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## Pedagogical and research work on Building Information Modeling in construction management

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### Abstract

Building Information Modeling (BIM) is an approach that is increasingly gaining ground in construction practice. It became a modern approach for managing construction projects not only in phases of design and construction preparation but also during the implementation process. A comprehensive approach, covering 3D, 4D and 5D BIM modeling, is becoming crucial for the successful realization of mentioned tasks. Therefore, students of the Faculty of Civil Engineering, Transportation Engineering and Architecture at the University of Maribor also learn about the BIM approach during their studies. Through subjects' implementation of the Chair of Construction Management, Technology and Economics, 4D and 5D BIM models are generated for actual constructions each year. As an example, the paper gives a brief review of students' work on the kindergarten facility in Pekre. The mentioned facility was also monitored during the construction within the framework of two research projects. The positive trend of BIM implementation is increasing both in the construction practice as well as in the final work of students due to greater awareness about the purpose and usefulness of such education for engagement in construction management.

*Keywords: Building Information Modeling, 4D and 5D BIM, Construction Management*

## Pedagoški i istraživački rad o informacijskom modeliranju građevina u organizaciji građenja

### Sažetak

Informacijsko modeliranje građevina (eng. *Building Information Modeling*, BIM) je pristup koji se sve više primjenjuje u građevinskoj praksi. Ne samo u fazama projektiranja i pripreme za gradnju, nego i u fazi implementacije, kao moderan pristup za praćenje te upravljanje građevinskim projektima. Sveobuhvatan pristup, koji uključuje 3D, 4D i 5D BIM modeliranje, postaje ključan za uspješnu realizaciju spomenutih zadaća. Stoga i studenti Fakulteta za građevinarstvo, prometno inženjerstvo i arhitekturu Sveučilišta u Mariboru upoznaju BIM pristup tijekom studija. Provedbom predmeta Katedre za operativno građevinarstvo se tijekom svake godine izrađuju 4D i 5D BIM modeli za realne građevine. U članku je kao primjer dan kratak pregled rada studenata za zgradu dječjeg vrtića Pekre. Spomenuti objekt se također pratio tijekom izgradnje u okviru istraživačkog projekta.

Trend implementacije BIM pristupa se povećava i u građevinskoj praksi i u završnim radovima studenata zbog sve veće svijesti o svrsi te korisnosti takve edukacije za angažman u organizaciji građenja.

*Ključne riječi: Informacijsko modeliranje građevina, 4D i 5D BIM, organizacija građenja.*

## **1. Introduction**

Building Information Modeling (BIM) is becoming more and more a standard in the AECO industry. Nowadays, BIM approach for management of building projects is already operatively used in many countries but still not generally integrated [1], [2]. Despite numerous advantages offered by BIM approach, its implementation represents a practice-based process that takes time and cost, as it requires a change in evolving procedures carried out by individual participants in construction projects. As a higher-education institution, our mission is to train students to become engineers, capable of taking on all the challenges and professionally performing all the tasks they will face in construction practice. Therefore, we adapted learning contents and included the BIM approach into several subjects. In subjects' implementation of the Chair of Construction Management, Technology and Economics, we address actual construction facilities every year, where students learn about the BIM approach. In this way, they acquire theoretical and practical knowledge from relevant subject areas and become qualified to apply comprehensive BIM approach in dealing with construction projects. At the end of the study, many students decide to connect their final work with the BIM approach [3]. In this context, this paper is demonstrating an example of 4D and 5D BIM models development for a kindergarten facility in Pekre, which was successfully conducted with students, and also an overview from two research projects, where we monitored the execution of the facility construction.

## **2. Presentation of kindergarten facility in Pekre**

The kindergarten facility is located in the local community Pekre of Municipality of Maribor, Slovenia, as shown in Figure 2.1. The object is designed in an "L" form with dimensions of 11.00 m x 17.00 m + 21.60 m x 9.80 m. The height of the building is 9.46 m on the highest part and 9.16 m on its lowest part. It represents a two-story building. The situation of the facility is shown in Figure 2.2.



