

Application of Building Information Modeling to Integrate Efficiency in Tendering Estimates on Infrastructural Development Projects – A Review

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Abstract - The aim of this research is to assist clients and consultants in improving the predictive ability of the cost estimating of infrastructure projects in India. This study introduces to the fundamental concepts of construction management, with emphasis on increasing the efficiency of the tendering estimates in all infrastructural projects. The conceptual design of a new facility for design and development of infrastructure projects is used as a case study to develop BIM models in this research. Certain key considerations and problems that are faced are highlighted so as to broaden the understanding of the subject. The investigation represents an exercise in performing the essential tasks that constitute a preliminary budget and plan. The conclusions include observations and suggestions that need to be considered while attempting such a job in practice. BIM can provide an efficient way to do sustainability evaluation, which is always a consideration when making decision, especially for public facilities. This research focuses on how BIM can enhance the implementation of tendering assessment for proposed projects at the preliminary stage. The emergence of BIM improves the efficiency of estimating the cost and duration of projects, as BIM enables users to integrate a variety of data into one model, where these data can be shared among, transferred to, and extracted from different tools for cost estimation and schedule planning purposes which in turn will mitigate the errors incurred in tendering processes. The proposed model consists of five modules, including a data collection module, a cost estimation module, a scheduling module, a sustainability evaluation module, and a 5D integrated module. Plug-ins were developed in the model to link BIM tool (i.e., Autodesk Revit) with Microsoft Excel to ensure automatic data transfer among these modules all within a BIM platform so that owners and designers can quickly generate a reliable construction cost estimate, construction schedule, preliminary sustainability evaluation, as well as construction process simulation

Key Words: Pune, construction management, BIM, Construction time, Cost estimates, Tendering.

1. INTRODUCTION

The Construction industry has a great influence on the economy of all countries. It is one of the parts that provide vital factors for the development of any economy. According to World Bank, the share of construction industry in

developing countries is approximately between 6-9% of the Gross Domestic Product (GDP). (Unit, South Asia Sustainable Development, 2007) The construction industry is an important part of the economy and has a considerable impact on the efficiency and output of other industries. It is not possible having extensive investment in manufacturing, agriculture, or service sectors without construction of infrastructure facilities in place. The construction industry, as a traditional industry with a long history, is one of the many industries that influence the economic backbones of many countries. Its progress is always related to the development of society and the advancement of technology. Construction costing and scheduling are essential factors to be considered at the early stages of a construction project because they are of high importance to investors before moving to the detailed design of a proposed project. This is why owners and decision makers are always eager to know the project's cost and duration at the preliminary stage, based on which they can make reliable decisions on the proposed project within a short period. However, cost estimation and scheduling have been seen as two complex processes in the field of construction engineering and management because they involve the estimation of the quantity of work, collection of cost and duration data, arrangement of resources for construction activities, which are time-consuming and labour intensive, especially for projects with several alternatives. The emergence of BIM improves the efficiency of estimating the cost and duration of projects, as BIM enables users to integrate a variety of data into one model, where these data can be shared among, transferred to, and extracted from different tools for cost estimation and schedule planning purposes.

2. APPLICATION OF BIM TECHNOLOGIES IN CONSTRUCTION TENDERING

2.1 Overview of BIM technologies-

The core technology of BIM is information, which uses model to express information. Through the BIM technology to establish 3D model, the details of the building can be more intuitive display to the owners and construction units. Compared with the traditional design drawings, BIM technology can be more clearly and accurately show the details of all the basic components of the construction

project also can test of some related structure. This technology has attracted the attention of construction units, which are widely used in construction bidding. Many software companies at home and abroad are constantly developing BIM technology software, but this technology also provides a more reliable basis for the construction cycle. Although the application of BIM technology has become increasingly mature, some application of BIM technology in architectural design and budget is very widely, but it appeared to connect the BIM software and the project bidding stage, there is no path to achieve data transfer. The combination of the date and BIM software is not good, which leads to the application of BIM software in the management stage of bidding requires a certain degree of buffer, although a short time is difficult to combine BIM and the construction project bidding management, the application of BIM technology in construction bidding management has become the future of development.

