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Challenges in the adoption of building information technology (BIM) technology in Indian construction industry (ICI)

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Abstract

Aim: This study aims to identify the challenges hindering the adoption of BIM technology in the ICI and provide insights into ways to overcome these challenges.

Methodology: A questionnaire using a Likert scale was developed and distributed to 121 participants working for developers in the ICI. Factor analysis was conducted using SPSS 25 to examine the obtained data and identify the primary reasons that impede the adoption of BIM technology.

Findings: Factor analysis of the data identified six main factors accounting for 74.31% of the variance. These factors included regulatory framework, lack of expertise, knowledge, and adoption, compatibility issues, resource limitations, and inadequate demand.

Originality Value: The research above is unique since it specifically examines the obstacles that are preventing the widespread use of Building Information Modeling (BIM) technology in the building sector in India. While there is existing research on BIM adoption in other countries, there is a lack of comprehensive studies on the specific challenges faced by the Indian construction industry. This study provides insights into the main obstacles to BIM adoption in India and identifies six main factors that have not been extensively studied before. Additionally, the study uses a Likert scale questionnaire and factor analysis to analyze

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the data, which is a unique approach that has not been widely used in previous research on BIM adoption.

Implications: The study's findings offer valuable insights into the primary barriers hindering the adoption of Building Information Modeling (BIM) in the construction sector of India.. The identified factors can help developers and policymakers in the industry overcome these challenges to improve project efficiency and outcomes. This study can also provide a foundation for future investigations into the adoption of Building Information Modeling (BIM) in India and other emerging economies.. The implications of this study can contribute to the broader understanding of technology adoption in the construction industry, which can lead to better decision-making processes and improved project outcomes.

Limitations and Scope for Future Research: The research has significant drawbacks. First, the study focused on the Indian construction industry and may not apply to other emerging or industrialized nations. Second, the limited sample size may restrict generalizability. The study solely examined BIM adoption barriers and did not provide solutions. Researchers might create techniques to overcome these obstacles and encourage BIM adoption in the Indian building sector. Finally, the research did not consider contractors, architects, and engineers, who may shed light on BIM adoption issues and solutions.

Subject Classification: *32J15.*

Keywords: *Building information modelling, Technology, Adoption.*

1. Introduction

The construction industry in India encompasses both real estate and urban development projects. In the 2021 fiscal year, infrastructure projects represented 13% of the total foreign direct investment inflows, which amounted to USD 81.72 billion. The industry is the second largest contributor to the economy, accounting for 8% of the total gross value added and employs 51 million people, making it the second largest employment sector after agriculture. The Indian construction market is anticipated to overtake the United States as the third largest market by 2025 (Make in India, 2022; Invest India, 2019).

The Indian government has promoted integrated townships, smart, sustainable, and connected cities, and low-cost affordable housing using cutting-edge technologies to boost the economy (Make in India,2022).

This study examines BIM, a sustainable approach in the ICI. BIM is adopting sustainable development pillars of social, economic, and environmental balances (Shah. D, 2017). Considering stakeholder demands is key to achieving social sustainability, which is described as the ability to live in an environment that satisfies their wants and delivers outcomes (Essam A, 2015). BIM can improve facility design to promote comfort. Owners may study the design and make input by viewing a 3D BIM before the facility is completed. BIM also increases project cooperation by

changing a highly fragmented traditional approach into a more cooperative effort. BIM has been shown to save 6.92% economically. Environmental sustainability may be strengthened by project materials and products. Virtual 3D BIM allows construction material testing (Heap & Chong, 2016).

Utilizing a single digital model system improves the coordination of the various documents created by the various professionals involved in the projects (such as the client, contractor, planner, architect, structural engineer, manufacturer, surveyor, supplier, MEP, project manager, facility manager, and subcontractors).

Using sophisticated connected digital models, BIM is a technique for collaboratively designing, developing, and maintaining infrastructure.

The evolution of BIM from 1-Dimension to the 8-Dimension with incorporation of different functions with advancement in technologies is given in Table 1.

