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Construction of Management and Sustainable Construction in the Engineering by Building Information Modeling

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Abstract Management projects that had been so far didn't work like it and were new project of its kind are one of the problems that were faced by managers then, available information about these project very low and implementation of them have high risk because management about process project have been any conception. For this reason, most of these projects have been done by trial and error, because there was no ability to planning for problems that will be happened. Project simulation and virtual three-dimensional model before starting the project greatly helps to project managers to organize it. New method of design and performance of building on the other hand based on resource efficient and ecological principles have been always considered by civil engineers, architectures and construction engineers. Any evolution of technology in the 21st century have been acquired by advances in computer science. In fact Building Information Modeling (BIM) is a multi-dimensional simulation model of the building geometry, geographic information, quantities and properties of building components and intelligent communication with each other. This technology is a new approach in the design, implementation and management of building with high quality and coordination simultaneously. In addition of introduce the technology of building information modeling (BIM) in this paper by two questionnaires were prepared for professionals and then analyzing the results of its application in project management and the achievement of sustainable construction has been investigated to the simulation of construction projects.

Keywords Building Information Modeling, Engineering and construction management, Sustainable design, Planning and project control

1. Introduction

1.1. Expresses Concern

Complexities and changes in construction projects were inseparable components and these changes and complexities were not related only to the design phase, often has been seen in the construction phase especially in fast projects due to the interaction of design and construction. Thus, in the complicated projects successful management of design for quality wok in the on time and with assigned budget is important. Building information modeling (BIM) is a process development and use of a simulation model of planning, design, construction and operation of the building that it is a set of rich data and information of all part of building during its life cycle and intelligent communication all member with each other, so that by making change in a small member of these set all other member compatible with them. Therefore this technology has been used for decision-making in order to improve the construction and operation. The energy crisis of the past few decades on the other hand, this is lead to engineers and architects thought about replacement for fossil fuel to protect the environment. And it has been appeared in the using of solar energy; building walls' insulation, using double-paned windows, re-use of rainwater, green roofs. Sustainable architecture is a type of design which, has been designed needs of the present without compromised resources of future generations. These designed requirements are energy needs, heating and cooling, lighting and equipment of buildings. According to growing the use of new technology in the design and construction with three-dimensional model of BIM which have been offered models to predict energy consumption, greenhouse gases CO_2, use of daylight, use of water, natural ventilation and other analytically models and it is very effective In the process of achieving a sustainable building. After the introduction of BIM Building Information Modeling technology and its software in this study application of BIM phase have been showed with examples and also by prepared questionnaires after talks with several members of the Association and the Institute of the questionnaire through the

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site Linked in members in America Society of Civil Engineers (ASCE), Society of Engineers and Construction Management America (CMAA) and Architects Association of America (AIA), and the companies that were used in the work of the BIM, received the document on energy and environmental design (LEED).

2. The Study

2.1. Introduction to Building Information Modeling (BIM)

Building information modeling (BIM) is a process of development and using of a simulation model of planning, design, construction and operation of building which, it is a set of rich data and information of all part of building during its life cycle and intelligent communication all members with each other. Thus, by making change in a small member of these set all other member compatible with them. Therefore, this technology has been used for decision-making in order to improve the construction and operation. Saving the important data of the manufacturing process with all its components is a difference BIM with a three-dimensional CAD model. This information will be consist of such as material properties (weight, color, size, degree of fire resistance, etc.), assembly and installation instruction, product warranty, maintenance requirements, information of parts and price. In other words, BIM is a three-dimensional CAD that connected to the database and operated as share resource information between the design team and construction. Sometimes BIM designed just for visualized and analyzed the safety and maintenance of the project building. The BIM process of designing and building a model in the BIM consist of intelligent components that represent the windows and doors, ceilings, beams, stairs, air conditioning, wiring, etc. these components known both their relation and other. Thus, it is not necessary to search several plan maps, sections, facades for information about a specific component such as window size, glass, and frame. Just enough referred to the component directly. This component saved all information about itself and compliance with the new design by any changed in its properties. In addition to created intelligent communication between different design parts, BIM have been given to study various scenarios for all groups virtually. One scenario, for example according to various aspects of solar radiation could rotate the model structure and the changed in its energy consumption. Other group designs as well as including structures and facilities by applying the changes to the model also be able seen the effects of these scenarios in the architectural project. Finally, contractors during the design and development of model building can experience such as a sequence of implementation, performance, production and installation virtually.

2.2. The Benefits of Using BIM Technology

Most of the projects in the world have been implementation with this technology which, confirmed the benefits of using BIM technology. We mention some of the benefits of BIM.

2.2.1. Saving Time for Project Implementation

There are all stages of preparation and implementation of a project with exact time in the BIM and that is to be ready martial before specified time to used it and the sequence of operations that made saved the time of project. Because of the general visualization project starting to work on the other hand, executive engineer can already specified the location for the installation of lifts, cranes, materials depot location and predicted operation of the mobilization the manufacture to can run this without spent time.

2.2.2. Cost Saving Project

The project has been availed as three-dimensional when implemented based on BIM, on the other hand BIM identified all part of projects that overlapped and warning to removal it. If, For example an installation channel placed in the path of beam structural, recognized it and declared. And this is will be avoided duplication of construction and cost savings. Also BIM provided very accurate estimate of the project's materials that prevented the bought surplus and shortage of materials and in turn saving costs.

