PRELIMINARY CHECKLIST PROPOSAL FOR ENHANCING BIM-BASED CONSTRUCTION PROJECT CONTRACTS

SUMMARY: In multi-participant BIM-based construction projects (BbCP), the organization of inter-stakeholder relationships has become challenging. The emerging BIM roles and responsibilities that are not clearly defined as a standard, complicate this process further. Legal regulations and contracts prepared according to traditional construction methods are insufficient to identify these new and complex relationships. This uncertainty hinders the spread of BIM-integrated projects, causing stakeholders to have legal concerns about BIM-based projects. Within the scope of this research, the legal concerns related with BIM-based projects and critical points to be considered in the contract preparation phase were determined through literature review, case law research, first and second stage interviews and a questionnaire survey. 25 main and 32 sub-critical points were identified and recommended to be considered in the contract phase were categorized under 9 headings (i.e., administrative decisions, analysis, legal issues, allocation of risks and responsibilities, intellectual property rights (IPR), information management, interoperability, data security and the operation phase). As an outcome, this paper proposes a preliminary checklist template that can be used as an input to the contract phase of BbCP. With the support of checklist, measures can be taken at the contract stage for potential legal problems that may occur in the project life-cycle. The checklist can serve as a starting point for legislators and regulators to ensure the compatibility of traditional construction contracts with new technologies. Finally, addressing legal issues in BbCP can alleviate stakeholders’ concerns and lead to the spread of BbCP in the construction industry.

KEYWORDS: BIM; Contract Management; Disputes in Construction; BIM Contracts

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1. INTRODUCTION

CI (construction industry) is one of the essential pillars of the economies thanks to its own and secondary industries. The CI is, however, also one of the most difficult and challenging industries to manage mainly due to its multi-disciplinary complexity and uniqueness as well as changes in building materials and construction methods. To overcome this managerial challenge, BIM offers several advantages: improved information management, interoperability potential and integrated supply chain (BSI, 2015a), effective and efficient management of tasks (Liu et al., 2017), communication and coordination improvement (Bryde et al., 2013), and reduction in delays and conflicts (Ghaaffarianhoseini et al., 2017). For example, 3D and 4D models prepared in BbCP (BIM-based construction project) can be integrated to various extended reality technologies to ensure that all stakeholders are included in the project from the first stage and that possible problems are detected early (Alizadehsalehi et al., 2019). Furthermore, conflicts which can arise especially in large and complex projects can be resolved through simulations (Heigermoser et al., 2019). Moreover, communication between the design team and the owner can be enhanced by making more understandable architectural presentations with the virtual reality model (Khalili, 2021). Consequently, management of large-scale digital data has become important in this integration process (Alizadehsalehi et al., 2020).

As BIM is becoming widespread in the CI, the project processes (e.g., design, procurement, construction and operation) have started to change (Ashworth et al., 2019). Collaborative environment offered by BIM, information management has gained more value as importance of communication and coordination between stakeholders has been increased. Although BIM has several advantages, BbCP involve various risks e.g., managerial (Perrier et al., 2020), technical, legal, financial, environmental risks (Chien et al., 2014). In order to cope with these risks, key stakeholders of the project (e.g., the project owner, design team, construction team) need to work together in the preparation of the BIM contract at the contracting stage (Dougherty, 2015). Most of the standard contracts and protocols that can be applied to BbCP are created as an addendum to the master contract and they cannot cover all risks (Chong et al., 2017). Moreover, since modern legal systems are typically constructed based on conventional construction techniques, they concentrate on individual rights and responsibilities of the stakeholders (Pandey et al., 2016). In contrast, as participants need to work together in the collaborative environment of BIM to get benefit from BIM, existing legislation and regulations lack arrangements for integrated design and for regulating cooperation between stakeholders (Azhar, 2011).

Elimination and minimization of disagreements is essential for the efficient and effective implementation of the project. Increase in the number and diversity of stakeholders and digital data reveals various risks in BbCP (Liu et al., 2017). The risks that may occur during the project process can be reduced/prevented through the collaborative and communication-supported structure of BIM (Ghaaffarianhoseini et al., 2017). Furthermore, these risks may turn into disputes due to some deficiencies in the contracting phase (Dougherty, 2015). The main issues that can pose these risks are: identifying BIM roles and stakeholders responsible for them (Arensman and Ozbek, 2012; Bosch-Sjitsema et al., 2017; Ussing et al., 2016); IPR (intellectual property rights) in the common information platform (Arshad et al., 2019; Manderson et al., 2015; Solihin and Eastman, 2015), software compatibility (Bynum et al. 2013; McAdam, 2010; Succar, 2010); data security (Chien et al., 2014; Dougherty, 2015; Eschenbruch and Bodden, 2018); and digital data storage (Bakhary et al. 2015; Lai et al., 2019). Preparation of a clear and detailed contract can minimize disputes in the project life-cycle (Sardroud et al., 2018).

This paper focuses on contract aspect of the BbCP and the main legal concerns related with the integration of BbCP’s requirements and needs into the contract. With this aim, international guidelines, standard contracts and protocols were examined, case law research was conducted, first and second stage interviews and an online-questionnaire survey were performed. As a result, critical points to be considered in BIM-based contracts were determined and a preliminary checklist template was proposed to support the contract preparation phase of BbCP.

2. LEGAL ASPECTS OF BbCP

2.1 BIM-based Construction Project Management

BIM facilitates the information flow by providing a collaborative decision-making platform (Heigermoser et al., 2019), and brings solutions to managerial problems through stakeholders’ involvement in the entire building lifecycle (Demian and Walters, 2014). Governments, universities and institutions have published several guidelines to assist project stakeholders in planning BIM integration processes. Among them the followings were
studied within the scope of this research (i.e., BBIM, 2015; CANBIM, 2012; COBIM, 2012; DASBIM, 2015; NATSPEC, 2016; NBIM, 2013; NBGO, 2017; PSUBIM, 2019; SBEncBIM, 2017; SBIM, 2013; USCBIM, 2012; USFBIM, 2018). Additionally, under the name of BSI Standard Publications, 2 ISO (International Organization for Standardization) (BSI, 2018a, 2018b) and 6 PAS (Publicly Available Specification) (BSI, 2013, 2014b, 2014a, 2015a, 2015b, 2018c). These guidelines were chosen based on their scope and content details.

2.1.1 BIM-based CPM process

In complex construction projects with multi-stakeholders, planning the interaction of stakeholders throughout the process can reduce risk of conflicts and disputes. Main headings, scopes and topics highlighted in the examined guidelines have been executively summarized in the Table 1.

| Main headings                        | Main points highlighted in the documents                                                                                                                                                                                                 |
|--------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Extent of the process                | Between pre-design and handover phases (BBIM, 2015; CANBIM, 2012; DASBIM, 2015; NATSPEC, 2016; NBGO, 2017; SBEncBIM, 2017; SBIM, 2013; USCBIM, 2012; USFBIM, 2018). From the organizational decisions before project initiation and operational stages after project handover (BSI, 2018a; COBIM, 2012; NBIM, 2013; PSUBIM, 2019). |
| Information management               | The procedures related to information management are detailed or referenced to specific documents. These procedures are generally specified under 3 titles as creating, sharing and archiving (BBIM, 2015; BSI, 2013; COBIM, 2012; NATSPEC, 2016; NBIM, 2013; NBGO, 2017; PSUBIM, 2019; USCBIM, 2012; USFBIM, 2018). |
| Legal status of BIM requirements     | The BIM goals and requirements as well as the roles and responsibilities that arise from them, should be legally binding in the contract. (BBIM, 2015; BSI, 2018a; CANBIM, 2012; COBIM, 2012; NATSPEC, 2016; NBGO, 2017; PSUBIM, 2019; SBEncBIM, 2017; SBIM, 2013) |
| IPR                                  | In the highly integrated and collaborative environment of BIM, the definition and protection of IPR are essential and the requirements should be specified in the contract (BBIM, 2015; BSI, 2013; CANBIM, 2012; COBIM, 2012; NBIM, 2013; NBGO, 2017; PSUBIM, 2019; SBEncBIM, 2017; SBIM, 2013). |
| Operation and maintenance            | The procedures for handing over the BIM model to the facility manager for the operational stage should be determined (BBIM, 2015; BSI, 2014b; COBIM, 2012; NATSPEC, 2016; NBIM, 2013; NBGO, 2017; PSUBIM, 2019; SBEncBIM, 2017; SBIM, 2013; USCBIM, 2012; USFBIM, 2018). |

2.1.2 BIM-based CPM stakeholders and teams

A collaborative environment including all supply chain participants is needed to get benefit from BIM. Ensuring that all expertise and knowledge of stakeholders are shared with each other through effective stakeholder management is important for the success in project management process (Srinivasan and Dhiyva, 2020). With the spread of BIM in the CI, new roles and responsibilities are evolved (Uhm et al., 2017). Although according to a recent study 35 different BIM related job titles have emerged (Uhm et al., 2017), there is no generally accepted definition of the duties and responsibilities of these roles (Bosch-Sijtsema et al., 2019).

