REPLICATING AN INFRASTRUCTURE PROJECT FOR PROFESSIONAL BIM EDUCATION

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ABSTRACT

One of the obstacles of implementation of the Building Information Modeling (BIM) method regards high-risk expectations. To address this issue, a joint project was launched to implement, accompany, and document a typical infrastructure project (road route bridge). The ex-post BIM-based replication of the project was successfully and jointly realized by members of academia, including students, by the public owner and by several consulting and construction companies. Results of the project include a thorough documentation of the entire BIM-based process and instructions on crucial steps as well as a detailed process map. Necessary documents, such as Employer Information Requirements, were generated. Usual output files, such as a coordination and different partial models as well as schedules, bills of quantities, service specifications, visualizations and drawings were also successfully generated. The project used for this case study is located in Thuringia. All output files are addressing the usual work environment of German construction partners.

Keywords: *Lean Technologies, Building Information Modeling, Information Requirements, Machine Readability, Project Management*

INTRODUCTION

The Building Information Modeling (BIM) method has been a topic of research and discussion for some years now. A lot of solidified knowledge has been collected (Borrmann, König, et al., 2021; Eastman et al., 2018) and experience has been shared within the academic community (Borrmann, Forster, et al., 2021; INFRABIM, 2018) as well as in the industry. But the acceptance among public investors is still very scarce. In consequence, this prevents engineering consulting and construction companies, mostly small and medium size enterprises, from adopting this method (Deutsches Ingenieurblatt, 2023).

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Given the soon mandatory application of the BIM method for public projects in Germany, a group composed of a university department and a selected group of students, a state office for construction and transport, an engineering office and contracting companies specialized in road construction decided to collect and share these experiences themselves. The goal was the low-risk BIM-based knowledge gain in both public and private sectors as well as discipline-specific knowledge transfer between all participating stakeholders.

The aim of the research project was to develop a project using the BIM methodology based on a chosen bridge structure, which is part of the B 88 Zeutsch bypass extension (construction km 3+850) and serves as an overpass for a service road. At first, the project was not planned as a BIM project, but it was converted into one ex-post as part of this research transfer project. The decision to choose a structure that does not conform to standard modelling elements (open frame, 8.50 m pure carriageway width, noise barrier, drainage channel, service walkway, 470 m arc with a subsequent clothoid A = 350, cross slope 6 %, longitudinal slope 2.694 %) was deliberate to force discussions and results that are not only due to savvy and experience with certain modelling tools, but require a deeper understanding of both problem and solution.

RESEARCH METHOD

The goals of the project included often-mentioned BIM tasks, such as improving communication and interface coordination, thus increasing planning reliability, transparency, efficiency as well as the associated minimisation of risks. The project was embodied by continuous modelling, model-based design planning and quantity take-off, model-based costing and preparation of a contractual specification. One of the research questions addressed the limitations of the IFC exchange format for infrastructure and road construction, including limitations in the implementation of the open standard by vendors. An accompanying objective included the evaluation of different applications (mainly Revit, Allplan and Allplan Bridge, Civil 3D and the ProVI add-on, iTWO Civil, Desite MD pro, Navisworks and iTWO). To address this evaluation and to make objective assessments regarding implementation, the approach of parallel modelling was used. Thus, problems in one application could be verified in another and vice-versa.

The complete modelling, attributing, coordinating, visualizing, model-checking, scheduling, quantity determination, costing, reporting, documenting, and writing was done by a group of students from both the Bauhaus-Universität Weimar and the University of Applied Sciences Erfurt, in the study programmes management [construction real estate infrastructure] and civil engineering respectively. These students used their BIM knowledge and acted as so-called “BIM envoys” to include company- and discipline-specific knowledge in the replication and implementation of the project. The group of BIM envoys was coordinated and headed by the authors.

RESULTS

In addition to the final coordinated model and all necessary partial models (digital terrain models, earth works and excavation, alignment, bridge model), as depicted in Figure 1, a wide range of documents were generated, among which the Employer Information Requirements (EIR) and annex object and attribute list (table), model-based schedule, Quantity Take-Off (QTO) and Bill of Quantities (BOQ), model-based 2D drawings, and a process map including all implemented steps according to the Business Process Modelling Notation (BPMN) play a central role.

