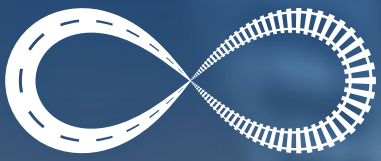

CETRA 2018

5th International Conference on Road and Rail Infrastructure
17–19 May 2018, Zadar, Croatia

Road and Rail Infrastructure V

Stjepan Lakušić – EDITOR

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APPLICATION OF BIM TECHNOLOGY IN LINEAR CONSTRUCTION PROJECTS

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Abstract

Adoption of BIM (Building Information Modelling) technology in AEC (Architecture, Engineering and Construction) industry and organisations in past few years has already outgrown to the phase of implementation especially in building and other more or less large-scale projects all around the world. With BIM project teams can use 3D digital models to collaborate, have consistent and more accurate project data regardless how many times the design changes, or who changes it among engineers, architects or building and infrastructure owners. These projects should be sustainable, faster completed and more economical. The boost for implementation in Europe has begun in 2014 after the European Parliament made a decision to modernize European public procurement rules by recommending the use of electronic tools like BIM. The European Union Public Procurement Directive (EUPPD) set a goal for all the European Member States which may encourage or mandate the use of BIM for publicly funded design contests and building projects by 2016. European countries like Denmark, Finland, Netherlands, Norway and United Kingdom already require the use of BIM for publicly funded building projects. In this paper emphasis will be taken on adoption of BIM technology in linear construction projects like roads, highways, city streets and other urban area surfaces. There are projects in this sector which are already designed using BIM tools but its technology is not fully utilized in all aspects in 'life-time' of construction. Needed preconditions will be shown for everyday implementation from design and documentation to building and field support, on example of Croatia according to its current laws and regulations.

Keywords: Building Information Modelling (BIM), EUPPD, linear construction, implementation

1 Introduction

Building Information Modeling (BIM) is a digital representation of the building process used to facilitate exchange and interoperability of information in digital format [1]. BIM approach can be shown as a technology and as a methodology. BIM as a technology is a digital representation of physical and functional building characteristics. It enables the coordination and combination of work of different project participants in the BIM model – an object-oriented model that integrates and connects information about the geometry and properties of the BIM elements that make up the building. Base of BIM technology are 3D space models that allow control all project elements. The spatial model is complemented by dimensions such as time (4D), cost (5D), sustainability and energy consumption (6D), and building management and maintenance (7D). BIM as a methodology enables collaboration of different participants in different stages of building life cycle. This enables support of decision-making processes, early detection of design errors, detailed analysis, quick changes and easier change manage-

ment, clearer understanding of project goals and relationships with other stakeholders in the project, visualization of project solutions and support for project life cycle and project cost analysis [2]. The fact that the spread of information modeling in the construction industry is global, is evidenced by publications that explore and analyze the business value of the BIM market: The Business Value of BIM for construction in Major Global Markets (McGraw-Hill Construction, 2014), The Business Value of BIM for Infrastructure 2017 (Dodge Data & Analytics, 2017), The Business Value of BIM in Europe (McGraw-Hill, 2010), The Business Value of BIM for Owners (McGraw-Hill Construction, 2014). Reports show accelerating BIM usage driven by private and government owners who want to institutionalize its benefits of faster, more certain project delivery, and more reliable quality and costs, return of investment (ROI) for BIM, investments in BIM and top BIM activities in pre-construction, construction and post-construction phase. According to the research of BIM application sectors, BIM in infrastructure appeared to lag about three years behind the building sector. Concepts that have pushed the construction market into BIM are interoperability and continuous and rapid flow of information between design and construction participants, and it is being developed in line with these needs [3]. The top project-related benefits that contractors are receiving from BIM are reduced errors and omissions and reduced rework, both of which have immediate positive impact and contribute to strong ROI. Reduced construction cost, reduced project duration and improved safety round up the top five project benefits of BIM. Contractors cite BIM's ability to enhance collaboration among key team members as its most important contribution to improving the project delivery process. Better cost control/predictability, and reduced cycle time for workflows and approvals are also acknowledged as important benefits of BIM [4].

2 A legislative framework that encourages the implementation of BIM

The boost for implementation in Europe has begun in 2014 after the European Parliament made a decision to modernize European public procurement rules by recommending the use of electronic tools. Directive 2014/24/EU of the European Parliament and of the Council of February 26, 2014 on public procurement encourage use of specific electronic tools in Member States, such as of building information electronic modelling tools or similar for public works contracts and design contests by 2016 [5]. European countries like Denmark, Finland, Netherlands, Norway and United Kingdom already require the use of BIM for publicly funded building projects. The use of BIM technologies and processes in public projects achieve the goals of Europe 2020 strategy. The directive is a legislative act that sets out the goal that all EU member states have to fulfill, but each country decides independently how will achieve that goal. The directive was adopted with the aim of making construction projects of public interest more transparent and accessible to a greater number of companies that are adopting new technologies and design processes.