According to the researchers, a specialist BIM manager should be appointed to manage and control all BIM processes and stakeholders (Eschenbruch and Bodden, 2018; Huzaimi and Fathi, 2019). Besides the manager, coordinator and modeller are among the most important BIM roles (Borrmann et al., 2018; Tulke and Schumann, 2018). The general definitions and the hierarchical scheme of BIM roles, which are described in the examined guides (i.e., BBIM, 2015; CANBIM, 2012; COBIM, 2012; DASBIM, 2015; NATSPEC, 2016; NBIM, 2013; NBGO, 2017; PSUBIM, 2019; SBEncBIM, 2017; SBIM, 2013; USCBIM, 2012; USFBIM, 2018) are shown in the Fig. 1.:
2.1.3 BIM-based CPM documents

Integration of BIM into the traditional construction process can be facilitated through the documents regulating this process. BIM Execution Plan (BEP), which contributes to the integration process through determination of the BIM requirements and goals at all project stages, is one of the most important documents (Abdirad, 2015). Although BEP content is not well defined as a standard in the literature, it should fundamentally include details on the following topics (Eschenbruch and Bodden, 2018): data production, level of detail, milestones of the process, responsible groups and coordination actors. Although the names vary, all investigated guidelines mention the BEP document. All guidelines state the importance of creating BEP in the early stages of the project for effective BIM integration. Some guides (COBIM, 2012; SBIM, 2013; NBIM, 2013; BBIM, 2015; NATSPEC, 2016; NBGO, 2017; BSI, 2018a) indicate that BEP should be seen as a dynamic document and updated through project phases. Along with the BIM Implementation Plan, various documents according to the stages of the project are highlighted (COBIM, 2012; NBIM, 2013; BSI, 2015a; NATSPEC, 2016; NBGO, 2017; PSUBIM, 2019). These documents can be classified under 3 main headings under the organizational, asset and project-based levels (BSI, 2018b) as follows:

Organizational Level: BSI ISO1 (2018b) emphasizes OIR (Organizational Information Requirements) and PIR (Project Information Requirements) respectively to determine the organization's high-level strategic objectives, portfolio planning and regulatory policies as well as to measure and monitor decisions on a project specific basis. PSUBIM (2019) recommends publishing a BIM Mission Statement document that specifies the importance of BIM to the company, and which details its usage for future corporate decisions.

Asset Level: BSI ISO1 (2018b) emphasizes the AIR (Asset Information Requirements), in which managerial and commercial decisions about the asset as well as production methods and procedures are determined. Furthermore, BSI ISO1 (2018b) emphasizes the AIM (Asset Information Model), where project-based responses to these asset decisions are specified. Moreover, while NBGO (2017) states that the expectations of the project stakeholders from the operation phase should be specified, NBIM (2013) recommends alternative investment evaluations to be made considering the building life-cycle.
Project Level: While the NBGO (2017) points out that the client must specify the design and facility approaches regarding the owner's demands, NATSPEC (2016) specifies a document called Project BIM Brief, which defines the needs of the employer during the project process. Similarly, BSI ISO1 (2018a) recommends the EIR (Exchange Information Requirements), which defines the information that the client must fulfil at the project close-out phase as well as the PIM (Project Information Model), which defines the information requirements and procedures in the project delivery phase. Differently, PSUBIM (2019) recommends the BIM Use Selection Worksheet, which regulates when each stakeholders will undertake BIM tasks throughout the process and which specifies their BIM competency levels.

Integration of BIM into the contract is challenging as it contains large amount of information directly used by stakeholders. Standard contracts and protocols have been established to overcome this challenge (Abdirad, 2015). The actual use of these documents, however, has not yet become widespread in the CI (Al-Shammari, 2014). Although many researchers (Arensman and Ozbek, 2012; Ussing et al., 2016) indicate that international standards should be established to prevent legal problems that may arise in BIM integration, they also agree that country specific differences should be considered. Within the scope of the research, 3 standard contracts [i.e., CIOB (the Chartered Institute of Building) (2013), JCT (Joint Contracts Tribunal) (2016), and NEC (New Engineering Contract) (2017)]; and 3 protocols [i.e., AIA (American Institute of Architects) E203 (2013), CIC (Construction Industry Council) BIM Protocol (2018), and CDOC (Consensus Documents) 301 (2015)] used in the BIM integration process were examined. Main headings, scopes and topics highlighted in these documents have been provided in the Table 2.

| TABLE 2: Main headings, scopes and topics highlighted in the examined standard contracts and protocols. |
|-----------------------------------------------|
| Main headings | Main points highlighted in the documents |
| Allocation of responsibilities | The employer should establish a completed protocol for defining and sharing of responsibilities as well as ensure that the protocol is integrated into all project agreements (CIC, 2018; JCT, 2016). Participants are responsible for their contribution to the model, the data generated from their contribution, and the data generated by contractually lower tiers of the participants (CDOC, 2015). |
| IPR | The written consent of the data-generating party is required for the usage and modification of data to ensure the protection of IPR (AIA, 2013; CIC, 2018). Shared data can only be used by the recipient party for the relevant construction work (AIA, 2013; CDOC, 2015; CIC, 2018). |
| Information management | The participants should establish a protocol to manage the centralized electronic documents management system AIA (2013). The models expected from stakeholders through project stages should be described in the protocol according to the project stages (JCT, 2016; CIOB, 2013). The participant cannot be held responsible for damages resulting from unauthorized data use and modification (CDOC, 2015; CIC, 2018). The software and formats to be used in the process should be determined to prevent interoperability problems (CIC, 2018; CIOB, 2013). All 2D drawings of the project should be extracted from the 3D common model (CDOC, 2015). |
| Data security and storage | Procedures should be established for uploading, viewing, modifying, backing up and archiving information on the common platform for IPR and data security (AIA, 2013; CDOC, 2015; CIOB, 2013). |

2.2 Contractual Aspects of the BIM-based CPM

There are several legal concerns in the integration of BIM-based projects into contracts (Dougherty, 2015). As contractual arrangements covering BIM goals and outcomes have been repeatedly identified as a challenge locally and internationally (Kuiper and Holzer, 2013), effective contract management with written provisions is vital for regulating legal concerns and implementing necessary procedures (Fan et al., 2019). It is necessary to define new services, responsibilities and legal issues arising from changes in the construction planning through BIM.

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integration. Nevertheless, due to the lack of experience, there is no common strategy for BIM contracts (Eschenbruch and Bodden, 2018).

BIM requires a number of stakeholders to work collaboratively to transform data into a 3D virtual model (Papadonikolaki et al., 2019). Since traditional construction contracts are mostly bipartite documents, various legal problems may arise during this collaboration (SBEnrc The Sustainable Built Environment National Research Centre, 2017). The main causes of legal concerns and disputes about BIM are:

- Ownership of the model, risk allocation, IPR and interoperability (Jo et al., 2018).
- Responsibility of the used data, responsibility of quantities, clash detection, professional reliability and third parties related to BIM (Ussing et al., 2016).
- Unclassified and/or non-prioritized documents (Charehzehi et al., 2017).

2.2.1 Critical aspects of contract management in the BIM-based CPM

High number of stakeholders and data in BIM integration reveals various risks (Liu et al., 2017). Although collaborative nature of BIM reduces conflicts (Ghaffarianhoseini et al., 2017), some deficiencies at the contracting stage can lead to various disputes (Dougherty, 2015). Causes of conflicts that occur throughout the life-cycle of BbCP can be grouped under four main headings (Ashcraft, 2008; Arensman and Ozbek, 2012; Kuiper and Holzer, 2013; Dougherty, 2015; Ashworth et al., 2019; Huzaimi and Fathi, 2019): allocation of risks and responsibilities, IPR, interoperability, data security and documentation. They can be described as follows:

Allocation of risks and responsibilities: The modern legal structure is based on the distinct concept of obligations (Arensman and Ozbek, 2012), while the collaborative and integrated system of BIM mixes levels of responsibility between different stakeholders (Azhar, 2011). Additionally, unlike the signature and stamp system in paper-based documentation, it is more difficult to identify responsible persons in the integrated model (Schapke et al., 2018). Consequently, the main contract should be supported by additional forms and protocols to protect the stakeholders involved in the BIM system (Azhar, 2011; Hsu et al., 2015).