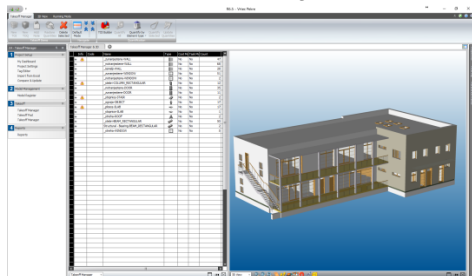
**Figure 2.1.** Location of kindergarten facility in Pekre [4]



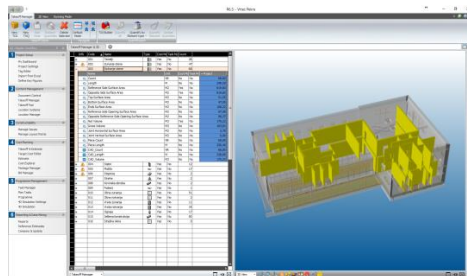
**Figure 2.2.** Situation of kindergarten facility in Pekre [5]

### 3. Development of 4D and 5D BIM models

The architectural design of the kindergarten facility in Pekre, as a 3D BIM model, was made with the modelling tool Graphisoft ArchiCAD [6]. The 3D BIM model was published into the Vico Office R6.5, which represents a Project Management Software for generation of 4D and 5D BIM models. Individual building parts were grouped into sets of construction elements for the aim of easier development of 4D and 5D BIM models, as demonstrated in Figure 3.1. In this way, we were able to obtain information about geometric characteristics for construction elements, e.g. as shown in Figure 3.2 for internal walls.

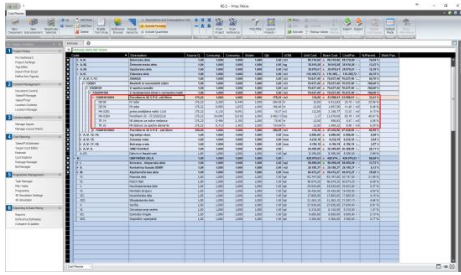


**Figure 3.1.** Sets of construction elements and 3D BIM model



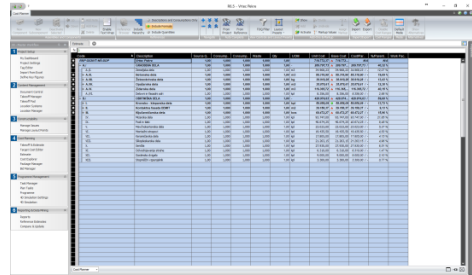
**Figure 3.2.** Geometrical characteristics for set of construction elements (internal walls)

Students were divided into several groups, where each group dealt with a single set of construction elements, taking into account the construction implementation technology. At this point, students used different study materials such as norms, price lists, standards, etc. In the module *Cost Planner/Estimate*, students entered the appropriate input data. For example, Figure 3.3 presents the price structure for building internal walls with bricks Porotherm 20 S P + E. All groups of students entered the input data in a similar way and the result was the 5D BIM model with cost information for each set of construction elements and, last but not least, the total value of project execution (Figure 3.4).



Item	Description	Unit	Quantity	Price	Total
1	Internal wall with bricks	m <sup>2</sup>	100	120	12000
2	Internal wall with bricks	m <sup>2</sup>	200	120	24000
3	Internal wall with bricks	m <sup>2</sup>	300	120	36000
4	Internal wall with bricks	m <sup>2</sup>	400	120	48000
5	Internal wall with bricks	m <sup>2</sup>	500	120	60000

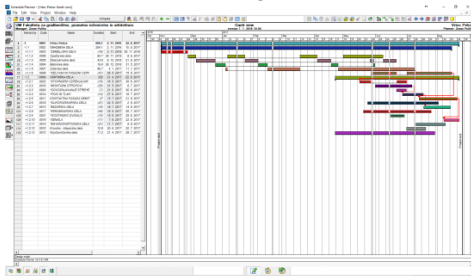
**Figure 3.3.** Price structure for building internal walls with bricks Porotherm 20 S P + E



