IMPLEMENTATION OF BIM IN PUBLIC TRANSPORT INFRASTRUCTURE WORKS IN THE CZECH REPUBLIC WITH RESPECT TO THE FIDIC STANDARDS

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Abstract

The paper describes the actual status of BIM implementation in public projects in the transport sector within global powers and the Czech Republic, emphasising the specific aspects of the construction market and legislation base in the Czech Republic. The research part of the paper presents the proposed methodology of BIM implementation in road construction, and demonstrates the different levels of detail and information using a BIM model. Last but not least, a risk analysis is introduced and the risks identified are briefly introduced.

Keywords: building information modelling/management (BIM), pilot project, BIM implementation, BIM model

1 Introduction

The Czech Republic plans to implement BIM as integral part of the project preparation and implementation of all public projects in civil engineering that are in terms of public procurement law defined as “above-the-limit” investments. This covers all public construction works (under Act no. 134/2016 Coll. on public procurement) amounting to an investment higher than CZK 149,224,000 (5 855 476 €) starting from January 1, 2022. The obligation of BIM implementation in public procurement works is stipulated by Resolution no. 682 of the Government of the Czech Republic dated September 25, 2017 on the Concept of BIM implementation in the Czech Republic – part III of material file no. 918/17.
The Resolution thus has an impact on all larger construction or rehabilitation projects in the road construction sector. The content of this paper focuses on the road construction issues, particularly in relation to motorways, 1st class (trunk) roads and structures like bridges, tunnels, utility networks etc.

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2 BIM implementation around the world

The literature search of available sources [1, 4-8] suggests that BIM has been so far gradually implemented in the construction industry all over the globe. The level of implementation is illustrated by Figure 1 below.

Figure 1 BIM implementation status over the world [9].

However, the problem is the difference between BIM implementation on private enterprise and public or state enterprise levels. This is also set out in [5]. Another incomparable aspect is the different character of road construction projects and building projects where BIM has been involved for a number of years. For example, [9] and Fig. 1 demonstrate that BIM has been completely or partly implemented on government project levels in the USA and Great Britain while other countries are in the implementation stage, or BIM is in preparatory stage or the initial implementation is already in place. Finding out whether the BIM implementation concerns at least the 4-5D level (including time scheduling and cash-flow) and whether heavy infrastructure/motorway projects and road construction projects in particular form a part of the implementation, is rather difficult. The literature search has failed to detect the precise methods applied in the individual countries around the globe where the implementation has already been completed, and the solutions applied to the specific road construction issues.

This means primarily the specific aspect associated with the linear character of the project whose trajectory passes through environments which might change significantly along the course (e.g. geological conditions, location of underground utility networks, geomorphology etc.). The linear nature also requires a huge volume of data to be processed which require a high level of detail. The search has failed to obtain any available methodologies applied by foreign public contracting authorities, procedures used and ways of implementing BIM with respect to risk analysis and overall economic assessment [1, 5].

3 Implementation of BIM in the Czech Republic and the legal framework

The Czech Republic presents a specific environment of local practices and existing, applicable legislation. The biggest public contracting authority in the field of road construction is the Road and Motorway Directorate of the Czech Republic (Ředitelství silnic a dálnic, hereinafter "ŘSD" or "Directorate"). Even though the Directorate has regulations which allow public procurement according to the FIDIC Yellow Book, it so far has tendered projects solely based on the methodology according to the FIDIC Red Book due to internal ŘSD regulations and in compliance with public procurement law. This means that both the Client and the Contractor accept roughly equal risks addressed on the basis of risk and claim management preparations. Another feature is the status of the project administrator: in the case of the Directorate, the project administrator is the public client itself. The competences of the administrator include independent claim handling, too.

In practice, the client first assigns work to prepare the project designs and documents on the individual levels, from the planning study to the tender specifications. All the levels may be compiled by a single independent designers, as well as up to four different ones. The documents are compiled separately for the Study, Urban Planning Decision, Building Permit and Tender Specification levels. Only then does the Client announce a tender for contractors to compete for the public project as General Contractor or as a construction consortium.

The FIDIC Yellow Book (D&B – Design and Build) has so far tended to be avoided in the Czech road construction market. The Yellow Book model is used in the developed countries like France, the UK, the Netherlands, the U.S. and others. In the Central European region it has been partly used in Poland or Austria and recently has also been applied to the tunnelling and construction projects on motorways in Slovakia.