IPR: The collaborative environment entails the risk of exposing and sharing data valuable to stakeholders (Hsu et al., 2015; Solihin and Eastman, 2015). Therefore, contractual status and ownership rights of the information generated and tools used in the project should be determined (McAdam, 2010; Kuiper and Holzer, 2013; Hsu et al., 2015).

Interoperability: Throughout the interactive and dynamic project process, the 3D common model must be on a controllable platform (Lai et al., 2019). Moreover, a contractually binding protocol regarding the production, exchange, share, approval, publication and certification of data in the project process should be established (Eastman et al., 2010; Siemens, 2017; Schapke et al., 2018).

Data security and documentation: Main problems of digital information transformation are ownership and data security issues of BIM deliverables (Solihin and Eastman, 2015). Additionally, accessibility of electronic data by all stakeholders, raises concerns about unauthorized online access and ownership violations (Chien et al., 2014). For this reason, as digital information must be protected against loss, corruption, and theft (Olatunji, 2011), data need to be gradually authorized based on data’s intended use and stakeholders’ responsibilities (Eschenbruch and Bodden, 2018; Schapke et al., 2018).

2.2.2 Critical points of BIM-based CPM

Within the scope of this paper, international standard contracts and protocols, and international guidelines were analysed to determine the critical points of BIM-based CPM. In total, 6 standard contracts and protocols, 13 guidelines and 36 articles were examined. In these examined articles and documents, there are imperatives, recommendations and warnings for the critical points. As a result of this examination, 49 critical points of BIM-based CPM have been identified. These critical points are shown in the Table 3 where “dark grey cell” indicates documents that strongly mention the critical points whereas “light grey cell” indicates documents that weakly mention the critical points.
### TABLE 3: The critical points of BIM-based CPM.

| Critical Points                                               | Standard Contracts and Protocols | BIM Guidelines |
|---------------------------------------------------------------|----------------------------------|----------------|
| Critical points of administrative decisions                  |                                  |                |
| Organization-related Decisions                                | NEC4 (2017)                      | NEC4 (2017)    |
| Asset-related Decisions                                       | CTB (2016)                       | CTB (2016)     |
| Project-related Decisions                                     | ALA (2016)                       | ALA (2016)     |
| Critical points of analysis                                   |                                  |                |
| Sustainability Analysis                                       |                                  |                |
| Time and Cost Analysis                                        |                                  |                |
| Critical points of legal issues                               |                                  |                |
| BIM Execution Plan                                            |                                  |                |
| Contractual Status of Protocols                               |                                  |                |
| Contractual Status of Model                                   |                                  |                |
| Critical points of allocation risks and responsibilities      |                                  |                |
| BIM Meetings                                                  |                                  |                |
| Pre-Qualifications                                            |                                  |                |
| Protocol for Obligations                                      |                                  |                |
| BIM Process Responsible                                       |                                  |                |
| BIM Discipline Responsible                                    |                                  |                |
| BIM Consultancy                                               |                                  |                |
| BIM Requirements of Owner                                     |                                  |                |

Articles

- (Ashworth et al., 2019)
- (Abdirad, 2015; Lin et al., 2016; Chong et al., 2017; Eschenbruch and Bodden, 2018)
- (Azhar, 2011; SEC group, 2017)
- (Arensman and Orzbek, 2012; Ussing et al., 2016)
- (Howard and Ciliberto, 2016)
## Critical Points

| Critical Points                                      | Standard Contracts and Protocols | BIM Guidelines |
|-----------------------------------------------------|----------------------------------|----------------|
|                                                      | GC-BIM (2018)                    |                |
|                                                      | NEC4 (2017)                      |                |
|                                                      | IFC (2016)                       |                |
|                                                      | GDOC 31 (2015)                   |                |
|                                                      | AIA-203 (2013)                   |                |
|                                                      | CIB (2013)                       |                |
|                                                      | BSIPBIM (2019)                   |                |
|                                                      | USEPBIM (2018)                   |                |
|                                                      | NBOA (2017)                      |                |
|                                                      | NSPSPEC (2016)                   |                |
|                                                      | BIM (ENBIM)                      |                |
|                                                      | DASBIM (2015)                    |                |
|                                                      | CANBIM (2012)                    |                |
|                                                      | SRBM (2013)                      |                |
|                                                      | BMB (2013)                       |                |
|                                                      | CORDM (2012)                     |                |
|                                                      | CIC BIM (2018)                   |                |
|                                                      | NEC4 (2017)                      |                |
|                                                      | IFC (2016)                       |                |
|                                                      | GDOC 31 (2015)                   |                |
|                                                      | AIA-203 (2013)                   |                |
|                                                      | CIB (2013)                       |                |
|                                                      | BSIPBIM (2019)                   |                |
|                                                      | USEPBIM (2018)                   |                |
|                                                      | NBOA (2017)                      |                |
|                                                      | NSPSPEC (2016)                   |                |
|                                                      | BIM (ENBIM)                      |                |
|                                                      | DASBIM (2015)                    |                |
|                                                      | CANBIM (2012)                    |                |
|                                                      | SRBM (2013)                      |                |
|                                                      | BMB (2013)                       |                |
|                                                      | CORDM (2012)                     |                |

### Articles

| Articles                                                                 |
|-------------------------------------------------------------------------|
| Kuiper and Holzer, 2013; Abdirad, 2015                                  |
| Kuiper and Holzer, 2013; Lin et al., 2016; Papadonikolaki et al., 2019 |
| Arensman and Ozbek, 2012; Ussing et al., 2016; Bosch-Sijtsema et al., 2019 |
| Abdirad, 2015; Borrmann et al., 2018; Bosch-Sijtsema et al., 2019       |
| Manderson et al., 2015; Arshad et al., 2019                            |
| Arensman and Ozbek, 2012; Solihin and Eastman, 2015                    |
| Manderson et al., 2015; Solihin and Eastman, 2015                      |
| Eschenbruch and Bodden, 2018                                           |
| Dougherty, 2015; Charehzehi et al., 2017; Ghaffarianhoseini et al., 2017; Eschenbruch and Bodden, 2018 |
| (Ashcraft, 2008; Lin et al., 2016)                                     |
| Critical Points                              | Standard Contracts and Protocols | BIM Guidelines |
|-------------------------------------------|---------------------------------|----------------|
| Software                                   | ITBIM (2018)                    |                |
| Native Data Format                         |                                |                |
| Authority to Access                        | NEC4 (2017)                     |                |
| Contact List of Authorized Users           | CT (2016)                       |                |
| Authority to Change                        | GD-2015 (2015)                  |                |
| Electronic Stamps                          | AIA E203 (2013)                 |                |
| Authority to Share                         | GBR (2019)                      |                |
| Digital Data Storage                       | BSI Publications                |                |
| Authority to Change                        | USEFVIM (2018)                  |                |
| Digital Data Archiving                     | NATSPEC (2016)                  |                |
| Back-up Procedures                         | BIM (BSI, 2014,b)               |                |
| Restore Procedures                         | BSIM (2013)                     |                |
| Critical points of interoperability        | BBIM (BSI, 2015)                |                |
| Modes of Collaboration                     | CANBIM (2012)                   |                |
| Clash Detection                            | SUBIM (2019)                    |                |
| Extracting 2D Drawings from 3D Model       | NBGO (2017)                     |                |
| Change Order Procedures                    | SBEnrcBIM (2017)                |                |
| Critical points of data security           | NATSPEC (2016)                  |                |
| Data Security for Loss, Corruption and Virus | (Chien et al., 2014)             |                |
| Encrypted Filing                           | (Dougherty, 2015)               |                |
| Access from Unknown Server                 | (Chien et al., 2014)             |                |
| Data Insurance                             | (Manderson et al., 2015)        |                |

Articles

(Chien et al., 2014; Dougherty, 2015; Eschenbruch and Bodden, 2018)

(Chien et al., 2014)

(Solihin and Eastman, 2015; Charehzehi et al., 2017; Schapke et al., 2018)

(Solihin and Eastman, 2015; Charehzehi et al., 2017; Schapke et al., 2018)

(Chien et al., 2014)

(Solihin and Eastman, 2015; Charehzehi et al., 2017; Schapke et al., 2018)

(Solihin and Eastman, 2015; Charehzehi et al., 2017; Schapke et al., 2018)

(Solihin and Eastman, 2015; Charehzehi et al., 2017; Schapke et al., 2018)

(Solihin and Eastman, 2015; Charehzehi et al., 2017; Schapke et al., 2018)

(Lai et al., 2019)

(Bakhary et al., 2017)

(Olatunji, 2011)

(Ussing et al., 2016; Li et al., 2017)

(Chien et al., 2014; Dougherty, 2015; Eschenbruch and Bodden, 2018)

(Chien et al., 2014)

(Manderson et al., 2015)
### 3. RESEARCH METHODS

This paper aims to develop a proposal for a preliminary checklist template that can be considered as a potential input to the contracting phase of these projects so that the contract preparation phase of BbCP can be improved. Research flowchart is provided in Fig. 2. The objectives determined in accordance with the aim are as follows:

- To review the BIM guidelines, standard contracts and protocols.
- To determine the critical aspects and issues to be considered in the BIM-based construction contracts.
- To propose a preliminary checklist template which can be considered as a potential input in the contract preparation phase of the BbCP.

