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BIM Execution Plan based on BS EN ISO 19650-1 and BS EN ISO 19650-2 Standards

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Abstract

The major requirement of architecture, engineering, and construction (AEC) industry is to effectively manage information gathered from different project stakeholders. A structured guideline requires for managing the process and information productively. The first global Building Information Modeling (BIM) standards, BS ISO 19650-1 and BS ISO 19650-2, are recently published for managing information over the whole life cycle of a built asset using BIM. The research objective of this study is to develop and implement a BIM execution plan (BEP) based on BS EN ISO 19650-1 and BS EN ISO 19650-2, and identify the benefits of using BS EN ISO 19650 standards in the BIM-based construction projects. The results of this study indicate that using ISO 19650 standards in the BIM projects allows stakeholders to (1) demonstrate a significant value proposition for purpose-driven, structured, verified and validated information models, (2) support data exchange in a collaborative information management system efficiently, and (3) minimize data over processing. This study makes a significant contribution to the AEC literature and industry by presenting the development and implementation process of a BIM Execution Plan based on BS EN ISO 19650-1 and BS EN ISO 19650-2 standards, and benefits of BS ISO 19650-based BIM projects. This study will promote the use of ISO 19650 standards in the BIM-based construction projects.

Keywords: ISO 19650, BIM, Building Information Modeling, BIM Execution Plan

1. Introduction

Implementing standards and performing data management in the construction projects streamline processes that in turn increase the value in the architecture, engineering, and construction (AEC) industry. System and software standardization help professionals minimize the project cost, reduce the need for specialized expertise, consolidate the vendor management, reduce incompatibility, and simplify the infrastructure and the ecosystem [1]. Construction projects may include a number of stages, or gateways, at which information is collated or produced. In such projects, consultants, clients, contractors and subcontractors generate huge amounts of data. Hence, information management becomes more significant for the construction project stakeholders. Information management ensures the parties to manage the resources in the most effective way with the aim of achieving the employer's project requirements (EPRs) [2]. Especially, information management is highly significant in the large-scale construction projects including multiple stakeholders from different disciplines due to numerous data. Such a problem can be solved by applying a standardized methodology throughout the project delivery process. For this purpose, the International Organization for Standardization (ISO) published the first global Building Information Modeling (BIM) standards which are BS EN ISO 19650-1 and BS EN ISO 19650-2. These standards represent a significant step for systematizing the information management requirements in the BIM-based construction projects with an internationally agreed set of concepts and principles [4]. BS EN ISO 19650-1 and BS EN ISO 19650-2 can be applied any sort of construction projects regardless of the project size and complexity. The ISO 19650 series describe the latest industry standards and best practices for managing information in the construction projects. Furthermore, BS EN ISO 19650-1 and BS EN ISO 19650-2 can be used for standardizing the project life cycle that in turn provides a transparent information flow, a good structure for data capture and a clear view for operational process in the construction projects [1]. Currently, any BIM standard or any converted standard does not exist in Turkey. The research objective of this study is to develop and implement a BIM execution plan (BEP) based on BS EN ISO 19650-1 and BS EN ISO 19650-2, and identify the benefits of using BS EN ISO 19650 standards in the BIM-based construction projects. It is expected that this study promotes the use of ISO 19650 standards in the BIM-based construction projects. Using a BS EN ISO 19650 standards based BEP in the construction projects allows parties to demonstrate a significant value proposition for developing structured, purpose-driven, verified and validated information models which supports data exchange in a collaborative information management system efficiently, minimizes data over processing and satisfies employer's information requirements.

2. Research Methodology

The research methodology of this study consists of three steps which are semi-structures interviews with subject matter experts (SMEs), literature review and case study, respectively. These methods were selected in order to integrate different perspectives on the subject domain. The information gathered by these research methods was triangulated for the purpose of determining the benefits and requirements of ISO 19650-1,2 standards in the BIM-based construction projects.

