Critical Success Factors for the Construction Industry in India

Submitted By

Rushabh Biren Parikh

(22MCLT06)

DEPARTMENT OF CIVIL ENGINEERING

INSTITUTE OF TECHNOLOGY

NIRMA UNIVERSITY

AHMEDABAD-382481

May 2024

Critical Success Factors for the Construction Industry in India

Major Project - II

Submitted in partial fulfillment of the requirements

for the degree of

Master of Technology in Civil Engineering (Construction Technology and Management)

Submitted By

Rushabh Biren Parikh

(22MCLT06)

Guided By

Dr. Kamalendra Kumar Tripathi

DEPARTMENT OF CIVIL ENGINEERING

INSTITUTE OF TECHNOLOGY

NIRMA UNIVERSITY

AHMEDABAD-382481

May 2024

Certificate

This is to certify that the major project titled **"Critical Success Factors for the Construction Industry in India"** submitted by **Rushabh Biren Parikh (Roll No: 22MCLT06)**, towards the partial fulfillment of the requirements for the award of the degree of Master of Technology in Civil Engineering (Construction Technology and Management) at Nirma University, Ahmedabad, is a record of work carried out by him under my supervision and guidance. In my opinion, the submitted work meets the level required for acceptance for examination. To the best of my knowledge, the results embodied in this major project part-II have not been submitted to any other university or institution for the award of any degree or diploma

Dr. Kamalendra Kumar Tripathi
Guide & Associate Professor,
Department of Civil Engineering,
Institute of Technology,
Nirma University, Ahmedabad.

Dr. Parul Patel
Professor,
Coordinator M.Tech - Civil (C.T.M.)
Institute of Technology,
Nirma University, Ahmedabad

Dr. Urmil. V. Dave
Professor and Head,
Department of Civil Engineering,
Institute of Technology,
Nirma University, Ahmedabad.

Dr R. N. Patel
Director,
Institute of Technology,
Nirma University, Ahmedabad

Signature of Examiner

Statement of Originality

I, **Rushabh Biren Parikh**, Roll No. **22MCLT06**, hereby declare that the Major Project titled "**Critical Success Factors for the Construction Industry in India**" submitted by me for partial fulfillment of the requirements for the degree of Master of Technology in **Civil Engineering (Construction Technology and Management)** at the Institute of Technology, Nirma University, Ahmedabad, contains no material previously awarded for any degree or diploma in any university or institution, to the best of my knowledge. It is the original work conducted by me, and I affirm that no instances of plagiarism have occurred. This work contains no material previously published or written by another person, except where due reference is made. I understand that if any similarity is subsequently discovered with any published work or any other dissertation, it will result in severe disciplinary actions.

Signature of Student
Date:
Place: Ahmedabad

Endorsed by
Prof. Dr. Kamalendra Kumar Tripathi
(Signature of Guide)

Acknowledgements

It gives me immense pleasure to express my thanks and profound gratitude to **Dr. Kamalendra Kumar Tripathi**, Associate Professor in the Department of Civil Engineering at the Institute of Technology, Nirma University, Ahmedabad, for his valuable guidance and continual encouragement throughout this work. The appreciation and continual support he has imparted have been great motivation for me in reaching goals. His guidance has triggered and nourished my intellectual maturity, from which I will benefit for a long time to come.

I am also immensely grateful to **Dr. Urmil. V. Dave**, the Head of Department of Civil Engineering at the Institute of Technology, Nirma University, Ahmedabad, for his insightful feedback, continuous encouragement, kind support, and for providing the basic infrastructure and a healthy research environment.

I would like to extend my sincere thanks to **Dr. Parul Patel**, Coordinator of M.Tech C.T.M. at the Institute of Technology, Nirma University, Ahmedabad, whose guidance and support have been vital to my academic and professional growth during this course.

I am deeply grateful to **Dr. R.N. Patel**, Honorable Director of the Institute of Technology at Nirma University, Ahmedabad for his visionary leadership and steadfast support he has provided throughout the course of this work.

Special thanks to the **Institution**, all **Faculty members** and **Staff** of the Department of Civil Engineering at the Institute of Technology, Nirma University,Ahmedabad. Their dedication to fostering an academic community and providing essential resources has been crucial to my studies and research.

Lastly, I owe a profound debt of gratitude to my family: my father **Biren Parikh**, my mother **Gemini Parikh**, and my sister **Vidhi Parikh**. Their love and support have been the anchor and refuge that sustained me throughout this journey. Their unwavering belief in me has been my constant source of encouragement and motivation, making this research possible. I also extend heartfelt thanks to my peers **Dev Patel**, **Dhyey Gondalia**, **Rahil Dudhrejia**, **Takshal Prajapati**, **Harshpalsinh Vaghela**, **Dev Shah** and **Brij Patel** for their companionship and support. Their contributions to my personal and academic growth during this period have been invaluable.

- Rushabh Biren Parikh
22MCLT06

Abstract

The dynamic nature of the Indian construction industry significantly impacts economic development by contributing to employment and Gross Domestic Product (GDP), while also playing a pivotal role in fostering infrastructural development that supports various other sectors. In order to effectively manage and enhance the industry's performance, sustainability, and competitiveness in a global market, it is crucial to identify critical success factors that contribute to the growth and expansion of the industry. Although extensive research has been conducted on success and performance factors at both the construction project and organizational levels, exploration at the industry-wide level remains largely unexplored. This research aims to address this gap by determining and evaluating the critical success factors essential for the construction industry in India. This study seeks to fill this void by providing a comprehensive analysis of these factors within the broader industry context.

This study employs an extensive literature review, identified 30 success and 15 performance attributes through surveys administered to 129 industry professionals averaging 15 years of experience. The study identified key success attributes such as the availability of equipment, materials, and workforce; qualified professionals; higher workforce productivity; and easy finance. In parallel, the key performance attributes highlighted include qualified professionals in the industry, technological development, annual growth rate, labor productivity, and high annual construction demand/market share.

