Earth Pressure Calculation EDB+

Contents

Basic Documentation – Overview

In addition to the individual program manuals, you will find basic explanations on the operation of the programs on our homepage www.frilo.com in the Campus-download-section.

Application options

The EDB+ program determines the horizontal earth pressure coordinates on a hypothetical earth pressure wall.

You can calculate the distribution of the earth pressure over the total height of the earth pressure wall as well as over a section defined via elevation levels.

Either a pure earth pressure calculation or a calculation of the lateral pressure is performed.

When selecting the calculation option “earth pressure”, the resulting horizontal and vertical earth pressure forces in line with the earth pressure distribution are put out.

When selecting the option “lateral pressure”, the resulting earth pressure force is compared to the flow pressure and the lateral pressure is calculated from this.

Calculation mode

- Earth pressure
- Lateral pressure

Earth pressure types

- Active earth pressure
- Earth pressure at rest
- Increased active earth pressure
- Passive earth pressure
  (earth resistance)
- Spatial passive earth pressure

Structural system

- Vertical and inclined earth pressure wall *(only with earth pressure calculation)*
- Any number of soil layers
- Groundwater at different levels on the left and right of the earth pressure wall *(with lateral pressure calculation: same level on both sides)*
- Ground water levels can be selected independently of layer borders
- Automatic consideration of the water pressure based on the groundwater level.
- Level, continuously sloped and broken ground surface (slope).

Load - ground surface loads

The following ground surface loads can be considered in EDB+:

- unlimited area loads
- limited strip loads
- limited block loads and
- line loads

The ground surface loads can be defined at a distance from the earth pressure wall. They can also be located in the soil layers below the ground top edge.

Load cases and superpositions

From the components

- self-weight
- groundwater
- compaction
- and for each ground surface load

load cases are generated, which are considered

- either in superpositions pre-defined by the user
- or in automatic superpositions with a target function.

In the case of pre-defined superpositions, the user defines the load case factors; in the case of an automatic superposition, the decisive superposition for the specified target function is searched for in accordance with EN 1990-1.

Possible target functions are

- max Eh: the maximum horizontal earth pressure force
- min Eh: the minimum horizontal earth pressure force

Calculation

In general, the calculation is performed in accordance with EN 1997-1 and the respective National Annexes for Germany, Austria, Poland and Great Britain which refer to

- DIN 4085
- ÖNORM B 4434

The lateral pressure is calculated according to the Recommendations of the Working Group Piles EA-Pfähle /7/. The minimum earth pressure can be taken into account in the determination of the earth pressure distribution.

Compaction earth pressure

In the case of active earth pressure and earth pressure at rest, layer-by-layer placement and compaction can increase the earth pressure considerably, especially in the upper soil layers.
EDB+ allows you to take the compaction earth pressure into account.

Results

EDB+ provides for the graphical evaluation of the earth pressure distribution for soil self-weight including cohesion

- groundwater levels
- compaction areas
- ground surface loads (individually)
- superposition of the earth pressure components
- complete overview of the respective earth pressure distributions *(with earth pressure calculation mode)*
- resulting earth pressure *(with lateral pressure calculation mode)*
- flow pressure *(with lateral pressure calculation mode)*
- lateral pressure *(with lateral pressure calculation mode)*

In the document output, load cases and superpositions are put out separately.

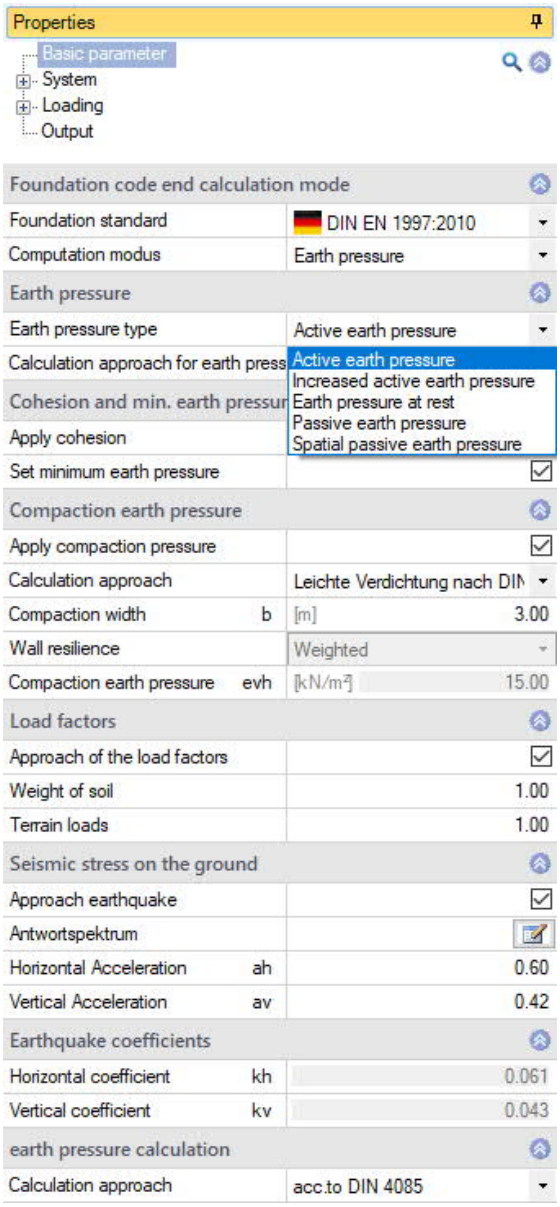
Basis of calculation

The earth pressure ordinates are calculated in accordance with the earth-pressure theory of Coulomb.

