Available online at www. jenams.com

Journal of Engineering and Management Studies

E-ISSN: 2978-0888

Vol. 1, No. 2, 2025

Integrating Constructıbility Programs into Constructıon Industries in India

Namrata Mendis[1*], Rameez Jabar[1*], Dyaa Hassan[1*]

[1]School of Engineering, Coventry University, Coventry, CV1 5FB, UK
* Corresponding author: ad6983@coventry.ac.uk

Received: 09/05/2025; **Accepted**: 05/06/2024; **Published**: 31/07/2025

ABSTRACT

This study investigates the integration of constructability programs into India's construction industry. The research assesses benefits, challenges, and strategies collecting information from existing sources such as research papers, reports, databases, and other published materials. In this case, you would analyze and synthesize the information available in these sources to draw conclusions for your study. Key advantages include improved visualization, clash detection, communication, and reduced rework. Challenges include cost, technical proficiency, and resistance to change. The proposed roadmap involves awareness campaigns, training programs, and incentives to promote seamless adoption. Findings aim to inform stakeholders, policymakers, and technology providers for a more efficient, cost-effective, and sustainable construction environment, driving economic growth and infrastructural advancement in India.

Keywords: construction industry, project efficiency, project execution, project completion, India

1. Introduction

Over the past five decades, India's construction industry has experienced substantial growth in terms of project size and complexity. Timely project completion, maintaining quality, and adhering to budget constraints are common goals for construction projects [1]. Construction projects play a crucial role in driving a country's economic, commercial, infrastructure, and industrial growth. However, delays are a prevalent issue in the construction industry, and their impact varies depending on factors such as project nature, design, and significance. Delays can lead to disputes, penalties, and additional costs, ultimately affecting project outcomes and client satisfaction. India's construction industry is a significant player compared to other sectors like agriculture, textile, and IT. However, it also faces critical challenges related to safety and security. Fatal accidents at construction sites, particularly falls from elevation and openings, contribute to a high rate of fatalities in the industry [2]. The industry's workforce constitutes 7.5% of the global workforce but accounts for 16.4% of fatal incidents worldwide. Safety concerns in the construction industry extend beyond the workers to affect the public, including children, damaging the industry's reputation, and resulting in a shortage of skilled labour [2].

As construction projects get more complicated, conflicts and disagreements are almost certain because of the long and intricate processes involved in planning, designing, and building. Involvement from various fields in projects also adds to conflicts among parties. Common causes of disputes include contract matters, delays, payment problems, technical needs, lack of information, client expectations, and limited resources [3]. The construction sector in India has seen significant growth and development lately. However, this growth also brings challenges that need careful handling to ensure projects are successful [4]. A crucial aspect is constructability, which means taking construction factors into account during the planning and design stages. Using constructability programmes can boost efficiency, cut costs, and improve overall performance. These programmes help companies plan better, manage risks, and allocate resources effectively by tackling issues early in the project’s life cycle. This research aims to explore the need for constructability in India, the challenges involved, and the best ways to integrate these programmes for better project results [5].

The construction industry in India faces many challenges in planning, execution, and completion, leading to cost overruns, delays, and poor quality. Despite new technologies, the industry has been slow to adopt modern management tools.

"Constructability programs" can improve coordination and collaboration, optimizing project outcomes. However, their adoption in India has been limited. This research aims to understand the barriers to widespread use of constructability programs in India and assess their potential impact on efficiency, cost management, risk reduction, and stakeholder collaboration [5].

The research question addressed in this essay has been developed because of the following three main factors: 1) Challenges in the Construction Industry: The first factor is the presence of significant challenges within the construction industry in India. The construction sector in the country is known to face complexities related to project planning, execution, and completion. These challenges lead to cost overruns, delays, and compromised project quality. 2)Advancements in Technology: The second factor is the rapid advancement of technology, including the emergence of constructability programs and modern construction management tools. These programs offer the potential to enhance coordination and collaboration among project stakeholders, optimize project outcomes, and streamline the construction process. However, despite these technological advancements, the adoption of such tools in the Indian construction industry has been relatively slow, necessitating research to understand the reasons behind this limited integration. 3) Potential Benefits of Constructability Programs: The third factor is the recognition of the potential benefits that constructability programs can bring to the construction industry. These programs have demonstrated positive outcomes in other contexts, such as improved project efficiency, cost management, risk reduction, and stakeholder collaboration. Given these benefits, there is a keen interest in understanding whether and how these advantages can be harnessed in the Indian construction sector to drive positive change and elevate its performance. The aim of this study is to investigate constructability and its relevance in the Indian construction industry. The study will: understand the importance of constructability in Indian projects; identify challenges in the industry; explore strategies for integrating constructability programs; and provide insights and recommendations to stakeholders, including companies, project managers, and policymakers, on adopting constructability principles. The key objectives are to: investigate the benefits of constructability programs in India; analyse the need for constructability in Indian projects; identify industry challenges; propose methods for integrating constructability programs; and provide guidelines for stakeholders on using constructability for better planning, resource allocation, risk management, and project performance [5].

2. Literature Review

2.1 Constructability

Competition and new product ideas have led to increased specialization in the construction industry, separating design from construction. This trend often results in designers lacking understanding of construction processes, leading to higher costs and sometimes impractical designs [6]. Constructability, a concept originating in the US and later adopted in the UK in the late 1970s, aims to improve construction industry productivity and quality by integrating design and construction. It emphasizes considering construction issues during the design phase. However, overlooking constructability has become common among designers and contractors, hindering project goals. Overcoming these obstacles is crucial for project success in both developed and developing countries [7]. Some of the advantages of constructability include: timely completion and following the initial planning; in some cases, the projects can be accomplished earlier than scheduled; saving project costs; reducing costs due to design changes; improving the quality of the project; achieving an acceptable level of productivity; improving team performance; reducing adverse risks of the project, remarkably, those related to unpredicted problems; improving communication between key stakeholders and increasing the satisfaction of customers and project stakeholders as shown in Table 1.

Table 1: The principles of constructability [5]

PROJECT LIFE					PRINCIPLES OF CONSTRUCTABILITY	
After construction	Construction	Design development		Planning / Feasibility		
		Detailed design	Conceptual design			
MR	MR	MR	VR	VR	Integration	P1
IR	MR	MR	VR	MR	Knowledge of construction	P2
IR	IR	VR	VR	R	Team skills	P3
MR	IR	IR	VR	VR	Common goals	P4
IR	IR	R	R	VR	Available resources	P5
IR	IR	MR	R	VR	External factors	P6
IR	R	R	VR	MR	Program	P7
IR	IR	VR	VR	MR	Construction methodology	P8
IR	R	VR	VR	IR	accessibility	P9
IR	IR	VR	IR	IR	Specifications	P10
IR	VR	IR	IR	IR	Technology	P11
VR	IR	IR	IR	IR	Feedback	P12
LEGEND: VERY RELEVANT (VR) MEDIUM RELEVANT (MR)				RELEVANT (R) USUALLY IRRELEVANT (IR)		

In short, constructability tries to minimize the gap between what the designers do and what the contractors implement on the project site. Based on the reports of the construction phase and results, implementing construction criteria at all project stages requires much information. However, in the initial phase of designing construction projects, there is a possibility of reducing the adverse effects and increasing the positive impacts of applying the concepts of constructability. One of the strategies is to use performance-based requirements. Indeed, it requires design processes and methods that support informed design selections [8]. The Construction Industry Institute (CII) in Australia has developed 12 principles over a 25 to 30-year period to address constructability. These principles, relevant to this study, dictate the optimal times for their application throughout a project's lifecycle. They emphasize integration during the design phase, incorporation of construction knowledge, alignment of team skills with project needs, clarity on common goals, compatibility of resources, consideration of external factors, detailed project planning, careful construction methodology selection, accessibility planning, inclusion of constructability in specifications, adoption of technology, and feedback evaluation for future improvement. These principles, drawn from various sources, provide a comprehensive framework for enhancing project outcomes and addressing constructability challenges in the construction industry [9 and 10].