Within frame of the European Commission the EU BIM Task Group is founded who's primary purpose is to encourage the adoption of BIM in public works, with the common aim of improving value for public money, quality of the public estate and for the sustainable competitiveness of industry [6]. A step towards a common approach to the introduction of BIM is taken with the launch of a new Handbook for the Introduction of Building Information Modelling by the European Public Sector. As a support for implementation of Directive in a Program for 2014, CEN (European Committee for Standardization) and CENELEC (European Committee for Electrotechnical Standardization) have initiated formation of technical committee CEN/TC 442 Building Information Modelling (BIM) with the aim of ensuring the normative framework for applying BIM technology in practice. In our country the field of work of the technical committee TO 551 Construction at the Croatian Standards Institute includes standardization in the field of structured semantic information of the life cycle of the built environment.

Croatian Chamber of Civil Engineers has joined the international efforts to implement BIM approach in public works in June 2017 by developing and publishing the General Guidelines

for BIM in Construction with the aim of encouraging the implementation of BIM in our country [2]. The Croatian Chamber of Architects in 2018 launched the BIM Open Architect's Guide (online https://www.arhitekti-hka.hr/hr/novosti/bim-otvoreni-vodic-za-arhitekte,3365.html) [7] in order to popularize the use of this approach in the architectural community.

3 BIM technology in linear construction projects

As stated above, BIM is intensively used during design, construction and maintenance of buildings. In contrast, linear infrastructure such as highways, roads or railways have their own specifics that in greater or lesser extent may hamper the implementation of BIM or make application of BIM significantly delayed in relation to the building construction. Reasons are numerous: it is a large area of operation extending over great length and relatively small width, with special geometrics in horizontal and vertical alignment, with lower number of standardized elements, etc. Except reasons mentioned, there are also constraints related to area specificities and construction methods, especially for roads in urban areas where a large number of project elements have to be accommodated and aligned in a limited space. A whole range of utilities and municipal installations need to be accommodated in road cross section, such as gas, electricity, TC lines, public lighting, along with inevitable installations of water supply, sanitary or precipitation drainage. Each subsystem of municipal installations is inherently independent and requires special attention in design, construction and maintenance, as well as the necessary cooperation of different professions. These installations are mostly laid underground in the roads corridor and engineers are faced with the unfortunate task of reconciling heterogeneous demands and interests of different stakeholders. When placing the installation it is necessary to respect certain rules or standards for depth and relative positions. Depending on the available corridor, the task may be simpler or more demanding (Fig. 1).