**FIG. 2: Flowchart diagram of the research.**

#### 3.1 Case Laws Research

Within the scope of the study, a litigation awards and case laws research was conducted through international (Lexisnexis.com) database to investigate the causes of BIM-related disputes that arise in BbCP. Among the search results, the ones originating from the BIM and BIM processes were examined.

#### 3.2 First Stage Interviews

First stage interviews were conducted with 5 professionals who actively use and have experience in BIM technology. Participants' information is provided in the Table 4.
TABLE 4: Interviewed professionals (First Stage).

| Profession     | Experience (in years) | BIM Experience (in years) | Role in the Project                                      |
|----------------|-----------------------|---------------------------|----------------------------------------------------------|
| Architect      | 20                    | 10                        | BIM Designer and consultant on the design party (Airport Project) |
| Architect      | 16                    | 7                         | BIM Manager and chief designer on the design party (TV&Radio Tower Complex) |
| Civil Engineer | 26                    | 13                        | BIM Director at the employer party (Metro Project)        |
| Civil Engineer | 8                     | 6                         | BIM Coordinator on the engineering party (Metro Project)  |
| Civil Engineer | 25                    | 10                        | Founding partner of the engineering firm                 |

3.3 Online Questionnaire Survey

Following the interview, an online questionnaire (following the pilot study conducted to 10 professionals) was conducted via LinkedIn and e-mail to a sample of professionals with BIM-related job titles actively working in the CI. The online questionnaire, which was kept on for 6 months. In total 69 people filled in the questionnaire.

3.4 Second Stage Interviews

In order to further improve and verify the preliminary checklist template proposal, second stage interviews were conducted with 10 professionals who are experts in BIM. Professionals evaluated the created checklist in terms of design, clarity and content. Participants’ information is provided in the Table 5.

TABLE 5: Interviewed professionals (Second Stage).

| Profession     | Experience (in years) | Professional Role                                                      |
|----------------|-----------------------|-----------------------------------------------------------------------|
| Architects     | 6                     | Project manager in the international real estate investment company.  |
|                | 5                     | Architect in the international design office.                         |
|                | 20                    | BIM Designer, consultant, and founding partner of the international design firm. |
|                | 15                    | Structural design engineer in the international construction firm.     |
|                | 8                     | Managing partner in the international engineering firm.               |
|                | 8                     | Project planner engineer in the international engineering firm.       |
| Civil Engineers| 8                     | BIM Coordinator on the international engineering firm.                |
|                | 17                    | Head of business development at international scaffolding firm.       |
|                | 32                    | Founding partner of the international engineering firm.              |
|                | 9                     | Tendering Engineer in international construction firm.               |
4. RESULTS AND DISCUSSION

4.1 Data Obtained Through Litigation Awards and Case Law Research

As a result of the research in the Lexis-Nexis database, case laws containing BIM-related disputes have been found in 3 out of 13 countries: United States, United Kingdom and Canada. Considering international case laws and literature (Ashcraft, 2008; Arensman and Ozbek, 2012; Kuiper and Holzer, 2013; Dougherty, 2015; Ashworth et al., 2019; Huzaimi and Fathi, 2019), it is seen that the main reasons for the disputes in BbCP are contractual problems. To summarize, dispute causes can be categorized under the following four main headings: allocation of risks and responsibilities; ownership and usage of right of the model and data produced; interoperability problems; and data security and documentation.

Comparison of the cases found by case law research with the critical points of BIM-based CPM (Table 3) according to their core terms is shown in Table 6 where the “grey coded cell” indicates the critical points causing disputes in the cases.

| Critical Points (determined based on the examined 6 standard contracts and protocols, 13 guidelines and 36 articles as presented and referred to in Table 3) | Case laws containing BIM-related disputes. |
|---|---|
| Pre-Qualifications | US 88641 (2019) |
| Protocol for Obligations | US 131299 (2018) |
| BIM Consultancy | US 1267 (2017) |
| BIM Requirements of Owner | US 4320 (2017) |
| BIM Requirements Through Project Stages | US 7805 (2017) |
| BIM Deliverables Through Project Stages | US 125136 (2015) |
| Definition of BIM Roles and Responsibilities | UK HT-000164 (2017) |
| Confidentiality of Information | Canada 254 (2019) |
| Ownership of Model | Canada 1284 (2019) |
| Copyrights of Produced Data | Canada 179 (2014) |
| Authority to Access | Authority to Share |
| Authority to Change | Authority to Change |
| Change Order Procedures | Clash Detection |
| Extracting 2D Drawings From 3D Model | As-Built Model Procedures |

Considering the findings obtained from the case law research; it has been determined that there are disputes arising from the issues that are emphasized (Definition of roles and responsibilities; procedures for change order and clash detection; and protocol for authorized access, sharing and confidentiality of information) and not emphasized (Procedures for pre-qualification, BIM consultancy, as-built model, and extracting 2D drawings) in the literature. The critical points where the research results correspond to the proposed preliminary checklist template proposal (Table 8) are shown with Case Law Research (CLR) coding.
4.2 Data Obtained Through Interviews and Questionnaire Survey

Following the case law research, first stage interviews and questionnaire survey was conducted with professionals within the scope of field research. In the first stage interviews, the interviewees emphasized mainly the importance of: the IPR protection, training of suppliers on BIM and updating of the legal regulations in accordance with BIM. Table 7 summarizes the critical points emphasised in these interviews.

The majority of the participants in the questionnaire survey were architects (63%) and civil engineers (21%). The project roles of the participants are as follows: BIM manager (40%), BIM coordinator (13%), BIM disciplinary manager (10%) and BIM engineer (9%). The majority of participants have less than 10 years of BIM professional experience. 67% have 2-7 years of BIM professional experience. The mean values of the responses given by the participants to the effect of BIM on the performance of various issues are shown in chart A in Fig. 3. The mean values of answers given by participants to appropriateness of BIM integration to the project types are provided in chart B in Fig. 3.

![Chart A]

| Tender Stage | 4.33 | 4.37 | 4.06 |
| Contract Stage | 2.82 | 3.47 | 4.56 |
| Design Stage | 2.87 | 3.38 | 4.28 |
| Intellectual Property | 3.07 | 3.18 | 3.97 |
| Data Security | 3.10 | 2.89 | 2.87 |
| Dispute Resolution | 2.12 | 2.91 | 3.51 |
| Clash Detection | 3.12 | 3.41 | 2.13 |
| Change Order | 1.12 | 1.41 | 2.34 |
| Interoperability | 2.12 | 2.14 | 2.13 |
| Health and Safety | 3.12 | 3.42 | 3.91 |
| Operating the Facility | 1.12 | 1.21 | 1.31 |
| Maintenance of Facility | 1.12 | 1.18 | 1.18 |
| Integration Management | 1.07 | 1.11 | 1.08 |
| Scope Management | 1.10 | 1.10 | 1.10 |
| Schedule Management | 1.10 | 1.10 | 1.10 |
| Cost Management | 1.10 | 1.10 | 1.10 |
| Quality Management | 1.10 | 1.10 | 1.10 |
| Resource Management | 1.10 | 1.10 | 1.10 |
| Communication Management | 1.10 | 1.10 | 1.10 |
| Risk Management | 1.27 | 1.27 | 1.27 |
| Procurement Management | 1.27 | 1.27 | 1.27 |
| Stakeholder Management | 1.27 | 1.27 | 1.27 |

1: Improve 2: Does not affect 3: Reduce

![Chart B]

| Tender Stage | 2.62 | 2.63 | 3.12 |
| Contract Stage | 3.12 | 3.12 | 3.12 |
| Design Stage | 3.12 | 3.12 | 3.12 |
| Intellectual Property | 2.95 | 3.13 | 3.13 |
| Data Security | 3.17 | 3.17 | 3.17 |
| Dispute Resolution | 3.29 | 3.29 | 3.29 |
| Clash Detection | 3.05 | 3.05 | 3.05 |
| Change Order | 3.12 | 3.12 | 3.12 |
| Health and Safety | 2.94 | 2.94 | 2.94 |
| Operating the Facility | 2.97 | 2.97 | 2.97 |
| Maintenance of Facility | 2.97 | 2.97 | 2.97 |

1: Strongly Agree 2: Agree 3: Neither Agree nor Disagree 4: Disagree 5: Strongly Disagree

![FIG. 3: The performance effectiveness (Chart A) and the appropriateness (Chart B) of BIM integration.]