2.2 Constructability Improvement Barrier (CIB)

In one of the earliest comprehensive studies on the subject, O'Connor and Miller (1994) [11] identified 41 barriers to constructability in the construction industry. These barriers were found to exist at both the corporate and project levels. The study highlighted prominent barriers such as "complacency with the status quo," "reluctance to invest additional money and effort in early project stages," "limitations of lump-sum competitive contracting," "lack of construction experience in design organizations," "designer's perception that we do it," "lack of mutual respect between designers and constructors," "construction input requested too late to be of value," and "belief that there are no proven benefits of constructability."

Disintegrated project delivery systems, which separate the design and construction teams without allowing for the exchange of ideas and collaborative innovation, were also identified as a barrier to constructability (Fisher and Tatum, 1997). This finding aligns with the conclusions of Pocock et al. (2006) [13], who emphasized that poor constructability often stems from a lack of communication between designers and builders recommended the use of delivery systems that enable early involvement of contractors to leverage their constructability inputs. They also identified important barriers to constructability, including "lack of mutual trust, respect, and credibility between project planners, designers, and constructors," "traditional contracting practices," and "lack of desire and commitment by the owners to commit funds and resources to implement constructability."

These insights highlight the multifaceted nature of barriers to constructability, emphasizing the need for improved communication, early involvement of contractors, and a shift away from traditional contracting practices [11; 12 and 13]. Different authors have put forward various techno-managerial approaches to address the barriers to constructability (CIB). These approaches include:

a) Modifying the sequencing of design and procurement processes
b) Introducing "barrier breakers" for the cultural, procedural, awareness, and incentive aspects of the constructability programme.
c) Involving personnel from contractors in the early planning stages of a project.
d) Implementing constructability improvement from the feasibility stage through construction and capturing lessons learned thereafter.

Pocock et al. (2006) [13] concluded that clients play a significant role in improving constructability by selecting an appropriate project delivery system that facilitates better communication between designers and contractors and by integrating constructability early in the project phases. Wong et al. (2007) [14] suggested three different approaches and found that a "quantified assessment of designs" was the most effective approach for constructability improvement. Also, identified 17 basic "constructability problem types" and 12 "constructability methods" and explored the relationship between specific problems and preventive methods. They concluded that a managerial approach, with a designated "constructability champion," was the most influential factor in improving constructability as shown in Figure 1 [15].

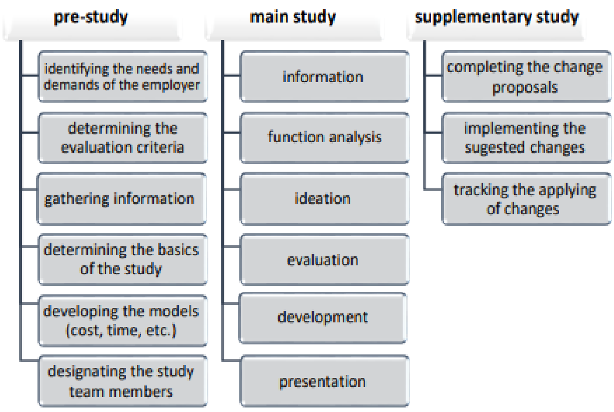

Figure 1. VE Work plan (Al-Yafei et al., 2017) [16]

2.3 Impact on Economy

The construction industry garners increased attention in developing countries, seen as vital for economic growth through job creation, income distribution, and output generation. Moreover, it fulfils essential needs by providing housing, infrastructure, and goods. Initially, rapid growth accompanies construction and manufacturing prominence, while agriculture diminishes. However, as development progresses, economic growth slows, stabilizing the construction sector's role. Government involvement is significant, as the industry relies heavily on investments. Offsite construction, resembling automotive assembly lines, proves beneficial for repetitive projects like apartments and hospitals, reducing waste and boosting worker efficiency. Ensuring project timelines with managed digital processes is crucial, preventing delays by granting access to current plans and documents for all parties involved.

2.4 Strategies of contracting organizational structure

The organizational structure for integrating constructability programs into India's construction industry is crucial for defining roles, responsibilities, and communication among stakeholders. Effective strategies include:

a) Integrated Project Delivery (IPD): Implementing IPD fosters collaboration among stakeholders, including owners, architects, engineers, contractors, and suppliers, by involving all parties early in planning and design stages, ensuring constructability and sustainability are integrated from the start [17].

b) Multi-Disciplinary Teams: Forming cross-functional teams with expertise in constructability, BIM, sustainability, and project management enhances decision-making and innovation, addressing constructability issues and implementing sustainable practices [18].

c) Clear Communication and Reporting: Establishing regular progress meetings and transparent communication channels ensures constructability objectives and sustainable practices are monitored and assessed, reducing conflicts and ensuring smooth information flow [19] .

d) Performance-Based Contracting: Adopting contracts with performance metrics related to constructability and sustainability incentivizes contractors to pursue innovative solutions, leading to improved project performance [20] .

e) Continuing Professional Development: Promoting ongoing training on constructability principles, sustainable practices, and BIM technologies ensures project teams stay current with industry best practices, enhancing their ability to implement constructability strategies effectively [21] .

2.6 Key Discussion

2.6.1 Why there is a need for constructability in construction Industry in India?

Constructability is vital in the construction industry in India for several reasons. It helps control costs by identifying potential challenges and cost-effective solutions early in the project. Efficient project delivery is ensured by smooth construction progress without delays. Optimizing resource utilization minimizes wastage and promotes sustainability. Constructability reviews enhance safety, quality, and early problem-solving. Collaboration among stakeholders is facilitated, adapting designs to local conditions. It encourages innovative solutions and compliance with regulations, giving companies a competitive advantage in the market. Overall, constructability ensures successful project execution to meet the demands of India's growing economy and population. There are some of benefits of Constructability such as: Constructability promotes collaborative planning and early issue resolution, resulting in better project outcomes, reduced construction time, cost savings, and improved safety by identifying and mitigating hazards early. Implementing constructability principles enhances client satisfaction by meeting or exceeding expectations through better understanding of project requirements. Strategies to promote constructability include conducting awareness campaigns and workshops, offering incentives for successful implementation, integrating constructability into project specifications, and collaborating with industry bodies to develop guidelines. The Indian government can support this by integrating constructability guidelines into building codes, providing incentives, and offering training programs. Industry collaboration among architects, engineers, contractors, and clients can foster awareness and knowledge sharing, while educational institutions and professional organizations should incorporate constructability principles into curricula and training programs to equip future professionals [5].

