Zeitschrift: IABSE congress report = Rapport du congrès AIPC = IVBH Kongressbericht

Band: 13 (1988)

Artikel: Development of CAE system in design of hydraulic structures

Autor: Baalen, Matthe van / Engering, Frank / Mostert, Jan

DOI: https://doi.org/10.5169/seals-12980

Development of CAE System in Design of Hydraulic Structures

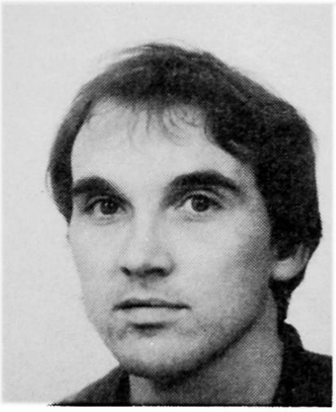
Système assisté par ordinateur pour les projets de structures hydrauliques

Computergestütztes Programm für den Entwurf hydraulischer Konstruktionen

Matthe VAN BAALEN
Civil Engineer
Delft Geotechnics
Delft, the Netherlands

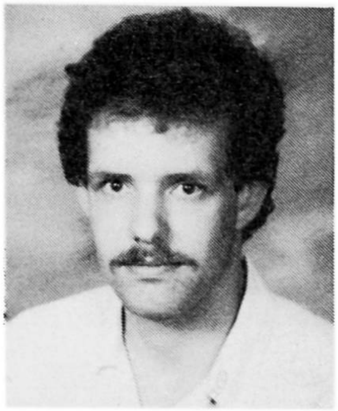
Frank ENGERING
Applied Mathematician
Delft Geotechnics
Delft, the Netherlands

Jan MOSTERT
Civil Engineer
Delft Geotechnics
Delft, the Netherlands



Matthe van Baalen, graduated at Delft university of Technology in 1984 and has worked at the same institute since 1979. He was detached to the university of Zambia for two years and is currently employed with Delft Geotechnics as project engineer.

Frank Engering received his mathematics degree at the University of Technology in Delft. For 8 years now, he has worked at Delft Geotechnics as a research engineer and specialised in technical-scientific computer applications.



Jan Mostert graduated at the institute of technology of Rotterdam in 1986 and is employed at Delft Geotechnics as system analyst.

SUMMARY
The analysis of geotechnical safety and the serviceability of new or improvement designs of hydraulic structures, such as river or sea dikes, breakwaters, large dams etc., generally involves the application of a variety of computational models. This paper contains a description of an interactive system and the experience with it in consulting practice.

RÉSUMÉ
L'analyse de la sécurité géotechnique et de l'aptitude au service de projets nouveaux ou améliorés de structures hydrauliques, tels que des digues fluviales ou maritimes, des brises-lames, des grands barrages etc., comprend en général l'application d'une variété de modèles mathématiques. Cette contribution contient la description d'un système d'analyse interactif, ainsi que son application dans la cadre de plusieurs études.

ZUSAMMENFASSUNG
Analysen der geotechnischen Zuverlässigkeit und Brauchbarkeit von neuen oder verbesserten hydraulischen Konstruktionen, wie z.B. Fluss-oder Seedeiche, Wellenbrecher, grosse Dämme u.a., erfordern im allgemeinen die Anwendung einer Vielfalt von Rechenmodellen. Dieser Artikel enthält die Beschreibung eines Programms im Dialog und die Erfahrungen damit bei der beratenden Tätigkeit.

1. INTRODUCTION

Being a geotechnical institute, the daily routine of Delft Geotechnics comprises the design and safety analysis of various soil structures. The generally complex design criteria require the application of a variety of computational models. For example, the design of embankment reinforcements involves the analysis of slope stability , settlement, consolidation, groundwater flow, etc. For each of these phenomena computer codes are available, which are applied and reapplied successively in the various design stages thus rendering an iterative design process.
The many repetitive actions concerning the preparation of input strings for the computer codes obviously are susceptible to human errors. In order to improve this situation an interactive computer system has been developed, which avoids complex and user-unfriendly input.
This paper gives a description of the interactive system, including software and hardware, and the experience with it in consulting practice.

