Geocentrix

Repute 2.5

Quick-Start Guide

Set in Optimum using Word version 2402.

Acknowledgments

Repute 2.0 was developed with the generous support of Corus, Atkins, and Stent Foundations. Repute 2.5 was designed and written by Dr Andrew Bond of Geocentrix, with the assistance of Ian Spencer of Honor Oak Systems.

PGroupN was designed and written by Dr Francesco Basile of Geomarc. Special recognition goes to the late Dr Ken Fleming of Cementation Foundations Skanska for his invaluable advice and support during the development of PGroupN.

The *Repute Quick-Start Guide* was written by Andrew Bond with the assistance of Jenny Bond.

The following people assisted with the production of the program and its documentation: Jenny Bond, Francesco Basile, Romain Arnould, Joe Bond, Tom Bond, Halcrow Group, Jack Offord, and Claire Bond. The following generously gave their time during initial beta testing: Francesco Basile and Dave Rowbottom.

Revision history

Last revised 13th March 2024 (for version 2.5.24.1).

Contents

Introducing Repute 2.5

Repute® provides a rich set of capabilities for engineers to design/analyse:

- various types of single pile, using current and historical design standards (such as Eurocode 7 and BS 8004:2015)
- pile groups under generalized 3-dimensional loading, using linear of non-linear soil models

Repute considers single pile response using a variety of calculation methods for ultimate and serviceability limit states. Both traditional lumped factors-of-safety and modern partial factors can be applied in these calculations.

Repute analyses pile group behaviour using the boundary element method, employing the leading analytical program PGroupN (developed by and included under exclusive licence from Geomarc). PGroupN provides a complete 3D non-linear boundary element solution of the soil continuum, which overcomes limitations of traditional interaction factor methods and gives more realistic predictions of deformations and the load distribution between piles.

What's new in Repute 2.5?

New features

- Multi-threaded boundary element engine, up to 100x faster than before
- Support for spun piles and micropiles
- Action Import Wizard
- Pile Group Import Wizard
- Ability to choose which sections and materials appear in the Stockyard
- Support for BS 8004:2015
- Direct support for rock within the boundary element analysis

Improved features

- Pile Group Wizard now supports a wider range of pile types

- Greater distinction between different calculations in Stockyard
- Updated Quick-Start Tutorial
- Support for using the program across wide area networks
- Numerous other minor improvements

Documentation

Repute is supplied with a detailed Quick-start Guide, comprehensive User Manual, and authoritative Reference Manual. The latest versions of these manuals (including any corrections and/or additions since the program's first release) are available in electronic (Adobe® Acrobat®) format from the Geocentrix website. (www.geocentrix.co.uk/repute and follow links to Repute's documentation).

Quick-Start guide (this document)

The *Repute 2.5 Quick-Start Guide* includes six tutorials that show you how to use the main features of Repute. Each tutorial provides step-by-step instructions on how to drive the program. There are three tutorials dealing with single pile design and three with pile group design. The tutorials increase in difficulty and are designed to be followed in order.

User manual

The *Repute 2.5 User Manual* explains how to use Repute. It provides a detailed description of the program's user interface and explains how to employ it to maximum effect.

Reference manual

The *Repute 2.5 Reference Manual* gives detailed information about the engineering theory that underpins Repute's calculations. The manual assumes you have a working knowledge of the geotechnical design of single piles and pile groups but provides appropriate references for further study if you do not.

Help system

Repute's help system contains detailed information about the program, including most of the content of the *Quick-Start Guide*, *User Manual*, and

Reference Manual – plus additional information that is not found in any of these documents.

Help appears in a separate window to Repute, allowing you to view the help topics while you continue to work with Repute itself. To open the help system:

- Press F1
- Click the Help button in any dialog box
- Click on the Help button on the right-hand side of Repute's Ribbon

Note

Screenshots in this document were produced on Windows 10 and 11. Their appearance may differ on your computer. Not all options are available in every edition of Repute.

In this document, '[Docs]' refers to the folder where the documents that ship with Repute were installed, typically here:

C:\Users\Public\Documents\Geocentrix\Repute\2.5

Software Re-Assurance™

Software Re-Assurance for Repute (including updates, upgrades, and technical support) is available direct from Geocentrix or through your local distributor. To obtain Re-Assurance, contact Geocentrix as follows:

Repute Technical Support
Geocentrix Ltd
Scenic House, 54 Wilmot Way, Banstead, Surrey, SM7 2PY, United Kingdom
tel: +44 (0)1737 373963
email: support@geocentrix.co.uk
web: www.geocentrix.co.uk/support

Please quote your licence number when contacting technical support

Tutorial 1. H-pile in clay and sand

Introduction

This tutorial demonstrates the basic features of Repute, through a worked example involving the analysis of a single H-pile installed in clay and sand:

- Ground conditions comprise 5 m of clay overlying 20 m of dense sand. The clay has unit weight of 20.5 kN/m^3, angle of shearing resistance of 23 °, and undrained shear strength of 60 kPa. The sand has unit weight of 18 kN/m^3 and angle of shearing resistance of 35°.
- The foundation comprises a 305 x 305 x 110 H-pile of steel grade S275.
- A vertical load of 700 kN is to be applied to the pile.
- You want to determine the minimum length of pile needed to safely carry the applied action according to traditional UK practice.

This tutorial is written for users of the Standard, Enterprise, and Trial Editions of Repute only. Users of the Professional Edition should look at Tutorials 4-6.

Overview

- In Step 1, you will use the Project Wizard to enter project information, select a design standard, and create scenarios to represent short- and long-term conditions.
- In Step 2, you will use the Borehole Wizard to create a borehole containing clay and sand layers.
- In Step 3, you will create an H-pile and specify its cross-section and steel grade.
- In Step 4, you will create the force applied to the pile.
- In Step 5, you will use the Calculation Wizard to create the calculations you want Repute to perform.
- In Step 6, you will perform the calculations and review the results.
- In Step 7, you will produce a report summarising the results of the calculations.
- In Step 8, you will close (and optionally save) the project.

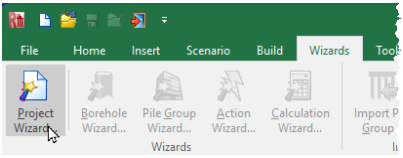
If Repute is not already running, open the program by pressing the Windows key, typing `Repute 2.5` in the search bar, and clicking on the `Repute 2.5` item that should appear. Once the splash screen has disappeared, Repute displays its Welcome screen.

If you have an existing project open, click **Close** on the program's **File** menu. (You will be prompted to save your work if you have not already done so.)

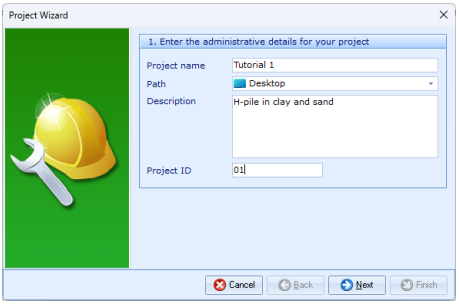
Step 1 – create the project

In Step 1, you will use the Project Wizard to enter project information, select a design standard, and create scenarios to represent short- and long-term conditions.

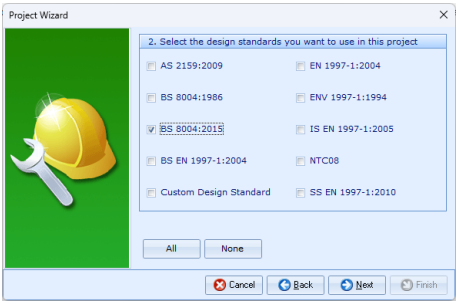
1. Open the **Project Wizard** by selecting the **Wizards** tab on Repute's ribbon and clicking on the **Project Wizard** button.



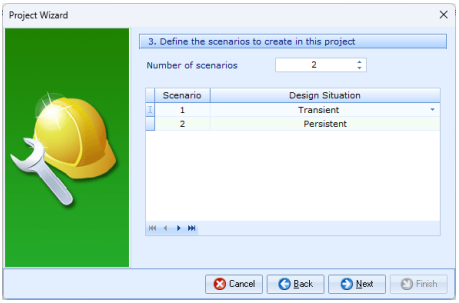
2. When the Wizard appears, type `Tutorial 1` in the **Project name** box. Choose the folder where you want to save this project by using the **Path** control. (If you do not change the setting here, it will be saved in your Documents folder.)
3. Enter `H-pile in clay and sand` in the **Description** box and `01` in the **Project ID** box.



4. Click **Next** to display the next page (the standards that appear depend on which edition of Repute you are running). Select `BS 8004:2015` by clicking on the relevant checkbox (a tick mark appears when a standard is selected).

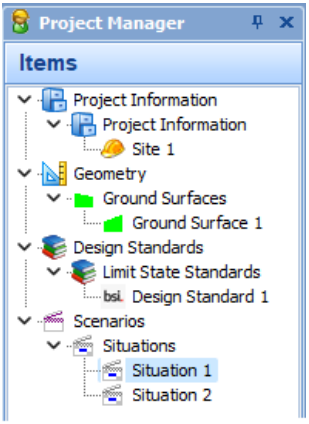


5. Click **Next** to display the next page. Increase the **Number of scenarios** to 2 and then change the **Design Situation** of Scenario 1 to `Transient` but leave Scenario 2 as `Persistent`.

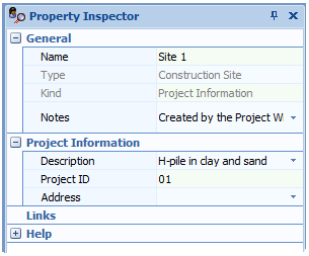


6. Click **Next** to display the final page. If you wish to review any of the settings you have made, click **Back** to return to the relevant page.
7. When you are ready, click **Finish** to generate the project. The **Project Wizard** then:
   - creates `Site 1`, `Ground Surface 1`, `Design Standard 1`, `Situation 1`, and `Situation 2`
   - adds `Ground Surface 1` to `Situation 1` and `Situation 2`
   - creates and saves a new project named `Tutorial 1.rpx` with all these items

8. You can view these items by right-clicking anywhere inside the **Project Manager** to display its context menu and selecting the **Expand All** command. The Project Manager will then look as shown in the picture alongside.



9. To view the properties of any particular item, select that item in the **Project Manager** (e.g. `Site 1`)
10. Display the Property Inspector for the item:
    - by right-clicking on the item, to display its context menu, and clicking the **Properties...** command; or
    - by double-clicking on the item
11. The program's **Property Inspector** will open and display the properties of the selected item. (For example, for Site 1 the **Description** is shown as `H-pile in clay and sand` and the **Project ID** as `01`.)

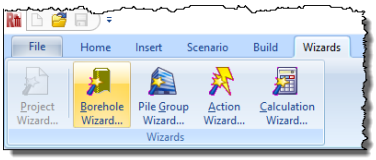


`[Docs]\Tutorials\Tutorial 1\Step 1.rpx` captures everything you've done so far.

Step 2 – create the borehole

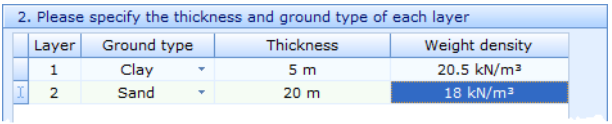
In Step 2, you will use the Borehole Wizard to create a borehole containing clay and sand layers.

1. Open the **Borehole Wizard** by selecting the **Wizards** tab on Repute's ribbon and then clicking on the **Borehole Wizard** button.

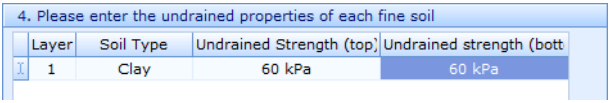


2. When the Wizard appears, increase the number of layers to 2.

3. Click **Next** to display page 2 of the Wizard. Change Layer 1 to `Clay`, its **Thickness** to 5 m, and its **Weight density** to 20.5 kN/m^3. Leave Layer 2 as `Sand` but change its thickness to 20 m and weight density to 18 kN/m^3.

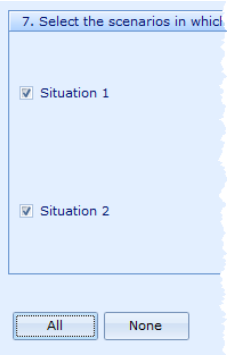


4. Click **Next** to display page 3. Change the **Internal friction** of Layer 1 to 23° and that of Layer 2 to 35°. Leave the **Cohesion** of both soils unchanged at 0 kPa and the **At Critical State?** boxes unchecked.
5. Click **Next** to display page 4. Change the **Undrained Strength (top)** and **Undrained Strength (bottom)** of Layer 1 to 60 kPa. Note that Soil 2 does not appear on this page, since – being a sand – it does not have undrained strength.



6. Click **Next** to display page 5. Since the ground profile does not include rock, there is nothing to set on this page.
7. Click **Next** to display page 6. Leave the stiffness properties (i.e. **Shear modulus**) of both layers unchanged.

8. Click **Next** to display page 7. Click **All** to select both scenarios.
9. Click **Next** to display the final page. If you wish to review any of the settings you have made, click **Back** to return to the relevant page.
10. When you are ready, click **Finish** to generate the borehole. The **Borehole Wizard** then:
    - creates `Soil 1` and `Soil 2`, `Layer 1` and `Layer 2`, and `Borehole 1`
    - links `Soil 1` to `Layer 1`
    - links `Soil 2` to `Layer 2`
    - adds `Layer 1` and `Layer 2` to `Borehole 1`

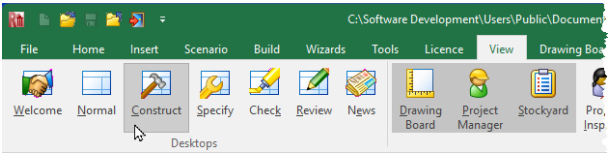


`[Docs]\Tutorials\Tutorial 1\Step 2.rpx` captures everything you've done so far.

Step 3 – create the pile

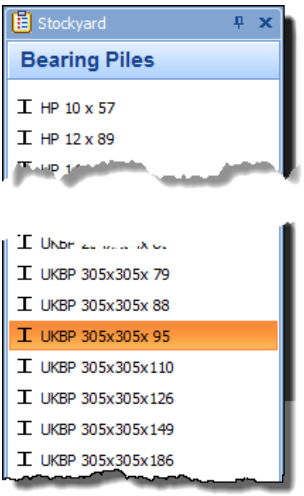
In Step 3, you will create an H-pile and specify its cross-section and steel grade.

1. Open the **Stockyard** by selecting the **View** tab on Repute's ribbon and then clicking on the **Construct** button.

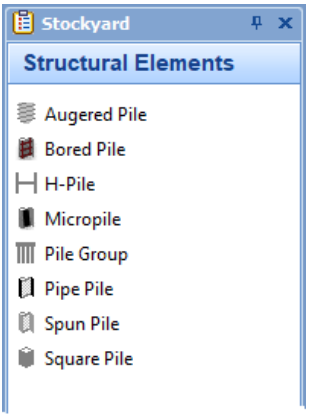


2. When the program has switched to its **Construction Desktop** (in which the **Drawing Board**, **Project Manager**, and **Stockyard** are displayed), right-click anywhere inside the **Stockyard** to display its context menu and select the **Sections > Bearing Piles** command. The Bearing Piles group will open.

3. Create the section by selecting the item labelled `UKBP 305x305x95`, right-clicking to display its context menu, and then selecting the command **Create 'UKBP 305x305x95'**. The newly created hot-rolled section will appear in the **Project Manager** (under Sections > Bearing Piles) as `Section 1`.



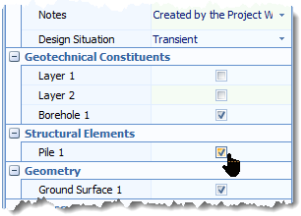
4. Next, right-click anywhere inside the **Stockyard** to display its context menu and select the **Steels** command. The Steels group will open.
5. Create the steel by holding the Ctrl key down and clicking on the item labelled `S275`. (When the Ctrl key is pressed, Repute automatically creates any item that you select in the Stockyard. This saves you the effort of displaying the popup menu each time you want to create a new item.) The newly created steel will appear in the **Project Manager** (under Materials > Steels) as `Steel 1`.
6. Finally, click on the **Stockyard**'s **Structural Elements** caption (near the bottom of the Stockyard). The Structural Elements panel will open.



7. Create the pile by holding the Ctrl key down and clicking on the item labelled `H-pile`. The newly created pile will appear in the **Project Manager** (under Structural Elements > Piles) as `Pile 1`.
8. In the **Project Manager**, right-click on `Pile 1` to display its context menu and select the **Properties...** command. The Property Inspector will appear.

9. In the **Property Inspector**, change the **Material Name** (under Material Properties) from `Not specified` to `Steel 1`. Then change the **Section Name** (under Section Properties) from `Not specified` to `Section 1`. Leave all other properties of the pile unchanged.

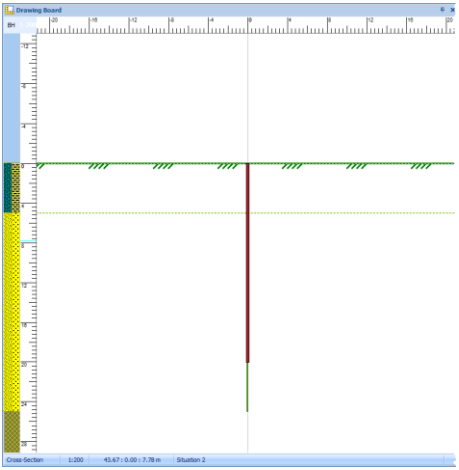
10. Returning to the **Project Manager**, select `Situation 1` (under Scenarios > Situations) and, in its **Property Inspector**, place a tick next to `Pile 1` (under Structural Elements) to add the pile to this scenario. The **Drawing Board** will refresh.



11. Repeat the previous instruction for `Situation 2`.

12. In this step, you have:
    - created `Section 1`, `Steel 1`, and `Pile 1`
    - linked `Section 1` and `Steel 1` to `Pile 1`
    - added `Pile 1` to `Situation 1` and `Situation 2`

13. The **Drawing Board** will now look something like this:

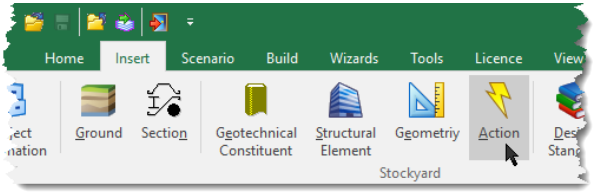


[Docs]\Tutorials\Tutorial 1\Step 3.rpx captures everything you've done so far.

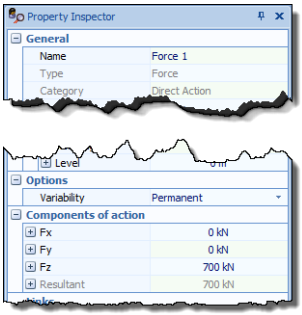
Step 4 – create the force

In Step 4, you will create the force applied to the pile.

