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Investigating the Impact of Fifth Dimension for Building Information Modelling on Cost Estimation of Building Construction Projects

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Abstract: Building Information Modeling (BIM) is a numeral alteration in global, commercial, economic and social infrastructure projects. It also enhances communication within construction project team (Wilkinson et al., 2016). This is a technological phenomenology in which construction project practical and physical attributes are characterized digitally for solution finding approach and analyze potential expected effects (Schlueter & Thessling, 2009). Meticulous tools of Building Research Establishment Environmental Assessment Method (BREEAM), Leadership in Energy and Environmental Design (LEED), CASBEE, SB Tool and Green Globes for rating, classification and standardization of sustainability and energy efficiency in buildings shall be adopted for configuration and enhancements of buildings and infrastructure designs, specifically its significance in building performance systems at all the frontiers of developmental perspective.
(Hetherington et al., 2010).

This paper is an attempt to investigate the impact of fifth dimension for Building information Modelling on cost estimation of building execution projects. This study would encapsulate the analysis of this impact on cost estimation of actual buildings under the process of execution.

It is estimated that approximately about 20% initial building cost can be saved through advanced BIM technology (Azhar et al., 2011). BIM reduces the risk error and enhance ability to transform the project teams and drives efficiency, transparency as well as productivity of project (Wilkinson et al., 2016). The construction industry re-evaluates the design processes and encapsulates the integration and synergism of entire life cycle period for the construction project (Jiang Xu., 2016).

Approximately 25% cost impact of public sector projects was secured in 2011 by the United Kingdom Government Construction Strategy (GCS), BIM has the capacity to decrease project's financial impact and increase value for time and money (Wilkinson et al., 2016).

INTRODUCTION

Building Information Modelling is also defined as the human activity to create modelling utilizing digital interventions (Conover et al., 2009). Establishing good communication amongst multi diversified stakeholders, which is favorable to good decision making and recognition of construction project, encapsulating its managerial perspective. (Jiang Xu., 2016).
BIM is asset operations also a digital form of construction, improves the client's and project's outcomes radially, bringing together technology and digital information, better decision making in buildings and public infrastructure assets, utilized to study and analyze across the project's whole lifecycle (Ciribini et al., 2016). It represents physical characteristics as well as functional abilities of a facility and a reliable resource for sharing knowledge and information about a facility (Rokooei et., 2015).
Modelling done through BIM technologies is data rich, item oriented and intellectual having parametric illustration of facility. data fitting to numerous users' desires is gained, analyzed and evidence is produced, to mark resultants and enhancing workability. (Boon et al.,2011). It portrays the functional and physical characteristics of construction project in a sophisticated digitized format.

The Building Informational Modelling Toolkit proves to be 10% faster and estimated as 80% more accurate than conventional methodologies. Documentation time is reduced to 30%, it enables relationship between the architect, structural engineer and other relevant professionals. (Czmoch et al.,2014). BIM model encapsulates great deal of information, that can be secured in one place and can easily be updated (Pučko et al.,2014).

It has special features that calculates the peak performance, energy analysis condensing information and rules for the building project and can stimulate and visualize all project information to enhance communication, performance and workability. Clashes can be detected by studying the overlaps of electrical, mechanical, plumbing or HVAC services. It enhances the project's productivity and performance and controls it both quantitatively and qualitatively. Thus proves a healthy signature on the whole project with reference to cost and performance efficiency. (Jiang Xu.,2016).

Building Information Modeling is human action by usage of BIM to generate and use in BIM model. Model includes 3D data. Software used for this purpose is AutoCAD. Software makes the complete project within less time. Design process using BIM has been estimated as 10% faster and 80% more accurate than the traditional designing method. BIM 3D model essentially facilitates collaboration between the architect and the structural engineer (Czmoch et al., 2014).

Schedule and time are added in 3D BIM it will become 4D BIM. Whole data in BIM can be associated with model or linked to integrate with architectural or structural design to make schedule and time estimation. Communication within BIM users is easy. BIM involves auto save and connections to project history (Conover et al., 2009).

For the evaluation of design benefits for planning will accrue better skills as a result of precise design and integrated data. Development skills who attain the benefits of BIM through construction detail, management skills, 4D and 5D data that will increase production and decrease time and cost, enhance quality control, risk management improved and safety tools improved. Better results for quality control can be deduced and good understanding of results find out through BIM (Wilkinson et al., 2016).

Problem Statement

Conventional tools and methodology utilized for construction management, cost control, quality assurance and timelines controlling procedures for an execution project have proved itself to be a disaster and inappropriate choice for the industry.

Research Objective

The purpose of this study is

- To compare and analyze the impact of 5D BIM on cost parameters of an existing project whose execution is under process with respect to the traditional cost estimation techniques.
- To inspect the flaws in commonly used Cost Estimation techniques and their application.
- To study steps involved in BIM 5D modeling
- Comparative analysis of modernized methods and traditional methods of cost estimation.

LITERATURE REVIEW

In building construction industry, there are various methods which are used for estimating the quantity of material. It can be of plenteous types, but most commonly the estimation which is mostly carried out is on manual base.

Traditional Methods

In this method, quantity estimator is provided with 2D drawings. By which estimator calculate estimated quantity of material by manually calculation. This calculation is mostly helped out by computer, different software is used (Excel etc.). But Using BIM as a helping tool we can manage this estimation puzzle becomes quite easier and more precise. For many centuries the

designers use sheets papers, ink and abacus. The classical method was improved and then remains unchanged for the long period. Always the architect was responsible for the whole project and its investigations. In the 20th century the architects and engineers changed the view of traditional methods, drawing and calculations for the cost estimations. They introduced tools as CAD/CAE systems. Progress of CAD design was a gradual change in the process. The developments in industry enforce the improvements in construction techniques.