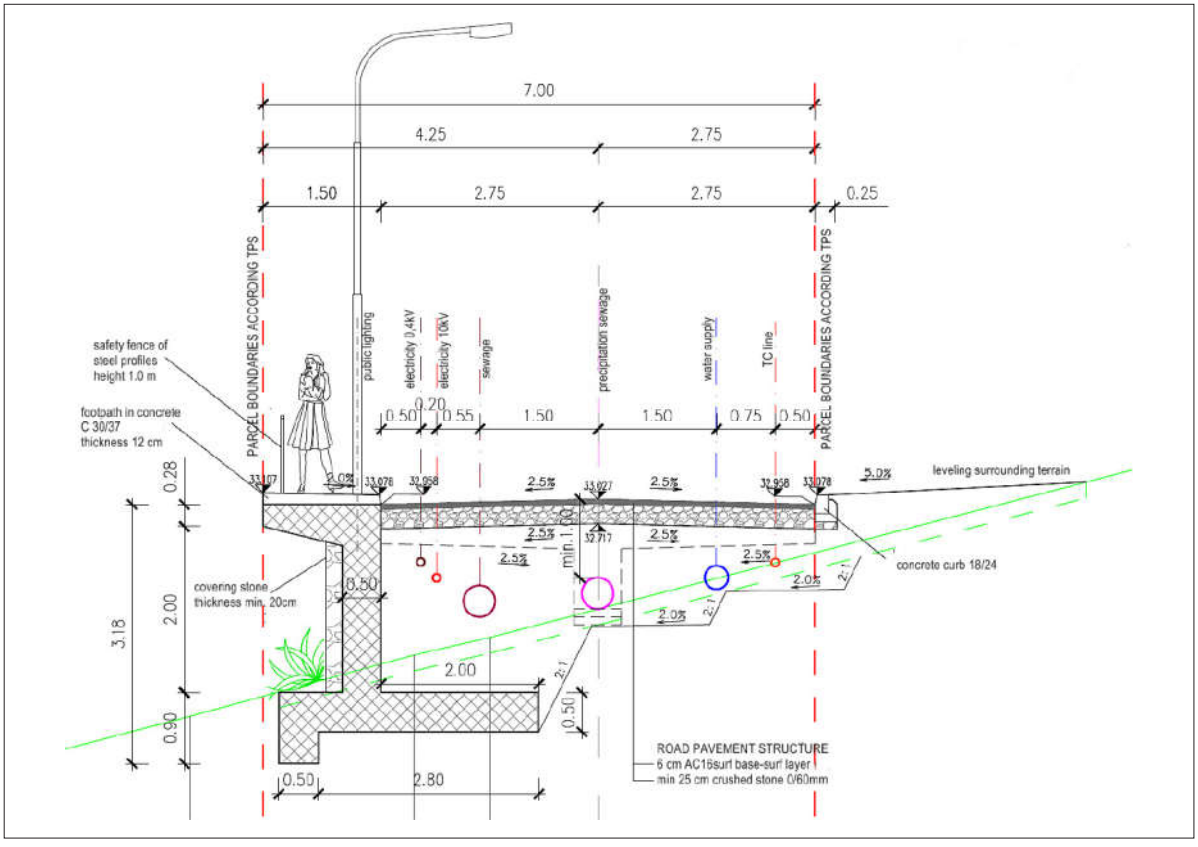

Figure 1 Demanding normal cross-section of the road with installation layout

In linear construction projects in addition to civil engineers (designers of transportation facilities, structures, sewage or water supply), electrical and mechanical engineers also participate, along with landscape architects in certain situations. Landscape design is important for the aesthetics of space but it also has a direct impact on the design of traffic surfaces. Therefore the landscape solution (horticulture and urban equipment) must be included during the design and preparation of project documentation.
Communication between project team members, coordination and discussion about technical solutions are an important part of design. Sometimes modification or correction of only one project element affects a large number of other elements which are again necessary to be reconciled. Rest of the paper describes some of the real problems that are currently an obstacle for the quality or basic application of BIM (3D level) in designing linear construction objects in the Republic of Croatia. Prior to the legal obligation of using BIM process and technology, it is necessary to create appropriate preconditions that will be in line with current practice and legislation.

3.1 The existing state of the cadastre of installations and GIS data for application in BIM

When designing a construction project that requires obtaining a building permit, the designer is required to obtain special conditions for construction from the relevant public administrative bodies. Those are mainly economic-legal entities that manage various linear infrastructure (such as electrical installations, communication infrastructure, gas pipeline, hot water, sewerage, water supply). As such, they are obliged, under the Building Act [8], to provide to designers all the graphic information they possess for any of the installations for a specific project. The problem is that most of the entities mentioned do not have a complete digitalized database about the position of their infrastructure in 3D format. At the worst case, the infrastructure is drawn in the form of raster images (PDF files, scanned paper drawings) without a geocoded record of the infrastructure position. But usually this infrastructure is mapped in 2D (CAD files) without a defined height position of particular installations or accurate data on the infrastructure itself (pipe profile, material, voltage, pressure, etc.). Such incomplete data, or elements, must be processed later on so that they can be used in a multi-dimensional environment what BIM model needs, which requires a lot of time and effort. In addition to installation data, in road reconstruction other data (descriptive, numeric, graphical) about the road and its objects are also important, such as axis geometry, vertical alignment, bicycle and pedestrian paths, pavement type and condition information, data about objects on the route (culverts, tunnels, support structures, service facilities, bus stops, intersections), traffic signaling data, drainage elements, parking lots etc. In order to implement the databases, they should be detailed and comprehensive but the existing GIS database are incomplete, not updated and in some cases they are not even created.

