Special Topic

Modelling geotechnical Components for Use in BIM Models

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This paper describes the parametrisation of selected geotechnical components for accelerated implementation in BIM models and concludes by highlighting the importance of the interface between the conventional and the digital method of working.

Geotechnics • BIM • Digitisation • Modelling • Shoring systems

1 Introduction

Digitisation has been gaining momentum in the construction industry in recent years, with aspects of digitisation technology increasingly being used in projects in order to enable forward and efficient planning over the entire life cycle of a component. At a practical level the interface between conventional planning and digitisation is created by way of Building Information Modelling (BIM). Introducing the concept of accompanying and supporting a structure or component by digital means at each stage of its life means fewer errors in the transmission of individual pieces of information within the process landscape. By this means it is possible to achieve a certain quality standard and production flow [1].

While the structural engineering sector already has extensive experience in the application of BIM, its use in the field of geotechnics is still at an early stage. A study carried out at Darmstadt University of Applied Sciences investigated the kind of opportunities available for the parametrisation of components for geotechnical tasks and their implementation in BIM models.

2 Modelling of geotechnical Components for Excavation Pit Lining

The study used the Revit software programme from Autodesk. Revit software generates 'families' for the planning and design of structural engineering solutions. A 'family' is a group of elements with common attributes, called 'parameters', and corresponding graphical features. Here the individual elements in a family can exhibit different values for some or all of the parameters.

The study used different parameter types (type and sample parameters) to create a user-friendly element. This involved modelling the following constituent elements of shoring systems:

- Soldier pile walls with Essen shoring (double U profile)
- Bored pile walls (secant pile walls)
- Anchoring with tiebacks

2.1 Soldier Pile Walls

The outline drawing at Fig. 1 serves to illustrate the basic principle that underlies the modelling process. In this case the U profile can, for example, be divided up into two modelling zones: the outer dimension and the

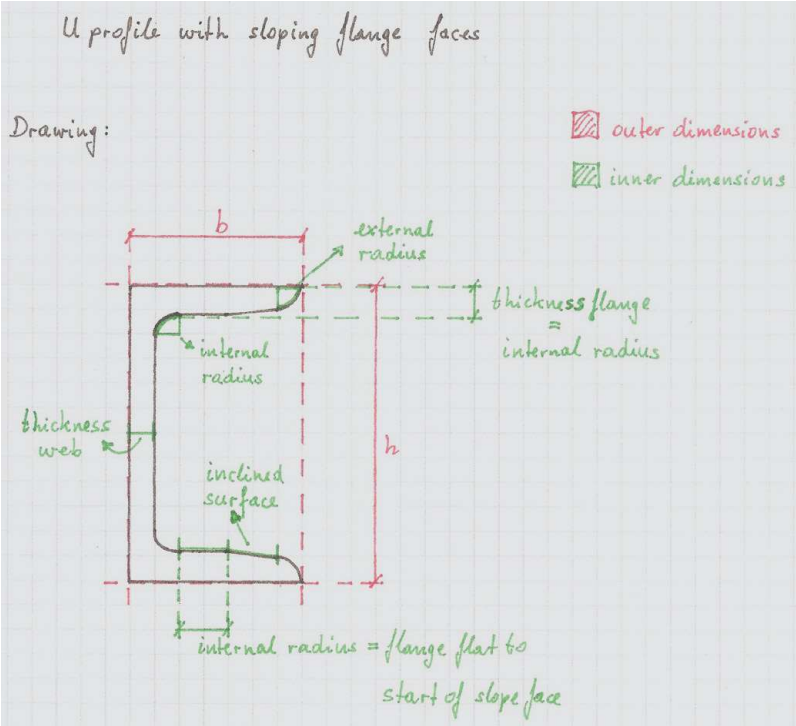


Fig. 1: Drawing – U profile with basic parameters

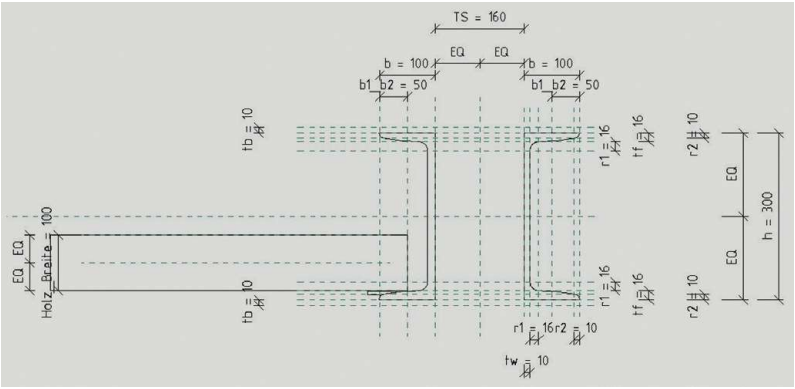


Fig. 2: Plan view of double U profile incl. timber infill

inner dimension. This conceptual outline is used as a basis for the modelling process undertaken by the software. After undergoing parametrisation the assigned parameters are in such a relationship to each other that the model can behave in a flexible manner in accordance with the user's requirements (Fig. 2). In practical application this facilitates the construction of a complete soldier pile wall that can be adapted to the specific circumstances as required (Figs. 3 and 4).

