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THE STUDY OF THE APPLICABILITY OF DIGITALISATION IN CONSTRUCTION THROUGH THE BIM CONCEPT. A REVIEW

P.A. CONSTANTIN[1*]   A.A. SERBANOIU[1]

Abstract: *For an organisation, industry, or nation, "digitisation" is adopting or expanding the use of digital technology or computers. In the comparatively advanced "technological era," an association or organisation's use or development of digital technology or computers is crucial. Once BIM was used, the construction sector entered the digital age. The concept behind it (BIM) is to digitise building construction and other technical data using software. Information sources must be found and assessed for relevance to meet specific needs before formal data analysis can begin. Production, reliability, and inter-organisational cooperation should grow with the elimination of manual work and its costs.*

Key words: *BIM, digitisation, construction management, software programmes.*

1. Introduction

The use of BIM (Building Information Modelling) technology is becoming more and more common within the specific processes in the field of construction , not only through the fact that its application leads to the development of projects with an accuracy that very well defines the work stages of each department but also as a means of reducing errors and contributing to both work efficiency and the scaling down/cutback of working hours. BIM technology has the potential to support the cooperation of various specialists who take part in the development of the project so that it becomes an essential working tool for a professional and efficient development of projects in different fields, such as construction. The organisation and management of construction can be greatly improved through BIM technology, which contributes substantially to achieving traceability which minimises the inhibiting factors that occur in the development of projects.

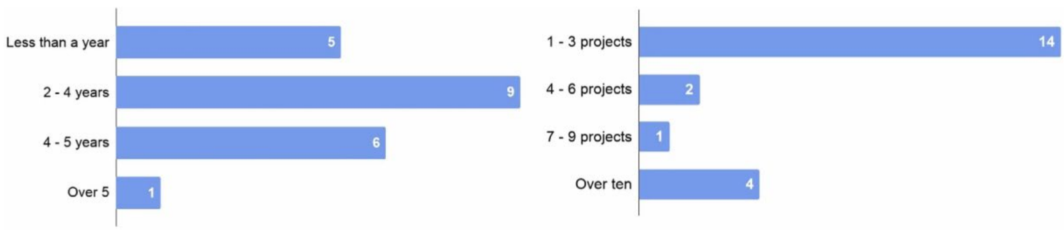
Information modelling is extremely complex, including geographical information, quantities, construction elements, costs, stocks, graphs of project stages, etc.

[1] Faculty of Construction and Installations, "Gheorghe Asachi" Technical University of Iasi.
* Correspondence: petronela-adriana.constantin@student.tuiasi.ro (P.A.C.)

The use of BIM technology was investigated, and the statistical data provided by the Erabuild Foundation in 2008 indicate that this technology, at the time, had a use of 20% in architectural design projects and 10% in construction projects, which include several Nordic countries that present projects with a high degree of complexity such as the Freedom Tower, the Eureka Tower, etc [3]. In construction management, a monitoring and control management system was developed by Zhang and collaborators [11]. The study has proven that it is possible to automatically control the construction progress on the construction site using a laser scanning system. During a review of the implementation of BIM by Haya and collaborators [1], the researchers found that, through this digitalisation technique, it is possible to increase productivity and, at the same time, improve the accuracy of the constructions that contribute to the realisation of projects at high quality standards.

For the purpose of better visualisation, this concept is also critical as it allows the creation of a virtual model of the building, which is characterised by elements that make up a project and specific data that must be visualised in real time throughout the development of the project, such as costs, analysis of engineering work stages, different criteria based on codes, and elements that must continuously reflect on the construction and budgeting of the project from its initial stage. This information modelling concept appeared through the transformation of information and the interaction and operation of different software within architectural, mechanical, electrical, structure, and building construction projects. Computer-Aided Design (CAD) tools are included in the BIM system, resulting in different information about buildings and their construction processes.

