GeoteknikPro

STUDIO — PILE FOUNDATIONS

USER GUIDE

and Calculation Methods Document

Bored · CFA · Micropile · Driven precast · Driven steel pipe · Piled raft
Axial compression and uplift capacity · p-y lateral analysis · Kinematic interaction · Raft slab solution · Reinforced concrete

In accordance with TBDY 2018 Chapter 16 and Appendix 16C and TS 500

Version 3.0.1

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Symbols and Units

The module works in SI units: metres, kN, kPa. Unless stated otherwise, the analysis is carried out either for a single pile or for the pile group as a whole, and every number carries the combination it comes from.

Table 1. Symbols used in the guide

Symbol	Description	Unit
D	Pile diameter	m · cm
L	Pile length	m
s	Centre-to-centre spacing of the piles	m
Q_{ks}, Q_{ku}	Characteristic shaft and base resistance	kN
Q_{tv}	Design axial bearing capacity	kN
γ_{Rs}, γ_{Ru}	Resistance factors for shaft and base	—
Q_n	Drag load due to negative skin friction	kN
f_s, q_u	Unit shaft friction and unit base resistance	kPa
α, β, K, δ	Undrained and drained shaft coefficients	—
N_q	Base bearing capacity factor	—
c_u	Undrained shear strength	kPa
ϕ', σ'_v	Effective friction angle and effective vertical stress	° · kPa
σ_c	Uniaxial compressive strength of rock	MPa
RQD	Rock quality designation	%
p, y	Lateral soil reaction and lateral displacement	kN/m · m
p_u, y_{50}	Ultimate lateral reaction and half-mobilisation displacement	kN/m · m
ε_{50}	Strain at half the peak strength in the laboratory	—
EI	Flexural stiffness of the pile section	kNm^2
M(z), V(z)	Moment and shear along depth	kNm · kN
$u_{ff}(z)$	Free-field displacement envelope	m
β_G	Group reduction factor for the kinematic effect	—
R	Factor by which the kinematic moments are divided	—
K_v, $K_{\theta\theta}$	Vertical spring and rotational spring at the pile head	kN/m · kNm/rad
k	Subgrade modulus beneath the raft	kN/m^3
G_p	Pasternak shear layer coefficient	kN/m
β	Angular distortion, Δs/L	—
M_r, V_r	Moment and shear resistance of the section	kNm · kN
ρ, ρ_s	Volumetric ratio of longitudinal reinforcement and of confining reinforcement	—
S_{DS}	Short-period design spectral acceleration coefficient	—

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1. Introduction

1.1 What the module does

The Pile Foundations module carries out the geotechnical and reinforced concrete design of a piled foundation from end to end: the soil profile and the pile section are defined, the foundation area is set up in plan, the piles are placed, and the loads from the superstructure are entered or read from the output of the structural analysis program; the program performs about twenty-four analyses and collects the results in a single design envelope.

Topics covered: axial compression and uplift capacity, negative skin friction and the neutral plane, single-pile and group settlement, load–settlement behaviour from load transfer curves, p-y based lateral analysis and Broms capacity, TBDY Appendix 16C Method III kinematic interaction, combination of kinematic and inertial effects, slab solution of the piled raft, reinforced concrete pile section and reinforcement selection, pile–raft connection, tie beam, quantity takeoff and cost.

1.2 Three basic rules

A number that has not been calculated is never written

Three rules apply throughout the module. A section that has not been calculated does not enter the report, and no number is invented for an empty field; every field that cannot be filled is given its reason. No sheet with empty axes is produced, because an empty chart gives the impression that a calculation was made. Every number is written together with its source and the decision that produced it.

These rules have concrete consequences. If the free-field displacement envelope has not been entered, the kinematic calculation does not start and no assumed profile is generated. A pile type for which no calculation is available is not calculated even though it appears in the list, and it is not calculated as some other type without notifying the user. If the lateral solver does not converge, it returns no result.

1.3 Scope

- Superstructure analysis is outside this module; column loads are taken as input or read from the output of the structural analysis program.
- Soil–structure interaction is represented not by finite elements but by p-y and t-z springs, and beneath the raft by a subgrade model.
- The program performs the design; whether construction conforms to the design is a matter for site supervision.
- Barrette and Franki piles appear in the list; since there is no axial capacity calculation for these types, the calculation is not started.

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2. Screen, Workflow Strip and Scenarios

2.1 Tabs

Table 2. Main tabs

Tab	Contents
1-2-3 · Soil · Plan · Section	Four inner pages: soil profile, foundation area, pile layout and view. The plan canvas on the left, the typical section beside it.
4 · Loads	Entering column loads by hand or reading them from Excel and DXF; building the combination envelope.
5 · Raft	Raft slab, soil spring, openings and slab solution.
6 · Analysis · Charts · Springs	About twenty-four analyses, design situation, load source and head condition choices.
7 · Results · Visuals · 3D	Multi-pile solution, diagrams, raft maps and the colour-coded three-dimensional view.
8 · Reinforced Concrete · Reinforcement	The tab where the reinforcement is defined: reading the demand, selecting or checking the reinforcement and writing it to the project. Reinforcement that is defined on screen and fits in the section is written to the project automatically before a sheet or report is produced.

The Pile Foundations module data are saved and opened together with the main project file (*.geos); there is no separate save or open command inside the module. The module menu contains the “New Project (this module only)” command, which resets this module’s data and starts it afresh; it does not touch the other modules of the main project. The Edit commands (Undo / Redo) and “Design wizard…” (see 3.4) are in the Pile Foundations menu, report and drawing commands in the main program’s Report / Drawing menu, and the settings are Pile Foundations tabs in the main program’s single Settings window.

2.2 Workflow strip

A seven-step workflow strip sits above the tabs. Completed steps are ticked, the next one is highlighted, and clicking a step takes you to the corresponding screen. Whether a step is complete is determined from the calculation status. The prompt line below the strip states the next task in one sentence.

In the embedded version a red “↓ Pull Data from GeoteknikRapor” button sits on the right of the workflow strip. It takes the layers, the groundwater level, the foundation area, the liquefaction and negative skin friction flags and the Method III envelopes from the main project; it writes them over the existing data in the model and shows what was transferred in a table. If any data have been corrected by hand, keep this in mind before pressing the button.

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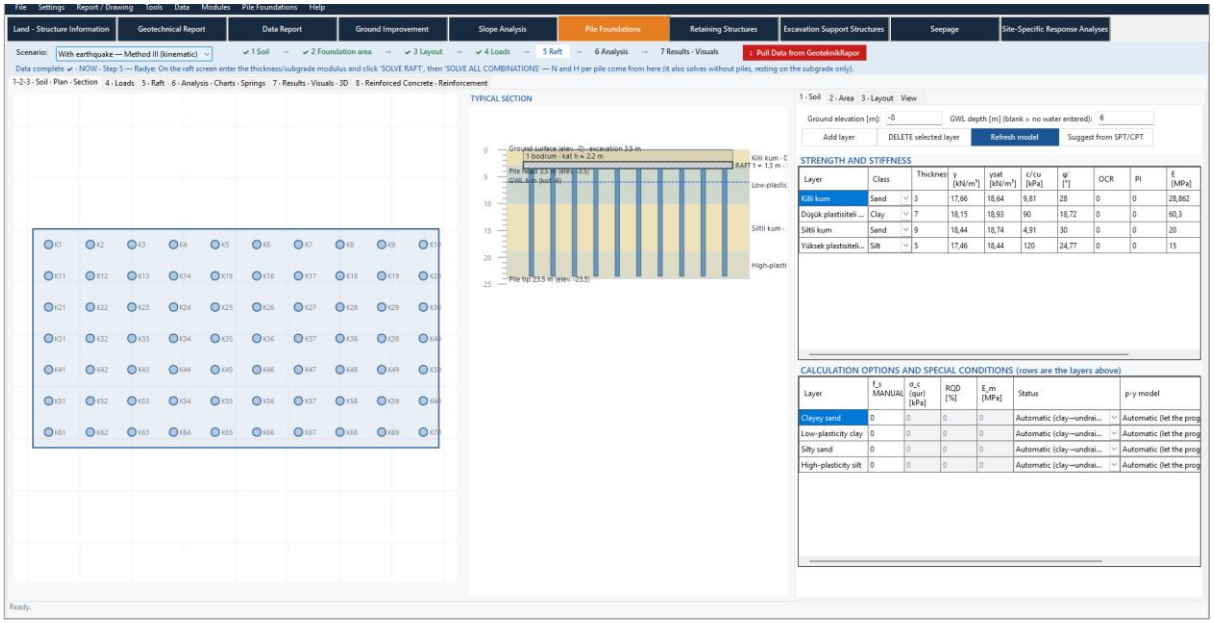


Figure 1. Pile Foundations screen: scenario selector, workflow strip and the 1-2-3 Soil page

2.3 Choosing a scenario

The scenario selector on the left of the strip changes the content and the order of the analysis list. There are three scenarios: conventional (static) design; seismic design with the Method III kinematic envelope; and seismic design with an estimate from a closed-form relation when no envelope is available. The third scenario is not a convenience but a declaration: it means accepting that without an envelope the kinematic moment can only be estimated as an order of magnitude.

If the “Full” scope is applied in the design wizard (see 3.4), the scenario is switched to seismic: Method III if a free-field envelope exists, otherwise the estimate. With the other scopes the scenario becomes conventional.

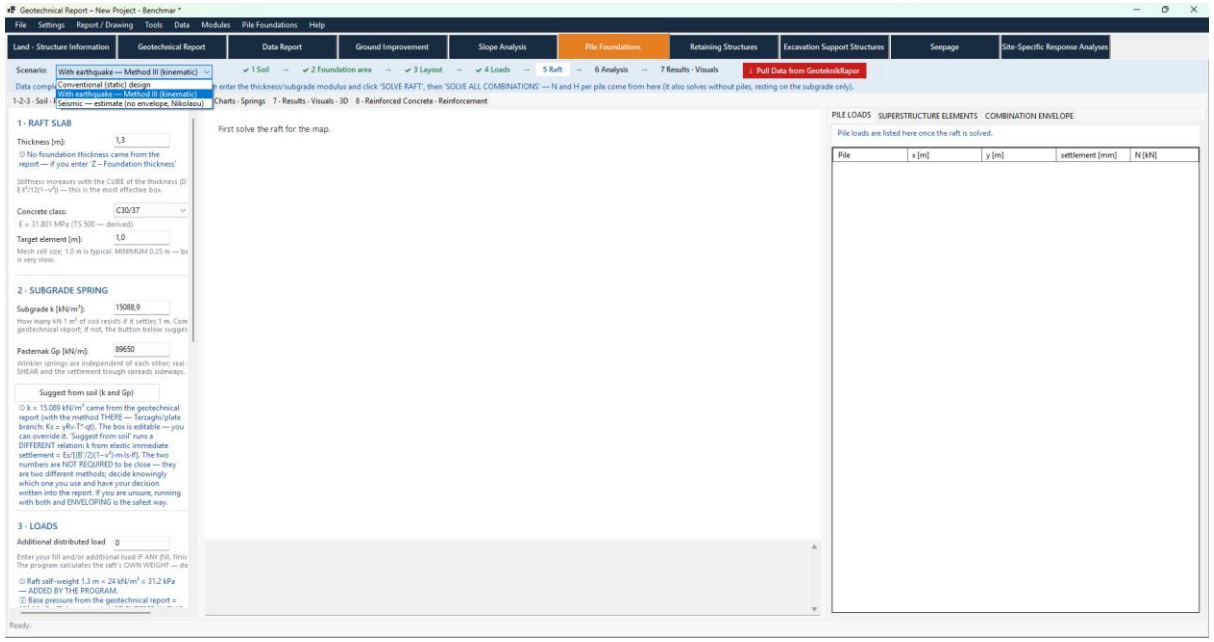


Figure 2. Scenario selector: conventional (static) design, seismic — Method III (kinematic) and seismic — estimate (no envelope, Nikolaou)

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3. Ways of Building the Model

3.1 Soil profile

Layers are defined in a table: thickness, soil type, unit weights, strength parameters, modulus of elasticity and the p-y curve family to be used in the lateral analysis. For rock, the uniaxial compressive strength and the rock quality designation are also entered.

Correlation does not change the model, it fills the gaps

The command that proposes parameters from field test data fills only the cells left empty; it does not overwrite a value that has been entered. Every proposed number carries the relation and the band it came from. No correlation is applied in rock — the strength and quality designation route is used for rock.

3.2 Foundation area — four ways

The foundation area is set up in four ways, and all four arrive at the same polygon.

