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An Examination of the Potential of Building Information Modelling To Increase the Efficiency of Irish Contractors on Design and Build Projects

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Abstract - **Competition between Irish contractors is more aggressive than ever before. In the current economic climate an ability to construct with greater efficiency could ensure a company's survival.**

The purpose of this research was to determine the extent to which efficiency benefits could be realised by contractors on design and build projects as a result of implementing a revolutionary process referred to as Building Information Modelling (BIM).

After a critical analysis on all aspects of BIM in the literature review, questionnaires were sent to establish the success of this system in the US and also in the comparatively few Irish firms that have more recently pioneered the adoption of BIM. In-depth interviews with two well established Irish firms were conducted to gain an understanding of the challenges and myriad factors that positively or negatively affect efficiency due to the use of BIM.

In compiling the results from these interviews and surveys, it was apparent that the use of BIM does indeed result in increased efficiency from pre-construction to the final execution of works. The results highlighted efficiency benefits through a reduction in man-hours, requests for information and rework, a greater capacity to use more pre-fabricated elements and an increase in on-time completions.

Keywords: Building Information Modelling, Design and Build, Ireland

INTRODUCTION

The current climate has tightened margins between success and failure for Irish construction contractors. Their survival has become dependent on their ability to adapt to change and improve their competitiveness by improving the efficiency of their construction projects from pre-construction planning to the timely execution of works. Building Information Modelling (BIM) is a process that begins with the creation of digital design models, which have been used by project teams in the manufacturing industry for decades. For efficient production in companies such as Boeing and Toyota, digital models have been placed at the centre of their collaborative, concurrent engineering processes for a long time, using them to support each stage of a project's life cycle, from design to manufacturing and field support. This approach can just as effectively be applied to construction projects to improve efficiency.

Building information modelling is defined as 'a process which involves the production of reliable and co-ordinated construction documentation from a virtual 3D model of a building project' [9]. The building information model is a 'data-rich, object-oriented, intelligent and parametric digital representation of the facility, from which views and data appropriate to various users' needs can be extracted and analysed to generate information that can be used to make decisions and to improve the process of delivering the facility' [1].

Hardin points to the efficiency gains available when BIM is utilised on Design and Build projects [4]. Design and Build can be defined as 'contractual arrangements whereby the contractor offers to design and build a construction project for a sum inclusive of both the design and construction costs' [10].

Humble defines being 'efficient' as *'acting or producing effectively with a minimum of waste or effort'* [7]. In order to be efficient it is necessary to maximise the ratio of output to input and do this in good time [7]. The construction industry has, so far, failed to maximise this ratio. On a macro scale, a major contribution to inefficiency in the construction industry as recognised by the Construction Managers Association of America [3] and confirmed by Haskell [5] is the horizontal and fragmented nature of the supply chain within the industry. On a typical project, a combination of designers, subcontractors and vendors, among others, assemble to deliver one-off projects in an accelerated time frame. Building project teams rarely work together more than once. Each of these parties has resorted to concentrating on contractual arrangements to prevent liability and this has formed impediments to collaboration and innovation in the design and construction phases. Various approaches such as design and build contracts have attempted to address these problems,

although none has succeeded in significantly reducing the cost of waste and inefficiency.

Findings from Haskell have shown that extant data on construction industry productivity in the US are *'conflicting and incomplete'* and points out that no aggregate productivity measures are maintained by either government or industry [5]. The absence of a consistent measure of productivity has led to much debate on the actual productivity of the construction sector. According to McNell, Allison, Black, Cukrow, Harrison, Hutchins, Sherred, Shirley, Singh and Wilts, there has been no productivity gain in the construction industry over the last 40 years; in fact, productivity has declined while over the same period all other non-farming industries increased productivity by 200% [8]. Haskell disagrees and has found some productivity gains in the construction industry, although does agree that productivity in most other industries has been far greater [5]. This is in spite of developments in labour saving machines and design tools such as Computer Aided Design (CAD) which have been introduced to increase productivity and efficiency. Progress has been hindered for a number of reasons. In a fragmented industry that has a strong culture of blame, buildings become more complex and take longer to build. A similar study of Ireland's construction productivity over the same 40 year period showed that its construction sector also increased far less in productivity than most other industries [2]. 'One thing is certain, in a shrinking or booming construction market, increasing productivity and coordination is imperative' and McNell et al recognises BIM as 'a key tool for accomplishing this' [8].

