Survey of Accomplishments in BIM Implementation in Croatia, the Czech Republic, Germany, and Slovenia

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SURVEY OF ACCOMPLISHMENTS IN BIM IMPLEMENTATION IN CROATIA, THE CZECH REPUBLIC, GERMANY, AND SLOVENIA

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Abstract: Building information modelling (BIM) may currently be considered the fastest developing concept in the field of construction management, aiming to become a global standard. Although the roots of the concept date back to the mid-1970s, some original expectations are still missing from its implementation. There has been a time gap between its theoretical and practical implementations. While the simultaneous development of information technologies is one reason for the implementation delay, other reasons remain unclear. This paper analyzes the gaps between theoretical and practical BIM application, as well as the legislation regarding BIM implementation in four countries (in alphabetical order: Croatia, the Czech Republic, Germany, and Slovenia). The paper additionally presents a survey of current practical BIM applications as well as general and theoretical feedback from construction projects that implemented BIM.

Keywords: BIM; construction industry; implementation; project management; survey

PREGLED DOSTIGNUĆA PRIMJENE BIM KONCEPTA U HRVATSKOJ, ČEŠKOJ, NJEMAČKOJ I SLOVENIJI

Sažetak: Jedan od najbrže razvijajućih koncepata u domeni metoda i alata za upravljanje građevinskim projektima, uz konačni cilj da postane globalni standard, je informacijsko modeliranje građevina, tj. BIM. Iako se koncept razvija od sredine 1970-ih, neka od originalnih očekivanja u njegovoj primjeni i danas nedostaju. Očito je da postoji vremensko odstojanje između njegove teorijske i praktične primjene. Istovremeno, razvijanje nužnih alata informacijske tehnologije je jedan od razloga zašto praktična primjena zaostaje, no ostali razlozi su još nejasni. U ovome radu autori analiziraju razlike između teoretske i praktične primjene BIM-a u zemljama odakle dolaze (Hrvatske, Češke, Njemačke i Slovenije). Rad predstavlja pregled trenutačnih dostignuća primjene BIM-a te povratnih informacija s projekata na kojima je BIM primijenjen.

Ključne riječi: BIM; građevinarstvo; implementacija; pregled; upravljanje projektima



1 INTRODUCTION

Building information modelling (BIM) may currently be considered the fastest developing concept in construction management. It focuses on construction market globalization, corresponding with the general trend towards globalization, and follows the also fast–developing information technology sector [1]. It has, however, been a while since Chuck Eastman [2] presented the revolutionary idea of BIM, and it is time to make a breakthrough towards matching expectations, potentials, and feasible practical outcomes. Asymmetry remains between the understanding and expectations of construction project stakeholders using BIM. Some authors define BIM as a 3D presentation of information gathered and compressed into a model by which a building should be constructed [3, 4], whereas others define it as a platform for integrating and visually presenting project management (PM) tools [5, 6]. Still other authors say BIM is changing the use of construction PM tools, stakeholders, contracting, and concepts by acknowledging and merging project life cycle phases [3, 7, 8], in practice becoming a modern PM tool itself. In addition to the different stakeholder and researcher perspectives on BIM, there are different levels of BIM acceptance among well-developed AEC industries (in the USA, EU, Australia, etc.).

Regardless of its global acceptance, BIM is developing on a local level wherein countries develop their own strategies based on previous global experiences and their AEC industry circumstances. In 2014, the EU commission issued directive 2014/24/EU [9], which recommends member states use building information electronic modeling tools in public construction projects. This clearly suggests a trend towards a unique construction market in the EU enhanced by BIM–based methodologies. However, there are significant differences in BIM acceptance levels across the EU, clearly demonstrated by the fact that BIM has been mandatory in northern EU countries (such as Finland, Denmark, and the UK) for almost a decade whereas the legislative framework for BIM is still a matter of discussions and pilot projects in other nations.

Motivated by the trend of "learning on experiences" in terms of gradual BIM implementation, this paper presents a review of the current levels of BIM implementation in several countries (in alphabetical order: Croatia, the Czech Republic, Germany, and Slovenia). These reviews of BIM acceptance, listing relevant BIM–concerning initiatives, national projects groups, standardization initiatives, legislation framework, relevant scientific achievements, and literature, were performed by authors from each country. The discussion and conclusions section presents the overall research findings both generally and for each analyzed country.