Employing methodologies such as factor analysis, stepwise regression, and structural equation modeling, the research delineated seven pivotal success factors: competent workforce, infrastructure and economic development, financial opportunity and industry image, favorable government policies, regulatory and skill development, market attractiveness and collaboration, and socio-economic stability. Additionally, the study revealed four performance factors: industry competence and societal impact, profitability and stakeholder satisfaction, industry attractiveness, and research and development strategy. The findings highlights a strong positive correlation among the identified factors, placing particular emphasis on the competent workforce, closely followed by infrastructure and economic growth. This study evaluates the relative weights of each success and performance factor using a consistent fuzzy preference relation, based on inputs from 20 experts

across various construction organizations. Additionally a model was constructed using fuzzy synthesis to elaborate on the interrelationships among these factors.

This investigation offers a thorough examination of the interplay between success and performance factors in the construction industry. This study provides invaluable insights for effective resource management and strategic decision-making in the construction industry. It also establishes a solid framework for policymakers aimed at enhancing industry standards and practices. It offers a novel, comprehensive framework for assessing the construction industry's performance. The findings of the study provide valuable guidelines for stakeholders facilitating the assessment and improvement of the construction industry.

Abbreviations

AMC	Ahmedabad Municipal Corporation
AMOS	Analysis of Moment Structure
AUDA	Ahmedabad Urban Development Authority
BAI	Builders Association of India
BIM	Building Information Model
CAGR	Compound Annual Growth Rate
CB	Covariance Based
CBPP	Construction Best Practice Programme
CFA	Confirmatory Factor Analysis
CFI	Comparative Fit Index
CFPR	Consistent Fuzzy Preference Relations
CIPI	Construction Industry Performance Index
CISI	Construction Industry Success Index
CSFs	Critical Success Factors
ECVI	Expected Cross-Validation Index
FPR	Fuzzy Preference Relation
FSE	Fuzzy Synthetic Evaluation
FY	Financial Year
GDP	Gross Domestic Product
GFI	Goodness of Fit Index
GOF	Goodness of fit
IFI	Incremental Fit Index
IMD	International Institute for Management Development
KM	Kilometers
KMO	Kaiser-Meyer-Olkin
KPIs	Key Performance Indicators
MPR	Multiplicative Preference Relation
PAF	Principal Axis Factoring
PCA	Principal Components Analysis
PFs	Performance Factors

PLS SEM	Partial Square Least Structural Equation Modeling
PMAY-U	Pradhan Mantri Awas Yojana-Urban
PMCs	Project Management Consultants
PPP	Public Private Partnership
RII	Relative Importance Index
RK	Ranking
RMSEA	Root-Mean-Square Error of Approximation
R&D	Research and Development
SE	Standardized path coefficients
SEM	Structural Equation Modeling
SMART	Simple Multi-Attribute Rating Technique
SPSS	Statistical Package for Social Sciences
SRCC	Spearman's Rank Correlation Coefficient
STV	Subject-to-Variable
TLI	Tucker-Lewis Index
USE	Unstandardized path coefficients
VB	Variance Based
CI3 India	Construction Industry Improvement Initiative

–

Contents

List of Tables

Chapter 1

Introduction

This chapter presents an overview of construction industry, need for study, research aim and objectives, scope of work, outline of thesis and summary.

1.1 Overview of construction industry:

The construction industry ranks among the world's largest and fastest-growing industrial sectors. It is pivotal in developing economies, including India (Datta et al. 2023). The construction sector significantly impacts the economies of developing countries worldwide. Governments use this sector to foster national growth and aspire towards a developed country status (Yap et al. 2019). According to a 2013 Oxford Economics and Global Construction Perspectives report, the industry is predicted to grow globally from US$8.7 trillion in 2012 to US$15 trillion by 2025 (Tsiga et al. 2016). For any country, the construction sector plays a crucial role by directly or indirectly boosting the performance of other economic sectors. In 2020, contributing about nine percent to India's Gross Domestic Product (GDP), the construction sector emerged as the second-largest sector, following the agriculture sector (Rani 2021, Tripathi & Jha 2019). As India's second-largest employer, the construction sector employs around 51 million people, nearly four percent of the population. India's construction industry is expected to become the third-largest globally by 2025 (Rani 2021).

The report by Frank (2023) forecasts a significant expansion in the Indian real estate market, estimating its value to reach US$1 trillion by 2030 from US$650 billion in 2023. Additionally, the sector is expected to contribute 13 percent to the nation's GDP by 2025, marking a substantial impact on economic growth. The real estate sector in India is expected to grow to US$5.8 trillion by 2047, contributing 15.5 % to GDP, up from 7.3 % today. The program launched by the Ministry of Housing and Urban Affairs, the Pradhan Mantri Awas Yojana-Urban (PMAY-U) initiative, had sanctioned 11.863 million houses as of 21 February 2024. Of these, 8.035 million homes have been completed and allocated to the urban poor, highlighting the program's progress in addressing urban housing needs (Ministry of Housing and Urban Affairs, Government of India 2024).

The development of the country is reflected by its infrastructure's growth, especially in India's sudden need for infrastructure has led to an increase in the construction industry (Barajei et al. 2023, Tripathi & Jha 2019). As per the report of International Institute for Management Development (IMD), India ranks 52th in the infrastructure area (IMD World Competitiveness Center 2024). The construction sector also plays a key role in the growth of manufacturing industries and building sectors in addition to the infrastructure sector (Sawhney et al. 2014).

