BIM TECHNOLOGY AND APPLICATION IN CIVIL ENGINEERING

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Abstract:

This paper describes BIM (Building Information Modeling) technology, which is an answer to question of how to build infrastructure object as efficiently as possible. It is important to know that by more efficient informatization and exchange of data during the design, construction and maintenance or facility management, we can achieve higher productivity, save time, reduce errors, achieve higher quality and reduce costs. In many countries, such as the US, UK and Scandinavian countries, the application of BIM technology is required by low.

The EU has adopted a directive that supports the implementation of BIM technology in all member states and announces mandatory legal implementation. In this paper are presented the experiences and the application of BIM technology in the field of civil engineering.

Key words*: BIM, Building Information Modeling, infrastructure, technology, efficiency, optimization of work process, preliminary planning, design, construction, maintenance.*

1. INTRODUCTION

BIM stands for „Building Information Model“ or „Building Information Modeling“. BIM (Building Information Modeling) is actually the answer to a number of questions brought by new, more difficult economic conditions; how to streamline construction and maintenance of facilities while increasing quality. BIM represents the next big step in computerizing construction work processes, after moving from pencil and paper 30 years ago to the CAD system. Unlike the step that once implied achieving computer and software skills, the contemporary step is much more complex and demanding. Implementation of BIM technology not only means investment in equipment and knowledge, but also requires changing work processes during design, construction and maintenance, and interconnecting them. Information technology has erased physical boundaries by developing the Internet and improving hardware components and portable (mobile) devices. BIM is part of technological revolution (of the 4th Industrial Revolution) that introduces coordination in the digitalization of the entire ecosystem of a building.

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The degree of digitalization in industries is different, so we can see that the construction industry is among the least digitalized sectors.

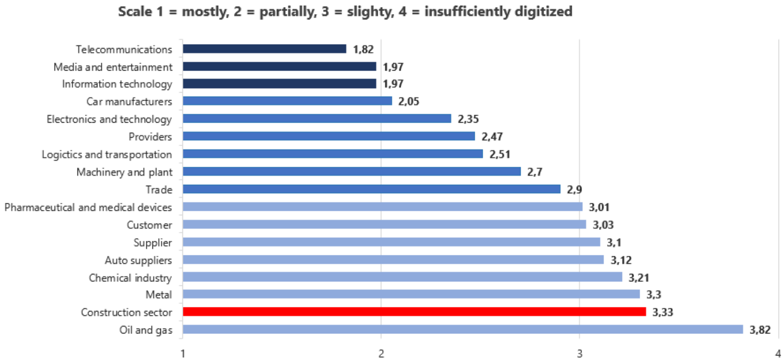

Image 1: Degree of digitalization in different industries

Industries such as auto-industry, engineering or electrical industry have increased the efficiently of their processes through digitalization. On the one hand, this is also understandable, as these are mostly industrial processes with serial products. Civil engineering has always been considered an industry where products (facilities) were unique, but digitalization in this area can certainly bring cost-efficiency and optimization.

According to the data of McKinsey world organization, published in the 2017 Guide to the introduction of information modelling in the European public sector by the EU BIM Task Group, the construction sector represents approximately 9% of European GDP.

The construction industry employs 18 million people, which includes 3 million companies. The average annual value of construction projects in the European Union is € 130 billion. If digitalization were to achieve 10% savings, this would mean € 13 billion annually. These are already values that encourage the European Union to actively support the introduction of digitalization in the construction industry.

The benefits of introducing digitalization are not only measurable in terms of financial performance, but also include:

- lower risks of exceeding time frames,
- better quality of the constructed facilities,
- higher productivity of the sector,
- adaptation to a sustainable built environment (climate change, circular economy),
- greater transparency of construction efficiency,
- new opportunities for the growth of the sector with exports and the provision of additional services,
- a stronger sector that attracts talents and investment.

The introduction of BIM methodology is one of the key tasks in the field of digitalization of the construction sector.

