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BIM-paved roads around Visegrád – The implementation and scientific feedback/ analysis of building information modelling in V4 countries

ABSTRACT

Construction economy faces new challenges in the 21st century. Sustainability has become an inevitable imperative. Digitalization has permeated every part of our lives. The digital transformation of the construction industry presents many benefits and opportunities, yet it also encounters various barriers that impede innovation and the implementation of new advancements.

Due to the conscious management and change of attitude of the construction economy, the adoption and mandatory implementation of Building Information Modelling (BIM) has already become a well-established tradition in Western Europe, the United States, and even Singapore. In Hungary, using BIM methods in public works is not mandatory, but its gradual implementation is on the agenda. Due to the shared economic and political traditions and solutions of the V4 countries, it is worth reviewing the current prevalence of BIM in practice and the available scientific results. This overview study examines public procurements and scientific literature on BIM in Poland, the Czech Republic, Slovakia, and Hungary. It presents the current state of BIM and the degree of its implementation in public works. In doing so, it highlights some important similarities, differences, as well as potential issues, providing valuable insights for consideration in the implementation process.

Keywords: BIM Building Information Modelling ■ digitalization ■ public works
■ public contract ■ public procurement ■ V4 countries ■ sustainability

I. INTRODUCTION

The cooperation of the Visegrad Four – the Czech Republic, Hungary, Poland, and Slovakia – focuses on the new challenges of the 21st century, joint searching and sharing experiences in the thirty-year history of the

V4. In the spirit of conscious shaping of the built environment, sustainability and digitalization, Building Information Model or Modelling (BIM) is the most important buzzword of the construction economy today. The mandatory introduction of BIM on the public procurement (PP) market is a topical issue in those European countries where it has not yet been implemented, including, to some extent, in the V4 countries. There is a wide range of research and experience that can be used, but it is a fact that these are primarily available in the field of engineering and technological sciences. Conversely, there are far fewer economic, legal and management approaches, despite their potential for significant contribution to the discourse on implementation. The aim of this study is to present the current BIM overview of the V4 countries, focusing on PP solutions and literature results.

1. Current challenges in the construction sector

The construction industry plays a pivotal role in shaping national economies, given its productivity, capital and raw material requirements, employment figures, technological adaptability, and environmental impact. It stands out as a particularly important factor in the recovery from the economic setback caused by the COVID-19 pandemic, as well as in challenges related to sustainability and energy dependence.^[1] In the 21st century, sustainability has become an unavoidable compelling issue, while digitalization has permeated every part of our lives. Digitalisation in the construction economy creates new solutions in the field of new construction technologies and industrialised prefabrication through robotics that have the potential to increase productivity. The Construction Industry 4.0 strategy, which emerges from the Industry 4.0 strategy, focuses on the change of attitude necessary for the transition.^[2] It takes into account the entire construction value chain, connects its elements with the means of digitalization, and is able to reduce the time, costs and environmental load of construction processes.^[3] It summarises the tasks of the transition towards our sustainable, green vision, the aims and means to achieve the goals of digitalization and sustainability. Construction Industry 4.0 guides decision-making processes not only for economic actors in the AEC sector (architecture, engineering and construction), but also in the policy and legislative processes of public decision-makers.

The scientific literature deals not only with the benefits and results of digitalization in the construction industry, but also with its obstacles. The digital transformation of the construction industry is proceeding slowly, for two main reasons. According to Nagy et al., it is due to the organizational, strategic culture of AEC companies and the lack of openness of the market to new technologies. Low digital literacy levels for managers and employees and rigid organisational

[1] Boros – Kovács, 2022.

[2] Shafei et al., 2022.

[3] Nagy et al., 2021.

structures unable to integrate new positions arising from digitalisation are major barriers. Young businesses that are able to absorb new technologies but are unable to meet demand due to their economic strength and numbers. Companies may not be willing to invest in adopting new technologies amid uncertainty about the usefulness of the technology. Above all, therefore, the supply and demand markets must be ripe to accommodate Construction Industry 4.0.^[4]

The construction sector is one of the main pillars of the EU economy, accounting for 9% of EU GDP and employing 18 million people.^[5] The European Parliament's Public Procurement Directive 2014/24/EU explicitly encouraged the use of electronic solutions in PPs which opened the possibility using BIM in public works. In 2017, the EU Commission published a handbook for the public sector on the implementation of BIM and supports digitalisation in several ways.^[6]

In relation to EU member states, the largest construction contractor is the state itself, i.e. government customers. Therefore, the importance of state involvement is outstanding not only in strategic but also in direct customer function. From a political point of view, it can act as a catalyst for the adoption of new technologies.^[7] Several studies confirm the key role of the customer in introducing innovations. Financial considerations play a major role in the customer's decision-making. A common problem is that the actors of the investment do not cooperate properly or the preparation is not thorough enough, therefore the project is delayed in time and often exceeds its planned budget.^[8] If public contracts are not performed within the financial or time-limited periods, the additional financing needs will be additional to public funds. The efficient and responsible management of public funds requires the prevention and the proper management of these negative consequences and risks, which can be adequately managed in higher-level BIM models (4D model – time scheduling, 5D model – cost planning). These aspects have also led to digitalisation in the construction sector in countries that are currently at the forefront, such as Great Britain.

Among the Visegrad countries, the Hungarian construction industry grew the highest in 2018, at 22.3%, yet its share of EU construction production was still only below 1%.^[9]

Cooperation between the Visegrad Four has varied throughout the thirty-year history of the V4. The cooperation has achieved its goal, as NATO and EU accession was realized, the establishment of good neighbourly relations and the introduction of minority protection measures and guarantees have been fulfilled. However, cooperation has continued and has been complemented by new policies such as energy, environment and digitalisation following a common

[4] Nagy et al., 2021.

[5] Rolling Plan for ICT standardisation.

[6] Handbook for the introduction of Building Information Modelling by the European Public Sector.

[7] Lindblad – Guerrero, 2020; Lindblad – Gustavsson, 2021.

[8] Walaseka – Barszcz, 2017.

[9] Boros, 2019.

search for a common path.^[10] In 2022, the ministers responsible for transport and infrastructure of the V4 countries signed a memorandum jointly declaring that digitalization is a key element of future mobility. The signatories noted that Cooperated, Connective and Automated Mobility (CCAM), an international organisation of the European Commission established in 2021,^[11] represents great potential for mobility challenges related to the growth, safety, accessibility, changing demand conditions and increasing emissions of transport.^[12] To this end, they agreed to cooperate legal, social, economic, technical and institutional processes as necessary in testing CCAM and related technologies. Priority areas for joint action and exchange of best practices have been identified. Given that CCAM's goals and operations are closely related to environmental aspects, the development of standardization and regulation, as well as its built environment. This thinking is not far removed from the standardization and digitalization efforts of the construction industry, whose buzzword today is BIM.

2. BIM in a nutshell

There are several definitions of BIM. BIM as a product (Building Information Model) is an authentic data set that integrates the physical and functional characteristics of a building or facility, which provides a reliable basis for decisions throughout its entire life cycle.^[13] BIM as a process (Building Information Modelling) can be considered as a complex collaborative process, in which all actors of the investment use an intelligent model-based design application from preparation, design through implementation to the maintenance-operation phase, and then also at the demolition, disposal and/or recycling phase. BIM as an approach covers the entire life cycle of buildings.^[14] BIM technology makes it possible to create a virtual environment for a construction site, thus opening up new modelling possibilities. It enables automation, creates a digital replica of the building (digital twin). The most important advantage of BIM for stakeholders is undoubtedly the ability to save money. In the BIM model, different versions of the facility can be created quickly, collisions can be investigated, which reduces or avoids unexpected costs and changes during the construction process. The method supports the entire life cycle of the building by providing information not only about the geometry of the building, but also about its individual elements for operation, maintenance, or sustainability aspects. It is now accepted that BIM can be applied not only to buildings, but also to linear installations and

[10] Stepper, 2022.