According to the India Brand Equity Foundation (2023), India's infrastructure development has accelerated, making it the world's second-largest in terms of the road network. The country, in terms of the road network, has over 6.3 million kilometers (KM), including 0.141 million km of national highways, 0.171 million km of state highways, and 6.06 million km of other categories of roads. According to the Ministry of Finance, Government of India (2023), construction of national highways and roads has significantly risen, with 10,457 km completed in the Financial Year (FY) 22, up from 6,061 km in FY16. By October FY23, 4,060 km were constructed, achieving nearly 91 percent of the prior year's total for the same period. Budgetary allocations for the sector have surged in the last four years, reaching approximately US$17 billion by October FY23. In line with a focus on maritime connectivity, the Sagarmala Programme has proposed 574 projects worth about USD$71.98 billion that are expected to be completed between 2015 and 2035. These projects fall into four key categories: modernizing ports and developing new ones; improving port connectivity; supporting port-related industrialization; and developing coastal communities. As of September 30, 2019, 201 of these projects, worth a combined USD$3.7 billion, were still in progress, while 121 of them, at a total of USD$362.13 million, had already been completed (Ministry of Ports, Shipping, and Waterways, Government of India 2024). According to the India Brand Equity Foundation (2023), India's infrastructure sector is expected to grow at a 9.57% Compound annual growth rate (CAGR) from 2023 to 2028, reaching US$294.12 billion, supporting India's goal for a US$5 trillion economy by 2025 through significant infrastructure improvements.

The exponential growth in infrastructure development has introduced numerous challenges within the construction sector (Datta et al. 2023). The issue of underperformance within the construction industry extends beyond India and affects nations globally, especially in developing and underdeveloped regions. These areas require significant structural and cultural transformations, moving away from traditional construction methodologies towards more modern practices to improve performance across the sector (Loganathan et al. 2017). Experts in the construction sector emphasize the critical need to enhance the performance of construction industries in developing nations by establishing connections between construction industry growth, infrastructure enhancement, and national development (Loganathan et al. 2017). To increase industry competitiveness and the nation's economic growth, it is essential to introduce new development policies. Introducing new development policies involves identifying key factors that influence the industry and prioritizing those with the most significant impact on performance enhancement. At the same time, it may be challenging to improve all influencing factors simultaneously, emphasizing critical success factors (CSFs) offers a strategic path to improve industry efficiency significantly (Datta et al. 2023). By concentrating on these CSFs, decision-makers can significantly enhance the industry's overall performance.

1.2 Need for study:

The construction sector contributes significantly to a country's socioeconomic growth by establishing essential infrastructure and productive facilities (Wells 1984). According to Hillebrandt et al. (2000) the construction sector significantly contributes to the national economy, accounting for a large share of the national economic output annually. This emphasizes the importance of identifying and understanding the factors that determine the construction industry's success.

Very few studies have been reported to determine and evaluate the success parameters at the industry level in India, even though researchers have previously identified various success parameters at the level of projects and organizations in different countries. This study aims to determine and assess the success factors specific to the construction sector, emphasizing India by combining various research outcomes. The construction industry will benefit from identifying success factors because it will enable them to improve their performance by addressing their weak and problem areas, the importance of which was previously unknown.

1.3 Research objectives:

This research aims to conduct a comprehensive investigation into the factors that drive success and enhance performance in the construction industry. It seeks to identify critical success factors for the construction industry in India, employing factor and regression analysis as the primary research methods.

- To determine the success and performance factors for the construction industry.
- To determine the critical success factors (CSFs) for the construction industry.
- To test the hypothesis that success factors significantly influence the success of construction industry.
- To investigate the relative impact of the success factors in the success of the construction industry measured against various performance factors.
- To develop a success and performance model using the fuzzy synthetic evaluation (FSE) approach.
- To assign relative weights to the attributes and factors that contribute to the success and performance of the construction industry.

1.4 Scope of work:

This study aims to identify factors influencing success and performance for the Indian construction sector. The research involved key stakeholders, including contractors, clients, and project management consultants (PMCs), focusing on professionals engaged with residential, commercial, and infrastructure projects in Gujarat.

The investigation explore the key factors that influence the performance and success of Indian construction industry, with a particular focus on projects in Gujarat. Although the study was exclusively conducted in this region, it involved companies operating nationwide. The regional focus does not limit the study's broader applicability; the findings are nationally relevant due to the consistent construction methodologies, economic conditions, regulatory frameworks, and socio-economic profiles maintained across India by these companies.

1.5 Outline of thesis:

The thesis is structured into eight chapters. The organization of the subsequent seven chapters is as follows.

Chapter 2 - Literature review: This chapter reviews existing studies on success and performance within the construction industry, emphasizing the success and the performance factors commonly employed to measure success. This extensive literature review identified the success and performance attributes, revealing a significant research gap in the context of the Indian construction industry.

Chapter 3 - Research methodology: This chapter outlines the methodology including development of questionnaire, sample selection, data collection through surveys and subsequent analysis using various statistical methods such as descriptive analysis, factor analysis, and regression analysis.

Chapter 4 - Success and performance factors for the construction industry: This chapter focuses on analyzing the responses collected through surveys to identify and evaluate the key success and performance attributes within the construction industry. Using factor analysis, success and performance factors were identified. The chapter then explores how these factors correlate using regression analysis. Critical success factors corresponding to each performance factor were identified.

Chapter 5 - Assessing success factors using structural equation modeling (SEM): This chapter utilized Structural Equation Modeling (SEM) to assess the relationships between identified success and performance factors. By testing the hypothesis that success factors influence the success of the construction industry.

Chapter 6 - Analysis of success and performance factors through fuzzy synthesis evaluation (FSE): This chapter used Fuzzy Synthetic Evaluation (FSE) to assess success and performance factors in the construction industry. It provides a detailed explanation of the FSE methodology and its application in analyzing complex multi-criteria decision-making problems. The findings highlight key success and performance factors identified through FSE and compare them with traditional evaluation methods.

These insights were used to develop a framework for assessing the success and performance of the construction industry.

Chapter 7 - Applying consistent fuzzy preference relations (CFPR) for evaluating success and performance factors: This chapter utilized the Consistent Fuzzy Preference Relation (CFPR) technique to assign relative weights to each of the success and performance factors and their respective attributes. These weights were then used to develop a framework for measuring the success and performance of the construction industry.