2.6.2 What are the challenges faced by the construction industries in India?

The small and medium-scale construction industry in India faces various challenges hindering its growth and development. Limited access to finance and capital poses a significant obstacle, making it difficult for these firms to invest in modern technologies, training, and quality equipment (Nataraja, 2016)[22]. Additionally, bureaucratic red tape and complex regulatory procedures impede timely project approvals and execution. Moreover, the industry grapples with a shortage of skilled labor and technical expertise, affecting overall productivity and project quality (Singh & Chaudhury, 2021)[23]. Furthermore, the absence of standardized safety practices and compliance with environmental norms raise safety and sustainability concerns (Sahu & Patil, 2019)[24]. Addressing these challenges is crucial to bolster the competitiveness and sustainability of small and medium-scale construction enterprises in India. Lack of access to capital presents difficulties for these businesses in obtaining funds for project execution, expansion, and working capital due to limited access to formal credit sources, high interest rates, and stringent collateral requirements. Delayed payments from clients and contractors exacerbate cash flow issues, impacting their ability to meet project deadlines, pay workers, and procure necessary materials. Additionally, specific obstacles to constructability adoption include limited awareness among industry professionals about its benefits, resistance to change due to the shift required from traditional project delivery approaches, and inadequate training and education programs on constructability, hindering its integration into construction practices [24].

2.6.2 How to integrate the constructability program into construction companies in India?

There are many different reasons to promote constructability among small and medium-scale construction companies, such as launching targeted awareness campaigns to educate them about the benefits of constructability through seminars, workshops, and conferences in collaboration with industry associations and government bodies; sharing case studies and success stories of companies that have successfully implemented constructability to highlight the positive impact on project outcomes, cost savings, and client satisfaction; developing and delivering training programs on constructability for construction professionals, workers, and project managers, covering key aspects like design review, project sequencing, value engineering, and safety planning; collaborating with educational institutions to incorporate constructability principles into construction-related curricula and fostering partnerships between industry practitioners and academia for hands-on exposure; promoting collaboration and communication among various stakeholders, including architects, engineers, contractors, and clients, and encouraging early involvement in project planning and design stages to identify and solve constructability issues collectively; and facilitating partnerships between small and medium-scale construction companies and larger firms experienced in constructability to encourage knowledge transfer and mentorship programs that enhance constructability capabilities [5].

2.7 Relationship between sustainability and Constructability

The link between sustainability and constructability in construction projects is their shared goal of optimizing resource use and promoting eco-friendly practices. Constructability ensures that project designs are practical and feasible to build, leading to efficient use of materials, labour, and equipment. This minimizes waste and simplifies processes, contributing to sustainability by reducing the project's environmental impact (Smith et al., 2018). Moreover, constructability facilitates the incorporation of sustainable construction methods and materials into the project. For example, using prefabricated or modular components reduces construction waste and allows for the use of energy-efficient materials [25]. This aligns with sustainable construction principles focused on conserving resources and using eco-friendly building practices. Considering sustainability during the constructability review process ensures that green building features are seamlessly integrated into the design. This includes aspects like energy efficiency, water conservation, and waste management [26]. Sustainable construction practices bring long-term benefits to the environment, society, and economy of the project and its surroundings.

In the context of the above project, several techniques can be used to promote constructability and enhance sustainability, aiming to streamline the construction process, optimize resource usage, and incorporate environmentally friendly practices. Building Information Modelling (BIM) enables digital project representation, facilitating collaborative design, construction planning, and environmental impact analysis [27]. Prefabrication and modularization reduce on-site construction time, minimize waste, and enhance efficiency, aligning with sustainable practices. Value engineering ensures functional requirements at the lowest cost by optimizing resources, supporting both constructability and sustainability [28]. Lean construction principles eliminate waste, improve productivity, and enhance project flow, contributing to resource conservation. Using sustainable materials and practices, like recycled or renewable resources, enhances sustainability and is effectively integrated into project design through constructability reviews [29]. These reviews also identify construction challenges and opportunities for sustainable design, fostering collaboration and informed decision-making [30]. Life Cycle Assessment (LCA) evaluates environmental impacts throughout the project's life cycle, helping assess the sustainability of design alternatives (Al-Ghafri et al., 2017) [31]. By combining these techniques, the project can achieve improved construction efficiency, reduce environmental impact, and enhanced long-term sustainability.

One significant research gap in constructability practices in India is the lack of awareness among construction professionals and industry stakeholders. Many companies, especially small and medium-sized ones, are not familiar with constructability and its potential benefits. Another obstacle is resistance to change, as traditional project delivery methods and stakeholder reluctance to depart from conventional practices hinder constructability integration. Moreover, there's a shortage of training and education on constructability in India, with limited availability of programs and insufficient inclusion of constructability principles in construction-related curricula. Additionally, regulatory challenges like complex permitting procedures and compliance with building codes present obstacles to constructability implementation due to the lack of streamlined processes and standardized guidelines.

3. Research Methodologies

The Indian construction industry, amid rapid growth and urbanization demands, requires effective project planning and execution. Early integration of constructability programs can enhance efficiency and cost-effectiveness. This study aims to justify and outline objectives for incorporating constructability in India by conducting a systematic literature review. This review will analyse secondary data from academic databases, industry publications, and government reports [31], focusing on global case studies and success stories in constructability practices. Insights gleaned will be assessed for their relevance and applicability to India. Industry reports and research studies will be scrutinized to gauge the potential impact of constructability programs on project outcomes, identifying both challenges and benefits in India's context [31].

The research on integrating constructability programs into construction industries in India will adopt a secondary data collection method, utilizing data from reputable sources such as academic journals, industry reports, government publications, and relevant construction industry organizations. A descriptive and exploratory research design will be employed to analyze the potential benefits and challenges of constructability implementation in the Indian construction sector. The research will be guided by Saunders' Onion Ring Model, a comprehensive approach to data analysis. The model consists of multiple layers, including the core layer, the first outer layer, the second outer layer, and the outermost layer [32] as shown in Figure 2. The core layer will focus on the central research question, which revolves around the feasibility and impact of integrating constructability programs in the Indian construction industry. The subsequent layers will expand on specific research objectives and themes related to constructability practices and their application in India. Secondary data from various sources, including academic research papers, case studies from other countries, and industry reports, will be analyzed using content analysis and thematic analysis techniques, following Saunders' Onion Ring Model. This systematic approach will enable the identification of patterns, trends, and best practices related to constructability integration in India's construction industry.

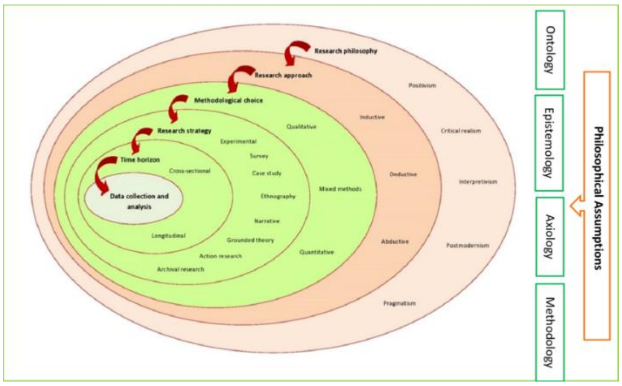

Figure 2. The Research Onion of Mark Saunders (Saunders et al., 2019) [32]

The research guiding the integration of constructability programs into India's construction industry adopts a pragmatic approach. This practical method examines the feasibility and benefits of applying constructability practices within the complex Indian construction context. The goal is to provide actionable insights for industry stakeholders. To achieve this, secondary data collection will be used, involving a thorough literature review of academic journals, industry reports, government publications, and case studies. Online databases, government websites, and industry associations will be key sources of information. The collected data will be analysed to identify common themes, challenges, benefits, and success factors in integrating constructability programs. The research strategy involves synthesising and interpreting existing qualitative and quantitative studies to gain a comprehensive understanding of the topic. This approach aims to explore diverse perspectives and challenges related to the integration of constructability programs in India's construction industry [33].

