GeoteknikPro

STUDIO — GEOTECHNICAL REPORT

Version 3.0.1

USER GUIDE

and Calculation Methods Document

Site and structure data · Boreholes, layers and SPT · Local site class · Bearing capacity · Settlement and swelling · Liquefaction · Horizontal sliding · Modulus of subgrade reaction · Reporting

In accordance with the Turkish Building Earthquake Code (TBDY 2018)

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Symbols, Abbreviations and Units

The quantities used in this guide and in the program interface are collected below. The program uses the SI system: stresses and pressures are in t/m^2 or kPa, unit weights in t/m^3 or kN/m^3, and lengths in metres. The unit in force on the screen is written in the label of each field; the two unit systems are never mixed.

Geometric and structural quantities

Table 1. Geometric and structural quantities

Symbol	Meaning	Unit
B, L	Short and long side of the foundation	m
B′, L′	Effective dimensions reduced for eccentricity, B−2e_x and L−2e_y	m
A, A′	Foundation area and effective foundation area	m^2
D_f	Foundation base depth (from the ground surface)	m
D_k	Maximum excavation depth	m
t	Foundation (raft) thickness	m
e_x, e_y	Load eccentricity	m
z	Depth (positive downwards from the surface)	m
H	Layer or sub-layer thickness	m
H_{dr}	Drainage path length (H/2 for double drainage)	m

Stress and load quantities

Table 2. Stress and load quantities

Symbol	Meaning	Unit
σ_v	Total vertical stress	t/m^2 · kPa
σ'_v	Effective vertical stress	t/m^2 · kPa
u	Pore water pressure	t/m^2 · kPa
σ'_p	Preconsolidation pressure	t/m^2 · kPa
$\Delta\sigma_z$	Vertical stress increase due to the foundation load	t/m^2 · kPa
q_0	Foundation base pressure (gross)	t/m^2 · kPa
q_{net}	Net base pressure (pre-excavation stress deducted)	t/m^2 · kPa
$\bar{q}$	Surcharge (overburden) stress at foundation base level	t/m^2 · kPa
q_{ult}	Ultimate bearing capacity	t/m^2 · kPa
q_t	Design (allowable) bearing capacity	t/m^2 · kPa

Soil parameters

Table 3. Soil parameters

Symbol	Meaning	Unit
γ_n, γ_{sat}	Natural and saturated unit weight	t/m^3 · kN/m^3
γ′	Effective (submerged) unit weight below water	t/m^3 · kN/m^3
ϕ, ϕ′	Angle of internal friction, effective angle of internal friction	°
c, c′	Cohesion, effective cohesion	t/m^2 · kPa
c_u	Undrained shear strength	t/m^2 · kPa

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Symbol	Meaning	Unit
E_s, E_u	Modulus of elasticity, undrained modulus of elasticity	MPa
v	Poisson's ratio	—
LL, PL, PI	Liquid limit, plastic limit, plasticity index	%
w_n	Natural water content	%
FC	Fines content (passing the No. 200 sieve)	%
C_c, C_r, C_s	Compression, recompression and swelling indices	—
e_0	Initial void ratio	—
m_v	Coefficient of volume compressibility	$m^2/t \cdot 1/kPa$
C_v	Coefficient of consolidation	$m^2/year$
OCR	Overconsolidation ratio, σ'_p/σ'_v	—
V_s	Shear wave velocity	m/s
V_{s30}	Harmonic mean shear wave velocity of the upper 30 m	m/s

SPT and liquefaction quantities

Table 4. SPT and liquefaction quantities

Symbol	Meaning	Unit
N	Raw SPT blow count (last 30 cm)	—
N_{60}	Blow count corrected to 60% energy ratio	—
$N_{1,60}$	Blow count with the overburden correction also applied	—
$N_{1,60f}$	Clean-sand equivalent with the fines correction applied	—
C_N	Overburden (effective stress) correction factor	—
C_R, C_S, C_B, C_E	Rod length, sampler, borehole diameter and energy correction factors	—
CSR	Cyclic stress ratio (seismic demand)	—
CRR	Cyclic resistance ratio (soil resistance)	—
r_d	Stress reduction factor	—
MSF	Magnitude scaling factor	—
K_σ	Overburden correction factor (resistance side)	—
FS	Factor of safety against liquefaction, $CRR \cdot MSF \cdot K_\sigma / CSR$	—
LPI	Liquefaction potential index	—
ε_v	Post-liquefaction volumetric strain	%

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Seismic and design quantities

Table 5. Seismic and design quantities

Symbol	Meaning	Unit
S_{DS}, S_{D1}	Short-period and 1.0 s design spectral acceleration coefficients	—
M_w	Moment magnitude	—
a_{max}	Peak horizontal ground acceleration; in the program $0.40 \cdot S_{DS} \cdot g$	g
k_h, k_v	Horizontal and vertical pseudo-static seismic coefficients	—
N_c, N_q, N_γ	Bearing capacity factors	—
s_c, s_q, s_γ	Shape factors	—
d_c, d_q, d_γ	Depth factors	—
i_c, i_q, i_γ	Load inclination factors	—
I_s, I_f	Immediate settlement shape and embedment factors	—
μ_0, μ_1	Chart coefficients for undrained immediate settlement	—
K_s	Modulus of subgrade reaction	t/m^3
β	Angular distortion, Δw/L	—

Abbreviations

Table 6. Abbreviations used in this guide

Abbreviation	Expansion
TBDY	Turkish Building Earthquake Code (2018)
KDYY	Turkish Regulation on Coastal and Marine Structures
TS 500	Turkish Standard: Requirements for Design and Construction of Reinforced Concrete Structures
USCS	Unified Soil Classification System
ESCS	European Soil Classification System
SPT	Standard Penetration Test
RQD	Rock Quality Designation
GSI	Geological Strength Index
UCS	Uniaxial Compressive Strength
GWL (YASS)	Groundwater level (Turkish: YASS)
LPI	Liquefaction Potential Index
NCEER	National Center for Earthquake Engineering Research
B&I 2014	Boulanger and Idriss (2014) liquefaction method
DXF	Drawing Exchange Format — CAD drawing exchange format

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1. Introduction

1.1 What the program does

GeoteknikPro Studio — Geotechnical Report is the program that produces the numerical content of a site investigation report in a single working environment. The user enters the site and structure information, the boreholes, the soil layers and the field and laboratory test results; from these data the program calculates the local site class, bearing capacity, settlement, swelling potential, liquefaction safety, the horizontal sliding check and the modulus of subgrade reaction, and turns the results into an editable report in Word format.

The tasks covered by the module are:

- Defining the site and structure data, and determining the foundation geometry and base pressure.
- Entering the boreholes, soil layers, SPT data and laboratory tests; deriving parameters that were not entered from correlations whose source is stated.
- Determining the local site class in accordance with TBDY 2018 Table 16.1 and checking the ZF conditions.
- Calculating the bearing capacity of shallow foundations, bearing capacity on rock and pressuremeter-based bearing capacity.
- Calculating immediate, undrained and consolidation settlements, the time-dependent development of settlement and the swelling potential.
- Solving the two-dimensional raft settlement surface; assessing differential settlement and angular distortion.
- Calculating liquefaction safety by two separate methods, and finding the post-liquefaction settlement and the LPI value.
- Horizontal sliding check and determination of the modulus of subgrade reaction.
- Drawing the borehole log, borehole section, liquefaction risk section and borehole influence area map.
- Producing the Word report and its appendices.

Site and Structure Information is an integral part of this module, not a separate program. The other modules (Slope Analysis, Retaining Structures, Ground Improvement, Pile Foundations, Excavation Support Structures, Site-Specific Response Analyses) share the same main project file (*.geos) and can inherit the soil profile from this module.

1.2 Scope

The module concentrates on the numerical content of the site investigation report. Neighbouring topics are dealt with in their own modules or by the user's input:

- Structural analysis and reinforced concrete design of the superstructure are done in the superstructure program; the module takes the loads coming from the superstructure as input.
- Deep (pile) foundation design is in the Pile Foundations module.
- Excavation support design is in the Excavation Support Structures module.
- Slope stability is in the Slope Analysis module.
- Settlement calculations are based on elasticity and consolidation theory; the two-dimensional raft solution is a plate–soil interaction solution, not a general-purpose finite element solver.
- The value entered as a soil parameter, or a correlation whose source is stated, is used; the suitability of the parameter for the site is the user's responsibility.

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1.3 Who it is for

This guide is written for an engineer who knows the principles of soil mechanics and foundation engineering but is opening this program for the first time. Concepts such as effective stress, consolidation, drained and undrained strength and SPT corrections are assumed to be known; what each field of the program means and how each setting changes the result are explained from the start.

1.4 Basic principles of the program

To understand how the program behaves, four design principles need to be known. They are not merely a statement of approach; each has a direct counterpart in the interface and in the report.

Principle 1 — A number that was not calculated does not enter the report

A report section enters the report only if the user has actually run the related calculation. An intermediate value shown in a box on the screen is not transferred to the report unless the calculation command has been given. This prevents a report taken after changing an input, without refreshing the calculation, from carrying an old result.

Principle 2 — The source of every derived value is stated

When the user does not enter a parameter, the program may derive it from a correlation; but the correlation used is named on the screen and in the report. The reader of the report can therefore tell which number was measured and which was derived.

Principle 3 — The reason for a result that could not be produced is stated

When a check cannot be carried out, or a result cannot be produced because data are missing, the reason is written on the related screen and in the report. An empty result does not mean “no problem”.

Principle 4 — The output must be reproducible

Every input and every setting that changes the result is saved in the main project file and shown in the report. It must be possible to set up the same analysis again starting from the report.

1.5 General layout of the interface

Ten module tabs run along the top of the main window: Land - Structure Information, Geotechnical Report, Data Report, Ground Improvement, Slope Analysis, Pile Foundations, Retaining Structures, Excavation Support Structures, Seepage and Site-Specific Response Analyses. The Geotechnical Report module consists of the first two tabs: “Land - Structure Information” and “Geotechnical Report”. The second tab is divided into the sub-tabs below.

Table 7. Sub-tabs of the Geotechnical Report tab

Sub-tab	Content
Soil Layers	Layer definitions, lithology, soil parameters and SPT data
Local Site Class	TBDY 2018 Table 16.1 criteria and ZF check
Bearing Capacity	Shallow foundation bearing capacity calculation and breakdown of the factors
Settlement / Swelling	Immediate, consolidation and time-dependent settlement; swelling potential
Liquefaction	SPT-based liquefaction safety and post-liquefaction settlement
Horizontal Sliding	Base sliding check under horizontal load
Modulus of Subgrade Reaction	Determination of the settlement-based modulus of subgrade reaction
Results	Summary of all analyses and the values to be carried into the report

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The left panel holds borehole management (borehole list; add, copy, rename, delete; influence area map and choice of the report borehole), the preliminary soil and seismic data and the calculation commands; the right panel holds the borehole log and the data fields of the selected layer. The status bar at the bottom reports whether the input has changed and whether the analyses need to be regenerated.

The menu bar has seven headings: File, Settings, Report / Drawing, Tools, Data, Modules and Help. All settings that change the result are collected in a single Settings window and explained one by one in Chapter 12. The calculation tools and Correlations in the Tools menu are described in Sections 10.7 and 10.8, and the “Report templates…” window in the Report / Drawing menu in Section 11.1.

The project is kept in a single main file (*.geos); the New Project, Open Project, Save and Save As commands are given from the File menu for all modules. When you switch to another module tab, that module’s menu is added to the menu bar; the first command in this menu is “New Project (this module only)”, which resets only that module’s data and sets the module up from scratch. The modules have no Save / Open commands of their own. The Report / Drawing menu and the Settings window are shared; in the Settings window each module has its own tab.

What the project file contains

The project is stored in a single file (.geos). The file contains the site and structure information, all boreholes, layers, SPT and laboratory data, the calculation settings and the calculated results.

Photographs and images that go into the report are also embedded in the project file; the images are not lost when the file is moved to another computer.

The data of the other modules (Data Report, Slope, Excavation Support, Retaining, Ground Improvement, Pile, Seepage, Site-Specific) are also stored in this main project file.

Saving is safe: the file is first written to a temporary .tmp file, read back and verified, and only then replaces the old file; the previous save remains as .geos.bak. If saving fails, the message “Project was NOT SAVED — the previous save is kept.” appears and the previous file is not touched.

Module blocks are written to the file compressed, which makes the file much smaller.

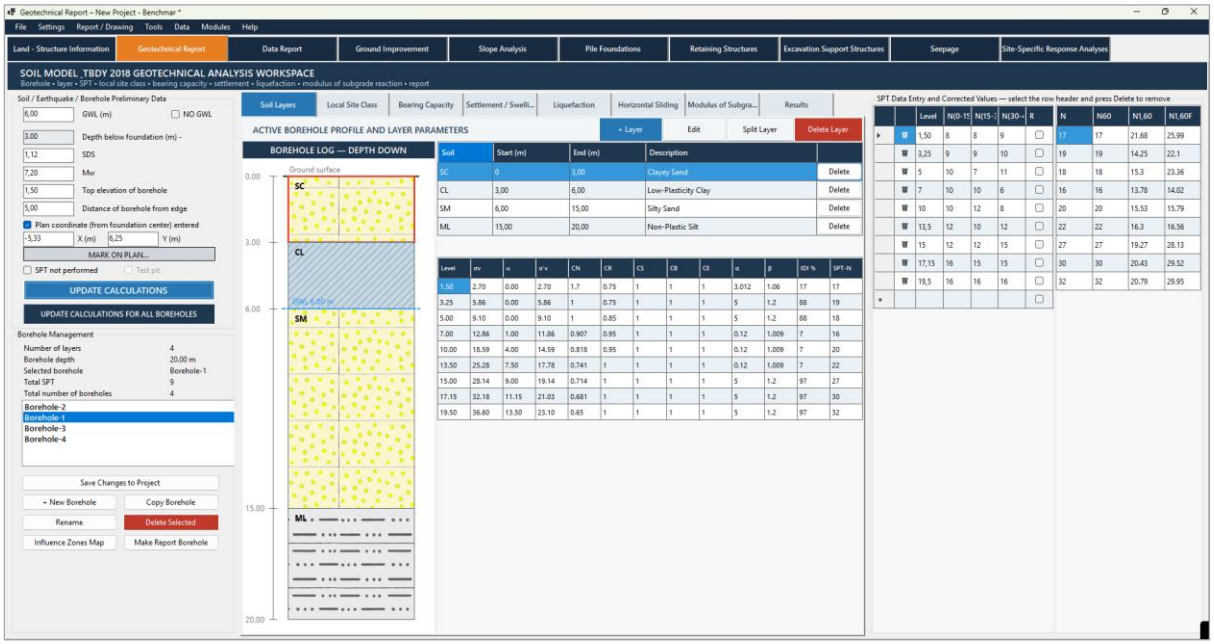


Figure 1. General layout of the Geotechnical Report tab: seismic and borehole data on the left, borehole log and layer table in the middle, SPT table on the right

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2. Ways of Getting Data into the Model

A geotechnical report is not fed from a single data source: borehole records are entered by hand, the foundation plan comes from CAD, superstructure reactions are taken from the structural analysis program, and laboratory data are read from test sheets. This chapter collects all of these paths and the limits of each.

Table 8. Data input paths

Path	Accepted	Feeds
Manual input	—	Borehole, layer, SPT, V_s, laboratory and pressuremeter data
Opening a project	.geos · .gtr · .json	Entire project
Foundation plan DXF	.dxf	Foundation boundary, borehole layout, influence areas, 2D settlement mesh
Marking on the plan	—	Borehole plan coordinates
TKGM parcel query	— (embedded browser)	Site information: province, district, neighbourhood, map sheet, block, parcel, area, parcel sides, latitude–longitude
Excel reaction import	.xlsx + .dxf	Column and wall loads in the 2D raft solution
Excel surface load map	.xlsx	X–Y–p load surface in the 2D raft solution
Report template	.docx	Format of the Word report
Images	.jpg · .jpeg · .png · .bmp	Report photographs

Entering data is not calculating

Whatever path it comes from, new data do not refresh the calculations by themselves; they only mark the existing result as “out of date” and write the reason to the status bar. To refresh the calculations, the corresponding update command must be given. The only exception is that stored correlations are reapplied immediately when the SPT changes; this is applying a correlation, not a calculation, and it does not enter the report on its own.

2.1 Manual input — boreholes, layers and SPT

The order matters: first the borehole, then the layers, and the SPT last. The reason is that the borehole depth is not entered as a separate field — the depth is derived from the bottom level of the layers. For an SPT row entered before the layers are defined, it cannot be known which depth limit it must respect.

Boreholes

A new project always starts with a single borehole. When a new borehole is added, its name is generated in sequence and its distance along the section is placed ten metres beyond the previous one; both values can be changed. Copying a borehole carries over the layers with all their parameters, but deliberately leaves the SPT table empty and says so: the layer sequence of two boreholes may be similar, their blow counts are not.

The borehole name is changed with the “Rename” button or by double-clicking in the borehole list. If the name is left empty a name of the form SK-n is given; the same name (regardless of upper / lower case) cannot be used for two boreholes. Section definitions, the pressuremeter profile, the hydrostatic uplift and 2D settlement records and the report borehole selection are updated together with the name.

The project must contain at least one borehole; the last borehole cannot be deleted. The delete confirmation states the number of layers and SPT rows that will be deleted.

For each borehole the top level, the distance from the edge and an optional plan coordinate are entered. The “SPT not performed” and “test pit” boxes declare the nature of that hole and change the reporting.

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Layers

The layer summary table is read-only; layers are opened in their own edit window. This window holds the level limits, soil code, lithology, unit weights, strength and compressibility parameters, consistency limits and consolidation parameters. Next to each parameter there is an “automatic” box: when it is ticked, the value is derived from a correlation chosen according to the soil type, and its source is named on the screen and in the report.

The layer stack is kept continuous automatically

On every save the layers are sorted by their top levels, the top of the first layer is moved to 0.00 m, the thickness of each layer is kept at no less than 0.10 m and the stack is chained end to end again. In this way no gaps or overlaps remain. The practical consequence is this: the “start” levels entered are a guide; what enters the calculation is the thicknesses and the order of the layers.

A layer can be split into two parts. When a layer is right-clicked in the borehole log, the first line of the menu shows the clicked layer and depth; the depth is rounded to 0.05 m. “Split the layer in two at this depth” splits the layer at the clicked depth. “Split layer… (enter depth)” opens the “Split Layer” window, in which the split depth is entered. “Edit layer” opens the layer edit window. The “Split Layer” window can also be opened with the “Split Layer” button above the layer table; the suggested depth is then the middle of the layer.

Each part must be at least 0.10 m thick. A thinner layer cannot be split; for an invalid depth the program states the permitted range. Both parts carry the same soil properties (code, γ, c, ϕ, description and all parameters); SPT and other depth-dependent data do not change. After a split the analyses are marked “out of date” and must be reproduced with UPDATE CALCULATIONS.

The layer edit window and some auxiliary windows (for example hydrostatic uplift, basement wall pressures, LPI and Vs profile) can be kept in front. To do this, choose “Keep on top” in the system menu opened by right-clicking the title bar of the window, or press Ctrl+Shift+T. The window then stays in front of a laboratory document open behind it. The option is off by default, is remembered per window type and changes no data or calculation.