Table 1

Evolution of BIM

N-DIM	DESCRIPTIONS	INCORPORATED ROLES
1D	Research & Planning	Strategies, Estimation, Planning.
2D	Drawings	2D Drawings, Views, Plans, Sections, Elevations, Project Documentation.
3D	Modelling	3D model, Rendering, Walk-throughs, Laser Scanning, MEP Design, Enables Clash detection.
4D	Time	Scheduling, Time lining, Equipment deliveries and Pre-fabrication.
5D	Cost	Detailed cost Estimation, Cost comparison, Material take-off, Fabrication models, . Logistics,Quantity Extractions
6D	Building Performance	Energy simulation system performance, Energy ratings, Sustainability.
7D	Facilities Management	Life-cycle analysis, Building maintenance.
8D	Safety	Safety-Security-Emergency Plans.
9D	Lean Construction	Ad. Safety-Security-Emergency Plans.
10D	Industrialized Construction	Ad. Safety-Security-Emergency Plans.

Table 1: Dimension of BIM(Delzendeh, n.d.).

According to National BIM Report 2018, 20% of the industry has used BIM successfully, a 12% rise over 2017, and by 2019, approximately 70% of construction professionals were utilizing BIM on projects. Countries like USA, Europe, France, Germany, Demark, The Netherlands, Spain, Austria, Norway etc. already started using BIM in public sector projects (World, 2018). Table 2, shows the adoption rate of the technology.

Table 2

Countries with above 50 percent of adoption of BIM (K Ullah, 2019)

Country	BIM adoption rate (Year and Source)
Australia	67.1%, 2016
Canada	78.1%, 2018
China	67.1%,2014
Denmark	78.2%, 2016
Estonia	51.2%, 2015
Japan	46.1%, 2016
United Kingdom	74.2%,2018
United States	79.1%, 2015

Source: Authors Compilation

Despite being second-largest sector in India, the industry is slowly but surely working on adopting BIM as reflecting on Table 2. For instance, Nagpur Rail Project, which utilised 5D BIM technologies including BIM Co-ordination and Clash detection, the private sector has begun utilising BIM standards (Source: Exceliza) Although BIM has begun to provide the groundwork for adoption in India, there is still more to be done. Most projects exhibit fragmentation, characterized by several teams operating independently with minimal synchronization or communication (Jagdeesh, 2019). Implementing BIM in the AEC sector is a challenging task that requires efficient management of many significant obstacles (Gardezi, 2014).

Evidently, India's utilization of technology, namely BIM, is at an early stage, and there exist certain obstacles impeding its acceptance in the architect, engineering, and construction (AEC) sectors. It is important to analyze the challenges that Indian developers encounter in adopting and using it.

2. Literature Review

BIM Technology has made Architecture, Engineering and Construction (AEC) industries to be more experimental in terms of economic structure of the project and to produce more complex designs concepts with quality and reduced delivery time (Azhar, 2008). BIM provides a virtual platform for conceptualizing the project and its facilities, from which data and needs may be retrieved and evaluated to help the developer make intelligent decisions and optimize project delivery (Azhar, 2008).

With numerous benefits, the Indian construction industry is still showing lukewarm response where the rate of adoption is 10-18% compared to 71% user in US alone Jagdeesh, (2019) and is a challenge for most of the developers of Small and Medium Enterprises (SMEs) to adopt BIM over conventional methods (Georgiadou.M, 2019).

BIM may save costs, time, and increase construction efficiency in this business. BIM expands the team's capacity beyond 3-D by adding time, cost, and sustainability to length, width, and height. The global construction sector poised to grows $15 trillion by 2025 when compared to $7.2 trillion

Table 3

Challenges In the adoption of BIM

Author, Year	Challenges & Barriers
Sonali and Arti (2022)	Lack of awareness , Hesitancy in usage, Lack of transparency in BIM model, Reverse approach from 3D to 2D is not possible
Sayali & Shalaka (2021)	Lack of Awareness, Return of investment, Lack vision of benefit, Codes are not available
Babatunde et al (2020)	High cost of hiring/training, Lack of regulatory framework, High cost of software, Lack of expert, Compatibility issues, Lack of awareness
Sharmila Jagadisan (2019)	Unwillingness to change, Lack of experts, Difficulties in adopting to changes in design (complexity), Compatibility issue , Resistance to change current management process.
Majrouhi et al (2018)	Legal issue, Cultural issue, Management issue (multiple stakeholder), Lack of experts, High initial cost
Sandeep Langar (2017)	Time constraint, High cost of hiring, Lack of official standards

Source: Authors Compilation

in 2013 with most others growth is expecting from emerging economies like China, India, Poland etc (Sawhney, 2014).