2.2.3. Increase Safety in Construction

Implementation of location of all project details are specified in the BIM thus, official site could identify locations and high-risk areas in the workshop and think about overcome the risk as well as identified the location of evacuation and exit during emergency and warned to workers. Executive's project with this technology could examine materials and equipment that needed for project in term of safety and replace it if necessary. Project simulation model is very closed to reality so; it can be used for worker training and told them safety points in the different places.

2.2.4. Loss Claims

Outbreaks of claim construction a project have always been integral part and occur almost in all projects. Complexity, the long duration of the project implementation and different interpretation of the parties be caused claim.

Having three-dimensional model of the project before implementation to parties rule all matters out about complexity and speed extra time and different interpretation of work. Therefor this strategy reduces the incidence of the claim in the assignment process and project management. Project risks' raised one another of incidence of claims in projects on the other hand, that in spite of availability of a simulation project with all detail and specified blind spot

during the implementation reduced the possibility of risk between the parties and thus controlled outbreaks of claim.

2.2.5. Done Quality

Because of Intelligent of all members in BIM and Error reduction in manpower, prevented interference in the running of different parts, increasing labor and work safety, there is a possibility to make changes in the architecture of the project and customer view and test various hypotheses and finally according to its needs can be defined the project models and thus provided a quality product.

2.3. Limitations of Using BIM Technology

2.3.1. Costs Software and Hardware

Purchase costs of BIM software package much more than the two-dimensional CAD model and hardware requirements are more costly similarity. Almost CAD applications on all laptops applicable now, but according to the complexity and heavy Rendering which done with BIM software, have been required special computers with highly functional.

2.3.2. Training Costs of People

Necessary training should be given to relate people about to work new system and have been justified made Investment. BIM must be trained to all who connected with architectural and structural design and mechanical and electrical to have appropriate control over completion of the construction process.

2.3.3. Cost of Employing Professionals and Specialist

Specialists that should be presented to the implementation of project who are dominate the software, know how to implement it throughout the project life cycle that BIM Manage are the main responsible and consist three team included Design Director, Structural Engineer and Project Architect. In each project number of BIM team variable depend on project and small or big. These people can be involved in the project at least 3 and up to 12.

2.4. Applications of BIM in Construction Management

2.4.1. Visualization Design

Interchange of design decisions with team members and employer has been one of the most obvious uses of BIM both for developers and for contractors. Ultimate visualization of the project on two-dimensional drawings and specifications were difficult for many. The three-dimensional BIM model thus, in addition showed the completed project as a virtual, capability to exchange Array of information systems, as well products and material used in its construction. BIM on the other hand allows to simulate various scenarios have been run or construction and offered analysis of different alternatives to the project team.

Finally BMI have been improved dramatically due to correlation between BMI with capabilities Stereoscopic Projection and visualization project, For example you can obtain more realistic understanding from the inside building when moved virtually.

2.4.2. Review the Stages of Construction and Assist to the Planning

One of the important benefits of BIM is that allow to contractor and its team before the operation analyzed and tested various methods and instruments required. This is made disclosure of the potential problems timely that implementation process will be a great challenged if it's late discovered. Contractor will be subject with the designer after the detected of an administrative problem to will be done about improvement of plane. This review on the other hand leads to confirm the standards of quality and safety evaluation of construction.

2.4.3. Planning of Mobilization

One of the critical issues related to the management of the project site is a planning of mobilization which will have been a significant impact on the overall success of the project. The project manager and the contractor with used of BIM could make depiction about study aids available and prepositional, access routes, evacuation in case of danger and safety issues, excavation and piling planning, location of crane, emplacement of martial depot, how to collect surface water and number of scenarios has been considered for that and if one of them approved, the results informed to whom involved in project and if necessary neighbors by contradictory.

2.4.4. Schedule and Sequence of Construction Operations

One of the most important issues in the construction management process is a construction planning and scheduling.

These efforts have been continued and monitored continuously for that the project did not get out of the right route. By adding scheduled data to three-dimensional structural information the fourth dimension that it is a time added it. Forth dimensional model help to those who are involved in the project can be visualized schedule and found out practically correct sequence of manufacturing operations how effective is the success of the project. Four-dimensional schedule a useful tool for staging, coordination and exchange operations planning with sub-contractor, designers, employers and other stakeholders of the project. Set schedule planning with BIM would improvements in the sequence of construction and Project Procurement Management.

2.4.5. The Estimated Cost of Construction

One feature of BIM that is each component defined contains information about the length, width and height, and anything else that is necessary for a quantitative estimation of the project. Therefore, with extract materials and components of model linked quantitative data with financial estimates programs we can have been got a precise estimate

of the cost of the project.

Plan and its quantitative estimation are so interdependent that effects of a financial and quantity visible to all those involved in the project at the moment with smallest change in design practices. With help of BIM thus, possibility of advanced plan from the cost of the project and eventually bankrupt are unlikely.

2.4.6. Information Integration of Sub-contradictors and Suppliers

Among the sub-contractors and suppliers of materials it is common that they created their own BIM model. These models have more details than the models created by the main contractors and contain information that it not available to the main contractor. The information including product specifications, details of construction and installation method. Finally, this model for the complete review coordination and systems analysis with exact detail has capable Integrated with the main contractor. Saving time and cost of early integrating is very much.

2.4.7. Coordination between Systems

Ability to detect collision or interference with structural components is one of the important features of BIM.

This feature is similar to the spell checker the text editor software.

Property of collision detection, identification, observation and reporting of interactions between different components and systems makes possible in the three-dimensional model.

