Analyzing BIM use and application in the building industry from 2008 to 2023

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Abstract

The Construction Industry (CI) is in a moment of enormous change. By 2025, India is anticipated to grow significantly and overtake China as the third-largest building market worldwide. Building Information Modelling (BIM) has become a potentially useful technique for improving construction projects. BIM is currently considered the most innovative methodology in the building industry as a model-based talented/enclosed nD ('n' dimensions) aims to provide tools for Architecture, Engineering, and Construction (AEC) experts to plan, design, and control construction projects further skillfully. In this paper study more than 130 papers are studied in-depth, out of which 79 papers found on review-based use of BIM in the CI. Among these, 42 are general reviews, 9 bibliometric and scientometric analysis, 8 papers each for a systematic and 9 critical reviews, 7 papers for overviews and 8 are for miscellaneous. Literature review research papers based on BIM use in the.CI, published during the last 15 years are analysed. Some BIM features like: Adoption (18), Benefits (14), Barriers (10), Challenges (10) and Risk Management (8). Rest of articles are based on safety, practice, scope, and framework, use and implementation are elaborated in the present study. Integration of BIM reviews with IoT, AR/VR, Digital Twin, Drone Technology, and AI offer enormous potential to enable a range of future applications in the construction business. It is equally important to incorporate BIM, its integration with cutting edge technologies academic institutions seeking to comprehend the significance and apply them in AEC in university curricula. The future of BIM in usage and applications in construction industry, construction management (CM) and construction projects (CPs) are discussed.

Keyword: BIM Dimensions, Barriers, Benefits, Risk Management, Construction safety, Challenges

1. INTRODUCTION

Building information modeling (BIM) is a trying to cut technology/process that makes it possible to construct structures that are better. Building Information Modelling (BIM) proffer a unique method to design, construction, and facility management in which a digital representation of the building product and process is employed to promote the sharing and the compatibility of digital information. Building information management (BIM) is a process that provides flexible design, simple interoperability, and other characteristics. This method has many benefits, including increased efficiency, lower costs, less rework, better coordination, and more. There are various BIM service categories, including 3D modeling, mechanical, and structural BIM services. India's population is growing at an exponential rate. By 2025, India's population is predicted to overtake China's as it would have 1.4 billion people, according to sources.

Amongst the most significant advancements in the architectural, engineering, construction, and operation (AECO) sector during the past 20 years is building information modeling (BIM). Government agencies have made using BIM while completing projects a requirement for contractors. BIM technology has been embraced by several nations, including the United States, the United Kingdom, Singapore, China, the Scandinavian nations (Norway, Denmark, Finland, and Sweden, among others), France, South Korea, etc. Government companies have an important role in advocating the use of BIM and raising public knowledge of it by establishing regulations, producing BIM standards, and developing BIM best practices that the private sector can accept and put into practice.

The deployment of BIM technology by the whole Indian AEC industry made the turn of the new millennium rather remarkable for India. Due to technological constraints, there was initially some

hesitation and resistance to adopt fully-featured BIM technology for building, although this has changed recently. The necessity for infrastructure arrangements like building Public Utility amenities like roads, highways, ports, hospitals, etc., has been prompted by the rapid industrialization and urbanisation of society. Drones, robotics, augmented reality, and other technologies have changed how construction activities formerly took place on job sites. Integration of BIM technology into modern information technology has guaranteed that projects are streamlined with a low chance of differences resulting in changes.

India is not an exception to the emerging nations' quick adoption of BIM technology. The introduction of BIM technology in India has been a lengthy process, but in recent years AEC professionals have taken a huge interest in it. Future trends tend to be beneficial, and BIM technology has a promising future in the Indian construction industry (ICS).

II. LITERATURE RESEARCH REVIEW

The implementation of BIM in India is still in its infancy due to a lack of knowledge on its advantages. Also, there aren't many case studies about BIM that have been done in India. According to past study (2008–2015), there are a various reasons for which BIM is not being adopted in the Indian construction sector in a meaningful way. Some of these include technical know-how, qualified managers, technicians, and operators, ignorance of BIM's methodology among industry professionals, a passive attitude towards researching cutting-edge technology, and a reluctance to switch from traditional practice to new technology. Several literary sources are used in the current paper. It includes studies pertaining to recent aspects based on literature sources. A review of the literature on BIM technologies that are often used in building processes was conducted by gathering references from journals, websites, conference papers, books, theses, surveys, and other reports. Journals make up the largest proportion of the resources discovered since 2015, followed by conference papers, websites and blogs, theses, books, and surveys, reports, and initiatives. This holds true for the use of BIM in building. The current paper uses published review research sources for literature-based BIM. Only 35% of literature review available Indian origin, however, worldwide is 65%. We have divided this paper description in (i) reviews (ii) critical reviews(iii) over reviews (iv) bibliometric and scientometric analysis (v) study on (semi review) i.e., very close paper to review(vi) theses (vii) research papers on BIM use in construction. Emphasis has been given to analyze reviews recently published particularly during post Covid 19 period. Table 1 gives distribution of various types of reviews, research papers on BIM use and application in CI studied during 2008-2022.Here is the description of BIM reviews for preparation of fresh review-based use of BIM in the CI. Figure 1 gives year-wise distribution of reference sources on BIM use in CI and Figure 2 shows various types of resources use to synthesis this review paper.

Table 1: Distribution of different types of reviews

Type of Paper	Review	Over review	Critical review	Bibliometric review	Semi review/other paper	A study on	Thesis	Report/survey/ Conf. paper	Web site	Total
No.	42	7	9	9	52	6	6	4	08	143

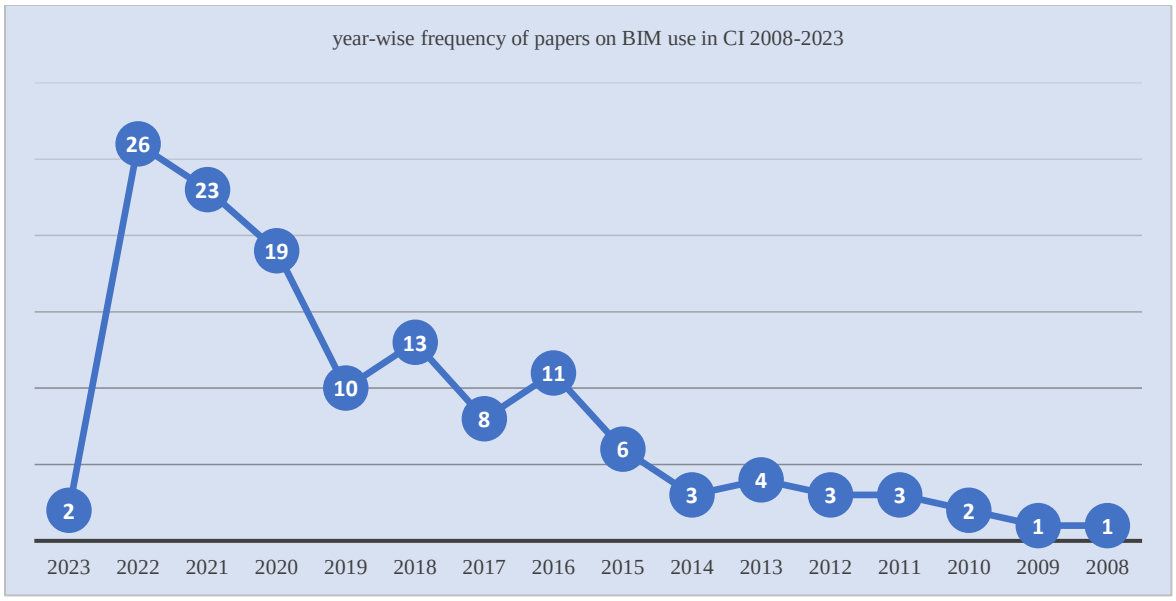

Figure 1: year-wise frequency of papers on BIM use in CI 2008-2023

The Architecture, Engineering, and Construction (AEC) business has emphasised Building Information Modeling (BIM) as a potent collection of design management's tools. BIM has significant advantages throughout the whole building lifecycle, including design, construction, and facility management. The entire implications of BIM on the advancement of design tools in the AEC sector have been the subject of recent research. Two major forms of BIM risk are legal (or contractual) and technological [1]. The first issue is that it is impossible to determine who is the owner of the BIM data, necessitating its protection through copyright laws and other legal channels. Another contractual concern is how to enter information into the model and who is accountable for any inaccuracy. BIM contributes to minimising physical risks and raising construction safety by spotting problems before they arise and anticipating site logistics. Safety evaluations and visual risk analysis can help ensure safety throughout project execution. The BIM technology still has to be developed, and it will take some time for the AEC industry to fully adopt the technology [2].