The traditional production of project documentation is time consuming, costly, and prone to human error [11]. In addition to this 'the project delivery process is fraught by lack of cooperation and poor information sharing' [6]. There is a consistent acknowledgement that 30% of construction costs can be attributed to waste [9]. Most often these inefficiencies are attributed to the ineffective production of construction documentation, wasted materials from inaccurate quantities, additional labour from making changes to completed works and untimely deliveries from unrealistic schedules. Haskell asserts that other industry manufacturers fund research and development which they benefit greatly from, while in the fragmented construction industry, very little research takes place as 'architects and engineers have neither the resources nor incentive to fund research and constructors have little ability to influence innovation in architectural, engineering, or product design' [5]. Haskell recognises the primary areas of near term productivity gain as coming from information technology and the pre-fabrication of elements [5].

BIM is more than 3 dimensional drawing; it is a data repository that holds design, construction and maintenance information combined in one convenient model that can be shared with all the stakeholders. There are some complications and limitations pertaining to the use of BIM, including some legal impediments, however, the use of parametric 3D models in a BIM process promises consistency in documentation, allows greater project visualisation, promotes collaboration among project participants and offers many applications that can be used to improve efficiency.

Aim and Objectives

The overall aim of this research project is to examine the extent to which Irish contractors can increase efficiency on large design and build construction projects by implementing a building information modelling system. In order to achieve this aim, the following were the specific objectives of the investigation:

- To identify the reasons for inefficiencies in the construction industry and to outline why it is more difficult to obtain efficiency gains in this sector when compared with other industries;
- To critically appraise the concept of building information modelling, its attributes and complications that arise pertaining to its use;
- To compare and contrast the views of construction contractors in the United States and Ireland in respect of BIM and its implementation on design and build projects;
- To evaluate the potential ability of BIM to increase efficiency within Irish contracting firms.

METHODOLOGY

Two email surveys were used to ascertain the experiences of contractors using BIM on design and build projects in Ireland and the US. The first survey was sent to forty Irish Contractors to obtain data on the views of these contractors as to why they have, or more often have not, implemented a BIM system. The motivation behind this survey was to gain primary research into the difficulties and complications of using BIM that have deterred the system's implementation within the Irish market. The second survey of 200 respondents focused on obtaining information on the success of BIM in US firms; such firms were more likely to be using BIM given its greater frequency of use in the US.

The second survey was considered very important to the credibility of the study. As the research aims to find the potential of BIM to increase construction efficiency, the Irish survey alone would have been insufficient as, due to the infancy of BIM in Ireland, it would not have provided a good representation of BIM's potential. In what was perhaps the most important question in this survey, respondents were asked their views on six Key Performance Indicators (KPIs) which were assessed on a Rating Scale. This type of question allowed the efficiency benefits of BIM to be measured.

In addition to the questionnaire survey, semi-structured interviews were arranged with respondents from two international architectural, engineering and construction firms based in Dublin who were familiar with the use of BIM on large construction projects. The purpose of these interviews

was to gain a more in depth analysis of the advantages and complications of using BIM in an Irish context.

A total of 14 questionnaires were returned from 40 Irish recipients and 26 US-based respondents replied from a total of 200, representing response rates of 35% and 13% respectively.

SURVEY RESULTS

The literature review identified many advantages of BIM and most of these advantages were recognised by those questioned in this study. One survey Recipient from the US declared 'my firm uses [BIM] on almost every major project now', and another acknowledged 'it is how we maintain our competitiveness'. When queried about the greatest benefit attributable to the use of BIM, risk reduction was ranked first with improved efficiency ranked second. Risk can be reduced at the design stage through applications such as clash detection and it is these applications that are important to contractors because they provide the information needed to be better equipped to take the risk of designing and constructing a project. They can be assured in terms of costs and time when they assign each element of the building to a schedule of works and where costs are automatically generated and updated should the design change at any stage. This subsequently will increase their efficiency during the construction stage.