[11] CCAM: What is CCAM.

[12] Memorandum of Understanding.

[13] NBIMS 2010, National BIM Standard - United States.

[14] Siniak et al., 2019.

other engineering works.^[15] BIM can be the backbone of projects, and thus various discounts and forms of support, not only as proof and generator of innovation, but also as authentic data sources.^[16]

II. RESEARCH METHODOLOGY

The readiness of the V4 countries for using BIM in public works is based on two empirical studies. First, we prepared a statistical analysis of the occurrence of BIM so far based on the available PP data, and secondly, we conducted a literature search on publications on BIM in V4 countries. Subsequently, we evaluate the situation by processing the content of scientific publications and publicly available professional materials and guidelines, and point out possible further directions of research. During the literature search, instead of focusing on engineering, technological and computer science publications, we highlighted those that could be relevant from the point of view of mandatory state introduction and legislation.

III. PUBLIC PROCUREMENT RESULTS

In order to detect the presence of BIM in public contracts, we reviewed publicly available PP information in the V4 countries. Our statistical analysis is based on the Public Procurement Supplement of Tenders Electronic Daily, the official journal of the EU. On the electronic search interface, we filtered for BIM in PP notices of the previous three calendar years to find procedures related to any subject (works, supplies, services) related to the BIM methodology in any detail. Based on the curiosity of BIM in this geographical region, it is not assumed that in the case of PP involving BIM in any depth, the word BIM will not appear in the call for competition, but only in the procurement documentation, which would require more detailed background research. These notices concern PPs at or above the EU threshold, which, due to their scale, value and complexity, are more likely to be carried out within a BIM framework compared to procedures of lower value and simplicity under national regimes. Experience in Western Europe, Asia and the USA also shows that the implementation of BIM is primarily implemented on high-value projects, its mandatory introduction is linked to investment value and in addition to the sectoral character (building construction, civil engineering, public utility construction).

[15] Tateyama, 2017.

[16] BAMB Buildings As Material Banks (BAMB2020) and Madaster Madaster — The Digital Library of Materials.

Figure 1 shows the total number of notices in which the term BIM appears in the years 2020-2022. The larger number of pieces (Notices) is deceptive, as corrections and information notices belonging to the same procurement also appear in it. To this end, we have narrowed the search to calls for competition (Contract notices 2), which shows the current reality. During the filtering, only the classic contracting authorities had a procedure, and we did not find any BIM procedures announced by public service providers. While 89 PP procedures containing BIM were launched in the Czech Republic during the period under review, Poland came in second place with 56 procedures, Hungary had 46 procedures and Slovakia had only 5 PP procedures in which BIM appeared.

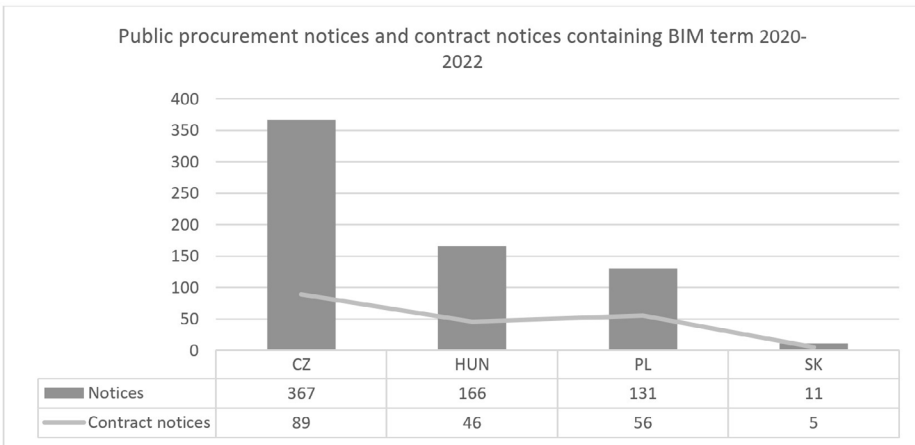


Figure 1: Public procurement notices containing BIM terms, 2020-2022
(Source: TED database, own collection)

The distribution of each procurement procedure by procurement object was as shown in Figure 2. The data clearly show the majority of procedures related to service orders: overall, these mainly design orders account for about 80% of the procedures, the proportion of which leads everywhere in countries compared to other procedural subjects. This is followed by the range of works, in a proportion that varies from country to country: Slovakia had no BIM-based works at all between 2020 and 2022, according to PP statistics. Hungary and the Czech Republic had 8.7% and 6.7% respectively, while Poland had a high share with 32%. Procurement of supplies specifically aimed at BIM solutions did not start in Hungary during this period, which may also indicate that contracting authorities did not have a demand for the purchase of software and tools enabling the use of BIM method. In contrast, all three V4 countries conducted such supplies.

	Works	Services	Supplies	Sum
CZ	6	79	4	89
HUN	4	42	0	46
PL	18	34	4	56
SK	0	3	2	5
SUM	28	158	10	196

Table 1: Distribution of public procurement notices containing BIM by public procurement subjects, 2020-2022
(Source: TED database, own collection)

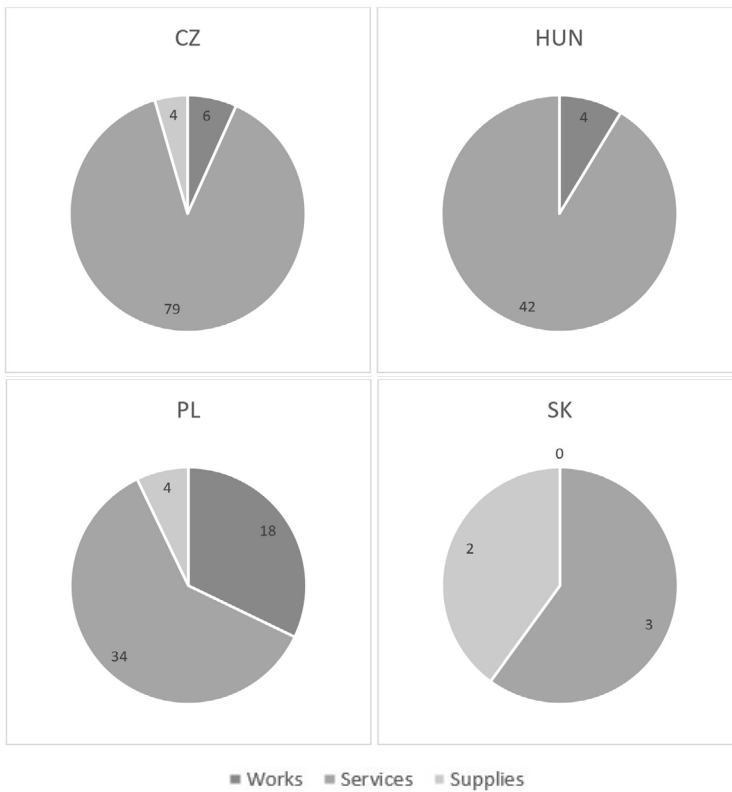


Figure 2: Distribution of public procurement notices containing BIM by public procurement subjects, 2020-2022
(Source: TED database, own collection)

Figure 3 shows the year-on-year evolution of BIM PP procedures in the four countries. For the Czech Republic and Hungary, there was a significant increase

from 2020 to 2021: the number of BIM-related procedures increased one-and-a-half times in the Czech Republic and by a quarter in Hungary. From 2021 to 2022, Hungary experienced a more significant decline. In Poland, there has been a decline in three years, while in Slovakia BIM has almost disappeared from the PP market.