2 BIM IN CROATIA

Since the recession in 2008, which had strong negative impact on construction, the Croatian AEC industry has been undergoing a type of reengineering focused on lean and automated construction processes [10]. As such, BIM has drawn attention in Croatia. Given its strengths in constructability, Croatian AEC oriented scientific, educational, and professional circles are generally aware of the potential and nigh–inevitability of BIM implementation in the future [11]. However, as with any new concept, the aforementioned circles are reluctant to adopt and implement, an obvious trend observed with CAD adoption in Croatia. Even though Croatia has well developed and organized AEC–focused professional associations and chambers, including general guidelines for the practical implementation of BIM published by the Croatian chamber of civil engineers in 2017 [12], BIM was and still is primarily emphasized and developed in scientific and educational circles. There is still no sign of BIM in Croatian construction legislation. However, there are active initiatives making the first steps towards standardizing BIM with the Croatian Standards Institute.

The first articles published in Croatia regarding BIM were on OTMC in a 2011 conference [13, 14]. The first related journal article published in Croatia was presented in 2013, concerning the prospects of adopting BIM for housing refurbishment projects in the UK [15]. In the following year, numerous BIM–related papers were published in Croatian publications and/or by Croatian authors, clearly signaling that BIM became a relevant topic in Croatia. Literature has been published presenting the relationship between BIM and project management from the perspective of stakeholders in the EU [8, 16], including an approach for implementing BIM in deconstruction projects, and [17] published an article with a quantitative proof that the main obstacle to practical BIM implementation is not its cost, but rather the lack of preexisting computational skills and knowledge, as well as a lack of awareness of its potential. The same year, [18] presented a paper on BIM applications in project monitoring by gathering and filtering construction photo data.



At the Croatian Civil Engineers' forum in 2014, [19] was presented regarding the improvement potentials and educational achievements in Croatian civil engineering faculties achieved by embracing BIM and incorporating it into study programs. The authors of the aforementioned paper underlined the necessity of multidisciplinary structured teams for structuring national frameworks and regulations, which would ease the transition of BIM from educational to practical uses, a conclusion shared by the authors of [20] as well. These theses were partially confirmed in the research published in [21], which revealed Croatian AEC practitioners are familiar with the concepts of BIM but in most cases have not yet implemented it in their projects. An analysis of BIM applications and its reliability in construction element load analyses was presented in [22] with a simple methodology for expanding the application concepts. Alongside the adoption of BIM in study programs at some Croatian faculties, there have been seminars, programs, and workshops organized by private companies as life–long learning seminars for practitioners and students, primarily oriented towards BIM tools (e.g. Autodesk, Graphisoft, etc.).

In recent years, the Croatian Association of Civil Engineers and Croatian Chamber of Architects and the Croatian Standards Institute have begun structuring multidisciplinary task groups (i.e. subcommittee TU B1) with the goal of creating national guidelines for BIM that will serve as a path for its implementation in the Croatian AEC industry. Unfortunately, feedback from executed BIM pilot projects in Croatia is either missing or insufficiently transparent for use as a tool in "learning on projects," further BIM development, or as supporting ground for BIM implementation in the Croatian construction industry.

3 BIM IN THE CZECH REPUBLIC

The current state of BIM methodology implementation in the Czech Republic is closely related to the status of BIM methodology as a relatively new issue in the country. Despite the promotional efforts of academics, some public organizations, and experts, BIM is not commonly used in practice. One of the first public organizations dealing with BIM was the Czech BIM Council [23]. This organization was founded in 2011 and was the primary trigger for discussions regarding the appropriateness of BIM methodology.