Basic parameters

Note: The available data-entry fields depend on the selected options.

Foundation code and calculation mode



Foundation standard — the following standards are available for the calculation of the earth pressure
- DIN EN 1997:2010
- ÖNORM EN 1997:2013
- PN EN 1997 2011
- BS EN 1997 2014

Calculation mode — allows you to select whether the earth pressure distribution or the lateral pressure (horizontal) distribution is to be calculated.

Consolidation state — *only with lateral earth pressure*. Allows the selection of the consolidation state the calculation is based on (Initial-, Final state or Partially consolidated).

Consideration time — *only with lateral pressure/partially consolidated*. Allows you to specify the time at which the partial consolidation is to be calculated.

Earth pressure

Earth pressure type — *only with earth pressure*. Allows you to select whether the earth pressure distribution for active-, increased active-, passive-, spatial passive earth pressure or earth pressure at rest is to be put out.

Calculation approach for earth pressure coefficients — Select the calculation approach to be used for calculating the earth pressure coefficients. For earth pressure at rest and increased active earth pressure, the "Goldscheider" approach can be selected.

Increased active eart pressure

Active earth pressure portion — *only with earth pressure/increased active earth pressure*. Increased active earth pressure must be included if the displacement of the wall is insufficient to trigger the limit state of the active earth pressure or to maintain it during the entire service life of the building.
You can either pre-select the portions of active earth pressure among the options 0.25 / 0.5 / 0.75 / 1.00 or enter a user-defined value.
Selecting 1.00 means that there is no increased active earth pressure.

Earth pressure at rest portion — *only with earth pressure/increased active earth pressure*. Example: if the active earth pressure is set to 0.75 (75 %), the earth pressure at rest is automatically set to 0.25 (25 %).

Cohesion and min. earth pressure

Apply cohesion — check this option to take cohesion into account. This has a favourable effect on the subsequent design.
Uncheck this option if the cohesions specified for the individual soil layers should not be considered.

Note:

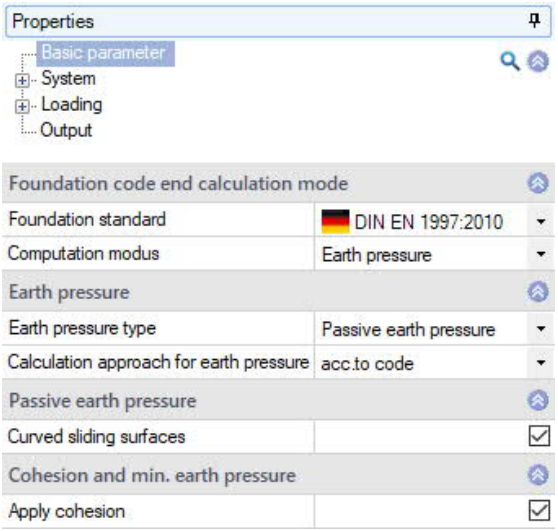
- Tension from cohesion is not included.

- DIN 4085 5.3.1 excludes the consideration of cohesion in connection with earth pressure at rest. Therefore, this option is not available in the calculation of the earth pressure at rest.

Consider minimum earth pressure — if minimum earth pressure is considered (option ticked) with active earth pressure, the software checks for each layer of cohesive soil whether the earth pressure resulting from the self-weight of the soil and a shear strength that corresponds to the angle of inner friction $\varphi = 40°$ becomes decisive at a cohesion of $c = 0$ kN/m². Calculation in accordance with the Recommendations of the Working Group “Construction Pits” EAB, 5th edition.

Passive earth pressure

Curved slidingsurfaces — you can calculate passive earth pressure either with linear or curved planes of rupture as per DIN 4085/Sokolovski Pregl. For passive earth pressure, the assumption of linear planes of ruptures is only permissible for the special case $\alpha = \beta = \delta = 0°$ (α: wall inclination, δ: angle of wall friction, β: slope inclination, φ: angle of friction)
The earth pressure coefficients for curved planes of rupture are determined in accordance with DIN 4085, Annex C. The graphical representation is always linear.



