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Building Information Modelling in Transport Infrastructure Sector

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Abstract. The Building Information Model concepts includes a range of IT tools supporting the collaborative processes in an organisation. This approach allows all stakeholders to have an integrated system in which editing and retrieving up to date information on shared models will become easier changing the businesses processes. This paper will be presenting a review of research on the Building Information Model in practice. The Building Information Model has been around for some time and is becoming more popular as of its mandate in the UK back in April 2016. This research is based on case studies on BIM in practice in the transport infrastructure sector. The methodology for this research is a case study on a Tier 1 contractor in the UK who are using BIM as one of their processes. A brief overview of BIM will be explained and the key findings in the research will be highlighted identifying the business value of BIM, the results will demonstrate how BIM is being practiced within the organisation and to improve design management, the challenges with the implementation of the new processes will be outlined, this paper will also show how the construction company have utilised the adoption of BIM to mitigate and manage communication issues within their projects. Research has shown that the key communication and management problems such as loss of documentation, poor communication and quality can be mitigated with the use of BIM. Finding out these challenges will allow the issues found along with the potential of BIM to be outlined and allows the conclusion that BIM is the future of construction.

Keywords: Building Information Model, Communication, Engineering and Construction, Collaboration, Infrastructure.

1 Introduction

The UK economy has been growing over the years averaging at 0.6% growth in three months back in September 2018 which has been the strongest increase since the last quarter of 2016[1]. The construction industry has played a major part in the economy growth as the UK government has invested over £600 billion over the next decade on infrastructure and at least £44 billion on housing[2]. On a global scale, construction projects are becoming more complex, construction project now include several stakeholders and with the rapid growth within the industry communication challenges

arise. Communication can affect the quality of the design which can have an impact on project costs.

Construction projects also go through frequent design changes and these changes need to be fed back to the construction team as soon as possible to ensure projects are built to the updated and latest designs. The Building Information Model has in a major topic in the construction industry globally as benefits of its use within construction have come to light. It has been noted that BIM can provide various benefits to the construction process, from the design stage to asset management. To better understand BIM this paper presents a case study to demonstrate the key challenges faced within the project. Key communication challenges are analysed and the key lessons learned are documented. The project currently uses the Building Information Model as one of its processes, this will be investigated, and this paper will highlight how the Building Information Model is being used within the project and if there have been any challenges with the use of BIM. The paper will be split into four sections which answer the research questions:

Research question 1: How important is design management within construction projects?

Research question 2: How does BIM benefit the construction Industry and what technologies are being used in the construction industry?

Research question 3: What is the current state of BIM within the case study project and what challenges and benefits are being faced?

Research question 4: what are the future recommendation for the use of BIM within this project?

2 Literature Review

2.1 Building Information Modelling (BIM)

The Building Information Model is a maturing technology that has the potential to efficiently manipulate and visualise the whole projects life cycle data[3]. The Building Information Model can be utilised during all stages of the project and functions during these stages include:

Design Stage (Pre-Construction); during this stage, the design can be visualised, and alternative designs can be rapidly generated, this allows the designers to choose the best solution for the project.

Construction Stage; BIM can create a communication platform between the designers and construction teams. With there being a 3D model, the design can be visualised by the construction team and the designs can be understood.

Asset Management (Post-Construction); Project data and asset data is all stored as as-built information during construction, this allows for better asset management once the construction is complete as all data is stored efficiently[4].

Many benefits of BIM have been documented such as reduction in project costs, saving time, improving projects communication and collaboration and project quality[5]. This Building Information Model also provides the means to increase design

quality through detecting clashed between the different disciplines on the design prior to construction, BIM also improves the sharing of Information within the different stakeholders via a Common Data Environment (CDE), this allows the construction teams to always have access to up to date information for construction.

BIM is a process and includes a wide range of other technologies which work together to provide more benefit to a project, this use of technologies is known as Industry 4.0 as the construction industry is going through a digitisation era.

2.2 Industry 4.0; IoT Technologies

The UK have now entered a new industrial era known as Industry 4.0, this is known as the trend towards the digitalisation and automation of the manufacturing and construction industry. Industry 4.0 comprises of various technologies including BIM to enable a digitalised environment for the construction and manufacturing industry[6]. The results of the use of Industry 4.0 have proved to improve quality and decrease time while improving performance within a project, despite all these benefits, the construction industry have yet to integrate these technologies as well as the automotive and manufacturing engineering sectors have[6].

Some of the technologies linked with Industry 4.0 are mentioned below:

Cloud: The construction Industry contains a lot of data which is to be stored at all stages of construction to enable a better asset management. Loss of data during the construction stage is a big issue, having a cloud to access data and store data can increase productivity and prove profitable for an organization[7].

Artificial Intelligence/Virtual Reality: Virtual reality is becoming more popular in the construction industry compare to Artificial Intelligence. With Virtual reality, the project can be view prior to its construction and its purpose can be viewed with the client and stakeholders making them confident in the project, the like of High Speed 2 railway in the UK have used this technology to show the public[7].