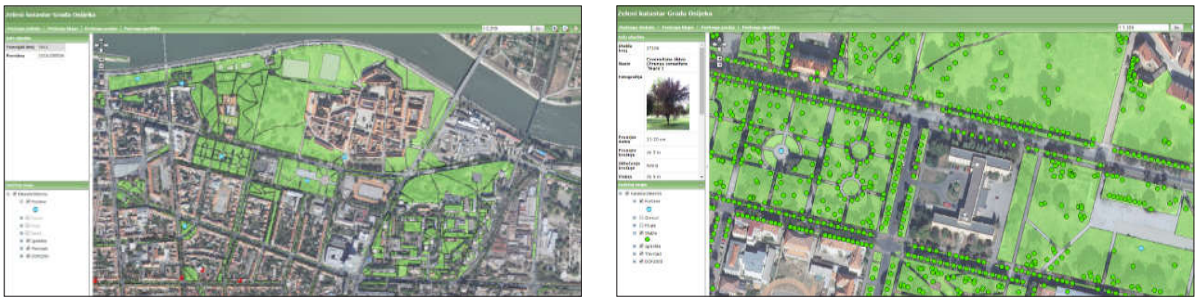

Figure 2 Example of GIS database "Green cadastre of the City of Osijek" (online http://zelenikatastar.osijek.hr/zelenikatastar/Default.aspx) [9]

Other data, such as information about large green areas or archeological sites, are important for design of civil infrastructure. Data on the boundaries and location of such areas is very important when making optimal design solutions. Databases with such advanced geocoded data would achieve even greater value and usability in everyday practice.
A good example of area management and data collection and updating are maps of green areas of the City of Osijek containing detailed information about each tree (type, age, height, damage etc.), bush, grass surface, but also urban equipment (benches, playgrounds, fountains) and information on the condition or degree of their damage (Fig. 2).

3.2 Detail and precision of the geodetic lining

For high-quality road projects, accurate data is essential and geodetic lining as a basic input for design of a road construction project is extremely important in terms of its precision and detail [10]. No matter whether the project is an suburban or urban road or a reconstruction of the existing road, the geodetic lining must contain detailed points (intersections, culverts, ditches, curbs, sidewalks, bus stops etc.) from which an accurate terrain model can be modeled. The precision of the geodetic lining as the basic input parameter for the road project has a major impact on the quality of the solution. Also, due to inaccurate data, unforeseen costs can occur during construction or even changes in the project can be necessary, lead to additional and unforeseen costs.
A problem during designing is also an update of the existing bases/maps of installations that were drawn up before 2004 in the HDKS cartographic system. That year, a new cartographic system HTRS96 was introduced, that doesn't overlap with the geodetic data from the older system, and transformation of the data is process that is undertaken according to needs.

3.3 Employee training and software equipment

Prior to upgrading the infrastructure database and everyday use, training of existing employees working on these jobs is needed, who unfortunately in many cases do not possess the appropriate (informational technology) knowledge to manage such data. Education for the use of BIM tools is currently taking place at university level, in the scientific community and within private design offices, who are willing to finance hardware and software capability to use them. The authors [11] highlighted the problem of fragmentation of architecture, engineering and construction industry, which is one of the biggest obstacles to adopting BIM and achieving its full potential, even greater than overcoming technological problems. The results indicate that innovation in BIM training is essential for advancement of education and practice, with necessary changes in curriculum design, which must take into account the development of the required skills, intensive communication and team coordination skills. Establishing a national framework and involving the profession in its implementation is a challenge for all participants in reaching more developed education systems of civil engineers in the BIM area. By application of BIM approach, new processes and new duties, roles and responsibilities in projects – BIM Manager, BIM Coordinator, BIM Engineer and BIM Technician are being launched.
To implement the BIM, it is necessary to provide the appropriate BIM tools and hardware support, which must accompany the complexity and the large amount of data to be processed. Contractors around the world are focusing most highly on investing in their internal collaborative processes, BIM training and BIM software in the next two years. Almost two thirds of contractors at the highest level of BIM engagement are focusing on new/upgraded tablets/mobile devices, which will allow them to bring the value of BIM to the staff in the field [4].

4 Conclusion

The introduction of BIM technology does not only mean investment in equipment and knowledge, but also the need to change work processes during design, construction and maintenance and their interconnection. The result of the BIM design process is an intelligent database that contains all the necessary information about the building. Using BIM technology, the potential gains can be attributed to increasing the level of co-operation of project designers, more accurate and comprehensive project documentation with greater value being delivered to the investor, making more relevant visualization of project solutions, reduction of design errors and cost, and increasing return on investment. The construction sector strives to act in accordance with BIM principles. Ideally this would mean that all participants at all stages of the construction project consistently use a common digital data model to avoid duplication of work and communication problems due to different data interfaces [12].
In the last couple of years in Republic of Croatia, the implementation of publicly funded infrastructure projects in civil engineering using BIM technology began [13] and it is expected that by adaptation and meeting of the necessary conditions the implementation of BIM in civil engineering will be intensified. It is not unrealistic to assume that in the next period the digital model will be the mean of delivering the project documentation, which includes a combination of various analysis carried out by software support and that BIM, along with new materials and energy efficiency design approaches, as well as advances in digital technology, will create a new wave of innovation within the construction industry.

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