The research design for this study involves the use of secondary data collection, as shown in Figure 2, which focuses on gathering existing information from various sources to investigate the integration of constructability programs into the construction industries in India. In this research, the secondary data collection is a cost-effective and efficient approach as it utilizes data that has already been collected and published by other researchers, organizations, and government bodies. The initial step in this research design involves conducting an extensive literature review, drawing insights from academic journals, industry reports, government publications, and other credible sources to gather relevant information on constructability programs and their application in the construction industry. By leveraging existing studies, this research aims to establish a solid foundation and highlight key aspects related to integrating constructability into the Indian construction context. Secondary data collection will utilize various credible sources, including academic databases like Google Scholar and research papers from renowned institutions, as well as industry reports and guidelines from organizations such as the Construction Industry Development Council (CIDC) to gain valuable insights into constructability program implementation [34].

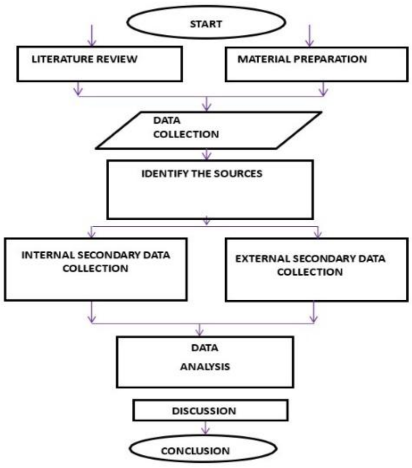

Figure 3. Research Design Flowchart

Government publications, including official guidelines and policy documents, will be reviewed to understand the regulatory environment and any initiatives supporting or hindering the integration of constructability programs in the sector. Furthermore, examination of case studies of construction projects in India that have successfully implemented constructability programs will provide practical examples and valuable lessons on best practices and integration challenges [35]. The collected secondary data will be analysed to derive meaningful insights and patterns related to the integration of constructability programs in the Indian construction industry, identifying common themes, challenges, and potential success factors influencing adoption and effectiveness. Additionally, analysing government publications and regulatory documents aims to identify any policy implications or barriers affecting the widespread adoption of constructability programs in the construction sector [35].

4. Data Analysis and Results

4.1 Introduction

The construction industry plays a vital role in the economic growth and development of any country. In recent years, the global construction sector has been witnessing significant advancements in technology and project management methodologies. One such innovative approach is the integration of constructability programs, which offer substantial potential to enhance project efficiency, cost-effectiveness, and overall quality [36]. This research project aims to explore the feasibility and potential benefits of integrating constructability programs into the construction industries in India. A constructability program is a sophisticated digital tool that facilitates the seamless collaboration of architects, engineers, and construction professionals throughout the project lifecycle [36]. It enables virtual analysis, visualization, and optimization of building designs, construction processes, and resource allocation, among other crucial aspects [36]. To achieve these objectives, this research will employ a secondary data collection method. Relevant academic literature, industry reports, case studies, and governmental publications will be extensively reviewed to gather valuable insights into the subject matter [34, 35 and 36]. The collected data will be critically analyzed, allowing for an in-depth evaluation of the opportunities and obstacles associated with implementing constructability programs in the Indian construction sector [37].

4.2 Introduction to Analysis Methods

To comprehensively explore the feasibility and potential benefits of integrating constructability programs into the construction industries in India, this research project will employ several powerful analysis methods. These methods include the TOWS (Threats, Opportunities, Weaknesses, Strengths) analysis, 4P's (Product, Price, Place, Promotion) analysis, and PESTEL (Political, Economic, Social, Technological, Environmental, Legal) analysis. The TOWS analysis is a strategic management tool that will allow us to identify and evaluate the internal strengths and weaknesses of the Indian construction sector while also considering external opportunities and threats [38]. By understanding these factors, we can create strategies to capitalize strengths, mitigate weaknesses, seize opportunities, and address potential threats, paving the way for successful integration of constructability programs. Additionally, the PESTEL analysis will enable us to assess the macro-environmental factors that could influence the integration of constructability programs into the Indian construction context. By examining the political, economic, social, technological, environmental, and legal factors, we can identify potential challenges and opportunities that may impact the adoption and implementation of constructability programs [39]. By applying these three analysis methods in tandem, this research aims to provide a holistic understanding of the challenges and potential solutions for integrating constructability programs into the construction industries in India. The findings from these analyses will serve as a foundation for developing strategic insights and recommendations, empowering stakeholders to make informed decisions and drive positive change within the Indian construction sector.

4.2.1 PESTEL Analysis

PESTEL analysis as shown in Table 3, is a strategic tool, examines macro-environmental factors affecting a project or industry. Integrating constructability programs into India's construction industry involves analyzing political, economic, social, technological, environmental, and legal aspects. Understanding these factors comprehensively aids stakeholders in devising strategies to leverage opportunities, address challenges, and facilitate successful program implementation.

Table 2. PESTEL Analysis

Factor	Description	Consequence
Political	Politically Positive	Government Policies and Regulations: Analyze government policies and regulations related to construction and technology adoption, which can impact the integration of constructability programs
Economic	Economic Growth	GDP Growth and Construction Industry Trends: Evaluate the overall economic growth of India and its influence on the construction sector's performance and willingness to invest in constructability programs
Social	Cultural Acceptance	Skilled Workforce and Training: Understand the availability of skilled labor in the construction industry and the need for training to ensure successful implementation of constructability programs.
Technological	Advancements in Construction Technology	Digital Infrastructure: Assess the availability and reliability of digital infrastructure, including internet connectivity, in various regions of India to support the implementation of constructability programs.
Environment	Environmental Regulations	Sustainability and Green Building Practices: Analyze the growing demand for sustainable construction practices and how constructability programs can contribute to resource-efficient and eco-friendly buildings.
Legal	Legally favorable to constructability	Intellectual Property and Data Privacy: Address legal issues related to intellectual property rights and data privacy concerns when utilizing constructability programs.

4.2.2 SWOT Analysis

Table 3. TOWS Analysis.