The first annual conference called "BIM Day" was organized by the Czech BIM Council (czBIM) in 2011 in Prague. At this conference, international experts from the Netherlands, Switzerland, the United Kingdom, Norway etc. gave lectures to participants in the field of BIM between 2011 and 2016. Since its inauguration, the conference has become a major annual event in the BIM field in the country. BIM Day 2017 featured exclusively Czech speakers for first time, indicating an increase in BIM projects and pilot experiments solved by companies and experts in the last few years. Over time, other annual conferences have appeared in the Czech Republic including "BIM in the construction industry," "BIM Revit Forum," and most recently "BIM and cost estimation." All these conferences bring together parties and experts interested in BIM. However, it should be noted they have very similar points of interest. Another public conference founded in the same year, called the BIM-Forum [24], focused on the uses, standards, and current trends of Autodesk Revit software. Given these developments, it can be stated that BIM implementation started "from the bottom" in the Czech Republic, rather than from a government decision.

Several working groups for particular areas of BIM implementation have been established as part of czBIM. Working group PS #01 - Standards & Legislation was established first. This working group published a BIM handbook in 2013 [25] in cooperation with czBIM and the scientific center AdMaS, a part of the Brno University of Technology. This BIM handbook focuses on explaining the main aspects of BIM methodology, terminology, and implementation advantages and disadvantages. It also presents a possible connection to Czech legislation and standards. The second published document was the BIM continuity to the European Parliament and Council Directive 2014/24/EU public procurement and repealing Directive 2004/18/EC, published by the czBIM in 2014 [26]. It focused on structuring transparency in public procurements and integrating BIM as a tool to achieve this. The group czBIM PS#01 also translated the European standards for BIM, ČSN ISO 12006-2 and ČSN ISO 16757-1, into the Czech language.

The main objective of the working group PS#02 BIM & Teaching is to create a dialogue for teaching BIM across the educational system in the Czech Republic. This group gathers representatives from various universities and high schools to create implementation concepts for BIM education in the Czech Republic. This group aims to define the conceptual role of BIM in the educational system of the Czech Republic in three basic areas. The first area, called BIM Knowledge Area Definition, assumes that BIM as a field of knowledge is related to and frequently overlaps other areas without clear boundaries defining what is or is not defined as BIM knowledge. The second

area is devoted to creating a basic definition of BIM education that could be implemented in the current education system. The third area discusses how BIM could be implemented in the Czech education system.

The working group PS#03 BIM & Realization aims to connect construction companies, making the concept of BIM implementation common in construction practices. Members of this working group also prepare a basic non-graphical data content standard 3D model for each type of element specified by the level of development (LoD). One of the main goals of this working group is to define and assign LoDs to each stage of project documentation specified in Czech legislation. The members of this group are designers, construction contractors, and cost estimation experts. Furthermore, working groups PS#04, engaged in Transportation Engineering, and PS#05, focused on BIM & GIS connections, were established in 2017. The aim of these groups is also to prepare a data structure that can be used for creation, transmission, and data management in infrastructure construction and linear structures.

The first scientific contributions regarding BIM in the Czech Republic [27-29] were published in 2013. Contributions discussing construction company risk management [30, 31] constitute a substantial portion of BIM publications and preliminary BIM implementation research results. Results indicated 41% of respondents had already met or observed some project implemented utilizing BIM. Furthermore, 19% of respondents currently used BIM at work [32].

Czech construction projects implementing BIM are presented in the Table 1. The following table shows some examples where BIM was used for more than the design phase of the project.

Table 1 BIM pilot projects in Czech Republic

Name	Utilization	Start and Finish of the project	BIM Aspects
State Opera and administrative building	Historical building	2012 - 2019	Laser scanning; Creating BIM model from the point clouds; Collaboration in design phase; Modeling and visualization.
Subway - Line D, Prague	Pair of subway tunnels with 3 stations	2012 - 2023	Creating a 3D model of the building; Creating a continuous 3D model; Coordination of project participants
CSOB bank new headquarters	7 story offices	2015 - 2018	BIM execution plan for bank institution; Model implementation from the study phase; BIM model of construction; BIM model of HVAC; Upgrade CAD & CAFM systems; Use in facility management for planning effective office space use; Monitoring operational requirements and maintenance via QR codes, RFID chips.
Palmovka Park IV	7 story office building; 111 parking places; Area: 18200 m^2	2016 - at the design stage	BIM project; HVAC technology, coordination, bill of quantities; Also scheduled for use during the construction execution.