SPT rows

Each row of the SPT table consists of a level, three blow counts and a refusal flag. If another cell is edited while the level cell is empty, the level is filled in automatically from the first SPT level and interval values in the settings. The blow count used in the calculation is, in line with TBDY practice, the sum of the second and third 15 cm; the first 15 cm is not counted. The corrected values (N_{60}, $N_{1,60}$, $N_{1,60f}$) are shown in a separate, read-only table; how much each correction changes the result can therefore be read directly.

SPT cannot be entered deeper than the borehole depth. Rows that exceed the limit are deleted, and the user is told what the limit is in metres, what the largest valid level can be and how many rows were deleted. If no layer has been defined, all SPT rows are removed and the user is asked to define the layers first.

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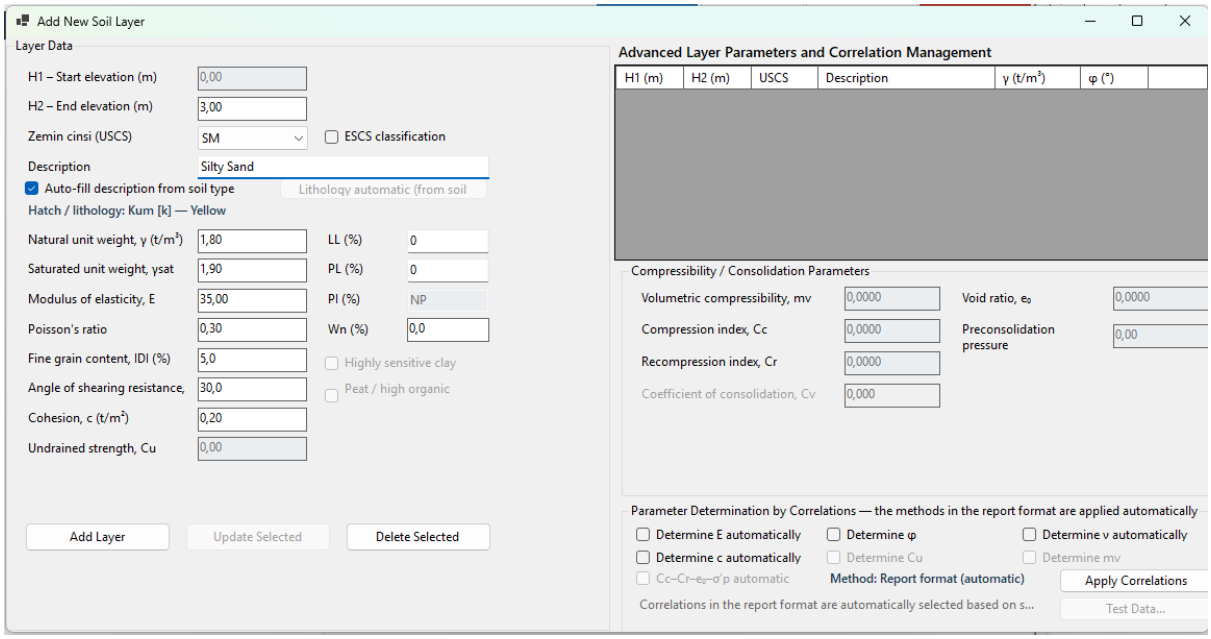


Figure 2. Add New Soil Layer window: layer data, compressibility parameters and correlation settings

2.2 Project file

The project is saved and opened as a .geos file from the File menu of the main program. Projects saved with earlier versions (.gtr, .json and .geos) can also be opened; the calculation results in these files are not taken over, the calculations are made again in the program, and a .geos file is written when the project is saved.

2.3 Reading the foundation plan from DXF

The foundation plan is held in the program as a single geometry and used in three places at once: the mesh of the two-dimensional settlement solution, marking the boreholes on the plan, and deriving the borehole influence areas. The plan is therefore defined once and stays the same everywhere.

Table 9. Source of the foundation plan — order of precedence

Order	Source
1	If a DXF foundation plan has been loaded, its closed outer boundary
2	If the foundation type is circular isolated, the circle generated from the diameter entered
3	The rectangle generated from the B × L dimensions entered

The DXF reader reads closed polylines, circles and old-style polylines; arc information on a polyline is expanded into the true curve, and circles are converted into a closed polygon. If there is a layer named RADYE_SINIR it is taken as the boundary; otherwise the closed boundary with the largest area is selected and the user is told which criterion was used. If no single closed shape can be found, an attempt is made to build a chain from line segments that can be joined end to end.

The unit is read from the unit definition in the DXF header; metre, centimetre, millimetre, inch, foot, decimetre and yard are supported. An unsupported unit is rejected. If no unit is defined at all, the program explicitly asks for confirmation before taking the coordinates as metres, and the default answer is no; this prevents working unknowingly with a foundation at the wrong scale.

A self-intersecting boundary, and a boundary too small for its area to be measured, are rejected; in both cases the user is told what to do. If reading succeeds, the area, the layer selected, the selection criterion and the unit are reported in a summary box.

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The origin is the centroid of the foundation

The polygon read is repositioned about its own centroid. All plan coordinates in the program are in metres and measured from the foundation centre; no absolute or map coordinate system is needed. This convention is the same for the foundation plan, the borehole layout and the influence areas.

2.4 Marking the borehole on the plan

The plan coordinate of a borehole can also be entered by hand; however, typing CAD or map coordinates into these fields is a common mistake that produces wrong results without any warning. The coordinate can therefore also be marked by clicking on the foundation plan.

The marking window draws the foundation plan built according to the order of precedence above: the DXF boundary if a DXF is loaded, otherwise the B × L rectangle or the circle entered. Clicking on the plan sets the point; the coordinate is read in metres with two decimals. The drawing has dashed axes and the label “(0, 0) — foundation centre”, the other boreholes as grey points with their names, the selected borehole as a red cross cursor, and a scale bar.

The view is fitted automatically and — deliberately — extended to include boreholes that fall outside the plan. A wrongly entered point therefore does not become invisible; it is visible and can be corrected. If no plan is defined yet, the window says so and asks either for the foundation dimensions to be entered or for the foundation plan DXF to be loaded.

Borehole influence areas

Boreholes with plan coordinates are divided into zones within the foundation boundary on a nearest-neighbour basis: each point is solved with the profile of the borehole nearest to it. A borehole with no coordinate does not take part in this division, and the user is told that it was not included in the map — assuming a borehole without coordinates at the origin would pile all boreholes on top of each other at a single point. If no borehole has coordinates, the profile is taken from the first borehole in the list; single-borehole projects therefore work without a map.

The influence area map shows the foundation boundary, the coloured zones, the borehole locations and, for each borehole, the distance to the farthest corner of its zone as a dashed circle; this circle answers the question “how far am I representing with this borehole”. The table next to it lists the area, percentage and farthest-corner distance of each borehole. The map does no calculation, it only displays; the assignment is always to the nearest borehole and cannot be changed by hand; the only thing the user can do is move the borehole coordinate.

2.5 Importing superstructure reactions

In the two-dimensional raft settlement solution the load can be built from the actual column and wall reactions instead of a uniformly distributed average pressure. This needs two files: a DXF plan carrying the column and wall locations, and an Excel table carrying the reaction values.

Plan file

In the DXF, members are recognised from the layer name: closed shapes on a layer whose name contains “KOLON” are columns, and those whose layer name contains “PERDE” or “PANEL” are walls. The raft boundary is found from the raft layer names; if it cannot be found, the largest closed non-structural shape is proposed as a candidate and the user is asked to confirm it together with its area. Text labels in the drawing are matched to the members; if the CAD name and the name in the analysis program are written differently, the names are simplified before being compared. Labels whose geometry cannot be built and members generated from section dimensions are reported one by one in a geometry report.

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Excel table

Only the .xlsx format is read, and only the first sheet is evaluated. The header row is searched for in the first twenty rows; the row must contain a cell including the heading “Eleman” and a cell starting with “F1”. The recognised columns are load case/combination, storey, member, location, F1, F2, F3, M1, M2 and M3; member and F1 are mandatory.

The unit is read from inside the header

Column units are taken from the parentheses in the header text — for example “F1 (tf)” or “M2 (kNm)”. Force and moment units must be consistent among themselves; if different units are found in the force columns, or a moment column has no unit, the import is rejected and an example of what should be written is given. The program does not guess units.

After the Excel table is loaded, the combination and the storey are selected; the member matching table shows one by one which members are in the DXF but not in the Excel file, and vice versa. The import is accepted only when the matching is complete, the total vertical load is greater than zero and the compression sign and moment mapping are defined. If part of a member’s load area extends beyond the raft mesh during the solution, this is reported with its percentage.

The torsional moment about the F1 axis is not applied in the vertical raft solution, and this is stated on the screen. Verifying that the X and Y directions of the Excel file and the DXF are the same is the user’s responsibility; the program cannot compare the axis systems of the two files.

Surface load map

As an alternative to importing reactions, the pressure on the raft can be given directly as an X–Y–p point table. This table can be filled in on the screen, pasted from the clipboard or read from an Excel file; no header is searched for in the file, the first three columns are taken as X, Y and pressure in that order, and non-numeric rows are skipped. The program can also generate an empty template file to be filled in. Numbers can be read with either a comma or a point as the decimal separator.

2.6 Other data paths

Table 10. Other data input paths

Data	How it is entered
Shear wave velocity profile	Entered by hand in a separate window; the start level is the foundation depth and only the part not exceeding 30 m is evaluated. V_s-based liquefaction does not run without this profile.
Oedometer test data	Entered by hand: the m_v table and the e–log σ’ table, point selection for the C_c and C_r lines, and the t_{50} or t_{90} method for C_v. There is no import from file. Whether the selection was made by hand or the automatic proposal was accepted is recorded and written in the report as the method name.
Pressuremeter data	Entered by hand, by borehole and profile, in the window opened from the Modules menu. The foundation dimensions and depth are taken read-only from the main screen.
Report templates	The default templates are always read from the program’s installation folder; the program does not copy them anywhere. The user can add their own .docx template under a different name to the %LocalAppData%\GeoteknikPro Studio\Sablonlar folder; as long as the placeholder names are kept, the Word formatting can be edited freely.
Photographs	JPG, PNG and BMP are accepted; images are embedded in the project file and extracted to the working folder when the project is opened. Images larger than 300 KB are compressed to JPEG in the background; the same image is kept only once in the file (Section 12.4).

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2.7 Data exchange with the Data Report

The Data Report is the module that runs on a separate tab of the main window and produces the Soil and Foundation Investigation Data Report (the content of Annex EK-11 of the Communiqué) as a Word document: the EK-5 scaled borehole log, test pit log, EK-6 legend, acceptance records, sample labels, per-borehole tables and the Communiqué compliance table are parts of this report. The module's screens, text templates, Regulation Check rules and report formats are described in a separate document (Data Report User Guide); this section covers only the data exchange with the Geotechnical Report.

Data flow in both directions, and in both directions only on a user command; no data are transferred automatically.

From the Geotechnical Report to the Data Report

The "↓ Pull Data from GeoteknikRapor" command on the Data Report tab takes the project identification, the authors, boreholes, layers, SPT data and groundwater level. Identification fields specific to the Data Report are not deleted; the transfer writes over a copy of the existing identification. The default coordinates in the Geotechnical Report are not transferred.

Building/foundation corners are not sent to the Data Report; the building position is drawn in AutoCAD and imported into the Data Report as DXF. Borehole plan coordinates are converted to Data Report positions only with a reliable reference: (1) a DXF foundation polygon whose position has been stored, (2) at least two boreholes positioned on both sides and agreeing within 0.5 m, or (3) a DXF foundation polygon identical to the Data Report building corners. Without one, the borehole is transferred without a position and the summary states how many were not computed.

From the Data Report to the Geotechnical Report

The "Transfer from Data Report to Geotechnical Report…" command in the Data menu works with these rules:

- Boreholes are matched by name. A borehole that exists only in the Data Report is added; a borehole that exists only in the Geotechnical Report is left untouched.
- If a layer boundary has changed, the new layer takes its design parameters (such as ϕ, c, E, ν, m_v) from the old layer it overlaps most.
- An empty incoming field does not delete the value in the Geotechnical Report. If there is no groundwater measurement, the water setting does not change. The SPT changes only if there are SPT data in the Data Report.
- A record whose name starts with "AÇ-" or "AC-" is treated as a test pit and marked "SPT not performed"; if there is an SPT record in the Data Report, this is written as a warning in the transfer summary.
- In a layer with an empty USCS class (topsoil, rock and the like) the soil code is derived from the EK-6 legend; the number of layers for which this was done is reported in the transfer summary.

The transfer does not refresh the calculations by itself; it marks the existing results as "out of date" (the box below Table 8). Because the screen is not reloaded, unsaved work in the other modules is preserved. After the transfer the calculations must be refreshed with the update command.

The Seepage (groundwater) tab takes the boreholes and the foundation with its own "⇄ TRANSFER DATA…" button. This button opens the "Seepage — Transfer Data" window, in which the source module (Geotechnical Report, Excavation Support, Slope or Retaining), the item (face, section or wall) and the data groups to be transferred are selected. Unit weight (t/m^3) and cohesion (t/m^2) values are converted to kN/m^3 and kPa. After the seepage solution, the "↑ Transfer back to source" button on the Results tab writes the result back to the source module of the transfer.

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3. Site and Structure Information

This tab consists of two groups. The site information goes only into the report and affects no calculation; part of the structure information, on the other hand, enters the calculation directly. The distinction matters: leaving a field that enters the calculation empty changes the result without any warning.

3.1 Site information

The project name, province, district, neighbourhood, map sheet, block and parcel number, parcel area, short and long side of the parcel, latitude–longitude, terrain slope class and zoning status are entered. All of these fields are carried into the report identification and the cover page.

If the “Parcel min elevation (m)” and “Parcel max elevation (m)” fields in the General section of the Report window are left empty or 0, the smallest and largest borehole collar elevations (those other than 0) are shown and written in the report; a value entered by hand always takes precedence. These values do not enter the calculation.

On the right of the Site Information tab, the TKGM Parcel Query application (parselsorgu.tkgm.gov.tr) opens in an embedded browser. A parcel is queried with the page’s own boxes or by clicking the map. The browser navigates only within this address; links to other sites do not open. The “Home” button in the top strip returns to the start of the query page. When the page returns the data of a parcel, the “Transfer to site data” button becomes active.

Nothing is transferred automatically. Pressing the button opens the “Transfer TKGM parcel data to site information” window, which shows the current and new value of each field side by side. Empty fields come checked. Filled fields come unchecked; if checked, they are overwritten. Fields that already have the same value are shown dimmed. The “Check all” and “Only empty” buttons change the selection at once; the “Transfer (n fields)” button writes only the checked rows.

The fields that can be transferred are province, district, neighbourhood, map sheet, block, parcel and area (m²). The short and long sides of the parcel are calculated from the smallest rectangle enclosing the boundary polygon, and the latitude and longitude from the centroid of the parcel. These values are approximate. If the area calculated from the boundary differs from the TKGM area by more than 5%, the window shows a warning. Zoning information and terrain slope cannot be obtained from TKGM; they are entered by hand.

If Microsoft Edge WebView2 Runtime is not installed on the computer, the tab says so and gives the installation address; the program keeps working and the site information is entered by hand. If no connection can be made, retry with “Home”. If the parcel data cannot be read, the program asks for the values to be entered by hand. The browser data are kept in the %LocalAppData%\GeoteknikPro Studio\WebView2 folder.

Parcel sides do not enter the calculation

The short and long sides of the parcel are written only in the report. The foundation dimensions are read from separate fields; taking a parcel side for a foundation side is a common mistake.

3.2 Structure information

The structure information that enters the calculation is as follows:

Table 11. Structure information used in the calculation

Field	Meaning and role in the calculation
Short side B, long side L	Foundation geometry for the bearing capacity, settlement and stress distribution calculations

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Field	Meaning and role in the calculation
Base area A	Derivation of the average base pressure from the structure weight
Number of basement floors	Excavation depth, hydrostatic uplift and temporary flotation assessment
Number of storeys	Automatic estimate of the structure weight
Foundation base depth D_f	Surcharge stress $\bar{q}$, depth factors, effective borehole depth
Maximum excavation depth D_k	Assessments around the excavation and report text
Foundation thickness t	Plate stiffness in the two-dimensional raft solution
Average base pressure	Load input of the bearing capacity check and the settlement calculation
Maximum base pressure	Eccentricity and corner stress assessment
Foundation type	Raft, Isolated, Strip or Circular Isolated; determines the shape factors and the settlement limit
Foundation concrete class	Enters only the plate bending stiffness in the two-dimensional raft solution

Foundation geometry and foundation plan

Foundation dimensions can be defined separately from the building dimensions. For a circular isolated footing the diameter is entered and the side of the equivalent square is used in the calculations. For raft foundations with an irregular plan, the foundation plan polygon can be drawn inside the project or read from a DXF file; this polygon is used in the two-dimensional settlement solution and in the borehole layout plan.

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Eccentricity and effective dimensions

When a load eccentricity is entered, the bearing capacity calculation is carried out with the effective dimensions: $B' = B - 2e_x$ and $L' = L - 2e_y$. If one of the effective dimensions drops to zero or below, the calculation is stopped and the reason is written; bearing capacity is not defined for such a section.

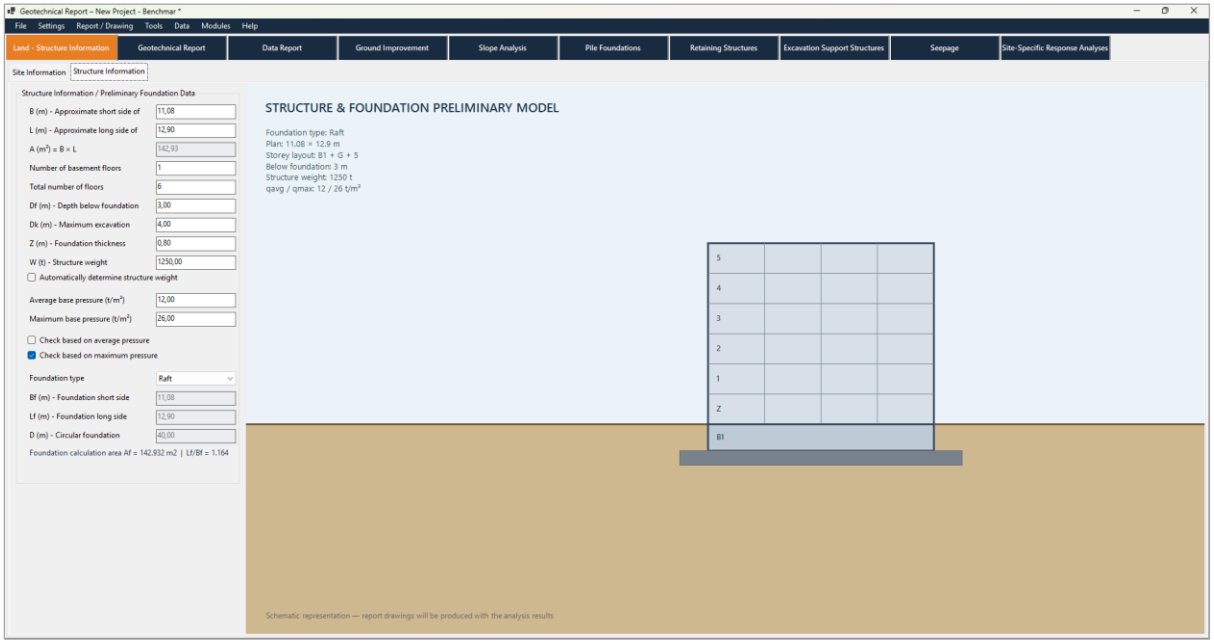


Figure 3. Structure Information tab: preliminary foundation data and preliminary structure–foundation model

4. Soil Information — Layers, SPT and Parameters

4.1 Borehole management

Any number of boreholes can be defined in a project. Each borehole has its own top level, distance from the edge, layer sequence and SPT data. A new borehole can be derived by copying one; its name can be changed (Section 2.1). When plan coordinates are entered for the boreholes, or the boreholes are marked on the foundation plan, the program determines which part of the foundation is represented by which borehole using the influence area (Voronoi) method; this assignment is used cell by cell in the two-dimensional settlement solution.

