CETRA2022 11-13 May 2022, Pula, Croatia
7th International Conferenceon Road and Rail Infrastructure

GUIDELINES FOR BIM APPROACH IN INFRASTRUCTURE PROJECTS

Zlata Dolaček-Alduk[1], Denis Šimenić[2], Dražen Galić[3], Martina Pavlović Cerinski[4], Filip Andabaka[5], Hrvoje Šolman[6], Anton Ecimović[7], Mirko Grošić[8], Igor Džajić[5], Dina Stober[1], Nina Dražin Lovrec[9]

[1] *Josip Juraj Strossmayer University of Osijek, Faculty of Civil Engineering and Architecture Osijek, Croatia*
[2] *Rencon d.o.o. Osijek, Croatia*
[3] *StudioARS d.o.o. Matulji, Croatia*
[4] *Intelika d.o.o. Zagreb, Croatia*
[5] *Institut IGH d.d. Zagreb, Croatia*
[6] *Arctis d.o.o. Zagreb, Croatia*
[7] *Projektni biro MAVIA, Karlovac, Croatia*
[8] *Geotech d.o.o. Rijeka, Croatia*
[9] *Croatian Chamber of Civil Engineers, Zagreb, Croatia*

Abstract

Encouraged by the trend of model-based working, integrated practice as a new context of construction projects and the planned number of investments at the state level, the Croatian Chamber of Civil Engineers has developed specialized guidelines for Building Information Modelling approach in infrastructure projects. The guidelines were presented to the professional public in 2021 with a clear message that it is the right time for Croatian companies to implement BIM approach in their operations to increase competitiveness in domestic and foreign markets, raise the quality of design and construction and reduce construction and maintenance costs. The Guidelines describes BIM approach and procedures during design, collaboration and coordination, construction and maintenance. An overview of the most widespread BIM tools in the field of infrastructure projects, basic settings of project cooperation, a common shared environment and interoperability is given. Digital collaboration modes, types of models, levels of detail and model management complete the first part of the document. The second part of the Guidelines describes key processes in BIM implementation at the company and project level. This content provides an overview of how BIM affects the current working model and what needs to be done to move to a fully collaborative model-based infrastructure project development. The guidelines are supported by LOD tables for the most common types of buildings in infrastructure projects. In order to overcome the lag in adoption of BIM in infrastructure projects it is necessary to identify the key challenges and the most common reasons that stand in the way of its significant and frequent application. The results of research conducted so far indicate that these include lack of cooperation, costs associated with the BIM adoption, lack of knowledge and skills, software limitations, lack of compatible product information, national context for classifying product data and clearly defined standards for sharing data between project participants.

Keywords: BIM guidelines, infrastructure project, BIM model

DOI: https://doi.org/10.5592/CO/CETRA.2022.1489

1 Introduction

After public procurement has been digitalized Europe in its strategic document Europe 2020: The strategy for smart sustainable and inclusive growth through the Resource Efficient Europe initiative encourages the advancement in construction sector by switching to the low carbon emission economy, using more renewable resources, green technology development as well as traffic sector modernization [1]. Digital technologies and energy efficiency as well as their integration into the construction sector are considered to be key elements which can assist in improving its productivity and competition growth. Political initiatives strongly affect the encouragement of digital technologies adoption, and among their creators there is a distinct interest in providing support to digitalization of construction sector. In most member states of the EU (16 of 27) there are policies which cover, or are directed towards digitalization of the construction sector. Policy measures related to providing support to digitalization are often followed by financial instruments by means of projects through which non-refundable resources, loans or investments are allocated, but also by means of technical support through ensuring virtual and physical platforms which gather private and public participants enabling synergy and knowledge exchange. BIM requests have been adopted by most of the member states in their public procurement processes through the EU Public Procurement and Repealing Directive (Directive 2014/24/EU) whose aim is to encourage member states to consider digitalization as a possible request in public procurement process [2]. Except for the digitalization of public procurement processes, the member states directed their efforts towards implementing digital technologies in construction sector by means of e-services. In that sense bigger number of the EU member states has implemented digital systems related to building permits, digital log books and real estate registries. Their level of sophistication is developing, and it is going to be essential for a complete sector transformation and its growth, as well as for reaching goals related to climate and sustainability. While the support to construction sector digitalization is provided by means of policy and financing frame, the efficient means of encouraging digitalization of construction businesses is represented by directives and standards. A series of initiatives whose goal is to provide support to digital technology standardization is developed by the European Commission - for example CEN/TC 442 Building Information Modelling, on the European level technical board of the European Standardization Committee (CEN) has the goal to develop and keep the standards within BIM scope. buildingSMART International has a key role in providing support to adoption of common and open international standards for infrastructure and buildings.
Digitalization levels are significantly differed among the EU member states. The total digital performance of Europe as well as development of states with respect to digital competition is followed by the Digital Economy and Society Index which provides data regarding digitalization of member states and assists in identification of the areas whose priority is investment and action. When it comes to digitalization of the construction sector, different policy approaches are followed by the member states, and they can be observed through 2 strategic approaches [3]:

- horizontal digitalization strategies - national digitalization policies which cover wide range of sector, technologies, and areas. Such strategies can, but are not obliged to, explicitly include construction sector.
- vertical digitalization strategies related to construction sector - specifically aim at construction sector digitalization which cover the whole or a part of the value chain, as well as specific digital technologies (such as BIM) or all digital technologies without exception.