2. ADVANTAGES OF BIM IMPLEMENTATION

The benefits of using BIM technology are great. Of course, the benefits for different target groups of participants and associates during the existence of the object are certainly different, but it is undoubted that with a well-organized intelligent data set, all participants are involved in the process. The greatest benefits are given to investors who, due to good planning and analysis of different project variants, get a better insight into the social, environmental and financial aspects of the project phase, not to mention the visual presentation of the project. In addition, investors have insight and control over temporal (4D) and financial (5D) aspects of the project during construction and in later object management, and thus effectively monitor their investments. Therefore, projects are realized in a more transparent fashion.

When drafting technical documentation, collaborators more easily and better exchange information, documentation is coordinated, data is in one place, the possibility of errors is reduced, collisions of various elements are checked, and that reduces unnecessary additional costs and time delays in construction phase. Parts of technical documentation are interconnected, so any changes are kept up to date in reports, analyzes, etc. which reduces errors and shortens the project build time.

Contractors have better insight into the project, more accurate data and access to all data that is relevant to the site. At the same time, the monitoring of construction works, materials used and time allows them and other interested in better monitoring of the project and fulfillment of obligations.

Managing a facility that has all the necessary design, construction and maintenance information is much easier than when it is incomplete or nonexistent. So, those involved in facility management can use all the information collected in the design and construction process with the help of an appropriate information system and easily edit and update it.

The advantage of BIM is that it's not just the digitization of physical objects, it's actually digital "twins" that contain all the information about the object, so in the event of certain catastrophic proportions such as floods, hail, landslides that could lead to destruction and destruction of facilities, BIM will provide rapid access to all facility information and data.

We can see through the diagram what is the difference between "traditional", in most companies the current process and the BIM work process through the basic stages of facility creation and operation.

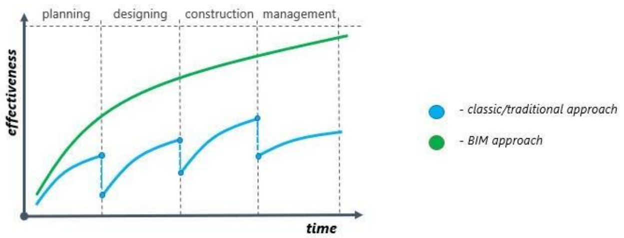

Image 2: Efficiency diagram in BIM implementation

3. HOW TO GET STARTED BIM IMPLEMENTATION

The implementation of BIM technology is a multi-step process. We can talk about the so-called levels of adoption of BIM technology, with the initial or zero level being the one that most of our companies are in today.

Level 0

The technical documentation is provided by the CAD system but it's unrelated. Projects are made in 2D, data transfer is done by exchanging drawings on paper or in electronic form.

Level 1

Project information is generated in CAD system in 2D or 3D form. The data is organized and standardized, using tools for remote collaboration. The financial data are processed separately from the technical documentation and are not linked to the technical data.

Level 2

All data is spatially determined (3D) and processed in BIM applications. Financial data is processed in special application, and is linked to a digital 3D model. English government has been demanding this level of BIM a construction profession since 4th of April 2016.

Level 3

Completely integrated collaboration system, supported by Internet services and the new Industry Foundation Classes (IFC) standard. This level allows for 4D, 5D, as well as 6D (spanning the entire life of project).

The adoption of BIM can therefore proceed gradually, in stages and throughout the lifetime of the facility. It is true that designers are most aware of the needs of adopting, but it is logical interest in BIM is shown by investors and those involved in facility management. They are the ones who have been working on the building for the longest time and ultimately have the biggest financial consequences or benefits.

4. NEW ROLES AND RESPONSIBILITIES, TERMS AND STANDARDS IN BIM

For the whole process of BIM implementation to be feasible and applicable, new roles (positions) are defined and crucial are the BIM manager, established by the client and the BIM coordinator as a person who care for designers, supervisors, contractors and other actors on the regularity of work and management of work processes.

BIM also brings with new standards for sharing and coordination from the design phase to the construction and maintenance of the facility. First of all, it's important to note what the IFC standard is and how objects must be modeled, with what attributes and information, or what LOD (Level of Development) must be applied in object modeling.