2. THE SYSTEM CONFIGURATION

The hardware configuration, the so-called workstation with an on-line connection to the control mainframe computer (super minicomputer), consists of a digitizer board, a colour graphical display terminal with a hardcopy unit and a video display terminal.
An interactive control program enables the user to call or recall on geotechnical computer codes in any desired sequence by using screen orientated input facilities.

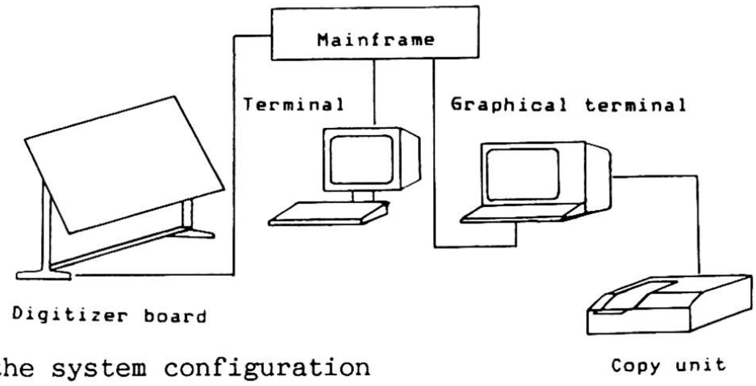


Figure 1: the system configuration

The general set up of the control program is such that any newly developed specific purpose computercode can be connected by means of a software interface.
At the present stage, the system enables analysis of stability and settlement of a geotechnical design, finite element analysis, including automatic mesh generation, groundwater flow, consolidation and deformation.

Different kinds of standard dump files are defined to achieve the communication between the different computer programs. For example, a finite element post-processor uses these files to interactively compose a graphical presentation of the results.

Future extensions will, among other things, contain connection of computer codes for probabilistic analysis of stability and piping, and connection of a regional geotechnical and geological database and statistical procedures for interpretation of geotechnical data.

3. COMPUTATION PROCEDURE

The design and/or control computations for any geotechnical structure starts with the initiation of the geometry, by using either the digitizer board or the keyboard. The geometry is shown instantaneously on the colour screen. This way the user ascertains visually, whether the desired geometry is generated properly.

After the geometry is generated, the various geotechnical computations can be initiated. When the analysis necessitates the use of finite element computer codes the geometry firstly has to be subjected to a interactive mesh generator and can be altered if necessary. Also the boundaries are automatically determined to the conditions in the finite element calculations.
In all stages of the process the user is permanently visually informed about his activity, while the system scans the input for syntax errors or other irregularities.

With design calculations it is common, that the original geometry is fit for improvement. Dependent on the result of the geotechnical computations the geometry will be adjusted and readjusted in order to achieve the most favourable construction design.
The system allows a rapid alteration of the original geometry and reapplication of the geotechnical computations.
The input and output of the computations can easily be transmitted to either a plotter, printer or colour copy device.

4. CONSULTING PRACTICE

The ability of the system is best illustrated by the experience with it in the daily consulting practice. A suitable case demonstration is found in one of the routine consultations of Delft Geotechnics concerning the design of embankment reinforcements. Firstly, the general design process will be discussed, after which a special case will be demonstrated.

4.1 Design process

The initial design of an embankment is based on the hydraulic boundary conditions and experience with embankments in general.
The design water level (with an occurrence frequency of 1/10000 per year) as well as the wave propagation and runup determine the necessary embankment height and slopes.
Subsequently, the settlement of the embankment is determined and the original design will be altered such that the deformed structure will still satisfy the imposed boundary conditions.
In practice this means that the crown height will be increased according to the expected settlements.

