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Challenges and Issues Involved in Adopting Lean and Bim in Construction

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Abstract: ***Lean Construction techniques have been introduced as an alternative way for conventional construction process in 1990's.. It is described as a process of eliminating waste, increasing worth and value, and meeting or extraordinary client necessities and requirements. Waste reduction and customer value satisfaction are important factors to be considered in implementing construction projects. Building Information Modeling (BIM) is an intelligent model based process. BIM implementation seems to more advantageous in construction industry, for instance, it makes use of visualization technique of a product to facilitate architecture, engineering and construction professionals to effectively plan, design and manage infrastructure. Review of literature is administered and a survey is conducted to identify major issues involved in adopting Lean and BIM in construction sector. The present study depends mostly on the survey questionnaires from building professionals. Totally forty construction companies were selected for the questionnaire survey. The results obtained were analyzed in Statistical Package for Social Science (SPSS). The outcome of the study indicates that Lean and BIM implementation is necessary for allocation of resources, quality improvement and it enhances the sustainability of building and also it signifies that there is a shortage in lack of awareness, lack of framework and professionals.***

Index Terms: ***Lean Construction, Building Information Modeling, Construction Project Management, Relative Important Index (RII)***

I. INTRODUCTION

Lean Construction (Lean) and BIM (Building information Modeling), plays an important role in designing and documenting of various types of construction projects. Project stakeholders like designers, contractors and suppliers implement BIM as a platform for successful cooperation among diverse construction professionals. Recent research works shows that there are synergies between Lean and BIM, and this can improve construction project performance. Lean and BIM need a very good understanding of ideas and they should be inter-operateable. BIM facilitates customer value satisfaction by proper time management which aids the successful completion of the construction project.

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Various functionality of BIM and Lean are recognized and practiced by the industry, however, certain areas (post construction phases) need further investigation.Many researchers has paid attention on the application of BIM and Lean within the initial phase of construction and fewer studies focused on operation and maintenance stages in construction (Arayici & Aouad, 2010; Dave et.al. 2008; Ballard, 2000; Marhani et.al.

2013; Salem et.al.2006). A complete investigation is necessary to validate the BIM application in operation and maintenance sector to address lean principles and waste minimization which in turn augments the value to the customer.

A. Lean Construction

Lean Construction is the collaboration of operational research and practical improvement in design and construction with the implementation of lean principles. Lean Construction expands from the idea of a lean production system which minimizes waste and cost (Bardalai & Arunima, 2015). Lean construction is about management and improvement of construction method to deliver the product based upon customer desires by waste elimination in the construction flow which includes construction contract and condition between consumer and other parties.

B. Principles of Lean Construction

Identify Value: It specifies customer needs and values.
Value Stream Mapping: This enhances the performance potential during construction and also it tries to make out the stream that is required to build a product
Make value flow without interruption: This is done by reducing delays and defects in construction activity.
Pull: It spots out the requirement of a consumer in delivering the product.
Perfection: This is done by identifying and eliminating waste.

C. Building Information modeling (BIM)

Building Information Modeling (BIM) is a software solution which gives 3D and 4D visualization facility of a construction project. It is database management system to store all the data / information items related to the construction project. It facilitates visualization techniques otherwise known as parametric modelling, which helps designers to create a plan, take necessary corrective action, and eradicate errors at the initial stage of construction process (Lauri Koskela, et.al. 2009). BIM promotes the construction activity in an organized manner by giving access to the information collected, collaborating with the stakeholders and also transmitting the data through electronic medium.

It facilitates the issues raising during construction between the stakeholders in an amicable manner, enables easy tracking of building components and minimizes cost and time and thereby it paves the way for customer full satisfaction.

D. Challenges in implementation of Lean and BIM

The greatest challenge in implementing BIM and Lean construction is change of mindset of management and staff working in construction companies (Rischmoller and Alarcon, 2006). Lean and BIM defy the traditional concepts followed in construction by its pros. Special training in software, design and modeling is essential for a person to implement BIM in construction.

E. Objectives of the study

The main objectives of the present study are as follows:

1. To comprehend the implementation of BIM in construction industry
2. To evaluate the challenges and issues involved in executing lean and BIM in construction
3. To demonstrate the interaction between lean and BIM in the construction industry

II. METHODOLOGY

Qualitative and quantitative analysis of Questionnaire survey done in various construction companies have been analyzed in SPSS software and the results are presented.

A. Method of survey

A Questionnaire survey has been conducted to collect the information regarding lean and BIM interactions from construction professionals. The questionnaire comprises a set of 20 questions to explore the opinion of professionals in regard with the reduction of different types of waste in construction practices, sustainability concepts in construction, challenges and issues involved in the execution of lean and BIM in the construction.

