in the relevant boxes.

1.11 Global Stability

This performs Global Stability verification with the classical DEM and Limit Equilibrium methods. Verification can be performed both with circular and free form slip surfaces. For circular surfaces, the program generated a default centres grid however the user can alter it and move it as required.

The command executes the software to perform global stability analysis.

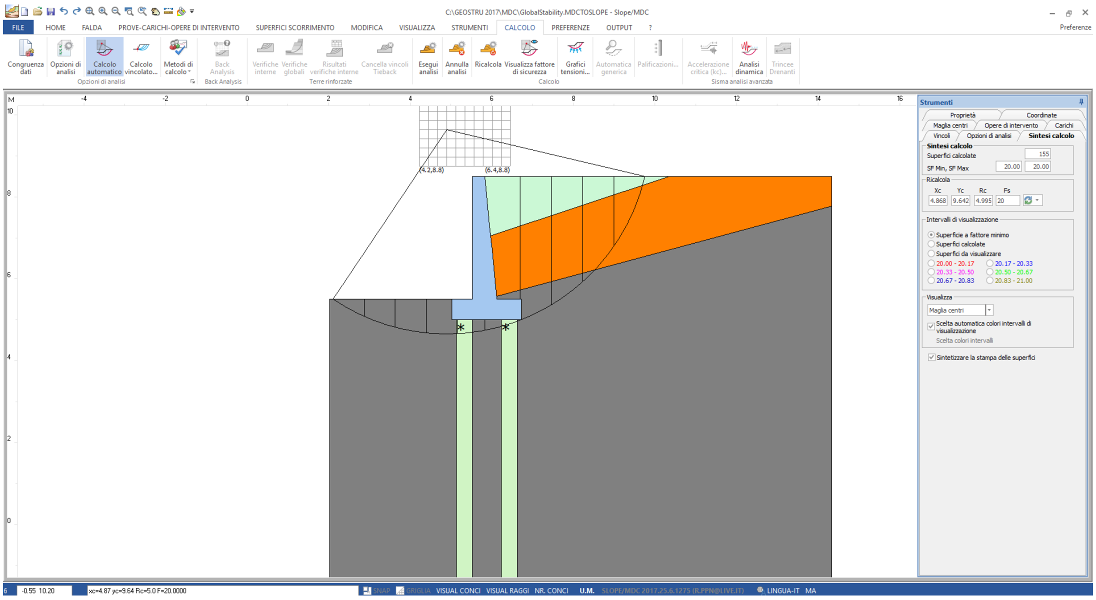


Environment for the procedure for initiating the global stability analysis

Clicking on the "Calculation" button will launch the Slope/MDC software. Verification is done for the selected load combination. The transaction of data in the global stability module is automatic, it is recommended to perform checks on the input data.

From the Calculation menu you can select the method to be used for the global stability analysis and start the calculation through the command "Run Analysis".

The Calculation Summary tab shows the minimum value of the safety factor to be compared with the acceptable degree of safety.



Environment Global Stability Analysis

The global stability report will be printed in Slope from the Output menu - *"Create relationship".*

N.B. *For more information on global stability analysis, see Slope's online help*

1.12 Diagrams

Layer View

Displays wall and soil layers.

Static-dynamic wedge

Displays magnitude of thrust wedge.

Discretization

Displays wall segmentation.

Soil Pressures

Displays diagram of soil pressures on wall.

Water table pressures

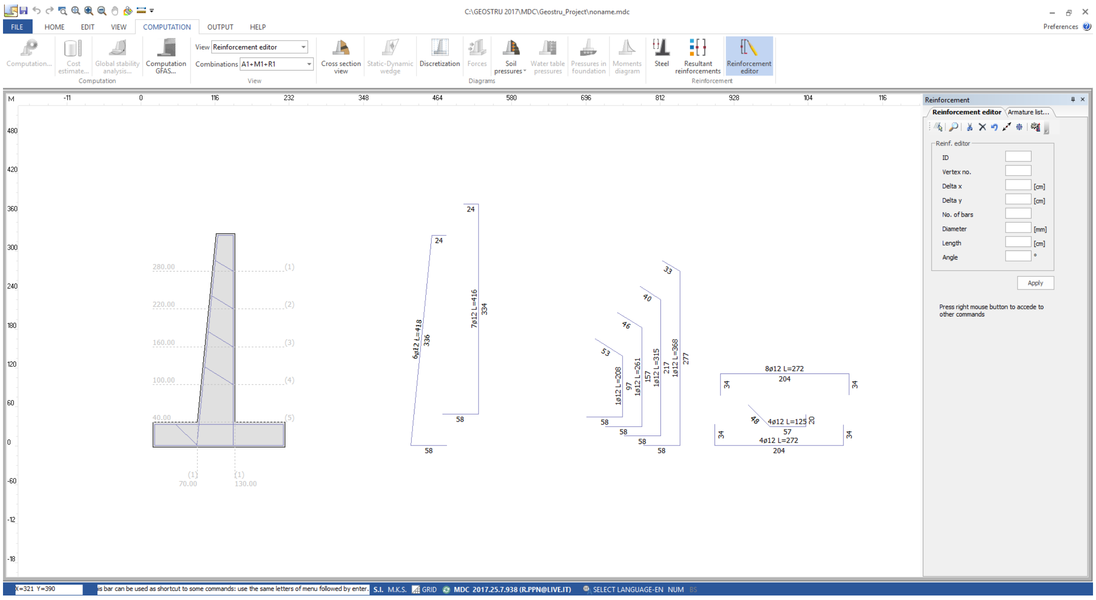
Displays diagram of water pressures.

Foundation pressures

Displays progress of pressures on foundation (only if no piles are used).

Moments diagram
Displays diagram of moments on stem and footings.

1.13 Armature



Armature
Displays armature list. Armature includes all armatures in combinations.

Resultant armature
For the combination selected in the tool bar, the armature involved is displayed.

Armature editor
This function opens the armature editor where in amendments to the armature can be made.

Bar selection
Amendment of the single bar requires that it be selected and this is achieved by utilising the Select command icon in the side pane and clicking on the target bar within the wall diagram. On selection, the ends of the bar are highlighted by small coloured spots at every vertex. The characteristics of the bar (number, diameter, length and inclination) are shown on the Armature Editor pane and may be altered there.
If a bar is selected from the explosion bar diagram beside the wall, as opposed to within it, it can only be moved.

Freeze and unfreeze a bar
As a safety measure it is possible to 'freeze' a bar, that is to prevent any

alteration to it. This function is available from a floating menu recalled by right clicking the mouse. On the same menu an unfreeze all releases all bars to editing.

Bar alterations
Each bar can be cut, shaped, by introducing one or more vertices, or removed. Commands for these operations are within the floating menu invoked by right clicking within the worksheet area and must be confirmed by the Apply command. Once removed a bar cannot be reinserted and in such cases the undo edits command should be used.

Armature Verification
After having altered the armature the alterations should be verified. Selecting the Armature list command (or pane tab), opens the Armature specification list showing value before editing. Pressing the Bar compute values button updates the list with the alterations.
At this point the Verify button performs verification of the armature and unless a message appears this can be taken as satisfactory. The amended armature is included in the Calculation Report.

Please note *that on the wall stem, the diameter of reinforcement bars on the same side, up or down hill, must be the same.*

1.14 Walls of gabion and blocks

The strength test shall be carried out in all the sections corresponding to the steps or to the separation between the gabions, in addition to the intermediate sections at the points of discontinuity. The rectangular near-inflected section is checked and sheared, consisting of non-reactive tensile material or with weak resistance. For gabion walls, the tensile strength of the material is always assumed to be zero.
The reactant section will turn out to be a partialization of the whole, and only in it will be active a certain distribution of internal stresses. In general, if the section is entirely reactive, the diagram of normal voltages will be trapezoidal, possibly interwoven;
If the cross-section is partialized and the material is not a tensile reagent, the diagram of the reacting part shall be triangular with a zero point at the neutral axis; if the cross-section is biased and the material has a certain tensile strength, the diagram shall be a butterfly, with a minimum value equal to the maximum tensile strength and a maximum such that the integral of the pressures balance the stress system.

Internal stability checks

This check is required to verify that the reaction caused by normal stress σ_i and tangential τ_i inside the structure (the subscript "i" indicates internal) must be below the corresponding limit values σ_{ilim} and τ_{ilim}, in such a way as to avoid the possibility of recording excessive deformations that can compromise the stability of the work. The values of the efforts σ_{ilim} and τ_{ilim} the following can be deduced from empirical formulas:

$$\sigma_{ilim} = 5 \cdot \gamma_{gabbioni} - 3$$

$$\tau_{ilim} = N \cdot \tan\phi^* + C_{gab} + \text{Shear design resistance}$$

Where:

- $\gamma_{gabbioni}$ gabions is the volume weight of the filling, which depends on the lithological nature of the filling and the degree of thickening, [t/m^3].
- ϕ^* is the fictitious internal friction angle of gabions, which is evaluated through an empirical formula $\phi^* = 25\gamma_{gab} - 10°$. This parameter depends, for obvious reasons, on the thickening of the filling stone material (the specific weight of the same provides indications).
- C_{gab} it's the fictitious cohesion, attributable to the presence of the metal mesh. It is estimated through a formula of an empirical nature, $C_{gab} = 0.03.Pu - 0.05$, where Pu is the weight of wire mesh present in a cubic meter of work, [Kg/m^3]. This parameter can be deduced from the tables below, where the approximate weight of the various gabions can be deduced depending on the type of mesh, the diameter of the thread used, the presence or absence of diaphragms, etc.

