Review on Benefits, Features, Applications and Implementation of Building Information Modeling (BIM) for construction project.

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Abstract - *The majority of construction companies deploy BIM every year since it has clear benefits for time, cost, and project quality. Nevertheless, there are sometimes implementation bottlenecks that make it challenging for businesses to realise these advantages. About 53 papers spanning the years 2012 to 2022 were studied and results show that there's a great evolution in the BIM industry The paper outlines the features/ benefits of BIM, its applications and the status of BIM adoption in various countries. Also, this paper sheds light on the scope of BIM and its challenge faced while implementation.*
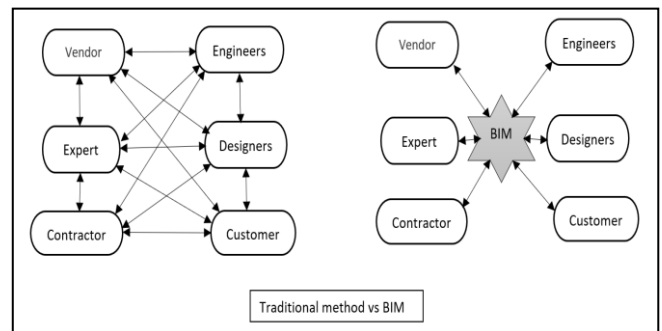
Key Words: **BIM (Building Information Modeling), benefits, features, application, implementation, 3D, 4D, 5D**

1.INTRODUCTION

Rapid technology advancement and fierce competition in the building sector for better service delivery have rekindled a keen shift toward the use of innovative techniques in the construction market. Building information modelling (BIM) is currently regarded as the most innovative methodology in the building industry. BIM allows provides quick-witted digital delineation of building to hold up sundry activities throughout the project's lifecycle. BIM is a model-based sharp-witted nD ('n' dimensions) platform that provides tools for AEC (architecture, engineering, and construction) experts to plan, design, and control construction projects more adroitly. In this paper study of about 53 papers is covered out of which approximately 11 papers are based on benefits of BIM, 27 are based on applications of BIM and 15 are based on adoption of BIM. Papers spanning the years 2012 to 2022 are reviewed. Ample disorganization in construction performance is illustrated in fig 1. The figure also depicts that in disparity, BIM provides a digital model offering absolute communication utilizing a usual database supporting all project details. It also facilitates impeccable operations, dealing with deficient or misconceive information. With the application of BIM technology, seamless collaboration between project teams is possible leading to improvement in cost, time, and quality of the construction project.

Fig 1: Traditional vs. BIM-based method

It has taken time for the different BIM benefits and applications to become widely known. The amount of BIM research, however, is growing yearly. Following fig. 2 illustrates how BIM has changed annually.
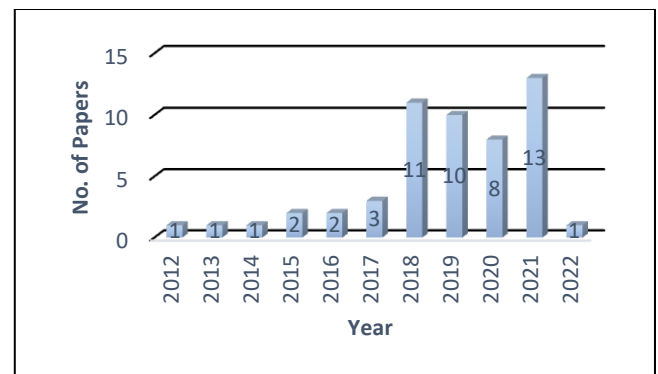

Fig 2: Time history of literature

2. Features and benefits of BIM

Various significant features of BIM are clash detection energy analysis, safety analysis and check on the progress of work, Demolition, cost efficiency, quantity survey, and quality management.