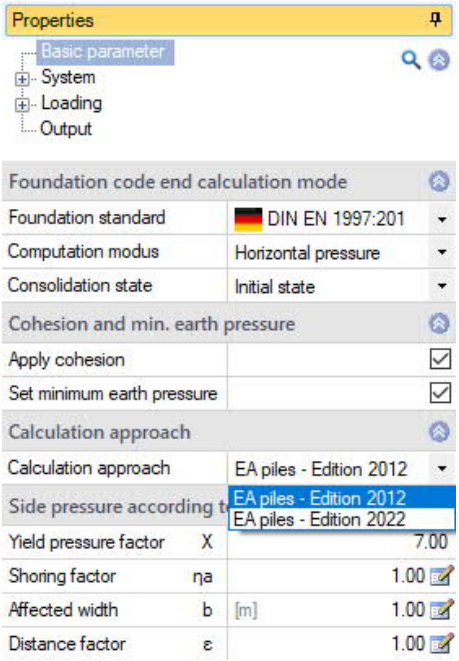
Compaction earth pressure

Compaction earth pressure — when soil is backfilled layer by layer and compacted, the earth pressure exceeds the one resulting from the self-weight of the soil.

Calculation approach — approach according to the selected National Annex of EN 1997
- either as per DIN 4085
- or as per ÖNORM B 4434:
The compaction earth pressure for intense compaction is calculated as per DIN 4085. For light compaction (vibrating plate with an operating mass of up to 250 kg), the method described by Franke (Franke, D., Verdichtungserddruck bei leichter Verdichtung, BAUTECHNIK 85 (2008) Booklet 3, p. 197 to 198) should be selected.
Alternatively, you can include the compaction earth pressure as per ÖNORM in addition to the earth pressure at rest.

Compaction width — width of the space to be filled. This value has only an influence in combination with earth pressure at rest and increased active earth pressure (with low-yielding walls).

Roller pressure — only available with ÖNORM.
With static rollers, p is the load per length unit of the roller lining; with vibrating rollers, p is composed of the weight of the centrifugal force. If the centrifugal force is unknown, you can set p by approximation to twice the weight per unit length (cf. ÖNORM 4435, clause 8.5).



Side pressure according to EA piles

Only with horizontal/lateral pressure

Yield pressure factor — In accordance with the Recommendations of the Working Group Piles EA-Pfähle/7/, the flow pressure coefficient is set to 7 by default.

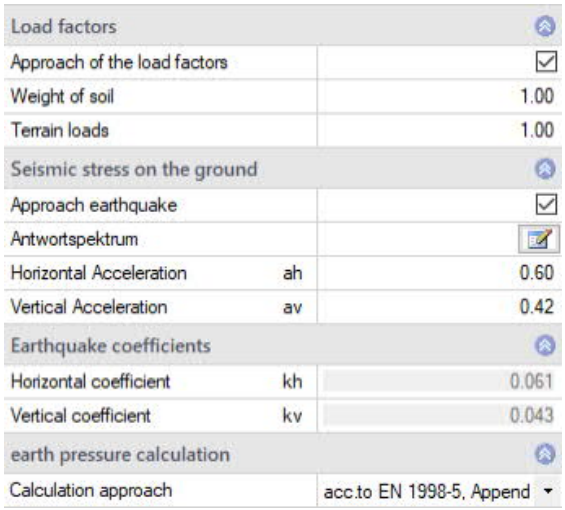
Shoring factor — This factor takes the mutual influence of the shoring and the subsoil into account.
This factor takes into account the mutual influence of piles in a group compared to a single pile. As a rule, in a pile group there is an increase in the flow pressure on a single pile, depending on the pile spacing. The shoring factor also takes into account the geometric arrangement of the piles in the pile group (offset/in a row).
Press the F5 key to open a dialog window for determining the installation factor.

Affected width — Determination of the decisive affected width.
Press the F5 key to open a dialog window for determining the affected width.

Distance factor — This factor takes the distance to lateral pressure-generating actions into account.
Press the F5 key to open a dialog window for determining the distance factor.

Load factors

Load factors for the resulting earth pressure forces can be specified here (for soil self-weight (global) and for terrain loads (as default)).



Seismic stress on the ground

If this option is checked, the input fields for calculating the earth pressure values under seismic loading are displayed.

Response spectrum: Use the edit button to open the dialog for the basic values for determining the ground acceleration response spectrum.

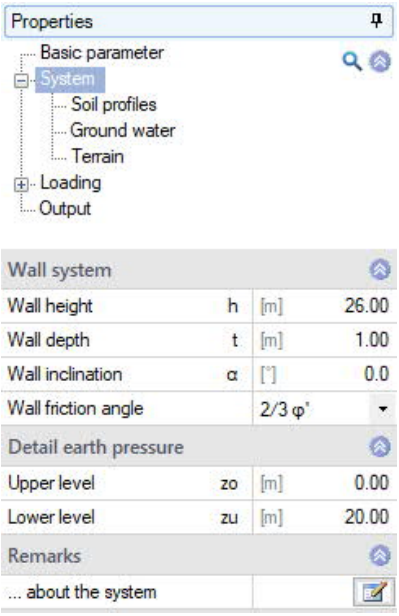
Eart pressure calculation

Earth pressure due to earthquake for active earth pressure: Earth pressure coefficients for soil self-weight according to DIN 4085, para. 10.2 or DIN EN 1998-5, Annex E, or according to ÖNORM B 4434, para. 8.8. For passive earth pressure DIN EN 1998-5, Annex E, is applied.

