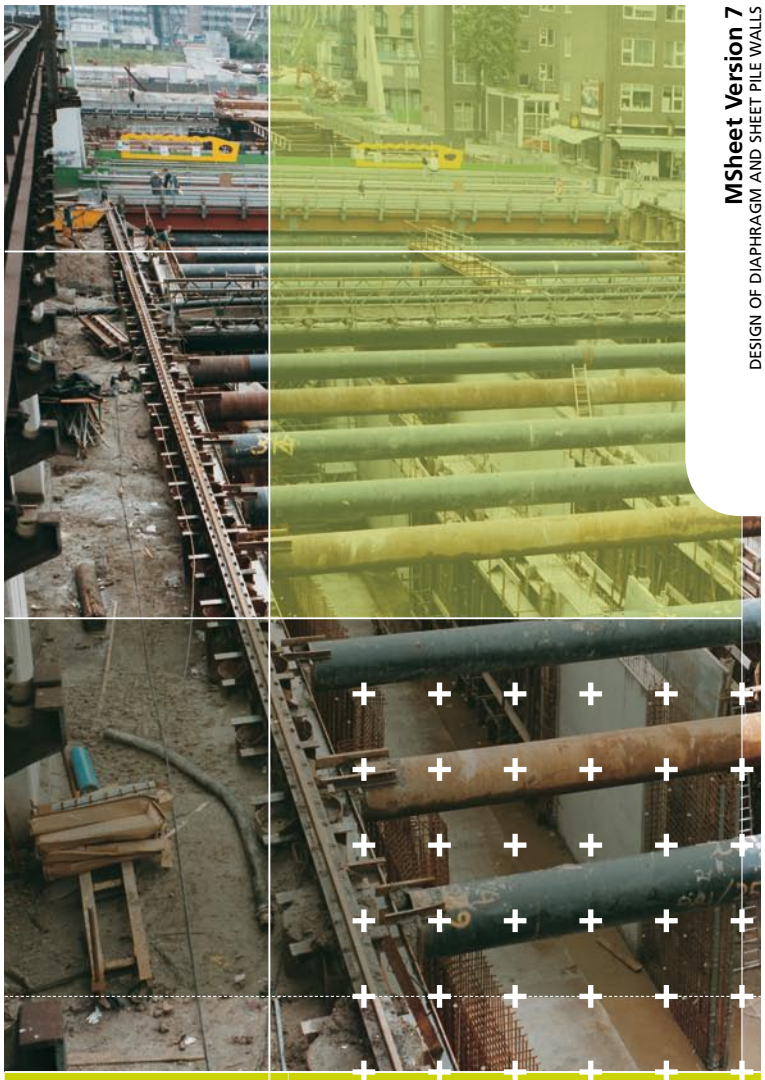
MSheet

Version 7

Design of Diaphragm and Sheet Pile Walls

GeoDelft

Delft GeoSystems



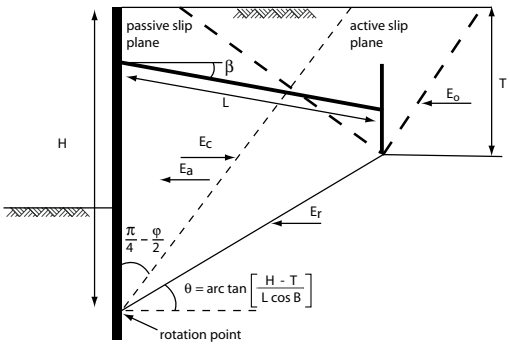
Design of Diaphragm and Sheet Pile Walls

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 design procedure (CUR 166, 2005) offers a clear step-by-step design process, checking against failure and allowing optimization of the design. Since its initial development many improvements have been made to suit the needs of geotechnical designers and consultants.
Initiated by the Dutch Ministry of Public works, the development on a software tool for the analysis and design of cantilever retaining walls started back in 1988. The stability for the majority of all retaining walls in the Netherlands has been checked using methods and tools developed by GeoDelft, the leading Dutch Institute in this field. In 2002 GeoDelft founded Delft GeoSystems. Through Delft GeoSystems these tools are now available in English for the international geotechnical engineering community. Delft GeoSystems tools come with a comprehensive manual and extensive validation and verification reports. Technical support and updates are available free of charge for a period of 3 months. In addition support and updates are available through annual support contracts.

