Software voor de beoordeling van primaire waterkeringen

D-Soil Model

Dutch Delta Systems

Functional Design

Deltares

Functional Design D-Soil Model

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Deltares

Titel
Functional Design D-Soil Model

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Trefwoorden
Stochastic subsoil schematization, soil profile, soil properties, macro stability, piping, flow slide

Summary
This document contains the requirements and functional design for the application D-Soil Model, which will be a part of the WTI 2017 software. The application supports the (stochastic) subsoil schematizations for the failure mechanism Macro stability and Piping. A subsoil schematization for soil segment consists of 1D and/or 2D soil profiles and soil material properties.

Samenvatting
Dit document bevat de eisen en het functioneel ontwerp voor de applicatie D-Soil Model welke deel uit maakt van de WTI-2017 software. De applicatie ondersteunt de (stochastische) schematisering van de ondergrond voor de faalmechanismen Macrostabiliteit en Piping. Per bodemsegment bestaat deze schematisering uit 1D en/of 2D profielen en materiaaleigenschappen.

Versie	Datum	Auteur	Paraaf	Review	Paraaf	Goedkeuring	Paraaf
02	mei 2016	Irene van der Zwan		Kin Sun Lam		Joost Icke	
				Hans van Putten			

Status
concept
Dit document is een concept en uitsluitend bedoeld voor discussiedoeleinden. Aan de inhoud van dit rapport kunnen noch door de opdrachtgever, noch door derden rechten worden ontleend.

Contents

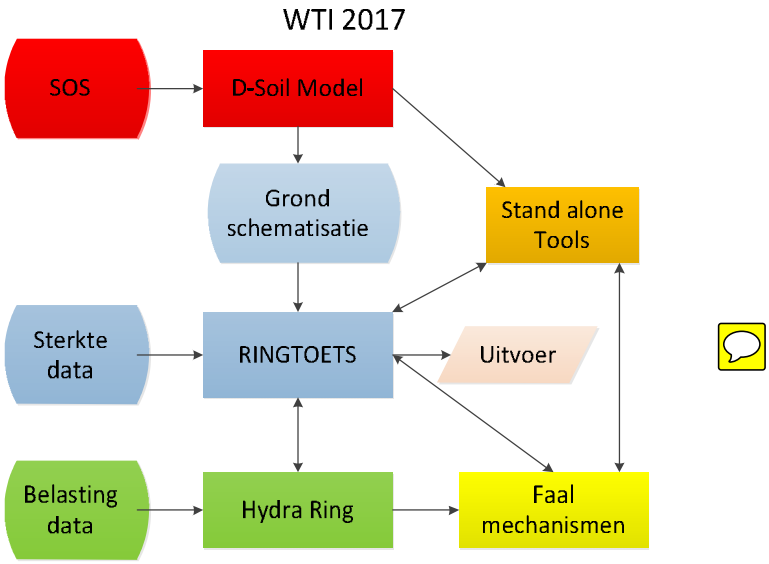
1 Introduction

1.1 Purpose and scope

This document contains the functional design for the application D-Soil Model, which will be part of the WTI 2017 software applications. This Functional Designs describes the functionality of the application.
The application supports the (stochastic) subsoil schematizations for the failure mechanism macro stability and piping. A subsoil schematization for a segment consists of soil profiles, profile properties, layer properties and soil material properties.

D-Soil Model is a software tool for schematization of the subsoil and is developed for the assessment of primary dikes according to the WTI2017. In this process of assessment the schematization of a stochastic subsoil model (WTI-SOS 2017) is a major source of information. This information is used in the stand alone tools and Ringtoets (see figure below). The D-Soil Model development focusses on use of this stochastic subsoil model (WTI-SOS 2017).

For background on the context of the WTI project and on the derivation or motivation of the supported schematizations, the reader is referred to the VTV 2017 and to its supporting technical reports and their background reports underneath.



This document is a revision of 1209430-003 WTI 2017 D-Soil Model Requirements and Functional Design and is applicable to version 16.1.

A glossary of used terms is placed in appendix A.

1.2 Other system documents

For the development of D-Soil Model different documents are available. The titles are posted in the table below.

Title	Content
Functional design	This document
Technical Design D-Soil Model [2]	Definition of the different software components and their interaction
Test plan and Test report [3]	Reports all test levels of the V model, as prescribed by the overall test plan
Technical Design Macrostability kernel [4]	Definition of the different software components and their interaction
Technical Design Piping kernel [5]	Definition of the different software components and their interaction

1.3 Former versions of the Functional Design of D-Soil Model

The first Functional Design was written in 2014. During the development of D-Soil Model the SCRUM method is used. This results in changes in requirements. Therefore the Functional Design has been adapted.

Together with Rijkswaterstaat there have been minimal requirements defined in the requirements document [1]. In appendix B an overview is presented where these minimal requirements are placed in the present Functional Design.

1.4 Constraints and non-functional requirements

1.4.1 Constraints

CNS 1. As a general constraint, the development process needs to comply with the Deltares DQMS system.

CNS 2. As a general constraint, the application needs to comply with the relevant general requirements and further design rules for the programming, documentation and testing of WTI software. This set of requirements and rules are available in a separate document [1].

1.4.2 Non-functional requirements

Synchronization between different views (REQ 8.16 from old version FO)
The user can switch between different kind of views of the data by clicking on the name. E.g. clicking on segment A in the table window, also selects this segment on the map and the properties of this segment are shown on the map. Applicable for names of: Soil segments, soil profiles, material, layer, CPT, boring, surface lines.
This will be tested via test scripts and reported in the test document.

As stated in the requirement overview [1]:

NFR2 The regular conventions, standards, tools and libraries for Deltares Systems software will be used. (must have).

NFR3 Data definitions will follow existing and emerging standards such as IRIS as much as possible. (must have).
Where possible emerging standards will be followed. For geometry a format has been used since the start of the development of Ringtoets which remained unchanged.

NFR12 The user-interface may not cause crashes during regular usage. (must have)
This will be tested via test scripts and reported in the test document.

NFR14 Consistency between the input data and the output data must be guaranteed. (must have)
This will be tested via test scripts and reported in the test document.