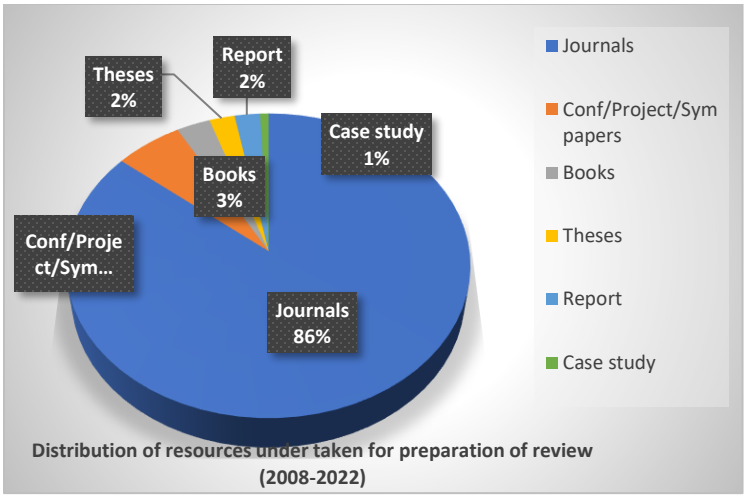

Figure 2: Distribution of resources under taken for preparation of review (2008-2022)

There has not yet been a BIM mandate in India. Recent research has revealed that the Indian construction industry (ICI) is adopting BIM technology/process for the reasons listed below: The benefits of BIM include: I a realistic image of the construction project; (ii) the elimination of unplanned alterations; (iii) cost monitoring; and (iv) the streamlining of the activity (v) Clash detection in BIM aids in addressing possible conflicts. It is noted that the distribution of references worldwide on BIM for CI review papers corresponds to Indian References 35% and International references 65 %. The construction business today demands high precise in planning, scheduling, and control of the project's progress in order to enable total cost, time,

and resource optimization. It has been discovered through the analysis of real building data from the construction site and the building simulation model that any duplication and rework can be prevented [3].

Building information modeling (BIM) is an integrated process for generating and managing buildings by examining a digital model both before and after the project is actually built, as well as during installation, use, and maintenance. According to [4], BIM has been embraced by architects and building contractors in the US and UK to enhance the planning and administration of construction projects. However, at that this was not a situation for Indian architect, contractors as they were lacking skill and fully aware of its use in building construction. In our country, architects have not fully incorporated this new thinking and technology into their working methods. And suggested need for development of a BIM implementation strategy. A comprehensive and exhaustive account on a guideline of various issues raised for adopting BIM in CI.[5] has investigated and summarized various strategies for adoption of BIM in construction industry. With the implementation of BIM to enhance the design, construction, and facility management of construction projects, the Indian architecture, engineering, and construction (AEC) sector is still in its very early stages. Indian AEC firms have been given advice on how to successfully integrate BIM into their current working procedures by [6]. The study methodology created by her provides a sense of the current level of BIM expertise in the ICI along with an online survey used to obtain information about the problems experienced by Indian AEC firms. Inferential statistics analysis of the data provides the most efficient means via which Indian AEC firms can use BIM.

In India, the BIM is a new and exciting strategy which is increasingly satisfying over owners, architects, engineers, and builders. BIM enables effective work processes and smarter judgements when utilized in the field to better communicate and integrate construction information across many trades. According to [7], using BIM allows for significant material and time cost savings, and architects and engineers in the CI greatly value its advantages. The adoption of BIM, [8] has brought a new approach to building design and construction management that has altered how industry professionals and people collaborate. [9] has demonstrated that BIM does supplement conventional scheduling and cost-estimating techniques with automated and more trustworthy technology. According to the data, the following conclusions can be drawn: (i)if BIM technology advances, higher levels of detail (LOD) will be possible; (ii) To give a scheduled financial analysis, building model BIM components will be linked to time and cost parameters concurrently; and (iii) resource allocation on a 4D BIM model will allow for analysis and planning of resource usage based on the most recent design, and also simulation of resource allotment. [10] has defined and identified thirty-two different BIM applications for commercial construction, with clash detection, 3-D modelling, team collaboration, constructability difficulties of design, and sales being the most used ones. Businesses reported that using BIM have a positive effect on profitability, construction time, and marketing.

According to [11], India needs to set up centres that will focus on broadly promoting BIM. As has been done in many other countries, the government must work with enterprises in the private sector and take the initiative to encourage the use of BIM. It is vital to research[12] both the favourable and unfavourable elements influence the adoption of BIM in the AEC sector. The principles for using BIM on a wide scale are discussed in [13]'s conclusion. [14] outlines three significant findings that revolve around employing BIM in the scheduling and management of construction projects. This study focused on enhancing the effectiveness and successful completion of building construction projects by examining the grade of BIM application and the BIM tools used in the Port Harcourt, Nigeria, construction industry. In his work, [15] outlines several crucial details regarding the practical application of the project management function using the BIM paradigm. By synchronising all these parameters, BIM allows us to integrate virtual three-dimensional models with real project time and actual construction cost, making it simple to maximise the project's overall efficiency. BIM is a holistic and collaborative methodology for the management of information for construction projects that has revolutionized the CI. The management of information for construction projects using BIM has completely changed the construction industry. India is now one of the nations with more potential for investors and BIM-qualified personnel due to the recent growth of BIM execution in the country's construction industry, in the public and private sectors. IBIMA is the primary national professional society for building information modeling and digitalization in the Indian AECO-Architecture, Engineering, Construction, and Operation sector. He founded the India BIM Association, or IBMA, which supports and advocates

on behalf of the entire Indian BIM community in order to create a favourable business environment for the successful usage of BIM technologies, procedures, and guidelines. [16]. Studying Ahmadabad City as an example,[17] implementation of BIM for real estate.

BIM is an innovative approach to design, construction, and facility management that uses a digital representation of the building product and process to enable information sharing and interoperability. Structures' appearance, functionality, and construction are starting to change as a result of building information modelling (BIM). Rafael et al. An in-depth overview of BIM technologies, as well as the commercial and organizational difficulties related to its implementation, is presented by [18] in their BIM Handbook (2018). [19] asserts that the use of BIM by Indian architectural firms is still in its "experimental" stages, with managerial backing, trialability, and expertise having a strong positive influence on its acceptance. The adoption status of BIM in India is also described in the paper using a multi-level social construct. With the use of this construct, the micro- and meso-levels of organizational sizes in India is where BIM adoption is at its highest level. The report discusses parallels and differences with prior studies in order to highlight the findings of this investigation.

Building Information Modelling (BIM), among the most intelligent 3-D models now showing promise, improves the administration and construction of design projects. One of India's largest and fastest-growing industries is the built environment. [20] has done research on the parameters that affects and hinder the use of the proposed paradigm. Design and construction information are both included in BIM. It includes both visual display and a simulation of state creation. [21] has examined the application of BIM in various construction phases, the barriers to its acceptance, and discussed how using BIM technology might be advantageous over using the traditional method employed by architects or designers and buildings built by contractors. The breadth of and obstacles to implementing BIM have been thoroughly discussed by Maan Singh [22] in his thesis[23] has demonstrated the significance of BIM application in the Indian construction and management business through awareness of BIM, implementation, and utilities in the country's established building structures and industries. The AEC sector needs to adopt BIM as soon as feasible in order to keep up with expanding technologies and developing problems. The authors discuss the general adoption of BIM in India at various levels of the construction procedures as well as challenges encountered throughout subsequent implementations. BIM software. [24] has substantially altered the architectural design process is organized, and it is anticipated that it will have a big impact on future advancements in product quality and industry productivity. Using questionnaire surveys for various users, [25] has highlighted the growth factors and the obstacles experienced for the usage of BIM in Indian construction projects with an emphasis on the risk, challenges, cause, and interest in adoption for ICI. He suggested that organisations make use of his findings to assess their existing BIM appropriation. [26] examined the volume of research on the application and uptake of BIM in several construction project domains. Author has analysed and established a cumulative analysis of the study disciplines and publishing advancement after looking at 130 publications from various sources. This report shows a steady rise in research into many aspects of construction projects. [27] concluded that the lack of government leadership for SMEs in the CI is the reason why New Zealand's BIM adoption assistance system is ineffective. The AEC industry has seen loose collaboration and a lack of coordination among its participants due to inconsistent standards and classifications. The research results are anticipated to deepen our understanding of the obstacles to BIM adoption in New Zealand. [28] has conducted study to comprehend the role that BIM plays in the improvement and application of Knowledge Areas (KAs) in the AEC business in Palestine. The findings showed how far BIM technology has advanced the application of KAs in the AEC industry.