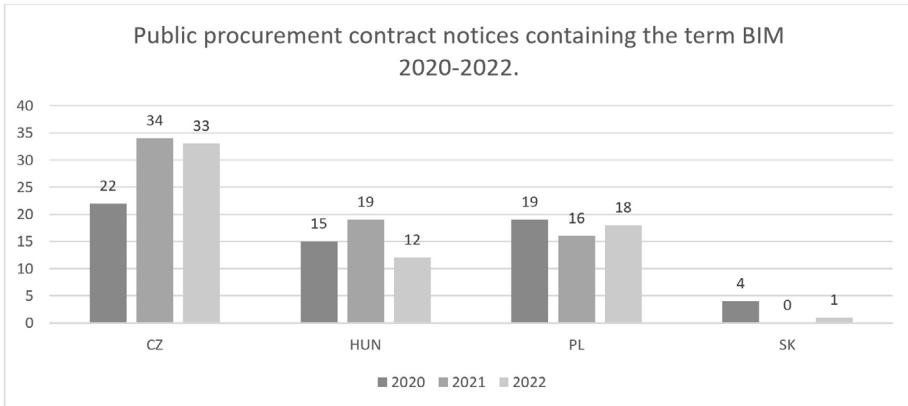


Figure 3: Public procurement notices containing the term BIM, 2020-2022
(Source: TED database, own collection)

IV. SCIENTIFIC ACHIEVEMENTS

A Scopus search for literature conducted in April 2023 on Building Information Model or Modelling yielded a total of 475,031 results for engineering, social sciences, decision sciences, environmental sciences, commercial and marketing, and energy, which was modified with the word BIM to get 5,166 results.^[17] For familiarity, we narrowed the results of our open access search to 1174 results, and then to 1134 without results that were definitely not related to the topic. Following the publication of the first studies in 2011, the number of units that rose sharply between 2016 and 2017 declined in 2018-2020, but scientific interest and research gained momentum again in 2022 and 2023. The result of 2023 so far in the first quarter exceeds the half-year figure of 2022 and the publication of all previous years.

The number of studies specifically aimed at PP and state implementation is

[17] 23th April 2023. The fields of biochemistry, genetics and molecular biology, as well as the field related to Earth and planets have been excluded, but the fields of social sciences and decision sciences still yield many other results not related to our topic. Partial occurrences of search terms also distort the results.

much narrower. There is no concentrated research on this topic, we need to look for PP difficulties behind the findings of individual studies. However, the professional organizations supporting BIM operation in certain states, as well as the books and guidelines issued by them, provide useful information for understanding international trends, so we used the latter for the preparation of this overview study.

Narrowing down the search on the Web of Science (WoS) to BIM and V4 countries, 330 scientific publication results were found.^[18] Focusing on the 10 largest results, the distribution of these disciplines is shown in Figure 4.

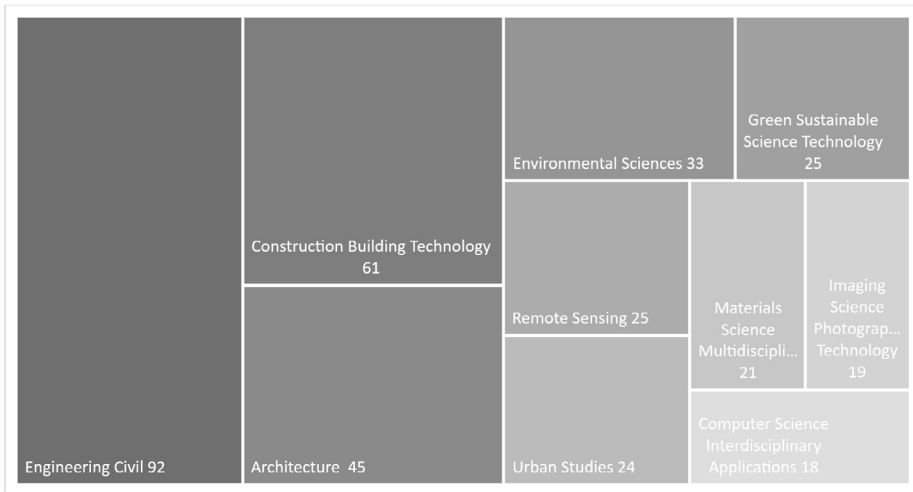


Figure 4: Distribution of scientific results related to V4 countries containing BIM expression, showing the ten most relevant scientific areas (Source: Web of Science, own collection)

Based on WoS data, scientometric analysis primarily brought results related to engineering and environmental sciences, as well as various technological disciplines, to the BIM expression. Management discipline hit 11 cases, which means a rate of 3.33%.

As a comparison, we also looked at the distribution of European countries and the entire spectrum in scientific fields, which yielded similar results. Globally, the proportion of hits belonging to the management discipline is higher, it has been included in the top 10.

Our search for the V4 countries did not result in any legal or administrative results, nor did the European search results.

[18] 1st June 2023.

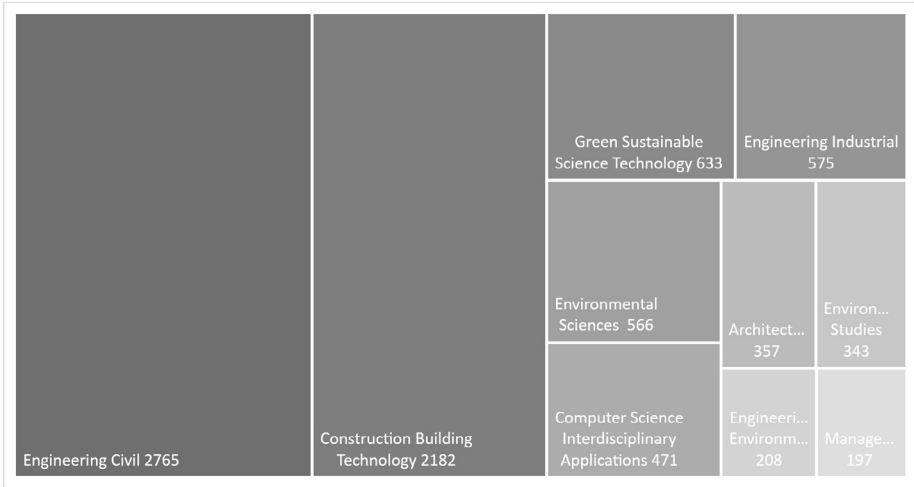


Figure 5: Distribution of scientific results worldwide containing BIM expression, showing the ten most relevant scientific areas (Source: Web of Science, own collection)