In the first step of this study, face-to-face semi structured interviews were performed with two SMEs in order to determine the benefits and requirements of the BIM standards. These interviews were conducted to gather the details of the published standards and the necessity of them in the BIM-based construction projects. In these interviews, the requirements and

deficiency of standardization, possible solution recommendations and applications of ISO 19650 standards including the relevant procedures and processes throughout the project design, construction and operation were discussed. Two interviewees are Civil Engineer. One of these interviewees has 25 years of experience in the AEC industry, the other has 10 years of experience. The first interviewee had PhD degree, and works as a Director of Engineering & Design in an international company. The second interviewee has MSc degree, and works as a Senior Information Management Lead in an international company.

In the second step, a literature review was performed. This technique was selected as one of the data collection method in this study because reviewing literature allows researchers to determine the major requirements of the AEC industry, and obtain detailed information on the subject domain. BS EN ISO 19650-1 entitled "*Organization and digitization of information about buildings and civil engineering works, including building information modelling (BIM)- Information management using building information modelling - Part 1: Concepts and principles"* and BS EN ISO 19650-2 entitled "*Organization and digitization of information about buildings and civil engineering works, including building information modelling (BIM) - Information management using building information modelling - Part 2: Delivery phase of the assets, and Transition guidance to BS EN ISO 19650"* were examined and used in this study for developing the BIM execution plan. In the literature review, keywords were used for reducing subjectivity and obtaining detailed information on the subject matter. Publications with any of the following keywords were identified: 'ISO 19650', 'BIM Standards' and 'BIM and ISO 19650'. Studies published between 2018 and 2020 were analyzed using databases such as Elsevier, IOP Science and Google Scholar in the literature review. The reason of short timeframe is that ISO 19650 standards were published in 2018. A total of five conference papers, one book and 3 journal articles were reviewed manually. The reason of the limited publications considered within the scope of this study is that a few studies based on ISO 19650 standards exist in the literature.

In the third step, a case-study was executed using 2D plans of a construction project. In the case study, a BIM Execution Plan (BEP) was developed according the ISO 19650-1,2 standards. Considering the BEP, 3D BIM model of the project including structural, architectural, and mechanical plans, 4D model of the project including the clash detections, scheduling were performed, respectively.

3. Development of BIM Execution Plan

BIM Execution Plan is a guideline that explains how the information management aspects of the appointment will be carried out by the project team throughout the project delivery process [6]. This comprehensive document helps project teams identify and execute BIM in the various phases of construction management process [5]. Developing a detailed BIM execution plan and effectively integrating BIM into the project delivery process are highly important in terms of project success.

To develop a BEP based on ISO 19650 standard frameworks and requirements, first, the BEP must be provided by a prospective lead appointed party in their tender response. According to ISO 19650-2, the BEP is one of the several resources developed by the lead appointed party (i.e. contractor) on behalf of the delivery team to convey the information management approach

[7]. [1] BIM Execution Plan is a succinct resource which is supplemented by additional resources to be used by the prospective delivery team if appointed [8].

BIM Execution Plan has two different purposes in supporting the tender process that are appointment[1] and information delivery activities. These activities provide evidence to the appointing party[1] that in turn allows the prospective delivery team to manage project information toward any information requirements supported to them (pre-appointment BEP), and present a delivery tool [8]. The appointed delivery team[1] will use the delivery tool for producing, managing and exchanging project information during the appointment alongside other resources [7]. Although only one BEP exists for each delivery team, there may be two early versions of it; because, BEP is an alive document, and expected from the project participants to keep the document updated in case of any change in information or workflow. The first version is for the (pre-appointment) BEP, and the second version offers an update in case of alteration; thereby, the revised BEP can fulfil the project goals as an appointment resource.