The newly created geometry will subsequently be subjected to stability analyses using Bishop's slip circle method. The stability is investigated during and just after construction as well as long after construction, when excess pore pressures in the underlying soil strata induced by the sudden loading have all dissipated.
Hence, in addition to the deformation and strength of the soil parameters the input comprises a thorough description of the (excess) pore pressure distributions.
The safety against failure during construction should not be less than 1.1, while the long term stability should be guaranteed by a safety factor of at least 1.3.
Since the stability is investigated in various construction stages the geometry as well as the input parameters have to be altered accordingly.

When the calculated safety factors do not satisfy the abovementioned design criteria the geometry needs to be adjusted, by for instance, an additional bank.

4.2 Case demonstration

The case presentation concerns a shore protection structure at the coast of the receding Nile delta. The settlement of the embankment is calculated using a finite element computational model (figure 2).

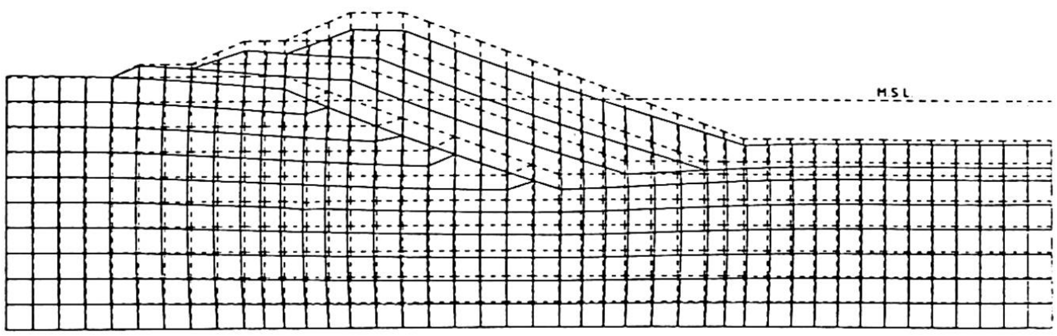
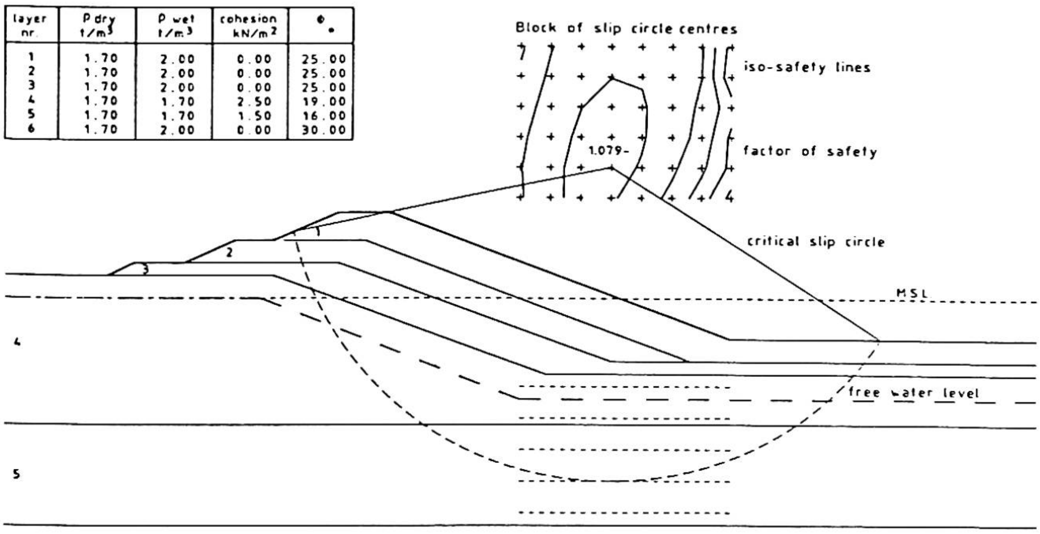