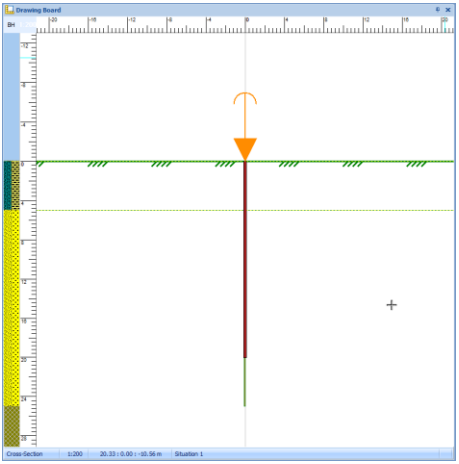
1. Open the **Stockyard**'s Actions panel by selecting the **Insert** tab on Repute's ribbon and then clicking on the **Action** button.



2. The Actions group will open in the **Stockyard**. Hold the Ctrl key down and click on the item labelled `Force`.
3. The newly created force will appear in the **Project Manager** (under Actions > Forces).
4. In the **Property Inspector**, change the **Variability** of `Force 1` (under Options) to `Permanent` and the value of **Fz** (under Components of Action) to 700 kN. The **Resultant** will automatically change to 700 kN.



5. Change the **Tether to ...** item to `Pile 1`. This will ensure that the force's plan position will always match the pile's plan position, even if the pile is moved.
6. In the **Project Manager**, select `Situation 1` (under Scenarios > Situations) and then, in its **Property Inspector**, place a tick next to `Force 1` (under Actions) to add the action to this scenario. The **Drawing Board** will refresh and now look like this:



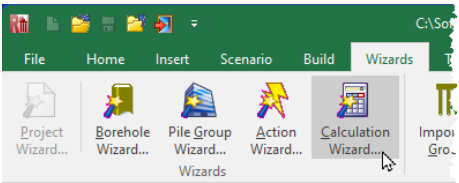
7. Repeat the previous instruction for `Situation 2`.
8. In this step, you have:
   - created `Force 1`
   - added `Force 1` to `Situation 1` and `Situation 2`

[Docs]\Tutorials\Tutorial 1\Step 4.rpx captures everything you've done so far.

Step 5 – create the calculations

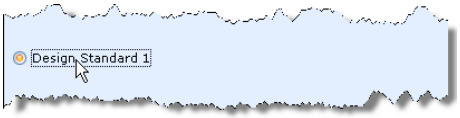
In Step 5, you will use the Calculation Wizard to create the calculations you want to perform.

1. Open the **Calculation Wizard** by selecting the **Wizards** tab on Repute's ribbon and then clicking on the **Calculation Wizard** button.



2. When the Wizard appears, select `Longitudinal ULS`. (The calculations that appear here depend on which edition of Repute you are running.)

3. Click **Next** to display page 2 of the Wizard. Select `Design Standard 1` (this is the BS 8004:2015 design standard created in Step 1 of this tutorial).



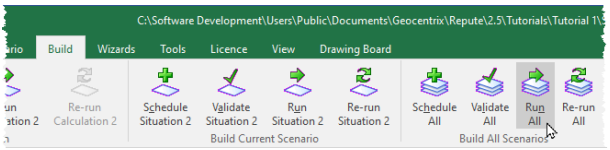
4. Click **Next** to display page 3. Click **All** to select both situations.
5. Click **Next** to display the final page of the Wizard. If you wish to review any of the settings you have made, click **Back** to return to the relevant page.
6. When you are ready, click **Finish** to generate the calculations.
7. The Calculation Wizard then:
   - creates `Calculation 1` and `Calculation 2`
   - links `Situation 1` to `Calculation 1`
   - links `Situation 2` to `Calculation 2`
   - links `Design Standard 1` to `Calculation 1` and `Calculation 2`

[Docs]\Tutorials\Tutorial 1\Step 5.rpx captures everything you've done so far.

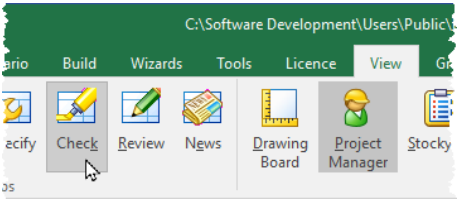
Step 6 – perform and review the calculations

In Step 6, you will perform the calculations and review the results.

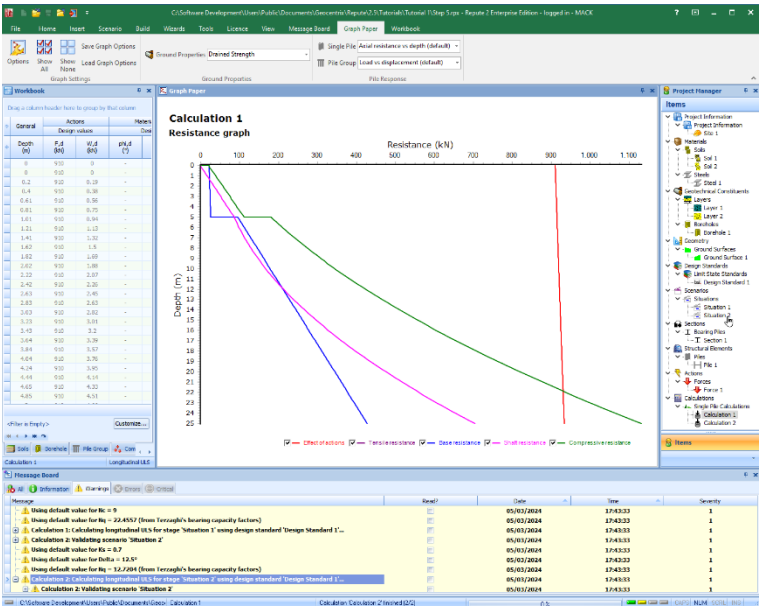
1. Run the calculations by selecting the **Build** tab on Repute's ribbon and then clicking on the **Run All** button.



2. Repute will perform all the calculations that you have specified (i.e. `Calculation 1` and `Calculation 2`) and then change to its **Checking Desktop** (which displays the Workbook and Graph Paper). You can switch to this display at any time by clicking on the **Check** button on the **View** tab of Repute's ribbon.



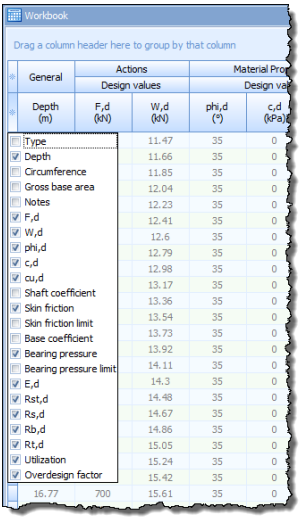
3. Your screen will now look something like this:



4. The **Graph Paper** (top-centre panel) shows:
   - the effects-of-actions *E* (the sum of the applied forces and the self-weight of the pile) increasing slightly with depth
   - separate components of shaft and base resistances, R_s and R_b

- the total compressive resistance, $R_c = R_s + R_b$, exceeding the effect of actions ($E \leq R_c$) at a depth between 13.5 and 14.5 m (depending on which calculation is displayed)

5. The **Workbook** (top-left panel) shows the same information, but in tabular format. The Workbook contains a lot more information than is initially shown. To display this additional information, click on the button labelled ***** in the top-left-hand corner of the Workbook (to the left of the heading **Depth**) and select the data you want to see.



6. The **Message Board** (bottom panel) shows any warning or error messages that were generated during the calculation. You should review these messages to ensure that the calculations have performed as you expected.

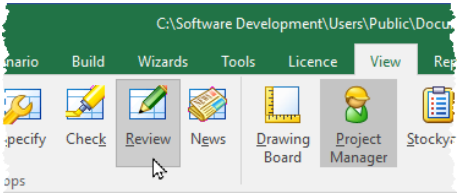
7. To view the results of the second calculation, select `Calculation 2` in the **Project Manager**. Repute will automatically update the Workbook and Graph Paper with this calculation's data.

[Docs]\Tutorials\Tutorial 1\Step 6.rpx captures everything you've done so far.

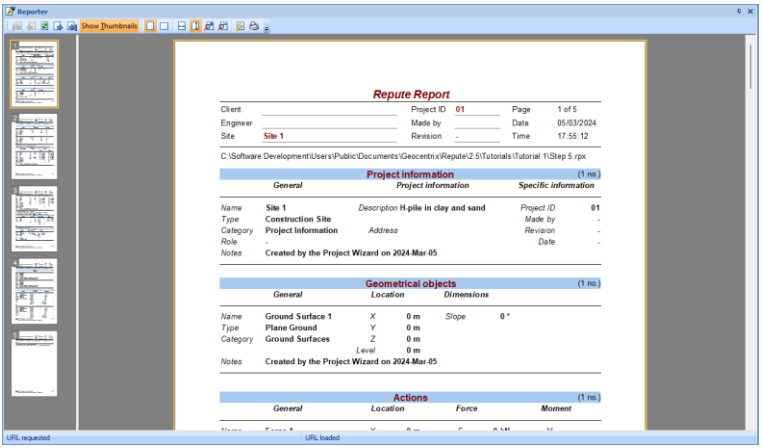
Step 7 – produce a report

In Step 7, you will produce a report summarising your calculations.

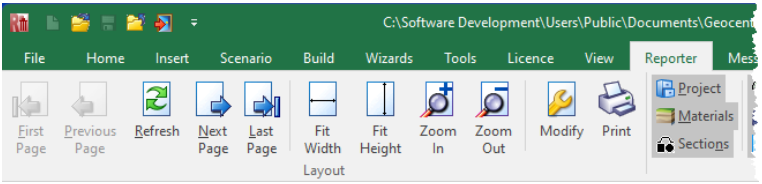
1. Display Repute's **Reporter** by selecting the **View** tab on the ribbon and then clicking on the **Review** button.



2. The Reporter will appear and automatically generate a report together with a set of thumbnails.



3. You can navigate around the report using the controls on the Reporter tab on the ribbon: **First Page**, **Previous Page**, **Next Page**, and **Last Page**. You can jump to specific pages by clicking on the thumbnails on the left-hand side.



4. You can also re-size the report using the **Fit Width**, **Fit Height**, **Zoom In**, and **Zoom Out** controls.
5. You can choose what to include in your report by selecting or deselecting individual items in the **Elements** group, then clicking the **Refresh** button.
6. Finally, you can output the report onto paper using the **Print** command and choosing from the options provided in the dialog box that appears on your screen.

Step 8 – close the project

In Step 8, you will close and – optionally – save the project. (Note: this is not available in the Trial Edition.)

1. Close the project by clicking on the File menu's **Close** command.
2. If you have made changes to the project since it was last saved, Repute will ask you if you want to save before proceeding. Click the appropriate button to answer **Yes** or **No**.
3. Repute will then (if requested) save and close the project.

You will find a copy of the project in its final form here:

[Docs]\Tutorials\Tutorial 1\Tutorial 1.rpx

What next?

Tutorial 2 shows you how to perform Fleming's hyperbolic analysis.

Tutorial 2. Fleming's hyperbolic analysis

Introduction

Tutorial 2 shows you how to construct a load vs displacement curve for a single pile, using Fleming's hyperbolic analysis, described in his 1992 Géotechnique paper *A new method for single pile settlement prediction and analysis* (see vol. 42, no. 3, pp 411-425). This tutorial demonstrates how to setup a calculation in Repute without using the program's built-in wizards, thereby showing you how versatile the program's user interface is.

The worked example is taken from Figure 6 in Fleming's paper, which is based upon from tests carried out at Wembley by Whitaker and Cooke. We are interested in replicating the load vs displacement curve given by Fleming's analysis.

- Ground conditions at the site are not given in the paper, so we will assume 25 m of London Clay with an undrained strength of 100 kPa and internal friction angle of 23°.
- The pile studied is a 12.2 m long, 775 mm diameter bored pile made of concrete with Young's modulus equal to 19.5 GPa.
- A vertical load of 200 tonnes (approximately 2000 kN) is applied at the centre of the pile.
- The ultimate load that the pile can carry has been calculated (separately) as 1994 kN on the shaft and 1002 kN from the base. The soil modulus below the pile base is 33.125 MPa. Other parameters used by Fleming are the shaft flexibility factor (0.0017 or 0.17%) and effective column length factor (0.45).

This tutorial is written for users of the Standard, Enterprise, and Trial Editions of Repute only. Users of the Professional Edition should look at Tutorials 4-6.

Overview

- In Step 1, you will enter project information about the site and the Engineer.
- In Step 2, you will define the site's ground conditions.

- In Step 3, you will create a bored pile and specify its cross-section and concrete grade.
- In Step 4, you will create the force applied to the pile.
- In Step 5, you will sleeve the pile through the made ground.
- In Step 6, you will create the scenario and calculation and link various items together.
- In Step 7, you will perform the calculation and produce a report showing the relationship between load and displacement.
- In Step 8, you will close (and optionally save) the project.

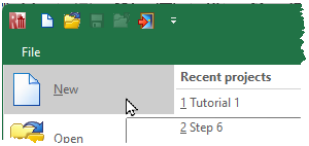
If Repute is not already running, open the program by pressing the Windows key, typing `Repute 2.5` in the search bar, and clicking on the `Repute 2.5` item that appears. Once the splash screen has disappeared, Repute displays its Welcome screen.

If you have an existing project open, click **Close** on the program's **File** menu. (You will be prompted to save your work if you have not already done so.)

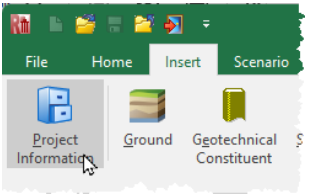
Step 1 – create the project information

In Step 1, you will enter project information about the site and the Engineer.

1. Click **New** on the program's **File** menu to create a blank project. Alternatively, click on the **New** button on the **Quick-access toolbar**, located on the right-hand side of Repute's icon in the tile bar.

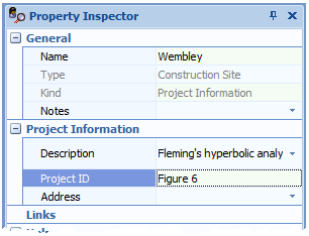


2. Open the Stockyard's Project Information group by selecting the **Insert** tab on Repute's ribbon and then clicking on the **Project Information** button.



3. In the **Stockyard**, hold the `Ctrl` key down and click on the item labelled `Construction Site`. A newly created site will appear in the Project Manager (under Project Information > Project Information).

4. In the **Project Manager**, double-click on the newly created site (`Site 1`) to open its Property Inspector.
5. In the **Property Inspector**, change the **Name** to `Wembley`; enter `Fleming's hyperbolic analysis` in the **Description** box and click **OK** to confirm what you have typed; and, finally, enter `Figure 6` in the **Project ID** box.

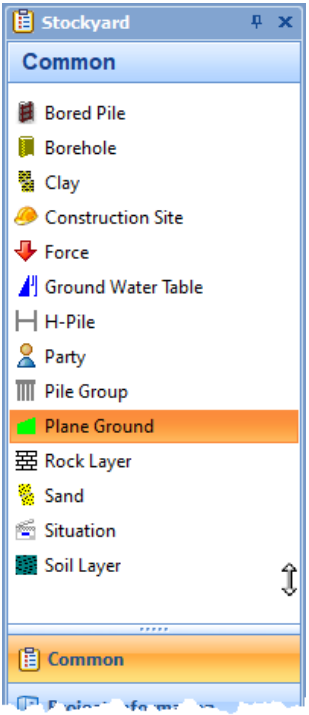


6. Returning to the **Stockyard**, create a Party by holding down the `Ctrl` key and clicking on the item labelled `Party`. A newly created party will appear in the Project Manager (under Project Information > Project Information) as `Party 1` and the Property Inspector will display its default properties.
7. In the **Property Inspector**, change the **Name** of the newly created party to `Whitaker and Cooke` and the role to `Engineer` (if not already selected).

[Docs]\Tutorials\Tutorial 2\Step 1.rpx captures everything you've done so far.

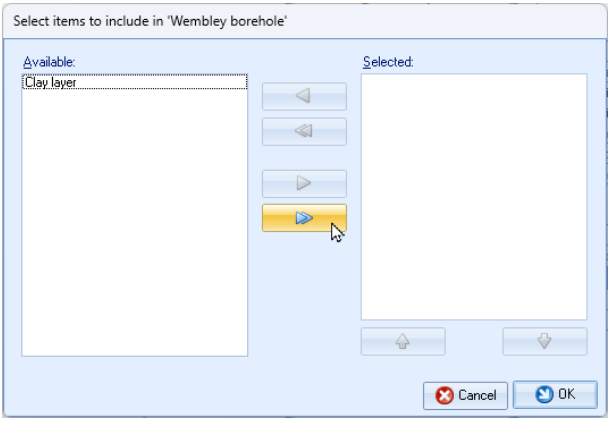
Step 2 – create the ground conditions

In Step 2, you will define the site's ground conditions.



1. Returning to the **Stockyard**, click on the button labelled **Common** to open the Common group, where you will find (amongst other items) Plane Ground.
2. Hold the **Ctrl** key down and click on the item labelled `Plane Ground` to create it.
3. In the **Property Inspector**, change the **Name** `Ground Surface 1` to `Horizontal ground` but leave the other (default) properties unchanged.
4. Back in the **Stockyard**, open the **Grounds** group so that you can create a Clay. You may need to click one of the small buttons at the bottom of the Stockyard to display this group. You can move the mouse over each button in turn to display a tooltip indicating which panels they control. Create the Clay by `Ctrl`-clicking on it.
5. In the **Property Inspector**, change the **Name** of the new Clay to `London Clay` and enter the following properties: under the heading **Strength > Drained Strength**, **Peak friction** = 23°; under **Strength > Undrained strength**, Undrained strength = 100 kPa.
6. In the **Stockyard**, open the **Geotechnical Constituents** group and create both a `Soil Layer` and a `Borehole`.
7. Select `Layer 1` in the **Project Manager** and then (in the **Property Inspector**) change its **Name** to `Clay layer`, its **Thickness** to 25 m, and select `London Clay` in its **Soil** box.
8. Now select `Borehole 1` in the **Project Manager** and (in the **Property Inspector**) rename it `Wembley borehole`. Next, press the **Select ...** button.

9. In the dialog box that appears, click on the **>>** button to move `Clay layer` from the **Available layers** box to the **Selected layers box**. Click **OK** to confirm the changes.

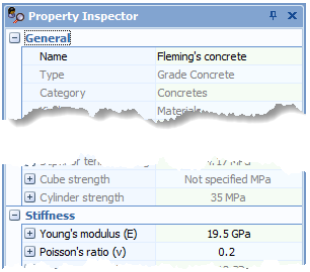


[Docs]\Tutorials\Tutorial 2\Step 2.rpx captures everything you've done so far.

Step 3 – create the pile

In Step 3, you will create a bored pile and specify its cross-section and concrete grade.

1. Right-click on the **Stockyard** and selected **Concretes** from the op-up menu that appears. Then `Ctrl`-click on the concrete grade `C35/45`.
2. In the **Property Inspector**, change the **Young's modulus (E)** of the new concrete to 19.5 GPa and its **Name** to `Fleming's concrete`.
3. Open the **Structural Elements** group in the **Stockyard** and create a `Bored Pile`.

