Utilization of building information modeling in infrastructure’s design and construction

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Abstract. Building Information Modeling (BIM) is a concept that has gained its place in the design, construction and maintenance of buildings in Czech Republic during recent years. This paper deals with description of usage, applications and potential benefits and disadvantages connected with implementation of BIM principles in the preparation and construction of infrastructure projects. Part of the paper describes the status of BIM implementation in Czech Republic, and there is a review of several virtual design and construction practices in Czech Republic. Examples of best practice are presented from current infrastructure projects. The paper further summarizes experiences with new technologies gained from the application of BIM related workflows. The focus is on the BIM model utilization for the machine control systems on site, quality assurance, quality management and construction management.

1. Introduction

BIM is an acronym that currently resonates in a number of conferences, seminars, roundtables and special events in the construction industry. In English, this acronym is known as Building Information Modeling, however in North America the same principles are called VDC (Virtual Design and Construction). On the basis of this term and differences in Czech technical language, the expression "Information Modeling" has become recognized as the Czech language alternative together with the use of English abbreviation “BIM”. Therefore in this article both fixed expressions (BIM and Information Modeling) are used.

Building Information Modeling is the process involving the creation, use and management of construction data throughout the asset’s entire life cycle [1]. Very closely related to Information Modeling are two other terms nowadays better known from mechanical engineering: Digitization and automation. This phrase means the same for construction as in other industries: With the increasing performance of computers and more specialized software, the use of information technologies in construction is ever expanding.

Processes commonly using paper-based documentation are changing due to the use of electronic data. Information Modeling is not about database-driven document management solutions with file extensions pdf, doc, xls, DGN, DWG, and their management and distribution; the information model contains the data and therefore the preparation of these documents is in many cases redundant. This process is called digitization of project documentation.
When digitization and automation took place in the automotive industry it increased production efficiency by 75%. A parallel can be drawn in construction: The introduction of Information Modeling in the life cycle of construction increases automation and prefabrication in the construction industry. Quantifying the savings in transportation construction by individual authors ranges between 8-35% [2]–[5].

2. Current state of BIM implementation in Czech Republic

2.1. Public procurement
One of the bases for the drafting of the new Czech Law on public procurement was Directive of the European Parliament and of the EP Council 2014/24 / EU, which recommends using the principles of Information Modeling. According to the Law on Public Procurement, § 103, paragraph 3 "contracting authority may specify in tender conditions mandatory requirement to use special electronic formats, including the tools of information modeling." The law came into force on 1st October 2016, allowing governmental authorities to require the use of the information model for the construction and preparation works.

The Czech State Fund for Transportation Infrastructure (SFDI) issued a press release at the end of 2016, expressing the intention to gradually introduce BIM into design and construction. Press releases followed Government Resolution dated 2nd November 2016 no. 958, on the importance of BIM for civil engineering practice and suggest next steps for its introduction. In acknowledgement of the need to tackle the topic, the SFDI established an expert working group dedicated to the topic of Information Modeling and its implementation in the transportation sector.

SFDI declared that in cooperation with Road and Motorway Directorate of Czech Republic and Railway Infrastructure Administration, they already plan to use building information modeling in several pilot projects in 2017. The goal is to broaden the use of digital methods in projects financed by SFDI. Detailed description of steps made by SFDI and other agencies can be found in [5].

The expert working group started work on two basic parallel tasks:

- Preparation of the strategy for the introduction of BIM in construction of transport infrastructure,
- Support for the preparation of pilot projects and their implementation.

Road and Motorway Directorate of the Czech Republic and Railway Infrastructure Administration will begin their selected pilot projects in 2017.

2.2. Associations
The Czech BIM council (CZ BIM) elected a new Board of Directors on 15th November 2016. Following this, the expert working group for Information Modeling in transportation was established. Currently, the following industry partners are actively represented in the Expert working group: Skanska, Metrostav, Hochtief, Sudop Prague, Mott MacDonald, Metroprojekt, CCE Prague and BIM Project.

The objectives of this working group are:

- Share news, experience and knowledge in the field (BIM);
- Prepare other materials relating to the topic as a team of co-authors;
- Comment on material originating outside the expert working group;
- Lay the foundations for cooperation in projects where the use of BIM is desired;
- Define a common approach to the topic of BIM.
An internal working group dedicated to the topic of Information Modeling is also based at the think-tank Association for Infrastructure Development (ARI). The first internal ARI members meeting was held on 13th January 2017.

