

Design of diaphragm and sheet pile walls

D-SHEET PILING

Deltares systems



Deltares systems

In The Netherlands, an extensive design procedure for sheet pile walls has been developed. Besides the partial safety factor concept of the Eurocode 7, the Dutch National Annex offers a clear step-by-step design process, checking against failure, verifying stability and allowing optimization of the design. Initiated by the Dutch Ministry of Public Works, the development of a software tool for the analysis and design of retaining walls started back in 1988. Since its initial development, many improvements have been made to suit the needs of geotechnical designers and consultants.

The stability of the majority of all Dutch retaining walls has been checked using methods and tools developed by Deltares (formerly known as GeoDelft), the leading Institute for Delta Technology. In 2002, GeoDelft founded Delft GeoSystems. Previous releases of D-SHEET PILING were named MSheet. Since the formation of Deltares in 2008, Delft GeoSystems has become Deltares systems. Deltares systems makes these tools available in English for the international geotechnical engineering community. Deltares systems tools come with a comprehensive manual and extensive validation and verification reports.

General

D-SHEET PILING is a tool used to design retaining walls and horizontally loaded piles. D-SHEET PILING's graphical interactive interface requires just a short training period, allowing the user to focus their skills directly on the input of sound geotechnical data and the subsequent design of the wall or single pile.

Besides features generally found in other retaining wall design software, D-SHEET PILING offers several specific design features:

- **Automatic interpretation of CPT's**

All geotechnical parameters needed for input are interpreted from CPT data.

- **Length optimization**

The critical length for the retaining structure is checked automatically by reducing the length of the wall step-by-step, until instability or unacceptable displacement occurs.

- **Safety**

D-SHEET PILING verifies the safety of the sheet pile wall for selected construction stages by applying partial safety factors defined according to the Eurocode 7, including Eurocode annexes for The Netherlands and Belgium. The user can also define their own partial safety factors.

- **Anchor wall stability**

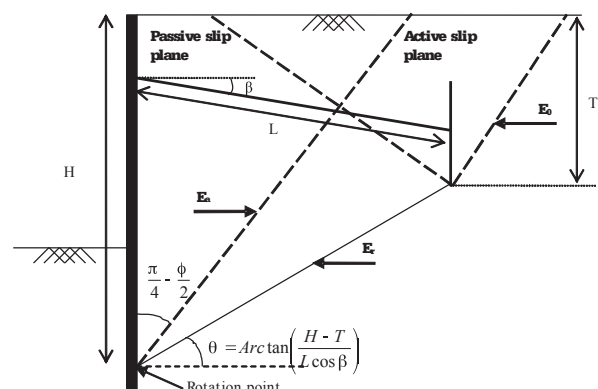
The stability of the anchor wall is checked according to the Kranz theory.

- **Overall stability**

A Bishop slip-circle analysis is used to check the overall stability of the wall and soil.

- **Feasibility comparison**

Projects can be compared to experiences of real projects and guidelines to help to ascertain if installation/vibration of a sheet pile wall of this type is feasible.



Stability of anchor for short anchor (Kranz theory)

D-SHEET PILING comes as a standard module, which can be extended further with other modules to fit more advanced applications:

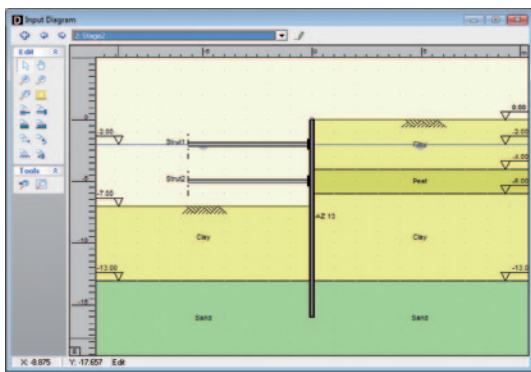
- **D-SHEET PILING Standard module (Earth pressure coefficients)**
- **Culmann module**
- **Eurocode 7 Verification module**
- **Single Pile module**
- **Feasibility module.**

Standard module (Earth pressure coefficients)

The standard module is intended for the analysis of retaining wall structures. It allows input of straightforward projects and provides tabulated and graphical output of results both on-screen and in a report. Some specific features include:

Geometry input

- Graphical user interface.
- Horizontal soil layers.
- Input of sheet pilings from an extensive library (Arcelor, Hoesch, Larssen, Chaparral).
- Wizard for fast input of combined walls (king piles).
- Anchors, including pre-stressing force and maximum loading force (yielding).
- Struts, including pre-compression force and maximum loading force (buckling).



