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INFORMATION MODELING'S POTENTIAL IN CIVIL ENGINEERING

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Research Article
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Abstract: Building, carrying out, and overseeing construction and business is the focus of the civil engineering sector, which is a significant industrial segment. There is increasing demand in this industry to increase productivity and effectiveness. Process automation is the primary instrument that promotes efficiency and productivity. Building information modeling is a model-based intelligent method that provides civil engineering professionals with an overview and tools for efficient planning, building management, building blueprints, and infrastructure. The main objective of building information modeling is to provide a consistent environment that enables building life-cycle management. The outcome of this effort in an enlisted setting is a multidimensional model that contains all the data. The dimensions of building information modeling are the focus of this article, which also provides a brief explanation of each dimension and the actual degree of use of the fifth dimension (cost estimation) in the Visegrad Four nations. Surveys conducted in the Visegrad Four countries show the extent of 5D use and provide a summary of the present state of implementation in these nations.

Keywords: Automation, Civil engineering, Building information modeling, Dimension

1. Introduction

Increased productivity, flexibility, and technological advancement are indicators of contemporary society's changing lifestyle. These facts have a significant impact on certain economic sectors. Based on these facts, the civil engineering industry is in favor of process automation. Building Information Modeling (BIM) is a crucial technique for increasing efficiency and affectivity in the civil engineering sector. Although the BIM idea was originally mentioned in 2002, support tool development started early in the history of computer technology. The first commercial software programs were created in the 60s of the 20th century. These were always changing and becoming better. Nowadays, a lot of software is recognized to represent sophisticated support tools for building design, administration, and control throughout its life cycle. Building information modeling is defined in a variety of ways. The following are the most popular definitions: According to Kreider and Messner [1], BIM is a technology that positively impacts the development of digital skills. BIM uses organized digital

capabilities that are free for all parties to describe the asset delivery process [1]. According to Hardin [2], BIM is a revolutionary technology and procedure that has altered how construction blueprints are created, realized, and managed. BIM offers several technical advantages as well as a cutting-edge, integrated work platform that boosts sustainability and efficiency throughout the course of a project [3]. According to these criteria, the primary objective of BIM is to provide a consistent environment—a model that allows for the control and management of a building's life cycle. BIM offers several features and a sophisticated and useful tool for managing construction production.
The generated model is a multidimensional model that has dimensions for both graphic and non-graphic data. There are seven recognized dimensions as a result of BIM principles:

- 3D - geometry;
- 4D - time;
- 5D - costs;
- 6D - sustainability;
- 7D - facility management (see *Fig. 1*, dimension of BIM) [4].



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– *Fig. 1* Dimension of BIM (Source: Author's own processing)

Third dimension: Because geometry depicts visual data, it is a visible component of a model. This dimension is a model manual that facilitates prefabrication, project/model visualization, and conflict detection [4].

The building site's time management is the fourth dimension. 4D enables process visualization, management, and control throughout a project's life cycle. This dimension's primary advantage is the optimization of all deliveries, operations, storage, etc. [4].
Better control is made possible by 4D, which can identify conflicts and changes that arise over the course of a project. Additionally, it provides information management and visualization techniques [4]. Making a building budget is a crucial aspect of a project. Cost analysis and budget monitoring are made possible by the fifth dimension. Setting a building's price and other expenses, such as profit, is crucial

throughout the building's realization [5].
The sixth BIM dimension is used to evaluate the project's operational and energy-efficient phases. Dimension makes it possible to comprehend building activities and develop a plan aimed at maximizing the building's energy use [4].

The seventh dimension is a mechanism for gathering pertinent data related to the upkeep and administration of a building and its amenities throughout the course of its existence. Dimension provides valuable information on building management and upkeep [4].
Establishing the realities of existing structures is a challenge in the construction business. For this, laser scanning technology is used. A cloud of points produced by laser scanning may be used and integrated into the BIM environment. High accuracy is a characteristic of this model [6].

2. Methodology

Although BIM is a revolutionary technique, its use is quite low, and some nations even do not utilize it. Every nation makes a different attempt to integrate BIM into its operations. BIM is used as a project tool in certain nations, although it is still in the construction planning stage in most. There is relatively little time and money planning involved in implementation. Software programs without BIM are used for cost control and pricing. A study that addresses the present state of implementation reflects the degree of use of BIM technologies in the civil engineering sector.

