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Assessing the Duration of the Lead Appointed Party Coordination Tasks and Evaluating the Appropriate Team Composition on BIM Projects

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Abstract: This paper addresses critical success factors for the delivery of BIM projects. The lack of experience with BIM projects on both the demand and supply side often leads to insufficient project teams, unsatisfied clients, schedule, and cost overruns. In order to better structure and control the information delivery in BIM projects requirements, planning and delivery must be standardized. The latter was achieved by EIR (Exchange Information Requirements), new BIM roles, BEP (BIM Execution Plan), and specified digital handover, which must be supported by a common data environment (CDE). This paper provides an analysis of the characteristics of BIM project delivery and duration in Architectural and Engineering companies in Slovakia. The analysis is based on the web survey of BIM managers and coordinators, which reveals that a significant amount of BIM project efforts must be executed by BIM specialists. The results also graphically depict the scope of critical BIM activities across project phases. The presented study is relevant for various project stakeholders and allows for a deeper understanding of the resources needed for the successful delivery of BIM projects in terms of adequate project team capacity, capability, organization, and planning.

Keywords: BIM; coordination; management; CDE; modeling; team; collaboration; cost; estimation; project schedule; project roles; ISO 19650; architect; appointed party

1. Introduction

Despite the growing use of Building Information Modeling (BIM) and the increasing demand for BIM models in the private and public sector, the national specification and recommendations for the geometric and non-geometric (information) details of Project Information Models (PIM) and Asset Information Models (AIM) are absent in Slovakia (for further reference, expression "BIM model" is used to cover both PIM and AIM [1,2]) [3]. The situation is similar to the specification and description of new positions that are interconnected with using BIM, e.g., BIM manager, BIM coordinator, and so on [4–7]. The role of such important employees who create, coordinate, and verify BIM models, and employees who are in charge of the data management and implementation of BIM throughout the company, are not yet officially defined. However, many companies in Slovakia, as well as abroad, create positions such as BIM manager, BIM coordinator, BIM specialist, BIM modeler, BIM consultant, etc. [4,7–15]. Despite the difference in their title, the appointed positions often have a similar job description.

This research focuses on the identification of activities performed by appointed parties, Design and Engineering Companies (for future reference, DEC abbreviation is used to describe the role of the appointed party and vice-versa), when processing and delivering BIM models in Slovakia, with a focus on the activities related to BIM management and

coordination (for further reference, BIM management and coordination is abbreviated BMC). The aim is to analyze the duration of BMC activities and to evaluate the BMC tasks duration in relation to the overall duration of the project. The information obtained can contribute to a better understanding of tasks that are relatively new for the majority of markets and to the development of price levels for the projects where BIM is required.

In the current situation, both the appointing and appointed parties need to estimate the suitable detail needed, duration of work, composition of project team, and set cost of the project. There are no national recommendations for forecasting the price of project delivery that consider individual project design stages based on a particular level of geometric and non-geometric information delivery. Appointing parties often expect the delivery of the BIM model and other BIM services at the price level equivalent to a common project submitted in traditional, usually 2D CAD form, either electronic or printed. The appointed party, on the other hand, point out that the processing of BIM models in high geometric and non-geometric detail, along with the implementation of BIM-related services, such as clash detection, the implementation of Common Data Environment (CDE), etc., is more expensive compared to a standard 2D CAD project. Moreover, it is with no dispute that various project stages of a project executed in CAD and BIM are not comparable from the perspective of the output quality in time. Using BIM brings significantly higher value due to its further use and streamlining of future processes.

1.1. Literature Review

Several authors have analyzed the activities related to BIM modeling, coordination, and management from different perspectives. Since it is still considered a relatively new topic for the majority of the market, it is obvious that a number of challenges and problems arise. First, they need to be empirically identified within a specific market; secondly, they need to be analyzed at the individual level; and finally, the proposal of appropriate solutions and improvements are suggested. The importance of research in this area can bring companies to the market knowledge that they will apply in planning the costs of implementing BIM within the company, a specific project, or in streamlining existing activities.

The issue of calculating the price of a BIM project is also relevant in other countries of the world. The following examples are sorted from the most important and most related to the topic, to the least. In South Korea, two methods are used: the so-called Construction Cost Percentage (CCP) and Cost-plus (CP), or a combination. While in the CCP method, the final price is a percentage of the total construction price, in the CP method, the price is the product of the sum of working hours estimated for individual project activities and the hourly rate of individual employees. In South Korea a few years ago, the situation was similar to Slovakia; there were no normative requirements for BIM in connection to the recommendation for pricing. Thanks to several professional organizations over the years, there are documents specifying level of geometry, a list of standard BIM activities, and the total average duration of design activities (based on hours or hours per m^2) for individual types of buildings (buildings, sports center, etc.) [16]. Additional research, which analyzed 54 BIM projects in South Korea, updated these values and, based on interviews with 20 BIM managers, divided the total duration into standard and non-standard activities. Standards were further divided between individual professions. The projects were also categorized into individual stages of project documentation and into Level of Detail (LOD) categories determined by buildingSMART Korea. Non-standard activities included, for example, clash detection, creation of the bill of quantity, and various static, financial, and energy analyses, as well as some activities related to the creation of drawings and visualizations. Coefficients were set for these non-standard activities (a different coefficient for each project documentation). Based on the mentioned data, an algorithm was developed that calculates the total duration of the project (in hours). In the beginning, the user enters the type of building and the gross floor area—the program automatically calculates the total number of hours for standard activities for each level of project documentation and for each

profession. Subsequently, the user enters "non-standard" activities that are expected to be included, with an appropriate level of project documentation and LOD. The algorithm also calculates the estimated duration of non-standard activities based on the entered values and coefficients. Depending on the number of total hours for each activity, it is possible to estimate the cost of the project using hourly rates and other direct and indirect costs. The program was subsequently verified by comparing the proposal with the costs of 10 real projects implemented with the costs calculated based on the program. The error rate was 5.3% [16].

Although there are many commercial tools to calculate the price of the BIM project, the study from South Korea [16] was identified as potentially suitable for the Slovak market due to the similarity of project cost calculations. The results from the survey presented in this paper also analyze the activities in the BIM projects and can be used for the selection of standard and non-standard activities similar to the approach in South Korea. However, more data from different companies and projects and from different phases need to be collected in the next years to achieve similar goals as were achieved in South Korea.

Several other areas of BIM coordination and procedures affecting its effectiveness have been addressed by other authors [17–20]. Santos and Ferreira have studied productivity comparing 2D and 3D BIM coordination [21]. Cost-benefit analysis of BIM-enabled design clash detection and resolution was conducted in [22], while Said and Reginato [23] analyzed the time spent on BIM design-related activities for professions and especially electrical designers. Duration of incorporation of BIM project changes required by the client and the so-called "Change Ripple Effect" (a chain reaction where one change affects other results in a row that also need to be changed) was evaluated by Moayeri et al. [24]. Based on the research, a BIM model was designed that can calculate the "Ripple Effect" of the changes requested by the appointing party and update the project schedule.

Khnazode, Fischer, and Reed [25] demonstrated the effectiveness and benefits of coordinating Heating, Ventilation and Air Conditioning (HVAC) professions through 3D/4D BIM tools and Lean collaboration using the "BigRoom" method in a case study of a hospital facility. A comparison of team interactions in traditional and BIM-Lean management was conducted in [26]. Kubicki et al. [5] dealt with the tasks of individual participants in BIM project coordination, designing procedures and diagrams of BIM project cooperation, analyzing the software and devices used (e.g., touch "smart" devices during coordination meetings), interaction of individual participants, and evaluated the effectiveness of resolving construction clashes.