Passing a beam structure of channels and pipe installation by BIM is an example of this report. With this feature, any interference between components, installations and structures together or in the architecture have been identified in the BIM model before manufactory.

Many reports of contractor have been registered regard to identification of the interactions before running. It is clearly that identified the interfered components before started construction operations will be made to saving of time and cost. The dramatic decline of RFI (request information and correspondence between the contractor and designer due to problems during implementation plans) to about 80% is one of it tangible results.

2.4.8. Implementation and Operational Planning Workshop

BIM information in order to determine the location of materials and systems in the workshop is applicable after the coordination of the whole project. Information of BIM model transferable to the surveying equipment directly.

2.4.9. Prefabricated

One of the benefits of BIM might have been provided many opportunities to improve the construction operation management are a high potential for application of pre-fabricated. Having a coordinate BIM model will be done isolate, analyze and optimize every part of the project. That is the contractor can used prefabricated techniques to deliver various sectors especially for reruns. Pre-fabricated obviously corresponded to high quality and cost less.

2.4.10. Operation and Maintenance

The response ability concept to the project "from the cradle to the grave" is a one of the more graceful of using BIM which included operation and maintenance after finished project.

Since BIM model during construction, will be updated continuously thus, the model delivered to the engineer who responsible for the operation and maintenance of equipment will be As Built drawings finally. In addition, all information about products, materials and systems installed in the project were related to the manual used directly which used by its charge.

2.5. Process Analysis Growing the Use of BIM

2.5.1. Research

First after talking with several members of the Association and the Institute of American Society of Civil Engineers (ASCE) and the Construction Management Association of America (CMAA) have been prepared a questionnaire consisting of 13 questions (Appendix 1) which proposed the amount of use, costs, and benefits of the BIM in project management and through the Linked in site were available for member of Engineers and Construction Management that they used BIM and then review role of technology in achieving successful project management.

49 responses were received from the 65 people who were given the questionnaire which among them 41 people using BIM in their projects management that their responses were received and analyzed.

2.5.2. Analysis of Results

Respondents were asked about the number of projects that use of BIM where 17.07% in less than 30% of the projects, 14.63% between 30-50% of the projects, 36.59% between 50-70% of the project, between 70-100%, 14.63% and 17.07% of the respondents have used BIM in all their projects and were mostly used in architectural design, structural design, project visualization, marketing, Avoid a collision of structural and non-structural facilities and planning consequently. (Figure 1)

About cost of implementation of BIM projects 65.85% of respondents said that the using BIM on project costs less than 2% of the total cost of the project. And 9.51% of them have spent of the total cost of the project cost between 2 to 3% for implement BIM in their projects. The next two questions were about the benefits of BIM technology and important experience the implementation of BIM in their projects were the most benefit that mention by them were quality control, completion of project timely, safety management and cost savings and most experience of people from the using of BIM were reduce the control impact of structural and

non-structural in three-dimensional model, finished of maintenance during the operation phase of the project. project on time, good safety management and easier

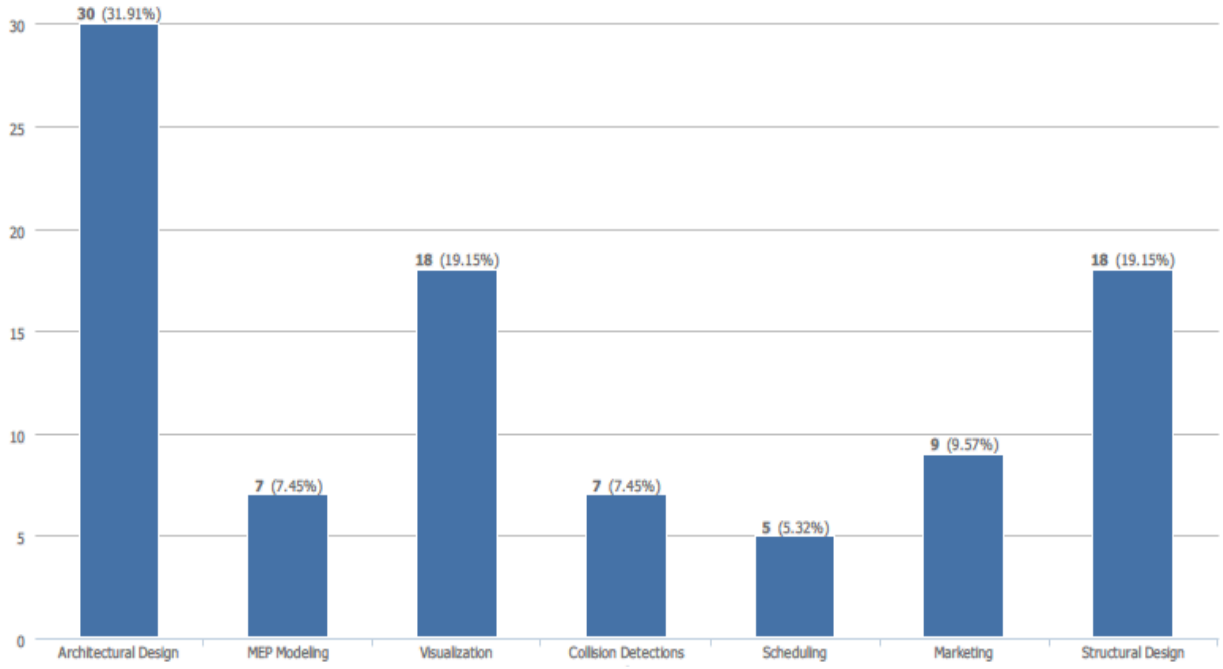


Figure 1.