The borehole coordinate can be entered by hand or marked by clicking on the foundation plan. The plan boundary is formed from that polygon if the foundation plan has been loaded as DXF, and otherwise from the B × L dimensions entered. The origin of the coordinates is the foundation centre, and this point is shown marked on the plan.

For each borehole the groundwater level can be inherited from the project as a whole or entered specifically for the borehole. The “No GWL” option declares that there is no water; this does not mean that the water is at zero depth, and all water-dependent calculations behave according to this declaration.

The report reads its single values (local site class, bearing capacity table, groundwater level sentence) from a single borehole; this is called the report borehole. By default the report borehole is the first borehole in the list. For another borehole, that borehole is selected in the list and the “Make Report Borehole” button is pressed; the selection is stored in the main project file and is kept even if the borehole is renamed. The Effective Borehole Depth module uses the same borehole.

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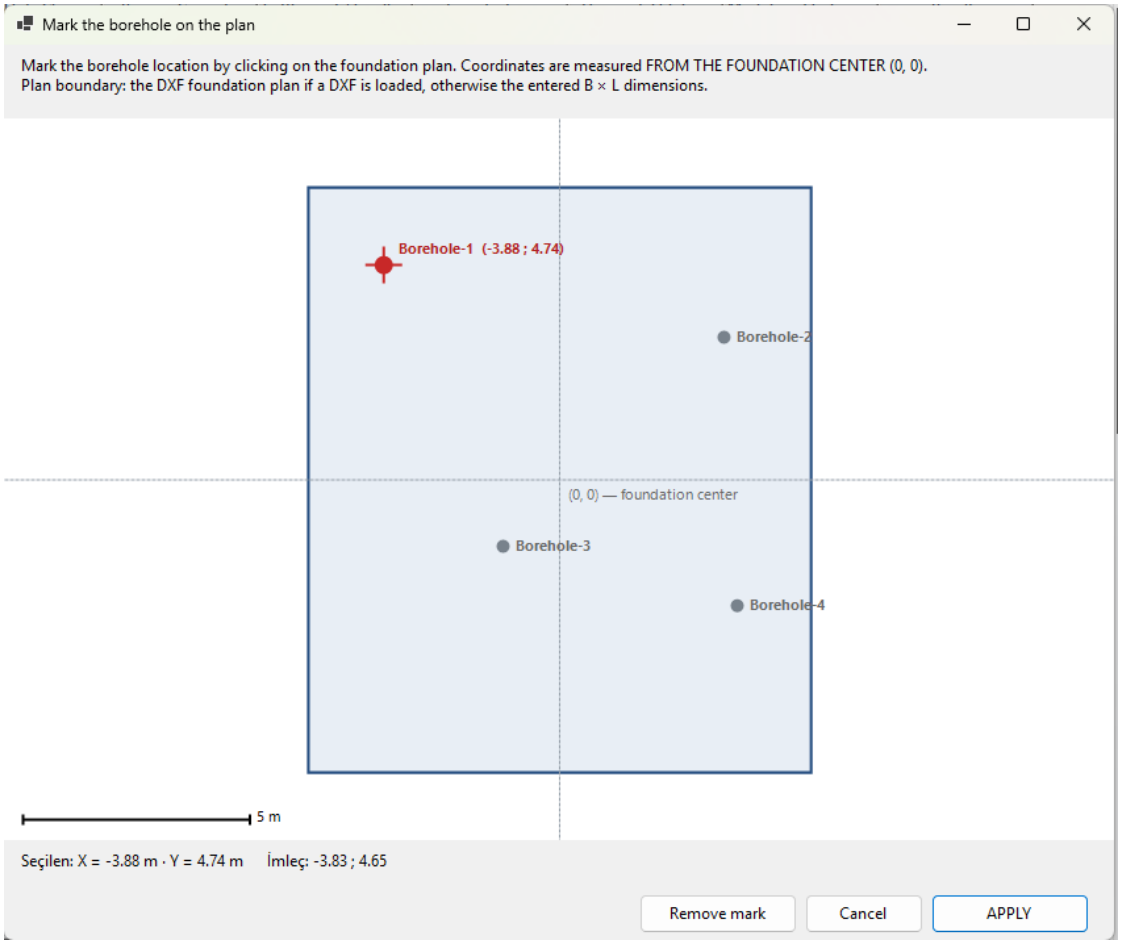


Figure 4. Mark the borehole on the plan window: setting the borehole coordinate by clicking on the foundation plan

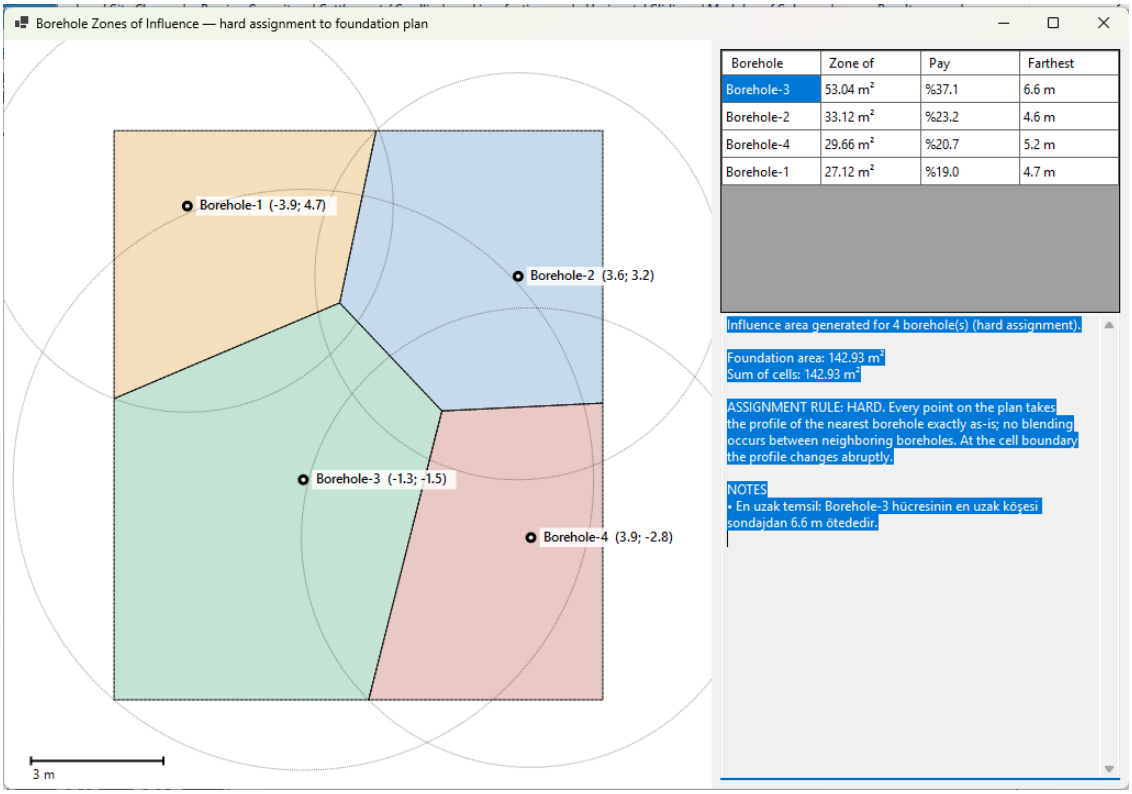


Figure 5. Borehole Influence Areas window: division of the foundation plan into zones by nearest borehole

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4.2 Soil layers

A layer is defined by its top and bottom levels. For each layer the soil class is selected according to the USCS or ESCS system; the selection determines the lithology scan, the liquefaction susceptibility assessment and the correlation family. The parameters that can be entered for a layer are collected below.

Table 12. Layer parameters

Group	Parameters
Definition	Soil code, lithology, description, top and bottom level
Unit weight	Natural unit weight γ_n, saturated unit weight γ_{sat}
Strength	Angle of internal friction ϕ, cohesion c, undrained shear strength c_u
Stiffness	Modulus of elasticity E_s, Poisson's ratio v
Consistency	Liquid limit, plastic limit, plasticity index, natural water content, fines content, clay percentage
Consolidation	C_c, C_r, C_s, preconsolidation pressure σ'_p, m_v, void ratio e_0, C_v and drainage condition
Swelling	Swelling pressure
Flags	Sensitive clay, organic soil, saturated layer where high pore water pressure is expected

Lithology and borehole log

Each layer is assigned a lithology pattern and drawn with this pattern in the borehole log. The choice of pattern is not only visual: the borehole log, borehole section and multi-borehole section drawings of the report use the same pattern catalogue, so the same soil looks the same in all outputs.

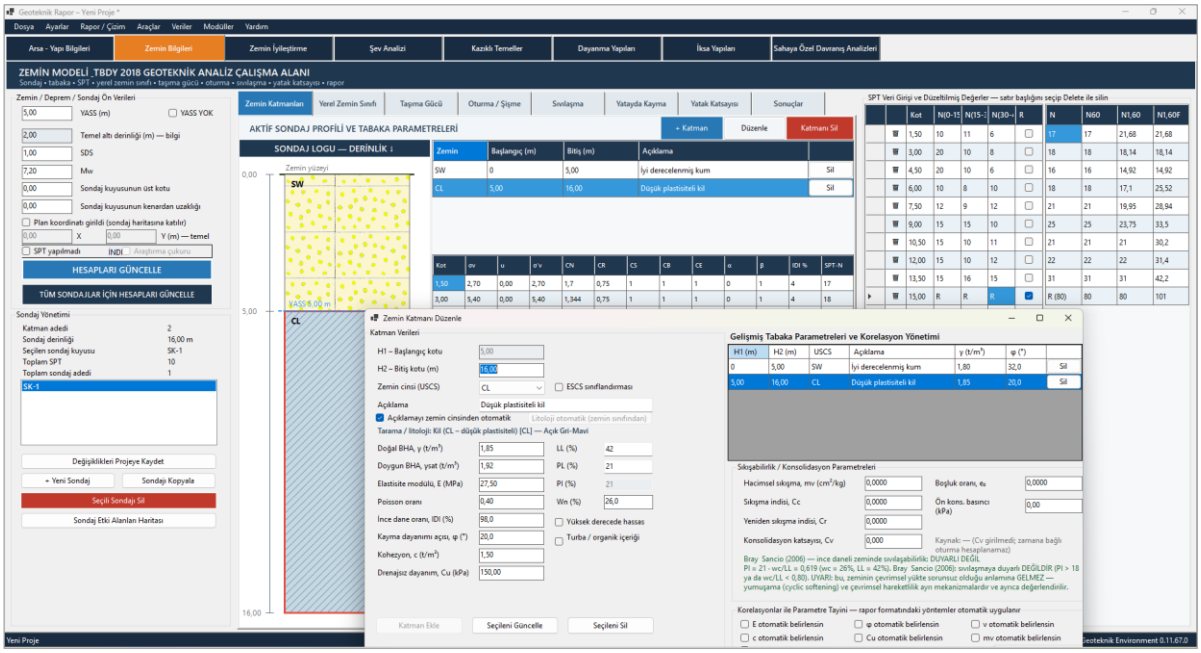


Figure 6. Borehole log, layer table and Edit Soil Layer window (Turkish interface shown)

4.3 SPT data and corrections

SPT blow counts are entered in increments of 0–15, 15–30 and 30–45 cm. Refusal is reported with a separate flag; it appears as "R" on the screen, and the refusal value defined in the settings is used in the calculation. SPT rows exceeding the borehole depth are detected by the program and reported to the user.

The corrections are applied in this order:

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Table 13. SPT correction factors and their sources

Factor	Definition and application	Source
C_E	Energy ratio correction; entered in the settings	TBDY 2018 Table 16B.1
C_R	Rod length correction; 0.75 for z<4 m, 0.85 for 4–6 m, 0.95 for 6–10 m, 1.00 for >10 m	TBDY 2018 / NCEER
C_S	Sampler correction; entered in the settings	TBDY 2018 Table 16B.1
C_B	Borehole diameter correction; entered in the settings	TBDY 2018 Table 16B.1
C_N	Overburden correction; $C_N = \min(1.70, 9.78 \cdot \sqrt{(1/\sigma'_v)})$	Liao–Whitman; TBDY 2018 16B.2.1.1
α, β	Fines correction; $N_{1,60f} = \alpha + \beta \cdot N_{1,60}$, according to the FC band	Youd et al. (2001), NCEER

By default the N_{60} value is calculated as $N \cdot C_E$. When "full correction" is selected in the settings, $N_{60} = N \cdot C_E \cdot C_R \cdot C_S \cdot C_B$. $N_{1,60}$ always includes the overburden correction as well: $N_{1,60} = N \cdot C_E \cdot C_R \cdot C_S \cdot C_B \cdot C_N$.

Level	σv	u	σ'v	CN	CR	CS	CB	CE	α	β	IDI %	SPT-N
1.50	2.70	0.00	2.70	1.7	0.75	1	1	1	0	1	5	19
3.00	5.40	0.00	5.40	1.344	0.75	1	1	1	0	1	5	19
4.50	8.10	0.00	8.10	1.097	0.85	1	1	1	0	1	5	19
6.00	10.80	0.00	10.80	0.95	0.95	1	1	1	0	1	5	19
7.50	13.60	1.00	12.60	0.88	0.95	1	1	1	0	1	5	18
9.00	16.45	2.50	13.95	0.836	0.95	1	1	1	0	1	5	17
10.50	19.30	4.00	15.30	0.798	1	1	1	1	0	1	5	19
12.00	22.15	5.50	16.65	0.765	1	1	1	1	0	1	5	20
13.50	25.00	7.00	18.00	0.736	1	1	1	1	0	1	5	24
15.00	27.85	8.50	19.35	0.71	1	1	1	1	0	1	5	24
16.50	30.70	10.00	20.70	0.686	1	1	1	1	0	1	5	27
18.00	33.55	11.50	22.05	0.665	1	1	1	1	0	1	5	27
19.50	36.40	13.00	23.40	0.646	1	1	1	1	0	1	5	30

Figure 7. SPT correction table: stresses with depth and the C_N, C_R, C_S, C_B, C_E, α and β factors

SPT Data Entry and Corrected Values — select the row header and press Delete to remove

		Level	N(0-15	N(15-3	N(30-4	R	N	N60	N1,60	N1,60F
▶		1,50	0	10	9	☐	19	19	24.23	24.23
		3,00	0	10	9	☐	19	19	19.15	19.15
		4,50	0	10	9	☐	19	19	17.72	17.72
		6,00	0	10	9	☐	19	19	17.15	17.15
		7,50	0	9	9	☐	18	18	15.04	15.04
		9,00	0	8	9	☐	17	17	13.5	13.5
		10,50	0	9	10	☐	19	19	15.17	15.17
		12,00	0	10	10	☐	20	20	15.31	15.31
		13,50	0	12	12	☐	24	24	17.67	17.67
		15,00	0	12	12	☐	24	24	17.04	17.04
		16,50	0	15	12	☐	27	27	18.53	18.53
		18,00	0	15	12	☐	27	27	17.96	17.96
		19,50	0	15	15	☐	30	30	19.37	19.37

Figure 8. SPT Data Entry and Corrected Values table: raw blow counts with N_{60}, $N_{1,60}$ and $N_{1,60f}$ values

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Overburden correction in cohesive layers

The overburden correction C_N was derived for sands. Not applying this correction in clay-type cohesive layers is a setting option; when it is selected, $C_N = 1$ is taken in those layers. In low-plasticity silt (ML) and organic silt (OL) layers C_N is applied in all cases. The assumption used is stated in the report.

4.4 Automatic parameter derivation

When a parameter is not entered, the program can derive a value from a correlation chosen according to the soil type. The source of every derived value is named on the screen and in the report; the user can always replace a derived value with their own measurement.

Table 14. Correlations used

Parameter	Soil	Source
Angle of internal friction ϕ	Clay	Carter — based on plastic limit and plasticity index
Angle of internal friction ϕ	Silt	Schmertmann (1975)
Angle of internal friction ϕ	Gravel	Clayton (1995)
Angle of internal friction ϕ	Sand	OCDI Japan (2002)
Undrained shear strength c_u	Cohesive	Kulhawy and Mayne (1990)
Modulus of elasticity E_s	Clay	Bowles — based on plasticity index, from c_u
Modulus of elasticity E_s	Silt	Schultze and Melzer (1965)
Modulus of elasticity E_s	Gravel	NAVFAC (1982)
Modulus of elasticity E_s	Sand	Bowles — from N_{60}
Coefficient of volume compressibility m_v	Cohesive	Stroud and Butler (1975) — based on plasticity index
C_c, C_r, e_0	Cohesive	Azzouz–Obaji–Terzaghi or the laboratory e–log σ′ curve

Shear wave velocity comes from measurement

The V_s profile consists of measured values or of the depth range–velocity table entered by the user; no SPT-based correlation is used.

V_{s30} is calculated as a harmonic mean and covers a depth of 30 m from the foundation base level. Where the profile does not cover 30 m, the thickness covered is written on the screen.

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5. Local Site Class

The local site class is determined according to the criteria of TBDY 2018 Table 16.1. The program evaluates the three criteria independently of each other and selects the most unfavourable class.

Table 15. TBDY 2018 Table 16.1 criteria

Class	V_{s30} (m/s)	$(N_{60})_{30}$	$(c_u)_{30}$ (kPa)
ZA	> 1500	—	—
ZB	760 – 1500	—	—
ZC	360 – 760	> 50	> 250
ZD	180 – 360	15 – 50	70 – 250
ZE	< 180	< 15	< 70

$(N_{60})_{30}$ and $(c_u)_{30}$ values are calculated by taking the harmonic mean with the corresponding layer thicknesses. The thickness covered is shown on the screen for each criterion; if the profile does not cover a depth of 30 m, this is also reported.

