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Exploiting the effectiveness of Building Information Modeling during the Stage of Post Construction

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ABSTRACT

It has been emphasized by owners and stakeholders for the construction cost of projects, although subsequent costs regarding post construction are considered to be far more than of those. Therefore, further considerations accounting to the stage of post construction stage like maintenance and asset management are necessary. The main aim of this paper is to examine the effects of Building Information Modeling (BIM) throughout post construction phase comprising of maintenance and asset management. Based on it the conclusion being drawn is that innumerable benefits can be gained by employing the BIM on aforementioned areas such as at first the knowledge is shared between construction and design, also the facility management leading to bridge the gap between them. Secondly, the effective asset management could come fruitful by providing information throughout the entire life-cycle assets.
KEY WORDS: Post construction phase, maintenance, asset management and Building Information Modeling.

1. INTRODUCTION

In general BIM can be entirely useful during the phase of construction and pre-construction but, many pitfalls occurred during the stage of post construction which can be decreased using BIM. The proper maintenance and management of buildings can certainly decrease the yearly cost of $15.8 billion that are connected with inefficient interoperability [1]. BIM is considered to be the new approach towards the design, construction and facility management, during which visualization of building process is exchanged and interoperability of information in the form of digital [2]. In the field of construction industry using BIM in facilities management (FM) has gained interest and is mostly required for consistent, coordinated, and computable building information to design and construct maintenance and cost operation during the different phases regarding life cycle of a building. The information obtained for the BIM process and the one which is stored in the form of BIM-compliant database can be useful for several FM practices, like closeout and commissioning, energy management, space management, quality control and assurance, maintenance and repair. In view of this, building information modeling has gained attention by many researchers and practitioners because of its capability to store essential date related to the different parts of buildings, which is highly required for the maintenance of buildings and to control the assets that are happening within the entire life cycle of construction. Moreover, this current paper has summarized the benefits of BIM utilization during the stage of post construction. At first the utilization of BIM has been focused on the maintenance of building and next the benefits involved by the use of BIM concerning the asset management are being detailed and discussed based on the previous records.

2. Facility managers and management

The maintenance and operations of the constructed and designed buildings for many years until now are being handled only by the facility mangers. Also, several other organizations are involved and the guidance of these organizations is starting to collaborate and communicate but till date they are not found to serve the facility and property managers in the context of BIM according to [3]. On the other hand, the constructors and designers do not know about the documents and other information required for the phase of facility management. Also, lack of operational knowledge and experience of these existing buildings has a huge setback for designing the phase for consideration according to [4]. The design and facility management link is normally avoided because it is not well

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understood [5] and the matters germane to facility maintenance are being overlooked owing to the process of making design decision [6].

2.1 Reactive and planned maintenance

The operational phase normally includes 60% of total cost arising during the project construction. The activities that are happening during these operations are largely related to the concept of maintenance and repair. Reactive repairs and maintenance results in the creation of huge expenses, although it should be considered that most of the maintenance works are reactive according to the findings of [7]. The maintenance cost of reactive repairs is considered to be four times more when compared to the planned maintenance as required for repairing, thus is not considered to be efficient [8]. Therefore, it is recommended to retain a planned maintenance work rather than reacting to the arising defects. Sullivan, et al[9] have suggested that for taking priority over the other components in a facility which can record the happenings of failure as to capture the reliable information that is required for the reactive maintenance cost and is nearly four times more than the planned maintenance cost. Indeed, a more suitable maintenance database including the historical information of repair and maintenance is crucial for the planned maintenance decision.

2.2 Status of employing BIM in the facility management

The research carried out by [10] shows the survey taken with a variety of respondents for determining the implementation of BIM in the facility management (FM). The colleges, universities, schools along with other institutions showed the highest response proportion accounting nearly 53% out of the total responses and were followed by large architecture and construction (9%), government agencies (13%), professional organizations (4%) and healthcare organizations (5%). The organizations that showed fluctuation in between the transportation and finance and transportation were grouped into the category "other" which has resulted in less than 3% of total respondents, moreover, based on the personal information 69% of respondents belong to positions of top management (directors, coordinators presidents, vice presidents and managers).It has been summarized that nearly 32 % of respondents urged their organizations to employ BIM for their current operation. The different practitioners for using the BIM or not were being analyzed separately during this course of study, it was noticed that 60% BIM non-users intend to exploit BIM in their projects.