The Architecture, Engineering, Construction, and Operations (AECO) sector typically adopts new technology slowly, which inevitably limits performance growth. According to preliminary results from [29], BIM drivers have a notable influence on BIM understanding during the project lifecycle's operating stage. The average R2 value for the Structural Equation Modelling (SEM) model is 23%, which is moderate. As a result, this research contributes to the pool of knowledge by providing crucial insight into how BIM drivers affect BIM awareness across the project lifecycle. Acquired information would assist government officials and industry stakeholders in creating policies that would promote the use of BIM in modern practise. BIM is quickly becoming a cutting-edge method for visually managing and designing projects. [30] discovered that the lack of modelling standards and the constant requests for design variation make the deployment of BIM in Malaysian CI somewhat ineffective in terms

of time and cost. The findings also suggest that Malaysian BIM has the potential to be as effective as that in other industrialised nations, provided that the key issues raised are resolved. [31] has expanded her research on the use of drone, BIM, IoT, and AR/VR technology in the field of digital construction technology trends. She places emphasis on the inclusion of these technologies in architectural engineering graduate and postgraduate curricula in Indian universities. These claims about using BIM in the educational ecosystem are backed up by a review published by [32]; [18]; [33]; and [34] as well as other recent academics.

Building information modelling (BIM), one of the most recent advances, offers the potential to manage safety on the construction site. This study examines the current level of BIM awareness in Indian construction, as well as its advantages and potential challenges. The advantages that BIM deployment can have for safety management are also discussed in this paper. According to a survey [35] performed on the Indian construction industry, there are three key areas that must be improved: corporate training in construction organisations; knowledge of BIM and its benefits for enterprises; and accumulation of BIM in the tertiary education system.

The collaborative BIM technique is growing in popularity in the building sector. BIM is a methodical procedure that combines all other geometric computer-generated models, or data, to produce simulations that the project manager, owners, facility manager, or other parties can use to manage the project and complete it more quickly. Due to ignorance about the benefits of BIM, the deployment of BIM in India is still in its infancy. A case study of a residential project in Gujrat has been presented by [36] for the study of benefit-cost analysis. Before construction, 8 flaws in the project's 3D and 4D models were found and detected.

The management of business information (BIM) has become an essential strategy for reducing project risks. The project life, starting with planning, design, and construction management, depends on BIM technology. BIM has been used successfully in many projects, but its application in the construction sector

III.MAJOR STUDIES AND CHARACTERISTIC FEATURES OF BIM FOR CI

The architecture, engineering, and construction (AEC) sector is undergoing a digital change. The way information is shared, how procedures are employed, and how things are handled are all being changed by

is questionable. BIM has been looked into and its relevance as the best solution for reducing project risks has been examined and studied [37]. Although many stakeholders use BIM as a modelling tool, he has stated that the first step in avoiding dangerous projects is defining clearly how these stakeholders can use BIM.

Very significant technology that covers a range of dimensions and maturity levels (Level 0, 1, 2, and 3) is building information modelling (BIM) (3D, 4D, 5D, 6D and 7D). Numerous past studies have demonstrated that the construction sector is however adopting technology at the rate that it should be, particularly in emerging nations like India [(https://biblus.accasoftware.com/en/), [38]; 39].

The literature on the obstacles to BIM adoption in the CI has numerous references. According to [40], BIM is not important for construction projects in India. [41] has looked into the dynamics of various BIM capabilities and used the Interpretive Structural Modeling (ISM) technique to understand how BIM capabilities are represented as a collection of connected pieces. This study provides a road map for BIM implementers by highlighting the driving and dependence power of each BIM element that is deemed to be helpful for enhanced delivery of construction projects. For both researchers and project managers, the findings of this study are anticipated to have major theoretical and practical consequences. This study [42] was expanded upon with more thorough research on the variables influencing the adoption of BIM in emerging countries, namely the instance of India. In the context of Indian architecture firms, the technological, environmental, and organizational aspects responsible for the adoption of BIM are investigated. [43] has thoroughly studied the development of BIM in the Indian AECO industry, with an aim in the past 15 years. Recently, [134] examined a real-world circumstance involving the use of project management knowledge areas (PMKA) in the sector of the construction business. Moreover, advantages and disadvantages of using technology as a tool to promote the implementation of PMKAs. BIM and knowledge technologies have an impact on how effectively building projects are managed.

technology. BIM is the method used to incorporate these technologies into a construction project. In what ways is BIM affecting the construction business, then? What are the advantages, obstacles, difficulties, risk management, and safety? To address these inquiries, please see the description below.

3.1. Benefits use of BIM in the Construction Industry

Initial literature text on benefits of BIM for CI before 2015 has been appeared in the literature as a basic guideline for use of BIM in CI in the form of textual text(matter) and not noted as a strong review. Figure 3 depicts some benefits for use of BIM in CI.[1] and [2] has given very initially some benefits and barriers of BIM use for construction industry.

Figure 3: Some benefits of BIM in construction Industry [Source https://www.bimspot.io/blogs/]

BIM has provided a detailed overview of the trends, advantages, dangers, and difficulties facing the AEC. The project benefits of BIM have been highlighted by [44]; in the same year, [45] and [46] have assessed the advantages of adopting BIM for the efficiency of construction projects. [47]]has examined the advantages of adopting BIM to boost performance in Iraqi CI. The advantages, characteristics, applications, and implementation of BIM for construction projects have recently been examined by [48]. The same year, [49] conducted a critical analysis of BIM implementation for CI with regard to adoption, difficulties, and advantages. BIM has provided a detailed assessment of the trends, advantages, risks and difficulties facing the AEC. [44] has given importance of the project benefits of BIM, and in the same year [45]] and [46] has reviewed BIM benefits on adopting BIM for construction project effectiveness .[47]]has reviewed on benefits of BIM adoption to improve performance in Iraqi CI. Recently, [48] has reviewed on benefits, features, applications and implementation of BIM for construction project. In the same year [49,] has critically reviewed BIM implementation for CI with respect to adoption, challenges and benefits. [39] has analysed the n-dimensional BIM's underutilised features with relation to an Indian building context. Many reviews on the advantages of BIM in CI were also published at the same time. [50] has discussed the advantages and difficulties of adopting BIM in UK residential projects. [51] has provided a summary of BIM adoption in the CI with regard to two concerns, namely advantages and industry constraints. Figure 4 highlights the drawbacks of safety application in addition to the advantages [https://springer.com].

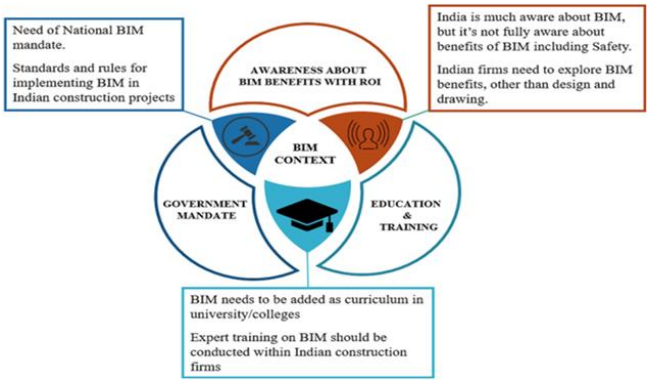

Figure 4: BIM usage benefits and challenges for safety application (https://link,springer.com/10.007/s42107-021-00379-8

3.2. Barriers in BIM for CI

Figure 5 displays an overview of the challenges to implementing BIM in CI. In order to execute the BIM process in construction projects, [45] examined the obstacles preventing BIM adoption in the AEC sector. The challenges to the implementation of BIM and the barriers to the implementation of BIM to the CI have been examined and investigated, respectively, by [52] and [53]. The factors, hurdles, and enablers of BIM Innovation in Developing Countries were recently reviewed and comparatively analyzed by [54], while [51] highlighted 18 barriers in his study.

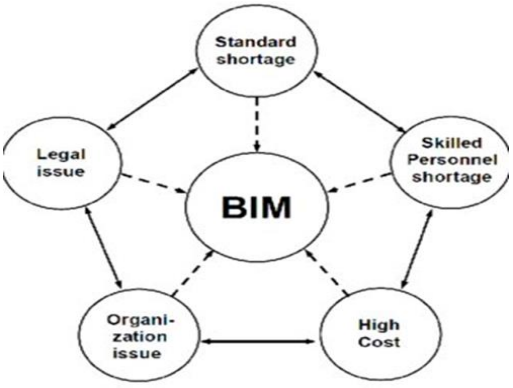

Figure5: Relationship between main barriers

(Source:https://www.researchgate.net/figure/Summary-of-barriers-in-BIM-implementation_tbl1_285630389

BIM compiles numerous project-related data into a centralised and easier-to-access format. Sharing this

with other team members and planners is simple. From the standpoint of project management, it enables more cooperative decision-making. This is due to the fact that everyone engaged has the opportunity to study building designs at most stages of the project life cycle [https://www.bimspot.io/blogs/]. Implementing BIM for construction safety is hampered by a lack of internal expertise, a lack of BIM training or education, a shortage of awareness, a lack of cooperation, consumer interest, ambiguity regarding the government's commitment to BIM, as well as the high cost of software. The following are some major obstacles to BIM adoption in the ICI: (i) Lack of knowledge, (ii) ignorance, cost-effectiveness for minor projects, (iii) cost-effectiveness for large projects, and resistance to change.(iv) Lack of collaboration among stakeholders[40].