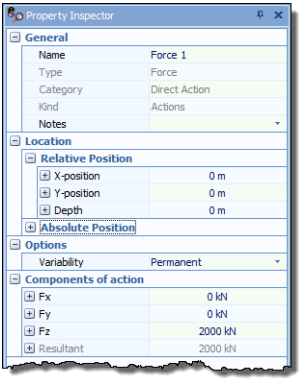


4. In the **Property Inspector**, change the **Length** of the new pile to 12.2 m and its **Shaft diameter** to 775 mm (its **Base diameter** will automatically increase to 775 mm). Finally, select `Fleming's concrete` in the **Material name** box.

[Docs]\Tutorials\Tutorial 2\Step 3.rpx captures everything you've done so far.

Step 4 – create the force

In Step 4, you will create the force applied to the pile.

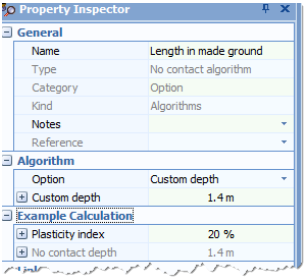


1. Open the **Actions** group in the **Stockyard** and create a `Force`.
2. In the **Property Inspector**, change the **Options > Variability** flag of the new force to `Permanent`.
3. Change **Fz** (under **Components of action**) to 2000 kN, whereupon the **Resultant** will automatically change to 2000 kN.

[Docs]\Tutorials\Tutorial 2\Step 4.rpx captures everything you've done so far.

Step 5 – sleeve the pile

In Step 5, you will sleeve the pile through the made ground.



1. Open the **Algorithms** group in the **Stockyard** and create a `No contact algorithm`.
2. In the **Property Inspector**, change the **Name** of the new algorithm to `Length in made ground` and its **Custom depth** to 1.4 m. The **Algorithm Option** will automatically change to `Custom depth`. In the example calculation, the **No contact depth** will also change to 1.4 m

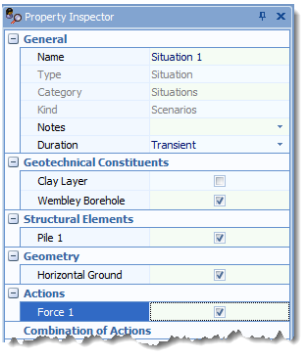
(which is depth of ground that the calculation will ignore when calculating shaft friction).

[Docs]\Tutorials\Tutorial 2\Step 5.rpx captures everything you've done so far.

Step 6 – create the scenario and calculation

In Step 6, you will create the scenario and calculation and link various items together.

1. Open the **Common** group in the **Stockyard** and create a `Situation`.
2. In the **Property Inspector**, change the scenario's **Duration** to `Transient` (if not already set). Then, tick the following items so that they appear in this scenario (as you do so, they will appear on the Drawing Board):



   - `Wembley borehole`
   - `Pile 1`
   - `Horizontal ground`
   - `Force 1`
3. Open the **Calculations** group in the **Stockyard** and create a `Fleming's Analysis`.
4. In the **Property Inspector**, set the **Scenario** to `Situation 1` and the **No contact algorithm** to `Length in made ground`.
5. Enter the following values for the calculation's other properties: **Ultimate shaft load (Us)** = 1994 kN; **Ultimate base load (Ub)** = 1002 kN; **Base stiffness (Eb)** = 33.125 MPa; **Shaft flexibility (Ms)** = 0.17%; and **Effective column length (Ke)** = 45%. These values are taken directly from Fleming's paper.
6. Finally, set the **Maximum settlement ratio** to 1%. This controls how much of the load vs displacement curve is generated. You

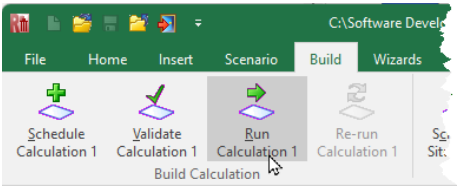
want to go up to about 8 mm displacement, which is 1% of the pile diameter.

[Docs]\Tutorials\Tutorial 2\Step 6.rpx captures everything you've done so far.

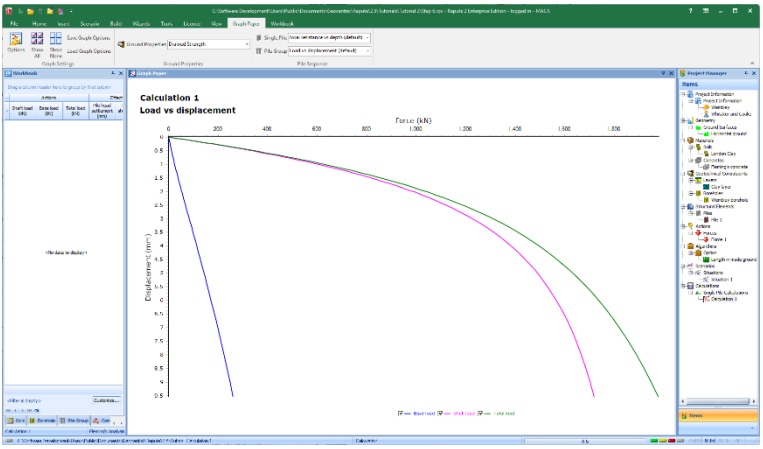
Step 7 – perform and review the calculation

In Step 7, you will perform the calculation and produce a report showing the relationship between load and displacement.

1. Run the calculation by selecting the **Build** tab on Repute's ribbon and then clicking on the button labelled `Run Calculation 1`.



2. Repute performs the calculation and then changes to its **Checking Desktop** (which displays the **Workbook** and **Graph Paper**).
3. Your screen will now look something like this:



4. The **Graph Paper** displays a graph which is near-identical to Figure 6 in Fleming's paper, showing:
   - base load vs displacement (in blue)

- shaft load vs displacement (in pink)
- total load vs displacement (in green)

5. You can view the data on which this graph is based in the **Workbook** (left).

Step 8 – close the project

In Step 8, you will close and – optionally – save the project. (Note: this is not available in the Trial Edition.)

1. Close the project by clicking on the **File** menu's **Close** command.
2. If you have made changes to the project since it was last saved, Repute will ask you if you want to save before proceeding. Answer **Yes** or **No** by clicking the appropriate button.
3. Repute will then (if requested) save and close the project.

You will find a copy of the project in its final form here:

[Docs]\Tutorials\Tutorial 2\Tutorial 2.rpx

What next?

Tutorial 3 shows you how to design a single pile in accordance with the requirements of Eurocode 7.

Tutorial 3. Single pile design to Eurocode 7

Introduction

Tutorial 3 shows you how to design a single pile according to the requirements of Eurocode 7. The worked example is taken from Chapter 13 of the book *Decoding Eurocode 7* by Bond and Harris (2008), London: Taylor and Francis.

- Ground conditions comprise 8 m of medium strength sandy CLAY overlying medium dense gravelly SAND. The clay has a representative undrained strength of 45 kPa and a representative weight density of 18.5 kN/m^3. The sand has a representative peak internal friction angle of 36°, zero effective cohesion, and representative weight density of 20 kN/m^3. The sand's constant-volume angle of shearing-resistance is 33°.
- Groundwater at the site is at 1 m depth and skin friction above groundwater will be ignored.
- The pile studied is a 10 m long, 400 mm square pile made of concrete with characteristic weight density of 25 kN/m^3.
- Vertical loads of 650 kN (permanent) and 250 kN (variable) will be applied to the pile.
- You want to determine the minimum pile length required by Eurocode 7 according to the National Annexes published in Ireland and in the United Kingdom.

Full hand calculations for this example are given as Examples 13.1 and 13.2 in Bond and Harris (2008).

This tutorial is written for users of the Standard, Enterprise, and Trial Editions of Repute only. Users of the Professional Edition should look at Tutorials 4-6.

Overview

- In Step 1, you will use the Project Wizard to enter project information, select design standards, and create a scenario to represent short-term conditions.

- In Step 2, you will use the Borehole Wizard to create a borehole containing the clay and sand layers.
- In Step 3, you will add a water table to the scenario.
- In Step 4, you will create a pile and specify its cross-section and concrete grade.
- In Step 5, you will use the Action Wizard to create the forces applied to the pile.
- In Step 6, you will use the Calculation Wizard to create a calculation and specify the design standard to use in that calculation.
- In Step 7, you will specify precise details of how you want the calculation to be performed.
- In Step 8, you will perform the calculations and review the results.
- In Step 9, you will create a second calculation, identical to the first but based on the UK National Annex to Eurocode 7.
- In Step 10, you will close (and optionally save) the project.

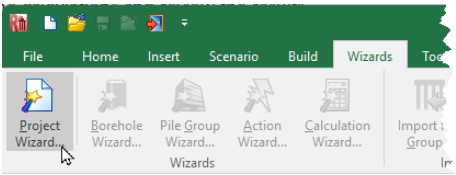
If Repute is not already running, open the program by pressing the Windows key, typing `Repute 2.5` in the search bar, and clicking on the `Repute 2.5` item that should appear. Once the splash screen has disappeared, Repute displays its Welcome screen.

If you have an existing project open, click **Close** on the program's **File** menu. (You will be prompted to save your work if you have not already done so.)

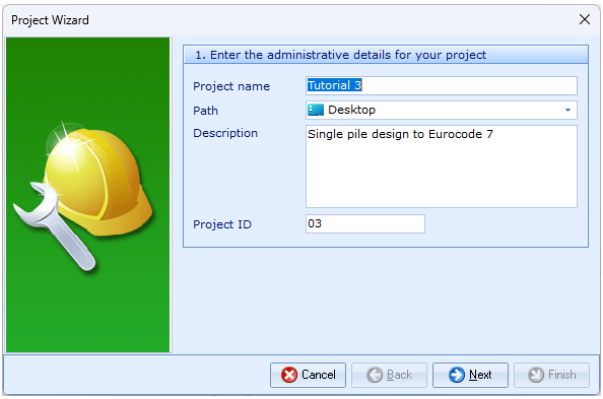
Step 1 – create the project

In Step 1, you will use the Project Wizard to enter project information, select design standards, and create a scenario to represent short-term conditions.

1. Open the **Project Wizard** by selecting the **Wizards** tab on Repute's ribbon and then clicking on the **Project Wizard** button.

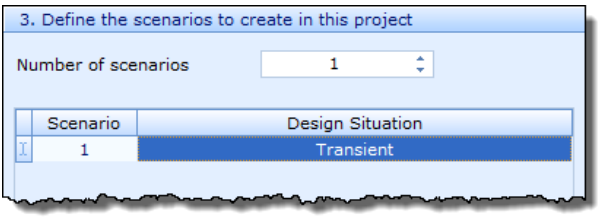


2. When the Wizard appears, type `Tutorial 3` in the **Project name** box. Choose the folder where you want to save this project by using the **Path** control – for example, choose `Desktop` if you want to save the project on Windows' Desktop.
3. Enter `Single pile design to Eurocode 7` in the **Description** box and `03` in the **Project ID** box.



4. Click **Next** to display page 2 of the Wizard. The design standards that appear here depend on which edition of Repute you are running (the Enterprise Edition supports more design standards than the Standard and Professional editions).
5. Select `BS EN 1997-1:2004` and `IS EN 1997-1:2005` by clicking on the relevant check boxes (a tick mark appears next to a standard when it is selected).

6. Click **Next** to display page 3. Keep the **Number of scenarios** as `1` but change the **Design Situation** of Scenario 1 to `Transient`.



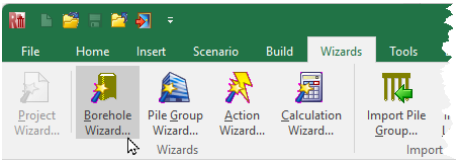
7. Click **Next** to display the final page of the Wizard. If you wish to review any of the settings you have made, click **Back** to return to the relevant page.
8. Click **Finish** to generate the project. The Project Wizard then:
   - creates `Site 1`, `Ground Surface 1`, `Design Standard 1` and `Design Standard 2`, and `Situation 1`
   - adds `Ground Surface 1` to `Situation 1`
   - creates a new project named `Tutorial 3.rpx` containing all these items
9. Finally, rename the design standards to make it easier to identify them later, as follows. In the **Project Manager**, right-click on `Design Standard 1` (under **Design Standards > Limit State Standards**) and select **Properties …**. The **Property Inspector** will appear. Change the **Name** of this standard to `EC7 with UK NA`.
10. Repeat the previous step for `Design Standard 2`, renaming it `EC7 with Irish NA`.

[Docs]\Tutorials\Tutorial 3\Step 1.rpx captures everything you've done so far.

Step 2 – create the borehole

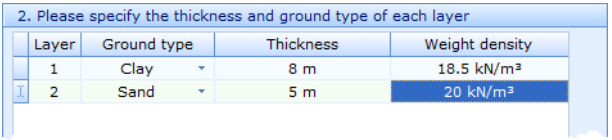
In Step 2, you will use the Borehole Wizard to create a borehole containing the clay and sand layers.

1. Open the **Borehole Wizard** by selecting the **Wizards** tab on Repute's ribbon and clicking on the **Borehole Wizard** button.

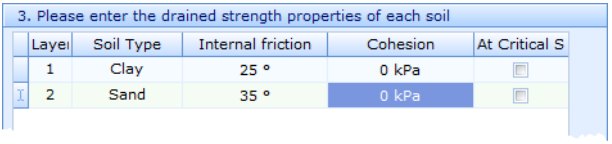


2. When the Wizard appears, set the number of layers to 2.

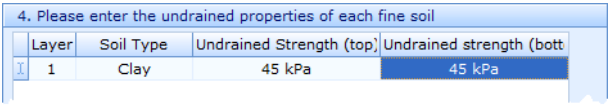
3. Click **Next** to display page 2 of the Wizard. Change Layer 1's **Ground type** to `Clay`, it **Thickness** to 8 m, and its **Weight density** to 18.5 kN/m^3. Leave Layer 2's **Ground type** as `Sand` and its **Weight density** as 20 kN/m^3 but change its **Thickness** to 5 m.



4. Click **Next** to display page 3. Leave the clay's properties unchanged but change the sand's **Internal friction** to 35°. Leave its **Cohesion** at 0 kPa and leave the **At Critical State?** box unticked.



5. Click **Next** to display page 4. The sand does not appear on this page since – as a fine soil – it does not have undrained strength. Change the **Undrained Strength (top)** and **Undrained Strength (bottom)** of the clay to 45 kPa.

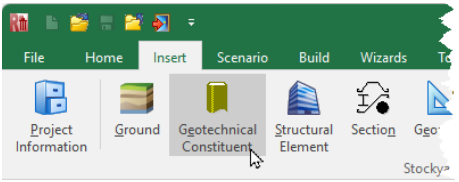


6. Click **Next** to display page 5. Since the ground profile does not include rock, there is nothing to set on this page.
7. Click **Next** to display page 6. Leave the stiffness properties (i.e. **Shear Modulus**) of both layers unchanged.
8. Click **Next** to display page 7. Tick `Situation 1` to add the new borehole to that scenario.
9. Click **Next** to display the final page of the Wizard. If you wish to review any of the settings you have made, click **Back** to return to the relevant page.
10. Click **Finish** to generate the borehole. **The Borehole Wizard** then:
    - creates `Soil 1` and `Soil 2`, `Layer 1` and `Layer 2`, and `Borehole 1`
    - links `Soil 1` to `Layer 1`
    - links `Soil 2` to `Layer 2`
    - adds `Layer 1` and `Layer 2` to `Borehole 1`

[Docs]\Tutorials\Tutorial 3\Step 2.rpx captures everything you've done so far.

Step 3 – add a water table

In Step 3, you will add a water table to the scenario.



1. Open the **Stockyard**'s Geotechnical Constituents panel by selecting the **Insert** tab on Repute's ribbon and then clicking on the **Geotechnical Constituents** button.
2. Hold the `Ctrl` key down and click on the item labelled `Ground Water Table`. The newly created water table will appear in the **Project Manager** (under Geotechnical Constituents > Water Tables).

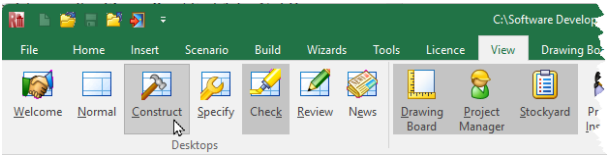
3. In the **Property Inspector** (under Location > Relative Position), change the **Depth** of `Water Table 1` to 1 m.
4. In the **Project Manager**, select `Situation 1` (under Scenarios > Situations).
5. In the **Property Inspector**, place a tick next to `Water Table 1` (under Geotechnical Constituents) to add the water table to this scenario. The **Drawing Board** will refresh.
6. In this step, you have:
   - created `Water Table 1`
   - added `Water Table 1` to `Situation 1`

[Docs]\Tutorials\Tutorial 3\Step 3.rpx captures everything you've done so far.

Step 4 – create the pile

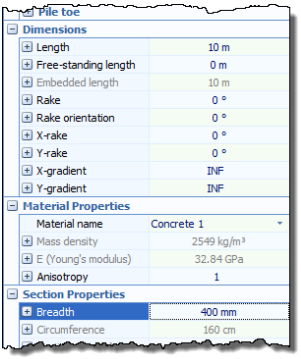
In Step 4, you will create a pile and specify its cross-section and concrete grade.

1. Display Repute's **Construct desktop** by



selecting the **View** tab and clicking on the **Construct** button. The program will display the **Drawing Board**, **Project Manager**, and **Stockyard**.
2. Right-click anywhere inside the **Stockyard** to display its context menu and select the **Concretes** command. The **Concretes** group will open.
3. Create the concrete by holding the `Ctrl` key down and clicking on `C30/37`. (When the `Ctrl` key is pressed, Repute automatically creates an instance of the item that is selected in the **Stockyard**.) The newly created concrete will appear in the **Project Manager** (under Materials > Concretes).
4. Next, click on the **Stockyard**'s Structural Elements caption (near the bottom of the Stockyard). The **Structural Elements** group will open.

5. Create the pile by holding the `Ctrl` key down and clicking on `Square Pile`. The newly created pile will appear in the **Project Manager** (under Structural Elements > Piles).
6. In the **Project Manager**, right-click on `Pile 1` and select **Properties ...**. The **Property Inspector** will appear.
7. In the **Property Inspector**, change the **Material name** (under Material Properties) from `Not specified` to `Concrete 1`. Then change the pile's **Length** (under Dimensions) to 10 m and its **Breadth** (under Section Properties) to 400 mm. Leave all other properties of the pile unchanged.



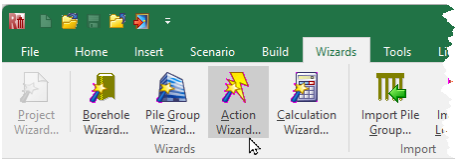
8. Returning to the **Project Manager**, select `Situation 1` (under Scenarios > Situation).
9. In the **Property Inspector**, place a tick next to `Pile 1` (under Structural Elements) to add the pile to this scenario. The **Drawing Board** will refresh.
10. In this step, you have:
    - created `Concrete 1` and `Pile 1`
    - linked `Concrete 1` to `Pile 1`
    - added `Pile 1` to `Situation 1`

[Docs]\Tutorials\Tutorial 3\Step 4.rpx captures everything you've done so far.