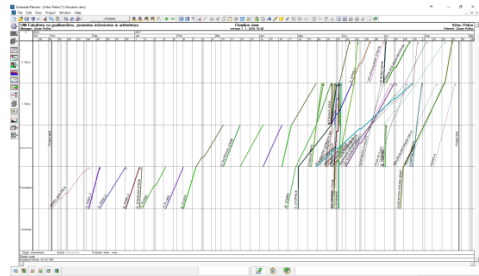
Element	Description	Unit	Quantity	Price	Total
1	Foundation	m <sup>3</sup>	100	150	15000
2	Foundation	m <sup>3</sup>	200	150	30000
3	Foundation	m <sup>3</sup>	300	150	45000
4	Foundation	m <sup>3</sup>	400	150	60000
5	Foundation	m <sup>3</sup>	500	150	75000

**Figure 3.4.** Execution costs for each set of construction elements and total value of project execution

Based on data for 5D BIM model, students subsequently generated a 4D BIM model in *Task Manager* module and *Schedule Planner* software (part of Vico Office), as shown by Figure 3.5 in Gantt view and Figure 3.6 in Flowline view.



**Figure 3.5.** Schedule plan as Gantt view.



**Figure 3.6.** Schedule plan as Flowline view

Applying the developed 4D BIM model, it was also possible to simulate the construction process as presented in Figure 3.7.

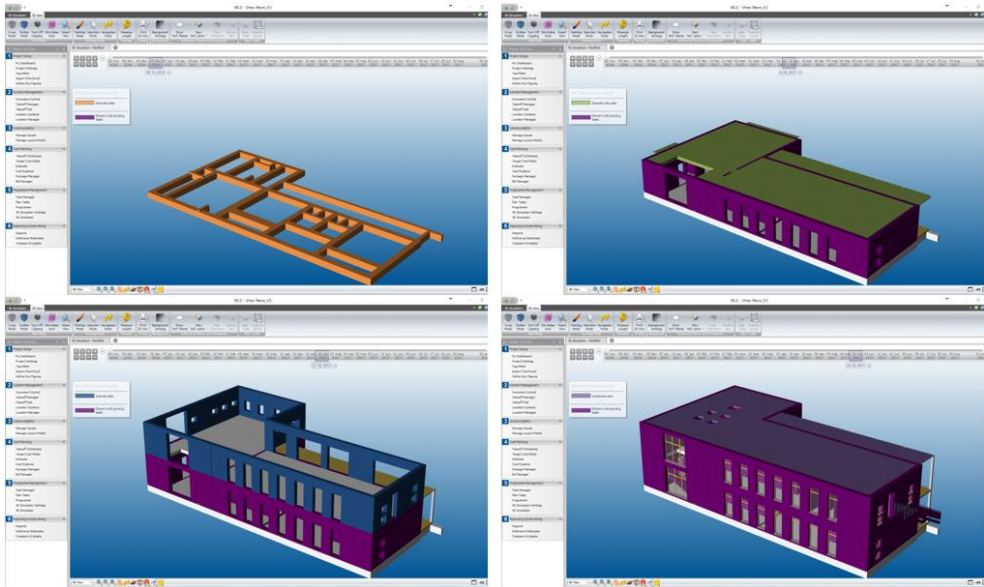


Figure 3.7. Simulation of construction process

#### 4. Research work with BIM approach

As a part of the research project [7], we were monitoring the facility construction using the photo documentation obtained by interval capture of photos with LTL Acorn 6310 camera, records in the construction log and other documentation. The aim was to follow the schedule plan for individual activities. For instance, a comparison between planned and realized execution for the set of construction elements (internal walls) can be seen from schedule plan as a Gantt view given in Figure 4.1 and as a Matrix Production Control view presented in Figure 4.2.