Adoption may provide challenges, particularly in compatibility, with several software firms. Software may not be compatible unless from the same company, and data may be lost during file transfers. Despite constraints, staff should prioritize learning to increase productivity. SMEs may be hesitant to embrace BIM owing to time and cost restrictions (Langer, 2017).

Adopting BIM for SMEs is complex due to factors such as limited resources, awareness, cooperation issues, data concerns, legal disputes, and policy uncertainty (Li & Zheng, 2019).

Multiple research papers were analyzed to comprehend potential challenges that many countries faced as shown in Table 3 before successfully implementing in their processes. Table 3 provides a detailed understanding of the challenges organizations encountered during adoption of BIM.

Based on the above discussion, the following are the objectives of our study:

- To analyze the factors that affect the adoption of BIM in India.
- To analyse significant factors that act as bigger hurdles in the adoption of BIM.
- To offer suggestion to developers and government for better performance of projects.

3. Research Methodology

The objective of this study is to examine the difficulties faced in the implementation of Building Information Modeling (BIM) technology within the construction sector in India. The study utilized a quantitative research methodology, specifically employing a survey method to collect data from people working in the construction business. A meticulously crafted questionnaire was developed, with a Likert scale spanning from 1 to 5, to evaluate the difficulties encountered in the use of BIM technology. The study focused on Delhi as the sample unit, and data was obtained using a non-probability sampling approach, namely convenient sampling. The survey was personally administered to a total of 121 participants.

A thorough literature review on BIM technology application in the Indian construction sector was conducted before conducting the study. It

helped identify potential difficulties that may be addressed in the survey form.

The survey questionnaire was tested on a small group of participants to ensure its clarity, comprehensibility, and relevance to the research aims. The pre-test comments was used to improve the questionnaire content and design.

The survey questionnaire did not collect personal information to protect the privacy and anonymity of participants. Participants were informed of their right to withdraw from the study without penalty.

The study further sought to evaluate the dependability and accuracy of the survey tool. The questionnaire's reliability was tested through the utilization of Cronbach's alpha coefficient, while the assessment of concept validity was conducted via component analysis and confirmatory factor analysis. Factor analysis was conducted in SPSS-25 to assess the obtained data and determine the major elements that contribute to the problems faced in the adoption of BIM technology in India's construction sector.

4. Data Analysis and Interpretation:

4.1 *Demographic Analysis*

Table 4

Demographic Profile

Age	Frequency	Percentage
< 30 Years	18	14.88
31-40 Years	37	30.58
41- 50 Years	35	28.93
51-60 Years	31	25.62
Gender		
Male	81	66.94
Female	40	33.06
Education		
Graduate/B.Tech	39	32.23
PG/ M. tech	41	33.88
Diploma	33	27.27
Any other	8	6.61
Income		
Less than 10 Lakhs	37	30.58

Contd...

10 - 15 Lakhs	45	37.19
15-20 Lakhs	32	26.45
More than 20 Lakhs	7	5.79
Experience in Industry		
< 5 years	21	17.36
5-10 Years	31	25.62
10-15 Years	41	33.88
More than 15 Years	28	23.14
Current Position		
Sr. Level Mgr/ Exe	41	33.88
Mid. Level Mgr/ Exe	49	40.5
Jr. Level Mgr/ Exe	31	25.62

Source: Authors Compilation

Analysis of the survey data collected from 121 individuals working in the construction business in Delhi, India as shown in Table 4, India reveals a rather uniform distribution of ages among the respondents. Most participants, aged 31-50, are the largest age group. Men dominated the survey, with 66.94% identifying as male and 33.06% as female.

Over two-thirds of respondents had a graduate or post-graduate degree, while the remaining third had a diploma or certification. The bulk of respondents earned between 10-15 Lakhs per year, followed by those earning less than 10 Lakhs per year. The majority of responders have 10-15 years of experience in the building business. The majority of respondents occupied mid-level management or executive jobs, with around one-third in senior and junior positions. The demographic features of respondents assist contextualize survey findings and offer a general picture of the sample group.