Box Gabions Alloy Zinc Aluminum Mesh cm 6x8						
Length	Width	Height	Capacity	Approximate weight per gabion - Kg		Diaphragm
				Without diaphragm	With diaphragm	
				Wire	Wire	
m	m	m	m³	Ø 2,7 mm	Ø 2,7 mm	n
1,5	1	0,5	0,75	11,3	-	-
2	1	0,5	1,00	13,3	15,6	1
3	1	0,5	1,50	19,0	22,5	1
1,5	1	1	1,50	15,3	-	2
2	1	1	2,00	18,6	21,5	3
1	1	1	1,00	13,0	-	4
3	1	1	3,00	25,8	29,2	-

Box Gabions Alloy Zinc Aluminum Mesh cm 8x10								
Length	Width	Height	Capacity	Approximate weight per gabion - Kg				Diaphragm
				Without diaphragm		With diaphragm		
				Wire	Wire	Wire	Wire	
m	m	m	m³	Ø 2,7 mm	Ø 3,0 mm	Ø 2,7 mm	Ø 3,0 mm	n
1,5	1	0,5	0,75	9,5	11,5	-	-	-
2	1	0,5	1,00	11,4	14,6	12,6	15,5	1
3	1	0,5	1,50	16,0	20,0	17,5	21,5	2
4	1	0,5	2,00	20,7	26,0	23,0	28,0	3
1,5	1	1	1,50	12,8	16,1	-	-	-
2	1	1	2,00	15,3	19,3	17,0	21,0	1
1	1	1	1,00	10,5	12,5	-	-	-
3	1	1	3,00	21,3	26,8	24,5	30,0	2
4	1	1	4,00	26,3	34,0	31,5	39,0	3

Box Gabions Alloy Zinc Aluminum Mesh cm 8x10						
Length	Width	Height	Capacity	Approximate weight per gabion - Kg		Diaphragm
				Without diaphragm	With diaphragm	
				Wire	Wire	
m	m	m	m³	Ø 2,7 mm	Ø 2,7 mm	n
1,5	1	0,5	0,75	11,3	-	-
2	1	0,5	1,00	13,6	14,8	1
2,5	1	0,5	1,25	16,4	17,7	1
3	1	0,5	1,50	18,7	21,00	2
4	1	0,5	2,00	22,5	26,00	3
5	1	0,5	2,50	27,0	32,2	4
1,5	1	1	1,50	15,3	-	-
2	1	1	2,00	18,2	20,0	1
2,5	1	1	2,50	20,4	23,1	1
3	1	1	3,00	24,3	28,4	2
4	1	1	4,00	31,2	37,0	3

When the normal stresses acting at the downstream edge σvi and the upstream edge σmi of the test section are determined by observing that these stresses are caused by stress composed of pressure bending:

$$\sigma_{vi} = \frac{N}{B_{base}} \cdot \left(1 + \frac{6 \cdot e}{Bbase}\right)$$

$$\sigma_{mi} = \frac{N}{B_{base}} \cdot \left(1 + \frac{6 \cdot e}{Bbase}\right)$$

where:

- N is the sum of all forces normal to the base plane of the work acting on the calculation section.
- B_{base} is the length of the base plane.
- e is the eccentricity of the result of the forces acting on the work, i.e. the distance of its meeting point with the verification section measured by the center of gravity of the section itself.

$$e = \frac{B_{base}}{2} - u$$

- u represents the distance of the point of intersection between the line of action of the resultant of the forces acting on the cage and the base plane, measured from the valley edge.

$$u = \frac{M_{stab} - M_{instab}}{N}$$

The stabilizing moment M_{stab} and the reversing moment M_{instab} are evaluated with respect to the valley edge of the work.

The shear stress acting at the verification section turns out to be:

$$\tau i = \frac{T}{B_{base}}$$

where:

- T is the result of all tangential forces acting in the verification section.
- B_{base} is the length of the verification section.

Indicated with σ_{max} and σ_{min} respectively the maximum value and the minimum value between σ_{vi} and σ_{mi}, the checks in question are passed if the conditions are verified for each limit state

Ed≤Rd

Ed it’s the design value of the action or effect of the action understood as the result of the integration of the effort diagram. Rd is the design value of the resistance of the geotechnical system calculated as a result of compressive limiting stresses.

The shear resistance of the additional bars was determined according to Ec3

Shear design resistance =0.6 * (Tensile strength bar) * (bar area) / 1.25) * Number of bars.

1.15 Output

General
Displays the master calculation report, exporting it in :*.doc, *.docx, *.pdf format. The user can choose to separate, by operating the corresponding commands, the general relation into: limit load, geotechnical, material and structural.

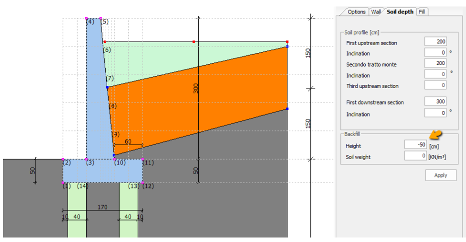
Export to DXF format
Stores in DXF format the contents of the worksheet window.

Export to Bitmap format
Stores in BMP format the contents of the worksheet window.

Note: *Exported file have the same name as the project with unique suffix and the type (DXF, BMP, RTF).*

1.16 Plan-campaign translation

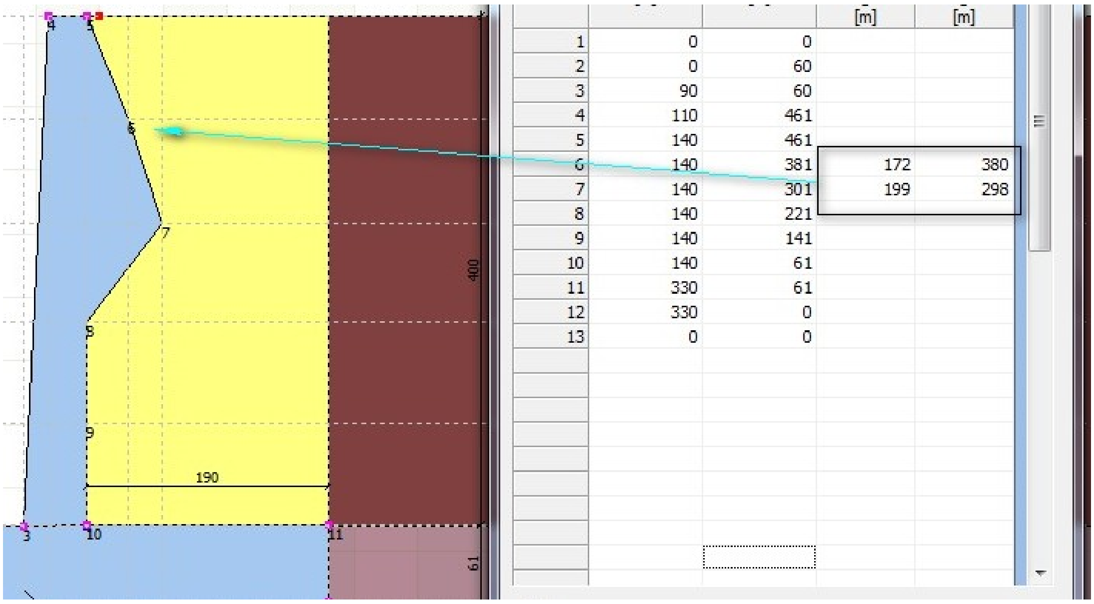
To lower the topographic profile, assign a negative relief height.



