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BIM with Lean principle Assist to Increase Product Efficiency and Waste Reduction in Cambodia

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ABSTRACT: *The rise of Construction industry has been increasing so high during this few years. As the technology getting more and more modern a lot of building are being build included small house, villa and skyline. However Construction industry have low increase in efficiency rate over this few decade. There's a lot of construction waste due to improper design, lack of management system. Lean Construction and (BIM) Building information Modelling both have been study that will provide efficiency rates and reduce construction waste. Both BIM and Lean construction are two individual concepts which applied independent they are not consistent however both of them are provide benefit to construction. Lean construction is divert Lean manufactory concept which is a method that focus to minimizing waste and maximizing productivity where BIM is software for developed modelling building the concept of BIM has existed since 1970 however because of that time early application and the computer hardware needed to run BIM were expensive and not powerful like now away that the reason which limited widespread adoption. This thesis study is purpose to use BIM technology with the assisted of Lean construction Principle technique together to improve the efficiency and reduce waste in a better way than apply them individually just like the use of both arm to increase strength rather than use only one arm. This study will prove they both can apply together because of the synergy that is possible due to the overlapping benefits in applying in both Lean Construction and BIM with both technique collaboration leads to a more integrated process in construction that in turn yields higher efficiency rates.*

KEYWORDS: *Building information, Lean construction, just in time, Total Quality Control, Total Productivity maintenance*

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I. INTRODUCTION

Construction projects normally involve with multiple individual organizations as working simultaneously on heavy crowded sites, they suffer from waste that is present in hold back and delay time for labor, rework, crew, unneeded movement of handling of construction materials, unutilized inventories space of materials, etc. .. . .To achieving best work flow with minimal waste requires not only proper construction planning, but also productive product management.According to a survey conducted by Government Statistical Service in 1998 in United Kingdom (UK), the construction industry produces over 70 million tons of waste, which is about four times the rate of household waste production produced by every person in the UK every week (Keys et.al, 2000).

Many improper order affect the design process that in turn affects the wastes emerging and the resultant opportunities for designing out waste. Such issues include materials choosing, complexity, Team communication and Team coordination. With the increased of competition in construction industrial, the shortage of skilled worker and the need to improve construction quality, there is an urgent demand to increase productivity, quality, and included new technologies to the AEC industry (Koskela, 1992).

The idea that lean principles are applied to construction has led to the development of planning and control systems and other practice improvements. With the lean construction paradigm, construction industry is being viewed as an industry with the possibilities of implementing these new lean perspectives of production concepts in the construction processes to optimize the overall construction performance on construction stage as well as design stage. A BIM is a digital rendering of physical model of building. BIM is used to build an accurate virtual model of a building before its actual construction. BIM building information modeling not only helps

reduce thiswaste and reduce inefficiency but also helps in reducing the potential for litigation (Chuck Eastman, 2009). Therefore, BIM helps improve the lean outcomes of any company/project on the Lean Journey (Sacks et al., 2010).Both Lean and BIM are independent they both can work separately though this study will try to emerge Lean principle to assist BIM technology to improve more efficiency than apply alone.

II. INTERACTION OF BIM AND LEAN

1. BIM as a waste reduction and increase efficiency

As we're all know that the upgrade from 2D drawings to 3D digital models is well advancing and gaining a lot of benefit in the architectural, engineering, and construction industries. With the accurate on the early design state will provide a lot of benefit on later on.

BIM technology integrates and uses available social resources at utmost, which increase efficiency and control ability of building design. And it helps architects realize theory of sustainable design and green building design. Besides it owns special priority on complex shape modeling and modifying, which also brought more possible choice for building design. Compared with the traditional design, BIM technology has advanced philosophy and huge advantages, such as follows:

*Parameterized design*Simplex 2D design (nodes-lines surfaces model) is replaced by elements design of buildings like walls, doors, windows, girders and columns etc.

*Correlations design of elements*it is attached to parameterized design. Change of parameters of elements will make the parameters of other related elements in the whole building model changed correlatively, which will solve the information loss among design drawings.

*More Dimensions*in BIMVirtual digital 3D parametric information model - nowadays accepted by designers as a natural upgrade from 2D design. BIM 4D upgrade from 3D model by provide one more function with project scheduling to create a simulation for construction activity. BIM 4D model help with risk identification and mitigation by stimulate more planning detail identify issues allow project team to resolved.
The BIM 4D visual construction simulations provide more detail and communication between project team.
BIM 5D upgrade from 4D by adding more addition function with cost estimation to model to generate accurate program data for the project.This is particularly useful for monthly cost reports and budgets.The use of BIM 5D technology can lead to higher accuracy and project estimates, changes in scope, changes in materials, equipment and human resources. BIM 5D provides a method to extract and analyze costs, evaluating options and impacts of change. Benefit Integrating BIM and 5D CAD simulation models can develop more efficient, cost-effective and sustainable buildings.5D is a five-dimensional way to display the physical and functional aspects of any project. With the development of BIM technology, we can find 5D information sharing and complete cooperation. BMI follows the cost of adding elements with 4D to the existing time management and information sharing construction component diagram. BIM 6D is upgrade from 5D by adding optimizing energy consumption in sort mean BIM Sustainability.6D-BIM (Sixth Dimension Building Information Model) is helpful for energy consumption analysis.Using 6D-BIM technology can produce a more complete and accurate energy estimate early in the design process. It also allows measurement and verification during building occupancy, as well as improving the process of gathering lessons learned in high-performance facilities. Advantages: Integrating BIM with 6D CAD simulation models can reduce energy consumption.
BIM 7D provide full life cycle management also known as BIM facility management7D-BIM (Seventh Dimension Building Information Model) is operated and maintained by managers throughout the entire of project life cycle.The use of 7D-BIM technology can make parts replacement easier and faster, optimizing Regulatory and simplify asset lifecycle management over time.7D BIM provides a process for managing subcontractor/supplier data and facility components throughout the facility life cycle.