NFR15 “De generieke code coverage wordt gesteld op 80%, met uitzondering van de Delta Shell Light componenten, waarvoor een code coverage van 60% zal worden gehanteerd.”
This will be reported in the test document.

U123 “De WTI Software moet tot een eenduidig en reproduceerbaar resultaat leiden.”
D-Soil Model does not have calculation functionlity but projects can be saved and reopened.
This will be reported in the test document. 

1.5 Interfaces

Using D-Soil Model the user can provide subsoil information to the WTI software. The schematization, made in D-Soil Model, can be imported in the WTI software.
Each WTI application can define which data to use from the D-Soil Model file (*.soil).
There is no API available. 

2 Functional design

D-Soil Model supports the user during the subsoil schematization proces
D-Soil Model is a software tool for schematization of the subsoil and is developed for the assessment of primary dikes according to the WTI 2017. In this process of assessment the given schematization of a stochastic subsoil model (WTI-SOS 2017) is a major source of information. The D-Soil Model development focusses on use of this stochastic subsoil model. The process of subsoil schematization consists of the following steps:

1. Collect relevant subsoil information
2. Combine and compare these information
3. Define subsoil schematization for macrostability
4. Define subsoil schematization for piping
5. Store the schematization
6. Export data for use in other applications

The user must be able to make a local schematization using the WTI-SOS 2017 schematization and use this schematization for calculations of the failure mechanisms Macro stability and Piping.

2.1 Use case 1 Collect relevant subsoil information

Possible information

a. WTI-SOS 2017
   Content of WTI-SOS 2017:
   - Soil segments
   - Soil profiles
   - Layers with materials and remarks

b. Soil survey; cpt, borings
c. Existing geometries (from D-Geostability)
d. Geotechnical length profile
e. Geo-related information in shape files

Explanation
The main functionality of D-Soil Model is to let the user combine different information about the subsoil, to make a schematization of the subsoil.
Not all information is digital or suitable to show on a screen.

Actions to support	***Requirement from [1]***	***Paragraph***
Import data	3 / 7.3	2.1.1
Show data on map	3.2 / 8.6 / 8.7 / 8.12	2.1.2
Show data in table	3.2 / 8.2	2.1.3
Show data in a cross section	3.2 / 8.3 / 8.14 / 8.15 / 9.23	2.1.4
Start, open or save project	U123	2.1.5, 2.1.6, 2.1.7

2.1.1 Import data

Data formats to import:

File	Data	View
*.sti, *geo	2D Soil profile and soil parameters	Table / Map [1] / Cross section
*.mdb	Soil parameters, see 'Schematiseringshandleiding' of relevant failure mechanism.	Table
soilsegments.csv	Soil profiles with probability	Table / Map / Cross section
soilprofiles.csv	1D Layers, soil material	Table / Cross section
surfacelines.csv	X,y,z coordinates (RD, m NAP)	Table / Cross section
characteristicpoints.csv	X,y,z coordinates (RD, m NAP)	Table / Cross section
*.gef	CPT, Boring	Map [2] I Table/ Cross section
soilsegments.shp	Segment lines	Map
*.shp	Not defined	Map

All data can be imported separately, but two items are depending on others (cannot exist without the other):
Characteristic points depend on surface lines.
Soil segments (csv and shp) depend on soil profiles.

The files are described in appendix C.

2.1.2 Show data on map

If data contains coordinates the information must be shown on a map with labels (name of id of the item).
The map can have a background map (imported).
User defined shapes can be shown on the map.

2.1.3 Show data in table

All imported data must be visible in a table, per row one item and information about this item in columns.

2.1.4 Show data in cross section.

Soil profiles
1D Soil profiles of WTI-SOS 2017 must be visible in a cross section so the user can see the layers in different (adjustable) colors.
The layers of the SOS profiles, modal and their minimum and maximum values of the layer limits must be clear in the cross section.
2D Soil profiles (*.sti-files) must be visible in a cross section so the user can see the layers in different (adjustable) colors.
Surface lines
Surface lines must be visible in a cross section.

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[1] *To plot a *.sti on a map, coordinates of one point of the surface line is needed, as well as the location of this point on the surface line, i.e. only coordinates is not sufficient*

[2] *The application can import borehole and CPT as GEF-file. The location of the borehole and CPT can be viewed in map. If the location in RD is known, it is plotted in the right location. If the RD location is not known, it is not plotted on the map.*

2.1.5 Start a new project
It must be possible to start a new project. An existing project must be closed and after a check with the user, all its data should be removed from the program

2.1.6 Open an existing project
It must be possible to open an existing project database.

2.1.7 Save current project
It must be possible to save all the data to a project database.

2.2 Use case 2 User must be able to combine subsoil information and view the combination

Explanation
The main functionality of D-Soil Model is to let the user combine different information about the subsoil, to make a schematization of the subsoil. Not all combinations are useful.

In table below are the combinations mentioned of the base item and the item to add (blue).

	Cpt	Boring	1D Soil profile	2D Soil profile	Soil segment	Surfaceline
Cpt						
Boring						
1D Soil profile	x	x	x		x	x
2D Soil profile	x	x	x		x	x
Soil segment (stability)						x
Surfaceline			x			

Actions to support	***Requirements from [1]***	***Paragraph***
Combine items in the cross section (one to one)	7.3 / 8.3 / 8.8 / 8.9 / 8.13/ 9.5 /	2.2.1
Connect items in batch (several to one)	7.3 / 8.5	2.2.2
View combination in a cross section.	7.3 / 7.4 /9.14 / 9.18	2.2.3
Incorporate settlements underneath an embankment.	9.20	2.2.4

2.2.1 Combine items in the cross section (one to one)

2.2.1.1 1D Soil profile can be combined with:

- Cpt
- Boring
- 1D Soil profile
  In WTI-SOS 2017 a 1D Soil profile is already combined with 1D Soil profiles of the same soil segment.
- Soil segment
  In the WT-SOS 2017 the connection is already present.

- Surface line
  Combining a 1D Soil profile with a surface line results in a 2D Soil profile. So the combination creates a new item.