The respondents were questioned to opt during which specific phase of their operation they will be using BIM, but it was found that no-one had even chosen a single project during this phase. It was noted that the existing users used BIM during the design phase with 83%, followed by its use in stage of construction with 79% and 42% during the phase of management and operation. The non-BIM users agreed for the usage of BIM during the management and operational stage, accounting for 78%. Also, the interest of non-users for using BIM was found to be in the range of (7 to 78%) during the three stages. So, it can be concluded that users who prefer and don't prefer BIM tend to have similar desire to adopt BIM during the phase of construction and designing. But, nonusers showed more tendencies towards employing BIM during the stage of maintenance and operation.

The users who don't user BIM were asked in regards to ones implementation of BIM for their organizations, it was found that nearly 11% stated that they are in the process of BIM adoption. It was stated by another 29% that they were intending to commence the process in less than two years from now and it was confirmed that 30 % have no intentions to employ or planning to start it within a period of five years from now.

The survey conducted by Liu, R. and Issa, R [11] showed the issues in BIM for the facility management in the perspectives of industrial practitioners with the aim of identifying BIM implementation in construction projects within the period of 1 year, and for which 25 respondents using BIM model were chosen. The results indicate that two of them responded in such a way stating that the model contained sufficient data for the facility maintenance and operation, whereas no information was needed for OM in BIM model and all information were manually input for OM as quoted by other three. Further nine respondents indicated that it contained a part of data required for OM but still the requirement of input was manual. Finally, the requirement of BIM model as indicated by eleven respondents was needed for the designing and construction, but still it was not exploited for FM stage or had many problems in using the model.

2.3 Applicability areas of BIM on FM

In this section, the applicable areas of BIM on FM are widely discussed.

1-Locating building components: The on-site FM relies on the paper-based blueprints, institution and judgment in locating the building equipment like HVAC system and electrical, gas and water lines that not readily visible which includes ceilings, underground floors and behind the walls. Locating the equipment is quite onerous activity leading

to frittering the repair technician and equipment manager time. It will use a designed3D BIM model to check the exact place of plumping, mechanical and electrical components in facility and make the localization of equipment on-site possible, plus can deliver the relevant data to operational context. This will lead to a reduction in the cost of maintenance, thereby reducing guesswork required for locating the equipment to be used for repairing, commissioning and replacing. The usage of, The BIM models can be navigated using the BIM tools on-site FM personnel which includes search, view, filter and highlighting to guide them to the target. The integration of BIM along with the navigation can facilitate the directing of FM personnel to components which are similar to the global positioning system, combined with the integration of maps to be used in the outer environment [12].

2-The real-time data access facilitation: The person belonging to the facility management fulfills a predictive, corrective, preventive and maintenance. At same time it also responds to various problems like if the room is too cold. The FM personnel needs to access according to the available amount of data and can log into ample databases for locating the information required and to print the information out for performing a particular task, at the same time executing the assigned tasks. The instant access to information can thereby minimizing the duration and labor required for the retrieval, thus can avoid ineffective decisions that are being made during the absence of information. Moreover, BIM's graphical interface can certainly help in providing the monolithic data access point as per the requirement of information. Moreover, the facilities management personnel can opt an object indication and gather the information required from FM system, stating its location [13].

3-Visualization and marketing: The essence regarding the visualization of BIM has been mooted during the different construction operations in terms of 3Dl graphical interface and their capability of integrating material texture, landscaping, and light sources. BIM also provides better space visualization to help managers during the designing of re-models, construction and renovations. The FM personnel can perform well with improved visualization and can aid in the presentations for the sessions of decision making. The capabilities of visualization during renovations can be applied for assessing the methods of construction and is important for the areas which are having high density where the equipment access and operational construction needs to be checked with the help of modeling. The 3D graphical model helps in representing the relationship occurring between the spaces and it can also be used for various training purposes. The walkthrough, navigating and virtual equipment modeling capabilities of building information modeling still have better edge for using it to market purposes, consequently create animations and images of the furniture, along with the interior spaces [14, 15].