Chapter 8- Summary and conclusion: This chapter provides a summary of the findings and conclusions from the various chapters. It also highlights the contributions to the field, identifies the study's limitations, and offers suggestions for future research.

1.6 Summary:

This chapter has introduces the significant role of the construction industry in India's economic development, emphasizing its impact on GDP and employment, which has inspired this research. It also briefly describes the objectives of the current study, the scope of work and the structure of the thesis. The following chapter will present a literature review, highlighting gaps in previous studies that have helped define the objectives for this study.

Chapter 2

Literature Review

This chapter presents definition of success and CSFs for the construction industry, previous study on success factors, previous study on performance factors, previous study on challenges in construction industry, identification of success and performance attributes for construction industry, research gap and summary.

2.1 Defining success and critical success factors for the construction industry:

The construction industry significantly contributes to India's economic growth, employing millions and impacting other economic sectors. Hence, the success or failure of the construction industry directly impacts the nation's economy. Numerous factors influence success, and the secret to success is to focus on the sectors that truly make the difference between success and failure.

Success within the construction industry is multifaceted and defined differently across various contexts. According to Arslan & Kivrak (2008), success is measured by the extent to which industry objectives and projections are achieved, while Tripathi & Jha (2019) argue that construction organizations are the backbone of the construction industry, and the success or failure of the construction industry is heavily reliant on the success or failure of construction organizations. Similarly, Abraham (2003) and Mellado et al. (2020) suggest that success in construction is largely determined by individual project outcomes, which are in turn gauged by specific performance measures linked to project objectives. The fundamental factors that influence project success are time, cost, and quality and are universally recognized as the "iron triangle" (Chan & Chan 2004). Since every project team is different and faces different challenges, there is no standardized definition of project success across the industry, meaning success criteria can vary significantly from one team to another (Gudienė et al. 2013).

CSFs are crucial for effectively utilizing resources within the industry and play a pivotal role for newcomers and established players in improving project delivery (Tsiga et al. 2016). CSFs can be used as indicators to assess organizational performance, and they allow top management to improve standard corporate management skills, which leads to improvement in company performance (Abraham 2003). Bullen & Rockart (1981) defined CSFs as the "key areas of activity where favorable outcomes are necessary to ensure that management achieves their objectives", while Tripathi & Jha (2019) defined CSFs as factors essential for a construction organization's success. In these critical domains, "things must go right" for the enterprise to succeed (Abraham 2003, Tsiga et al. 2016).

2.2 Previous study on success and performance factors:

2.2.1 Success factors:

The current study aims to determine the factors that affect the construction industry's success. Literature reveals very few studies in this area. The researchers have mainly worked on the factors that affect the success of construction projects and organizations. However, very few researchers have focused on determining the factors required for the overall success of the construction industry. However, to put things into perspective, some of the studies performed globally in this area are discussed in the following sections.

Abraham (2003) conducted a questionnaire survey among the top 400 contractors recognized by Engineering News-Record in 2000 to identify CSFs at the industry level. The study highlights critical external and internal factors influencing organizational success, including competitive strategy, market dynamics, political environment, and technology use. Later, Fox & Skitmore (2007) utilized factor analysis to identify eight key success factors from 62 attributes that influenced the global construction sector. Identified factors comprise financial resources, human skills, industry best practices, research and development, government policies, construction culture, institutional support, and positive organizational attitudes, deemed vital in developed and developing countries.

A similar study was conducted by Kabak et al. (2016) for the iron and steel industry in Turkey, identifying CSFs to enhance the competitiveness of this sector. The study highlights the link between national competitiveness and industry-specific performance, emphasizing key factors such as financial stability, taxation, and customs processes. These factors are vital not only for the iron and steel industry but also for other sectors in Turkey. Various methodologies, including a web-based poll, a Delphi-style workshop, and Fuzzy DEMATEL analysis, were employed to identify CSFs. This approach provides unique insights into the interrelationships among various influencing factors, offering strategic guidance for policymakers and industry stakeholders.

The research conducted by Tripathi & Jha (2019) in India provides a deep dive into the determinants of success for construction organizations. The research utilized factor and regression analyses to identify eight key success factors for construction organizations: experience and performance, top management competence, project factors, supply chain and leadership, availability of resources and information flow, effective cost control measures, favorable market and marketing team, and availability of qualified staff. Tripathi & Jha (2018*a*) previous study on performance measurement factors for construction organizations is enhanced by this research. This study explores the factors that directly contribute to organizational success, offering a broader view of what drives success in the construction industry in developing markets like India. Similarly, Arslan & Kivrak (2008) employed the Simple Multi-Attribute Rating Technique (SMART) to investigate critical factors affecting the success of construction firms. As per the author, a company's success depends on its financial situation, owner/manager qualities, and business management. This management practice is essential for success in this highly competitive construction market.

Datta et al. (2023) conducted a study in Bangladesh to explore the critical success factors in project management within the construction sector. They employed a survey method among various stakeholders in the building industry. The study utilized the Relative Importance Index (RII) to rank and categorize the identified factors. Congestion and cost overruns were examined as major obstacles to construction projects. Ultimately, the research aims to enhance project management in the building industry by improving knowledge management and addressing key success factors. In a similar vein, Gudienė et al. (2013) conducted an investigation into the CSFs for projects in Lithuania, engaging construction experts through a survey. They categorized 71 identified success attributes into seven groups, assigning priorities to each. This study highlights the essential roles of the project manager and the project management team in achieving a project's objectives. The findings emphasize key areas that require attention to ensure project success and provide valuable insights for researchers and professionals in the building sector.

Later, Barajei et al. (2023) explored the CSFs for Public-Private Partnership (PPP) projects within Ghana's public road construction sector, employing factor analysis based on data from a questionnaire survey. The researchers identified three key CSFs: 1) Project management, 2) Procurement, and 3) External environment. This study offers insights for enhancing the efficiency and effectiveness of road projects in Ghana, emphasizing the importance of these factors in achieving project success.

