To Investigate Utility of Building Information Modelling (BIM) to Improve Productivity of the Construction Industry

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Abstract

Productivity of construction industry is lower in contrast to other industries. The industry is also lacking behind to adopt technology as equivalent to other industries. Building Information Modelling (BIM) is a revolutionary development in the Architecture, Engineering and Construction (AEC) industry. There are numerous factors that contribute to reduce efficiency of the industry. This study aims to investigate the potential of BIM to solve issues that can reduce productivity of the construction industry. A questionnaire survey is conducted for this purpose from the practitioners of the construction industry of Pakistan. The results of 171 valid responses greatly support the hypothesis that BIM has the potential to solve issues that can cause loss of productivity of the sector. Linear regression analysis is also conducted. The analysis shows that collaboration, elimination of rework and conflicts are significant factors. This research will be beneficial for academics, as well as, industry to enhance productivity of the construction industry by identifying factors and mitigating them with the help of BIM.

Keywords: Construction Industry, Productivity, BIM, AEC

1. INTRODUCTION:

According to Global Construction 2030 (2015) the extent of construction production will increase by 85% to $15.5 trillion globally by 2030 due to China, India and USA. These countries are leading the way and rate for 57% of over-all global growth. Construction sector is the second largest contributor to Pakistan's economy. Around 30-35% of employment is directly or indirectly linked to the construction industry. The industry has played a significant function in creating jobs and facilitating the increase of the economy (Rizwan *et al.*, 2008). According to estimates published by the Economic Survey of Pakistan (2018), the industry grew via 9.13% in the past year and contributed 2.82% to a country's Gross Domestic Product (GDP). Regardless of its remarkable contribution to the GDP, Pakistan's development industry is one of the most unnoticed and unorganized sectors.

Productivity in the construction industry is usually defined as output per labor hour. As labor comprises a significant proportion of a construction value and the quantity of labor hours in accomplishing a task in the industry is greater inclined to the influence of administration than are materials, this productivity rate is frequently referred to as 'labor productivity' (David, 1994). Literature shows that a number of factors affect productivity, however, there are unidentified factors that need to be studied even in advanced nations (Makulsawatudom and Emsley, 2002).

Certain policies to improve productivity of the construction industry are not usually comparable in every country. It is found that there are some special factors that affect labor productivity and are bracketed together according to their attributes such as design, execution plan, material, equipment, labor, fitness and safety, management, work-time, tasks, collegiality and coordination, owner/consultant, and some external factors (Arditi, 2005).

BIM represents physical and functional chrematistics of a facility digitally. It's a revolutionary development in the Architecture, Engineering, and Construction (AEC) industries. It simulates a construction project virtually at the outset of a project (Eastman *et al.*, 2008). Building Information Model is an intelligent parametric virtual representation of a building that provides all the necessary data required by various users for analysis and to generate information that can be utilized in different decision-making processes (AGC, 2005 in Azhar *et al.*, 2008, p.436).

Many studies have been conducted on the issue of productivity in the construction industry, such as, Latham Report and Egan Report. However, BIM wasn't fully developed or adopted back then. The present study is focused to find out if the latest ICT development i.e. BIM can be utilized to improve productivity of the construction industry.

2. RESEARCH METHODOLOGY:

Literature review is conducted regarding productivity of the construction industry, factors that can reduce productivity, BIM and its potential benefits. A questionnaire survey is prepared to conduct survey from the industry to find out if BIM can improve productivity of the construction industry. A total of 180 responses were obtained but 171 responses were valid. The results of the surveys are analyzed and shown graphically. Additionally, linear regression is also employed to find out significance contribution of factors. The methodology adopted is shown below:

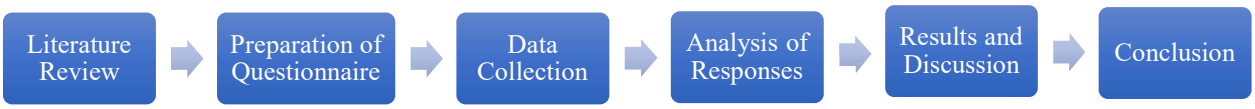

Figure 1: Steps of Methodology

3. RESULTS AND DISCUSSION:

The results of the survey are given in the tabular form. The responses of questionnaire from the industry shows a spectrum between strong agreement and strong disagreement as shown in the table below. However, percentages of agreement for each question is more than percentage of strong disagreement.

