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Adoption and Scope of Building Information Modelling (BIM) in Construction Industry of Pakistan

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Abstract: Building Information Modelling "BIM" is becoming a better known established collaboration process in the construction industry. Owners are increasingly requiring BIM services from construction managers all over the world, but the adoption of BIM in building construction industry of Pakistan is very slow. Globally one of the great advantages of BIM is the ability to create an accurate model that is useful throughout the entire life of the building, from initial design through occupancy and operations. The benefits of BIM are evident in its capability.
There are two objective of this research work, first to identify the problems faced in construction management and secondly to identify the barriers in adoption and implementation of BIM in local building construction industry.
The research objectives were achieved through literature review, case studies, and questionnaire. First, the research identified the uses of Building Information Modelling for construction industry, and then identified the problems faced by construction managers in construction management. On the basis of literature review a questionnaire was prepared and surveyed to identify the source of construction management problems in the building construction industry of Pakistan. Then, the project examined the uses and benefits of BIM in the construction of a research facility by minimizing the sources of many identified problems in questionnaire survey. Finally, the project concluded and recommended the ways to increase the use of BIM in building construction industry of Pakistan.

Keywords: BIM, Construction Industry, Construction Management, Labour Productivity

1. Introduction

The construction industry showed progressive reduction of labor productivity in the early 1960s. Meanwhile, the non-agricultural industries, such as the construction industry have increased the productivity of labor. The reduction in labor productivity in the construction sector requires more hours of work per contract dollar amount. This shows that the construction industry is in deficient to developing the concept of labour saving and to save economy.
The role of participants in planning and construction phase is fragmented in traditional construction project delivery approach which is design bid build approach. In other words, it hinders the mutual participation of construction manager or the general contractor during the design phase of the project.
Secondly, the use of traditional and common two-dimensional CAD drawings does not promote a genuine partnership approach. Engineers and architects produce their own fragmented CAD documents for owners and contractors which are usually consist of errors and usually give rise to conflicts of information, which leads to inefficiency in labor productivity. So the construction industry has been under great increasing pressure to improve its practice (LATHAM, 1994; EGAN 1998, HOWELL, 1999). Fragmented nature of construction industry, the problems in communication and coordination between project participant, informal and unstructured learning process, adversarial contractual relationships and lack of customer focus are factors that inhibit the industry performance (COOPER ET AL 2005).
Furthermore, the manufacturing industry workers are paid higher wages than the construction workers. Because of high cost and risk associated with new technology construction firms do not have as much as resources and incentive to invest in research and development. Construction industry is always very slow to adopt new technology due to local constraints and practices even when it is necessary to use new methods and technique then applied for a specific project only. In late 1970's, the first steps was taken towards the use of 3D solid modeling which was very late as compare to manufacturing industry. Because at this time, they were doing all design and analysis of their products on 3D model. In the construction industry, the use of 3D modeling was caught up "by the cost of computing power and later by the

successful widespread adoption of CAD" (Eastman, 2008).

Building Information Modeling (BIM) is one such approach which is now considered as a whole new process and methodology rather than just a technology. Building Information Modeling (BIM) is getting increasingly valuable in construction industry.

Therefore, the basic objective of this research is to study BIM and BIM tools to determine its benefits for construction managers. In this research, the uses of BIM which include 3D coordination, visualization, cost estimation, construction planning and monitoring, prefabrication and record model are discussed in detail. And the source of these common problems of construction managers is identified. Finally a model is proposed to implement BIM as BIM tools has potential to minimize most of these problems.

2. Research Methodology:

Literature Review: Literature review is used to systematically review earlier writings so as to learn more about the subject and other topics which collectively establish the context of this study. The goal was to gain a comprehensive understanding of the Building Information modeling and how the BIM is currently addressing the problems of construction managers in construction industry. It was completed in two phases. Firstly, it was used to gain a comprehensive understanding of BIM, BIM scope for construction managers and its adoption in construction industry. Previously conducted researches were reviewed to obtain knowledge about barriers and challenges which inhibits BIM adoption in industry.