In the research work on BIM tools carried out by Haya [1], the rate of adoption and implementation of BIM was highlighted through a survey in which 30 organisations took part. Twenty-one of them, representing a percentage of 70% of the total participants mentioned the fact that they use, or have used, BIM tools in the projects carried out. During the survey, both the length of time that they had been using BIM tools and the number of projects, either in the past or in the present, that called for the utilisation of BIM were taken into consideration. Those organisations which implemented these digitisation tools provided the research data, as shown by the percentage number, and Figure 1 shows a visual representation of the degree to which these digitisation tools have been used throughout the course of the years.



a) b)

Fig. 1. *Use of BIM digitization tools. (a) years of use; (b) BIM wrapping* [1]

These digitisation tools prove to be effective in the development of projects, being intended to complement traditional methods. It is proven that BIM makes a crucial contribution, both in terms of the performance of a building and the management of projects within the construction [1], [6].

2. Research pertaining to the use of BIM digitalisation products

The use of Building Information Modelling for the examination of cracks on the surface of buildings was the subject of a study that was written by Tan and his coworkers [7]. A correlation was also found between digital tools (BIM), edge computing and multipurpose cameras (UAV – Unmanned Aerial Vehicles) during the experiments. The research shows that employing BIM technologies for the purpose of conducting building inspections has the potential to help reduce labour expenses. BIM generates the inspection points of the building, which are basic components for tracing the constitutive elements of the inspection process, by using an aircraft and a camera to capture the elements that must be scanned or visualized. First, inspection points are generated based on BIM and the FOV (Field of View) of a wide-angle camera particular and then, the global optimal flight path of UAV is obtained using GA and A star algorithm. Then, the proposed method involves one or more FOV, used to cover the target inspection area (TIA), in real time, to ensure a complete image of the building surface. Inspection points are a set of optimal hovering positions for a UAV to take photos for crack identification. Finally, the local optimal flight path of the UAV for each FOV is obtained according to the identification results and the parameters of the zoom camera to achieve fine identification and quantification of the crack. In Figure 2, you can see the inspection plan, which includes the following stages: selection of the inspection area, route planning and inspection mission.

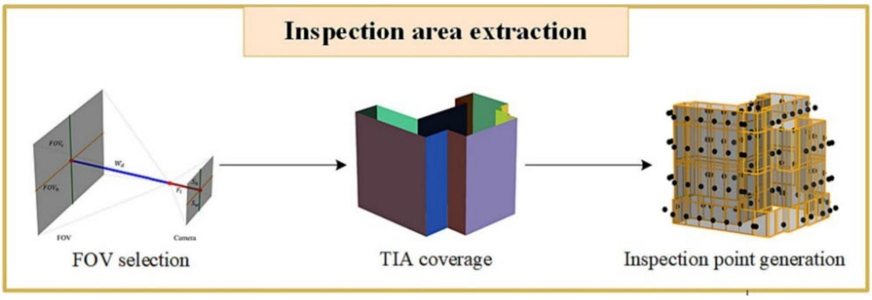


Fig. 2. *A schematic view of the building inspection methodology* [7]

BIM tools prove to be extremely useful in research by allowing the planning of the inspection route. However, additional research is needed. Although the inspection route is established, it cannot be done without considering, in advance, for any obstacles that may be around the building. The BIM tools refer, for the most part, only to the building. This fact requires additional work.

Research was carried out by Waqar and his colleagues [9], on the use of building information modelling in the context of enhancing the level of sustainability in construction projects. The adoption of BIM, as well as the concept and design elements of the buildings, were outlined in an overview which was created as a response to the need to know the extent to which this concept has a positive and significant impact on resource efficiency, energy performance, waste, and other related topics. This overview also confirms the significance of utilising these digitisation tools. To improve factors connected to resource efficiency, waste reduction, energy performance, decision-making and other associated aspects, ecological construction approaches are integrated with building information modelling technology at the time of project execution. The effect that the introduction of BIM in building projects has brought about may be seen in Figure 3.