Yarmohammadi and Ashuri [27] analyzed coordination meetings in terms of the composition of participants, the technology and software used, the complexity of the coordination of the professions, and the effectiveness of each meeting (how many hours the meetings lasted, how many people attended, how many clashes resolved, etc.). Zheng [28] analyzed the effectiveness of design collaboration based on the cloud BIM platform and the resulting project quality.

The management of BIM project cooperation on an infrastructure project was discussed by Lin et al. [29]. Project management skills and competences interconnected with BIM were evaluated by Mesaros, Mandicak et al. [30,31]. The effectiveness of the proposed cooperation among personnel was subsequently demonstrated in a case study of an MRT (Mass Rapid Transit) project in Taiwan. Lin and Yang designed a system for BIM cooperation, as well as for building construction projects [32]. Gegana and Agirachman conducted a similar analysis on the stadium project [33], while behavior and performance of BIM users in a collaborative work environment were processed in [34]. The impact of BIM implementation on the quality, expected duration, and cost of BIM projects among small businesses was analyzed in [35,36], perspective on BIM utilization in budgeting and lifecycle related costs are presented in [37–40].

Hong et al. [41,42] used an artificial neural network and machine learning to quantify the costs associated with the implementation of BIM in companies, which allow start-ups to make a better decision in regard to implementation (what and when), including the

knowledge of what level of detail is appropriate, etc., in order to maintain the highest possible added value with BIM implementation. Lin and Huang have also used machine learning to speed up the filtering and the elimination of irrelevant clash detection results in their research [43]. A Genetic algorithm (GA) that improved a neural network and then was used with BIM software to train a GA network model that gave a prediction of construction costs was developed in [44]. The effectiveness of BIM modeling and coordination processes in Multi-Trade Prefabrication (MTP) was analyzed in a case study by Jang and Lee [45]. Mobility and certification of BIM experts in ASEAN countries were analyzed in [46]. The probability of winning the tender when proposing a BIM strategy was analyzed in a case study in Saudi Arabia [47]. A method to evaluate the activities of BIM staff by introducing a time-dependent queuing model was proposed in [48].

1.2. Paper Structure and Organization

The approach of this research is presented in the following chapters of the paper. First, the selection of data collection methods is described in Section 2.1. Details about the criteria for the selection of respondents and the survey preparation and execution are presented in Sections 2.2 and 2.3.

Section 3 presents the results of the research divided into five subsections, each focusing on the different parts and scope of the BMC processes. Key findings of these results and their differences with existing approaches are discussed in Section 4.1, while implications to practice and contributions to knowledge are presented in Section 4.2. The whole paper is summarized in the last section, the Conclusions.

2. Materials and Methods

According to the National BIM Implementation Survey, performed on an annual basis by the BIM Association of Slovakia, missing standards and recommended processes (38%), higher costs (36%), and a lack of time (29%) are frequently identified as barriers related with BIM implementation on projects. The most common barriers are presented in Figure 1 [10].
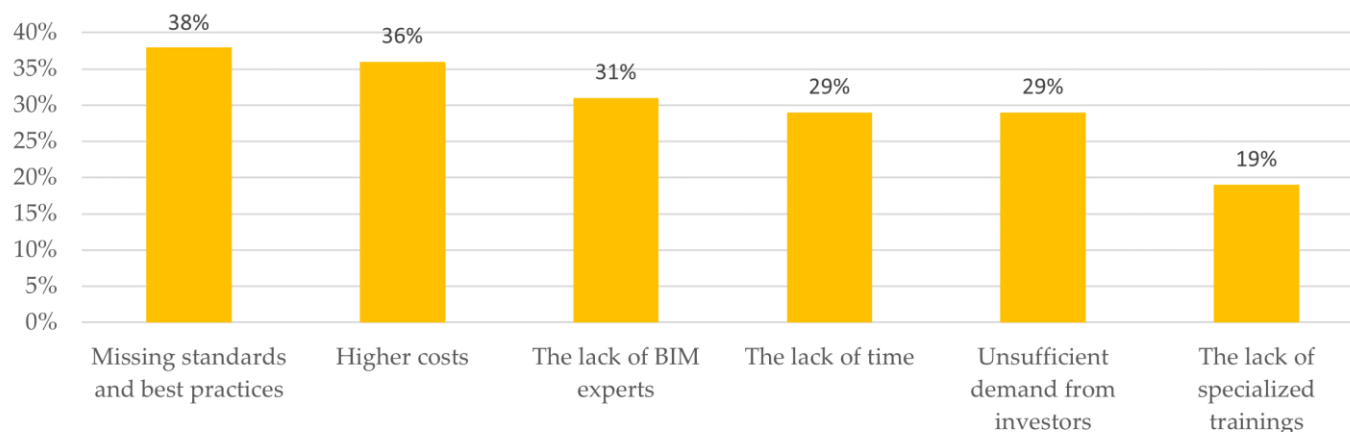

Figure 1. Main barriers to BIM usage in projects (note: respondents can identify more than one barrier) adapted from ref. [10].

The average number of respondents in the last two years (2020, 2021) was 1549 [10,15,49]. Based on the overall implementation rate in Slovakia in the reviewed period, 17.02% (2020) and 20.50% (2021), the number of projects is growing moderately, which has a direct impact on the number of BIM managers and coordinators [10,15,49].

The survey reveals that the number of BIM managers and coordinators was 2.20% (2020) and 2.48% (2021) of the total number of respondents, which is on average 7.30% of active BIM users [10,15,49].

In order to address the research questions and maintain uniformity of collected data about user experience in the field of BMC from the perspective of task identification and

time-cost related issues, a survey in the form of an electronic questionnaire was selected. Data were collected in December 2020 and analyzed and evaluated during the year 2021. Within the analysis, we focus on this particular information.

2.1. Research Questions

To explain how the BMC tasks affect the team composition and how they impact a workload, quantitative research was selected using the measurable data from the survey. Two research questions were formulated as a combination of descriptive and comparative questions.

1. Research question one—descriptive:

What is the time proportion of BMC activities out of the total project time?

2. Research question two—comparative:

Is it viable to execute BMC tasks by draftsman/designer, or should it be handled by specialists—BIM managers and/or BIM coordinators?

2.2. Selection of Data Collection Method

The basis for the selection of suitable companies was the abovementioned survey of the BIM Association, Slovakia.

When selecting suitable candidates for a detailed coordination survey, we identified small and medium-sized enterprises (SMEs) that work actively with BIM and act as the general contractor for project documentation. The focus on SMEs is mainly because they often form the largest group in construction supply chains and therefore have a major impact on overall use. In the survey, representatives of such companies make up 83.28% of respondents [50].

If we consider the number of companies that meet the set criteria and the fact that BIM is still not widespread in the field of architecture and design, utilization at the level of 24.63% (2020) [15] and 27.97% (2021) [10,49], the number of companies that have a suitable BIM manager or BIM coordinator is relatively low, and the information obtained would not be relevant in the case of open survey data collection.

For this reason, we decided to conduct a targeted survey with selected candidates who form a representative sample of the market. A process map of the research methodology is shown in Figure 2.
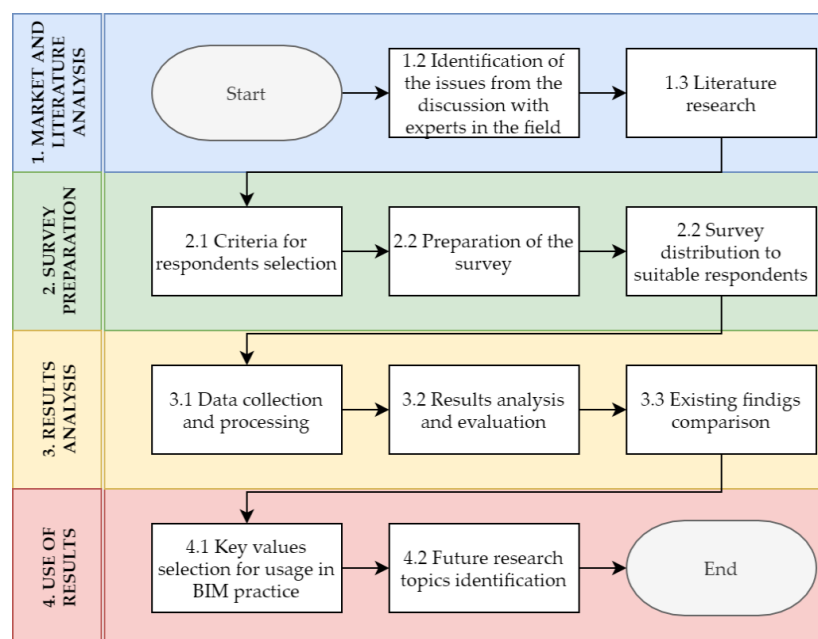

Figure 2. Process map of the research methodology.