Case Study: A case study approach is adopted to understand the solution of problems related to construction management and how BIM is minimizing the source of these problems.

Survey Questionnaire: Surveys are part of quantitative research and the focus of quantitative research is on objective measures rather than subjective experience. Surveys include cross sectional and longitudinal studies using questionnaires or interviews for data collection with the intent of estimating the characteristics of a large population of interest based on a smaller sample from that population *(RUIKAR, 2004).* Due to the nature of research question, a survey approach was used to obtain primary research data. The reason to select questionnaire is because questionnaire offer several advantages as they are widely distributed and low cost, interviewer bias is eliminated, anonymity of respondents, respondent can answer at leisure. In addition to that, *NAOUM (1998)* described questionnaire as the most popular form of getting primary data from a relatively large number of respondents within a limited time frame.

3. Literature Review:

Building Information Modeling (BIM):

The Building Information Model is primarily a three dimensional digital representation of a building and its intrinsic characteristics. According to the National BIM Standard, Building Information Model is "a digital representation of physical and functional characteristics of a facility and a shared knowledge resource for information about a facility forming a reliable basis for decisions during its life-cycle; defined as existing from earliest conception to demolition" ("About the National BIM Standard-United States", 2010). National Institute of Sciences (2007) defines BIM as:

"A BIM or Building information model uses digital technology of last generation to model a computable representation of all the functional and physical characteristics of the facilities and concern information during its life cycle and is intended to be a source of information for the service owner/operator to use and maintain that service during its life cycle."

According to Autodesk (2002), BIMs have three basic characteristics. Create and operate in digital databases for collaboration. To manage the change through these databases in order to make a change in any part of the database is coordinated with all other parts. Capture and preserve the data for reuse by adding industry-specific applications.

The findings of NIBS (2007), MAUNULA (2008)&SUCCAR (2008) that acronym BIM is used in three different ways. BIM can refer three different schools of thought which consider BIM as:

i. A product
ii. An activity/Process
iii. A system , a whole new concept

Problems faced with Construction Management:

In a CAD project, after the hundred percentage construction documentation and addendum and revision information has been turned over to the contractor, construction begins. Before the first scoop of dirt is moved, it is the construction manager responsibility to verify that the immediate information need is adequate and the most recent. Further issues for the project need to be identified and put on a path of resolution for all scopes of work. In theory, this review period for the project allows the construction manager to identify issues and give responsibility to the correct subcontractors. In itself, this is an arduous process.

Analyzing and overlaying CAD files and sheet drawings is time consuming work, it lack in visibility and it is prone to errors and missing information. In reality the construction manager is often cannot juggle managing the project documentation, the trades, the field management, and the construction managers own management team.

Advantages of BIM for Construction Management:

Each professional and user will have a point of view about the benefits of BIM in construction industry especially for construction managers. Their judgment approach or orientation may be different but as whole they are agree that BIM has remarkable effects on construction management.

a. Visualization

Building Information modeling (BIM) is an excellent visualization tool. It can provide a three-dimensional virtual representation of the building. It can help the contesting companies during bidding process because it can provide a better understanding what they have to construct and how it will look like after completion. It is possible due to renderings, walkthrough videos extracted from BIM model by using BIM tools.

b. 3D Coordination

Coordination is very important for a construction manager, especially when dealing with dense urban environment or challenging site. Coordination involves working and communicating with subcontractor, supervisors, materials suppliers, fabricators and equipment suppliers. In addition to juggling the scheduling, managing the budget, sorting through constructability issues, and managing relationship, the construction manager is also responsible who is doing what work on a project. Therefore the coordination efforts in advance of construction will reduce design errors and provide better understating of work ahead of time to be done.

c. Prefabrication

Offsite fabrication required considerable planning and accurate design information. It is becoming more common for contractors to fabricate component offsite to reduce labor cost construction time and better quality control. In offsite fabrication, different component or items can be assembled or fabricate in controlled environment and with greater precision and if any alteration is required then more option are available than site. A ductwork contractor can also use BIM model to installed branches and leave opening where required so that later on diffusers or hood can be installed. Carpenter can also use BIM information to fabricate accurately different size and types of cabinets and wardrobes for different location. Pipe manufactures and plumbers can also have information regarding pipe size, length and location from BIM.