2.2.1.2 2D Soil profile can be combined with:

- Cpt
- Boring
- 1D Soil profile
- Segment
- Surface line
  The combination of a 2D Soil profile and a surface line results in a new 2D Soil profile. The desired behavior is described in a separate design document [7].

2.2.1.3 Soil segments can be combined with:

- *Cpt*
- Boring 
- Surface line
  The combination of a segment (only macrostability) and a surface line results in a segment with all new 2D Soil profiles by combining the surface line with each 1D profile of the segment. The probability of the profiles stays unchanged.

2.2.1.4 A surface line can be combined with: 

- 1D Soil profile
  Combining a surface line with a 1D Soil profile results in a 2D Soil profile. So the combination creates a new item.
- 2D Soil profile
  Combining a surface line with a 2D Soil profile results in a new 2D Soil profile. The design of how the combination should be made is described in [7].

2.2.2 Connect items in batch (several to one)
The combination of cpt/borings to a segment can be done in batch, not only one by one.
The user can make a selection of the cpts or borings in the table or on the map and connect them to a segment.

2.2.3 View combination in a cross section.
To all combinations it is important that the Z-values remain intact (in m +NAP); show items at the right height. There is no definition of the x-value of 1D profiles, only Z values.

For some combination there are more detailed requirements:

2.2.3.1 1D profile – other 1D profiles of the soil segment
All 1D profiles of one soil segment must be visible at the same time. With large (>6) numbers of 1D profiles a 'filmstrip' is provided, so the user can scroll through the 1D profiles.

2.2.3.2 2D profile - cpt and boring
The cpt and boring are placed in the middle of the 2D soil profile. The user can drag them to the desired X-coordinate.

2.2.3.3 *2D profile – surface line*

When combining 2D profiles and surface lines there is a mapping necessary for the x-coordinates.
This mapping is done based on the reference line. The user can define this X-value in the 2D profile. On the surface line is the reference line situated at the middle of the characteristic points 'Kruin buitentalud' and 'Kruin binnentalud'.
The behavior when the length of 2D profile and surface line is not equal is described in [7]

2.2.3.4 *Soil segment – Cpt/borings*

When a soil segment is combined with cpt and borings a cross section of the soil segment is needed. The soil segment is drawn as a straight line and the cpts and borings are situated relatively among this line. This is called a length profile.

2.2.4 Incorporate settlements underneath an embankment.

The user must be able to define settlements underneath the embankment.
When combining a 1D soil profile with a surface line, draw vertical geometry lines at 1/3 of the slopes. So the user can define the settlement by dragging the soil layers under the embankment.

2.3 Use case 3 User must be able to adapt the WTI-SOS 2017 to local situation.

Explanation
The WTI-SOS 2017 is a general schematization of the subsoil at the inner toe of the primary dikes in the Netherlands. To perform the assessment it is needed that this schematization is adapted to the local situation (more detailed).

Actions to support	***Requirement from [1]***	***Paragraph***
Save a selection of the WTI-SOS 2017 as a new project	3.3	2.3.1
Splitting the soil segments per failure mechanism	5.1 / 6.3	2.3.2
Deleting soil profiles per segment	5.1 / 6.3	2.3.3
Changing probability of the soil profiles	9.2	2.3.4
Make and edit 2D soil profiles	9.3 / 9.4 / 9.7 / 9.18	2.3.5
Adding 1D and 2D soil profiles to a soil segment	9	2.3.6
Copy/ paste segments for one failure mechanism to the next	9	2.3.7
Add materials to the material table	9.8	2.3.8

2.3.1 Save a selection of the WTI-SOS 2017 as a new project

The user can make a selection of segments (per failure mechanism, or all) and save this as a project. All soil profiles of these soil segments are included in this project, as well as all their materials. Also by user connected cpts and borings are included in this project.

2.3.2 Splitting the soil segments per failure mechanism
The user can add a split location to a soil segment in the map or in the length profile. When splitting the soil segment, all soil profiles and their probability are connected to both new soil segments. The name of the new segments consists of the old name and a number.

2.3.3 Deleting soil profiles per soil segment
The user can remove soil profile(s) from a soil segment. If the total probability is not 100%, a message should be given. The probability of a soil profile can be zero.

2.3.4 Changing probability of the soil profiles
The user can edit the probability of soil profile(s) from a soil segment. If the total is not 100%, a message should be given.

2.3.5 Make and edit 2D soil profiles
The user can make 2D Soil profiles either from scratch, either from using 1D Soil profile. The user can draw lines to make soil layers. Per layer a soil material can be defined.

2.3.6 Adding 1D and 2D soil profiles to a segment
The user can add soil profile(s) to a soil segment. If the total is not 100%, a message should be given.

2.3.7 Copy/ paste segments for one failure mechanism to the next
The user can copy a segment of one failure mechanism and use it for another failure mechanism.

2.3.8 Add materials to the material table
The user can add new materials to the material table, so this can be used in new or changed soil profiles.

2.4 Use case 4 Define subsoil schematization for the failure mechanism ‘Macrostabiliteit binnenwaarts (STBI)’

Explanation
For the assessment the user must be able to define the subsoil schematization for the failure mechanism ‘Macrostabiliteit binnenwaarts (STBI)’.

Actions to support
Save soil segments for the failure mechanism ‘Macrostabiliteit binnenwaarts (STBI)’.

Actions to support	***Requirement from [1]***	***Parapraph***
Save soil segments for the failure mechanism ‘Macrostabiliteit binnenwaarts (STBI)’.	5.1	2.4.1
Define aquifer layers per soil profile.	5.1 / 6.6	2.4.2
Define soil parameters for the failure mechanism ‘Macrostabiliteit binnenwaarts (STBI)’.	5.1 / 6 / 6.1 /7	2.4.3

Define yield stresses per 2D soil profile (optional for undrained calculations).	5.1 / 6.3 / 6.5 /8.17 / 9.10	2.4.4
Filter of the soil parameters needed for the use in the stand alone tool 'BM-Macrostabiliteit'	9.1	2.4.5

2.4.1 Define aquifer layers per soil profile.
The user must be able to define a layer as an aquifer. A soil profile can contain more than one aquifer.