Table 3. The four ways of defining the foundation area

Way	How it works
DXF underlay	The file is loaded, the foundation outline is selected in line-selection mode and the area is built from the selection. The underlay does not decide; the area is built from the selection. If the unit is doubtful you are asked; no correction is made without asking. If the file contains a single closed polygon it is proposed, not built automatically. If the drawing has a GP_SLAB layer (see 5.3), the foundation area proposal comes only from that layer. The reader also reads circles, arcs and aligned texts.
Rectangular and circular template	For a rectangle, the width and length are entered and the area is built. For a circular or annular foundation (tank, chimney), the “Build circular / ring” command is used: the centre, outer diameter and inner diameter are entered; if the inner diameter is greater than zero, there is no slab and no pile in the inner void.
Free drawing	The foundation is drawn by hand; self-intersection is checked before closing.
Edge editing	In the edges table, length, setback, overhang, adjoining-building and zero-to-road data are entered for each edge and applied to the model.

The setback distance is applied to the outer face of the pile, not to its centre; giving an overhang to an edge marked as adjoining produces a warning.

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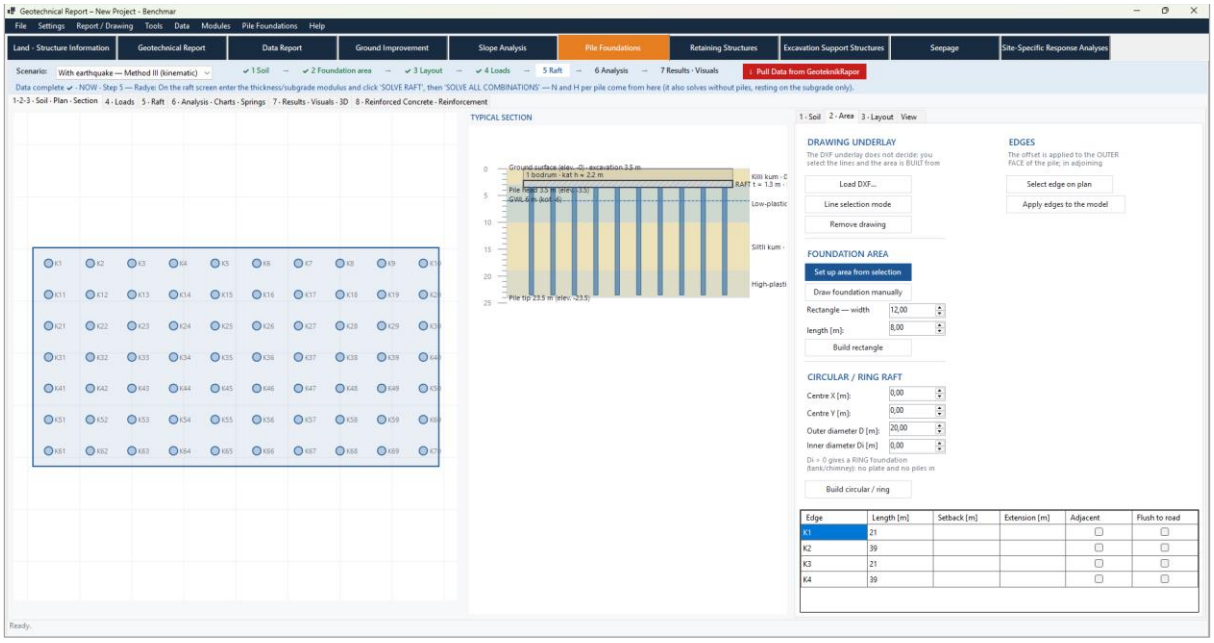


Figure 3. Area page: drawing underlay, foundation area and edges

3.3 Pile layout

The layout is generated from a rule: type (square grid, triangular or ring), spacings, angle, minimum clear spacing and pattern anchor. The anchor ties the pattern to the world origin or to a corner or the centre of the foundation; in this way the user decides where the leftover strip falls.

For the ring type the layout is defined by a table: for each ring the ring diameter and pile spacing are entered, the number of piles is found automatically (if a number is entered, the spacing is calculated) and the ring length is shown for information. Rows are managed with the “+ Add ring” and “− Delete selected ring” buttons, and the total number of piles in the rings appears below the table. Numbering runs from outside to inside; if desired a pile is placed at the centre and the angle of the first pile is adjusted.

The layout wizard (not to be confused with the design wizard in 3.4) scans the spacing pairs that fit the boundary exactly: from the given total vertical load and the single-pile capacity it works out the required number of piles, evaluates each candidate arrangement and presents a list. If the MODE B combination table has been loaded, the load field is filled automatically from the most unfavourable combination, the raft self-weight and, for a double foundation, the upper foundation weight W. If no capacity has been entered, the wizard looks only at geometry and says so.

The clash check decides in one move

Every edit is applied in one move: if the clear spacing would be violated, no pile moves, and the program states which two piles would clash and how much overlap or clearance would remain. In layout generation, however, if the spacing ratio falls below the recommended lower limit, generation continues and a bold warning is raised, because this is not an error but an engineering decision.

Manual editing tools: single-pile insertion mode, select all, delete, drag with the mouse, step-by-step moves with the arrow keys, moving by a given offset and placing a single pile at a given coordinate. Undo and redo cover all these operations.

Pile numbers start at one; on the sheets the piles are named FK-01, FK-02 … and the prefix is changed with the “Pile name prefix” box on the Drawing settings tab in Settings. In addition, row numbers with respect to the earthquake direction are extracted from the plan: the pile centres are projected onto the direction and a new

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row starts when the successive difference exceeds the clustering tolerance. These rows are the source of the group reduction factor and the lateral row multiplier.

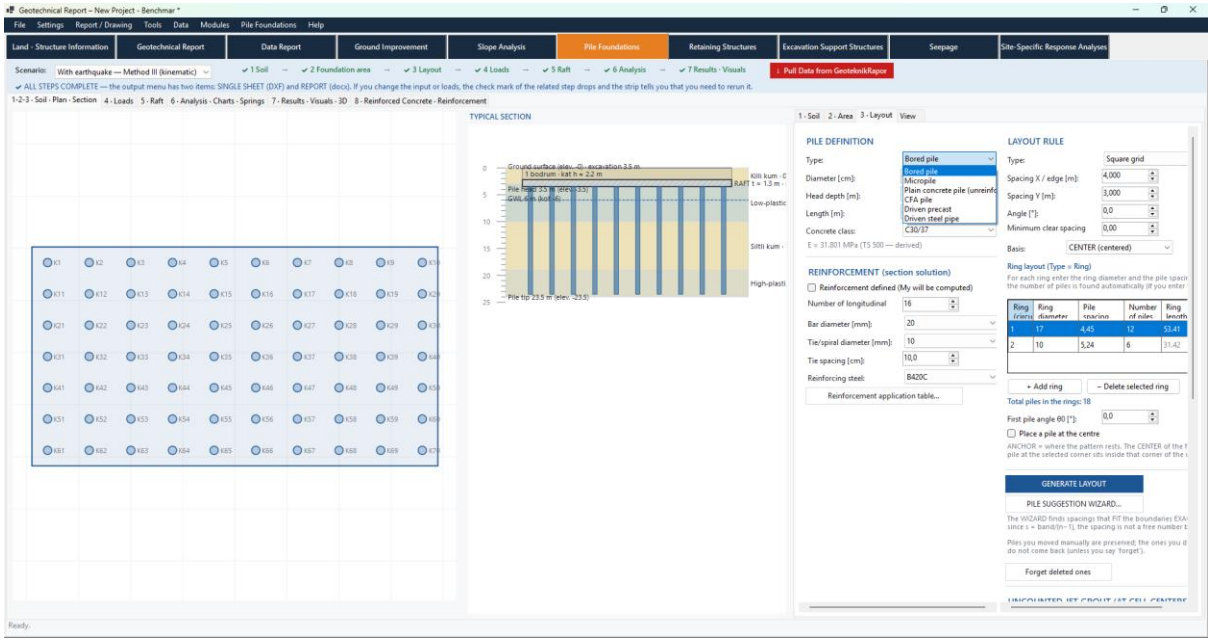


Figure 4. Layout page: pile definition, reinforcement and layout rule

3.4 Design wizard

The design wizard is a tool separate from the layout wizard in 3.3. The layout wizard only scans spacing pairs for a defined pile; the design wizard proposes the pile type, diameter, length and layout together. It is opened with the "✦ Design wizard" button on the left of the workflow strip or with the "Design wizard…" command in the module menu.

The wizard does not replace the tabs. It runs the existing calculation methods in order and writes the chosen result to the tabs. Everything can then be edited by hand.

- **0 · What do I have?** Lists the foundation area, soil profile, GWL, loads, column/wall positions and seismic data.
    - A missing mandatory item is red; a missing optional item is amber.
    - The program does not stop you. Without area, soil and load, however, no pile count can be derived; the notes say why.
- **1 · Pile type and construction:**
    - Several types can be selected: bored, CFA, plain, driven precast, driven steel pipe, micro.
    - Enter the candidate diameters, the length range and the length step.
    - Rig limits: largest diameter and length.
    - Minimum s/D (default 3) and extra edge distance.
    - A diameter outside the type's practical band is not tried for that type. Length is limited by the depth of the soil profile.
    - **Rock socket:** minimum embedment of the toe into rock (0 = free). Shorter lengths are not tried.
    - **Row under walls:** a pile row is placed along the wall axis. Grid piles closer than the minimum spacing are removed. No row is placed under L/U walls; a note says so.

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  - **Openings** (lift pit, shaft …): one x1; y1; x2; y2 per line. No piles are placed inside them.
- **2 · Scope and objective:**
  - **Static** (common practice): seismic combinations are not checked. The report gets a "seismic effects are outside the scope" paragraph (see 12.3). A single warning is shown on apply.
  - **Static + simple seismic** (default): the program's seismic combinations are checked as well.
  - **Full:** the scenario is switched to seismic (see 2.3); kinematic effects are run on the Analysis tab.
  - Objective: least total length (default), fewest piles, shortest length, balanced, or least concrete.
  - Enter the allowed settlement (default 50 mm) and the maximum utilisation.
  - **Self weight as G** ("Add raft / upper foundation self weight as G"): raft and upper foundation weight enter every combination with that combination's G factor (see 5.4).
  - **Group / block capacity check** (TBDY 16.9.3.3).
  - **Lateral (p-y) check:** the suggestions are solved with the pile-head H_max; the allowed lateral displacement defaults to 25 mm.
- **3 · Results:** "Calculate" tries every type × diameter × length candidate:
  - single-pile capacity
  - fully fitting grid patterns
  - rigid-cap distribution of every combination
  - most loaded pile compared with the capacity
  - settlement with an equivalent raft
- The pattern with the fewest piles that satisfies capacity is the candidate's result. The best three suggestions are marked ★ in green; failing candidates are listed in grey with the reason. The results table shows the candidate's pile pattern in the Pattern column; it also has the Group [kN] and y_o [mm] columns.
- **Apply selected:** the pile type, diameter, length, layout rule and piles are written to the project. If a plan already exists, the wizard asks first. "Edit › Undo" reverts the change. The wizard answers are saved with the project and come back when it is reopened. After applying, "Run calculations and produce outputs" is offered (see 12.5).

The wizard is a preliminary sizing

Group efficiency, lateral load (p-y), reinforced concrete and kinematic checks are done on the Raft, Analysis and Reinforced concrete tabs; follow the workflow strip.

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4. Pile Types and Section

4.1 Pile types

Table 4. Pile types and calculation coverage

Type	Behaviour
Bored pile (reinforced, connected to the foundation)	Full calculation: axial, uplift, lateral, reinforced concrete section.
CFA (continuous flight auger)	Same branches as bored; shaft coefficients are separate for each type.
Micropile	Capacity is from the shaft only, the base is neglected; the shaft is the soil–grout bond. A buckling check is also made.
Plastic pile (unreinforced bored)	Not connected to the foundation and takes no tension; no uplift calculation is started for this type.
Driven — precast concrete	Separate shaft coefficients for driving; the installation effect is reflected through the ratio K/K_0.
Driven — steel pipe	Section properties are derived from the wall thickness; the pipe can be filled with concrete.
Barrette and Franki	There is no axial capacity calculation. They appear in the list, but when selected the calculation is not started and the reason is written.

4.2 Geometry and materials

Pile definition: diameter, head depth (the top level lies this far below ground level), length and concrete class. The modulus of elasticity of the concrete and the section moment of inertia are not entered; they are derived from the concrete class and the diameter, and the E value is shown read-only on screen.

When steel pipe is selected, a separate box opens and the reinforcement section is hidden: the steel grade (the two common designations are written together), yield strength and wall thickness are entered; the moment of inertia is calculated from the hollow circle. If the pipe is to be filled with concrete, the core is added through the modular ratio and the tension of the concrete is not counted.

If the wall thickness is not entered, the section is taken as solid

If the wall thickness is left empty, the program takes the section as a solid circle and writes that, for a pipe section, this means a stiffness far above the real one. Since the shape of H-sections or composite sections cannot be defined, the stiffness of such sections remains approximate.