Step 5 – create the forces

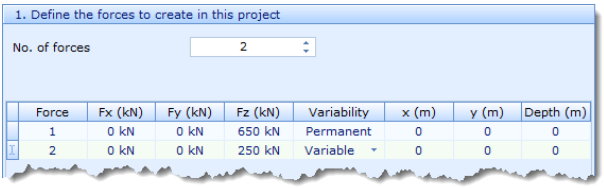
In Step 5, you will use the Action Wizard to create the forces applied to the pile.

1. Open the **Action Wizard** by selecting the **Wizards** tab on Repute's ribbon

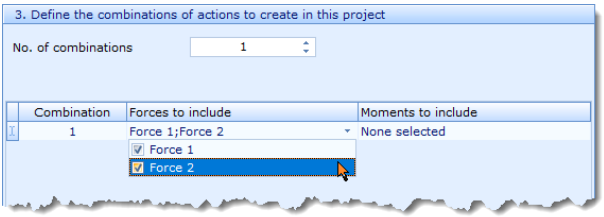


and clicking on the **Action Wizard** button.

2. When the Wizard appears, increase the **No. of forces** to 2; `Force 1` and `Force 2` will be created.
3. Set the **Fz** value for `Force 1` to 650 kN and change its **Variability** to `Permanent`. Then set the **Fz** value for `Force 2` to 250 kN but keep its **Variability** as `Variable`. Leave all other properties unchanged (at zero).



4. Click **Next** to display page 2 of the Wizard. Since no moments are applied to the pile, leave the **No. of moments** as 0.
5. Click **Next** to display page 3. Increase the **No. of combinations** to 1; `Combination 1` will be created. Click on the label `None selected` under the column **Forces to include** and then tick `Force 1` and `Force 2`.



6. Click **Next** to display the last page of the Wizard. If you wish to review any of the settings you have made, click **Back** to return to the relevant page.
7. Click **Finish** to generate the actions and their combination. The **Actions Wizard** will then:
   - create `Force 1` and `Force 2`
   - create `Combination 1`
   - add `Force 1` and `Force 2` to `Combination 1`
8. Returning to the **Project Manager**, select `Situation 1` (under Scenarios > Situations).

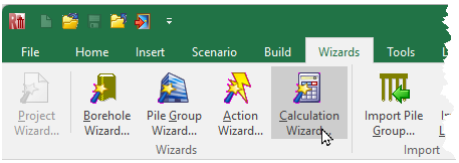
9. Then, in the **Property Inspector**, place a tick next to `Combination 1` (under Actions) to add the combination to this scenario. The **Drawing Board** will refresh.

[Docs]\Tutorials\Tutorial 3\Step 5.rpx captures everything you've done so far.

Step 6 – create the calculation

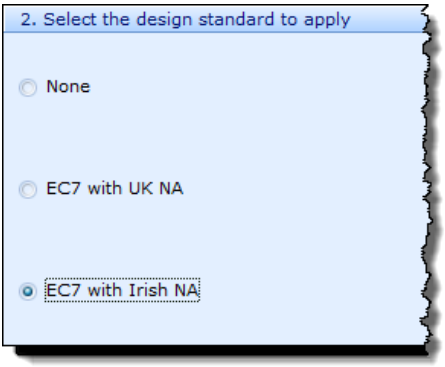
In Step 6, you will use the Calculation Wizard to create a calculation and specify the design standard to use in that calculation.

1. Open the **Calculation Wizard** by selecting the **Wizards** tab on Repute's ribbon and then clicking on the **Calculation Wizard** button.



2. When the Wizard appears, tick `Longitudinal ULS`. (The calculations that appear here depend on which edition of Repute you are running. The Enterprise Edition provides more calculations than the Standard and Professional editions.)

3. Click **Next** to display page 2 of the Wizard. Select `EC7 with Irish NA`.



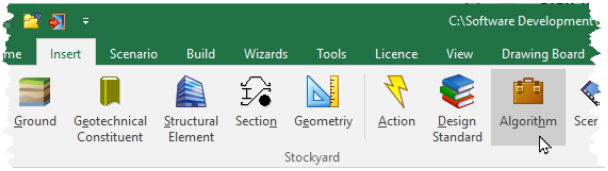
4. Click **Next** to display page 3. Tick `Situation 1`.
5. Click **Next** to display the final page of the Wizard. If you wish to review any of the settings you have made, click **Back** to return to the relevant page.
6. When you are ready, click **Finish** to generate the first calculation. The **Calculation Wizard** then:
   - creates `Calculation 1`
   - links `Situation 1` to `Calculation 1`
   - links `EC7 with Irish NA` to `Calculation 1`

[Docs]\Tutorials\Tutorial 3\Step 6.rpx captures everything you've done so far.

Step 7 – customize the calculation

In Step 7, you will specify precise details of how the calculation is to be performed, following the decisions made by Bond and Harris, 2008.

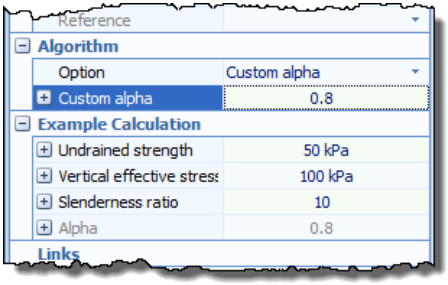
1. Open the **Stockyard**'s Algorithms group by selecting the **Insert** tab on Repute's ribbon and then clicking on the **Algorithm** button.



2. Hold the `CTRL` key down and click on `No contact algorithm` in the **Stockyard**. Then, in the **Property Inspector**,

change the **Name** of the new algorithm to `No skin friction` and enter `Ignore skin friction above water table` in its **Notes** field. Enter a value of 1.0 m into the **Custom depth** box, whereupon **Algorithm > Option** will automatically change to `Custom depth`.

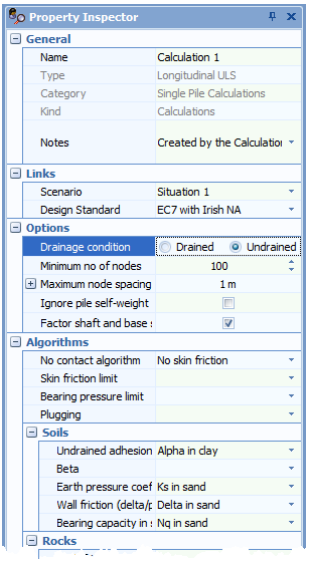
3. Hold the `CTRL` key down and click on `Alpha` in the **Stockyard**. Change the **Name** of the new algorithm to `Alpha in clay` and enter `From US Army Corps of Engineers` in its **Notes** field. Enter a value of 0.8 into the **Custom alpha** box, whereupon **Algorithm > Option** will automatically change to `Custom alpha`.



4. Hold the `CTRL` key down and click on `Earth pressure coefficient` in the **Stockyard**. Change the **Name** of the new algorithm to `Ks in sand` and enter `Nq/50` in its **Notes** field. Enter a value of 1.59 into the **Custom compression coefficient** box, whereupon **Algorithm > Option** will automatically change to `Custom earth pressure coefficient`.
5. Hold the `CTRL` key down and click on `Wall friction` in the **Stockyard**. Change the **Name** of the new algorithm to `Delta in sand` and enter `critical state friction angle` in its Notes field. Enter a value of 33° into the **Custom friction value** box, whereupon **Algorithm > Option** will automatically change to `Custom friction value`.
6. Hold the CTRL key down and click on `Bearing capacity algorithm` in the **Stockyard**. Change the **Name** of the new algorithm to `Nq in sand`. Change the **Option** to `Berezantzev`. In the **Example Calculation** group, change the

Angle of shearing resistance to 35° and the **Slenderness ratio** to 25. The value of **Nq** will update (to 47.23), while **Nc** remains `Not specified` (Berezantzev's algorithm is only applicable to sands, hence N_c is not available).

7. In the **Project Manager** (under Calculations > Single Pile Calculations), select `Calculation 1`.
8. In the **Property Inspector**, link the calculation to the algorithms you have just created by selecting the appropriate items in the drop-down boxes next to the following headings.
9. Under **Algorithms**:
   - **No contact algorithm** – select `No skin friction`
10. Under **Soils**:
    - **Undrained adhesion** – select `Alpha in clay`
    - **Earth pressure coefficient** – select `Ks in sand`
    - **Wall friction (delta/phi)** – select `Delta in sand`
    - **Bearing capacity in soil** – select `Nq in sand`
11. Finally, set the **Drainage condition** to `Undrained` to tell the program to base the calculation in clay on total stresses.

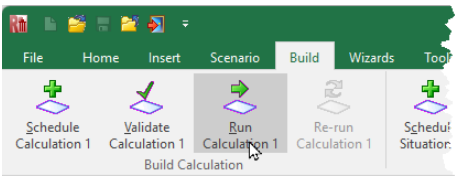


[Docs]\Tutorials\Tutorial 3\Step 7.rpx captures everything you've done so far.

Step 8 – perform and review the calculations

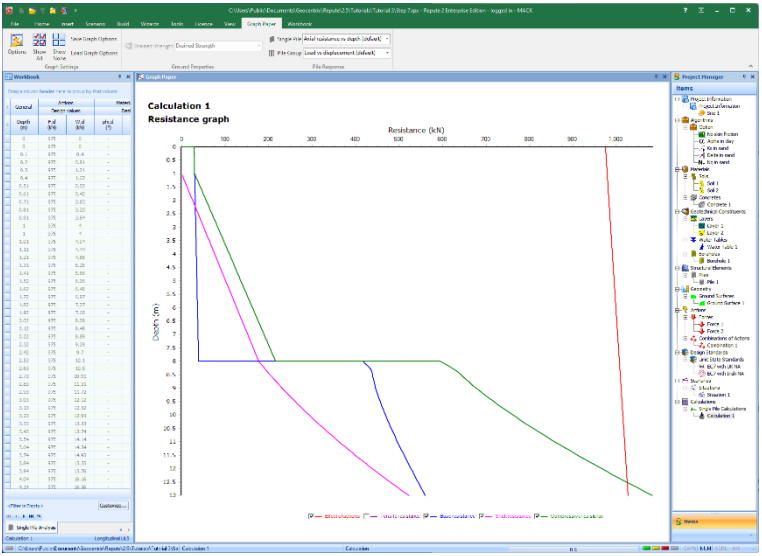
In Step 8, you will perform the calculation and review the results.

1. Run the calculation by selecting the **Build** tab on Repute's ribbon and then

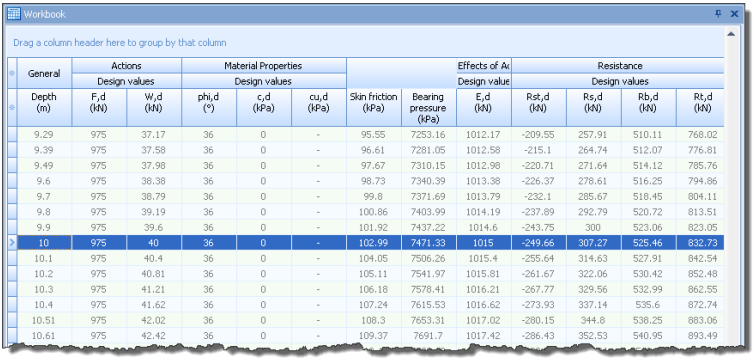


clicking on the `Run Calculation 1` button.

2. Repute will perform the specified calculation and then change to its **Check Desktop** (which displays the **Workbook** and **Graph Paper**). Your screen will now look something like this:



3. The **Graph Paper** (middle panel) shows the:
   - effect of actions (E, equal to the sum of the applied forces and the self-weight of the pile) increasing with depth
   - separate components of tensile resistance (R_t), base resistance (R_b), and shaft resistance (R_s) also increasing with depth
   - the total compressive resistance ($R_c = R_s + R_b$) exceeding the effect of actions ($R_c > E$) at a depth between 11 and 12 m
4. The **Workbook** (left panel) shows the same information in tabular format. The Workbook contains a lot more information than is initially shown. To display this additional information, click on the button in the top-left-hand corner (labelled *****) and select the data you want to see. The picture here shows results for the depth 10 m.

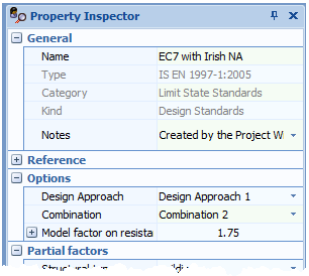

Workbook

Drag a column header here to group by that column

General	Actions		Material Properties					Effects of Ac	Resistance			
	Design values		Design values					Design value	Design values			
Depth (m)	F,d (kN)	W,d (kN)	phi,d (°)	c,d (kPa)	cu,d (kPa)	Skin friction (kPa)	Bearing pressure (kPa)	E,d (kN)	Rst,d (kN)	Rs,d (kN)	Rb,d (kN)	Rt,d (kN)
9.29	975	37.17	36	0	-	95.55	7253.16	1012.17	-209.55	257.91	510.11	768.02
9.39	975	37.58	36	0	-	96.61	7281.05	1012.58	-215.1	264.74	512.07	776.81
9.49	975	37.98	36	0	-	97.67	7310.15	1012.98	-220.71	271.64	514.12	785.76
9.6	975	38.38	36	0	-	98.73	7340.39	1013.38	-226.37	278.61	516.25	794.86
9.7	975	38.79	36	0	-	99.8	7371.69	1013.79	-232.1	285.67	518.45	804.11
9.8	975	39.19	36	0	-	100.86	7403.99	1014.19	-237.89	292.79	520.72	813.51
9.9	975	39.6	36	0	-	101.92	7437.22	1014.6	-243.75	300	523.06	823.05
10	975	40	36	0	-	102.99	7471.33	1015	-249.66	307.27	525.46	832.73
10.1	975	40.4	36	0	-	104.05	7506.26	1015.4	-255.64	314.63	527.91	842.54
10.2	975	40.81	36	0	-	105.11	7541.97	1015.81	-261.67	322.06	530.42	852.48
10.3	975	41.21	36	0	-	106.18	7578.41	1016.21	-267.77	329.56	532.99	862.55
10.4	975	41.62	36	0	-	107.24	7615.53	1016.62	-273.93	337.14	535.6	872.74
10.51	975	42.02	36	0	-	108.3	7653.31	1017.02	-280.15	344.8	538.25	883.06
10.61	975	42.42	36	0	-	109.37	7691.7	1017.42	-286.43	352.53	540.95	893.49

5. The results calculated by Repute differ from those given in the book by Bond and Harris (2008), where a model factor on resistance of 1.5 was used (following the draft Irish National Annex). Instead, Repute uses the value 1.75 that appears in the published version of that Annex.

6. You can check this by selecting the **View** tab on Repute's ribbon and then clicking on the **Specify** button. Then, select `EC7 with Irish NA` in the **Project Manager** to display its properties in the **Property Inspector** – the value given for **Options > Model factor on resistance** is 1.75.


Property Inspector

General	
Name	EC7 with Irish NA
Type	IS EN 1997-1:2005
Category	Limit State Standards
Kind	Design Standards
Notes	Created by the Project W
Reference	
Options	
Design Approach	Design Approach 1
Combination	Combination 2
Model factor on resista	1.75
Partial factors	

A Repute project that reproduces Bond and Harris's results can be found here:

[Docs]\Examples\Bond and Harris (2008) Ex 13.1.rpx.

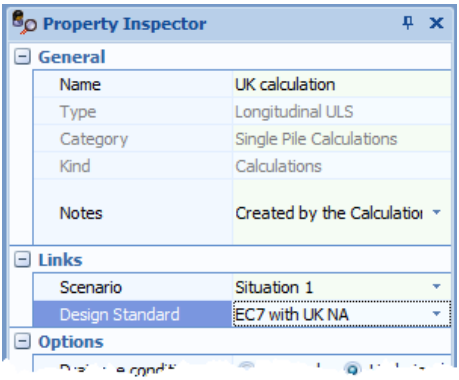
Step 9 – change the design standard

In Step 9, you will create a second calculation, identical to the first but based on the UK National Annex to Eurocode 7.

1. Returning to the **Project Manager**, create a copy of `Calculation 1` by right-clicking on it (look under Calculations

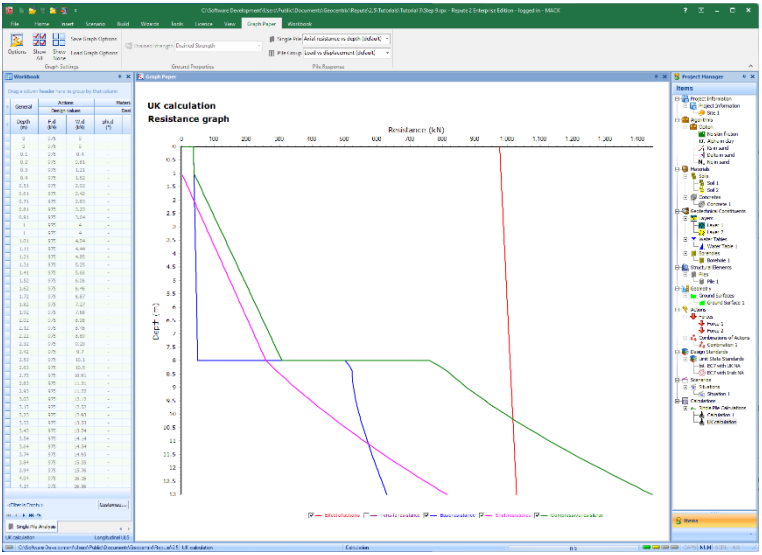
> Single Pile Calculations) and selecting the **Edit > Duplicate** command.

2. In the **Property Inspector**, change the **Name** of the newly created calculation to `UK calculation` and its **Design Standard** to `EC7 with UK NA`.



3. In the **Project Manager**, select the Design Standard `EC7 with UK NA` (under Design Standards > Limit State Standards).
4. Then in the **Property Inspector**, set **Options > Pile testing** to `Investigation tests`. The values of the model factor and the resistance factors will change. This setting is appropriate when the calculated resistance will be checked by static pile load tests taken to ultimate load.

5. In the **Project Manager**, select the `UK calculation` (under Calculations > Singler Pile Calculations) and then run the calculation by selecting the **Build** tab on Repute's ribbon and clicking on the `Run UK calculation` button. Your screen will now look something like this:



[Docs]\Tutorials\Tutorial 3\Step 9.rpx captures everything you've done so far.

Step 10 – close the project

In Step 10, you will close and – optionally – save the project. (Note: this is not available in the Trial Edition.)

1. Close the project by clicking on the File menu's **Close** command.
2. If you have made changes to the project since it was last saved, Repute will ask you if you want to save before proceeding. Answer **Yes** or **No** by clicking the appropriate button.
3. Repute will then (if requested) save and close the project.

You will find a copy of the project in its final form here:

[Docs]\Tutorials\Tutorial 3\Tutorial 3.rpx

What next?

Tutorial 4 shows how the boundary element method can be used to analyse a pile group.