Architectural engineering design includes tasks for bigger projects having specialization as an architect, constructor, Quantity surveyor, projects manager, installation engineer. Initially the projects were started with the proposal of the two-dimensional drawings (plans, elevations, sections) according to the principles of designed buildings. For the complex calculations systems, the collaborations with CAD were developed. They use the comprehensive modeling of the structure, load patterns etc. In order to adjust the architectural drawings and structural drawings (dimensioning and reinforcement drawings, detailed design of steel connections etc.) the analysis results have been transferred to CAD/BIM systems (Czmoch et at., (2014)).

What is Building Cost?

For the accuracy and precision in cost estimation, investment decisions of building projects, owner's assessment of bids prepared by contractors, calculation of the tender price of the contractors, cost control during the design decisions are all destined. Cost is a measurement of the functionality and the performance of a building.

Hence, for the evaluation of the building designs, use of appropriate cost model is essential. Using a cost model, the initial step is a data collection. For the quality assurance of building cost model, useful elements, the level of data and thus the convenience of the chosen model must be evaluated. As new data are developed during the application of the model, they must be attached to the previous data.

Building Cost Estimation Models

The definition of Cost modeling is a symbolic establishment of a system and the content of it is defined with the factors affecting the cost (Holm, 2005). The models of 2^{nd} generation have been used since mid-1970 and resulting from the deterioration analysis and (McCaffer, 1975). In the beginning of 1980's the third-generation models started to develop and they generally based on Monte Carlo simulation technique (Touran, 1992).

The cost models can be divided into two sets: deterministic and probabilistic models.
In deterministic models, it is expected that the values can be qualified with type of variable and all these are accurately known. Whereas, in probabilistic models although the values of some variables that can be calculated are not unconditionally certain.

The Traditional Cost Estimation

As the models on the bases of quantities; e.g., in the representative design phase simple prices cost estimation models are used (such as unit, cube and building envelope models), in the

construction phase models on the basis of resources are used, models used are based on functional elements and building functioning units.

The Untraditional Models

Models based on new methods of construction and practices; e.g., the investigational models, deterioration models and reproduction models (Akintoye & Fitzgerald, 2000). On cost estimation models some of the recent works are as follows. (Chan and Park, 2005).

Trost and Oberlander, studied to create a model to that qualify business managers and estimators of early estimates to accurately evaluate the accuracy (Trost and Oberlander, 2003). Yu, proposed PIREM (Principal Item Ratios Estimating Method) for the integration of numerous existing theoretical estimating methods that includes the parametric estimation, ratios estimation, and cost noteworthy modeling with progressive nonlinear planning techniques, and adopts a scheme of a cost item with the quantities that separates unit (Yu, 2006). To predict the construction cost of buildings it described the progress of linear deterioration models.

Background to Computer-Aided Building Cost Estimation Systems

The process of cost estimation of building includes monotonous repetitive, calculation and numerical study activities. To help cost estimating the use of Computers have been used nearly for 40 years. For the data collection, calculation and secretarial features of estimation, Computer-based estimating plans are used efficiently. (Sun & Howard, 2004).

In communication and information technologies recent advancement increased the speed, correctness and output of building cost estimation process and made following tasks easy:

- Processing electronic bill-of-quantities (BOQ) either directly from digital CAD files or paper-based documents through digitizers.
- Setting up computer-aided cost databases,
- Setting up computer-aided cost estimation systems.

Computer-Aided Cost Estimation Systems

There is a classification of Computer-aided cost estimation systems into two groups:

Systems in schematic design phases and those which are used in design development and construction documentation phases. Cost estimation packages and integrated CAD for design and drawing working together with cost estimation which have graphical user edges is one of the computer-aided cost estimation systems used in schematic design phases. If the relationship of the design variables and building cost are modeled it is assumed that it can be analyzed mathematically and recommendations can be given using some ratios these are the second one the parametric systems.

The third one is those who are taking the benefit of recent advancements. Spreadsheet applications bundled in office is one of the systems used in design development and construction documentation phases in the artificial intelligence domain and knowledge-based approach. For building cost estimation model based on functional elements 77 automation

software Wide range of built-in function and formulas, what-if analysis, vast graphical reporting facilities are used (such as Microsoft Excel™). For widely used CAD, accounting, scheduling and complex cost estimation packages spreadsheet + add-ins supply integration and data transfer facilities.

Traditional Approach to Construction Management

There have been numerous methods implemented throughout the development of construction industry. There are traditional tools like critical path method (CPM) and 2D drawings commonly used in the AEC industry to analyze project designs and pan their construction process.
(Nunnally, 2007). This part will review existing methods, their benefits and drawbacks.

- **Gantt Chart**
  Developed by Henry L. Gantt, Gantt chart is a time schedule. According to planned schedule and actual performance Gantt chart occurs as several variations of which system and applications depend on the scope of projects (Nunnally, 2007).

- **Critical Path Method (CPM)**
  since late 1950s, aerospace industry developed CPM and it has been used in the construction industry. However, it has been well served in construction industry in several aspects, According to Sriprasert and Dawood (2002), due to its difficulty to evaluate and communicate interdependencies, inability to cope with non-standard restrictions and insufficiency for work-face productions, the CPM has been widely criticized. numbers were used to indicate activity durations and titles to designate activities (Dawood, N., Sikka, & S., 2004).
- **Linear Scheduling Method (LSM)**
  In the early 1950s, Linear scheduling method (LSM) and also called location-based scheduling (LBS) was firstly expressed (Andersson, N., Christensen, & K., 2007). For construction projects it is mainly functional such as multiple housing units, railway, highway and high-rise building. (Nunnally, 2007)

5D Modeling

In calculation of Quantity of materials, Cost and Quantity Estimation is 5^{th} dimension of BIM (Building Information Modeling) which is helpful. By extracting pre-defined information in the model, it just gives you the quantities of every building component.

BIM Implementation

Traditionally these methods contain much of errors and ambiguities that's why they are less reliable. There is a huge probability of wrong calculations and quantity take offs because all

information is gotten through 2D drawings. Moreover, 2D drawings are not showing details of clashes between different disciplines of buildings.