4.2 *Factor Analysis*

It is essential to note that preliminary inspections were conducted to ensure data suitability for factor analysis before presenting the result table. The sample size is sufficient for factor analysis, as shown by the Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy of 0.85. Additionally, a Cronbach's alpha rating of 0.81 indicates strong internal consistency in the variables. The research findings might shed light on the challenges faced by developers and workers in using BIM technology in the Indian construction industry. The results indicate that the data is acceptable for factor analysis and provide accurate information. After

completing preliminary testing, we proceeded to analyze the factor analysis output table to identify the key factors causing these challenges.

Table 5

Factor analysis

Factor Analysis			
Items-Description	**Factor Loading**	**Factors**	**% of Variance**
Usage of BIM increases cost of training.	0.81	Resource constraint	17.23
BIM experts are relatively highly paid.	0.75		
There are substantial upfront and ongoing expenses associated with BIM implementation.	0.67		
BIM implementation requires a considerable quantity of time.	0.65		
There are currently no established standards for BIM.	0.72	Regulatory framework	14.35
The application of BIM is not governed by any contractual obligations.	0.63		
Licensed experts exhibit reluctance in reviewing documents that have multiple contributors.	0.69		
The Indian government offers no incentives to promote the adoption of BIM.	0.77		
BIM adoption and implementation is complex	0.87	Compatibility issues	13.78
The BIM model is quite complicated.	0.75		
Loss of data while using different software.	0.75		
Problems with data ownership and mistake liability.	0.78		
Unwilling to change construction sector culture because they like old techniques.	0.79	Awareness and willingness	12.98
Lack of top-management backing.	0.81		
BIM financial benefits in India are unsupported by case studies.	0.79		
Clients are unaware of BIM model implementation.	0.83		

Contd...

India lacks BIM training facilities.	0.81	Lack of experts	8.87
Training quality falls below the standards.	0.79		
Lack of hand on experienced individually.	0.71		
Hiring a traditional software specialist is simple and affordable.	0.69		
BIM isn't lucrative for small projects.	0.73	Lack of client demand	8.76
Lack of BIM knowledge prevents government/client from mandating it.	0.74		
Client has a doubt about ROI.	0.76		

Source: Authors Compilation

The analysis revealed six major factors contributing to the challenges faced by employees of developers in the adoption of BIM technology in ICI as shown in Table 5. These factors together accounted for 74.31% of the total variance. The factors identified were: resource constraints, regulatory framework, compatibility issues, lack of awareness and willingness, lack of experts, and lack of market demand. Resource constraints were found to be the most significant barrier, accounting for 17.23% of the variance, followed by regulatory framework (14.35%), compatibility issues (13.78%), lack of awareness and willingness (12.98%), lack of experts (8.87%), and lack of market demand (8.76%). These findings suggest that addressing these key factors is critical to overcoming the challenges in the adoption of BIM technology.

4.2.1 Explanation of the factors:

4.2.1.1 Resource constraints

Resource constraints have been identified as one of the most significant factors contributing 17.23% of the total variance and act as a barrier in the implementation of BIM in ICI (Babatunde, 2020; Shakil Ahmed 2018; Yaser Gamil, 2019). These constraints refer to limitations on the available resources needed to complete a task, project, or goal, and can include physical, financial, personnel, and material resources. These limitations can restrict the amount of time, money, personnel, or materials that are available, which can ultimately affect the success of a project or the achievement of a goal. Specifically, the cost of training and hiring personnel, the cost of software licenses, and the cost of hardware are often

cited as major resource constraints in the implementation of BIM. These findings are consistent with previous research on the barriers to BIM adoption in the construction industry (Shakil Ahmed 2018; Yaser Gamil, 2019).

4.2.1.2 Regulatory Framework

Regulatory framework is the second momentous factor contributing 14.35% of the total variance (Hair et al., 2019). It is a collection of laws, regulations, norms, and procedures that control how a company or organisation functions (Chua & Shen, 2017). These frameworks are intended to guarantee that firms follow specific norms and rules, as well as to protect stakeholders' interests (Davies et al., 2017). Government agencies and commercial groups can create them, and they may include industry-specific rules, consumer protection legislation, and other restrictions that relate to a certain sector or industry (Makrygiannis & Liyanage, 2017). A regulatory framework's objective is to guarantee that organisations adhere to appropriate legal and ethical standards, as well as to provide a fair playing field for enterprises to operate in. Regulatory frameworks also assist organisations responsible for their conduct and safeguard the public from possible harm.