IFC is an open source code format that enables the exchange and flow of information from the design phase to the final maintenance phase - the end of the facility's exploitation and demolition. This means that the created model in the project must contain the information that will be necessary in the next stages, and in order to provide it at the outset the investor must define the levels of model development (LOD) on the project. BSi (buildingSMART) is an organization dedicated to the development and refinement of IFC standards, the issuing of guidelines that should be based on BIM processes and the promotion of BIM. From this organization comes a proposal for the development of a model that ranges from LOD 100 to LOD 500. Therefore, for each model or model element in the project, the investor should require a certain level of development.

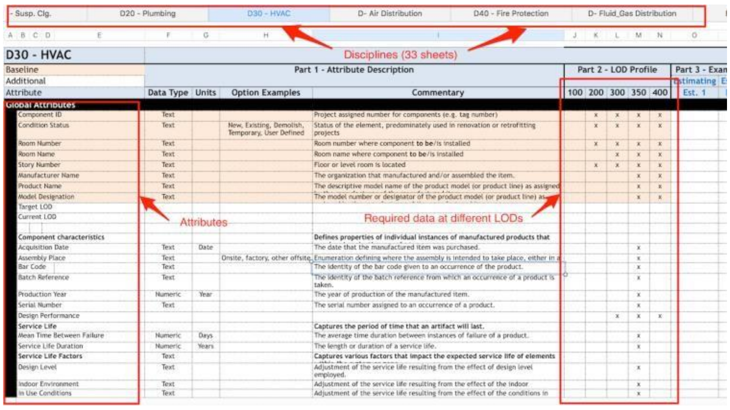

Image 3: Example of defined LODs and attributes for models by building elements

An example of defined LODs and attributes for models by building elements.

5. BIM WORKFLOWS IN CIVIL ENGINEERING

We will show how to create BIM models for infrastructure objects such as roads and railways through one example of designing an infrastructure road overpass with CGS Labs software solutions Plateia and Ferrovia. CGS Labs software solutions are localized software which supporting engineering work process and standards for the target market, also including Bulgaria.

As in every BIM process, a CDE (Common Data Environment), or a common environment for sharing data and information with participants, was initially established, and Viewpoint for project software was used, which provides document control (graphic and non-graphic), communication between participants and a validation system, management and creation with the final BIM model (Federated model) and site control.

With Plateia software was created the conceptual design of a roundabout and an access road with an overpass.

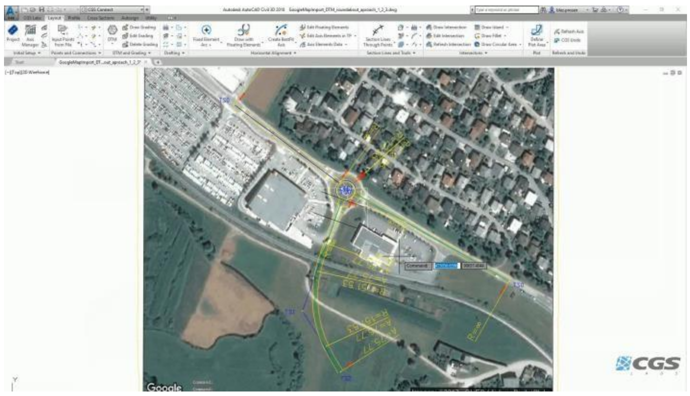

Image 4: The process of designing infrastructure in layout

The further process was to create a longitudinal profile and cross sections profiles of the road. What makes it easier is that elements from the layout, longitudinal profile and cross sections profiles are dynamically linked, so any changes made to certain elements are reflected in the others.

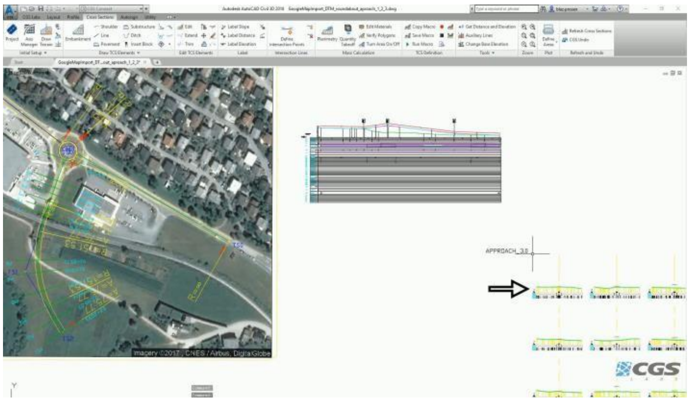

Image 5: Longitudinal profile of the projected road

Based on the defined cross-sectional elements, Plateia enables the generation of BIM models so that each road element contains the necessary BIM information (metadata).