4.3 Reinforcement

The number and diameter of the longitudinal bars, the diameter and pitch of the spiral and the reinforcing steel grade are entered. The bars are distributed at equal spacing on a circle in the section. The reinforcement area, ratio and how many bars of that diameter fit in the section are shown live on screen; the minimum ratio required by the code for the confinement zone is written alongside, according to the seismic design class.

If a single ring does not resist the moment, a second (inner) ring is added at the pile head. The reinforcement proposal command fills the outer ring with the maximum number of bars that fit in the section and adds the inner ring if necessary; the length of the inner ring is calculated from the moment profile of the lateral analysis (the deepest point at which the capacity of a single ring is exceeded + 40Φ, at least 2D). The double ring enters the P–M solution, the cross-section drawing and the quantity takeoff (bar marks 1b and 2b). If three rings are needed, no design is made and a “does not fit” warning is given.

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The concrete cover is not here but on the Reinforcement detail tab in Settings; it is entered in one place only. The moment resistance is not entered: if reinforcement is defined, it is calculated from the section solution as a function of the axial load.

4.4 Raft and pile cap

The pile cap is not a separate member; the raft slab acts as the cap. The raft thickness, concrete class and target element size are entered; the raft self-weight is added by the program and enters every combination with that combination's G factor (see 5.4). Lift and stair openings can be defined as holes.

The pile–cap connection and the tie beam between caps are separate analysis branches; the raft's own flexural reinforcement is not a subject of this module.

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5. Loads and Combinations

5.1 Where the loads come from — two ways

Table 5. The two ways of entering loads

Way	How it works
1 · I WILL ENTER MANUALLY	Dead, live and earthquake cases in two directions are entered in a table. The program builds the combinations — signs, combination of directions and vertical earthquake; the user supplies the cases, not the combinations.
2 · I WILL UPLOAD EXCEL (and DXF if needed)	The output of the structural analysis program is read. The program recognises the table layout itself: case by case, a ready-made combination table, or a single load case. When the drawing is read without layer mapping, the DXF is for location only; in a plan in GP format or with mapped layers, the footprints of columns and walls are also read from the drawing (see 5.3). If the Excel file has a coordinate column, no DXF is needed.

The reader matches the column names with the locations in the plan. If the force unit cannot be recognised, the default is assumed and this is stated explicitly. In a ready-made combination table the envelope rows are separated and do not enter the calculation — an envelope row is not a load case, and treating it as a combination would be double counting.

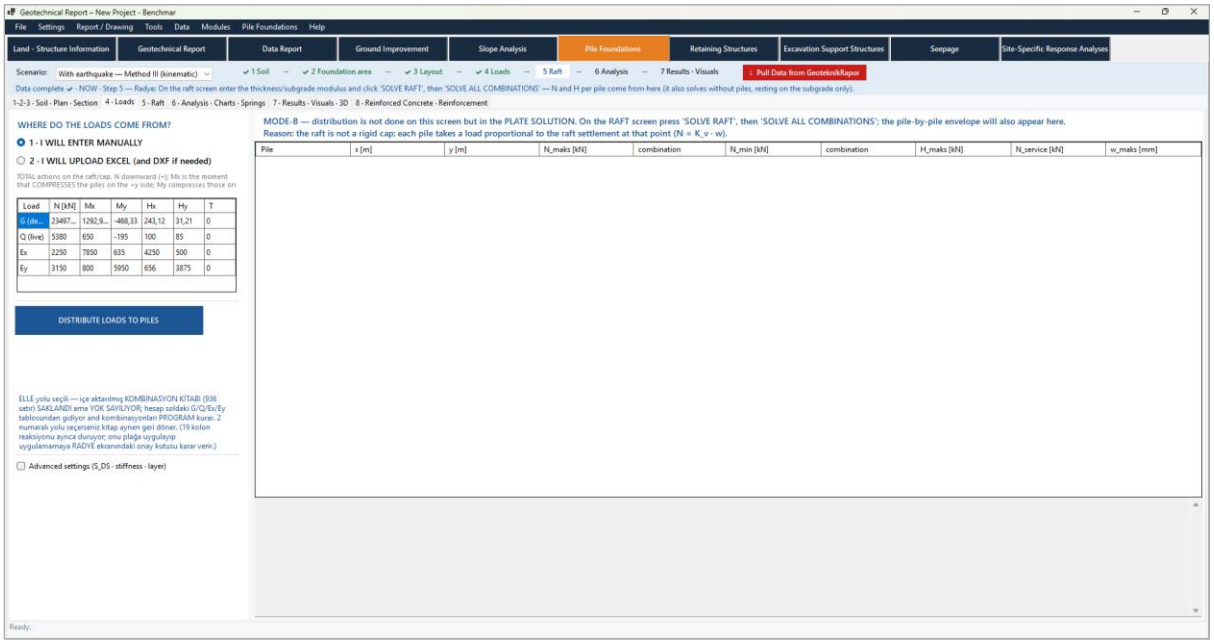


Figure 5. 4 · Loads tab, manual entry: G, Q, Ex and Ey cases and distribution of the loads to the piles

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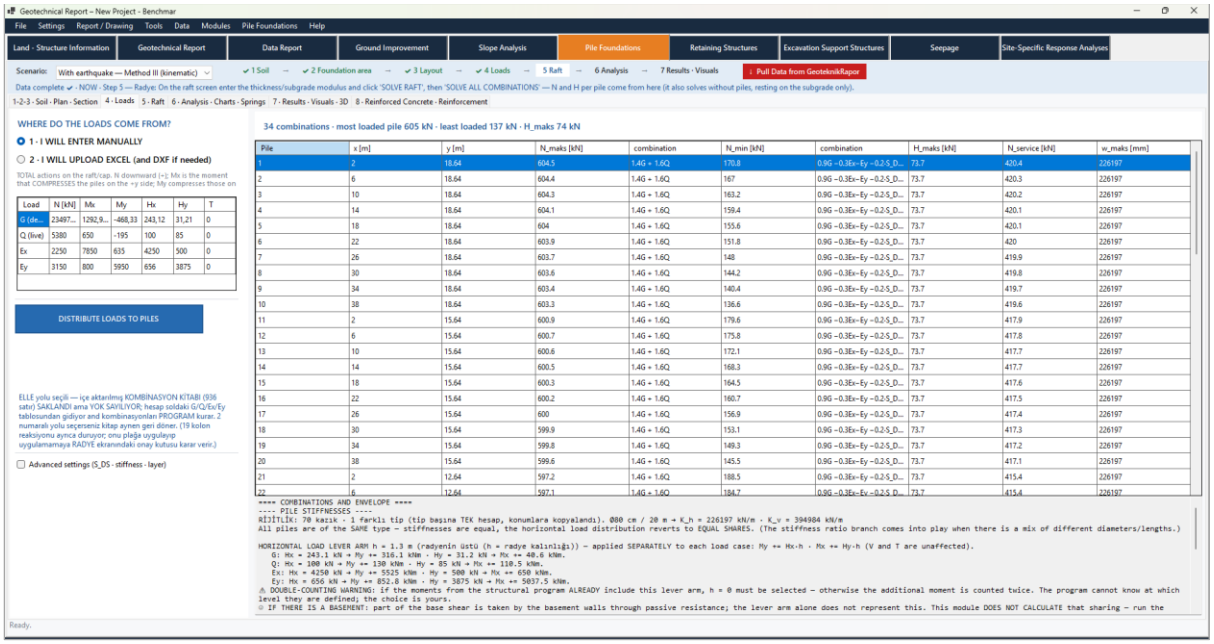


Figure 6. 4 · Loads tab: reading the loads from Excel and DXF

5.2 Combinations

The non-seismic vertical combination and the seismic combinations are built on code principles. On the seismic side, the combination of the two directions and the vertical earthquake are expanded with all sign options; the resulting number of combinations exceeds thirty. The settlement calculation is made separately with the service load — settlement is a serviceability matter.

Every combination passes through the rigid cap distribution: the vertical load and the moments are transferred to the centroid of the pile group and distributed to the piles. If the piles differ in diameter or length, the general rigid cap equilibrium is set up. For each pile the maximum compression, the minimum compression (which may be tension) and the maximum horizontal force are kept as an envelope, and every value carries the combination it comes from.

The lever arm for converting the horizontal load into moment is the raft thickness; this is a rule and is not offered as a choice. In the vertical combination, torsion is set to zero as statics requires; a threshold is defined for the numerical residual, and torsion above the threshold is not discarded without notifying the user.

5.3 DXF plan: GP format and layer mapping

The DXF plan from which the column and wall positions are taken is read in one of two ways.

- When a DXF plan is selected, a drawing in **GP format** is read exactly, without questions. The GP format is a drawing rule with fixed layer names:
    - **GP_SLAB:** raft outline (closed polyline); inner closed lines are openings.
    - **GP_COLUMN:** column (closed polyline or circle).
    - **GP_WALL:** wall (closed polyline); L/U and rotated walls allowed.
    - **GP_LABEL:** the element name written inside it (S12, P3 …); Excel loads match by this name.
    - **GP_PILE:** pile circle (optional).
- Users move the lines of their own plan to these layers. Other layers are ignored. The empty template is obtained with “Map layers… → Save empty GP template…”.

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- If the drawing is not in GP format, the **layer mapping window** (“DXF layer mapping”) opens after the file is selected with “Browse…”, or with the “Map layers…” button:
    - Each layer is given a role: Raft, Column, Wall, Label (name text), Pile or Ignore.
    - “Recognise and preview” shows the result in colour; “Use this mapping” applies the mapping.
    - In the diagnostics the raft line gives the area and the number of vertices (“RAFT: … m² (… vertices …)”; openings are deducted). If no closed shape has the Raft role, it reads “RAFT: no closed shape with the Raft role — the raft outline was not taken from this drawing.”
    - Issues are listed: unclosed chains, unnamed elements, duplicate names. Clicking an issue zooms to it.
    - The mapping is saved; layers with the same name are mapped automatically in later drawings.
    - “Save DXF in GP format…” converts the plan to the GP rule; that file then opens without questions.
    - “Continue without mapping” reads the drawing by guessing from the layer names.
- Rotated and L/U walls are accepted; the wall load is distributed inside the real footprint. Circular columns are recognised. The reader also reads circles, arcs and aligned texts in the DXF.

5.4 Raft and upper foundation self weight = G

The program adds the raft self weight and, for a double foundation, the upper foundation weight W. W enters every combination with that combination’s **G factor**, read from its name:

- 1.4G+1.6Q → 1.4
- G+Q±E → 1.0
- 0.9G±E → 0.9

A combination without a G term uses 1.0, with a note. In the single raft solution the G factor of the combination selected in MODE B is applied; with case-by-case manual input the plate is solved for a single load and the factor is 1.0. In the design wizard this rule is a separate option (see 3.4).

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6. Axial Analysis

6.1 Axial bearing capacity

The design bearing capacity is obtained by dividing the shaft and base resistances separately by their own resistance factors; the factors depend on whether a load test has been performed and come from the code table. If a regional reduction has been specified, its cap is also applied.

Table 6. Sources of shaft and base resistance

Soil / condition	Method
Clay, undrained	Adhesion factor method. The source of the factor can be chosen: automatic (one source for driven piles, another for bored/CFA), an explicitly chosen source, or a simple linear relation. The base resistance is the classic nine-times relation.
Sand, drained	Effective stress method: the product of the horizontal stress coefficient and the interface friction angle. Their ratios differ by pile type and can be changed in the settings — the installation effect is not the same for bored, precast and steel piles.
Base bearing factor	Three options are offered; the default is the chart-based source, which also accounts for the pile length-to-diameter ratio. Values outside the chart range are clipped and reported.
Micropile	Capacity is from the shaft only; the shaft is the soil–grout bond, and the middle of a band published by soil type is proposed. If the proposal is used, a note is added.
Rock socket	Shaft and base come from relations based on the uniaxial compressive strength of the rock; the strength is limited to the lesser of rock and concrete. A reduction based on the rock quality designation is applied; if the designation has not been entered, no reduction is made and this is stated. If the socket is short, a separate reduction is applied to the base resistance.

Shaft and base caps

Cap values are applied to the unit shaft friction and the unit base resistance. The default is a published table defined by friction angle bands; since the table's own logic is stepwise, no interpolation is made between the bands. If the table is turned off, a single fixed pair of caps is used.

For a rock socket, two caveats are written in every output: the lower band has been used deliberately for the shaft (the much higher values of a roughened socket cannot be used unless proven by construction), and the base resistance relies on the assumption of a socket with a cleaned base.

6.2 Uplift capacity

There is no base resistance in uplift: the capacity consists of the reduced shaft resistance and the submerged self-weight of the pile. For bored and CFA piles a reduction is applied to the shaft in uplift; it is not applied to driven piles or micropiles. An unreinforced plastic pile cannot take tension and no uplift calculation is started.

