Bouwput^{++}. A knowledge based engineering system for designing building pits

P.W.H. Meeuwissen & J. Overbeek
Hollandsche Beton- en Waterbouw bv, P.O.Box 63, 2800 AB Gouda, Netherlands

SUMMARY

In recent years there has been an increasing interest in the development of engineering design applications using Artificial Intelligence (AI), with a particular focus on expert or knowledge based systems. Practical applications of such AI systems in the construction industry however are still rare.

A couple of years ago HBW decided to investigate the possibilities of creating a Knowledge Based System (KBS) to take over all engineering and estimating activities for an often encountered engineering problem using a straightforward set of design rules, experience and calculation programs. This investigation led to a KBS for the design and optimisation of building pits which is currently successfully being used in the company.

1 INTRODUCTION

HBW, as a general contractor, is often involved in design temporary works such as building pits. Design and optimisation of these requires experience of the engineer as well as many tedious calculations, growing in complexity with the implementation of new design codes while the time to make the design is decreasing. Beside this HBW, and other Dutch companies, face the loss of experience due to early retirements and decreasing workweeks.

To avoid the loss of quality HBW decided to create a knowledge based system for the design of building pits. This system, currently in use, is called Bouwput^{++}.

1.2 *Objectives*

In general terms the objective was to integrate experience, code requirements, soil information, pit geometry, construction phases, construction element characteristics and calculation programs in a single system that generates a standardised, high quality output whilst saving time.

2 BOUWPUT^{++}

Bouwput^{++} is not intended to be a 'black box'. The engineer still chooses basic concepts and parameters but is guided through the design process. The system asks for relevant input, structural and geotechnical knowledge are still required from the engineer, design items can be ignored but they can not longer be forgotten.

2.1 *The process model*

The system guides the engineer along the required design steps as indicated in Figure 1, this is

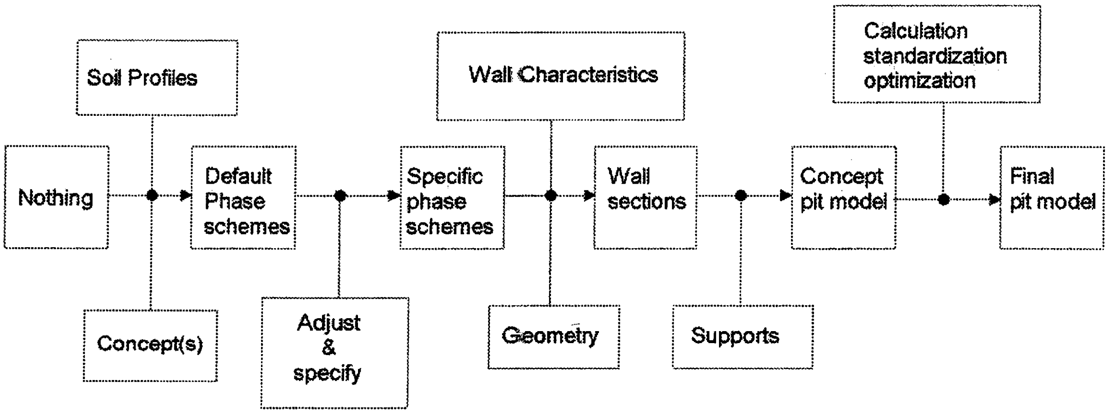

Figure 1. Process model.

done in an interactive fashion making use of the systems databases as background. A major part of the design is still the choice of input parameters.

Codes
At the start of the design the applicable code has to be chosen, currently these can be the Dutch CUR 166 and the German EAU/EAB. After this the system requires code relevant data concerning safety levels etc. and will use the appropriate load and material factors.

Soil information
A number of soil profiles can be generated for a problem. The system has a database with common soils and their upper and lower bound design values, these boundaries avoid typing errors or wrong interpretation but can be circumvented by creating a 'new' soil.

Pit geometry
Practically any conceivable pit geometry can be entered in the system. This pit can be divided into sections coupled to their own soil profile and excavation scheme.

Phase schemes
A number of concept phase schemes for the excavation are available in the program taking into account multiple strut or anchor levels, possible water level in the pit, use of under water concrete and possible prestressing of anchors. These concepts can be adjusted to the current situation and combined with one of the soil profiles as indicated in figure 2.

Element characteristics
Extensive databases are present with information on different grades of sheet piles, combi piles, tension anchors and struts.

Calculations
After reducing the real life problem in these abstract segments the pit elements can be calculated and optimised. Following specification of the theory to be used the system calculates and checks the full design using the appropriate safety factors in both design (strength) and normal (deformation) conditions. The penetration depth is first checked using a program based on Blum after which the calculations are continued using a spring model program where the wall supports are represented as springs. With this model deformations and support reactions can be determined. The struts and or anchors and their influence on the overall stability of the pit are also incorporated. Beside these calculations several stability checks are also performed on the walls.

The most time is gained and the real strength of the system is shown here for it can perform a multitude of iterations optimising the design. This optimisation can be made on support