4-Checking maintainability:4-Checking maintainability: The maintainability is being described as the sufficiency in which optimum performance during the entire life cycle of the available facility including minimum costing could be achieved. The primary schedules and costs are taken priority in many project, whereupon they ignore the fact that entire life cycle are the most expensive stage that is coming due to the operation and maintenance. However, BIM can facilitate maintainability on the desired performance during the different stages of a life cycle facilities [10]:

- In preventive maintenance: components selection which prevents the slipping and falling, inspection of improperly protected or installed components that might require easy access for examination, repairing of components, devices, systems should be protected from the fall off that can cause roof damage.
- During sustainability of materials: it is to neglect the materials that causes several defects, also for identifying the nature of defect been caused by assessing the total material performance, durability and clean ability of materials.
- For accessibility: it is important to check for the temporary access to the building façades that contains amorphous shapes, physical inspection capacity and line of sight for equipment that requires inspection on a basis of regular activities which includes proper and rapid identification of parts that needs to be repaired or changed along with the fire protection systems.

5-Creation and updating of digital assets: The digital assets are uploaded to FMS only after the completion of building commissioning for supporting the work order management, repair and maintenance. Moreover, it is necessary to have digital assets in the form of electronic which includes efficient organization to make the distribution and access simple as to ensure that they could be easily traceable and retrievable. BIM implementation during the phases of design and construction according to the clients need can be an ideal chance for the FM to digitalize, transfer and capture these assets after the completion of commissioning. The vendors and equipment manufacturers should be able to provide radio frequency identification labels or standardized bar code on the installed equipment as to refer it during the commissioning and which may be required during the later stage of FM stage based on its assumption of having an active role during the

process it can be automated and made sure that its free from manipulation, if the information present in the BIM models are proven to be precise and well-balanced along with other document and information sources that are being digitalized according to the time frame. During the process of construction and designing the digital assets to be captured in BIM includes [16-18]:

- Data: vendor manufacturer/ information (model, serial, part numbers), information of location (room, building, floor, zone), description of (type, equipment group, asset number, status and criticality), and attributes(weight, power, energy consumption)
- For system and equipment: plumbing, fire and life safety, electrical, special equipment, HVAC, sensor and networking systems.
- In the case of documents: includes warranties, specifications, operation, and manufacturer instructions, certificates, test reports and maintenance manuals.

6-Space management: CAD files are traditionally employed for space management, whereas the identifiers are used for displaying space attributes and having several updates. The two primary issues with the current practices include incompatible naming conventions and taxing attribute. The BIM can predict the attributes of space and host space as required for identifying the underutilized spaces, managing the move process and comparing the planned space utilization with the actual plan, simplified space analysis, forecast space requirements, This information can be useful for different purposes like office schedules for efficient maintenance and compilation, precise identification of spaces for different purposes and the assets for different events, control of spaces and optimal assignment. The insurance purposes are fruitful for FM personnel to view and reproduce how their building was regarded prior to remodeling [19].

7- The feasibility and planning studies for the purpose of noncapital construction: The renovation, remodeling and demolishing of the existing buildings is within the responsibilities of FM. The BIM can assist in analyzing, remodeling, planning, designing, demolition or renovation of work. BIM can also help in modeling the planned work more extensively including visual characteristics of interiors and exteriors of the project's surroundings, it can be easily estimated along with the type and model of equipment. The historical data, such as cost for constructing and designing of the current projects, labor, and materials is being elicited from the model which is linked to the data storage [10].