*Analysis of concept designs*BIM model is a tool which changes in a thorough the conceptual phase of design and design optimize which structural design is suitable for architect ideas with traditional method the cost is expensive and consume more timeNowadays, a 3D model rendering by architect can be fairly easily and quickly converted to the analytical model that structural engineer can analysis and calculation. In a few simple steps structural engineer can obtain the stresses, force or deflections and proceed with detailed checking of code requirements.

*Distributed models*Designers can't finish all the design work by BIM, individual design model, construction model and construction progress (the fourth dimension) needs to be done by design institutes and construction companies. Those distributed models can be combined by data base and then BIM can form a virtue construction model and inspect the mistakes, neglects, pipeline collisions and scarcity of building design。

*Cooperative design*by non-collision and cooperative style, designers co-work under one platform that gets information exchanged normalized and assure of smooth of information exchange inside the system. From this point of view, cooperation isn't simplex drawings reference any more but a cooperative design under this

uniform platform involved several majors and professions. In conclusion, BIM can save design time and reduce lead-time range. Through integrated data base, it affords better interactive cooperation, prevents mistakes happening, increases qualities of drawings and cut the design cost. Then, it will bring new profits and business opportunities

*Visualization*allows generation of 3D renderings in-house with very little effort. This is very important for visualization of the project. The early CAD technology brought people from the computer drawing of the flip board to turn the drawings into 2D visual electronic documents, which can be said to be a upgrade. However, for the performance of hidden places, and the lack of 3D drawing graphics, CAD can only show the plane dimensions of points, lines and planes in terms of visualization. The visual design based on BIM can bring architects and designers into a wider space. After joining the Y axis, the plan drawings are converted into 3D models. In addition, many of the previous imagination of the space is not enough, through BIM technology It can be achieved, which satisfies the imagination of the architect more, and for the lack of 2D expressiveness and omissions earlier, the BIM visualization model can allow designers to improve accuracy and work efficiency, and provide better project quality. Imagine that BIM visual design can be realized, such as shadowed 3D views, photorealistic renderings, and animation roaming. These design visualization methods can effectively represent 3D designs, reuse these data, and avoid re-use in visualization applications. The time and cost of creating a model and adding structural analysis or energy analysis applications.

*Conflict, Interference and Collision detection*another powerful feature of BIM visualization is the collision check function. This is difficult to achieve in traditional CAD systems. In the past, in order to check the conflict points in the project, countless designers worked hard to compare, and check thousands of drawings for a project day and night, and finally made a lot of mistakes. The BIM visualization feature can greatly reduce the occurrence of such problems. After the model is built using software based on BIM technology, mold clamping can be performed. During this process, collision check can be performed on the models between various professions, because the model is 3D, so this work is also based on 3D. The data model included in the BIM model allows the BIM system to intelligently identify the attributes of any component in the project, allows the software to intelligently apply some engineering rules, check the rationality of the entire project, and help us find the design before the project is constructed The mistakes in the drawings are considered wrong. Through BIM visualized collision inspection, software collisions and hard collisions can be checked between various professions and professions in the building, and BIM software can also automatically generate inspection reports, through which the designer can check defects and omissions in the design. The construction party can take the construction basis in turn. This project can greatly reduce design changes, construction rework, and reduce waste of costs.

*Cost estimation*BIM software can be used for accurate detailed estimating. They have built in cost estimating features, which helps in updating the material quantity whenever any changes are made to the model. In many studies, the use of BIM is mentioned to contribute to improve cost savings, reduced time consumption, and improve collaboration (Hartmann et al. 2008). The total Costs obtained via traditional method and BIM method share close similarities with real project construction cost

2. BIM application

Visualization BIM allows generation of 3D renderings in-house with very little effort. This is very important for visualization of the project. The early CAD technology brought people from the computer drawing of the flip board to turn the drawings into 2D visual electronic documents, which can be said to be a upgrade. However, for the performance of hidden places, and the lack of 3D drawing graphics, CAD can only show the plane dimensions of points, lines and planes in terms of visualization. The visual design based on BIM can bring architects and designers into a wider space. After joining the Y axis, the plan drawings are converted into 3D models. In addition, many of the previous imagination of the space is not enough, through BIM technology It can be achieved, which satisfies the imagination of the architect more, and for the lack of 2D expressiveness and omissions earlier, the BIM visualization model can allow designers to improve accuracy and work efficiency, and provide better project quality. Imagine that BIM visual design can be realized, such as shadowed 3D views, photorealistic renderings, and animation roaming. These design visualization methods can effectively represent 3D designs, reuse these data, and avoid re-use in visualization applications. The time and cost of creating a model and adding structural analysis or energy analysis applications.

*Fabrication/Shop Drawings*For various building systems, the shop drawings can be very easily generated as soon as the model is complete. Example: shop drawings of sheet metal ductwork

*Code Reviews*Fire departments and other official unites to review the building projects for safety and better results use the BIM drawings.

