BIM – Evolution and Emerging Research Trends

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Abstract

Sustainability, resource efficiency are the important trends in construction industry. Several approaches have been deployed, where BIM is the most famous existing technology which is used for numerous applications in construction projects. The complete life cycle of the projects is visually modelled in BIM from the pre-construction phase, construction to the post construction such as operations and maintenance. Due to its advanced technology of 3D visualization and effective communication which results in accurate constructional procedure saving time and costs. Due to these reasons, BIM serves as an exceptionally high rated technology among the architectural, engineering and construction sectors. This papers reviews on the theory behind the conceptualisation of BIM, its evolution, future research trends, benefits, merits and demerits highlighting its status in developing country such as India.

Keywords: Building Information Modelling, Construction Industry, Architectural Design, 3D modelling, BIM software

INTRODUCTION

The construction industry has undergone several changes during the past decades. Scarcity of resources is a major problem worldwide and hence efficient usage of resources is an integral part of construction sector. Sustainability, recycling and retrofitting are also an important trend in Architecture, Engineering and construction sector. National Institute of Standards and Technology (NIST) reported that the U.S construction industry suffers a loss of about $15.8 billion per year due to poor communication [1]. BIM is a unique technology which aids in design,planning and construction of new buildings [2].It consists of information about different phases of the projects such as design, planning, operations and management, where it would help the users to visualize, design, plan, schedule and estimate. The model defines the entire life cycle of the building, where the geometry, spatial information, quantities and properties of building elements, cost estimates and project schedules.BIM simulates the construction project in a virtual environment and an accurate virtual model of a building is digitally constructed. The building information model contains precise geometry and relevant data needed for the design, procurement, fabrication, and construction activities to achieve a realistic project [3].On its due course the model can further be utilized for operations and maintenance purposes. This really eases out the work schedule by easily knowing known quantities of raw materials. It has also several advantages such as coordination in the systems and process such as visual identification of points of conflicts and the rapport between different stakeholders and the personnel which saves cost and time simultaneously. This paper reviews about Building Information Modelling, its benefits, issues pertaining and its development in India.

OVERVIEW OF BIM

Building Information Model (BIM) is defined "shared digital representation of physical and functional characteristics of any built object which forms a reliablebasis for decisions".A Building Information Model is a 3D object-oriented model consisting of parametric objects with embedded information. Objects may have geometric or non-geometric attributes with functional, semantic ortopologic information. The model is built up of elements connected to each other which are coined as objects. These objects are presented with individual identity with its geometry and properties. This object-oriented approach eases in organisation of the model by developing interactions with one another and the details are stored in them. Identification of the element, its geometry and its properties on site becomes less tedious since the information are embedded in every object.

BIM is also understood as a process, that encloses all the systems, aspects in a single virtual model. This allows the team members of the project to collaborate and exchange information in an efficient manner finally resulting in a more precision construction process and also saving the resources (i.e) production of lesser waste and cheaper operational costs. Construction documents such as drawings, procurement details, submittal processes, and other specifications can be easily interrelated[4].and that related information are well developed, shared and manged for better collaboration. Various commercial groups are involved in the automated building modelling and some of the software related to BIM are listed in Table 1.

Table 1 List of BIMSoftwares[5].

Organization	Product	Features
Carrier	HAP	Peak load calculation HVAC system sizing Energy Modeling
Elite	Chvac	Maximum heating and cooling loads for commercial buildings are determined quickly and accurately.
Energy Design Resources	eQuest	Quick Energy Simulation Tool
Trane	TRACE700	Designing, optimization based on energyutilization and life-cycle cost.
Wrightsoft	Right-Suite Universal	Digital automated application for both new constructionandreplacement systems
Autodesk, Inc	BIM360	Decision making by considering life cycle of the project
Autodesk, Inc	BIM360 Glue	Cloud-basedBIM managementstandard work progress.Easy accessibility
Autodesk, Inc	Navisworks Manage 2017	Integrated project model Improved, interferencemanagement and clashdetection and 5D analysis.
Autodesk, Inc	*Revit MEP*	Building Information Modeling (BIM) solution for mechanical, electrical, and plumbing engineers.
CADPIPE	*ArTrA BIM*	Constructionmanagement, fit-out and facilities management. Multiutility and easy accessibility
Bentley Solutions	Bentley Building Mechanical Systems	Handling and plumbing systems for buildings and industrialplants moredesign optionsbetter informed design decisions. Predicts costs and Performance.