According to ISO 19650-2, a simplified process leading up to the (pre-appointment) BIM execution plan composed of three steps [7]. In the first step, ISO 19650-2 Clause 5.1, the appointing party identifies the project wide information requirements and other resources. In the second step, ISO 19650-2 Clause 5.2, the appointing party defines the appointment specific Exchange Information Requirements (EIR) and issues tender information to prospective lead appointed parties. The last step, ISO 19650-2 Clause 5.3, the prospective lead appointed party develops a (pre-appointment) BEP that is returned alongside other tender response resources [7]. Further, the (pre-appointment) BEP should covers seven different key information management assessments as recommended in ISO 19650-2 clause 5.3.2. These assessments provide (1) the details of individuals undertaking the information management function, (2) proposed information delivery strategy, (3) proposed federation strategy to be adopted by the delivery team, (4) the delivery team's high-level responsibility matrix, (5) proposed adds/amends to project's information production methods and procedures (if there are any), (6) proposed adds/amends to project's information standard (if there are any), and (7) proposed schedule of software, hardware and IT infrastructure [7]. As the BEP is a formal appointment resource, it will need to be subject to a change management process throughout the appointment process. Additionally, this document serves as a series of defined project level instructions including guidelines on the method of integrated BIM processes that are followed throughout the project delivery process.

Within the scope of the research a BIM execution plan was developed and implemented in a case study. Development and implementation of BEP was illustrated by IDEF0 diagram (Fig 1). In the first step, a BIM execution plan was developed in accordance with the ISO 19650 standard's frameworks and requirements, and its mechanism was provided with BEP cycle. Then, BIM implementation was performed in a construction project according to the BEP document prepared in the first step.

[1] Appointments is agreed instruction for the provision of works, goods or services. Appointed party is provider of works, goods or services. Appointing party is receiver of works, goods or services from a lead appointed party. Delivery team is lead appointed and their appointed parties. [6]

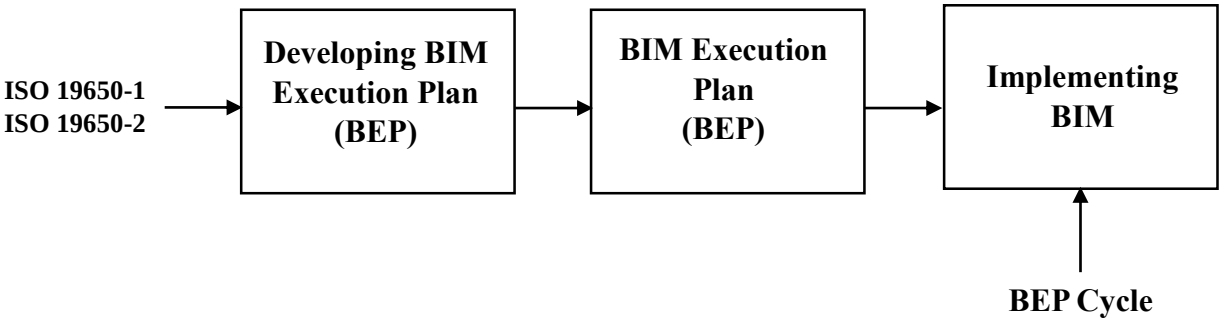

Figure 1. Methodology of BEP

For this study, a BIM execution plan was generated with the aim of applying BIM process throughout the design process of a project based on ISO 19650-1, 2 standards' frameworks and requirements. During the BIM implementation process, A BEP cycle was applied that consists of eleven steps (Fig. 2).

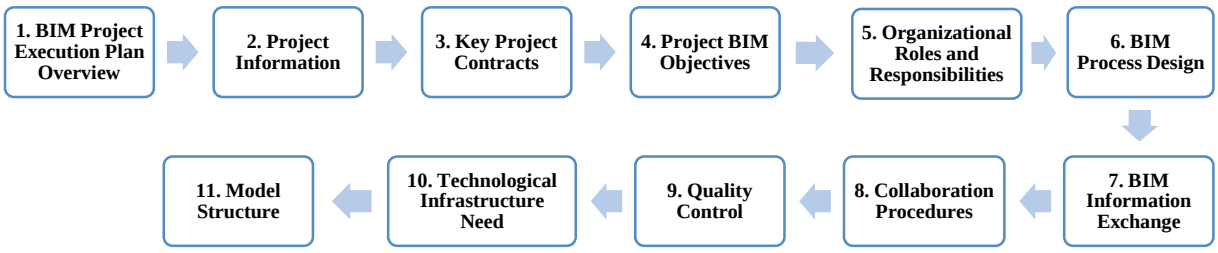

Figure 2. BEP Cycle

4. Case Study

In the case study, a residential 4-floor building was modeled via Autodesk Revit 2020. The main model of the building, which is the completed version of the project, is demonstrated in Figure 3.