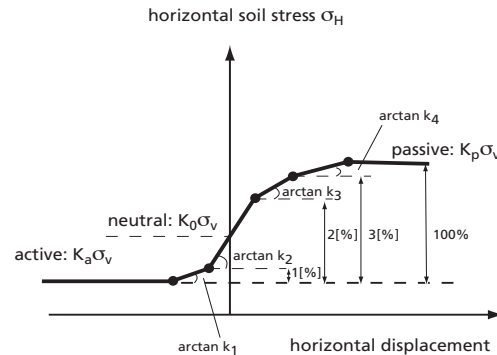
Staged excavation with struts

Loading input

- Uniform distributed loads at ground level.
- Line loads directed perpendicularly to the wall, moments, variable normal force along the beam axis.
- CPT input from GEF-file or DINO via GEFPlotTool database.

Soil modelling

- CPT interpretation model.
- Subgrade reaction model.
- Earth pressure coefficients (K_a , K_o and K_p).
- Elasto-plastic modelling of loading/unloading.



Stress displacement diagram

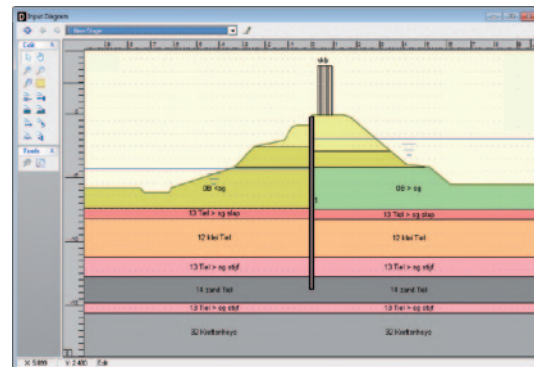
Modelling of groundwater and water pressures

- Hydrostatic pore fluid pressure from the input of a phreatic surface.
- Additional excess pore pressures.

Construction stages

All settings relevant to staged construction are available in a spread sheet like window. This allows for fast control and provides overview. The following changes can be made between stages:

- excavation or elevation of soil
- adding or removing loads
- adding or removing anchors and struts
- pre-stressing or pre-compressing in anchors and struts
- alteration of the water table.

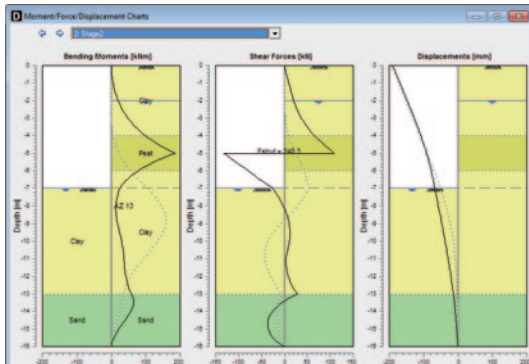


Inputted geometry

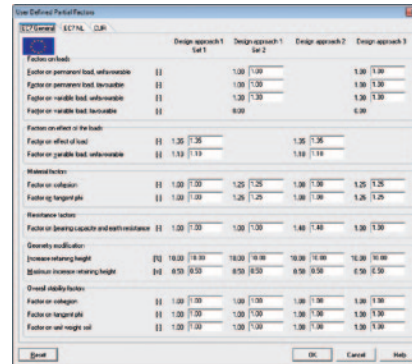
Output

Input and output tables, graphs and a report are available for printing, viewing and for export with standard Windows applications through the Windows clipboard. Graphs are available for:

- displacements
- bending moments
- shear forces
- pore pressures and soil stresses along the beam axis
- results of length design and overall stability checks can be viewed



Stresses in sheet pile wall



Eurocode 7 partial factors

- reports can be generated for ordinary and verification calculations, containing input and output data, graphs and summaries
- information can also be exported to D-GEO STABILITY for more comprehensive stability analysis.

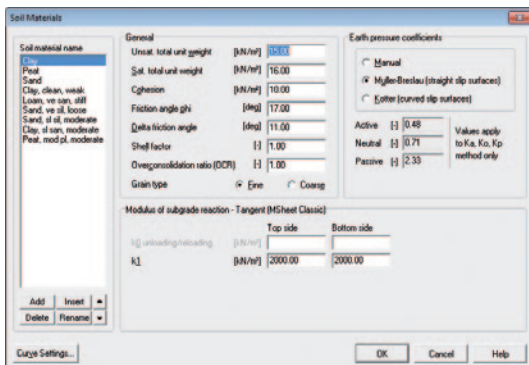
- Checking forces in anchors against allowable values according to slip surface theory.
- Detailed verification report.

Culmann module

- Refined calculation of earth pressure coefficients.
- Non-horizontal ground level.
- Non-uniform surcharge loads.
- Initial stage for input of non-horizontal initial ground level or initial surcharge avoiding deformation in the wall due to their pre-existence.

Single Pile module

- Soil layers and water pressures as for sheet pile walls.
- Ability to input piles with different cross-sections and stiffnesses at different depths.
- Connections to foundations and other restraints modelled by supports resisting rotation and/or translation.
- Loading by horizontal forces, forces along the pile axis and moments.
- Alternatively, loading by soil displacement. This option is especially useful for horizontally loaded piles where the displacement of soil due to external loading results in pile bending.