3.3. Challenges in use of BIM in AEC

A paradigm shift is occurring in a variety of industries as a result of the creation and uptake of innovative technologies. The construction industry is not an exception. Since the introduction of BIM Technology and particularly in the last several years, the way the construction industry operates has undergone tremendous transformation. In many countries, including the UK, using BIM has become crucial for large-scale public projects. [https://excelize.com/blog/the-most-common-bim-adoption-challenges. The difficulties in applying building information modelling in the construction industry have been reviewed by [55]. We have already seen how [25] has discussed the ICI's knowledge of BIM, its motivators, and obstacles. [40]. Applications and difficulties with implementing BIM for the creation of smart buildings have been reviewed by [56]. Recognising the challenges of using immersive technologies in CI and architecture has been well reviewed by [57] the identical year. A critical analysis of the effects of successful technological applications in building has been done by James O. (2022) [58]. The ranking study's findings revealed that the top five important barriers were "lack of rules and guidelines," "lack of BIM schooling," "lack of skills," "high cost," and "lack of study and BIM implementation."

3.4 Risk and risk management in use of BIM in CI

Construction risk management is the process of determining and implementing strategies to mitigate the effects of hazards in construction projects. This methodical planning process results in the development of a risk management strategy that enables project managers to identify, monitor, and mitigate risks as they emerge. Building schedule risk simulation utilising BIM and the Monte Carlo technique has been evaluated by [59]. Critical risk considerations for the use of modular building have been assessed by [60]. A study of the literature on the combination of BIM and risk management has been conducted by [61]. The use of BIM in reducing hazards for construction projects has been examined by [62]. [63] studied how risks affected the implementation of BIM throughout the building phase and listed the critical success factors for BIM. [64] has examined the risk factors associated with applying BIM in the operation and maintenance phase of construction projects. A systematic literature review on collaboration and risk in BIM has been written by [65]. The observations of [37] on project risk mitigation provide strong support for the conclusions of earlier authors.

3.5. The future of BIM is being shaped by innovative trends, and it will be integrated with new digital technology.

Several authors working in the field of study have described recent rising digital trends addressing the types of innovative trends driving the future of BIM through its integration with emerging digital technologies. [58] [,66]. [67],[68]. Building information modelling (BIM) software had a successful year in 2021 in the architecture, engineering, and construction (AEC) industry. Yet, because technology is advancing so quickly, new BIM trends are continually showing up in the building industry. The use of digital information tools in the building sector fosters an atmosphere that is favourable for the establishment and growth of companies that specialise in the use of technology to design and construction. While some of the technologies are unique, many of them implement ideas from construction research that were impracticable decades ago without a strong digital building knowledge base. Building information modelling (BIM), ideas for artificially intelligent design and code checking tools, and construction robots have all been present since the middle of the 1980s and have spent decades working in research labs. [69] explores their reliance on digital information, their known past, uncertain present, and increasingly optimistic future to give a number of recommendations for advancements in digital construction. The evaluation finds new problems, producing a list of research questions that could lead to a variety of potential uses for artificial intelligence (AI) in the future. [70] has examined the application

of Blockchain Technology (BT) and given a summary of the various BIM adoption levels in the building industry. In order to comprehend the current research trend, authors looked at the numerous application areas within the BIM process. Also, they spoke about drawbacks and provided advice on how to best carry out upcoming BIM-blockchain integration work.

In recent years, cloud technology has developed into an extraordinarily practical way for users to store data and quickly retrieve it as needed. Throughout time, the BIM industry has gradually increased its adoption of this technology. As many participants in the project as possible can access the most recent project information in real-time thanks to cloud computing, which also fosters enhanced cooperation, productivity, and idea sharing throughout every stage of the project [https://www.digitalschool.ca/]. There have been four things made extremely clear: (i)BIM Software may become more (ii)cloud-focused, and cloud technology may speed up project processes (ii)sustainability and environmental friendliness are also hot topics with BIM (iv)AR/VR are current and upcoming trends in BIM technology in CI and CM (i)BIM Software may become more (ii)focused on the cloud [71] . According to [72], the primary study themes are BIM, IoT, and DT in the construction industry, Heritage BIM (HBIM), Smart Contracts, BIM, and Ontology, and VR and AR in BIM and DT. Also, they documented and noted a number of potential research fields, including BIM and Metaverse technology, BIM and Artificial Intelligence (AI), Metaheuristic algorithms for BIM optimization, and the Circular Economy using BIM and IoT. In order to advance end-of-life decision-making, [73] has contributed by installing the software module that creates a link between BIM and machine learning technologies.

BIM implementation in CI is evolving towards greater adaptability. The purpose of [www.intechopen.com, 2022] was to provide students, academic researchers, and practitioners with an in-depth, current analysis of the significance of integrating BIM with developing technologies in architectural educational programmes. These technologies included artificial intelligence (AI), cloud technologies, the internet of things, virtual and augmented reality (VR/AR), laser scanning, 3D printing, and drone technology. The time is right for the construction sector to embrace cutting-edge, innovative technologies like BIM, GIS, and Digital Twin. It must be required by the decision-makers throughout the course of the project. By utilising geospatial and other digital technologies like BIM, Digital Twin, and Artificial Intelligence, projects are delivered on schedule and run smoothly on the job site [65]. The foundations for increasing productivity and efficiency in the Indian building and infrastructure sectors are BIM and Digital Twin [74]. In order to comprehend the difficulties encountered when mainstreaming immersive technology (ImT) within the A & C business, [58] undertook a systematic review. 51 publications published between 2010 and 2019 were found using a systematic process (inclusive). The research develops a broad taxonomy with several features. The results led to the identification of nine major challenges, which were then ranked in the following order: infrastructure, algorithm improvement, interoperability, universal health and safety, virtual content modeling, cost, skills availability, multi-sensory constraints, and ethical considerations. The phases of the construction project life cycle are, in fact, at dramatically varied levels of automation and digitalization, as shown by [67]. The phases of initiation, design, and planning all had low levels of automation and digitalization, while the execution phase had higher levels of automation but lower levels of digitalization. Since the subject is always evolving, this research might be carried out soon to see how far the current findings have progressed. [75] has conducted a thorough analysis of the benefits of BIM and IoT technology. He introduces the fundamental work and explains how to design a sophisticated management system for building materials using IoT and BIM technology. Further reviews based on usage and applications in CI are elaborated with respect to authors name, year, title, key findings, significance and remarks in the tabulate form (Table 2-7).

Table 2: Reviews on implementation of BIM in CI

Sr No.	Author/Year/Reference No.	Contents	Key Findings
1	Annilise Nairne Schamme and	Contributes to the analysis of the improvement of BIM research and helps to clarify the limitations of its	BIM supports in reaching some sustainability goals, but the software's interoperability issues make it impossible for an integrated study to pull

	Andre Nagalli (2022). [76]	applicability to sustainability rating systems. (ii) highlights the need for increased BIM use in building sustainability assessments, (iii) Using BIM to manage waste and meet material and resource needs on building sites.	data directly from the programme to satisfy the needs of building sustainability assessments (BSAs).
2	Chavan Sayali, and Gorade S. B. (2022). [48]	(i) Studied literature for application of BIM. (ii) Implementation of BIM for 3D,4D,5D,6D,7D & 8D	The paper explores the features and advantages of BIM, its uses, and the state of BIM adoption in various nations. This study also clarifies the application of BIM and the difficulties encountered in doing so.
3	Hafez Mohammad Faisal Shehzad et al. (2022) [77]	Identifies the study's challenges and evaluates the models utilised, the state of BIM adoption, and technology acceptance theories. acknowledges the roles played by mediators, independent and dependent constructs, and moderators in the analysis of BIM adoption.	(i) Finding provides an detail description of the various stages of BIM adoption. (ii) Maslow's theory and the diffusion of innovation theory both shed light on how cognitive concerns affect adoption.
4	Moustaf S. Algjamdiet et al.,(2022). [78]	Identified some issues in South Arabia(i) the failure to achieve sustainability (iii) the failure to use BIM in both public and private projects (iv) the development of BIM-supported methodologies for both public and private projects.	(i) Findings and evaluation of the many perspectives on sustainability held by specialists and the general public; (ii) creation of a framework of sustainable design measures for buildings that takes into account particular elements. (iii)indicating the present level of BIM technology use.
5	Pinti Lidia; Codinhoto Ricardo; Bonelli Serena (2022). [79]	(i)Use information on BIM-FM that is already in the public domain by examining and categorising articles that were written between 2010 and 2021. (ii) examines the application of BIM for FM purposes in various public buildings.	(i)Findings indicate there are number of publications concerning BIM-FM. BIM-FM for public and private companies differ, although not equally. (ii)BIM-FM research is still in its infancy for public organisations and is not uniform.
6	Sahil Salvi et al. (2022). [80]	Reviews the use of BIM for life cycle assessment (LCA) of buildings. This technique aids in understanding the effects of the built environment.	The findings of the research imply that BIM can be utilised to lessen the negative effects of building on the environment.
7	Silva, T. F.et al. (2022). [63]	Identified areas for improvement and the direction of upcoming research in the realms of risk management and BIM. It also looks into the connections between project success factors and risks related to BIM deployment.	(i)The three concerns that are identified the most commonly are technological programme interface, interoperability problems, and a lack of understanding. (ii) The risks connected to BIM, particularly during the design phase, are shown to be positively correlated with key BIM success factors.
8	Shubham A. Bhendkar, and. Prakash S. Pajgade (2022). [81]	Increasing use of BIM in civil and structural engineering, professionally practice and focus research on BIM use.	BIM aims to increase project efficiency and produce better outcomes. Construction management can more efficiently collect and communicate data and information from the relevant disciplines thanks to BIM.