*Forensic Analysis*Potential failures can be graphically generated illustrated using BIM. Example, water leaks, evacuation plans

*Cost Estimating*BIM software can be used for accurate detailed estimating. They have built in cost estimating features, which helps in updating the material quantity whenever any changes are made to the model. In many studies, the use of BIM is mentioned to contribute to improve cost savings, reduced time consumption, and improve collaboration (Hartmann et al. 2008). The total Costs obtained via traditional method and BIM method share close similarities with real project construction cost. The results show that both the traditional method and the BIM method can help achieve cost control during the construction phase, although there may be differences in the results, such as excessive use of concrete due to improper construction (PengAlex, Changxin 2014).*Conflict, Interference and Collision detection*aAnother powerful feature of BIM visualization is the collision check function. This is difficult to achieve in traditional CAD systems. In the past, in order to check the conflict points in the project, countless designers worked hard to compare, and check thousands of drawings for a project day and night, and finally made a lot of mistakes. The BIM visualization feature can greatly reduce the occurrence of such problems. After the model is built using software based on BIM technology, mold clamping can be performed. During this process, collision check can be performed on the models between various professions, because the model is 3D, so this work is also based on 3D. The data model included in the BIM model allows the BIM system to intelligently identify the attributes of any component in the project, allows the software to intelligently apply some engineering rules, check the rationality of the entire project, and help us find the design before the project is constructed The mistakes in the drawings are considered wrong. Through BIM visualized collision inspection, software collisions and hard collisions can be checked between various professions and professions in the building, and BIM software can also automatically generate inspection reports, through which the designer can check defects and omissions in the design. The construction party can take the construction basis in turn. This project can greatly reduce design changes, construction rework, and reduce waste of costs.

3. *Lean construction tools*

Lean construction is extended from lean production. Lean production is produced by flowing products and fixed people, and construction is produced by fixed products and flowing people.

Lean construction refers to the transformation and application of "lean thinking" in the construction industry, completely eliminating waste and uncertainty in the construction process, satisfying customers' requirements to the utmost, thereby maximizing the profits of construction enterprises.

Lean construction is extended from lean production. Lean production is produced by flowing products and fixed people, and construction is produced by fixed products and flowing people.

Lean construction Technology Center defines leanconstruction as: a comprehensive production management theory, construction management theory and the particularity of construction production, facing the full life cycle of construction products, continuously reduce and eliminate waste, and maximize the system to meet customer requirements nature approach. Compared with traditional construction management theories, lean construction emphasizes the full life cycle of building products, continuously reduces and eliminates waste, and takes full satisfaction of customer needs as the ultimate goal. Below are lean technique to reduce waste:

*Just in Time (JIT)***:**The intention of JIT is when needed, only produce in the required quantity, production and sales are synchronized. In other words, production is carried out at the speed of sales, so that the balance of logistics can be maintained, and any premature or too late production will cause losses. In the past, Toyota used the "kanban" system to pull, and with the information system supplemented by the ERP or MRP information system, it was easier to achieve material pull outside the enterprise.

Any activity that adds budget cost without adding value is defined as waste. It could be due to unnecessary moving of materials, the mass build up too much inventory, or the use of malfunction production methods that create products requiring later need to rework. The JIT concept can help increase profits and return on investment by reducing inventory quantities, improving product quality, reducing variability, reducing delivery lead times, shortening production time, and reducing other costs (such as costs related to machine settings and equipment failures) (Koskela , 1992). Traditionally, manufacturers predict the future demand for their products and smooth production to meet the expected demand. In order to improve production efficiency, they try to keep everyone as busy as possible. This resulted in a large amount of inventory, prolonged production time, shortened production time, increased defect rate, and failed to meet the delivery schedule, and (ironically) high costs. These could have been avoided if "just in time" (JIT) manufacturing was adopted.

In a Just in Time condition, the flow of goods is controlled by a pull system. It is a concept where each process is produce Each component is consistent with another department to build a final part to the exact expectation of delivery from the customer. The pull System uses Kanban Methods, The Kanban Method is a means to design, manage, and improve flow systems for knowledge work. The method also allows company to start with their existing workflow and drive development change. They can achieve this by visualizing the workflow, limiting WIP (work in progress), and stopping the stop starting and start finishing. The Kanban

method is named after using Kanban, which is a visual signal mechanism used to control the ongoing work of intangible work products. It is described as a visual aid to indicate that you have completed a process or need to do more work (Schonberger, 1984). The purpose of seeking visual help is to make people who get help from work or provide you with work quickly realize your needs.

*Total Quality Control (TQC)*It emphasizes that quality is produced rather than obtaining through inspected, and the final quality is guaranteed by the quality control during production. The inspection and control of quality in the production process are carried out in each process. Focus on cultivating the quality awareness of each employee, pay attention to quality detection and control during each process, and ensure that quality problems are found in a timely manner. If quality problems are found in the production process, production can be stopped immediately according to the situation until the problem is solved, So as to ensure that there is no invalid processing of unqualified products.For the quality problems that occur, the relevant technical and production personnel are generally organized as a group to work together and solve them as soon as possible.

*Total Productive Maintenance (TPM)*Total productive maintenance is the autonomous maintenance to maximize production output by maintaining ideal operating conditions of production machinery by Divide multi-skilled operators into small groups (Nakajima, 1988). (TPM) Total production and maintenance labor can maximize production output by maintaining ideal operating conditions, Train production workers to perform routine maintenance tasks on a regular basis, while engineers and technicians handle more specialized tasks based on their capabilities. The scope of TPM production and maintenance comprehensive plan includes preventive maintenance by designing or selecting equipment that is easy to maintain for equipment improvement, preventive maintenance, and anticipate maintenance (determining when to replace the part or component before they fail or can't be use anymore).