Results obtained through the online questionnaire survey revealed that the participants emphasized the following topics: IPR should be stated in the contract; BIM requirements, purpose and responsibilities of the owner should be defined; a data security protocol should be established; and LOD levels should be defined according to the project stages. Table 7 further summarizes the critical points supported by the questionnaire survey participants.

The preliminary checklist template proposal, which was created based on the literature review, case law research, first stage interview and questionnaire, was verified with second stage interviews performed with the participation of 10 professionals having BIM expertise and experience. All interviewees stated that the suggested checklist was sufficient and useful and that all identified critical points were important. Furthermore, they have specifically emphasized the points specified in Table 7.
The points emphasized in the litigation awards and case law research, first stage interviews, questionnaire survey and second stage interviews are shown in grey cells in Table 7.

**TABLE 7: Points emphasized in the field research.**

| Critical Points (determined based on the examined 6 standard contracts and protocols, 13 guidelines and 36 articles as presented and referred to in Table 3) | Points highlighted as a result of field research | Case Law Research | First Stage Interviews | Questionnaire Survey | Second Stage Interviews |
|---|---|---|---|---|---|
| **Critical points of administrative decisions** | | | | | |
| Organization-related Decisions | | | | | |
| Project-related Decisions | | | | | |
| **Critical points of analysis** | | | | | |
| Sustainability Analysis | | | | | |
| Time and Cost Analysis | | | | | |
| Quality & Supply Chain Analysis | | | | | |
| **Critical points of legal issues** | | | | | |
| BIM Execution Plan | | | | | |
| **Critical points of allocation risks and responsibilities** | | | | | |
| BIM Meetings | | | | | |
| Pre-Qualifications | | | | | |
| Protocol for Obligations | | | | | |
| Responsible Persons for BIM Processes | | | | | |
| BIM Consultant | | | | | |
| BIM Requirements | | | | | |
| BIM Model Requirements and Deliverables | | | | | |
| Definition of BIM Tasks | | | | | |
| Definition of BIM Responsibilities According to the Tasks | | | | | |
| **Critical points of intellectual property rights** | | | | | |
| Confidentiality of Information | | | | | |
| Ownership of Model | | | | | |
| Copyrights of Produced Data | | | | | |
| Term of Usage Letter | | | | | |
| **Critical points of information management** | | | | | |
| Protocol for Information | | | | | |
| Centralized File System | | | | | |
| Level of Development | | | | | |
| Type and Version of Software | | | | | |
| Native Data Format | | | | | |
| Authority to Access | | | | | |
| Authority to Change | | | | | |
| Authority to Share | | | | | |
| Electronic Stamps | | | | | |
| Digital Data Storage | | | | | |
| **Critical points of interoperability** | | | | | |

*ITcon Vol. 26 (2021), Erpay & Sertyesilik, pg. 354*
As a result of the examination of the findings obtained from the field research and the studies in the literature, the issues highlighted under the 4 main headings (Ashcraft, 2008; Arensman and Ozbek, 2012; Kuiper and Holzer, 2013; Dougherty, 2015; Ashworth et al., 2019; Huzaimi and Fathi, 2019) are as follows:

Allocation of risks and responsibilities: BIM roles and the stakeholders responsible for these roles should be distinctly specified in the contract (Azhar, 2011; CANBIM, 2012; Arensman and Ozbek, 2012; COBIM, 2012; NATSPEC, 2016; Ussing et al., 2016; BSI, 2018; Bosch-Sijtsesma et al., 2019; PSUBIM, 2019). The contractual status of the model should be determined in case of conflict or dispute (McAdam, 2010; Azhar, 2011; CANBIM, 2012; SBIM, 2013; BBIM, 2015; NATSPEC, 2016; USFBIM, 2018). As stated under the subheadings 4.1 and 4.2 of this paper and the literature (Kuiper and Holzer, 2013; Abdirad, 2015; Lin et al., 2016; Papadonikolaki et al., 2019), BIM requirements and outputs should be defined according to the project phases. As seen in the subheadings 4.1 and 4.2 of this paper, the contract should include procedures related to supply chain (CANBIM, 2012; COBIM, 2012; Oviedo-Haito et al., 2014; BSI 2018; PSUBIM, 2019), BIM consultancy (USCBIM, 2012; BBIM, 2015; BSI 2018; PSUBIM, 2019), and as-build model (COBIM, 2012; SBIM, 2013; NBIM, 2013; BSI 2014).

IPR: The most emphasized issues in the literature (Arensman and Ozbek, 2012; Manderson et al., 2015; Solihin and Eastman, 2015; Arshad et al., 2019) and under the subheadings 4.1 and 4.2 of this paper, are: the protocol for information; information confidentiality; copyright of the data produced and the authority sharing. Therefore, definition regarding the IPR should be included in the contract, and access to the common platform should be authorized (Manderson et al., 2015; Solihin and Eastman, 2015). Moreover, before the generated information is shared, a “term of usage letter” must be signed by the receiving party regarding ownership and user rights (CANBIM, 2012; AIA, 2013; CIC, 2018; Eschenbruch and Bodden, 2018).

Interoperability: It is important to regulate the stakeholders’ relationships communicating through the common model and information systems (Eastman et al., 2010; Rahman et al., 2016). Therefore, as specified under the subheadings 4.1 and 4.2 of this paper, the access, change and sharing rights of the data in the common model or information system should be authorized (CDOC, 2015; CANBIM, 2012; USCBIM, 2012; COBIM, 2012; NBIM, 2013; CIoB, 2013; AIA, 2013; SBIM, 2013; BBIM, 2015; Solihin and Eastman, 2015; DASBIM, 2015; NATSPEC, 2016; NBGO, 2017; SBEncBIM, 2017;Charehzehi et al., 2017; Schapke et al., 2018; USFBIM, 2018; BSI, 2018a; CIC, 2018; PSUBIM, 2019). As mentioned under the subheadings 4.1 of this paper, definitions and regulations for modes of collaboration, clash detection, change order procedures, centralized file system, and BIM meetings must be specified in BEP (CANBIM, 2012; USCBIM, 2012; COBIM, 2012; NBIM, 2013; BBIM, 2015; DASBIM, 2015; Ussing et al., 2016; NATSPEC, 2016; SBEncBIM, 2017; Li et al., 2017; NBGO, 2017; USFBIM, 2018; BSI, 2018a; PSUBIM, 2019). As highlighted under the subheadings 4.1 of this paper, the LOD level should be determined as early as possible according to the project phases (Ashcraft, 2008; CANBIM, 2012; USCBIM, 2012; COBIM, 2012; NBIM, 2013; AIA, 2013; SBIM, 2013; BBIM, 2015; DASBIM, 2015; Lin et al., 2016; NATSPEC, 2016; NBGO, 2017; SBEncBIM, 2017; USFBIM, 2018; BSI, 2018a; PSUBIM, 2019). As noted under the subheadings 4.1 and 4.2 of this paper, all 2D drawings to be used in the project process should be extracted from the common 3D model through certain procedures (CDOC, 2015; CANBIM, 2012; USFBIM, 2018).