2.3. Criteria for the Selection of Respondents

As was already mentioned, there are not many BIM managers or coordinators in Slovakia. Despite that, some companies have qualified and experienced BIM specialists that work on projects of different scales and purposes. The aim of the survey was to analyze data, evaluate the results, and select key values for the professionals in the field of building construction. Due to the first criterion (Table 1), we determined that the suitable respondent shall work as BIM manager or BIM coordinator in the architectural company that is primarily focusing on the sector of building construction. They should be responsible for BEP preparation, BIM model checking, CDE management, and other activities that include BIM model processing and management. To define which architectural company is suitable, we set the following criteria (Table 1) that the firm must meet: the main focus is in the sector of building construction, the minimum number of employees must be 10 (according to SME definition), the minimum annual revenue of the company is more than EUR 0.5 million, and the company needs to have at least one active BIM project with a minimum total cost of EUR 15 million, to eliminate small projects with low levels of collaboration.

Table 1. Criteria for selection of respondents for a survey.

No.	Criteria for Suitable Respondent
1.	Respondent must work in the architectural company as a BIM manager/coordinator
2.	Architectural company where respondent works must focus mainly in building construction
3.	Architectural company where respondent works must have min. 10 employees
4.	Architectural company where respondent works must have annual sales of at least EUR 0.5 mil
5.	Architectural company where respondent works must have at least 1 active BIM project of min. total cost of EUR 15 mil. in 2020

The elimination process of companies and respondents is on the Figure 3. Firstly, 173 companies that meet criteria No. 3 and 4 (Table 1) were selected from a public database of Slovakian companies [50]. This database contains mostly financial data about the companies from their tax returns and other publicly available data (e.g., number of employees). However, companies usually have several different official types of their businesses, so the results of this database may not meet criterion No. 4 in every case. Some of the firms may have reached the required number of annual sales by the different business activities, not only by architectural and engineering work.
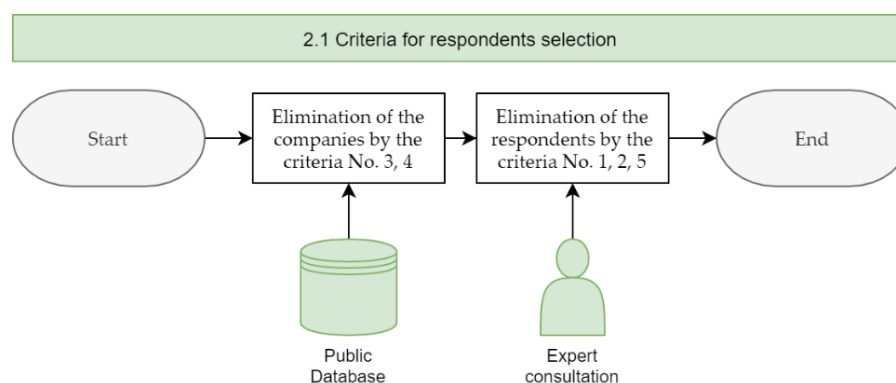

Figure 3. Process of elimination of inappropriate companies and respondents.

To eliminate the inappropriate results of the search and to find out how many respondents match all criteria (Table 1), the BIM Association of Slovakia [3] was contacted. The BIM Association of Slovakia (BIMaS), a member of the Construction Classification International Collaboration (CCIC) [51], unites more than 45 architectural and civil engineering companies, organizes events for BIM experts and students, develops recommendations for

national BIM standards in expert working groups, and has members in working groups of CEN/TC 442 [52].

After the elimination and questionnaire preparation, a total of 15 people meeting the criteria (Table 1) were contacted for the survey. Their detailed information is presented in Table 2.

Table 2. Detailed information about the people meeting the criteria in Table 1 and contacted for the survey.

Variables		Percentage of Contacted People	No. Contacted People
Sex	Male	80.00%	12
	Female	20.00%	3
Age	<30 years	13.33%	2
	30–40 years	60.00%	9
	40–50 years	26.67%	4
	>50 years	0.00%	0
Work Experience	<5 years	66.67%	10
	5–10 years	26.67%	4
	>10 years	6.67%	1
Educational Level	High school	0.00%	0
	Bachelor's degree	0.00%	0
	Master's degree	100.00%	15
	Ph. D.	0.00%	0

Information about the annual sales and number of employees in the companies where do they work are presented in Table 3.

Table 3. Statistics of annual sales and number of employees of the companies where contacted people work.

Company Statistics	Percentage of Contacted People	No. Contacted People
Annual sales in 2020 ≥ EUR 5 million	13.33%	2
Annual sales in 2020 = EUR 4–5 million	6.67%	1
Annual sales in 2020 = EUR 3–4 million	13.33%	2
Annual sales in 2020 = EUR 2–3 million	13.33%	2
Annual sales in 2020 = EUR 1–2 million	40.00%	6
Annual sales in 2020 = EUR 0.5–1 million	13.33%	2
No. employees in 2021 = 50–99	20.00%	3
No. employees in 2021 = 20–49	33.33%	5
No. employees in 2021 = 10–19	46.67%	7

2.4. Preparation and Execution of the Survey

2.4.1. Structure of the Survey Questionnaire

The form of the survey was an electronic questionnaire that consisted of 13 questions divided into six sections:

1.　Introduction

Contained the information about the research and instructions for the correct completion of the survey.

2.　Questions related to scope of BIM models

Number of questions: 2
The goal of the questions was to find out how complex the BIM models in the surveyed sample of companies are. The complexity and scope of the BIM project has a direct impact on time consumption.

3.　Questions about what tasks of BIM design, BIM management, and BIM coordination have been done in the project

Number of questions: 5

The prerequisite for asking these questions was to find out the level of BMC activities and automation in companies. It is assumed that the higher the level and complexity of these activities, the higher the time and staffing requirements. On the other hand, the higher level of automation, the less the time consumption.

4.   Questions about BIM positions in the project team and the time spent with tasks of BIM management and coordination

Number of questions: 3

The questions in this section focused on identifying the real time required for BMC activities and the need for specialized positions.

5.   Questions about BIM positions in the project team in the future

Number of questions: 3

This section was aimed to identify how relevant the data collected in Section 4 are for future use. Because the survey did not contain sensitive questions about project delays, or the final quality of deliverables, answers to the questions in this section could help to analyze the actual needs of the companies in BMC activities.

6.   Conclusion

Contained the text box for the comments.

2.4.2. Software Used for Questionnaire Preparation, Execution, and Data Analysis

The electronic questionnaire was prepared in the online application Google Forms and bulk sent to respondents as a link in the body of the e-mail. Besides the link, there was information about the purpose and goals of the questionnaire and overall research.

The results were collected automatically in the application, exported to Google Sheets, downloaded in the .xlsx format, and then analyzed and processed in Microsoft Excel. All questionnaire replies were anonymous because the electronic form did not collect any personal data about the respondents, and they answered only on questions presented in Sections 3.2–3.5.