EXTERNAL AND INTERNAL FACTORS	OPPORTUNITIES (O)	THREATS (T)
	Government Initiatives (O1): The Indian government's focus on infrastructure development and "Digital India" initiatives can provide a supportive environment for the integration of constructability programs. **Sustainable Construction Demands (O2):** The increasing demand for sustainable and energy-efficient buildings creates opportunities for constructability programs to optimize resource use and design green structures[36].	**Data Security Concerns (T1):** The implementation of digital tools may raise data. security concerns, necessitating robustness. cybersecurity measures to safeguard sensitive. project information. **Skills Gap (T2):** The rapid adoption of constructability programs might outpace the availability of skilled personnel proficient in using such tools[40].
STRENGTHS (S) **Skilled Workforce (S1):** The Indian construction industry boasts a pool of skilled and experienced professionals, providing a strong foundation for adopting and utilizing constructability programs effectively. **Rapid Technological Advancements (S2):** The country has witnessed significant technological advancements in recent years, making it well-suited to embrace innovative digital tools like constructability programs[36].	**SO** **S1-O1:** Collaborate with government agencies to establish training programs that leverage the skilled workforce for the successful implementation of constructability programs in government infrastructure projects. **S2-O2:** Promote the integration of constructability programs as part of sustainable construction certification initiatives, aligning with the demand for green building practices[36].	**ST** **S1-T1:** Establish partnerships with reputable cybersecurity firms to ensure the secure usage of constructability programs, utilizing the skilled workforce to address potential data security concerns.[40] **S2-T2:** Foster collaborations with educational institutions to develop specialized courses on constructability programs, bridging the skills gap and reducing threats arising from inadequate training.
WEAKNESSES (W) **Resistance to Change (W1):** The industry may face resistance to the adoption of new technologies, including constructability programs, due to traditional practices deeply ingrained in the sector. **Lack of Standardization (W2):** The absence of standardized processes and protocols could pose challenges during the implementation of constructability programs across various projects. [36]	**WO** **W1-O1:** Form partnerships with technology providers and industry experts to offer comprehensive training and support programs, addressing resistance to change while aligning with government initiatives. **W2-O2:** Engage with sustainability organizations to develop standardized constructability practices that align with green building guidelines, leveraging the opportunity for sustainable construction demand [36].	**WT** **W1-T1:** Implement data encryption and secure access controls for constructability programs, mitigating data security threats while addressing resistance to change through transparent data protection measures. **W2-T2:** Collaborate with industry associations and regulatory bodies to develop certification programs that mandate constructability training, ensuring that the lack of standardization is addressed effectively.

The SWOT analysis is a strategic tool that allows us to evaluate the internal strengths and weaknesses of the Indian construction industry while considering the external opportunities and threats related to the integration of constructability programs. By conducting a SWOT analysis, we can develop strategies that leverage strengths, address weaknesses, capitalize on opportunities, and mitigate potential threats, aiming to facilitate a successful implementation of constructability programs as shown in Table 2 [38].

4.3 Constructability Approach Selection

In the context of the project "Integrating Constructability Programs into Construction Industries in India," Fig. 1 presents a rule-based decision model for the systematic selection of constructability approaches. This model consists of a hierarchy of decision levels aimed at facilitating the selection process. Critical variables representing the key characteristics of owners' organizations, and their projects were used to develop the framework. Through data analysis, parameters defining each variable were identified. Approach recommendations, either "formal" or "informal," were evaluated and combined to arrive at an approach recommendation for the owner and project characteristics (step 1 in Fig. 1). The second step in the model involves combining both owner and project characteristics, resulting in a recommended constructability approach: "Informal" or "Formal." If the informal approach is recommended, the decision process terminates. However, if the formal approach is recommended, step 3 is initiated, leading to two outcomes: "Formal project-level" or "Comprehensive tracking"[42] as shown in Figure 4.

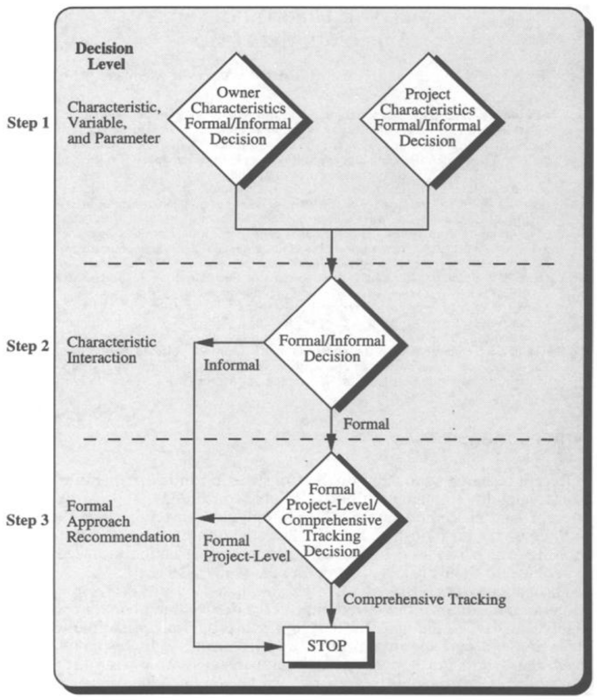

Figure 4. Constructability Approach Selection decision model Radtke, M. W. (1992a)[41].

The informal approach acknowledges the importance of construction input, though it often limits construction's participation to a reactive-review role. In cases where construction personnel can participate during the design process, their input provides cost estimates of design alternatives. However, procedural guidelines for this approach are usually limited to design review checklists that focus on document completeness and conformity. The lack of procedural guidelines indicates a tendency not to recognize constructability as a distinct work process. However, the formal project-level approach uses procedures to ensure effective application of constructability in selected projects. Lessons learned from projects may be tracked at the project level for future reference. Initially, benefits and costs of the associated constructability efforts are tracked to demonstrate program effectiveness. Once the benefits of constructability are demonstrated, the collection of benefit/cost data is discontinued [42]. Owners adopting the comprehensive tracking approach maintain a database or file of lessons learned. These lessons represent ideas implemented in past projects that enhanced construction efficiency and should be replicated in future projects. Also, benefit/cost data are regularly collected and used to document the constructability program's performance. This performance data can also be used to monitor the program's maturity.

4.3.1 Step 1: Owner Characteristics, Variables, and Parameters

The variables presented in Fig. 2 encompass the characteristics of an owner, including (1) Owner type, (2) Objectives, (3) In-house expertise, and (4) Constructability resources. Owners can be categorized into five types: (1) Public agency, (2) Large general builder, (3) Regulated private owner, (4) Industrial owner, or (5) Commercial developer. The study identified a correlation between the constructability approach chosen and the type of owner. For instance, public agencies governed by the Federal Acquisition Regulations (FAR) tended to favor "post-facto" in-house design reviews. However, these reviews primarily focused on the completeness of design documents rather than optimizing the construction process, making it an "informal" approach to construction input [44]. Using insights from the CII Design Task Force ("Input Variables," 1987) and data analysis conducted by the researchers, the project objectives have been identified and ranked in descending order of influence on constructability implementation. These objectives will be considered in the context of the project "Integrating Constructability Programs into Construction Industries in India." Secondary data collection methods will be utilized to gather relevant information from industry reports, studies, and expert analyses (References: CII Design Task Force, Research reports on construction industry objectives). The findings from this step will provide crucial insights into the specific characteristics of owners and their objectives, informing the subsequent stages of the project as shown in Figure 5.

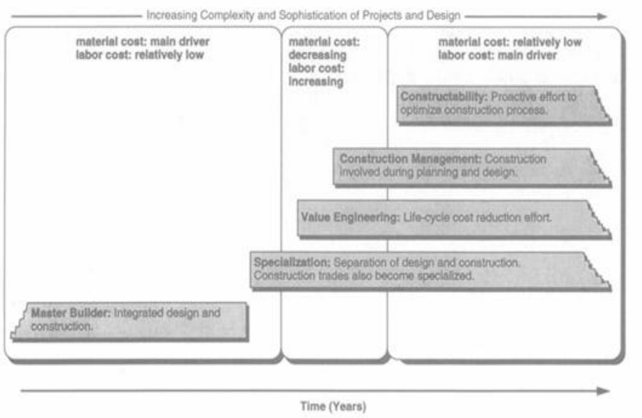

Figure 5. Hierarchical Framework: Owner Characteristics Gugel, J. G. (1992) [43]

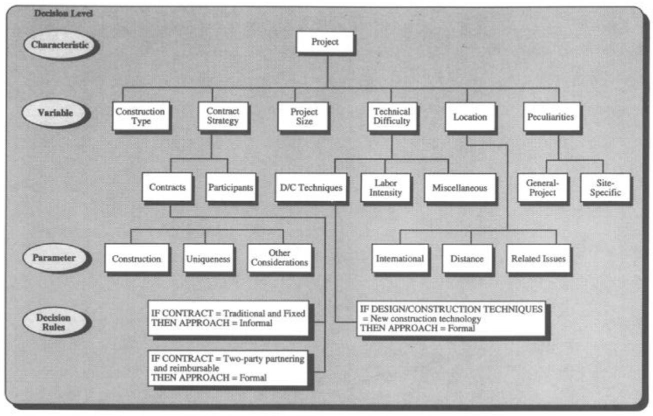

Figure 6. Hierarchical Framework: Project Characteristics Constructability implementation guide." (1993).