Structural system

Note: *You can change the default units via ▸ File ▸ Settings ▸ Units.*

Wall system



Wall system

Wall height — height of the hypothetic earth pressure wall.
Height: positive z-coordinate.

Wall depth — depth of the hypothetic earth pressure wall.
Depth: positive y-coordinate

Wall inclination — *only with earth pressure*. Wall rotation about the upper wall edge. An anti-clockwise rotation corresponds to the positive direction of rotation (α positive).
The lateral pressure is determined in accordance with EA-Pfähle /7/, 4.5.4(1) on a vertical wall.

Wall friction angle — *only for earth pressure.* Friction angle δ between wall and soil.
Automatically determined with earth pressure at rest.
With lateral pressure, δ is set to zero in accordance with EA-Pfähle /7/, 4.5.4(1).

Detail earth pressure

Upper elevation — upper elevation level in relation to the upper edge of the earth pressure wall, of the area for which the earth pressure is to be calculated and put out.
Upper elevation: positive z-coordinate

Lower elevation — lower elevation level in relation to the upper edge of the earth pressure wall, of the area for which the earth pressure is to be calculated and put out.
Lower elevation: positive z-coordinate

Remarks

You can optionally enter comments to the system that are subsequently included in the output.
See also Remarks Editor.

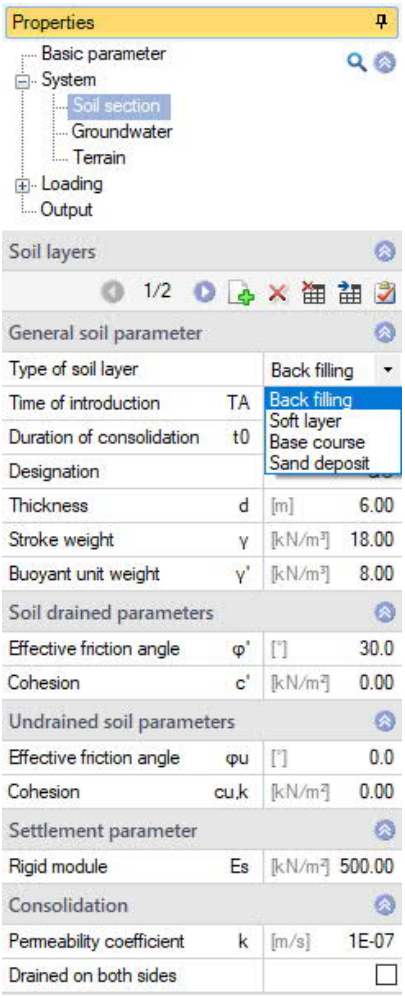
Soil section

General

See Data-entry via tables in the document Operating Basics-PLUS.pdf.

Tip: *A description is displayed in the status line each time you click into a data-entry field.*

General soil parameters



Type of soil layer — *only with lateral pressure*. You can select either a backfill, a soft layer or a base layer in this section.

Time of introduction — *only with lateral pressure*. Time of the soil backfill or placement in [days] in relation to the time 0, which represents the initial state (not consolidated).

The installation time is only active if a backfill has been selected as the soil layer and a partially consolidated state is considered.

Duration of consolidation — *only with lateral pressure*. Period of consolidation of this soil layer in [days].

Designation — name or geotechnical designation of the soil layer.

Thickness d — thickness of the soil layer

Stroke weight γ — specific weight of the soil.

Buoyant unit weight γ' — specific weight of the soil in the groundwater.

Parameters of the drained/undrained soil

(undrained only for lateral pressure)

Effective friction angle — friction angle of the drained/undrained soil.

Cohesion — cohesion of the drained/undrained soil.

Settlement parameter

(undrained only for lateral pressure, partially consolidated)

Rigid module Es — enter the stiffness modulus in kN/m².

Consolidation

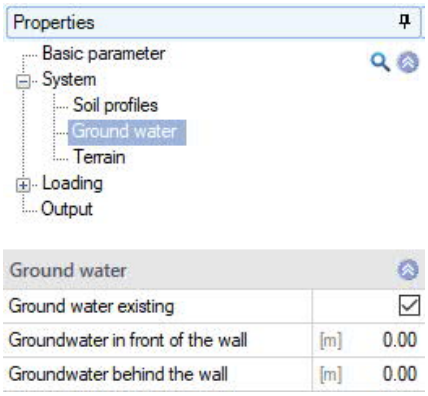
(undrained only for lateral pressure, partially consolidated)

Permeability coefficient k — coefficient of permeability in [m/s] for the consolidation speed. The value can be taken from the soil survey.

Drained on both sides — For the calculation of the consolidation period, half the layer thickness is used for drainage on both sides.