2.4.2 Save soil segments for the failure mechanism 'Macrostabiliteit binnenwaarts (STBI)'.
The user must be able to save the soil segment with all their connected data, such as the soil profiles (including yield stresses), materials, cpt and borings.

2.4.3 Define soil parameters for the failure mechanism 'Macrostabiliteit binnenwaarts (STBI)'.
The user must be able to define the soil parameters needed for the failure mechanism 'Macrostabiliteit binnenwaarts (STBI)'. These soil parameters are defined in appendix D.

2.4.4 Define yield stresses per 2D soil profile (optional for undrained calculations).
The user can define yield stresses in a 2D soil profile.

2.4.5 Filter the soil parameters needed for the use in:
- Stand alone tool 'BM–Macrostabiliteit' for failure mechanism 'Macrostabiliteit binnenwaarts (STBI)'.

2.5 Use case 5 Define subsoil schematization for the failure mechanism Piping (STPH)

Explanation
For the assessment the user must be able to define the subsoil schematization for the failure mechanism Piping (STPH).

Actions to support	***Requirements from [1]***	***Paragraph***
Define 1D soil profiles in 2D soil profiles.	5.2 / 6.4	2.5.1
Define aquifer layers per soil profile.	5.2	2.5.2
Define soil parameters for the failure mechanism Piping (STPH).	5.2 /7	2.5.3
Save soil segments for the failure mechanism Piping (STPH).	5.2 / 6.3	2.5.4
Filter the soil parameters needed for the use in Ringtoets - Piping	9.1	2.4.5

2.5.1 Define 1D soil profiles in 2D soil profiles.
When 2D soil profiles are used, the user must be able to define a failure mechanism location where a 1D soil profile is available for the piping kernel.

2.5.2 Define aquifer layers per soil profile.
The user must be able to define a layer as an aquifer. A soil profile can contain more than one aquifer.

2.5.3 Define soil parameters for the failure mechanism Piping (STPH).
The user must be able to define the soil parameters needed for the failure mechanism Piping(STPH). These soil parameters are defined in appendix D.

2.5.4 Save soil segments for the failure mechanism Piping (STPH).
The user must be able to save the soil segment with all their connected data, such as the soil profiles, materials, cpt and borings.

2.5.5 Filter the soil parameters needed for the use in:
- Ringtoets for failure mechanism Piping (STPH).

2.6 Use case 6 Export data for use in other applications

Explanation
D-Soil Model is developed for the WTI-2017. Therefore it is necessary that the schematizations from D-Soil Model can be used in Ringtoets and the Stand alone tools (BM - Macrostabiliteit).

Actions to support
Filter the soil parameters needed for the use in:
- Ringtoets for failure mechanism Piping (STPH).
- BM - Macrostabiliteit for failure mechanism Macrostabiliteit binnenwaarts (STBI).

Actions to support	***Requirements from [1]***	***Paragraph***
Make a selection of the soil parameters needed for the use in: Ringtoets – Piping BM - Macrostabiliteit	9.1	2.6.1
Export (part of) tables	9.24	2.6.2
Import (part of) tables	9.24	2.6.3

2.6.1 Make a selection of the soil parameters.
The usage of a D-Soil Model project in Ringtoets or the Basis Modules differs in the use of deterministic or stochastic values of soil parameters. The user must be able to see this difference, so the user knows which parameters are used.
In appendix D an overview is given of the needed parameters per usage.

2.6.2 Export (part of) tables
Complete tables must be exportable as a table (examples: csv- of xls-format). Part of tables (columns, rows or cells) must be exportable by copying and pasting.

2.6.3 Import (part of) tables

Complete tables and part of tables (columns, rows or cells) must be importable by copying and pasting.

2.7 Error handling

In case of malfunction of the program the user must be informed via messages. This takes place via log messages and validation messages. Each of these messages has a tab at the tables window.

2.7.1 Validation messages

Validation means checking the input data against certain requirements. This results in a list of errors and warnings. If there are no errors, calculations in a stand alone and/or Ringtoets are possible, otherwise calculation is prohibited. If there are warnings, calculation is discouraged, but not prohibited.
The project can always be saved, even if there are errors (and/or warnings) in the validation window.

Validation happens against simple requirements, such as an exceeded maximum value (like mentioned in appendix D), or against advanced requirements, where the combination of several data leads to an error (profiles with layer ‘no soil assigned’).

The user will be informed about the errors and warnings and if present, the user will be supported to solve them. This support is a suggested repair action, when possible.
The repair option shows the severity (error or warning), the subject (object to which the error or warning applies), the properties (one or more properties of the subject to which the error or warning applies) and the suggested repair action (example: “Assign maximum value”).

2.7.2 Log messages

After each import by the user, the activity is mentioned in the log window.
Possible log messages about the imported data are given in the log window. Possible errors are non-compatible data (example: GEFs referring to a tiff-file) or missing data (example; 1Dprofiles with materials without defined parameters).

3 References

1 Requirement list WTI 2017 software, version “20160428 fundament software.xlsx” N:\Projects\1230000\1230088\C. Report - advise\036 Acceptatie software\20160428 fundament software.xlsx

2 Bokma, J et al. (2015). WTI D-Soil Model- Technical Design, Deltares report 1209430- 003-DSC-0021. (will be updated). https://repos.deltares.nl/repos/Ringtoets/trunk/doc/WTI/DSoilModel/System/DSoilModel - Technical design.docx

3 Trompille, V (2014). WTI D-Soil Model- Testplan, Deltares report 1209430-003-DSC-0008. https://repos.deltares.nl/repos/Ringtoets/trunk/doc/WTI/DSoilModel/System/DSoilModel - Test plan.docx

4 Technical design Macro Stability kernel. https://repos.deltares.nl/repos/FailureMechanisms/FailureMechanisms/DikesMacroStability/trunk/doc/DikesMacroStability Kernel - Requirements and Functional Design.pdf

5 Technical design Piping kernel. In preparation https://repos.deltares.nl/repos/FailureMechanisms/FailureMechanisms/DikesPiping/trunk/doc/DikesPiping Kernel - Requirements and functional design.pdf