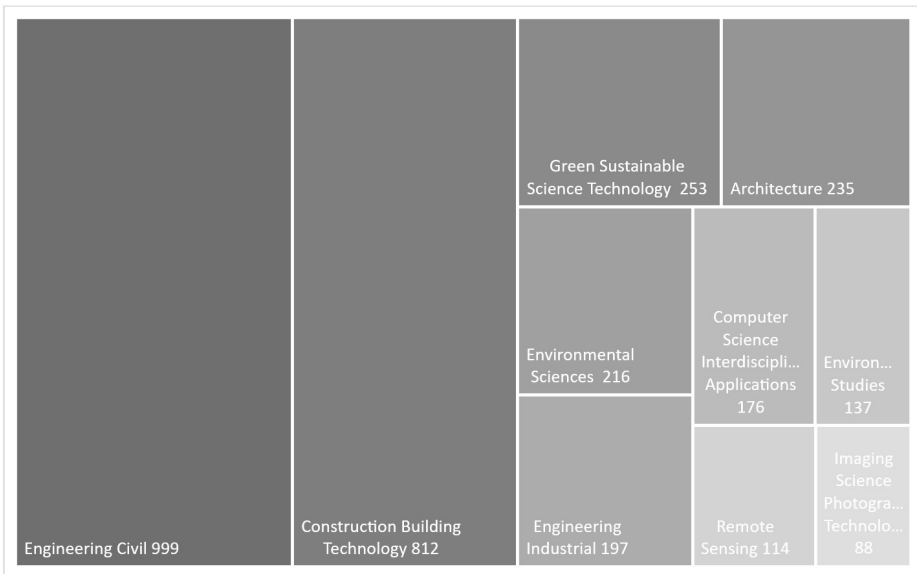


Figure 6: Distribution of scientific results related to European countries containing BIM expression, showing the ten most relevant scientific areas (Source: Web of Science, own collection)

V4 states			Worldwide			Europe		
WoS Categories	Record Count	% of 330	WoS Categories	Record Count	% of 4666	WoS Categories	Record Count	% of 1830
Engineering Civil	92	27.88	Engineering Civil	2765	59.26	Engineering Civil	999	54.59
Construction Building Technology	61	18.49	Construction Building Technology	2182	46.76	Construction Building Technology	812	44.37
Architecture	45	13.64	Green Sustainable Science Technology	633	13.57	Green Sustainable Science Technology	253	13.83
Environmental Sciences	33	10.00	Engineering Industrial	575	12.32	Architecture	235	12.84
Green Sustainable Science Technology	25	7.58	Environmental Sciences	566	12.13	Environmental Sciences	216	11.80
Remote Sensing	25	7.58	Computer Science Interdisciplinary Applications	471	10.09	Engineering Industrial	197	10.77
Urban Studies	24	7.27	Architecture	357	7.65	Computer Science Interdisciplinary Applications	176	9.62
Materials Science Multidisciplinary	21	6.36	Environmental Studies	343	7.35	Environmental Studies	137	7.49
Imaging Science Photographic Technology	19	5.76	Engineering Environmental	208	4.46	Remote Sensing	114	6.23
Computer Science Interdisciplinary Applications	18	5.46	Management	197	4.22	Imaging Science Photographic Technology	88	4.81

Table 2: Comparison of the distribution of scientific results containing BIM term in disciplines (Source: Web of Science, own collection)

V. BIM RESULTS IN V4 COUNTRIES

1. Poland

The use of BIM in Poland is optional. According to Zima et al.^[19] and PlanRadar, in 2019, 43% of design and construction companies said they use BIM.^[20] Surveys conducted by Autodesk in 2015 and 2019 show that BIM literacy rates have increased significantly for both design firms and public actors.^[21] For the period up to 2019, the Polish Ministry of Construction reported the implementation of 70 state projects in BIM in public buildings, road and infrastructure investments.

BIM was introduced in 2014 with the Polish Public Procurement Act. The law obliged the President of the Polish Public Procurement Authority to prepare and publish the model contract documents. The new PP guidelines of 2014 also helped with the implementation, primarily by preferring the quality evaluation criteria, in which innovative quality, functional, sustainability, social and innovation aspects and operating costs are covered through BIM.^[22] The method was initially intended to be used in the construction of the Jozef Pisludski Museum Complex in Sulejóweki and other building projects. State regulations on the early introduction of BIM were halted until 2020, when the Polish Ministry of Development, Technology and Labour published a roadmap for the phased mandatory introduction of BIM. The roadmap would introduce BIM for large investments from the state budget by 2030.^[23]

Poland has an accepted BIM standard (BIM Standard PL, PN-EN ISO 19650). There is a declared government intention for mandatory implementation, and it is more advanced than in Hungary, as the roadmap has also been adopted. Another similarity is that the driving force behind the spread of BIM is the private sector, with its actors voluntarily applying it. Legal work has already begun for its implementation, the main challenge of which was to include BIM in PP contracts. The government's goal is to achieve the greatest possible savings through BIM.

Among the international scientific publications we can find several excellent analyses with an economic approach on the topic.

Reizgevičius et al.^[24] examine the advantages of using BIM technologies from the point of view of design firms, using the method of return on investment (ROI). Their study concludes that there are economic reasons behind the slow implementation of BIM, which can be changed by private and public clients and policy. Policy must address not only implementation, but also financial and other incentives. In addition to buildings, they recommend BIM implementation ef-

[19] Zima – Plebankiewicz – Wieczorek, 2020, 10., 16.

[20] PlanRadar: BIM adoption in Europe..., 2021.

[21] Damassets: BIM – polska perspektywa.

[22] CMS: BIM Law and regulation in Poland.

[23] PlanRadar: BIM Adoption in Europe.

[24] Reizgevičius et al., 2018.

forts for other structures (bridges, engineering facilities, linear infrastructure), as the externalities in these areas are very high, which BIM offers excellent solutions to mitigate.

SWOT analysis was used by Zima et al.^[25] to examine the strategic implementation of BIM in the construction industry in Poland. The analysis showed that BIM is present on the Polish market, but its uptake is very slow. According to the authors, the best way to speed up the process is through an aggressive development strategy based on the full exploitation of strengths and opportunities. The promotion of BIM requires leveraging leading market players, creating incentives, and enhancing education and training for BIM professionals. The study identified three main reasons – two human and one financial – for BIM implementation in Poland: low levels of knowledge regarding BIM technologies, limited awareness of the benefits of BIM, and low construction documentation costs during investments that do not cover the costs associated with BIM implementation.

Gryzl et al.^[26] in their case study demonstrated that significant benefits, such as time savings in the design process can be achieved by using BIM even in smaller projects. The article challenges the general perception that BIM is more suitable for large projects and less effective for small and medium-sized buildings.

Lesniak et al.^[27] examined why BIM adoption and acceptance is much lower in Poland than in Western and Northern Europe. They saw an important obstacle in the regulation, which, in most cases, does not permit the use of electronic documents in the construction processes.

Walasek and Barszcz^[28] also investigated barriers to widespread BIM adoption. The authors pointed out that the introduction of BIM increases costs at the design stage, but at the same time brings the greatest benefit to the owner, so the decision and incentive of the owner is the main driver.

Wójtowicz^[29] presents the possibility of introducing BIM in Polish defence investments. Other recent studies include Kłapa and Gawronek's^[30] investigation into the application of BIM to monumental buildings. In the case of cultural heritage elements, BIM means not only a 3D model, but also an authentic recording of the current state, which is extremely important from the point of view of preservation and presentation. The European Commission is proposing that EU Member States carry out a digital 3D survey of at least 50% of their most visited monuments by 2030, which will also allow the faithful preservation of buildings in cyberspace.

[25] Zima et al., 2020.

[26] Grzyl et al., 2019.

[27] Lesniak et al., 2021.

[28] Walaseka – Barszcz, 2017.

[29] Wójtowicz, 2019.

[30] Kłapa – Gawronek, 2023.