2.1. Research topics and goals

The primary study areas were established based on the issue description. The study's foundation is the examination of surveys pertaining to the use of 5D in building production cost estimate in certain nations. This fact led to the establishment of the primary research aim, which was to provide an overview of the application of 5D (BIM) in the Visegrad Four (V4) nations. Partial goals were also established, as follows: • to outline the advantages of 5D BIM; - to provide an overview of software applications in relation to 5D; - to present an overview and comparison of the existing status of BIM 5D implementation in a few countries—Visegrún Four.

2.2. Processing research

To accomplish the research aim, it is crucial to complete many research assignments. The first stage was looking at a number of research and surveys that address this problem. Results and data were gathered, categorized by chosen areas, and then examined. The study's findings included theoretical 5D analysis, a summary of software programs that enable the creation of 5D models, and the current state of BIM

implementation in the Visegrad Four nations' cost estimation processes.

3. 5D: Estimating costs

Accurate cost assessment is essential to any project's success. Numerous variables may lead to cost overruns, including poorly specified beginning costs, unforeseen technical issues, missing or poorly defined task range, modifications, external influences, etc. [7]. Every stage of the project benefits greatly from the 5D data model, which is evident in increased safety and reduced expenses. The 5D data model offers the following advantages throughout the project phase:

• ensuring a high-quality and economical building process through planning coordination, conflict analysis, blueprint optimization and planning evaluation, calculations, process planning, etc. • improving communication and limiting failures, which can lower productivity and teamwork effectiveness [8]. • accurate conflict analysis through the creation of various construction animations, which removes concept deficiencies and improves constructing, or deficiencies are totally removed. The realization phase is a crucial stage in an object's life cycle. The 5D data model may greatly increase efficiency, openness, and collaboration throughout this stage. Rejuvenating these operations may reduce the expenses associated with logistics, materials, products, equipment, and labor. Participants may monitor the construction progress, keep an eye on urgent resource requirements, visualize plans, and reevaluate procedures using this data model [8].

5D provides full building details throughout the consumption phase. The maintenance phase, or facilities management, accounts for over 80% of financial resources. According to this perspective, the 5D data model is very beneficial for reducing and efficiently using financial resources [7]. Because of these facts, 5D offers the ability to automatically generate accurate quantity takeoffs (directly and immediately with a high degree of accuracy), specify life cycle costs, compare costs, give the project team a detailed project, and work with BIM libraries.

A number of software programs that enable the creation and manipulation of 5D digital models have been created. These programs enable the creation of bill of quantities, budgets, and computations. The USA is one of the leading nations in the creation of these apps (software INNOVAYA Visual Estimating Software). Exactal COST X is a European application created in Great Britain that facilitates the construction of 5D models and BIM.

Neveris Nemetschek in Germany, BIM estimate in Poland, GALA Construction in Croatia, Terc in Hungary, and so forth (see Fig. 2 for more software programs).



Fig. 2. Overview of software applications (Source: Author's own processing)

3. Implementation of the 5D - cost estimating in Visegrad Four

BIM represents modern, intelligent processes for facility management. BIM term is not new on the market, what documents raising level of implementation in civil engineering industry. A lot of countries has already started to use and support information modeling tools in its industry. Leading users are Nordic countries - Finland, Norway and Denmark. Quite high is the implementation level in Netherland, United Kingdom, France, Germany, Austria, Spain, USA, UAE, Middle-East, Asia, Australia, etc. These countries continuously implement BIM into its laws and standards and do researches about BIM implementation in civil engineering industry.

3.1. Slovakia

Slovak construction industry is constantly improving, what is shown on the level of occupancy. In 2017, occupancy has increased by 4.4%, so the capacity of construction companies is occupied on record-breaking 93% (2017) [9].

Implementation of BIM, which is low in Slovakia, would help the growth of civil engineering industry. One of main reason of slow implementation is an absence of technical standards implementing BIM. In 2013, BIM Association Slovakia was created, which is the first organization supporting BIM implementation into civil engineering industry. Continuously is BIM getting into awareness of professionals and they're starting to implement.

