## Guidelines for securing the excavation walls with grading

- Earthworks are particularly dangerous, therefore planning, preparation and proper conduct of earthworks is a necessary condition for ensuring the safety of their contractors. It should be remembered that earthworks should be carried out on the basis of a design specifying the location of underground installations and devices that may be within the range of the works.(1) The project should also contain information on the method of securing the excavation and the results of geological surveys.
- Excavations with unreinforced vertical walls, without bracing or support, may only be made to a depth of 1 m in compact soils, if the area at the excavation is not loaded in a strip of width equal to the depth of the trench. Excavations without reinforcements, with a depth of more than 1 m, but not more than 2 m, may be carried out if the results of soil tests and geological and engineering documentation allow it. (2)
- One of the methods of securing the walls of wide excavations is grading, i.e. excavation slope in order to obtain the slope specified in the project. The safe slope of the excavation walls should be specified in the project documentation when:
  a. earthworks are carried out in the soil hydrated;
  b. area next to excavation slope is to be loaded in a strip equal to the depth of the excavation;
  c. soil is clays prone to swelling;
  d. excavation is carried out in landslide areas;
  e. depth of the pit is more than 4 m.(3)

  All design and construction works depend on the type of soil on which the slope will be constructed, the expected time of use of the excavation, on the dynamic and static loads acting on the slopes and adjacent areas, and also depends on the level of desired slope static. Before starting the works, Method Statements should be developed based on the construction design and the requirements contained in the BIOZ Plan. Broad-space excavations with vertical walls or with slopes with a slope greater than the safe one are allowed, when the edge of the slope is unloaded and the excavation depth does not exceed:
  - 4 m - in mechanically detached solid rocks;
  - 1,25 m - in cohesive and less cohesive soils, e.g. loam sands, dusts, loess, tills;
  - 1 m - in rubble, weathered rocks, cracked rocks and non-watered sands.

  In the event of exceeding the specified of a wide excavation, but not more than 4 m, a safe slope of the slopes should be used. (4) (Fig 1.)


*Fig. 1 The inclination of the walls of the trench depending on the type of soil* (5)

- If the above parameters are exceeded, for the excavation depth not exceeding 4 m, the slope slope should be applied according to the values shown in the drawing. For the walls of the trench deeper than 4 m, protection should be applied, made in accordance with the developed design documentation and the use of solutions such

(1) Journal of Laws 2003.47.401 - Regulation of the Minister of Infrastructure of February 6, 2003 on occupational health and safety during construction works (§ 143)
(2) Journal of Laws 2003.47.401 - Regulation of the Minister of Infrastructure of February 6, 2003 on occupational health and safety during construction works (§ 147)
(3) Journal of Laws 2003.47.401 - Regulation of the Minister of Infrastructure of February 6, 2003 on occupational health and safety during construction works (§ 149)
(4) The official website of the Agreement for Safety in Construction http://www.porozumieniedlabezpieczenstwa.pl/standardy-bhp/03/3-1-wykopy-doly-rowa.html (accessed on 24/05/2021)
(5) The official website of the Agreement for Safety in Construction http://www.porozumieniedlabezpieczenstwa.pl/standardy-bhp/03/3-1-wykopy-doly-rowa.html (accessed on 24/05/2021)

as: diaphragm wall, Berlin wall, sheet piling and others. When securing the excavations with the slope method, the following factors should be considered:

- The appropriate slope angle, depending on the type of soil where the slope will be made and the depth of the excavation;
- The size of the expected loads in the vicinity of the slope;
- Estimated time of use of the excavation;
- Effects of possible loss of slope stability;
- In the strip of land adjacent to the upper edge of the slope, on a width equal to three times the depth of the trench, slopes should be made to enable rainwater to drain away from the trench;
- Materials and spoil should be stored outside the natural natural wedge broken off soil;
- The surface protection of slopes should be provided with foil or geotextile or other solutions;
- It is necessary to control violations of the soil structure of the slope on an ongoing basis and remove disturbed soil (taking care to maintain safe slopes of the slope);
- The condition of the slope should be checked after rain, frost and longer breaks in works;
- The walls of embankments or spoil storage yards should be protected by their appropriate slope and fencing of hazardous areas.

Slopes inclined at a greater angle than their natural angle may collapse (fracture wedge) under the influence of their own weight or a force applied from the outside. The splinter wedge is located between the slip or fall surface and the slope slope. The natural slope angle is the greatest angle at which the soil can hold a steady slope on a slope [(6)] (Fig 2.). It is forbidden to store output, materials and products:

- At a distance of less than 0.6 m from the edge of the trench, if the walls of the trench are encapsulated, and if the weight load excavated material is provided in the choice of the housing;
- In the wedge zone of the natural fraction of ground, if the walls of the excavation are not encapsulated;
- n the vicinity of excavations, the movement of means of transport should take place beyond the border of the natural soil wedge.[(7)]

The principle of calculating the wedge for hardware:[(8)]

L=h*WSP+0,6m;
L - safe distance;
WSP - coefficient depending on the soil class;
h - excavation depth

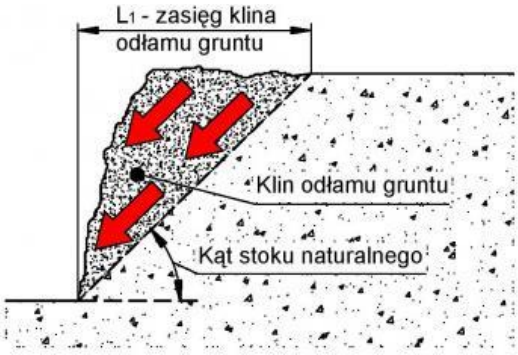


*Fig. 1 The angle of slope of the natural ground and splinter wedge [(9)]*

## ATTENTION!

It is forbidden to make the excavation slope as a replacement solution without prior consultation with the designer and the OHS & EE department (applies to a situation where, for example, the excavation project contains information on the type of system protection of the excavation walls, such as a sheet pile wall, a Berlin wall, a diaphragm wall, etc., but despite this, the decision is changed later and the excavation is slope grading). Such a change causes a high risk related to improper grading excavation, e.g. due to the lack of space for the proper slope of the walls.

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[(6)] The official website of the Machine Operators Training Center https://osom.pl/badania/publikacje/kat-stoku-naturalny-gruntu-i-klin-odlamu (available on May 24, 2021)

[(7)] Journal of Laws 2003.47.401 - Regulation of the Minister of Infrastructure of February 6, 2003 on occupational health and safety during construction works (§ 154, §155)

[(8)] Website: https://uprawnienia-budowlane.com/wykopy-budowlane-zab Security-klin-odlamu (available on May 24,2021)

[(9)] The official website of the Machine Operators Training Center https://osom.pl/badania/publikacje/kat-stoku-naturalny-gruntu-i-klin-odlamu (available on May 24, 2021)