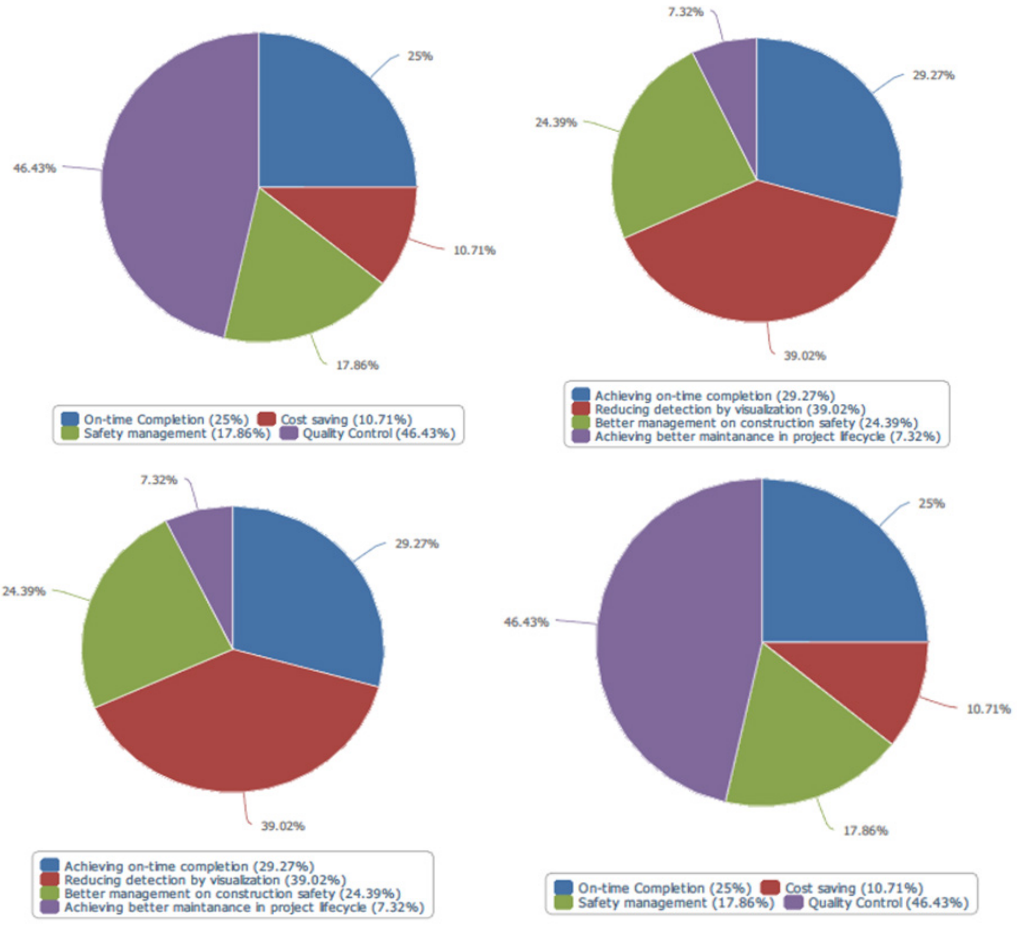


Figure 2.

In the next section of the questionnaire was designed 5 questions were respondents said their opinions in favor, against and abstentions. These questions are all about the benefits of using BIM in project management. The first question about was whether the BIM have helped you better understand the architectural design of the project (walls, roofs, floors)? That 78.05% agreed. 82.93% of the respondents with BIM were able to have a better understanding of the system of building installations. And 87.8% of them believed that have better understanding of all aspects with three dimensional BIM projects are.

BIM to 92.68% of the people helped in the safety management in their workplaces; finally, 75.61% of people have underestimate costs in the use of BIM against the saving on the project.

2.6. Conclusions

One of the goals of the complex projects worldwide is of projects good management to finish the projects based on high quality, budge in the certain time. Adoption of building information modeling on projects not only will be beneficial to the employer economically according to research this studies , but also allows to project managers compared their own projects different models of design and implementation and then chosen the best and made best decision in the critical and part of project. By BIM managers also have the ability before the start of the project have been seen a virtual mode fully and measure the hidden angles and also because the simulation model changing according to the design team, project managers therefore can monitored the progress of projects step by step and finally provided quality project.

3. Building Information Modeling and Sustainable Development

3.1. Introduction

In the past few decades energy crisis have been made to engineers and architects thought to find a replacement for fossil fuels in order to protect the environment. This thought have been appeared to use of solar energy, insulate the walls of buildings, using double- paned windows, re-use of rainwater, green roofs.

A kind of design is sustainable architecture that has designed the needs of the present without compromising the next generation.

These requirements include energy, heating and cooling, lighting and equipment. Due to the growing use of new technologies in the design and construction in the three-dimensional BIM model were simulates the d design, construction and operation of a project fully as well as models to predict energy consumption, greenhouse gases CO2, use of daylight, use of water, natural ventilation and other prepared analytic model is very effective in achieving a sustainable building.