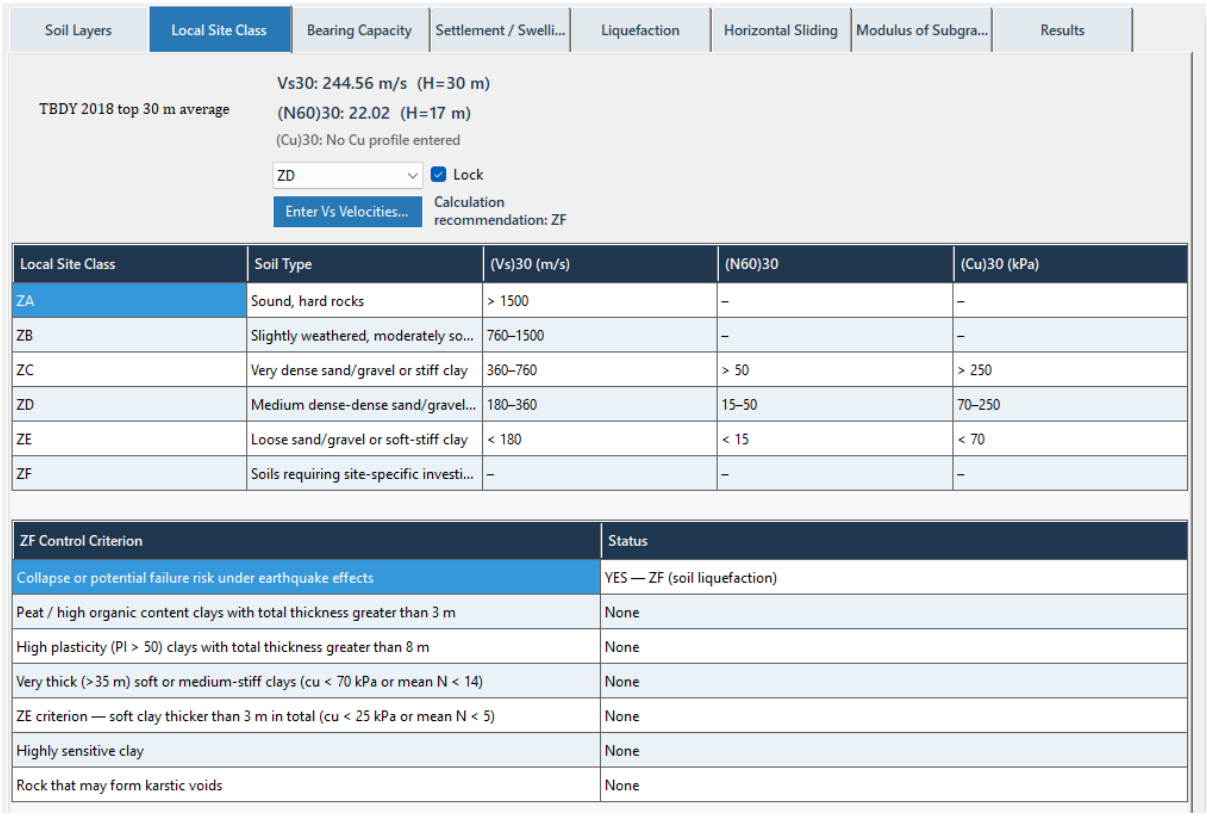


Figure 9. Local Site Class tab: class determined from $(N_{60})_{30}$, TBDY 2018 class table and ZF check criteria

5.1 Checking the ZF conditions

Under certain ground conditions TBDY 2018 makes a site-specific assessment (class ZF) mandatory. The program checks the following conditions one by one and marks each as “YES” or “None”:

- Presence of liquefaction risk within the upper 20 m.
- Presence of organic soil thicker than 3 m.
- Presence of very high plasticity clay with a plasticity index above 50 and thicker than 8 m.
- Presence of soft / medium stiff clay thicker than 35 m.

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- Presence of sensitive clay.

If any of the conditions is met, the class is forced to ZF and the reason is written. In the ZF case the design spectrum is produced from the “Horizontal Elastic Design Spectrum (ZF)” window in the Modules menu or from the Site-Specific Response Analyses module.

Fixing the class by hand

The user can fix the local site class by hand. In that case the class calculated by the program and the fixed class are shown separately in the report; the calculated value is not hidden.

6. Bearing Capacity

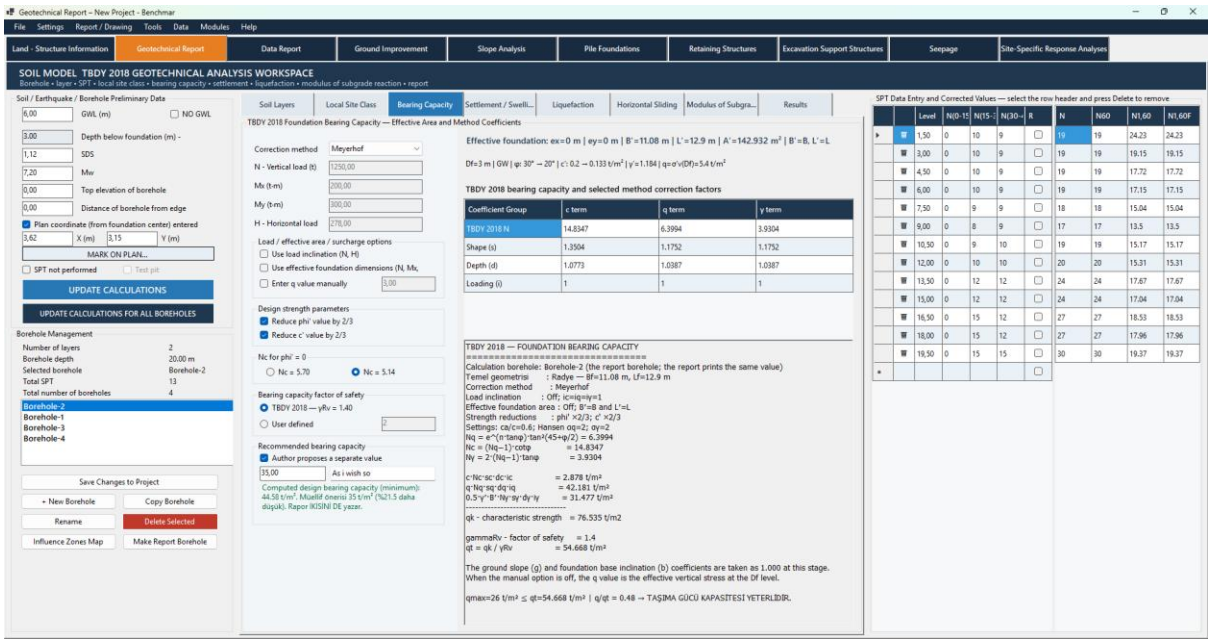


Figure 10. Bearing Capacity tab: effective area, correction method, bearing capacity factors and calculation breakdown

6.1 General equation

The bearing capacity of shallow foundations is calculated in the multiplicative form of TBDY 2018 Equation 16.8a:

$$q_{ult} = c \cdot N_c \cdot s_c \cdot d_c \cdot i_c + \bar{q} \cdot N_q \cdot s_q \cdot d_q \cdot i_q + 0.5 \cdot \gamma' \cdot B' \cdot N_\gamma \cdot s_\gamma \cdot d_\gamma \cdot i_\gamma$$

The bearing capacity factors are independent of the method and taken from the TBDY 2018 set:

- $N_q = e^{\pi \cdot \tan\phi} \cdot \tan^2(45° + \phi/2)$
- $N_c = (N_q - 1) / \tan\phi$
- $N_\gamma = 2 \cdot (N_q - 1) \cdot \tan\phi$

For the case $\phi = 0$ the user chooses between two values of N_c: 5.70 (Terzaghi) or 5.14 (Prandtl). The choice is written in the report.

The “N_γ definition” option on the Settings › Bearing Capacity tab is by default the TBDY equation ($N_\gamma = 2 \cdot (N_q - 1) \cdot \tan\phi$), and it is used in the same way in all three correction methods. If required, the selected correction method’s own N_γ equation (Meyerhof, Hansen or Vesić) can be chosen; in that case only N_γ changes, N_q and N_c do not change.

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6.2 Correction factors — choice of method

The shape, depth and load inclination factors are calculated by choosing one of three methods: Meyerhof, Hansen or Vesić. The choice changes all of the factors; no mixed set is used. The factors of each method are calibrated against its own test base, and mixing them produces an inconsistent result.

Table 16. Differences between the correction methods

Method	Ratio used in the shape factors	Inclination factor
Meyerhof	B / L	Depends on the load angle, form $(1 - \theta/90°)^2$
Hansen	B′ / L′ (effective dimensions)	Depends on the horizontal force, exponents from the settings
Vesić	B / L	Form with exponent m depending on the load direction

For the same soil and the same geometry the three methods give different results; the difference is sometimes of the order of a factor. This is not an inconsistency but the consequence of the methods' different assumptions. The method used and the numerical values of all factors enter the report in a separate table.

6.3 Undrained case (ϕ = 0)

In saturated cohesive soils with zero angle of internal friction the program can use the special undrained equation of Hansen and Vesić:

$$q_{ult} = 5.14 \cdot c_u \cdot (1 + s'_c + d'_c - i'_c - b'_c - g'_c) + \bar{q}$$

Here s'_c, d'_c and i'_c are additive factors; they are not the same as s_c, d_c and i_c in the multiplicative form. The base adhesion $c_a = \alpha \cdot c_u$ is calculated and the ratio α is read from the settings.

The undrained equation differs from TBDY 16.8a

This equation is additive, whereas TBDY 2018 Equation 16.8a is multiplicative. If full agreement with the Code form is required, the Meyerhof correction set must be used. The program reports this difference as a warning on the screen and writes the equation used into the report.

If the sum in the parentheses drops to zero or below, the calculation is stopped: the equation is not defined for such a section and producing a number would be misleading.

6.4 Effect of groundwater

If the groundwater level is above the foundation base level, the effective (submerged) unit weight γ′ is used instead of γ in the bearing capacity equation. If the water level is below the base level but at a depth smaller than the foundation width, a transition equation that can be switched on in the settings varies γ linearly with depth between γ′ and γ. This assumption and its source are stated in the report.

6.5 Factor of safety and recommended bearing capacity

The design bearing capacity is found by dividing the ultimate value by the factor of safety. The default factor is 1.40 in accordance with TBDY 2018; the user can enter their own value.

The user can also declare a separate "recommended bearing capacity" value to be carried into the report. This value cannot be greater than the smallest of the calculated values; if a greater value is entered it is rejected. It is free in the downward direction. The report gives the calculated value and the value recommended by the author separately and shows the difference between them as a percentage.

The report always recalculates the bearing capacity (q_k and q_t) with the report borehole (Section 4.1): if no borehole has been selected, with the first borehole in the list. The calculation on the screen is done with the

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selected borehole; if the selected borehole differs from the report borehole, a note of the form “Calculation borehole: SK-3; the report calculates bearing capacity with SK-1” appears on the screen. The screen value saved in the project does not pass into the report as a number; it is only a “calculation done” flag. In the report, the upper limit of the recommended bearing capacity is the q_t of the report borehole (or, if pressuremeter and rock values also exist, the smallest of these).

6.6 Bearing capacity on rock

For rock there are four separate paths in the Modules menu. All four are collected in the same window, and their results can be read side by side.

Table 17. Bearing capacity methods for rock

Method	Input	Output
Hoek–Brown	Rock type (m_i), GSI, disturbance factor D, uniaxial compressive strength	m_b, s, a; rock mass strength; equivalent c–ϕ; bearing capacity
Uniaxial compression test	UCS and RQD	Ultimate and allowable bearing capacity
Point load test	$I_s(50)$, size correction factor, RQD	UCS equivalent and bearing capacity
EN 1997-1 Annex G	Rock group (1–4), UCS, discontinuity spacing	Allowable base pressure read from the chart

The GSI value is determined from a descriptive selection window. The uniaxial compressive strength can be derived from a laboratory test, a Schmidt hammer reading or a point load test; which one was used is written in the report.

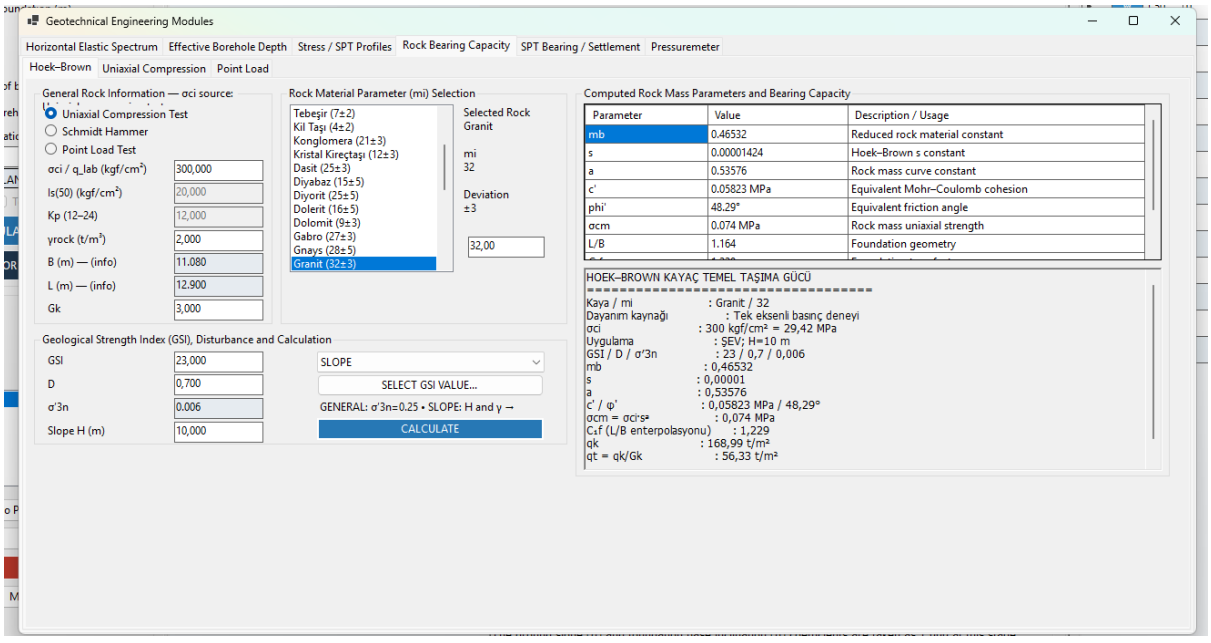


Figure 11. Rock Bearing Capacity window, Hoek–Brown tab and GSI Value Selection window (partly Turkish output shown)

Eurocode 7 Annex G is a chart

EN 1997-1:2004 Annex G Figure G.1 is a chart. The program uses this chart in digitised form and interpolates in two directions. If the UCS and discontinuity spacing entered fall outside the range covered by the chart, the program reports this and produces no result.

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6.7 Pressuremeter-based bearing capacity

When Ménard pressuremeter test data are entered, the bearing capacity is derived from the limit pressure. The equivalent limit pressure is found as the geometric mean of the measurements around the foundation base level; the bearing capacity factor K_p is selected according to the foundation geometry and the soil type. Settlement is calculated with the Ménard–Rousseau (1962) equation, with the rheological factor α and the shape factors λ_c, λ_d according to Briaud (1992). The pressuremeter modulus E_d separates the zones according to the Clarke (1995) definition. If there is no measurement in the E_2 or $E_{3\text{-}4\text{-}5}$ zone, the calculation does not stop: E_d is calculated only with the terms of the zones that have data, and the numerator is taken as the sum of the coefficients of these terms for homogeneous soil; in this way $E_d = E$ for homogeneous soil. A missing zone is not filled from a neighbouring zone. If there are no data in the E_1 zone, E_d is not calculated and this is written on the screen.

6.8 SPT-based bearing capacity and settlement

In sand and gravel soils, an allowable bearing capacity can be estimated directly from the SPT blow count (Meyerhof–Bowles empirical equations, with a depth factor). In the same window, immediate settlement is calculated with the Burland and Burbidge (1985) method; the method takes into account the soil type (coarse sand, fine/silty sand, gravelly sand), the static or dynamic loading case and the time-dependent creep component.

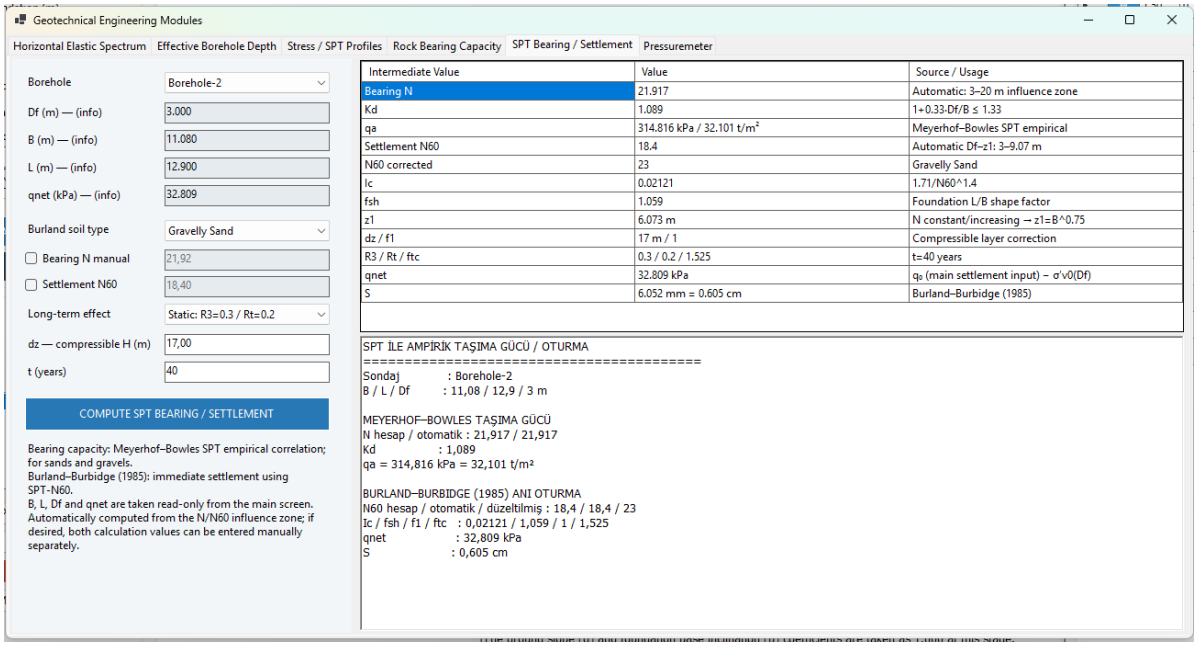


Figure 12. Settlement / Bearing Capacity with SPT (Meyerhof-Bowles, Burland-Burbidge) (partly Turkish output shown)

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7. Settlement and Swelling

The settlement calculation consists of three components: immediate (elastic) settlement, consolidation settlement and the time-dependent development of settlement. The swelling potential is assessed separately. For raft foundations with an irregular plan or variable loading, a two-dimensional settlement surface can be solved.

7.1 Immediate settlement — elastic method

Elastic immediate settlement is calculated with the following equation:

$$s = q_0 \cdot B' \cdot (1 - \nu^2) / E \cdot m \cdot I_s \cdot I_f$$

The shape factor I_s is taken from the Steinbrenner solution and the embedment factor I_f from the Fox (1948) solution. Both factors are calculated in closed form; no chart reading is involved.