d. Construction Planning and Monitoring

The planning of construction activities or project is basically about its scheduling and sequencing of virtual model to coordinate in time. The progress of construction work can be linked with virtual model to monitor the project schedule and time is introduced as the 4th dimension. To create 4D BIM model, Critical path method (CPM) and line of balance are two common scheduling methods can be used. In critical path method, each and every activity is listed in construction sequence and every activity is linked with another activity. Then time required to complete that activity is assigned on the basis of work break down structure and available resources like money, machinery and manpower.

e. Cost Estimation

Extracting quantities, areas and volume from a 3D model in one of the most useful function BIM technology offers. Cost estimation is basically two step procedure, first is quantity take off from drawings and second is pricing of all items of work. Quantity take off is very laborious and time taking process from 2D drawings and it also has a chance of error in calculation. But it is very easy to take off quantities from 3D BIM model and can be import to a cost database.

f. Record Model

At the end of every project, owner has to deal with a huge amount of documentation with end of project information. In most of the cases owner are not specialized to understand and handle all the construction related information from 2D drawings. So it is better if they have a 3D model of their project. By using BIM tools, after all alteration and as build variations, a record model of BIM can be obtained and handed over to the owner by the construction managers at the end of the project. The recorded model contains all the information of as build and shop drawings from the subcontractors. On the other hand each object properties of the model may also include links for operation and maintenance, submittals and warranty claims and information.

g. Project Cost

By Using BIM, the productivity of design member is increased drastically and more work is done with

less resource and people. A small design team will not only reduce the overall cost but also there is less chance for interruptions and miscommunication as fewer minds are working on a project. So by this collaboration is increased. Because the documents are coordinated by the main BIM server or one common data base computer and therefore can be more complete and refine with less error, the cost of various changes at different stages is reduced.

4. BIM Tools

Table 1: Respondent Profile

Product Name	Manufacturer	Primary Function
Revit Structure	Autodesk	3D Structural Modeling and parametric design
Revit Architecture	Autodesk	3D Architectural Modeling and parametric design.
AutoCAD Architecture	Autodesk	3D Architectural Modeling and parametric design
Cadpipe HVAC	AEC design group	3D HVAC Modeling
Cadpipe Commercial Pipe	AEC design group	3D Pipe Modeling
AutoCAD MEP	Autodesk	3D MEP Modeling
AutoCAD Civil 3D	Autodesk	Site Developer
Revit MEP	Autodesk	3D Detailed MEP Modeling

5. Initiating with BIM

BIM is not only a new technology, process or system; there are always some stages, phases and processes behind the technologies. The Building Information Modelling should also be seen as an initiator and founder of significant process improvement in the building industry. This part describes some characteristics, benefits and barriers of the Building Information Modelling.

6. BIM as a Process Changer

BIM not only improves the technology but also changes the process of proceeding with design and build. WALTER claims that: "BIM helps to make a better decisions, it can eliminate the abstraction and coordinates among multiple disciplines, including documentation and design. And BIM can integrate detail design, plans, sections, graphics, and processed data which is not possible to integrate in 2D." On the basis of WALTER's argument, the time that is spent on the design of a facility can be cut into half with half the cost. On the other hand, it will not only save money but that also is to reduce the delivery time of a construction project.

7. Data Analysis and Results

a. Respondent Profiles

A questionnaire is distributed through web based questionnaire survey site and about 210 responses were received. This questionnaire was distributed to construction managers and project managers of CA, CB, C1 and C2 Categories Company of Punjab, Pakistan as define by Pakistan Engineering Council.