8-Emergency management: The energy management includes emergencies occurred from humans (utility failures, epidemics, spill of chemicals, fires, epidemics), the natural disasters include (tsunamis, earthquakes, tornadoes), the internal disturbances account for (demonstrations, riots, violent strikes) and attacks occurring from (nuclear, biological wars, terrorism). The BIM can help the emergency responders in identifying and locating the most important emergency problems and through the graphical interface the hazards are being pinpointed. The spatial information obtained from the BIM can be useful in identifying the hidden relationships occurring between environmental risks and evacuation routing position therefore the uncertainty in emergency decision making is reduced. As and when the emergency conditions are specified the requirements of mitigation can be discovered and based on it prioritized. Detailed information could be provided through BIM prior to the emergency units arrive depending upon the situation of emergency. During the situation of fire happening in a commercial building, and to find the exit for evacuation it will be helpful to identify the nearest electrical panels, hydrants, floor plan and hazardous materials of the building. Whereas if earthquake occurred, BIM can guide to recognize facilities which includes evacuated shelters, bed space, quantity of supplies etc., In case of emergency, BIM can not only be used for FM personnel emergencies, but that to serve as modeling tool, and to reduce the possibility of emergencies that might result in damaging, which can be appraised and further response plans can be examined [20].

9-Controlling and monitoring energy: Sustaining economy could be realized through considerable contributions of energy efficiency improvement within the buildings. The personnel of facility management count on energy management systems for controlling and monitoring energy, which the energy usage could be measured in a project in real time or at zone level over a long period of time. The important issues that are arising with these systems include floor plans of new building and monitoring of equipment such as (terminal boxes, diffusers, ducting and thermostats) updating and maintaining visual information that are nearly expired. To convert the floor plans into the energy management system graphics a large amount of duration is being devoted. In the graphical representations are found to be lacking in the lack interconnectivity in some cases like lining of different volume of air boxes to air

handling units. However, it is found that the equipment and components that are visualized is well isolated from other building user and features and found to be lacking in the details of the desired level [21].

In order to analyze the behavioral model of building BIM can be used to simulate the energy systems work based on the different arrangements of buildings and in order to discover the efficient energy solutions and the BIM-based visualization environment, energy consumption and integration of occupancy sensors can be controlled easily. For instance, taking the corrective measures are possible when a room is not occupied, like when the lights are switched off with remote; looking into the permanent resident room along with their profile, emails or text messages sent to them for providing suggestions to reduce the consumption of energy. BIM can also be applied for tracking the use of historical energy based on occupant, zone, room, also comprising with historical information for visualizing the objects in order to analyze and predict the energy consumption behavior and as a result it can support for the conservation activities and budgeting related to energy [10].

10-Personnel training and development: Training is normally handled via site visits, self-study, presentations and hand-by-hand demonstrations where the requirement of time is more, intensive preparation and entirely depends on the trainers' capabilities and experience. BIM can help trainees to use the facilities, components, equipment, building spaces can be investigated and the pertinent semantic information can be reviewed. This will lead to better perceiving of the assigned tasks and work zones, hence aid to perform new responsibilities sooner and as a result the BIM post-training appraisal can be performed easily in order to assess the preparation of trainees for the newly assigned tasks [10].

2.4 Definition of data requirements for the requirements of BIM-enabled facilities management:

The major concern involved in supporting BIM-enabled facilities management is for discovering the date requirements and for identifying the data throughout the life cycle of the project [10]. The data are categorized into two types namely geometric and non-geometric. The geometric data for the needs of BIMs to be implemented are mentioned below:

- Accurate for all the building components, including mechanical, structural, architectural, plumping, electrical, site plan including safety access and fire protection systems; annotated, labeled and colored spaces as per the FM guidelines
- Accurate as built-up model to the buildings for main utility lines;
- Precise telecommunication representation which includes proper annotation and placing of outlets;
- To manage different components present within the model as Logical object tree organization;
- To build in the schedules as per the requirements of the model
- Precise and proper requirements for plumping, mechanical and electrical equipment to undergo maintenance on the basis of technical specifications.

Whereas, the classifications of non-geometric data requirements include:

- **Service zone**: building, site, floor, zone and room
- **Group and type:** Based on organization specific categories or Industry Standards such as (Uniformat, Master format, or Omni class)
- **Manufacture and vendor data:** Manufacturer, Serial Number, Model, Vendor, Acquisition Date, Warranty Usage Warranty Expiration Date
- **Specifications and attributes:** Specifications like Unit, Type, Lower and Upper Limits, Value and Description and attributes such as spare parts, weight, energy consumption, power.
- **Operation and maintenance data:** maintenance and activity status, space occupancy data, maintenance history.