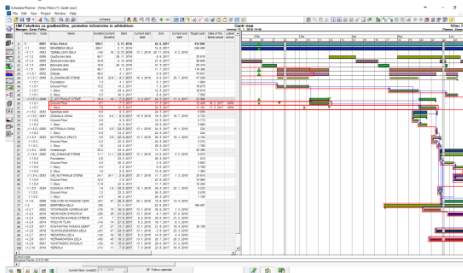


Figure 4.1. Gantt view for planned and realized execution for set of construction elements (internal walls)

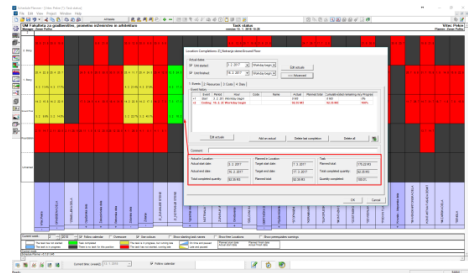
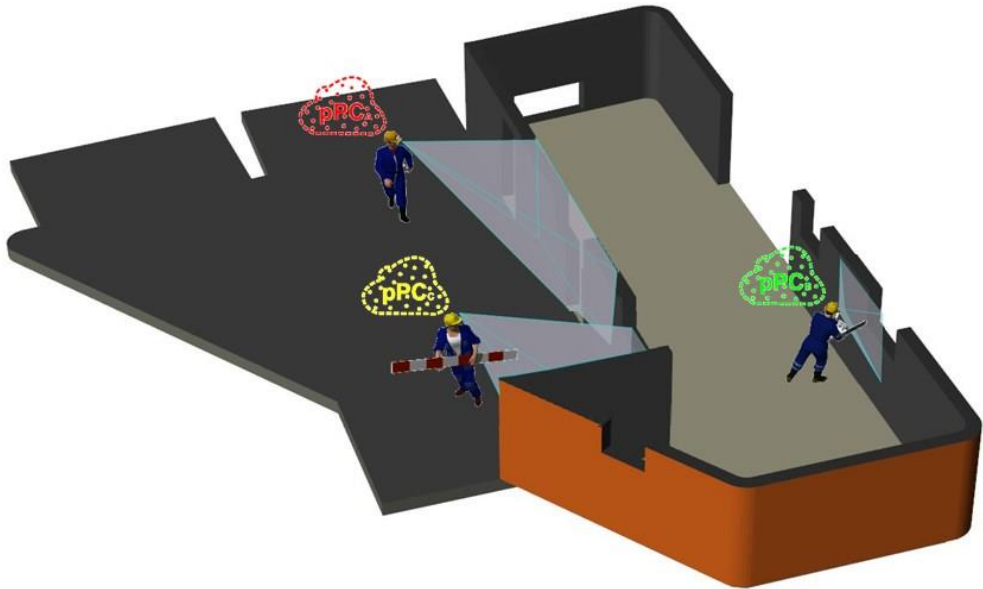


Figure 4.2. Matrix Production Control view for planned and realized execution for set of construction elements (internal walls)

In parallel, research (within the framework of a doctoral dissertation) intended for verification of a newly developed method called automated continuous construction progress monitoring

(ACCPM) was carried out [8] and represents a part of wider research in the field of automated construction progress monitoring (ACPM) [9]. The main contribution of mentioned approach was given to the process of continuous partial point cloud acquisition on-site using multiple 3D scanners integrated in workers' helmets for the purpose of automated construction progress monitoring as shown in Figure 4.3.



**Figure 4.3.** A scenario of indoor and outdoor continuous partial point cloud acquisition on-site using multiple helmet-mounted scanners [8]

## **5. Conclusion**

The paper briefly outlined the efforts at the Chair of Construction Management, Technology and Economics to effectively implement BIM into construction practice. Our students also took part in the development of 4D and 5D BIM models for the facility of kindergarten Pekre as it was presented. At the same facility, we continued research work for the aim of construction monitoring, where the pre-developed 4D and 5D BIM models served as bases for determining the differences between the planned and the realized execution, more commonly known as As-planned vs. As-built comparison. We will continue research work in the direction of automation of processes by developing new methods and including examples of good practice, thus contributing to the effective implementation of BIM into the construction industry.

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