9	Sood, R. and Laishram, B.,(2022). [39]	Various key factors reported. (i)various dimensions, (3D, 4D, 5D, 6D and 7D).and level of maturity and present situation in ICI (ii) presented some future research work.	Policymakers and practitioners may find the findings to be extremely helpful in implementing a BIM-based framework that is mandatory for ICI and other developing countries.
10	Zul-Atfi Bin Ismail (2022). [82]	(i)employing BIM technology that includes automated evaluation methods, (i)identified the various system approaches (ii) The majority of BIM research has been on theoretical frameworks for acceptability in the green building (GB) maintenance sector.	(i)Building information modelling (BIM) offers the ability to improve building control instrument performance and design understanding (BMC). (iii)BMC and its impact on maintenance planning have not received enough attention.
11	Abubkar Altohami,Nuzul Azam (2021)' [83]	(i)Covers obstacles that prevent BIM-IoT integration while also addressing interoperability problems and cloud computing. (ii) investigates and discovers common growing application areas and common design patterns of the traditional BIM-IoT integration, then develops better integrating IoT in BIM methodologies.	(i)This method and discovery are based on combining real-time data from IoT devices with BIM studies in order to increase operational and construction efficiency and produce high-fidelity BIM models for a variety of applications. (ii) draws the conclusion that a high-tech solution is necessary to connect IoT devices more effectively across the Internet infrastructure.
12	Ang Yang et al. (2021) [56]	Provide the key findings and implications regarding the research needs and trends, including (i) enhancing the software's interoperability; (ii) examining the role of BIM during the maintenance and renovation stage of smart buildings; and (iii) concentrating on BIM technology in the field of transportation infrastructure.	(i)Provides a thorough understanding and encourages critical thought about how BIM and smart buildings are related. (ii) Proposes a three-dimensional framework with BIM attributes, project stages, and smart attributes for the intersection of BIM application in smart buildings.. (iii)Explicitly defining the financial advantages of BIM projects
13	Manoj U. Deosarkar et al., (2021). [84]	(i)Designed building by using Autodesk Revit Software. Autodesk Revit BIM software for landscape architects, landscape architects, structural engineers, MEP engineers and contractors(ii) estimations of building also using Revit Architecture (iii)planning, modelling, scheduling commercial building.	provides authentic families of furniture and lighting fixtures, as well as the ability to import pre-existing models from other programmes like Auto CAD. Authors have developed families for both residential and commercial structures.
14	Narendra A.1., L Pinky Devi (2021).[85]	(i)BIM may be able to satisfy an owner's desire for predictable pricing, high quality, and on-time delivery. (ii) . Implementation of BIM for ,4D,5D, and ,6D,	recognised the essential components of BIM awareness, benefits, obstacles, and implementation options.
15	Yidan Zhang, Yi Yang, Wei Pan and Mi Pan (2021). [86]	Key performance indicators (KPIs) for Construction Supply Chains (OSC) supply chains from December 2000 to March 2021 have been identified. Additionally, by examining and analysing current measurement efforts from a variety of angles, this research	Authors created a measurable assessment technique, built on the framework, and gave ignored KPIs, particularly those related to social and environmental issues, greater attention.

		helps to improve understanding of OSC supply chain performance..	
16	N.Zaini et al.(2020). [87]	(i)Identify the essential components of BIM implementation, including its benefits, methods, and execution. (ii)Top ten ranking of BIM awareness, advantages, obstacles, and adoption methods for industry players (ii) The application of BIM technology is focused on meeting customer demands in Sarawak CI	(i)BIM process execution, productivity improvement through efficient teamwork, increased return on investment, and decision-making assistance (ii) increased effectiveness brought about by an integrated design process, (iii) precise and trustworthy cost estimates, (iv) decreased financial risk, and (v) avoided possible conflict.
17	Vimal kumar, et al .(2020). [88].	Use of BIM in industry and comparison and synthesis of pertinent research findings. The BIM tools intend to expand their industrial applications in the future.	The outcomes demonstrate many effects from BIM adoption, including 3D/4D/5D/6D functionality. The article's final goal is to promote the full range of BIM capabilities that can be used in construction activities.
18	Jingming Li et al.(2020) J.of cleaner production (2020). [33]	The first review-based study evaluating current BIM developments in AEC-related fields in higher education. This study presents the most recent developments in BIM adoption in AEC education and surveys the state of the BIM education literature.	The current research predicts that there will be some ongoing effort in BIM education, including (i) interdisciplinary collaboration to reduce fragmentation among AEC disciplines and (ii) creative teaching techniques that include both technical and management aspects of BIM.
19	Wang, L, Huang, M, Zhang, X and Jin, R (2020). [34]	Identified relevant publications of BIM educational research outputs, such as journals and conference proceedings, and examined current research keywords.	This Technical Note examines current BIM adoption patterns in higher education for AEC and (AEC)-related fields and is one of the first review-based studies in the area.
20	Zaid Saad Hadi (2020). [47]	(i)The key reasons for Iraq's poor project performance were highlighted (ii) exploited to improve project performance, raise project competency, time, and cost, and (iii) strengthen stakeholder engagement and communication.	(i)BIM has significantly enhanced all phases of the project life cycle—design, pre-construction, construction, and post-construction. (ii)BIM offers comprehensive, cutting-edge management and maintenance plans.
21	Mohammad Firdaus Razali et al., (2019) [89]	The deployment of building information modelling (BIM) over the course of building life cycles is reviewed in this article with an eye towards addressing problems and identifying potential areas for further research. The report finishes by stating that the majority of BIM research primarily focuses on the planning and construction phases (iii) Three phases were studied.	Classified Virtual Design and Construction (VDC) development into three main phases: Phase 1 (Visualization). II. Phase 2 (Integration). III. Phase 3 (Automation). (ii) The AEC industry will reap the most financial benefits from BIM through ongoing professional development and increasing awareness. (iii) The AEC industry acknowledged the advantages of BIM.
22	Sachin Nalawade et al (2019) [24]	The architectural design process has undergone significant organisational change as a result of BIM technology, and it is expected to continue to play a significant role in improving product quality and industry efficiency.	BIM use, application, benefits and limitations of BIM are discussed.
23	Yin Rui (2019). [90]	(i)analyzes BIM application in practices and compare(ii) explores relevant	(i)The outcomes show different effects from BIM adoption, including 3D/4D/5D/6D functionalities.

		articles systematically, including BIM 3D/4D/5D/6D applications.	(ii)promote the full implementation of BIM functionality in construction-related activities.
24	Ziwen Liu, Yujie Lu and Lu Chang Peh (2019). [91]	(i)Outlines the difficulties the AEC sector has had adopting and implementing BIM technologies. In this regard, differences are noted between emerging and (ii) established nations in terms of the pros and cons of adopting BIM, as well as potential issues and fixes.	(i)Researchers and industry experts believe that the widespread use of BIM in the construction industry would result in many benefits and increased efficiency. (ii)SWOT analysis was performed when researching the usage of BIM in construction.
25	Debasis Sarkar and Harsh Shah (2018). [61]	The risks associated with the deployment of BIM ensure the potential advantages. Model the risks' routes and identify the dangers related to BIM AEC projects.	Explores an integrated BIM and risk management model for infrastructure projects possibility of develop
26	Ensar Ademu and Selin Gundas (2018). [92]	Explains the difficulties BIM adoption and implementation have experienced in the AEC industry.	In this regard, a distinction is drawn between emerging and established nations in terms of the strengths and weaknesses of BIM adoption as well as potential issues and solutions.
27	Shakil Ahmed (2018). [53]	In this study, a number of factors were discovered, including (i) social and habitual reluctance to change, (ii) conventional contractual practises, (iii) expensive training expenses, (iv) high software acquisition costs, and (v) a lack of knowledge of BIM.	Because BIM technology offers so many advantages, it is critical to eliminate the barrier based on priority with the aid of the government and other project stakeholders. A barrier that prevents the use of BIM technology in the construction sector has also been documented.
28	S.Meganathan and N.Nandhini Jan (2018). [55]	(i)Advocates a plan for Indian construction companies' current working procedures to properly incorporate BIM. (ii) The research method entails examining the current BIM information situation in the Indian manufacturing sector.	Inadequate project experiences, management process damage difficulties, a lack of top management commitment, high software costs, low client demand, inadequate project experiences, unclear legal liabilities, and a lack of skilled and trained employees are just a few of the numerous factors and conditions.
29	Srimathi. S and R.N.Uma (2017), [93]	Presented (i) BIM tools with 4D capacity (ii) use of 4D BIM tool link the 3D BIM model with project schedule	(i)BIM creates competence and enables users to gain a number of advantages (ii). helps to better manage the construction process, increase collaboration, and schedule the work.
30	Subhi,M and Uma ,R.N. (2017). [127]	Current study is concept of BIM derives a platform (ii) recognize potential design, construction and operational problems	This review gives a clear view on implementing the 5DBIM technique in the residential projects
31	Yang Zou,et al. (2017). [94]	(i)Designing a framework for general risk management developing a knowledge-based system (ii), proposing safety risk management using reactive IT-based safety systems (iii), and concentrating on analysing technical advancements and managing risks related to the safety of construction workers	Future study is recommended to: (i)have a multidisciplinary system-thinking approach, (ii) examine implementation methods and procedures, (iii) integrate conventional risk management with new technologies, and (iv) assist the development process in order to close this gap.
32	Saundharya R .and Uma R.N. (2016). [128]	Due of their distinctive features, BIM is commonly employed in major construction projects. The usage of BIM technologies has also spread to the small-scale construction sector. They provide	Using BIM in CI is explained in this study. BIM has a helpful method for CI that increases customer satisfaction and cuts down on time.