2. Czech Republic

The introduction of BIM in the Czech Republic was driven by the need for more efficient construction management and project administration. A parallel was drawn between the 75% productivity increase achieved by the digitalization of the automotive industry and the possible digitalization solutions in the construction industry, as a result of which savings of 8-35% were indicated in the construction of transport facilities. An important milestone in the implementation process starting in 2016 was the PP regulation enabling the introduction of electronic solutions from 2016.^[31] STFI (the Czech organization responsible for transport infrastructure) informed market players that it intends to use BIM in its PPs, such as in the planning and implementation of transport infrastructure projects and conducted several pilot projects in 2017-2018. In 2017, a decision was made regarding the introduction of BIM.^[32] Therefore, the main intention behind implementation is to save costs. BIM is expected to save 20% on the strategy, which obviously applies to the construction period.^[33]

The next important milestone is 2022, when BIM was made mandatory for public works worth more than €5.7 million, as well as their design and documentation work.^[34]

Professional working groups on various BIM topics also played an important role in the introduction of BIM in the Czech Republic. These groups brought together practitioners, representatives of science, and decision-makers.^[35] The working groups and their members were and are able to clash diverse professional viewpoints in connection with different aspects of BIM.

The Czech legislation introduced several international standards under the BIM CTS (Czech Technical Standard).^[36]

The progress of the Czech Republic's digitalisation transition in the construction industry and the government's commitment are confirmed not only by the search results, but also by the content of the currently available active PP notice-

[31] Government Resolution No. 958, 2nd November 2016.

[32] Ministry of Industry and Trade: „Concept of introducing the BIM method in the Czech Republic”, Decree no. 682. 26 September 2017.

[33] BIM Implementation Strategy in the Czech Republic, September 2017.

[34] Zak – Vitasek, 2018.

[35] Prušková, 2019.

[36] CTS ISO 12006-2: 2015 Building construction - Organization of information about construction works - Part 2: Framework for classification, CTS ISO 12006-3: 2014 Building construction -- Organization of information about construction works -- Part 3: Framework for object-oriented information, CTS ISO 16354: 2014 Guidelines for knowledge libraries and object libraries, CTS ISO 22263: 2014 Organization of information about construction works -- Framework for management of project information, CTS ISO 29481-1: 2014 Building information models -- Information delivery manual -- Part 1: Methodology and format, CTS ISO 29481-2: 2014 Building information models -- Information delivery manual -- Part 2: Interaction framework, CTS ISO-TS 12911: 2014 Framework for building information modelling (BIM) guidance, CTS ISO 16739: 2014 Industry Foundation Classes (IFC) for data sharing in the construction and facility management industries.

es. For example, in 2022, the Ministry of Foreign Affairs launched a purchase of computer-aided facility management services (CAFM) worth CZK 6 million. This service enables the preparation and management of construction, technological and technical passports for buildings, automating planned and extraordinary maintenance, as well as building management processes. This is specifically intended to meet the requirements of the upcoming Building Information Modelling Act, and it consistently seeks to leverage the use of the BIM model.

Zak and Vitasek's 2018 article presents the process and experiences of BIM implementation in the Czech Republic.^[37] The study emphasizes the key importance of the commitment of the public client. Based on the extensive experience gained in pilot projects conducted in cooperation with the ministry under the guidance of a professional working group, the state leadership itself has established the benefits and effectiveness of the introduction of BIM.

The difficulties and obstacles of BIM implementation are dealt with by Nývlt,^[38] then Matejka and Tomek,^[39] and Prušková.^[40] While in his 2015 study Nývlt identifies knowledge and information management as critical success factors (CSF) and grouped barriers to BIM adoption around the triad of education, government, and technology (including factors such as lack of senior management knowledge, training and software costs for implementation, divergent interests, legal uncertainty or professional resistance), in 2019, Prušková examines some key topics to motivate AEC actors to develop implementation proposals and guidelines, and introduce approval processes from legislation to internal regulators.

Wernerova et al.^[41] shows three different building projects of VŠB – Ostrava University of Technology in their case study. Among many others, this study also proves that in practice, organizational implementation can take place through a series of small steps, and the verification of BIM procedures and methods can provide clear lessons.

Matejka and Tomek^[42] provides an excellent overview of BIM ontology, introducing the distinction between BIM as a product, as modelling, and as an approach. Recognizing that BIM users have limited knowledge of the system, as each user is acquainted with only their specific part, creates an epistemically problematic environment around BIM.

There are also several studies from an economic perspective in the Czech scientific literature. BIM's 5D model and cost estimation solutions are constantly evolving, and each has its own application, advantages and disadvantages.^[43]

[37] Zak – Vitasek, 2018.

[38] Nývlt, 2018.

[39] Matějka – Tomek, 2017.

[40] Prušková, 2019.

[41] Wernerová et al., 2020.

[42] Matějka – Tomek, 2017, 1080-1087.

[43] Matejka – Vitasek, 2018.

Vitasek^[44] investigates BIM costing schemes for transport projects. By linking graphic solutions to classification, the 5D model can provide direct information about the project budget, allowing for a more accurate consideration of fit into the local pricing system and budgeting practices.

The BIM approach can be implemented not only at the level of individual facilities, but also on a large scale. Kramářová and Prušková^[45] deal with BIM solutions for brownfield projects. A topical and sensitive subject for policymakers is the management of brownfield investments, which can be successful with BIM solutions. Kořínek et al.^[46] published on the need to develop Digital Twins models for smart cities.

The relationship between life-cycle analysis (LCA) and BIM model was researched by Veselka et al.^[47] case study, in which the authors conclude that Czech markets and legislation are mature enough and ready to implement BIM. It is proposed to link the SBToolCZ green certification – the Czech equivalent of BREEAM or LEED – to the BIM model. Two important lessons can be drawn from the LCA-BIM context. Incorporating basic environmental data into a BIM model is a simple and easily repeatable process, which would need to be prescribed and introduced, as it would also enable more sustainable facility management solutions.

Among the very recent publications, Shults^[48] case study focuses on civil engineering structures and introduces a new concept of geospatial monitoring. Stančík et al.^[49] points to the excellent potential of using BIM in evacuation planning. Seligová et al.^[50] introduces R-WIM (Rain–Water Information Management/Modelling), which provides a BIM solution for precipitation management within urban water infrastructure, which can be an effective solution for municipalities to simulate and find suitable technical solutions.

In his study, Macek^[51] draws attention to the fact that the BIM model can also be used during the tendering of facility management services, since the BIM model spans both the implementation and operation phases. Since the ultimate goal of BIM is cost optimization throughout the entire life cycle of a construction project, this is also relevant during the period of operation and maintenance. The author points out that the largest FM companies in the Czech Republic do not participate in PP procedures due to their depressed prices. During PPs, the criterion of the lowest price is prioritised in the Czech Republic. Against this, the author proposes incorporating professional aspects, including the application of BIM, which he supports by analysing previous Czech FM tenders.

[44] Vitasek, 2020.

[45] Kramářová – Prušková, 2018.

[46] Kořínek et. al., 2021.

[47] Veselka et. al., 2019.

[48] Shults, 2022.

[49] Stančík et al., 2018.

[50] Seligová et al., 2023.

[51] Macek, 2023.

3. Slovakia

In Slovakia, using BIM methods is not mandatory. There are no related standards or classifications.