2.5 Obstacles of BIM implementation in FM

BIM when implemented to FM, the information related to building can be managed, attained, maintained and can be employed in a specific and automated manner during the entire life cycle of the building. On the other hand, there are numerous organizational challenges that are coming up while adopting the BIM to FM which includes the technical ones [10]:

- Diversity in FM and BIM software tools;
- Absence of cooperation amongst the project stakeholders for model utilization and modeling;
- Cultural barriers towards opting a new technology;

- Difficulty in the involvement of vendor's software as per necessity which includes segregation among the vendors, competition and absence of interest
- The requirement of undefined fee structures for creating additional scope;
- Ambiguity in obligations and roles for presenting data to the databases/model and the maintenance of model;
- Absence of validity and real cases regarding the truthful return of investment
- Organization-wide tendency to refuse the acceptance of requirement for throwing money at training, new software tools and infrastructure;

2.6 Employing BIM tool for the maintenance of building

An interview germane to a case study was carried out by using FM information system manager amongst numerous owners [22]. The FM manager indicated the use of MS Excel file for collecting data for the equipment from the contractors and designers through Automaid software for feeding the information onto their CMMS (Computerized Maintenance Management Systems). The MS Excel format is reported to be used for the past 14 years. The importing of details was already not a problem as per the CMMS perspective. The different ways in which MS Excel file from BIM model for importing the data automatically can be added onto CMMS software was the main focus of this case study. The BIM tool chosen for the caste study was Revit MEP and the authors focused the problem on maintaining the MEP system. Shared parameters can be employed for various projects and can be exported to external database which is hold through investigation of the Revit MEP function. Subsequently, when the aforementioned parameters are being created for the purpose of maintenance, then Revit template could be mainly built. The Revit data can be exported through DB Link connections to an external database such as Access was also investigated in the study. A case study of an educational facility was performed with the aim of accrediting the proposed method for automatically updating information between BIM software and FM software.

2.7 The procedure for database linkage between BIM and FM

The first step is to prepare the template in Revit, further to add the required parameters to the Revit Model as the use of database export was essential, when the information needed and data fields are defined through investigation of the existing FM software and having interviews with the FM staff. The shared parameters were used mainly because it can share a multiple of families and projects thus can be exported to ODBC. Project parameters can only be used for current project and cannot be shared with other projects, since the parameters are to be used for different projects. As a result, the shared parameters are considered very essential.

A schedule for single or multiple categories mainly on a basis of the requirement of the end user could be created using Revit, subsequently, the different schedule types can be selected. Moreover, the template created in Revit MEP can be saved in the MS Excel file format or it can be exported to ACCESS as mdb file with the help of DBLink based on the acceptance of import format by the FM software. The mdb file can be imported back to the Revit model and any change that happens during ACCESS can have the corresponding change automatically to the BIM model after getting imported only if the data behind 3D visualization of BIM Model is calculated with DBT link. All new fields will serve to be shared parameters in BIM model when new fields are added by the users in the ACCESS database as a bonus [23]. The authors concluded based on the results obtained that template can be used repetitively without needing the succeeding projects to be rebuilt if it is built once in Revit and different data is not required by the FM software. The template would be populated automatically and considered to be ready for export when the required data is input by the contractors and designers during modeling process.

3.Integration of knowledge management and BIM

The comprehensive system as required by BM facilitates capturing/retrieving knowledge/information regarding every pertinent component for better planning and analyzing the different ways in which any buildings would be deteriorated or served. Moreover, the lack of knowledge/ information may have serious repercussions on maintenance plan and replication of mistakes for other building elements. Also, numerous applications as regards KM with the aim of implementing BIM have been improved for enhancing the performance of BM process as reported by Ali et al. [24], Lepkova and Bigelis [25], and Fong and Wong [26]. Sharing, capturing and reusing knowledge by the stakeholders; who can lead in facilitating the communication between parties, selecting the most suitable contractor, identifying problems and allowing feedback for the completed work or task, are included as the functions of these applications. In spite of the beneficial functions as provided by these applications, it is found that when a knowledge case of a maintained element is retrieved, then they are lacking the capability of searching through all the affected building elements. The BIM technology advancements can change these work applications. The communicating knowledge between stakeholders in reporting and describing the problem, or between the

contractor and BM manager in quotes price negotiations, estimation and payment processes would be facilitated through KM systems for BM. In addition, maintenance and shared details and knowledge about the cases throughout the life-cycle of the buildings for all the pertinent components of a building could be improved if the KM systems are integrated efficiently. Therefore, integrated knowledge-based BIM system which enables retrieving/capturing information and knowledge on BM are expounded in this research on a basis of the building elements for any type of maintenance operation which could be affected.