6.3 Negative skin friction and the neutral plane

The presence of negative skin friction depends on three conditions: the toe is in a stiff layer, there is a compressible layer above, and there is an ongoing cause of settlement. The first two are read from the profile; the third is asked of the user — new fill, groundwater lowering, surcharge, or fresh fill on site that is still settling. If the user has not answered, the decision remains "uncertain"; the program does not make an assumption on its own.

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Drag load does not consume capacity, it stresses the section

Although drag load looks like an item deducted from the geotechnical capacity, it is physically different: it is not a load but the result of displacement compatibility. The program therefore carries the design bearing capacity without drag load separately and does not mix the two. The neutral plane analysis gives the actual mobilised drag load; the capacity branch uses that, not its own upper bound.

6.4 Settlement — three branches side by side

Table 7. Settlement branches

Branch	Assumption
Simple branch	The sum of the elastic shortening of the pile shaft and the toe settlement; the toe settlement is an assumption tied to the mobilisation ratio of the capacity. Coarse but transparent: every term can be traced by hand.
Elastic chart branch	Tabulated reading of published influence factor charts. The uncertainty of the chart reading is written, and values outside the chart range are clipped and reported. This result is not added to the total settlement; it is a second opinion.
Load transfer branch	The pile is divided into segments, a shaft spring is placed at each node and a base spring at the toe; iteration is performed with secant stiffness. The curves come from published tables. The resistances are characteristic; the negative skin friction layer does not become a spring.

If softening is counted in clay in the load transfer branch, the system peak may remain below the sum of shaft and base capacity; this is the source of the difference between the detailed branch and the simple one. The program checks the divergence between the two branches: if the ratio or difference between them at working load exceeds a given limit, it gives a warning. If the two branches do not agree, the reason should be sought.

6.5 Group bearing capacity and group settlement

Group bearing capacity follows the wording of the code literally: the lesser of the sum of the single-pile capacities and the block failure capacity is taken. The block dimensions are measured from the plan — the outer outline of the edge piles; if there is no plan, a square group approximation is used and this is stated. The classic group efficiency factor is also calculated but reported for information only; the decision is still the lesser value.

Group settlement is calculated with the equivalent raft approach: the load is taken down to a given fraction of the pile length in a friction-dominated group, and to the pile toe in an end-bearing group; below that the stress is distributed by classic spreading. This branch gives the final magnitude; the time of consolidation is a separate branch, and in that branch the layered profile is reduced to a single equivalent layer.

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7. Lateral and Seismic Analysis

7.1 p-y curve families

The lateral soil reaction is defined by a curve family selected layer by layer. There are eight families, each for a different soil and water condition.

Table 8. p-y curve families

Family	Where it is used
Soft clay	Soft clay below water; the classic static curve. If the half-mobilisation strain has not been entered, it is taken from a table according to strength.
Stiff clay (with free water)	Stiff clay below water (Reese, Cox and Koop 1975). The default is the static curve (as in sand); the cyclic curve is selected in the settings. [RAPOR] The static curve has been checked against the LPile Technical Manual equations; it has not yet been compared numerically with the LPILE program, so use the results with caution.
Stiff clay (no free water)	Stiff clay above the water table; there is no softening and the exponent of the curve is different.
Sand (two separate families)	One is the classic sand curve, the other the hyperbolic-tangent offshore practice curve; in the second, the distinction between static and cyclic envelopes is made with a factor.
Weak rock	Weak rock and highly weathered rock layers.
Liquefied sand	Residual curve for a liquefied layer; it is concave upward and its range of validity is limited.
c–ϕ soil	Silty soils with both cohesion and friction; the two contributions are added. This family is not activated unless explicitly selected; the default behaviour is a single mechanism.

Cyclic curves are off by default

The cyclic envelope in sand, cyclic degradation in clay and the cyclic coefficients of sand are turned on with separate check boxes; all come switched off. The reason is that the code requires the kinematic analysis to be static incremental. No double reduction is made in a liquefied layer: if the residual curve is selected, no additional liquefaction factor is applied.

For stiff clay below water (Reese et al. 1975; LPILE / Reese and Van Impe form) the static curve consists of five parts: (1) the initial straight line $k_s \cdot x \cdot y$; (2) $0.5 \cdot p_c \cdot (y/y_{50})^{0.5}$, up to $A_s \cdot y_{50}$; (3) the branch with $-0.055 \cdot p_c \cdot ((y - A_s \cdot y_{50})/(A_s \cdot y_{50}))^{1.25}$ added, up to $6 \cdot A_s \cdot y_{50}$; (4) a linear descent with slope $0.0625 \cdot p_c / y_{50}$, up to $18 \cdot A_s \cdot y_{50}$; (5) a constant residual resistance $p_c \cdot (1.225\sqrt{A_s} - 0.75 \cdot A_s - 0.411)$. k_s is taken as 135 / 270 / 540 MN/m^3; instead of the A_s chart, the relation $A_s = 0.2 + 0.4 \cdot \tanh(0.62 \cdot x/b)$ (LPile Technical Manual Eq. 3-28) is used and, at shallow depth, the residual branch is clipped to $p \geq 0$. The static curve agrees one-to-one with LPile Technical Manual Eq. 3-26…3-35; the spring report states this source. The cyclic curve (LPile Eq. 3-36: $Ac = 0.2 + 0.1 \cdot \tanh(1.5 \cdot x/b)$; kc 55 / 110 / 220 MN/m³) is selected with the “REESE STIFF CLAY (below water): cyclic curve” box on the Settings → p-y curves tab.

7.2 Lateral solver

The pile is solved as a beam discretised by finite differences; the p-y springs are iterated with secant stiffness and a damping factor is used. If the solution does not converge, no result is returned; the numbers of an unconverged solution can look reasonable.

There are three head conditions: derived from the pile type, free, or fixed. When fixed is selected, an entered head moment is ignored and this is stated in a note — at a fixed head the rotation is zero and the moment is a result.

Outputs: displacement, moment and shear along depth; head displacement, maximum moment and its level, toe displacement, and the effective lateral depth — the depth at which the displacement falls below a small fraction of its head value. The last value shows whether the pile can be regarded as laterally “long”.

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The classic closed-form capacity method is offered as a separate branch; it gives short- and long-pile solutions for free and fixed heads and for clay and sand mechanisms. Its result is characteristic — since the code gives no resistance factor for lateral capacity, the factor is left to the user and this is stated. If the section reinforcement is not defined, the moment resistance is unknown; in that case only the short mechanism is solved and it is written that the yield mechanisms could not be checked.

7.3 Lateral behaviour within a group

In a group, a pile in a trailing row is shadowed by the one in front and develops less reaction at the same displacement. This is expressed through a row-dependent P-multiplier. Two sources can be selected: a stepwise code table (default) or a source giving continuous relations; since the range of validity of the second is narrow, values outside it are clipped and a warning is given.

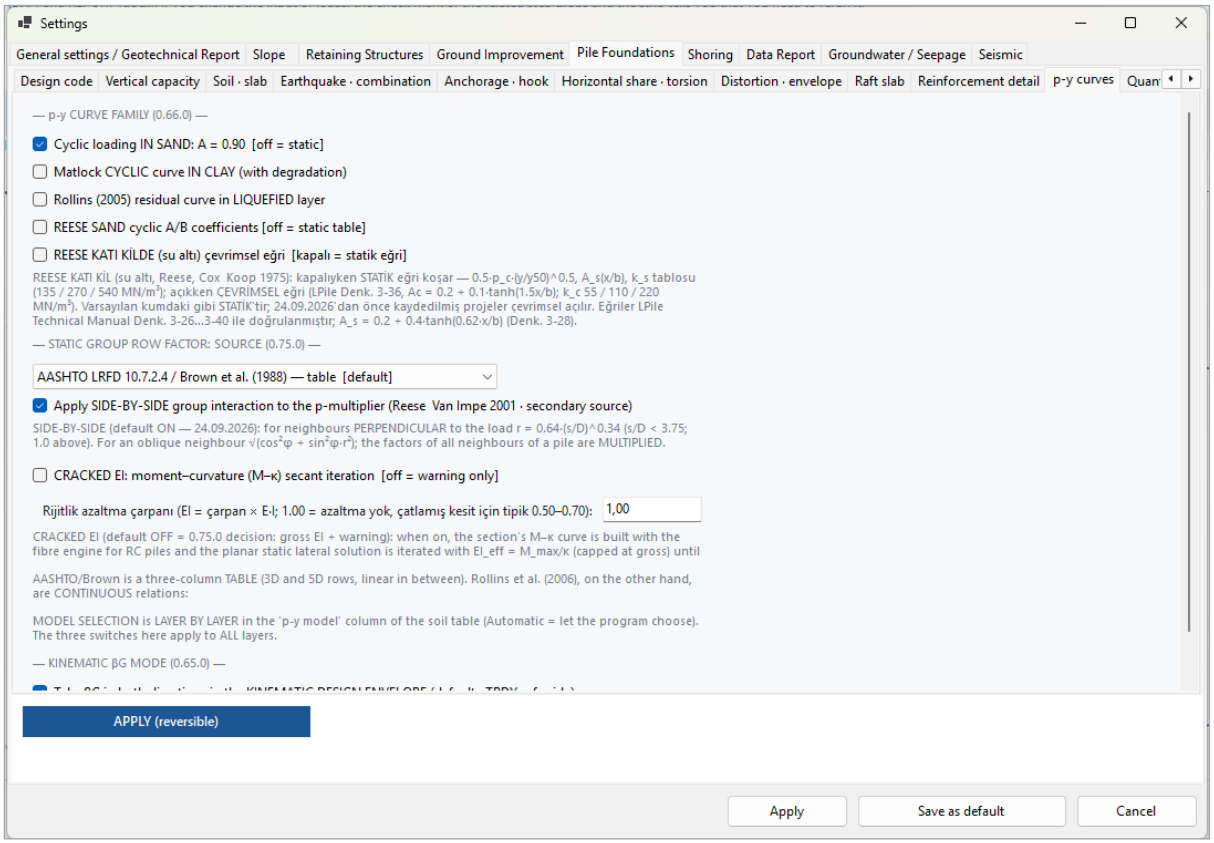


Figure 7. Settings window, Pile Foundations › p-y curves tab: cyclic curve options and source of the group row multiplier

The geometry of shadowing is continuous and directional: for each pile, the extent to which its neighbours shadow it with respect to the earthquake direction is weighted by angle, and a fractional row number and a row spacing are derived. With this method a group in an oblique direction shows no sharp jumps.

The interaction of neighbours perpendicular to the load direction (side by side) is on by default (Reese and Van Impe 2001 / GROUP; secondary source): $r = 0.64 \cdot (s/D)^{0.34}$ ($s/D < 3.75$; 1.0 above); for an oblique neighbour $\sqrt{(\cos^2\phi + \sin^2\phi \cdot r^2)}$; the multipliers of all neighbours of a pile are multiplied together. It is applied only to the static p-multiplier, not to the kinematic β_G. It can be turned off on the Settings → p-y curves tab; if it is turned off, an unsafe-side warning is printed on the results and in the report. The output and the report state “side-by-side interaction: on — Reese & Van Impe (2001) / GROUP, secondary source”.

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Figure 8. 7 · Results, 3D view: piles coloured by the group reduction β_G

7.4 Kinematic interaction

During an earthquake the soil forces the pile through its own displacement. In the third method of the code, the total free-field displacement envelope is applied statically and incrementally to the far ends of the p-y springs, and the pile is solved in this forced spring system. The bending moments obtained are divided by a factor specified by the code; shear and axial forces are not divided.

Without an envelope there is no kinematic calculation

The free-field envelope comes from two routes: from the Site-Specific Response Analyses module, or entered by hand with an Excel template. Without an envelope no kinematic calculation is made and no assumed profile is generated. Since the envelope comes from a one-dimensional soil column it has no horizontal direction, and in the design envelope a single kinematic profile is applied to all piles; this is stated explicitly and piles of different length are flagged.

For cases where no envelope is available, an estimate from a closed-form relation is offered. This is the permanent-situation moment; no transient-situation reduction is applied, and in the verification it is tied to a band rather than a point — the scatter of the relation itself is wide.

7.5 Combining kinematic and inertial effects

The two effects are combined by absolute sum as the code specifies; alternatively the square root of the sum of the squares can be selected, and when it is selected the output also states what the code rule would give.

The order matters and is deliberate: the reduction factor is first applied to the kinematic moment, then the sum is taken. The rationale is physical: the kinematic effect is displacement-controlled and the inertial effect is force-controlled; the reduction belongs only to the first.

In a group the kinematic effect is lowered with a reduction factor; the factor comes from the pile's row extracted from the plan and is tabulated combination by combination. The design envelope branch scans all piles: for each pile the inertial moment from its own combination envelope and the single kinematic profile are combined section by section, and the governing share is written.