BIM Implementation Issues

BIM is an advanced tool which is frequently being used in international construction industry. Using BIM as a tool most of the companies are modeling their projects. But 5D modeling is not frequent at this stage. The following are main reason for that

- lack of knowledge or lack of expertise about BIM's further functions.
- Moreover, Experts working with BIM has high demand in industries therefore are paid highly.

Table 1 shows the difference between CAD and BIM.

Table 1: CAD vs BIM

CAD – Computer Aided Design	BIM – Building Information Modeling
Combination of 2D Lines (lines, arcs, circles)	Combination of (Doors, windows, walls)
Uses layers system	Uses architectural classification system
Lack of connection between different 2Ddocuments	Intelligent connection between different documents
More time to draft- less time to design	More time to design – Less time to draft
Updating- More chances of errors	Updating – No chance of errors

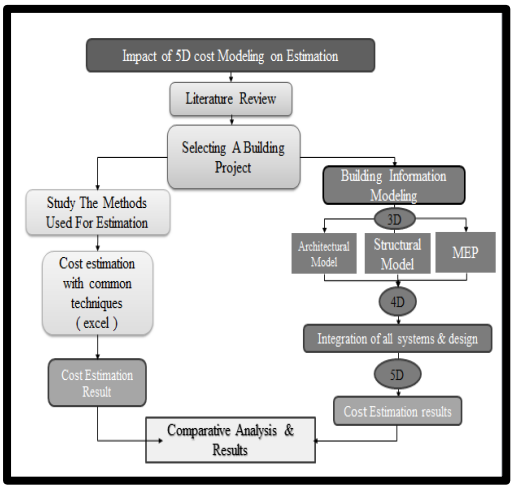
Figure 1 : Schematic Diagram

RESEARCH METHODOLOGY

This section would describe the working procedure on 5D cost estimation of selected buildings and comparison of cost estimation of construction materials particularly steel reinforcement, cement, bricks and concrete. Methodology adopted and whole setup for this research is explained.

Based on knowledge extracted from relevant extensive literature review on BIM and 5D cost modeling through several books, existing thesis, reports, research papers and journals, a case study was conducted on the selection of three existing commercial building using 5D BIM tools and applications to study the impact of 5D BIM on estimation in the construction industry of Pakistan. Selected buildings were Millat Tiles Lahore, Millat Tiles Multan and Attock Oil Office Rawalpindi those possess nearly same area and

For the selection of the most appropriate BIM tool for this research, A literature review was conducted. Revit architecture 2017 was used for creating the 3D BIM model and estimation of the building. Revit structure 2017 was used for generating structure of all selected buildings. After completion of 3D modeling, cost estimation was done on Revit 2017.Result generated through common techniques are compared through results attained through Revit. On the basis of both results we conclude our comparative analysis and results. Schematic diagram of methodology adopted is given in Figure 1.



There are different research techniques that are generally used in research process. Case study is a research technique which involves an in-depth, detailed and closed-up examination or study of a contemporary phenomenon particularly when limitations between spectacle and contexts are not evidently obvious (Neuman, 2006). This research technique is very useful for exploratory research. Another research technique is controlled experiment that compares the results from an experimental sample against a control sample. At the beginning of an experiment two or more sample groups areas created, which are almost equivalent. This equivalency is found out by the amount of variation between individuals and the number of individuals in each group. Once groups have been formed, they will be treated identically by the experimenter except for the one independent variable.

Direct observation is also a simple research technique to gather data about how users interact with products. There are two types of direct observation: Structured observation and unstructured observation. A structured observation is used when the researcher predefines what behaviors are to be observed before the observation starts. In an unstructured observation, there is no predefined plan about what to be observed. The researcher records behaviors as they occur and analyze them afterwards.

A survey is a process of observing a social phenomenon involving an individual or a group in order to gather information through observation or asking. Commonly, surveys are conducted through questionnaires and interviews. There are two types of questionnaires: open and closed. In open questions, the respondents are free to answer in whatever form and content they wish. Whereas in closed questions, there is a set numbers of predetermined responses that respondents can choose (Neuman, 2006).

The topic of research was first selected after an extensive literature review on the current issues and technologies used in the construction industry. A number of books, existing thesis, reports, research papers and journals were studied. Then the topic was derived for this study, that is: Impact of 5D modeling on cost estimation. This literature review began at the start of the research and continued till results and discussions were made. It means at the back end of case studies, survey and analysis the literature review was continued. This review was performed in order to attain a comprehensible understanding of the main subjects relevant to the research. Figure 2 shows the steps followed to produce case studies.

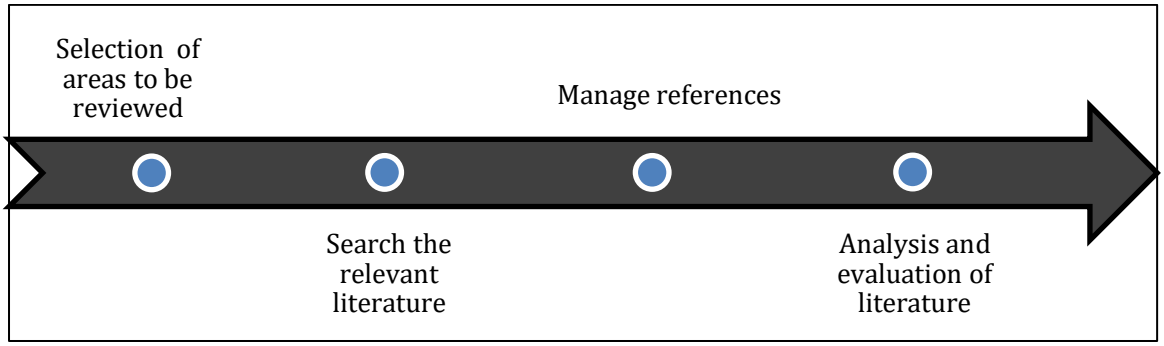
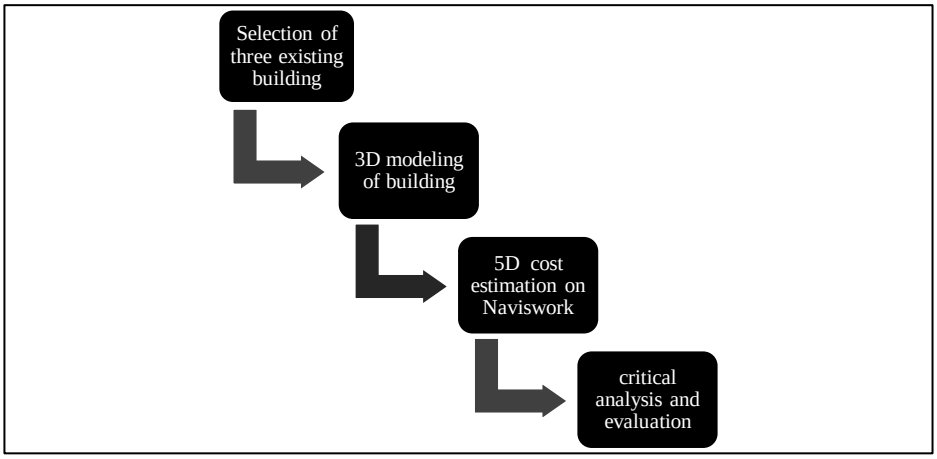