Drones: Drones can be used for a variety of things in the construction industry, site data can be collected cutting surveying time to hours instead of days. Up-to-date and accurate site information can also be collected which can be used to check for the sites progress and productivity[8].

Simulation: Simulations are becoming more popular in the construction industry, they are extensively used for plant training which allows operators to use machines at its trial period in the virtual world before using it on site[6].

Additive Manufacturing: The construction industry has been using Additive manufacturing, it is where products are pre-constructed off-site such as modular blocks, and then transported to site to allow for construction. This allows for complex designs to be constructed in an environment where the detail can be constructed accordingly and then placed of the site with no delays[6].

These are just a few of the technologies that are related to Industry 4.0, the Building Information Model is also one of the technologies linked with Industry 4.0, however BIM in cooperates some of these technologies to provide more benefits. Drones can be used with BIM to compare site data with the 3D model of the design to check progress.

3 Research methodology

For this research, a combined methodology was used, for the purpose of answering research question 1 and 2, a systematic literature review was conducted to explore construction processes and identify the technologies linked with Industry 4.0 and BIM. For the purpose of answering research question 3, a case study research approach was adopted to investigate the Building Information Model in practice, identifying and analysing its use.

Systematic Literature Review

First, a literature review was conducted to gain a solid base of data for the context analysis, scholarly context was analysed which enabled the findings of the basics of technologies used in the construction industry and BIM, it was clear that the research had to be broadened which was conducted by using Google search with the key phrases of this research.

Qualitative and Quantitative context analysis

It was clear that one form of analysis would not provide as much data as a combined methodology, within the qualitative analysis, recommendations from [9] was followed: Preparation of the research questions, Introduce categories of definitions, Check categories are relatable to topic, and Interpretation of the results collected.

Case Study Research

The aim of this case study research is to examine BIM in its natural settings and by employing multiple methods of data collection and obtaining data from professionals in the business, during this investigation we follow a framework strategy recommended by Robert K. Yin[10]. Two factors are to be considered when interpreting the results. First, due to the limitation of investigated research paper from the year 2010, it cannot be guaranteed that all relevant publications have not been covered hence the research should be validated with further studies, e.g. expert interviews or empirical study. Secondly, a few of the research publications are non-peer reviewed, for example blog posts which may contain information that cannot be verified. Data collection was obtained through 15 interviews and questionnaires were handed out to 20 employees. 8 observations were held with different disciplines within the project.

Through observing the employees, key interactions between the different disciplines were recorded, important points within meetings and communication methods were recorded. During the interviews the responses were recorded and the main analysis method for the interviews was classifying the patterns and arguments. Notes were also taken during the interviews which were studied and the document analysis method was adopted to support the findings from the data collecting methods.

4 Results

The following section will start by providing related work to demonstrate the uniqueness of this contribution. The results are the presented as well as the findings from the case study research and finally future work and recommendations will be demonstrated.

4.1 Project description

The UK government has invested in smart motorways all over the country in the hopes of converting normal motorways with three lanes and a hard shoulder into All Lanes Running motorways. The M23 Junction 8-10 is one of the current projects which commenced construction in 2018 and is expected to last a duration of three years.
The proposed All Lane Running scheme would provide four permanent running lanes through converting the hard shoulder into a running lane and various technologies will be in cooperated to assist with safety and keep traffic moving. These technologies include installation of 26 new gantries (the existing gantries are to be demolished/ retained and upgraded where possible), which will be fitted with message signs and AMI's (Advanced Motorway Indicators, strategic signs and variable message signs. Speed limits will be displayed based on traffic conditions to allow traffic to keep flowing and CCTV cameras and loop detectors will be fitted to provide information support to a control centre. The central reserve will also be hardened, and a rigid concrete barrier will be fitted. The projects overall view can be seen in Figures 2

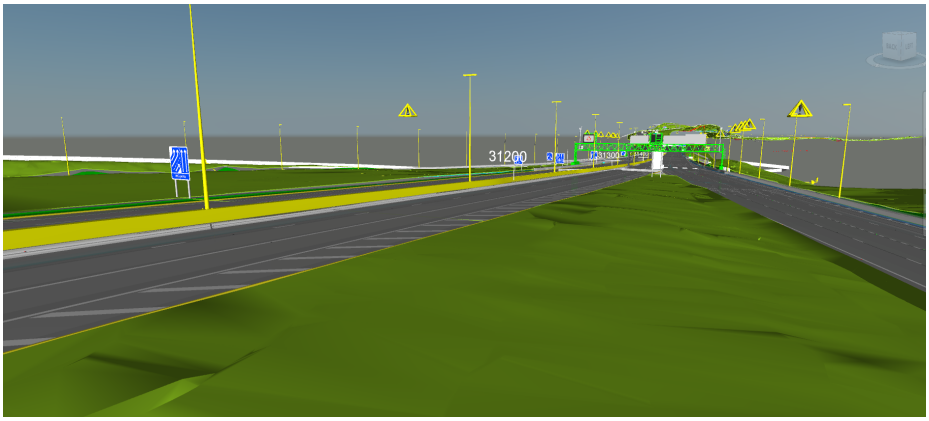

Figure 2 3D model of project; Junction 8

The project has adopted as required by the UK government and a design 3D model was created as demonstrated in Figure 2. The project comprises of three different organisations, the designers, the contractor and the client, and sub-contractors. The project has a BIM coordinator, BIM manager and BIM Coordinator of the designer's company.