The compressible layer thickness is taken automatically as H = min(H_σ, 5B, H_{rigid}). H_σ is the depth where the stress increase falls to 10% of the effective stress. H_{rigid} is the top of the first layer whose E is at least k times the thickness-weighted mean modulus $\bar{E}$ of the zone above (k = 10 by default, Settings › Settlement). The layer name or code (“rock unit”, “rock”) does not cut H: weathered tuff, marl or other rock with a soil-like modulus enters $\bar{E}$ with its own E. A layer without E is not taken as rigid and is flagged.

The Settlement Sensitivity Scan always covers the full range 0 – min(H_σ, 5B); the top of a layer named rock is only an information line. The screen and the report state the H used, why it was chosen, and the largest settlement in the scan. A manually entered H is used, and the full scan is still shown.

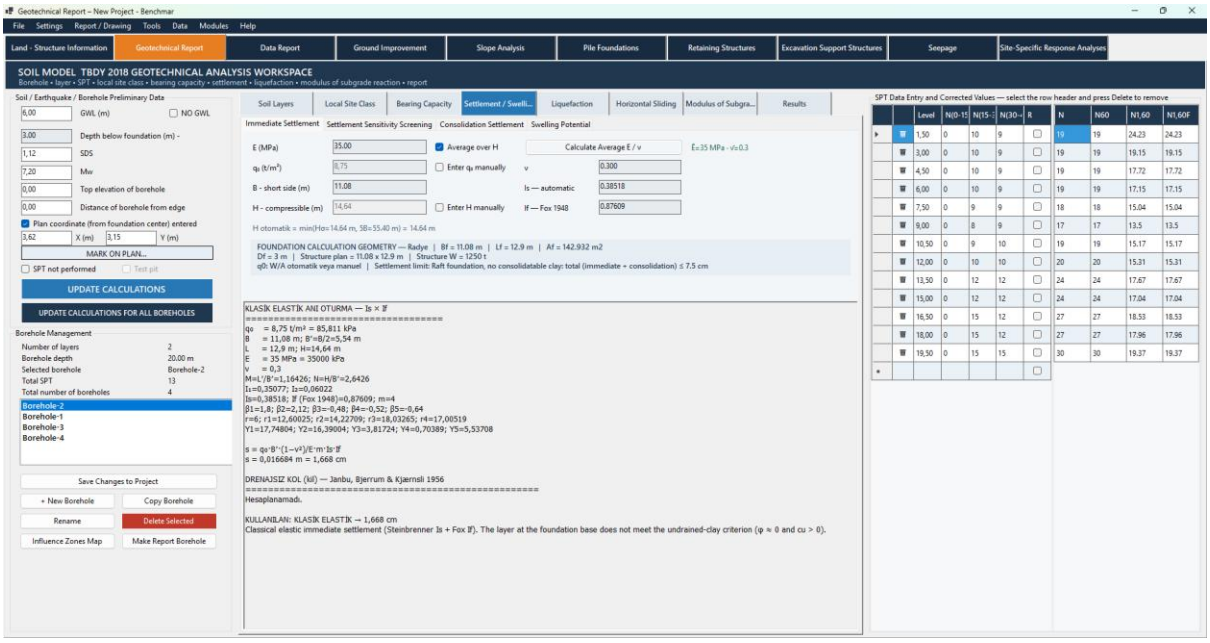


Figure 13. Settlement / Swelling tab, Immediate Settlement: elastic parameters and calculation breakdown

7.2 Undrained immediate settlement — cohesive soils

In saturated cohesive soils the immediate settlement can be calculated with the method of Janbu, Bjerrum and Kjærnsli (1956):

$$s_i = \mu_0 \cdot \mu_1 \cdot q \cdot B / E_u$$

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μ_0 depends on the embedment ratio (D/B), and μ_1 on the thickness of the compressible layer and the slenderness of the foundation (H/B, L/B). The program interpolates these charts on a logarithmic axis; if the geometry entered falls outside the range covered by the chart, the value is clipped and the clipping is reported.

The undrained modulus of elasticity is derived as $E_u = \beta \cdot c_u$. The β factor is given by Duncan and Buchignani (1976) according to the plasticity index band and the overconsolidation ratio. If OCR is not entered it is derived from the preconsolidation pressure; if that is not available either, 1 is assumed and this assumption is written in the report.

This method is used only in layers whose angle of internal friction is close to zero and whose undrained shear strength is defined; it can be switched off in the settings.

7.3 Consolidation settlement

Consolidation settlement can be calculated in two ways; both are on separate tabs of the same screen and their results can be compared.

Table 18. Consolidation settlement methods

Method	Input	Application
m_v method	Coefficient of volume compressibility m_v (laboratory $\Delta\sigma$–m_v points)	m_v is selected by linear interpolation at the effective stress at mid-layer
C_c–C_r–e_0 index method	Compression index C_c, recompression index C_r, void ratio e_0, preconsolidation pressure σ'_p	Normally and overconsolidated branches separately; divided into sub-layers 0.50 m thick

The stress increase $\Delta\sigma_z$ is calculated according to the spread method selected in the settings: the Boussinesq elastic solution or a 63.5° spread angle (the classical 2:1 approximation). The choice affects the whole depth profile and is written in the report.

Net pressure convention

The load used in the settlement calculation is the net pressure, found by deducting the pre-excavation effective stress from the contact pressure. As the excavation depth increases the net pressure decreases and may become negative; a negative value is clipped at zero, because a foundation cannot pull the ground upwards.

Laboratory e–log σ′ curve

When oedometer test data are entered, the preconsolidation pressure is determined by the Casagrande construction. The compression and recompression lines are proposed by the program; however, the proposal is not used until the user confirms it. The lines can also be selected by hand.

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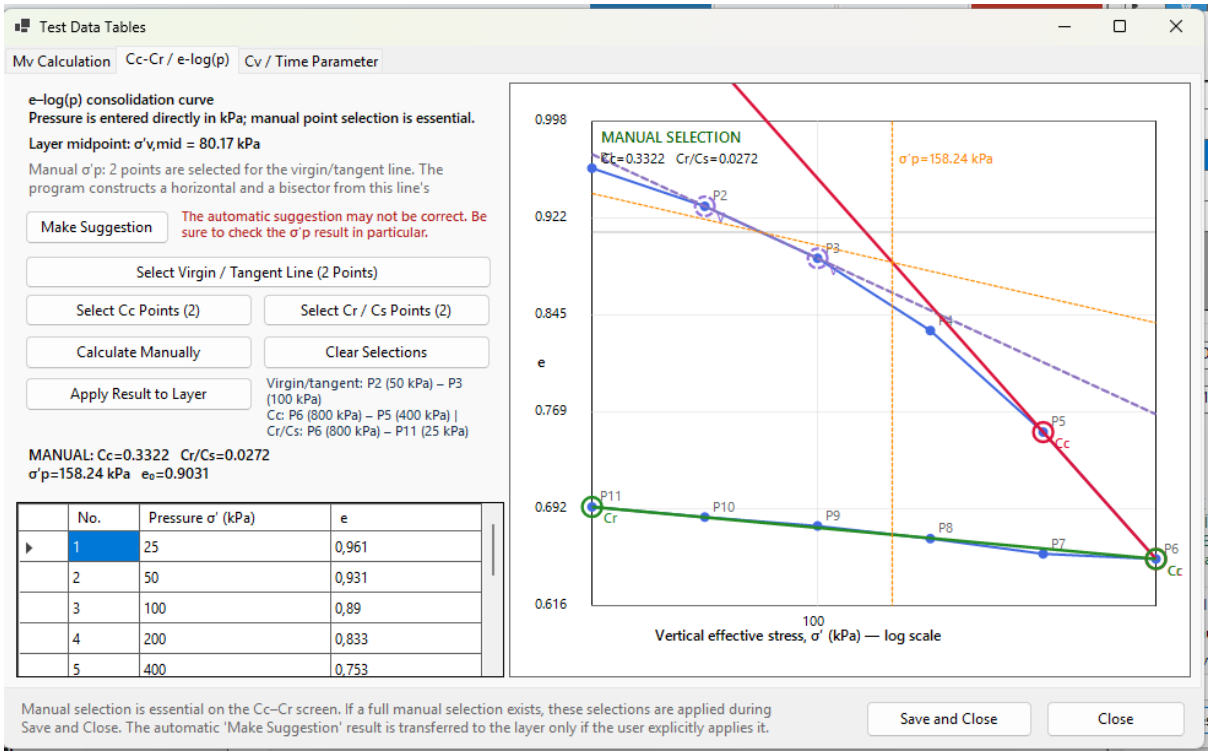


Figure 14. Test Data Tables, C_c–C_r / e–log(p) tab: preconsolidation pressure by the Casagrande construction and compression lines

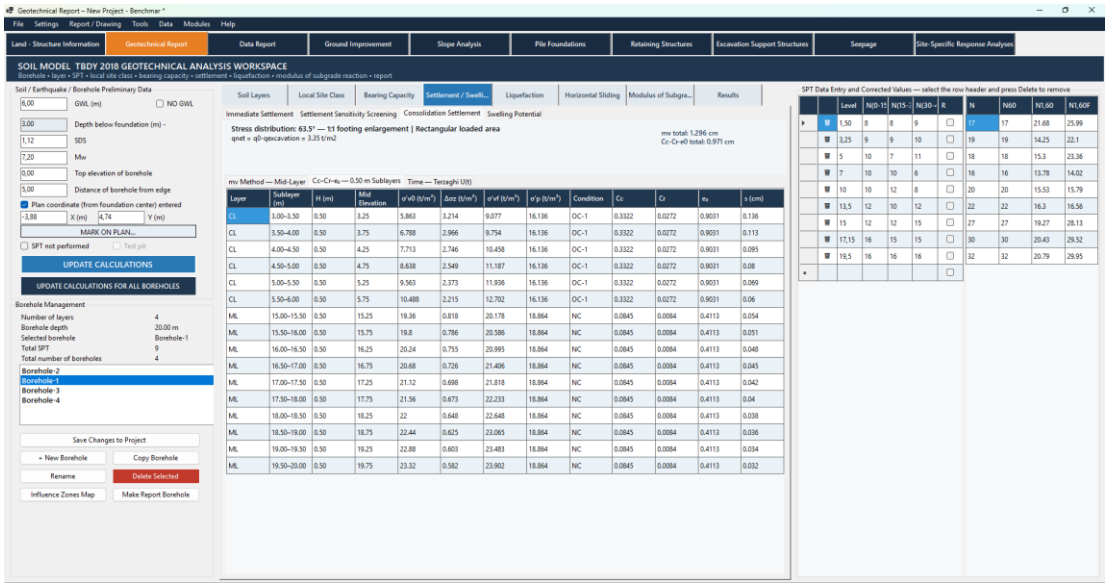


Figure 15. Consolidation Settlement: calculation table by sub-layer

7.4 Time-dependent development of settlement

Time-dependent settlement is calculated with Terzaghi's one-dimensional consolidation theory. The time factor $T_v = C_v \cdot t / H_{dr}^2$ and the average degree of consolidation U(t) are found from the series solution. The drainage path H_{dr} is determined according to the drainage condition of the layer: H/2 for double drainage, H for single drainage.

The coefficient of consolidation C_v can be derived from laboratory data (by the t_{50} or t_{90} method) or entered directly. In layers where C_v is not defined no calculation is made and the layer is marked "no C_v" in the table; no default value is assumed.

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7.5 Swelling potential

The swelling assessment is based on the clay percentage and the plasticity index. The activity is defined as A = PI / (clay percentage) and classified as low, normal or active according to the Clayton et al. (1995) classification. The swelling percentage is estimated with an empirical equation depending on the activity and the clay percentage; the result is assessed with the O'Neill and Poormoayed classification.

If a swelling pressure has been entered for a layer, this pressure is compared with the foundation base pressure. If the swelling pressure exceeds the base pressure the program warns: in that case the foundation cannot restrain the swelling of the soil.

7.6 Settlement sensitivity scan

To see how sensitive the settlement result is to each parameter, the layer thickness, modulus of elasticity, Poisson's ratio and shape factors are swept and a sensitivity table is produced. This table does not make a design decision; it shows which parameter, if measured, would improve the result most.

7.7 Two-dimensional settlement surface

For raft foundations with an irregular plan, variable thickness or variable loading, a settlement calculated at a single point is not sufficient. In this case the program models the raft as a plate and solves it together with the soil:

- The raft is modelled with four-node plate elements; the plate bending stiffness is derived from the foundation thickness and the concrete class.
- The soil flexibility is built on the layered profile either by Boussinesq integration or by the elastic half-space solution; which one is used is a setting.
- The contact takes no tension: zones where the soil reaction becomes negative are switched off iteratively and the load is redistributed over the remaining contact area.
- Each cell can use its own soil profile according to the borehole influence area assignment.

The load can be defined in three ways: a uniformly distributed average pressure, a load surface built from reference points, or the column/wall reactions coming from the superstructure solution. In the third way the column locations are read from the DXF foundation plan and the reaction values from the Excel table.

Outputs: maps of the applied pressure p(x,y), the soil reaction q(x,y), immediate settlement, consolidation settlement and total settlement; a settlement map for a requested time; sections along B and L; maximum and minimum settlement; angular distortion β = Δw/L and tilt.

Table 19. Angular distortion classes

Limit	Structure type
1 / 250	Structures insensitive to distortion
1 / 500	Conventional structures (default)
1 / 850	Important structures sensitive to distortion
User-defined	Special cases

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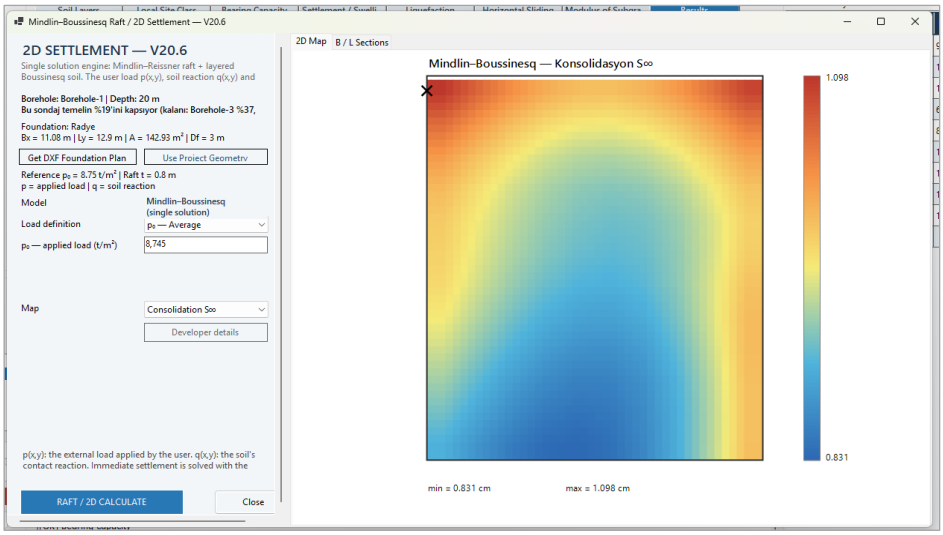


Figure 16. 2D Settlement window: foundation settlement map from the Mindlin–Boussinesq solution (partly Turkish output shown)

7.8 Settlement limits

The calculated settlement is compared with limits defined according to the foundation type. The limits can be changed in the settings; the default values are given below.

Table 20. Default settlement limits

Foundation type	Case	Limit
Raft	On consolidating clay, total	12.50 cm
Raft	Total	7.50 cm
Isolated / Strip	Immediate settlement	5.00 cm
Isolated / Strip	Total settlement	7.50 cm

8. Liquefaction

Liquefaction safety is assessed by comparing the cyclic stress ratio (demand) with the cyclic resistance ratio (resistance):

$$FS = CRR \cdot MSF \cdot K_\sigma / CSR$$

The program offers three liquefaction options: TBDY 2018 / NCEER (Youd et al. 2001), Boulanger and Idriss (2014), and a TBDY 2018 option that uses the TBDY 2018 equation for the stress reduction factor ($r_d = 1 - 0.015z$). The choice is made once, according to the code, on the Settings › Liquefaction tab and not on the liquefaction screen; on the liquefaction screen the selected method is shown for information only. The methods use the same SPT data but their correction and resistance equations differ; their results can be compared directly.

The fines (IDI/FC) correction depends on the selected method: in the TBDY 2018 / NCEER method the α–β correction is applied (α = 0, β = 1 for a fines content of 5% or less); in the Boulanger and Idriss (2014) method the correction is added directly to the blow count as $\Delta N_{1,60}$. The overburden correction C_N also depends on the method: the TBDY 16B.2 equation (Table 13) is used in the TBDY 2018 / NCEER method and an iterative equation in the Boulanger and Idriss (2014) method. The C_N and α values of the two methods therefore differ for the same borehole; this is not an inconsistency.

8.1 Method 1 — TBDY 2018 / NCEER (Youd et al. 2001)

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This method is consistent with the principles of TBDY 2018 Appendix 16B.

Table 21. Components of the NCEER method

Quantity	Definition
CSR	Cyclic stress ratio; with the 0.65 factor, the total/effective stress ratio, the ground acceleration and r_d
r_d	Piecewise depth-dependent stress reduction equation (z ≤ 9.15 m / ≤ 23 m / ≤ 30 m / > 30 m)
$CRR_{7.5}$	Cyclic resistance ratio depending on the clean-sand equivalent $N_{1,60f}$
MSF	Magnitude scaling factor; Idriss equation
K_σ	Overburden correction; exponential form depending on relative density, limited to the range 0.50 – 1.00

8.2 Method 2 — Boulanger and Idriss (2014)

This method is widely used in current international practice. Its differences from NCEER are:

- The fines correction is added directly to the blow count in the form $\Delta N_{1,60}$.
- The overburden correction C_N is solved iteratively because it depends on the clean-sand equivalent blow count, and is limited to 1.70.
- The stress reduction factor r_d depends on the earthquake magnitude as well as on depth.
- The magnitude scaling factor MSF depends on the density of the soil; the same value is not used for loose and dense soil.
- K_σ factor has a logarithmic form, and its coefficient again depends on density.

8.3 Seismic demand

By program convention the peak horizontal ground acceleration is taken as $a_{max} = 0.40 \cdot S_{DS} \cdot g$. The moment magnitude M_w is entered by the user. Both values are written in the report.

S_{DS} can be entered with three decimals (e.g. 1.155); it is also shown with up to three decimals in the report and in other windows.