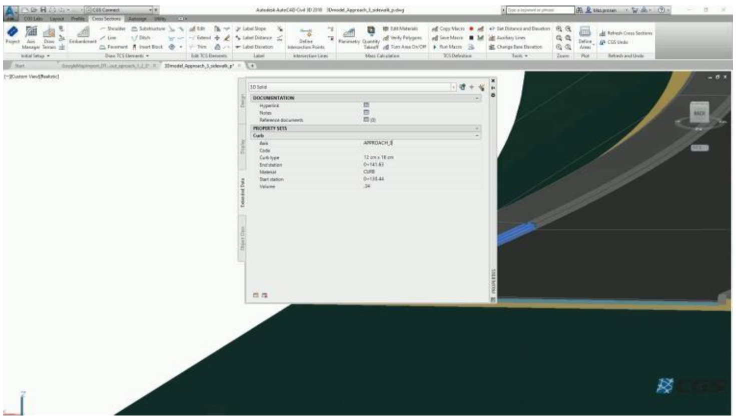

Image 6: Metadata of a single BIM road element model

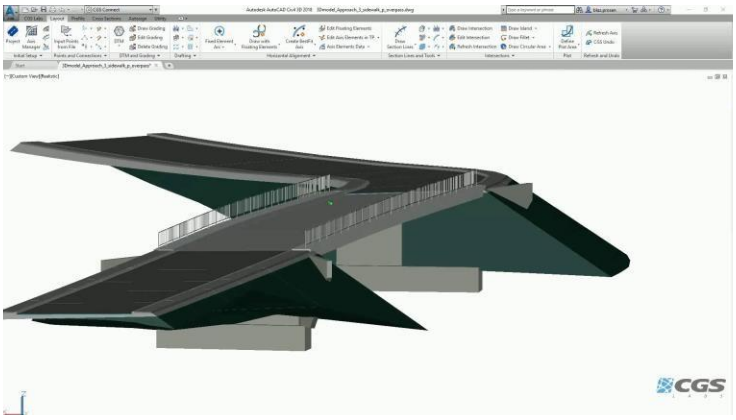

Image 7: Road BIM model

Using CDE, a collaboration was established between the engineer who worked on the design of the road and bridge and the engineers who designed the railway with Ferrovia software, intended for design and reconstruction of the railway infrastructure. After the connection of the road model and the BIM model of the railway, collisions were observed between two models, which was followed by the leveling of the bridge.