2.3. Standards
Czech office for Standards, Metrology and Testing have established ‘152 TNK’: Technical Normalization Committee (TNC) for BIM. The committee has been named as Information Organization of construction and building information modeling.

Comments and revision of following standards are currently ongoing: ISO 12006-2 Building construction – Organization of information about construction works – Part 2: Framework for classification and ISO 16757-1 - Data structures for electronic product catalogues for building services – Part 1: Concepts, architecture and model.

3. Examples of BIM in transportation in the Czech Republic and Slovakia
One of the contractors who sees significant advantages in the use of BIM and is not waiting for the introduction of an investor-led standardized process is Skanska. Examples of Skanska projects which use BIM are: D4 Skalka - Crossroads II / 118, modernization of railway stations Česká Lípa, D1 Přerov - Lipník nad Bečvou, R1 Nitra - Mlynářce and D1 Budimir-Bidovce. The following figures include several photos of information models from these projects. Data is used to detect inaccuracies in project documentation and resolve potential issues before they happen on site; information on the construction works is taken from the information model in certain cases instead of project documentation. One very important use for this data has been for earthworks and geodetic works.

Figure 1. Modernization of the railway station Česká Lípa – BIM model.
4. BIM in other countries

BIM is commonly used in the Netherlands, Norway, Finland, Sweden and Singapore in civil engineering [6]–[8]. A new country that plans to introduce the obligation to use BIM for procurement from 2017, is France. In Germany this is planned to be the case from 2020. Unlike Europe, North American countries know BIM under the term Virtual Design and Construction; It is an inseparable part of the preparation of project documentation, construction and management of large highway projects.

4.1. BIM in UK

One of the examples which may be mentioned is the use of BIM in the United Kingdom (UK), where it is compulsory to use BIM principles for publicly funded civil projects.

BIM in the UK is governed by British Standard BS 1192:2007 Collaborative production of architectural engineering and construction information – Code of practice: It defines the process for using a Common Data Environment and code conventions for document status and numbering. It is supported by the suite of Publicly Available Specifications PAS 1192 documents, which give practical guidance for information management during the delivery of projects using Building Information Modeling. It outlines the information flow through-out the asset life cycle, management documents that should be produced, and project delivery team roles and responsibilities.
In 2011 the British Government published a strategy for reducing the cost of publicly funded assets, which required the use of BIM level 2 (as defined by the Bew-Richards BIM Maturity model below) for all centrally-procured government construction projects by 2016.

Figure 4. BIM Maturity Model [9].

In practice this means that all project data and asset information is electronic, with the design in the form of one 3D coordinated model. Although this is only a requirement for government projects, the use of these BIM processes is being widely adopted across other projects as the industry recognizes the benefits. Some examples of how Skanska are advancing the use of this information during the delivery phase are: 4D planning by adding a time dimension to the 3D model, and 5D modeling by using the 3D model to produce a bill of quantities and a calculation of embodied carbon, during the tender phase. The use of 3D information has also led to the use of survey techniques such as the use of 3D laser scanning and the production of Digital Terrain Models for earthworks.

Mobile technology has also become a familiar sight on Skanska sites, with smart phones and tablets being linked to the Common Data Environment. This access to the coordinated model, drawings and other project documentation improves the quality of work, reducing rework and time spent looking for information. The use of this mobile technology has also grown organically, with the people in possession of the devices finding ever more innovative uses for them. The devices are currently also used to produce paperless quality documentation, carry out site inspections, mark-up drawings and keep site progress records. The move towards paperless documentation has created efficiencies in
administrative processes, and also created data that can be used to drive continuous improvement during the construction process, for example using data from health and safety inspections and quality checks to analyze trends and address them accordingly.

5. Conclusion

The transportation sector will be implementing pilot projects using Building Information Modeling principles in the near future. There are many questions associated with broader BIM implementation to be solved on governmental level. Thus it is planned that even during the preparation of pilot projects, the expert working group will continue to prepare the standardization and methodologies for processes associated with the digitization of the construction industry.

Future steps to be taken have been summarized by Ministry of Industry and Trade and SFDI in their strategies defining mandate for BIM implementation. Both of the strategies are currently in agencies internal document review process and should be issued in August 2017.

The reported use of Information Modeling in the Czech Republic and Slovakia is an example of collaboration between design firms, construction contractor, and surveying offices for achieving savings during construction, whilst also improving quality and safety. The contractor was a leader of the whole process in the presented examples, which defined the terms of cooperation, the technical content of BIM models and methods for its use. Experience of these pilot projects will be very valuable in the further development of this theme.

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