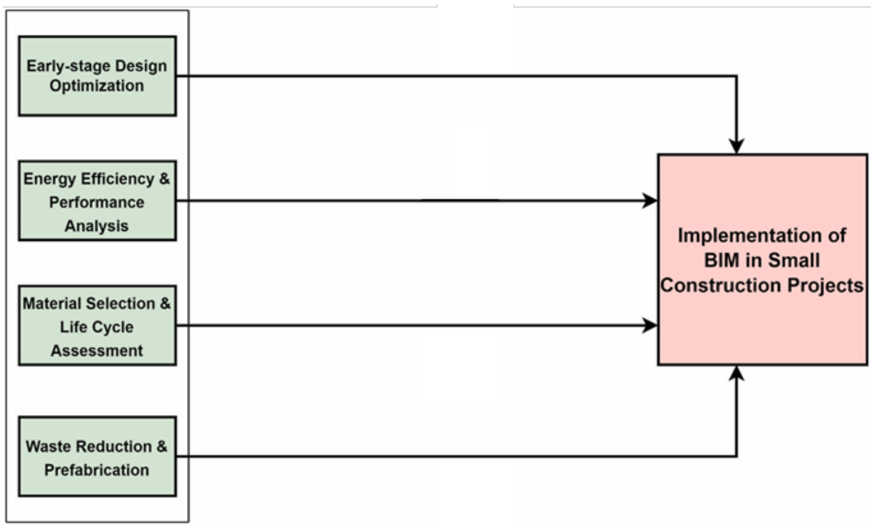


Fig. 3. *The objectives of BIM implementation in ecological construction* [9]

The BIM concept can be exploited to its maximum potential if it is used throughout the construction process, starting with the design phase.

In a research paper carried out by Valinejadshoubi and collaborators [8] BIM tools were studied in the framework of high precision automatic systems in terms of taking quantities and verifying accuracy in architectural and structural projects. Through this system, the procurement department receives extremely precise quantities to start the procurement procedures that are necessary for each category of products or services. In the BIM model, a workflow has been developed based on the system for the precise extraction of QPT/QTO (Quantity Take-offs) quantities, which allows for the automatic calculation of quantities [4, 5]. Figure 4 shows the main components of the system and the connections between them.

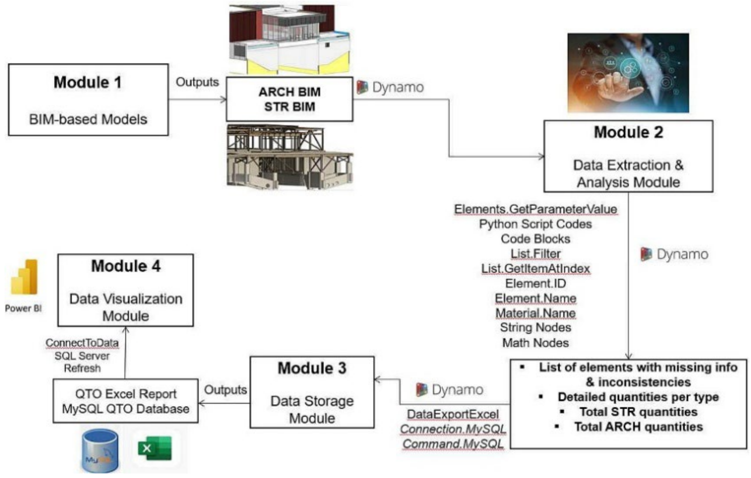


Fig. 4. T*he main elements of the system that integrates BIM for determining the quantities needed for construction projects* [8]

As shown in Figure 4, Module 1 consists of architectural and structural BIM models with the information required for a QTO (quantity take off) process. Module 1 is connected to Module 2, Data Extraction and Analysis Module, using Dynamo, which is a visual programming and computational design tool applied for automation. The data extracted from the BIM models using Module number 2 are filtered, listed, analysed, checked, calculated, and transferred. Different types of nodes, such as Elements.GetParameterValue, List.Filter, List.GetItemAtIndex, Code Blocks and Python Script, Element.ID, Element.Name, Material.Name, String, and Math nodes are used for data extraction and analysis. Depending on the type of storage, Module 2 is connected to Module 3 in Dynamo using nodes such as DataExportExcel, and Connection.MySQL and Command.MySQL to store its outputs, including a list of elements with missing information and inconsistencies, detailed quantities per type, and total structural and architectural quantities. Finally, Module 3 is connected to Module 4 to visualise reports such as QTO Excel reports or MySQL QTO database files using Power BI ConnectToData, SQL server (Structured Query Language), and Power BI auto-refresh commands [8].