Some larger construction companies in the Czech Republic have introduced a new job position, the BIM manager. The BIM manager position can be defined as a hygienist of BIM models, because they input actual and correct information into models. It should be noted that these companies usually develop their own BIM Execution Plans (BEPs). These plans typically are not centrally harmonized with standards and legislation.

The implementation of BIM was supported by the Government Council for the construction industry. Government approval of this material confirmed the importance of BIM for the Czech construction industry. The government determined the Ministry of Industry is the coordinator for BIM implementation. A document compiled by the ministry called the Concept of Implementation of the BIM Method in the Czech Republic [33] was presented in June 2017. The concept was discussed with the BIM Inter-Ministerial Expert Group (MES BIM) established by the ministry. The document includes an analysis of the current state–of–the–art BIM and contains key themes such

as Construction 4.0, e-government, and smart cities. Other topics are BIM models and requirements for modeling features, a definition of BIM project documentation, and the connections between BIM and geographic information systems (GIS), national standards, copyright issues, public tender issues, facility management, teaching, etc. This document also defines the next workflow and time schedule for BIM implementation.

In the Czech Republic, standards are published by the Office for Technical Standardization. At the national level, a technical standardization committee called TNK 152 – Organization of Information on Buildings and Information Modeling of Buildings (BIM) started work in 2016 and will further elaborate upon BIM methodology standards.

4 BIM IN GERMANY

A study conducted by the Fraunhofer Institute for Industrial Engineering in 2015 analyzed applied planning tools and methodologies in Germany, and concluded that BIM use has not yet become standard. The majority of planners involved in the study were satisfied with 2D-files and traditionally based plans [34]. When determining whether this statement from 2015 is still valid, it is beneficial to look at BIM from a standardization perspective. A standard contains knowledge that is generally accepted by a number of representative experts [35]. This requires a general acceptance of a new method or technology. Typically, experiences with these innovations are collected by practitioners in the industry, promoted by different stakeholders, and, after a period of intense use on the market, can form a standard if commonly accepted. The quality of technical specifications (earlier stage) and standards (advanced stage) regarding BIM can be considered an indicator for assessing the level of implementation in the construction industry.

Being convinced of the advantages of BIM utilization, different initiatives are actively facilitating its use in Germany as well as internationally, making construction stakeholders familiar with BIM as a working methodology. These intentions are expressed in several formats including written recommended practices, guidelines based on practical analysis, and the policy of promoting nationwide entrepreneurial projects applying BIM. The common goal of all available programs appears to be low-threshold access to this specific digital construction process control. Thus, they can be regarded as a precursor to potential industry standard development.

The BIM-Guideline requires further discussion [36]. It was developed by an engineering brain trust and the Federal Ministry of Traffic, Construction, and Urban Development to describe a first approach to practical BIM use for German building owners, architects and engineers, building companies, software enterprises, and prefabricated component manufacturers. However, the BIM-Guideline cannot be classed with general information about software functions, judicial and regulatory construction measures, or the Fee Structure for Architects and Engineers. Conversely, this guideline defines BIM as a combined model–based collaborative working method involving all life-cycle phases of construction projects. It provides an overview of current applications in Germany as well as themes in business ventures, building authorities, and academic and professional education. The report clarifies the challenges connected with the responsibilities of all actors in a model alongside necessary organizational structures and data integrity within BIM–based construction projects. It contains also a simple BIM-implementation plan on an enterprise level [36]. Different requirements for stakeholders from planning and execution standpoints are mentioned alongside the advantages for operating companies in the utilization phase of projects. Technical references and background editing functions for the conjoint work of different actors are discussed. Thus, the reader receives practical support regarding the contents of BIM-settlement plans. According to necessity, the report incorporates data management references within the model and recommended model access instructions. The review summarizes the possibilities for software selection relating to their range of application and gives regulations for minimizing model collision risks. The essential advantages and structures of building information models are explained, informing the user about all types of professional models. Those contents give an overview of architectural, structural, and heating, ventilation, air conditioning and refrigeration (HVACR) exposition as well as extending cost and time dimensions [36].