The bulk sending of the questionnaire and the answers collection was held in December 2020.

3. Results

Based on the criteria in Table 1, a total of 15 people were contacted for the survey. Detailed information about them and their companies are in Tables 2 and 3. After the bulk sending of the e-mails, 10 anonymous filled forms were collected. The results are presented in the following subsections.

3.1. Survey Introduction

In the introduction part of the form were the following instructions:

1.   The questionnaire is intended for BIM managers/specialists/coordinators in companies that are in the role of lead appointed party.
2.   For the questionnaire, consider the most developed company's BIM project. If you have more equivalents, consider their average values.
3.   If you participated in more than one stage of the project (e.g., project for building permission and execution documentation), consider the higher one (in this example—execution documentation).

3.2. Questions Related to Scope of BIM Models

According to the BIMaS survey [10,15,49], engineering disciplines (actual implementation rate at 19%), e.g., HVAC, Mechanical, Electrical and Plumbing (MEP), etc., are not commonly included in the federated models. Three situations can occur. Model of a particular discipline is:

1. Calculated and designed by an engineer in BIM;
2. Calculated in different environment and modeled by engineer in BIM;
3. Calculated and designed in CAD environment and remodeled in BIM.

The first two questions were focused on BIM models and the means of their creation. Table 4 presents the answers to the question: "What disciplines were calculated and/or modeled in BIM by an engineer?". This includes both options 1 and 2. The aim of this question was to find out, which BIM models were modeled by engineers themself, so there is no need for remodeling from other delivered sources (e.g., CAD drawings) by the lead appointed party or by another subcontractor. This process can be very time-consuming and erroneous, especially when there are many project changes. Figure 4 shows that while the disciplines like architecture, structural engineering, plumbing, and ventilation were delivered in BIM by an engineer in each case, disciplines like fire protection, geotechnics, and electrics were created and delivered in the form of BIM rarely.

Table 4. Responses to the question: "What percentage representation had the positions in the team of the lead-appointed party? (e.g., 1 person of the team with 10 members = 10%)".

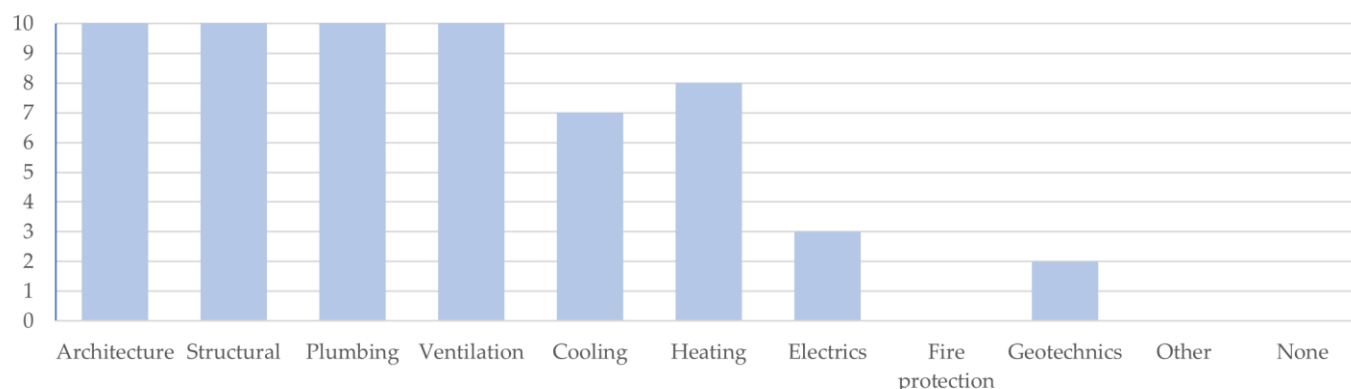|	0%	1–10%	10–20%	20–30%	30–40%	40–50%	50–60%	60–70%	70–80%	80–90%	90–100%	Average
Designer that works in BIM	-	-	1	2	1	-	3	-	2	1	-	39.0%
Designer that does NOT work in BIM	2	4	1	1	-	-	1	-	-	-	-	11.5%
BIM modeler	2	1	2	1	1	1	-	-	1	1	-	30.0%
BIM manager/coordinator	2	5	2	-	-	1	-	-	-	-	-	8.5%
Other position (not related to BIM)	5	4	-	-	1	-	-	-	-	-	-	5.5%

Figure 4. Responses to the question: "What disciplines were calculated and/or modeled in BIM by an engineer?".

Figure 5 shows the results of the question: "What disciplines were remodeled from CAD to BIM by your team?". This includes the abovementioned option 3. These answers mostly correspond with the answers in Figure 4, but they also show that some disciplines, like electric, geotechnics, or fire protection, are not modeled in BIM at all. These data also correspond with the annual analysis from BIMaS, where only 5% of electrical engineers and none of the fire protection engineers or geotechnical engineers work in BIM [10,15,49]. In some cases, disciplines, e.g., cooling, were absent from the project.
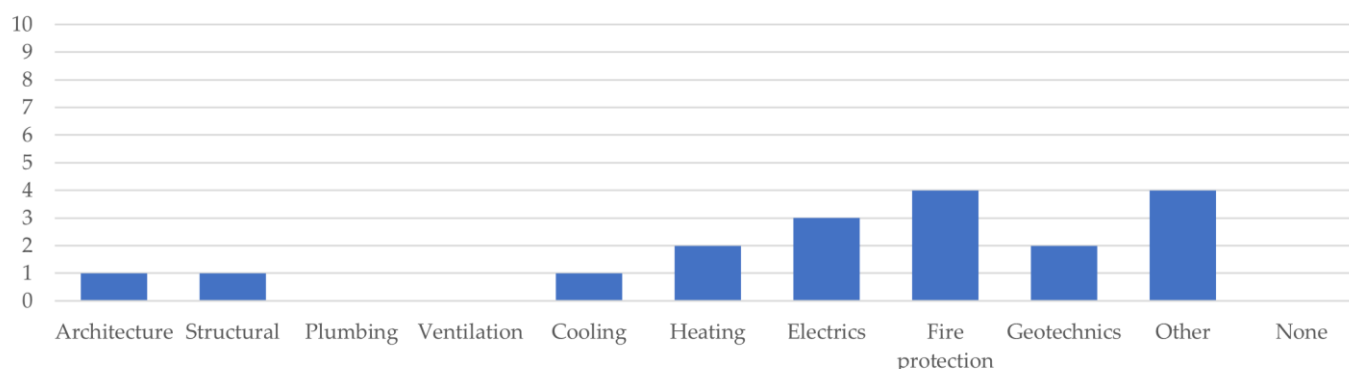
Figure 5. Responses to the question: "What disciplines were remodeled from CAD to BIM by your team?".

3.3. Questions about What Tasks of BIM Design, BIM Management, and BIM Coordination Have Been Done in the Project

The second section of the questionnaire was focused on the topic of BIM management, BIM coordination, and BIM design/modeling tasks that have been done by the team of the lead appointed party in the project. The first goal was to identify what tasks needed to be done by BIM coordinators to successfully complete the project. This information is important in the stage of price offering preparation by the lead appointed party and can be crucial because managers often do not realize how many things related to BIM need to be done before the design and parallel with it. Because of that, they often estimate only the time of architects and engineers. The second goal was to link these data with the data presented in Section 3.4., in which questions related to staff engagement and time duration are discussed.