Because there are no legal standards or procedures for working on BIM, and there are no contractual requirements to use BIM, it has become a barrier in implementation of BIM Technology, and the government hasn't taken any action to urge business to switch to BIM (Pengfei Li et al., 2019). The above finding matches with the findings of Sandbhor (2021), Pengfei Li et al. (2019), and Kamthan (2014).

4.2.1.3 Compatibility issues

The third major factor contributing to 13.78% of the total variance in the implementation of BIM is compatibility issues. Compatibility problems occur when different hardware, software, or other technological products cannot communicate with each other. In the case of BIM, it is a complex technology that involves the use of multiple software applications to create a model throughout a project's lifecycle. This leads to compatibility issues arising between different software applications. These issues can range from minor to severe, depending on the extent of the mismatch. Furthermore, legal issues regarding data ownership have also been identified as a significant compatibility issue in the adoption of BIM technology.

Multiple studies have also emphasized compatibility as a major obstacle to the implementation of BIM technology in the building sector. According to M. Jagadeesh (2019), a significant obstacle in the deployment of BIM is the absence of compatibility between software and hardware systems. Moreover, according to a study conducted by Yaser Gamil in 2019, the compatibility of BIM with other software and systems is a major worry when it comes to its deployment. (Gilligan & Kunz, 2007) emphasize the need of interoperability and compatibility while using BIM.

4.2.1.4 Lack of awareness and willingness

The primary obstacle to the adoption of Building Information Modeling (BIM) in the construction sector is a notable deficiency in both awareness and willilngness, which accounts for 12.98% of the overall variability. Many professionals in the industry continue to rely on traditional approaches such as using CAD and Staad. Pro software without integrating BIM technology. Furthermore, senior management is often hesitant to change to new technology. There is also a misconception that BIM is only suitable for large-scale projects, which is not entirely accurate.

Research has documented the difficulties associated with implementing Building Information Modeling (BIM) in the construction sector, mostly stemming from a limited understanding and reluctance within the industry. Dhopte and Daga (2022) examine the progression of BIM in the Indian AECO business between 2008 and 2022, emphasizing the notable obstacle of insufficient awareness and training. Hire and Sandbhor (2021) delineate the advantages and difficulties associated with employing Building Information Modeling (BIM) for ensuring site safety in the building industry of India, emphasizing the need of fostering awareness and providing enough training. Furthermore, Georgiadou (2019) presents a comprehensive analysis of the advantages and obstacles associated with the use of Building Information Modeling (BIM) in residential projects in the United Kingdom. The author emphasizes that a notable hindrance to BIM adoption is the limited knowledge and resistance to embracing new practices.

4.2.1.5 Lack of experts.

Lack of experts in the construction industry is a significant factor that accounts for 8.87% of variance in the adoption of BIM technology. In India, there are relatively few individuals who possess a comprehensive understanding of BIM and are capable of implementing it. This can be

attributed to the limited number of training institutions that offer BIM technology education, and the quality of instruction provided by some of these institutions is inadequate. Additionally, the market for BIM expertise is relatively small in India due to the fewer number of BIM-enabled projects. The above finding is supported by the research conducted by Yaser Gamil (2019) and Sherif M. Ahmed (2014).

4.2.1.6 Lack of market demand

The lack of demand is another significant factor, accounting for 8.76% of variance. Clients are not fully aware of the benefits of BIM and its applications, which results in lower demand for BIM in projects. Additionally, the government does not make BIM mandatory due to the lack of industry, which further reduces demand. If BIM were made mandatory, there would be fewer firms using it, resulting in less competition and potentially leading to a monopoly, ultimately defeating the goal of cost reduction. Studies conducted by (Yaser Gamil, 2019; Pengfei Li, 2019); support this finding.

5. Conclusion

From the research, it can be inferred that the adoption of (BIM) in the ICI faces numerous challenges such as resource constraints, regulatory framework, and compatibility issues. These challenges must be addressed by both developers and the government to facilitate the widespread adoption of BIM technology, which can lead to significant benefits for all stakeholders involved in the construction process.