3.1The definition of case-based reasoning module (CBR)

In order to eliminate ambiguity regarding integrated knowledge-based BIM system, the exact definition of CBR is needed prior to explanation of the scenario used. In order to eradicate problems for mankind, reasoning by reusing past cases as a potent and frequent way of application is taken into account through the cognitive psychology research. The CBR is capable of utilizing the precise knowledge of the previously gained problem cases for identifying a solution for the new outcome of problems, since the general knowledge of a problem area or making relationships between the problem descriptors and findings do not need to be counted immensely. The future problems that will arise could be eradicated and immediately are available because a new experience is maintained each time whenever a problem is solved, so that the CBR is regarded as an ideal approach towards increasing and preserved learning [27]. A typical CBR system can operate with regard to the following 1) define the existing problem situation, 2) solve the current problem based on retrieving the most similar case, 3) find any similarities between projects conducted in the past and new one and, 4) update the system with the help of learning from this experience and to 5) evaluate the proposed solution.

3.2 The framework used for integrated knowledge-based BIM system

Similar to the process of any conventional BIM model as per (the BIM application used for this system is Autodesk Revit [28]), the building information model needs to be stored in the application of BIM. In order to enter maintenance date as a measure for the whole components of the building, the building information needs to be updated after construction. Additional fields added to Revit BIM model for accommodating the maintenance data needed are regarded to be an integral part of improved system. When the BIM model is uploaded in the system, then these fields can be added automatically in the BIM application. In order to identify the maintenance case that could be similar to any category of the adopted components of buildings, the system requires users to fill up these fields. The maintenance problem and the solution which is adopted are very crucial for each case description and the requirement of searching the system library for referring to any similar case is needed when the maintenance team faces new problem and users are able to describe the new case through the system interface. In addition, the users are capable of modifying these weights to better demonstrate his/her evaluation regarding case attributes when the default weights assigned to these attributes will be used by the system. Then, the CBR library which is able to retrieve all similar cases and rate them with regard to the similarity index could be searched by the system. Further details regarding a particular case from this search result would be demonstrated if they are selected by the users including all information about the maintenance of work for the components of the buildings that are affected to the retrieved case. As a result, it will provide much more clear information about the further possibility of maintenance work to other pertinent components of the building. When an element is selected through a BIM module, the whole building elements maintenance data regarding myriad cases to be demonstrated from any interface would be practicable, which means all the information, particularly the information of maintenance would be retrieved. Apart from this, when CBR module is used based on a maintenance case searched in advance, the information pertinent to the maintained element and any other affected components by this maintenance could be retrieved [29].

4. Integration of BIM and asset management

In order to achieve an effective asset management, the availability of proper and authentic information about assets plays a key role, since planning, decision making and execution of activities related to assets are supported by that. Thus, if a structured framework for creation, collation and exchange of information about assets using BIM is provided, then supporting effective asset management comes to fruition. On the other hand, information pertinent to the whole life cycle of assets through BIM is strongly needed [30].

4.1 Advantageous of the combined approach

A report commissioned by the Innovation and Skills (BIS) and the Cabinet Office in 2008 and UK Department for Business [31], suggests the usage of BIM:

- There would be even more advantageous at the stage of post-construction.

- If it is extended to the whole life-cycle of construction projects, then between £1 billion and £2.5 billion annually savings within the UK could be realized in the construction phase alone.
- The expectations regarding the long-term in-service performance and the outcomes of design-stage decisions over life cycle performance and cost could be improved significantly.
- Decrease the project start-up costs through availability of better information at the beginning of the project.
- Decrease the operational and construction costs that stem from reduced construction defects.
- Enhance life cycle management when consolidated design and construction information as a single source of data are available.
- Improving energy efficiency and reducing carbon emissions through facilitate better modeling of infrastructure resilience and identification of the most effective opportunities for them.
- Decrease management process costs arising from incomplete data.
- Enable optimization of operation and maintenance costs.