In Slovakia, surveys were realized in connection to BIM implementation. One of first surveys was realized in 2015 - BIM Crunch 2015 - Report. Following in 2017, exploitation and benefits of BIM in construction project management and in 2018, pre- research current state of BIM implementation in building production pricing, were realized. These results brought the conclusions in *Table I* [10], [11]. There was also conducted survey entitled impact of management decisions based on managerial competencies and skills developed through BIM technology on performance of construction enterprises. The survey has shown that BIM technology affects management decisions and the development of managerial competencies and skills. The survey confirmed the impact on cost savings and construction time [12].

Table I

Implementation of BIM in Slovakia - summary of surveys [10], [11]

TITLE	YEAR	RESULTS
BIM crunch 2015 - Report	2015	66% addressed companies did not plan to implement BIM in next 5 years, 25% respondents know BIM benefits, however, they did not plan to use BIM, 65% respondents did not know BIM,
Exploitation and Benefits of BIM in Construction Project Management	2017	75.2% companies do not use the BIM, 24.71% respondents are use BIM technology in construction project management, 89.34% cost reducing in construction project management, 87.56% increasing the quality of the document, the elimination of error project documentation, 75.36% increasing of financial control.
Current state of BIM implementation in building production pricing	2018	77.4% asked do not use BIM tools, 67.7% did not meet BIM tools, the most used tool in cost estimating is Cenkros (87.1%), but it´s not a BIM software solution, 12.9% use BIM tools but only for bill of quantities and only 6.5% use BIM for bill of quantities and the budget itself.

From these results it is clear that interest in BIM is raising, however building production pricing in Slovakia is realized through standard building works databases in CENEKON structure code or TSP. Currently, on the market are available software applications CENKROS 4, Kalkulus and Odis, but they cannot be evaluated as BIM software applications. More and more appears an effort to connect building production pricing and building information modeling, but currently it is not possible to state, that in cost estimating, BIM tools are used.

3.2. Czech Republic

The Czech Republic's building sector has a low degree of BIM approach practical use. The lack of technical standard information in the 3D model is the primary cause of the implementation's poor pace. An organization called the Czech BIM Council was founded in this nation to aid in the use of BIM; it promotes awareness and facilitates the use of BIM in the construction sector. The Czech BIM Council produced the BIM Handbook (2013) [13] and BIM Handbook for investors (2018) [14] based on this information. At the moment, BIM is solely used in Czech industry to create 3D models.

However, there are several initiatives to include BIM into BIM Execution Plans (BIM-EP), which raises utilization and solves fundamental BIM procedures and techniques [15].

The government of the Czech Republic authorized the document titled "Conception of

BIM implementation in the Czech Republic" on September 25, 2017, in order to facilitate the expansion of implementation in the country [16]. This paper contains a roadmap for the Czech Republic's ongoing BIM implementation from 2018 to 2027. It is anticipated that in 2022, regulations pertaining to the use of BIM for over-limit public contracts for construction projects funded by public funds would be considered [17]. A study on BIM utilization hypotheses was conducted in 2015. Architects, engineers, owners of construction businesses, and investors have participated in the study. The study's conclusion is that public professionals have very little knowledge of the BIM approach. Of those surveyed, just 41% were aware of projects completed using the BIM approach. Interesting findings concerning gathering data about the BIM approach were also discovered via research. Of the respondents, 42% have actively taken competency-boosting courses, 8% have read about this topic in scientific literature, and 8% have heard about it at conferences. Just 19% of respondents—mostly architects and builders—actively employed BIM in 2015. Lack of expertise (58%), low customer demand (25%), and the expensive expense of acquiring the necessary software tools were the main reasons why businesses did not adopt the BIM approach [18]. Similar to Slovakia, the building database, or TSP, is used in the Czech Republic for building production price. Currently, the most popular software programs in the nation are Callida, Kros, and BuildPower; however, these programs do not support BIM [19], [20].

ASPE software, which offers a BIM software solution, is an innovation in the Czech market. This program is a tool for managing and monitoring sophisticated electrical buildings. ASPE provides a data environment that makes it possible to use BIM to manage and see building documents in one location. Budgets, timetables, billings, and modifications during construction are all possible in a software environment [21]. As shown by the creation of the BIM Implementation Plan in the Czech Republic, the usage of BIM is expanding there, and the pace of implementation is anticipated to rise. The Czech Republic's BIM implementation concept includes well-defined processes and significant benchmarks that facilitate the technology's adoption.