2.1 Clash Detection

Clash detection is the main feature included in building modelling information modelling. The clash detection programme allows members of each system to effectively identify the clash between specified systems

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and checks the clash between the mechanical and structural modelling. [5], clash detection simulations help foresee upcoming errors and devise solutions or alternatives before occurrence. Thus, reducing unwanted costs and wasted material.[53]

2.2 Cost-efficiency

BIM has the ability to update, maintain, store and share data in multiple dimensions. A key advantage of this is in the efficiencies achieved at each stage of the project lifecycle, thus leading to cost reduction. [7] Reducing mistakes will result in lower costs of redoing the work, and these funds could be reallocated to more innovative tasks, such as designing green spaces or solar heating systems. Instead of investing money to correct errors, eliminating these errors will increase funding to consider more sustainable and long-lasting materials.[53] Estimates planned in bim have an accuracy of upto 3% and upto 80% reduction in time in estimation. As it reduces the financial risks related to the construction and design.[5] Kristen Barlish in their paper studied three case studies which showed At Company 1, calculated returns were: change orders saw a savings of 42% of standard costs in Case 1, RFIs decreased 50% per tool or assembly, and duration reduction was a savings of 67% based off the standard duration. In Case 2, calculated investments were: 31% increase in design costs due to A&E costs, 34% increase in design costs due to 3D background model creation, and a contractor savings of 5% of contractor costs. When totalled in dollar value and percentages computed investments in both design and construction resulted in a savings of 2% of the combined awarded design and construction scope. The data provided by Case 3 held that specific areas of semiconductor manufacturing, such as those that are more complex, may have increasing returns as compared to less-complex areas.[13]

2.3 Quantity and Quality Management

Manual quantity surveys take a massive time range and may have an inaccuracy of about 5 to 10 per cent which is a huge loss compared to quantity surveys performed in the BIM process in softwares.[5] The gap between "designed" and "actual" scheduling activities which often results in inaccurate forecasts is fill with the help of being increasing quality of the project.[7]

2.4 Collaboration

Collaboration is an essential part of innovation and requires process innovation.[54] BIM has the potential to be the catalyst for Project Managers to reengineer their processes to better integrate the different stakeholders involved in modern construction projects.[6] All the project partners (including engineers, contractors, manufacturers, suppliers and designers) would use a

single, shared 3D model, cultivating collaborative working relationships.[34]

2.5 Visualization

By using the integrated 5D BIM model to visualize and explore the impact of changes, s/he can keep the project scope in check and become a trustworthy liaison between the designers and the Owner.[6] The low degree of visualization of the traditional management mode brings communication and coordination difficulties in design disclosure, site construction and other aspects, and increases the risk of project management, making the uncertainty of project management increase. Through the comparison between traditional pattern and BIM models, BIM implements visual management in the information management and transfer, and eliminates the trouble of missing information.[47]

3. APPLICATION OF BIM

A case study (a project to build a three-story school of 18 classrooms) by Rehab Abdul Razzaq Ibraheem [2] shows BIM application during the design phase. The BIM functions such as 3D visualization, structural analysis, clash detection, and coordination were applied to the case study during the design phase which solved deficiencies or error in the design, drawings, or specifications due to the designer during the design phase and design changes by the designer during the implementation phase by reducing the cost and duration of the project, by (34,240,000 ID) and(128 days).The application of BIM functions led to a decrease in the cost of claims by (57.2%), the time of claims by (53.2%), Thus reducing claims by (55.2%).The top five applications of BIM utilized by leading BIM contractors included clash detection, 3D modeling, team collaboration, constructability issues of designs, and sales, utilized between about 70% and 85% of the companies on at least 75% of the total company projects. Applications with little use by leading BIM commercial contractors included integration with GPS, evaluating building life cycle, sonar scanning, tracking time spent/punch cards, and integration with GIS. [14] An explanatory study in Canada examines the application of BIM in Supply Chain Management.[19] Project coordination and clash detection are the main determinants of BIM application toward enhancing the quality and 4D BIM (project schedule and construction sequencing) and 5D BIM (construction cost estimation) are the subsequent beneficial effects on the construction project in Iran.[23] It is found by the use of BIM that the variance between planned costs and actual costs decreased from 12% to 5% when 5D BIM is used instead

of traditional methods.[28] A case study (Stanislav Vitasek 2019) showed an analysis of the current situation using information models of two administrative buildings (currently under construction) and links these models to construction budgets. The transferred data made up for more than sixty percent of the construction budget, which means that four-fifths of the total budget could be predicted from automated calculations. [29] BIM has been very successful in the field of architecture, there is a significant increase in interest for IBIM applications in the infrastructural field.[39] A construction project in Beijing is completed by using the building information model building software autodeskrev, and then the 3D model and construction schedule are integrated into NavisWorks software to realize 4D simulation and visual display, as shown in figure 2.[41]

Fig 3: BIM modeling case in design phase[41]