6 Terminologielijst WTI2017 P:\1200109-sbw-algemeen\J. Uitvoeringsjaar 2015\16-Parameterlijsten en basisinformatie\Terminologielijst

7 Provide reference points to draw surface line on 2D profiles, Deltares memo, 1230088-026-DSC-0003 N:\Projects\1230000\1230088\C. Report - advise\026 D-Soil Model\Designs\1230088-026-DSC-0003-v3-m-DSB-184 Provide reference points to draw surface line on 2D profiles.docx

8 Geotechnisch uitwisselformaat voor boor-data (GEF-bore-report) versie 1.0.0, CUR, maart 2002

9 Geotechnical exchange format for cpt-data, CUR, april 2004

A Glossary

Following glossary is a selection from Terminologielijst [6]

Term	Definition
Aquifer	Soil layer with a high permeability compared to aquitards (i.e. Sand layers).
Aquitard	Soil layer with a low permeability compared to aquifers (i.e. clay layers). The horizontal flow in a aquitard is very low, while a vertical flow could be significant.
Failure mechanism	The way a construction fails due to high loads or load effects which are larger than the strength and what reduces the water retaining capacity.
Inner crest line	Line marking the transition between crest and slope.
Inner slope	Sloping face of the embankment at the inner side.
Inside toe	Lower boundary of the embankment at the land side (transition to ground level)
Outside slope	Sloping face of the embankment at the water side.
Outside toe	Lower boundary of the embankment at the water side (transition to ground level or foreland)
Deterministic	During assessment the parameter is considered as 'known' and not modelled as a stochast.
Dike	A dike as part of a defense system.
Failure mechanism	Process that leads to the failure of the system. This is often the result of a sequence of partial processes, derived from partial failure or the system, but without complete function loss.
Geometry	Collection of points in RD coordinates on a straight line, perpendicular on the dike line with a height in m+NAP, which represent the geometry of the dike. Outside/riverside is always visualized on the left side.
Characteristic points	Characteristic points of the surface level, right-angled at the dike.
Crest	1. Area between inner and outer crest. 2. Highest point in dike geometry 3 Outer crest line
Crest inner slope	The intersection point of the slope at the polder side and the crest of the dike
Macro stability	The mechanism that causes slope shear failure of dike embankments
Subsoil profile	A sequence of subsoil layers, either 1D or 2D.
Subsoil scenario	subsoil scenario with certain occurrence probability, in case of stochastic subsoil modelling.
subsoil schematization	A schematic reproduction of (a part of) the subsoil for a certain area.
Probabilistic analysis	Probabilistic determination of failure probability, using stochastically distributed variables for loading and strength.
stochastic (soil) scenario	The soil profile, together with its chance of occurrence, is a scenario.
(soil) segment	In the SOSWTI2017 the dikes are divided in segments. Soil segments are line elements (soil areas are polygons).To each segment soil scenarios with possible soil profiles are assigned.
Stochastic variable	Stochastic variable is a variable whose value is subject to variations due to chance.
Stochastic (as in WTI-SOS 2017)	'Stochastic' means that a certain aspect is variable. These variability is visible in the chances of occurrence of the soil profiles.
Toe dike inner side	The intersection point of the surface level at the dike side and the slope of the shoulder at the inner side (if no shoulder: dike)

Term	Definition
Toe dike outer side	The intersection point of the slope of the berm at the outer side and the surface level at the outer side

B Reference Requirements [1] and paragraph Functional Design

See also remarks below this table.

	1.3	2.1.1	2.1.2	2.1.3	2.1.4	2.1.5	2.1.6	2.1.7	2.2.1	2.2.2	2.2.3	2.2.4	2.3.1	2.3.2	2.3.3	2.3.4	2.3.5	2.3.6	2.3.7	2.3.8	2.4.1	2.4.2	2.4.3	2.4.4	2.4.5	2.5.1	2.5.2	2.5.3	2.5.4	2.5.5	2.6.1	2.6.2	2.6.3	2.7.1
REQ 3		X																															
REQ 3.2			X	X	X																												
REQ 3.3													X																				
REQ 4.1																																	
REQ 5																				X													
REQ 5.1														X	X						X	X	X										
REQ 5.2																										X	X	X					
REQ 5.3																																	
REQ 5.4																							X					X					
REQ 6																				X	X	X	X	X	X	X	X	X					
REQ 6.1																							X				X						
REQ 6.3														X	X													X					
REQ 6.4																									X								
REQ 6.5																							X										
REQ 6.6																										X							
REQ 7																						X					X						
REQ 7.1																																	

	1.3	2.1.1	2.1.2	2.1.3	2.1.4	2.1.5	2.1.6	2.1.7	2.2.1	2.2.2	2.2.3	2.2.4	2.3.1	2.3.2	2.3.3	2.3.4	2.3.5	2.3.6	2.3.7	2.3.8	2.4.1	2.4.2	2.4.3	2.4.4	2.4.5	2.5.1	2.5.2	2.5.3	2.5.4	2.5.5	2.6.1	2.6.2	2.6.3	2.7.1
REQ 3.4																																	
REQ 7.3		X	X	X																													
REQ 7.4											X																						
REQ 8																																	
REQ 8.1									X																								
REQ 8.2				X																													
REQ 8.4					X																												
REQ 8.5										X																							
REQ 8.6			X																														
REQ 8.7			X																														
REQ 8.8									X																								
REQ 8.9									X																								
REQ 8.10																																	
REQ 8.11																																	
REQ 8.12			X																														
REQ 7.2																																	
REQ 8.14					X																												
REQ 8.15					X																												
REQ 8.16	X																																
REQ 8.17																							X										
REQ 9																		X	X														
REQ 9.1																								X					X	X			