B. Questionnaire design

The methodology flowchart is depicted in fig 1.

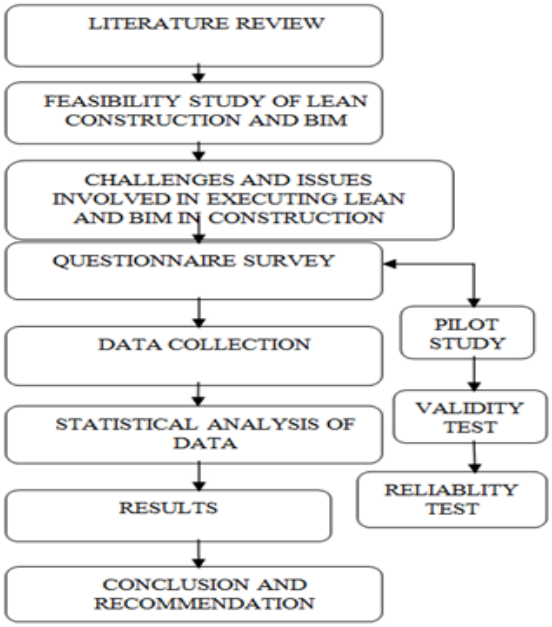

Fig 1. Methodology for challenges and issues in espousing Lean and BIM in construction.

The primary purpose of the survey lies in the identification of Lean and BIM professionals. The questionnaire consists of 20 close-ended questions to explore about the general details of the respondents including their experience, to examine the sources causing waste in construction, to identify various factors that affect the sustainability of building, to understand lean and BIM concept adopted in construction industry and also the issues faced during execution.

C. Method of Data analysis

The questionnaire survey was done. Totally forty respondents completed the survey successfully. Then, the response were analyzed in SPSS software and it is represented in the form of pie charts, bar charts and radar charts and a ranking was assigned 1 to 5 based on their score value or priorities. The Relativity Importance Index (RII) of the responses were calculated.

$$RII = \frac{\text{Mean value}}{\text{Max. Point on the likert scale.}}$$

If RII < 0.06 item, then it is termed as low rating.
RII ≤ 0.80 item, then it has high rating.
RII≥ 0.06, it is considered as high rating.
RII ≥ 0.80 item, then it has terribly high rating.

III. DATA ANALYSIS

Forty companies had an effective reply for the Questionnaire survey conducted. The Survey has been carried out to the professionals with different designations working in various organizations. Twelve of them were contractors,

sixteen were Engineers and ten were Project managers and remaining of them belongs to other disciplines. The results were analyzed with the help of SPSS tools (Statistical Package of Social Studies).

A. Service experience in the construction field:

From the questionnaire survey, the service experience of the respondents working in the construction field are shown in figure 2.

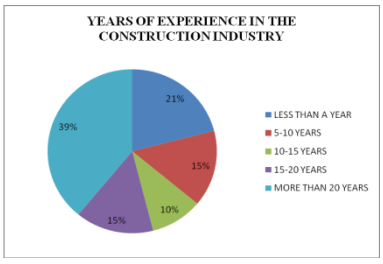

Fig 2. Service experience in the construction field

B. Professional experience in Lean Construction and BIM

From the questionnaire survey, the professional experience of the respondents in Lean construction and BIM are illustrated in fig 3.

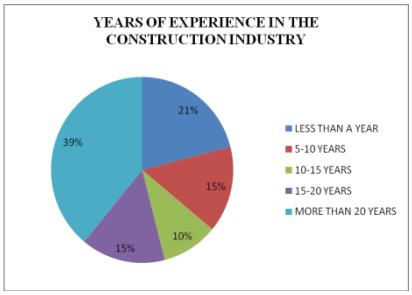

Fig 3. Professional experience in Lean Construction and BIM

C. Factors affecting resource utilization

Table 1 list down the factors that affect utilization. The results indicate that ineffective communication between different professionals; correction or defects and unnecessary movements of laborers and vehicles are the most affecting factors.

Table 1. Factors affecting resource utilization

Factors affecting resource consumption	Mean	RII
Ineffective communication	3.59	0.898
Correction or defects	3.47	0.867
Unnecessary movements of laborers and vehicles	3.30	0.825
Lack of management	3.22	0.83
Underutilization people	3.20	0.8
Transportation of material	3.15	0.787
Over production	2.84	0.71
Safety in workplace	2.71	0.677

D. Factors influencing resource efficiency

Table 2 shows the factors influencing resource efficiency.