| Critical Points (determined based on the examined 6 standard contracts and protocols, 13 guidelines and 36 articles as presented and referred to in Table 3) | Points highlighted as a result of field research |
| --- | --- |
| Clash Detection | Case Law Research |
| Extracting 2D Drawings from 3D Model | First Stage Interviews |
| Change Order Procedures | Questionnaire Survey |
| Critical points of data security | Second Stage Interviews |
| Data Security Protocol for Loss, Corruption and Virus | |
| Critical points of operation phase | |
| As-Built Model Procedures | |
| Operation and Maintenance | |
Data security and documentations: As mentioned under the subheadings 4.1 and 4.2 of this paper, for data security, authorized access should be given within the responsibility of stakeholders (CDOC, 2015; CANBIM, 2012; USCBIM, 2012; COBIM, 2012; NBIM, 2013; CIOB, 2013; AIA, 2013; SBIM, 2013; BBIM, 2015; Solihin and Eastman, 2015; DASBIM, 2015; NATSPEC, 2016; NBGO, 2017; SBEEnrcBIM, 2017; Charehzehi et al., 2017; Schapke et al., 2018; USFBIM, 2018; BSI, 2018a; CIC, 2018; PSUBIM, 2019). In majority of the manuals (CANBIM, 2012; USCBIM, 2012; COBIM, 2012; BSI, 2013; SBIM, 2013; NBIM, 2013; BBIM, 2015; NATSPEC, 2016; NBGO, 2017; SBEEnrcBIM, 2017; USFBIM, 2018; PSUBIM, 2019) and in the literature, it is emphasized that a protocol regarding data storage (Lai et al., 2019), data archiving (Bakhary et al., 2017) and data security (Chien et al., 2014; Dougherty, 2015; Eschenbruch and Bodden, 2018) should be established. As specified under the subheadings 4.1 and 4.2 of this paper, after the end of the project, the common model should be handed over to the operation team by making various corrections and simplifications (USCBIM, 2012; COBIM, 2012; SBIM, 2013; NBIM, 2013; BSI, 2014b; BBIM, 2015; NATSPEC, 2016; NBGO, 2017; SBEEnrcBIM, 2017; USFBIM, 2018; Eschenbruch and Bodden, 2018).

5. PRACTICAL IMPLICATION

Preliminary checklist template categorized under 9 headings is provided in the Table 8. The roots of each item has been provided referring to the relevant literature, standards and documents as well as to the field studies. Accordingly, in Table 8 QS stands for questionnaire survey, IS1 for first stage interview, IS2 for the second stage interview, CLR for case law research. The checklist consists of 25 main 32 sub-critical points as well as their descriptions and highlights. The checklist was created in line with the findings and critical points obtained from the literature review (Table 3) and field research (Table 7). Considering the proposed checklist as a support document during the contract preparation phase of BbCP can contribute to reduce the potential disputes that may arise. Furthermore, stakeholders’ legal concerns arising from the BIM integration can be alleviated through integration of all stakeholders into the contract preparation phase. This paper and the proposed checklist can be considered as an input to the establishment of legal standards for BIM-based construction projects. They can be beneficial to academic researches, to academics and researchers in this field. Furthermore, the identified 9 main categories of the preliminary checklist template proposal and their relation to the Project Management Institution (PMI, 2017) knowledge areas and BSI PAS 1 (BSI, 2015a) project stages are provided in Fig. 5.

FIG. 5: The nine main categories of the proposed checklist and their relations.
**TABLE 8: Checklist proposal to enhance the contract preparation phase of BbCPs.**

| 1. Critical points of administrative decisions. |
|-----------------------------------------------|
| - **Organization-related Decisions** (COBIM, 2012; NBIM, 2013; BSI, 2018a; Ashworth et al., 2019; PSUBIM, 2019) |
| Define the high-level strategic goals of the organization and includes the strategic decisions of the organization, portfolio planning, regulatory tasks, and policies. |
| Prepare a statement for the organization’s future BIM-related organizational decisions, and describe why BIM is important to the organization and how to use it. |
| Stakeholders working with complex and large projects should determine their organizational decisions. IS2 |
| If the organization needs to be departmentalized for BIM applications, determine its procedures. IS2 |
| Set your own BIM specifications on why you prefer BIM and how to implement it. IS2 |
| Determine whether BIM process management will be done by the company or outsourced to third parties. IS2 |
| - **Asset-related Decisions** (COBIM, 2012; NBIM, 2013; BSI, 2018a; Ashworth et al., 2019) |
| Determine the production methods and procedures as well as the managerial and commercial decisions regarding the asset. |
| - **Project-related Decisions** (CANBIM, 2012; USCBIM, 2012; COBIM, 2012; NBIM, 2013; SBIM, 2013; NBIM, 2015; DASBIM, 2015; NATSPEC, 2016; SBEncrBIM, 2017; NBGO, 2017; USFBIM, 2018; BSI, 2018a; Ashworth et al., 2019; PSUBIM, 2019) IS, QS |
| Measure and monitor that organizational decisions are supported in a particular project. |

| 2. Critical points of analysis. |
|---------------------------------|
| - **Sustainability Analysis** (CANBIM, 2012; USCBIM, 2012; COBIM, 2012; SBIM, 2013; NBIM, 2013; NBIM, 2015; DASBIM, 2015; NATSPEC, 2016; SBEncrBIM, 2017; NBGO, 2017; USFBIM, 2018; BSI, 2018a; PSUBIM, 2019) QS |
| Identify the analyses and their procedures to be performed to measure the environmental impact and efficiency of the project. |
| - **Time and Cost Analysis** (Azhar, 2011; CANBIM, 2012; USCBIM, 2012; COBIM, 2012; NBIM, 2013; CIOB, 2013; SBIM, 2013; NBIM, 2015; BSI, 2015a; DASBIM, 2015; NATSPEC, 2016; SBEncrBIM, 2017; NBGO, 2017; USFBIM, 2018; PSUBIM, 2019) IS, QS |
| Determine the time and economic efficiency analysis and their procedures, taking into account the construction and operation phases of the project. |
| Time and cost analysis also includes the marketing of the project. IS2 |
| - **Quality Analysis** IS2 |
| Identify the desired level of quality of implementations made in the project and quality measurement processes. |
| - **Supply Chain Analysis** IS2 |
| Determine the Supply chain analysis and their procedures for materials and human resources should be done by considering the geography where the project will be made. IS2 |

| 3. Critical points of legal issues. |
|-----------------------------------|
| - **BIM Execution Plan** (CDOC, 2015; CANBIM, 2012; USCBIM, 2012; COBIM, 2012; NBIM, 2013; SBIM, 2013; Abdirad, 2015; NBIM, 2015; DASBIM, 2015; JCT, 2016; Lin et al., 2016; NATSPEC, 2016; NBGO, 2017; NEC, 2017; SBEncrBIM, 2017; Chong et al., 2017; Eschenbruch and Bodden, 2018; USFBIM, 2018; BSI, 2018a; CIC, 2018; PSUBIM, 2019) IS, QS |
| BEP should be created comprehensively with the contribution of all project participants in line with the requirements of the owner, specific to the project. |
| Make sure that the contract and BEP are compatible and there are no contradictions. IS2 |
| Milestones of the project should also be specified in BEP. IS2 |
| - **Contractual Status of Documents** (CDOC, 2015; Azhar, 2011; CANBIM, 2012; USCBIM, 2012; COBIM, 2012; NBIM, 2013; CIOB, 2013; AIA, 2013; SBIM, 2013; NBIM, 2015; DASBIM, 2015; JCT, 2016; NATSPEC, 2016; NBGO, 2017; NEC, 2017; SBEncrBIM, 2017; USFBIM, 2018; BSI, 2018a; CIC, 2018; PSUBIM, 2019) |
| Determine the contractual and legally binding status of the documents (protocol, guideline and/or standard) used in case of dispute. |
| - **Contractual Status of Model** (McAdam, 2010; Azhar, 2011; CANBIM, 2012; AIA, 2013; SBIM, 2013; CIOB, 2013; NBIM, 2015; NATSPEC, 2016; Bormann et al., 2018; USFBIM, 2018) |
| Determine the contractual and legally-binding status of the common BIM model and the information it contains in case of Dispute. |
4. Critical points of allocation risks and responsibilities.

- BIM Meetings (COBIM, 2012; USCBIM, 2012; SBIM, 2013; NBIM, 2015; DASBIM, 2015; NATSPEC, 2016; NBGO, 2017; BSI, 2018a; USFBIM, 2018; PSUBIM, 2019) IS, QS
  
  Establish the protocol that includes the communication procedures and meeting schedules for collaborative utilization.

- Pre-Qualifications (CANBIM, 2012; COBIM, 2012; Oviedo-Haito et al., 2014; NATSPEC, 2016; BSI, 2018a; PSUBIM, 2019) CLR, IS, QS
  
  Prepare a comprehensive pre-qualification in terms of BIM competency and risk management capacity of suppliers before being included in the project.