In conclusion, the BIM-guideline recommends subjects for a prospective general BIM instruction to be developed by appropriate governmental institutions. It is recommended this instruction should broach the issues of BIM–methodology implementation by government authorities and further regulatory framework development [36]. In addition to public authorities, diverse associations are engaged in supporting nationwide, standardized BIM applications. The Association of German Engineers (VDI), as the major technical and scientific registered



engineering society, serves as an initial national developer for generalities. In January 2017, the VDI (row VDI 2552) published a policy row emphasizing the current activities of standardization concerning BIM utilization. It focused on the use of BIM models for activity quantity replication; the division of cost estimation, time scheduling, floating of tenders, and awarding of contracts in structure control; and the execution of construction work and accounting through all project phases. The target group consisted of participants in construction works who are willing to design processes with commonly usable data. This policy represents the German national standard within international standardization activities. The aim of national and international BIM-committees is to generate universally valid engineering standards applicable to and consistent with all national and international boards. Calls for tenders (public procurement), planning, construction work, and facility management should be executed based on this norm [37].

The German Institute for Standardization (DIN) is the national standards body and represents Germany in the official committees of the European (CEN) and international (ISO) standardization organizations. In those committees, BIM–related standards are developed to facilitate the use of BIM by providing harmonized interfaces, data structures, terminology, and processes. The necessity of converting BIM–related scientific results and practical experiences into commonly accepted standards resulted in the foundation of a new standardization committee at DIN focusing on exclusively BIM–related topics in April 2015. This can be understood as a major step in BIM development in the construction industry because it demonstrated that earlier innovations had now entered the market and were becoming more settled. All standardization efforts undertaken by different parties facilitate the collaboration of individual stakeholders in construction projects and are prerequisite for effectively implementing BIM in the AEC industry.

Alongside others related, two private sector initiatives are deeply involved in BIM implementation. The Building Smart e.V. is an association established in 1995 as an initiative of leading German design, execution and software companies to facilitate the use of model–based planning tools in construction. This initiative primarily focuses on the exchange of data between different parties in construction and missing or insufficient software interfaces for existing tools [38]. The second initiative, the Planen Bauen 4.0 GmbH, can be regarded as the central initiative for implementing digital processes in all organizations involved in the life-cycle of design, building, and operations in construction in Germany. Under the authority of the federal ministries for traffic and digital infrastructure (BMVI), a step–by–step plan for implementing BIM in all public infrastructure projects in Germany has been developed.

On the governmental side, the BMVI is an active player in BIM implementation in Germany. The ministry supports the idea of first building virtually by different means including, for example, funding research and pilot projects, legislation, and networking. The BMVI describes the public sector as one of the largest clients in construction, deriving from this the responsibility to support the cultural change BIM necessitates [39]. The BMVI established a reform commission for large construction projects to analyze the causes of delays and cost increases in some recent construction projects in Germany (e.g. Stuttgart 21, Berlin Airport, Elbe Philharmonic Hall in Hamburg, etc.). The final report produced by the commission generally regarded the use of digital methods like BIM as beneficial and, thus, recommended [40]. The BMVI has defined a public BIM implementation strategy, including structured planning stages alongside contractor and purchaser influences. BIM introduction is planned to last until 2020, with the demand of a special proficiency level 1 for BIM applications. Figure 1 shows three planning stages of the implementation strategy. Stage one was characterized by preparation and practice in pilot projects, standardization in education and advanced trainings, clarification of legal opinions, and the development of BIM–guidelines for precise utilization. From 2017–2020, stage two began with level 1 (as described below) aimed at advanced pilot projects, whereas stage three aims to implement level 1 across the field [39].