*Employee Involvement*is extremely important for functioning of any company. Rapid response to problems requires empowerment of workers. Continuous improvement is heavily dependent on day-to-day observation and motivation of the workforce, hence the idea of quality circles is in order to avoid waste associated with the division of labor multi skill or self-directed team have to been established for production project and customer based production. (Kano andLillrank, 1989).

*Continue Improvement*is to keep and improve the working standards through small, gradual improvements. It's a never-ending process. The inherent wastes in the process are targeted all the time for continuous improvement. A continuous improvement strategy involves everyone from the very bottom to the very top, the basic premise being that small regular improvements lead to a significant positive improvement over time.The main goal of the continuous improvements is to affect the mindset as well as achieve the improvements of the techniques. In this case, everyone help assist and receives training in the appropriate skills; responsible for their own efforts, areas and progress of their teams and employees will continuously suggest improvements to meet quality, cost and delivery target improvements. The key idea of continuous improvement is to continue and improve working standards by gradually improving (Koskela, 1992).

*Time based competition*is the process of compressing time throughout the organization for the competitive benefit is known as time based competition. This is the generalize form of just in time philosophy (JIT philosophy), which is well known by the pioneers of JIT. According to TaiichiOhno, reducing of lead-time provide a lot benefits such as reduce in the work not related to processing, a reduce in the inventory store, and ease of problem identification. Time based competition has become popular, especially in management and information work where the Just in Time concepts sound unfamiliar. (stalk and Hout, et.al, 1989), (Robinson, 1991)

*Concurrent Engineering*During the design and development of the product, the concept design, structural design, process design, final requirements, etc. are combined to ensure the completion of the required quality at the fastest speed. Each work is completed by the project team related to this. In the process, the team members arrange their own work, but they can feedback information regularly or at any time and coordinate and solve the problems that arise. According to the appropriate information system tools, feedback and coordination of the entire project. Using modern CIM (Computer-integrated manufacturing) technology, during the research and development of products, it assists the parallelization of the project process.

*Value based strategy (or management)*is refers to "conceptualized and clearly connect value as the basis for competing. Compared with competitor-oriented companies, value-based strategy-driven companies are customer-oriented. Continuous improvement to increase customer value is one of the basic characteristics of value-based management (Carothers and Adams 1991).

*Visual Management*is an orientation towards visual control in production, quality and workplace organization is what visual management is about (Grief, 1991). This is one of the original ideas of "just in time", the goal is to provide the standard to be applied, and anyone can immediately identify the deviation from the standard. The core principle of visual management is the ability to understand that, with a quick look at the shop

floor what orders are being done, if the production is ahead, on par or behind and what needs to be done next. No orders are missed or lost and everyone knows if they are behind or ahead on the day's production. Shop floor staff will take more self-managing responsibility with this method as day-today decisions are handled on the shop floor. Visual management has been systematically applied only recently in the west.

*Re-engineering*mention to the total organization of processes and tasks, especially with respect to implementation of information technology. According to Hammer (1990), recognizing and update from obsoleted rules and fundamental assumptions are the key issue in re-engineering (Hammer, 1990).

4. BIN with Lean together for better outcome

Two developments, Lean Construction and Building Information Modeling (BIM), have been introduced, which have shown improvements in building efficiency, respectively. Both BIM and Lean are used to reduce waste and increase product efficiency. Below are literature of BIM and Lean merge together

(Arayici et al., 2011). In a study, the results of BIM implementation techniques using lean construction practices showed that the design of BIM should consider the elimination of waste and value creation (lean principles) to implement the system from the bottom up.

(*Hamdi&Leite, 2012*) The maturity of BIM provides different levels of enhanced efficiency for lean construction.

Sacks (2010) Lean Construction having an objective to create flow of the tasks with BIM resources can be allocated in a way that is planned for a flow to keep going without resources being over or under used

(Mattsson&Rodny, 2013) When BIM application is used together with collaborative planning then the effectiveness in eliminating non value task is possible

(Sacks, et al., 2009) BIM supports changes in design and production brought about by lean