RESPONSES	QUESTIONS				
	1	2	3	4	5
STRONGLY AGREE	29%	20%	27%	31%	31%
STRONGLY DISAGREE	2%	2%	5%	1%	0%

3.1 Summary of SPSS Analysis:

- **Predictors:** (Constants), Digitalization, Collaboration, Rework, Conflicts.
- **Dependent Variable:** Intelligent Parametric 3D Model.

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	**0.599**	**0.358**	**0.343**	**0.906**

MODEL	UNSTANDARDIZED COEFFICIENTS		STANDARDIZED COEFFICIENTS	T	SIG.
	B	STD. ERROR			
(Constant)	0.393	0.537		0.732	0.465
(Collaboration)	-0.252	0.121	-0.175	-2.072	0.040
(Rework)	0.634	0.093	0.459	6.808	0.000
(Conflicts)	0.490	0.086	0.382	5.669	0.000
(Digitalizing)	-0.026	0.117	-0.017	-0.224	0.823

$$[Y = 0.393 - 0.252*B_1 + 0.634*B_2 + 0.490*B_3 - 0.026*B_5]$$

B_1 (improving co-ordination using shared model) is a significant factor because lack of co-ordination can result in poor design and conflicts in the design that would lead to rework, which means loss of man-hours spent, as well as, materials used. Additionally, access to updated information would be readily available through a shared BIM model. B_2 (avoiding rework by detecting clashes in design phase) is a significant factor because rework results in cost and time overruns. Since BIM uses parametric 3D model technology, it can detect clashes during design phase. B_3 (conflicts) is a significant factor since by using BIM designing and constructing a facility would be more efficient and information is available through shared model. As all information can be integrated into a single model so there is no or less ambiguity for a consultant, a contactor or a client and disputes can be easily tackled. B_5 (Insignificant - Improving design by constructing/deconstructing project digitally) is insignificant since number of factors considered for this study are few therefore this might be the main reason of insignificancy of this point, as well as, R square value. Its significance and value of R square might increase in future by adding more factors to the survey.