Figure 6 represents the responses to the question: "Which of the following tasks have been done by your team in the project?—part Project Management". Most of the respondents (80%) prepared BIM Execution Plans (BEP) on their projects. According to STN EN ISO 19650 standards, BEP should be prepared by the lead appointed party as a response to Exchange Information Requirements (EIR) prepared by the appointing party [1,2]. The first version of BEP should be prepared in the pre-appointment stage, and the other versions after the appointment. The lead appointed party should communicate about the BEP content with the appointing party that approves the BEP. Because of the low BIM implementation in Slovakia, BEP is sometimes prepared by the appointing party, and during the project, changes are expected. This is probably reflected in the task "BIM management", which was only chosen by 50% of respondents.
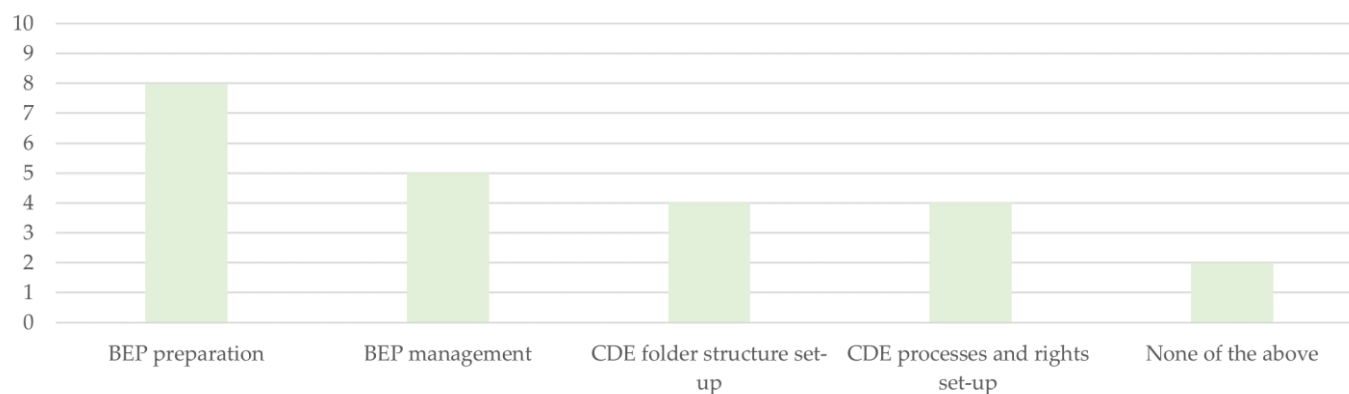

Figure 6. Responses to the question: "Which of the following tasks have been done by your team in the project?—part Project Management".

Another important topic in BIM projects is the Common Data Environment (CDE), also mentioned in the STN EN ISO 19650 standards, which recommend it as an environment

and tool for transparent digital communication and one source of the truth (based on BIM) for all project participants [1,2]. It also describes the information states (work in progress (WIP), shared and published). In the CDE platforms, there is usually a need to set the project folder structure and set the workflow between different project participants. This workflow must meet the criterion for information states as are described in STN EN ISO 19650. As the appointing party hires the delivery team and creates the EIR, they usually also buy the CDE platform license and manage the CDE. This is probably reflected in the responses of the tasks: CDE folder structure set-up and CDE processes and access rights set-up, where only four respondents chose these tasks. However, according to STN EN ISO 19650, the delivery of information to the appointing party should only be done by the lead appointed party, which can lead to more appointed parties and task groups (different disciplines). Therefore, the information exchange between different appointed parties, managed by the lead appointed party, could be realized in the same CDE platform or a different CDE platform. This has an impact on who will be the owner and manager of the CDE platform/s. In both cases, the lead appointed party should create a system of cooperation between the appointed parties—including folder structure, workflow chain, information exchange, approvement, and so on. On the other hand, the appointing party should create the same level of information exchange between them and the lead appointed party [1,2,53].

In Figure 7, it is possible to see how the EIRs can have an impact on the tasks of the architect team. Different owners or appointing parties can have different requirements on BIM models, so the BIM coordinators must prepare the templates for BIM designing software (e.g., Autodesk Revit, Graphisoft Archicad, etc.) for the whole team to meet the criteria in the EIR. Requirements on the level of geometry and information affect the time spent on the creation of parametric objects (families in Autodesk Revit) with the exact list of parameters (attributes) and their categorization and classification.
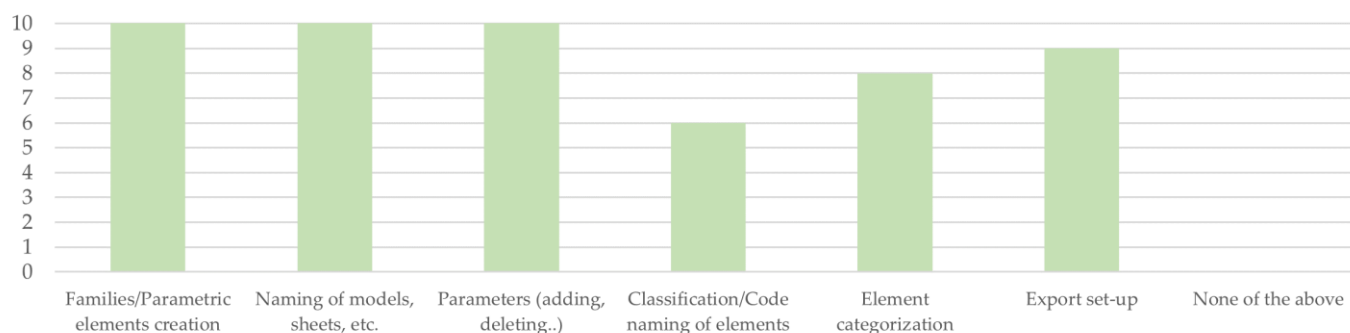

Figure 7. Responses to the question: "Which of the following tasks have been done by your team in the project?—part Templates preparation in BIM design software".

Requirements on deliverables usually affect the time spent on the naming of elements, models, drawing sheets, and set-ups of exports (e.g., what should be exported to Industry Foundation Classes (IFC) and in what version of IFC). Figure 7 shows that most of the mentioned tasks were completed in the projects. Forty percent of respondents do not classify the elements by any classification systems. This is probably due to the absence of national classification and because of the incompatibility of classification systems deployed by other countries for nationally accepted methods of cost estimation in Slovakia.

Figure 8 shows responses to the question: "Which of the following tasks have been done by your team in the project?—part Creation of BIM models and project documentation". Every project team, represented by the respondent in the survey, designed the project in BIM and created the drawings directly from the BIM models. Only 20% of them did not create a detailed list of elements that included the drawing, and 40% did not create the project details in BIM or in a combination BIM + Computer Aided Design (CAD). Details

in very small scales are often created in CAD applications because they contain very small parts and layers or elements (e.g., screws) in very high detail, not modeled in BIM.
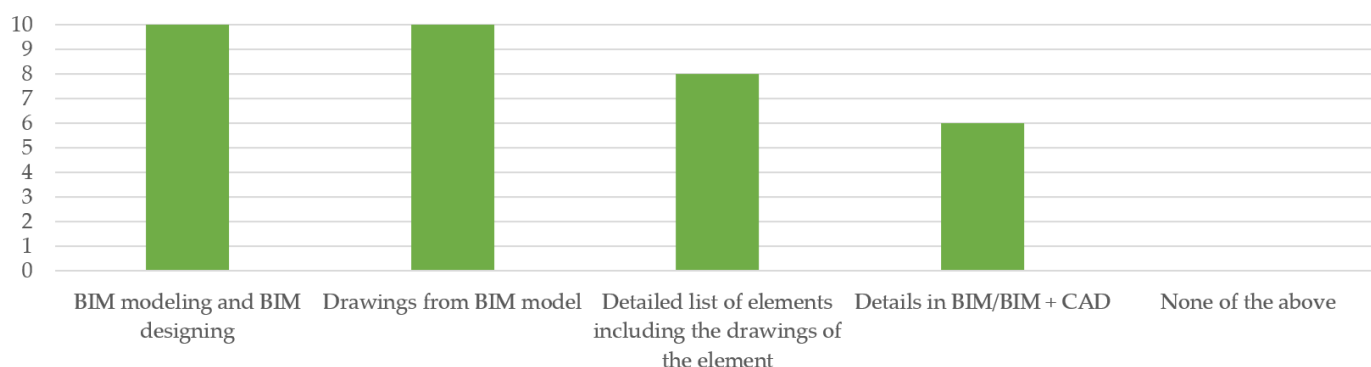

Figure 8. Responses to the question: "Which of the following tasks have been done by your team in the project?—part Creation of BIM models and project documentation".