Tutorial 4. Pile group in clay and sand

Introduction

Tutorial 4 demonstrates how the boundary element method can be used to analyse a pile group. The worked example involves a group of four bored piles in stiff clay overlying dense sand:

- Ground conditions comprise 8m of stiff clay overlying dense sand. Both soils will be modelled as linear elastic materials.
- The stiff clay has a vertical Young's modulus of 40 MPa and a horizontal modulus of 20 MPa, with Poisson's ratio equal to 0.5.
- The dense sand has the same Young's modulus vertically and horizontally, equal to 50 + 10 *z* MPa (where *z* is the depth below the top of the sand in metres), and Poisson's ratio equal to 0.3.
- The bored piles are installed on a 2 x 2 grid, at 3 m spacing (centre-to-centre). Each pile is 20 m long, 1050 mm in diameter, with a Young's modulus (vertically and horizontally) of 30 GPa.
- A characteristic vertical force of 12 MN (permanent), horizontal force of 1 MN (variable), and moment of 2 MNm (variable) are applied at the centre of the pile group.
- You want to determine the displacement and rotation of the pile cap under serviceability conditions.

This tutorial is written for users of the Professional, Enterprise, and Trial Editions of Repute only. Users of the Standard Edition should look at Tutorials 1-3.

Overview

- In Step 1, you will use the Project Wizard to enter project information and create a scenario to represent a persistent design situation.
- In Step 2, you will use the Pile Group Wizard to create a 2 x 2 pile group and specify the piles' properties.
- In Step 3, you will use the Borehole Wizard to create a borehole containing stiff clay and dense sand layers.
- In Step 4, you will enter the stiffness parameters for Soils 1 and 2.

- In Step 5, you will use the Action Wizard to create the actions applied to the pile group.
- In Step 6, you will use the Calculation Wizard to create the calculation you want Repute to perform.
- In Step 7, you will perform the calculation and review the results.
- In Step 8, you will produce a report summarising the calculation.
- In Step 9, you will close and (optionally) save the project.

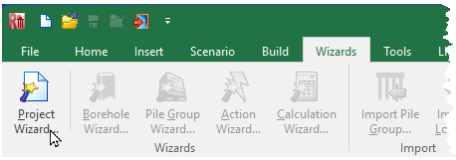
If Repute is not already running, open the program by pressing the Windows key, typing `Repute 2.5` in the search bar, and clicking on the `Repute 2.5` item that should appear. Once the splash screen has disappeared, Repute displays its Welcome screen.

If you have an existing project open, click **Close** on the program's **File** menu. (You will be prompted to save your work if you have not already done so.)

Step 1 – create the project

In Step 1, you will use the Project Wizard to enter project information and create a scenario to represent the design situation to be analysed.

1. Open the **Project Wizard** by selecting the **Wizards** tab on Repute's ribbon and then clicking on the **Project Wizard** button.



2. When the Wizard appears, type `Tutorial 4` in the **Project name** box. Choose the folder where you want to save this project by using the **Path** control. If you do not change the setting here, the file will be saved in your `Documents` folder.
3. Enter `Pile group in clay and sand` in the **Description** box and `04` in the **Project ID** box.
4. Click **Next** to display page 2 of the Wizard. Since we are not going to use a design standard, there is nothing to set on this page.

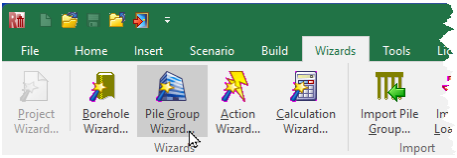
5. Click **Next** to display page 3. In the table, change the **Design Situation** of Situation 1 to `Persistent` (if it is not already set).
6. Click **Next** to display the final page of the Wizard. If you wish to review any of the settings you have made, click **Back** to return to the relevant page.
7. When you are ready, click **Finish** to generate the project. The **Project Wizard** then:
   - creates `Site 1`, `Ground Surface 1`, and `Situation 1`
   - adds `Ground Surface 1` to `Situation 1`
   - creates a new project `Tutorial 4.rpx` containing all these items

[Docs]\Tutorials\Tutorial 4\Step 1.rpx captures everything you've done so far.

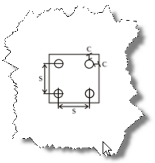
Step 2 – create the pile group

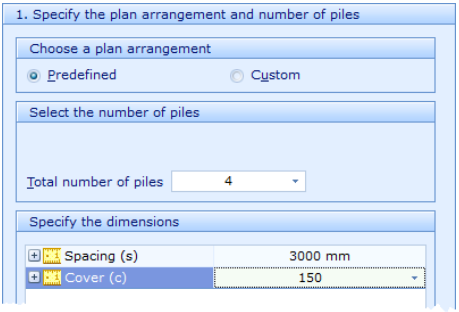
In Step 2, you will use the Pile Group Wizard to create a 2 x 2 pile group and specify the piles' properties.

1. Open the **Pile Group Wizard** by selecting the **Wizards** tab on Repute's ribbon and clicking on the **Pile Group Wizard** button.

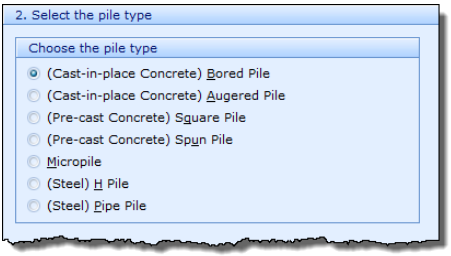


2. When the Wizard appears, choose the `Predefined` plan arrangement and change the **Total number of piles** to 4. The picture on the left-hand side of the Wizard will change to show you the default 2 x 2 pile arrangement. Change the **Spacing** between the piles to `3000` mm but leave the **Cover** at its default value (150 mm).

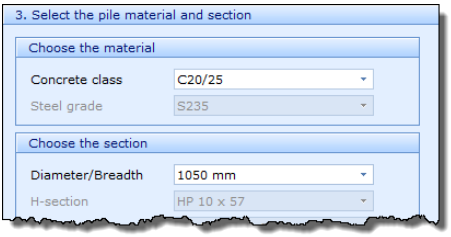




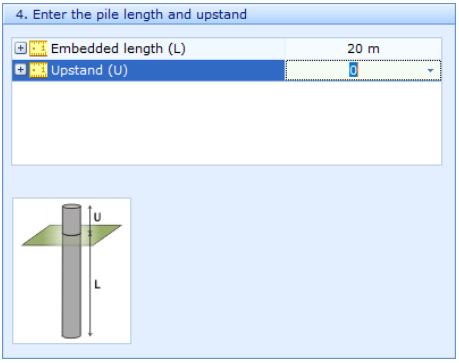
3. Click **Next** to display page 2 of the Wizard. If not already set, set the pile type to `(Cast-in-place Concrete) Bored Pile`.



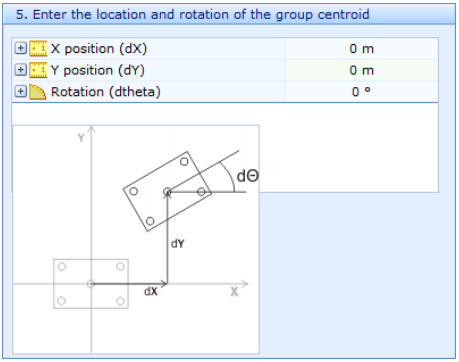
4. Click **Next** to display page 3. Change the **Concrete class** to `C20/25` and the **Diameter/Breadth** to `1050` mm. By default, this concrete's Young's modulus will be set to 30 GPa (not shown).



5. Click **Next** to display page 4. Change the **Embedded length (L)** to `20` m but leave the **Upstand (U)** as 0 m.

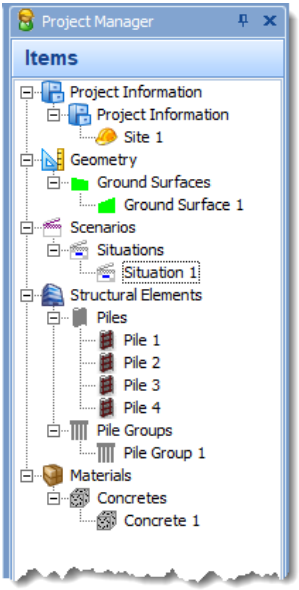


6. Click **Next** to display page 5. Leave all the values on this page as zero – this will position the pile group centrally in the co-ordinate system (and not rotated).



7. Click **Next** to display page 6. Tick `Situation 1` to add the pile group to the scenario.
8. Click **Next** to display the last page of the Wizard. If you wish to review any of the settings you have made, click **Back** to return to the relevant page.

9. When you are ready, click **Finish** to generate the pile group. The **Pile Group Wizard** then:
   - creates `Piles 1` to `4`
   - creates `Pile Group 1`
   - creates `Concrete 1`
   - links `Piles 1` to `4` to `Concrete 1`
   - adds `Piles 1` to `4` to `Pile Group 1`
   - adds `Pile Group 1` to `Situation 1`



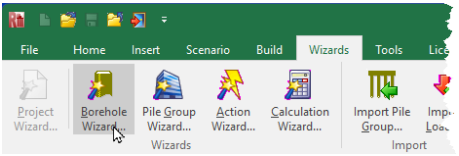
10. In the **Property Inspector**, set the **Pile Cap > Pile cap thickness** to `1.5` m and press `ENTER`.

[Docs]\Tutorials\Tutorial 4\Step 2.rpx captures everything you've done so far.

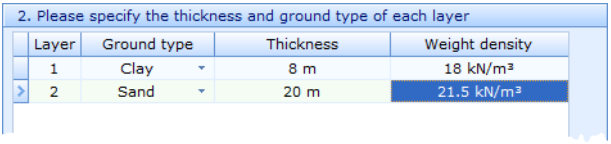
Step 3 – create the borehole

In Step 3, you will use the Borehole Wizard to create a borehole containing stiff clay and dense sand layers.

1. Open the **Borehole Wizard** by selecting the **Wizards** tab on Repute's ribbon and clicking on the **Borehole Wizard** button.

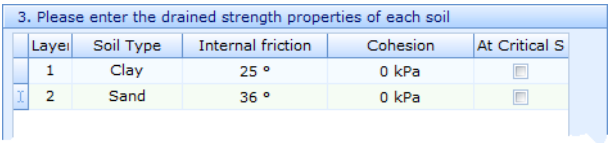


2. When the Wizard appears, increase the number of layers to 2.
3. Click **Next** to display page 2 of the Wizard. Change the **Ground type** of `Layer 1` to `Clay`, its **Thickness** to 8 m, and its **Weight density** to 18 kN/m^3. Leave the **Ground type** of `Layer 2` as `Sand` but change its **Thickness** to 20 m and its **Weight density** to 21.5 kN/m^3.


2. Please specify the thickness and ground type of each layer

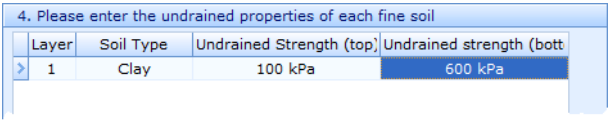
Layer	Ground type	Thickness	Weight density
1	Clay	8 m	18 kN/m³
2	Sand	20 m	21.5 kN/m³

4. Click **Next** to display page 3. Change the **Internal friction** angle of `Layer 1` to 25° and that of `Layer 2` to 36°. Leave the **Cohesion** of both soils as 0 kPa and the **At Critical State?** boxes unchecked.


3. Please enter the drained strength properties of each soil

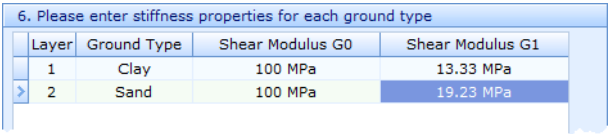
Layer	Soil Type	Internal friction	Cohesion	At Critical S
1	Clay	25 °	0 kPa	
2	Sand	36 °	0 kPa	

5. Click Next to display page 4. Change the **Undrained strength (top)** of `Layer 1` to 100 kPa and its **Undrained strength (bottom)** to 600 kPa. This strength increase will occur over the full thickness of `Layer 1`, i.e. 8 m (as specified above). `Layer 2` does not appear on this page because – as a sand – it has no undrained properties.


4. Please enter the undrained properties of each fine soil

Layer	Soil Type	Undrained Strength (top)	Undrained strength (bott
1	Clay	100 kPa	600 kPa

6. Click **Next** to display page 5. Since the ground profile does not include rock, there is nothing to set on this page.
7. Click **Next** to display page 6. For `Layer 1`, to obtain a large-strain undrained Young's modulus E_u = 40 MPa, enter its **Shear modulus G1** as `13.33` MPa, which is equal to $E_u/2(1 + \nu_u) = E_u/3$, with a Poisson's ratio ν_u = 0.5. Leave its **Shear Modulus G0** value as 100 MPa.
8. For `Layer 2`, to obtain a large-strain drained Young's modulus E' = 50 MPa, enter its **Shear modulus G1** as `19.23` MPa – which is equal to $E'/2(1 + \nu) = E'/2.6$, with a Poisson's ratio ν = 0.3. Leave its **Shear Modulus G0** value as 100 MPa.


6. Please enter stiffness properties for each ground type

Layer	Ground Type	Shear Modulus G0	Shear Modulus G1
1	Clay	100 MPa	13.33 MPa
2	Sand	100 MPa	19.23 MPa

9. Click **Next** to display page 7. Tick `Situation 1` to add the borehole to the scenario.
10. Click **Next** to display the last page of the Wizard. If you wish to review any of the settings you have made, click **Back** to return to the relevant page.
11. When you are ready, click **Finish** to generate the borehole. The **Borehole Wizard** then:
    - creates `Soils 1-2`
    - creates `Layers 1-2`
    - creates `Borehole 1`
    - links `Soil 1` to `Layer 1`
    - links `Soil 2` to `Layer 2`
    - adds `Layers 1-2` to `Borehole 1`
    - adds `Borehole 1` to `Situation 1`

[Docs]\Tutorials\Tutorial 4\Step 3.rpx captures everything you've done so far.

Step 4 – modify the soils' stiffness properties

In Step 4, you will modify the stiffness properties of Soils 1 and 2.

1. Select `Soil 1` in the **Project Manager** (under Materials > Soils).
2. In the **Property Inspector**, change the value of **Stiffness > Undrained Young's modulus (Eu) > Large strain stiffness > Undrained Young's modulus (Eu)** to `40` MPa (from 39.99 MPa).
3. The **Stiffness ratio G1/G0** is shown as 13.33%, which is obtained by dividing the **Small strain stiffness > Shear modulus (G)** value of 100 MPa (= G_0) by **Large strain stiffness > Shear modulus (G)** value of 13.33 MPa (= G_1). Look under the heading **Stiffness > Shear modulus (G)** for these values.

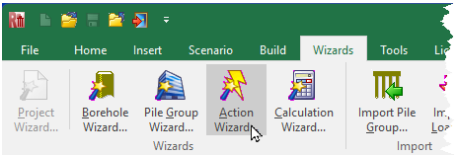
4. Type `0.5` in the **Stiffness > Anisotropy** box to change the **Large strain stiffness > Horizontal Young's modulus (Eh)** value to 20 MPa (i.e. 40 MPa x 0.5).
5. Back in the **Project Manager**, select `Soil 2`. The **Property Inspector** will change to display its properties.
6. Under the heading **Depth**, check that **Reference depth 1 (z,ref1)** is equal to 8 m (this is the top of the soil layer) and **Reference depth 2 (z,ref2)** is equal to 28 m (this is the bottom of the layer).
7. Under the heading **Stiffness**, check that the **Poisson's ratio (v)** of this soil is equal to 0.3.
8. Under the heading **Young's modulus (E) > Large-strain stiffness**, expand the heading **Variation with depth** by clicking on the **+** button. Enter `250` MPa into the **E',ref2** box. The value of **Young's modulus gradient (dE/dz)** will change to 10 MN/m^3 – equal to (**E',ref1** – **E',ref2**) / (**z,ref1** – **z,ref2**) = (250 MPa – 50 MPa)/(28 m – 8 m).

[Docs]\Tutorials\Tutorial 4\Step 4.rpx captures everything you've done so far.

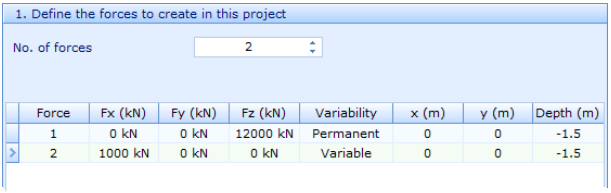
Step 5 – create the forces and moments

In Step 5, you will use the Action Wizard to create loads applied to the pile group.

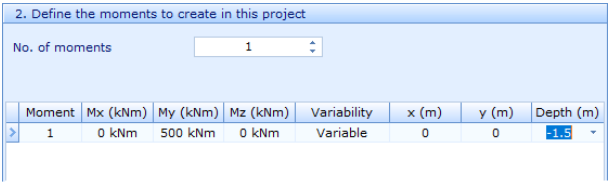
1. Open the **Action Wizard** by selecting the **Wizards** tab on Repute's ribbon and clicking on the **Action Wizard** button.



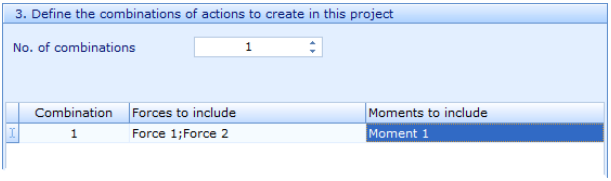
2. When the Wizard appears, increase the **No. of forces** to 2. Set the **Fz** value of `Force 1` to `12000` kN, its **Variability** to `Permanent`, and its **Depth** to –1.5 m. Set the **Fx** value of `Force 2` to `1000` kN, its **Fz** value to `0` kN, and its **Depth** to –1.5 m but leave its **Variability** as `Variable`.



3. Click **Next** to display page 2 of the Wizard. Increase the **No. of moments** to 1. Set the **My** value of `Moment 1` to 500 kNm and its **Depth** to –1.5 m but leave its **Variability** as `Variable`.



4. Click **Next** to display page 3. Increase the **No. of combinations** to 1. Under the column **Forces to include**, click the text `None selected` and then tick `Force 1` and `Force 2`. Click away. Then, under the column **Moments to include**, click the text `None selected` and then tick **Moment 1**. Click away.



5. Click **Next** to display the last page. If you wish to review any of the settings you have made, click **Back** to return to the relevant page.
6. When you are ready, click Finish to generate the actions and their combination. The **Actions Wizard** then:
   - creates `Forces 1 and 2`
   - creates `Moment 1`
   - creates `Combination 1`
   - adds `Forces 1 and 2` and `Moment 1` to `Combination 1`

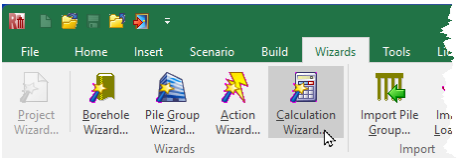
7. Going back to the **Project Manager**, select `Situation 1` (under Scenarios > Situations).
8. Then, in the **Property Inspector**, tick `Combination 1` (under Actions) to add the combination to this scenario. The **Drawing Board** will automatically update.

[Docs]\Tutorials\Tutorial 4\Step 5.rpx captures everything you've done so far.