2.2 The significance of BIM technology in bidding

Through the application of BIM technology, the investigation, design and control of construction projects can be come true, which play a very important role in the management of bidding. The construction unit can effectively control the project cost and the whole process of every stage of the construction by using BIM technology, there is a convenient conditions to operation and maintenance. The BIM technology combined with bidding management can not only strengthen the operation and management work but also can effectively solve some problems of the construction bidding, it has important significance for the calculation of quantities bill. The cost of the project and the construction of the whole process can be under the control through the using of BIM technology, the extraction of BIM model and analysis can gain effectively project cost of the various stages of the construction, which can reduces the cost.it plays a very important role to improve the enterprise's own competitiveness. Through BIM technology, the construction corporation can show the design scheme of the project, which helps to avoid change of engineering, this method can reduce the cost caused by engineering change. BIM project will be integrated into the bidding management, which can fully enhance the profit of enterprises. The management of construction projects has become more reasonable, it can also promote the application of BIM technology in the management of the whole process of construction project.

2.3 Application status of BIM technology in bidding

The development of software application of India's construction engineering is very quickly, but there are some

problems in the application process. The different regions don't have charge standard. Because of the emergence of BIM technology, these problems are fully solved. With the continuous development of BIM, it will be widely used in the construction industry and it will become the mainstream of technical software in the construction industry in the future. Although compared with some developed countries, India's BIM technology started relatively late, but the development is very rapid, and has been unanimously praised by the industry. Because the BIM technology has attracted much attention, in order to better promote the application of BIM technology in the bidding process, the Indian government should introduce many policies and mandatory requirements the application of BIM technology in the bidding process, which will prove very important significance for promoting the development of BIM technology.

3. RESEARCH PROBLEM

This study evaluates the workability of the developed model and validates its capabilities of executing the necessary tasks while designing proposed projects at the conceptual stage. The validation will be fulfilled by using a proposed road project, which currently is under its feasibility study stage in an attempt to be built in 2020 in Pune. Its owners and designers will have an idea about the budget and construction schedule of different alternatives in an efficient and reliable way. This validation will present how the model can shorten the preparation time for cost estimation and scheduling and obtain a preliminary evaluation of the project's sustainability at its initial design stage

4. RESEARCH SCOPE AND OBJECTIVES

This research aims at developing a model that integrates BIM with cost estimating, procurement and tendering assessment at a project's preliminary stage for infrastructural projects

Therefore objectives of this research to fulfil the above aim are:

- a) To investigate the errors in existing tendering estimates;
- b) To understand various methodologies that will help in identifying the factors that lead to inaccuracy in pretender estimates through extensive literature survey;
- c) To undertake a questionnaire to investigate the existence and the reasons of the factors that

influence the pretender cost estimates in infrastructural projects in Pune, India;

- d) To develop a model that integrates BIM with cost estimating, scheduling and sustainability to improve the efficiency on the selected case study site.

5. LIMITATIONS OF THE STUDY

The work for evaluation of BIM Models of infrastructural projects is carried out only in the data available for the tenders obtained. The work is limited to the analysis of this data and cannot be interpreted to other areas of work.

6. EXPECTED OUTCOME

Considering the traditional methods applied in cost estimation and scheduling in Tendering processes, this research is dedicated to improve the efficiency and reliability of using these methods by integrating BIM with cost and duration estimation. The main expected contributions are follows:

- 1) Developing plug-ins in BIM tool to enhance the data extraction, which means the 3D architectural model data can be exported automatically from BIM tool to Excel and other analysis applications for cost estimation and scheduling.
- 2) Creating a plug-in in Microsoft Excel for automatic data transfer between it and Microsoft Project.
- 3) Creating new shared parameter "TaskID" in BIM tool, which is used to identify construction activities in infrastructural project to make the model's application more generic.

7. LITERATURE REVIEW

- [1] **Ruoyu Jin, Botao Zhong, Ling Ma, Arman Hashemi, Lieyun Ding (2019) [1]-Integrating BIM with building performance analysis in project life cycle-** this study performed a holistic review consisting of a bibliometric analysis of existing literature, content analysis of selected studies, as well as follow-up qualitative discussion in BIM integration with BPA. The bibliometric analysis identified 60 relevant studies; the content analysis of these studies revealed the research focuses of BIM enabled BPA, including interoperability, semantics, and sustainability rating systems; the qualitative discussion further highlighted the learning

process throughout project delivery stages and addressed the potential gap between 'as-designed' building performance and 'as-built' performance. Overall, this study contributes to existing research by identifying key input attributes and workflow in BPA, reviewing the state-of-the-art research on BIM integration with BPA, and investigating the major research areas, namely, interoperability issues in BIM enabled BPA within the context of life-cycle BPA.