Project Explanation

As shown in Fig. 3 which illustrates the variables that define the characteristics of a project, including (1) Construction type, (2) Contract strategy, (3) Project size, (4) Technical difficulty, (5) Location, and (6) Peculiarities. The construction type encompasses three parameters: (1) Construction, (2) Uniqueness, and (3) Other considerations. The construction parameter focuses on the type of projects undertaken by the owner. Four identified project types, ranked from higher to lower tendencies for formalizing constructability efforts, are: (1) Process-driven, (2) Manufacturing-driven, (3) General building, and (4) Civil works [44]. The uniqueness parameter deals with the level of uncertainty linked to successfully executing a proposed project due to its uniqueness. Case studies of a one-of-a-kind, high-rise office building, and a small, standardized processing facility demonstrate examples of the uniqueness parameter [42]. The general-building case study involved a unique structure type where a formal program to capture lessons learned had limited applicability to future projects. Conversely, the latter case study dealt with a standardized process facility where the captured lessons learned could directly apply to future projects. Additionally, the uniqueness parameter considers whether the project is grassroots (completely new project) or a retrofit/rehabilitation. The level of formality is linked to the uncertainty associated with the construction process. Retrofit/rehabilitation-type projects are more likely to have a formalized constructability program for two reasons: (1) The need to perform work while permitting the facility to remain operational, and (2) construction input into the design of retrofit/rehabilitation projects can alleviate coordination difficulties [43].

For the project "Integrating Constructability Programs into Construction Industries in India," secondary data collection methods will be employed to gather relevant information on project characteristics, including case studies and industry reports (Russell et al., 1992a, Research reports on construction projects). Understanding these project-specific factors will be essential for effectively implementing constructability programs in the Indian construction industry as shown in Figure 6.

4.3.2 Step 2: Characteristic Interaction

After obtaining recommendations, either formal or informal, for both owner and project characteristics, their interaction is evaluated at the final approach selection level. Table 1 outlines the four possible conclusion alternatives at this decision point [43]. Owner characteristics are regarded as modifiable constraints, subject to adjustments by the owner's project team. On the other hand, project characteristics are considered fixed constraints. When alternatives 2 and 3 involve owner and project characteristics suggesting different recommendations, the project-characteristic recommendation takes precedence and determines the approach recommendation. If the outcome of step 2 indicates a formal recommendation, step 3 is initiated; otherwise, the result of step 2 indicates an informal approach [42]. Table 4 Explained that, for the project "Integrating Constructability Programs into Construction Industries in India," secondary data collection methods will be employed to assess the interactions between owner and project characteristics, allowing for a comprehensive evaluation of the final approach selection (Research methodology for construction studies, Project proposal for Integrating Constructability Programs in Construction Industries in India). Piercy, N. (2002). Understanding how these characteristics interact will be crucial in determining the most suitable approach to successfully integrate constructability programs in the Indian construction industry.

Table 4 Characteristic-Interaction Level Alternatives [42].

Alternatives	Recommendation of Owners characteristics	Recommendation of Project characteristics	Step-2 Conclusion	Further Actions
1	Formal	Formal	Formal	Step -3
2	Formal	Informal	Informal	Stop
3	Informal	Formal	Formal	Step-3
4	Informal	Informal	Informal	Stop

4.3.3 Step 3: Formal Approach Recommendation

Alternatives 1 and 3 both suggest implementing a formal constructability program. In step 3, a specific approach decision must be made, considering either the formal project-level or comprehensive tracking approach. This decision is based on five variables: (1) Objectives, (2) In-house expertise, (3) Constructability resources, (4) Construction type, and (5) Technical difficulty. If one of the owner's primary objectives is a "constructability program pilot project," then the recommendation for the objective's variable is comprehensive tracking. Otherwise, the recommendation for the objective's variable is a formal project-level program. This rule is derived from the observation that many organizations implement a formal constructability program on selected projects to validate its benefits [44]. Tracking lessons learned and monitoring cost savings document these benefits. Additionally, the corporate-level support provided in the comprehensive tracking approach (such as policy statements and executive sponsors) enhances the likelihood of a successful "pilot" program [43]. Regarding in-house expertise, if the owner's staff plans to perform detailed design of the facility, the recommended variable-level approach is comprehensive tracking. Otherwise, the recommended variable-level approach is a formal project-level program. The comprehensive tracking recommendation based on the constructability resources variable depends on the constructability tools and users available to the owner. This recommendation considers two types of constructability tools (a written program and a lessons-learned database) and two tool-user parameters (experience and coordinator availability) [42].

Concerning technical difficulty, if owners express the intention to incorporate a new construction technology in their projects, the recommended variable-level approach is comprehensive tracking. On the other hand, if the owners do not plan to adopt a new construction technology, the variable-level approach is a formal project-level program. This rule is derived from the observed strong inclination towards the comprehensive tracking approach associated with this variable. Potential reasons for this inclination include the owner's interest in documenting lessons learned for future application of the technology and their desire to track the associated benefits and costs resulting from its implementation.

4.4 Practical Applications

To address the practical implementation of the decision model, the following aspects are taken into consideration: (1) Benefits of using the model; (2) Potential users of the model; (3) Timing of model implementation; and (4) Considerations for model implementation. Distinguishing itself from previous research on constructability implementation, this model relies on the intricate interplay of owner and project characteristics to make recommendations. The model proves advantageous by providing a formalized process to select the appropriate constructability approach, thereby establishing a deliberate effort to integrate construction knowledge and experience into the design process. Recognizing such a constructability program can help overcome barriers to its implementation [43]. The model caters to two types of organizations: (1) Owners; and (2) Design/construct organizations. While primarily designed to assist project owners, design/construct organizations can also use the model in turnkey contract arrangements to determine the appropriate level of formality for their internal constructability processes (i.e., construction input from personnel within their organization). For optimal results, the model should be implemented during the early stages of the planning phase (i.e., prior to 50% completion). Early adoption allows the owner to establish the desired constructability approach in time to reap the highest potential benefits.

5. Conclusion

This paper introduces a decision-making model that recommends a constructability approach based on the characteristics of both the owner and the project. The model is organised into three hierarchical steps: first, an individual assessment of the owner and project characteristics; second, the combination of these characteristics into a single, cohesive recommendation; and third, a decision on whether a formal constructability approach at the project level or comprehensive tracking is necessary if a formal approach is indicated. The model was tested by six owners across seven completed projects, with its recommendations aligning with successful project outcomes. This model aids owners in effectively incorporating construction knowledge into project designs and may encourage those less familiar with constructability to adopt these practices. The study explores the integration of constructability programmes within India's construction industry, focusing on the necessity of constructability, the challenges faced, and the methods for effective integration. It introduces a rule-based decision model, structured into three steps, and supports its findings through secondary data collection methods.