To overcome resource constraints, such as a lack of skilled professionals or financial resources, developers can optimize the implementation of BIM and maximize its potential benefits. Additionally, the regulatory framework surrounding BIM adoption needs to be evaluated and updated to ensure that it aligns with current industry standards and encourages the use of BIM. Furthermore, compatibility issues between various BIM software and tools can be addressed by standardizing the technology or implementing appropriate integration protocols.

Organizational implications of the study suggest that companies need to invest in training their staff in BIM technology and develop strategies to address the identified challenges. The government needs to create awareness campaigns and provide financial incentives to promote the adoption of BIM. Additionally, industry associations can play an

important role in advocating the benefits of BIM and encouraging collaboration between stakeholders. The study highlights the need for a collaborative approach among stakeholders to successfully implement BIM in the Indian construction industry.

References

[1] Ahmed, S. M., Building information modelling in the construction industry. *Procedia Engineering*, 77, 229-237 (2014). https://doi.org/10.1016/j.proeng.2014.07.030.

[2] Almahmoud, E., Building information modeling (BIM) for facilities management: Critical challenges and practices. *Journal of Information Technology in Construction* (ITcon), 20, 165-175 (2015).

[3] Azhar, S., Building information modeling (BIM): Trends, benefits, risks, and challenges for the AEC industry. *Leadership and Management in Engineering*, 8(4), 241-252 (2008). https://doi.org/10.1061/(ASCE)1532-6748(2008)8:4(241).

[4] Babatunde, S. O., Exploring the Barriers to Building Information Modeling (BIM) Adoption in Nigeria's Construction Industry. *Journal of Engineering, Design and Technology*, 18(4), 888-904 (2020). https://doi.org/10.1108/JEDT-08-2019-0213.

[5] Chua, D. K. H., & Shen, L., Regulatory reform and governance in Malaysia: A review of recent initiatives. *Journal of Contemporary Asia*, 47(1), 1-20 (2017).

[6] Davies, S., Harrigan, P., & Dixon, R., 'Regulatory space'and the role of the state: A critical review. *Journal of Political Power*, 10(2), 191-211 (2017).

[7] Dhopte, S., & Daga, A., Exploring the journey of BIM in the Indian AECO industry (2008–2022) an excelize perspective. *Journal of Engineering, Design and Technology*, 20(1), 135-152 (2022). doi: 10.1108/JEDT-05-2020-0169.

[8] Gamil, Y., Factors affecting the implementation of BIM in the construction industry in Saudi Arabia. *Journal of Engineering, Design and Technology*, 17(2), 375-393 (2019). https://doi.org/10.1108/JEDT-08-2018-0112.

[9] Gamil, Y., The impediments to BIM adoption in the AEC industry in developing countries: A critical review. Engineering, Construction

and Architectural Management, 26(3), 369-387 (2019). https://doi.org/10.1108/ECAM-11-2017-0298.

[10] Georgiadou, M., An overview of benefits and challenges of Building Information Modelling (BIM) adoption in UK residential projects. *Journal of Information Technology in Construction*, 24, 214-230 (2019). Retrieved from https://www.itcon.org/paper/2019/12.

[11] Georgiadou, M., BIM implementation challenges in Small and Medium Enterprises (SMEs) in the construction industry. *International Journal of Construction Management*, 19(3), 207-220 (2019).

[12] Hair, J. F., Hult, G. T. M., Ringle, C. M., & Sarstedt, M., A primer on partial least squares structural equation modeling (PLS-SEM). Sage publications (2019).

[13] Hatem, W. A., An investigation into BIM adoption and implementation in the United Arab Emirates construction industry. *Journal of Information Technology in Construction*, 23, 219-234 (2018). https://doi.org/10.36680/j.itcon.2018.014.

[14] Heap, T., & Yih Chong, H., The impact of building information modelling adoption on project performance: An exploratory case study. *Journal of Engineering, Design and Technology*, 14(3), 508-527 (2016). doi: 10.1108/JEDT-08-2014-0056.

[15] Hire, S., & Sandbhor, S., BIM usage benefits and challenges for site safety application in Indian construction sector. *Journal of Engineering, Design and Technology*, 19(5), 1069-1085 (2021). doi: 10.1108/JEDT-08-2020-0271.

[16] Ian Lerche. Epidemic evolution: Source, lock-down and removal modifications to the SIR model, *Journal of Statistics and Management Systems*, 25:8, 1767-1780 (2022), DOI: 10.1080/09720510.2021.1972622.