Table 2: Respondent Profile

Respondent Profile			
1	Designation/Position in Company	Construction managers	63%
		Project Managers	37 %
2	Construction Experience	More than 4 Year	32%
		More than 7 year	44 %
		More than 10 [[[[year	24%
3	Company Category (As per PEC)	CA	24%
		CB	27%
		C1	19%
		C2	30 %

As shown in respondent profile, about 63 % respondent are working as construction managers and 37 5 are working as project managers. On the basis of their construction experiences, all respondents are divided in to three categories. So 24 % respondent having more than 10 year construction experience, 44 % having more than 7 year construction experience and 32 % having more than 4 year construction experience. These respondents are working in construction companies of different categories which is shown in respondent profile.

a. Respondent Knowledge about BIM/BIM Tools

The figure shows that 51 % respondents have medium level of knowledge about BIM, 9 % have high level of knowledge and 28 % have very low level of BIM knowledge. About 7 % claims that they have no knowledge of BIM. It reflects the present BIM adoption situation in construction industry of Pakistan. Those respondent have very high knowledge of BIM probably have working

experience on international project with international consultant and designers.

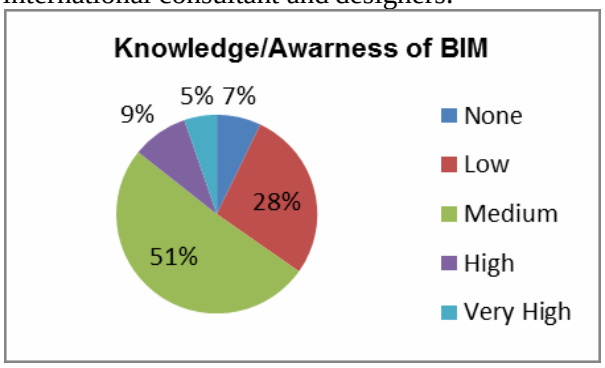

Figure 1: Benchmarking of BIM Knowledge

b. Barrier in BIM Adoption and Implementation

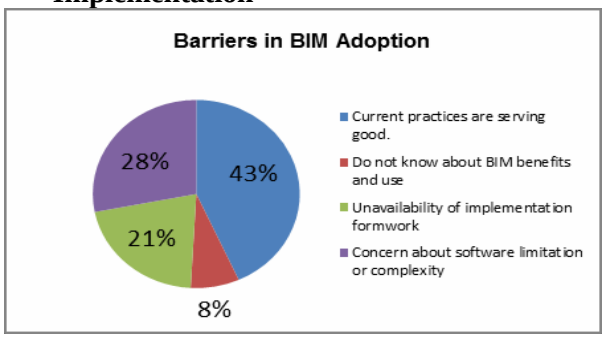

Figure 2: Barriers in BIM Adoption

The figure shows that respondent believe in that current practices are serving best in very high, it is about 43 %. But about 28 % respondents have believe that BIM tools are complex, expensive and not easily available which is a hurdle in BIM adoption. About 21 % respondents claim that every new technology must have an implementation frame work for its adoption in construction industry. It is the common problem with every new technology that people don't know about its uses and benefits.

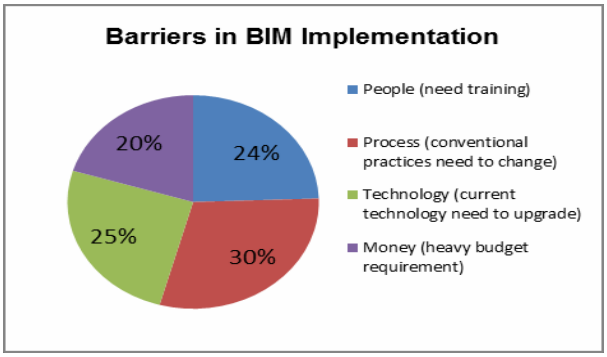

Figure 3: Barriers in BIM Implementation at Company Level

It has been pointed out by 30 % respondents that current practices of construction management need to change and about 24 % and 25 % think that people training and technology up gradation is the barrier in implementing BIM. As all respondent belong to large size construction companies so 2o % believes that money required for up gradation and training is also another barrier.

c. External Constraints in BIM Implementation

Figure shows that the adoption of BIM in construction industry of Pakistan is very slow which is reflecting from response as about 34 % respondents are agreed.

