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A BIM (Building Information Modeling) Application Review Reflection and Planning for the Future During the Pre-Construction Phase

Rozana Zakaria[1], Aswadi Yusofghb[2], Muhammad Fatihi[3]

Department of Civil Engineering,

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Abstract. One of the most unpredictable and risky parts of a building project is pre-construction, which deals with information on the underlying ground conditions. To make sure that major hazards couldn't be realistically expected, there has to be a lot of detailed data collected before construction, particularly for site investigation and existing data modeling. There are limitations to the current methods used to analyze data at this step of the process. The construction sector had several challenges as a result of its reliance on antiquated methods, such as paper-based documents that often included duplicate or missing data. Because building information modeling (BIM) has the ability to alleviate many of the problems encountered by the infrastructure sector, it has recently become the preferred method of construction. The promise of building information modeling has led to its meteoric rise to prominence in the construction industry, particularly in industrialized nations. Adopting BIM at the pre-construction stage is the next logical step for individuals in the BIM process. Thus, the focus of this study is a survey of research on building information modeling (BIM) integration in the preconstruction phase. However, at the present time, there has been a dearth of research that is grounded in practice. Despite the abundance of research on building information modeling (BIM) over the last decade, experts in the field still can't agree on how best to use it in the pre-construction phase or what data integration tools are available for use in geotechnical projects. In order to gather and analyze data, a thorough literature research was carried out. Following a comprehensive literature search on building information modeling (BIM), this research provides a synopsis and critical appraisal of BIM-based geotechnical data integration in the pre-construction phase. Finding commonalities and areas of focus among the BIM community for future study is facilitated by these findings.

1. Introduction

The classic project life cycle consists of three stages: planning, building, and finishing [1]. Considering the underlying ground conditions and geotechnical knowledge, pre-construction poses one of the greatest risks and uncertainties in building projects. In this stage, as described by Ham et al. [2], the data needed to determine the project's course and kick off construction are gathered in advance. Site investigation and data interpretation from public sources is the first step in any project involving geotechnical data, according to Tegtmeir [3]. Subcontractors then need to integrate the results into a 3D program and simplify them for use in design and construction. Building Information Modeling (BIM) has become an integral part of many construction projects in recent years. This trend stems from a desire to make the industry more efficient, less harmful to the environment, more globally competitive, and more quality and safety conscious. There is no one good definition of building information modeling (BIM), and while various individuals use different words to describe it, the underlying principle is the same. According to Papadonikolaki et al. [5], BIM stands for "Building Product Modelling," an abbreviation that has largely replaced "Building Product Modeling" (BPM) as a term to define IS in the construction industry. Building information modeling (BIM) is undeniably transforming data collection and analysis methods, particularly in the pre-construction phase, from paper-based documents to object-based modeling.

There is a chronic lack of data for accurate 3D modeling in present practice, and subsurface aspects like geology and geotechnical engineering are often disregarded [4, 7, 8]. Research comparing and contrasting the data integration processes of conventional systems and BIM adoption during the pre-construction phase is currently lacking. Research gaps in this area might be filled up using the results of such an investigation into the present state of building information modeling (BIM) implementation in geotechnical data integration. Thus, the purpose of this article is to examine the present state of building information modeling (BIM) adoption for geotechnical data integration during the pre-construction stage, to draw comparisons between traditional and modern pre-construction development techniques, and to pinpoint the areas where BIM is lacking. In order to find answers to the problems raised above, this study examines the process of integrating geotechnical data into Building Information Modeling (BIM) during the pre-construction phase of a project. The following is the outline of the paper's structure for this review. The methods used to compile this study is detailed in Chapter 2. The use of building information modeling (BIM) in the pre-construction phase is covered in chapter 3.