3.2. Using BIM and Got Standards LEED

Leadership in Energy and Environmental Design (LEED) is a green building certification system is recognized internationally which have been developed by the United States Green Building Council in March 2006 and building owners and operators familiar and offers with a framework for identifying and implementing practical and measurable green building, construction and operations and maintenance solutions. LEED advanced sustainable building and developed the techniques through a series of graded systems were identified those project have been implemented strategies for better environmental and health. Many LEED standard regulations in sustainable design need to calculate the surfaces, volumes, costs of construction activities and requirement materials. Preparation of materials including the use of recycled materials, reuse of materials, use of local materials and the cost of the materials and each have several parts. All activities calculated and analyzed in BIM software. Because of all the components connected to the database structure in the BIM every small component included all specification (profile) about itself and the impact of each type of material have been evident in cost, time and performance in all buildings intelligently.

This technology also gives designers ability to see their simulation model for energy saving and the use of daylight in all directions rotated and energy consumption in different scenarios and analyzed the effect of insulating double-glazed windows in all parts of the building.

3.3. Study of the Importance and Benefits of BIM for Sustainable Construction

3.3.1. Research

Consultation with a member of the Architects Association of America (AIA) in this study were prepared a questionnaire consisting of 12 questions (Appendix 1) which discussed the amount of use, costs, and benefits of using BIM in sustainable architecture. And through the Linked in site were available for member of Engineers architects of America and companies which was used in BIM to receive credit on energy and environmental design (LEED) to Review the role of technology in achieving sustainable architecture.

37 responses were received and analyzed from the 50 people who were given the questionnaire.

3.3.2. Analysis of Result (Appendix 2)

What percentage use of BIM in the first question to be asked in their project that 21.62% of respondents in all your projects of BIM used have less than 30% of the projects, 18.92% between 30 and 50%, 35.14% between 50 and 70%, 16.22% between 70 and 100% and 11.8% that most use of BIM in selecting the proper materials and sustainable architecture, energy consumption analysis, design optimization and the use of daylight consequently. 0.27% of

the participants believed that cost of implementation of BIM has been equivalent of less than 2% of the total project cost and over 90% of these people were able to made balance between the cost of implementing BIM and its ability to achieve environmental standards. What extent they have been able to earn points for LEED standards with using of BIM in opinions of respondents were 24.32%, up 10 points, 20 points to 43.24%, 27.03% was answered and 5.41% of the respondents have earned in their projects earn LEED points to 40 point.

In the next section 7 questions were designed that respondents said their opinions in favor, against or abstained. These questions were all about the benefits of BIM for sustainable design. The first question is about easy access to tools in BIM for an immediate feedback to the original design and corrected it that 91.28% of respondents agreed. 86.42% of respondents believe that any design and view and schedule connected to the database directly and the whole project will be changed when it is changed. And 83.78% of the respondents agreed about if the use of BIM for Sustainable Design and LEED standard business gives them requirement information. To determine the reuse of materials and use of recycled material can be used from the obtained model directly in Building Information Modeling that at 86.49% of people agree.

The next question was about marketing project if three-dimensional model BIM can convince customers that the project was done with green design and sustainable? 70.27% of them agreed the displayed three-dimensional has helped them.

83.78% were able to study various design options in single model using of BIM simultaneously. 94.59% respondent believe that BIM allowed designed team to review the most sophisticated models using day lighting accordance with standards in the projects. Statistics and figures finally show that how users of these technologies have been able to enjoy the benefits in order to achieve sustainable architecture?

4. Conclusions

One of the major objectives of the project have gained the required standard of LEED points to build its projects based on the environment and natural resources and according to the studies in this paper 20 points are attainable by using BIM LEED in the project. Sustainability are available in BIM quickly and with low cost and allow to designed team compared the different model and chosen the best sustainable design. The largest feature of this technology also is that the project employer could alternated the customer with a virtual model of the project before making the project and customer selected and saw the projects according to green design too. Also because the simulation model changing according to the design team slightly therefore ate end of the project the model is As-built model which would be very useful during the operation.

Appendix

Appendix 1. Survey Questionnaire

1. Have you ever used BIM as a tool for your projects?

☐ Yes ☐ No

2. What BIM tools have been used more in yoyr projects?

☐ Revit Architecture ☐ Revit Structure ☐ Revit MEP

☐ Bently BIM ☐ Site Planning

3. What is the most common use of BIM in your projects?

☐ Architectural Design ☐ MEP Modeling ☐ Visualization ☐ Collision Detections

☐ Scheduling ☐ Marketing ☐ Structural Design

4. What is the most important benefit of using BIM in your projects?

☐ On-time Completion ☐ Cost saving ☐ Safety management ☐ Quality Control

5. What is the most important experience you have got so far by implementation of BIM in your projects?

- Achieving on-time completion
- Reducing detection by visualization
- Better management on construction safety
- Achieving better maintanance in project lifecycle

6. The approximate costs expended for implementation of BIM in your projects is ... percent.

- More than 5
- 3 - 5
- 2 - 3
- less than 2

7. How much time does it take you to implement BIM in your projects?

- Less than 2 mont
- Between 2 - 6 month
- More than 6 month
- It depend on project's heaviness