Table 2. Factors influencing resource efficiency

Factors influencing resource efficiency	Mean	RII
Compatibility and communication between different professionals	4.33	0.866
Proper scheduling and planning	4.16	0.832
Review of the design impacts in the final product	4.01	0.802
Visualization of the final product	3.99	0.798
Virtual prototype and simulation	3.87	0.774
Safety in work place	3.78	0.756
Testing of final products	3.30	0.66

E. Reduction of waste

Table 3 and figure 4 illustrates the factors manipulating reduction of waste

Table 3. Factors manipulating reduction of waste

Factors manipulating reduction of waste	Mean	RII
Adopting new project management techniques	3.39	0.847
Knowledge sharing between employees on reduction of waste	3.35	0.837
Applying BIM tools and techniques	3.21	0.802
Increasing the awareness	3.1	0.775

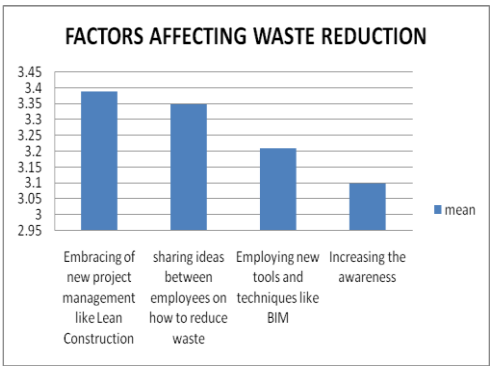

Fig 4. Factors manipulating waste reduction

F. Sustainability

Table 4 shows factors that influence energy, water and material conversion. Table 5 and table 6 depict factors that affect lifecycle design and humane design respectively. Figure 5 portrays the factors concerning sustainability.

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Table 4. Factors concerning Energy, Water and Material conversion

Factors concerning Energy, Water and Material conversion	Mean	RII
Building design	3.28	0.82
Construction materials	3.19	0.797
Scheduling and planning of a building	2.89	0.722
Visualization of a product	2.79	0.697
Work site arrangement	2.64	0.66
Conformity with codes and standards	2.58	0.645

Table 5. Factors life influencing cycle design

Factors influencing life cycle design	Mean	RII
Building design	3.39	0.847
Construction materials	3.21	0.802
Scheduling and planning of a building	3.13	0.782
Visualization of a product	3.06	0.765
Work site arrangement	2.59	0.647
Conformity with codes and standards	2.68	0.67

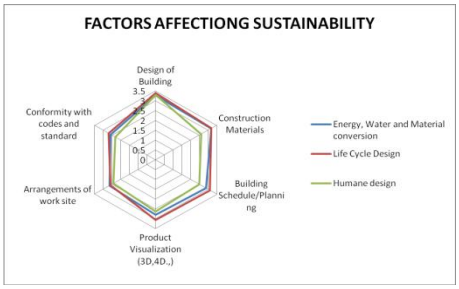

Fig 5. Factors affecting sustainability

Table 6. Factors manipulating humane design

Factors manipulating humane design	Mean	RII
Building design	3.3	0.825
Construction materials	2.62	0.655
Scheduling and planning of a building	2.5	0.625
Visualization of a product	2.63	0.657
Work site arrangement	2.41	0.602
Conformity with codes and standards	2.3	0.575

It is inferred from the table that building design and construction materials are considered to be the most important factor concerning sustainability of building.

G. Perception about Lean Construction and BIM

From figure 6, it is understood that BIM implementation is costly to apply, whereas Lean Construction implementation is easy to apply for the organizations who have already implemented BIM

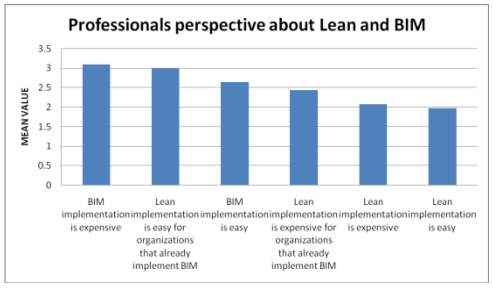

Fig 6. Professional perspective about Lean and BIM

H. Implementation of Lean and BIM

It is inferred from table 7 and figure 7 that construction industry culture seems to be the most difficult factor in implementing lean construction and BIM.

Table 7. Difficulty of Lean implementation with BIM

Difficulty of Lean implementation with BIM	Mean	RII
Construction industry culture	3.81	0.762
Time required for implement	3.1	0.62
New staff training and hire	2.84	0.568
Collaboration between construction professionals	2.64	0.528
Cost of implementation	2.31	0.462

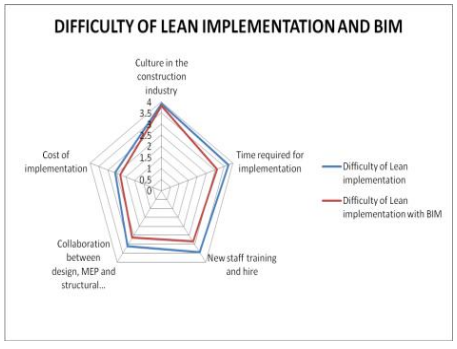

Fig 7. Difficulty of Lean implementation and BIM

I. BIM benefits

Table 8 portrays BIM benefits.