Figure 1 BIM with Lean assist to get better outcome

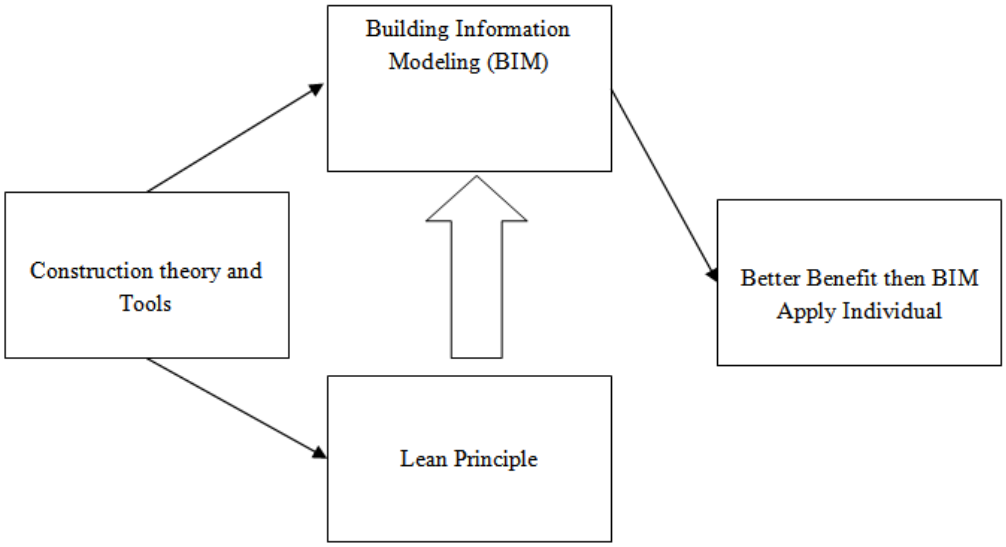


Table 1Intersection of Lean and BIM application

Application BIM intersect with Lean	JIT	TQC	TPM	Employee Involvement	Continuous Improvement	Time based Competition	Concurrent Engineering	Value Based Strategy	Visual Management	Re-engineering
Visualization	√	√		√	√	√	√	√	√	
Fabrication/Shop Drawings	√	√				√		√		√
Code Reviews								√		
Forensic Analysis		√			√			√		
Cost Estimating		√			√		√	√		

Construction EngineeringSequencing	√	√	√		√	√	√	√	√	
Conflict, Interference and Collision detection		√		√	√			√		

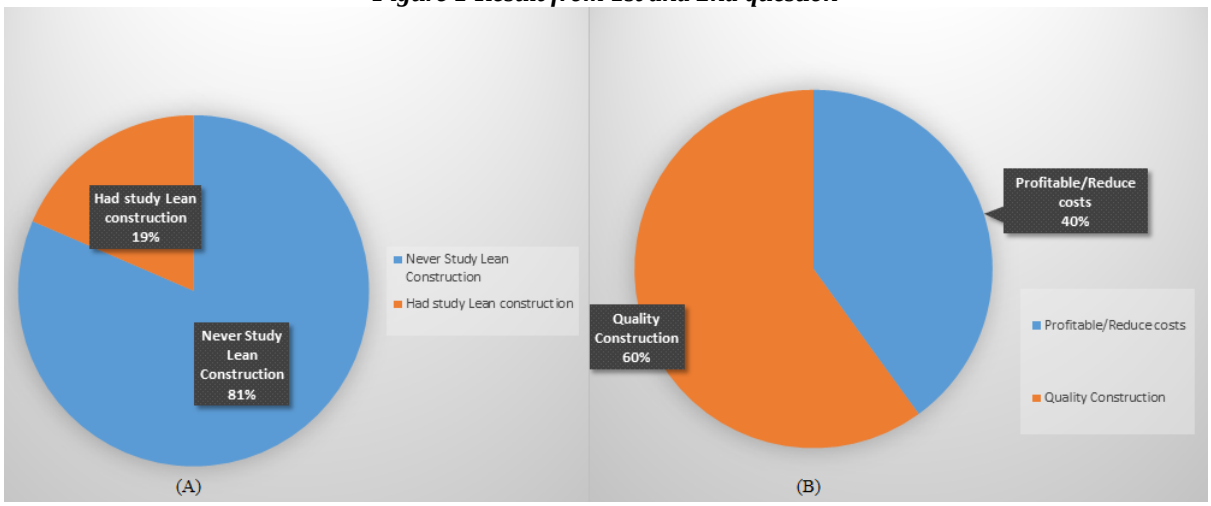
III. RESEARCH METHODOLOGY

This thesis is part of a comprehensive study of building information models with the help of BIM, and aims to prove that lean is a process that helps BIM. The main purpose of this study is to prove whether BIM assisted by lean principles can improve product efficiency and reduce waste.

1. Research Questionnaire: Drawing Conclusions from survey which target with people that have knowledge related to construction field.

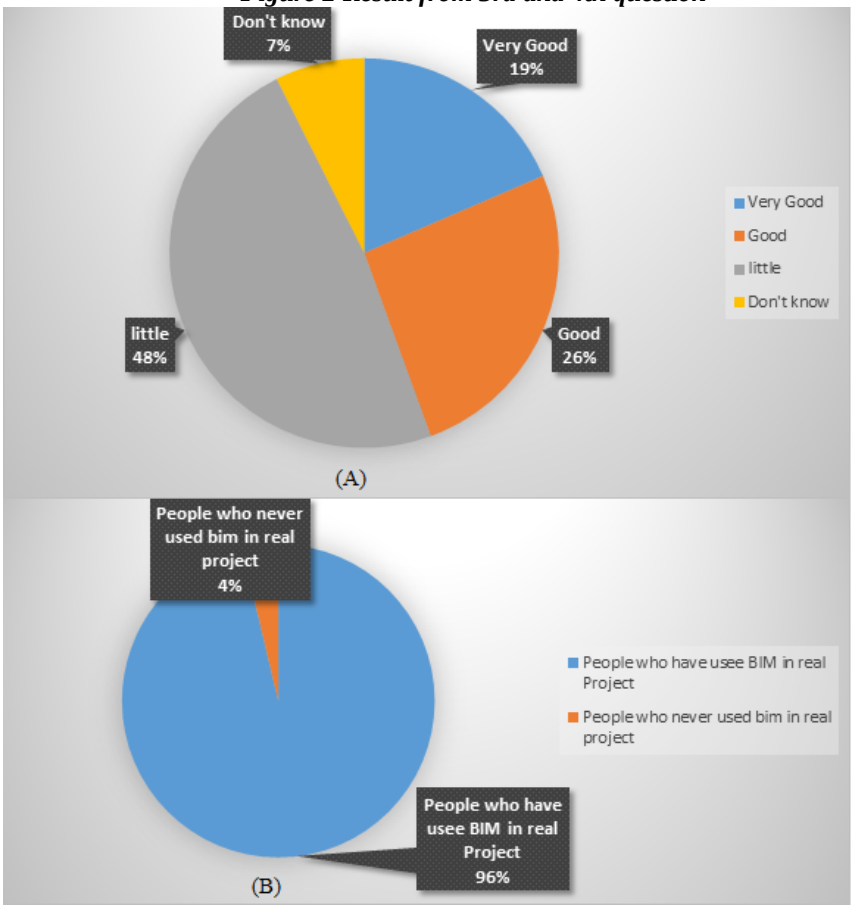
This research method purpose is to study research intended to document the current status of adoption and use of building information modelling (BIM) in the Cambodia construction industry. This study is a soft research paper survey which was send to 30 people whose currently working with construction industrial include site engineer, structure design engineer, sub-contractor and architecture. The respond rate was 90% of the total firms included in the survey which may be explained that the majority of current construction practitioners know little or nothing about BIM.