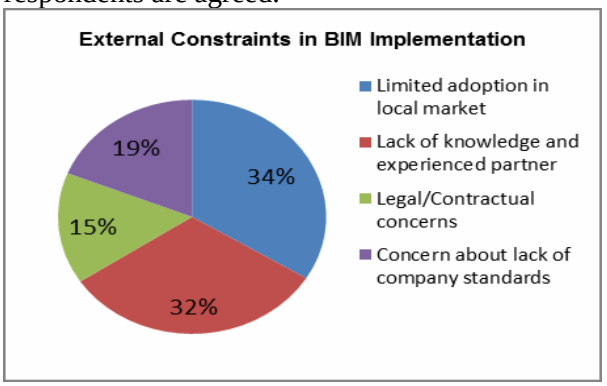

Figure 4: External Constraints in Implementation of BIM

And about 32 % of the respondents believe that lack of knowledge about BIM and unavailability of experienced partner is the main external constraints in the implementation of BIM. So the construction industry of Pakistan need to aware this latest construction management technology and must start with some pilot project. While 19% and 15% are assuming that BIM implementation has external constraints due to lack of company standards and contractual constraints respectively.

d. Problem in Planning and Scheduling

This is revealed from the survey that unavailability of trained staff and interpretability of planning tools with 2D CAD drawing is the main source of problem in planning and scheduling of a project. A small percentage of respondents claim that confusion in construction sequence is creating problem in planning and scheduling.

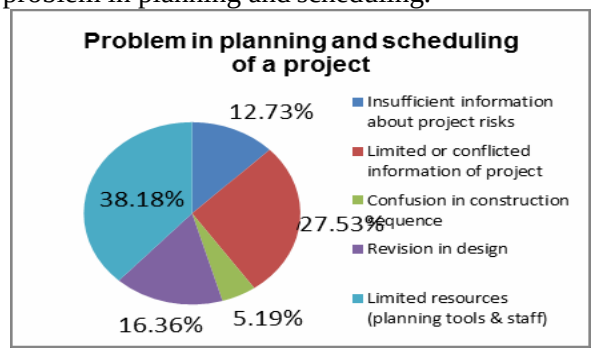

Figure 5: Problem in Planning & Scheduling

e. Problem in Site Coordination

Site coordination refers to the organization of the site, materials, equipment, safety and site security.

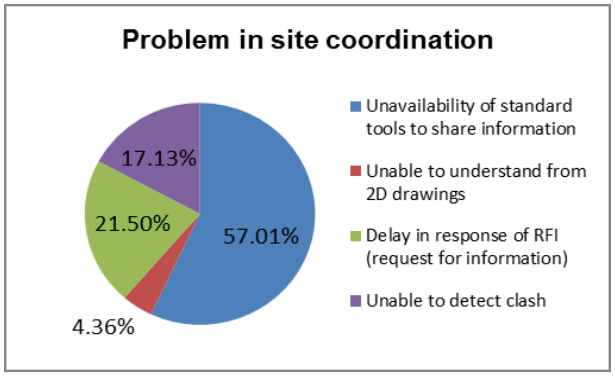

Figure 6: Problem in Site Coordination

Site coordination is very important for smooth running of all construction activity.

f. Problem in Procurement Management

As per site requirement, the construction manager is also responsible to procured required construction items prior to the start of construction activities at site. It is very important for avoiding any delay in construction. The figure shows that delay in procurement is due to low progress of quantity survey department because they have to take off quantities from 2D CAD drawing after coordination between architecture, structure and MEP drawings.