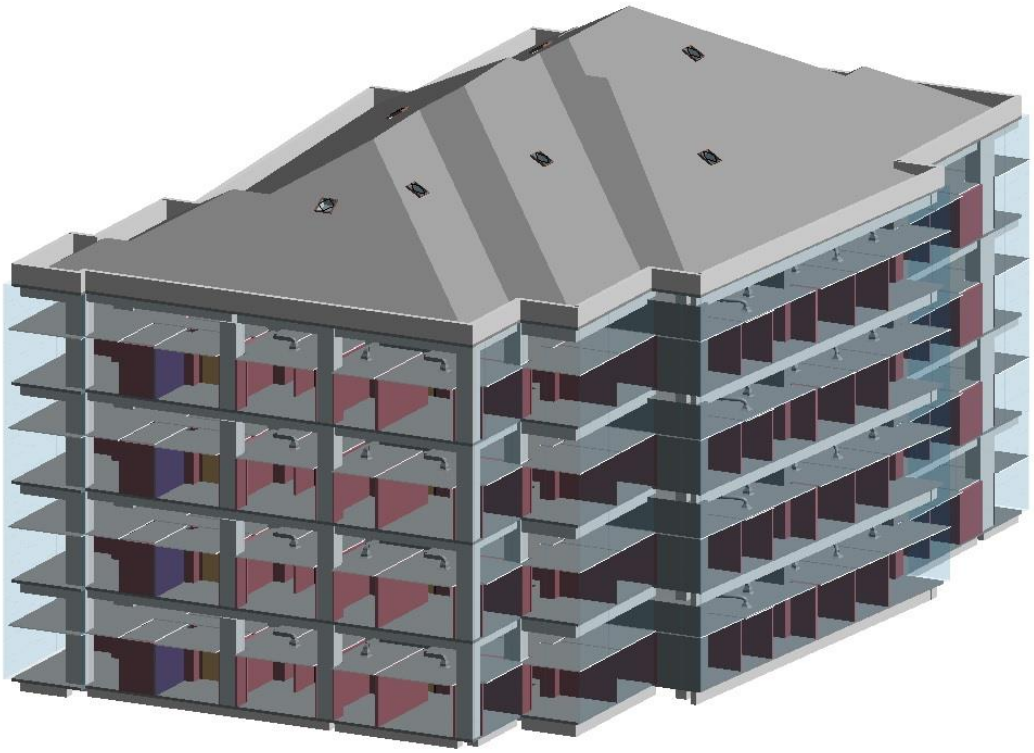

Figure 3. Main model of the building

BIM process implemented using the BEP which was developed according to ISO 19650-1, 2 standards. In the scope of BIM implementation, the architectural, structural and mechanical 3D BIM model designed using the determined LOD specification via Revit 2020. The structural 3D BIM model was sketched which includes structural elements such as column, beams with respect to 2D model of plan. During drawing process, the models, files, families, views and clashes were entitled, and the quality was controlled correctly according to the constituted BEP, respectively. In the next step, with the use of these models the clash test was launched, detected, and resolved consummately. First clash test was performed between structural and mechanical models. The second test was executed between architectural and mechanical models. Then, the results of clash tests were reported. The clash test conducted by rules such as tolerance was 0.000 m. After performing the clash tests, totally 28 clashes between structural and mechanical, and 508 clashes between architectural and mechanical were detected. The project schedule was created via MS Project 2018 in detail. Totally, the project workflow includes 126 activities. In the last step, the 4D modelling of the project was conducted by linked the imported 3D view of elements with respect to relevant activity from the imported schedule by using Navisworks 2020. Simulation was made after linking all activities with the 3D view in Revit.

5. Results

According to the triangulation of literature review and face-to-face semi structured interviews with SMEs, eight benefits of using ISO 19650 standards in the BIM-based construction projects were identified. These benefits are represented in Table 1 with their related source of data.