Figure 2 : Steps to Produce Literature Review

Based on knowledge extracted from relevant literature, a case study was conducted on three existing large scale commercial building using 5D BIM tools and applications to study the impact of 5D BIM on cost estimation in the construction industry of Pakistan. For the selection of the most appropriate BIM tool for this research, A literature review was performed. Revit architecture 2014 was used for creating the 3D BIM model and estimation of the building

It also provides the basic model geometry necessary for analysis, such as day lighting studies, energy usage simulation, material takeoffs, and so on. Whereas in CAD workflow, The team creates each and every view (plan, sections, elevation etc) separately and in a predefined sequence. First architectural plans are created then using those architectural plans the sections, elevations and detail drawings are created. More time is spent on drafting as compared to designing. Autodesk Navisworks Manage 2017 was used to 5D simulation of the building. These steps are shown in Figure 3



Three case studies were performed to illustrate the process of scheduling in BIM. I

Figure 3 : Steps to 5D BIM analysis

In order to produce more reliable results, three case studies covering projects with a variety of scope were performed. All the case studies involved the implementation of 5D BIM in the construction practices. The case studies were selected keeping in view the different diversity of projects. The projects also varied from small to large scaled projects located in different parts of the Pakistan.

Introduction-Millat Tiles, Lahore

An existing small scale commercial building was selected to illustrate the process of visualization, scheduling and cost estimating in BIM. The building selected for this purpose was Millat Tiles Lahore. This was selected because it has simple architectural and structural design, data was easily available, relevant to research, traditional tools were used for designing and construction process. Figure 4 shows the perspective view of the building.

Figure 4 : Millat Tiles, Lahore

Millat Tiles Lahore is a four-Storey building in Lahore. Its covered area is 9022 sq. ft. and total height of the building is 47'. The building was designed and constructed by renowned contractors and consultants of Lahore i.e. Shahid Saqib Consulting Engineers (SSCE). The building is equipped with brick masonry work. The estimated project duration was calculated to be 1.0 year, but it actually got completed in 1.3 years. The estimated cost of project is 28.4 million.

Tradition Tools - Design and Construction Process

The traditional tools used for the design and construction process of this building are mentioned below. These are the widely used traditional tools in the construction industry of Pakistan.

- Design Works – AutoCAD
- Quantities and Cost estimation – Excel
- Project Scheduling – Primavera and MS Project

Cost Analysis of Millet Tiles, Lahore

Cost analysis of constructional materials during construction phase was conducted. The cost analysis is shown below in Figure 5. The bars in blue shows the BOQ's cost and bar in black shows the 5D estimated cost. The BOQ's quantities of concrete, reinforcement bars and bricks was 54071 cft. 206254 kg and 6777 cft. respectively. The total 5D estimation quantities of concrete, reinforcement bars, bricks and concrete estimated as 193853 kg, 6524 cft and 57573 cft respectively.

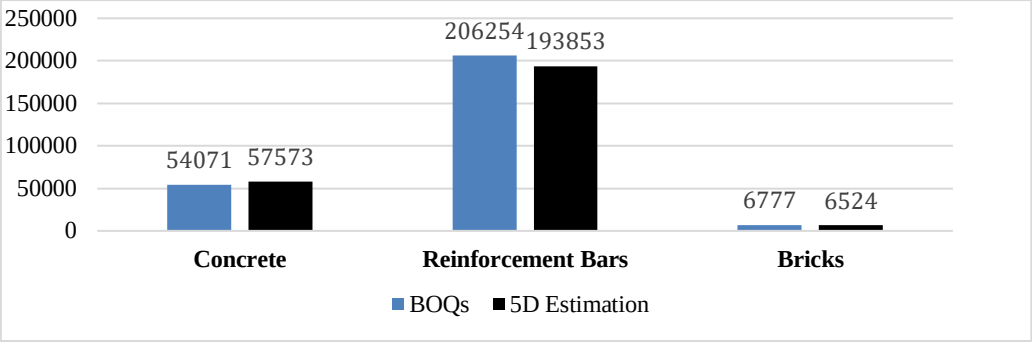


Figure 5 : Difference in Quantities of Construction Materials

The quantity of bricks in BOQ was 6780cft. shown in blue bar. The total 5D estimation quantity of bricks estimated as 6524cft shown in black bar. Difference in quantity of brick was estimated as 256cft as shown in Figure 6:

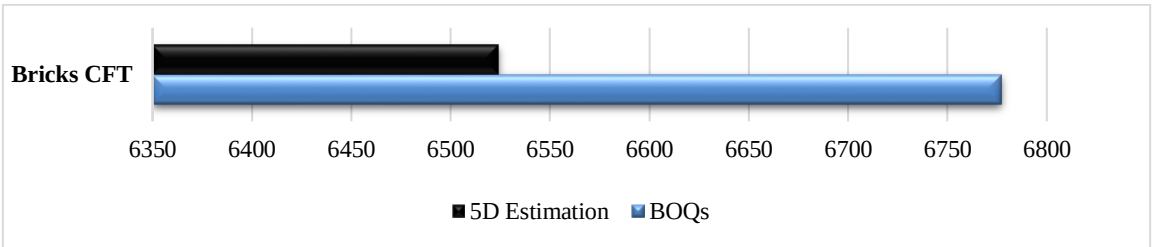


Figure 1 : Difference in Quantities of Bricks of Millat Tile, Lahore

The quantity of concrete in BOQ was 54070cft shown in blue bar. The total 5D estimation quantity of concrete estimated as 57573cft shown in black bar. Difference in quantity of concrete was estimated as 3503cft as shown in Figure 7:

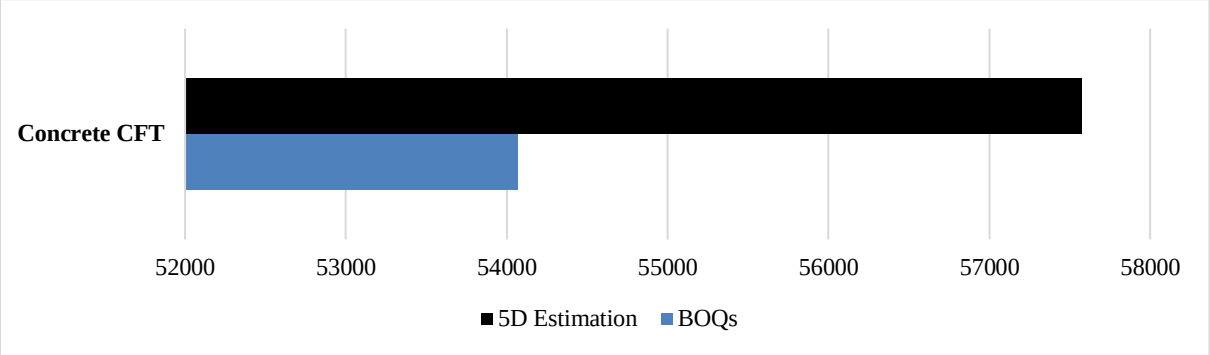


Figure 2 : Difference in quantities of concrete of Millat Tiles, Lahore

The quantity of rebar steel in BOQ was 267254 kg shown in blue bar. The total 5D estimation quantity of rebar steel estimated as 193855 kg shown in black bar. Difference in quantity of rebar steel was73399 kg shown in Figure 8:

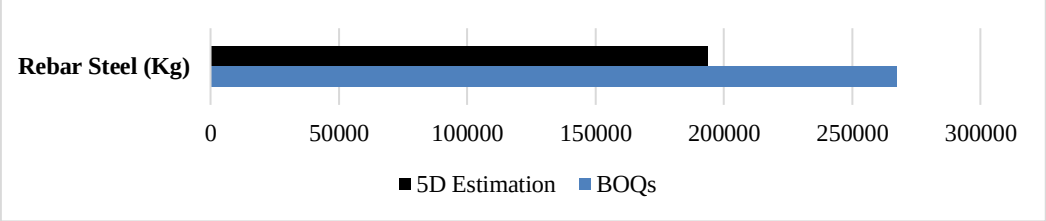


Figure 3 : Difference in Quantities of Rebar Steel of Millat Tiles, Lahore

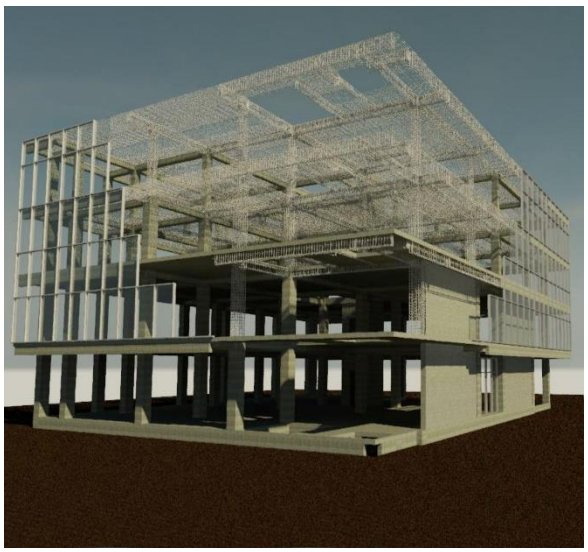


Figure 9 : BIM Structural Model of Millat Tiles Lahore

Millat Tiles, Multan

An existing commercial building was selected to illustrate the process of visualization, scheduling and cost estimating in BIM. The building selected for this purpose was Millat Tiles Multan. This was selected because it has simple architectural and structural design, data was easily available, relevant to research, traditional tools were used for designing and construction process. Figure 10 shows the perspective view of the building.

Figure 10 : Millat Tiles Multan

Millat Tiles Lahore is a six-Storey building in Lahore. Its covered area is 2260sq. ft. and total height of the building is 47'. The building was designed and constructed by renowned contractors and consultants of Lahore i.e. Shahid Saqib Consulting Engineers (SSCE). The building is equipped with brick masonry work. The estimated cost of project is 43.2 million.

Tradition tools - Design and Construction Process

The traditional tools used for the design and construction process of this building are mentioned below. These are the widely used traditional tools in the construction industry of Pakistan.

- Design Works – AutoCAD and 3D MAX
- Quantities and Cost estimation – Excel
- Project Scheduling – MS Project

Cost Analysis of Millet Tiles, Multan

Cost analysis of constructional materials during construction phase was conducted. The bars in blue shows the BOQ's cost and bar in black shows the 5D estimated cost. The BOQ's quantity of concrete, reinforcement bars and bricks were 30580cft, 13660 kg and 6830cft respectively. The total 5D estimation quantities of concrete, reinforcement bars and bricks estimated as 28474cft, 11065 kg and 6377cft respectively.