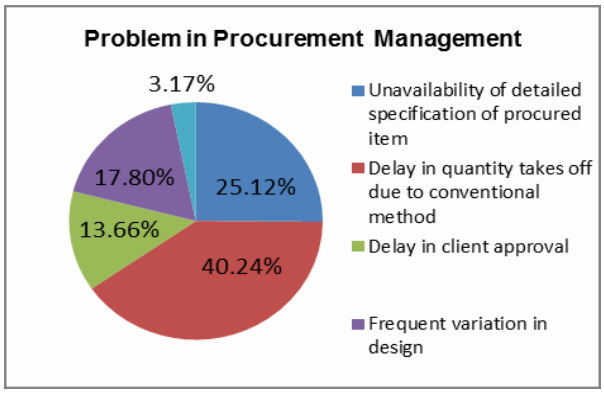

Figure 7: Problem in Procurement Management

g. Problem in Cost Estimation and Quantity Take Off

Cost estimation is consisting of two part, first quantities of all items of work need to calculate accurately and it need to multiply with unit price for cost estimation.

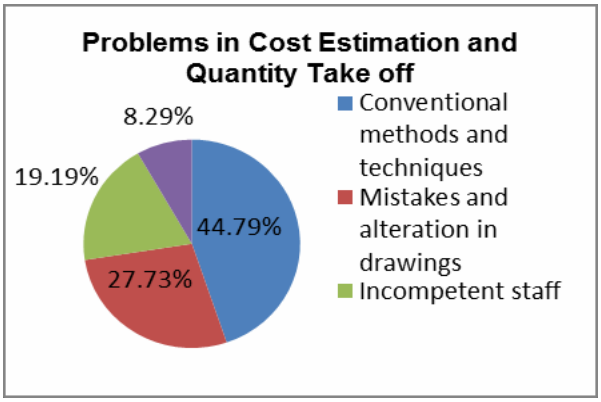

Figure 8: Problem in Cost Estimation and Quantity Take Off

From 2D CAD drawings it is very laborious and time taking and chance of error is always there. The figure shows that conventional methods and tools are creating problems in cost estimation and quantities take off which need to be changed and have to adopt new tools and technologies.

h. Difficulties in Cost Controlling

The construction manager at site is unable to control the overheads due to different reasons like excessive redoing, inappropriate sources allocation, low productivity of labors and machinery and construction delay etc. the figure shows the sources of problem in cost controlling.

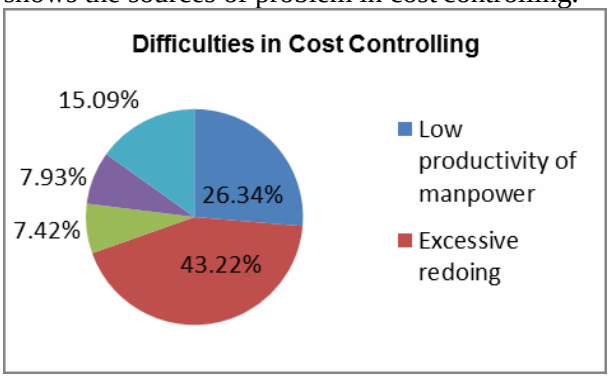

Figure 9: Difficulties in Cost Controlling

i. Problem of Excessive Redoing of Work

Excessive redoing at site is not only the loss of money but also the loss of time. Redoing at site is possible due to many reasons, some of them are avoidable and some are unavoidable. The figure shows the sources of redoing work and respondents experiences about this problem.

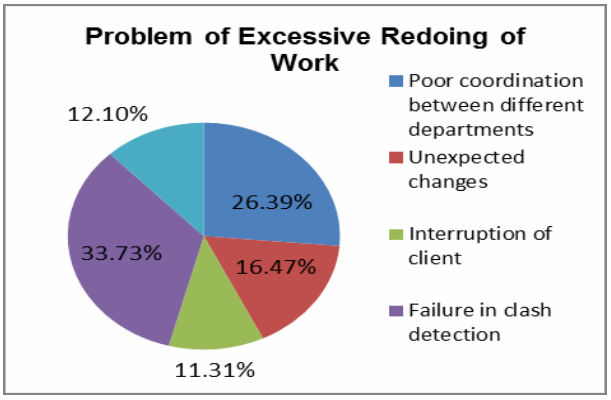

Figure 10: Problem of Excessive Redoing of Work

j. Problem of Low Productivity

The construction managers are facing this problem due to fragmented nature of construction industry. It will results in increase in construction time. This figure shows that improper planning of manpower is the main reason of low productivity.