- [2] **Oriabure Ayodeji E. Oke, and Clinton O. Aigbavboa, T. Ijie, (2017) [2] – Assessment of Qualitative Factors Influencing Contractors Tender and Project Success in an Emerging Economy-** this study examines factors affecting tender prices submitted by contracting firms in Nigeria. The study also assess various variables influencing their successful delivery of construction projects from the viewpoint of tendering process and procedure in the quest to improving their competitiveness and success rate locally and internationally. Using quantitative design approach, data were obtained through questionnaires administered on registered construction professionals and contracting firms with adequate practicing experience. Prior to the main data collection, pilot study was carried out to ensure proper validity and reliability of the instrument. From the final survey, technical background of the firms is the major determinant of contractors' tender success while the remaining qualitative factors are found to be important as well. To deliver projects successfully after an award of contract, tender period and quality of available information were identified as major influencing factors. In view of this, there is a need for continuous training and development for management and technical personnel of contracting firms for proper sensitization and awareness of the basic factors influencing tender price and project success. More so, for the contractors to remain in construction business, there is a need for innovation and advancement in the use of new and modern technique, process and practice.
- [3] **Elhag, T. M. S., Boussabaine, A. H., & Ballal, T. M. A. (2005) [2] "Critical determinants of construction tendering costs: Quantity surveyors' standpoint" -** The main of this study aim was to evaluate and rank cost-influencing factors of construction projects considered at the pre-tender stage. Factors affecting costs of construction projects were reviewed based upon research work undertaken in different countries. The analysis and findings of these studies varied on the one hand according to the different aims and objectives

they addressed and on the other, according to the economic environment under which the studies were conducted. The study presented and discussed in this paper, consulted UK-based quantity surveyors via interviews and questionnaire survey. The findings of this study indicated that construction project costs were more affected by architects and consultants than by contractors. This outcome is consistent with many literature views that the project costs are more determined by decisions at the briefing, feasibility and initial design stages rather than by later construction stages.

construction stakeholders, inadequate organizational support and structure to support BIM and lack of BIM standard in Hong Kong. Meanwhile, the key benefits include better cost estimation and control, efficient construction planning and management, and improvement in design and project quality. Practical and insightful recommendations were suggested for policymakers, local authorities, construction firms, and other key stakeholders to increase the uptake of BIM in construction projects as well as to aid them in the quest for full adoption of BIM in the built environment. The practical implications of the research findings were also presented and discussed.