The next question (Figure 9) addressed the topic of BIM coordination activities during the project. While most of the respondents say that their team completed hard clash detection (90%) and a name check of exported files (80%), slightly less of them applied checks of the exported IFC files (70%), manual parameter checks (70%), and a check of duplicates (60%). However, only half of the respondents did soft clash detection, and only 30% of them automated the process of parameter checking.
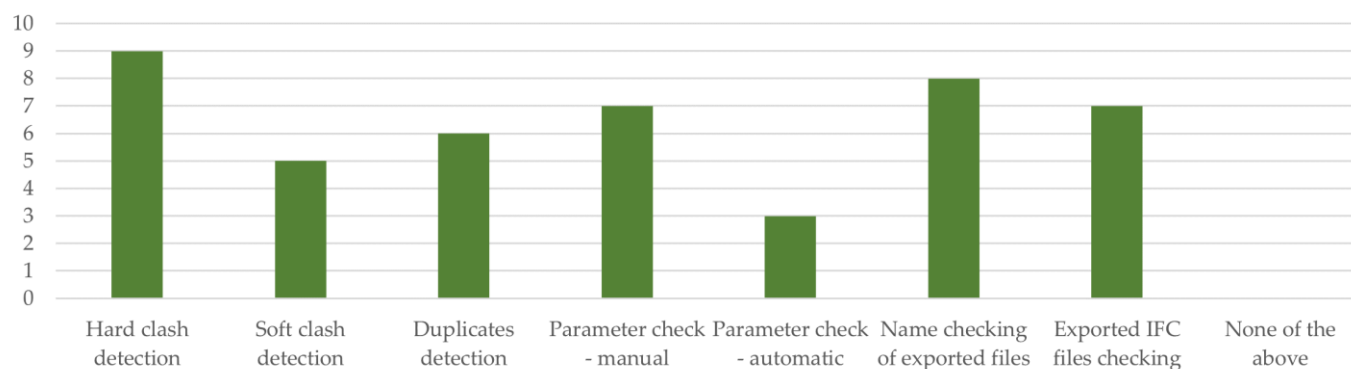

Figure 9. Responses to the question: "Which of the following tasks have been done by your team in the project?—part Checking processes".

The last question of the section (Figure 10) was focused on the communication, distribution, coordination, and handover of the information. The results show the low implementation of CDE and modern collaborative cloud-based BIM coordination because teams communicate and exchange information mainly via e-mail, even if they find issues in BIM models. The handover was, in 80% of cases, done by uploading the deliverables to some Digital Management System (DMS) platform (e.g., simple cloud-based application like Microsoft OneDrive, or Dropbox). However, these may, or may not, support the process of information exchange in CDE as described in the STN EN ISO 19650 (basic cloud-based systems, or DMS, do not support the different states of the information and options to manage user rights to change these states, as described in STN EN ISO 19650).
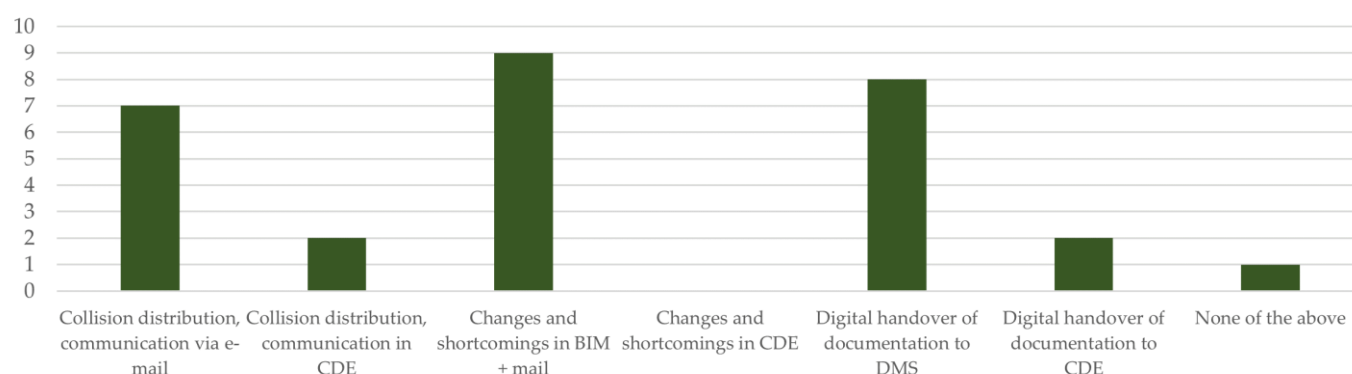
Figure 10. Responses to the question: "Which of the following tasks have been done by your team in the project?—part Communication, coordination, handover".

These data (Figures 6–10) are important because they are closely connected with time and staff consumption, of which the results are presented in Section 3.4. While some of the tasks (e.g., BEP preparation, change of model naming system) need to be completed and checked manually, many other tasks (e.g., collision distribution) can be done semi-automatically or in a more sophisticated way, for example, by using CDE, or BIM collaboration files (BCF). Use of the CDE saves time for all participants when they need to find information, assign a task, make a request for information (RFI), or change a request. The use of modern cloud-based BIM coordination systems, which exchange issues and change requests in BCF file format, saves time for architects and engineers, who do not need to find every issue in the BIM models with thousands of elements. All the elements must be hided or transparent with a goal to see the one issue. Every issue in a .BCF file contains data about the location in the BIM model, so the user does not have to find it manually.

Hypothetically, the low implementation of such technologies and systems can lead to high time consumption of tasks that must be done manually. In some projects, these tasks are not done at all because they seem to be too difficult, time-consuming, or need an extra specialist (e.g., another BIM coordinator). On the other hand, the high implementation of these technologies requires more software applications, licenses, and experts that need training. This can increase the costs, but also the quality and effectiveness. Moreover, the saved time can be used for the implementation of new technologies.

All these variables and options need to be considered before the analysis of the results and usage for processes of project duration and price estimation; this is discussed in Section 3.4.

3.4. Questions about BIM Positions in the Project Team and the Time Spent with Tasks of BIM Management and Coordination

The fourth section of the form was dedicated to BIM positions and the time needed to complete BIM-related tasks as BIM design, BIM coordination, BEP preparation, and so on, as mentioned in previous subsections. The questions were asked with the goal of identifying the amount of time and people needed for BIM-related activities in the context of a total project time of a whole lead-appointed party team.

At first, the respondents were asked about the project team composition (Table 4).

This question was in the form of a matrix, and every respondent could choose the percentage of each position on the team. For example, if there were two BIM coordinators in the team of 15 people, BIM coordinators were 13.33% of the whole team, so respondents should choose the option 10–20%. The average value of the answers is in the rightest column. For empty categories, en dash sign (-) was used.