The liquefaction effect comes with a separate flag; the program rejects a flag that falls within the code's exclusion criteria. The lateral spreading thrust is a separate branch and a pressure method: it does not model the lateral displacement of the free field.

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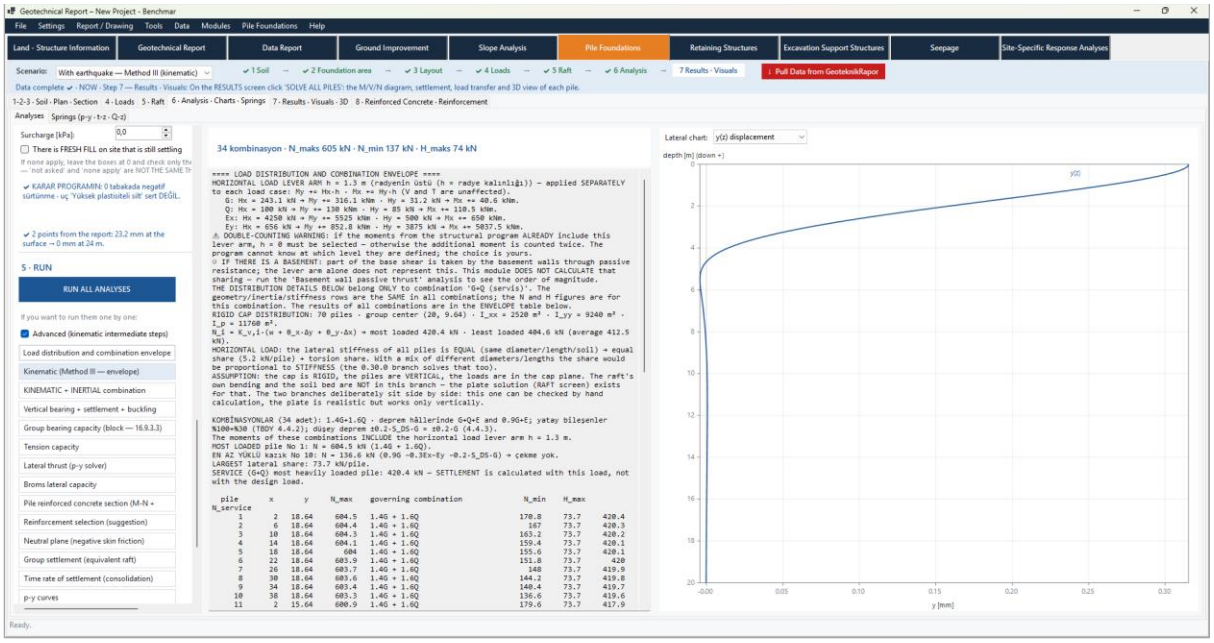


Figure 9. 6 · Analysis tab: combination of kinematic and inertial effects and moment along depth

8. Piled Raft and Reinforced Concrete Section

8.1 Slab solution

The raft is solved as a plate on a subgrade. The main solver is a conforming rectangular element with four degrees of freedom per node; the system is assembled from the plate stiffness and the sum of the subgrade and pile springs. The piles enter the plate as vertical and rotational springs; for an unreinforced plastic pile only a vertical spring is placed.

The subgrade can be set up as pure Winkler or with an added shear layer coefficient; the latter prevents adjacent springs from behaving independently of each other. The subgrade modulus preferably comes from an elastic relation, and the value in the geotechnical report governs; the program's own proposal only fills the gap. The source of the value is always written.

In polygonal rafts and rafts with openings, elements are activated with a mask. To measure boundary fidelity on a raft with oblique edges, a second solver with a triangular mesh is offered; it is not a backup but a measuring tool, and it does not support the shear layer coefficient — so if the coefficient is used, the two results naturally diverge and this is stated.

The mesh density has a hard lower limit

A hard lower limit is defined for the element size and cannot be changed in the settings; the program rejects a value below it and writes the reason with the number. Above it there is also a warning threshold: you are informed that the analysis may take very long. Mesh density is not an engineering choice but a limit on the program's workability; it is therefore not counted as a setting.

Outputs: settlement map, deviation-from-mean (differential settlement) map and moment maps in two directions; also the ratio of the pile shares to the total load. Additional checks: consistency of the rigid cap assumption with the plate stiffness, angular distortion and the position of concentrated loads.

The double foundation option (Settings › Raft slab, off by default) sets up the case where the building foundation is cast separately on top of the pile cap raft. On the same tab the upper foundation thickness (0 = not entered; if it is not entered, the upper foundation self weight is not calculated and the double foundation sheet is not produced) and the overhang (default 0.50 m) are entered. Compression is transferred from concrete to concrete;

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in every combination the ΣN and ΣH coming down through the interface and any tension are reported. The column moment is not applied to the lower slab; instead, the load is spread over the lower slab as a trapezoidal or triangular partial contact pressure with the eccentricity e = M/N, and the lower slab reinforcement is derived from this distribution. In tension the contact opens and a warning is given. The upper foundation's own checks (sliding, overturning, punching, interface pressure, starter bars and reinforcement) belong to the structural design and are not made in this module. The upper foundation weight W is added automatically (see 5.4).

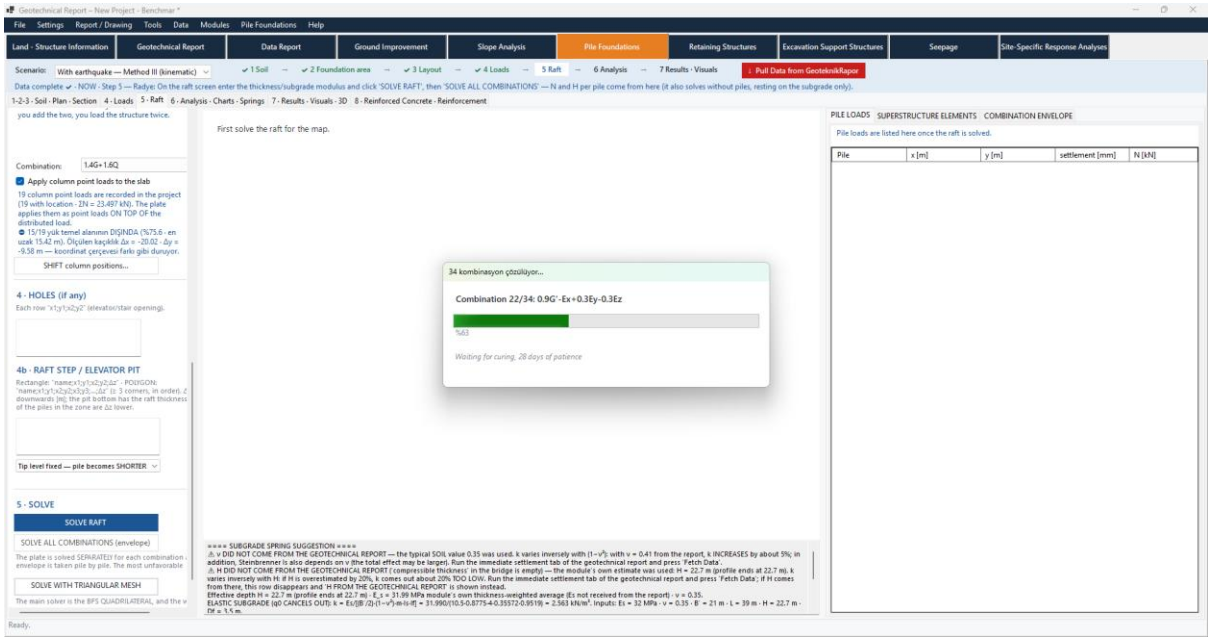


Figure 10. 5 · Raft tab: progress window while all combinations are solved

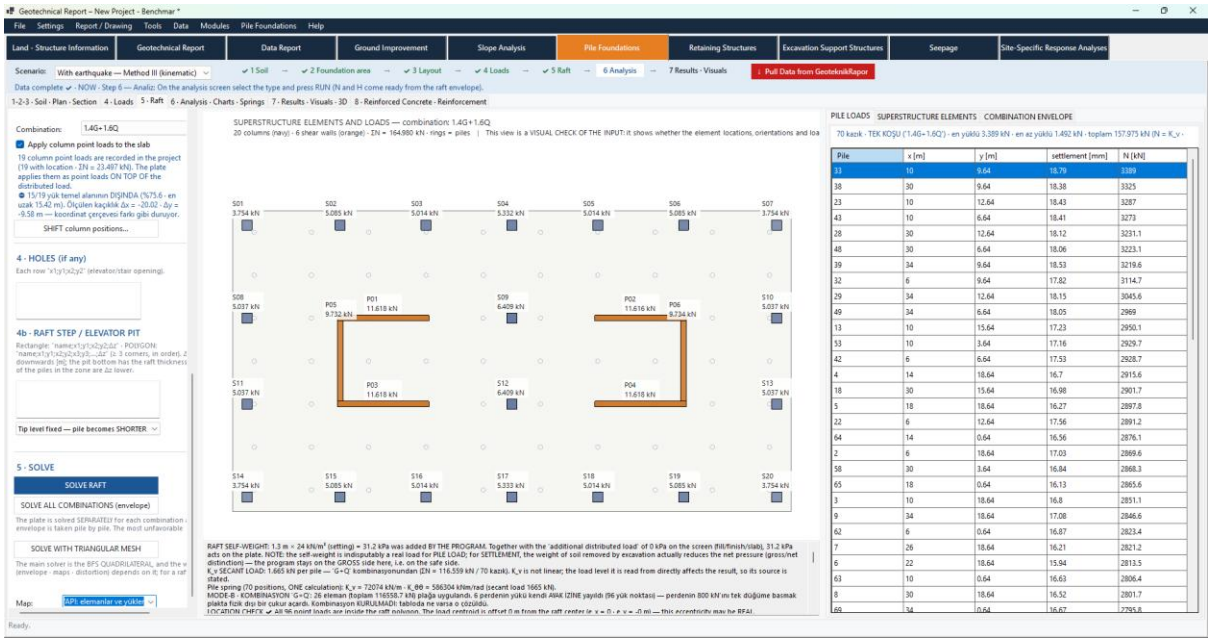


Figure 11. 5 · Raft tab: superstructure members and pile loads

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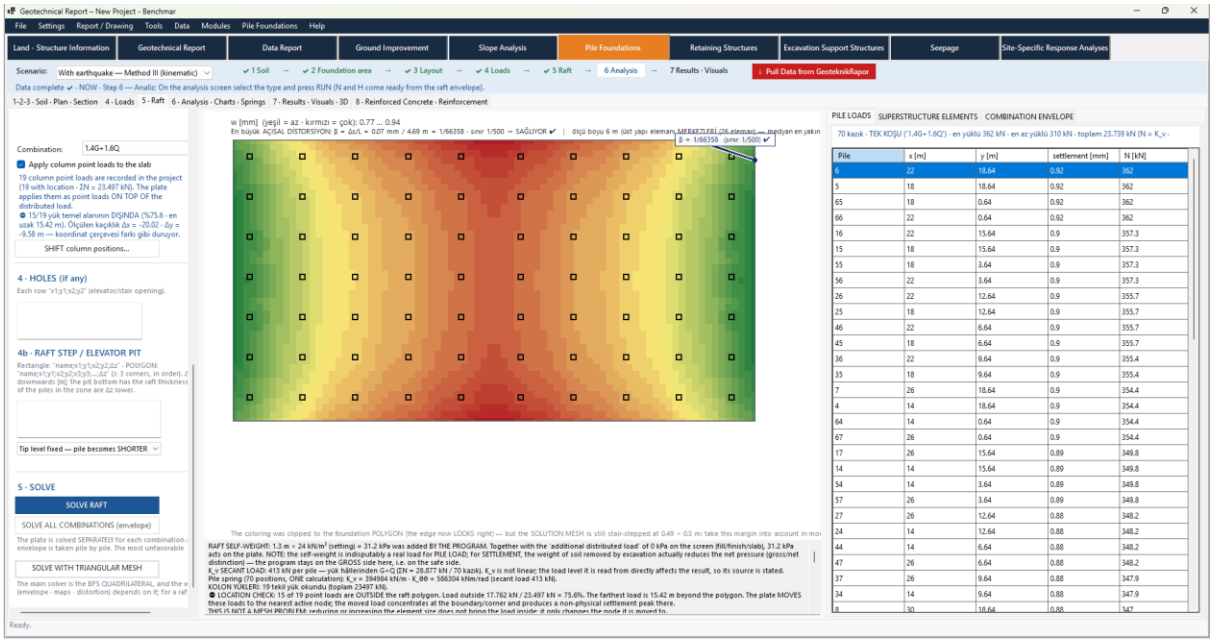


Figure 12. 5 · Raft tab: differential settlement map and angular distortion

8.2 Reinforced concrete section

The section solution is a fibre-based axial load–moment calculation; it uses the same method as the circular section calculation of the Excavation Support Structures module, and it has been verified that both modules give the same results.