		thorough descriptions of a structure, which aids in documentation.	
33	Abuzar Aftab Shaikh, et al.(2016) . [133]	The survey information is (i)gathered from various research materials, including the Smart Market report, NBM National BIM reports, and BIM surveys. (ii) The study looked at the awareness and acceptance of BIM in various countries; (iii) India had the lowest levels, at 22%.	(i)involves the identification of BIM adoption and awareness in a subset of eight nations with significant construction markets. (ii) investigates the usage % for BIM.
34	Rafed Sackset al.,(2016) . [95]	(i)The set of guidelines offered for significant construction client organisations to assist with the creation or updating of their own BIM guides (ii)contributes a checklist of the crucial topics that must be covered, including subjects that are not yet covered in the majority of the ground-breaking BIM documents	In order to find both recurring themes and unrecognised details, the author presents a qualitative content analysis of fifteen BIM guidelines, standards, and protocol documents that have been published thus far. While the primary subjects covered by all of the standards and guidelines - interoperability, cooperation modes - are identical, there is still a need.
35	C.Allen and W.Shakantu (2016). [96]	(i)Indicates a rethinking of the structure of the construction industry and the manner in which projects are delivered; (ii) indicates the development of more effective project delivery methods and the onset of a process that will fundamentally alter the construction industry.	(i)BIM, a tool for business process re-engineering, can be utilised as the foundation for changing the project delivery process, enabling the construction industry to undergo a digital revolution. (ii)BIM will be essential for enhancing project delivery outcomes.
36	Doumbouya, L., Gao, G. & Guan, C. (2016). [46]	(i)It is important to better understand the advantages of BIM, study its adoption, and assess its value at different phases of construction projects. (ii) Identifies pertinent BIM elements and results, and establishes a framework for further research. Reviewing the advantages of BIM adds to the corpus of material already written about AEC and BIM.	(i) Throughout all stages of the construction project, BIM succeeds in achieving its objectives, offering benefits like improved design quality, simplicity in implementation, and information sharing capability. (ii) Reduction of construction costs and design errors, quicker work and shorter construction times, increased energy efficiency, and support for construction and project management.
37	Nam Bui, et al. (2016). [97]	(i)Discusses various BIM implementation challenges and offers solutions that are specific to low- and middle-income economies. (ii) identifies gaps in previous studies on the use of BIM in underdeveloped nations	According to research, construction companies in developing nations frequently outsource their IT needs or create workarounds to cut costs and enable BIM, such as employing "fake" IT licences. (ii) offers recommendations for implementing BIM in poor nations
38	Volk, R., Stengel, J. & Schultmann, F. (2014). [98]	BIM implementation in existing buildings will be encouraged and extended by new technologies like cloud computing, semantic web technology, and mobile BIM devices as well as long-term trends like increased digitalization and automation, a growing stock of existing buildings, and sustainability requirements.	Results show that BIM implementation in existing buildings is still risky due to difficulties with (i) high modeling/conversion effort from captured building data into semantic BIM objects, (ii) updating information in BIM, and (iii) handling of uncertain data, objects, and relations in BIM occurring in existing buildings.
39	Hassan Suhall and Yaqoob	(i) The value of teamwork in design management and what it can contribute	When used in design management as a collaborating tool, BIM was found to be most

	Nowsheeba (2013) . [99]	to collaborative design (ii) The discovery that organisational culture and the human element are still lacking in collaborative design using BIM (iii) The automatic introduction of lean thinking into the industry	effective (i) in collaborative environments (ii) for reducing the amount of rework (iii) and for detecting collisions much earlier in the design stage (iii), among other benefits covered in the paper.
40	Cristoph M erschbrock. ans Bjerm E. Munkvold, (2012). [100]	Research reveals that, to a certain extent, IS serves reference discipline. Modern BIM research is informed by (i) IS research theories (ii) the planned and recognised value of BIM	Area identified: interactions between functional affordances, human agency, and BIMs adoption and application of BIM for cross-organizational cooperation, the impact of corporate culture on BIM practises, and the capacity of BIM to change industrial practise
41	Maria Bernardete Barison and Eduardo Toledo Santos (2010). [130]	(i)The procedure of content analysis was utilised as the research methodology to investigate a collection of articles and course outlines that detail experiences in schools that have been recognised as leaders in BIM education. (ii) a focus on course preparation, including prerequisites, aims and objectives, material, teaching methods, evaluation, and activities	determined types of BIM courses based on students' actions and to propose a fundamental structure for a BIM-enabled curriculum along with recommendations
42	Jorge Jerez Cepa, et al. (2023). [135]	The key drivers of smart construction include the usage of BIM in various project phases together with IoT, Big Data, Blockchain, and GIS.	BIM's integration into FM through ICTs enables decision-making based on data analysis and resource optimization.

Table 3: A systematic review on BIM use in construction building sector

Sr.no	Author	Content	Key findings
1	Ali, K.N.; Alhajlah, H.H.; Kassem, M.A. (2022). [65]	Focuses on the research materials gathered from databases and WOS that are connected to risk management and BIM cooperation.	(i)Talk about the BIM for CI collaboration risk concern. (ii) Supports the need for research on the subject in order to increase the likelihood that a BIM project would be successful.
3	Bernardus Ariono, et al. (2022). [54]	(i)identified the influences on BIM innovation in six developing nations from three distinct continents, including their motivators, constraints, and facilitators. (ii) Developing countries have developed BIM adoption in light of global problems.	(i)investigated the value of BIM's innovation aspects in underdeveloped nations (ii). The findings of this study will help AEC stakeholders develop effective BIM deployment strategies.
3	Ali Saad, and Ajayi, SO and Alaka, HA (2022). [101]	(i)presents a framework that makes it easier to comprehend the programming dynamics involved in creating BIM-based plugins (ii) captures how BIM has evolved to have additional problem-solving capability.	Indicate that key building is a crucial feature of custom-built plugins that has been shown to: (i) increase productivity and efficiency towards cost (ii) decrease time spent and the likelihood of error.
4	Alia Besné , et al. (2021)	According to the analysis, there is agreement that academic guidelines that	A set of legislative standards that could serve as a uniform framework for institutions to boost this

	[102]	are common to all university centres and specify a plan for curricular changes as well as teaching and learning techniques are needed. Future study directions are then determined.	integration process is identified after analysing the methods higher education institutions used to implement BIM in AEC degrees around the world.
5	Behzad Abbasnejad et al. (2021). [131]	Identified to contribute wide utilization of BIM at organizational level in AEC firms.	AEC companies in assessing organisational preparedness for the implementation process, as well as the necessary innovations and capability development for BIM application.
6	Yu Cao, et al.(2022) [103]	The goal of the authors was to encourage the use and enhancement of BIM capabilities during the development of green buildings.	Facilitate for BIM during three construction phases of the green building
7	Min Deng et al. (2021). [74]	As a starting point for more research, they suggest the idea of an advanced digital twin for building management..	It was discovered that the majority of earlier research projects have not fully utilised or realised the imagined concept of the Digital Twin, which inspires trends in ongoing study.
8	Hamid, A., & Dossic, C.S. (2016). [104]	(i) Brings attention to the need for additional varied study settings and designs to close the gaps seen in the BIM curriculum research conducted so far. (ii) developing pedagogical methodologies for BIM teaching in AEC programmes	Outlines a framework for BIM curriculum design methodologies based on the literature as (i)a list of suggestions that BIM educators and researchers (ii)can utilise as (iii)a guide for creating or assessing their BIM curricula in future studies.Discussion of benefits and drawbacks

