

Slope stability software for soft soil engineering

D-GEO STABILITY

Deltares systems



Deltares

Enabling Delta Life



D-GEO STABILITY

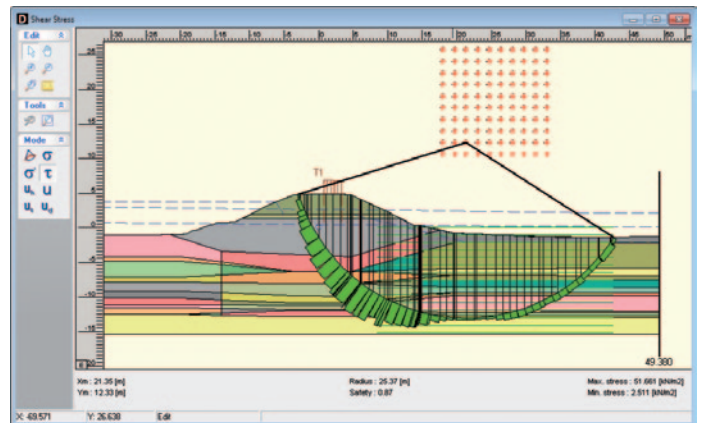
Deltares systems

For The Netherlands the safety and stability of the primary sea and river dikes is essential since over half the population lives below sea level. In total, 3,500 kilometres of primary dikes and over 100,000 kilometres of other embankments protect the country from flooding. Over the past 75 years, the stability of the majority of the dikes and embankments has been checked using methods and tools developed by Deltares, the leading Dutch Institute in this field. In 2002, GeoDelft founded Delft GeoSystems. Since the formation of Deltares in 2008, Delft GeoSystems has become Deltares systems.

Through Deltares systems these tools are now available in English for the International GeoEngineering community. Deltares systems tools come with a comprehensive manual and extensive validation and verification reports.

General

D-GEO STABILITY is a slope stability package for soft soils. Previous releases of D-GEO STABILITY were named MStab. Deltares systems tools follow best practice, and are developed according to modern software standards; therefore they are user-friendly and easy to learn.

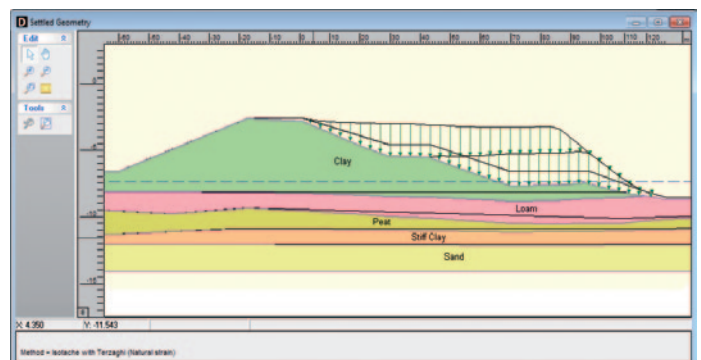


Bishop slip circle with shear stresses

Besides features generally found in other slope stability packages, D-GEO STABILITY offers several specific features for the design of river dikes and road embankments:

- **Integration with other Deltares products**

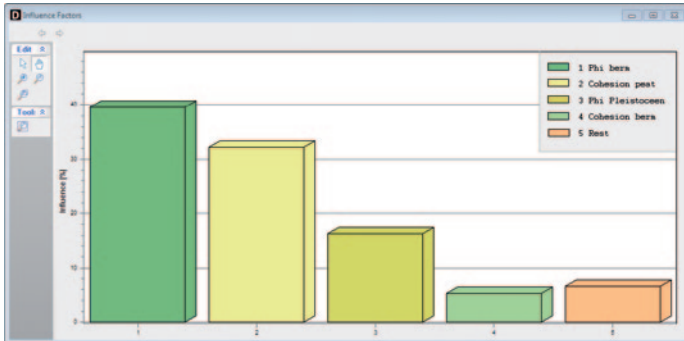
Integration with the suite of other Deltares systems products. For example, settlements can be introduced using the D-SETTLEMENT program. In this way, safety analyses for various (settled) construction stages can be performed.



Settled geometry can be imported from D-SETTLEMENT

- **The reliability analyses module**

The reliability module supports the Eurocode 7, allowing for the input of partial safety factors. A stochastic distribution of parameters allows for semi-probabilistic analysis as well as



Influencing factors, resulting from a reliability analysis

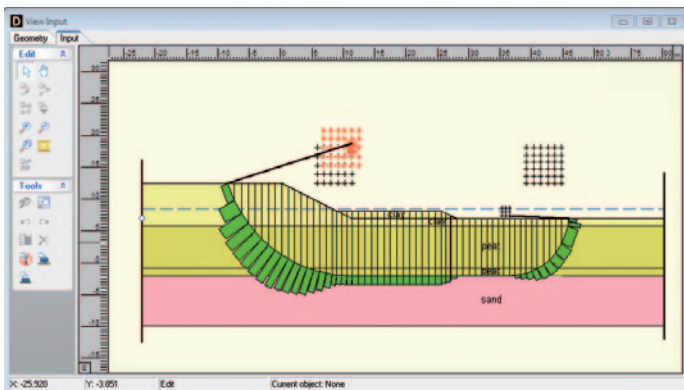
probabilistic analyses. Using the model default parameters for stochastic properties, the user can easily switch from a standard safety analysis to a reliability analysis without additional input data.