8. You use BIM in ... percent of your projects

- Less than 30
- 30 - 50
- 50 - 70
- 70 - 100
- 100

9. Creating BIM models helped you to better understand architectural systems.(wall, floor, roof, etc)

- Agree
- Disagree
- Neutral

10. Creating BIM models (MEP) helped you to better understand MEP systems. (air terminals, duct, plumping, etc

- Agree
- Disagree
- Neutral

11. By 3D modelling in BIM, you gained better understanding of you project.

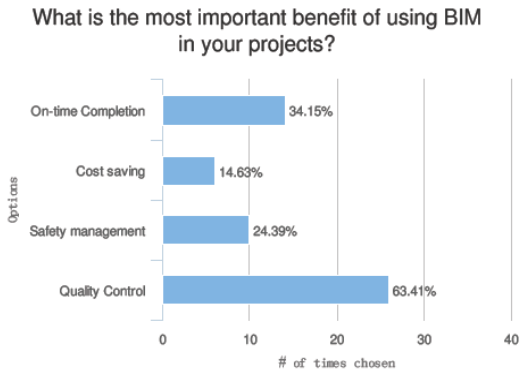
- Agree
- Disagree
- Neutral

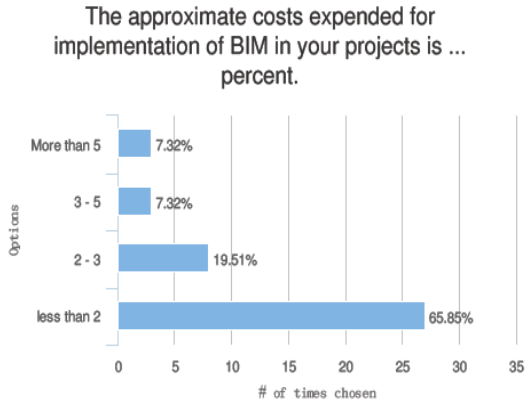
12. Using BIM helped you in building mobilization and construction safety management.

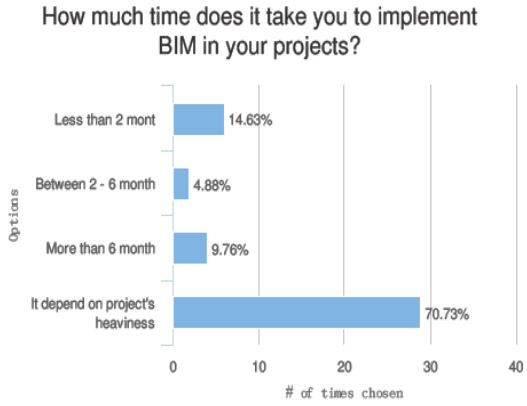
- Agree
- Disagree
- Neutral

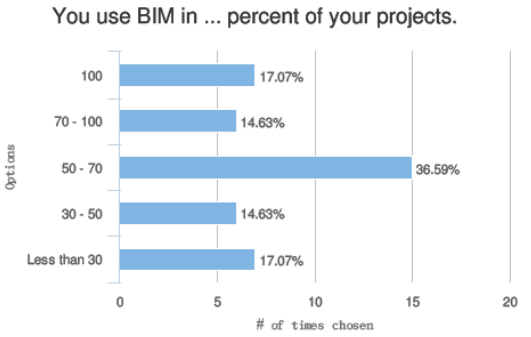
13. Using BIM according to its implementation cost beside its saving cost had economic justification for your project

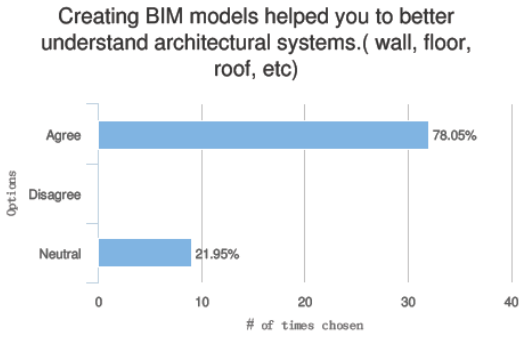
- Agree
- Disagree
- Neutral

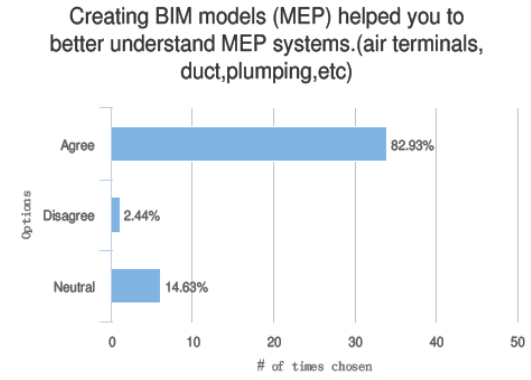


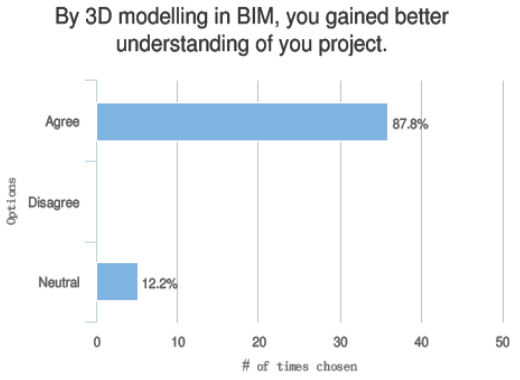

The approximate costs expended for implementation of BIM in your projects is ... percent.
More than 5
7.32%
3 - 5
7.32%
2 - 3
19.51%
less than 2
65.85%
Options
0 5 10 15 20 25 30 35
# of times chosen

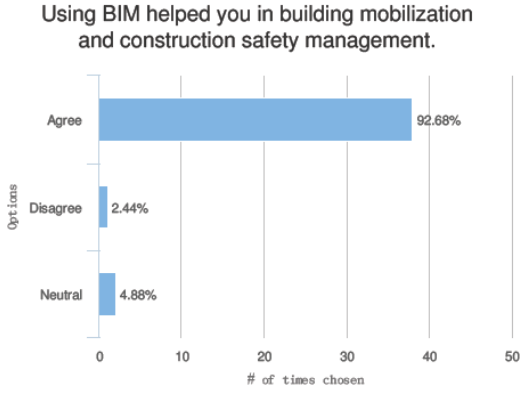

How much time does it take you to implement BIM in your projects?
Less than 2 mont
14.63%
Between 2 - 6 month
4.88%
More than 6 month
9.76%
It depend on project's heaviness
70.73%
Options
0 10 20 30 40
# of times chosen