Table 2.1 summarizes various global studies identifying factors influencing construction organizations' and projects' success and failure. However, research explicitly targeting the context of the construction industry remains limited.

Table 2.1: Summary of literature review on success factors and attributes

Researcher's name	**Tools Used**	**Country**	**Success/ Failure Factors**	**Attributes/Factors Identified**
Chan et al. (2004)	Literature review, Factor analysis	Global	Success factors	Human-related factors, project-related factors, project procedures, project management actions, external environment
Wong & Ng (2010)	Factor analysis, Predictive modeling techniques	US and UK	Failure factors	Human and organizational factors, economic conditions, market conditions, operational factors, financial health indicators, regulatory environment, external risks
Continued on next page				

Table 2.1 Continued from previous page

Researcher's name	Tools Used	Country	Success/ Failure Factors	Attributes/Factors Identified
Yap et al. (2019)	Importance index, Factor analysis	Malaysia	Failure factors	Poor image/reputation, safety issues, lack of skilled labor, bureaucracy and corruption, reliance on traditional procurement
Kulemeka et al. (2015)	Mean score ranking	Malawi	Failure factors	High lending interest regimes by financial institutions, strict conditions for accessing capital, currency fluctuation, high taxes
Asamoah et al. (2019)	Literature review	Ghana	Success factors	GDP, exchange rate, inflation, interest rate, employment, monetary policy, number of registered construction firms
Gao et al. (2021)	Factor analysis, SEM	China	Success factors	Alliance stability capability, technological innovation capability, effective cooperation capability, political environment, industry specifics, economic performance
Tabish & Jha (2011)	ANOVA, Factor analysis, Regression analysis	India	Success factors	Awareness of and compliance with rules and regulations, effective partnering among project participants, external monitoring and control
Hardcastle et al. (2005)	Descriptive analysis, Factor analysis	UK	Success factors	Effective procurement, government guarantee, favourable economic conditions, available financial market

2.2.2 Performance factors:

Performance measurement techniques have been widely used in many different industries and are becoming more and more popular. The construction industry, however, has faced criticism for its poor performance (Yang et al. 2010). Numerous scholars such as Willis & Rankin (2012) and Yang et al. (2010) emphasize the importance of applying these techniques to improve the industry's current state. Regular performance measurement is necessary to identify deviations from established standards. The construction sector often employs key performance indicators (KPIs) to gauge performance. In this study, performance factors refer to both financial and non-financial metrics, which closely align with KPIs.

The KPIs model, developed as a general framework, has been extensively used in the construction industry. The KPI framework, introduced by the Construction Best Practice Programme (CBPP) in the late 1990s, aims to facilitate the measurement of project, organizational, and industry performance across the construction sector (Yang et al. 2010). Performance measurement is defined as the process of quantifying the efficiency and effectiveness of past actions, while a performance indicator is a parameter used to quantify this efficiency and/or effectiveness (Yang et al. 2010). Performance indicators can be defined through either quantitative measures, such as safety rate, or qualitative measures, such as stakeholder satisfaction (Cox et al. 2003). According to Tripathi & Jha (2018*a*) a definition, "a key performance indicator is a financial or non-financial measure used to assist an industry in tracking progress toward a specified goal or objective." However, to put things into perspective, some of the studies performed globally in this area are discussed in the following sections.

Ingle & Mahesh (2022) conducted a comprehensive study to identify key performance areas for construction projects in India, employing factor analysis and SEM. Through a survey method engaging various stakeholders within the construction sector, the study pinpointed ten critical performance areas, namely customer relations, safety, schedule, cost, quality, productivity, finance, communication and collaboration, environment, and stakeholder satisfaction. The validity of these performance areas was tested using Confirmatory Factor Analysis (CFA) and Partial Least Squares Structural Equation Modeling (PLS-SEM).

In a parallel, Chan (2009) utilized the Balanced Scorecard approach to evaluate performance and identify KPIs for the Malaysian construction sector. Similarly, Ofori (2001) developed indicators to measure and monitor construction industry development in developing countries. These indicators cover a broad range of factors, including economic, efficiency, and quality factors and provide a structured methodology for their implementation. Both studies highlight the critical importance of establishing clear, measurable goals to enhance the evaluation and growth of the construction industry effectively.

Yang et al. (2010) provides a comprehensive literature review on performance measurement in the construction industry, highlighting the application of models such as the EFQM excellence model, balanced scorecard, and key performance indicators. By analyzing the strengths and weaknesses of these frameworks, the study emphasizes their application at project, organizational, and stakeholder levels. It offers insights for constructing a comprehensive performance measurement model essential for enhancing operational efficiency and supporting strategic decision-making in the construction sector.

Literature reveals only few researcher have identified performance factor at the industry level. The researchers have mainly worked on the performance factors at construction projects and organizations.

2.3 Previous Study on Challenges in Construction Industry

In the construction industry, challenges and success factors are directly linked, with other each influencing the outcomes of industry. Challenges such as corruption, regulatory changes, and workforce management issues can significantly hinder industry success if not adequately managed. Conversely, identifying and addressing these challenges as key success factors such as effective cost management, compliance with regulations, and robust labor strategies can enhance operational efficiency and industry success. This connection highlights the importance of focusing on both challenges and success factors as integral components of industry practice. However, to put things into perspective, some of the studies performed globally in this area are discussed in the following sections.