2. Methodology

There were three stages to the examination of the geotechnical data integration throughout the pre-construction stage utilizing BIM. In order to better comprehend the data integration process during the pre-construction phase and the distinctions between the conventional approach and the BIM-based method, a thorough literature research was first carried out. The primary notion of "geotechnical data integration" that will be covered in this review article is the connection between BIM and the pre-construction stage. In order to conduct a thorough literature review later on, this procedure first requires the selection of a list of keywords. "Building Information Modelling," "geotechnical data," "data integration," "safety," "quality," "time," "cost," and "budget" are some of the primary keywords that may be used to describe this evaluation. The second stage, after identifying all the keywords, is to use them in a web search in online databases of academic publications, such as "Web of Science," "Sciencedirect," scopus, and google scholar. Academic and applied articles pertaining to this subject are compiled by all of these online search engines. We may only include readings that are directly related to the topic at hand, such as articles, conferences, theses, and dissertations. Works published with keywords included in the title and abstractReview of chosen keywords is underway. Conference proceedings, articles from leading journals in the field, publications from standard committees (such as HSE and ISO), and authoritative sources constituted the bulk of the journal articles retrieved for this study. These included Safety Science, Automation in Construction, International Journal of Project Management, Journal of Computing in Civil Engineering, Renewable & Sustainable Energy Reviews, Reliability Engineering & System Safety, and many more. The final stage is to critically examine all publications and compare them in order to find the present process, the impediments, and the work that needs to be done to address these gaps. Many earlier research have also used this approach, including Zou et al. [10] and Li et al. [11].

3. Findings

3.1. Pre-construction Phase

The preconstruction phase of a project also known as planning and design phase [12]. Pre-construction phase is one of the important phases in construction that control the successful of project as stated in a study by Bakar et al. [13]. In response to that, many researchers have already acknowledged the significance of effective planning practices and integration of designer and contractor in the early stages of construction project life cycle [13]. Basically, the amount of detail data needed in pre-construction information especially for existing data modelling and site analysis should be sufficient enough to ensure that significant risks could not reasonably be anticipated. Gathering all information for the sake of designer and contractor really needed throughout the project before they can start work on any particular element such as design.

Kolltveita and Gronhau [14] stated that pre-construction or sometimes called as early phase is the process and activities that lead to, and immediately follow, the decision to undertake feasibility studies and to execute the main project. He continued to explain that the main tasks in this part of the early phase are feasibility studies, value analysis, formulation of project goals.

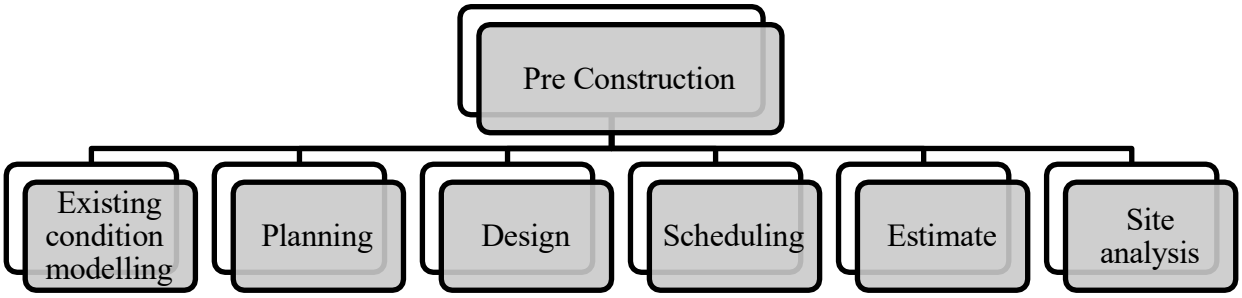


Figure 1: Activities in pre-construction phase by Latiffi et al. [1]

3.2. Workflow of Traditional Practices

Some countries still follow the traditional method of obtaining data for geotechnical information during pre-construction which is based on traditional surveying techniques such as total stations, physical measurement, and photography [15]. Then, all the data will be transferred to software before it can be used for design stage and the product of the integration is a paper-based document [14]. The method used to integrate data for geotechnical activity is via reports containing 2D site plans and log sheets and the engineer will think and visualize it in 3D [16]. Figure 1 shows the principle of geotechnical data journey laid out by Child et al [17] where the workflow is a linear waterfall process and will be ended up at national and local archive in form of paper-based document. The result data is passed to the following phase after the work in one phase is done [18].

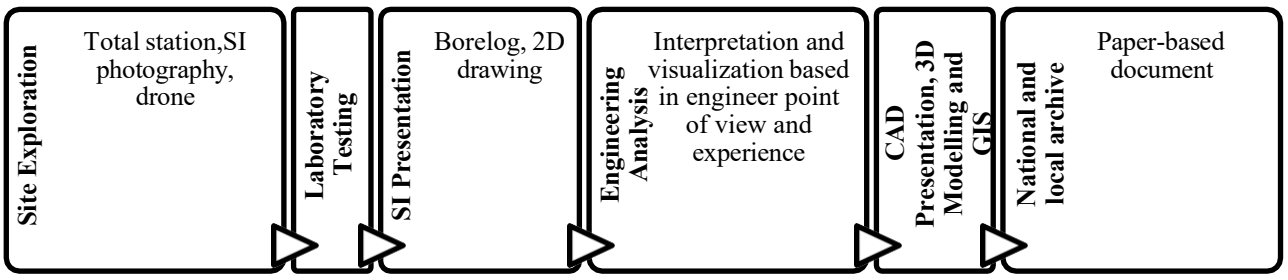


Figure 2: Traditional Approach by Child et al. [18]