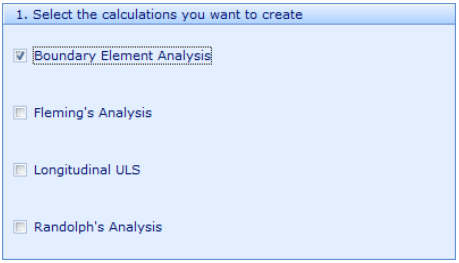
Step 6 – create the calculation

In Step 6, you will use the Calculation Wizard to create the calculation you want Repute to perform.

1. Open the **Calculation Wizard** by selecting the **Wizards** tab on Repute's ribbon and then clicking the **Calculation Wizard** button.

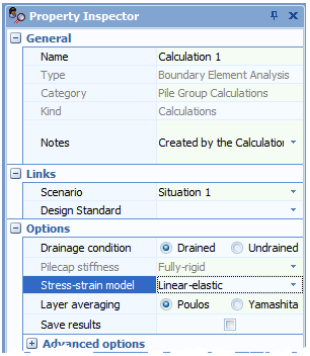


2. When the Wizard appears, select `Boundary Element Analysis`. (The calculations that appear here depend on which edition of Repute you are running. The Enterprise Edition provides more calculations than the Standard and Professional editions.)



3. Click **Next** to display page 2 of the Wizard. Since there are no design standards to select from, there is nothing to do on this page.
4. Click **Next** to display page 3. Select `Situation 1` to link the boundary element analysis to that scenario.

5. Click **Next** to display the last page of the Wizard. If you wish to review any of the settings you have made, click **Back** to return to the relevant page.
6. When you are ready, click **Finish** to generate the calculation. The **Calculation Wizard** then:
   - creates `Calculation 1`
   - links `Calculation 1` to `Situation 1`
7. In the **Property Inspector**, for `Calculation 1`, change the **Stress-strain model** (under Options) to `Linear-elastic`. The strength of the soils is irrelevant in a linear-elastic analysis and hence it does not matter whether the **Drainage condition** is set to `Drained` or `Undrained`.

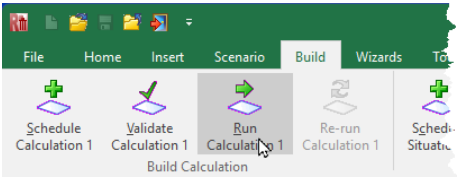


[Docs]\Tutorials\Tutorial 4\Step 6.rpx captures everything you've done so far.

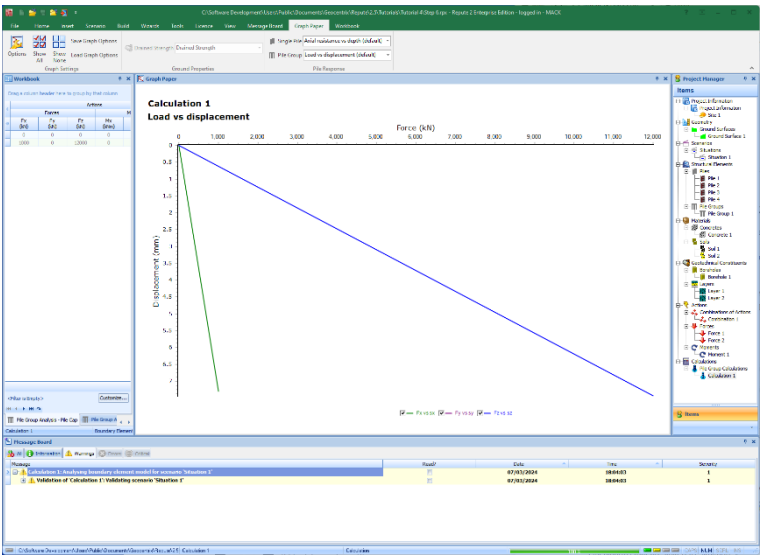
Step 7 – perform and review the calculation

In Step 7, you will perform the calculation and review the results.

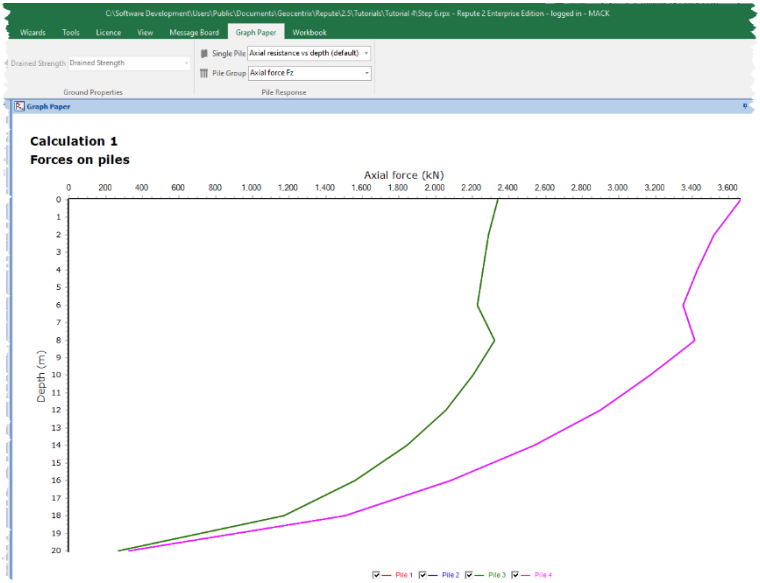
1. Run the calculation by selecting the **Build** tab on Repute's ribbon and clicking on the `Run Calculation 1` button.



2. Repute will run `Calculation 1` and then change its display to show its **Checking Desktop** (which displays the **Workbook** and **Graph Paper**). You can switch to this display at any time by clicking on the **Check** button on the **View** tab of Repute's ribbon.
3. Your screen will now look something like this:



4. To display the force distribution along the piles, select **Axial force Fz** in the drop-down box labelled **Pile Group** on the **Graph Paper** tab. The graph will change to display:



Step 8 – close the project

In Step 8, you will close and – optionally – save the project. (Note: this is not available in the Trial Edition.)

1. Close the project by clicking on the **File** menu's **Close** command.
2. If you have made changes to the project since it was last saved, Repute will ask you if you want to save before proceeding. Answer **Yes** or **No** by clicking the appropriate button.
3. Repute will then (if requested) save and close the project.

You will find a copy of the project in its final form here:

[Docs]\Tutorials\Tutorial 4\Tutorial 4.rpx

What next?

Tutorial 5 shows you how to set up a non-linear boundary element analysis of a pile group in stiff clay overlying rock.

Tutorial 5. Pile group in stiff clay over a rigid layer

Introduction

This tutorial demonstrates non-linear boundary element analysis of a pile group. It shows you how to:

- Specify a non-linear analysis
- Introduce a rigid layer into the calculations
- Produce a load displacement graph for the pile cap
- Print the results of your calculations

The worked example involves the analysis of a group of 4 piles installed in stiff clay overlying a rigid layer.

- The ground conditions at the site comprise 35 m of stiff clay (Young's modulus 75 + 10 *z* MPa vertically and half that horizontally, where *z* is the depth below the top of the layer; Poisson's ratio 0.5) overlying a rigid layer.
- A non-linear soil model will be used for the clay, with unit weight 19.8 kN/m^3, undrained strength 75 + 10 *z* kPa, and adhesion factor 0.5.
- The water table is at the ground surface.
- The piles will be installed on a 2 x 2 grid, at 3 m spacing (centre-to-centre) along the edge of the grid. Each pile is 20 m long, 1.05 m in diameter, with a free-standing length of 0.5 m and Young's modulus of 30 GPa (both axially and laterally). This is the same pile group as was used in Step 2 of Tutorial 4.
- You are interested in the displacements and rotation of the pile cap under a combined vertical load of 20 MN, horizontal load of 2 MN, and moment of 3 MNm. The loads will be applied at the centre of the pile cap.
- Hyperbolic curve fitting constants of 0.5 (for the shaft), 0.99 (for the base), and 0.9 (for lateral response) should be used.

This tutorial is written for users of the Professional, Enterprise, and Trial Editions of Repute only. Users of the Standard Edition should look at Tutorials 1-3.

Overview

- In Step 1, you will use the Project Wizard to enter project information and create a scenario to represent the design situation to be analysed.
- In Step 2, you will create four piles and connect them together in a pile group.
- In Step 3, you will create a stiff clay and specify its properties.
- In Step 4, you will create a layer, borehole, and water table.
- In Step 5, you will create a force, moment, and combination of actions (to combine the force and moment).
- In Step 6, you will create the calculation that you want Repute to perform.
- In Step 7, you will perform the calculation.
- In Step 8, you will export results to a Microsoft Excel spreadsheet.
- In Step 9, you will close and (optionally) save the project.

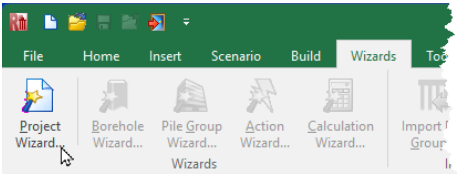
If Repute is not already running, open the program by pressing the Windows key, typing `Repute 2.5` in the search bar, and clicking on the `Repute 2.5` item that should appear. Once the splash screen has disappeared, Repute displays its Welcome screen.

If you have an existing project open, click **Close** on the program's **File** menu. (You will be prompted to save your work if you have not already done so.)

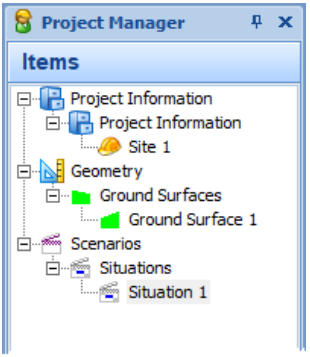
Step 1 – create the project

In Step 1, you will use the Project Wizard to enter project information and create a scenario to represent the design situation to be analysed.

1. Open the **Project Wizard** by selecting the **Wizards** tab on Repute's ribbon and then clicking on the **Project Wizard** button.



2. When the Wizard appears, type `Tutorial 5` in the **Project name** box. Choose the folder where you want to save this project by using the **Path** control. (If you do not change the setting here, it will be saved in your `Documents` folder.) Enter `Pile group in stiff clay over a rigid layer` in the **Description** box and `05` in the **Project ID** box.
3. Click **Next** to display page 2 of the Wizard. Since we are not going to use a design standard, there is nothing to set on this page.
4. Click **Next** to display page 3. Since the **Design Situation** of `Situation 1` is already set to `Persistent`, there is nothing to change on this page.
5. Click **Next** to display the final page of the Wizard. If you wish to review any of the settings you have made, click **Back** to return to the relevant page.
6. Click **Finish** to generate the project. The **Project Wizard** then:
   - creates `Site 1`, `Ground Surface 1`, and `Situation 1`
   - adds `Site 1` and `Ground Surface 1` to `Situation 1`
   - creates a new project with `Tutorial 5.rpx` with all these items in it

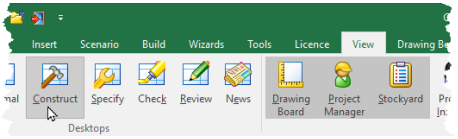


[Docs]\Tutorials\Tutorial 5\Step 1.rpx captures everything you've done so far.

Step 2 – create the pile group

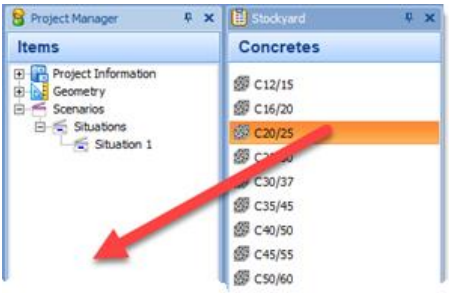
In Step 2, you will create four piles and connect them together in a pile group.

1. Switch to Repute's **Construction Desktop** by selecting the **View** tab on Repute's ribbon and

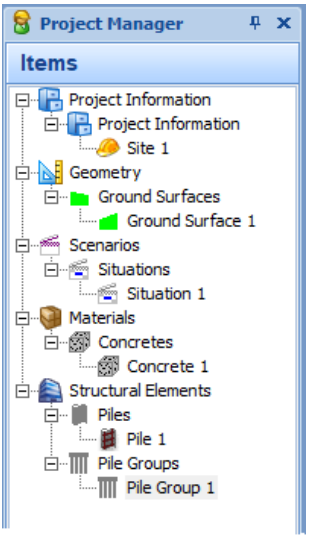


clicking on the **Construct** button. (The **Construction Desktop** displays the **Drawing Board**, **Project Manager**, and **Stockyard**.)

2. Right-click anywhere in the **Stockyard** and select **Concretes** from the pop-up menu to open the **Concretes** group. Then:
   - click on `C20/25`, keeping the left mouse button pressed
   - drag the cursor away from the **Stockyard** (whereupon the cursor will change to signal the dragging operation) and position it over the **Project Manager**
   - release the mouse button to drop the concrete in the **Project Manager** (where it will appear as `Concrete 1`, under the heading Materials > Concretes).

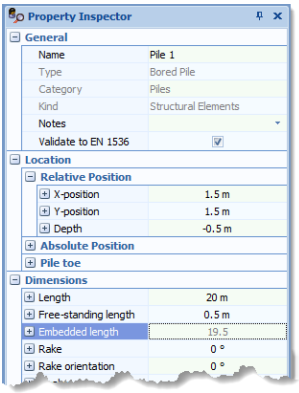


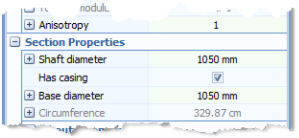
3. Back in the **Stockyard**, click on the heading **Structural Elements** to open the **Structural Elements** group. Then drag a `Bored Pile` to the **Project Manager** as described above.
4. Repeat the previous instruction for a `Pile Group`.
5. Switch to Repute's **Specification Desktop** by selecting the **View** tab on Repute's ribbon and clicking on the **Specify** button. (The **Specification Desktop** displays the **Drawing Board**, **Project Manager**, and **Property Inspector**.)



6. In the **Project Manager**, select `Pile 1` (under Structural Elements > Piles). The **Property Inspector** will change to show its properties.

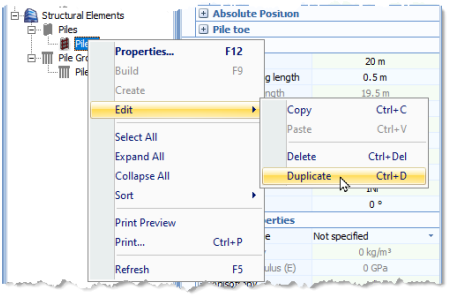
7. In the **Property Inspector**:





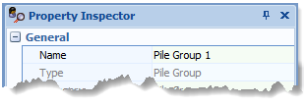
   - under Location > Relative Position, change both the pile's **X-position** and **Y-position** to `1.5` m.
   - under Section Properties, tick the box **Has casing** and change the pile's **Shaft diameter** to `1050` mm. The pile's **Base diameter** will change to 1050 mm as well.
   - under Material Properties, select `Concrete 1` in the **Material name** box.
   - under Dimensions, change the pile's **Length** to `20` m (if not already set) and its **Free-standing length** to `0.5` m.

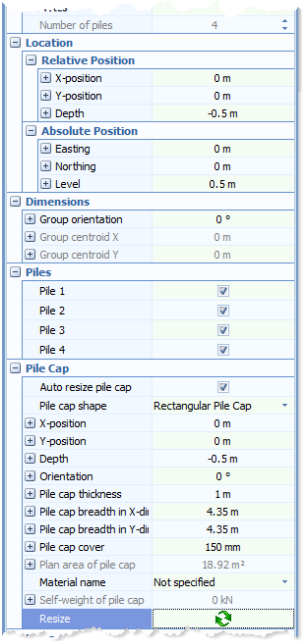
8. Next, duplicate `Pile 1` by right-clicking on it in the **Project Manager** and selecting **Edit > Duplicate** on the pop-up menu. `Pile 1 - Copy` will appear in the **Project Manager** and its properties will be displayed in the **Property Inspector**.



9. In the **Property Inspector**, change the **Name** of the copied pile to `Pile 2` and its `X-position` to `-1.5` m. Leave all its other properties unchanged.

10. Duplicate `Pile 2` via the **Edit > Duplicate** command (as described above) or – even quicker – select `Pile 2` and then press `CTRL+D` to duplicate it.
11. In the **Property Inspector**, change the **Name** of the copied pile to `Pile 3` and its **Y-position** to `−1.5` m, keeping its **X-position** as –1.5 m.
12. Finally, duplicate `Pile 3`, changing the duplicate's **Name** to `Pile 4` and its `X-position` to (plus) 1.5 m and keeping its **Y-position** as −1.5 m.
13. Next, select `Pile Group 1` in the **Project Manager** and, in the **Property Inspector**:

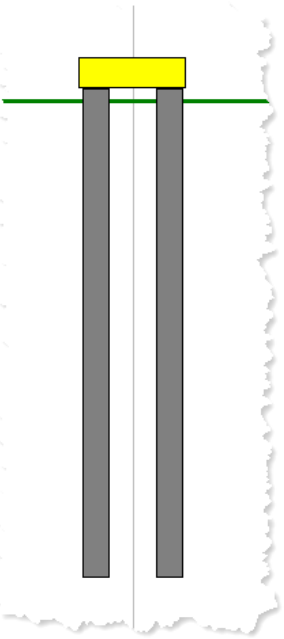




- change its **Level** (under the heading Location > Absolute Position) to 0.5 m.
- tick all four piles (under the heading Piles)
- change the **Pile cap thickness** to 1.25 m (under the heading Pile Cap) and click the **Resize** button to ensure the pile cap's dimensions reflect the piles' new positions

14. Finally, in the **Project Manager**, select `Situation 1` (under Scenarios > Situations) and tick `Pile Group 1` in its **Property Inspector** to add the pile group to the scenario.

15. The Drawing Board will now look something like this (note that the pile cap appears in yellow, since we have not specified a material to link to this element).



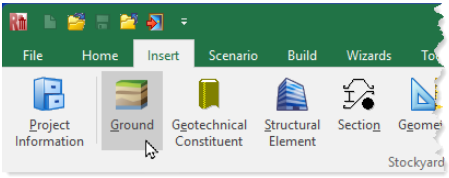
16. In this step you have:
    - created `Concrete 1`, `Pile 1`, and `Pile Group 1`
    - linked `Pile 1` to `Concrete 1`
    - duplicated `Pile 1` to create `Piles 2, 3, and 4` and changed their locations
    - added `Piles 1-4` to `Pile Group 1`
    - added `Pile Group 1` to `Situation 1`

[Docs]\Tutorials\Tutorial 5\Step 2.rpx captures everything you've done so far.

Step 3 – create the soil

In Step 3, you will create a stiff clay and specify its properties.

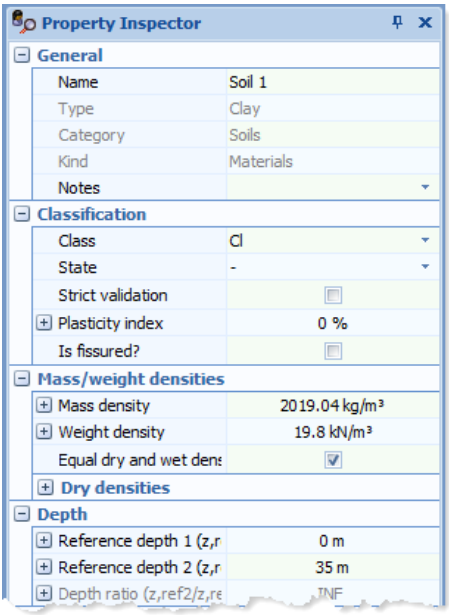
1. Open the **Stockyard**'s Grounds group by selecting the **Insert** tab on Repute's ribbon and clicking on the **Ground** button.