Table 8. BIM benefits

BIM benefits	Mean	RII
Facilitating the collaboration between various construction professionals	3.1	0.775
Implementation of final product visualization	2.96	0.737
Minimal time required to implement lean construction	2.77	0.692

J. The contribution effect of different sectors on Lean and BIM implementation

The different sectors on implementation of Lean and BIM is shown in figure 8.

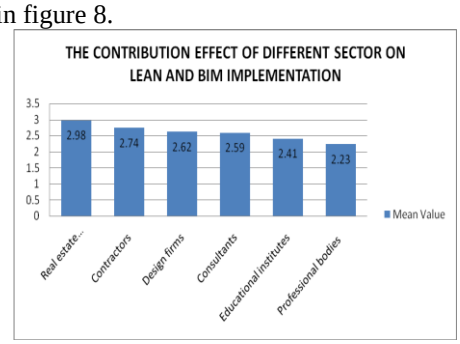

Fig 8. The contribution effect of different sectors on Lean and BIM implementation

K. Challenges in adopting Lean and BIM implementation

.From table 9 and figure 9 it is understood that attention should be given to need for construction management concepts in the industry.

Table 9. Challenges in adopting Lean and BIM implementation

Challenges in adopting Lean and BIM implementation	Mean	RII
Need for construction management concepts in the industry	3.7	0.74
Availability of professionals	3.56	0.712
Availability of legal framework	2.9	0.58
Awareness of Lean and BIM benefits in the construction industry	2.83	0.566
IT infrastructure investments	2.34	0.468

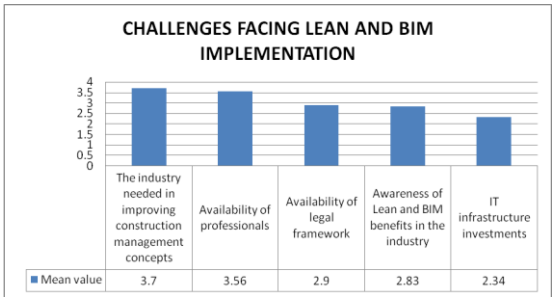

Fig 9. Challenges in adopting lean and BIM implementation

L. The effect of Lean and BIM on final product

Table 10 and figure 10 illustrates the effect of lean and BIM on final product.

Table 10. The effect of Lean and BIM on final product

The effect of Lean and BIM on final product	Mean	RII
Overall quality	3.7	0.74
Safety in the work place	3.56	0.712
Resources usage	2.9	0.58
Final product cost	2.83	0.566
Delivery time	2.34	0.468

Adopting Lean and BIM concept enables interoperability, client involvement in each and every construction activities, product visualization and review of design changes on the final product which help for proper project management and higher safety in the workplace. These factors directly lead to resource efficiency. The high level of visualization and prototyping enabled by Lean and BIM facilitates the design process and provides more control over their designs. It also helps in choosing proper construction materials and arrangement of work at sites which helps in achieving sustainability in construction.

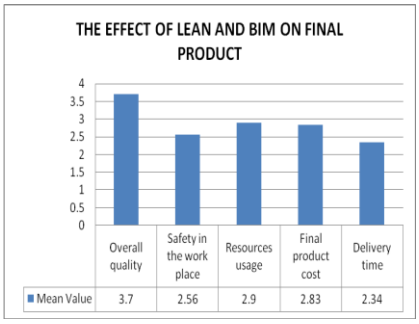

Fig 10. The Effect of Lean and BIM on final product

IV. CONCLUSION

The purpose of this research was to identify benefits and constraints in implementing Lean and BIM concepts in the construction industry. It is expensive to implement BIM in construction industry. It facilitates collaboration between various construction professionals. It enhances construction of 3D and 4D visual models for any specifications, able to store and examine data related to the construction project, facilitates knowledge sharing and also collaboration between b stakeholders. Lean and BIM helps in achieving higher resource optimization by waste reduction. It seems that there is a lack of knowledge in implementing Lean and BIM techniques. The awareness of Lean and BIM is still remains the major problem in the construction industry.

V. RECOMMENDATIONS

The main facet of lean that need to be incorporated are those pertaining to decrease in unevenness of production, production cycle and also recommended to invest in BIM according requirements of the organization. Awareness regarding lean and BIM should be magnified among the construction professionals about the importance of introducing new concepts within the industry. To enable cooperation between all the construction professionals, a new forms of legal framework and contracts should be implemented.

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