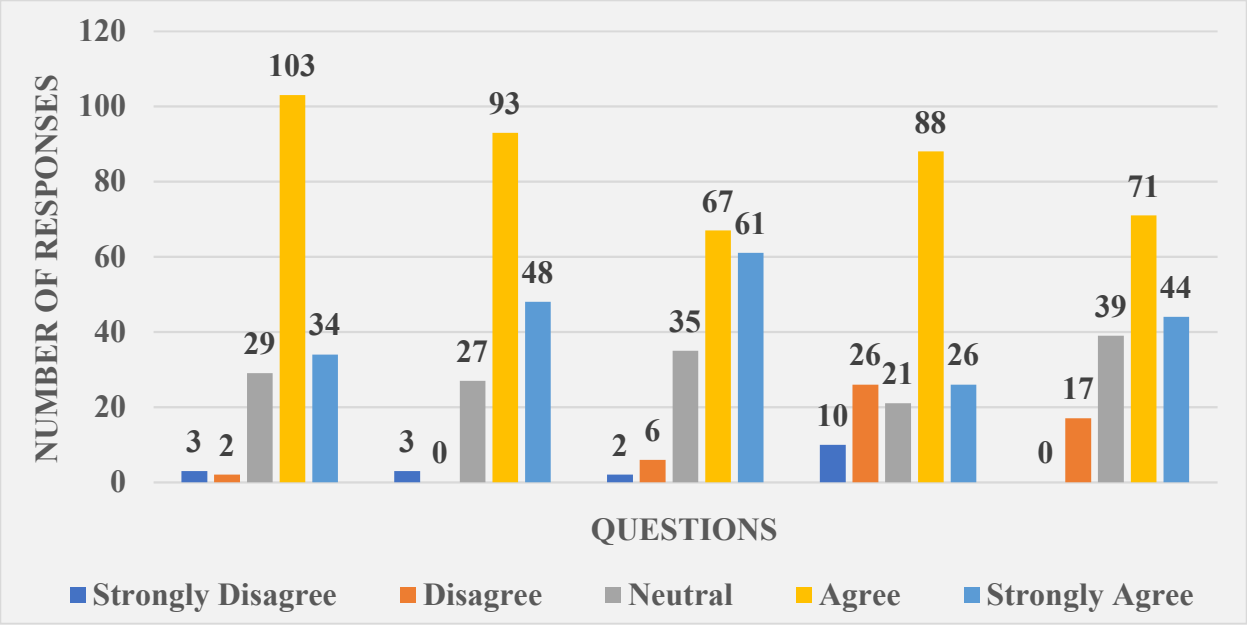

Figure 2: Survey Results

Figure 2 shows an overview of the responses of the respondents. It can be seen that a major portion of the responses show greater acceptance. Some respondents stayed neutral probably due to lack of information about the utility of BIM at the moment. However, a small portion of respondents did not agree that BIM can increase productivity in some cases as evident from the above responses. When asked whether BIM can improve design of a facility, a great number of respondents 103 (60%) agreed while only 3 respondents (2%) strongly disagreed to this statement. Similarly, 93 respondents (54%) agreed that collaboration can be improved by incorporating BIM in construction projects while 3 (2%) of them strongly disagreed. According to 67 (39%) respondents, clashes could be minimized with the help of BIM but 20% (35 respondents) stayed neutral and 6 of them (4%) disagreed. When enquired if productivity can be increased using 3D model instead of error prone 2D drawings, 88 respondents (51%) agreed while 26 of them (15%) disapproved. And finally, when respondents were queried about how utility of BIM can mitigate conflicts, a large portion agreed i.e. 42% (71 respondents) while 17 (10%) respondents disapproved.

Using a 3D model, ambiguity in the design can be minimized. In a case study carried out by Darius Migilinskasa (2013) accessibility to use single prepared 3D frame model for visualization and structure analysis, it saved almost 20% of time for inspecting and redrawing a 2D drawing with errors correction when deviations occur. The 3D model was used for approximation of the bill of quantities for the work packages, which made the negotiation procedure easier with subcontractors and contractors (Darius Migilinskasa *et al.,* 2013). The BIM 3D technology is very helpful throughout the design as a key tool for construction drawings & coordination during the project as it permits all the members of construction project to stay in touch with the design at once. Receiving the maximum aids from the BIM technology is directly associated to the ability to maximize collaboration in project. No matter who is leading, all key members have the access to a shared data base which in turn offers most benefits for the project team in terms of collaboration. It also empowers to classify clashes and disputes which in turn prevent reworks during the project (Popov *et al.,* 2010).

4. CONCLUSION:

The results of the survey show that a wider majority of practitioners of the construction industry of Pakistan believe that BIM has potential to improve productivity of the construction industry. Most of the respondents agree with potential strengths of BIM, such as, collaboration, elimination of rework and conflicts, to solve issues that can lead to loss of productivity. Collaboration among project participants is significant for productivity, which is also the prime objective of BIM. Furthermore, lack of rework due to clarity in scope of work in the design phase would yield better progress during execution phase of a project. Moreover, mitigation of conflicts because of co-ordination plays a significant in improving productivity.

REFERENCES:

Associated General Contractors of America. (2005). The Contractor's Guide to BIM, 1st ed. AGC Research Foundation, Las Vegas, NV.

Azhar, S., Nadeem, A., Mok, J. Y. N., and Leung, B. H. Y. (2008). "Building information modeling (BIM): A new paradigm for visual interactive modeling and simulation for construction projects." Proc., First International Conference on Construction in Dev.

David W. Halligan (1994), "Action-response model and loss of productivity in construction". Journal of Construction Engineering and Management, Vol. 120, No. 1, March, 1994.

Eastman, C; Teicholz, P.; Sacks, R; and Liston, K. (2008). BIM Handbook: A Guide to Building Information Modeling for Owners, Managers, Designers, Engineers and Contractors, John Wiley and Sons, NY, 2008.

Economic Survey of Pakistan (2018). Economic Survey of Pakistan. [online] Finance.gov.pk. Available at: http://www.finance.gov.pk/survey/chapter_10/01_Growth_and_Investment.pdf

Global Construction 2030 (2015). Global Construction 2030. Ice.org.uk. Available at: https://www.ice.org.uk/ICEDevelopmentWebPortal/media/Documents/News/ICE%20News/Global-Construction-press-release.pdf

Makulsawatudom, A and Emsley, M (2001) Factors affecting the productivity of the construction industry in Thailand: the project managers' perception. In: Akintoye, A (Ed.), 17th Annual ARCOM Conference, 5-7 September 2001, University of Salford. Association of Researchers in Construction Management, Vol. 1, 281-90.

Polta, G., and Arditi, P. 2005. The JIT Management System in developing countries" Construction Management and Economics, 23(7), 697-712.

Popov, V., Juocevicius, V., Migilinskas, D., Ustinovichius, L., Mikalauskas, S., 2010. The use of A Virtual Building design and Construction model for developing an effective Project concept in 5D environment. Automation in construction 19(3), pp. 357-367.

Rizwan, M., Shahzad, N., Sheikh, Q., Batool, S., Riaz, M. & Saddique, S. (2013) Variables that Have an Impact on Employee Satisfaction and Turnover Intention, International Journal of Research in Commerce, Economics and Management, 3(3), 131-13.