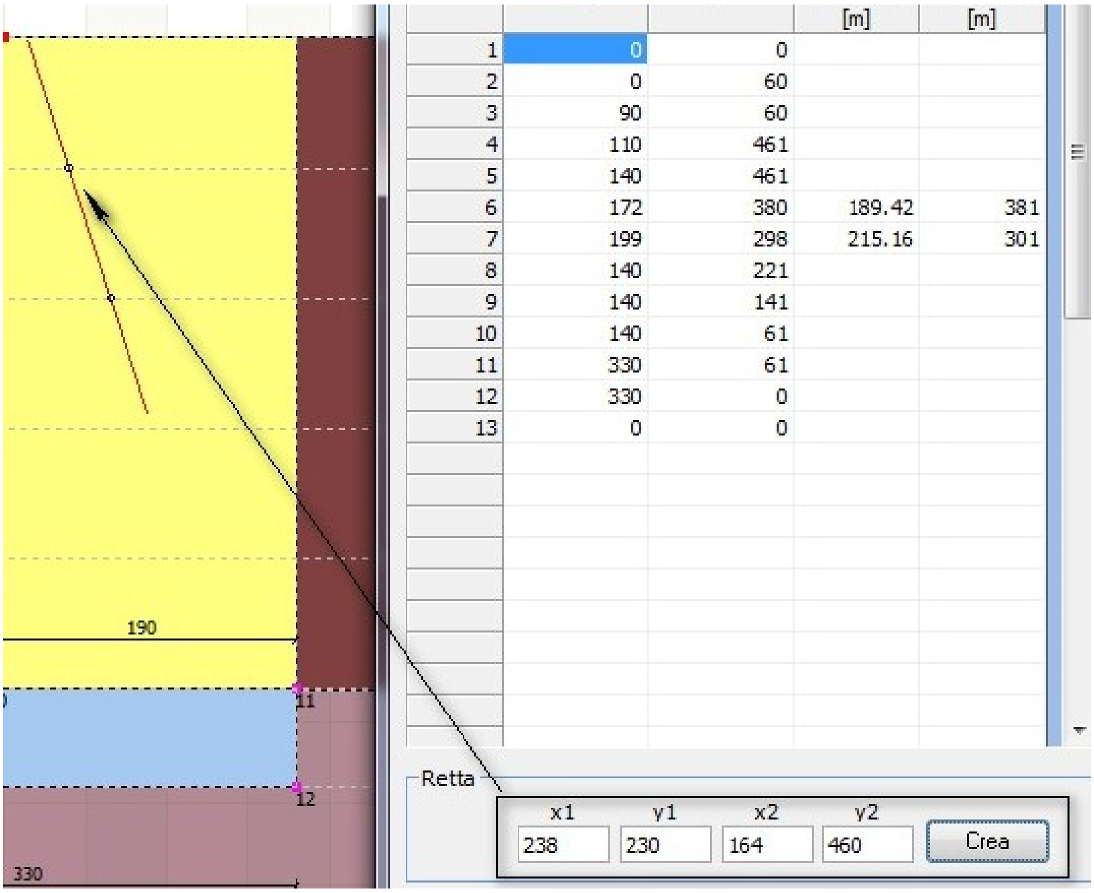
1.17 Wall coordinates

The command for the advanced management of the coordinates of the section of the wall "Wall Coordinates" is activated only after having defined a type and having assigned the geometric quantities in wall geometry.

To change the coordinates you must assign them in the 4°and 5° columns of the grid, you must assign them both as shown in the figure.



To facilitate the input system, it is possible to define a modification line as shown in the figure:



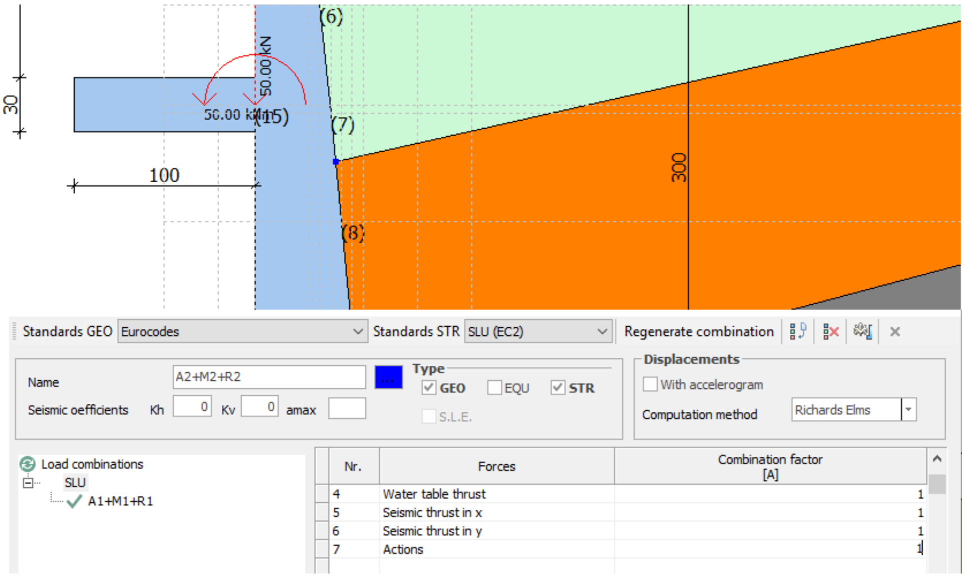
			[m]	[m]
1	0	0		
2	0	60		
3	90	60		
4	110	461		
5	140	461		
6	172	380	189.42	381
7	199	298	215.16	301
8	140	221		
9	140	141		
10	140	61		
11	330	61		
12	330	0		
13	0	0		

The create command will create and display in the 4° and 5° column the coordinates to be assigned to the profile.

With the Reset command, you can return to the initial coordinates.

1.18 Downstream shelf

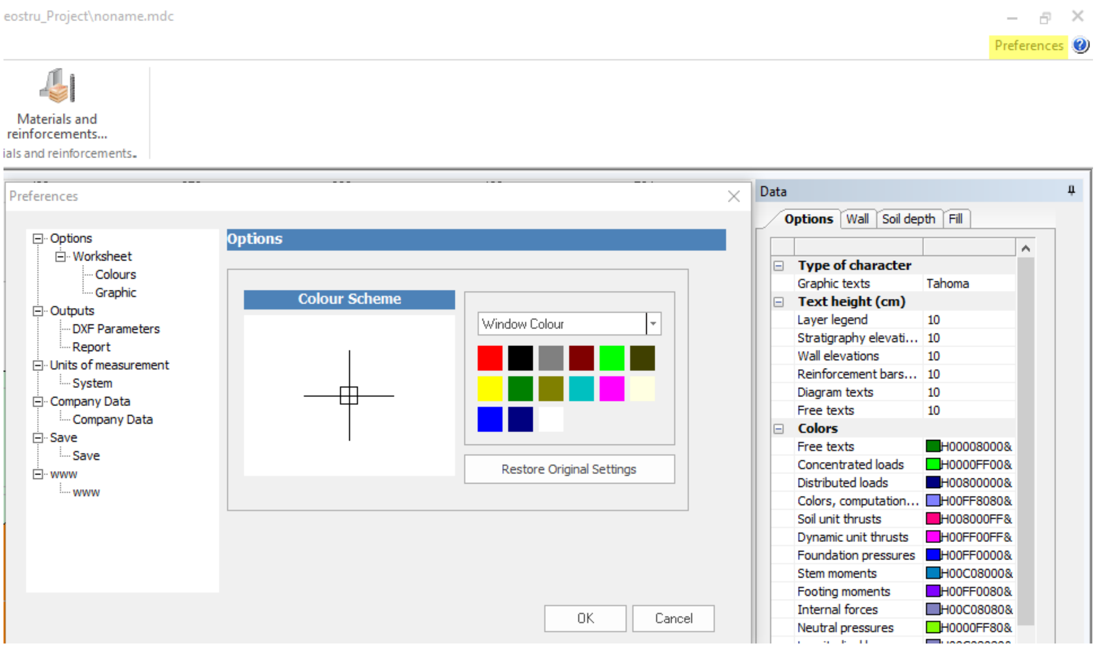
After geometrically inserting the shelf downstream, actions such as external loads and combination factors must be introduced into the calculation window. The actions will be assembled in the system for global and structural geotechnical verifications.



Downstream shelf for modifying reinforcements

1.19 Options

Access from Preferences, selecting options displays the dialog box for setting the parameters related to the work area: You can customize the background and line colors; the position of the screens and their size in percent, as well as the thickness of the lines, the tolerance of the cursor and the pitch of the work grid.



1.20 Theoretical Notes

1.20.1 Computation Process & Conventions

Verification of the wall is done in the following sequence:

Phase I

Terrain pressures and any surcharge on the stem are calculated. The stem is then divided into a fixed number of segments that will hereafter be the verification segments. For this phase, the thrust surface is taken to be the face of the stem. If Coulomb 's method is selected the thrust is considered at an angle corresponding to the terrain wall angle of friction declared in the geotechnic properties. If Rankine's method was selected the thrust is considered to be horizontal. In phase I, the program determines stresses only on the stem and performs structural verification using the materials specified by the user and the selected criterion (Admissible Tension, or Limit State).

Phase II

In this phase pressures calculations are repeated taking as thrust surface the vertical line that passes through the uphill edge of the foundation heel. This time, with Coulomb’s method, it is the angle of soil resistance that is used. Then all pressures (Overturning and stabilizing moments) are determined in respect to the datum point that is the lower corner of the foundation toe. Thereafter the program performs Ultimate limit state, Overturning, Sliding, and Limit load verifications.

Phase III

In this phase the stresses on the footing shelves, segmented to a fixed number, are determined. Then structural verification on the footing is performed.

If the footing is not anchored on piles, this completes the calculation.

Phase IV

This phase is only relevant where pile further support the footing. Stresses transmitted by the wall to the piles are consist in the moments obtained in phase II. The user may chose to have transmitted to the piles the net resulting moment (difference between overturning and stabilizing) or only the overturning one. Clearly this latter choice is only reasonable where the overturning moment far exceeds the stabilizing. If more than one line of piles is declared, the program performs verification calculation on the line that is most stressed (normally by compression).

1.20.2 Standards

The Standards that can be chosen for geotechnic and structural calculation are European Union Eurocodes and also specific Italian National legislation norms as listed below, that may be of relative interest to the non Italian user.

Eurocode 2
Projects involving concrete structures. Part 1-1: General Rules.

Eurocode 7
Geotechnic Projects. Part 1: General Rules.