Figure 1 Result from 1st and 2nd question



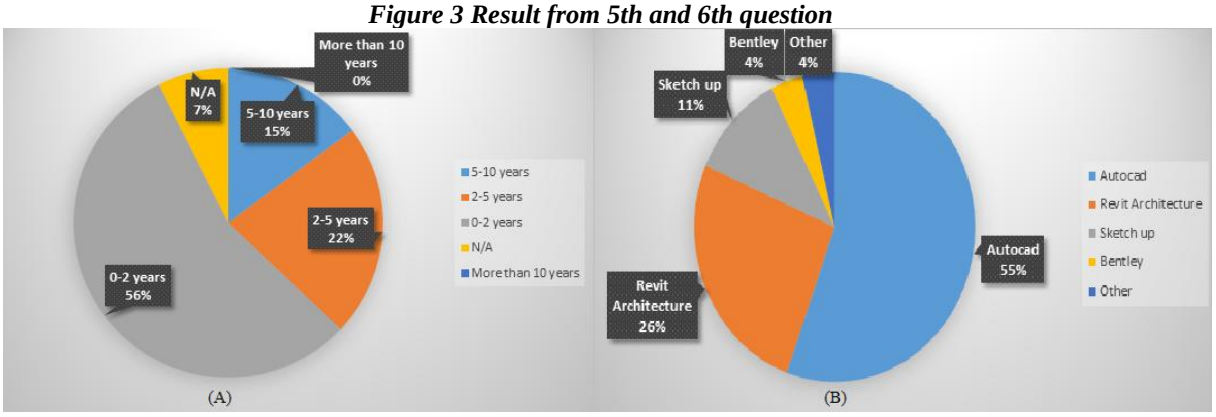
According to Figure (A) Survey responses 5 of 27 people who had study Lean construction. Most of them are online self-study and some were taught by their company and revealed that the majority of surveyed practitioners still have sufficient level of knowledge about Lean while BIM on other hand are getting more and more popular due to it benefit and superior over traditional design. Half of these practitioners have a BIM experience less than two years and two people never practice BIM before. Figure (B) following the question what is the most important benefit of using Lean in your projects? The answer were 60% said to increase quality construction and 40% said provide profitable and reduce cost.Total quality control (TQC) technology is applied to their projects to improve overall performance by inspecting raw materials and production, such as extending quality control from production to all departments from workers to management, and extending the concept of quality to cover all operations in the factory. The company. Using just-in-time technology (JIT), purchase materials and produce units only to meet the actual needs of the project to prevent unnecessary material movement and the accumulation of excess inventory, thereby increasing profits and return on investment, reducing excessive inventory.

Figure 2 Result from 3rd and 4th question



According to the graph (A) which following the question how do you rate your knowledge and skill in BIM? As the result 48% were have little knowledge, 26% good skill in BIM, 19% very good skill and 7% don't have BIM skill. For graph (B) the following question were ask have you ever used BIM as a tool for your projects. The answer that recieved were 96% have used BIM in real project while 4% never apply BIM in real project.

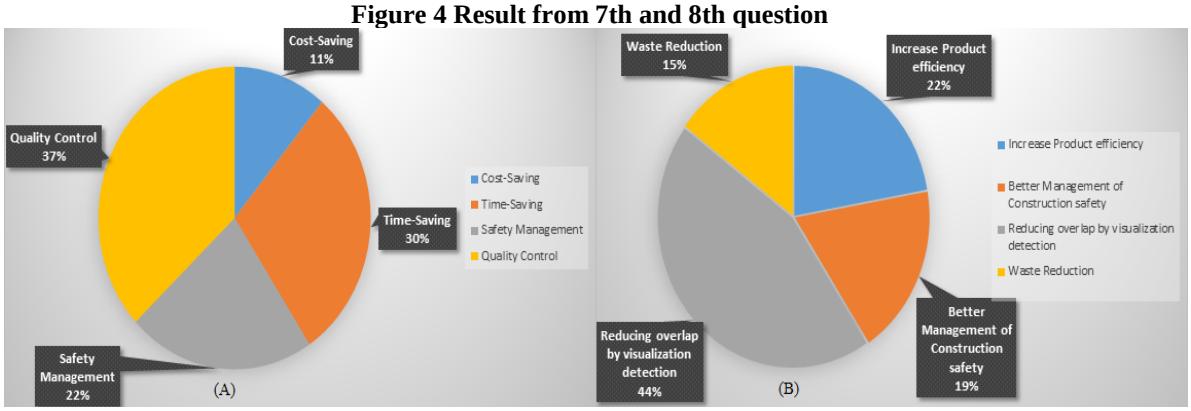
Figure 3 Result from 5th and 6th question