Table 1. Benefits of using ISO 19650 standards

ID	Benefits of using ISO 19650 standards	Related source of data
A#1	Enable teams to minimize non-value added activities, and increase predictability for cost and time	SMEs (semi structured interviews)
A#2	Identify employers' project requirements in the tender process (i.e., state exchange information requirements (EIR))	SMEs (semi structured interviews)
A#3	Digitalize the process, and prevent paperwork by using common data environment (CDE)	SMEs (semi structured interviews)
A#4	Enable teams to manage the information management process effectively	SMEs (semi structured interviews)
A#5	Provide a data standardization framework by assigning the responsibilities for information delivery	SMEs (semi structured interviews)
A#6	Allow employers/operators or clients to meet particular requirements or respond to their national contexts	ISO 19650-1
A#7	Able to apply to whole life cycle of a built asset and construction projects of all level of complexity	ISO 19650-1
A#8	Reduce the time and cost in producing coordinated information with the use of shared information containers by adopting CDE	ISO 19650-1

According to the SMEs' comments, A#2 is the prominent benefit of using ISO 19650 standards in the BIM-based construction projects. . In case of the employer's information requirements (EIRs) may not specify at the beginning of the project, and could cause major problems in terms of cost and time. By the virtue of ISO 19650 standards, employer's information requirements will be identified in tender process, and involved in the contracts that in turn assist project teams to prevent possible non-value added activities such as delays, defects. Further, A#6 and A#2 have a cause-effect relation. If the EIRs are identified in the tender process, these requirements can be met efficiently with the limited non-value added activities. Similarly, A#1, A#3, A#4, A#5 and A#7 have a cause and effect relation. Applying ISO 19650 standards in the BIM-based construction projects ensures the use of common data environment (CDE) that in turn digitalizes the processes, enables project teams to manage the information management process and prevents non-value added activities. Generally, except A#7, the other benefits are interrelated issues. A#6 shows that even intricate BIM-based construction projects can be efficiently managed throughout project life cycle by using ISO 19650 standards.

6. Discussion & Conclusions

This paper presents the development and implementation process of a BIM Execution Plan based on BS EN ISO 19650-1 and BS EN ISO 19650-2 standards, and identifies eight benefits of using ISO 19650 standards in the BIM-based construction projects by conducting, semi-structured interviews with SMEs, literature review and case study. This study makes a significant contribution to the AEC literature and industry by presenting the development and implementation process of a BIM Execution Plan based on BS EN ISO 19650-1 and BS EN ISO 19650-2 standards, and benefits of BS ISO 19650-based BIM projects. This research will

promote the use of ISO 19650 standards in the in the construction projects. Accordingly, this study will increase the awareness of importance for the usage of ISO 19650 standards in the BIM-based construction projects. Results of this study can be used by all stakeholders involved in the BIM-based construction projects.

According to the experts' comments, A#1, A#2, A#3, A#4, A#5, A#6 and A#8 are interrelated benefits and have a cause-effect relation among them. Experts also highlighted that A#2 is the most prominent benefit because if the employer' project requirements are identified at the beginning of the tender process in detail, the project success can be reached in terms of time and cost. A#6 presents that ISO 19650 standards can be adopted in any size and complexity of the construction project throughout the whole project life cycle. All these benefits prove that the use of ISO 19650 standards in the BIM-based construction projects streamline the processes by minimizing non-value added activities such as delays, paperwork and defects.

Findings of the study indicate that considering ISO 19650 standards framework and requirements in the BIM-based projects allows project stakeholders to demonstrate a significant value proposition which are structured, purpose-driven, verified, and validated information models. The value proposition supports data exchange throughout a collaborative information management system efficiently, minimizes data over processing, and satisfies employer's information requirements. According to the SMEs' comments, using a BEP based on the ISO 19650 allows project teams to conduct the data management system by standardizing the information throughout the project delivery process.

A future direction of this study could be developing a BEP in accordance with ISO 19650 standards for various types of buildings such as hospital, industrial building and shopping center. Another future direction could be analyzing and developing a BEP considering the ISO 19650-3, ISO 19650-4 and ISO 19650-5.

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