Digital parametrised ground model in tunnelling

Concept and sample application

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ABSTRACT: The goal of the hereby summarised master's thesis is, next to a basic evaluation of the current geotechnical planning in tunnelling, to develop a concept of the future implementation of the digital ground model in all project phases of tunnel construction to its full extent. With the first step, the sample application KÖSA, it is shown what already can be done today. In a second step, the concept development, the Tunnelpixel as a possible future solution are outlined.

Complete thesis: *www.uibk.ac.at/ibt/lehre/abgeschlossene-masterarbeiten/*

KEYWORDS: TIM, BIM, Digital Ground Model, Geotechnics, Geology, Tunnelling, Tunnelpixel, Digitalisation

1 INTRODUCTION

„It is not the question, whether BIM will come or not, rather how quick and persistent" [1]

This master's thesis can be seen as a contribution to make the implementation of building information modelling (BIM) in ground modelling for tunnelling as persistent as possible.

2 INITIAL SITUATION

2.1 Standards

Due to the lack of tunnel specific BIM standards, the conventional standards for tunnel construction in combination with the current general BIM-norms are used.

2.2 Conventional geotechnical planning

In Austria, the current analogue geotechnical planning is based on the guidelines of the OeGG for geotechnical planning of continuous and cyclic tunnelling. Fig. 4-1 shows the first two steps of the schematic process. Thereby the definition of the soil types is based on project-related geotechnical properties. With further properties the ground zones are defined in step 2. Subsequently, the 11 predefined ground behaviour types (BT) are mapped to the ground zones accordingly.

3 SAMPLE APPLICATION KÖSA

3.1 Initial Situation

Within the project to renew the rail corridor Köstendorf – Salzburg, a BIM pilot project of the Austrian Federal Railway (ÖBB), the development of a basic digital parametrised ground model was carried out. Being in the project phase of the environmental impact declaration (UVE), the focus lies upon implementing alphanumerical information as well as a parametrised evaluation of masses. One of the derived BIM use cases is the determination and evaluation of the to be opened tunnel cavity in the correct position.

3.2 Approach

The pictured basics in Fig. 3-1 are assumed to be available for the sample application. With the following step, all the necessary modelling is done, to provide for a complete evaluation of the model. During the parameterisation, all necessary alphanumeric Data is added to the tunnel cavity model, so the geotechnical planning up to the mapping of the BTs can be performed on the model and a following full analysis of the resulting data can be provided.

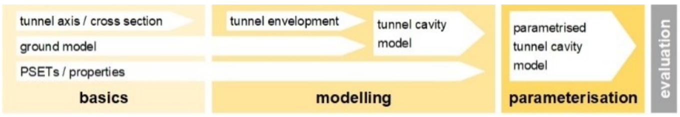

Fig. 3-1: Diagram of the chosen approach

3.3 Outcome

One possible analysis report is shown in Tab. 3-1. It shows a categorised evaluation of the share each BT-combination has in the overall tunnel drive volume.

GVT dominant > 30%			GVT subordinated 10-30%			GVT very subordinated <10%		
GVT	overall volume	share	GVT	overall volume	share	GVT	overall volume	share
GVT7 GVT8 GVT9	90362 m³	3,7%	-	244956 m³	9,9%	-	151739 m³	6,2%
GVT4	2259628 m³	91,6%	GVT2 GVT9	2108972 m³	85,5%	GVT2 GVT7	1007958 m³	40,9%
GVT7	115712 m³	4,7%	GVT2	111773 m³	4,5%	GVT3 GVT8 GVT9	1251670 m³	50,8%
						GVT8 GVT9	54335 m³	2,2%
	2465701 m³			2465701 m³			2465701 m³	

Tab. 3-1: Analysis report of the BTs

Further analysis possibilities are the distribution of the BTs within the ground zones or the overall tunnel drive volume for each ground zone and ground layer. All these evaluations include the relevant properties and alphanumeric information.

3.3.1 Findings

The sample application shows that the available tools at the time of the examination already allow for a rudimental implementation of the BIM method for subsoil planning in tunnelling. Based on proven workflows, supported by an integral approach, a parametrisation of a ground model is already possible.

3.3.2 Potential Improvements

The automation of the developed process holds great potential for improvement by automating all repetitive steps. Moreover, the complete, exact and easy implementation of properties throughout different software products has to be enhanced.

4 CONCEPT DIGITAL GROUNDMODELL

4.1 Basis

The basis for a digital parametrised ground model shall be developed upon the relevant steps from Fig. 4-1. Such a model has to be able to include all relevant properties for the geotechnical planning process, while at the same time being as differentiated as possible, to apply for different workflows by separate stakeholders.