General

MSheet is a tool used to design retaining walls and horizontally loaded piles. MSheet'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, MSheet offers several specific features for design:

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: MSheet verifies the safety of the sheet pile wall for selected construction stages by applying partial safety factors according to CUR 166 (2005) or EuroCode 7. The user can also define their own set of 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 real experiences and guidelines to help ascertain if installation/vibration of a sheet pile wall of this type is feasible.



STABILITY OF ANCHOR WALL FOR SHORT ANCHOR (KRANZ THEORY)

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

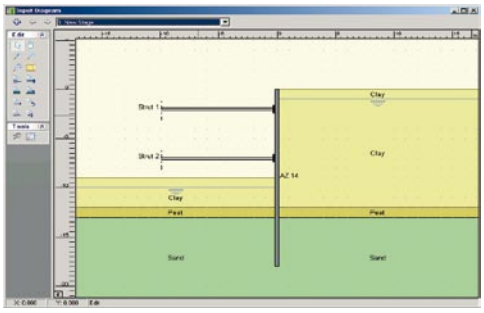
- "C, phi, delta" (Culmann) module
- Verification module
- Single piles module
- E-Consult module

Standard module

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:

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



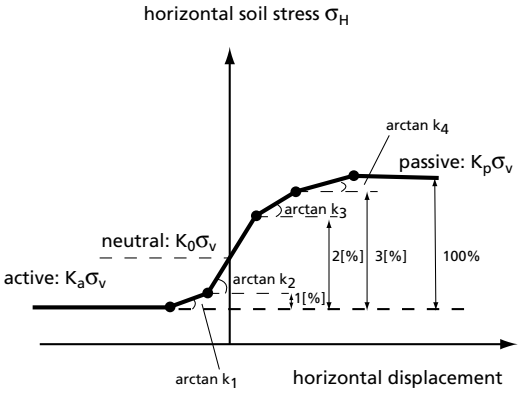
STAGED EXCAVATION WITH STRUTS.

Loading input:

- Uniform distributed loads at ground level
- Line loads directed perpendicularly to the wall, moments, variable normal force along the beam axis

Soil modeling

- Subgrade reaction modulus
- Earth pressure coefficients (Ka, Ko and Kp)
- Elasto-plastic modeling of loading/unloading



STRESS DISPLACEMENT DIAGRAM

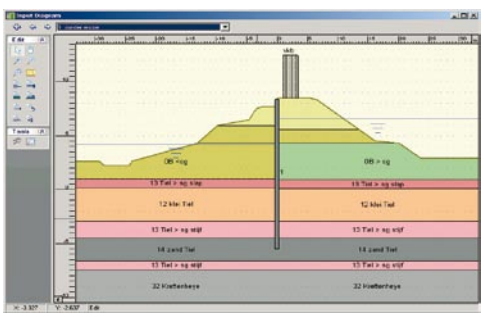
Modeling of groundwater and water pressures

- Hydrostatic pore fluid pressure from the input of phreatic surface positions
- 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:

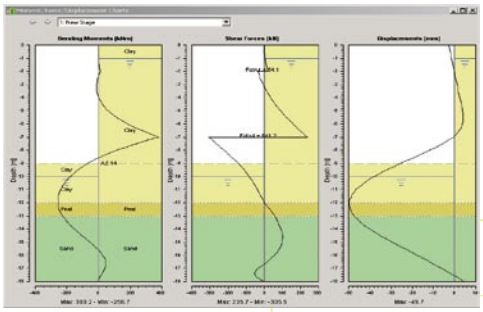
- Excavation or elevation of soil
- Addition or removal of loads
- Addition or removal of anchors and struts
- Pre-stress or pre-compression in struts and anchors
- Alteration of the water table



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. Reports can be generated for ordinary and verification calculations, containing input and output data, graphs and summaries. Information can also be exported to MStab for more comprehensive stability analysis.



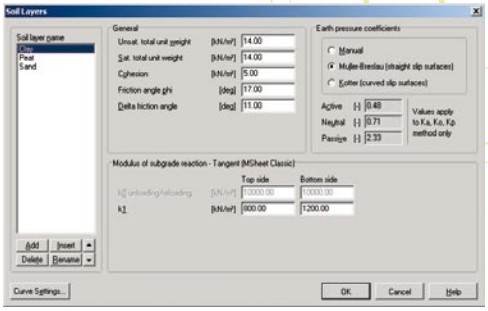
STRESSES IN SHEET PILE WALL

Interaction with other Delft GeoSystems tools:

The geometry from MSheet can be directly exported to MStab for more detailed stability analysis.