There is no single yield moment

In a reinforced concrete section, the moment resistance depends on the axial load. The program therefore does not keep a single yield moment; it calculates the moment resistance for each axial load and draws the axial load–moment envelope. The value requested at zero axial load is the pure bending case and is usually a lower bound.

The shear resistance and the cracking moment of the unreinforced section are also calculated; the latter is a benchmark showing when an unreinforced pile will crack. Cracked section stiffness is not applied automatically: the program measures and warns, runs the calculation with gross stiffness and leaves the decision to the engineer.

The reinforcement tab reads the demand, and the reinforcement is either selected by the program or imposed by the user; in both cases the source of the reinforcement is marked on the model and stated on screen. Entered reinforcement can also be checked. The code's minimum reinforcement ratio is applied for the confinement zone according to the seismic design class.

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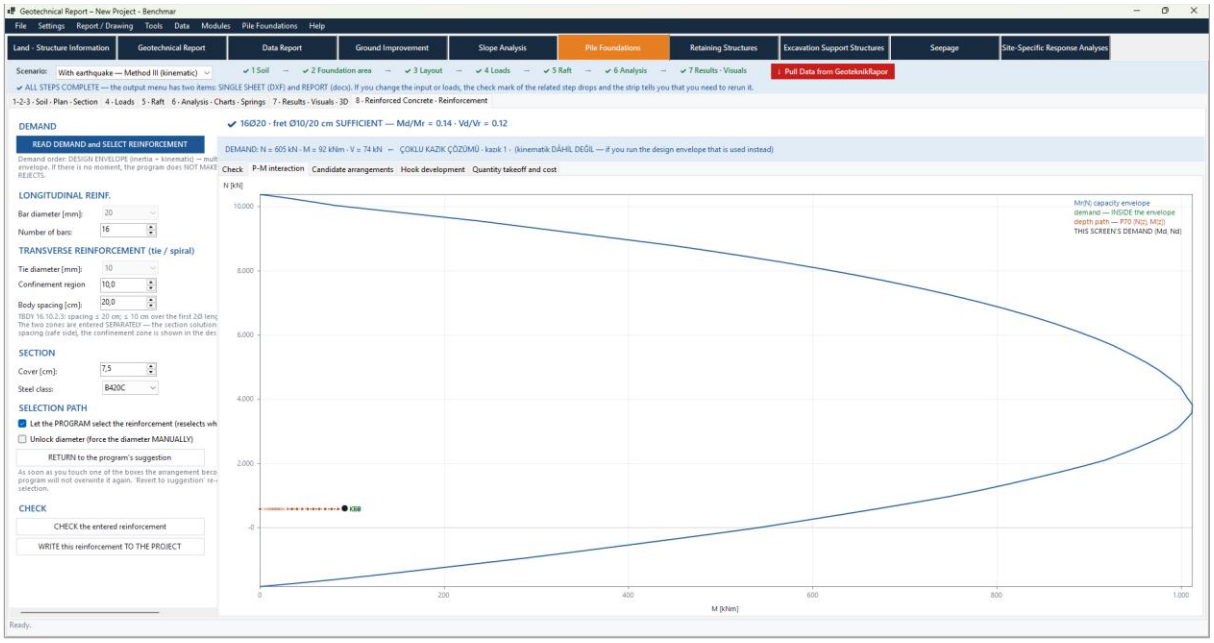


Figure 13. 8 · Reinforced Concrete · Reinforcement tab: demand, reinforcement selection and P–M interaction diagram

8.3 Pile–raft connection and tie beam

The connection branch does two things: it checks the raft against punching around the pile, and it gives the anchorage length of the pile reinforcement into the raft. Anchorage is calculated assuming straight bars; if a hook or a headed bar is selected, a reduction is applied and the bend level and development of the hook enter the drawing. Punching checks the vertical load only; it is stated that moment transfer would increase the stress. This branch does not calculate the flexural reinforcement of the raft.

The tie beam branch looks at the axial load only: the minimum section and reinforcement of the beam against tension and compression are checked. Bending from differential settlement and slab load is outside the scope of this branch; no code clause number is given for the factor used.

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9. Reading the Results

The Results tab works in three branches: the multi-pile solution (all piles solved one by one and collected in a table), diagrams and the three-dimensional view.

Table 9. Diagrams

Diagram	What it shows
Moment, shear and displacement	Along depth for the selected pile; the effect of the head condition and the p-y families is read here.
Axial force	Along depth; if there is negative skin friction, the neutral plane is seen on this curve.
Envelope diagrams	Absolute moment and shear envelopes of all piles together; which pile governs is seen at a glance.
Load transfer	Capacity, mobilisation and the variation of axial force with depth together. On the mobilisation ratio (t / t_{max}) curve the horizontal axis is fixed at 0–1: 1 is full mobilisation and the curve appears at the right edge.
Pile head settlements	In plan order; shows where differential settlement is concentrated.

The three-dimensional view colours the piles by a selected quantity: shaft mobilisation, axial force, displacement, moment, head settlement, kinematic quantities and group reduction factor. This makes visible a pattern that gets lost in number tables — for example, corner piles being systematically more heavily loaded.

The spring table tab generates the springs to be given to the structure: lateral, shaft and base springs. The tables can be copied to the clipboard or saved as CSV.

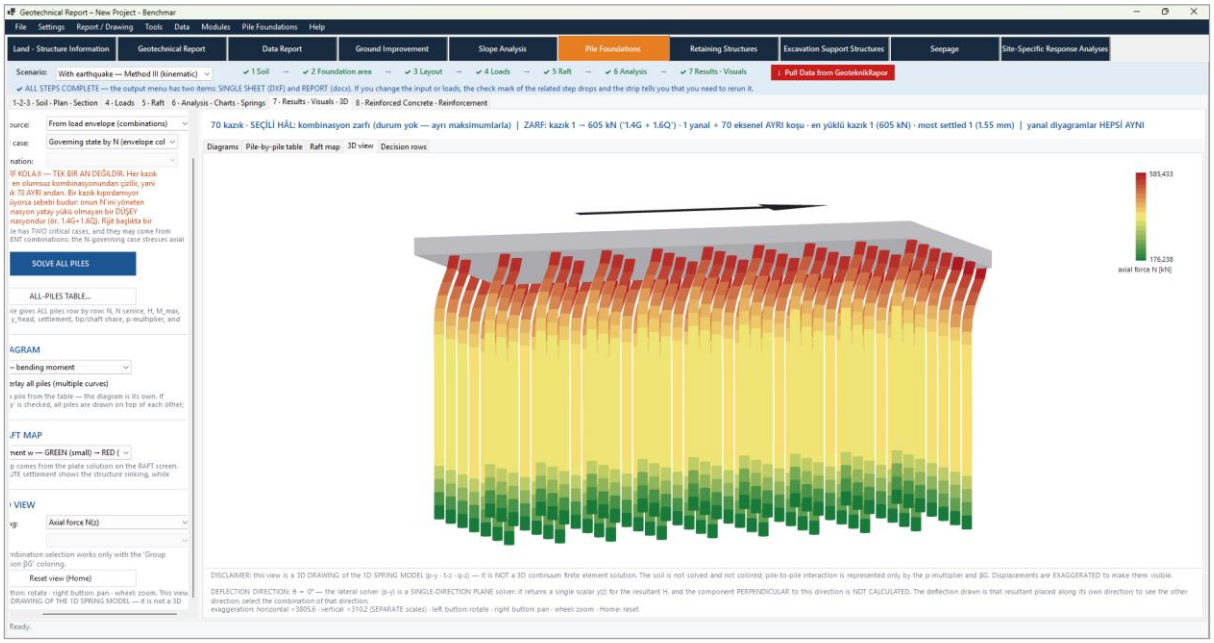


Figure 14. 7 · Results, 3D view: piles coloured by combined moment

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Figure 15. 7 · Results, 3D view: piles coloured by horizontal displacement



Figure 16. 7 · Results, 3D view: piles coloured by combined shear

10. Settings — What Changes the Result

A setting is a setting only if it is an engineering choice

Every item in the Settings window is an engineering decision. The technical values that determine the accuracy of the solution (mesh density, step size, convergence criteria) are limits on the program's workability and are not offered as settings. The Pile Foundations settings open as module tabs in the main program's single Settings window and are carried in the main project file; whoever opens the project also receives the assumptions with which the model is to be solved.

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Design code: the code to which the calculation is made is selected here and saved with the main project file. Only codes implemented in the program (Active) can be selected; the others appear greyed out with the note “Not available in this version.” No coefficient of a code without a source is written into the program.

Table 10. Setting groups

Group	Contents
Axial capacity	Base bearing factor method, critical depth multiplier, shaft and base caps, undrained adhesion factor source and value, drained interface angle and horizontal stress ratios (by type), shaft reduction for uplift, short socket criterion and base multiplier.
Lateral and p-y	Row multiplier source; side-by-side interaction (on by default); cyclic envelope in sand, cyclic degradation in clay, residual curve in a liquefied layer, cyclic coefficients of sand and the Reese stiff clay cyclic curve — these five off by default.
Settlement and load transfer	Residual resistance ratio in clay, critical mobilisation displacement in a rock socket.
Raft	Plate Poisson’s ratio, whether column moments are applied to the plate, whether raft base friction reduces the horizontal load reaching the piles (off by default; an unsafe-side assumption, to be turned on deliberately), the double foundation option (off by default) with the upper foundation thickness and overhang, and post-envelope nonlinear calibration.
Seismic	Kinematic–inertial combination rule, whether the kinematic group reduction is taken with a two-directional envelope, structure and soil periods (for the resonance check).
Reinforced concrete and connection	Concrete cover, minimum clear bar spacing, minimum number of bars, anchorage type and reduction factors, hook direction and bend level values.
Quantity takeoff and drawing	Stock bar length, lap multiplier, steel and concrete waste percentages, ring and Z bar dimensions (diameter, zone spacing, leg length), unit prices, sheet hatching and content, pile name prefix.
Check limits	Angular distortion limit and gauge length, zeroing of torsion in the vertical combination and the numerical residual threshold.
Design code	Design code: default TBDY 2018 (Chapter 16, Appendix 16C); reference sources AFAD example 16E and TS 500. EN 1997-1 not available in this version (greyed out). The selection is written in the first row of the decision/caveat table of the report.

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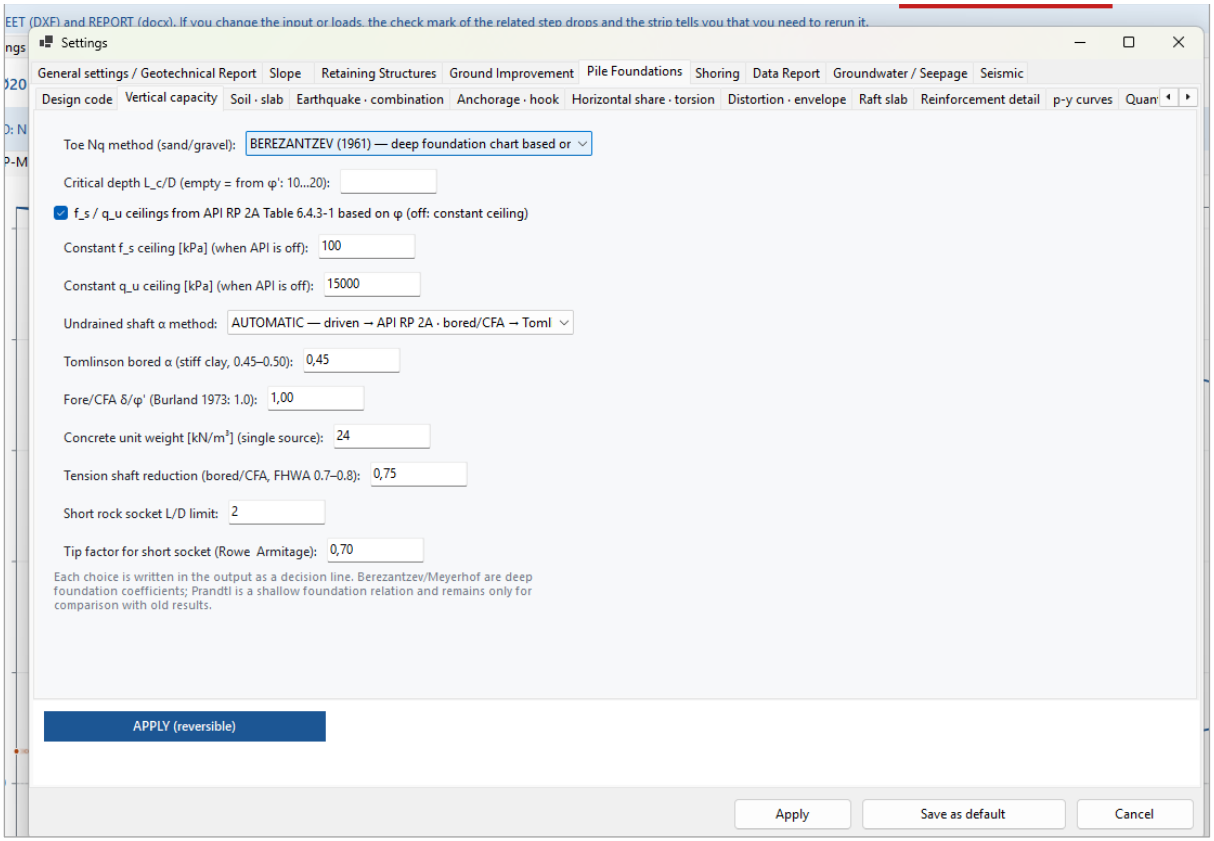