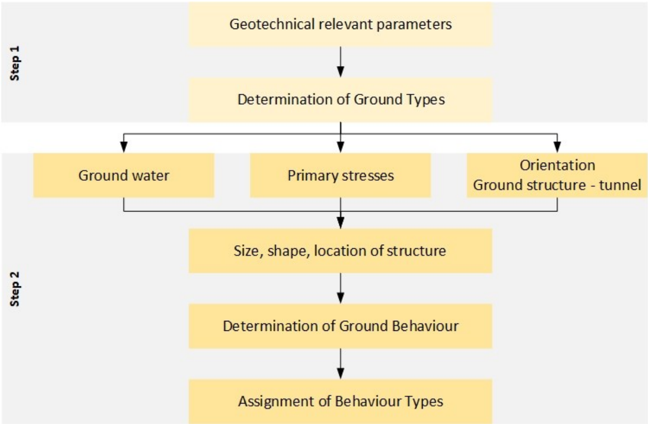

Fig. 4-1: Relevant steps from the schematic process of the geotechnical planning [4]

4.2 Concept

This resulted in the concept of the Tunnelpixel. The fundamental consideration thereby is what the smallest to be modelled unit has to be. By rasterizing the tunnel cavity solid along the tunnel axis, individual solids are created. Each of these solids can hold individual properties. The raster-interval can be adapted to variable boundary conditions which mainly depend on the project phase.

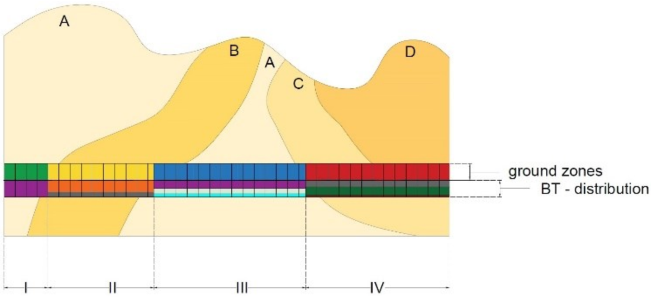

Fig. 4-2: Concept depiction of the rasterised Tunnelpixel

Fig. 4-2 shows an exemplary depiction of the Tunnelpixel concept for a tunnel segment. It comprises of different ground layers, ground zones and BT-distributions.

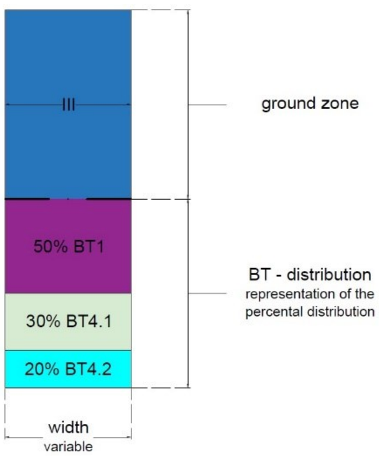

Fig. 4-3: Single Tunnelpixel showing the ground zones and the BT-allocation

4.3 Advantages

A single and detailed picture of one Tunnelpixel is seen in Fig. 4-3 and shows that a further extension of the depicted information can easily be implemented. Another advantage of this concept lies within trans-sectoral properties. When checking the model, these do not show up as clashes, since it is based on individual solids. Furthermore, the smallest to be modelled unit makes updating the model easier and helps to support the single source of truth (SSOT) approach, which is a main goal of the digital ground model as well.

4.4 Use Cases

Based on the literature a list of possible BIM use cases has been worked out.

5 CONCLUSION

The sample application KÖSA has shown, that the BIM method is compatible with the proven workflows within ground modelling and provides a wide range of advantages. Simple evaluations and semi-automated methods can already be implemented and made use of. The concept of the Tunnelpixel can furthermore be seen as the basis for an extensive implementation of digital workflows within subsoil planning for tunnelling.

6 OUTLOOK

To evaluate this concept, a validation on the basis of further projects is needed, as well as discussions within groups of experts. Derived from the results, further questions have been defined.

The best possible interaction between the structure model, the ground model and the construction site model has to be resolved. A structure for properties which are needed for a digital parameterised ground model and for the geotechnical planning of tunnels in all project phases and for all use cases has to be defined. The extension of the concept to a 5D BIM approach, in order to incorporate information about time and cost has to take place. Furthermore, it has to be analysed, if the digital ground model helps reach true-cost pricing and if the industry can be transformed towards fairer prices.

7 REFERNECES

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