Mengistu & Mahesh (2020) divided challenges into four primary categories in the Ethiopian construction industry. Their study employed factor analysis and mean score surveys to identify and classify significant difficulties many industry professionals face. They concluded that delays in implementing policies, corruption, inadequate capacity of contractors and consultants, lack of cooperation, and inadequate benchmarking procedures are some of the main problems. Loganathan et al. (2017) conducted parallel research in India, exploring challenges in the construction industry. They identified 19 significant challenges, including lack of client involvement, inadequacies in quality and productivity, and hurdles in adopting new technologies and work practices. The study emphasizes the importance of creating the Construction Industry Improvement Initiative (Ci3 India) to tackle these critical problems, out of which 10 Action Items were addressed by 7 Action Teams, reflecting a collaborative effort towards enhancing the construction industry's performance and sustainability. Sawhney et al. (2014) conducted a similar study in India, employing expert opinions to identify and determine the top challenges faced by the Indian construction industry using the Deiphi and Grand Challenges technique. Key issues identified include streamlining land acquisition, updating building standards, improving public sector transparency, and standardizing approvals, which are some challenges in the Indian construction industry. The study suggests that the government and regulations are vital in improving fundamental changes and technological advancement for industry growth and development.

Thompson (2000) explores the challenges of real estate development in developed markets, highlighting issues such as inadequate infrastructure, complex administration, investment restrictions, substandard materials, and building standards. This study discusses the shift in corporate real estate management from reactive approaches in emerging markets to proactive strategies in developed ones, driven by globalization and advanced practices. It outlines common pitfalls in India, such as verifying legal titles, navigating local bureaucracies, and maintaining construction quality. The research provides valuable insights for corporate real estate executives and developers on overcoming these challenges while optimizing business operations and financial performance.

Table 2.2 summarizes various global studies that identify factors influencing challenges in the construction industry. However, research specifically focusing on the context of the challenges in the construction industry.

Table 2.2: Summary of literature review on challenges in the construction industry

Researcher's name (Country)	**Challenges or issues in the construction industry**
Windapo & Cattell (2013) (South Africa)	1) Public-sector capacity 2) Skills mismatch 3) Globalization and economic factors 4) Procurement practices and empowerment 5) Financial accessibility 6) Poverty 7) Technology 8) Land and infrastructure availability 9) Enterprise viability 10) Material costs 11) Regulatory environment
Elkhalifa & Shaddad (2010) (Sudan)	**A) General challenges faced in construction industry:** 1) Lack of capacity 2) Regulatory and institutional inefficiencies 3) Absence or inefficiency of quality assurance system national standards and quality specifications 4) Poor organization 5) Unfavorable operating environment 6) Contractor capabilities 7) Lack of planning 8) Economic volatility 9) Financial constraints 10) Information scarcity 11) Corruption and bureaucracy 12) Shortage of skilled labor 13) Lack of infrastructure 14) Taxes and governmental fees **B) Challenges specific to building materials:** 1) Inadequate capacity and inefficiency 2) High production transportation and energy costs 3) High prices and lack of materials 4) Limited local production 5) Reliance on imports 6) Security issues
Yap & Cheah (2020) (China)	1) Changes in regulation 2) Cost control 3) Contract clauses 4) Language barrier 5) Quality control 6) Difference in culture 7) Human resource management 8) Bureaucracy 9) Cost estimation 10) Construction labour productivity 11) Risk allocation 12) Financial capability 13) Inflation 14) Labour supply 15) Exchange rate 16) Interest rate 17) Inadequate design capacity 18) Equipment supply 19) Material supply 20) Hot-humid climate

Continued on next page

Researcher's name (Country)	Challenges or issues in the construction industry
Sultan & Kajewski (2004) (Yemen)	**A) Barriers to construction sector development:** 1) Administrative problems and red tape 2) Informal sector 3) Lack of research and experimental projects 4) Lack of standardization of local materials 5) Inappropriate law and legislation 6) Poor utilization of local building technologies and local building materials 7) Difficulties in acquiring skilled labour and materials 8) Absence or inefficiency of specifications 9) Inadequate affordable land 10) Inadequate infrastructure 11) Inadequate finance system **B) Barriers to building materials industry development:** 1) Market problems 2) Machinery lacking 3) Poor plant locations and land problems 4) Lack of studies and information **C) Causes Of high construction costs:** 1) Lack of cost effective methods 2) Inflation and fluctuation of prices 3) Expensive and inefficient transportation and delivery 4) Inefficient local construction 5) Inefficient design methods 6) Excessive wastage 7) Expensive imported material 8) Expensive local materials 9) Cost of labour **D) Causes of construction waste:** 1) Lack of planning and management 2) Resources misused 3) Unclear information and information quality problems 4) Resource quality problems 5) Lack of execution skills 6) Lack of control 7) Inefficient procurement and unnecessary transportation
Ngowi (2002) (Africa)	1) Project overruns 2) Poor quality of structures 3) Inappropriate procurement systems 4) Failure to cope with infrastructure 5) Inadequate housing supply 6) Resistance to best practices 7) Limited technology transfer 8) Innovative practice

Continued on next page

Researcher's name (Country)	Challenges or issues in the construction industry
Khalid (1996) (Malaysia)	1) Reliance on foreign labor 2) Skill shortages 3) Dependency on imported materials 4) Supply chain issues 5) Site safety 6) Declining quality of construction 7) Technology transfer and acquisition 8) Inefficiencies in construction methods 9) Trade imbalance 10) Regulatory and policy issues
Yap et al. (2019) (Malaysia)	1) Changes of design during construction 2) Cost overruns 3) Late completion 4) Competitive tendering procedures 5) Late payment 6) Lack of skilled labor 7) Excessive overtime 8) Time constraints and/or accelerated completion 9) Safety issues 10) Failure of subcontractors 11) Inexperienced management and supervision 12) Poor Quality/Workmanship 13) Bureaucracy and corruption 14) Absenteeism of labor 15) Wastage 16) Cowboy builders 17) Low productivity 18) Over-specification 19) Reliance on traditional procurement 20) Fragmentation 21) Poor image 22) Shortage of materials 23) Low plant utilization and availability

2.4 Identification of success and performance attributes:

To identify success attributes for the construction industry, a thorough review of existing literature. A similar process was adopted to identify performance attributes. For the literature review search engine databases like Scopus, and Google Scholar were used. The keywords "Critical Success Factors," "CSF for the Indian construction industry," "CSF for the construction project," and "CSF for construction organization" were used to find relevant literature. Similarly, relevant keywords such as "KPIs for the construction industry," "KPIs for construction projects," "KPIs for the construction organization," and "Key performance indicators" were used to locate relevant literature. From 2000 to 2023, the study of literature was conducted.