- [4] **Iyer, K. C., & Jha, K. N. (2005) [4] Factors affecting cost performance: evidence from Indian construction projects** - This paper presents the findings of a questionnaire survey conducted on the factors affecting cost performance of Indian construction projects. Factor analysis of the response on the 55 success and failure attributes identified through literature review and personal interview extracted seven factors. Critical success factors obtained by the analyses are: project manager's competence; top management support; project managers coordinating and leadership skill; monitoring and feedback by the participants; coordination among project participants; and owner's competence and favorable climatic condition. However factors adversely affecting the cost performances of projects, are: conflict among project participants; ignorance and lack of knowledge; presence of poor project specific attributes and nonexistence of cooperation; hostile socio economic and climatic condition; reluctance in timely decision; aggressive competition at tender stage; and short bid preparation time. Further analysis indicates coordination among project participants as the most significant of all the factors having maximum positive influence on cost performance.
- [5] **Chan, D. W. M., Olawumi, T. O., & Ho, A. M. L. (2019) / -Perceived benefits of and barriers to Building Information Modelling (BIM) implementation in construction: The case of Hong Kong-** This study aims to identify and assess the perceived benefits of and barriers to BIM implementation in the Hong Kong construction industry. The study adopted a quantitative research design using a structured empirical questionnaire survey. Also, a comparative analysis of the perceptions of the respondents' groupings was conducted. The major barriers to BIM adoption are related to the inherent resistance to change by
- [6] **Ali Ghaffarianhoseini, John Tookey, Amirhosein Ghaffarianhoseini, Nicola Naismith, Salman Azhar, Olya Efimova, Kaamran Raahemifar (2016), Building Information Modelling (BIM) uptake: Clear benefits, understanding its implementation, risks and challenges** - This paper aims to discuss the reality of BIM, its widespread benefits and current level of uptake. The risks and challenges associated with the adoption of BIM, as well as recommendations regarding how future BIM adoption could be developed are also highlighted. The paper begins by introducing BIM as a concept, its definition and purpose, as well as its' historical context. It goes on to examine a wide range of current benefits associated with the use of BIM. The study reviews the current level of uptake of BIM in practice, which is limited in terms of geographic context and level of its industry implementation. Given this lack of BIM uptake it is important to establish the challenges associated with the use of BIM and to provide recommendations for future BIM adoption.
- [7] **Isidro Durazo-Cardenas, Andrew Starr, Christopher J. Turner, Ashutosh Tiwari, Leigh Kirkwood, Maurizio Bevilacqua, Antonios Tsourdos, Essam Shehab, Paul Baguley, Yuchun Xu, Christos Emmanouilidis (2018),** - An autonomous system for maintenance scheduling data-rich complex infrastructure: Fusing the railways' condition, planning and cost - Despite modern developments, the British rail network maintenance intervention planning still employs informed human decision-making, involving the interpretation and contextualization from multiple-sources of information. As demand for new train services increase and the network infrastructure modernizes, planning for an ever increasing number of interventions will be required. This demands systems that not only support the decision making process, but

truthfully and cost-effectively schedule the necessary interventions autonomously. An integrated approach that fuses asset monitoring, planning and scheduling and cost has demonstrated a feasible option to achieve the automatic planning and reduced maintenance costs demands. Our system architecture design and underlying modules are generic enough to be applicable to a range of scenarios, including complex systems with abundant sensors and monitoring systems, for example in oil rig drilling, nuclear decommissioning and marine systems. It can raise asset degradation alarms that trigger the system response, supported by information sources and expert systems, resulting in cost factored automatic maintenance tasks and resource sequence. Our system design has been well received by the British rail industry. It clearly is in line with their future strategy. We have set the foundations for future autonomous infrastructure maintenance planning execution. In further technology readiness iterations, a larger scale strategy and approach will be clearly required.

- [8] **Xue Li, Jing Xu, Qun Zhang (2017), Research on Construction Schedule Management Based on BIM Technology** - The earliest research on project management in the United States, there are many sufficient theoretical knowledge and a lot of practical experience after a long period of development. With China's development of economy and improvement of science and technology continuously, the concept of project management also has been introduced in the field of construction projects. Project management in the progress of management directly affects the economic benefits of the project, so the importance and application value of progress management that one of the three objectives of the project management can't be ignored. At present BIM technology is developing rapidly, the application of BIM technology makes the progress of the efficiency of management, progress management of the content of information. The objective environment and the subjective environment, leading to the interruption or obstruction in the construction process. But in the actual construction process, through assisting the BIM model and BIM5D software in the construction schedule management, not only ahead of schedule can be aware of the next step schedule of the required resource requirements, equipment demand and capital requirements; but also in the actual construction process Timely monitoring the progress of the completion of the percentage of the plan, the actual use of the amount of funds accumulated and

the amount of budgetary funds deviation and soon; at the same time in the actual construction process can form a set of complete construction schedule management mode that timely supervising the construction quality and safety issues, recording defects on the spot, integrating data and associating model, timely rectifying or Repairing defects, and then checking the project.