3.3. Workflow of BIM Practices

3D scanning to modelling can be an impressive tool for facilities that are facing difficulties dealing with old and traditional systems like paper-based document in post-construction phase. Furthermore, particular technologies, such as the use of cloud computing [19], and 3D scanning [20] have facilitated adoption and added value to BIM. The integration of BIM through the model provided via 3D scanning ensure higher functionality [21], waste reduction, higher productivity and profit [22]. BIM provide benefit: overlap, reduce real project risks; irrelevant document eliminated; waste reduces; productivity increase; costs decrease; profit increase as improve product, improve services deliver, or expand market share [22].

Bentley [23] and Autodesk [16] are the example of a leading global provider of comprehensive software solutions that provide software to integrated data of geotechnical such as terrain, subsurface condition and etc and provide a modelling to represent surface condition and information. By that, a comprehensive project can be delivered. BIM application stops at the preconstruction phase with a limited amount of research regarding data collection of the construction process [24]. In recent years, most virtual 3D city models have been realised as purely graphical or geometrical models, neglecting semantic and topological aspects.

Previously, the data journey believed to be flat but nowadays it should be round (as in figure 3) and ingoing which available throughout the life of project and lead to the effective interpretation of ground conditions and characterization of the site [17]. Child et al. [17] continued to explained that visualizations being generated by tools and ended in the form of a digital archive.



Figure 3: The data journey transformed by Child et al. [17]

3.4. Challenges with BIM Practices

The use of BIM for pre-construction phases is not as popular as other phases of the project despite these successful applications [25]. Even, the application of BIM in pre-construction phase is more evident [1][26] than during the construction and post-construction phases because there are many activities in pre-construction but the use of BIM for pre-construction phase still not gained a wide acceptance in industry [25]. BIM became compulsory for applying to the tenders in developed countries [26] although it took some time for the government to encourage the development of modelling [17] but rarely used in developing countries such as Malaysia [27] due to the comfortableness of using the old method and cost that need to be considered to change to new method. Current software available also has lacking as tabulated in table 1.

Table 1: Software available for data integration modelling

Name	Author/ Date	Using	Primitive	Entity object	Model base	Advantage	Disadvantage
SSM	Zlatanova [28]	City visualization	Node, Planar face	Point, Line, Surface, Body	Simplex concept	Abstract primitives easily, small storage	Update dynamically and modify are complex, constructive objects are multi-values
UDM	Coors [29]	City visualization	Node, Triangle	Point, Line, Surface, Body	Triangulation	Abstract primitives easily, small storage, facial visualize	Update dynamically and modify are complex
OO3D	Shi Wenzhong, Yang bisheng [30]			Point, Line, Surface, Volume	OO modeling	Complex object, LOD, Visualization	
GTP	Wu LiXin [31]	Geological engineering	Node, Line (TIN-L, side-L), Face (TIN-F, Side-F), GTP, diagonal	Point, Line, Surface, Body	Body divide	Topology completely, 3D expression of geology, based on drill hole data	Difficult to visualization of complex geological object
TEN+Octree	Li Qingquan, Li Deren [32]	Geological engineering	Octree、TEN		Octree express whole, TEN express part	Improve the precision of objects, reduce data storage	Difficult to build topology of spatial objects
CityGML	Tegtmeier, [3], Jayakody et al. [33]	Geotechnical extension	3D-GEM, XML-based format		Geo-information	Representative of 3D digital terrain models, buildings, vegetation, water bodies, transportation facilities or city furniture.	Less presentative to users
GIS	Hack [34]	BIM extensio			Point, edge,	3D visualization	No proper integratio

		n	polylin e, polygon , 3d Solid	system of built environment and urban system	n of the boreholes and other geological and geotechnic al data.
GeoBIM	Hack [34]	BIM extensio n		Integration of surface and subsurface data	Not a complete set of integrated formats to handle surface and subsurface data.
Holebase SI	Morin, 2014 [35]	Autocad Civil 3D Extensio n		HoleBASE SI and AutoCAD Civil 3D combine to generate and maintain comprehensive 3D models of the geology that can be integrated with any other project designed data.	