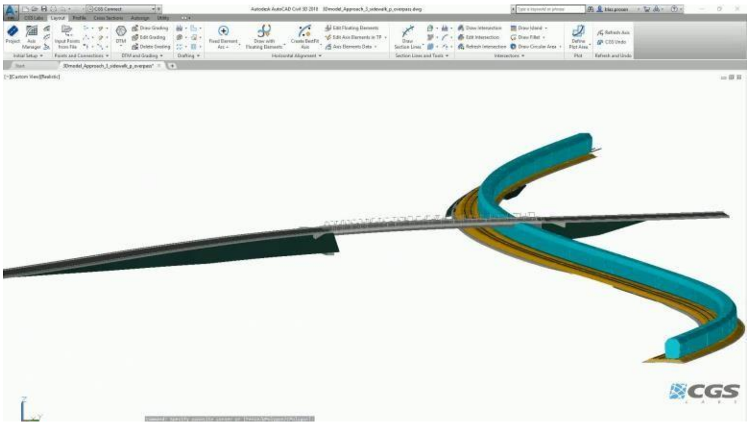

Image 8: Road and railway BIM model

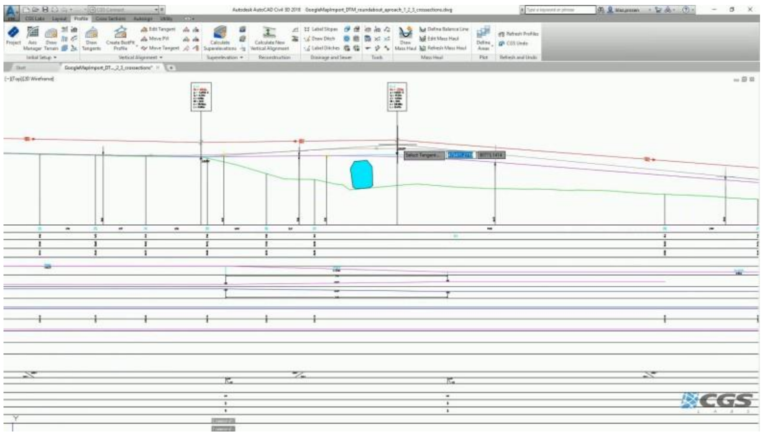

Image 9: Level correction

The federated BIM model (FM) was obtained as the final model containing the road section, the railway track, the roundabout, and the facility with the arrangement adjacent to the route.

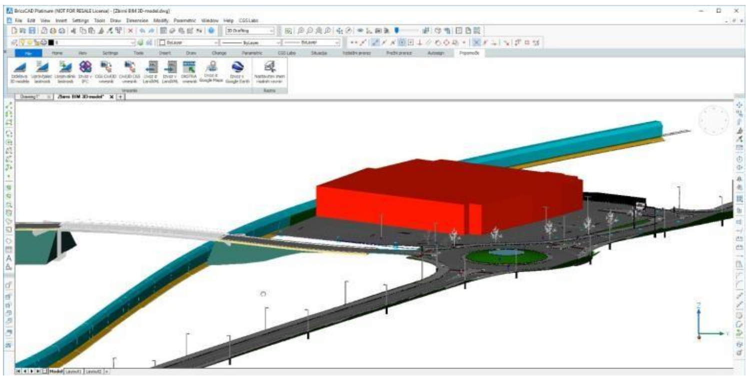

Image 10: FM model of infrastructure and object

The final model, as a BIM model, is ready for further analysis and use so that 4D and 5D analysis using Navisworks software is done using export to IFC format (which is the format for BIM methodology and implemented in all CGS Labs software).

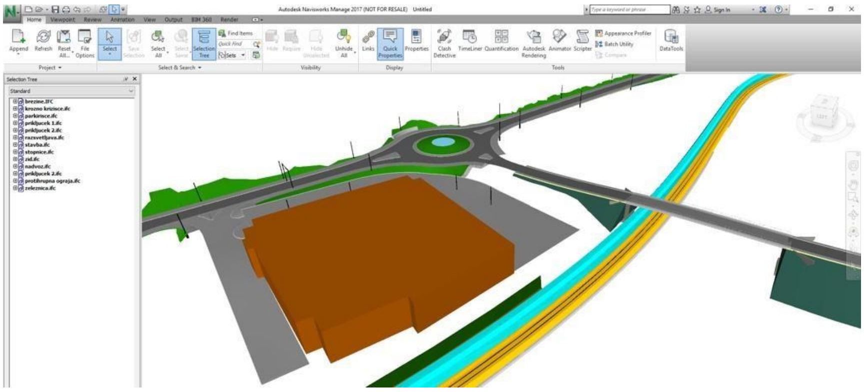

Image 11: 4D and 5D analysis of BIM model

The created models also allow for a better presentation perspective on new or reconstructed objects because astonishing 3D visualizations are also provided, that will allow all students and stakeholders to understand the project.

Image 12: Project visualization

Watch the entire process of creating a BIM road and railway model through the video.

(scan QR code to watch the video)

6. CONCLUSION

BIM as a methodology has many advantages over the traditional approach to building and maintaining facilities. Unlike the 90s, when a shift occurred to computer engineering from manual design, BIM requires more effort in engaging in initial phases and implementation. In our experience, gained by working on introducing and implementing BIM processes, as well as by consulting on tender creation and responding to tenders, for both public administration and private sector, BIM provides organizations and firms with greater competitiveness both domestically and internationally.