According to the graph (A) which following the questionHow Many years are you experience with BIM? And (B) question What BIM tools have you been used more in your project? The (A) result 56% were 0-2 years, 22% were 2-5years, 15% were 5-10 years and 0% more than 10 years' experience since BIM is still new especially in developing country like Cambodia, as for graph (B) Autodesk product are very popular in Cambodia 81% of practitioner using Autodesk product which AutoCAD and Revit .Most of the project in Cambodia are small house such as villa and flat those of the majority of construction design in Cambodia still

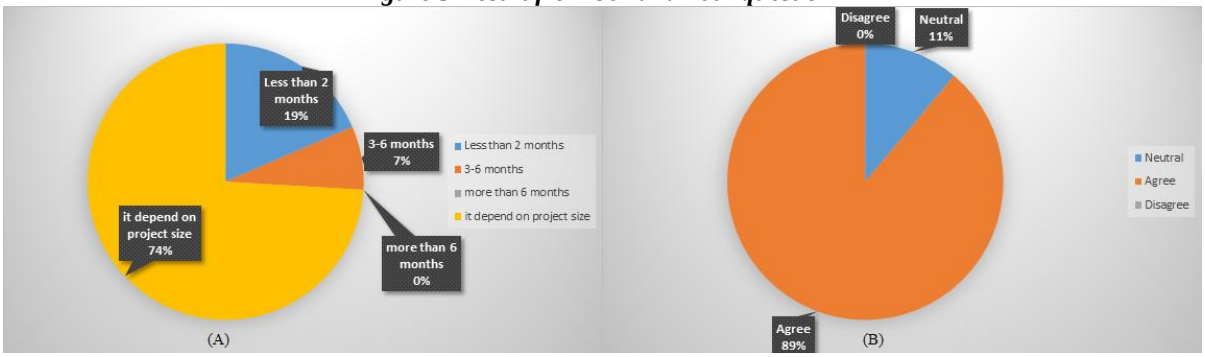
use traditional 2D method some of house design have no proper calculation which only use by knowledge of contractor by working experience only big project like condominium are using BIM technology, though BIM need more advertising and one more problem is computer spec. But since computer spare part are getting cheaper and more BIM course were taught in university the amount of people that use BIM will be increase dramatically. The government's pace on BIM is incorrect and does not promote the use of BIM in public work. The adoption of BIM in government projects will encourage contractors and suppliers to continue to use BIM.

Figure 4 Result from 7th and 8th question



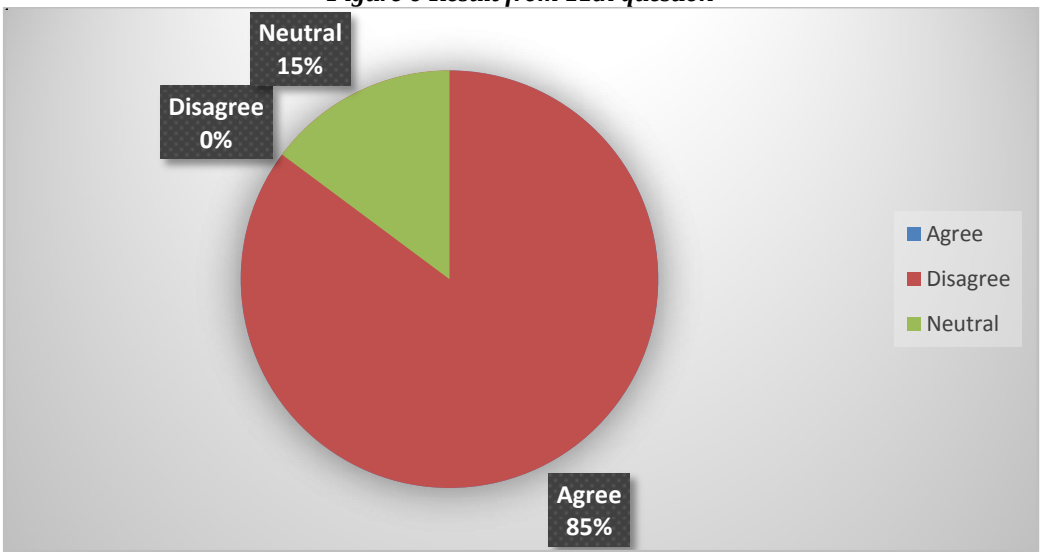
According to the graph (A) which following the question What is the most important benefit of using BIM in your projects And The (A) result 37% were Quality Control, 30% Time-Saving, 22% were safety Management and 11% were Cost Saving. Graph (B) question what is the most important experience you have got so far by implementation of BIM in your Projects? 44% were reducing overlap by visualization detection, 22% increase production efficiency and 15% were waste reduction. With BIM 3D can detect repeated duplicate clashes, soft and hard clashes clearance and visual inspection.