- Protocol for Obligations (CDOC, 2015; CANBIM, 2012; Arensman and Ozbek, 2012; COBIM, 2012; CIOB, 2013; AIA, 2013; SBIM, 2013; NBIM, 2015; NATSPEC, 2016; Ussing et al., 2016; JCT, 2016; NBGO, 2017; NEC, 2017; SBEncBIM, 2017; BSI, 2018a; CIC, 2018; PSUBIM, 2019) CLR, IS, QS
  
  Identify the obligation and liability issues of each party in relation to allocation of risk and responsibility.

- Responsible Persons for BIM Processes (CDOC, 2015; Azhar, 2011; CANBIM, 2012; USCBIM, 2012; COBIM, 2012; NBIM, 2013; CIOB, 2013; AIA, 2013; BSI, 2013; NBIM, 2015; DASBIM, 2015; Hsu, 2015; JCT, 2016; NATSPEC, 2016; NBGO, 2017; NEC, 2017; SBEncBIM, 2017; Tulke and Schumann, 2018; USFBIM, 2018; Borrmann et al., 2018; CIC, 2018; PSUBIM, 2019) IS, QS
  
  Identify who is responsible according to BIM processes
  
  - BIM Process Responsible (Manager)
  - BIM Main Discipline Responsible (Coordinator)
  - BIM Sub-Discipline Responsible (Discipline Lead)
  - BIM Consultant (USCBIM, 2012; BSI, 2013; NBIM, 2015; PSUBIM, 2019) CLR, IS
  - BIM Information Technology Manager (USCBIM, 2012; BSI, 2013)

- BIM Requirements (USCBIM, 2012; CANBIM, 2012; COBIM, 2012; CIOB, 2013; SBIM, 2013; Kupfer and Holzer, 2013; Abdurad, 2015; NBIM, 2015; NATSPEC, 2016; Howard and Ciliberto, 2016; JCT, 2016; NBGO, 2017; BSI, 2018a, 2018b; PSUBIM, 2019) CLR, IS, QS
  
  Determine the requirements throughout project stages for effective BIM integration.

- BIM Model Requirements and Deliverables (CANBIM, 2012; USCBIM, 2012; COBIM, 2012; CIOB, 2013; SBIM, 2013; Kupfer and Holzer, 2013; NBIM, 2015; JCT, 2016; Lin et al., 2016; NATSPEC, 2016; NBGO, 2017; BSI, 2018a, 2018b; Papadonikolaki et al., 2019; PSUBIM, 2019) CLR, IS, QS
  
  Determine the objectives, requirements and outcomes of the common BIM model according to the project stages.

- Definition of BIM Tasks (USCBIM, 2012; CANBIM, 2012; COBIM, 2012; NBIM, 2013; SBIM, 2013; Abdurad, 2015; NBIM, 2015; DASBIM, 2015; NATSPEC, 2016; NBGO, 2017; SBEncBIM, 2017; USFBIM, 2018; Borrmann et al., 2018; BSI, 2018a, 2018b; PSUBIM, 2019; Bosch-Sijtsema et al., 2019) CLR, IS, QS
  
  Identify the tasks required to achieve the objectives, requirements and outcomes of the common BIM model determined according to the project stages.

- Definition of BIM Responsibilities According to the Tasks (CDOC, 2015; CANBIM, 2012; USCBIM, 2012; Arensman and Ozbek, 2012; COBIM, 2012; NBIM, 2013; CIOB, 2013; AIA, 2013; SBIM, 2013; NBIM, 2015; DASBIM, 2015; JCT, 2016; NATSPEC, 2016; Ussing et al., 2016; NBGO, 2017; NEC, 2017; SBEncBIM, 2017; CIC, 2018; USFBIM, 2018; BSI, 2018a, 2018b; PSUBIM, 2019; Bosch-Sijtsema et al., 2019) CLR, QS
  
  Identify the people responsible for the tasks required to achieve the objectives, requirements and outcomes of the common BIM model determined according to the project stages.

5. Critical points of intellectual property rights.

- Confidentiality of Information (CDOC, 2015; CANBIM, 2012; COBIM, 2012; CIOB, 2013; AIA, 2013; BSI, 2013; SBIM, 2013; NBIM, 2015; Manderson et al., 2015; NATSPEC, 2016; NBGO, 2017; SBEncBIM, 2017; CIC, 2018; PSUBIM, 2019; Arshad et al., 2019) CLR, IS, QS
  
  Identify the information that should be confidential by stakeholders such as design works, rates and prices that produced or used throughout the project.

  The definition of confidential information should also be specified. IS2

- Ownership of Model (CANBIM, 2012; Arensman and Ozbek, 2012; COBIM, 2012; BSI, 2013; SBIM, 2013; NBIM, 2015; Solihin and Eastman, 2015; NATSPEC, 2016; SBEncBIM, 2017; NBGO, 2017; PSUBIM, 2019) CLR, IS, QS
  
  Identify ownership rights of the common BIM model during project process and for operation and maintenance stage.

  Ownership of the model can switch between the stakeholders depending on the project stages. IS2
5. Critical points of intellectual property rights.

- Copyrights of Produced Data (CDOC, 2015; CANBIM, 2012; COBIM, 2012; AIA, 2013; BSI, 2013; SBIM, 2013; NBIM, 2015; Solihin and Eastman, 2015; Manderson et al., 2015; NATSPE, 2016; NBGO, 2017; NEC, 2017; SBEncBIM, 2017; CIC, 2018; PSUBIM, 2019) CLR, IS, QS
  Identify copyrights of information produced by all disciplines in line with project goals throughout the process.
  - Term of Usage Letter (CANBIM, 2012; AIA, 2013; CIC, 2018; Eschenbruch and Boddan, 2018) QS

6. Critical points of information management.

- Protocol for Information (CDOC, 2015; CANBIM, 2012; USBCBIM, 2012; COBIM, 2012; NBIM, 2013; AIA, 2013; BSI, 2013; SBIM, 2013; NBIM, 2015; DASBIM, 2015; JCT, 2016; NATSPE, 2016; Ghaffarianhoseini et al., 2017; NBGO, 2017; SBEncBIM, 2017; Charehzehi et al., 2017; Eschenbruch and Boddan, 2018; USFBIM, 2018; CIC, 2018; PSUBIM, 2019) QS
  Identify the processes of converting construction applications to as-built models and those responsible for control of this process.

The information protocol should include an information map that contains all the information produced and shared according to the stages of the project. IS2

- Centralized File System (CANBIM, 2012; USCBIM, 2012; COBIM, 2012; AIA, 2013; BSI, 2013; NBIM, 2015; NATSPE, 2016; NBGO, 2017; USFBIM, 2018; PSUBIM, 2019) QS
  Set up a centralized file system where documents are shared, stored and archived for effective information management throughout the project process.

- Level of Development (Ashcraft, 2008; CANBIM, 2012; USBCBIM, 2012; COBIM, 2012; NBIM, 2013; AIA, 2013; SBIM, 2013; NBIM, 2015; BSI, 2015a; DASBIM, 2015; Lin et al., 2016; NATSPE, 2016; NBGO, 2017; SBEncBIM, 2017; USFBIM, 2018; PSUBIM, 2019) IS, QS
  Determine the development levels of the information to be used according to the stages of the project as much as the needs of the stakeholders.

- Software
  - Type and Version of Software (Succar, 2010; McAdam, 2010; CANBIM, 2012; USBCBIM, 2012; COBIM, 2012; NBIM, 2015; CIOB, 2013; BSI, 2013; SBIM, 2013; Bynum et al., 2013; NBIM, 2015; DASBIM, 2015; NATSPE, 2016; NBGO, 2017; SBEncBIM, 2017; USFBIM, 2018; CIC, 2018; PSUBIM, 2019) QS
    Specify the types and versions of the software in which the information to be used according to the project stages will be created.
    Update procedures should also be determined. IS2
  - Native Data Format (CANBIM, 2012; BSI, 2013; Bynum et al., 2013; CIOB, 2013; CIC, 2018) QS
    Specify that information should be shared and archived in the native data format in which the information is produced to prevent corruption and loss of information.
    Industry Foundation Classes (IFC) can be used. IS2