The quantity of bricks in BOQ was 6830cft shown in blue bar. The total 5D estimation quantity of bricks estimated as 6377cft shown in black bar. Difference in quantity of bricks was 453cft as shown in Figure 11:

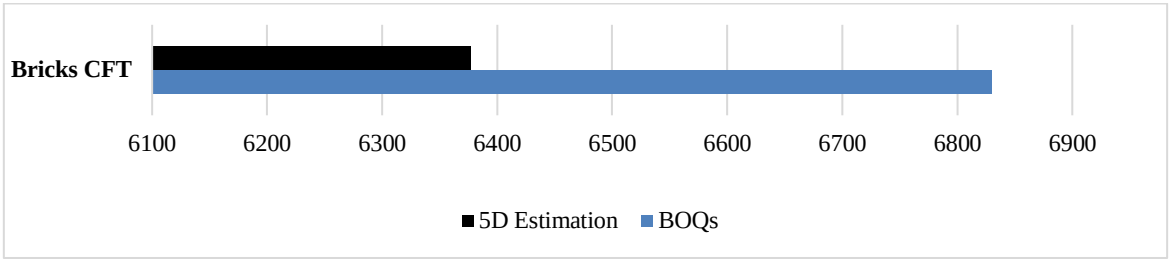


Figure 4 : Difference in Quantities of Bricks of Millat Tiles, Multan

The quantity of concrete in BOQ were 30580cft shown in blue bar. The total 5D estimation quantity of concrete estimated as 28474cft shown in black bar. Difference in quantity of concrete was 2106cft as shown in Figure 12:

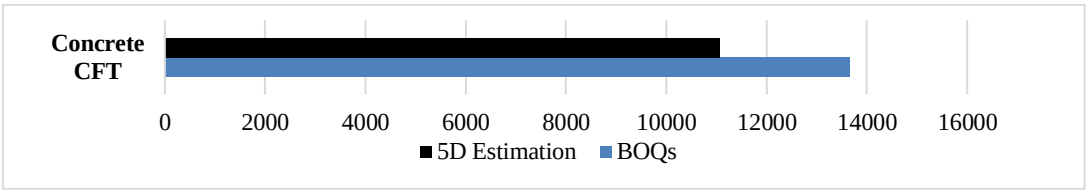


Figure 5 : Difference in quantities of concrete of Millat Tiles, Multan

The quantity of rebar steel in BOQ was 13660 kg shown in blue bar. The total 5D estimation quantity of rebar steel estimated as 11065 kg shown in black bar. Difference in quantity of rebar steel was 2595kg as shown in Figure 13:

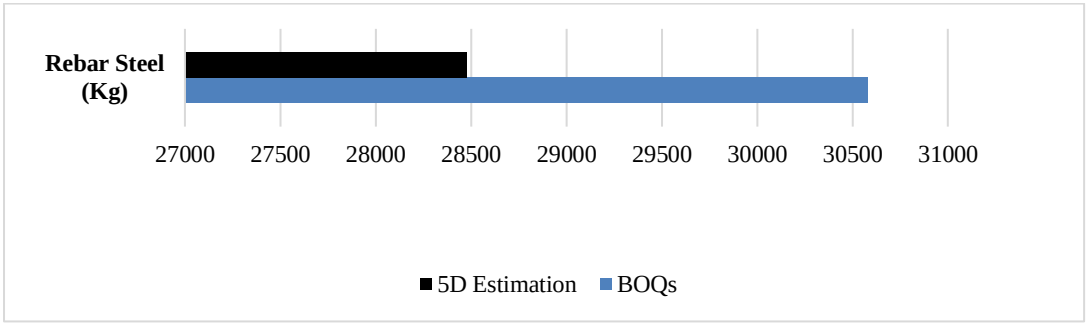


Figure 6 : Difference in Quantities of Rebar Steel of Millat Tiles, Multan

Figure 14 : BIM Structural detailed Model of Millat Tiles Multan

Attock Oil Office

The building selected to illustrate the process of visualization, scheduling and cost estimating in BIM was Attock oil office. Attock oil office is a thirteen-Storey building in Rawalpindi. It's covered area is 18508 sq. ft. and total height of the building is 150'. This was selected because it has simple architectural and structural design, data was easily available, relevant to research, traditional tools were used for designing and construction.

Tradition tools - Design and Construction Process

The traditional tools used for the design and construction process of this building are mentioned below. These are the widely used traditional tools in the construction industry of Pakistan.

- Design Works – AutoCAD and 3D MAX
- Quantities and Cost estimation – Excel
- Project Scheduling – MS Project

Cost Analysis of Attock oil office

Cost analysis of constructional materials during construction phase was conducted. The bars in blue shows the BOQ's cost and bar in black shows the 5D estimated cost. The BOQ's quantity of cement, sand and aggregate was 31300 sq. ft. 58270 sq. ft. and 82070 cft respectively. The total 5D estimation quantities of cement, sand and aggregate estimated as 30302 sq. ft., 56455sq. ft. and 79515cft respectively. Structural model of Attock Oil Refinery by using BIM is shown in Figure 15.