Figure 11 shows the answers of respondents on the question related to the percentage representation of the time spent on the BMC activities of the total project time expressed in man-hours. While half of the respondents chose the option "1–5%", one-third of them chose the option "10–15%", and one chose "15+%"; on average, it was 7.75%. These

data can be used by the project management and could be crucial in the decision-making moments of the project for the lead appointed party, as well as for the appointing party. Therefore, if there is a project that needs to be done in 6 months and requires approximately 10,000 man-hours, management will need 10 people in the team, and one of them will be a BIM coordinator, that will spend approximately 775 h on the project. In this case, the management will expect less involvement of BIM activities in the project; this can lead to non-compliance with requirements from the appointing party (project delay or lower quality).
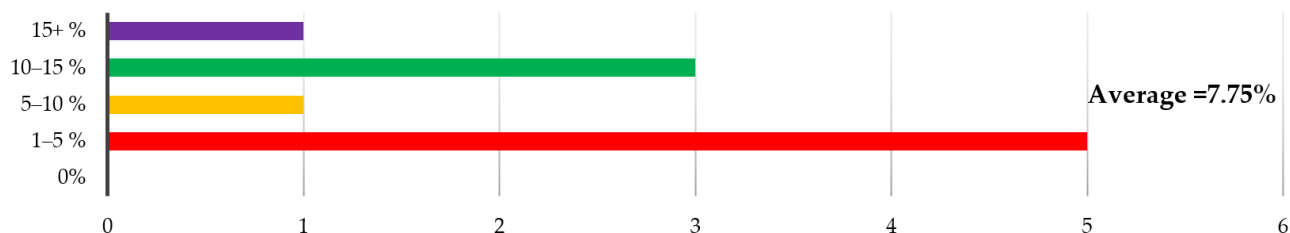

Figure 11. Responses to the question: "How much time did your design team (in the role of lead-appointed party) spend on BIM management and coordination activities? E.g., if the whole project was processed for a total of about 5000 h, and 250 h were allocated for BIM coordination, then 250/5000 = 5%".

More important data for the management of the lead-appointed party is in Figure 12. On average, 42.0% of the project time is devoted to BIM modeling activities. If we eliminated one answer (0%), which was probably chosen unintentionally, the average would be 46.67%. One-third of the respondents chose the option "50+%", so it is possible to assume that on the projects with higher BIM requirements, 50% of the total project time will be needed for BIM modeling activities. However, this can be reduced by using different kinds of modeling automation and by hiring more qualified and trained people.
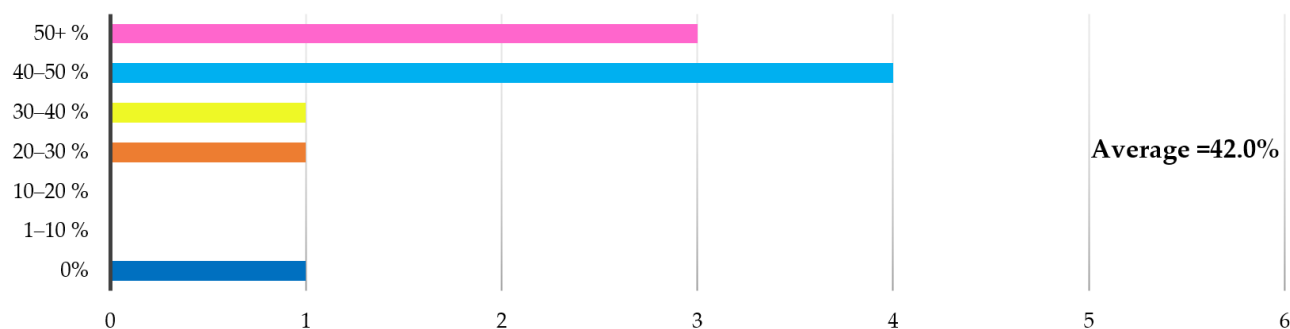

Figure 12. Responses to the question: "How much time did your design team (in the role of lead-appointed party) spend on BIM modeling activities? E.g., if the whole project was processed for a total of about 5000 h, and 1000 h were spent on BIM modeling, then 1000/5000 = 20%".

3.5. Questions about BIM Positions in the Project Team in the Future

Section 5 of the electronic questionnaire collected answers with subjective opinions about the sufficient involvement of BIM coordinators in the team of the lead appointed party and about recommended time dedicated to BMC. The aim of these results is to confront the data collected in the previous subsections, where the questions about the real projects were. The hypothesis was that based on the experience of respondents, they would recommend more specialists and time to accomplish the activities related to Building Information Modeling. The hypothesis was confirmed. Figure 13 shows that according to respondents, 70% answered that they think more specialists in the team of the lead-appointed party should be dedicated to BIM management and BIM coordination activities in the future.

Figure 13. Responses to the question: "Do you think that more specialists in the team of the lead-appointed party should be dedicated to BIM management and BIM coordination activities in the future?".

In the following question (Figure 14), respondents stated the ideal percentage of BIM managers/coordinators within the overall team of the lead-appointed party. Forty percent of them chose the option "20%," and the average value of all answers was 13.1%, which is 4.6 percentage points more than the average value of results in Table 4 (8.5% for BIM managers/coordinators).
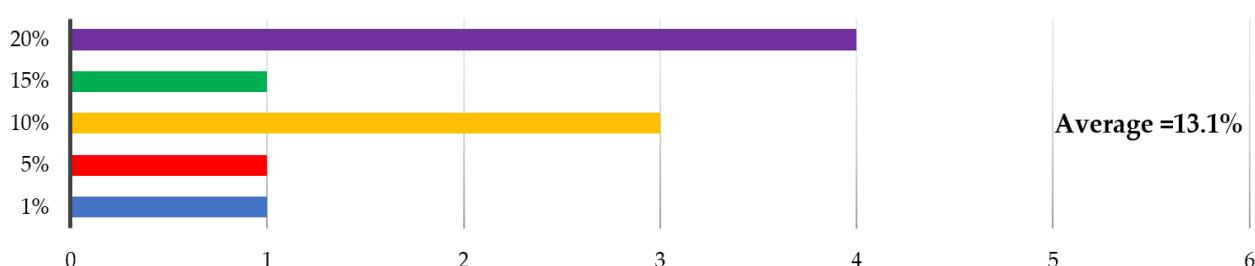

Figure 14. Responses to the question: "In your opinion, what should be the ideal percentage of people assigned to BIM management/coordination within the overall team of the lead-appointed party? For example, 1 person in a 10-member team = 10%".

Figure 15 shows the results from the last question of the survey, where the respondents stated the ideal percentage of man-hours dedicated to BMC within the total project man-hours. As assumed in the hypothesis, respondents chose the higher values than they experienced in the past projects. The average value of the answers was 14.5 percent, which is 6.75 percentage points more than the average value in Figure 11. The option "20%" was selected by four respondents and option "25%" by one, while in the question represented in Figure 11 with the highest value, "15+%", was picked only once.
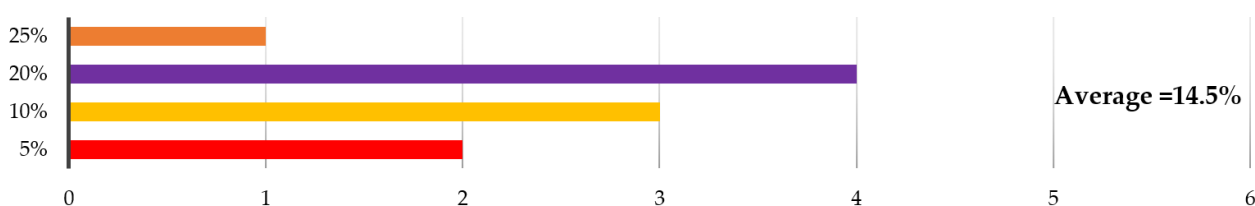

Figure 15. Responses to the question: "In your opinion, what should be the ideal percentage of BIM management/coordination hours of total hours of the lead-appointed party team? E.g., 1000 h of BIM coordination out of 5000 h of total team time = 20%".

From these results (Figures 13–15), it can be assumed that survey participants experienced BIM projects, where the role of the BIM managers/coordinators was underestimated as well as the time needed for the BMC activities. This could lead to project delay, cost increase, or both. The project managers of the lead-appointed parties can benefit from these data in the pre-appointment activities, but they should consider them with the data in Figures 4–12 and Table 4, and also with their own experience and expertise from BIM projects.