Input window for soil parameters

Eurocode 7 Verification module

- Overall stability check using a slip circle according to Bishop.
- Ability to apply partial factors to loads, material properties, soil and water levels, all according to the Eurocode 7 general setup and according to the National Annexes for The Netherlands and Belgium, or according to user specified partial factors.
- Application of different safety classes/partial factor sets to different construction stages.



Vibrating mooring piles

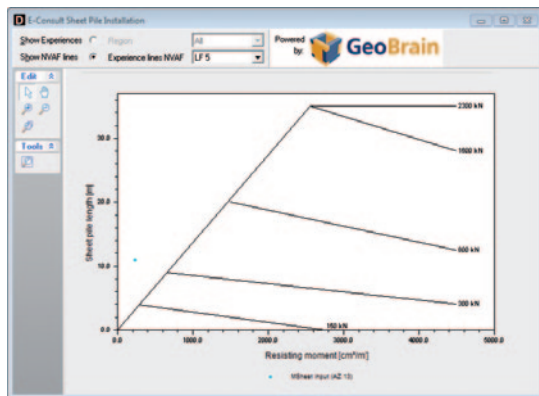


Feasibility module

During the design of a sheet pile wall, the stability of the construction is checked according to guidelines like the Eurocode. In practice, this does not guarantee that the project is feasible. This may depend on many other local factors, among which the equipment used during construction. For this purpose, the use of the Feasibility module helps the user to evaluate the project's feasibility by comparison with experiences. Three sources are available in the Feasibility module:

NVAF lines

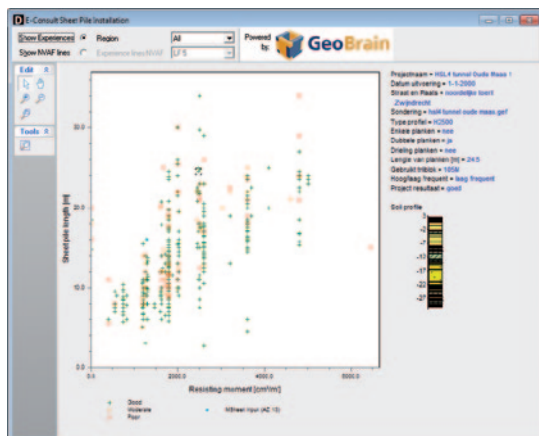
The Dutch Society for Foundation Engineering Contractors (NVAF) has written guidelines to prevent sheet pile driving failure. The Feasibility module supports some NVAF graphs on pile driving failure, using vibrators. These graphs are based on the relation between the sheet pile length and the resisting moment. Depending on the equipment used, several graphs exist giving the user an indication of the feasibility.



NVAF experience lines

GeoBrain Foundation technics experiences

In 2002, GeoDelft started a project called GeoBrain which aim was to develop a prediction model for the feasibility of foundation

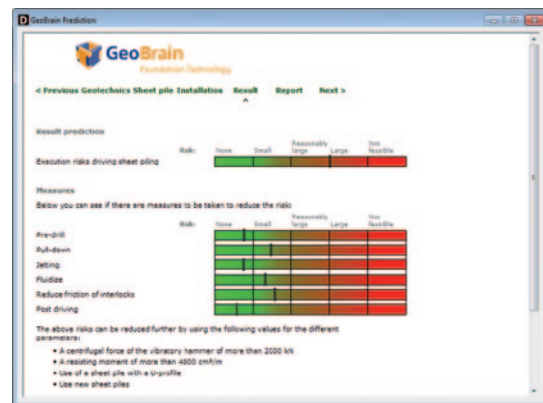


Visualization of GeoBrain experiences in D-SHEET PILING

works. Hundreds of project experiences concerning the driving of sheet pile walls and piles were therefore received for study. The Feasibility module provides access to these experiences. Based on the relation between the sheet pile length and the resisting moment the user is confronted with stored experiences. These may help the users to predict the feasibility of their projects.

GeoBrain Foundation technics predictions

The GeoBrain Foundation technics predictions model introduces expert knowledge based on input parameters used in D-SHEET PILING. The prediction model will indicate the feasibility of the project and provide suggestions for practical improvements.



Visualization of GeoBrain predictions in D-SHEET PILING

Interaction with other Deltares systems tools

The geometry from D-SHEET PILING can be directly exported to D-GEO STABILITY for more detailed stability analysis.

Support

Deltares systems tools are supported by Deltares. A group of 70 people in software development ensures continuous research and development. Support is provided by the developers and if necessary by the appropriate Deltares experts. These experts can provide consultancy backup as well.

On-line software (Citrix)

Besides purchased software, Deltares systems tools are available as an on-line service. The input can be created over the internet. Heavy duty calculation servers at Deltares guarantee quick analysis, while results are presented on-line. Users can view and print results as well as locally store project files. Once connected, clients will be charged by the hour.



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