The Yellow Book is mostly based on the Red Book with the significant difference of having the Project Specifications prepared by the construction contractor itself (the contractor has been known right from the start) based on the Investor's requirements, and the contractor is also duly liable for the specifications. The price of the work is not measured or quantified; it is determined by a fixed fee which poses equal risks for both contracting parties. With respect to the lump-sum drawdown of funds, the claim management must be established in advance as well as the conditions for invoicing, etc.

The process normally involves selecting a contractor to prepare the Project Specifications. The great advantage is having one entity (internal or external) that prepares the project documents and designs for all or at least several design levels. The compilation of the documents may involve some optimisation of work flow, materials etc. which might ultimately have a positive effect on the final price of the project. Technical changes and optimisations in the Red Book regime are a nightmare for all parties in the construction process with respect to the administration workload associated with administrative process known as "changes during construction".

The "single contractor" concept and the possibility of changes/optimisation then encourages the application of e.g. observation methods of earthworks but, primarily, BIM. This is because a single model is made which carries all the information from the initial design through to the last part of the Construction Design Specifications. The project is managed, ideally from the very start, by a single principal designer who is aware of all the aspects of the project and the environment. He knows the client´s requirements and the contractor's limits. This eliminates the tardy process associated with the quantification/measurements of the contract where each new designer of a new design level, including the contractor itself, must study the documents and get an understanding of the continuity and logic of all operations first. This also means that number of aspects might be omitted.

As ensues from the above, the use of BIM within the Design and Build model is the most effective application. Considering that the BIM model allows even facility management and offers the option of facility management by private sector entities, we are almost reaching the level of Public-Private Partnership projects (PPPs) wherein BIM might play an interesting role. The biggest problem and, therefore, the biggest risk in BIM-designing for a public contracting authority in any specification level lower than the implementation specifications is the fact that, the designer is not allowed to use precise specification, company name or characteristic of a component that would conspicuously encourage the use thereof (legal requirement of the public procurement law).
As an example, it is impossible to specify anything other than the material, height and length for a crash barrier according to the existing regulations. Under no circumstances may the brand name, length of the crash barrier as declared according to the manufacturer's specifications, or the shape of the crash barrier be indicated. The problem of BIM, or its clients, is an enormous effort to achieve the highest precision, level of detail and reflection of reality (digital twin). However, there is no potential for that in the public sector. A crash barrier, for instance, will therefore be modelled as a rectangle – the envelope of the deformation and construction space occupied by the crash barrier. The barrier may only be modelled in detail in the Construction

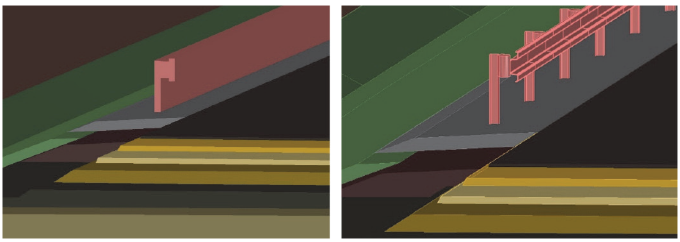

Figure 2 The difference between traffic barrier for lower levels (LOD200) and implementation specifications (LOD400)

Design Specifications stage and afterwards. The difference between the BIM model for the general level and for the Construction Design Specifications is obvious from the Figure 3. Two pilot projects were completed in 2018 within the framework of BIM implementation. The first one was the reconstruction of junction of a trunk road (No. I/32) and a regional road (No. II/125) at Exit 42 from the motorway D11 (about 40 km to the east of the capital city Prague) – conversion to roundabout (the author was a member of the design team). The second project was a part of D1 motorway modernisation – section 04, Exit 34 Ostředek – Exit 41 Šternov, Overpass no. D1-040 and local road at km 37,170.