4.2 Project Analysis

The following section details some of the issues being faced within the project which have been identified after the data analysis regarding the use of the Building Information Model. Th discussed issues include communication tools, implementing BIM, collaboration with sub-contractors and up-skilling.

189 **Table 1** Challenges of BIM within Case Study Project

Implication Challenge
• **Acceptance:** The project has adopted BIM from the start and training session are held in order to be Level 2 BIM compliant and utilise the Common Data Environment. All project information is uploaded on the contractors CDE and distributed to the relevant disciplines, however when distributed, there is a lack of responses as the disciplines do not download the updated documents form the CDE as they would grab a paper copy from team members. This is an issue because the printed copies may be previous revisions.
• **Process Changes:** The implementation of BIM must take place at all levels of the organisation which requires re-engineering the business practices, as most employees in the organisation have been in the industry for over 15 years, the reluctant to change the way of working is quite difficult. Training sessions are held every week to allow employees to understand the BIM Level 2 processes, however once training is completed most employees tend to revert to their old ways of working.
• **Communications:** Within this project there are three CDE's. The client has their own CDE which a number of people have access to and is used for Technical Queries and raising PMI's (Project Managers Instruction), the designers also have their own CDE which the client, Document Controller of contractors and themselves have access to where documents are issued, and the contractors have their own CDE which everyone has access to, as there are three CDE's with limited access for employees to two of them this can be difficult as not everyone has access to view all project information.
• **Use of 3D model:** the 3D model is available for use and everyone on the project has access to it, however not everyone uses it to gain the benefits it provides even though they have been trained.
• **Communication** Tool: the contractors CDE contains a communication tool which can be used to communicate with sub-contractors etc. however this has not used, and emails are mainly sent which can cause loss of data.

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191 Even though there a number of issues with the use of BIM on this project, there are
192 various benefits which BIM is providing to the project which are demonstrated in Table
193 2.

194 **Table 2** Benefits of BIM to Case Study project

Implication Benefits
• **4D planning:** The project has produced a 4D sequence which was requested by the client, this allowed the Planners, Operational team, CAD technician, BIM team and designers to collaborate as the design model was needed along with the programme and works sequence to produce the 4D model. The 4D sequence was produced at a section where major works were to be conducted and there were a lot of risks involved with the works. the sequence allowed the operational team to view the programme and justify that there will be enough space for the machinery and plant.
• **CDE:** There are pitfalls with the CDE as there are three of them, however the CDE being used by the contractors takes a major role in the works, the contractors CDE is where all construction information in obtained by the operational team, however there is still to be a push for employees to adapt to obtaining the current revision of drawings uploaded.

• **Asset management (Life cycle benefits):** At this project, as the construction process is happening, asset data is being collected and this will be inputted into the model, the will allow the asset to be maintained in an easier way as all asset data is stored in one place and is attached to the model itself.
• **Clash Detection:** At the early stages of the project the model was used for clash detection between the sub-contractors and the contractors, the model was used to visualise where the proposed temporary CCTV cameras were to be placed and to check if it clashes with the proposed works, a number of clashes were found which enabled the team to move the CCTV cameras to locations where there were no clashes. this saved time of re installing the CCTV bases if the clash detection was not conducted.
• **Walk through of job:** A fly through of the job has been recorded by the BIM Team, which is regularly used to show stakeholders and visitors to the site and the works. Most visitors visit the site office and do not get to see the job, however with the fly through in place that is possible and reduces the safety risk as visitors do not physically go on site.

5 Conclusion

This research presents a detailed study which was executed between April 2018 and January 2019 on the Building Information Model in practice on a Smart Motorway Project. The case confirms several points identified: (i) The Building Information implementation process is a tough one, it involves a lot of awareness and training to staff for level 2 to be adopted in the right manner. (ii) communication can be improved with the use of BIM, the likes of subcontractors and different disciplines in the organisation can communicate easier with the use of a CDE while all data is also stored, this however is a process that team members must undertake and adopt. (iii) BIM can contribute to communication between team members, as the results suggested the 4D sequence was a collaboration between different teams showing the planned programme of works which helped the client understand how the works are going to be undertaken. The two most important findings in the research were that the contractor should enforce a communication framework within the organisation to ensure the use of the right BIM processes to communicate between disciplines. Secondly BIM competencies between the different disciplines should be similar and although training is being provided, more awareness on BIM would enable the organisation to raise interest on the BIM level 2 standards and processes.

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