- Authority to Access (CDOC, 2015; CANBIM, 2012; USBCBIM, 2012; COBIM, 2012; NBIM, 2013; CIOB, 2013; AIA, 2013; BSI, 2013; NBIM, 2015; Solihin and Eastman, 2015; DASBIM, 2015; NATSPE, 2016; NBGO, 2017; SBEncBIM, 2017; Charehzehi et al., 2017; Schapke et al., 2018; USFBIM, 2018; CIC, 2018; PSUBIM, 2019) CLR, QS
  Provide authorized access to data in the common model to prevent data corruption, loss and errors.
  - Contact List of Authorized Users (CDOC, 2015; USBCBIM, 2012; BSI, 2013; NBIM, 2013; NBIM, 2015; DASBIM, 2015; NATSPE, 2016; USFBIM, 2018; PSUBIM, 2019) CLR, QS
    Identify the contact information of authorized users to monitor changes and revisions in the common model, and to resolve potential problems quickly.
  - Authority to Change (CDOC, 2015; CANBIM, 2012; USBCBIM, 2012; COBIM, 2012; NBIM, 2013; CIOB, 2013; AIA, 2013; BSI, 2013; SBIM, 2013; NBIM, 2015; Solihin and Eastman, 2015; DASBIM, 2015; NATSPE, 2016; NBGO, 2017; SBEncBIM, 2017; Charehzehi et al., 2017; Schapke et al., 2018; USFBIM, 2018; CIC, 2018; PSUBIM, 2019) CLR, IS, QS
    Provide authorized modification permissions to the data in the model to prevent conflict caused by changing data without controlling.
  - Electronic Stamps (CANBIM, 2012; NBIM, 2013) QS
    Use electronic signature or stamp so that the status of the information, the last changes and the people responsible for the information can be followed.
  - Authority to Share (CDOC, 2015; Eastman et al., 2010; CANBIM, 2012; USBCBIM, 2012; NBIM, 2013; CIOB, 2013; AIA, 2013; BSI, 2013; SBIM, 2013; NBIM, 2015; Solihin and Eastman, 2015; DASBIM, 2015; NATSPE, 2016; NBGO, 2017; SBEncBIM, 2017; Charehzehi et al., 2017; USFBIM, 2018; CIC, 2018; PSUBIM, 2019) CLR, QS
Provide authorized sharing of data in the common model to prevent data from being shared to unauthorized 3rd parties.

- **Term of Usage Letter** (CANBIM, 2012; AIA, 2013; CIC, 2018; Eschenbruch and Boddren, 2018) QS
  Before sharing the created information with other stakeholders, be sure to sign the Term of Usage Letter, where the information usage and sharing permissions are specified.

- **Documentation**
  Determine the procedures for storing the produced and shared information during the project and archiving it at the end of the project.

  - **Digital Data Storage** (CANBIM, 2012; AIA, 2013; BSI, 2013; SBIM, 2013; NBIM, 2013; NBIM, 2015; NATSPEC, 2016; NBGO, 2017; Li et al., 2019; PSUBIM, 2019) IS, QS
    Determine the procedures for storing all data of the project and the BIM model during the project process.

  - **Digital Data Archiving** (CANBIM, 2012; USCBIKM, 2012; COBIM, 2012; AIA, 2013; BSI, 2013; NBIM, 2013; NBIM, 2015; NATSPEC, 2016; Baklary et al., 2017; NBGO, 2017; USFBIM, 2018; PSUBIM, 2019)
    Determine the archiving procedures of all data of the project and the BIM model after the close-out phase of the project.

  - **Back-up and Restore Procedures of Data** (CDOC, 2015; Qlatanji, 2011)
    Set backup and restore procedures for Deterioration and loss problems that may occur in the 3D common model.

### 7. Critical points of interoperability.

- **Modes of Collaboration** (CANBIM, 2012; COBIM, 2012; AIA, 2013; BSI, 2013; NBIM, 2013; NBIM, 2015; NATSPEC, 2016; PSUBIM, 2019) IS, QS
  Identify procedures, priorities and critical points for the collaboration of different disciplines in the common model.

- **Clash Detection** (CANBIM, 2012; USCBIKM, 2012; COBIM, 2012; AIA, 2013; BSI, 2013; NBIM, 2015; BSI, 2015a; DASBIM, 2015; Ussing et al., 2016; NATSPEC, 2016; SBElecBIM, 2017; Li et al., 2017; NBGO, 2017; USFBIM, 2018; PSUBIM, 2019) CLR, IS, QS
  Determine the clash detection procedures to be performed over the common model during the design phase to prevent overlapping construction implementations during the construction phase.

- **Extracting 2D Drawings from 3D Model** (CDOC, 2015; CANBIM, 2012; USFBIM, 2018) CLR, IS, QS
  To avoid differences between the model and construction implementations, determine the procedures required to extract all 2D drawings that will be used during the construction application from the 3D model.

- **Change Order Procedures** (CDOC, 2015; CANBIM, 2012; USCBIKM, 2012; COBIM, 2012; AIA, 2013; BSI, 2013; CIOB, 2013; DASBIM, 2015; NATSPEC, 2016; SBElecBIM, 2017; NBGO, 2017; BSI, 2018a; USFBIM, 2018; PSUBIM, 2019) CLR, IS, QS
  Set change order procedures to reduce time and cost related issues that will occur due to any changes in the project.

  - **Change order transmittals in the project need to be archived to ensure that stakeholders are noticed the changes and take responsibility.** IS2

### 8. Critical points of data security.

- **Data Security Protocol for Loss, Corruption and Virus** (CDOC, 2015; CANBIM, 2012; COBIM, 2012; CIOB, 2013; SBIM, 2013; Chien et al., 2014; NBIM, 2015; BSI, 2015b; Dougherty, 2015; NATSPEC, 2016; NBGO, 2017; Eschenbruch and Boddren, 2018; PSUBIM, 2019) IS, QS
  Establish a data security protocol to protect the BIM model and its digital data from loss, corruption and theft.

  - **Encrypted Filing** (CDOC, 2015)
    Identify encrypted filing systems and system procedures for data security.

  - **Access from Unknown Server** (CIOB, 2013; Chien et al., 2014) QS
    Identify procedures for accessing unknown servers to protect data from viruses or theft.

  - **Data Insurance** (CDOC, 2015; Manderson et al., 2015)
    Use data insurance to cover financial losses that will arise from any problems with data security.

### 9. Critical points of operation phase.

- **As-Built Model Procedures** (COBIM, 2012; BSI, 2013; SBIM, 2013; NBIM, 2013) CLR, IS, QS
  Identify the processes of converting construction applications to as-built models and those responsible for control of this process.

  - **The layouts should be updated regularly during the construction phase of the project.** IS2
Operation and Maintenance

Prepare the necessary procedures for the operation and maintenance phase after the project is realized for an effective BIM integration

Handing Over of Model (USCBIM, 2012; COBIM, 2012; SBIM, 2013; NBIM, 2013; BSI, 2014b; NBIM, 2015; NATSPEC, 2016; NBGO, 2017; SBEarcBIM, 2017; USFBIM, 2018; Eschenbruch and Bodden, 2018; PSUBIM, 2019) IS, QS

Specify the necessary regulations regarding the models that will be transferred to the operator following the realization of the project

Maintenance Manuals (COBIM, 2012; USCBIM, 2012; BSI, 2014b; NBGO, 2017; SBEarcBIM, 2017; USFBIM, 2018; PSUBIM, 2019)

Indicate the necessary procedures for the transfer of maintenance manuals related to construction materials and technical equipment used in the project to the operator.

6. CONCLUSION

This paper proposed a preliminary checklist template that can be considered as a potential input to the contracting phase of these projects so that the contract preparation phase of BbCP can be improved. With this aim, existing standard contracts, protocols and guidelines were examined and compared to each other. Furthermore, legal disputes in BbCP were investigated through litigation awards and case law research in international databases. Subsequently, first stage interviews and questionnaire surveys were conducted with BIM professionals. Based on the findings obtained through literature review, litigation awards and case law research, first stage interviews and questionnaire survey, the proposed checklist template has been created. Lastly, the proposed checklist template was verified through the second stage interviews. The proposed checklist template consists of 25 main 32 sub-critical points.

Future studies on the legal issues of BbCP are recommended to focus on electronic contracts, where the BIM model can be part of the contract. In this way, the common model, which is one of the most important advantages of BIM, becomes legally binding among stakeholders.

In conclusion, the proposed preliminary checklist template can be used as an input to be considered for supporting the contract preparation phase of BbCP considering project-specific requirements and limitations. The proposed template can be useful to reduce legal concerns of stakeholders in the CI arising from BIM integration and to support the spread of BIM in the CI. With the development of construction technologies, the proposed preliminary checklist template can be updated or further developed with the experience and expertise gained from existing and future BbCP. Finally, the proposed preliminary checklist can be useful for BIM-based projects stakeholders as well as for lawmakers and public institutions dealing with legislation related to construction practices.

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