2. In the **Stockyard**:
    - click on `Clay` while keeping the left mouse button pressed
    - drag the cursor away from the **Stockyard** over the **Project Manager** (The cursor will change to signal you are dragging)

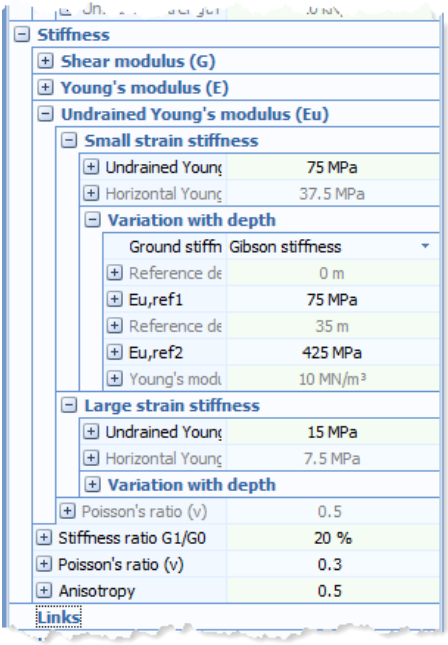
- release the mouse button when the cursor is over the **Project Manager** to drop the clay there (it will appear as `Soil 1` under the heading Materials > Soils)

3. Double-click on `Soil 1` to open its **Property Inspector**.
4. In the **Property Inspector** for `Soil 1`:
   - if necessary, untick **Strict validation** (under Classification)
   - change the clay's **Weight density** (under Mass/weight densities) to 19.8 kN/m^3 – its **Mass density** will change accordingly
   - set **Reference depth 2 (z,ref2)** (under Depth) to `35` m – this is the bottom of the soil layer
   - change the clay's **Undrained strength** (under Strength > Undrained strength) to `75` kPa
   - open the heading Undrained strength > Variation with depth by clicking on the **+** button to the left of it and set **cu,ref2** to `425` kPa – the **Undrained strength gradient (dcu/dz)** will change to 10 kN/m^3



5. Continuing in the **Property Inspector** for `Soil 1` – under the heading **Stiffness > Undrained Young's modulus > Small strain stiffness**:

   - set the clay's **Undrained Young's modulus (Eu)** to `75` MPa – the **Large strain stiffness > Undrained Young's modulus (Eu)** will change to 15 MPa, since the **Stiffness ratio G1/G0** – and hence E_{u1}/E_{u0} – is (by default) set to 20%
   - open the heading **Variation with depth** and enter `425` MPa as the value of **Eu,ref2** – the **Young's modulus gradient (dE/dz)** will change to 10 MN/m^3



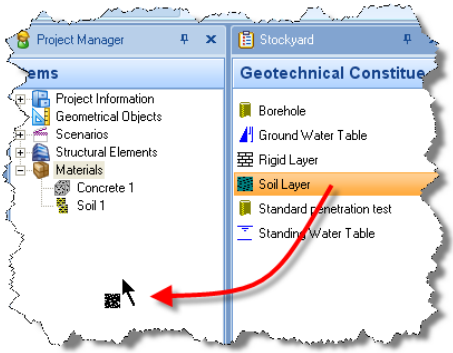
6. Finally, change the clay's **Anisotropy** (under Stiffness) to `0.5` – the clay's **Small strain stiffness** > **Horizontal Young's modulus (Eh)** changes from 75 MPa to 37.5 MPa

[Docs]\Tutorials\Tutorial 5\Step 3.rpx captures everything you've done so far.

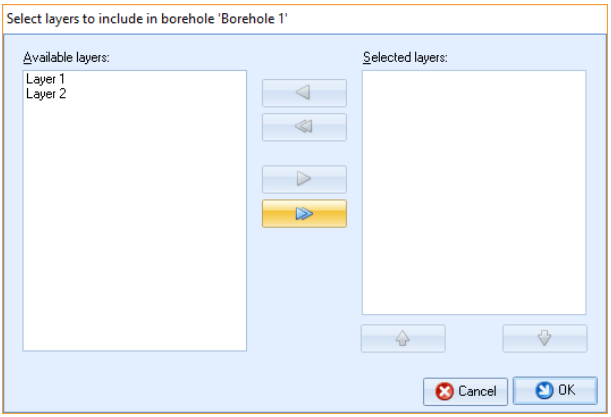
Step 4 – create a layer, borehole, and water table

In Step 4, you will create a layer and borehole to hold the stiff clay and a water table (at ground surface).

1. In the **Stockyard**, open the **Geotechnical Constituents** group and then create a Soil Layer, a Rigid Layer, a Borehole, and a Ground Water Table by dragging-and-dropping these items from the **Stockyard** to the **Project Manager**.



2. Add `Water Table 1` to the scenario by dragging it from the **Project Manager** to the **Drawing Board**.
3. Select `Layer 1` in the **Project Manager** and then, in the **Property Inspector**, change its **Thickness** to `35` m and its **Soil** to `Soil 1`.
4. Select `Borehole 1` in the **Project Manager** and, in the **Property Inspector**, press the **Select ...** button. In the dialog box that appears, click on the **>>** button to move `Layer 1` and `Layer 2` from the **Available** box to the **Selected** box. Click **OK** to confirm the changes.



5. Select `Situation 1` in the **Project Manager** and, in the **Property Inspector**, tick `Borehole 1` to add it to the scenario.

The borehole column will appear on the left-hand side of the **Drawing Board**.

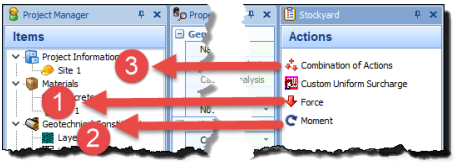
6. In this step you have manually:
   - created `Layers 1-2`, `Borehole 1`, and `Water Table 1`
   - added `Water Table 1` to `Situation 1`
   - linked `Soil 1` to `Layer 1`
   - added `Layers 1-2` to `Borehole 1`
   - added `Borehole 1` to `Situation 1`

[Docs]\Tutorials\Tutorial 5\Step 4.rpx captures everything you've done so far.

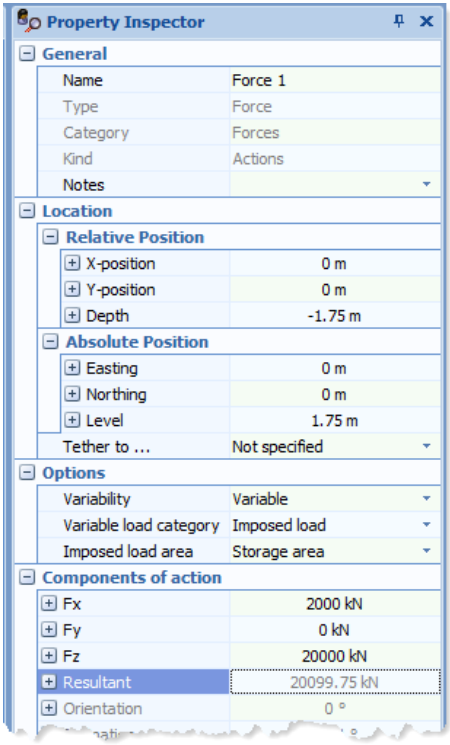
Step 5 – create forces and moments

In Step 5, you will create a force, moment, and combination of actions (to combine the force and moment).

1. In the **Stockyard**, open the **Actions** group and then create a Force, a Moment, and a Combination of Actions by dragging-and-dropping these items from the **Stockyard** to the **Project Manager**.



2. Select `Force 1` in the **Project Manager** and, in the **Property Inspector**, change its **Level** (under Location > Absolute Position) to `1.75` m – the **Depth** will change to –1.75 m as you do this (the change in level is necessary to place the force on top of the pile cap). Change the force's **Fx** value to `2000` kN and its **Fz** value to `20 000` kN – the **Resultant** will change to 20 099.75 kN.



3. Select `Moment 1` in the **Project Manager** and, in the **Property Inspector**, change its **Level** to `1.75` m but leave its **My** value as 500 kNm.
4. Select `Combination 1` in the **Project Manager** and, in the **Property Inspector**, tick both `Force 1` and `Moment 1`. Note that the **My** value is shown as 4000 kNm because of the additional moment due to **Fx** (which is at a level of 1.75 m) is 2000 kN x 1.75 m = 3500 kNm. If you change the **Level** of `Combination 1` to `1.75` m, then the **My** value will revert to 500 kNm as the lever arm of **Fx** becomes zero.
5. Finally, select `Situation 1` in the **Project Manager** and, in the **Property Inspector**, tick `Combination 1` to add it to the scenario. Arrows representing the applied force and moment will appear on the **Drawing Board** above the pile group.
6. In this step you have manually:

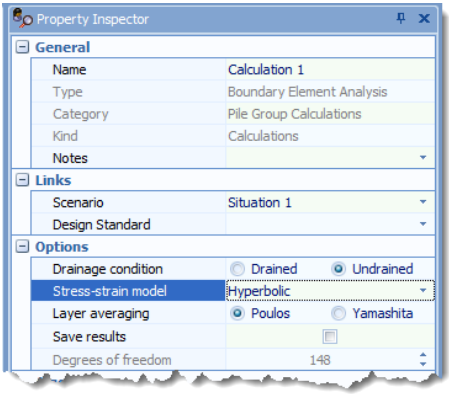
- created `Force 1`, `Moment 1`, and `Combination 1`
- added `Force 1` and `Moment 1` to `Combination 1`
- added `Combination 1` to `Situation 1`

[Docs]\Tutorials\Tutorial 5\Step 5.rpx captures everything you've done so far.

Step 6 – create the calculation

In Step 6, you will create a boundary element analysis of the pile group.

1. In the **Stockyard**, open the **Calculations** group by right-clicking and selecting **Calculations** from the pop-up menu.
2. Drag-and-drop a Boundary Element Analysis from the **Stockyard** to the **Project Manager**.
3. In the **Property Inspector**, change the **Scenario** (under Links) to `Situation 1`. Then, change the **Drainage condition** (under Options) to `Undrained` and the **Stress-strain model** to `Hyperbolic`.



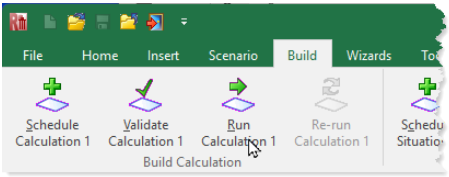
4. In this step you have:
   - created `Calculation 1`
   - linked `Situation 1` to `Calculation 1`

[Docs]\Tutorials\Tutorial 5\Step 6.rpx captures everything you've done so far.

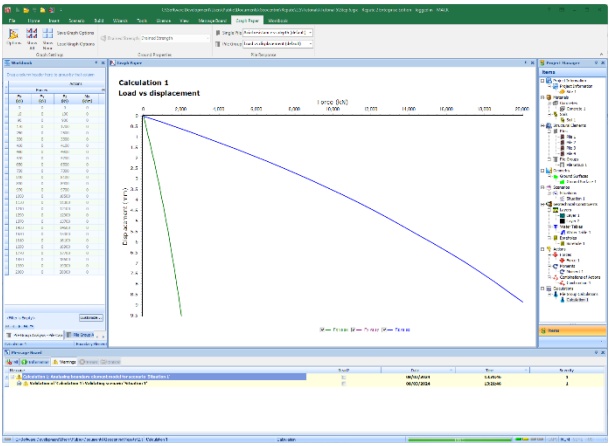
Step 7 – perform and review the calculation

In Step 7, you will perform the calculation and review the results.

1. Run the calculation by selecting the Build tab on Repute's ribbon and then clicking on the **Run All** button.



2. Repute will perform the calculation and then change its display to show its **Checking Desktop** (displaying the **Project Manager**, **Workbook**, and **Graph Paper**). You can switch to this display at any time by clicking on the **Check** button on Repute's **View** tab.
3. Your screen will now look something like this:

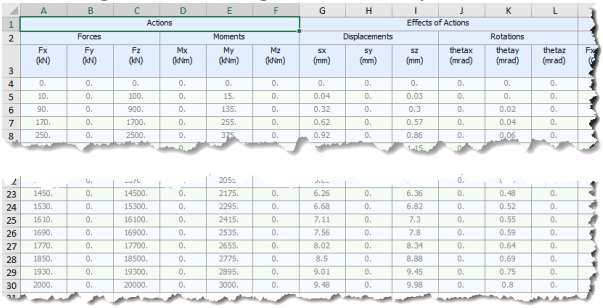


Step 8 – export the results

In Step 8, you will export results to a Microsoft Excel spreadsheet.

1. Right-click in the **Workbook** to reveal its context menu and select the **Export …** command. Only the data that is currently displayed in the **Workbook** will be exported. To include other results, click on the asterisk ***** in the top left corner of the worksheet and select the results you want to include.
2. Enter the **File name** for the spreadsheet, navigate to the folder where you want to save it, and then click on the **Save** button. By default, Repute will save the data in a Microsoft Excel workbook (*.xlsx) file.

3. If you open that workbook in Microsoft Excel, it should look something like the image below (if opened in Excel 2016).



	A	B	C	D	E	F	G	H	I	J	K	L
1	Actions						Effects of Actions					
2	Forces			Moments			Displacements			Rotations		
3	Fx (kN)	Fy (kN)	Fz (kN)	Mx (kNm)	My (kNm)	Mz (kNm)	sx (mm)	sy (mm)	sz (mm)	thetax (mrad)	thetay (mrad)	thetaz (mrad)
4	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
5	10.	0.	100.	0.	15.	0.	0.04	0.	0.03	0.	0.	0.
6	90.	0.	900.	0.	135.	0.	0.32	0.	0.3	0.	0.02	0.
7	170.	0.	1700.	0.	255.	0.	0.62	0.	0.57	0.	0.04	0.
8	250.	0.	2500.	0.	375.	0.	0.92	0.	0.86	0.	0.06	0.
23	1450.	0.	14500.	0.	2175.	0.	6.26	0.	6.36	0.	0.48	0.
24	1530.	0.	15300.	0.	2295.	0.	6.68	0.	6.82	0.	0.52	0.
25	1610.	0.	16100.	0.	2415.	0.	7.11	0.	7.3	0.	0.55	0.
26	1690.	0.	16900.	0.	2535.	0.	7.56	0.	7.8	0.	0.59	0.
27	1770.	0.	17700.	0.	2655.	0.	8.02	0.	8.34	0.	0.64	0.
28	1850.	0.	18500.	0.	2775.	0.	8.5	0.	8.88	0.	0.69	0.
29	1930.	0.	19300.	0.	2895.	0.	9.01	0.	9.45	0.	0.75	0.
30	2000.	0.	20000.	0.	3000.	0.	9.48	0.	9.98	0.	0.8	0.

[Docs]\Tutorials\Tutorial 5\Tutorial 5.xlsx contains the exported data in Microsoft Excel format.

Step 9 – close the project

In Step 9, you will close and – optionally – save the project. (Note: this is not available in the Trial Edition.)

1. Close the project by clicking on the **File** menu's **Close** command.
2. If you have made changes to the project since it was last saved, Repute will ask you if you want to save before proceeding. Answer **Yes** or **No** by clicking the appropriate button.
3. Repute will then (if requested) save and close the project.

You will find a copy of the project in its final form here:

[Docs]\Tutorials\Tutorial 5\Tutorial 5.rpx

What next?

Tutorial 6 looks at the more complicated case of an asymmetric pile group under 3-dimensional loading.

Tutorial 6. Asymmetric pile group under 3D loading

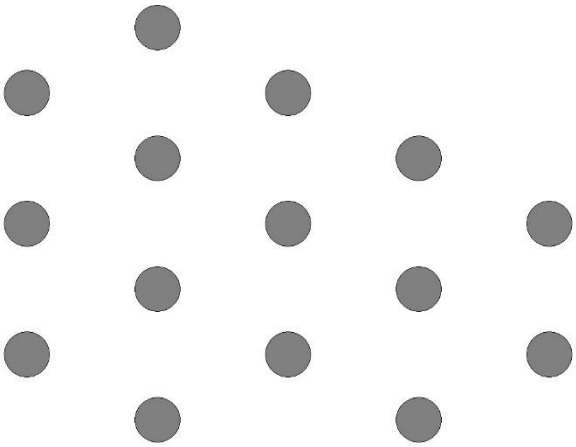
Introduction

Tutorial 6 considers a more complicated project: that of an asymmetric pile group under general 3-dimensional loading. This tutorial shows you how to:

- Modify an existing project
- Change the location of individual piles within a pile group
- Specify 3D loading

The worked example involves the analysis of a group of 15 piles installed in stiff clay overlying dense sand.

- The ground conditions at the site are identical to those in Tutorial 5.
- The piles will be installed on an irregular grid, shown below. The spacing between adjacent rows is 3 m in the X-direction and 1.5 m in the Y-direction.
- Each pile is 20 m long, 1 m in diameter, and has a Young's modulus of 30 GPa (both axially and laterally).



You are interested in the displacements and rotation of the pile cap under a combined vertical load of 50 MN, horizontal loads of 10 MN (in the X direction) and 7 MN (in the Y direction), and moments of 5 MNm (in the XZ

plane) and 3 MNm (in the YZ plane). The vertical load will be applied on the pile cap at the location of Pile 9.

This tutorial is written for users of the Professional, Enterprise, and Trial Editions of Repute only. Users of the Standard Edition should look at Tutorials 1-3.

Overview

- In Step 1, you will open and modify an existing project.
- In Step 2, you will delete the existing pile group from the project.
- In Step 3, you will create a new pile group.
- In Step 4, you will move the piles to their final positions.
- In Step 5, you will modify the actions on the pile group.
- In Step 6, you will perform the calculation and review the results.
- In Step 7, you will close and (optionally) save the project.

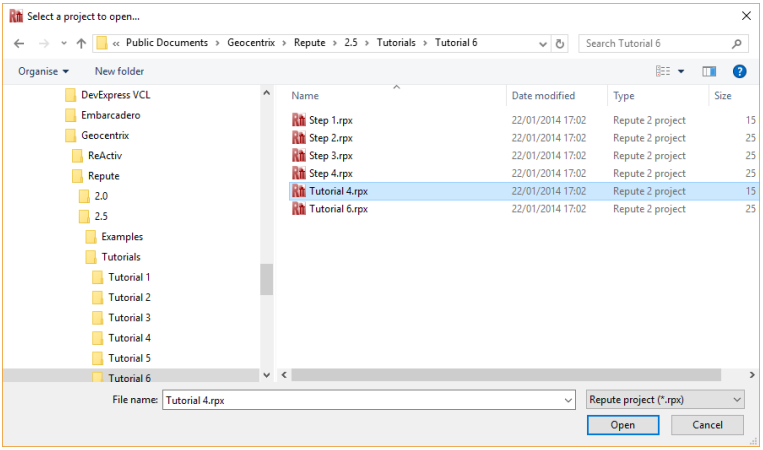
If Repute is not already running, open the program by pressing the Windows key, typing `Repute 2.5` in the search bar, and clicking on the `Repute 2.5` item that should appear. Once the splash screen has disappeared, Repute displays its Welcome screen.