- **Probabilistic Random Field method**

Experts in probabilistic analysis can use the Bishop Probabilistic Random Field module, allowing users to take into account spatial variation of parameters.

- **Uplift calculation**

The Uplift module allows for the safety analysis of river embankments under the influence of changing water levels in aquifers. This may result in the uplift of the hinterland, a mechanism causing numerical difficulties in most FEM approaches.



Uplift failure mechanism for river embankments

- **Integration with Watex**

The movement of rising water levels as a result of extensive rainfall events is an important issue for river embankments. The Deltares Watex program allows for fast analysis, resulting in time dependant water pressure distributions that can be imported into D-GEO STABILITY.

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

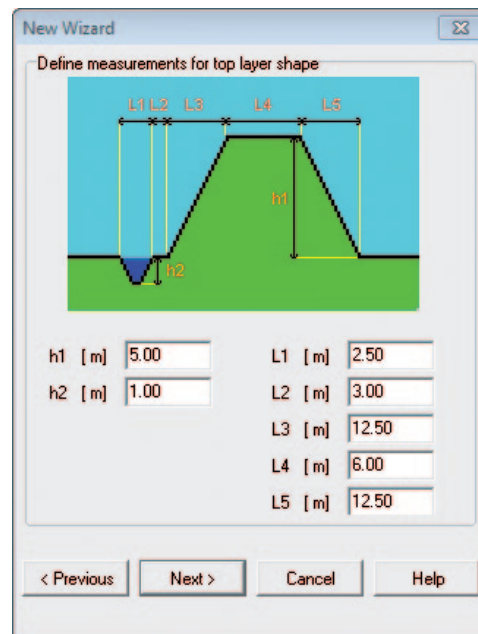
- **D-GEO STABILITY Standard module (Bishop and Fellenius)**
- **Spencer module**
- **Uplift module**
- **Reliability Analyses module**
- **Probabilistic Random Field module.**

Standard module (Bishop and Fellenius)

The standard module contains the graphical user interface and an automatic slip circle determination for the lowest safety factor for both Bishop and Fellenius methods. The standard module provides an output report and tabulated and graphical output. Some specific features are:

Geometry input

- Graphical user interface.
- Geometry wizard.
- Arbitrary shaped soil layers (< 499 layers).
- Geometry export to Plaxis.



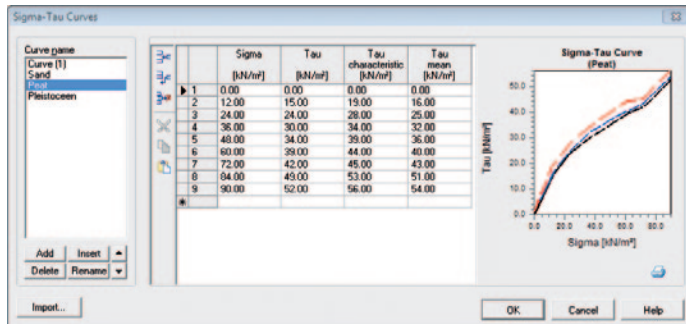
Geometry wizard

Loading input

- Line load (option for load distribution in soil).
- Uniform loads (option for load distribution in soil).
- Temporary uniform loads (input for degree of consolidation).
- Earthquake loads (acceleration).

Soil modelling (drained and undrained behaviour)

- Phi and c.
- Stress tables (sigma/tau).
- Undrained shear strength (cu). Either as values or as a calculated ratio with the pre-consolidation stress.



Input window for stress tables

Soil reinforcement modelling

- Sheet-piles (slip circle cannot cross “forbidden” lines).
- Geosynthetics.

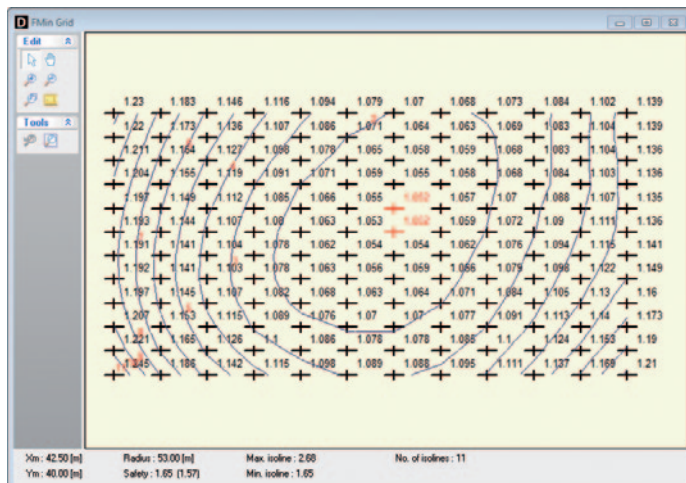
Modelling of groundwater and water loads

- Piezometric head along boundary lines, or layer-by-layer.
- Pore pressure induced by loads (temporary/permanent).
- Excess pore pressures (pore pressure profile).