Table 4: An overview review on BIM in construction building sector

Sr no	Author /year	Contents	Key Findings
1	Bipin Kumar (2022). [105]	Published BIM- overview as a book chapter Author explains the concept of BIM-ecosystem, include client and service organization in AEC industry	Identified and suggested various elements of BIM-ecosystem
2	Gayatri Mahajan (2022). [106]	This study extends & cover objectives based on (i) to set a revolution in construction technology (CT)trends (ii) How technology is changing the CI and CT (iii) Advanced BIM application in CI (iv) the new age of Civil Engineering CE&. Practicing these technologies, in CT/CI/CE increases levels of quality, efficiency, safety, sustainability, & economics.	The results reveal that construction trends vary from 5 to 10; however, it reaches 27 in case of CE. In the near future, a perspective on the most recent innovations, trends, tools, problems, and solutions used in the fields of building construction and civil engineering has evolved. (ii) Tabulated various aspects and significance of BIM technology adoption in CI for the period 2016-2020
3	Keshav Er. and Harvinder Singh (2022). [71]	(i) increasing curiosity, being able to increase project facilitation through 3D modelling and 3D viewing, (ii)implies the advantages of CM integrating BIM AR with CM to create transparency in design, costing, and progress.	(i)visualization for the addition of 3D-live viewing to do away with time-lapse and local data impediment (ii). Also, this study offers future paths for dealing with technological changes that could significantly increase on-site efficiency.
4	Corbett, (2021) [107].	(i)includes information about restoring buildings and other stationary structures, building roads and operating service facilities. (ii)From planning	The study provides information on market dynamics like drivers, barriers, and opportunities in this industry. The profiles of current leading companies provide an overview of the Indian

		through completion, the process of building a structure, a piece of infrastructure, an industrial facility, as well as other operations, is referred to as construction.	construction market's competitive environment .The paper also includes market effects and forecasts for COVID-19.
5	Georgiadou, M. C. (2019). [50]	investigates which general BIM ready drivers and barriers are more pertinent to the planning and execution of housing projects.	Widespread knowledge of BIM but a financial barrier preventing investment in developing digital capabilities, especially for small- and medium-sized firms (i)indicates that the most frequently highlighted advantages are linked to collaboration, usage of software, and process innovation.
6	Kaleem Ullah ,Irene Lill and Ernlyn Wilt (2019). [51]	(i) A survey can be used to model the barriers to BIM adoption in the Estonian CI based on the results. (ii) This study offers information on BIM adoption in the CI and will lay the groundwork for further investigation.	This study looked at how BIM was used in the construction industry across several countries and showed how it was advantageous at every stage of the building lifecycle. There is study on the widespread use of BIM and discussion of 18 barriers.
7	Noor Akmal Adillah Ismail et al.et (2017). [108]	The adoption of BIM in several Asian developing nations is reviewed in the paper, which also looks at how widely it is used in Asian regions.	Given the forces driving and impeding the adoption of the technology in these nations, and how this is expected to alter in the near future, (i) In the majority of underdeveloped nations, BIM is not as advanced. (ii) Share some information about how BIM is evolving in those countries.

Table 5 : Critical review/analysis on BIM in CI

Sr no	Author /year	Content	Findings
1	James O. Toyin and Modupe Mawomo (2022). [58]	(i)Researched how BIM-t installation affected how quickly construction projects were completed. The information in (ii) includes reports on knowledge gaps and suggested future research initiatives. (iii)used a methodical study of pertinent literature from 2008 to 2021 on the subject of BIM-t.	The results show that out of 41 examined papers, there have been seven (17) favourable impacts. The various building phases were used to group the stated advantageous effects.
2	Satyajit B. Patil (2022). [49]	(i)offers a workable answer to a variety of problems (ii)listed numerous strategies for overcoming the difficulties encountered throughout the construction project. focuses on recent research conducted between 2015 and 2022	Examines the adoption, challenges, and benefits of BIM in CI by taking into account studies from the greatest number of nations in the world.
3	Abdulkadir Ganah and Gavin Lea (2021). [68]	(i) Identifies and contrasts BIM guidelines, standards, and templates from throughout the world (ii) Used a qualitative research methodology approach supported by document analysis of BIM standards created in various nations across six continents.	(i)Provided suggestions for standards development based on the gaps identified (ii) government, industry organisations, or academic institutions to assist in the establishment of BIM standards to close the gaps in contract and design documents
4	Albert P.C. Chan et al., (2018).	The institutional framework and regulatory governance of BIM in putting	(i)analyses data to create a study plan for project management BIM studies. (ii) concentrates on

	[109]	project management strategies into practise, the scopes and integration issues of BIM research for project management, and studies of the outcomes and strategies of BIM adoption and implementation in projects	how the various research trajectories relate to one another as well as the contributions and theoretical ramifications of this review.
5	Druv Gor, et al. (2018) [132]	The perceived relevance of 6 variables varied significantly between BIM writers and BIM consumers, according to an analysis of perception variations across different respondent groups. There were 26 factors used in total.	The findings show that the questioned architects and contractors concur on the majority of the offered features, including model economy, model usefulness, and model productivity.
6	Rajesh Gangani, et al.(2018). [110]	Each phase of the project—Pre-Construction, Construction, and Post-Construction—uses BIM. Construction materials cost between 40 and 60 percent of the entire project cost. Cost	BIM-based dynamic inventory control model with an emphasis on inventory management in the construction industry
7	Y. Araya and Shakilmeya S. Malek (2018). [111]	Provided a mixed review of prior reviews, compared benefits of BIM	(i)Discussed BIM use in different phases of construction (ii)Stated the future of BIM as a compulsory practice in India.
8	F.H. Abanda et al. (2015). [126]	The various BIM software systems now being used to handle construction project information are thoroughly and critically evaluated using the following five key methodologies.	Examines the entirety of BIM systems; the study employs a holistic approach, looking at 122 application cases that are typical in the AEC sector and most of the major BIM system types.
9	Z. Sriyolja ,N.Harwin and K. Yahya (2021). [113]	Recognises, classifies, and examines the challenges that come with implementing BIM as a digital information technology in the CI and offers critical insights for future research to overcome those challenges.	According to the study, from the 26 articles that were selected, 15 categories of barriers could be successfully retrieved and addressed. Among the 15 different types of barriers are those related to cost, legality, knowledge, interoperability awareness, culture, processes, management, demand, project scope, technology, skills, training, contracts, and standards.

Table 6`: Bibliometric and Scientometric analysis on BIM use in CI

Sr no	Author /year	Content	Findings
1	Shishehgarkhaneh, M. et al. (2022). [72]	The study demonstrates the application of Heritage BIM (HBIM), Smart Contracts, BIM, and Ontology in the construction industry, as well as BIM, IoT, and DT. The usage of BIM and Metaverse technology, BIM with AI, Metaheuristic algorithms for BIM optimisation, and the Circular Economy with BIM and IoT are among the recognised trends.	The study's key findings include (i) the use of metaverse technology in BIM and the construction sector; (ii) the integration of AI and digital twins with BIM; and (iii) the implementation of the circular economy in the construction sector utilising BIM and IoT. The primary study themes are VR and AR in DT and BIM.