5.1. Constructability in the Construction Industry

The first key theme addresses the crucial necessity of constructability in the construction industry. The study highlights how adopting a constructability approach can significantly impact project outcomes positively. By considering owner and project characteristics, constructability programs facilitate a proactive approach to project planning, reducing risks and uncertainties. The integration of constructability at the early stages of project development enables better resource allocation, improved stakeholder collaboration, and enhanced project management. This theme emphasizes the importance of embracing constructability as an essential element in modern construction practices. The construction industry in India is experiencing rapid growth and development, with numerous large-scale and complex projects underway. In this dynamic and challenging environment, the need for constructability is paramount. Constructability refers to the systematic consideration of construction-related factors during the early stages of project planning and design. By incorporating constructability principles, construction professionals can identify and address potential issues and constraints that may arise during the project lifecycle. This proactive approach ensures better coordination between various stakeholders, optimizes resource allocation, and reduces the likelihood of costly rework and delays. Additionally, constructability enhances overall project efficiency, leading to improved project outcomes and contributing to the sustainable growth of the construction industry in India. As construction projects become increasingly intricate and demanding, embracing constructability has become indispensable for successful and competitive construction practices in the country as shown in Figure 7[45].

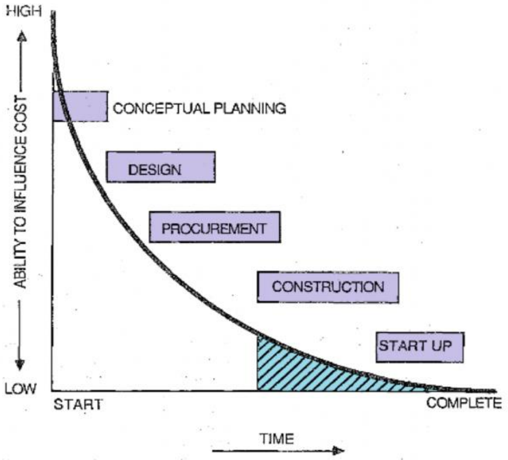

Figure *7:* The graph showing various stages of design process and cost savings potential in construction industry[45]

5.2. Challenges Faced by the Construction Industry in India

The second key theme delves into the challenges faced by the construction industry in India. The study identifies and discusses various challenges, such as project complexity, resource constraints, regulatory hurdles, and skill shortages. The findings highlight the need for effective solutions to overcome these challenges and streamline construction processes. Integrating constructability programs offers a potential solution to address these challenges. By considering project characteristics and aligning them with owner requirements, construction companies can devise effective strategies to tackle obstacles and enhance project performance.

Table 4: Advantages and Disadvantages of Globalization Considering Construction Industries in Developing Countries

Advantages	Disadvantages
Involvement of international finance makes possible the implementation of several projects, such as those of major infrastructure.	Local construction firms have no funds or expertise to participate in the sponsorship of privatized projects.
Direct foreign investment in projects leads to increase in construction demand, creating work opportunities for local firms.	Local construction companies lack the technical and managerial capability to undertake most of the foreign-funded projects.
Competition among foreign firms lowers the costs of projects to developing countries.	It is possible that local firms will be deprived of the opportunity to grow (Hillebrandt, 1999).
The presence of large numbers of international firms offers scope for technology transfer and the development of local firms and upgrading of the industry. The large number of such firms also means that technology transfer can be a tool for competition.	Foreign construction firms may pay lip service to technology transfer (Carillo, 1994) or take measures to avoid it. Moreover, local companies may not be able to benefit from technology transfer, or to subsequently utilize the acquired expertise.

5.3. Integrating Constructability Programs into Construction Companies in India:

The third primary theme addresses the practical integration of constructability programs within construction firms in India. This study introduces a rule-based decision model that provides a systematic approach to informed decision-making. The model is organized into hierarchical decision levels, enabling a comprehensive evaluation of both owner and project characteristics. This helps guide stakeholders toward an optimal constructability strategy. The theme emphasizes the importance of adopting a formal approach when necessary, either at the project level or through continuous tracking. It offers valuable guidance for construction firms on effectively implementing constructability programs to improve project outcomes.

A key component of this integration is the introduction of a rule-based decision model, which guides the decision-making process through three essential steps. First, the individual characteristics of the owner and project are thoroughly evaluated to determine whether an informal or formal constructability approach is suitable, establishing the foundation for further decision-making. In the second step, the traits of the owner and project are combined to generate a single recommendation. This synthesis allows construction firms to gain a comprehensive understanding of the project's unique requirements and complexities, leading to informed choices about the most appropriate constructability approach. Finally, if a formal approach is recommended, the third step involves deciding whether to implement a formal project-level constructability program or to adopt comprehensive tracking throughout the project's lifecycle. A formal project-level constructability program involves implementing specific measures tailored to the project's needs, while comprehensive tracking entails continuous monitoring and improvement of constructability throughout the entire project duration.

Integrating constructability programs offers several benefits for construction firms in India. First, it enhances project planning by identifying potential challenges and opportunities early, enabling the development of effective strategies for successful project execution. Second, by aligning the traits of the owner and project, it improves resource allocation, reducing the likelihood of cost overruns and schedule delays. Additionally, constructability programs promote better collaboration among stakeholders, ensuring that all parties involved have a clear understanding of the project's objectives and requirements. This leads to improved communication and cooperation, reducing conflicts and increasing overall project efficiency. Moreover, the integration of constructability programs addresses the challenges faced by the Indian construction industry. As projects become more complex and resources more limited, these programs enable well-informed decisions, optimize resource use, and manage risks effectively, addressing issues such as regulatory compliance, labor shortages, and supply chain disruptions.

References

[1] Wesam S Alaloul, Mohd Shahir Liew, Noor Amila Wan Abdullah Zawawi and Bashar S Mohammed (2018), Industry Revolution IR 4.0: Future Opportunities and Challenges in Construction Industry, MATEC Web Conf., 203 (2018) 02010, DOI: https://doi.org/10.1051/matecconf/201820302010.

[2] Arpit Singh, Vimal Kumar, Pratima Verma, Jayakrishna Kandasamy,(2023). Identification and severity assessment of challenges in the adoption of industry 4.0 in Indian construction industry, Asia Pacific Management Review, Volume 28, Issue 3, 2023, Pages 299-315, ISSN 1029-3132, https://doi.org/10.1016/j.apmrv.2022.10.007.

[3] Bekr, Ghanim. (2017). Factors affecting performance of construction projects in unstable political and economic situations. Journal of Engineering and Applied Sciences. 12. 5384. [3] H. Attar, M. Calin, L. C. Zhang, S. Scudino, and J. Eckert, "Manufacture by selective laser melting and mechanical behavior of commercially pure titanium," *Mater. Sci. Eng. A*, vol. 593, pp. 170–177, 2014, doi: 10.1016/j.msea.2013.11.038. *(Journal article).*

[4] Jaffar, Noman & Abdul Tharim, Asniza Hamimi & Shuib, Mohammad. (2011). Factors of Conflict in Construction Industry: A Literature Review. Procedia Engineering. 20. 193-202. 10.1016/j.proeng.2011.11.156.