Figure 17. Settings window, Pile Foundations › Vertical capacity tab: base bearing factor method and shaft / base caps

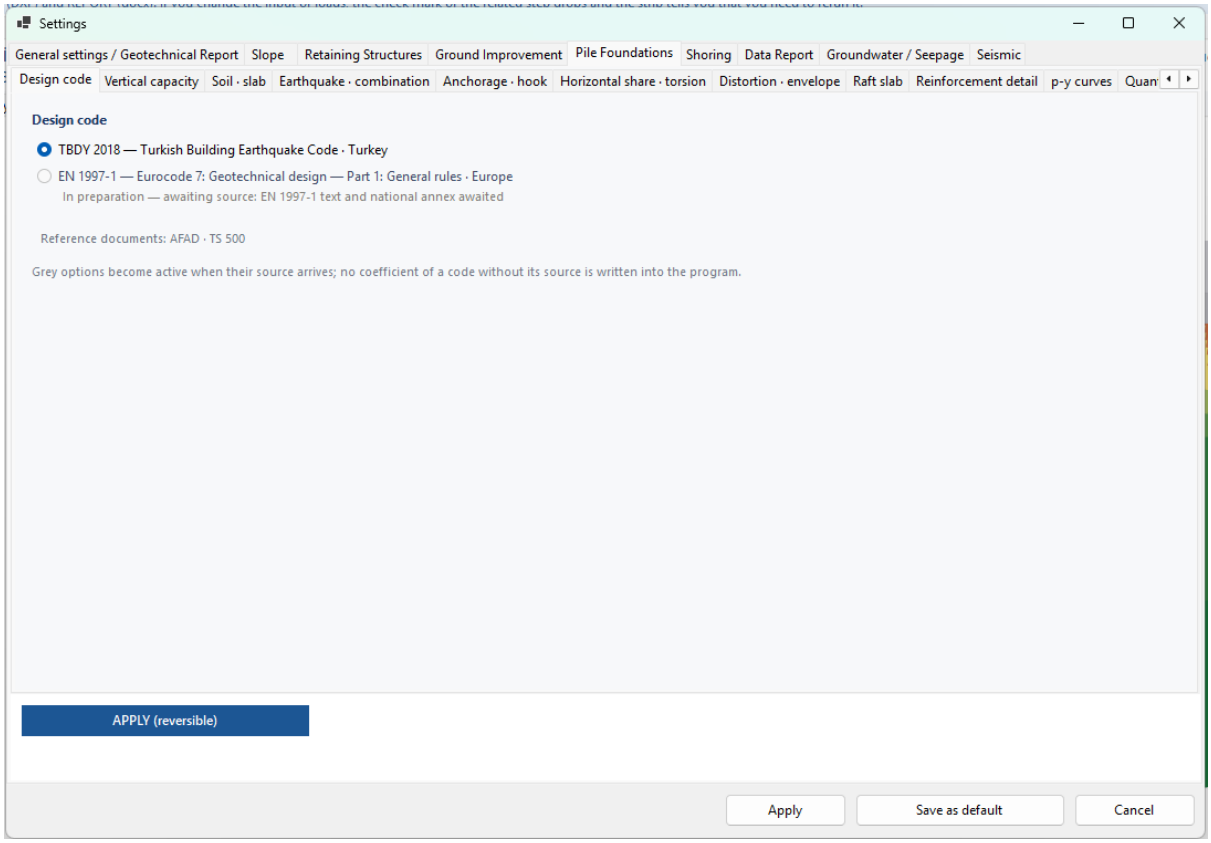


Figure 18. Settings window, Pile Foundations › Design code tab: TBDY 2018 active, EN 1997-1 not available in this version

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11. Verification and Benchmarking

The calculations in this module have been checked against independent verification examples and hand calculations. The verification falls into three categories.

Table 11. The three categories of verification

Category	Coverage
Numerically verified against a published source	The code's official worked piled foundation example is the external benchmark: group reduction factors, ultimate reactions of the p-y families, equivalent layer thicknesses and design bearing capacity are compared number by number. Two errors in the example's own text have been identified, and reproducing it exactly has deliberately not been the aim. The kinematic estimate relation is tied to a band rather than a point, because the scatter of the relation itself is wide.
Compared with closed-form solutions	Analytical solutions for plates and beams on an elastic subgrade, closed-form lateral capacity relations, the algebraic formula of the rigid cap distribution, closed-form expressions of section geometry. Stronger than internal consistency, but not a published field measurement.
Internal consistency checks	No two different numbers produced for the same quantity, load bookkeeping and equilibrium, convergence on mesh refinement, symmetry, save–load round trips, one-to-one agreement of the envelope with the individual solution, completeness of sheet and report fields, re-creation of real user cases.

No comparison with independent software has been made

The results of this module have not been compared numerically with common commercial pile software (LPILE, GROUP); those programs are mentioned only as sources of methods. Use the results with caution unless you compare them with independent software.

11.1 Comparison with a published example: the TBDY Appendix 16E piled foundation example

The worked piled foundation example in the code appendix (AFAD publication): a thirteen-storey building, Ø1.0 m bored piles, 18 m length with a 2 m rock socket, 4×8 piles, 4D centre-to-centre spacing, groundwater at 4 m. The table below compares the hand-calculation values of this example with the values given by the program; the "Tolerance" column is the absolute deviation accepted in the comparison (units as in the reference column).

Table 12. Comparison with the TBDY Appendix 16E example

No.	Quantity	Reference value	Tolerance	Status
E1	Group reduction factor β_G, s = 4D, rows 1–4	0.88 · 0.78 · 0.72 · 0.68	Exact	Exact agreement
E2	Soft clay p_{ult} (depth 5.28 m)	206.2 kN/m	± 0.3 kN/m	206.16
E3a	Stiff clay p_c (cap)	1330 in the book; hand calculation $11 \cdot c_u$ = 1320 kN/m	± 1 kN/m (relative to 1320)	Error in the source (see below)
E3b	Stiff clay p at start of plateau	373.5 in the book; 370.7 kN/m based on 1320	± 0.6 kN/m	370.66 (difference 0.75%)
E3c	Stiff clay residual p (large y)	206.7 in the book; 205.1 kN/m based on 1320	± 0.5 kN/m	205.13 (difference 0.77%)
E4a	Reese sand p_s	4927 kN/m	± 10 kN/m	4926.83
E4b	Reese sand $P_{ult} = 0.88 \cdot p_s$	4335 kN/m	± 10 kN/m	4335.61
E4c	Reese sand cyclic $p_m = 0.55 \cdot p_s$	2709 kN/m	—	2709.76
E5a	Weak rock p_{ur}	17 913 kN/m	± 30 kN/m	17 920

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No.	Quantity	Reference value	Tolerance	Status
E7a	Q_{ks}	6452 kN	± 8 kN	6452.83
E7b	Q_{ku}	18 849 kN	± 10 kN	18 849.56
E7c	Negative skin friction Q_n	458 kN	± 2 kN	458.04
E7d	Design axial bearing capacity Q_{tv}	13 267 kN (18 849/2 + 6452/1.5 − 458)	± 12 kN	13 268.62

Because two groups of tables in the book were found to be in error, the equivalent layer thicknesses (Georgiadis approach) are compared not with the book's numbers but with closed-form results derived with the correct relations. The book's fill table was produced with the coefficients for ϕ′ = 30° instead of 32°; the clay tables were produced with the form of the Matlock relation written with d^2/b, and they contradict the book's own hand calculation (E2). The difference below is due to the error in the source; reproducing the book's number exactly has deliberately not been the aim.

Table 13. Starting depth of the equivalent layer: book table and closed form

Layer	Book table	Closed form (agrees with the program within ± 0.05 m)	Difference	Status
Clay	4.28 m	6.63 m	54.9%	Error in the source
Silty clay	3.15 m	3.29 m	4.4%	Error in the source
Gravelly sand	7.79 m	9.79 m	25.7%	Error in the source

The percentage differences are calculated relative to the book value. There are two errors in the book: (1) the book's fill table was produced with the coefficients for ϕ′ = 30° instead of 32°, and the application of the coefficient is inconsistent in rows where the depth/diameter ratio exceeds 3; since the shear integral of the fill (1083.7 kN) passes through this table, it affects all rows. (2) The clay tables use the form of the Matlock relation written with d^2/b; this error additionally affects the clay and silty clay rows. The program's values are 6.65 m (clay), 3.30 m (silty clay) and 9.80 m (gravelly sand), agreeing with the closed form within ± 0.05 m.

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12. Outputs

The outputs are the single sheet, the design envelope sheet and the report; the fourth command, “RUN CALCULATIONS AND PRODUCE OUTPUTS (report + drawing + quantities)…”, runs the calculations in order and writes all of them to one folder in a single pass (see 12.5). The plan, section and reinforcement views are within the single sheet; if reinforcement is defined, a reinforcement detail sheet is also written next to the single sheet. The commands are collected under Pile Foundations in the main program’s Report / Drawing menu (Figure 19).

12.1 Single sheet and reinforcement detail sheet

The single sheet consists of four views: layout plan, system section, pile reinforcement detail (cross-section and hook development) with the reinforcement schedule, quantity takeoff and title block. Each view has its own scale written beneath it; the scales are standard (plan and section 1/50, reinforcement detail 1/25). If no reinforcement is defined, the program asks before producing the single sheet: with Yes the reinforcement is selected automatically and drawn (if there is no demand analysis, the TBDY minimum reinforcement is used; the model does not change) and the reinforcement detail sheet is also written; with No the sheet is drawn without reinforcement and with a warning on it; Cancel abandons the command. On the “Run calculations and produce outputs” route the automatic selection is used. The sheet makes no calculation of its own; all numbers come from the calculation branches.

In the sections the soil layers are hatched according to their class (clay, silt, sand, gravel, rock); if a groundwater level has been entered, it is shown with the GWL symbol and its level. Pile head and toe are marked with level symbols, and the raft and pile shaft with callouts. On the sheets the piles are named FK-01, FK-02 ….

Layers are separate and an unused layer is not written to the file. Soil layers carry the names shared with the other modules (ZEMIN-TARAMA, ZEMIN-SINIR, ZEMIN-SU, ZEMIN-YAZI); pile layers start with the prefix KZ-. Hatching is a real hatch entity, i.e. it can be selected and edited in CAD; dashed lines are real linetypes. Lengths on the sheet are written in centimetres.

If reinforcement is defined (or has been selected automatically), a reinforcement detail sheet named <name>_DONATI_DETAY.dxf (DONATI_DETAY = reinforcement detail; the Turkish file name is fixed) is also written when the single sheet is produced. Piles of different lengths are not drawn with a single average length; each length group gets its own sheet and the length is added to the file name. The sheet contains: the longitudinal pile section (head level, raft, longitudinal reinforcement, confinement zones, rings, Z bar zones, depth dimension chain and bar mark balloons), a bar schedule for one pile, DETAIL-1 (confinement spacing), developments of the spiral, ring and Z bar, DETAIL-2 (spacer and Z bar bending shape), sections A-A and B-B, general notes and the pile plan.

If the longitudinal reinforcement exceeds the stock length it is split into bar marks 1 and 1a; 1a is the remaining lapped piece. The schedule gives the total weight of one pile and the “GRAND TOTAL” (number of piles × weight). The confinement development is a side view of the helix: the front half-turn descends half the pitch and the rear half-turn descends the remaining half. The pile shaft and the reinforcement sections are not hatched, so the reinforcement reads easily. Reinforcement defined on screen is written to the project automatically before the sheet is produced; if it does not fit in the section, it is not written.

If the double foundation is on and the upper foundation thickness has been entered, <name>_CIFT_TEMEL.dxf (CIFT_TEMEL = double foundation) is also written next to the single sheet: plan and section of the lower and upper foundations, the interface plane, load transfer notes and the quantities of the lower foundation. The sheet has no check tables for the upper foundation (see 8.1).