Groundwater

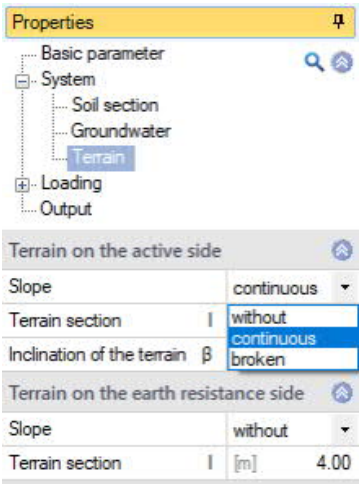
Groundwater existing	check the option if groundwater is to be considered.
Groundwater in front of the wall	elevation of the groundwater level on the wall face away from the earth. Height: positive z-coordinate.
Groundwater behind the wall	elevation of the groundwater level on the wall face in contact with the earth. Height: positive z-coordinate.



In combination with lateral pressure, you cannot specify different groundwater levels behind and in front of the wall.

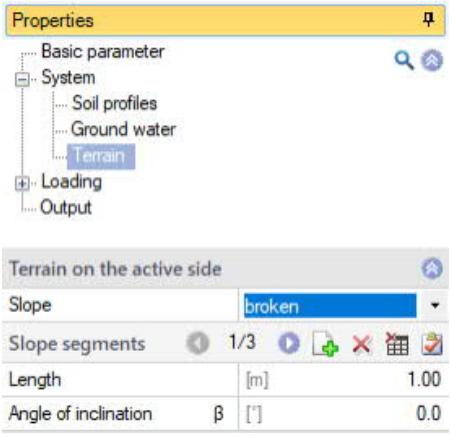
Terrain

Horizontal or continuously sloping ground surface



Slope	topology of the ground top edge: - horizontal - continuous slope - broken slope
Terrain section	specify the ground surface dimension for horizontal and continuously sloped surfaces. For broken ground surfaces, this value results from the slope sections.
Inclination β	inclination of the slope measured against the horizontal. Anticlockwise is positive. Negative values are also allowed.

Broken ground surface

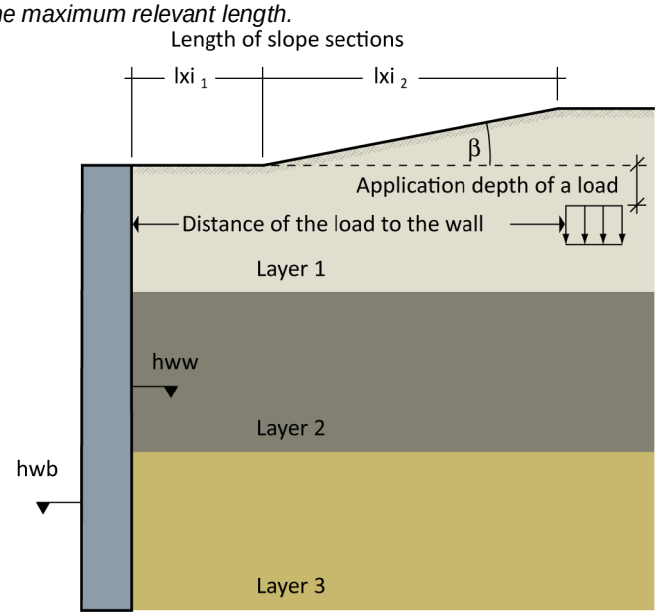


Length	length of the slope section in the x-direction. The length of the last section is automatically increased if required.
Inclination β	inclination of the slope measured against the horizontal. Anticlockwise is positive. Negative values are also allowed.

Note concerning slope sections:

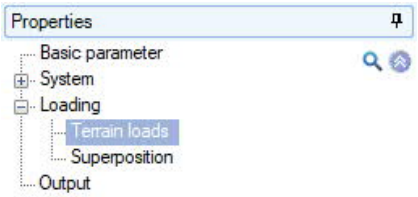
The slope section defined last is automatically adjusted to the maximum relevant length.

See also Data entry via tables in the Basic operating instructions PLUS.pdf



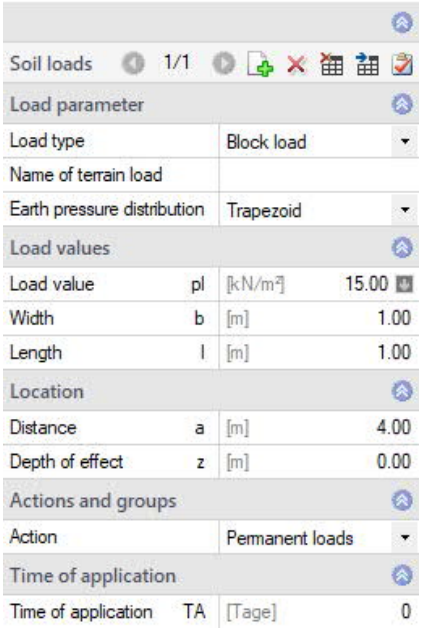
For lateral pressure, a ground surface is defined for each side, the active side and the earth resistance side.