4.2 BIM justification based on its Return on Investment (ROI)

There is a reluctance to employ BIM due to its high cost for implementing, which could lead to an owner's willingness to pay for that during contractor's decision to use a virtual design and construction (VDC). If data on the possible cost savings of implementing BIM is collected and analyzed, and then the owners would be convinced to pay for implementing BIM as additional fees.

4.3 ROI Definition

In order to compare the benefit achieved from an investment in regards to the costs involved, ROI is regarded to be one of the most useful ways for evaluating the proposed investments. As quoted by Feibel [32], it is stated that ROI is usually being calculated by taking into consideration the ratio of profits attained as sequence of investment over the price of investment which is multiplied by 100, where a percentage of it can be used as the indicator of performance that is being established. It is also mentioned that ROI can be measured as the ratio of net savings to costs, when it is applied to BIM due to its potential savings resulting from this technology that designers, contractors and stakeholders would be benefited from its implementation as a source of great profit.

4.4 ROI associated with using BIM

In this research as carried out by [33] a loose framework has been explained to quantify the savings cost that are integrated by using BIM. By doing so, three phases were organized which includes; data collection, analysis and ROI estimation as discussed below:

4.4.1 Data collection:

The recommendations of a Company's X personnel and their desire to study a diverse sample of project types and scales and entirely based on the selection of three sets of comparable projects. A recently constructed BIM-assisted project was picked as to compare it with a similar project that was constructed in the absence of BIM during the period of each study. The original contract value, total cost of change orders and finally the building size, ,duration of schedule delay that was or was not experienced, original schedule duration, type of construction are used as metrics to justify their similarities.

4.4.2 Analysis:

The analysis of each project was made individually on the basis of comparison with the metrics of its counterpart such as number of RFIs, change orders and the delay during the proportion of project was experienced where it was applicable.

4.4.3 ROI estimation:

The indirect and direct costs which would have been saved by the owner related to the constructed projects excluding the utilization of BIM were estimated based on the archived cost records from the Company X and the collected data. By using BIM, the direct costs that are involved during the sum of all the BIM preventable change orders along with other costs that can be avoided by the can be eliminated. The total cost of BIM includes the indirect cost which is the preventable schedule over runs to the owner due to the delay in finishing the project. The costs related to this category include the architect's contract administration fee, daily cost of contractor's general conditions, cost of interest on the owner's construction loan and the developer's administrative fees. The discoverable issue is multiplied with daily cost penalties as outlined by the project contract especially when the

number of days belonging to each of the project are attributed to the BIM, also the categories related to indirect cost can be calculated. The indirect savings related to avoidable change orders in terms of direct savings and time are later summed up for estimating the total BIM related savings. The cost of BIM has to be subtracted from total estimate in order to find out the total savings involved with BIM. Finally, the ROI value can be determined by dividing the net BIM savings with the total cost involved with BIM. The steps involved can be replicated and applied for assisting the BIM related projects in order to get the estimate of the total cost saving by using this technology.

The obtained results from applying the BIM in the above mentioned case studies are based on three organized phases which indicate that high return of investment is possible. The benefits gained can be categorized as measurable, qualitative and reduced schedule over run. The followings are the advantages of using BIM during pre-construction that leads to the influential impacts on ROI:

- Collaboration amongst the various major contradictions happening during the period of preconstruction ,disciplines and documentation

- Quick detection of 2D errors and omissions during the construction drawings;
- The possibility of supplemental field drawings and produce in-house shop from the BIM effort;
- Accelerated discovery of dimensional discrepancies in the construction documents;
- The practicability of recognition and prevention regarding direct clashes between disciplines; and
- Resolution of the building grid

4.5 Benefit realization method (BRM):

In the normative literature, the definitions of realization management (BRM) benefits vary based on its propagation [34]. It is defined as the process that realizes the benefits that are being achieved and are the one that manages the unexpected ones by Farbey et al. [35]. According to Bradley [36] BRM is "the potential benefits arise from the investment in change that are actually achieved, since it is the process of organizing and managing," (p.23). The expected benefits of capital investments such as BIM can be ensured through enacting BRM [37–39]. In order to realize the benefits of implementing IT as per Peppard et al. [37, 39], five underlying principles are revealed based on the analysis of the normative literature and it is suggested that the process of realizing the business value of BIM could be underpinned if such principles are employed. These principles are discussed hereinafter.