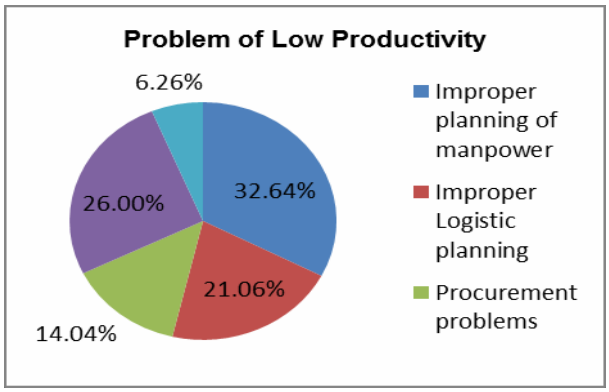

Figure 11: Problem of Low Productivity

k. Increase in Construction Time

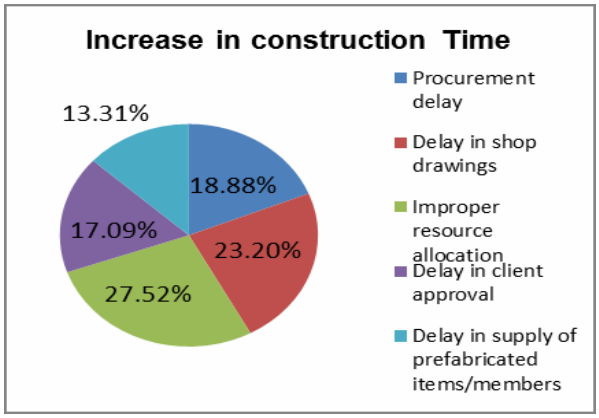

Figure 12: Increase in Construction Time

Construction manager is responsible to complete the project in time as per schedule and assigned budget. Sometime this is not possible to complete the project due to many reasons but construction manager has to minimize the problem which results in increase in construction time.

l. Increase in Project Cost

The owner is always very conscious about the cost of the project. The construction manager is also at stake in construction manager at risk project delivery system. Increase in project cost is the loss of construction manager in CM at risk delivery system. A small percentage of respondents believe that extreme weather condition and activity crushing is the reason to increase in construction cost as shown in figure.

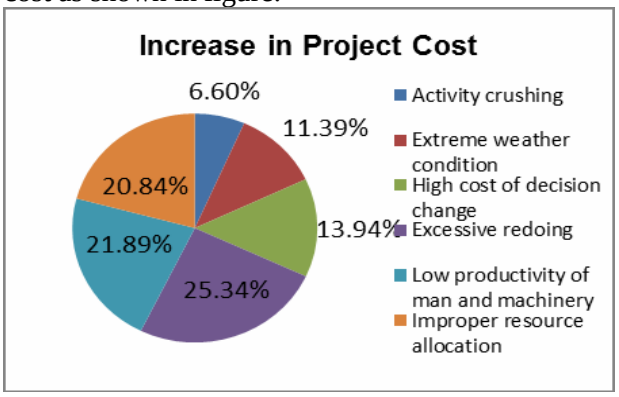

Figure 13: Increase in Project Cost

m. Problem in Facility Management

This phase is usually started after the construction of a project. The figure shows that 42% construction managers have problem in facility management due to limited information for as build drawings especially regarding the service lines. Unavailability of information about building components is also a source of problem in facility management.