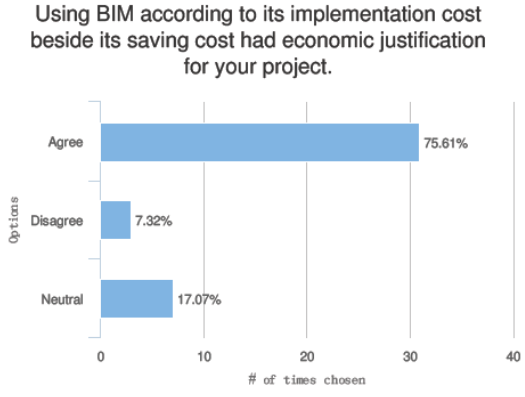

You use BIM in ... percent of your projects.
100
17.07%
70 - 100
14.63%
50 - 70
36.59%
30 - 50
14.63%
Less than 30
17.07%
Options
0 5 10 15 20
# of times chosen


Creating BIM models helped you to better understand architectural systems.(wall, floor, roof, etc)
Agree
78.05%
Disagree
Neutral
21.95%
Options
0 10 20 30 40
# of times chosen

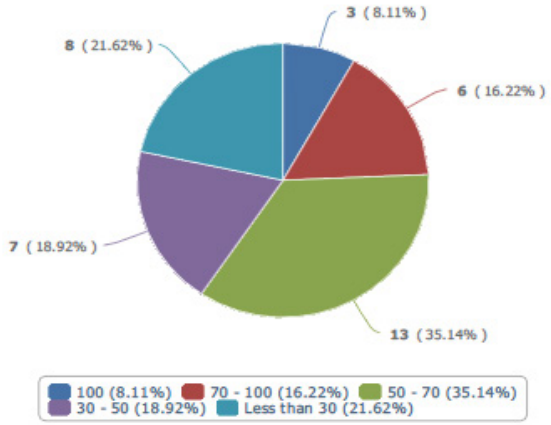

Creating BIM models (MEP) helped you to better understand MEP systems.(air terminals, duct,plumping,etc)
Agree
82.93%
Disagree
2.44%
Neutral
14.63%
Options
0 10 20 30 40 50
# of times chosen


By 3D modelling in BIM, you gained better understanding of you project.
Agree
87.8%
Disagree
Neutral
12.2%
Options
0 10 20 30 40 50
# of times chosen

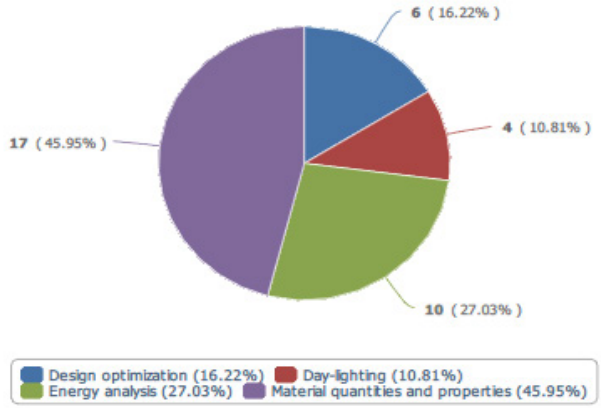

Using BIM helped you in building mobilization and construction safety management.
Agree
92.68%
Disagree
2.44%
Neutral
4.88%
Options
0 10 20 30 40 50
# of times chosen


Using BIM according to its implementation cost beside its saving cost had economic justification for your project.
Agree
75.61%
Disagree
7.32%
Neutral
17.07%
Options
0 10 20 30 40
# of times chosen

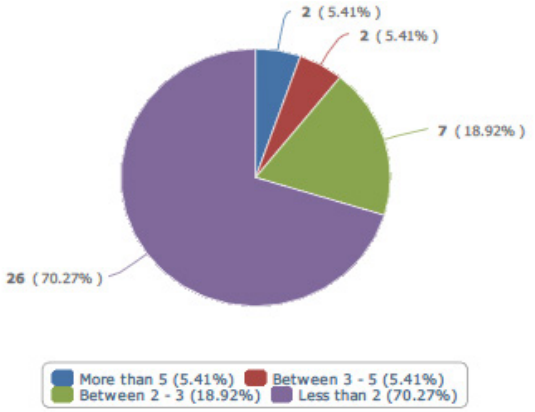
Appendix 2. Survey and Analysing of the Results



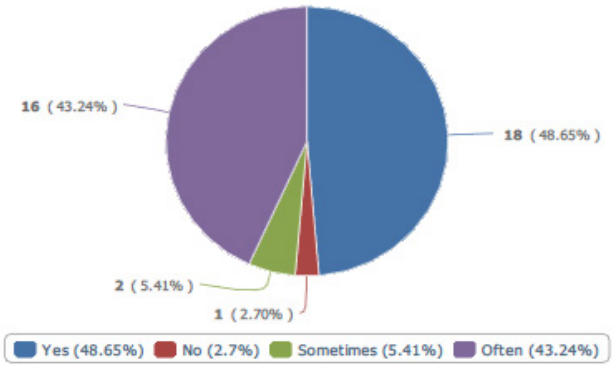
1. You use BIM in … percent of your projects.