	1.3	2.1.1	2.1.2	2.1.3	2.1.4	2.1.5	2.1.6	2.1.7	2.2.1	2.2.2	2.2.3	2.2.4	2.3.1	2.3.2	2.3.3	2.3.4	2.3.5	2.3.6	2.3.7	2.3.8	2.4.1	2.4.2	2.4.3	2.4.4	2.4.5	2.5.1	2.5.2	2.5.3	2.5.4	2.5.5	2.6.1	2.6.2	2.6.3	2.7.1
REQ 9.2																X																	
REQ 9.3																	X																
REQ 9.4																	X																
REQ 9.5									X																								
REQ 9.7																	X																
REQ 9.8																				X													
REQ 9.9																																	
REQ 9.10																							X										
REQ 8.13									X																								
REQ 9.12											X																						
REQ 9.14																																	X
REQ 9.15																																	
REQ 9.16																																	
REQ 9.18									X																								
REQ 9.19																	X																
REQ 9.20												X																					
REQ 9.21					X																												
REQ 9.23					X																												
REQ 9.24																															X	X	
U123						X	X	X																									

REG	Remark
REQ 4.1	Functionality M-Soil Base is not described.
REQ 5.3	is build but not testable, since FlowSlide is not using D-Soil Model
REQ 6.1	" Per mechanisms the partial factor is stored in Ringtoets such that a stochastic variable can be turned into a semi-probabilistic designvalue." is not correct any more, so D-Soil Model provides Deterministic and Stochastic values (independent from each other).
REQ 3.4	Waterdata is not implemented in D-Soil Model to not confuse the user; schematisation of the waternet is not done in D-Soil Model. Other items are implemented.
REQ 8.1	First (priority for combining data) a referenceline was needed for matching surfacelines on 2D profiles. Introducing another reference is confusing. This reference line could be used for REQ 8.3 in future versions by defining 'the middenkruinlijn' as the referenceline.
REQ 8.5	Since the reference line from 8.1 is not used (yet) for cpt and borings, the automatic connection is made per segment instead of crosssection.
REQ 8.10	Is implemented under 5.1
REQ 8.11	Not implemented yet
REQ 7.2	Pre-definition via GIS-file is not implemented
REQ 9	divided per failure mechanism 2.4 and 2.5
REQ 9.4	"similar way he can do in DGeoStability is not described
REQ 9.15	Not implemented yet
REQ 9.16	Not implemented yet

C Input files

C.1 Materials.mdb

There is only one MSoilbase-file: <filename>.mdb. This material database has to be edited with MSoilbase.exe. It contains the soils and their parameters.

C.2 1D profiles

Name	Type	Unit	Required	Description
soilprofile_id	StringId	-	yes	Name of Soil Profile
top_level	Float	m	yes	Level of top of layer
soil_name	StringId	-	yes	Reference to soil (in soilmaterials.mdb)
soiltype	StringId	-	no	This column is obsolete. This parameter has to be set in the soil database, but even then it is not used anymore to define aquifer layers. There is now a new parameter “IsAquifer” to define aquifers. Possible options - Klei - Leem - Grind - Veen - Zand
max-d	Float	m	no	Optional SOS parameter holding the maximum value for the top of the layer.
min-d	Float	m	no	Optional SOS parameter holding the minimum value for the top of the layer.
remark	StringId	-	no	Optional SOS parameter to be used for remarks on max-d and min-d or other specifics for the layer.

C.3 2D profiles

All *.sti files can be imported in D-Soil Model. These are the file format from D-Geostability These files can be produced and edited in D-Geo Stability. The geometry will be shown in D-Soil Model, as well as the material with the available parameters.

C.4 Surfaceline and characteristic points

A specification of a surface line and corresponding characteristic points are used to create 2D profiles from 1D profiles or adjust 2D profiles with a new surface line.

Surface line

The surfaceline.csv is a csv-file containing an ID of the location in the first column, in the following columns the X- and Y coordinates (in RD-coordinates) and the Z value (height in m NAP). The coordinates have to be consecutive in a line.

Example:

LOCATIONID	X1	Y1	Z1	Xn	Yn	Zn				
AD640M00	160146	424333.5	6.763	160145.8	424332.6	7.082	160145.6	424331.6	7.492	etc
AD642M50	159891.6	424372.9	6.319	159891.5	424371.9	6.328	159891.4	424370.9	6.333	etc
AD645M00	159641.7	424402.4	6.128	159641.6	424401.4	6.17	159641.5	424400.4	6.183	etc
AD647M30	159374	424357.3	0.841	159374.1	424356.3	1.11	159374.2	424355.3	1.165	etc

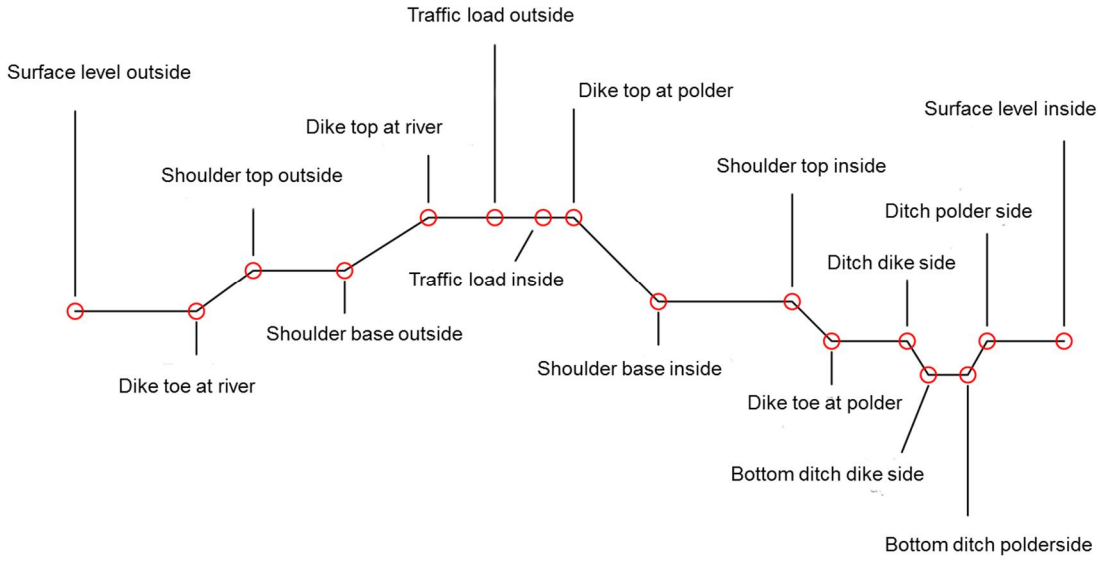
Enz.