Fig. 3 depicts the general flow chart of project management. Except for the early stage of the project, it belongs to the stage of project management, including the design stage, construction management stage, delivery stage and completion operation stage.[42]
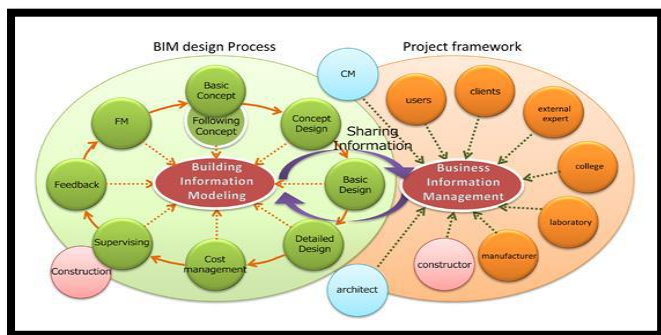

Fig 4: BIM project management process [42]

Successful application of BIM leads to the smooth implementation of the project. The statistics are:
• Problem was found from the structural and architectural drawings and the cost was saved of about 220,000 yuan.
• Resolved the collision problem that was found and saved 68,000 yuan.
• Safety awareness increased saving 30,000 yuan costing.[43]

The application of BIM is advantageous in different construction phases such as decision phase, design phase, construction phase, and completion phase.[44] The application of BIM in china's urban public infrastructure development management aims at reducing cost and improvement in quality of Hubei Jingzhou Bus Terminal project. Through the implementation of BIM technology design quality can be improved by 3D visualization and the elimination of errors caused by improper coordination between different disciplines at the time of the project under construction can be done.[46]

Table - 1: Summary of literature for application of BIM

Reference	3D	4D	5D	6D	7D	8D
2	✓		✓			
3					✓	
14	✓	✓	✓			
21	✓	✓				✓
22						✓
23	✓	✓	✓	✓		✓
28	✓		✓			
29	✓		✓			
33	✓	✓	✓			
39	✓		✓			
41	✓	✓	✓			
42	✓	✓	✓			
43	✓	✓	✓			
44	✓	✓	✓			
45	✓	✓	✓			
46	✓					
49	✓	✓	✓			
50	✓	✓				
51	✓		✓			

4. ADOPTION/MPLEMENTATION OF BIM

Although BIM has been widely adopted in the AEC industry, its implementation in AEC projects still experiences various barriers. a list of barriers to BIM implementation in AEC are Extra investment on BIM use, Lack of related technical personnel, Lack of knowledge and experience for BIM implementation, Insufficient training and consultancy, Lack of client's requirement or management support, Lack of motivation to implement BIM in projects, Missing evaluation and feedback for BIM implementation in projects, etc [18]. The nine categories

of intra- and inter-organizational challenges are related to the public client's implementation of BIM for driving AEC industry change are Changing work practices, providing education and learning, developing a mutual BIM definition, evaluating the business value of BIM, demanding in BIM procurement, creating incentives, including maintenance department, creating new roles, managing interoperability.[20] More than 70% of the projects has implemented BIM Level 1, there are still 17% of projects that implemented the Pre-BIM Level, in which paper based documentation occurs. Compared to the BIM knowledge result, Indonesian construction practitioners have implemented BIM Level 1 without having a proper knowledge of BIM.[25] The construction stakeholders including owner, consultants and contractors should play their very own role by transferring the paradigm from using the traditional method right into a greater innovative method. Through their governments Countries like, Australia, United Kingdom (UK), Singapore and Hong Kong have implemented the use of BIM in their construction industry [26]