The final part of the electronic questionnaire was a conclusion, where respondents could address their comments and advice to the survey and ideas for future research.

Completion was voluntary, and only two minor comments, not related to the topic, were collected.

4. Discussion

4.1. Key Findings and Comparison with Existing Approaches

The electronic questionnaire survey brought several interesting results. Firstly, it identifies that while the disciplines like architecture, structural engineering, and some of the MEP professions are designed in BIM by the engineers from the beginning, disciplines like fire protection and electrics needed to be modeled with BIM from CAD by the lead-appointed party, or are not modeled in BIM at all.

Secondly, common BIM activities were identified (Figures 6–10), as well as some that were rare: BEP management, CDE set-up, classification of elements, details drawings in BIM, soft clash detection, automatic parameter checks, and use of CDE for communication and documentation handover. One of the least implemented technologies is the CDE, which is surprising because CDE is recommended by the STN EN ISO 19650, and also the implementation of CDE between the Slovak construction companies is increasing [54]. The low implementation of CDE may be one of the reasons why some of the companies find some processes too difficult or time-consuming, and it also may be the reason behind some other results presented in this paper.

Thirdly, Table 4 and Figures 11 and 12 show that BIM managers/coordinators represented approximately 8.5% of the lead-appointed party teams, on average. The BMC activities made up 7.75%, and BIM modeling activities 42.0% of all project man-hours on average. To confront this data, respondents were asked for their opinion in terms of the ideal percentage of BIM managers/coordinators and the ideal percentage of man-hours spent on the BMC activities. According to the survey participants, the ideal percentage of BIM managers should be 13.1% of the whole team (in contrast with Table 4—8.5%), and 14.5% of all man-hours should be spent on BMC activities (in contrast with Figure 11—7.75%).

Data obtained from a case study [4] confirms the presented results in this paper. The case study was a residential project where all disciplines mentioned in Figure 4, except the fire protection and geotechnics, were modeled in BIM in the Level of Development (LOD) 300–400 (specification by AIA and BIM Forum) [55,56] and with the parameters that are required by the Slovak technical standards [57]. The man-hour statistics about the activities: BMC, BIM design, and BIM modeling were collected for the 14 months of the project. The BMC activities were 11.8% of all project man-hours, with a peak in the beginning (13.2%), in the 10th month of the project (15.5%), and in the last month of the project (50.34%). These peaks are the natural result of the project progress because most of the work has to be done by BIM managers/coordinators at the beginning of the project when BEP and all the templates must be prepared for designers and then at the end of the project when all the checking and detection activities are in process.

It can be assumed that with the increasing requirements on BIM models, the number of hours dedicated to BIM coordination will also increase. However, it is also possible to expect an increase in the level of knowledge of BIM coordinators and the use of automation, which will result in an increase in the efficiency of BMC processes. These processes, therefore, need to be further monitored and analyzed in order to improve preparation processes by the lead-appointed party.

4.2. Implications to Practice and Contribution to Knowledge

The presented data can be used for the improvement of the processes of tender response preparation by the lead-appointed party. The managers in the architectural companies that have to estimate the time and financial scope of the project need data about the activities on the BIM projects—such as man-hours spent by BMC and BIM modeling, and they also need to know how many specialists they need to have in the team dedicated to these activities. While on the small projects, the BMC can be done by the architect,

larger-scale projects require specialists for clash detection and parameter checks, CDE management, issues management, and other BMC processes.

Different project stakeholders can immediately use the presented data for their estimations. In this case, they calculate the total project duration based on the requirements from the appointing party; they could use the presented data for clarification or check of their calculation. To be more precise, if the requirements on the BIM project are average (average values from the presented survey), the manager can assume that the team will spend 40–50% of the total project time with BIM modeling (Figure 12), 7–15% with BMC activities (Figures 11, 13 and 15), and approximately 8–15% members of the team should be BIM specialists (Table 4 and Figure 14).

The results show the need for these specialized positions, mainly on the projects where higher levels of BIM are required. It can be assumed that with an increasing implementation in private and public sectors, these positions will be needed even more. However, as the annual survey shows, it is not enough of them in Slovakia yet [15].

The provided data can help the managers to prepare for the project better, which could lead to fewer project delays, misunderstandings, and financial losses. Moreover, the well-planned and non-delayed project could have a significant effect on the quality of the documentation, which will lead to an efficient and less erroneous construction process. All of the mentioned benefits have a direct or indirect impact on the country's GDP and environment.

5. Conclusions

Companies use Building Information Modeling (BIM) to increase the quality and efficiency of their work, but due to the low experience with such projects, companies often underestimate the size of the project team and duration of project delivery. Both the size of a project team and the duration of a project directly affect the project's cost. With the increasing requirements and growing number of projects and their scale, this plays an important role. Today, the underestimation is quite common because the amount of time that BMC processes consume has not been measured and, therefore, it is generally not well known. The lack of information on the duration of coordination activities has a negative impact on the price estimation before the project execution.

BIM coordination and management not only brings a number of new tasks to the project, but also creates a demand for new positions and the transfer of competencies within the project team. Understanding the range and scope of tasks interconnected with the deployment of BIM on a project is critical to determining team efforts and workload.

This paper presents the key findings of the anonymous survey realized with BMC professionals in the lead appointed parties, focusing on the duration of BIM-related processes within the project delivery in the Architectural and Engineering companies in Slovakia. Findings are presented in the tables, graphs, and discussion.

The survey focused on the scope of the BIM projects executed by respondent companies and on the identification of the processes related to BIM modeling and coordination. Following questions aimed at the percentage representation of BIM managers in the whole team of the lead-appointed party and on time spent with BMC-related tasks. The last section of the survey focused on the opinions of experts for the appropriate number of BIM managers/coordinators and estimated man-hours needed solely for BMC.

The results show that the BIM management and coordination tasks represent a significant proportion of the total project time (7.75%) and need to be done by specialists.

Based on the survey, we also recommend that BMC tasks should no longer be executed by draftsman/designer and need to be handled by specialists—BIM managers and/or BIM coordinators due to the nature of activities and the workload.

To our best knowledge, and based on an extensive and in-depth literature review in this field, we believe that the quantification of BMC tasks from the perspective of workload has not been yet described. The novelty of outputs presented within the paper can contribute to a better understanding of the project's workload, which is crucial for

appropriate team composition and important for the preparation of more accurate project schedules and price estimations at the time of tender or procurement.

The main shortcoming of the analysis is a relatively small survey pool; however, as described in the previous sections, the number of contacted persons includes a vast majority of the market and is determined by the overall level of BIM use in Slovakia. We expect that with a greater number of case studies evaluated in the future, recommendations for team composition and time estimation for BMC tasks will be more complex and precise.

The data from the survey can also be used for further research and development of the methodology for project price estimation, which will cover different types of buildings and different project phases, including the Level of Information Need.

Nomenclature

AIM	Asset Information Model [1,2]
BCF	BIM Collaboration Format [58]
BEP	BIM Execution Plan [2,59]
BIM	Building Information Modeling [1,2,59–62]
BMC	BIM management and coordination (abbreviation used in this paper)
CAD	Computer Aided Design [63]
CCIC	Construction Classification International Collaboration [51]
CDE	Common Data Environment [1]
DEC	Design and Engineering companies (abbreviation used in this paper)
DMS	Digital Management System [64]
EIR	Exchange Information Requirements [1]
IFC	Industry Foundation Classes [59,65]
LOD	Level of Development [55,56,59]
LOG	Level of Geometry [59,66]
LOI	Level of Information [59,66]
PIM	Project Information Model [1]
STN	Slovak Technical Standard [1]
SMEs	Small and medium-sized enterprises [67]
WIP	Work in Progress [1,53]

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