Figure 5 Result from 9th and 10th question



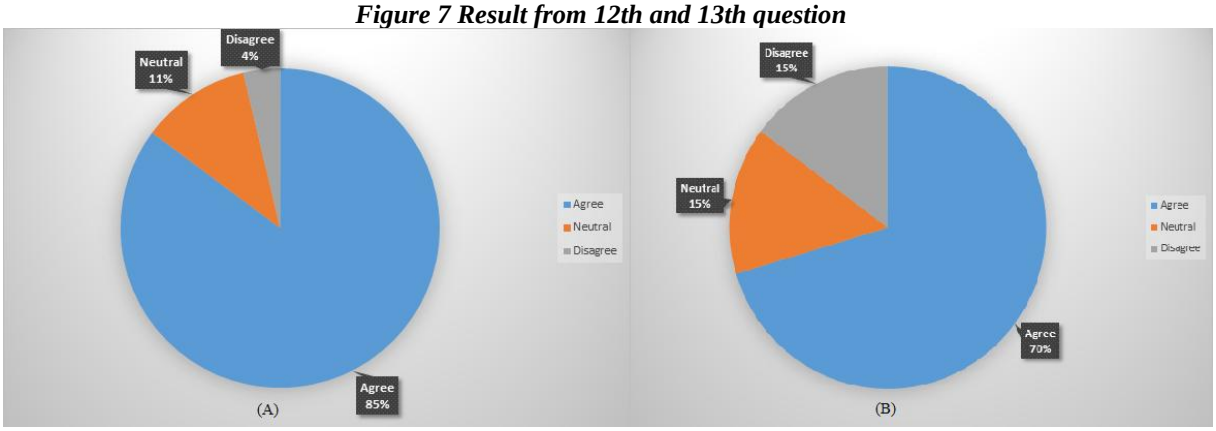
According to the graph (A) which following the question how much time does it take you to implement BIM in your Project? And (B) question is creating BIM model helped you better understanding architectural system (wall, floor, and roof….etc.)? The result from graph (A) 74% said it depend on project size, 19% less than 2 months, 7% 3-6 months and 0% were more than 6 months. From graph (B) 89% agree than BIM model helped better understanding architectural system (wall, floor, and roof….etc.)

Figure 6 Result from 11th question



The following question were ask in 11th question is creating BIM MEP model helped you better understanding MEP system (Duct. Plumping, wire, air terminal…..etc.)? According to the graph 85% agree that creating BIM MEP model helped you better understanding MEP system (Duct. Plumping, wire, air terminal…..etc. Since BIM helps better co-ordination all the elements are color-coded such as MEP wire water pipe and hence better clarity.

Figure 7 Result from 12th and 13th question



According to the graph (A) by rendering 3D model in BIM, you gained better understanding of your project? And (B) question is Using BIM is saving cost had economic justification for your project? According the graph result 85% agreeby rendering 3D model in BIM, will gained better understanding of project. And Graph (B) 70% were agree Using BIM is saving cost had economic justification for project.

2. Focus interviews: analysis results obtained by interviewing different expert in the AEC industry with BIM experience.

The purpose of this section is to identify those people who are used BIM and conduct a detailed interview to get their perspective on BIM with Lean principle apply as increase product efficiency and a waste reduction tool based on their experience and identifying benefits. A total of 9 people were interviewed.

Table 2 Interviewers Target

Interviewers Target	Number of people Interview
Engineers	3
BIM Specialists	2
Architecture	2
Construction Manager	1
Project Owner	1

As result will break down below

Table 3 Type of Waste reduce during interview

Type of Waste reduce	Engineers	BIM Specialists	Architecture	Construction Manager	Project Owner
Correction (or defects) waste	√	√	√	√	√
Inventory waste	√	√		√	
Motion waste	√			√	
Over (Excess Processing waste)	√		√	√	√
Over production waste	√	√		√	
Transportation waste	√			√	
Un-utilized potential				√	
Waiting time	√	√	√	√	√

Table 4 Lean technique that were apply during interview

Lean technique that were apply	Engineers	BIM Specialists	Architecture	Construction Manager	Project Owner
Just in Time (JIT)	√			√	√
Total Quality Control (TQC)	√			√	
Total Productive Maintenance (TPM)	√			√	
Employee Involvement	√			√	√
Continue Improvement	√	√	√	√	√
Time based competition	√			√	√
Concurrent Engineering	√	√	√		
Value based strategy		√	√		
Visual Management	√		√	√	√
Re-engineer	√	√	√	√	

IV. CONCLUSION

In this paper from the above methods are adopted, it was realized that BIM with assist of Lean helps in reducing waste and improve product efficiency. The research questionnaire, and interviews were conductedwith BIM experienced of AEC professionals;all of them provide evident that BIM helps reduce waste in the construction industry. The first method was research questionnaire. This method aim to study research and intended to document the current status of adoption and use of building information modelling (BIM) in the Cambodia construction industry as the result Most of the project in Cambodia are small house such as villa and flat those of the majority of construction design in Cambodia still use traditional 2D method and minority are use BIM on tall building. However as the country are in developing stats there will be many skyline to build in the future as now there are a lot of high rise project such as condominium and apartment. Most of this project are BIM implement this will lead to the development of BIM In the future. The second method is Focus Interview 9 of people who familiar with BIM were interview the aim are to provide evident that BIM help reduce waste. Lean is a process that was adopted by the manufacturingindustry to reduce waste in the processes the attempt to apply Lean to construction industry have been success which adopted Lean construction. The full potential are not achieved due to nature of construction project which is different from manufacturing. How BIM can overcome this problem by achieve and support during early process with better visual, better model information, and Conflict, Interference and Collision detection. This were apply during pre-construction stage that mean will lead to provide better benefit since collision is eliminated. Now with the nature of construction project has been overcome by BIM which mean lean can be apply together assist with BIM and the result both of them apply together will provide better benefit.

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