Loading



Ground loads

Load parameters



Load type
- area/surface load
- strip load (not with passive earth pressure)
- block load (not with passive earth pressure)
- line load (not with passive earth pressure)

Name
designation of the load

Earth pressure distribution
(only for strip- or blockloads with distance a>0) rectangular or trapezoidal with block loads and strip loads:
If limited live loads apply, you can select between a rectangular distribution and a trapezoidal distribution of the load.
The ordinates of the trapezoidal distribution result from a linear interpolation that depends on the distance to the wall and the width of the load.

Load values

Load value pl
load coordinate in kN/m² for – area/surface load - strip load - block load.
By clicking on the arrow icon you can access a load value compilation.

Line load p
load coordinate in kN/m for - line load.
By clicking on the arrow icon you can access a load value compilation.

Width b
width of the load perpendicular to the wall (with block loads and strip loads).

Length l
load length parallel to the wall (block load).

Location

Distance
distance of the load to the wall.
In the positive x-direction for active earth pressure and earth pressure at rest.
In the negative x-direction for passive earth pressure.

Application depth z
depth at which the load applies. Positive values mean that the load applies below the wall head.

Actions and groups

Action	select the action to be assigned to this load from a list.
Concurrency group	you can assign variable loads to groups that always act simultaneously. You can create new groups. Names are assigned automatically. The loads of a group must be assigned to an action. ▸ See the following chapter Load groups.
Alternative group	the loads of an alternative group are always assumed to act individually, i. e. only one load of the alternative group applies at a time. You can create new groups. Names are assigned automatically. ▸ See the following chapter Load groups.

Application time *(only with lateral pressure)*

Time of application TA	Time of application of a load in [days] in relation to time 0, which represents the initial state (not consolidated). The application time is only active if lateral pressure has been selected and a partially consolidated state is being considered.

Load groups

The load grouping has only an effect on the p loads. g loads are always considered.

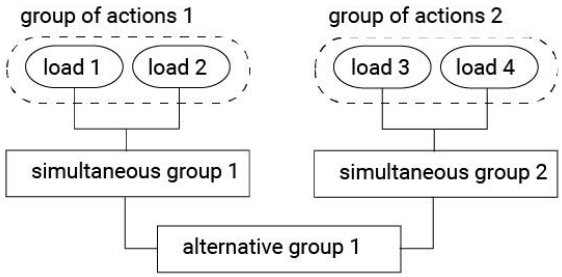
Loads of a particular action group can be defined as "always acting simultaneously" In addition, loads or load groups can be set as mutually exclusive (alternative).

This method corresponds to the typical superposition load case.

Note: *In case of conflicting entries in the data-entry fields “Concurrency group” and “Alternative group”, the entries in the “Concurrency group” fields have priority.*

Example of groups of actions and load groups within an item

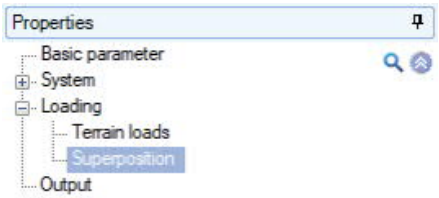
- The loads 1 and 2 are assigned to the group of actions 1.
- Correspondingly, the loads 3 and 4 are assigned to the group of actions 2.
- Load 1 and load 2 are assumed to be wind loads, for example, that always apply together because they act in the same direction.
- Load 3 and load 4 are assumed to be wind loads, both acting in the opposite direction.

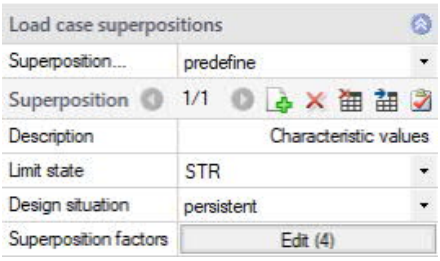


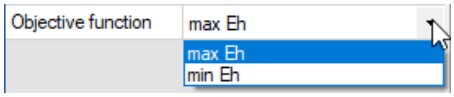
- As wind can only blow in one or the other direction, both combination groups 1 and 2 are assigned to the alternative group 1.
- The effect is that either the Concurrency group 1 or 2 or none of both is considered depending on whether the loads become decisive for the design or not.

Superposition

Superposition...	Choice between predefined and automatically determined superpositions.
Designation	name of the superposition
Limit state	limit state for which the partial safety factors are applied by the program. This setting has no effect if the partial safety factors are specified by the user.
Design situation	design situation for which the partial safety factors are applied by the program. This setting has no effect if the partial safety factors are specified by the user.
Superposition factors	with selected predefined superpositions you open a dialog for defining the superposition factors via the edit button.
Target function	If the automatic determination of the superpositions is selected, you enter a target function here as a criterion for the automatic load case combinations.
	max Eh maximum horizontal earth pressure force
	min Eh minimum horizontal earth pressure force