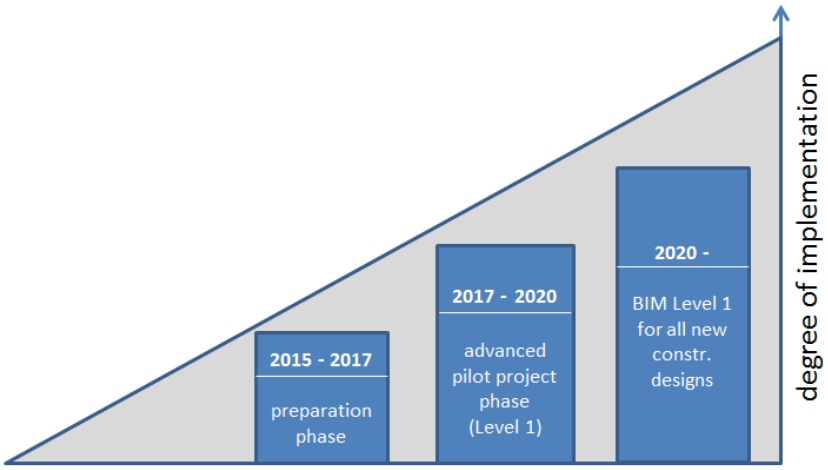


Figure 1: BIM implementation plan by federal ministry for traffic and digital infrastructure [39]

"Level 1" describes the minimum requirements which must be fulfilled by all public BIM projects beginning in 2020. It is the responsibility of government authorities to circulate these requirements as new tenders are floated. The requirements divide into three parts: data, processes and qualification. The requirements are shown in Table 2 [39].

A series of BIM pilot projects, also considered as BIM reference projects, has been conducted in Germany. Table 2 gives examples and outlines BIM aspects of special interest from these projects.

Table 2 BIM pilot projects [37, 38, 40-42]

Name	Utilization	Begin and end of project	BIM aspects
Office Center Pionierkaserne	4 stories; underground parking, offices and shops	October 2015 – Beginning of 2017	Collaboration between small- and medium sized companies.
Bürogebäude Haus H	5 stories office and seminar rooms seminar	August 2015 – End of 2016	Collaboration and as–built model to be used in operation phase (life cycle approach).
Viaduct Auenbach	Total length 290 m Span lengths 20 – 35 m	Beginning of 2015 – End of 2016	Collaboration of special planners. Single central model server. Quantity and cost estimation. Modeling and visualization. Model based scheduling.
Railway Viaduct Filstal	Total length 485 m Span lengths max 150 m	2014 -2021	Risk minimization; communication between stakeholders; development of role models for participants
Tunnel RASTATT	Total length 8.3 km Diameter: 10.6 m	5 years construction period	Transparency and visualization. Plausibility check of construction scheduling and resource allocation.

The coordinated preparation of BIM pilot projects allows knowledge for various project types to accumulate, thus facilitating the use of BIM in similar future projects. Additionally, research projects evaluating current BIM practices have been conducted. In 2013, a methodical approach was published by the Karlsruhe Institute of Technology. By addressing different enterprise groups within the construction branches (planners, construction firms, investors, and facility managers), researchers attempted to determine BIM method uses in Germany and the barriers facing this approach [43].

In Germany, a growing number of innovative companies have successfully executed construction projects by utilizing BIM–technologies. Whereas previous projects were primarily located abroad, the tendency to use BIM in national projects has increased. However, BIM is not yet used comprehensively in Germany [44]. This is generally confirmed by [45], who reported the incomplete adoption of BIM and incomplete capitalization of BIM benefits. Challenges relating to the submission and accounting of BIM–based construction projects and the experiences of

pilot projects will be used to provide the necessary guidance in these fields [40]. Furthermore, standardizations in terminology, procedures, and software interfaces are required for effective cooperation between stakeholders in BIM–based projects as well as regulations relating to model and data copyrights [37].

5 BIM IN SLOVENIA

A broader awareness of the varied benefits BIM brings to project management in the construction industry spread between Slovenian experts and academics years ago. Breakthrough ideas regarding the potentials of BIM were introduced to universities through scientific publications and scholar participation in international conferences. Several years back, Slovenian universities adopted BIM topics into the curricula of their civil engineering study programs, and learning contents are now periodically supplemented accordingly to current developments.
Mutual collaboration between universities and industry quickly revealed the requirement for an integrated BIM approach in construction operations. For instance, some early BIM–based projects such as DEGRIP [46] and jaBIM [47] were even supported by Slovenian Human Resources Development and Scholarship Fund, which acts within the European Social Fund framework. The outputs of the DEGRIP project provided 3D and 4D models for underpasses in Grlava and Ljutomer, whereas the implementation of the jaBIM project provided a BIM model for the Vinarium Tower in Lendava containing equal informational dimensions (see Figure 2).