In 2018, a survey was conducted to assess the current state of BIM application in Slovakia, in which only 15% of the 350 surveyed companies– target cost managers specifically – provided feedback. 77.4% of respondents do not use BIM, while 67.7% have never encountered such a solution.^[52] In 2017, construction project managers were surveyed. 24.71% of the respondents use BIM technology in their work, and 89.34% reported that BIM solutions have helped reduce costs.^[53]

According to the comprehensive research conducted by the Slovak BIM Association in 2021, 38% of the respondents identified the lack of standards as a significant obstacle to BIM implementation. Other challenges reported include higher costs (36%), a shortage of specialists (31%), insufficient time and resources (29%), inadequate customer demands (29%), and a lack of specialized BIM training (19%). Mayer et al.^[54] discusses critical success factors for implementing BIM projects. Lack of experience with BIM projects results in dissatisfied actors and substandard projects on both the demand and supply sides.

In connection with the above, there are several publications related to Slovakia in the field of construction management (CM), education and training,^[55] as well as on the 5th dimension of BIM.^[56] In many cases, these publications provide comparisons to Czech or other Central European solutions.

In the Slovak PP market, BIM approach has only made a marginal appearance. The design and construction tenders according to BIM technology were related to building construction projects. But in 2023 we find road construction and design tasks among the tenders for the first half of the year. It is worth mentioning that five public tenders using BIM have been published so far in 2023, the same number as the total number of procedures in the previous three years.

4. Hungary

The application of the BIM method is not mandatory in Hungary, but it is not without precedent. Based on their own business considerations, pioneering ACE actors already apply BIM methodology in their design, production and construction processes and have developed their best practices. Some large investors and operators are also benefiting. However, data on prevalence so far

[52] Mesároš et al., 2019.

[53] Mesároš et al., 2017.

[54] Mayer et al., 2021.

[55] Kolarić et al., 2018; Mandičák et al., 2018.

[56] Mesároš, et al., 2019.

are scarce. According to a non-representative survey conducted in 2017, more than half of respondents have already used BIM processes on the ACE corporate side. Another 30% of companies planned to try BIM in the near future. Among the respondents, 65% of private investment actors have already used BIM-based solutions, while only 35% of public investment actors (contracting authorities) have already used BIM-based solutions.^[57]

As our statistics above show, the use of BIM in PP appeared in very small numbers, and only in building construction.

At the same time, the intention to digitalize has been explicitly present among the government's goals since 2015.^[58] The publication of the Hungarian BIM standard in 2019 was a major achievement, which introduced a unified conceptual system, defined the principles related to the BIM method, and defined the standards for the implementation phase of facilities.^[59] Development has been launched to set up a 3D-based public building cadastre, and to establish the state and state public building registers for more cost-effective room management and operation.^[60] Today, there is a very concrete government intention to introduce BIM for public works, buildings, facilities and public utilities as well, based on PP.

The planned transformation of the Hungarian construction sector is imminent. The reform is planned to be implemented by two new codes: the Act on Architecture and the Act on the Order of Public Works. These two acts are currently being discussed and have not yet been adopted. The proposed changes aim, *inter alia*, at concentrating construction management, implementing investments reaching the national threshold under state management, in a regulated order with designated actors. The objective is to change the landscape for accessing public investments in the spirit of transparency, establishing a uniform and transparent order in investment processes, strengthening cooperation, trust and predictability among investment actors. and All of this is framed in the spirit of responsibility for present and future generations, with a commit-

[57] Architects' Forum, 05.12.2017.

[58] Government Decision No 1398/2019 (VII.4.) amending Government Decision No 1031/2018 (II.8.) on the strategy aimed at the general development of the construction economy, the domestic production of building materials and the extraction of raw materials in the domestic construction industry, and on providing funding for increasing the efficiency of domestic construction enterprises; Government Decision No. 1567/2015 (IX.4.) on the action plan aimed at the transformation of the construction sector and the related tasks.

Government Decision No. 1567/2015 (IX.4.) prescribed the establishment of the National BIM (Building Information Modelling) standard within the scope of specific tasks in order to establish the state public building cadastre, its sustainable operation and its continuous filling with reliable and up-to-date data.

Government Decision No. 1398/2019 (VII.4.) envisaged the examination of the possibility of making the use of building information planning (and Design & Build construction mandatory) for the general development of the construction economy, above a certain public procurement threshold.

[59] MSZ EN ISO 19650-1 and MSZ EN ISO 19650-2.

[60] Lechner Tudásközpont: ÁKÉK – Korszerű középület-nyilvántartás 3D támogatással, 2019.

ment to “take part in the implementation of economically and environmentally sustainable, low-cost-effective construction projects with low environmental impact”.^[61] The Investment Framework Law proposal authorises the Minister responsible for construction and transport to develop a building information model (BIM) based system for public works projects, and to regulate the application and scheduled implementation in a decree. Based on the general justification of the proposal, BIM serves primarily to monitor and transparently report the costs associated with construction works. The proposal stipulates that, once introduced, BIM will be mandatory for all public works above the EU threshold. According to the current government vision, BIM will be applicable throughout the life cycle of an investment.

The BIM approach across the entire life cycle is consistent with international literature findings. The ultimate goal of the interdisciplinary and holistic approach, as proposed by Kovács and Micsik, is to provide the actors and decision-makers of the project with the necessary information for making decisions at each milestone.^[62] Furthermore, we must not forget about the quality control function of BIM.^[63] Aldebei and Dombi^[64] propose the introduction of artificial intelligence and BIM in the context of the growing demand for raw materials in the construction industry and the recycling of construction debris. Urban mining requires extensive knowledge of the disused building stock, which can only be acquired through labour and time-consuming processes or new technologies, such as building information modelling.

Kiss and Szalay^[65] identifies BIM, which can integrate the method of LCA as a possible tool for the energy optimization of buildings. In their study, they set up a modular framework that can be integrated into the design process.

VI. CONCLUSIONS

Building Information Modelling is one of the fastest-growing fields of construction economics, both in terms of practical application and scientific research. According to our current knowledge, its development shows no sign of stopping. New doors are opening, as we are already at the 10th dimension. Of course, there is still a long way to implement BIM 10D, in general the entire industry digitalization. In any case, it is likely that classic 2D design work will slowly but surely be replaced by design in a 3D model, and this will increasingly appear in the PP markets of countries that do not yet use BIM. State and local

[61] Bill for the Order of Public Works (as of 03.04.2024) § 38.

[62] Kovács – Micsik, 2019.

[63] Kovács – Micsik, 2019.

[64] Aldebei – Dombi, 2021.

[65] Kiss – Szalay, 2020.

government customers recognize the advantages of BIM: more accurate cost planning, faster planning processes, efficient communication during design and construction, retrieval of accurate and authentic drawing and metadata, accuracy of cost planning, opportunities for sustainability and operational optimization, to name but a few. As Prušková writes, “The benefits that BIM can bring with its proper use are countless”.^[66]

The V4 countries are still behind the European pioneers (Great Britain, Finland, Denmark, Norway and the Netherlands) in the application of BIM, and the crisis of previous years did not contribute to catching up either. But they can draw on previous experiences and good practices, and use the elaborated standards, classifications and recommendations as models. So “there is no need for Hollywood BIM” (Matějkaa et al., 2017).^[67]

Among the V4 countries, Poland and the Czech Republic have already started to introduce BIM in their construction projects above a certain threshold and in related design services. In Hungary, mandatory introduction is imminent. Professional organizations in Slovakia are open to implementation.