Eurocode 8
Project guidelines for structural resistance to seismic events. Part 5: Foundations, Retaining structures, and geotechnical aspects.
Italian National legislation:
(quoted from relevant legislation)

STAS 3300-10107/0-90

STAS 3300-10107/0-90

1.20.3 Evaluation of active thrust according to Coulomb

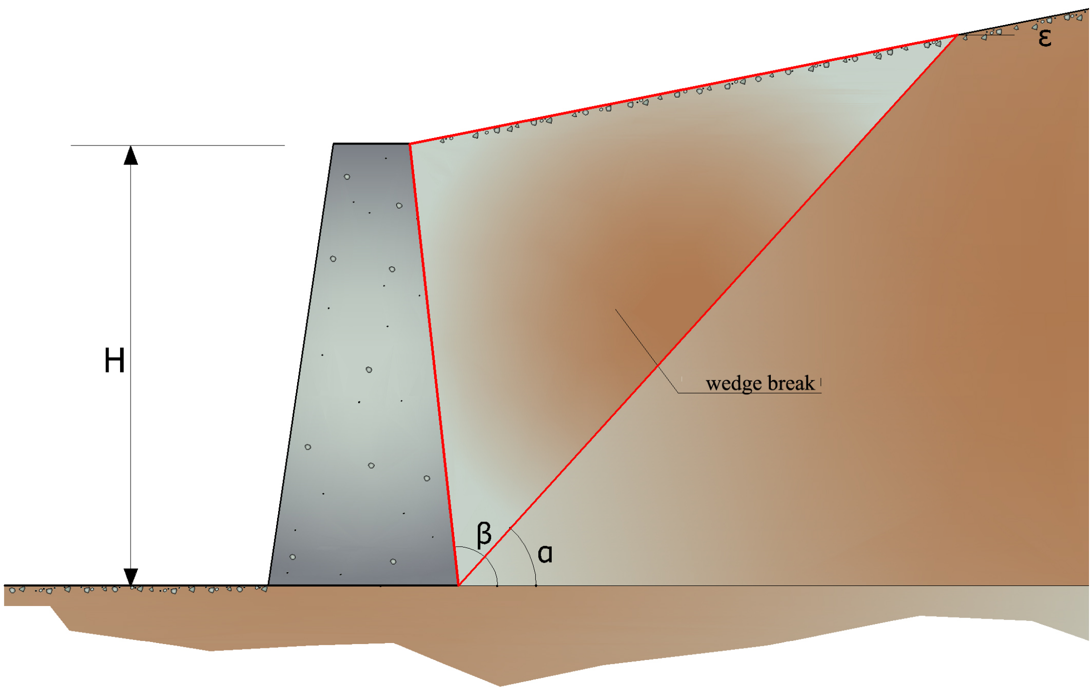
Active thrust calculation using Coulumb's method is based on global limit equilibrium theory of a system whose components are the wall and the wedge of homogeneous terrain behind the work assuming rough surface.
Where terrain is dry and homogeneous the pressure diagram is expressed linearly by the following:

$$P_t = K_a \gamma_t z$$

Thrust St is applied at 1/3 H with the value:

$$S_t = \frac{1}{2}\gamma H^2 K_a$$

Having:



$$K_a = \frac{\sin^2(\beta - \phi)}{\sin^2\beta \times \sin^2(\beta + \delta) \times \left[1 + \sqrt{\frac{\sin(\delta + \phi) \times \sin(\phi - \varepsilon)}{\sin(\beta + \delta) \times \sin(\beta - \varepsilon)}}\right]^2}$$

Limit value of K_a:

$\delta < (\beta - \varphi - \varepsilon)$ according to Muller-Breslau

γ_t = Terrain unit volume weight;

β = Inside wall surface inclination to horizontal plane of footing;

φ= Terrain shear resistance angle;

δ = Angle of friction terrain to wall;

ε = Field level inclination to horizontal - Positive if anticlockwise;

H = Wall height.

Active thrust calculation according to Rankine

If $\varepsilon = \delta = 0$ e $\beta = 90°$ (wall with smooth surface and backfill with horizontal surface) thrust St is simplified to:

$$S_t = \frac{\gamma \cdot H^2(1-\sin\phi)}{2(1+\sin\phi)} = \frac{\gamma \cdot H^2}{2} tg\left(45 - \frac{\phi}{2}\right)$$

that coincides with Rankine's equation that gives active thrust where backfill is horizontal.

Effectively Rankine used the same hypothesis as Coulumb except that he ignored wall-terrain friction and cohesion. Rankine's expression for K_a in general form is as follows:

$$K_a = \cos\varepsilon \frac{\cos\varepsilon - \sqrt{\cos^2\varepsilon - \cos^2\phi}}{\cos\varepsilon + \sqrt{\cos^2\varepsilon - \cos^2\phi}}$$

Active thrust calculation according to Mononobe & Okabe

Mononobe & Okabe's evaluation of active thrust concerns thrust in seismic states with pseudo static method. This is based on global limit equilibrium theory of a system whose components are the wall and the wedge of homogeneous terrain behind the work in an artificial configuration in which both field level inclination and the angle b - inclination of internal wall surface to horizontal -are increased by an amount q such that:

$$tg\delta = k_h/(1 \pm k_v)$$

where kh is the horizontal seismic coefficient and kv the vertical.

Where no specific studies exist coefficients k_h & k_v should be calculated as:

$$k_h = S \times ag/r \qquad k_v = 0,5\ k_h$$

where S×ag is the maximum seismic acceleration in the various categories in the stratigraphic profile.

Factor r can take the value 2 where the work is one of some flexibility (e.g. gravity walls). In all other cases (Stiff concrete walls, On piles, Fixed head)) it should be set to 1.

Effect due to cohesion

Cohesion introduces negative constant pressures as:

As it is not possible to calculate a priori the thrust reduction caused by cohesion a critical height Zc has been calculated as:

$$Z_c = \frac{2 \times c}{\gamma} \times \frac{1}{\sqrt{K_a}} - \frac{Q \times \frac{\sin\beta}{\sin(\beta+\varepsilon)}}{\gamma}$$

where:

Q = Loads acting on the backfill.

If $Z_c<0$ the effect may be applied directly as a decrease whose value is:

$Z_c = P_c \times H$

applied at H/2.

Uniform load on backfill
A load Q, uniformly distributed on the backfill generates constant pressures as:

$$P_q = K_a Q \cdot sen\beta / sen(\beta+\varepsilon)$$

Integrating, a thrust Sq:

$$S_q = K_a \cdot Q \cdot H \frac{\sin\beta}{\sin(\beta+\varepsilon)}$$

Applies at H/2, indicating as Ka the Muller-Breslau active thrust coefficient.

Active thrust in seismic state

In seimic state the calculation force exercised by the backfill on the wall is given by:

where:

H= wall height

k_v= vertical seimic coefficient

γ = terrain unit volume weight

K = total thrust coefficient (static + dynamic)

E_{ws} = hydrostatic water thrust

E_{wd} = hydrodynamic thrust

For impermeable terrains, hydrodynamic thrust Ewd = 0, but a correction on evaluation of the angle q in Mononobe & Okabe's formula is made as follows:

$$tg\vartheta = \frac{\gamma_{sat}}{\gamma_{sat} - \gamma_w} \cdot \frac{k_h}{1 \pm k_v}$$

In highly permeable terrain in seismic states, the same correction is applied but hydrodynamic thrust assumes the following value:

$$E_{wd} = \frac{7}{12} k_h \gamma_w H'^2$$

where H' is the height of the groundwater tables(Gwt) from the base of the wall.

Hydrostatic thrust

Gwt whose surfac is at height Hw from the base of the wall generates hydrostatic pressures normal to its surface that at depth z are expressed as:

$P_w(z) = \gamma_w \cdot z$

Resulting as:

$$S_w = 1/2 \cdot \gamma_w \cdot H^2$$

Thrust of submeged terrain can be obtained substituting γ_t con γ'_t($\gamma'_t = \gamma_{saturo} - \gamma_w$), effective weight of submerged material.

Passive resistance

In homogeneous terrain a linear diagram of pressures results:

$$P_t = K_p \cdot \gamma_t \cdot z$$

integrating with passive thrust:

$$S_p = \frac{1}{2} \cdot \gamma \cdot H^2 \cdot K_p$$

having:

$$K_p = \frac{\sin^2(\phi + \beta)}{\sin^2 \beta \times \sin(\beta - \delta) \times \left[1 - \sqrt{\frac{\sin(\delta + \phi) \times \sin(\phi + \varepsilon)}{\sin(\beta - \delta) \times \sin(\beta - \varepsilon)}}\right]^2}$$

(Muller-Breslau) with d limit values at:

$$\delta < \beta - \varphi - \varepsilon$$

The expression for K_p according to Rankine assumes the following form:

$$K_p = \frac{\cos\varepsilon + \sqrt{\cos^2\varepsilon - \cos^2\phi}}{\cos\varepsilon - \sqrt{\cos^2\varepsilon - \cos^2\phi}}$$

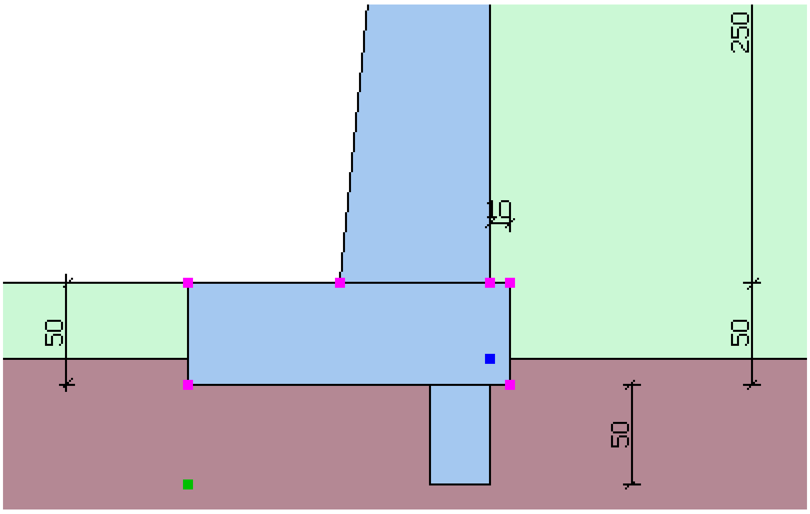
1.20.4 Limit load of surface foundations

Observation

If the stratigraphy is differentiated, foundation soil different from that of elevation, if possible, avoid making the base stratigraphy share perfectly coincide with the foundation dimension.