Different dynamics is noted when it comes to moving of the European construction market towards the BIM. Germany, Estonia, France, Ireland, Italy, Lithuania and Spain have strategic, legal and normative regulations (Table 1). Most of other countries have normative frame or national bodies which are about to define BIM adoption.

Table 1 BIM support policy and measures [3]

	BIM/digital construction strategy	BIM standards and/or guidance	National working group on BIM
Germany, Estonia, France, Ireland, Italy, Lithuania, Spain	○	○	○
Austria, Belgium, Denmark, Greece, Finland, Luxembourg, Netherlands, Poland, Romania, Slovakia, Sweden		○	○
Czech Republic, Latvia	○		○
Bulgaria, Croatia			○
Hungary, Slovenia, Portugal		○	
Cyprus, Malta			

Market research and experience with the well-shaped and developed BIM mandates (such as Great Britain) show that companies which were the first to conduct drastic steps regarding systematic implementation already have significant benefits. Research results have demonstrated that digital transformation, if applied properly, could result in the productivity increase between 14 and 15 % as well as cost reduction between 4 and 6 % [4]. On the other hand, for the companies that made no success in nothing more than experimenting with technological solutions it is time for the prompt reaction and investing additional efforts. The construction sector is one of the least digitalized sectors in the economy irrespective of the data suggesting the common acceptance of the BIM and its influence on the market which is evident in expanding the BIM use, its benefits, return on investment index and further investments associated with the BIM. Only a few digital technologies have been widely accepted except for the Building Information Modeling (BIM). However, as it has recently been stressed in the report of the European Commission, the digitalization of construction sector exceeds the use of BIM alone, and includes data gathering, process automation, 3D printing, 3D scanning, drone and sensor use, as well as other technologies associated with the digital information and analyses [3]. The advantages of the BIM approach become more evident with time, and as a result, it is applied to infrastructure projects alongside supported processes. Error and failure reduction (final processing reduction, construction costs reduction and the total project duration reduction) as well as improvement of the cooperation with the investors and project designers (bigger integration among all team members). Adopting the BIM approach as a digital transformation could mean different things for different participants, and it should cover operational changes and technology as well. Operational improvements are particularly important for the building contractors with advanced technologies and the ways which are used to improve development as well as processes relevant to project realization. Transformation achievement will be highly dependent on how successful the company will be in encouraging new working modes enabled by contemporary technologies.

Encouraged by recognizable and accepted technological trends on the market as well as planned numerous infrastructure investments at the state level, The Croatian Chamber of Civil Engineers has made new specialized guidelines - Guidelines for BIM approach in infrastructure projects. The Guidelines have been presented to professional public in 2021 on the 15th Days of the Croatian Chamber of Civil Engineers with the clear message that it is the right time for Croatian companies to implement BIM approach in their operations to increase the competition on both home market and foreign market, to enhance the level of design and building quality as well as to reduce construction costs and building maintenance costs [5]. A complete BIM approach in infrastructure projects is considered by the Guidelines, and the

approach can be used as a tool by which integration of engineering task results is allowed with the purpose to reduce the possibility of uncoordinated technical solutions and to shorten the time needed for possible changes of the project. The Guidelines are available on the web page of the Croatian Chamber of Civil Engineers under Chamber's professional editions.

2 Guidelines for BIM approach in infrastructure projects

2.1 Objectives of the guidelines

The Guidelines are aimed at promoting the adoption of the BIM approach in infrastructure projects as well as ensuring the continuity of information in the life cycle of a project by which the quality and productivity are improved. The adoption of the BIM approach in the civil engineering is not fully standardized and defined. In making of the paper, the authors have been guided by the principle that it is possible to adopt described and recommended procedures considering the current state of technology and existing functionality of usual software tools for the BIM procedures to be integrated in standardized design processes and construction in civil engineering. Almost all guidelines for the BIM approach adoption are comprised of 4 elements: BIM execution plan, modeling methodology, levels of attention to details, and BIM protocol as well as information organization. In the same way the Guidelines are comprised of the BIM approach in infrastructure projects, level of development of the BIM model (LOD) for infrastructure projects, key processes regarding the BIM approach adoption at the level of company and at the level of project, contractual approaches, elementary BIM documents - Employer's Information Requirements (EIR) and BIM Execution Plan (BEP) by which their adoption is allowed as a reference guide for BIM adoption [5].