- [9] **Wei-Chih Wang , Shao-Wei Weng , Shih-Hsu Wang , Cheng-Yi Chen (2014), Integrating building information models with construction process simulations for project scheduling support** - This study proposes an interface system that uses the BIMs ability with regard to quantity takeoffs of required materials (such as steel, forms, and concrete) to support site-level operations simulation, ultimately leading to the generation of a project schedule. Our proposed system includes mechanisms that collect, store, and transfer information among various software packages. Facilitated by the BIM's quantity takeoffs, the operations simulation is able to consider uncertain durations of work tasks, which allows it to consider the competing needs for resources among multiple work tasks, and to evaluate various resource allocation strategies in order to create a suitable construction plan. Finally, the resulting project schedule is also linked to the BIM 3D components, thus producing an improved BIM-based 4D model.
- [10] **Hui-Yu Chou, Pei-Yu Chen (2017), Benefit Evaluation of Implementing BIM in Construction Projects** - This study established a benefit evaluation index and method for the implementation of BIM suitable for contractors in Taiwan. The three main principal indexes are: (1) RCR means the effects of reducing costs associated with rework; (2) SDR & DPR mean the effects of mitigating delays that occur due to construction interface coordination or rework, as well as the effects of reducing the penalty costs associated with overdue delivery; (3) AQE means the effects of improving the ability to estimate the amounts of building materials and resources. This study also performed a benefit evaluation calculation of a real world case study construction project using the first two established indexes. The results showed a 0.16% reduction in rework costs, a 6.49% reduction delays that occur from construction interface coordination or rework, and a 5.0% reduction in penalty costs associated with overdue deliveries. The results demonstrated the applicability of the benefit evaluation index established in this study for

real world construction projects. This study aims to establish an index for benefit evaluation through first, collecting and analysing prior BIM implementation benefit evaluations and case studies from several countries abroad. Next, taking into account the feasibility of BIM implementation within the current climate of construction project delivery in Taiwan, a suitable method, process, and subsequent benefit evaluation index will be established.

- [11] **Kun-Chi Wang , Wei-Chih Wang , Han-Hsiang Wang , Pei-Yuan Hsu , Wei-Hao Wu , Cheng-Ju Kung (2016), Applying building information modeling to integrate schedule and cost for establishing construction progress curves** - This paper a cost-based progress curve (called S-curve) is often used to control construction project schedules. To establish a progress curve, the costs that are associated with each scheduling activity must be determined. However, the distributions of the quantities (costs) of cost items among various activities are time-consuming to obtain and error prone, yielding an unreliable S-curve. This work proposes the use of three-dimensional building information model (BIM) objects to integrate schedule and cost by using the powerful BIM for data acquisition and storage. BIM objects are incorporated into a proposed four-step model to establish construction progress curves. The proposed model defines search criteria (cost item, object, floor, and zone) that precisely identify takeoff objects for extracting the quantities of cost items associated with each activity. The BIM uses keynote, assembly code, and family type catalog functions to provide pop-up menus for the efficient identification of cost items that are associated with each object to preventing errors in the manual typing of cost-item names. Finally, this work demonstrates that uploading the cost items and unit prices into cost estimation software in advance is critical to automating cost estimations in BIM. Developing a cost-based progress curve is essential for effective control of a construction project schedule.
- [12] **Premjeet Singh, Ayan Sadhu (2019), Multicomponent energy assessment of buildings using building information modeling** - This paper, it is proposed to develop newer strategies to identify critical variables contributing to energy efficiency and design more energy-efficient housing architectures. The need to reduce global warming and achieve near-zero-energy building leads to the development of new research idea where multicomponent energy

assessment of the buildings can be performed by changing various parameters such as orientation and surroundings of a house, materials and other internal and external configurations. It is proposed to use Building Information Modeling (BIM) to virtually model a house and evaluate its energy performance. Changes of internal and external configurations of a structure can impact annualized maintenance budget of residential houses and other public infrastructure such as walk-in clinics, shopping complexes or office buildings. Various case studies are conducted which enable the building owners to better understand the practical aspects of designing green buildings, thereby leading to significant cost-savings and strengthen the quality of life in major cities.