12.2 Design envelope sheet

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Moment and shear curves of the inertial, kinematic and combined envelopes, with a pile-by-pile envelope table. If the envelope analysis has not been run, the sheet is not produced and the reason is given: a sheet with empty axes creates the illusion that a calculation has been made.

12.3 Report and Excel appendix

Before the report is produced, the project identification is asked for; leaving it blank does not block the report. Then the common report pre-check window lists, section by section, missing items such as pile diameter and length, soil profile, reinforcement, load, seismic spectral acceleration coefficient and project details, and out-of-date results. The list is not added to the report; the report can be produced with “Continue anyway”, and “Cancel” is the default. The report runs the missing analysis branches itself and consists of fourteen main sections: introduction and scope, idealised soil profile, pile geometry and layout, axial bearing capacity, settlement, structural loads and pile load envelope, piled raft load sharing, behaviour under horizontal load, seismic effect and kinematic interaction, design envelope, pile reinforced concrete section and reinforcement, group bearing capacity, conclusions and evaluation, references.

A section without data does not enter the report

A section that has not been calculated is removed from the report. For every individual field that cannot be filled, a reason text is written: no raw placeholder appears and no number is invented. After the report is produced, the fields that were not calculated and those left empty are reported in two separate boxes.

An Excel appendix is written next to the report; only sheets that have data are created. The sheets include the pile list, shaft friction, load–settlement, pile loads and combinations, lateral envelope, spring tables, design envelope and quantity takeoff. The charts are real charts linked to the cells, not pictures, so the chart changes when the data change.

If the “Static” scope has been applied in the design wizard, the following paragraph enters section “1. Introduction and Scope” of the report: “SCOPE: This report covers the design of the piled foundation under STATIC loads (axial bearing capacity, settlement and static load distribution). Seismic effects (inertial and kinematic effects, liquefaction) are NOT within the scope of this report; under TBDY 2018 Chapter 16 the seismic effects must be assessed separately.” With the other scopes this paragraph does not enter the report.

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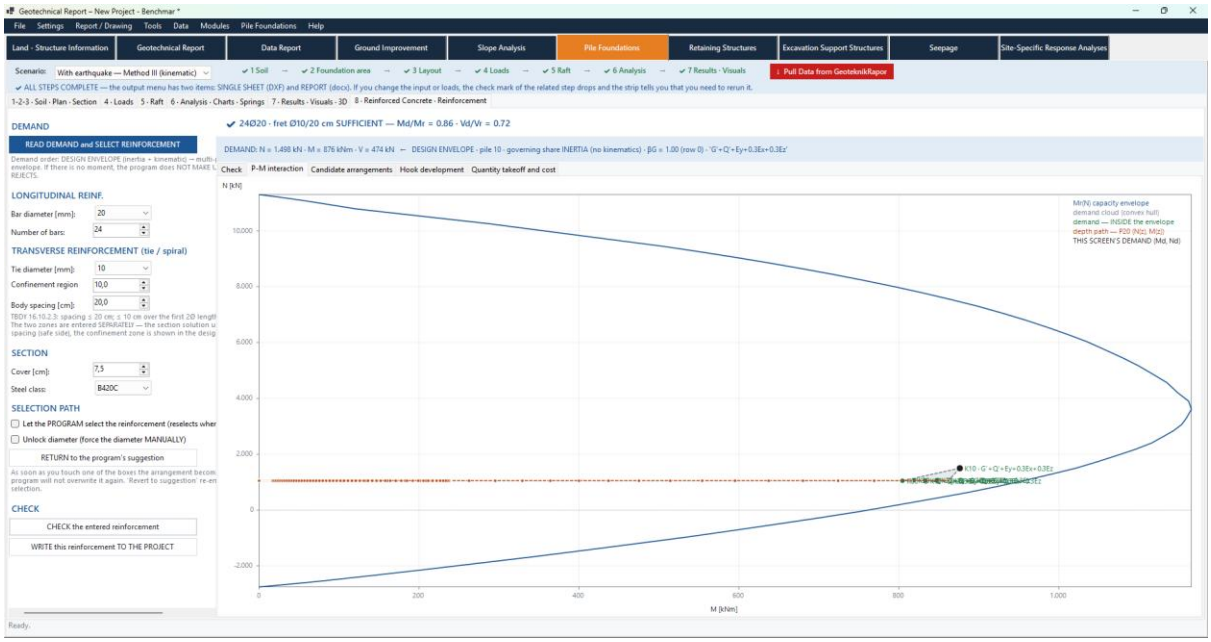


Figure 19. Report / Drawing menu: Pile Foundations › Report (docx + Excel appendix) and Drawing commands

12.4 Quantity takeoff

The quantity takeoff is derived from the lap plan of the reinforcement and from the geometry: piece and cut lengths of the longitudinal bars, the true length of one turn of the hoop or spiral, rings, Z bars (diagonal bars inside the cage) and connection bars, welding allowances. The number of piles is counted from the plan. The totals are given separately as theoretical steel and concrete and as order quantities including waste; if no unit price has been entered, no cost line is produced.

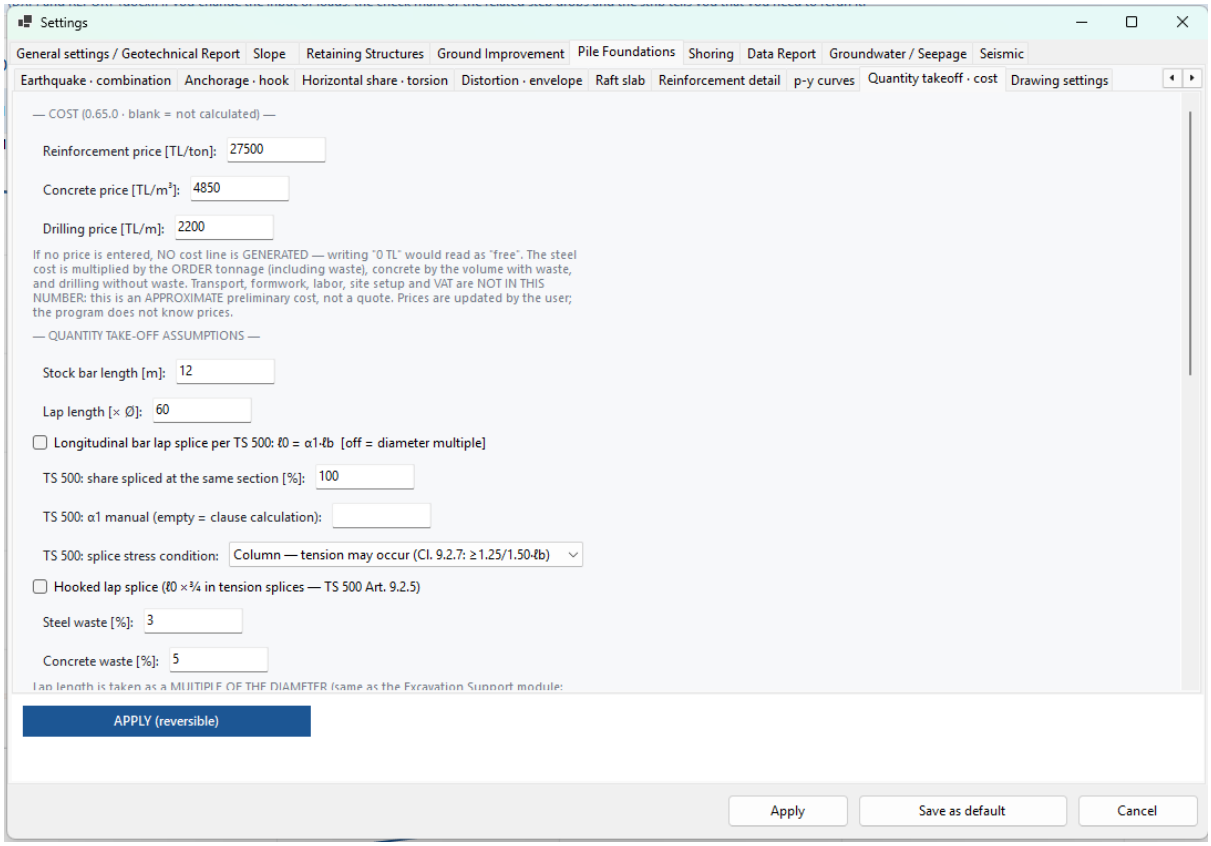


Figure 20. Settings window, Pile Foundations › Quantity takeoff · cost tab: unit prices and quantity takeoff assumptions

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12.5 Run calculations and produce outputs

The “RUN CALCULATIONS AND PRODUCE OUTPUTS (report + drawing + quantities)…” command runs the tabs’ own buttons in order and writes the outputs in a single pass. Together with the other output commands it is under Pile Foundations in the main program’s Report / Drawing menu; it is also offered after “Apply selected” in the design wizard. It does not run if there are no piles in the plan: first generate the layout or apply the wizard.

- The user selects the folder to which the outputs are written.
- The calculations are run in order: if MODE B is not used, Loads “Distribute”; then Raft “Solve” (+ “Envelope” in MODE B); then Analysis “Run”.
- Then <name>_RAPOR.docx (with the Excel annex, quantities included), <name>_TEK_PAFTA.dxf and, if the design envelope has been computed, <name>_TASARIM_ZARFI.dxf are written to the chosen folder. If no reinforcement is defined, the reinforcement for the single sheet is selected automatically (see 12.1).
- The report identification and report pre-check windows open on this route as well (see 12.3).
- A step without a result does not stop the chain; the closing summary marks each step with ✓ (produced a result), — (no result) or ⚠ (error).

Kinematic and multi-pile solutions are not in the chain

The kinematic (Method III) analysis and the multi-pile solution are not run by this command; the program says so in the summary message. If the scenario is seismic, run these branches on the Analysis and Results tabs and produce the report again.

13. Points to Watch

13.1 When building the model

- The DXF underlay does not decide; the area is built from the selection. If the unit is doubtful you are asked — this question should not be skipped.
- If the DXF plan is not in GP format, give the layers their roles (see 5.3); “Continue without mapping” reads the drawing by guessing from the layer names.
- The setback distance is applied to the outer face of the pile, not to its centre.
- When the spacing ratio is below the recommended lower limit, generation does not stop; it warns. The warning is not an error, but it calls for a decision.
- Jet grout inclusions that are not counted do not enter the calculation; placing them and expecting the bearing capacity to increase is wrong.
- For a steel pipe, if the wall thickness is not entered, the section is taken as a solid circle and the stiffness comes out far above the real one.

13.2 When analysing

- The negative skin friction decision remains uncertain as long as the user has not answered. This uncertainty does not mean absence.
- Drag load does not consume capacity, it stresses the section. The two quantities stand separately in the report and should not be confused.
- If the three settlement branches do not agree, the reason should be sought; the program already reports this divergence.

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- The kinematic calculation does not run without a free-field envelope. The estimate branch does not replace it; it gives an order of magnitude.
- Cyclic p-y curves are off by default. Turning them on is a deliberate decision, and no double reduction can be made in a liquefied layer.
- Raft base friction is off by default: turning it on reduces the horizontal load reaching the piles and is on the unsafe side.
- Moment resistance depends on the axial load. Looking for a single yield moment is a misreading of the section’s behaviour.
- Cracked section stiffness is not applied automatically; the program measures and warns, and the engineer makes the decision.

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14. Known Limits and Out-of-Scope Topics

Table 14. Out-of-scope and limited topics

Topic	Status
Barrette and Franki piles	There is no axial capacity calculation; the calculation is not started.
Torsion in the plate	Not applicable: the plate theory used has no rotational degree of freedom about the vertical axis. Torsion is used only in the horizontal distribution.
Triangular-mesh raft branch	Does not support the shear layer coefficient; distributed load is lumped at the nodes. It is a measuring tool, not a backup of the main solver.
Three rings	No more than two rings, outer and inner, are designed at the pile head; if three rings are needed, the analysis stops with a “does not fit” warning.
Intermediate mechanism in closed-form lateral capacity	The intermediate mechanism in sand with a single hinge at the head has not been implemented; in the transition zone the p-y branch should be used.
Pile–raft connection	Does not cover the flexural reinforcement of the raft or the detailed design of the hook geometry; punching checks the vertical load only.
Tie beam	Axial branch only; flexural sizing is out of scope.
Consolidation time	The layered profile is reduced to a single equivalent layer.
Group settlement	Gives the final magnitude; shortening of the pile shafts is not included.
Rock socket	The shaft is deliberately in the lower band; the base relies on the assumption of a socket with a cleaned base; if the quality designation has not been entered, no mass reduction is made.
Lateral spreading	A pressure method; it does not model the lateral displacement of the free field.
Large-diameter lateral correction	Not applied — it underestimates the resistance at large diameters, i.e. it is on the safe side; no assumed factor is written.
Field test correlation in rock	Not applied; the strength and quality designation route is used for rock.

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