Figure 15 : BIM Model of Attock Oil Office

The quantity of cement in BOQ was 31300 sq. ft. shown in blue bar. The total 5D estimation quantity of cement estimated as 30302 sq. ft. shown in black bar. Difference in quantity of cement was 998 sq. ft. as shown in Figure 16:

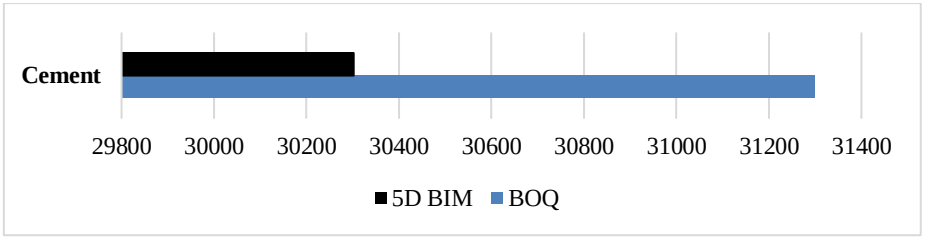


Figure 7 : Difference in Quantities of Cement of Attock Oil Office

The quantity of sand in BOQ was 58270 sq. ft. shown in blue bar. The total 5D estimation quantity of sand estimated as 56455 sq. ft. shown in black bar. Difference in quantity of sand was 1815sq. ft. as shown in Figure 17:

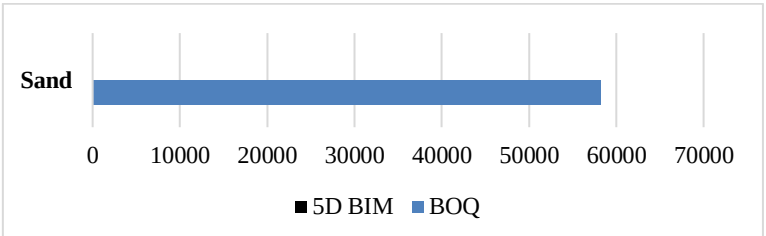


Figure 8 : Difference in Quantities of Sand of Attock Oil Office

The quantity of aggregate in BOQ was 82070 sq. ft. shown in blue bar. The total 5D estimation quantity of aggregate estimated as 79515 sq. ft. shown in black bar. Difference in quantity of aggregate was 2555sq. ft. as shown in Figure 18:

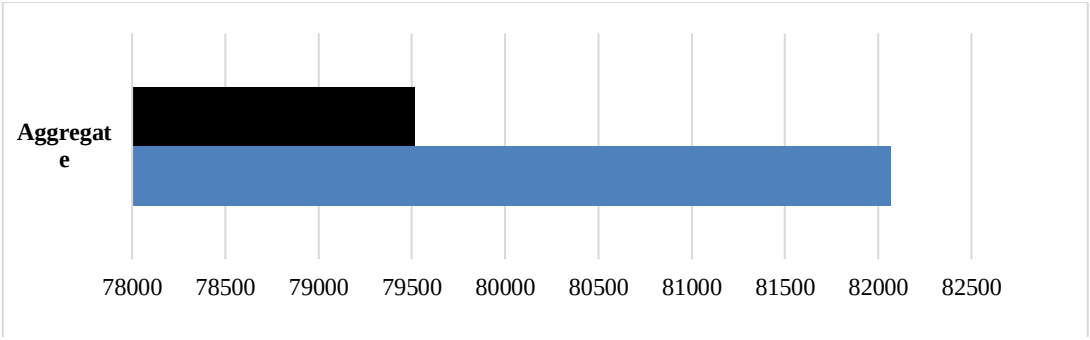


Figure 9 : Difference in Quantities of Aggregate of Attock Oil Office

The quantity of rebar steel in BOQ was 1325240kg shown in blue bar. The total 5D estimation quantity of aggregate estimated as 1051775kg shown in black bar. Difference in quantity of aggregate was 273465kg as shown in Figure 19:

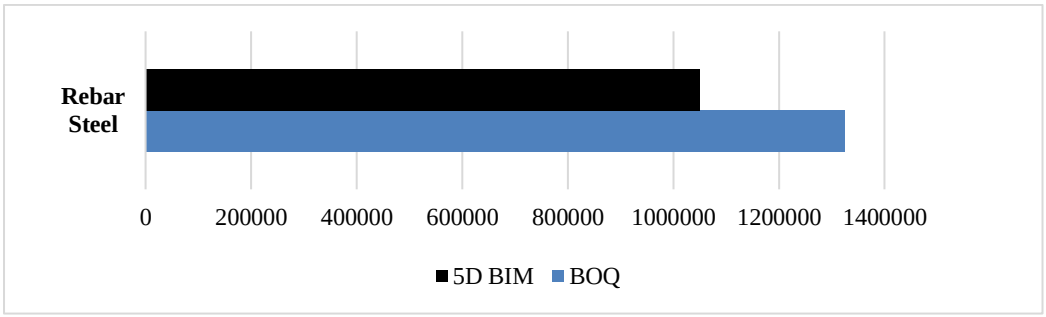


Figure 10 : Difference in Quantities of Steel Rebars of Attock Oil Office

Factors affecting Time and Cost of Project

According to the project team, the factors that lead to unexpected cost and time overruns were as follow:

- At the time of tender, the detail design being incomplete.
- Changes in owner brief due to poor visualization of project design.
- Lack of proper coordination during design phase.
- Weak cost and time planning in pre-contract and post-contract stages.
- Unforeseen soil and site conditions.
- Lack of proper coordination during construction phase.
- Delay in material ordering and delivery.
- Changes in design during construction stage.
- Errors in BOQ (Bill of Quantities).
- Inflationary material costs.
- Inaccurate estimation of materials.

On the basis of the factors affecting the time and cost of projects four factors were considered as major factors that can affect the time and cost of any project including this project. If these factors were handled and managed well, time and cost could have been managed.

- Poor Visualization
- Lack of Communication in different project phases (pre-construction, construction and

post-construction phase)
- Late and Inaccurate Cost estimation/ quantity take-off
- Inappropriate Project Planning Process

5D BIM Analysis

The purpose of the case study is to illustrate the visualization, scheduling and cost estimating processes with BIM model and find out the improvements that can be made to avoid time and cost overruns. The BIM model and software tools used were all adapted from the Autodesk since Autodesk provides full access of its products to students. The selection of the software tool may have limitations.

The assumptions of this research included the following:

1. The contractors will have full access to all the selected software tools.
2. The building model in the project is drawn correctly with no clashes and errors so that the measurements and quantities of the objects in the model are reliable.