- [13] **A.D. Britto , Perera B.A.K.S, Illankoon I.M.C.S. (2013), Factors Affecting the Accuracy of Pre-Tender Estimation of Road Construction in Sri Lanka** - This research has been conducted through a literature review of topics related to the cost estimating process, followed by a questionnaire survey. The analyzing of 59 factors conclude that the main factors affecting the accuracy of pre-tender cost estimation of road construction are: accuracy and reliability of cost information, material (prices /availability/supply /quality /imports), clear and detailed drawings and specifications, completeness of cost information, designer's experience level. "Spearman's Rank Correlation Coefficient" test was used as a measure of agreement between the three groups of respondents with regard to factors ranking, and it appears that they are generally in strong agreement. Finally, 15 expert interviews were conducted to identify the existing practices of cost estimation of road construction in Sri Lanka. These conclude that the main existing practices are: comparison with past similar projects based on personal experience, established standards ex. HSR (Highway Schedule Rates) and comparison with similar past projects based on documented facts.
- [14] **Shen XU, Kecheng Liu and Llewellyn C. M. Tang (2013), Cost Estimation in Building Information Model** - This paper introduces a new philosophic stance for cost estimation to address the development of model based cost estimation, addresses the importance of contextual information and the needs of extension of pricing information according to the general process of cost estimation by using the IFC standard. Information requirement as specified in IFC for cost estimation is established and instances of IFC relationship have been

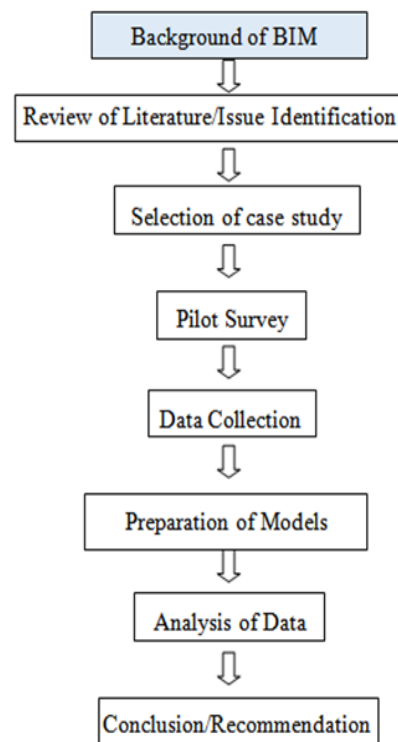
identified. The knowledge of cost estimation is demonstrated and discussed. Initial analysis of the IFC schema has been completed, including analyze classification & inheritance structure. It can be concluded that the IFC standard has the capacity fully facilitate the cost estimation within ideal environment and the direction of automating cost estimation for BIM has been pointed out. This paper is organized in the following way: firstly a new view on a quantity surveyor as an information system is provided, which brings us an idea that cost estimating is a process of information digesting, where cost estimation information needs to be modelled to reduce the time of information processing; secondly a new philosophic stance has been established via organizational semiotics in order to illustrate how cost estimation could be accomplished under the situation of building models. Section 4 illustrates the relationship between the IFC standard and cost estimation process, which provides information requirement model for cost estimation and it's instance in the IFC standard. Section 5 expend the information model in order to alien with the knowledge of cost estimation. The general process of cost estimation by using IFC is illustrated to address the importance of pricing information. Finally the direction of automating cost estimation has been pointed out, a discussion has been facilitated in order to address the needs of a proper research of cost estimation in BIM and conclusion is presented.

[15] **Daniel W.M. Chan, Timothy O. Olawumi, Alfred M.L. Ho (2019), Perceived benefits of and barriers to Building Information Modelling (BIM) implementation in construction: The case of Hong Kong** - The study adopted a quantitative research design using a structured empirical questionnaire survey. Also, a comparative analysis of the perceptions of the respondents' groupings was conducted. The major barriers to BIM adoption are related to the inherent resistance to change by construction stakeholders, inadequate organizational support and structure to support BIM and lack of BIM standard in Hong Kong. Meanwhile, the key benefits include better cost estimation and control, efficient construction planning and management, and improvement in design and project quality. Practical and insightful recommendations were suggested for policymakers, local authorities, construction firms, and other key stakeholders to increase the uptake of BIM in construction projects as well as to said them in the quest for full adoption of BIM in the built environment. The

practical implications of the research findings were also presented and discussed. The paper will also discuss the current process to develop a BIM standard for Hong Kong construction industry spearhead by the HK Construction Industry Council (CIC). Also, the practical implication of the research findings will be highlighted as well as recommendations on how the full implementation of BIM can be achieved in the construction sector.