The scientific literature of the specialty is concentrated in technical, environmental sciences, with a secondary presence in the field of management and economic sciences. Legal and administrative statements are typically contained in management and economic studies, while an independent legal approach can only be found in semi-literature materials (studies, recommendations, guidelines). However, the mandatory introduction of BIM is also a matter of legal policy and certainly raises regulatory and substantive problems. First, it is necessary to correctly and expediently define the scope of investments and the level of multi-layered BIM solutions where the mandatory implementation achieves the desired goals and benefits. The apparent additional labour and time requirements of BIM solutions are compensated by the achieved results, as proven by studies from a management point of view. PP challenges need to be addressed, in line with EU policy and policy objectives. Currently, BIM’s cost planning and cost-keeping goal is a general preference. In addition, several other solutions of BIM are especially useful for public clients in the long run. These are also supported by international literature, for example, in licensing processes, monument protection, in achieving sustainability goals through the integration of LCA, waste recovery and energy aspects, in optimizing maintenance and operation processes, but also in city operation or via real GIS data related building or utility cadastres.

[66] Prušková, 2019.

[67] Matějkaa – Tomek, 2017.

BIBLIOGRAPHY

- Aldebei, Faisal – Dombi, Mihály (2021): Mining the Built Environment: Telling the Story of Urban Mining. In: *Buildings*. Vol. 11/2021.
DOI: <https://doi.org/10.3390/buildings11090388> 388.
- Boros, Anita – Kovács, László (2022): Green Innovation in Construction Industry and in Public Works Procurement. In: *Hungary – Review. Journal of Central European Green Innovation*. 10(2), 18–36.
DOI: 10.33038/jcegi.3469.
- Boros, Anita (2019): The relationship between Hungarian construction and construction economy. In: *Civil Review*. Vol. 15/2019, Nos. 4-6, 100-119.
DOI: 10.24306/psz.2019.1208.
- Grzyl, Beata – Migda, Wojciech – Apollo, Magdalena (2019): Building Information Modeling in Small and Middle Sized Buildings – Case Study. In: *IOP Conf. Series: Materials Science and Engineering*. 603 (2019) 032077, IOP Publishing.
DOI: 10.1088/1757-899X/603/3/032077.
- Kiss, Benedek – Szalay, Zsuzsa (2020): Modular approach to multi-objective environmental optimization of buildings. In: *Automation in Construction*. Volume 111, March 2020, 103044.
DOI: <https://doi.org/10.1016/j.autcon.2019.103044>.
- Klapa, Przemysław – Gawronek, Pelagia (2023): Synergy of Geospatial Data from TLS and UAV for Heritage Building Information Modeling (HBIM). In: *Remote Sens*. 2023.
DOI: <https://doi.org/10.3390/rs15010128> 15, 128.
- Kolarić, Sonja – Mandičák, Tomáš – Vukomanović, Mladen – Mesároš, Peter (2018): BIM training in construction management educational practices in Croatia and Slovakia. In: Skibniweski, Mirosław J. – Hajdu, Miklós (eds.): *Creative Construction Conference 2018*. DOI: 10.3311/CCC2018-130.
- Kořínek, Milan – Tázlar, Ondřej – Štekerová, Kamila (2021): Digital Twin Models: BIM Meets NetLogo. In: *Hradec Economic Days*.
DOI: 10.36689/uhk/hed/2021-01-040.
- Kovács, Ádám Tamás – Micsik András (2019): Method for Evaluating a Building Information Model. In: *Periodica Polytechnica Civil Engineering*. 63(2).
DOI: <https://doi.org/10.3311/PPci.12563>.
- Kovács, Ádám Tamás – Micsik András (2021): BIM quality control based on requirement linked data. In: *International Journal of Architectural Computing*. Vol 19. Issue 3. 13 May 2021.
DOI: <https://doi.org/10.1177/14780771211012175>.
- Kramářová, Zuzana – Prušková, Kristýna (2019): Brownfield database in light of the BIM method. In: *MATEC Web of Conferences* 279, 01013 (2019).
DOI: <https://doi.org/10.1051/mateconf/201927901013> Building Defects 2018.
- Lesniak, Agnieszka – Gorka, Monika – Skrzypczak, Izabela (2021): Barriers to BIM Implementation in Architecture, Construction, and Engineering Projects – The Polish Study. In: *Energies*. Vol. 14/2021
DOI: <https://doi.org/10.3390/en14082090>.
- Lindblad, Hannes – Guerrero, Jacob Rudolphsson (2020): Client's role in promoting BIM implementation and innovation in construction. In: *Construction Management and Economics*. 38:5, 468-482.
DOI: 10.1080/01446193.2020.1716989.
- Lindblad, Hannes – Gustavsson, Tina Karrbom (2021): Public clients ability to drive industry change: the case of implementing BIM. In: *Construction Management and Economics*. 39:1, 21-35.
DOI: 10.1080/01446193.2020.1807032.

- Macek, Daniel (2023): Use of BIM as a Support for Tendering of Facility Management Services. In: *Buildings*. Vol. 13/2023.
DOI: <https://doi.org/10.3390/buildings13030664>.
- Mandičák, Tomáš – Mesároš, Peter – Tkáč, Matúč (2018): Impact of management decisions based on managerial competencies and skills developed through BIM technology on performance of construction enterprises. In: *Pollack Periodica*. Volume 13: Issue 3. DOI: <https://doi.org/10.1556/606.2018.13.3.13>.
- Matejka, Petr – Vitasek, Stanislav (2018): Comparison of different cost estimation methods with use of building information modelling (BIM). In: *Engineering For Rural Development*. Jelgava, 23.-25.05.2018.
DOI: 10.22616/ERDev17.2018.N154.
- Matějka, Petr – Tomek, Aleš (2017): Ontology of BIM in a Construction Project Life Cycle. In: *Creative Construction Conference 2017*. CCC 2017, 19-22 June 2017, Primosten, Croatia. In: *Procedia Engineering*. Vol. 196/2017.
DOI: 10.1016/j.proeng.2017.08.065.
- Mayer, Pavol – Funtík, Tomáš – Eredélyi, Ján – Honti, Richard – Cerovšek, Tomo (2021): Assessing the Duration of the Lead Appointed Party Coordination Tasks and Evaluating the Appropriate Team Composition on BIM Projects. In: *Buildings*. Vol. 11/2021. DOI: <https://doi.org/10.3390/buildings11120664>.
- Mesároš, Peter – Mandičák, Tomáš (2017): Exploitation and benefits of BIM in Construction Project Management. In: *IOP Conf. Series: Materials Science and Engineering*. 245 (2017) 062056. DOI: 10.1088/1757-899X/245/6/062056.
- Mesároš, Peter – Smetanková, Jana – Mandičák, Tomáš (2019): The Fifth Dimension of BIM – Implementation Survey. In: *IOP Conf. Series: Earth and Environmental Science*. 222 (2019) 012003 IOP Publishing.
DOI: 10.1088/1755-1315/222/1/012003.
- Nagy, Orsolya – Papp, Ilona – Szabó, Roland Zsolt (2021): Construction 4.0 Organisational Level Challenges and Solutions. In: *Sustainability*. Vol. 13/2021, 12321.
DOI: <https://doi.org/10.3390/su132112321>.
- Nývlt, Vladimír (2018): The role of managing knowledge and information in BIM implementation processes in the Czech Republic. In: *MATEC Web of Conferences* 146, 01003 (2018). DOI: <https://doi.org/10.1051/mateconf/201814601003>. Building Defects 2017.
- Prušková, Kristýna (2019): Beginning of Real Wide use of BIM Technology in Czech Republic 2019 IOP Conf. Ser.: Mater. Sci. Eng. 471 102010 IOP. In: *Conf. Series: Materials Science and Engineering* 471 (2019) 102010 IOP Publishing.
DOI: 10.1088/1757-899X/471/10/102010.
- Reizgevičius, Marius – Ustinovičius, Leonas – Cibulskiene, Diana – Kutut, Vladislavas – Nazarko, Lukasz (2018): Promoting sustainability through investment in Building Information Modeling (BIM) Technologies: A design company perspective. Published: 26 February 2018. In: *Sustainability* 2018, 10, 600. DOI: 10.3390/su10030600.
- Seligová, Natalie – Faltejsek, Michal – Teichmann, Marek – Kuda, Frantisek – Endel, Stanislav (2023): Potential of Computed Aided Facility Management for Urban Water Infrastructure with the Focus on Rainwater Management. In: *Water* 2023, 15, 104. DOI: <https://doi.org/10.3390/w15010104>.
- Shafei, Hazwani – Radzi, Afiqah R. – Algahtany, Mohammed – Rahman, Rahimi A. (2022): Construction 4.0. Technologies and Decision-Making: A Systematic Review and Gap Analysis. In: *Buildings*. 2022, 12, 2206.
DOI: <https://doi.org/10.3390/buildings12122206>.