The figure shows the correct scheme to follow.

Attention: this is only a trick because by making them coincide MDC assumes the geotechnical characteristics of the base layer for limit load checks.



VESIC - Project limit load in short term

In order that a foundation may safely sustain the projected load in regard to general rupture for all combinations of load relative to the ultimate limit state, the following must be satisfied:

$$V_d \leq R_d$$

where:

V_d is the project load at ultimate limit state normal to the footing, including the weight of the foundation itself;

R_d is the projected foundation ultimate limit load for normal loads, also taking into account eccentric and inclined loads. When estimating R_d for fine grained soils short and long term situations should be considered.

Limit load undrained conditions is calculated by:

$$\frac{R}{A'} \leq (2+\pi) \cdot c_u \cdot s_c \cdot i_c \cdot d_c + q$$

where:

Project effective foundation area. There where eccentric loads are involved, use

	the reduced area at whose center the load is applied.
c_u	Undrained cohesion.
q	Total lithostatic pressure on footing.
s_c	Foundation shape factor.
$s_c \leq 0.2 \cdot \left(\frac{B'}{L'}\right)$	Rectangular shapes.
$s_c = 1$	Strip foundations
$i_c = 1 - \frac{2H}{A_f \cdot c_a \cdot N_c}$	Correction factor for inclination of load H.
$d_c \leq 0.4 \cdot K$	Depth factor.

$$\mathrm{K} = \frac{\mathrm{D}}{\mathrm{B}} \text{ if } \frac{\mathrm{D}}{\mathrm{B}} \leq 1 \text{ else } \mathrm{K} = \arctan\frac{\mathrm{D}}{\mathrm{B}} (\text{no B}')$$

VESIC - Project limit load in drained conditions is calculated as follows:

$$\frac{R}{A'} \leq c' \cdot N_c \cdot s_c \cdot i_c \cdot d_c + q' \cdot N_q \cdot s_q \cdot i_q \cdot d_q + 0.5 \cdot \gamma' \cdot B' \cdot N_\gamma \cdot s_\gamma \cdot i_\gamma \cdot d_\gamma$$

where:

$$N_c = (N_q - 1)\cot\varphi'$$

$$N_\gamma = 2 \cdot (N_q + 1)\tan\varphi'$$

Form factors

$$s_q = 1 + \left(\frac{B'}{L'}\right)\tan\varphi'$$ Rectangular shape

$$s_\gamma = 1 - 0.4 \cdot \left(\frac{B'}{L'}\right)$$ Rectangular shape

$$s_c = 1 + \frac{N_q}{N_c} \cdot \frac{B'}{L'}$$ Rectangular, square, or circular shape

Resultant inclination factors due to an horizontal load, H parallel to B'

$$i_q = \left(1 - \frac{H}{V + A_f \cdot c_a \cdot \cot\varphi'}\right)^m$$

$$i_\gamma = \left(1 - \frac{H}{V + A_f \cdot c_a \cdot \cot\varphi'}\right)^{m+1}$$

$$i_c = i_q - \frac{1 - i_q}{N_c \cdot \tan\varphi'}$$

$$m = 1 + \frac{2 + \frac{B'}{L'}}{1 + \frac{B'}{L'}}$$

Depth factor.

$$d_q = 1 + 2 \cdot \tan\varphi \cdot (1 - \sin\varphi) \cdot K$$

$$\text{con } K = \frac{D}{B} \text{ if } \frac{D}{B} \leq 1 \text{ else } K = \arctan\frac{D}{B}$$

$$d_\gamma = 1$$

HANSEN - Project limit load in short term

Limit load undrained conditions is calculated by:

$$\frac{R}{A'} \leq (2 + \pi) \cdot c_u \cdot s_c \cdot i_c \cdot d_c + q$$

where:

$A' = B' \cdot L'$	Project effective foundation area. There where eccentric loads are involved, use the reduced area at whose center the load is applied.
c_u	Undrained cohesion.
q	Total lithostatic pressure

on footing.

$$s_c = 1$$

Strip foundations

$$i_c = 0.5 - 0.5\sqrt{1 - \frac{H}{A_f \cdot c_a}}$$

Correction factor for inclination of load H.

$$d_c \leq 0.4 \cdot K$$

Depth factor.

$$\mathrm{K} = \frac{\mathrm{D}}{\mathrm{B}} \text{ if } \frac{\mathrm{D}}{\mathrm{B}} \leq 1 \text{ else } \mathrm{K} = \arctan\frac{\mathrm{D}}{\mathrm{B}} \text{ (no B')}$$

HANSEN - Project limit load in drained conditions is calculated as follows:

$$\frac{R}{A'} \leq c' \cdot N_c \cdot s_c \cdot i_c \cdot d_c + q' \cdot N_q \cdot s_q \cdot i_q \cdot d_q + 0.5 \cdot \gamma' \cdot B' \cdot N_\gamma \cdot s_\gamma \cdot i_\gamma \cdot d_\gamma$$

where:

$$N_q = e^{\pi \tan\varphi'} \tan^2\left(45 + \frac{\varphi'}{2}\right)$$

$$N_c = (N_q - 1)\cot\varphi'$$

Form factors

Rectangular shape

$$s_\gamma = 1 - 0.4 \cdot \left(\frac{B'}{L'}\right)$$ Rectangular shape

$$s_c = 1 + \frac{N_q}{N_c} \cdot \frac{B'}{L'}$$ Rectangular, square, or circular shape

$$s_c = s_q = s_\gamma = 1$$ Strip foundations

Resultant inclination factors due to an horizontal load, H parallel to B'

$$i_q = \left(1 - \frac{0.5 \cdot H}{V + A_f \cdot c_a \cdot \cot\varphi'}\right)^3$$

$$i_\gamma = \left(1 - \frac{0.7 \cdot H}{V + A_f \cdot c_a \cdot \cot\varphi'}\right)^3$$

$$i_c = i_q - \frac{1 - i_q}{N_c \cdot \tan\varphi'}$$

Depth factor.

$$d_c = 1 + 0.4 \cdot K$$

$$d_q = 1 + 2 \cdot \tan\varphi \cdot (1 - \sin\varphi) \cdot K$$

$$\text{con K} = \frac{\text{D}}{\text{B}} \text{ if } \frac{\text{D}}{\text{B}} \le 1 \text{ else K} = \arctan\frac{\text{D}}{\text{B}}$$

1.20.5 Foundation Pile Computation

Sign convention

1. Vertical force Fy is positive when directed downwards;
2. Horizontal force Fx is positive when directed towards the right;
3. Couple M is positive when acting to produce movements such as those produced by horizontal force Fx.

Winkler model analysis of pile in operating status

Winkler's model enables variations in mechanical properties of terrain and layers to be taken into consideration simply.

Where material is homogeneous (K constant) Hetènyi's classification is adopted that defines three different pile behaviour for Winkler depending on relative terrain rigidity (I) soil/pile that is: short or rigid pile, relatively flexible pile, infinitely flexible pile.

Limit vertical load

Limit vertical load is calculated with static formulas that express it in function of pile geometry, of terrain properties and of the interface pile soil.

For the purposes of calculation limit load Qlim is conventionally apportioned in two parts: tip resistance Qp and lateral resistance Qs.

Tip resistance

Tip resistance qp where the terrain displays friction (j) e cohesion (c), is give by:

$$q_p = c \cdot N_c + \gamma \cdot D V N_q$$

where:

γ = Terrain unit volume weight
D = Pile length;
N_c & N_q= Bearing capacity factors including form factor (circular).

Factor N_q is calculated according to Berezantzev.

Stem resistance

Lateral bearing capacity is calculated using method A proposed by Tomlinson (1971) according to the following:

$$f_s = A \cdot c + q \cdot K \cdot tg\, \delta$$

c = Average cohesion value (or shear resistance in undrained conditions).
q = Effective vertical pressure of the terrain.

k = Coefficient of horizontal thrust. This depends on the technique of the pile and on the previous compaction state and is calculated as:

For driven piles	$K = 1 + tg^2\varphi$
For drilled piles	$K = 1 - tg^2\varphi$

δ = Pile/soil friction coefficient as function of pile surface.