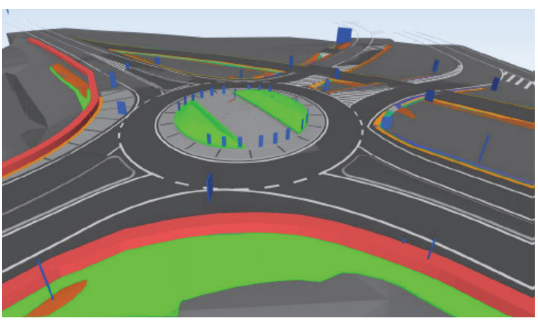

Figure 3 Sample from the Directorate's pilot project – conversion to roundabout

The pilot projects were expected to verify particularly the possibility of compilation of the Construction Design Specifications and as-built drawings. The scope – overpass and junction – defined these two as points rather than linear structures. Another problem was having the BIM model created based on 2D construction documents during the implementation stage. The possibility of clash detections and coordination was checked.
Although the projects were characterised as points, interesting findings transpired. For example, the bridge cones were more precise in BIM than in traditional documents, allowing an incorrect bill of quantities to be optimised. Clash detection demonstrated hundreds of unreal clashes within the framework of relocations of utilities networks crossing the sewer line excavations or side posts on the road edge. Contrastingly, some relevant clashes were difficult to be identified, e.g. the large traffic signs in the field of view at the junction.
During 2020-21 the Directorate envisages further pilot projects which should also include the permit-granting process and document compilation for early design stages.

4 Implementation method

The CESTI Competence Center and the student research project no. SGS OHK1-083/18, "BIM – implementation in the road construction practices in the Czech Republic" involved the generation of a BIM model for road construction, see figures 2-3, used as the basis for the examination of the required information detail level. The basic attributes (non-graphic information, see Figure 4) were designed and the Methodology for BIM process utilisation in road construction and road construction project management was proposed [10].
The BIM Implementation Methodology is proposed containing seven separate levels:
Preparation work; Target definition; Project preparation pilots; Construction execution pilot projects; Asset/facility management; Education and awareness; Implementation.
The completion of the aforementioned levels brings the methodology to the next stage. The sequence is designed to prevent leaving out any levels although the individual levels can be initiated in overlapping time windows. It should be borne in mind that completion of the seven levels in itself does not guarantee a smooth and easy start of the mandatory BIM system, and that it will be necessary to continue improving the process, optimisation and review even after the implementation.

5 Methodology and used processes

The methodology in question addresses the method of BIM implementation in the road construction industry. It is divided into the aforementioned seven levels. Each level aims to provide the completion or checking of a certain theme, contributing to the overall implementation. The individual levels always require a risk analysis, discussion of the results by a broad expert public community and the requirement for the final report to be published. A time schedule of the individual levels and the proposed attributes (non-graphical information) for non-solid pavements, road crash barriers and vertical traffic signs are attached to the methodology. For some objects the attributes are designed for noise barriers as well. The attributes are designed for the design levels from building permit documents to Construction Design Specifications and facility management model.

Level 1: Preparation work – This level is dedicated particularly to reviews of the work completed, and existence of supporting materials in the Czech Republic, reviews and provision of available documents from abroad and, mainly, the degree of relevance of the document content. An overall summary of the findings of the aforementioned sources also forms a part of the level.

Level 2: Target definition – The second level addresses the definition of the BIM project preparation targets, including its added value for the technical study, zoning decision documents, building permit documents, Tender and Construction Design Specifications levels. It also defines the objectives of the facility completion and management with an emphasis on the project's life cycle. The second level also entails the identification of necessary amendments to the legislative documents (laws, Government decrees and decisions, technical standards and other regulations). Last but not least, this level is dedicated to the issues of liability for defect and total demands for funding the project preparation which will undoubtedly be higher than the current market prices.

Level 3: Project preparation of pilot projects – This level handles the pilot projects for design work on the various levels of project specification documents. It first designs an independent pilot project for a road relocation, bypass as a conclusion of a complex project involving objects in classes 100-500 according to the national classification system for construction elements and objects. It appeals primarily to the quality and price of obtaining good quality source materials for BIM, especially the approximate course of utilities networks and structure diagnostics, or geological surveys. The level requires a time and economy-related examination involving a risk analysis. Projects where no difficult and lengthy property-related issues are expected should be selected as pilots. Last but not least, the level also researches the possibilities of construction project permit granting and positions of the state administration bodies concerned or other parties to the proceeding within BIM.