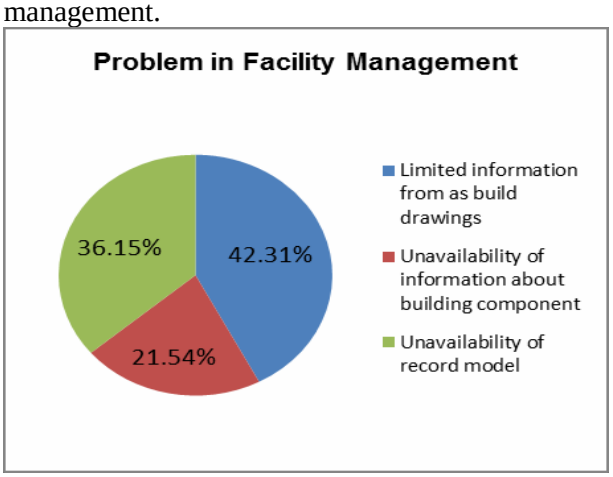

Figure 14: Problem in Facility Management

8. BIM Implementation Model

After gone through literature review and case study, the objective of this research of this study is to make an implementation model of BIM for construction management. This model is implemented it three steps, the first is Initiation, second is Adoption and the last step is Implementation of BIM.

a. Initiation

In the first step of initiation for BIM, the construction management companies have to evaluate the current construction management practices on their ongoing projects. Are they

fulfilling the requirement of company and client? If it is not, then need to identify the problems first, then the sources of these problems. They have to take input from field staff even from their subcontractors as well. Some time it is not possible to identify the problems when you are the part of the system. So if feeling difficulties in identifying those problems then the organization may take consultancy.

b. Adoption

After decision has been made by the management for the adoption of BIM, the first step is activate all available resources for achieve target and target is BIM implementation in the construction organization. Allocate fund for the training of staff, hiring of new staff, purchasing of BIM softwares and training of current staff.

c. Implementation of BIM

To start with implementation of BIM project, there must be a **contract** document which clearly defines the responsibilities of project participants. The intention of a contract, especially when geared towards BIM users, is not to point fingers if something goes wrong but rather to clearly define tasks, responsibilities and rights at the onset of a project. In a typical BIM contract, there are three groups of professionals: the owner, the design team (architects and engineers), and the contractors. These groups are professionals who share similar but different rights

and privileges when completing a BIM led construction project. Contracts on a BIM project determine a contractor's ability to influence and collect and share data throughout the project life cycle.

After successful implementation of BIM on pilot project, evaluate BIM benefits and outcomes. If there is any discrepancy in implementation then identify the route cause so that it must not be repeated on next project. Also share the benefits and outcomes of BIM model with all project participants, it will become the source of awareness and information for others to implement BIM model.

9. Conclusion

The results of the research have shown that the adoption of Building Information Modeling is very slow in Pakistan as compare to other neighboring country, like in 2010, Singapore has planned to shift about 80% of their construction industry on Building Information Modeling.

- The majority of construction managers and project managers have medium level of knowledge about BIM and current practices for construction management is claimed to be the barrier in BIM adoption.
- But if any organization is willing to adopt BIM then people and conventional practices are the major internal constraints.
- "Limited adoption in local construction market" is pointed out as one of the major external constraint in BIM adoption and implementation.
- Most of the problems faced in construction managements can be minimized with the help of Building Information Modeling (BIM).
- Owners should demand BIM on their project.
- Large construction organization should come forward to adopt and implement BIM on their projects by dedicating some sources (like money etc.).
- Building Information Modeling should be taught as a course in professional education, and seminar should be conducted on BIM to show success stories which could be a source of information and inspiration to construction organizations.

10. Recommendation

The findings of this study raise some future research questions that should be addressed in the context of the implementation of BIM. First of all, the developed framework has several limitations as it is suggested as a guideline framework, so its validity needs to be tested in practical scenario to form a rigorous methodology for BIM adoption in accordance with project and organisation based BIM implementation.

Secondly, the study has considered BIM implementation within large contracting organisations because current BIM awareness level in market is not very supportive of small and medium enterprise in Pakistan. But it would be interesting to investigate that what difference it will make when implementing BIM in small and medium contractors as it is been claimed that small and medium enterprise have some unique characteristics . Another interest may be discovering the BIM implementation effect on supply chain relationship of large contractors. As BIM adoption will make new bonds in market relations that will disturb the existing relations with clients, suppliers or vendors so intensity of this drift, need to be evaluated.

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