Table -2: Summary of literature

Authors	Key findings
Hire Shalaka 2021 [1]	This report is a subsection of a larger investigation on "BIM for safety" in the Indian construction sector. Therefore, the initial part of this research has mainly concentrated on determining the global trends of BIM use in the construction sector before focusing more narrowly on its adoption for safety objectives.
Rehab Abdul Razzaq Ibraheem 2021 [2]	The study demonstrated that claims can be minimised by implementing BIM and utilising its features (3D visualisation, clash detection, coordination, and quantity take-off) during the design process.
T. Lukianova et.al 2020 [3]	A cornerstone of a remedy for the UBP issue could be the methodical production of an as-built BIM. Because BIM is currently primarily utilised for the design and building of new facilities, further research and improvements to current BIM workflows are required to enable the effective use of BIM in this context.
Mohammad Dastbaz et.al 2017 [4]	In a data-intensive and complex environment that heavily depends on good collaboration amongst a varied range of disciplines, BIM has been praised as a catalyst for a fundamental transformation in how the industry does its business is found in this paper
Isac et.al 2019 [5]	In this paper the building lifecycle using BIM and the conventional construction cycle is discussed. Additionally, a number of essential BIM characteristics are accurately defined.
Bryde et.al 2013[6]	The study demonstrated the benefits of BIM on a cross-section of construction projects.
Georgiadou 2019 [7]	Study showed the development and use of BIM in the UK. BIM is an evaluation methodology that supports the management of digital information throughout the course of a project. The main advantages of BIM are also outlined, including its cost effectiveness, quality assurance, on-time delivery, improved collaboration and communication, design optimization, lifecycle thinking, and sustainability.
Chan, Daniel WM 2019 [8]	Paper analysed BIM implementation's advantages and challenges in the construction sector in Hong Kong.
Sami Ur Rehman, 2020 [9]	The paper studied BIM's amazing effect on schedule management. They discovered that BIM can pinpoint scheduling risks and offer helpful remedies for them. Literature and source data were used to analyse different BIM characteristics, and a case study was also created.
Andrew Dainty 2017 [10]	This paper outlined the BIM mandate and construction industry policies. The AEC sector's connectivity and overall performance are enhanced by BIM-stimulating technologies.
Sherif Mostafa et.al 2018 [11]	Study intends to identify BIM-related possibilities and constraints for the Australian prefabrication sector.
Racha Chahrour et.al 2020 [12]	This study developed a clash detection method based on BIM that results in cost reductions.
Barlish et.al 2012 [13]	This paper created a strategy for evaluating the advantages of BIM. BIM expands and is applied throughout entire organisations. Measurements and estimates beyond 3D are untimely until BIM is viewed favourably and used by owners.
Clifton B. Farnsworth et.al 2014 [14]	explained the frequency of application of BIM, the advantages and effects of BIM utilization.
Solomon Belay	This study investigated the benefits

et.al 2021 [15]	and challenges in the adoption of BIM in the Ethiopian infrastructure market.		regional construction sector.
Ruth M. Dowsett et.al 2018 [16]	The goal of this paper was to draw attention to crucial BIM implementation components. The interspatiality of BIM implementation in a sociotechnical system and the distance between organizational-level and project-level BIM implementation were both made clear in this study.	Mostafa Khanzadi et.al 2018 [23]	In this study, BIM applications in Iranian project life cycles were identified and given priority. The top three KPIs (Key Performance Indicators) that can benefit from BIM applications in the construction stage of building projects are quality improvement, environmentally friendly building, and construction cost reduction.
Nguyen Van Tam et.al 2021 [17]	This study attempts to identify the international elements that affect the adoption of BIM in the building sector. 39 important components of labour productivity were examined and grouped into 5 categories: management, people, projects, and technology.	Charef R et.al 2020 [24]	This paper's goal was to examine BIM applications that could aid practitioners in embracing a circular economy mindset. After data analysis, 35 BIM applications that could support the adoption of a circular economy strategy were found.
Xiaozhi Ma et.al 2020 [18]	This paper examines the obstacles to BIM deployment at the AEC project level and investigates their root causes in the project environment in China.	Andreas F Van Roy et.al 2020 [25]	This study attempts to determine the knowledge and existing practises of Indonesian construction industry practitioners, as well as the obstacles to adopting building information modelling.
Phuoc Luong Le et.al 2019 [19]	This paper outlines the challenges and opportunities that affect BIM's ability to contribute to supply chain (SC) developments in relation to the categories of expertise, governance, SC-related problems, training, benefits, demand, and costs. The investigation of BIM's contributions to current SCM developments in construction is the primary goal of this study.	Shakil Ahmed 2018 [26]	In this paper number of factors that contribute to the slow pace of BIM implementation in the construction industry, including (1) social and habitual resistance to change, (2) traditional methods of contracting, (3) high training costs and a steep learning curve, (4) high software purchase costs, and (5) a lack of awareness of BIM. Therefore, if the government wishes to see the construction industry able to compete on a worldwide scale, these issues must be addressed.
Susanna Vass et.al 2017 [20]	This journal article examined the difficulties with BIM deployment in the Swedish AEC sector. This study's primary objective was to better understand the intra- and interorganizational problems that emerged during the implementation of BIM in significant Swedish public infrastructure.	Tatjana Vilutiene et.al 2019[27]	This research depicts the BIM methodology is centred on interdisciplinary and cross-organizational collaboration, BIM adoption in SMEs, benchmarking the BIM use level, BIM technology integration with web technologies and augmented reality technologies, BIM-based digital fabrication, and HBIM applications.
Sávio Santana Martins et.al 2020 [21]	In order to identify obstacles to implementing 4D BIM technology, this research examined the integration of Navisworks, Revit, Tally, and Green Building Studio using a case study in Brazil.	Mohamed Abdel Hamid et.al 2021[28]	This paper illustrates 5D BIM (project cost estimation) and compared it to the traditional 4D BIM method (project time). Additionally,
Adnan Enshassi et.al 2016 [22]	The purpose of this article is to elicit contracting parties' perceptions on building information modelling (BIM), its most significant safety-related applications, and the challenges to BIM adoption in the		