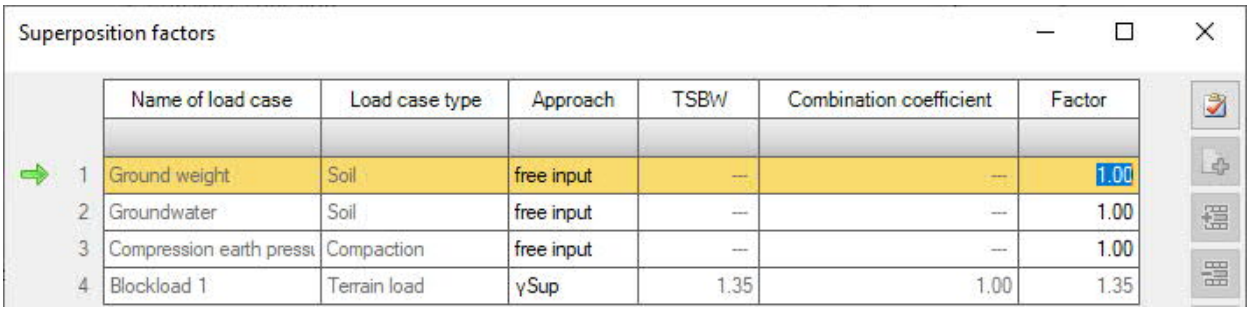






Superposition factors

With selected predefined superposition.



General

The load cases

- soil self-weight
- groundwater
- compaction earth pressure

are created automatically by the software.

For each defined ground surface load, another load case is automatically created. All load cases can then be included in the superposition with the specified partial safety factors.

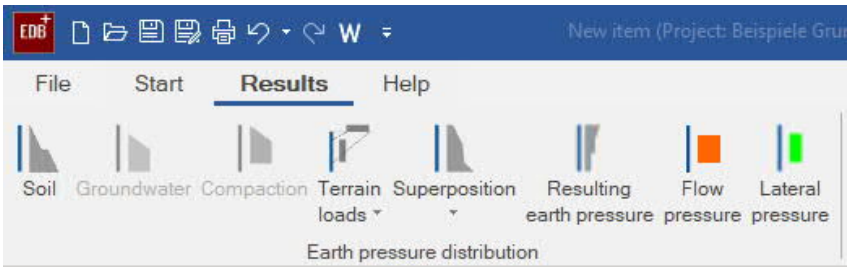
For this purpose, the upper and lower partial safety factors are available depending on the defined limit state and the defined design situation. Alternatively, you can also enter user-defined superposition factors.

Definition of the superposition factors

Designation load case	name of the load case. For the standard load cases soil self-weight, groundwater and compaction earth pressure, the name is assigned automatically by the program. Load cases representing ground surface loads are given the name of the ground surface load. User-defined specifications are not provided.
Load case type	the type of load case gives information about the kind of load case. User-defined specifications are not provided.
Approach	there are three approach options to include load cases in the superposition: γ_{inf} lower partial safety factor γ_{sup} upper partial safety factor user-defined. For the options γ_{inf} and γ_{sup}, the partial safety factors are given depending on the settings for limit state and design situation. Alternatively, the user can specify freely selectable user-defined partial safety factors. In the case of terrain loads, the load can also be set to "not active".
TSBW	partial safety factors in accordance with EN 1990 or the respective National Annex.
Combination coefficient	combination coefficient in accordance with EN 1990 or the respective National Annex.
Factor	final superposition factor.

Results

The respective earth pressure distributions can be called up via the following functions.