2.2 Bored Pile Wall

In practice, a secant bored pile wall is constructed using the 'step-back' method. The diagram at Fig. 5 shows the sequence used for the fabrication process. This also serves to determine which geometric shapes have to be transferred to the software so that a secant bored pile wall can be modelled. A breakdown of the required geometric shapes helps provide a starting point for the modelling process. This breakdown allows the selected bored pile wall to be parametrised and modelled (Fig. 6). Using the entered parameters, e.g. the pile diameter, and their relationship to each other it is possible, for example, to determine the spacing between the pile axes and/or the amount of application-specific overlap. A secant bored pile wall can then ultimately be created for the project and adapted to meet the user's specific conditions on the basis of the provided or selected parameters (Fig. 7).

2.3 Tiebacks

The Revit software allows parametrisation to be presented from different perspectives. This option is useful for creating elements that exhibit interconnections with certain dimensions and angles in different sections and aspects. One example of this is the design of a grouted ground anchor or tieback. A grid system built from reference planes constitutes the basic framework for the parametrisation and modelling process (Fig. 8). This creates the ideal opportunity for defining parameter values by using formulas in order to generate trigonometric connections for the parameter relationships. It is also possible to use suitable parameters to reproduce constructional design rules. When designing tiebacks, for example, this helps avoid interference between the force application zones. The example shown in Fig. 9 depicts the minimum distance to be maintained between adjacent grout bodies.

2.4 Sheet Piling

Individual family elements can be assembled together in the project in a goal-oriented way in order ultimately to create a complete unit. Building on the developed elements it is then eventually possible to depict the model of a complete sheet piling structure using, for example, a combination of a soldier pile wall and a bored pile wall, together with an anchoring system of tiebacks, as shown in Figs. 10 and 11. Comparing this model with an actual sheet piling wall constructed for a real-life project (Fig. 12) shows that the digital concept is the ideal planning and design tool.

3 Conclusions

The study showed that the geotechnical components of a sheet piling wall can be modelled and parametrised in such a way that they can be applied to real-life con-



Fig. 3: Model of soldier pile wall



Fig. 4: Soldier pile wall (actual build)