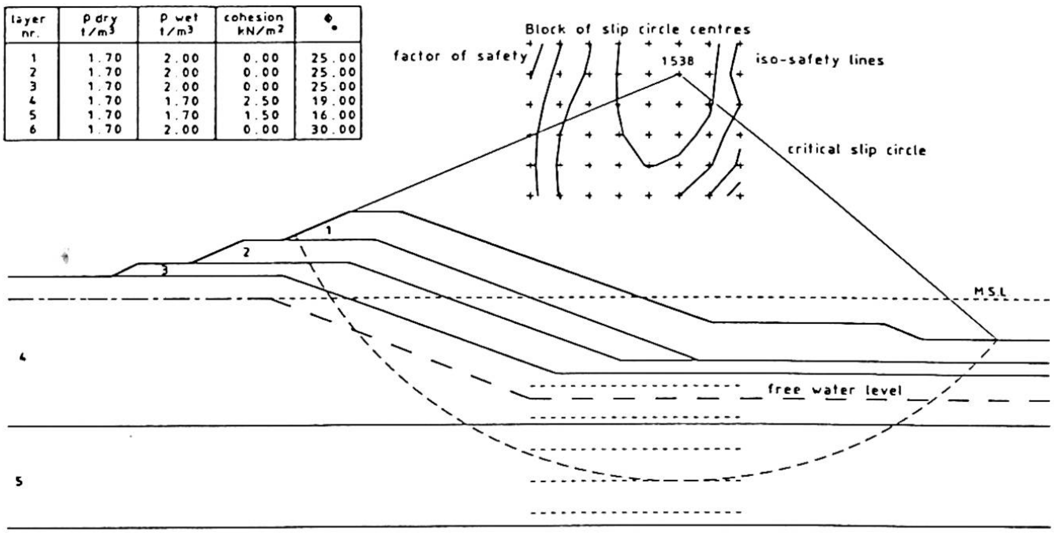
Figure 2: settlement determination using a finite element model.

The originally generated mesh in figure 2 is represented by the dotted lines, while the drawn configuration emphasizes the deformed structure. In order to account for the settlements the embankment is altered accordingly. Stability analyses on the altered structure indicated: insufficient safety factors during construction and long after construction. Figure 3 outlines the result of the slip circle analysis for the embankment long after construction.
Indicated are the block of analysed slip circle centres, the various tangent levels (dotted lines) and iso-safety lines. The minimum factor of safety turned out to be 1.08 and was found for the circle drawn in the figure.
In order to increase the stability of the embankment and satisfy the prescribed safety against failure, an additional bank is applied as shown in figure 4. Again the analysis of the long term stability is shown.
Due to the additional bank the safety factor increases from 1.08 to 1.54.



layer nr.	ρ dry t/m³	ρ wet t/m³	cohesion kN/m²	φ
1	1.70	2.00	0.00	25.00
2	1.70	2.00	0.00	25.00
3	1.70	2.00	0.00	25.00
4	1.70	1.70	2.50	19.00
5	1.70	1.70	1.50	16.00
6	1.70	2.00	0.00	30.00

Figure 3: long term stability analysis



layer nr.	ρ dry t/m³	ρ wet t/m³	cohesion kN/m²	φ
1	1.70	2.00	0.00	25.00
2	1.70	2.00	0.00	25.00
3	1.70	2.00	0.00	25.00
4	1.70	1.70	2.50	19.00
5	1.70	1.70	1.50	16.00
6	1.70	2.00	0.00	30.00

Figure 4: long term stability analysis with an additional bank.

5. CONCLUSION

Summarizing, the experience with the interactive system on design computations as described above has shown the evident advantages. Especially with a frequent alteration of geometry and input parameters to achieve the most favourable construction design the interactive qualities of the system result in a tremendous saving of time and money.

Leere Seite
Blank page
Page vide