Figure 2 Grlava underpass (DEGRIP project) [46] and Vinarium Tower (jaBIM project) [47]

In practice, some relatively satisfactory attempts to introduce the BIM approach to Slovenian construction firms have been made. However, those BIM applications, which proved to be effective, were usually achieved notwithstanding the absence of particular investor demands or state instructions, and were generally performed as single projects with no specific guidelines for the further use of acquired models. Nevertheless, the BIM paradigm is steadily expanding into the Slovenian construction sector and such developments are mostly guided by the requirement for improved business performance.

The establishment of the BIM Association Slovenia (siBIM) in 2015 [48] appears to signify a more intensive shift in the systematic introduction of the BIM approach in Slovenia. The siBIM Association was developed as a voluntary, independent, and non-profit organization connecting experts from academia and industry who are active in the BIM field. Its main objective is to provide professional development, training, networking, socializing, and experience–based collaboration. The previously mentioned association now consists of over 135 members from the academic community, government, and companies. Two successful conferences were recently organized by siBIM association, the siBIM2015 [49] and siBIM2016 [50], including a BIMathlon event [51].

The first BIM Forum was another significant event for BIM implementation in Slovenia, which took place at Bled in June, 2016 [52]. The organization of this event was motivated by the demonstration of good practices and sharing of ideas for setting a national BIM implementation strategy into practice. The aforementioned event hosted many prominent BIM experts and members of the EU BIM Task Group, which operates under the patronage of the European Commission. Slovenian participants consisted of siBIM members, managers, directors, and other decision-makers active in industry and the public sector. Representatives from the Ministry of Infrastructure, Ministry of the Environment and Spatial Planning, Ministry of Public Administration, Ministry of Health, Ministry of Defense and Slovenian Chamber of Engineers also participated in the event.



Figure 3 Members of EU BIM Task Group [53]

The inclusion of Slovenia in the EU BIM Task Group, which currently contains 21 members within the frame of European Commission (see Figure 3), represents yet another important milestone in furthering the introduction of BIM. The primary intention of this group is to unite national endeavors into a common and harmonized European methodology to digitalize the construction industry [53].

The successes of past events have motivated the siBIM Association to set challenging goals for the future, including the implementation of national BIM research activities, creating working groups to determine Slovenian BIM guidelines, the development of a register of successfully completed projects which were supported by BIM, and increasing membership in buildingSMART. There already exist successfully completed BIM applications in the Slovenian construction sector that can be utilized as examples of good practices. Many instances have also been collected in reference [54], and some recent examples are briefly introduced below.

Construction on the residential block in Ljutomer [55] utilized BIM to create variant 4D and 5D models relating to optional technologies for building external walls. The objective was to determine the most suitable solution for building from the perspectives of construction duration, costs, and energy savings. The outputs of the project demonstrated that such BIM models are particularly useful in preliminary project phases. The modeled and completed residential blocks in Ljutomer are presented in Figure 4.



Figure 4 Modeled and completed residential block in Ljutomer [56]

The BIM approach was also practically applied to construction monitoring of a parking garage Gabrijela [57], located at Prešernova Street in Maribor. Here, the developed 4D model was applied to support construction monitoring and time deviation analysis. The construction process was monitored bay digital interval camera positioned at an appropriate height on a nearby existing building. The outputs of the BIM model and recorded photographic data were employed to analytically compare planned and executed activities, as shown in Figure 5.

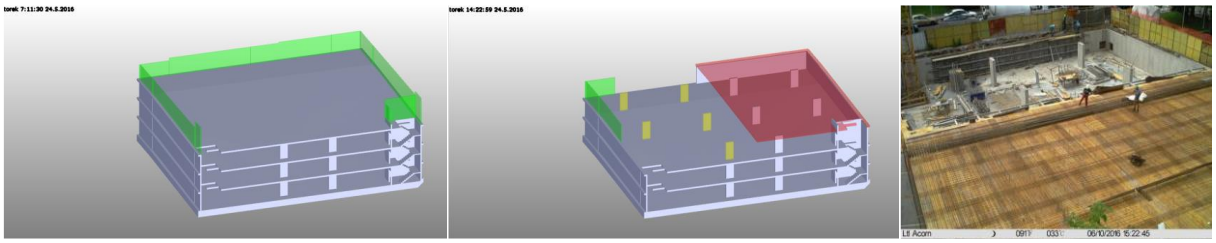


Figure 5 BIM–supported comparison of planned and realized activities for parking garage in Maribor [58]