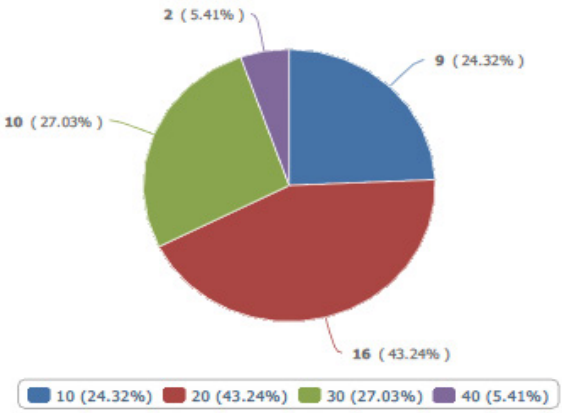
2. What is the common use of BIM for sustainable design in your projects?



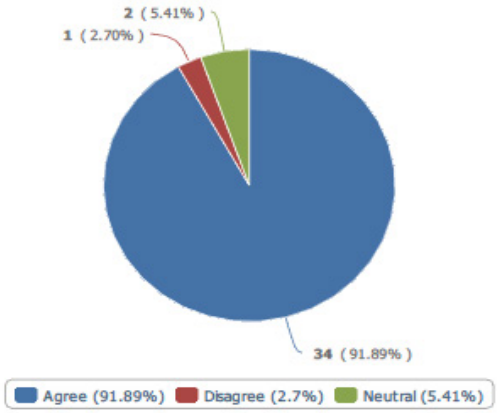
3. The approximate costs expended for implementation of BIM in your projects is … percent.



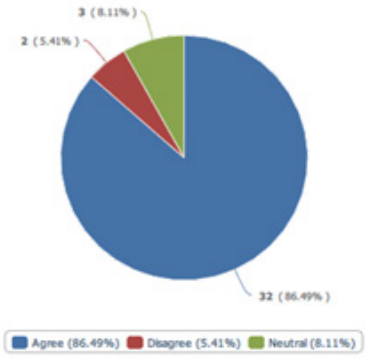
4. Could you find a balance between environmental consideration and economic constraints with BIM in your projects?



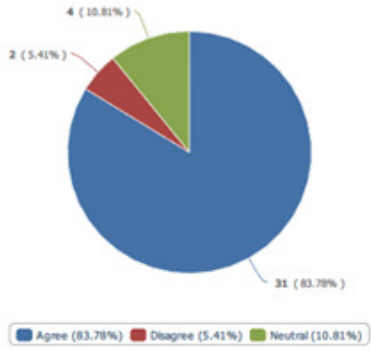
5. Through BIM you could facilitate up to … points for LEED certification.



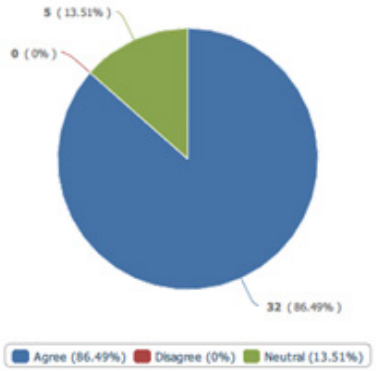
6. BIM gives you easy access to tools that Provides immediate feedback on design alternatives early on the design process.



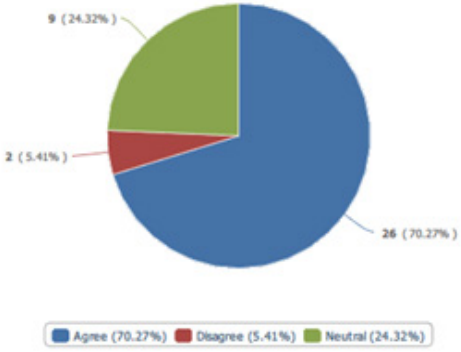
7. In BIM every drawing, every view, every schedule is a direct presentation or information from the same underlying database.



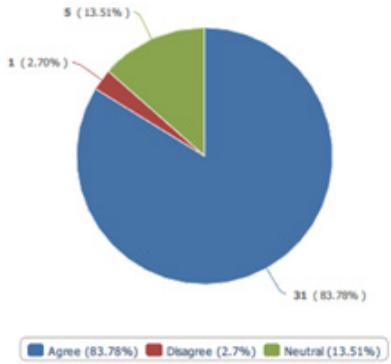
8. The BIM model carries a wealth of information necessary for many aspects of sustainable design or LEED certification.



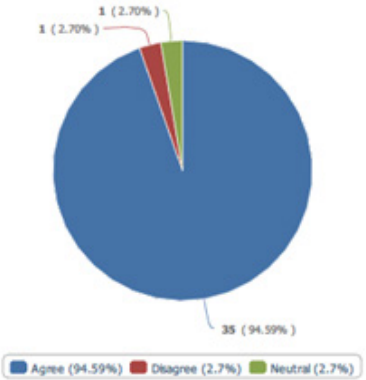
9. In BIM schedules of building, components can be obtained directly from the model to determine percentage of material reuse, recycle or salvage.



10. Advance visualization techniques in BIM can convince client that green design performs well and looks good.



11. BIM supports design optimization by letting architects develop and study multiple design alternatives simultaneously within a single model.



12. BIM allow the design team to undertake the modeling, measurement and documentation of complex interior daylight designs within their standard design environment.

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