This system is complex, has a particular accuracy for data collection, and requires continuous improvements throughout the work to ensure maximum correctness of the extracted quantities. At the same time, the visualisation of the data must be easy to expose, to facilitate the clarity of the information for all project participants.

Hedayatzadeh and his colleagues [2] conducted research in which they investigated the possibility of integrating the design and construction processes of tunnels by using BIM in conjunction with Geographic Information System (GIS). During the design of the tunnels, the data such as table layers, geometries, dimensions of excavations, rock screws, is exported to BIM to maintain an updated record of the design. Figure 5 shows the importing of the data.

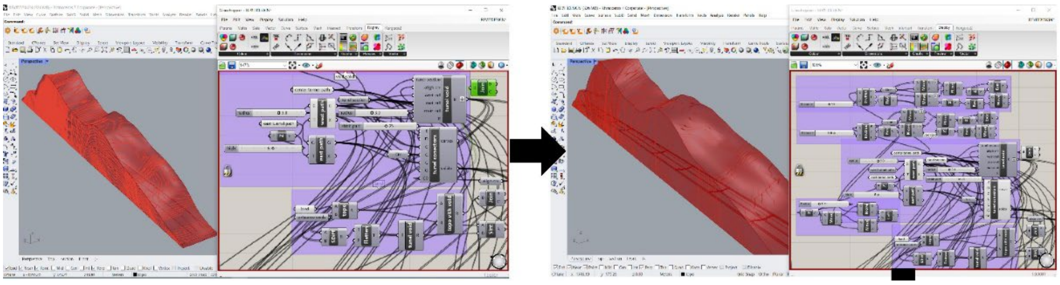


Fig. 5. *Shared canvas between Rhino and Grasshopper for importing the data* [2]

A meticulous control of the geometry of the tunnel was allowed, and the BIM modelling, including the technical documentation of the drawings (CAD), facilitated the rapid progress of the realisation. By means of BIM, many problems could be solved before the execution phase of the construction, such as: changing the dimensions for better accuracy of the values; arranging the screws; and specifying linings. Figure 6 illustrates how Building Information Modelling is included in the process of project realisation [2].

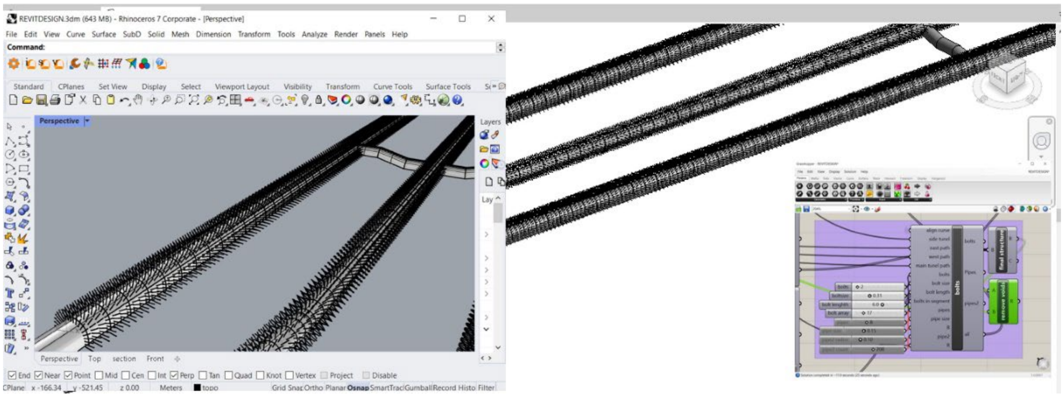


Fig. 6. *The integration of BIM in the work process of project realisation* [2]