	it benefited from the construction project's use of 5D BIM.	Bryan Franz et.al 2019[37]	This paper investigated the effects of BIM use adoption and BIM Execution Planning participation on project performance: a model of moderation, a model of indirect effects.
Stanislav Vitasek.2019[29]	demonstrates how BIM data may be utilised to generate item-by-item construction budgets. This article mainly focuses on the documents required to create a BIM model, with their graphic and non-graphic specifications. It outlines the requirements that must be completed in order to use the BIM 5D model to its full potential. The process described in the article is based on maintaining a close correlation between construction budget line items and BIM model components.	Pavel Chelyshkov et.al in 2021[38].	The author of this work investigated the problems with automated quality control of building information models at various life cycle stages. The essay is directed at a group of people who are experts in information modelling and who create and validate models of buildings as well as develop rules and other documentation on the high calibre of models.
		Giovanna Acampa et.al 2018[39]	This paper aims to demonstrate the potential of BIM tools in managing all the elements of a multidisciplinary infrastructure project by applying the BIM oriented design technique to the subterranean railway extension in the metropolitan area of Catania.
Syed Wajhi U. H. Naqvi et.al 2019 [30]	The purpose of the study is to identify the main obstacles to the general use of I-BIM for lifecycle management in the horizontal construction sector. Based on percentages of the replies received from experts in the infrastructure industry, key factors were identified and ranked by predominance using the quantitative research technique. In light of the fact that employers in the infrastructure industry do not fully recognise the potential advantages of I-BIM, this article concludes that there is a widespread lack of demand.	Aryani Ahmad Latiffi et.al, 2015 [40]	This paper depicts that every country will face identical issues to implement BIM in their AEC industry.
		Yu Jia 2021[41]	The study identifies the entry point of BIM Technology Application and extensively explores Method B of BIM-based Project Management and Control.
		Yu Jia 2021[42]	The paper focuses on large-scale construction projects as the research object. It analyses the process of application of BIM in large-scale engineering projects
Mutonyi Nasila et.al 2018[32].	This study identified the benefits of BIM application and the challenges to BIM application in Kenya		
Amjed N.Hasan et.al, 2019 [33]	Study depicts Benefits and Challenges to Implement 5D BIM in Construction Industry.	Xiaojuan Shi 2020 [43]	In order to achieve comprehensive BIM application results, this paper acquires software like Revit, Magicad Navisworks, and focuses on the construction project. It uses BIM technology to aid in project management and covers topics like 3D site layout and simulation, BIM 5D management, optimization collision check, visualised disclosure, sample planning, panoramic technology, etc.
Kenneth Agyekum-Kwatiah 2018[34].	This paper discussed Benefits and Challenges of BIM and its Application to the Residential Unit Development Project: The Brent Cross Regeneration Project, Barnet, London.		
Mohamed H. Shaban et.al. 2018[35]	This study recognized the challenges and key influencing variables for implementing BIM in Syria's AEC industry.		
M A Hossain et.al 2018[36]	The current state of BIM for existing buildings was examined in terms of possible prospects and significant impediments in developing a semantically rich as-built BIM.	Peng cheng et.al 2021 [44]	This study illustrates a BIM-based cost control technique for such complicated projects. In this study, a sizable retail mall is used as a case study, and the advantages and applications of BIM in cost