4. Discussion

This study aims to identify research needs in the area of current BIM-based data integration via a systematic and critical evaluation. An essential part of this review is covered below: The evaluated article states that the most important factors are the data required and the program employed. It is well-known that building information modeling (BIM) is a cutting-edge breakthrough that can effectively plan, design, build, and manage infrastructure and buildings. A new innovation called "reality capture" will utilize drones to take aerial photos of a site and then combine that data with building information modeling software to create a more accurate map of the area. However, the data integration procedure is of utmost importance. It was noted in the evaluation that the ideal BIM software has not been discovered yet [36]. Even though most building information modeling (BIM) systems do not include geology, Kessler et al. [9] confirmed that geotechnical data may be accessed and visualized using industry-standard software. as well as protocols for the transmission of data. Table 2 shows that each piece of software has its own set of pros and downsides. Soil stratigraphy, a

parameter for soil strength, and a characteristic of bearing capacity are all missing from the given program. If future building information modeling (BIM) software can generate an intelligent model taking these three factors into account, it will be an intriguing technological development [37]. The Improving the structure and interpretation of standardized geotechnical data will provide a comprehensive understanding of the subsurface state, which will benefit the whole project life cycle.

5. Conclusion

Finally, more studies should look at data integration modeling, specifically how to discover new technologies or tools that can complement BIM to create semantic models and 3D topological models. Moreover, it is necessary for the research in this field to investigate the implementation's conditions. The software components that were developed, verified, and validated during the research served as a technical proof-of-concept for the transfer of building information and the use of building information models to facilitate these processes. It is feasible to represent a high level of geometric and semantic information acquired from BIMs in the geospatial environment, according to the research. Additionally, the research showed that there are still barriers in the transformation process, but that BIMs provide the necessary amount and quality of building-related data for these processes to be fully automated. Despite the fact that much of the study in this field is centered in geometric information transfer to the geospatial environment, the effectiveness of this endeavor will hinge on how well the semantic information is represented in the geospatial environment.

6. References

[1] An article published in 2013 by Latiffi A A, Mohd S, Kasim N, and Fathi M S titled "Building information modeling (BIM) application in Malaysian construction industry" provides valuable insights into this topic. 2(A) 1-6. [2] In the 2008 November issue of the IEEE Convergence and Hybrid Information Technology conference, ICCIT'08, a research was published by Ham, Min, Kim, Lee, and Kim examining the use of building information modeling (bim) for pre-design in construction projects (Vol. 1, pp. 42–49). “3D-GEM: Geo-technical extension towards an integrated 3D information model for infrastructural development” was published in 2014 by Tegtmeier, Zlatanova, Van Oosterom, and Hack in the journal Computers & Geosciences, volume 64, pages 126–135. Wang Y, Zhang J, Ma Y, Wu Y, and Mao X 2017 [4] Computing for Geotechnical Information Management in a Construction Project using BIM. portions 1–17. [5] In the 1st Conference on Building Information Modelling (BIM) in Design, Construction and Operations (pp. 181-193), Papadonikolaki E, Vrijhoef R, and Wamelink J W F presented a BIM-based supply chain model for the architecture, engineering, and construction industry in September 2015. Published in the WIT Transactions on the Built Environment series. [6] Cerovesek T. (2011a) A multi-perspective framework for technological development: A "Building Information Model" (BIM) evaluation and outlook Advanced engineering informatics. pages 224–244. "3D geo-database research: retrospective and future directions" (Breunig & Zlatanova, 2011) appeared in Computers and Geosciences, volume 37, issue 7, pages 791–803. The integration of surface and subsurface data for civil engineering was discussed in Hack R 2010 - November. Geo-Engineering Information Technology. 37–49. [9] “Building Information Modelling (BIM)—A Route for Geological Models to Have Real World Impact” (Vol. 101) by Kessler, Wood, Morin, Gakis, Mcardle, Dabson, and Dearden (2015).

In 2017, Zou, Kiviniemi, and Jones conducted a study on the use of building information modeling (BIM) and associated technologies for risk management. An article titled "Mapping

the knowledge domains of Building Information Modeling (BIM): A bibliometric approach" was published in 2017 by Li X, Wu P, Shen G Q, Wang X, and Teng Y in the journal Safety Science, volume 97, pages 88–98. September 1984, Volume 84, Pages 195-206. [12] Review of the Preconstruction Stage of a Construction Manager/General Contractor Project by Schierholz J. (2012). Business and management journals. 2, 25-27.