2.2 Content of the guidelines

The Guidelines describe the BIM approach and BIM procedures during design, collaboration and coordination, construction and maintenance. An overview of the most widespread BIM tools in the field of infrastructure projects, an overview of the basic settings of project cooperation, a common shared environment and interoperability is given. The role of IFC open standards as a mechanism to support new processes, and to enable the extensive design and construction information available to asset operators and managers, is highlighted. Digital collaboration modes, types of models, levels of detail and model management complete the first part of the document [5].
The second part of the Guidelines describes the key processes in the implementation of BIM at the company and project level: contractual approach, the relationship between BIM models and standard project documentation, transition BIM models in different phases of the project and highlighted the need for change. This content provides an overview of how BIM affects the current model of working and what needs to be done to move to a fully collaborative model-based infrastructure project development. The Guidelines are supported by LOD tables for the most common types of buildings in infrastructure projects (Figure 1). A support related to the choice of the appropriate (optimal) level of development of model elements, or a support in making of the BIM Execution Plan is provided for investors by means of given examples of LOD definitions which are presented in the tables. A chosen table display related to the level of development of selected BIM model elements is one of the possible solutions, and it was chosen so that the Guidelines could provide information about modeling type, as well as the types of geometric and attributive data [5].
In order to overcome lagging related to adoption of the BIM in infrastructure projects key challenges have been identified in the Guidelines, as well as reasons that most often stand in the way to its significant and frequent use [5]:

- absence of demand is almost always at the top of the research result list, and it is related to lower presence of the BIM in civil engineering as opposed to structural engineering, though with time, its influence weakens because mandatory adoption of BIM approach easily becomes contractual obligation for more significant projects in more countries. The situation is changed in the Republic of Croatia as well because the BIM approach adoption has been obligatory on the part of Hrvatske ceste as a public investor, and similar reaction is expected from other public companies.
- the BIM adoption costs are often said to be an obstacle which discourages small and medium enterprises (most often those are design companies) from adopting the BIM approach. It includes personnel training costs, supply costs, as well as software and hardware maintenance costs, etc. Generally, it is considered that the costs for the BIM approach are higher than for 2D designing.
- a lack of time needed for adopting new working modes is also a factor of successful BIM adoption. A lack of time or a little available time required for planning and designing often leads to designers continuing to work in a traditional way. Failure to meet the deadlines is a result of the lack of experience related to the BIM, and it is thus represented as an important obstacle for the BIM adoption.
- knowledge and training - lack of knowledge and training is also an obstacle for a successful BIM adoption. Preferably, designers should be in direct contact with the people who have already acquired necessary knowledge and experience in some segments of the BIM and 3D modeling. The fact that people do not often use it will change with time since new working modes and necessary knowledge will be adopted by experts by means of good practices.
- a lack of clearly defined standards is recognized as particularly complex, because, to overcome it, the development of new standards are required, standards which are compliant with the needs of profession, guidebooks and examples of good practice. The issues that are necessary to deal with and to offer adequate guidelines are required levels of development related to main project phases and to particular professions, related to defining corresponding formats of data exchange (the issue of interoperability), to types of delivery, and etc.
- software limitations - there are many software packages which openly provide support to the BIM in infrastructure (BIM ready). Software producers know one tool is not enough for a complete BIM adoption, and therefore, a series of products which should cover the whole procedure is offered by more affordable prices. However, in real use, the suggested workflow is not easily applicable and many procedures require being competent with more than one primary software, even a specific level of programming or the use of additional tools (for example creating user's normal cross sections in Autodesk Subassembly Composer program) in order to finish the task. A problem related to the possibility to lose a part of information is represented by means of data transfer from one application to another (or from one project phase to another).

The adoption of the BIM approach in civil engineering has a great potential, big opportunities for all the participants in projects are possible by means of improving the process efficiency, and by adequate understanding of the BIM approach. In some areas it is necessary to show more innovation and openness, to explore new possibilities, adopt good pieces of experience and advanced technologies. It is necessary to be critical regarding existing workflow in the process, and to look for advancement wherever possible.