3.3. Poland

In Poland, there are not created standard and laws for investments with BIM technology, however implementation of BIM is still moving forward. In 2012, union BIM Klaster was created, which deals with connecting building industry and information technologies. The mission of this organization is to support using the innovative technologies in building industry, through project support, propagation and implementation of innovative management ways, developing the relationships, cooperation etc. [22].

Success of BIM Klaster is shown by researches and survey, which were realized in Poland, in 2015. Preliminary research results (Michał Juszczyk, Miloslav Výskala,

Krzysztof Zima [15]) or in 2016, research realized by Polish Ministry of Infrastructure

and Construction. Results of the researches are shown in *Table II* [18], [23].

Table II

Implementation of BIM in Poland - summary of surveys [18], [23]

TITLE	YEAR	RESULTS
Prospects for the use of BIM in Poland and the Czech Republic - Preliminary research results	2015	81 % of respondents admitted that they had heard about this concept, 23% respondents do use the BIM, 93% of the respondents understood the necessity to implement BIM in Poland, Plans for the implementation of BIM in the company - 17% respondents did not know about any plans to introduce BIM in their companies within the following 2 years, 17% said that there were no such plans, and only 9% stated that BIM would be introduced in their company soon.
Polish Ministry of Infrastructure and Construction - Current state of BIM implementation in building production	2016	until 68% design documentation is in paper form (30% - in dwg format, pdf format and other CAD format), 80% heard about BIM technology, but don´t have experience, 18% know the technology and apply its some solutions, 2% know the technology and apply it in full.

Increasing level of implementation is shown also by cost estimating in building production. In Poland, specialized software is used for pricing and calculation of building production, for example BIMestimate is the tool that supports building information modeling.

BIM estimate allows project planning and cost estimating process. Software works with BIM models in IFC format, by which it can presents various designs, calculate volumes, surfaces, lengths, it can detect contradictions and allows to create budgets and analyses [24]. The BIM methodology is increasingly used in the Republic of Poland and is expected to be expanded further.

3.4. Hungary

Hungary is a frontrunner in the use of BIM among the V4 nations. The first V4 nation to establish BIM mandatory requirements is Hungary. In order to promote the use of BIM in Hungary for professional purposes, the organization MABIM was founded. With investments, projecting, construction, and building management, MABIM takes part in setting regulated limits for the Hungarian building industry. The handbook BIM Handbook was produced by this group in 2018 [25]. Every stage of the project demonstrates an increasing degree of implementation in Hungary. Building information modeling is often employed in time, according to the

BIM Handbook. Budget: 5D BIM; planning: 4D BIM and cost estimate. Table III [26] displays use across each period.

Table III

Use of BIM in individual phases time planning and cost estimate, budget [26]

Process	Phase						
	Project preparation and impact studies	Concept design and feasibility study	Authorization process	Creation plans	Tendering	Realization	Feasibility
Time planning (4D BIM)	normally used	normally used	normally used	normally used	normally used	normally used	unused
Cost estimate, Budget (5D BIM)	normally used	normally used	normally used	normally used	normally used	normally used	unused

As it is shown in *Table III*, BIM is often used in Hungary also in cost estimating. For pricing, except standard software applications (Kôvet, Kimmer Szofverfejlesztés), software applications supporting BIM are also used (Terc and STR Vision CPM) [27], [28]. These applications allow complex electronically monitoring and managing of the buildings - create budgets, analyses, schedules, etc.

4. Conclusion

In the construction sector, building information modeling is a crucial automation tool. Throughout the whole building life cycle, BIM offers intelligent project management and improves digital abilities. Every participant is aware of the technology's efficacy and is making an increasing effort to incorporate it into every stage of the project. An overview of BIM deployment in the building sector in a few chosen nations is provided in this article. With a focus on cost and economical aspects, the article primarily addresses implementation circumstances as well as methods for better controlling and planning each stage of the life cycle. Although Slovakia, the Czech Republic, and Poland are increasingly taking steps to adopt BIM, these nations still lack the necessary standards. Hungary is the only V4 nation with precise BIM mandatory requirements. Currently, software that does not enable BIM is utilized in Slovakia and the Czech Republic for cost estimation in building manufacturing. The goal of incorporating BIM into standards is continually evolving. According to the report, BIM is a crucial tool for construction decision-making and realization, especially when it comes to cost estimation. Slovakia is not a leader in this field, according to research that demonstrates the variations in BIM implementation across the V4 nations.

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