Based on the literature review, a list of success attributes was developed, with 30 success attributes identified, and a list of performance attributes was developed, with 15 performance attributes identified. As the success attributes and performance attributes were compiled, it became evident that many of the attributes had been mentioned by various researchers in a variety of contexts as the reasons for the successful construction industry. Success attributes and performance attributes that were cited by two or more researchers were taken into consideration, to keep the list of these attributes reasonable. As far as possible, the attributes that were only cited by one researcher have complied with the other equivalent research (Tripathi and Jha, 2019). Table 2.3 and Table 2.4 show the list of success and performance attributes with sources.

Table 2.3: List of success attributes with sources

Sr No	Success Attributes	Id	Source
1	Favorable taxation system applicable to the construction industry	SA-1	Kabak et al. (2016), Kulemeka et al. (2015), Mengistu & Mahesh (2020), Sawhney et al. (2014)
2	Efficient registration system (firms and professionals)	SA-2	Asamoah et al. (2019), Fox & Skitmore (2007), Mengistu & Mahesh (2020)
3	Favorable government policy in supporting capacity building of organizations	SA-3	Datta et al. (2023), Fox & Skitmore (2007), Gao et al. (2021), Kulemeka et al. (2015), Mengistu & Mahesh (2020), Tripathi & Jha (2019)
4	Government promoting labour-intensive schemes to create employment	SA-4	Fox & Skitmore (2007), Mengistu & Mahesh (2020)
5	Growing GDP of the country	SA-5	Asamoah et al. (2019), Barajei et al. (2023), Kulemeka et al. (2015), Mengistu & Mahesh (2020), Tripathi & Jha (2019))
6	Availability of foreign direct investment and foreign aid	SA-6	Asamoah et al. (2019), Fox & Skitmore (2007), Kabak et al. (2016), Mengistu & Mahesh (2020)

Continued on next page

Table 2.3 – continued from previous page

Sr No	Success Attributes	Id	Source
7	Favorable external environment (social political factors)	SA-7	Deng et al. (2013), Fox & Skitmore (2007), Gudienė et al. (2013), Kulemeka et al. (2015), Tripathi & Jha (2019), Tsiga et al. (2016)
8	Good image of the industry in terms of employment opportunities business opportunities etc.	SA-8	Fox & Skitmore (2007), Gao et al. (2021), Mengistu & Mahesh (2020), Yap et al. (2019)
9	Transparency in the industry	SA-9	Barajei et al. (2023), Deng et al. (2013), Fox & Skitmore (2007), Kulemeka et al. (2015), Sawhney et al. (2014), Yap et al. (2019)
10	Favorable rules and regulations	SA-10	Asamoah et al. (2019), Gudienė et al. (2013), Mengistu & Mahesh (2020), Tsiga et al. (2016)
11	Certification by various agencies (ISO, PMI, ISI, MSME, etc.)	SA-11	Gudienė et al. (2013), Mangla et al. (2016)
12	Standardized bye-laws and codes	SA-12	Fox & Skitmore (2007), Gudienė et al. (2013), Mengistu & Mahesh (2020), Sawhney et al. (2014), Tsiga et al. (2016)
13	Availability of equipment, materials, and workforce	SA-13	Barajei et al. (2023), Datta et al. (2023), Fox & Skitmore (2007), Gao et al. (2021), Gudienė et al. (2013), Tripathi & Jha (2019)
14	Availability of physical infrastructure such as rail, road, telecom, etc.	SA-14	Asamoah et al. (2019), Deng et al. (2013), Fox & Skitmore (2007), Kabak et al. (2016), Mengistu & Mahesh (2020)

Continued on next page

Table 2.3 – continued from previous page

Sr No	Success Attributes	Id	Source
15	Availability of the latest technologies such as automation, robotics, 3D printing, etc.	SA-15	Gao et al. (2021), Gudienė et al. (2013), Kabak et al. (2016), Mangla et al. (2016), Sawhney et al. (2014), Tripathi & Jha (2019)
16	Availability of qualified professionals in the industry	SA-16	Deng et al. (2013), Gudienė et al. (2013), Mangla et al. (2016), Tripathi & Jha (2019)
17	Availability of easy finance	SA-17	Fox & Skitmore (2007), Gudienė et al. (2013), Kabak et al. (2016), Kulemeka et al. (2015), Sawhney et al. (2014), Tsiga et al. (2016)
18	Low-interest rate on finance	SA-18	Asamoah et al. (2019), Arslan & Kivrak (2008), Kulemeka et al. (2015)
19	Favorable market conditions	SA-19	Abraham (2003), Kabak et al. (2016), Tripathi & Jha (2019)
20	Low fluctuation in the currency exchange rate	SA-20	Asamoah et al. (2019), Gao et al. (2021), Kulemeka et al. (2015)
21	Positive impact on the environment	SA-21	He et al. (2021), Rimbalová & Vilčeková (2013), Tripathi & Jha (2019)
22	Positive impact on society	SA-22	He et al. (2021), Rimbalová & Vilčeková (2013), Tripathi & Jha (2019)
23	Favorable weather conditions	SA-23	Barajei et al. (2023), Datta et al. (2023), Sharma & Goyal (2022)
24	Low waste production and recycling	SA-24	Datta et al. (2023), Mangla et al. (2016), Sawhney et al. (2014), Sharma & Goyal (2022), Yap et al. (2019)