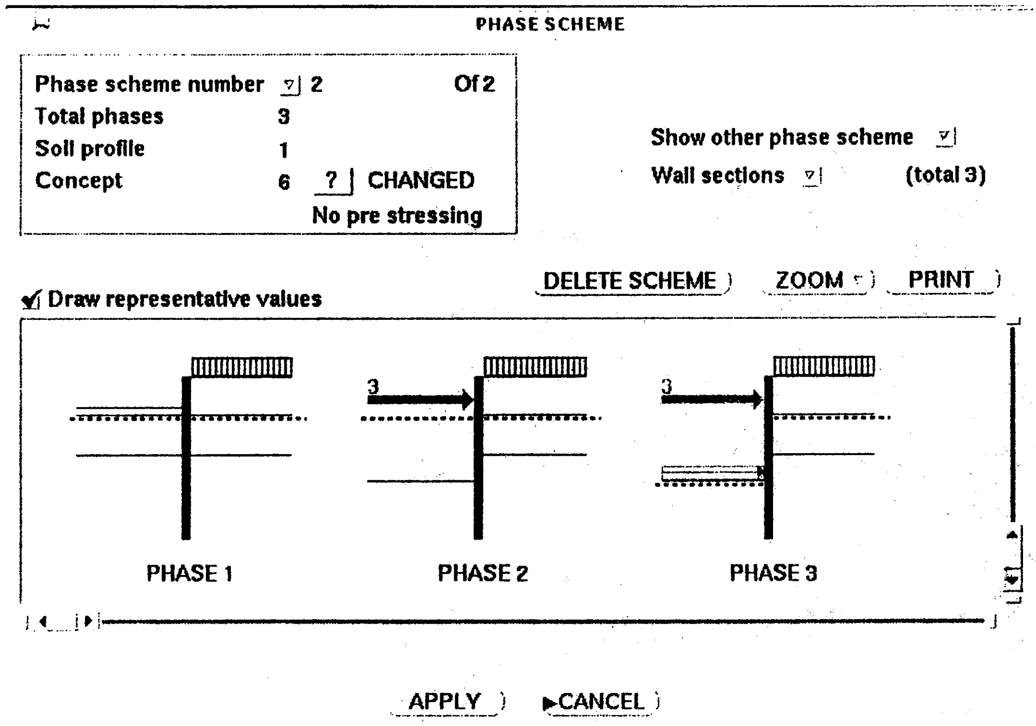

Figure 2. Interactive input of a phase scheme.

(strut/anchor) level, sheetpile or slurry wall length, material quantity, material availability or a combination.

Experience
Past experience is integrated in the system in the form of choices that can or can not be made. The standard phase schemes for instance are those most commonly used. The details that can be added to the drawings are proven concepts that aid the engineer and the estimator in their work.

Reporting
The results of above input and calculations are presented in a standardised calculation report mirroring the input and summarising the output. Numerical and graphical calculation results can be printed at the engineers discretion. Beside this the system produces a layout drawing of the pit where the actual designed cross sections can be added at the push of a button. This drawing has the level of a tender drawing and typical details of wall strut connections etc. can be added from a standard library. A bill of materials required is also available for estimation purposes.

3 TOOLS

The whole system utilises a number of computer programs, an 'off the shelf' word processor and CAD program and 2 sheetpile programs, developed by HBG and also used as stand alone but the core of the system is the 'object oriented knowledge based reasoning shell' Design^{++}. This program, based on product modelling, can contain 3 dimensional geometric data (sheetpiles, anchors, waling, etc.) and manages the required databases and other programs.

Design^{++} is suited to build configuration systems which link components from the database in order to create installations, structures etc. It creates a product model based on the outcome of the design rules and/or the calculation results. If the reasoning system lacks information it will ask the user for input and then proceed. To avoid random requests for input HBW developed a shell around

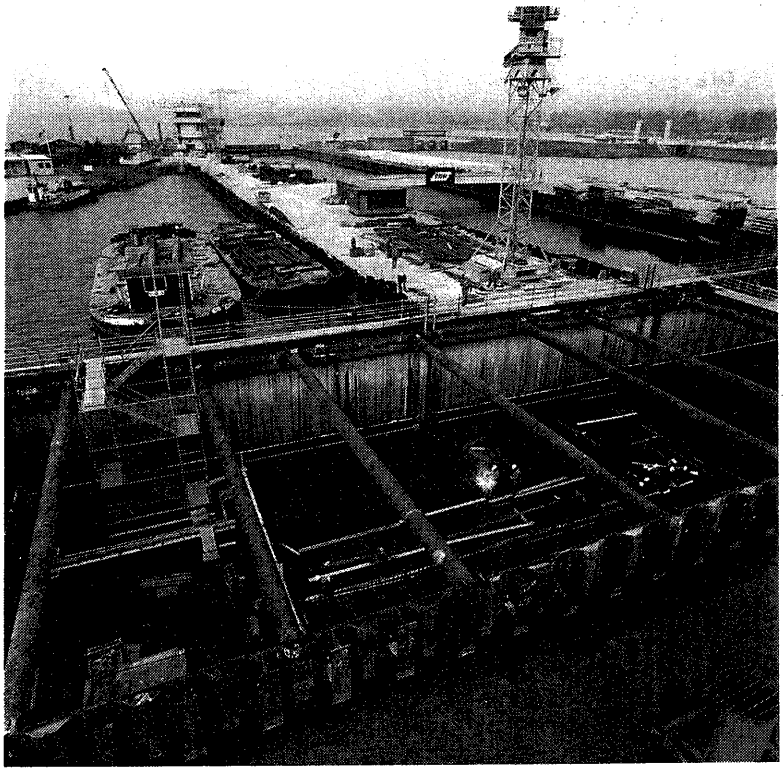

Figure 3. Realisation of a concept.

Design^{++} with a graphical user interface. This interface is also used to present the results of calculations and reasoning.

4 CONCLUSIONS

This computer aided engineering system has proven it's value in everyday reality. It is a powerful tool for the experienced engineer and a definite aid to the less experienced. The fact that a large amount of iterations is possible has lead to reduction in design time and optimised designs. Setting up this system required that the thoughts and experience of engineers were captured and committed to paper, though has not been an easy process it is proving to be well worth the effort.

REFERENCES

1. Plenter R. and Vriend A.C., Bouwput^{++} an user-friendly design-program for building pit constructions and quay walls, HBG technology review 1996, number 2.
2. Design$^{++®}$ is a registered trademark of Design Power, Inc.