The final example of good BIM practice reviewed here was a 6D model applied to covering maintenance planning for a business–storage facility located in Hoče [59]. The developed 6D BIM was intended to be a service–book for the constructed object, including all required maintenance activities and related costs from the beginning of usage to the end of the projected lifecycle. The BIM model and completed business–storage facility are shown in Figure 6.



Figure 6 BIM model and completed business-storage facility in Hoče [60]

The successful completion of BIM projects is expected to encourage more intensive implementations of new BIM projects in the Slovenian public sector and industry. Some forecasted construction projects have developed an informal tendency to use the BIM approach; however, no requirement for use exists at the national level.

6 DISCUSSION AND CONCLUSIONS

As expected, there exist significant differences in the acceptance and implementation of BIM in the analyzed countries. Though BIM is a relevant topic in all analyzed AEC industries, it is yet to be defined as a standard regardless of its implementation level. Construction projects implementing BIM are considered to be pilot projects, and their feedback on the benefits of BIM are still being analyzed. However, it is possible to conclude that BIM will inevitably be used in the future of all construction sectors (e.g. education, practice, legislation, public procurement process, contracting, etc.). The works of various BIM organizations and initiatives, standardizations, and expert groups aiming to carry out the EU directive indicate that BIM is becoming an important national issue in the EU.

Although there is a clear trend of BIM expansion in the Croatian AEC, there remain obvious gaps and a lack of practical experience–based feedback for its implementation. It is expected that BIM in Croatia, driven from educational and scientific levels, will first be developed in legislation and standardization framework, and will afterwards be practically implemented in construction projects.

The construction industry in the Czech Republic has all the necessary preconditions to fully implement BIM. Architects and engineers have a good knowledge of the issue due to the frequency and availability of information and conferences. Unfortunately, the standards and legal framework that would speed practical implementation are still lacking. The first projects that were designed and processed in BIM appeared in the field of construction management. The first examples of implementation used only 3D models; other dimensions were not meaningfully exploited. The other model dimensions that were not exploited include a large database of default price list items (around 170,000 items) which could be connected using 4D BIM. Additionally, 5D BIM has the potential to be implemented using an extensive database of time standards (around 50 typical network diagrams). There is great potential for BIM development hidden in these areas.



Different industry and government–driven organizations are facilitating BIM implementation in Germany. In the public sector, a step–by–step plan has been developed to ensure BIM will be implemented in the design phase of all new public projects starting in 2020. In the private sector, companies began implementing BIM technologies on a departmental level to increase efficiency in typical areas such as quantity estimation, site layout planning, and 3D and 4D representations of project specifications.

The need to implement the BIM approach in the AEC industry was first identified by academic circles where early pilot projects were conducted primarily for research purposes. These projects soon attracted much attention in commercial and non-commercial companies. This led to the foundation of the BIM Association of Slovenia, which began with the integration and systematic regulation of BIM in a broader sense. Successfully executed BIM conferences, the BIMathlon, and BIM Forum events, alongside inclusion into the EU BIM Task Group, set a cornerstone for the further development and use of the BIM approach in Slovenia. The activity program recently set by the BIM Association of Slovenia gives some directions for creating standards for the BIM approach, national guidelines for practical BIM implementation, regulations for the BIM approach, etc.

It can be concluded that BIM is a developing topic in the analyzed countries. Active initiatives exist with the primary goals of BIM educational and practical implementation. However, as a concept changing current and adopted AEC business methods, its adoption is formally supervised or entirely framed. Furthermore, it can be concluded that BIM adoption tools and methodologies are similar in the analyzed countries. The path of recognizing and implementing BIM in EU member countries appears to be directionally progressing from northern to southern EU countries. Regarding the theoretical prospect of BIM as a “bridge” towards a unified construction market, it can be assumed that BIM will require standardization on the union level similar that formed by Eurocodes.

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