If you have an existing project open, click **Close** on the program's **File** menu. (You will be prompted to save your work if you have not already done so.)

Step 1 – open and modify an existing project

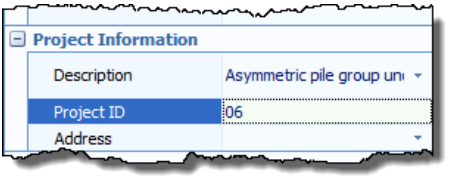
In Step 1, you open an existing project and modify its project information.

1. Click on the **File > Open** command and, in the dialog box that appears, navigate to the folder [Docs]\Tutorials\Tutorial 6 and select the file `Tutorial 4.rpx` (this is a copy of the file that was saved at the end of Tutorial 4).

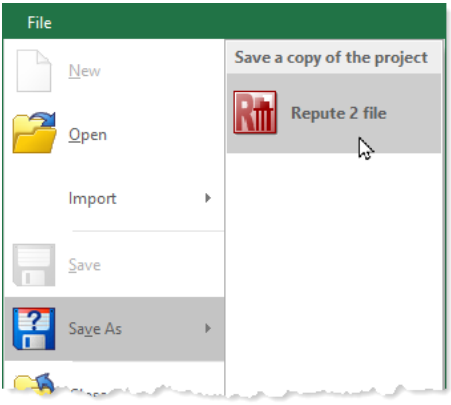


2. Click on the **Open** button to open this project.

3. In the **Project Manager**, double-click on `Site 1` to display its properties. Then, in the **Property Inspector**, change the **Description** to `Asymmetric pile group under 3D loading` and the **Project ID** to `06`.



4. Save the project under a different name, by clicking the **File > Save As** command and then clicking on **Repute 2 file**. In the dialog box that appears, change the **File name** to `Tutorial 6` and click on the **Save** button. It will automatically be saved in the folder [Docs]\Tutorials\Tutorial 6 unless you choose another location for it.

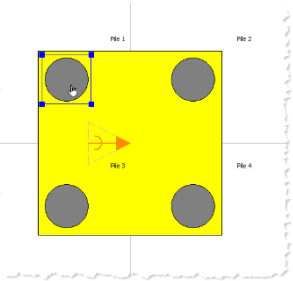


[Docs]\Tutorials\Tutorial 6\Step 1.rpx captures everything you've done so far.

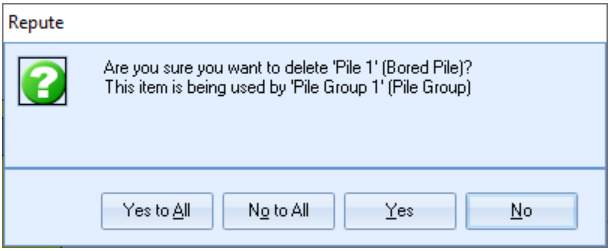
Step 2 – delete the existing pile group

In Step 2, you will delete the existing pile group from the project.

1. `Right-click` anywhere on the **Drawing Board** and select **Plan**. (Alternatively, select the **Drawing Board tab** on Repute's ribbon and then click on the **Plan** button.)
2. Increase the scale of the drawing by right-clicking on one of the rulers at the edge of the **Drawing Board** and selecting **1:50**. (Alternatively, click on the **1:50** button on the **Drawing Board tab**.)
3. `Click` on the top-left pile (`Pile 1`) in the pile group. A blue selection rectangle will appear with square handles at each corner and `Pile 1` will be highlighted in the **Project Manager**.



4. Select `Pile 1` in the **Project Manager**. Then, while holding the `CTRL` key down, select (one at a time) `Pile 2`, `Pile 3`, `Pile 4`, and `Pile Group 1`. When all five items are highlighted, right-click on the **Project Manager** and select **Edit > Delete** on the pop-up menu that appears. Click **Yes to All** to confirm that you want to delete all these items from the project (whereupon they will disappear from both the **Project Manager** and the **Drawing Board**).

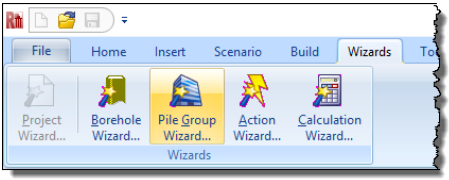


[Docs]\Tutorials\Tutorial 6\Step 2.rpx captures everything you've done so far.

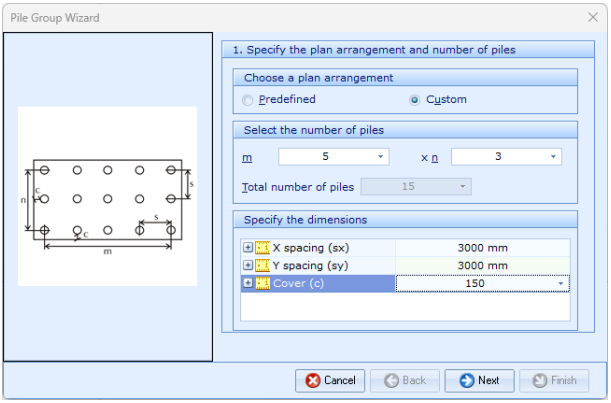
Step 3 – create a new pile group

In Step 3, you will create a new pile group to replace the old one.

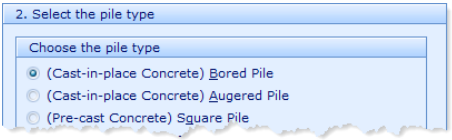
1. Open the **Pile Group Wizard** by selecting the **Wizards** tab on Repute's ribbon and clicking on the **Pile Group Wizard** button.



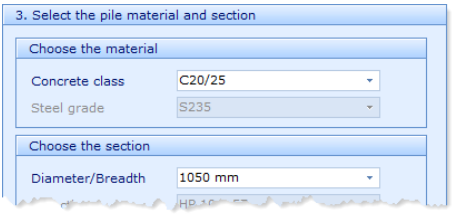
2. When the Wizard appears, choose the **Custom** plan arrangement and change the number of pile rows to **m** = 5 by **n** = 3. (The picture on the left-hand side of the Wizard will change to show you a generic rectangular pile arrangement.) Enter `3000` mm as both the **X spacing (sx)** and the **Y Spacing (sy)** but leave the **Cover (c)** as 150 mm.



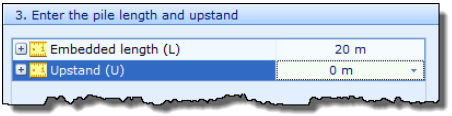
3. Click **Next** to display page 2 of the Wizard. Choose `(Cast-in-place Concrete) Bored Pile` as the **pile type**.



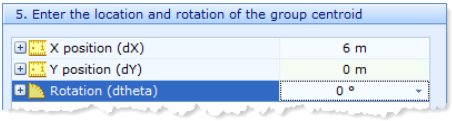
4. Click **Next** to display page 3. Change the **Concrete class** to `C20/25` and the **Diameter/Breadth** to `1050` mm. By default, the concrete will be assigned a Young's modulus of 30 GPa.



5. Click **Next** to display page 4. Change the **Embedded length (L)** to `20` m but leave the **Upstand (U)** as 0 m.



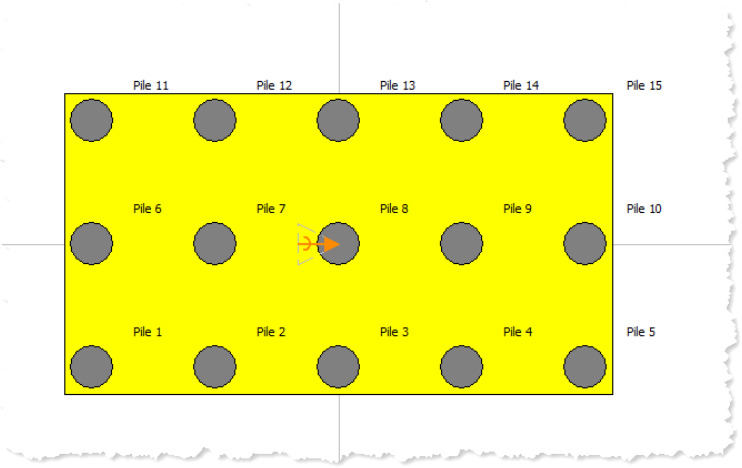
6. Click **Next** to display page 5. Change the pile group's **X position (dX)** to `6` m but leave its **Y position (dY)** as 0 m and its **Rotation (dθ)** as 0°. This will move the piles in the group closer to their final positions.



7. Click **Next** to display page 6. Tick `Situation 1` to add the pile group to the scenario.
8. Click **Next** to display the last page of the Wizard. If you wish to review any of the settings you have made, click **Back** to return to the relevant page.
9. When you are ready, click **Finish** to generate the pile group. The **Pile Group Wizard** then:
   - creates `Piles 1-15` and `Pile Group 1`
   - creates `Concrete 2`

- links `Piles 1-15` to `Concrete 2`
- adds `Piles 1-15` to `Pile Group 1`
- adds `Pile Group 1` to `Situation 1`

10. The Drawing Board will now look something like this (change the scale to 1:100 to see this more clearly):

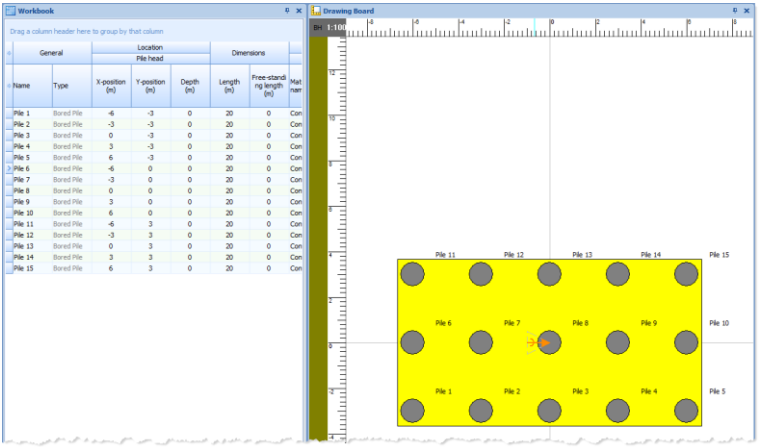


[Docs]\Tutorials\Tutorial 6\Step 3.rpx captures everything you've done so far.

Step 4 – move the piles to their final positions

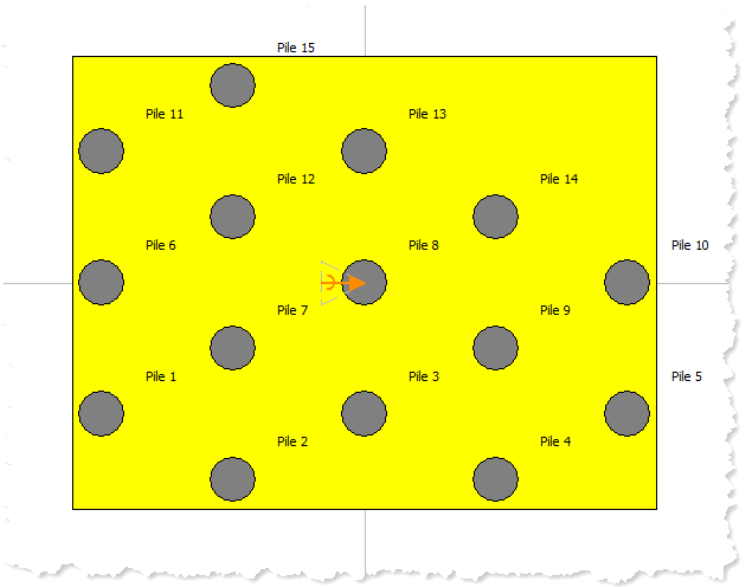
In Step 4, you will move the piles to their final (asymmetric) positions.

1. Select `Pile Group 1` in the **Project Manager** and then, if it is not already visible, open the **Workbook** by clicking on **View > Workbook** on Repute's ribbon. Widen the Workbook so that you can (see at a minimum) the columns headed **General**, **Location**, and **Dimensions** while still displaying the **Drawing Board**, like this:



2. In the row for `Pile 2`, select the cell under the column **Y-position (m)** and enter the value `-4.5` and press ENTER. The pile's position on the Drawing Board will change automatically.
3. Repeat the previous instruction for `Pile 4`.
4. Change the **Y-position (m)** of:
   - `Piles 7 and 9` to `-1.5` m
   - `Piles 12 and 14` to `1.5` m.
   - `Pile 15` to `4.5` m.
5. Finally, change the **X-position (m)** of `Pile 15` to `-3.0` m.

6. Back in the **Property Inspector** for `Pile Group 1`, click on the **Resize** button to enlarge the pile cap. The **Drawing Board** will now look something like this:



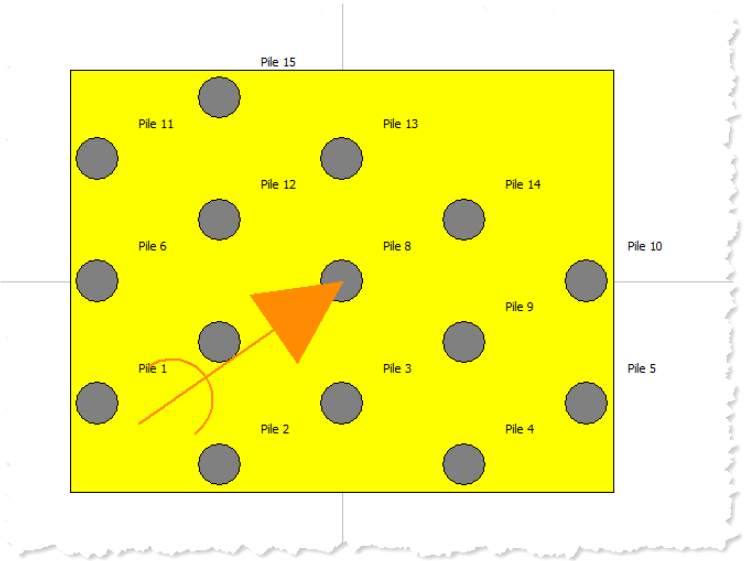
[Docs]\Tutorials\Tutorial 3\Step 4.rpx captures everything you've done so far.

Step 5 – modify the loads

In Step 5, you modify the actions on the pile group.

1. Select `Force 1` in the **Project Manager** and then, in its **Property Inspector**, change **Fz** to `50 000` kN and select `Pile 8` in the **Tether to ...** box (this will automatically change the **Depth** of `Force 1` to 0 m to match that of `Pile 8`).
2. Select `Force 2` in the **Project Manager** and, in its **Property Inspector**, change **Fx** to `10 000` kN, **Fy** to `7 000` kN, and select `Pile 8` in the **Tether to ...** box.
3. Select `Moment 1` in the **Project Manager** and, in its **Property Inspector**, change **Mx** to `3 000` kN, **My** to `5 000` kN, and select `Pile 8` in the **Tether to ...** box.

4. The Drawing Board will now look something like this:

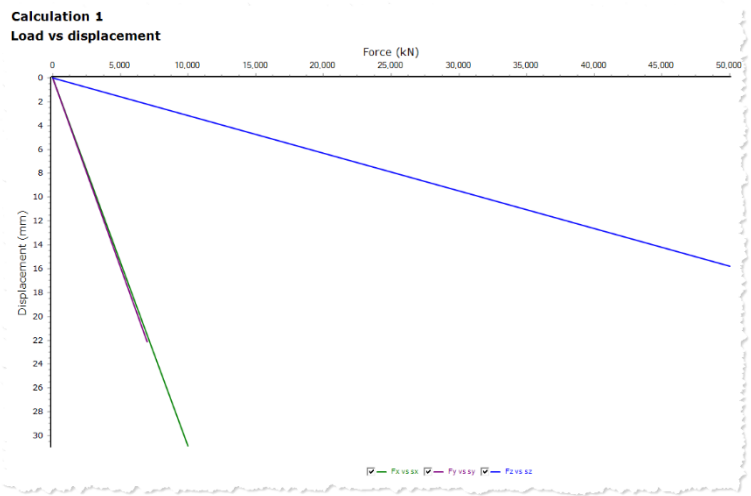


[Docs]\Tutorials\Tutorial 6\Step 5.rpx captures everything you've done so far.

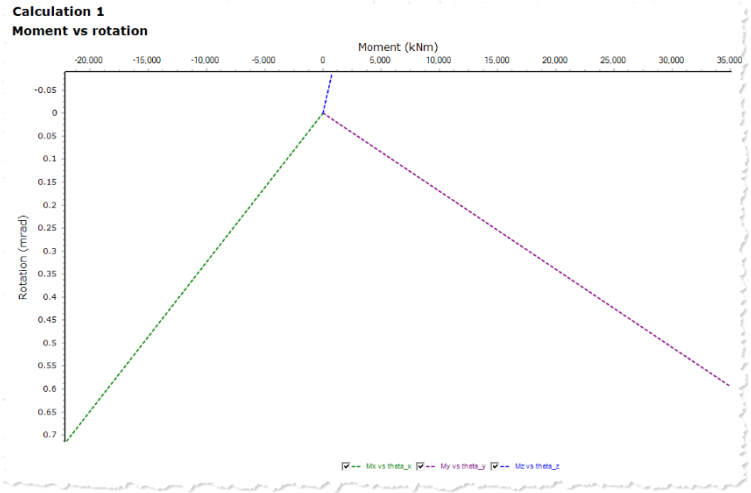
Step 6 – perform and review the calculation

In Step 6, you will perform the calculation and review the results.

1. Right-click on `Calculation 1` in the **Project Manager** and select the **Build** command on the pop-up menu that appears. Repute will perform the calculation and then change its display to show its **Checking Desktop** (which displays the **Project Manager**, **Workbook**, and **Graph Paper**). You can switch to this display at any time by clicking on the **Check** button on the **View** tab. The load vs displacement graph will now look something like this:



2. You can change the graph that appears on the screen by selecting one of the options in the **Pile Group** drop-down box on the **Graph Paper tab**. For example, if you select the Moment vs rotation option, the graph will change to look something like this:



3. You can change the appearance of the graph by experimenting with the extensive set of controls provided via its **Options** box. To display this box, click on the **Options** button on the **Graph Paper**

tab. Click on the help button to find instructions for using this box to customize your graph.

Step 7 – close the project

In Step 7, you will close and – optionally – save the project. (Note: this is not available in the Trial Edition.)

1. Close the project by clicking on the **File** menu's **Close** command.
2. If you have made changes to the project since it was last saved, Repute will ask you if you want to save before proceeding. Answer **Yes** or **No** by clicking the appropriate button.
3. Repute will then (if requested) save and close the project.

You will find a copy of the project in its final form here:

[Docs]\Tutorials\Tutorial 6\Tutorial 6.rpx

What next?

Further information about the program's capabilities can be found in the *Repute 2.5 User Manual* and the program's built-in help system. Details of the theory that underpins the program's calculations can be found in the *Repute 2.5 Reference Manual*.

Further resources are available from the Geocentrix website:

www.geocentrix.co.uk/repute