For driven piles	$\delta = 3/4 \cdot tg\ \varphi$
For drilled piles	$\delta = tg\ \varphi$

α is a coefficient as below:

Driven pile coefficient

c < 0.25	α = 1.00
0.25 < c < 0.5	α = 0.85
0.5 < c < 0.75	α = 0.65
0.75 < c <2.4	α = 0.50
c >2.4	α = 1.2 / c

Drilled pile coefficient

c < 0.25	α = 0.9
0.25 < c < 0.5	α = 0.8
0.5 < c < 0.75	α = 0.6
0.75 < c < 2	α = 0.4
c > 2	α = 0.8 / c

Further according to Okamoto guidelines where seismic state occurs lateral resistance ie reduced depending on the seismic coefficient k_h as follows:

$$C_{reduct\_coeff} = 1 - k_h$$

Finally:

1. For driven piles both resistance properties (c,φ) and the coefficient of the terrain horizontal modulus are reduced by 10%.

2. Where drag action is encountered, tip load is null and lateral load is reduced by 70%.

3. In the vertical safety margin the weight of the pile has been taken into account.

Settlements

Vertical settlements are calculated using the Davis-Poulos method, according to which the pile is considered as rigid (undeformable) embedded in an elastic medium, semi space, or layer of finite thickness.
The hypothesis considers that the interaction between pile and soil is constant for each (n) cylindrical segments in which the pile side surface is subdivided.
The settlement of the i th surface due to the load transmitted by the pile to the soil along the j th surface may be expressed as:

$$W_{i,j} = (\tau_j / E) \cdot B \cdot I_{i,j}$$

where:

τ_j = Increment in tension at the mid point of the segment;
E = Elastic modulus of the terrain;
B = Diameter of the pile;
$I_{i,j}$= Influence coefficient.

Total settlement is obtained by the sum of $W_{i,j}$ for all j areas.

1.20.6 Global stability analysis

Global stability determines the safety factor of the joint wall, backfill complex, in regard to slide along possible failure surfaces.
The safety factor according to the ordinary strip method may be expressed by:

$$F_s = \frac{\sum c \cdot l + \sum \left[(W+Q+F)\cdot \cos\alpha - K_s(W+Q+F)\cdot \sin\alpha + F_0 \sin\alpha \cdot l \cdot u\right]\cdot tg\phi}{\sum\left[(W+Q+F)\cdot \sin\alpha + K_s(W+Q+F)\cdot {e_s}/{r_0}\right] - \sum\left(F_0 \cdot {e_t}/{r_0}\right)}$$

where:

W= Typical slice weight;
Q= Distributed load;
F= Point load;
K_sW= Inertial force;

K_S= Seismic intensity coefficient;
l= Length of typical slice base;
α= Slice base angle to horizontal;
c= Terrain cohesion;
ϕ= Terrain shear resistance angle;
r_o= Radius of typical slip surface;
u= Gwt generated pressure;
Fo= Tieback horizontal load generated by tiebacks;
e_t= Anchorage force eccentricity in respect of centre of rotation;
e_s= Seismic forces eccentricity in respect of centre of rotation.

1.20.7 Seism

Calculation of seismic movement effects is dependent on a number of parameters, that in turn are dictated or recommended by various legislative norms. This program, with Italy as country of origin includes norms native to that country as well as the Europe wide Eurocodes 8.
This latter is the more relevant for users outside Italy and will be treated here. If it is desired to consult the Italian standards, the user is referred to the Italian language help file, accessible directly by executing the file: Muri_IT.chm in the home folder for the program.
The following parameters can/should be entered or considered by the user.

Soil Category

Type A soils	Stone like formations or very rigid homogeneous soils	S=1
Type B soils	Deposits of highly condensed sands or gravels or highly consistent clays	S=1.25
Type C soils	Deposits of moderately condensed sands or gravels or medium consistent clays	S=1.25
Type D soils	Deposits of granular, loose or slightly dense soils, or else cohesive soils of slight to medium consistency	S=1.35

Project seismic acceleration

- No seism Zone
- Zone 1 = 0.35g
- Zone 2 = 0.25g
- Zone 3 = 0.15g
- Zone 4 = 0.05g

Factor r

The recommendation for reinforced concrete walls factor r is a value of 1. Only for gravity walls or such as are deformable can this set to 2.
The factor is used in the determination of horizontal seismic coefficient.

Horizontal seismic coefficient Kh

See Theoretical notes. Used in evaluating project force in seismic condition.

Vertical seismic coefficient Kv

See Theoretical notes. Used in evaluating project force in seismic condition with sign + or – depending on a more unfavourable effect.

The values of the horizontal and vertical seismic coefficients can be manually assigned by the user. They can also be calculated automatically by the software on the base of the maximum acceleration at site.

For the application of Eurocode 8 (geotechnical planning), the horizontal seismic coefficient is defined as follows:

$$K_h = \frac{a_{gR} \cdot \gamma_I \cdot S}{g}$$

$$K_v = \pm 0.5 \cdot K_h$$

where:

a_{gR}: reference peak acceleration on hard outcropping ground,
γ_I: importance factor,
S: soil factor, depending on the kind of ground (from A to E).

is the "design ground acceleration on type A ground".

1.20.8 Buttresses

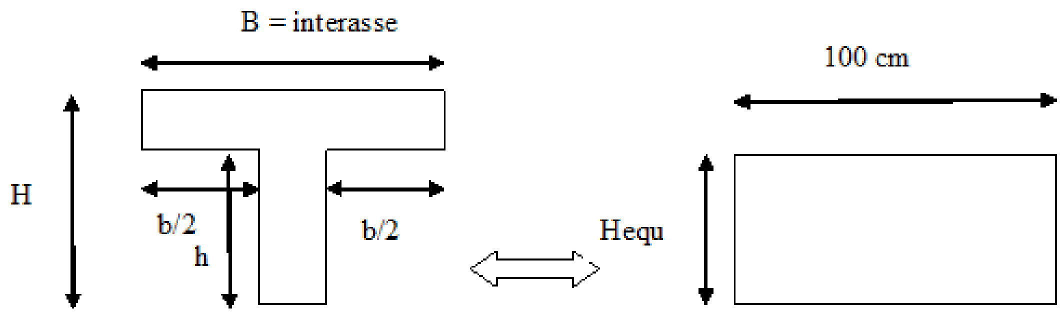
CALCULATION OF WALLS IN THE PRESENCE OF BUTTRESSES

The case of buttress walls requires the insertion of geometric data, i.e. thickness and longitudinal interaxis. The buttress can be placed inside (ground side) or outside.
The height of the buttress is assumed equal to the height of the wall itself, while the base is placed equal to the length of the shelf of upstream foundation, for internal buttresses, downstream, for external ones.

The calculation of the thrust on the wall is independent of the presence of the additional element and is carried out with the same procedure as for the corbel wall.
The presence of the buttress has an effect, with the weight force, both in terms of stress on the shelf in elevation, and in the global checks to tipping, limit load and sliding.
The weight force of the buttress is counted in the resulting Fy of the stresses on the wall, as well as an external force, but does not appear in the load conditions of the Calculation Menu: this implies that it is not possible to assign to it a combination factor other than unity.

Verification of the section in c.a. and armor calculation

At each calculation section along the height of the wall, the program considers the T-check section as an equivalent rectangular section with equal moment of barycentric inertia.



That is, the section a T with dimension B equal to the center distance of the buttresses is assimilated to an equivalent rectangular section of width equal to 1 m and height Hequ such that the moment of barycentric inertia of the two sections is equal.

$$\frac{100 \cdot H^3 equ}{12} = \frac{\left(BH^2 - bh^2\right)^2 - 4\,BHbh\left(H-h\right)^2}{12\left(BH - bh\right)}$$

With this assumption, the equivalent rectangular sections are designed and verified.

1.20.9 Gravity wall

The crushing verification of the elevation-foundation shelf attachment section is carried out taking into account the acting forces (bending moment and normal stress).
In the summary table given in relation (stresses on the wall) the actions refer to the center of gravity of the relevant section.
The eccentricity is calculated from the relation :

$$e = \frac{M}{F_y}$$

Using the eccentricity thus calculated, u is determined or the distance between the point of application of the result of vertical actions Fy and the outer edge of the foundation:

$$u = \frac{B}{2} - e$$

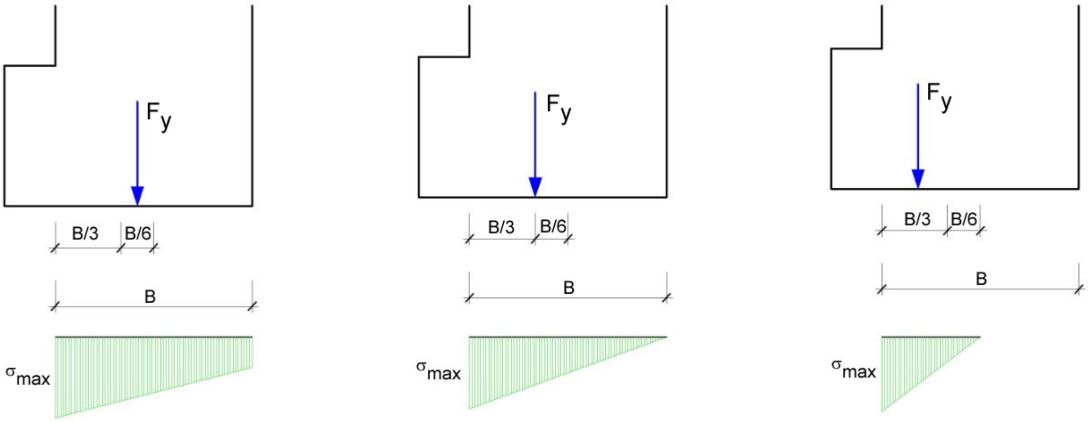
If u < B/3 and e > B/6, the result of the vertical actions Fy is external to the central core of inertia, the section is partialized and the maximum compression stress is calculated from the relation:

$$\sigma_{max} = \frac{2 \cdot N}{3 \cdot u}$$

If u > B/3 and e < B/6, the result of the vertical actions Fy is internal to the central core of inertia, the section is fully compressed, the maximum compression voltage is:

$$\sigma_{max} = \frac{F_y}{B} \cdot \left(1 + \frac{6e}{B}\right)$$

also u = B/3 and e= B/6, it coincides with the central core of inertia, the section is entirely stressed by compression with triangular diagram, the maximum compression stress is given by:



2 Utility

2.1 Conversion Tables

Inclination (%)	Angle (°)	Inclination (%)	Angle (°)
1	0.5729	26	14.5742
2	1.1458	27	15.1096
3	1.7184	28	15.6422
4	2.2906	29	16.1722
5	2.8624	30	16.6992
6	3.4336	31	17.2234
7	4.0042	32	17.7447
8	4.5739	33	18.2629
9	5.1428	34	18.7780
10	5.7106	35	19.2900
11	6.2773	36	19.7989
12	6.8428	37	20.3045
13	7.4069	38	20.8068
14	7.9696	39	21.3058
15	8.5308	40	21.8014
16	9.0903	41	22.2936
17	9.6480	42	22.7824
18	10.2040	43	23.2677
19	10.7580	44	23.7495
20	11.3099	45	24.2277
21	11.8598	46	24.7024
22	12.4074	47	25.1735
23	12.9528	48	25.6410
24	13.4957	49	26.1049
25	14.0362	50	26.5651

Converting slope inclination in degrees

From	To	Operation	Factor
N	kg	Divide by	9.8
kN	kg	Multiply by	102
kN	Tonn	Divide by	9.8
kg	N	Multiply by	9.8
kg	kN	Divide by	102
Tonn	kN	Multiply by	9.8

Forces conversion: 1 Newton (N) = 1/9.81 Kg = 0.102 Kg ; 1 kN = 1000 N

From	To	Operation	Factor
Tons/m^2	kg/cm^2	Divide by	10
kg/m^2	kg/cm^2	Divide by	10000
Pa	kg/cm^2	Divide by	98000
kPa	kg/cm^2	Divide by	98
Mpa	kg/cm^2	Multiply by	10.2
kPa	kg/m^2	Multiply by	102
Mpa	kg/m^2	Multiply by	102000

Pressures conversion: 1 Pascal (Pa) = 1 Newton/mq ; 1 kPa = 1000 Pa; 1 MPa = 1000000 Pa = 1000 kPa

2.2 Database of soil physical characteristics

Soil	Minimum value	Maximum value
Loose sand	0.48	1.60
Average compact sand	0.96	8.00
Compact sand	6.40	12.80
Average compact clayey sand	2.40	4.80
Average compact silty sand	2.40	4.80
Compact sand and gravel	10.00	30.00
Calyey soil with qu < 2 Kg/cm²	1.20	2.40
Calyey soil with 2 < qu < 4 Kg/cm²	2.20	4.80
Calyey soil with qu > 2 Kg/cm²	>4.80	

Approximate values 8f Winkler's constant K in Kg/cm^3

Soil	Minimum value	Maximum value
Dry gravel	1800	2000
Wet gravel	1900	2100
Compact dry sand	1700	2000
Compact wet sand	1900	2100
Loose dry sand	1500	1800
Loose wet sand	1600	1900
Sandy clay	1800	2200
Hard clay	2000	2100
Semisolid clay	1900	1950
Soft clay	1800	1850
Peat	1000	1100

Approximate values of the volume weight in Kg/cm^3

Soil	Minimum value	Maximum value
Compact gravel	35	35
Loose gravel	34	35
Compact sand	35	45
Loose sand	25	35
Sandy marl	22	29
Fat marl	16	22
Fat clay	0	30
Sandy clay	16	28
Silt	20	27

Approximate values of the friction angle φ, in degrees, for soils

Soil	Value
Sandy clay	0.20
Soft clay	0.10
Plastic clay	0.25
Semisolid clay	0.50
Solid clay	1
Tenacious clay	2÷10
Compact silt	0.10

Approximate values of cohesion in Kg/cm^2

Soil	Maximum value of E	Minimum value of E
Very soft clay	153	20.4
Soft clay	255	51
Medium clay	510	153
Hard clay	1020	510
Sandy clay	2550	255
Loess	612	153
Silty sand	204	51
Loose sand	255	102
Compact sand	816	510
Clayey schist	51000	1530
Silt	204	20.4
Loose sand and gravel	1530	510
Compact sand and gravel	2040	1020

Approximate values of the module, in Kg/cm^2, for soils

Soil	Maximum value of n	Minimum value of n
Saturated clay	0.5	0.4
Not saturated clay	0.3	0.1
Sandy clay	0.3	0.2
Silt	0.35	0.3
Sand	1.0	-0.1
Gravelly sand commonly used	0.4	0.3
Loess	0.3	0.1
Ice	0.36	
Concrete	0.15	

Approximate values of the Poisson's ratio for soils

Rock	Minimum value	Maximum value
Pumice	500	1100
Volcanic tuff	1100	1750
Tufaceous limestone	1120	2000
Coarse sand dry	1400	1500
Fine dry sand	1400	1600
Wet fine sand	1900	2000
Sandstone	1800	2700
Dry clay	2000	2250
Soft limestone	2000	2400
Travertine	2200	2500
Dolomite	2300	2850
Compact limestone	2400	2700
Trachyte	2400	2800
Porphyry	2450	2700
Gneiss	2500	2700
Serpentine	2500	2750
Granite	2550	2900
Marble	2700	2750
Syenite	2700	3000
Diorite	2750	3000
Basalt	2750	3100

Approximate values of specific weight for some rocks in Kg/m^3

Rock	Minimum value	Maximum value
Granite	45	60
Dolerite	55	60
Basalt	50	55
Sandstone	35	50
Calyey schist	15	30
Limestone	35	50
Quartzite	50	60
Marble	35	50

Approximate values of the friction angle j, in degrees, for rocks

Rock	E		n	
	Maximum value	Minimum value	Maximum value	Minimum value
Basalt	1071000	178500	0.32	0.27
Granite	856800	142800	0.30	0.26
Crystalline schist	856800	71400	0.22	0.18
Limestone	1071000	214200	0.45	0.24
Porous limestone	856800	35700	0.45	0.35
Sandstone	428400	35700	0.45	0.20
Calyey schist	214200	35700	0.45	0.25
Concrete	Variable		0.15	

Approximate values of the elastic module and Poisson's ratio for rocks

3 Geoapp

Geoapp: the largest web suite for online calculations

The applications present in Geostru Geoapp were created to support the worker for the solution of multiple professional cases.
Geoapp includes over 40 applications for: Engineering, Geology, Geophysics, Hydrology and Hydraulics.

Most of the applications are free, others require a monthly or annual subscription.

Having a subscription means:

- access to the apps from everywhere and every device;
- saving files in cloud and locally;
- reopening files for further elaborations;
- generating prints and graphics;
- notifications about new apps and their inclusion in your subscription;
- access to the newest versions and features;
- support service throught Tickets. Enter topic text here.

3.1 Geoapp Section

General and Engineering, Geotechnics and Geology

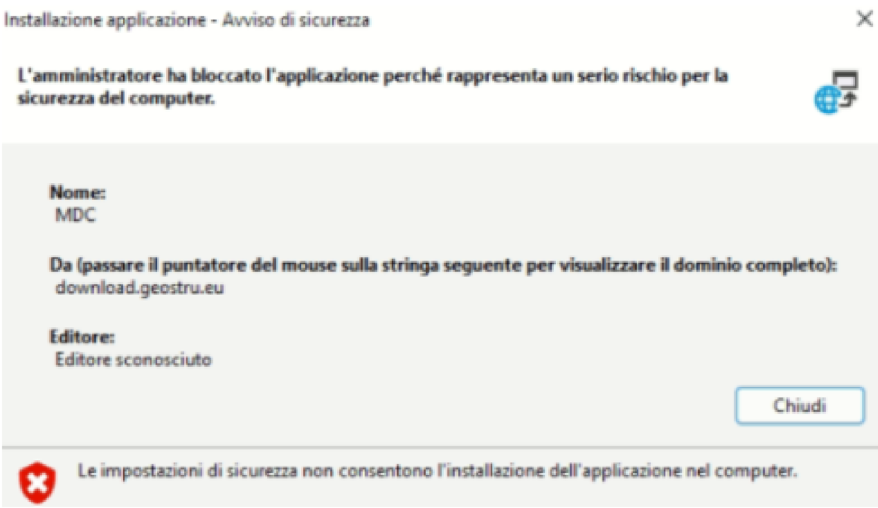
Among the applications present, a wide range can be used for **MDC**. For this purpose, the following applications are recommended:

- Horizontal reaction coefficient of foundation piles
- Calculation
- Poles and micropoles
- Load test
- Soil classification
- Newmark

4 Initial Setting

The administrator blocked this application because it could pose a security risk to the computer while installing MDC.

