Bouwput^{++}
A Knowledge based System for Designing Retaining Walls

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1. Introduction

The environment in which the structural engineer nowadays performs is extensive and fast, interactive with a variety of disciplines and surrounded by an increasing spread of techniques, highly specialised software, regularly changing codes, strict specifications to comply with and forms of contract which create a considerable risk exposure.
The Engineer's performance is expected to be reliable, fast and also to reflect the state of the art of modern techniques and technologies. This environment is challenging but requires, in addition to knowledge and experience, appropriate tools.
From a recent publication in Civil Engineering it was conducted that, in general, there is a gap between software as offered by the market and the engineer's needs. The suggestion to opt for object oriented technology is considered by the author as a sensible direction. This direction has been the basis for the development of a knowledge based system for designing retaining walls, Bouwput^{++}. The most powerful application of the system is the tender phase of projects.

2. Why a Knowledge System

The triggers to develop a knowledge system can be itemised as follows:

2.1 Complexity of Calculational Procedures.

The ability to describe the theoretical performance of structure has gained considerably in strength through the application of a larger number of parameters. As a consequence the calculational procedures have increased in complexity over the recent years. Also the application of codes has gained in complexity by their increasing level of detail and substantial changes in contents. As such it is quite a challenge to manage the integral process of calculations and code checks to their full extent. To cope with this challenge a knowledge system has been built, in wihch the integral know-how and understanding of a core team of highly qualified engineers in the field of retaining structures has been brought together. As such the system provides the state-of-the-art in engineering as a supporting tool for qualified engineers: qualifications remain required to avoid excessive black box consequences.

2.2 Risk Control

HBG Civil operates in the contractor's sector of the market in heavy civil engineering. As such substantial efforts are spent in the tendering process. During tenders last minute changes often occur: addenda to technical specifications, last minute offers from suppliers, not fully transparent with the invitation to bid and last minute optimisations. Many changes do require redesign to check compliance with the specifications, especially for design-construct tenders. Due to the strongly increased level of detail of specifications, regulations and codes, last minute changes do create a risk: as the available time is limited, a full redesign is normally not feasible. What is understood to be the governing case is checked and the full proof of compliance is shifted to the detailed design phase. This risk exposure can be managed and brought back to acceptable levels by the knowledge system as changes can be processed to their full extent and as such all consequences can be assessed by the fast performance of the system where detailed levels of calculations are combined with code checks, and in-house design rules.

2.3 Quality of Conceptual Design

There are two aspects of importance with support the increase of conceptual design quality which has been experienced with the system:

2.2.1 Strongly Reduced Process Time

Due to the home made pre- and post processors the required time to fully develop a concept is strongly reduced. As a consequence there is more time available to seek opportunities, the core activity of any tender.

2.2.2 Standardisation of Concepts and Details

Given HBG Civil's position in the market of heavy civil engineering, retaining structures often occur. As such a large variety of concepts and details have been developed over the years. Management, throughout the whole organisation, of the gained know-how and experience is complex. New projects have triggered the development of concepts and details which could have been drained from the past or, based on previous experience, which were not preferred for future application. A wide and deep investigation of preferred options has been carried out throughout the organisation and has been brought in the system as internal standards. As additional spin-off the information exchange between disciplines involved in the tender has become more precise and more unambiguous by the standardisation.

2.3 Quality of Design Reports

On the input side gross error checks have been incorporated in the system for a variety of parameters. As the analysis, criterion checks and reporting follow, a strict protocol according the present state-of-the-art, all involved know the common basis and as such this avoids loss of efficiency by unnecessary discussions on approach, assumptions and interpretations.

3. Bouwput^{++} , the system

3.1 Field of Applications

Bouwput^{++} has been designed particularly for the tender phase of projects although many options can be applied for detailed design as well.
The system provides a full design including design report, drawings and a bill of quantities. The system can handle complete building pits consisting of:
[1] Retaining walls: steel sheet piles, combi walls and diaphragm walls
[2] Anchorage: anchor walls and tierods, grout anchors and MV piles.
[3] Strut and tie systems to support opposite walls.
The system optimises the material demand through variations of toe levels and anchorage/ support levels, incorporating a large library of profiles and using a variety of Dutch and international standards [among others EAU and EAB]

3.2 Components which together form Bouwput^{++}

The core of the system is an object oriented, knowledge based reasoning shell called Design^{++}. This shell is linked to Autocad to provide drawings. With a link to Oracle product information of components like sheet piles, structural profiles and anchors can be incorporated. The reasoning system requires information. If such information is not available, the user will be asked for information. To structure this process a shell around Design^{++} has been developed with Galaxy, a graphical user interface.
The actual analysis is performed by well established systems for sheet piles and structural analysis of frame works.
Finally Framemaker is used to automatically generate the design report.

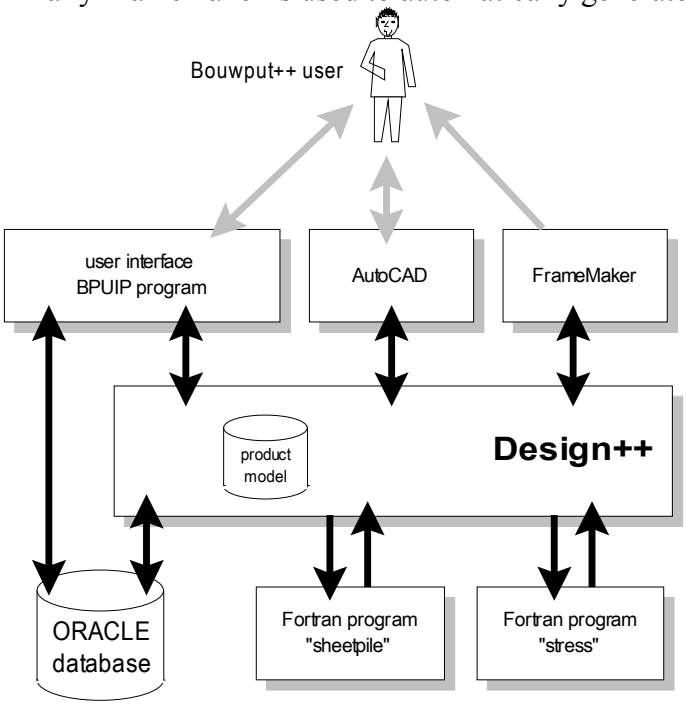

Fig. 1 ……

4 The Role of the Engineer

Bouwput^{++} is a powerful tool. Anybody can organise output. As output from a knowledge system is not transparent with a professional solution to engineering questions unless operated by qualified engineers, quality systems should avoid a do-it-all-yourself attitude of non professionals.
The engineer has a vital position, also with the availability of the knowledge system Bouwput^{++}.
The engineer

[1] Creates the basic concept, selected and judged by considering the relevant boundary conditions defines the soil profiles
[2] Performs an interpretation of the results
[3] Judges the final result in terms of overall concept and details.

All items listed above require professional input and, if covered correctly, make the significant contribution of Bouwput^{++} feasible.

5 Conclusion

If handled by qualified engineers Bouwput^{++} is a very powerful tool to support the tender phase of retaining structures with specific emphases on building pits. Many components have a significant meaning for the detailed design phase as well.The in-house experience with the system, effective as from 1st July 1996, supports this conclusion unambiguously.