Name	Type	Unit	Required	Description
Profile name	StringId	-	yes	Name of surface line
X1	Float	m	yes	X coordinate 1-st point
Y1	Float	m	yes	Y coordinate 1-st point
Z1	Float	m	yes	Z coordinate 1-st point
.....				
Xn	Float	m	yes	X coordinate n-th point
Yn	Float	m	yes	Y coordinate n-th point
Zn	Float	m	yes	Z coordinate n-th point

Characteristic points

Characteristic points are certain points on the surface line which enables to combine surface lines and is used for the waternet creator of the stability kernel.

The characteristic.krp.csv is a csv-file containing an ID of the location in the first column, in the following columns the X- and Y coordinates (in RD-coordinates) and the Z value (height in m NAP) of the characteristic points. For combining the surfaceline with the corresponding characteristic points the locationID (Key id) in both files must be equal.



Example:

LOCATIONID	X_Maaiveld binnenwaarts	Y_Maaiveld binnenwaarts	Z_Maaiveld binnenwaarts	X_Insteek sloot polderzijde	Y_Insteek sloot polderzijde	Z_Insteek sloot polderzijde	X_Slootbodem polderzijde	Y_Slootbodem polderzijde	Z_Slootbodem polderzijde	Enz.
AD720M00	153999.5	422183.9	3.588	153938.1	422198.1	3.462	153935.2	422198.8	2.769	
AD722M50	153945.8	421957.2	3.33	153881.9	421961	3.204	153878.9	421961.1	2.633	
AD724M90	153887.2	421695.5	2.77	153828.9	421710	2.878	153828	421710.2	2.832	
AD727M50	153816.8	421456.3	2.75	153763.3	421469.4	2.759	153759.5	421470.4	2.332	
AD730M00	153755.5	421213.4	3.101	153710	421224.8	2.787	153709	421225.1	2.75	

Enz.

The sequence of the columns is fixed.

Name	Type	Unit	Required	Description
Profile name	StringId	-	yes	Reference to surface line (in surfacelines.csv)
X_Maaiveld buitenwaarts	Float	m	yes	Coordinates of surface level outside
Y_Maaiveld buitenwaarts	Float	m	yes	
Z_Maaiveld buitenwaarts	Float	m	yes	
X_Teen dijk buitenwaarts	Float	m	Yes	Coordinates of dike toe at river
Y_Teen dijk buitenwaarts	Float	m	Yes	
Z_Teen dijk buitenwaarts	Float	m	Yes	
X_Kruin buitenberm	Float	m	no[3]	Coordinates of shoulder top outside
Y_Kruin buitenberm	Float	m	no	
Z_Kruin buitenberm	Float	m	no	
X_Insteek buitenberm	Float	m	no	Coordinates of shoulder base outside
Y_Insteek buitenberm	Float	m	no	
Z_Insteek buitenberm	Float	m	no	
X_Kruin buitentalud	Float	m	yes	Coordinates of dike top at river
Y_Kruin buitentalud	Float	m	yes	
Z_Kruin buitentalud	Float	m	yes	
X_Verkeersbelasting kant buitenwaarts	Float	m	no	Coordinates of traffic load outside
Y_Verkeersbelasting kant buitenwaarts	Float	m	no	
Z_Verkeersbelasting kant buitenwaarts	Float	m	no	
X_Verkeersbelasting kant binnenwaarts	Float	m	no	Coordinates of traffic load inside
Y_Verkeersbelasting kant binnenwaarts	Float	m	no	
Z_Verkeersbelasting kant	Float	m	no	

[3] • *When a characteristic item is absent at one location, but present in others, the value of -1 is given for X,Y en Z. Absence is possible for sloot (ditch), berm and verkeersbelasting (traffic load).*

Name	Type	Unit	Required	Description
binnenwaarts				
X_Kruin binnentalud	Float	m	yes	Coordinates of dike top at polder
Y_Kruin binnentalud	Float	m	yes	
Z_Kruin binnentalud	Float	m	yes	
X_Insteek binnenberm	Float	m	no	Coordinates of shoulder base inside
Y_Insteek binnenberm	Float	m	no	
Z_Insteek binnenberm	Float	m	no	
X_Kruin binnenberm	Float	m	no	Coordinates of shoulder top inside
Y_Kruin binnenberm	Float	m	no	
Z_Kruin binnenberm	Float	m	no	
X_Teen dijk binnenwaarts	Float	m	yes	Coordinates of dike toe at polder
Y_Teen dijk binnenwaarts	Float	m	yes	
Z_Teen dijk binnenwaarts	Float	m	yes	
X_Insteek sloot dijkzijde	Float	m	no	Coordinates of ditch dike side
Y_Insteek_sloot dijkzijde	Float	m	no	
Z_Insteek sloot dijkzijde	Float	m	no	
X_Slootbodem dijkzijde	Float	m	no	Coordinates of bottom ditch dike side
Y_Slootbodem dijkzijde	Float	m	no	
Z_Slootbodem dijkzijde	Float	m	no	
X_Slootbodem polderzijde	Float	m	no	Coordinates of bottom
Y_Slootbodem polderzijde	Float	m	no	
Z_Slootbodem polderzijde	Float	m	no	
X_Insteek sloot polderzijde	Float	m	no	Coordinates of ditch polder side
Y_Insteek sloot polderzijde	Float	m	no	
Z_Insteek sloot polderzijde	Float	m	no	
X_Maaiveld binnenwaarts	Float	m	yes	Coordinates of surface level inside
Y_Maaiveld binnenwaarts	Float	m	yes	
Z_Maaiveld binnenwaarts	Float	m	yes	

C.5 Soilsegments

Name	Type	Unit	Required	Description
segment_id	StringId	-	Yes	Name of segment
soilprofile_id	StringId	-	No	Reference to 1D-Soil profile
probability	Float	%	yes	Chance of occurrence of profile (value between 0.0 and 100.0)
calculation_type	StringId	-	yes	- Piping - Stability

C.6 GEF files

All *.GEF files can be imported if the GEF. This format is described in CUR reports [8 for borings] [9 for cpt].