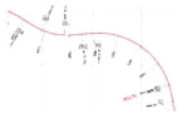
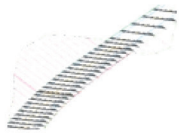
Category:	Traffic roads			
Group:	Route			
Element:	Traffic road corridor			
LOD:	Modeling mode	Output geometries	Attributive data	Draft
LOD 100	Osijek traffic roads and corresponding level line.	CAD file with 2D traffic road axes and vertical profile.	Horizontal and vertical geometry labels.	
LOD 200	Corridor made of the elements based on usual cross sections. Certain elements of cross section are modeled according to attached descriptions of the Guidelines.	CAD file with 2D traffic road corridor. 3D illustrations of the designed corridor. fbx file in which the designed corridor is included	Applied elements of usual cross sections, chosen computational speeds across sections.	
LOD 300	Corridor made of precisely modeled components. Cross section elements are modeled according to attached descriptions in the Guidelines for the level in question.	CAD file with 2D illustration of the traffic road corridor. Total final 3D corridor surface. 3D solids of all the elements which need to be modeled for the level in question, and which are in accordance with the attached descriptions. LandXml file of the final corridor surface.	Applied elements of usual cross sections, chosen computational speeds across sections. Attributive data have been assigned to all corridor elements which are in accordance with the attached descriptions for the level in question.	
LOD 400	Corridor made of precisely modeled components. Cross section elements are modeled according to attached descriptions in the Guidelines for the level in question.	CAD file with 2D illustration of the traffic road corridor. Total final 3D corridor surface. 3D bed surface. 3D solids of all the elements which need to be modeled for the level in question, and which are in accordance with the attached descriptions. Digital recording of the detailed marking off of the traffic road corridor. LandXml file of the final corridor surface and bed level.	The same as in LOD 300.	
LOD 500	The same as in LOD 400.	3D final corridor surface based on the snapshot of the derived state. 3D final bed surface based on the snapshot of the derived state. LandXml file which is made of the final corridor surface and bed surface.	Performed work data.	

Figure 1 Level of development (LOD) display for the road corridor [5]

3 Application of BIM guidelines in practice

The Guidelines have caused attention and positive reactions of Croatian civil engineers. Within their usual activity such as BIM approach adoption and education, the authors of the Guidelines have referred to the published Guidelines, i.e. to particular parts of the Guidelines. For example, hereafter the BIM approach adoption in the state company Hrvatske ceste, new versions of Employer's Information Requirements (EIR) and BIM Execution Plan (BEP) documents have been made with the aim to facilitate and standardize BIM approach adoption in most of the projects conducted by the public company. Some of the procedures related to the BIM approach have been adopted in some projects during the design phase (for example, Brestovac - Godinjak motorway, Bjelovar - Virovitica - Terezino Polje motorway, Pleternica - Požega motorway). Generally, it could be stated that education and adoption of the BIM approach have been used by larger number of companies in their standard projects. As expected, the biggest interest has been evident with design companies, especially be-

cause the BIM delivery is demanded from public client, as well as with the employees of Hrvatske ceste who are more in touch with the elements of the BIM approach. A certain discontinuity of digital information transfer (and the BIM model as well) is inevitable upon finalization of the main projects and the beginning of construction, i.e. detailed project, especially considering the most common contractual approach for infrastructure projects in the Republic of Croatia. Therefore, contractors must be involved in the making of and/or use of the BIM model by which procedures typical for the building phase (4D and 5D analyses) are allowed. Moreover, supervisory engineers should hold certain knowledge related to examination and analysis of the BIM model.

The process takes place gradually, though it has already been adopted in practice on certain complex projects (for example, traffic connection with the southern Dalmatia, building of state road DC 403; building of the Omiš bypass road). Certain activities within the National Recovery and Resilience Program have been conducted by the Ministry of Physical Planning, Construction and State Assets, and they have been directed towards support and further development of the BIM approach in Croatia. Standing Committee related to the BIM has been formed in the Croatian Chamber of Civil Engineers by which the BIM approach in the Republic of Croatia would be further developed by more activities and projects.

References

[1] Europe 2020: A strategy for smart, sustainable and inclusive growth, COMMUNICATION FROM THE COMMISSION COM (2010) 2020 final, Brussels, 3.3.2010.

[2] Directive 2014/24/EU of the European Parliament and of the Council of 26 February 2014 on public procurement and repealing Directive 2004/18/EC, http://eur-lex.europa.eu/legal-content/HR/TXT/?uri=CELEX:32014L0024

[3] European Construction Sector Observatory: Digitalisation in the construction sector, Analytical Report, 2021, https://ec.europa.eu/docsroom/documents/45547?locale=pt

[4] McKinsey Global Institute: Reinventing construction through a productivity revolution, 2017, https://www.mckinsey.com/business-functions/operations/our-insights/reinventing-construction-through-a-productivity-revolution

[5] Andabaka, F., Dolaček-Alduk, Z., Ecimović, A., Galić, D., Grošić, M., Pavlović Cerinski, M., Šimenić, D., Šolman, H.: Smjernice za BIM pristup u infrastrukturnim projektima, Hrvatska komora inženjera građevinarstva, Zagreb, 2021.