	management are analysed.
Lianguang Mo 2018 [45]	The paper illustrates how BIM technology can be used for cost control management and its advantages. The effectiveness and calibre of cost management can both be enhanced through BIM.
Xin QIU 2018 [46]	The optimization of industrial project management using BIM technology is shown in this paper.
Mo Lianguang 2016 [47]	The benefits of BIM project management are discussed in this study, along with project organisation structure analysis, BIM frame structure based on traditional management mode application, and analysis of BIM project management pattern selection in China.
LiJuan Chen et.al 2014 [48]	This paper explores the advantages of the application of BIM regarding quality management in construction.
Karen Castaneda et.al 2021 [49]	This paper dispenses a methodological structure that is BIM-based for traffic analysis and road intersection design simulation.
Ahmed.M. Eldeep Et al 2021 [50]	The paper scrutinizes BIM as a lean tool in the construction process along with the help of a case study.
Anna Baldrich et.al 2021 [51]	The main aspects related to the duties and expertise required for quantity surveyors in this new BIM technology pattern are explained in this article.
Tan Tan et.al 2021[52]	This study shows how BIM and Multi-Criteria Decision Making (MCDM) together can enhance decision-making and information aggregation.
Dr Abdussalam Shibani et.al 2021 [53]	This study offers a useful perspective on how BIM might be used effectively for prefabrication in the housing industry.

4. DISCUSSION ON SCOPE OF BIM

For international-based businesses including general contractors, design consultants, architects, and developers, BIM work-sharing in India has emerged as the top option. Several BIM services, including 3D BIM Services, Scan to BIM Services, Drawing Production, Virtual Reality, 4D Construction Sequencing, 5D Cost Integration, and Facility Management, have been outsourced to Indian businesses. These services give hope for the future, making India a top location for BIM outsourcing or work-sharing for international nations.

There are numerous chances in India for implementation. One of the biggest and fastest-growing building markets is in India.

The future appears bright. The top BIM users in the Indian market are architectural firms, followed by structural engineering consultants. The adoption of BIM by structural engineers, as well as mechanical, plumbing, and interior consultants, is taking longer than expected.

It's time to push on. The perspective of important stakeholders needs to change. Government officials could accomplish more by lobbying for a law requiring BIM because it has many advantages, if not in every major project. Making a certificate in BIM installation and management for experts in the industry is another option. By altering the procedure and procedures now used, it is feasible to assist the construction industry in creating projects that are better before they are built. Designing a product catalogue specifically for India, documenting successful BIM implementation efforts in India, and creating BIM implementation plans for specific projects are a few examples.

5. FUTURE CHALLENGES IN IMPLEMENTATION OF BIM

Despite the numerous potential benefits of use of BIM, developed action plans, and likely future higher usage rates, the overall efficiency of BIM has not been fully established. Real-time management of BIM outputs is a difficult task. BIM implementation involves risks like technical risk, management risk, environmental risk, financial risk, and legal risk. While sharing information between team members gives access to project data where there is chance of copyright violation and unauthorised online access.

The problem with design and data ownership rises where information is provided by third parties. If any error occurs during project the teamwork of different BIM model designers complicates the process.

The person in charge of BIM activities is in charge of tracking errors, access restrictions, security, information exchange, legal agreements, etc. Extra time is required to preserve data accuracy between input and output. Therefore, before using BIM, it is vital to identify, assign the risks involved, and take the cost into account. It will only be possible for BIM to fulfil its promise to advance the sustainability agenda if those who use it modify and adopt appropriate working methods.

6. CONCLUSION

Building Information Modelling is a process which includes the collaboration of various BIM software for smooth project management. Diverse features and benefits of BIM have made it the most innovative methodology across the construction sector. BIM is mainly

useful for Visual conceptual Models, Clash detection to avoid rework, 4D and 5D cost management and most importantly for quick quantity takeoff. However, implementation of BIM varies from country to country but it is found that various countries are adopting this methodology by crossing numerous hurdles/ barriers while the implementation stage.

The important reasons for not implementing BIM are high cost, demand and certain risks involved. The lack of skills, experience, costly and non-user friendly software's are other difficulties in implementation of BIM for small construction projects. But implementation of BIM will give client satisfaction through model visualisation, clash detections, reduction in errors, improved team work, data sharing and improve quality project in time. It will also help green building energy analysis.

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