The six KPIs used to measure the extent to which efficiency benefits from the use of BIM were being realised in practice were: man hours, the number of requests for information, rework, material measurement accuracy, the option to use more prefabricated elements and on-time completions.

Eighty-four per cent of U.S. respondents found a reduction in man hours. The respondents noted the substantial reduction in requests for information due to greater collaboration between parties, visualisation benefits, and the clarity and consistency of the information. Both interview participants agreed that there was a reduction in rework which was related to the quality and consistency of documentation but was most closely related to clash detection. The point here is that it is much easier and simpler to make changes at the preconstruction stage than when the project is under way so making these changes early is one of the greatest influences on project efficiency.

42% of US respondents found that the use of BIM had no effect on material measurement accuracy. The results show there is a significant increase in the ability to use more pre-fabricated elements as 21% of respondents acknowledged a 'substantial increase', 32% said there was a 'moderate increase' while no respondent ranked it negatively. On-time completions were most often ranked as having a 'slight increase'. Twenty-six per cent said it moderately increased on-time completion while 11% found it to substantially increase on time completions. There are myriad factors that affect the completion date of a construction project and it is thought the positive influence of BIM shown on other KPIs represent some of the reasons for the increases found in on-time completions.

Overall Project Cost Savings

The majority of respondents (72%) estimated the overall project cost savings as being no more than 5%, however this would be a very substantial figure on large projects and perhaps the difference between success and failure of a project. One survey recipient from the US commented:

> [Cost savings vary] completely from project to project as well as [depending on] whether BIM is used for just construction or just design. Many costs are incalculable factors such as side-effects of side-effects when something is not done correctly. 10%+ is believable on some jobs where litigation would otherwise have occurred. But, 5-6% is a safe approximation in these relatively early years of BIM adoption.

Challenges of Implementation

The initial cost of software and training was rated as being the most significant obstacle in introducing BIM into an organisation. Resistance to change was described by an interview participant as being 'always a problem' while a survey respondent noted the need for a 'culture change at top level management'.

There is also a problem of operability between new software packages which has been seen in many sources in the literature review as a major stumbling block for BIM implementation, although as discussed in the literature review, some major software designers have pledged to increase the interoperability of software packages. For design and build contractors, this is perhaps less of a problem as it is most likely that all team members will be using the same software.

Deterrents to the Increased Uptake of BIM

As was expected there was a web of influences on the decision of Irish and US contractors to implement BIM. The greatest deterrent from an Irish perspective was the cost of software and this view was shared by the US contactors. In line with this deterrent in terms of influence, Irish contractors admitted that their lack of knowledge of BIM was of equal influence.
Contractors from both countries gave considerable weighting to the fact that employees are under enough pressure at work and do not need the increased workload. This is very understandable and reflects the current economic climate; however, BIM could give Irish contractors the opportunity to differentiate themselves from their competitors by providing a better service which could meet modern needs such as, energy and acoustic analysis while at the same time increasing their own efficiency.

CONCLUSIONS

The results of this research study suggest that the successful implementation of a BIM system will increase the efficiency of Irish Contractors on Design and Build Projects in terms of reducing man hours, requests for information and rework, increasing on time completions and the ability to use more prefabricated elements. Some contractors may also find efficiency benefits by increased material measurement accuracy.

BIM is emerging as an innovative way to increase project efficiency and it is apparent that although costs of its implementation are high, the return on investment is most likely to be substantial if the system is implemented correctly. BIM is more than technology or software programs, it is a change of processes at every level and as with many paradigm shifts, there will be risks associated with change. Firms should be careful of legal pitfalls such as model ownership and shifting responsibilities. Current contract terms are tailored to paper based practices and these terms will become redundant in their use and must be replaced with terms that govern the new practices and procedures that BIM creates.

There is an urgent need for consistent productivity measurements in the construction industry. If standard measurements were developed, they could be used to evaluate new technologies and processes, such as BIM, and allow the industry to develop its productivity levels in line with other industries.

BIM will become mandatory on government projects over £5 million sterling in Britain by 2016. The Irish government should consider this in its policies as this would be beneficial, not only for the government but also for the contractors. It would promote BIMs use for all contractors and it may result in the development of BIM information in an Irish context.

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