Culmann Module

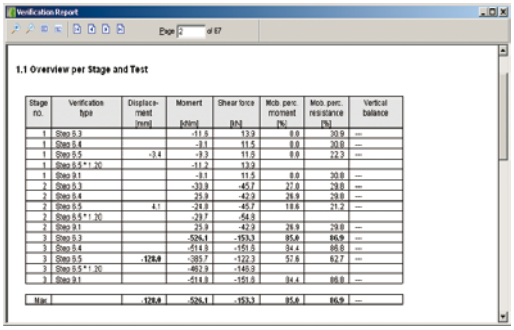
- Refined calculation of earth pressure coefficients
- non-horizontal ground level
- non-uniform surcharge loads
- Initial stage for input of non-horizontal initial ground level or initial surcharge that will not cause deformation in the wall due to their preexistence



INPUT WINDOW FOR SOIL PARAMETERS

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
- Application of Dutch design procedure (CUR 166, 2005) values to check safety according to this code, or according to user specified partial factors
- Application of different safety classes/partial factor sets to different construction stages
- Checking forces in anchors against allowable values according to slip surface theory
- Detailed verification report



SECTION OF VERIFICATION REPORT.

Single pile module

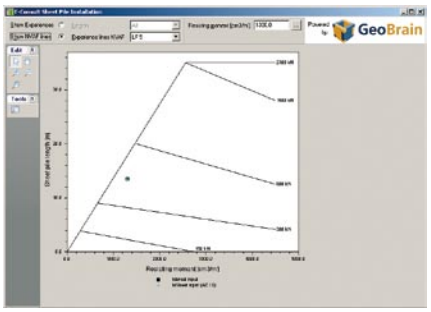
- Soil layers and water pressures as for sheet pile walls
- Ability to input piles with different cross-sections and stiffnesses at different depths
- Connections to foundations and other restraints modeled by supports resisting rotation and/or translation
- Loading by horizontal forces, forces along 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 and subgrade reaction

VIBRATING OF MOORING PILES

E-Consult module

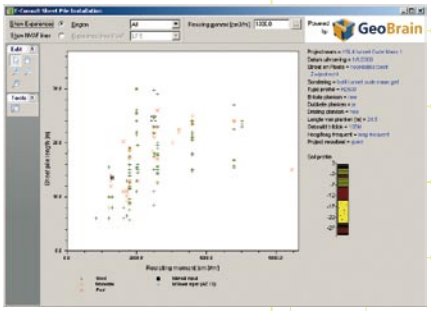
During the design of a sheet pile wall, the stability of the construction is checked according to guidelines like the EuroCode. In practice this does not guarantee the project is feasible. This may depend on many other local factors, among which the equipment used during construction. For this purpose, the use of the E-Consult module helps the user to evaluate the feasibility of its project by comparison with experiences. Two experiences source are available in the E-Consult module:

NVAF lines: The Dutch Society for Foundation engineering Contractors (NVAF) has written guidelines to prevent sheet pile driving failure from occurring. The E-consult 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 that give the user an indication of the feasibility.



NVAF EXPERIENCE LINES.

GeoBrain experiences: In 2002 GeoDelft started a project called GeoBrain which aim is to develop a prediction model for the feasibility of foundation works. Hundreds of project experiences concerning the driving of sheet pile walls and piles were therefore received for study. The E-Consult 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.



VISUALIZATION OF GEOBRAIN EXPERIENCES IN MSHEET

Support

Delft GeoSystems tools are supported by GeoDelft. A group of 10 people in software development ensures continuous research and development. Support is provided by the developers and if necessarily by the appropriate GeoDelft experts. These experts can provide consultancy backup as well.

On-line software (Citrix)

Besides purchased software, Delft GeoSystems tools are available as an on-line service. Input can be created over the internet, then heavy duty calculation servers ensure quick analysis, and results are presented on-line. Users can view and print results as well as store project files locally. After hook-up clients are charged by the hour. A 20 minute free trial at www.DelftGeosystems.com allows the on-line software to be experienced.

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DESIGN OF DIAPHRAGM AND SHEET PILE WALLS

Agent:

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GeoDelft

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