1-BIMtechnology has no inherent value: Both asset owner and the project team would make loss on the implementation of such technology and only if it is used effectively, then its benefits can be achieved. In general the management and operations of the facility are not regarded in the formative stages, since the asset owners do not engage in the design and engineering of a new project. In addition, the location of the site and its real construction costs are emphasized rather than focusing on the problems that arise during the operation and maintenance by the asset owners. The information required in COBIE (construction operation building information exchange) file and how it is integrated with their existing systems in order to achieve the goals of the project must be fully in a charge of asset manager. If all the parties involved in BIM execution plan in the form of employers' information requirements would communicated effectively at the beginning of any projects, then all project members could take benefit from its implementation.

2- If people and organizations are enabled to do things differently, then BIM benefits would be achieved: The advantages involved in the utilization of BIM would be achieved only if the project team members, individuals, and the asset owner carry out their roles in a more proper and effective way. If BIM is adopted by an asset owner, then it alters their value proposition as intra and inter organizational processes that may need to be re-designed with the aim of facilitating the new work practices.

3- The benefits of BIM are solely released by business managers and users: The upsides originated from BIM would be realized through the alteration and innovations in different ways of working. As a consequence, these changes could be made by solely the users, manager's customers and suppliers with an asset owner's supply chain. Hence, in order to take the advantage of realizing its business benefits, project team members and IT managers involved in delivering the building information model cannot be held accountable [37]. In a fundamental way the staff involved with the utilization of BIM to conduct daily business activities must be given the full responsibility

for ensuring the benefits of materializing [40]. In order to be ensured regarding the involvement of staff with the investment in BIM, this principle needs to be acknowledged by them.

4-All projects exploited BIM have results; however, all outcomes are not regarded as beneficial: Having said that, there are numerous instances pertinent to the failure of the projects in which technology is used. Therefore, it must be ensured that negative results are avoided and the positive outcomes should deliver explicit business benefits [37].The direct benefits will include:

- Utility costs reduction
- FM labor utilization savings
- Data accuracy
- Space optimization
- Configuration management
- Comfort management
- Fuel and material savings
- Improved inventory management
- Regulations compliance

5-Planning and managing the benefits arise from BIM implementation when they are actively managed: The major advantages of the utilization of BIM would come to fruition only if asset owners plan carefully and manage the defects occurred at any time. Moreover, when the technical implementations are completed, managing for the benefits does not stop. In order to measure the overall business results arising from a building information model employed, a performance measurement system, like 'Balanced Score Card (BSC)' or 'Work flow Measurement Model' to manage and maintain the asset is needed by the asset owners.[41].If realizing both operational and financial goals are the major concern of the asset owners, then governance, performance measurement, change management and stakeholder management should be done properly by asset owners through managing the implementation of BIM with a disciplined approach to portfolio the management.

5. Conclusion

The BIM was recognized as a solely beneficial tool to be used in the designing and construction phase. However, it has been recently used throughout the whole life cycle of construction comprising construction, pre-construction and post construction. Among these, post construction phase that includes building maintenance and asset management is of great boon for fulfilling the requirements as required by the asset owners and facility managers through declining the costs that are associated with the occurred deficiencies. Therefore, this paper has mainly focused on scrutinizing the utilization of BIM for the building maintenance and asset management. So, therefore the outcome of the author's investigation it is plausible to conclude that exploiting BIM can lead to the following aspects:

- The gap occurring between design and construction and facility management can be bridged through enhancing the practicability of sharing knowledge between them; and
- To support the effective asset management through providing information throughout the whole life cycle of assets.

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