Waqar and collaborators [10] conducted studies on the impediments to BIM implementation in risk management in high-rise buildings where complexity and hazards are extremely high. Through a survey in which experts in the field took part, data was collected. The research shows that there are obstacles such as technical integration, operational correctness, confidentiality, and application of standards. It is vital to incorporate such obstructions that have been recognised as risk factors in order to be able to accomplish optimal management when it comes to the implementation of BIM in the identification of risks. By using these tools and information, it is much easier for the project organisers to overcome these obstacles. In Figure 7, you can see the organisation chart that is the basis of the concept of identifying the impediments that appeared in the implementation of BIM. The statistical methodology known as Exploratory Factor Analysis (EFA) is utilised to detect latent dimensions or factors within a given set of variables. The present study employed EFA to analyse the pilot survey data and identify the salient constructs pertaining to BIM impediments in terms of the management of risks for tall buildings.

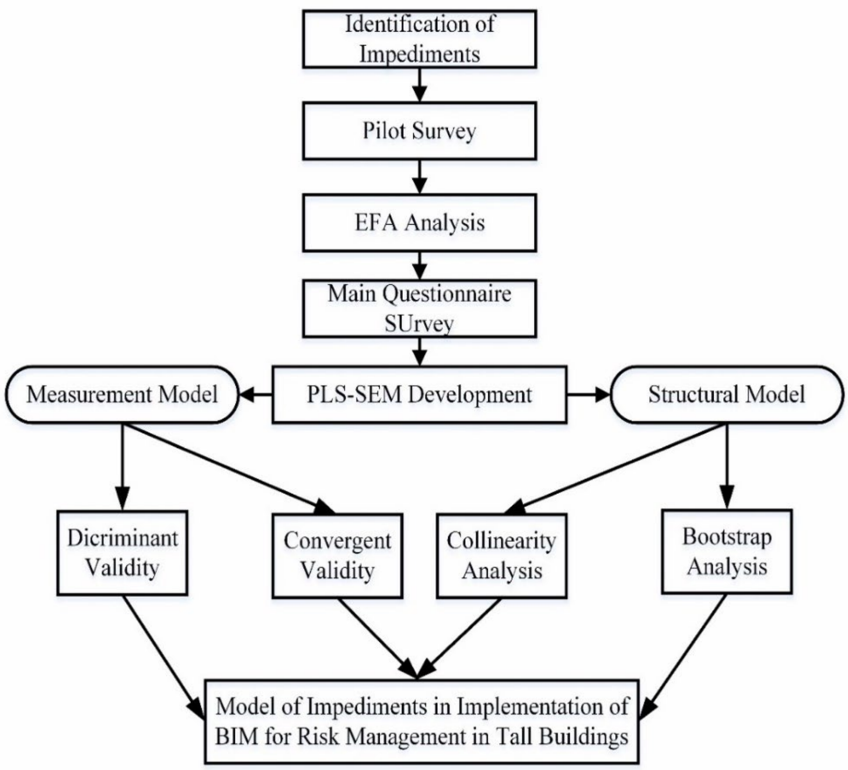


Fig. 7. *The phases of the research work carried out with reference to the identification of the obstacles that are preventing the deployment of BIM in tall buildings* [10]

3. Conclusions

1. Building Information Modelling technology is increasingly used in the construction sector.
2. BIM accelerates project development and improves data quality.
3. Although building information modelling (BIM) has been effectively applied to building crack inspection projects, further studies is required to minimise the time and resources required for the development of linked building parts.
4. BIM is useful in projects that need concrete data for greening, waste and pollution abatemento and other sustainability criteria.
5. BIM technologies for quantity production during project development improved data accuracy and reduced labour time and errors.
6. Building information model (BIM) and geographic information model (GIF) were combined in tunnel construction projects to create a more comprehensive illustration of the phases of the work and of construction components, such as screw placement

in the rock, caps, sizes, etc.

7. The research work on BIM application in high rise construction projects found technical, integrative, operational, creative, confidential, and standard-related barriers. The awareness of these obstacles helps foresee problems that may be avoided during design work.

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