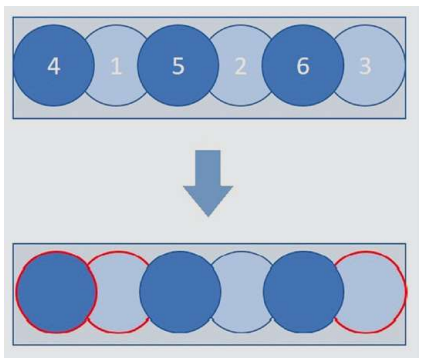


Fig. 5: Layout drawing of secant pile wall

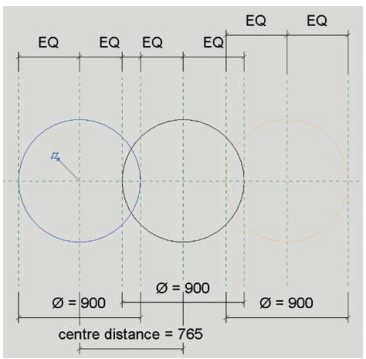


Fig. 6: Construction of the bored piles

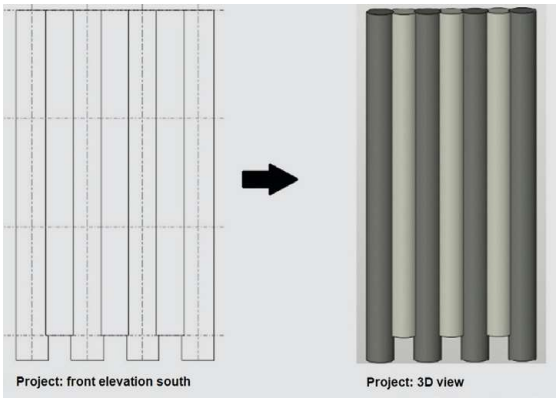


Fig. 7: Graphic depiction of secant bored pile wall for construction project



Fig. 8 Revit depiction of tieback in the reference plane system

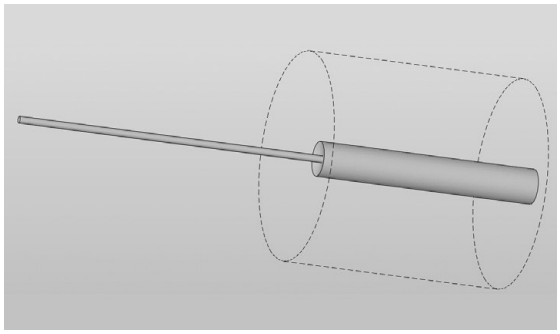


Fig. 9: 3D image of tieback incl. distance parameters

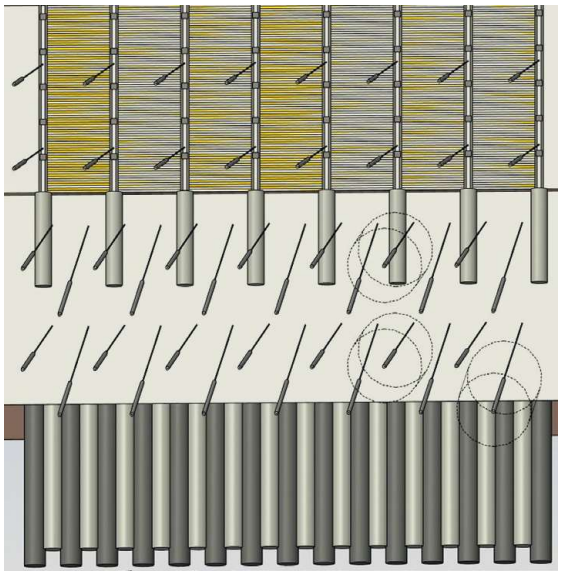


Fig. 10: Rear face of sheet piling wall

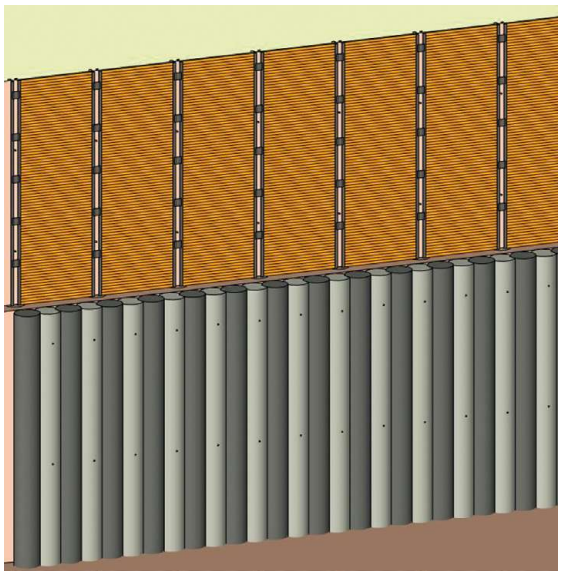


Fig. 11: Front face of sheet piling wall



Fig. 12: Sheet piling wall (actual build)

struction projects. Moreover, the special parametrisation process allows the elements to be flexibly deployed and adapted in planning and technical terms while fully complying with standards and constructional design rules.

The variety of tools and options that the software provides for presenting and depicting a physical body is likely to tempt users to contemplate launching a project without any pre-planning, even though sound preparations are essential for such a task. The basic prerequisites for such an operation include a fundamental examination of the subject matter, a transfer of the acquired specialist knowledge to one's own needs and requirements and, having regard to the relevant information available, the translation of preliminary ideas into a potential concept plan. Then, finally, the original idea can be transferred into a digital conceptual drawing.

From a user's point of view a structured preparation and planning process is therefore very much recommended. The transition from own concept to the application of the design software is made much easier by having properly structured preparations in place and experience shows that the turnaround time is significantly reduced as a result. A step-by-step working method excludes any overlapping of systematically important processes, such as familiarisation with the software and the processing of the models. Such unnecessary duplication of processes or work stages can have a negative impact on overall efficiency.

In the construction sector the interface between conventional and digital working methods is an important element and one that is set to be a crucial factor in the ongoing digitisation process. BIM-supported digitisation certainly requires a certain affinity with the digi-

tal processing of data, however this does not imply that independent input in the form of sound preparation and planning has to take a back seat. There is in fact a risk that the promotion and take-up of digitisation will lead to a schematised working behaviour on the part of the user. The ongoing development of digitisation in the construction industry is both important and desirable, though it should also be treated with caution in a number of respects. Human beings have a tendency to choose the path of least resistance. If 'the path of least resistance', in the figurative sense, is equated with the unimaginative entry of random values into an input mask then digitisation in this case will not be progressive in nature but rather will have a degressive effect on the user. In reality we therefore have to look at this development – metaphorically speaking – as something of a double-edged sword. On one hand the flow of information within a project can be optimised in such a way that there is clear added value in terms of technical execution and efficiency, on the other there is also a risk that the user who is dealing with macro details, in other words who is in a non-managerial position, will lose touch with the actual hands-on skills required for the application. We therefore appeal to those working in this sector to keep the 'traditional' tools and instruments in mind and to avoid relying blindly on digital workflows. Only then can the benefits of digitisation with BIM be exploited to the full.

4 References

[1] Borrmann, A.; König, M.; Koch, C.; Beetz, J.: Building Information Modeling: Technologische Grundlagen und industrielle Praxis, Wiesbaden: Springer Vieweg Verlag, 2015.

[2] Boley, C.: Handbuch Geotechnik: Grundlagen - Anwendungen - Praxiserfahrungen, Wiesbaden: Vieweg + Teubner Verlag, 2019.

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