It may occur that during the installation of MDC software, the following error message is displayed:



Causes:
The Windows ClickOnce Trust request message is disabled. Clickonce, a component of . NET Framework, must be enabled for running MDC.

Solution:
To solve the problem, activate this registry key.
1. Open the registry editor.

2. Find the following registry key.
\ HKEY_LOCAL_MACHINE \ SOFTWARE \ Microsoft \ .NETFramework \ Security \ TrustManager \ PromptingLevel \ Internet

If the key doesn't exist, create it.

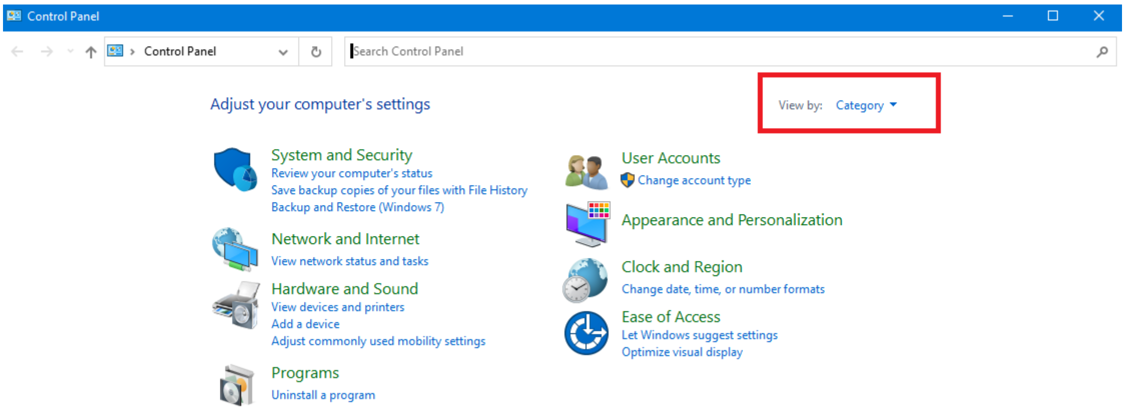
3. Set the value to Enabled, save.

Decimal Separator Settings and Digit Grouping Symbol from Control Panel (for 2022 version)

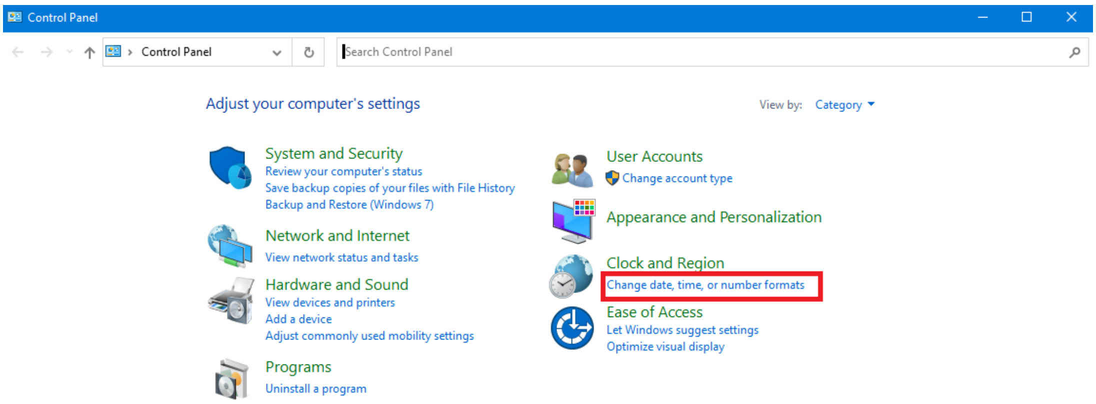
The program requires, for proper operation, as a decimal separator the "point" and symbol grouping digits the "comma".

- **How to make settings**

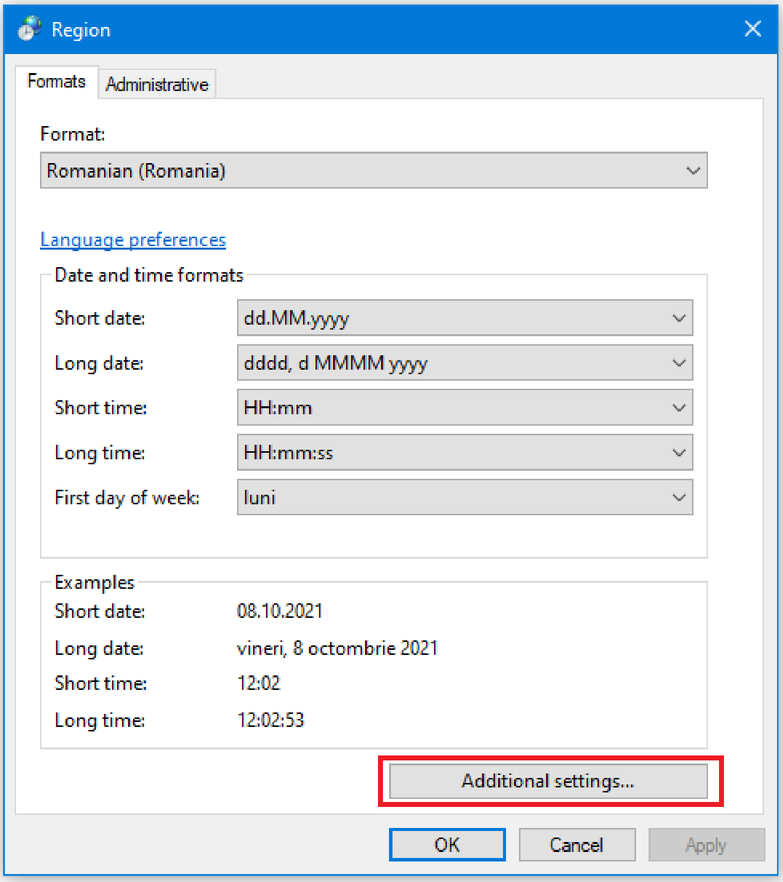
Access the control panel and select the view by category



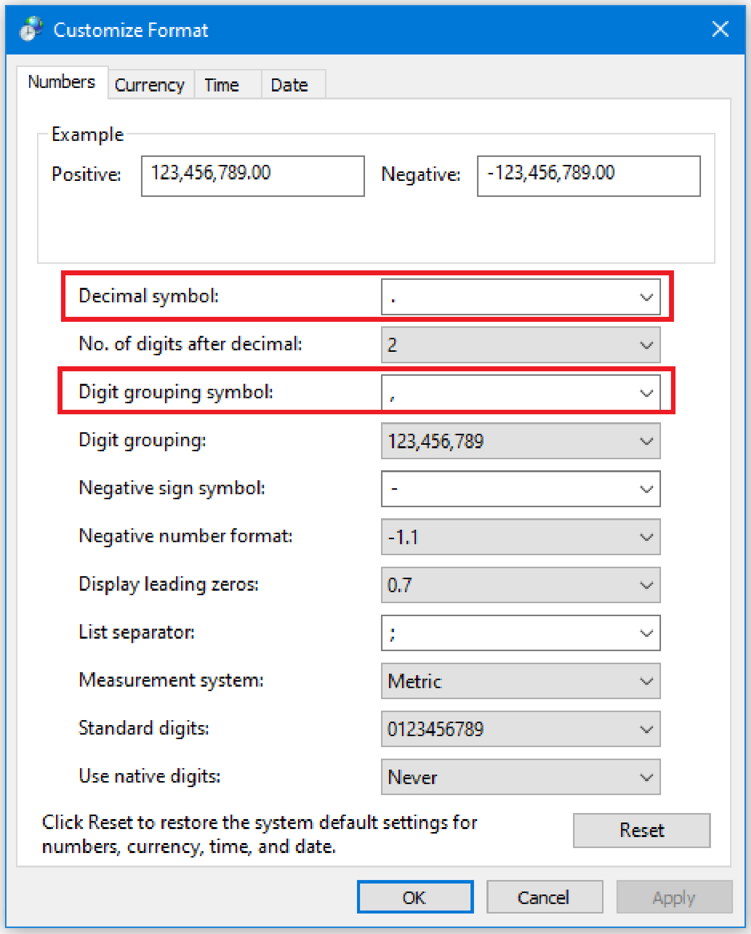
Choose **the Change date, time or number format** option.



Select **Additional Settings**



Set the "point" as the decimal separator and the "comma" as the digit grouping symbol.



Confirm with the **Apply and Ok** button.

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6 Shortcut commands

The bar shown in figure below can be used for a variety of functionalities:

1) With the shortcut letters of the menu followed by Enter you have quick access to commands.

Ex.: **N + Enter** to create a new file.

2) You can ask a question followed by ? + Enter. In this case an advanced research will be made in the Help manual.

Ex.: **Seism+?+Enter** for information on seismic analysis.

3) Opening a program in a quick way.

Ex.: **Slope+Enter** to open GeoStru Slope software.

4) Quick access to GeoStru contacts.

Ex.: **Contact+?+Enter** to access the contact list.

5) Quick access to web features:

Shortcut commands bar

7 Contacts

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	Monday-Friday Ore 9-17