Level 4: Construction execution of pilot projects – This level is dedicated to Construction Design Specifications and the as-built documents where BIM has a great potential because the document is subsequently used as an input for the BIM facility management model. The level also handles BIM processes during project completion. The recommendation for this level is to complete the projects from the preceding level which have been prepared in BIM right from the start. Relevance and effectiveness shall be pointed out as well, e.g. whether BIM should include (and if so, in what level of detail) also construction objects to be handed over to other owners for whom the information is of no value (municipalities, private owners, technical infrastructure managers etc.). Lastly, there is a requirement for a time and economy-related assessment with a risk analysis.

Level 5: Asset/facility management – This level concerns facility management and structure/building life cycle. A pilot project (which will necessarily take several years and extend over to the post-implementation period) should check the essential problems – primarily the supporting documents for the BIM maintenance model, the level of detail and identification of the information needed by the facility manager as opposed to unnecessary ballast information (i.e. relevant level-of –information).
The BIM facility management model must be clear and systematic, simple and sophisticated at the same time. It must be tailored to any management or road maintenance and operation centre. The greatest potential is the implementation of planning regular and winter maintenance, as well as heavy maintenance schedules, standard and extraordinary inspections etc. The model must certainly avoid causing unnecessary delays and administrative load and it must effectively improve the overall process. Finally, an analysis of economy and risk is required in this stage as well.

Level 6: Education and awareness – This level is dedicated to the education and awareness-raising of broad specialist public, state administration bodies concerned, public contracting authorities, students as well as the public which might be interested in the reasons why more financial means should probably go into project preparation. The crucial problem is the method of teaching young students not only at universities but at secondary schools already. Their instruction should start as of now but there are far from enough experts with practical experience in the BIM processes in road construction.

List of Hazards

Number	Identification		Hazard materialisation scenario	Proposed measures and objectives
	Classification	Hazard		
23	Target definition (level 2)	Lack of clarity in the brief and the consequent LOD	The public contracting authority will require an insanely high LOD disproportionate to the importance of the design level and construction item content (e.g. simultaneous relocation of drainage).	Reduce LOD, only do the main items to be managed by the Client in the future (or items with difficult coordination) in BIM.
24	Target definition (level 2)	Economy and time effectiveness of BIM for design document compilation in different levels (zoning permit, consturction permit, realization).	BIM is an uneconomical tool with too high time demands. The cost and efficiency is disproportionate to the importance of the work.	Use common CAD tools. Partial sections of BIM may be used (3D object creation).

Figure 4 List of risks (example)

At the same time, there are not enough experts to provide education and training for state administration staff or public contracting authorities and road management experts.
Each level requires an economic assessment and risk analysis. The risk analysis of the individual levels of BIM implementation forms a part of the main author's dissertation thesis currently in progress. The dissertation will present a catalogue of approximately 100 risks detected through the examination of the existing applicable legislation, BIM models and the proposed Methodology for BIM process utilisation in road construction and road construction project management. The risks identified will then be assessed by a selected exact method (e.g. Failure mode and effects analysis - FMEA or Universal Matrix of Risk Analysis - UMRA) and an evaluation will be prepared. Based on the degree of risk and its total weight, the most suitable measure will be recommended. The full risk analysis will be conducted latest by the end of 2021.
The figure 4 gives an example of the list of risks with the expected scenario for risk development and the proposed mitigation measures.

6 Conclusion

As a conclusion we may state that there is almost one year left till January 2022 and the majority of problems are likely of having been addressed and solved by then. Still, it is worth thinking about the ways of handing the major problems as mentioned above. Within the framework of the available information, there has been no similar project (handling a BIM model of a construction project, risk analysis and methodology) in the working groups addressing the BIM implementation in the Czech Republic. The country proceeds on the level of the Ministry of Industry and Trade with the State Fund of Traffic Infrastructure and the working groups by gradually formulating regulations and partial sections of a complex methodology (e.g. [2]) along with the pilot projects. This can be characterised as rather chaotic in comparison to methodology of phasing in proposed by this paper. Unfortunately, the fact that the progress of BIM implementation in road construction is partly a closed-door discussion issue to the specialist public [1] and there is no involvement of broader academic community which has been suggesting the completion of a due risk analysis with an economic evaluation for a long time, seems another major problem.

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