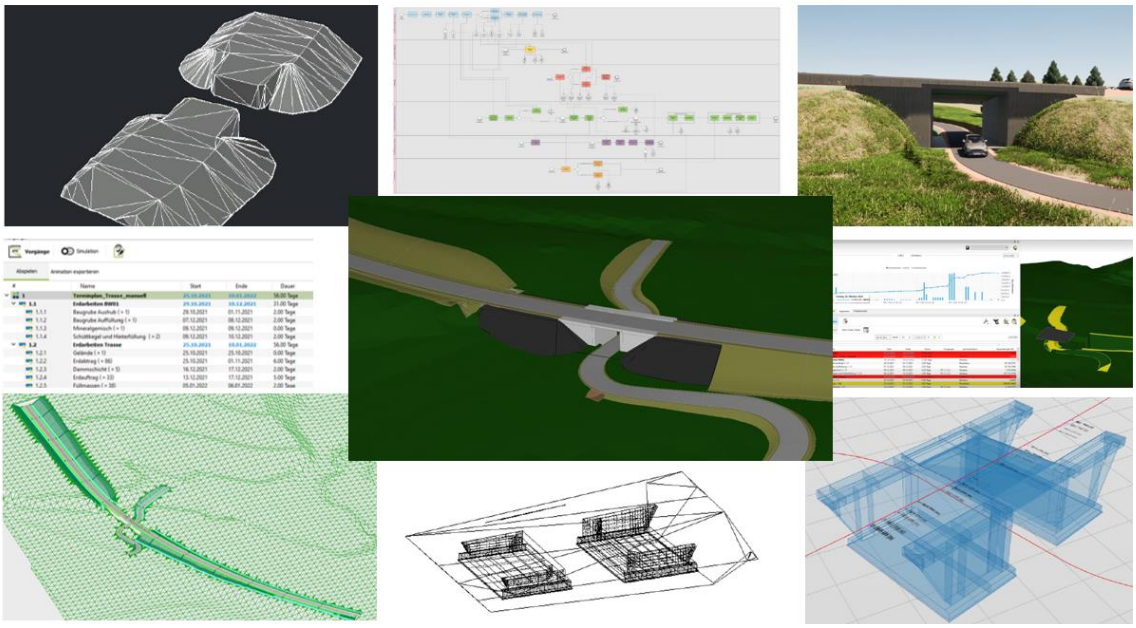

Figure 1: Overview of the partial models and partial results of the project (digital terrain model, alignment, earth work models, process map, marketing visualizations, quantity take-off, structural model, bridge model and finally, the overall coordination model in the middle).

In the course of the study, various coordination applications were tested (Desite MD, Navisworks and iTWO), whereby the focus was on the application Desite MD. In general, the quality of the IFC import of the partial models from different modelling applications proved to be very heterogeneous. For the model coordination, a so-called mix model was consolidated with partial models from the Civil 3D (with ProVI add-on), iTWO Civil and Allplan applications. Regarding the coordination step, the close communication between the BIM envoys must be emphasised. Based on the coordinated model, the model-based construction scheduling, quantity take-off (QTO), cost ramp-up as well as the compilation of service specifications (X81 and X82 files according to the German specifications set by

(GAEB - Gemeinsamer Ausschuss Elektronik im Bauwesen, 2020)) were realized (using mainly Desite MD and iTWO, but also in parallel using Navisworks).

CONCLUSIONS

The execution of a non-standard bridge structure using BIM-methods was successful and very insightful both for participating companies and institutions as well as for the students acting as BIM envoys. During the project, many stages were undergone and typical documents, files and models were generated successfully (even if sometimes arduously).

Formulating tendering documents, such as the EIR, requires a reflection by the employer about the project and its' subsequent steps. Those can regard the tools used by the employer itself and possible specific IT requirements related to it, requirements resulting from prior experience in construction supervision, building inspection, or (prior) contracted services.

Correct and gapless geometrical modelling of volumes is vital for QTO as well as the compilation of service specifications, given that only closed volumes are recognized and thus regarded in the results. In road construction, this is especially relevant for earth work modelling, where errors in volume calculation can trigger unnecessary excavation works. The import of GIS-related data (Geographic Information Systems), such as the terrain model, to so-called BIM modelling applications is still very limited. In the used applications (Revit, Allplan), the only successful non-proprietary import occurred using the LandXML and XYZ formats. All partial models (terrain and earth works, alignment and bridge) underwent IFC mapping. The model coordination in this project was only possible due to IFC schema version 4X1 because of the alignment element(s), but it was possible and complete, nonetheless. It is worth mentioning, that in certain applications it was necessary to undergo the IFC mapping step separately/additionally. This should not reflect a limitation of the IFC schema itself, but of both the user-friendliness and seriousness of implementation of specific applications. Further, the understanding that geometric modelling (1) and alphanumeric and semantic modelling (2) are two (almost) separate and equally important steps is crucial for the successful BIM-based project execution.

Finally, one of the main success factors for BIM-based construction processes recognized in this project is deep knowledge of how the technologies and applications work in order to use the correct functionalities within applications.

FUTURE

The adopted system of students acting as BIM envoys was very fruitful for the overall BIM education within this project. Future considerations should address further applications of that system. Also, immersing students in a complex, long-term project over two or more semesters showed promising results. In the development and IFC adoption area, further project in cooperation with vendors could be feasible to address problem areas of IFC implementation or geometrical and alphanumerical modelling jointly. In that regard, an interesting topic could be geometrical modelling approaches that are volume-based instead of the current vector-based approach.

ACKNOWLEDGMENTS

This project was supported by the Thüringer Landesamt für Bau und Verkehr. Further contributions by Bauer Bauunternehmen GmbH, Bickhardt Bau Thüringen GmbH, EUROVIA Verkehrsbau Union GmbH, INVER – Ingenieurbüro für Verkehrsanlagen GmbH, STRABAG SE as well as the Building Industry Association Hesse-Thuringia are acknowledged.

We would like to thank the students Josephine Gohlke, Vanessa Jung, Christian Nürnberger, Marie Pfeifer, Tobias Rolf and Leon Heiko Wiesner for their enthusiastic work throughout the project.

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