History of BIM

Introduction of computers have evolved the designing aspects in construction industry, till then manual drawings were used for reference. BIM technology has taken the architectural drawings to an advanced level. Till 1980's manual drawings consisting of plan, section and elevation were used for the real-time construction. Different lines and symbols were used to represent the objects which should be constructed practically. Invention of computers changed the scene in 80's to 90's where 2D computer drafting designs were highly utilized. Complex structures required more and more information where 3D modelling came into play. BIM softwares are an integrated package consisting of various tools, where they have evolved gradually. BIM platforms offer integrated data management,component libraries and general functionalities. Widespread differentiations of BIM are 3D (spatialmodel with quantity take off), 4D (plus construction scheduling) and 5D (plus cost calculation).Fundamentally the BIM technology of basic platforms such as preplanning anddesign, clash detection, visualization, quantification, cost analysis and data management. Lately, specialized tools were included in the modelssuch as energy analysis, structural analysis, scheduling, progress tracking or jobsite safety. BIM basically focuses on preplanning, design, construction and integrated project delivery ofbuildings and infrastructure but Life cycle aspects are taken into consideration such as early stage development and maintenance. refurbishment, deconstruction and end-of-life considerations. Several countries have regulated and formulated the basic codes for BIM technology (Table 1)

Table 1: A list of guidelines for BIM implementations [6]

Country	Organization	Guidelines	Description
Australia	CRC-CI	National Guidelines & Case Studies (2008)	Open and consistent processes and tests for selection of software compatibility.
Denmark	BIPS	Digital Construction Guidelines (2007)	3D CAD Manual, Working Method, Project Agreement, and Layer and Object Structures.
Finland	SENATE Properties	BIM Requirements Guidelines (2007)	Design phase and general operational procedures in BIM projects and detailed general requirements of BIM.
Netherlands	E-BOUW	E-BOUW BIM Framework (2008)	Seventeen orthogonal dimensions about BIM in general
Norway	STATS-BYGG	HITOS Documented Pilots (2006)	Full-scale IFC test project experiences
U.S	NIST	National BIM Standards Guidelines (2007)	Standard definitions for information exchanges to support critical business contexts

Research trends in BIM

The "BIM Research Compass" has been developed by Isikdag and Underwood [2010] characterises the current research directions of BIM [7]. Twelve research directions for BIM were identified which would make us to understand the research areas in which BIM can progress as following.

- Conceptualization: The scope and limitations of the BIM
- Organizational adoption: BIM to be implemented in AEC industry from contractstill completion of projects
- Functionality: processes, technologies, and methodologies to enable BIM
- Standardization:inter exchange of data between groups
- Sustainability: sustainability and productivity within construction operations
- Process simulation and monitoring: Construction process visualization
- Building information services:Exchange of information in various web servers
- Geo-information integration: Integration between geospatial information systems and BIM
- Emergency response: BIM to use in hazards such as fire, earthquakes, gas leakages, and possible terror attacks
- Acceptability: BIM on developmental projects in widespread level
- Education and training:Education and training related to BIM
- Real-life cases: BIM case studies within an industry

Research in future can be extended based on the above-mentioned criterions.

Benefits of BIM

The key benefit of a building information model is its accurate geometricalrepresentation of the parts of a building in an integrated data environment[8].Building Information Modelling is generally used during design, construction and operationin order to:

- Aids in decision making process
- Structured communication and programmed work methods
- Centralized data administration with complete information on so that the stakeholder has clear understanding of the project objectives & interfaces
- Constantly updated information and easily accessible
- Increase in quality of the process and the product through early recognition of wrong planning and effective monitoring
- Visualizedesignssolutions(3D)
- Assist in design and the coordination of designs
- Minimize risks in execution period
- Lifecycle analysis of the project and cost management
- Time and cost savings