[5] Ramiz Jabbar, Integrating Constructibility Programs Into Construction Industries In India , MEng Dissartation, 2023.

[6] Russell, J. S., Swiggum, K. E., Shapiro, J. M., & Alaydrus, A. F. (1994). Constructability Related to TQM, Value Engineering, and Cost/Benefits. Journal of Performance of Constructed Facilities, 8(1), 31–45. https://doi.org/10.1061/(asce)0887-3828(1994)8:1(31)

[7] Saghatforoush, E., Hasim, S., Jaafar, M. S., & Abdul Kadir, M. R. (2009). Constructability implementation among Malaysian building contractors. European Journal of Scientific Research, 29(4).

[8] Eldin, N. N. (1999). Impact of employee, management, and process issues on constructability impl - ementation. Construction Management and Economics, 17(6), 711- 720. https://doi.org/10.1080/014461999371051

[9] Trigunarsyah, B. (2007). Project designers' role in improving constructability of Indonesian construction projects. Construction Management and Economics, 25(2), 207–215. https://doi.org/10.1080/01446190600830649

[10] Mathern, A. (2019). Sustainability-, Buildability- and Performance-driven Structural Design [Masters, Chalmers University of Technology]. https://research.chalmers.se/publication/510271/file/510271_Fulltext.pdf .

[11] O'Connor, J. T., & Miller, S. J. (1994). Barriers to constructability implementation. Journal of Performance of Constructed Facilities, 8(2), 110-128.

[12] Fischer, M., & Tatum, C. B. (1997). Characteristics of design-relevant constructability knowledge. Journal of Construction Engineering and Management, 123(3), 253-260.

[13] Pocock, J. B., Kuennen, S. T., Gambatese, J., & Rauschkolb, J. (2006). Constructability state of practice report. Journal of construction engineering and management, 132(4), 373-383.

[14] Wong, F. W., Lam, P. T., Chan, E. H., & Shen, L. Y. (2007). A study of measures to improve constructability. International Journal of Quality & Reliability Management, 24(6), 586-601

[15]Raviv, G., Shapira, A., & Sacks, R. (2012). „Relationships between Methods for Constructability Analysis during Design and Constructability Failures in Projects‟, Construction Research Congress 2012: West Lafayette, Indiana, United States. May 21-23, 2012. ASCE. pp. 515-524.

[16] Yafei Johnson, G., Scholes, K., & Whittington, R. (2008). "Exploring Corporate Strategy: Text and Cases." Pearson Education.

[17] Khemlani, L., & Sawhney, A. (2013). Integrated project delivery: An example of lean project management in construction. Lean Construction Journal, 1(1), 48-57.

[18] Chen, D. Q., Love, P. E., & Irani, Z. (2014). Integrated delivery: An exploration of organisational transformation in construction projects. Construction Management and Economics, 32(7-8), 727-742.

[19] Hwang, B. G., Tan, J. S., & Leong, B. (2016). An evaluation of the organizational structure of a project based organization using the competing values framework. International Journal of Project Management, 34(1), 82-96.

[20] Tatum, C. B., & Horman, M. J. (2018). Performance-based contracting in construction: A survey of practice and research. Journal of Construction Engineering and Management, 144(4), 04018010.

[21] Navon, R., Carter, K. R., & Ayer, S. K. (2018). Developing and delivering a professional development program on building information modeling (BIM).

Journal of Professional Issues in Engineering Education and Practice, 144(3), 04018016.

[22] Nataraja, M. V. (2016). Challenges and opportunities for SMEs in the construction industry in India. International Journal of Scientific and Research Publications, 6(3), 511-515.

[23] Singh, J., & Chaudhury, S. (2021). Analysis of labor shortage in the Indian construction industry: Causes and implications. International Journal of Applied Engineering Research, 16(4), 465-472.

[24] *Sahu, S. K., & Patil, V. M. (2019). Sustainable construction practices in small and medium enterprises: A study in India. International Journal of Civil Engineering and Technology, 10(1), 233-244.*

[25] Neville, A. M. (2019). Properties of concrete. Pearson.

[26] Kibert, C. J. (2016). Sustainable construction: Green building design and delivery. John Wiley & Sons.

[27] Eastman, C. M., Teicholz, P., Sacks, R., & Liston, K. (2011). BIM handbook: A guide to building information modeling for owners, managers, designers, engineers, and contractors. John Wiley & Sons.

[28] Carr, C., & Voelker, T. A. (2017). Strategic project portfolio management for value maximization. Routledge.

[29] Howard, R., & Perera, S. (2016). Handbook of sustainable construction. Springer.

[30] Betts, M. P., & O'Leary, K. P. (2018). Successful project management in construction. John Wiley & Sons.

[31] Al-Ghafri, M. A., Al-Busaidi, A. S., & Al-Maamari, R. S. (2017). Environmental sustainability in construction projects. Journal of Civil Engineering and Architecture, 11(3), 187-193.

[32] Saunders, Mark & Lewis, Philip & Thornhill, Adrian & Bristow, Alex. (2019). "Research Methods for Business Students" Chapter 4: Understanding research philosophy and approaches to theory development.

[33] CIDC (Construction Industry Development Council). (2017). National Guidelines for Constructability Implementation in Construction Projects.

[34] CIDC. (2019). "Report on Construction Industry in India: Trends and Analysis."

[35] Government of India. (2020). Model Request for Proposal (RFP) for National Infra Pipeline Projects *https://mohua.gov.in/upload/uploadfiles/files/Model%20RFP%20BIM%20Implementation%20in%20NIP%20Projects.pdf.*

[36] Smith, J. (2020). "Advancements in Constructibility Programs: A Review of Global Practices." Construction Management Journal, 45(2), 67-82.

[37] Gupta, A., & Kapoor, R. (2018). "Implementation Challenges of Technology in Indian Construction Projects." International Journal of Construction Engineering and Management, 7(4), 123-135.

[38] Weihrich, H. (1982). "The TOWS Matrix: A Tool for Situational Analysis." Long Range Planning, 15(2), 54-66.

[39] Johnson, G., Scholes, K., & Whittington, R. (2008). "Exploring Corporate Strategy: Text and Cases." Pearson Education.

[40] *Kotler, P., Armstrong, G., Harris, L. C., & Piercy, N. (2002). "Principles of Marketing." Pearson Education.*

[41] Russell, J. S., Gugel, J. G., and Radtke, M. W. (1992a). "Benefits and costs of constructability: four case studies." Source Document 83, Construction Industry Institute, University of Texas, Austin, Tex.

[42] Russell, J. S., Radtke, M. W., and Gugel, J. G. (1992b). "Project-level model and approaches to implement constructability." Source Document 82, Construction Industry Institute, University of Texas, Austin, Tex.

[43] Gugel, J. G. (1992). "Models for constructability approach selection and input-source evaluation," MSc thesis, University of Wisconsin, Madison, Wisconsin.

[44] Ashley, D. B., and Bonner, J. J. (1987). "Political risks in international construc- tion." J. Constr. Engrg. and Mgmt., ASCE, 113(3), 447-467.

[45] Glavinich, T. E., (1995), "Improving Constructability during Desihn phase", J. of Architectural Eng., Vol 1., No. 2, 73-76.

[46] "Constructability implementation guide." (1993). Publication 34-1, Construction In- dustry Institute, University of Texas at Austin, Austin, Tex.,