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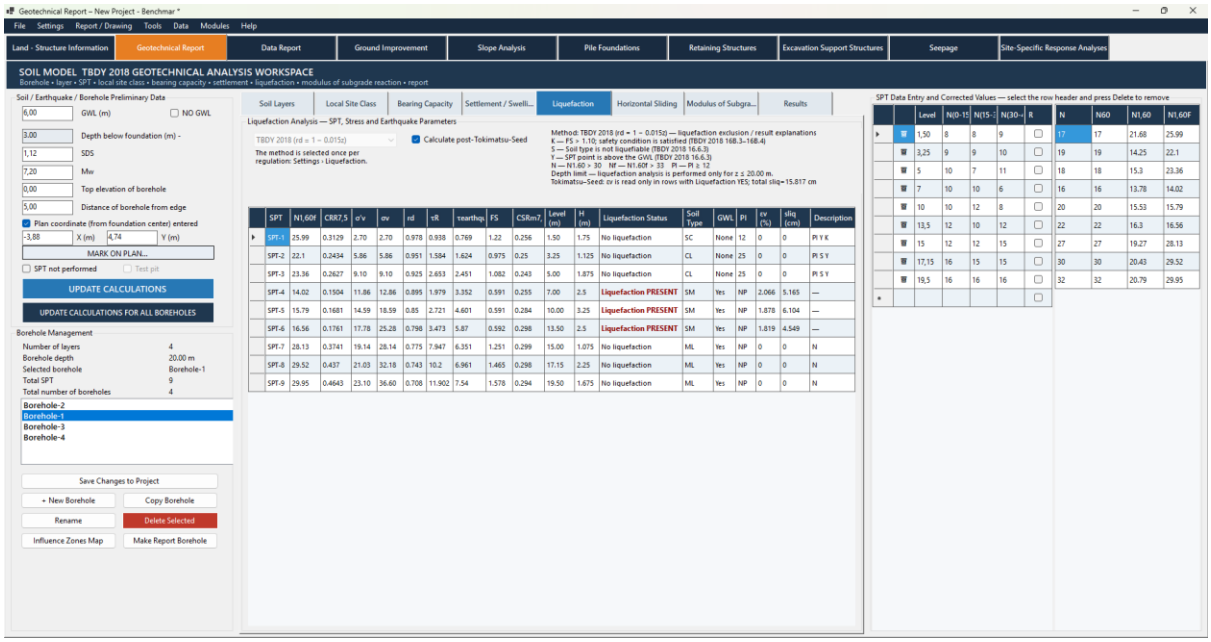


Figure 17. Liquefaction tab: SPT-based factor of safety, exclusion codes and Tokimatsu–Seed post-liquefaction settlement

8.4 Exclusion criteria

The reasons why no liquefaction assessment is made at a depth are shown in the table by a letter code. The exclusion criteria are taken from the principles of TBDY 2018 regardless of the selected method.

Table 22. Exclusion grounds

Code	Reason
S	The soil type is not liquefiable
Y	The SPT point is above the groundwater level
N	The $N_{1,60}$ value is above 30
Nf	The fines-corrected $N_{1,60f}$ value is above 33
PI	The plasticity index is above the limit value
K	The factor of safety is above 1.10

The liquefaction susceptibility of fine-grained soils is also assessed with the Bray and Sancio (2006) criterion; according to the plasticity index and the water content / liquid limit ratio the soil is classified as “susceptible”, “moderately susceptible” or “not susceptible”.

Chinese Criteria

The Chinese Criteria, proposed by Wang (1979) and used for many years, have been abandoned in current literature because they assess the liquefaction susceptibility of fine-grained soils on the unsafe side. The program uses the Bray and Sancio (2006) criterion instead and gives the reason in the report.

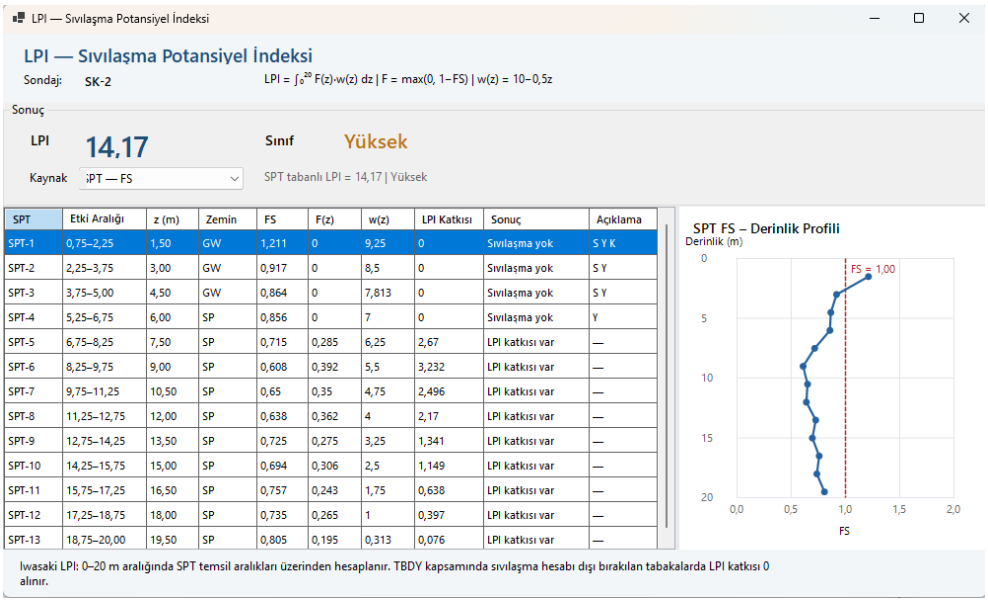
8.5 Post-liquefaction settlement

In liquefied layers the volumetric strain is derived from the Tokimatsu and Seed chart. The inputs are the corrected blow count and the cyclic stress ratio; the output is the volumetric strain in percent. Only layers whose factor of safety is below 1, that is, layers assessed as “liquefaction occurs”, are included in the sum.

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8.6 Liquefaction potential index (LPI)

By Iwasaki's definition, the LPI is the depth-weighted integral of the deficit at depths where the factor of safety is below 1. The weighting function is w(z) = 10 − 0.5z and the integration limit is 0–20 m. SPT-based or V_s-based results can be chosen as the source of the factor of safety.



SPT	Etki Aralığı	z (m)	Zemin	FS	F(z)	w(z)	LPI Katkısı	Sonuç	Açıklama
SPT-1	0,75–2,25	1,50	GW	1,211	0	9,25	0	Sıvılaşma yok	S Y K
SPT-2	2,25–3,75	3,00	GW	0,917	0	8,5	0	Sıvılaşma yok	S Y
SPT-3	3,75–5,00	4,50	GW	0,864	0	7,813	0	Sıvılaşma yok	S Y
SPT-4	5,25–6,75	6,00	SP	0,856	0	7	0	Sıvılaşma yok	Y
SPT-5	6,75–8,25	7,50	SP	0,715	0,285	6,25	2,67	LPI katkısı var	—
SPT-6	8,25–9,75	9,00	SP	0,608	0,392	5,5	3,232	LPI katkısı var	—
SPT-7	9,75–11,25	10,50	SP	0,65	0,35	4,75	2,496	LPI katkısı var	—
SPT-8	11,25–12,75	12,00	SP	0,638	0,362	4	2,17	LPI katkısı var	—
SPT-9	12,75–14,25	13,50	SP	0,725	0,275	3,25	1,341	LPI katkısı var	—
SPT-10	14,25–15,75	15,00	SP	0,694	0,306	2,5	1,149	LPI katkısı var	—
SPT-11	15,75–17,25	16,50	SP	0,757	0,243	1,75	0,638	LPI katkısı var	—
SPT-12	17,25–18,75	18,00	SP	0,735	0,265	1	0,397	LPI katkısı var	—
SPT-13	18,75–20,00	19,50	SP	0,805	0,195	0,313	0,076	LPI katkısı var	—

Figure 18. LPI — Liquefaction Potential Index window: SPT-based LPI calculation and FS–depth profile (Turkish interface shown)

8.7 Shear-wave-velocity-based liquefaction

If a V_s profile has been measured, liquefaction safety can also be calculated with the Andrus and Stokoe (2000) method. The corrected shear wave velocity V_{s1} is compared with the upper limit V_{s1}* that depends on the fines content; if V_{s1} is above the upper limit, the soil is taken as non-liquefiable. This path does not replace the SPT-based method; it is used as a second line of evidence.

8.8 Liquefaction risk map and section

In projects with several boreholes, the factor of safety is shown with colour bands in the depth–distance plane. The section is built from the plan positions and levels of the boreholes; it is exported as JPEG and added to the report.

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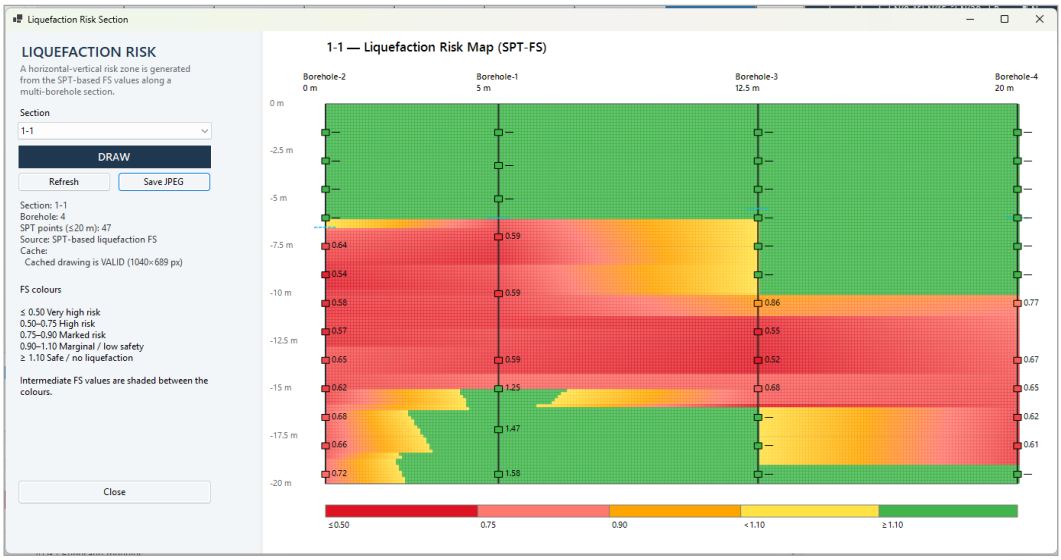


Figure 19. Liquefaction Risk Section window: distribution of the SPT-based factor of safety between boreholes

9. Horizontal Sliding and Modulus of Subgrade Reaction

9.1 Horizontal sliding check

The safety of the foundation against sliding under horizontal load is checked according to the principles of TBDY 2018. The base resistance is calculated in one of two ways according to the drainage condition of the soil:

- Drained case: with base friction, the effective vertical load and the interface friction angle.
- Undrained case: with base adhesion, the undrained shear strength and the foundation area.

The passive resistance acting on the embedded face of the foundation is calculated separately and divided by its own partial factor. The check has two stages: the horizontal demand is compared first with the base resistance alone, and then with the sum of the base resistance and a limited share of the passive resistance. The full passive resistance is not relied on, because mobilising the full passive resistance requires an unacceptably large displacement of the foundation.

The calculation of the passive resistance depends on the “Sliding — calculate passive K_p” option on the Settings › Bearing Capacity tab. With the option off (default), the passive earth pressure coefficient is taken as $K_p = 1.00$. With it on, the Rankine equation $\tan^2(45° + \phi'/2)$ is used in the static case and the TBDY 2018 16C passive pressure coefficient in the seismic case; the seismic K_p does not exceed the static value and ϕ' is taken as thickness-weighted over the embedment.

The check is carried out separately in the x and y directions. The seismic coefficients k_h and k_v are derived from the S_{DS} value by program convention.

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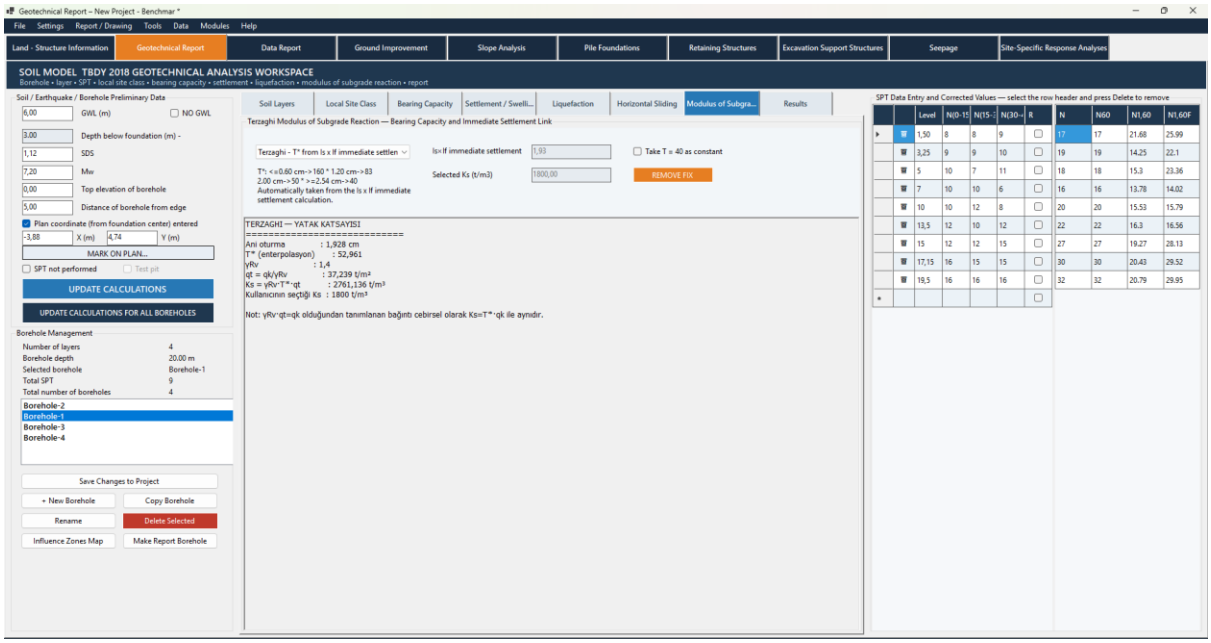


Figure 20. Horizontal Sliding tab: TBDY 2018 foundation sliding check and load cases

9.2 Modulus of subgrade reaction

By Terzaghi's definition, the modulus of subgrade reaction is derived from the ratio of the design bearing capacity to a reference settlement value. The program interpolates the reference coefficient using the calculated immediate settlement; if desired, the user can choose to use a fixed reference value.

The calculated modulus of subgrade reaction does not pass directly into the report; the value declared by the user with the "fix" command enters the report. In this way the value used in the superstructure solution and the value written in the report do not diverge.

The calculated value in the modulus of subgrade reaction section of the report is found with the equation $K_s = T^* \cdot q_k$, using the q_k of the report borehole (Section 6.5). A fixed (declared by hand) K_s is printed as entered.

If the layer at the foundation base is rock, the modulus of subgrade reaction is calculated with the elastic half-space equation from the modulus of elasticity, Poisson's ratio and influence factors of the immediate settlement calculation; in this case the product of K_s and the settlement gives the base pressure. If an input is missing, the calculation does not switch to the Terzaghi method without notifying the user; it writes the reason. The method used and its justification are written in the report with two separate fields (|ykYontem| and |ykKaya|); placing these fields in the Word template is up to the user.

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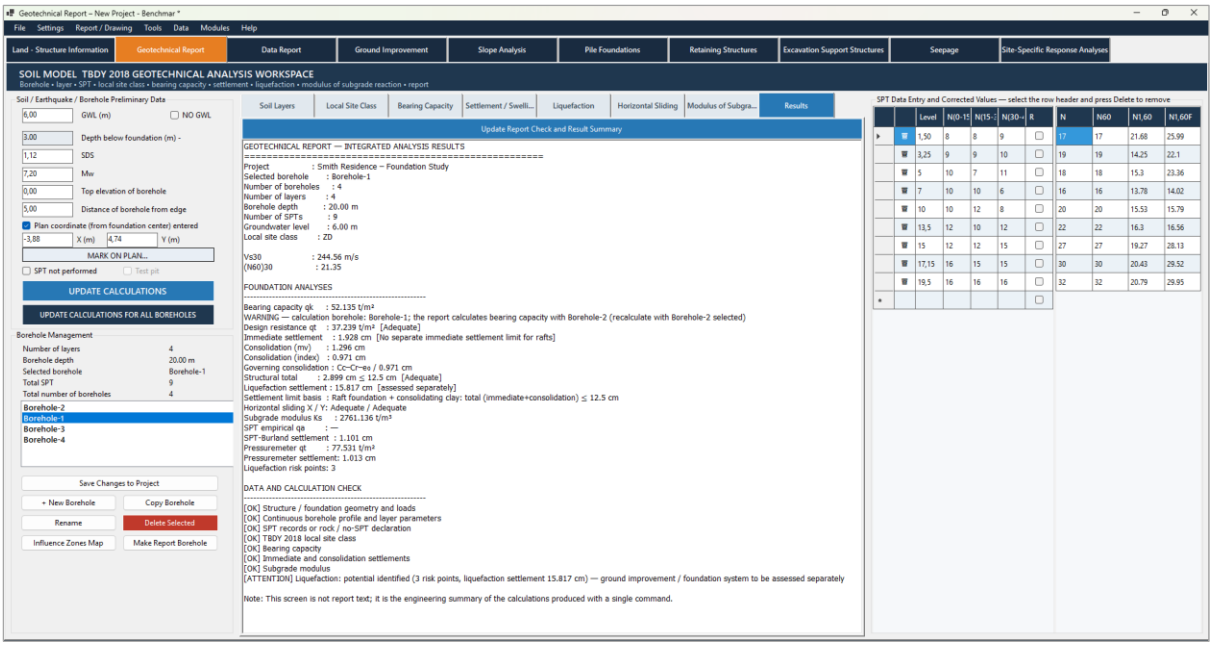


Figure 21. Modulus of Subgrade Reaction tab: modulus of subgrade reaction from bearing capacity and immediate settlement

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10. Auxiliary Calculation Modules

The Modules menu collects calculations that lie outside the main workflow but are often needed in a site investigation report. Each runs in its own window. For a module calculation to enter the report, that window must have been opened and its own CALCULATE button pressed; the background recalculation made when the project is opened or with the UPDATE CALCULATIONS command does not qualify it for the report. This qualification is kept per borehole (for example, a calculation made for SK-1 does not count for SK-2) and is saved in the project file.