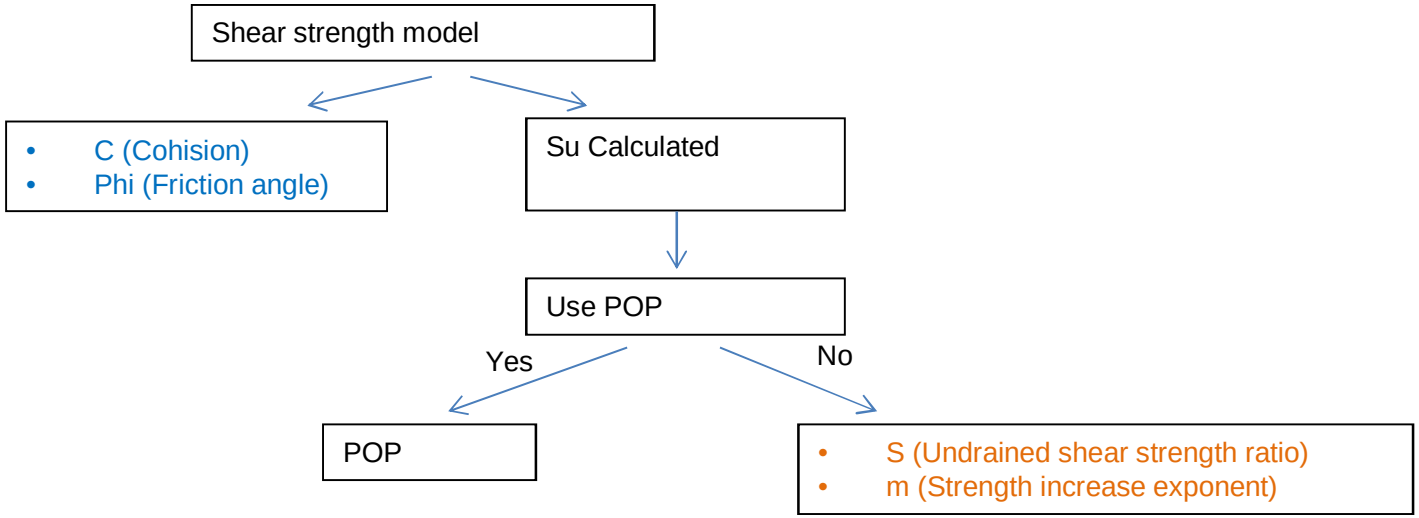
D Material parameters

Material parameters of Macrostabiteit - BM Macrostabiliteit :

WTI-ID (STBI-..)	**Parameter**	**Unit**	**Description**	**Determinist/ Stochast**	**Default value**	**Min. value**	**Max. value**
n.a.	n.a.	n.a.	Soilname	n.a.	Undetermined	n.a.	n.a.
n.a.	n.a.	ARGB-code	Color	n.a.	White	n.a.	n.a.
n.a.	n.a.	n.a.	Type	n.a.	Sand	n.a.	n.a.
n.a.	n.a.	n.a.	Description	n.a.	empty	n.a.	n.a.
M04	γ_{unsat}	[kN/m^3]	Unit weight of soil above phreatic level	D	NaN	NaN	∞
M03	γ_{sat}	[kN/m^3]	Unit weight of soil below phreatic level	D	NaN	NaN	∞
n.a.	Shear strength model	n.a.	Shear strength model (choice between **C-Phi** and **Su-calculated**)	n.a.	C-Phi	n.a.	n.a.
Following parameters are editable depending on selection of Shear strength model. When not editable, the field is greyed out (value is not visible[4]). Even when all fields of a column are greyed out, the column stays visible. This is also represented in a flowchart below.							
M05	c'	[kN/m^2]	Cohesion	D	NaN	0	∞
M06	φ'	[°]	Friction angle of shearing resistance	D	NaN	0	89

[4] *When a value is entered and the field is greyed-out later on, the value is stored and saved when project file is saved.*

WTI-ID (STBI-..)	**Parameter**	**Unit**	**Description**	**Determinist/ Stochast**	**Default value**	**Min. value**	**Max. value**
n.a.	*Use POP*	n.a.	Checkbox to chose between POP and yield stress. 'Use POP' = TRUE: POP editable. 'Use POP' = FALSE : S and m editable (=default).	n.a.	FALSE	n.a.	n.a.
n.a.	*POP*	[kN/m^2]	Pre overburden pressure	D	0	0	∞
M14	*S*	[-]	Undrained shear strength ratio (normally consolidated)	D	NaN	0	∞
M15	*m*	[-]	Strength increase exponent	D	NaN	0	1



Figuur D.1 Flowchart Shear strength model

Materialparameters for Piping - Ringtoets:

WTI-ID (STPH-..)	**Parameter**	**Unit**	**Description**	**Determinist/ Stochast**	**Default value**	**Minimum value**	**Maximum value**
n.a.	n.a.	n.a.	Soilname	n.a.	Undetermined	n.a.	n.a.
n.a.	n.a.	ARGB-code	Color	n.a.	Whtite	n.a.	n.a.
n.a.	n.a.	n.a.	Type	n.a.	Sand	n.a.	n.a.
n.a.	n.a.	n.a.	Description	n.a.	empty	n.a.	n.a.
M07	PipingLayer.AbovePhreaticLevel	[kN/m^3]	Unit weight above phreatic level	S	Type: Lognormal Mean: 10 **Variation: 0** **Shift: 0**	0	100
M08	PipingLayer.BelowPhreaticLevel	[kN/m^3]	Unit weight below phreatic level	S	Type: Lognormal Mean: 10 **Variation: 0** **Shift: 10**	0	100
M13	D70	[m]	70% fractile of the aquifers grain size distribution	S	NaN	1E-8	1
M15	DarcyPermeability	[m/s]	Permeability (Darcy)	S	NaN	0	1000

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