2	Amarnath C.B. (2021). [124]	(i)A study provides a bibliometric examination of the global and ICI use of BIM. (ii) The analysis was done twice, taking keywords into consideration. as well as the volume of materials and research	Reviewing adoption globally while focusing only on BIM adoption in ICI, (i)examines the use of BIM in worldwide construction for safety and restricts the outcomes to BIM usage for safety in India
3	Shalaka Hire, et al. (2021). [114]	gives a bibliometric examination of the worldwide construction industry's and Indian CI's use of BIM. The use of BIM for safety in the international and Indian CI is also reviewed. examines the global adoption of BIM	(i)Examines the implementation of BIM for safety in worldwide construction, focusing on India, and presents the findings. (ii) BIM could provide the ICI with significant advantages. (iii) Several supplementary products for building site safety, such as VOSviewer and iMapbuilder
4	Saka, Abdullahi B., and Daniel W. M. Chan. (2019). [115]	(i)Provides a scientometric analysis and meta-synthesis of BIM development in the African AEC sector. (ii) Examines the conceptual development of BIM, the current state of BIM in various areas, and any potential roadblocks to BIM adoption.	The key obstacles to BIM adoption were identified as being people- and process-related. I Results demonstrated a diverse amount of BIM growth, with North Africa, West Africa, and Southern Africa leading the research development, while East Africa and Central Africa are slightly lagging behind.
5	Tatjana Vilutience et al., (2019). [116]	shows that efforts to conduct study in this area have mainly focused on addressing generic BIM issues, such as information management; however, technical structural challenges in engineering that could be resolved using BIM capabilities have gone ignored.	(i) Shows how after 2014, research on the application of BIM in structural engineering grew rapidly. (ii) Discusses a variety of issues relating to research gaps and crucial areas required for project completion.
6	Ziwen Liu, Yujie Lu and Lu Chang Peh (2019). [91]	(i) Create the 3 stages of formulating, accelerating, and transforming. (ii) examined Singapore's BIM policy and noted the connection between the development of BIM policy and international BIM research.	Findings highlight the need for additional study in the field of BIM and visualise the current state of the subject's advancement for researchers, practitioners, and policymakers.
7	Ruben Santos ,et al. (2017). [117]	(i) Recognized interoperability and collaborative settings, sustainable building (ii) The academic contribution of BIM, parametric modelling, and quantity take-off is quite limited.	It was noted that the creation of BIM tools, analysis of BIM adoption globally, energy simulation using BIM-based data, and, more recently, semantic interoperability and ontology, were the topics that had received the most research.
8	Yalcinkaya, M. & Singh, V. (2015). [118]	The study's twelve main research areas are revealed by applying Latent Semantic Analysis (LSA), a method of natural language processing, to the abstracts of 975 academic papers.	Recognized numerous distinct research themes connected to each major area These main research issues and areas of study highlight the patterns and developments in BIM research.
9	Tsengunn Ganbat Et al. (2018).	Research trends and possibilities for risk management in BIM-enabled international construction have been identified and explored, and frameworks for BIM risk management in international construction (BIM-RM-INTL) have been developed.	findings demonstrate the increasing BIM adoption not only piques the interests of all stakeholders but also carries some dangers. Current research findings and their connections were mapped for use in risk management in BIM-enabled international building.

Table 7: Miscellaneous research paper on BIM for Construction industry

Sr no	Author /year	Contents	Findings
1	Sonali Dhopte and Arti Daga (2022). [43]	(i)Examines the past, present, and future of BIM adoption in India from the viewpoint of the business community. (ii) Studied and Excelize, an Indian BIM service provider with nearly 20 years of experience in the AECO sector.	(i) Finds that BIM offers a number of benefits for a project's general efficacy and wellbeing throughout its entire life cycle. The study includes both project participants and BIM service suppliers (ii). BIM adoption still encounters a variety of challenges.
2	Abdullahi B. Saka and Daniel W.M. Chan (2020). [120]	(i)The SMEs that make up the construction industry's backbone are examined holistically from the standpoint of existing BIM research in this article. (ii) Created a conceptual model based on a literature review and the framework, model, and institutional theory of innovation diffusion.	(i)Results showed a lack of BIM studies in SMEs, the adoption state, and identified motivations, benefits, and constraints. (ii) The report makes significant arguments for promoting BIM in SMEs.
3	M F Antwl-Afari ,et al. (2018). [112]	Analysis shows that certain nations have created distinct critical success factors (CSFs) for gauging the success of BIM deployment. Common CSFs include: Planning and site safety; cooperation between design, engineering, and construction stakeholders	(i)research on CSFs used for BIM deployment from 2005 to 2015. (ii)better site layout, coordination and planning of construction projects, sooner and more accurate 3D representation of designs, increased information exchange, and knowledge management
4	Sharma Piyush, Gupta; (2016). [121]	(i)Presented an overview of BIM with a focus on its core ideas, difficulties, applications, and management issues among project stakeholders at all phases of the project life cycle. (ii) The ACE industry needs more time to use BIM technology.	Software addresses project complexity while managing the diverse demands and standards of designers and contractors. BIM is backed by its potential to bring about positive, long-lasting change and by its commitment to continue playing a vital role in the industry's efficiency gains and enhancements to product quality.
5	Sawhney, Anil (2014). [129]	According to the report, 27% of respondents stated they are aware of and actively considering utilising BIM, while 22% of respondents currently use BIM. Unexpectedly, 43% of respondents claimed they were aware of BIM but weren't sure if they will implement it in their organisations anytime soon.	In order to accelerate the adoption and adaptation of BIM in India, emphasis is placed on developing tripartite centres of excellence, which unite government, business, and academic organisations.
6	Benedict D. Hozor and David J. Kelly (2012) [122]	The BIM/IPD Integration Model is a novel conceptual framework for comprehending the technologies and their interactions that: (i)identifies important advantages/deficiencies in the literature; synthesises the material with comparative analysis; and (ii) conceptualises the major benefits/deficiencies.	(i)Establish relationship between BIM and/or IPD adoption (ii)project performance measures (e.g., cost, profit, ROI, schedule, safety,

7	Anthony Muttai, Bowling and Stan Guidera (2010). [32]	Provides a framework for advice to construction engineering professors interested in incorporating BIM technology into their curricula by analysing data and methods.	Students in all AEC-related areas may benefit from this kind of professional training if civil engineering, construction, and architectural instructors collaborate and integrate their programmes.
8	J. Vinodkumar Mahua Mukherjee, (2009). [123]	Examines the BIM application status in India. A survey has been created to gauge BIM uptake through 2009.	In many different countries, this acceptance for managing project information with capabilities for cost management and FM is well acknowledged.

IV. CONCLUSION

The most intricate component of the AEC sector is the BIM model. Practically every aspect of a building's operation can be carried out by it. BIM is helpful. [https://www.united-bim.com] BIM may be used to reinvent collaboration across everything and everyone.

BIM has the potential to bring about a variety of direct and indirect advantages for the built environment industry, such as: (i) improved information sharing throughout the entire value chain; (ii) cost and time savings; (iii) improved quality; (iv) increased accountability and transparency in decision-making; (v) increased sustainability; and (vi) improved end-user/customer satisfaction.

With the use of BIM, it is possible to improve collaboration and communication, model-based cost estimation, structural analysis, structural design, 3D modelling construction, increase productivity through prefabrication, design structural steel, detail steel structures, and create 3D, 4D, and 5D BIM services. This (xiii) improved scheduling and sequencing also includes the extraction of structural components, high-quality construction records, conflict identification, and risk reduction.

BIM has a significant impact on CI because it enables companies to prevent costly mistakes caused by human error. BIM is yet another method for bringing cutting-edge technologies to the building industry and raising project quality. Due to its incredible visualisation, simulation capabilities for diverse data sources, and capability to merge numerous stages into a single process, BIM technology has the potential to dramatically revolutionise how organisations carry out construction. Teams involved in design and construction can work more productively thanks to BIM, which also enables them to record the data they generate during the process for use in operations and maintenance. BIM data can help with project, city, and national level planning and resource allocation. This is the reason that more countries are requiring BIM.

On the basis of the literature review research, below are some inferential points summarized on adopting BIM use in the CI.

The results of BIM :The capacity to exchange accurate and useful information with many different groups of people, such as designers, managers, stakeholders, etc., is one of the key benefits of BIM as a process and platform in general. The BIM process's main objective is to force collaboration and make it easier for all project participants to cooperate and work more efficiently. Building a solid relationship between the two is made feasible through BIM.Projects could achieve sustainability with the use of BIM.

By providing architects and engineers with access to more sophisticated technology tools than ever before to properly integrate and analyse aspects like heat gain, solar, ventilation, and energy efficiency in BIM may improve facility management, BIM has, in particular, made sustainable design possible.Facilities managers may optimise their performance and foster a more data-driven culture to deliver facilities management (FM) services more efficiently and improve building performance thanks to BIM, which enables the management of knowledge throughout a building's entire life cycle.

[iv]BIM increase productivity: BIM significantly improves productivity during the project's design and construction phases. Its advantages include minimising the amount of errors produced, completing jobs faster, and discovering prefabricated material uses to reduce expenses.

[v]Construction industry change brought on by BIM

Using BIM allows the construction team, which consists of architects, engineers, and contractors, to provide the owner with more meaningful information much earlier in the process. A contractor can often provide a very accurate construction cost estimate when the BIM documentation is about 40% complete.

[vi]BIM can increase construction productivity When compared to non-BIM projects, the ability of BIM to identify and resolve problems before construction begins minimises unplanned modifications in construction by 40% and can save as much as 10% of the total cost of the project.

[vii] BIM helps keep construction expenses down. A case investigation was carried out in a building project that made use of BIM. The results show that BIM may save costs by 52.36% and time by 50%. Because fewer people are needed and the project is completed faster, there are time and money savings that have an impact on funding.

[viii] Projects can be completed with the help of BIM, on schedule, and with effective teamwork. Owners of buildings and projects can lower risk by effectively employing BIM. With BIM, owners can expect improved project quality and easier lifecycle management.

[ix]Further, with the help of AI the BIM in construction, The AEC market is predicted to increase at a CAGR of 15.20% during the forecast period of 2023-2028, aided by the incorporation of artificial intelligence (AI) in BIM software. By 2027, the market will be worth approximately USD 7.6 billion [https://www.uniquescadd.com]. The construction market is in good shape for the balance this year and next.

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