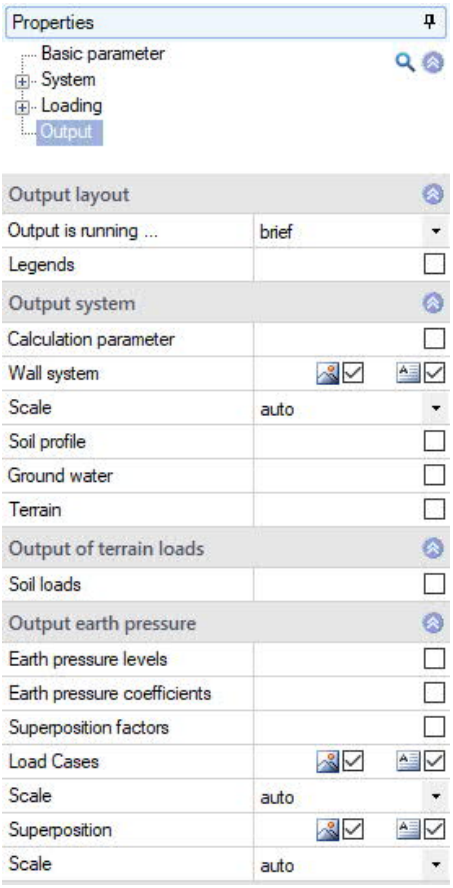


Soil	earth pressure from soil self-weight, including cohesion.
Groundwater	hydrostatic pressure from groundwater. Only enabled when groundwater levels have been defined.
Compaction	increased earth pressure due to compaction of the soil. The earth pressure distribution shown here corresponds to the upper limit of the earth pressure to be applied under compaction. Only the area in which the compaction pressure is to be applied is shown. Applies only to active earth pressure and earth pressure at rest. Only enabled if compaction earth pressure has been selected in the parameters section.
Ground surface loads	earth pressure from ground surface loads. Select the appropriate ground surface load from the pull-down menu.
Superposition	earth pressure from the superposition - of soil self-weight, including cohesion and compaction - groundwater - and the sum of all ground surface loads. Select the appropriate superposition from the pull-down menu.
Overview	*only with earth pressure.* Overview of the earth pressure distribution - for soil self-weight, including cohesion and compaction and groundwater - sum of all ground surface loads - superposition Select the appropriate superposition from the pull-down menu.
Resulting earth pressure	*only with lateral pressure.* The decisive earth pressure is displayed that results when the affected width is considered.
Flow pressure	*only with lateral pressure.* Flow pressure distribution.
Lateral pressure	*only with lateral pressure.* The decisive lateral pressure according to EA-Pfähle /7/ is displayed.

Output

Scope of the output and options

By checking the desired options, you can determine the scope of texts to be put out.

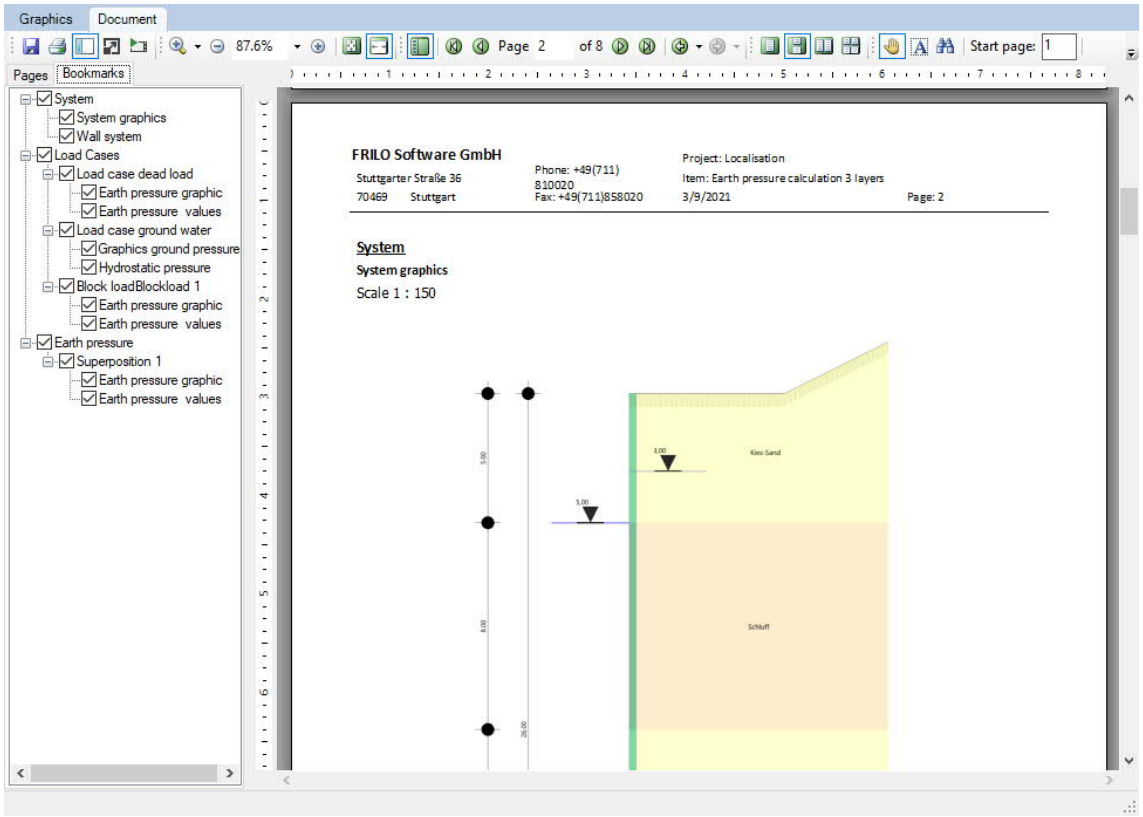


Output as a PDF document

On the “Document” tab, a PDF document is displayed.

Tip: colour graphics can optionally be set in the page layout (tab on the right) under "General" - the standard is black and white.

See also the document "Output and Printing".



Reference literature

/ 1/ EAB, 5th edition, Empfehlungen des Arbeitskreises "Baugruben" (Recommendations of the Construction Pits Working Group)

/2/ DIN 4085 [2011-05]

/3/ ÖNORM B 4434

/4/ Franke, D., Verdichtungserddruck bei leichter Verdichtung, BAUTECHNIK 85 (2008) Booklet 3, pages 197 to 198

/5/ Jenne, F., Praktische Ermittlung des Erddrucklastbildes, BAUTECHNIK 37, Booklet 6, pp. 233 to 237

/6/ Pregl, O., Bemessung von Stützbauwerken, Handbuch der Geotechnik, vol. 16, self-published by the Institute of Geotechnics, University of Natural Resources and Applied Life Sciences, Vienna, 2002

/7/ EA-Pfähle (Recommendations of the Piles Working Group), 2nd edition