8. METHODOLOGY

The data collection for the study involved two stages. The primary data was gathered through a questionnaire survey targeted at some contractors, clients, and consultants in construction projects in Pune and some of the local tradesmen's and businesses. The secondary data will be obtained from the literature. Using this approach, some of the causes that are helpful in obtaining a case study details will be obtained. A questionnaire is then developed to collect this information.



9. RESEARCH GAP

From the available literature review it is noted that there is no significant research been done to analyze the efficiency of pretender cost estimates using BIM. From past researches it is observed that BIM is an efficient tool in the construction and it has many advantages. But

these applications have been limited only for design, architectural purpose and there is no significant research performed to improve the efficiency of infrastructural projects during the pre-tendering process. Hence, this gap is to be fulfilled by achieving the objectives of this research to create BIM modules for improving pre tendering cost estimates.

CASE STUDY

Jay Malhar Enterprises is a civil and construction company that has built a strong reputation for delivering a quality service on time and at a competitive price which has been remarkable since its formation in year 2006. They undertake a variety of projects for a wide range of cliental – from small private developments to large Government projects.

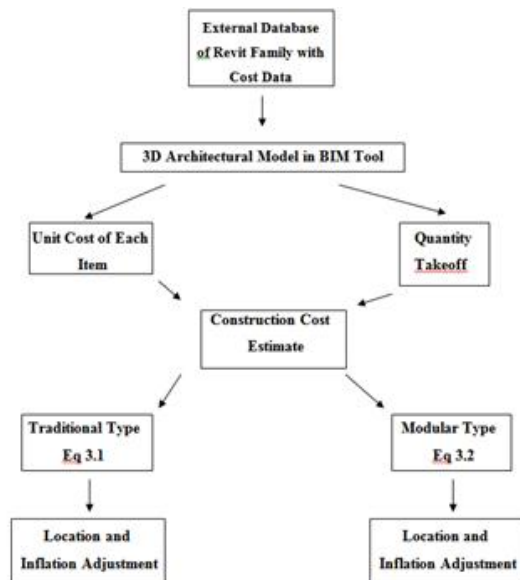


Fig - 1: Cost estimation flowchart

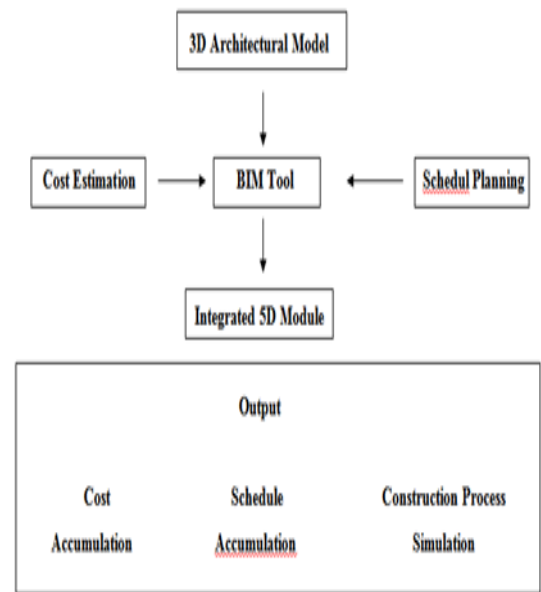


Fig - 2: Flowchart of the integrated 5D module

9. PROBLEM STATEMENT

From the schedule B and the final estimates obtained from the site, there are variations observed in the actual cost and schedule of the targeted planned cost and durations (See appendix A and appendix B). And through the extensive literature review carried out in the previous chapters it can be seen that cost and time overruns are generally observed on all infrastructural sites. Also the efficiency of BIM has been observed by studying the past research papers carried out by various authors. Hence an attempt will be made to apply BIM tools and develop models so that the advantages of using BIM can be achieved to minimize the cost overruns and improve the efficiency of the pre tender cost estimates

10. CONCLUSION

This study has described a database development methodology, which is based on collecting Revit families and RS Means cost information. This database is the foundation of the other three modules: the cost estimate module, the scheduling module, and the sustainability module. Subsequently, this study has explained how the data can be efficiently input, stored and transferred and shared among these modules on a BIM platform. The most important contribution of this methodology is that data can be automatically transferred among the BIM tools and other analysis software, shortening the preparation time for the cost estimate and for the scheduling of construction projects.

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