- Shults, Roman (2022): Geospatial Monitoring of Engineering Structures as a Part of BIM. In: *The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences*, Volume XLVI-5/W1-2022 Measurement, Visualisation and Processing in BIM for Design and Construction Management II, 7–8 Feb. 2022, Prague, Czech Republic. DOI: <https://doi.org/10.5194/isprs-archives-XLVI-5-W1-2022-225-2022>.
- Siniak, Nikolai – Žróbek, Sabina – Nikolaiev, Vsevolod – Shavrov, Sergey (2019): Building Information Modeling for Housing Renovation – Example for Ukraine. In: *Real Estate Management and Valuation*. Vol. 27/2019, no. 2. DOI: 10.2478/remav-2019-0018.
- Stančík, Adam – Macháček, Roman – Horák, Jiří (2018): Using BIM model for Fire Emergency Evacuation Plan. In: *MATEC Web of Conferences* 146, 01012 (2018). DOI: <https://doi.org/10.1051/mateconf/201814601012>.
- Stepper, Péter (2022): Political theoretical explanation(s) of V4 cooperation. A structuralist alternative to functionalist integration theory. In: *Foreign Affairs Review*. 1.1.2022.
- Tateyama, Kazuyoshi (2017): A new stage of construction in Japan. i-Construction. In: *IPA News Letter*. Volume 2, Issue 2 June 2017.
- Veselka, Josef – Růžička, Jan – Lupíšek, Antonín – Hájek, Petr – Mančík, Štěpán – Žďára, Vladimír – Široký, Martin (2019): Connecting BIM and LCA: The Case Study of an Experimental Residential Building. Sustainable Built Environment Conference 2019 (SBE19 Graz). In: *IOP Conf. Series: Earth and Environmental Science* 323 (2019) 012106 IOP Publishing. DOI:10.1088/1755-1315/323/1/012106.
- Vitasek, Stanislav (2020): Further Steps in Application of BIM for Budgets of Transportation Constructions. In: *Engineering for Rural Development*. Jelgava, 20.-22.05.2020.
- Walaseka, Dariusz – Arkadiusz Barszcz (2017): Analysis of the adoption rate of Building Information Modeling [BIM] and its Return on Investment [ROI]. In: *Procedia Engineering* 172 (2017) 1227 – 1234. DOI: 10.1016/j.proeng.2017.02.144.
- Wernerová, Eva – Endel, Stanislav – Kutá, Dagmar (2020): Implementation of the BIM Method at the VŠB - Technical University of Ostrava International. In: *Journal of Engineering Research in Africa*. ISSN: 1663-4144, Vol. 47. 2020-03-17. DOI:10.4028/www.scientific.net/JERA.47.133
- Wójtowicz, Maciej (2019): Design and Execution of Building Investments Using BIM Technology for Facilities Subject to The Polish Military Administration. In: *AIP Conference Proceedings* 2078, 020103 (2019). DOI: <https://doi.org/10.1063/1.5092106>.
- Zak, Josef – Vitasek, Stanislav (2018): Bim Superior Approach for Infrastructure Construction in the Czech Republic. In: *Engineering For Rural Development* Jelgava, 23.-25.05.2018.
- Zima, Krzysztof – Plebankiewicz, Edyta – Wieczorek, Damian (2020): A SWOT analysis of the use of BIM technology in the Polish construction industry. Published: 20 January 2020. In: *Buildings*. Vol 10/2020, 16. DOI:10.3390/buildings10010016.

SOURCES OF LAW

- Czech Government Decree no. 682. 26 September 2017. “Concept of introducing the BIM method in the Czech Republic” (Available at: <https://www.mpo.cz/en/construction-and-raw-materials/bim/concept-of-introducing-the-bim-method-in-the-czech-republic---233659/>. Downloaded on: 01.06.2023).
- Czech Government Resolution No. 958, 2nd November 2016.
- Hungarian Government Decision No 1398/2019 (VII.4.).
- Hungarian Government Decision No. 1398/2019 (VII.4.).
- Hungarian Government Decision No. 1567/2015 (IX.4.).

OTHER SOURCES

- Architects’ Forum research, 05.12.2017. (Available online: <http://epiteszforum.hu/megerkezett-a-lechner-tudaskozpont-bim-kerdoivenek-eredmenye>. Downloaded on: 01.06.2023).
- BAMB Buildings As Material Banks (BAMB2020)—BAMB 2015. (Available at: <https://www.bamb2020.eu/>. Downloaded on: 01.06.2023).
- BIM Implementation Strategy in the Czech Republic, September 2017. (Available at: https://www.mpo.cz/assets/en/construction-and-raw-materials/bim/2019/3/Koncepcie-zavadeni-metody-BIM-v-CR_EN.pdf. Downloaded on: 01.06.2023).
- CCAM documents. (Available at: <https://www.ccam.eu/what-is-ccam/ccam-association/>. Downloaded on: 01.06.2023).
- CMS documents. (Available at: <https://cms.law/en/int/expert-guides/cms-expert-guide-to-building-information-modelling-bim/poland>. Downloaded on: 01.06.2023)
- CTS ISO 12006-2.
- Damassets: BIM – Polska perspektywa. Autodesk researches. (Available at: https://damassets.autodesk.net/content/dam/autodesk/www/campaigns/bim-event/BIM_raport_final.pdf. Downloaded on: 01.06.2023).
- Handbook for the introduction of Building Information Modelling by the European Public Sector. EUBIM Working Group. (Available at: <http://www.eubim.eu/>. Downloaded on: 01.06.2023).
- Hungarian Bill for the Order of Public Works.
- Lechner Tudásközpont: ÁKÉK – Korszerű középület-nyilvántartás 3D támogatással, 2019. (Available at: <http://bim.lechnerkozpont.hu/hu/aktualis/akek-korszeru-kozepulet-nyilvantartas-3d-tamogatassal>. Downloaded on: 01.06.2023).
- Madaster Madaster—The Digital Library of Materials. (Available at: <https://madaster.com/>. Downloaded on: 01.06.2023).
- Memorandum of Understanding among the V4 states. (Available at: <https://www.visegradgroup.eu/download.php?docID=498>. Downloaded on: 01.06.2023).
- MSZ EN ISO 19650-1 and MSZ EN SIO 19650-2.
- PlanRadar: BIM adoption in Europe: 7 countries compared. (Available at: <https://www.planradar.com/gb/bim-adoption-in-europe/>. Downloaded on: 01.06.2023).
- Rolling Plan for ICT standardisation. (Available at: <https://joinup.ec.europa.eu/collection/rolling-plan-ict-standardisation/construction-building-information-modelling>. Downloaded on: 01.06.2023).