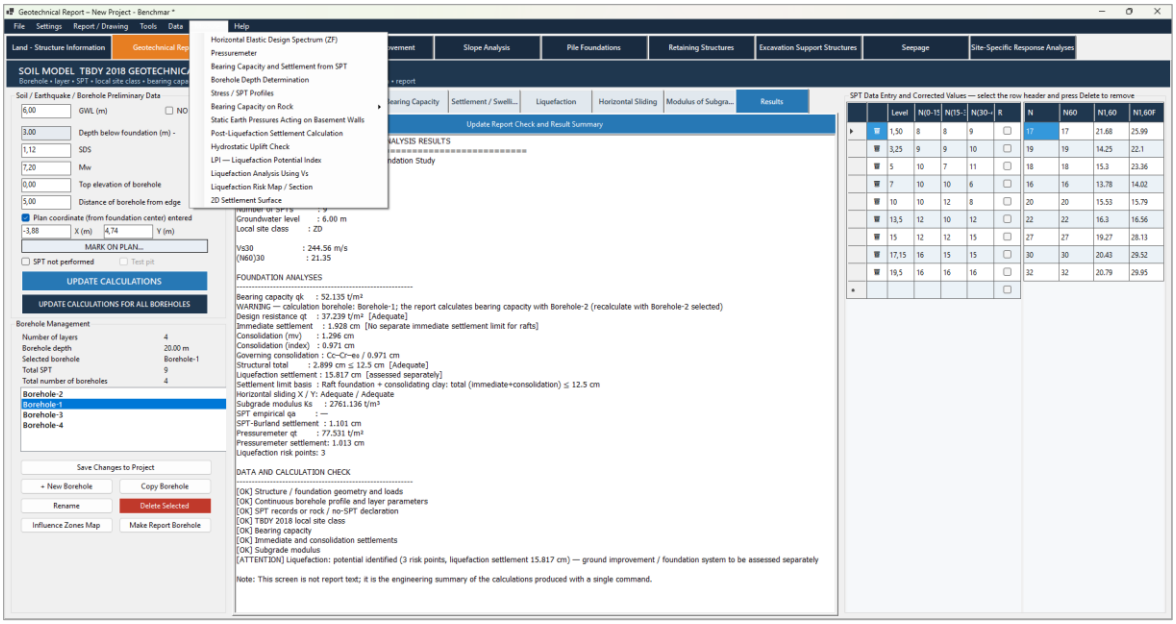


Figure 22. Auxiliary calculation modules in the Modules menu

10.1 Horizontal elastic design spectrum

When the local site class turns out to be ZF, or for comparison, the TBDY 2018 horizontal elastic design spectrum is produced. The inputs are the S_{DS} and S_{D1} coefficients, the behaviour factor R, the importance factor I and the overstrength factor D. The corner periods T_A and T_B are derived from these coefficients. The elastic and reduced spectra are drawn together and can be exported as a text file.

10.2 Effective borehole depth

The adequacy of the borehole depth is assessed by the depth at which the stress increase due to the foundation load falls to a given ratio (default 10%) of the overburden stress. The stress spread can be calculated with the classical 2:1 approximation or with the Boussinesq solution. Alternatively the 1.5·B criterion can also be applied. The calculation is done with the report borehole (Section 4.1); the result can be printed to a separate preliminary report template. On this tab the “NO GWL” option sits on its own row below the groundwater level box; while it is ticked, the groundwater level box is disabled and the calculation is made with no groundwater.

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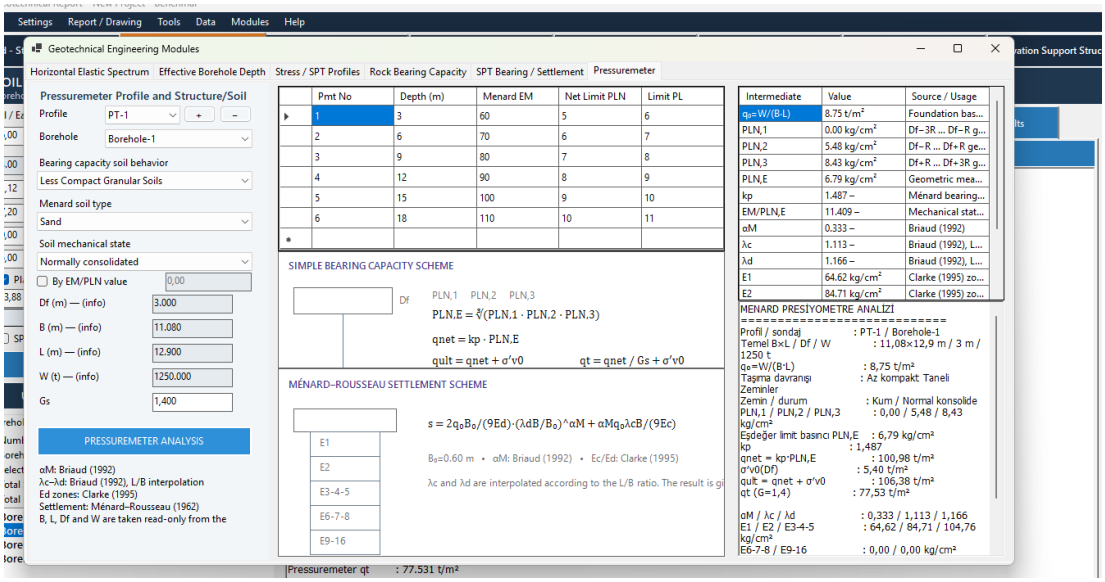


Figure 23. Effective Borehole Depth tab: depth at which the $\Delta\sigma_z$ and 10%·σ'_v curves intersect

10.3 Stress and SPT profiles

The variation of total stress, pore water pressure and effective stress with depth is produced as a table and a graph. In the same window the raw blow count is shown side by side with the N_{60}, $N_{1,60}$ and $N_{1,60f}$ correction steps; how much each correction changes the result is read directly.

10.4 Pressures acting on basement walls

The static earth and water pressures acting on basement walls and the additional pressures in the seismic case are calculated along the depth. The lateral earth pressure coefficient is chosen according to the expected behaviour of the soil. The output is a pressure table in 0.10 m steps and graphs of the static, dynamic and resultant distributions.

10.5 Hydrostatic uplift check

For structures with basements, the safety of the submerged part of the structure against uplift is checked for two separate conditions: the short-term condition (construction stage, or the excavation filling with water) and the long-term condition (existing groundwater level). When the safety ratio falls below the limit, a mitigation paragraph enters the report.

Separately from this, the risk of temporary structural flotation is assessed for basement structures whose foundation soil behaves as impermeable. This risk can arise even when there is no groundwater: the perimeter excavation opened for the basement works acts like a tub in impermeable soil, and surface water collecting during continuous rainfall cannot drain away. The assessment criterion is not the water table but the impermeability of the foundation soil together with the presence of a basement; a warning can therefore arise even when the hydrostatic uplift check is satisfied.

10.6 Pressuremeter modulus

Ménard pressuremeter test data are entered, limit pressure and pressuremeter modulus profiles are built, and bearing capacity and settlement are calculated. The modulus zones are separated according to the Clarke (1995) definition; if data are missing in one of the zones, the E_d calculation is carried out only with the zones that have data, as in Section 6.7. The results can also be obtained as a separate pressuremeter report.

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10.7 Tools menu

The Tools menu collects calculation tools that work independently of the project data. The tools in the menu are, in order: Sieve Analysis & Classification, Unit Converter, Phase Relationships, Atterberg Limits, Proctor / Compaction, Oedometer / Consolidation, Stress Calculator, SPT Corrections, Shear Test Evaluation and TBDY Site Class Quick Check. They are followed, in separate groups, by Correlations (Section 10.8) and the “Write Added Calculations to Word...” and “Clear Items Added to Report” commands.

Each tool opens in its own window. The inputs are typed into the parameter boxes and test tables; the “Sample data” button loads sample values. The result is produced with “Calculate” and shown as tables, graphs, warnings and notes. “Copy” puts the results on the clipboard. “Export to Word...” writes only that tool’s calculation to a separate Word file.

“Add to report” adds the calculation to the tool records. One record is kept per tool; a new record replaces the old one. If “Calculate” has not been pressed, or the input has changed since Calculate, the calculation enters neither the records nor Word; the window asks for it to be calculated again. “Write Added Calculations to Word...” in the Tools menu writes all records to a single Word document; “Clear Items Added to Report” deletes the records.

Tool results are not transferred to the project: they are not written to layers, boreholes or the main Geotechnical Report calculations, and they do not enter the main Word report. The records are kept in memory only while the program is open and are not saved in the project file (.geos). Limits and coefficients that could not be verified against the source are shown in the result with an “UNVERIFIED” warning. The limits of the TBDY Site Class Quick Check tool are in this state; the tool is indicative only. The local site class of the report is determined as in Chapter 5.

10.8 Correlations

The Tools › Correlations window calculates, side by side, all suitable relationships in its library for the selected soil type and main test. First the “Soil type” (with the naming system USCS or EN ISO 14688 in the “Naming” box) and the “Main test” (SPT, CPT / CPTu or index properties) are selected; the “Stress unit”, the “CPT unit” and the “CN method” for (N1)60 are set. The “Input data” table lists only the variables required by the relationships suitable for this selection. Additional inputs are optional; a missing input does not block the calculation, and the related row appears as “missing”.

“Calculate” evaluates those of the 109 relationships and 4 class tables in the library that suit the selection. In the “Results” tab each row gives the parameter, correlation, value, unit, source, badge and condition / note. The program does not pick a “recommended” value; the summary table gives the lower, median and upper values of the rows ticked in the “Select” column. The badge shows the source status of the relationship: USER SOURCE, VERIFIED (secondary) or UNVERIFIED. The “Derived values”, “Typical ranges” and “Warnings” tabs show, respectively, the pre-processing results (such as N60 and (N1)60), typical value ranges for the soil type and warnings specific to the selection.

“Export to Word” writes the result to a separate Word document and does not work before Calculate is pressed. If the inputs change after Calculate, the status line states that the results shown belong to the last calculation. The window is independent: it takes no data from the project, transfers no data to another module and does not enter the main Geotechnical Report. This window should not be confused with the correlations that derive layer parameters from the soil type (Section 4.4) or with the correlation graphs in Table 24.

11. Report and Drawings

11.1 Word report

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The report is produced from an editable Word template. The placeholders in the template are replaced with the values calculated by the program; table blocks are repeated according to the number of rows. The consequence of this approach is that the format of the report belongs to the user and its content to the program. The company letterhead, heading layout, font and section order can be edited freely in Word.

The default templates (AAGeoteknikPro and AAGeoteknikProMevcutYapi) are always read from the program's installation folder; the program does not copy them anywhere. The user's template folder is %LocalAppData%\GeoteknikPro Studio\Sablonlar. If this folder contains an older copy with the same name as a default template, it is not used and not deleted; the program reports this only once. To use your own edits, save the template under a different name and select it in the list, or add it with the "Add Report Draft" button. "Restore Default" overwrites no file; it only selects the program's default template.

Table 23. Report outputs

Output	Content
Geotechnical report	Main report covering all analyses
Existing structure report	Report using a separate assessment language for an existing structure
Borehole depth preliminary report	Effective borehole depth assessment
Test pit report	Test pit records
Pressuremeter report	Ménard pressuremeter test results
Basement pressures	Pressure distributions acting on basement walls

Why the existing structure report is separate

When bearing capacity or settlement turns out "inadequate" for an existing structure, the language of a design report becomes meaningless: the structure has already been built and is standing. The existing structure report uses a four-state language that assesses the result of the calculation together with the condition observed in the structure: calculation adequate or inadequate, observation sound or damaged.

Report templates window

The "Report templates…" command at the end of the Report / Drawing menu lists the Word templates supplied with the program in a single window: Geotechnical Report (design, existing building and effective depth preliminary report), Retaining Structures, Ground Improvement, Pile Foundations, Seepage (Groundwater) and Data Report. Slope, excavation support and seismic reports are built without a template and are not listed. Each row shows the module, the template, the template in use and the default file.

- "Save a copy…" writes a copy of the default template to the chosen location. The copy is edited in Word for your company; the placeholders (|…|) must be kept.
- "Add custom template…" adds the edited template to the related folder under %LocalAppData%\GeoteknikPro Studio\Sablonlar. The template is compared with the default. If placeholders are missing, a warning is given; those fields stay empty in the report and the report is still produced. A file that cannot be opened is not added.
- "Choose custom template…" makes one of the added custom templates the template in use. "Back to default" removes this choice; the custom file is not deleted and stays in the folder.
- "Back up templates…" writes all .docx files in the template folder to a single zip file. "Restore from backup…" unpacks this file; if a file of the same name exists in the folder, it asks whether to overwrite it. "Open template folder" opens the template folder of the selected module.

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Geotechnical Report and Data Report templates are added from this window, but the template in use is chosen from the list in the module's own report window; "Choose custom template…" is not active for these rows. For the Geotechnical Report this list is the template list of the Report window described above.

11.2 Photographs

There are two kinds of images for the report. Fixed images (cover, site view, soil section, laboratory photographs) are placed in predefined fields. Free site photographs are placed according to the section headings of the selected template: the user chooses under which section a photograph is to go. All images are embedded in the project file.

11.3 Drawings

Table 24. Drawings produced

Drawing	Content
Borehole log	Layer patterns, soil codes, SPT values and groundwater level
Single borehole profile	Detailed profile drawing of the selected borehole; opened in the "Borehole Section" window with the Report / Drawing › Geotechnical Report › Drawing › Borehole Section command
Multi-borehole section	Correlation of several boreholes along a section; with distance, top level and GWL. Drawn in the "Borehole Sections" window opened with the Report / Drawing › Geotechnical Report › Drawing › Multiple Borehole Section command; if the project has a single borehole, it draws the single-borehole soil section
Liquefaction risk section	Display of the factor of safety with colour bands in the depth–distance plane
Borehole influence area map	Display on the plan of the zones represented by the boreholes
Correlation graphs	N_{60}–c_u, plasticity index–m_v and e–log σ' curves

In the multi-borehole section the layer correlation can be drawn in two ways: organic correlation, in which the layers are joined to each other with smooth transitions, or a sharp boundary, in which a layer ends in a wedge. The choice changes the interpretation of the drawing and is written below the section.

Single-borehole soil section

- If the project has a single borehole, the "Borehole Sections" window assumes the layers to be horizontal and extends them across the section width. The section width is the foundation width B plus max(0.5·B; 5 m) on each side.
- The section shows the foundation, the basement and a shortened superstructure (if "Show building schematically (basement + superstructure)" is on), Df and the foundation base level, the groundwater level and the effective depth ($\Delta\sigma = 0.1\cdot\sigma'_{v0}$).
- If the borehole has a plan coordinate and a foundation outline exists, the borehole is drawn at its real position in the section. The section line passes through the borehole, parallel to the short side of the foundation; the "Single borehole: section parallel to the long side of the foundation" tick switches it to the long side. A borehole inside the foundation lies within the foundation trace; a borehole outside it lies beside the foundation at its real distance.
- Without a coordinate or foundation outline, the borehole column is placed at the foundation edge and the position is schematic.
- The note "Single borehole — layers are assumed horizontal; the lateral variation of layer boundaries is unknown." is printed below the section, followed by whether the position is real ("Borehole at its REAL position (from the plan coordinate).") or schematic ("Borehole position is SCHEMATIC (no plan coordinate or foundation outline).").

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- In the report this section replaces the soil-section image; if the user has selected their own soil-section image, it is kept.

11.4 Selecting the report sections

The Report / Drawing › Geotechnical Report › Reporting › Geotechnical Report… command opens the window in which the report sections are listed as a tree; each heading is taken into or left out of the report by ticking it. The main headings (1–13) come ticked each time the window opens and can be unticked if required; sections 1.3, 10 and 11 are mandatory in the report. In addition, sections 1.1, 1.2, 4.1, 8.1, 8.2, 9.2, 9.3 and 9.4 always start ticked; a saved selection or missing data does not change this. The user can remove these sections; the program does not prevent it, but the pre-check before the report warns that a mandatory section is missing from the report. Sections 4.1, 8.1 and 8.2 enter the report without waiting for Calculate. Other sections whose calculation has not been done do not enter the report (Principle 1); they appear grey in the tree and the reason is shown when the pointer is held over them. An intermediate node all of whose items are unticked is also shown unticked. Note the following points when selecting sections:

- Seismicity (Chapter 8): 8.1 Assessment of the Local Site Class always starts ticked; its sub-analyses (8.1.1 SPT, 8.1.2 Vs30, 8.1.3 cu) are enabled only if the related data exist. In projects where the local site class is determined only from V_s data (no SPT analysis, for example rock), 8.1 and 8.1.2 also enter the report.
- AFAD data (8.2): for each of the DD-1, DD-2, DD-3 and DD-4 levels that is ticked, the S_S, S_1, PGA and PGV values are entered; the spectra of all ticked levels are drawn on the same graph (active level bold, the others dashed). The report writes all ticked levels. Section 8.2 starts ticked even if the AFAD data are incomplete and enters the report without waiting for Calculate.
- Liquefaction (8.3): in a project with SPT data the heading is selectable; the calculation appearing “out of date” after an input change does not disable the section. For the section to enter the report, the liquefaction calculation must have been run (Principle 1). 8.3.1 can be selected only for boreholes where liquefaction occurs, 8.3.2 and 8.3.3 when the related LPI and V_s calculations have been made.
- Chapter 10 (Excavation support – slope stability analyses) always enters the report and is ticked. Its content is fixed text; the Geotechnical Report does not pull data from the calculations of the downstream modules (Slope, Excavation Support).
- Bearing capacity on rock: the Hoek–Brown, uniaxial compression and point load methods enter the report with independent ticks; every method that has been calculated appears in the report.
- Site photographs are placed by default at the end of the related section; the end of the report can also be chosen. A photograph that cannot be placed is added at the end of the report and this is reported.
- A section you untick in the tree stays unticked after the project is saved. A section that had no data when the project was saved (e.g. 7.5 / 7.6 before SPT was entered) comes ticked automatically once its data is entered.

Report pre-check

When the command to build the report is given in the Report window, a pre-check runs before the report is written. The pre-check makes no calculation and adds nothing to the report; it only reads the existing inputs and results. If there are no findings, the report is produced directly. If there are findings, the “Geotechnical Report — report pre-check” window opens and lists them in a table with the section, the finding, the missing field, why it is needed and where it is entered. “Continue anyway” produces the report as it is; “Cancel” cancels report generation. The program does not block the decision and changes no value. The pre-check warns in the following cases:

- The difference between the SDS used in the calculations and the SDS of the selected AFAD level exceeds 5%.

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- SDS is still at its default (1.00) and no AFAD data are entered; or the earthquake magnitude Mw is still at its default (7.2).
- Ground improvement is required, but no improvement method has been selected in the Report window. This instruction is not printed in the report; the report states that improvement is required without naming a method.
- “Existing building” mode is on, but the selected template is the design template. AAGeoteknikProMevcutYapi must be selected for an existing-building report.
- Immediate settlement has been calculated with a borehole other than the report borehole.
- Bearing capacity, horizontal sliding or settlement has not been calculated, or the local site class has not been determined. Without a bearing capacity calculation the conclusion of the report says that no judgement could be made.
- A mandatory section has been removed from the selection, or the input of an analysis in the Modules menu has changed after Calculate (the old result enters the report).

When the inclined load or eccentricity box is off, that load counts as 0. This is not a deficiency; the pre-check gives no warning.

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12. Settings — What Changes the Result

The settings below change the result of the calculation. All of them are saved in the main project file and shown in the report; when two reports produced with different settings are compared, these tables are the place to look.