ApplicationsofBIM

BIM is widely used in the following applications

- Visualization: Easy 3D renderings could be drawn
- Codal Provisions: Departments can us the existing codal procedures embedded in the model
- Cost estimating: BIM software has in built cost estimating features. The materials could be estimated for real life scenario
- Sequence of the process: effective and faster implementation of procedures and is easily shared. The procedures such as materials procurement, fabrication, and delivery schedules are analysed.
- Conflictdetection: MEP systems could be generated alongside where the interference points could be identified.Graphical representation of potential failures, leaks, evacuation plans.
- Facilities management: Renovations, space planning, and maintenance operations could be used
- Innovative solution: better analysis and higher rate of simulations
- Sustainable data: LCA costs are understood and environmental aspects ofbuildingare studied
- Automated outputs: Flexible documentation and digital products. Process could be down streamed for the assembly and manufacturing of systems
- Consumer service: products are delivered in better finishing and faster pace
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ISSUES IN BIM UTILIZATION

The major issues pertaining to the BIM usage are technical, economic and legal issues. The technological risks are the lack of BIM regulations. Since such standards are not been in use every firm has its own protocols leading to inaccuracies. Communication problems also lead to risks in BIM utilization. Inter exchange data and interoperability of data also poses significant threat due to re-entry and automation. High cost of BIM softwares hinders the abundance usage of softwares in AEM industry in developing countries. Copyright and ownership issues are the major legal issues, where the copyright problems arise upon the stakeholders [1]. Responsibility of inaccuracies and mishaps are also an important issue in legal risks since the integrated approach hides the actual proprietorship.

BIM IN INDIAN SCENARIO

Construction sector is second largest industry contributing to the Indian economy. High multiutility buildings, airports and hotels have utilized BIM technology in recent years. A conducted surveyhas shown that 22% of respondents currently use BIM and 27% respondent reported that they are aware and actively considering BIM usage. Technical expertise and economical deficit are the major hurdles hampering the involvement of BIM in construction projects[9,10].Indian users though have known about BIM are sceptical to use due to high cost of software, low demand from clients and lack of skilled or trained employees, lack of support from clients, uncertainty and adoption to traditional practises.

CONCLUSION

The BIM is a promising revolutionary approach of construction projects and is gaining widespread acceptance which would become anessential procedure in AEC industry in forth coming years. The paper reviews on the overview and the basic conceptualisation of BIM technology highlighting the further research trends, its current applications and merits highlighting the issues in existing technology. It is identified that codal provisions and economic deficiency are the major cause for the lower usage of BIM in India.Indian government should take initiatives to encourage BIM usage in construction industry through education, training and formulate the related codal provisions so as to maintain the pace of the industry to global standards.

References

[1] Azhar S, “Building information modeling (BIM): Trends, benefits, risks, and challenges for the AEC industry”, Leadership and management in engineering, vol. 11, no. 3, **(2011)** June 15, pp. 241-52.
[2] S Azhar, A Nadeem, J Y Mok and B H Leung, “Building Information Modeling (BIM): A new paradigm for visual interactive modeling and simulation for construction projects”, Proceedings of the First International Conference on Construction in Developing Countries, **(2008)** August 4, pp. 435-446.
[3] CM Eastman, YS Jeong, R Sacks and I Kaner, “Exchange model and exchange object concepts for implementation of national BIM standards”,Journal of Computing in Civil Engineering, vol. 24, no. 1, **(2009)** December 15, pp. 25-34.
[4] L Khemlani., K Papamichael, and A Harfmann, “The potential of digital building modeling”,http://www.aia.org/SiteObjects/files/potentialofdigital.pdf,accessed on **(2017)** November 20.
[5] Ashrae Technical Document, “An Introduction to Building Information Modeling (BIM)”, http://cms.ashrae.biz/bim/pdf/BIMGuide_Rev_110309.pdf, accessed on **(2017)** November 20.
[6] Gao, J, “A characterization framework to document and compare BIM implementations on construction projects”, PhD Thesis, **(2011)**, pp. 1-174.

[7] U Isikdag and J Underwood, "A synopsis of the handbook of research on building information modelling", Proceedings of CIB 2010 World Building Congress, Salford, MA, **(2010)** May 10.
[8] CRC Construction Innovation, "Adopting BIM for facilities management: Solutions for managing the Sydney Opera House", Cooperative Research Center for Construction Innovation, Brisbane, Australia**(2007)**.
[9] Sawhney A., "State of BIM adoption and outlook in India", RICS school of built environment, Amity University,**(2014)**.
[10] Chougule NS and Konnur BA, "A Review of Building Information Modeling (BIM) forConstruction Industry", International Journalof Innovative Research in Advanced Engineering (IJIRAE), vol.2, no. 4, **(2015)**April.