Data required for 5D BIM Analysis of Projects

The data required to perform 5D BIM analysis of the existing buildings is as under:

1. Architectural, structural designs.
2. Bill of quantities.

Software Tools selected

"Revit Architecture 2014" was utilized to develop 3D intelligent model of the building. detailed information about elements used to develop the model such as (Length, Width, Height, Material of wall, door etc.). It helps understanding the building paraphernalia through visualization. Quantity's takeoff and detailed technical information is possible to extract.

3D BIM Model

Utilizing Autodesk Revit version 2014, comprehensive 3D model was developed that encapsulated the basic architectural and structural elements. In this study MEP (Mechanical, Electrical and Plumbing) designs were not developed.

Quantities Takeoff

BIM model not only allows to create detail views of the buildings but also enable to create detail quantities schedule of various building elements like column, beams, walls etc. The quantities schedules created in Revit architecture are automatically updated if any changes are made in BIM model. In order to generate a more accurate project quantities takeoff, the following steps were followed:

- Creation of a detailed 3D BIM model
- Creating quantities schedule for every component separately
- Filtering and formatting the schedule quantities
- Exporting schedule to Microsoft Excel

RESULTS AND DISCUSSIONS:

In this section, the results extracted from different sources were discussed, such as case studies and interviews.

Results from Case Studies

On the basis of 5D BIM analysis of three projects, cost analysis was evaluated. It can be observed that by the use of 5D BIM technology, the project could have been completed as per the estimated cost. As compared to traditional CAD method, BIM based detailed project design documentation can improve the visualization of the project hence reduce the design changes during construction phase.

BIM quantity take-off is faster and accurate as compared to traditional quantity take-off. In BIM every element has a parametric relation with one another. When plans are created elevations, sections, even schedules are created automatically. So, time wastage in drafting procedures and chances of error are mitigated. The 5D BIM links the building components with tasks and simulate these tasks in the 5D environment—the design and the construction schedule are synchronized. The simulation of the progress can also help contractor to adjust the project schedule according to the design change in building model.

5D BIM can enable a fresh engineer, with less experience of project management, to produce a well-managed project.

Results from Interviews

By the results gathered from the interviews it is evident that Professionals who participated in the interviews were aware of BIM technology. Majority of respondents were interested in implementation of 5D BIM technology at local projects. Therefore, it is need the need of industry to escape from future clashes and cost overruns.

Benefits of 5D BIM

There are six major benefits of 5D modeling for construction planning identified after reviewing the case studies which are analyzed below.

Fast and Accurate

Design process using BIM has been estimated as 10% faster and 80% more accurate than the traditional designing method.

Improve Project Management

BIM improves the project management, especially in the cases of large and complex construction projects in which the project goals are usually related to the quality of the building.

Technological Progress

Model of the construction object can contain information about the type of building elements, the geometrical quantities, the number of items, the resources needed for implementation, the execution times of project activities, the technology implementation, the costs, etc.

Resolve Conflict

BIM helps for clash detection of project elements that are perfectly fitted and made on site and allowing elements to be perfectly bolted.

Sequence Steps

After completion of model during construction activities will be listed in a sequence, then materials will be sequenced, and construction process will be more efficient.

Improve Quality

It improve the construction quality, reduce construction costs and achieve the green construction of fine management requirements for BIM Technology in the construction process management.

Minimize Costs:

Time saved on drawing was used on coordination and elimination of clashes in the designing.

Better Communication:

5D modeling played an important role in communication between client and planners during the planning phase.

Planning of Temporary Structures and Works

Temporary works and structures play an important role in the execution of projects supporting the main construction process. Traditional 2D planning methods like CPM scheduling and Gantt charts usually do not consider temporary works and structures during the planning process which might result in difficulties at site during execution.

Barriers in Future Implementation of 5D BIM

It has a potential to bring drastic change in construction industry, but they were unable to implement this technology because of various barriers.

The main barriers for 5D BIM implementation in the construction industry are:

- Unawareness of 5D BIM benefits
- Lack of technical knowledge about implementation of BIM framework.

- Disruption to current process / resistant to change
- Need for suitable data sharing standards.
- Lack of skilled personnel to provide proper training.
  Time and cost required to train existing staff.

CONCLUSIONS

- From performed interviews, survey and analysis, 5D is concluded as one of the promising tools for construction planning. 5D modeling helps to complete the project on time and within budget as compare to traditional method. Results of analysis of quantity comparison through BIM of Millat tiles Lahore, Millat tiles Multan and Attock oil office Rawalpindi is 15.1%, 26.5% and 22.5% respectively. Results show that 5D BIM can facilitate cost managers for estimation of construction materials.
- Comparing 5D BIM to Traditional tools, BIM increase productivity in terms of time, cost and quality. 5D modeling gives better visualization project, better communication among team members and increased efficiency of planning. It also contributes in achieving precise and accurate work plans and quantity takeoffs. 5D BIM not only increased the efficiency of project schedule and reliability but also increase the constructability and site safety.
- This research also concluded that 5D BIM can help the project manager in the task of delivering a successful project, improved depiction of authenticity can be provided.
- The lack of 5D BIM standards, technical knowledge and disruption to current process are few barriers that are resisting the implementation of BIM in construction industry.
- 5D technology can be propitious development for construction firms and can help mitigation the most common problems faced in the construction projects with enhanced planning efficiency.

RECOMMENDATIONS

- In order to increase the awareness of 5D BIM and other technologies, educational institutes and professional should play an important role. Educational institutes dealing with building related subjects must include courses related to BIM.
- A company employing BIM must be capable of providing effective link within the core competencies and provide suitable training to the staff thus shifting the people to BIM from the traditional methods.
- If the implementation barriers of 5D BIM can be overcome, then a large number of BIM benefits can be utilized to bring drastic change in the construction industry of Pakistan.
- 5D modeling system can be applied on real time projects for collecting actual data and information and determining the effectiveness of 5D modeling. This will develop a

broader and holistic perception of 5D planning in construction projects.

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