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:

- stresses along the vertical
- global safety factor
- stresses along the slip plane

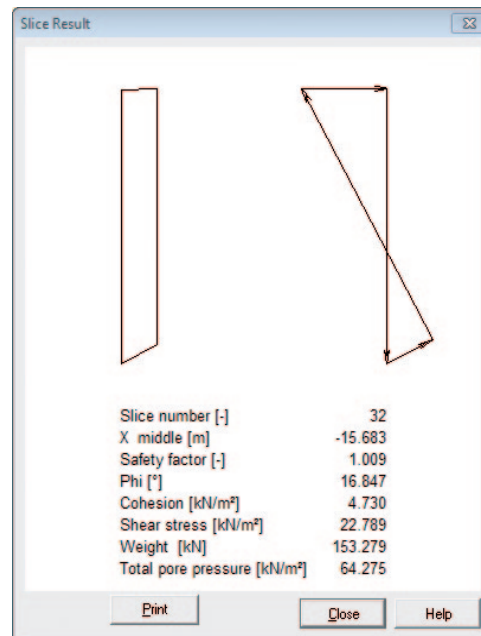


Safety contours

- safety contours
- safety grid
- chance of failure (with reliability analyses module)
- influencing factors on soil parameters (with reliability analyses module).

Spencer module

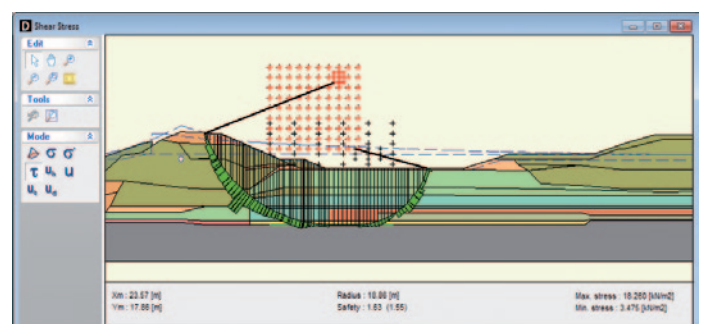
This module comprises the Spencer method that allows stability analysis for user-defined non-circular failure surfaces. Equilibrium is ensured for moments, vertical and horizontal forces.



Results per slice

Uplift module

This module allows for the analysis of uplift stability, a mechanism responsible for failure of river embankments. The failure mechanism consists of a horizontal part, bounded by two circles (Uplift Van) or by one circle and a straight line (Uplift Spencer).



Reconstruction of river embankment

Reliability Analyses module

Standards such as the Eurocode 7 require the execution of a reliability analysis. Such an analysis takes into account the variation of strength and loading. With the Reliability module one can choose between the partial factors concept and a probabilistic analysis. Users may manually input the actual parameter probability distributions, or simply use D-GEO STABILITY'S defaults for an approximate analysis without additional input. Using the default values, three different design methods are available that require no additional input:

- **Mean value analysis**

Traditional calculation of the safety factor, using fixed mean values of the parameters.

- **Design value analysis**

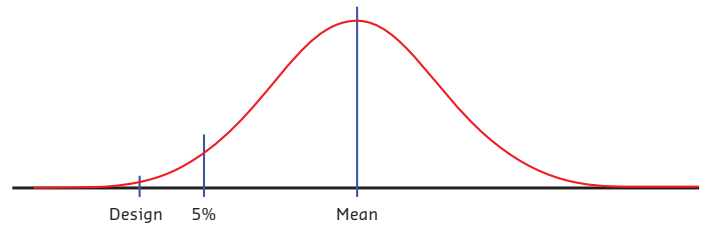
Calculation of the safety factor, using fixed design values of the parameters. D-GEO STABILITY derives these unfavourable lower or upper limits from stochastic parameter distributions and partial factors.

- **Probabilistic design**

Calculation of the safety factor (mean value), a probability of failure and influence factors. The probabilistic FORM (First Order Reliability Method) method uses variations of stochastic parameters for strength parameters and pore pressure. The uncertainty in external water loading is also taken into account, using a Gumbell distribution.



Embankment failure



Parameter probability distribution

The Reliability Analyses module can be applied in combination with all regular options of the Bishop model and the Uplift models.

Probabilistic Random Field module

The Bishop Probabilistic Random Field module aims at experts in probabilistic analysis. Compared to the Reliability Analyses module, the Probabilistic Random Field module offers the additional modelling of spatial variability in the plane and out of the plane, by using autocorrelation functions. The module incorporates a Bishop model with c-phi soil parameters.

Interaction with other Deltares systems tools

D-GEO STABILITY interacts with other Deltares systems tools for settlement analysis, seepage analyses, central project and database storage:

- **D-SETTLEMENT** for exchange of geometry
- **D-SETTLEMENT** for import of settled geometry
- **D-GEO PIPELINE** for exchange of geometry.

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.



Deltares systems

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