12.1 SPT settings

Table 25. SPT settings

Setting	Effect
C_E, C_S, C_B values	Energy, sampler and borehole diameter corrections; N_{60} and $N_{1,60}$ change directly
Full N_{60} correction	When off, $N_{60} = N \cdot C_E$; when on, $N_{60} = N \cdot C_E \cdot C_R \cdot C_S \cdot C_B$
$C_N = 1$ in clay-type soils	The overburden correction is not applied in clay-type cohesive layers; C_N is applied in ML and OL layers
Refusal blow count	Value used in the calculation at points where refusal is recorded
First SPT level and interval	SPT row sequence set up when a new borehole is opened

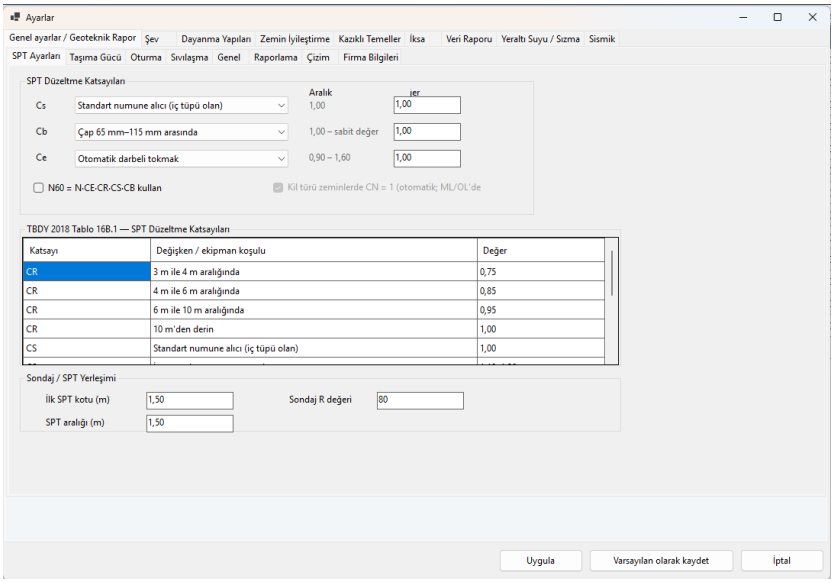


Figure 24. Settings window, SPT Settings tab: correction factors and borehole / SPT layout (Turkish interface shown)

12.2 Bearing capacity settings

Table 26. Bearing capacity settings

Setting	Effect
Correction method	Meyerhof, Hansen or Vesić; determines all of the shape, depth and inclination factors
$\phi = 0$: N_c	5.70 (Terzaghi) or 5.14 (Prandtl)
Adhesion ratio c_a/c_u	Base adhesion in the undrained equation
Hansen inclination exponents	i_q and i_γ factors under horizontal load
Vesić horizontal load direction	Whether the m exponent is calculated from the B or the L direction
Water depth effect	Transition of the unit weight with depth when the water level is below the base
Factor of safety	Conversion of the ultimate bearing capacity to the design value

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Setting	Effect
N_γ definition	TBDY equation (default) or the selected correction method's own N_γ equation (Meyerhof, Hansen, Vesić)
Sliding — passive K_p	When off (default) K_p = 1.00; when on, K_p is calculated with Rankine in the static case and with the TBDY 16C equation in the seismic case

12.3 Settlement settings

Table 27. Settlement settings

Setting	Effect
Stress spread method	Boussinesq or "2:1 stress distribution (2V:1H on each side, 63.5° from horizontal) → (B+z)×(L+z)"; affects the whole depth profile
Undrained immediate settlement calculation	Whether the Janbu–Bjerrum–Kjærnsli method comes into play
Rigid base ratio k	Compressible layer thickness H in immediate settlement: a layer with E ≥ k·Ē of the zone above is taken as a rigid base; the layer name (rock) does not cut H. Default 10 (Section 7.1)
Use of the elastic modulus	E_s directly or converted to the oedometric (constrained) modulus
Soil flexibility model	Layered Boussinesq or elastic half-space in the two-dimensional solution
Angular distortion class	1/250, 1/500, 1/850 or a user-defined limit
Settlement limits	Acceptance limits according to the foundation type

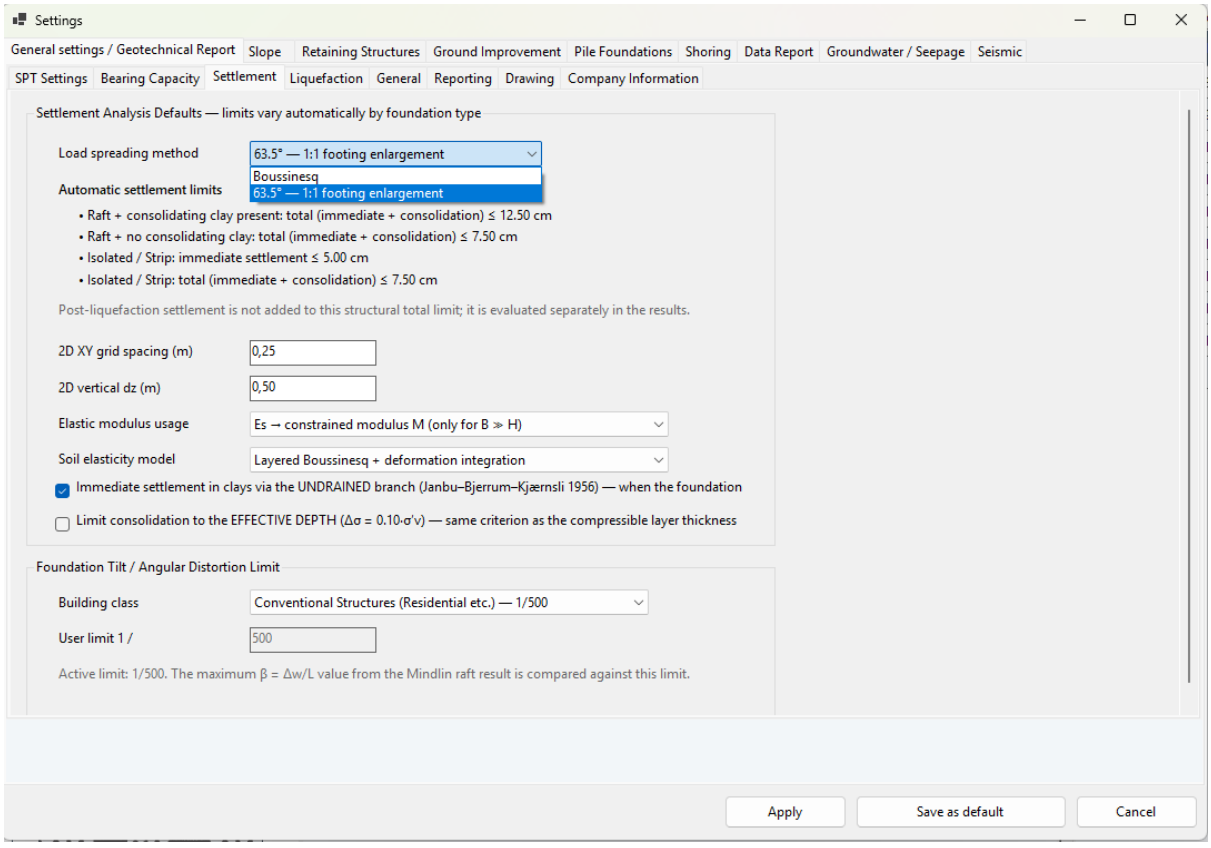


Figure 25. Settings window, Settlement tab: load spread method, settlement limits and angular distortion limit

12.4 Liquefaction and other settings

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Table 28. Liquefaction and other settings

Setting	Effect
Liquefaction method	TBDY / NCEER (Youd 2001), Boulanger and Idriss (2014) or TBDY $r_d = 1 - 0.015z$; the fines and overburden corrections depend on the method
Post-liquefaction settlement	Turning the Tokimatsu–Seed calculation on or off
Hydrostatic uplift defaults	Wall and slab thickness, basement storey load
Company information and letterhead	Report cover and header
Template selection	Which Word template is used
Image compression (Reporting tab)	Report images larger than 300 KB are converted to JPEG in the background (quality 85; 80 and then 75 if the result exceeds 1 MB). If necessary the resolution is reduced in 10% steps; the longest edge never goes below the “Longest-edge lower limit (px)” value (default 1600 px, range 800–4000 px). No compression is done at the moment of saving; images that were already compressed are not processed again.
Fines (IDI/FC) correction	Depends on the liquefaction method: α–β correction (TBDY / NCEER) or $\Delta N_{1,60}$ (Boulanger and Idriss)

12.5 Program language (Türkçe / English)

The program language is selected in the “Dil / Language” group on the General tab of the Settings window. The choice is a single setting for all modules: Geotechnical Report, Data Report, Slope Analysis, Excavation Support Structures, Retaining Structures, Ground Improvement, Pile Foundations, Seepage and Site-Specific Response Analyses use the same language. Besides Türkçe and English, the language group also offers Español and Русский. The program must be restarted for the change to take full effect in all modules.

When English is selected, all Word reports, Excel tables and DXF drawings are produced in English together with the screens; the decimal separator in numbers depends on the “Decimal separator” choice in the same group: “By language (EN point · TR/ES/RU comma)”, “Always point” or “Always comma”. Calculation results are independent of the language: the same project gives the same numbers in both languages. In number boxes either a comma or a point is accepted as the decimal separator in both languages.

Texts entered by the user (project name, soil descriptions, company information) are not translated. If the user has changed the Word template, the English equivalent of newly added text may not be in the dictionary; such text remains in Turkish in the report.

Below the language group on the General tab there is a “Design code” group. Design code: the code according to which the calculation is carried out is selected here and saved with the project. Only codes implemented in the program (Active) can be selected; the others appear grey with the note “Not available in this version.” The default for the Geotechnical Report is TBDY 2018; EN 1997-1 is not available in this version (grey). The choice is written in the report.

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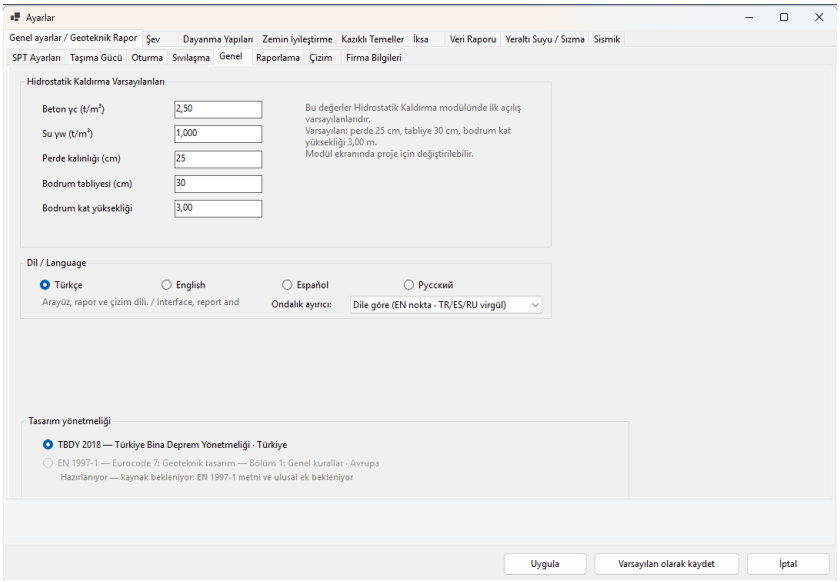


Figure 26. Settings window, General tab: “Dil / Language” selection (Turkish interface shown)

12.6 Structure of the Settings window

The Settings command in the top band opens a single Settings window. The first tab (“General settings / Geotechnical Report”) carries the settings described in this chapter; the tabs next to it hold the settings of the other modules (Slope, Retaining Structures, Ground Improvement, Pile Foundations, Excavation Support, Data Report, Groundwater / Seepage, Seismic). When the window opens, the tab of the module selected at that moment comes to the front; the module tabs are built the first time they are entered.

The Geotechnical Report settings are divided into these tabs: SPT Settings, Bearing Capacity, Settlement, Liquefaction, General, Reporting, Drawing and Company Information. The liquefaction method and the fines correction are not options to be changed frequently on the screen; they are selected once according to the code. For this reason the method is selected on the Settings › Liquefaction tab, not on the Liquefaction screen.

Common buttons sit at the bottom of the window: Apply, Save as default and Cancel. “Save as default” stores the settings on the selected tab to be used as starting values in new projects.

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13. Compliance with TBDY 2018

The table below compares the relevant clauses of the Code with the behaviour of the program. “Applied” means that the provision is taken into account by the program; “user declaration” means that whether the provision is satisfied depends on the user’s input.

Table 29. TBDY 2018 clauses and program behaviour

Clause / Topic	Program behaviour
Table 16.1 — Local site class	Applied. The three criteria are calculated separately and the most unfavourable class is selected
ZF conditions	Applied. The five conditions are checked one by one and the reason is written
Equation 16.8a — Bearing capacity	Applied. Multiplicative form; N factors from the TBDY set
16.8 — Factor of safety	Default 1.40; the user can change it and the change appears in the report
Appendix 16B — SPT corrections	Applied. C_N, C_R, C_S, C_B, C_E and fines correction
Appendix 16B — Liquefaction	Applied. The NCEER method is based on the Code
16.6.3 — Liquefaction exclusion criteria	Applied. Written in the table with reason codes
Horizontal sliding check	Applied. Two-stage, with base resistance and limited passive resistance
Seismic coefficients	k_h and k_v, derived from S_{DS} by program convention and written in the report

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14. Points to Watch in the Analysis

14.1 When entering data

- Groundwater being “absent” is not the same as it being “very deep”. The “No GWL” option is a declaration and changes the behaviour of all water-dependent calculations.
- Layer boundaries must not exceed the borehole depth. SPT rows exceeding the borehole depth are deleted by the program and this is reported.
- Entering an angle of internal friction as well in a layer for which undrained shear strength has been entered makes it unclear which branch will be used. The condition under which the soil is to be solved must be chosen deliberately.
- A parameter derived from a correlation does not take the place of a measured parameter. The report distinguishes the two; the reader should too.

14.2 When calculating bearing capacity

- The choice of correction method can change the result by a factor. The choice should be stated in the report together with its justification.
- When an eccentricity is entered the effective dimensions shrink; the bearing capacity decreases twice, through both the area and the factors.
- When the undrained equation is used, remember that the result differs from the TBDY 16.8a form.
- On rock, the results of the four methods may differ. Taking the smallest is not always right; decide which method represents the rock mass on site.

14.3 When calculating settlement

- The stress spread method (Boussinesq or 2:1 stress distribution, 63.5°) produces a marked difference in deep layers. The two methods must not be mixed in the same project.
- Consolidation settlement is calculated only in layers with defined consolidation parameters. A layer without parameters does not give zero settlement; it does not enter the calculation at all, and this is visible in the table.
- When no preconsolidation pressure is entered, the soil is assumed to be normally consolidated; for an overconsolidated soil this overstates the settlement.
- In the two-dimensional solution the angular distortion may be more decisive than the total settlement. Even if the total settlement stays below the limit, differential settlement can strain the structure.

14.4 When assessing liquefaction

- The two methods may give different factors of safety on the same site. The method used must be stated clearly in the report.
- The moment magnitude M_w affects the result directly. A value appropriate to the site must be chosen.
- Post-liquefaction settlement is not added to static settlement. They are separate phenomena and are assessed separately.
- Liquefaction risk within the upper 20 m moves the local site class to ZF; this also means that the design spectrum changes.

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- The liquefaction method and the fines correction are selected once in Settings, according to the relevant code. When the method is changed, the liquefaction risk section cache is treated as invalid; the calculations must be refreshed with the update command.

14.5 Before generating the report

- If an input has been changed, the calculations must be refreshed. The status bar reports this.
- A section that has not been calculated does not enter the report; a section that is empty in the report means that the calculation was not run.
- If you edit the program’s default template under the same name, that copy is not used. Save your edits under a different name and select it in the Report window.
- If the pre-check window opens when the report is built, read the findings; “Continue anyway” produces the report as it is (Section 11.4).

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15. Verification

This chapter collects the comparisons of the Geotechnical Report module's calculations with hand calculations and published table values. The calculations in this module have been checked against independent verification examples and hand calculations.

15.1 Comparison with hand calculations and published values

In the table below each example is compared with an independent hand calculation or a published value. The values in the "Program" column are the values found equal to the reference within the tolerance given in the last column.

Table 30. Comparison with hand calculations and published values

Example	Reference	Program	Difference / status
N_γ, $\phi = 30°$, Meyerhof	Bowles (1996), Table 4-1: 15.67	15.67	Difference below 0.01% (tolerance ±0.02)
N_γ, $\phi = 30°$, Hansen	Bowles (1996), Table 4-1: 15.07	15.07	Difference below 0.01% (tolerance ±0.02)
N_γ, $\phi = 30°$, Vesić	Bowles (1996), Table 4-1: 22.40	22.40	Difference below 0.01% (tolerance ±0.02)
Terzaghi U(t): H = 4 m, double drainage, $T_v = 0.197$	U = 0.50; s(t) = 5.0 cm (s_∞ = 10 cm)	Equal to reference	Consistent (tolerance ±0.005 for U; ±0.05 cm for s)
Terzaghi U(t): $T_v = 0.848$	U = 0.90; s(t) = 9.0 cm	Equal to reference	Consistent (tolerance ±0.005; ±0.05 cm)
Single drainage (H_{dr} = H)	T_v falls to a quarter; the same U when the time is quadrupled	Equal to reference	Consistent (tolerance ±0.0005)
K_σ, σ'_v = 200 kPa, relative density unknown (f = 0.6)	Hand calculation: $2^{-0.4} = 0.757858$	0.757858	Consistent (tolerance $1 \cdot 10^{-9}$)
Sliding: passive K_p, static, $\phi = 30°$	$\tan^2(60°) = 3.000$	3.000	Consistent
Sliding: passive K_p, TBDY 2018 16.25, $\theta = 10°$	Independent hand calculation: 2.6761	2.6761	Consistent

The passive pressure equation used in the sliding check (TBDY 2018 16.25) is the same Code equation as in the Retaining Structures module. Its counterpart in the Retaining Structures module has been compared with the TBDY 2018 worked example (Appendix 16A) and with an example from a commercial software package; details are in the verification chapter of the Retaining Structures guide.

For bearing capacity on rock, the Hoek–Brown parameters (mb, s, a, ϕ', c') have been checked against an independent hand calculation with the Hoek, Carranza-Torres and Corkum (2002) equations. The Boulanger and Idriss (2014) CRR, rd, MSF and Kσ equations, the NCEER (Youd et al., 2001) CRR and Liao–Whitman rd equations, and the Burland–Burbidge and Ménard equations have been compared line by line with the published equations. The EN 1997-1 Annex G rock chart, the Ménard pressuremeter settlement, the Tokimatsu–Seed volumetric strain curves and the two-dimensional raft solution have not yet been compared with an independent source; use these results with caution and read them together with the limitations in Chapter 16.

16. Known Limitations and Out-of-Scope Topics

This chapter collects the scope of the program and the topics it solves approximately; it is a statement of scope, not a statement of shortcomings.

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Table 31. Out-of-scope and limited topics

Topic	Status
Shear wave velocity correlation	V_s is taken only from the measured or manually entered profile; no SPT–V_s correlation is used
Eurocode 7 Annex G rock chart	Digitised interpolation layer; no result is produced outside the chart range
Tokimatsu–Seed chart	Digitised interpolation layer
Janbu–Bjerrum–Kjærnsli charts	Interpolated on a logarithmic axis; outside the range the value is clipped and reported
Secondary compression (creep)	Not included in the time-dependent settlement calculation
Three-dimensional stress–strain analysis	Out of scope. The two-dimensional raft solution is a plate–soil interaction solution
Eurocode 7 design approaches	The design route with partial material factors is not applied in this module
Probabilistic / reliability-based assessment	Out of scope
Deep foundation, excavation support, slope and ground improvement design	Subject of separate modules

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