[17] Jagdeesh, A., Investigating the challenges to building information modelling (BIM) adoption in the Indian construction industry. *Built Environment Project and Asset Management*, 9(5), 618-630 (2019). doi: 10.1108/BEPAM-08-2018-0149.

[18] Kamthan, P., Building information modeling: adoption and implementation from a government perspective (Doctoral dissertation, George Mason University) (2014).

[19] Langer, I., Adoption of Building Information Modelling (BIM) in Small and Medium-sized Enterprises (SMEs). *Procedia Engineering*, 196, 212-218 (2017).

[20] Li, M., & Zheng, D., Critical factors affecting BIM adoption in small and medium-sized enterprises (SMEs): A case study in China. Advances in Civil Engineering, (2019). https://doi.org/10.1155/2019/7485383.

[21] Li, P., Factors affecting the implementation of BIM in small and medium-sized construction enterprises in China. *Journal of Civil Engineering and Management*, 25(7), 683-691 (2019). https://doi.org/10.3846/jcem.2019.10256.

[22] Makrygiannis, A., & Liyanage, C., Building information modelling (BIM) implementation and remote construction projects. *Journal of Engineering, Design and Technology*, 15(2), 220-239 (2017).

[23] Pengfei Li, Hui Li, Jing Zhao, & Qian Li. Analysis on Barriers to the Implementation of BIM in Construction Industry from Regulatory Perspective. In 2019 3rd International Conference on Architecture, Civil and Hydraulic Engineering (ICACHE 2019), pp. 397-400 (2019). Atlantis Press.

[24] Safdar Gardezi, S. S., Critical factors affecting the implementation of building information modeling (BIM) in construction projects. *Journal of Management in Engineering*, 31(6), 04014045 (2014). https://doi.org/10.1061/(ASCE)ME.1943-5479.0000241.

[25] Sandbhor, S. S., Exploring Barriers to Implement Building Information Modeling (BIM) in Construction Industry: A Systematic Literature Review. *Journal of Engineering, Project, and Production Management*, 11(1), 59-71 (2021).

[26] Sardroud, J. M., Mehdizadehtavasani, M., & Khorramabadi, A., Factors affecting BIM adoption in developing countries: An empirical study in Iran. *Journal of Construction Engineering and Management*, 144(2), 04017111 (2018). https://doi.org/10.1061/(ASCE)CO.1943-7862.0001414.

[27] Sawhney, A., The global construction market: drivers and trends. Engineering, Construction and Architectural Management, 21(5), 505-521 (2014). https://doi.org/10.1108/ECAM-08-2013-0081.

[28] Shah, D., Building Information Modeling (BIM) for Construction Project Management. *International Journal of Engineering and Management Research*, 7(6), 132-137 (2017).

[29] Shah, D., Role of Building Information Modeling (BIM) in construction project management. *International Journal of Research in Engineering and Technology*, 6(5), 379-385 (2017).

[30] Shakil Ahmed Department of Building Engineering and Construction Management. A Study on the Factors Affecting the Adoption of Building Information Modelling (BIM) in the Construction Industry of Bangladesh. Engineering, Technology & Applied Science Research, 8(3), 3022-3026 (2018). https://doi.org/10.48084/etasr.1875.

[31] Syed Shujaa Safdar Gardezi. Barriers to BIM implementation in the AEC sector. *Journal of Construction Engineering, Management, and Innovation*, 1(1), 24-34 (2014).

[32] Sofia Khan, R. K. Tailor, Ranu Pareek, Rashmi Gujrati & Hayri Uygun. Application of Robotic Process Automation in education sector, *Journal of Information and Optimization Sciences*, 43:7, 1815-1834 (2 022), DOI: 10.1080/02522667.2022.2128534.

[33] Osman Kamari & Morad Alizadeh. The type 2 extended exponentiated family of distributions, *Journal of Statistics and Management Systems*, 25:8, 1735-1749 (2022), DOI: 10.1080/09720510.2021.2011115.

[34] Yaser Gamil. Factors Affecting the Adoption of BIM in the Saudi Construction Industry: An Exploratory Study. *Journal of Construction in Developing Countries*, 24(2), 91-105 (2019). https://web.usm.my/jcdc/vol24_2_2019/JCDC%2024(2)%20-%20paper%205.pdf.