Continued on next page

Table 2.3 – continued from previous page

Sr No	Success Attributes	Id	Source
25	Low accident rate, fatality rate, etc.	SA-25	Datta et al. (2023), Gudienė et al. (2013), He et al. (2021), Sawhney et al. (2014), Sharma & Goyal (2022), Tripathi & Jha (2019)
26	Higher productivity of the workforce	SA-26	Asamoah et al. (2019), Deng et al. (2013), Sharma & Goyal (2022), Yap et al. (2019)
27	Collaborative culture in the industry, i.e., relationships among key stakeholders	SA-27	Abraham (2003), Deng et al. (2013), Fox & Skitmore (2007), Mengistu & Mahesh (2020), Sharma & Goyal (2022)
28	Level of competition among industry players	SA-28	Arslan & Kivrak (2008), Deng et al. (2013), Gao et al. (2021), Kabak et al. (2016), Mangla et al. (2016), Tripathi & Jha (2019)
29	Appropriate training and education	SA-29	Deng et al. (2013), Fox & Skitmore (2007), Kabak et al. (2016), Mengistu & Mahesh (2020), Sawhney et al. (2014), Tsiga et al. (2016)
30	Investment and encouragement in research and development	SA-30	Deng et al. (2013), Fox & Skitmore (2007), Mengistu & Mahesh (2020), Sawhney et al. (2014)

Table 2.4: List of performance attributes with sources

Sr No	Performance Attributes	ID	Source
1	High annual construction demand/Market share	PA-1	Chan (2009), Deng & Smyth (2013), He et al. (2021), Kim et al. (2021), Ofori (2001), Tripathi & Jha (2018*a*)

Continued on next page

Table 2.4 – continued from previous page

Sr No	Performance Attributes	ID	Source
2	High profitability ratio (Industry generating profit)	PA-2	Cha & Kim (2011), Chan (2009), Deng & Smyth (2013), Ingle & Mahesh (2022), Kim et al. (2021), Rimbalová & Vilčeková (2013), Yeung et al. (2013)
3	Annual growth rate of the industry	PA-3	Deng & Smyth (2013), Ofori (2001), Tripathi & Jha (2018*a*)
4	Positive impact on society	PA-4	He et al. (2021), Ingle & Mahesh (2022), Ofori (2001), Tripathi & Jha (2018*a*), Ugwu & Haupt (2007)
5	Positive impact on the environment	PA-5	Cha & Kim (2011), Ingle & Mahesh (2022), Ofori (2001), Rimbalová & Vilčeková (2013), Tripathi & Jha (2018*a*), Ugwu & Haupt (2007), Yeung et al. (2013)
6	Safety (Accident rate, fatality, etc.)	PA-6	Cha & Kim (2011), Chan (2009), He et al. (2021), Ingle & Mahesh (2022), Kim et al. (2021), Ofori (2001), Rimbalová & Vilčeková (2013), Tripathi & Jha (2018*a*)
7	Technological development of industry	PA-7	Chan (2009), Deng & Smyth (2013), He et al. (2021), Kim et al. (2021)
8	Construction research and development (innovative material, technique, number of patent registers, etc.)	PA-8	Chan (2009), Deng & Smyth (2013), He et al. (2021), Kim et al. (2021), Ugwu & Haupt (2007)
9	Qualified professionals in the industry	PA-9	Cha & Kim (2011), Chan (2009), Ofori (2001), Rimbalová & Vilčeková (2013), Yeung et al. (2013)

Continued on next page

Table 2.4 – continued from previous page

Sr No	Performance Attributes	ID	Source
10	Employment opportunities in the construction industry	PA-10	Ofori (2001), Ugwu & Haupt (2007)
11	Human resource training and development	PA-11	Chan (2009), Deng & Smyth (2013), Kim et al. (2021), Ofori (2001), Rimbalová & Vilčeková (2013), Tripathi & Jha (2018*a*)
12	Low staff turnover	PA-12	Chan (2009), Rimbalová & Vilčeková (2013), Tripathi & Jha (2018*a*), Yeung et al. (2013)
13	Higher wages of employees	PA-13	Rimbalová & Vilčeková (2013), Tripathi & Jha (2018*a*), Yeung et al. (2013)
14	Labour productivity	PA-14	Deng & Smyth (2013), Ingle & Mahesh (2022), Ofori (2001), Rimbalová & Vilčeková (2013), Tripathi & Jha (2018*a*), Yeung et al. (2013)
15	Stakeholder satisfaction	PA-15	Chan (2009), Deng & Smyth (2013), He et al. (2021), Kim et al. (2021)

2.5 Research Gap

The literature review in the earlier section reveals that very few studies have been conducted to determine and evaluate success parameters at the industry level in India, even though researchers have previously identified various success parameters at the project and organizational levels in different countries. However, there are still some gaps in previous research:

- The literature review reveals that success factors at the project and organizational levels in the construction industry have been extensively studied, especially in countries like the Middle East, China, and the United Kingdom. However, research on these success factors at the industry level, particularly within the Indian context, remains limited. While previous studies have identified key factors contributing to the success of construction projects and organizations, but have overlooked the broader success of the industry as a whole. Additionally, most research has not adequately pinpointed the critical factors contributing to the overall success of the construction industry.

- The literature review indicates that there is extensive research focusing on the challenges and issues facing the construction industry. However, a significant research gap exists regarding the success factors of the construction sector.
- Most studies have not yet addressed the extent of the impact of success factors on individual performance factors. Examining the role of success factors in isolation from performance factors can lead to inaccurate conclusions.
- The relevance of success factors in the construction sector may vary significantly from one country to another, suggesting that findings in one country may not be as applicable in another (Tripathi & Jha 2019).
- According to Willis & Rankin (2012), for many years, research scholars and professionals have focused on identifying methods to measure and enhance performance in the construction sector. This effort has led to the development of various performance measurement frameworks and models, focusing on both organizational and project-specific aspects. However, there is currently a significant gap in established frameworks or models that assess the construction industry's performance at a national industrial level.

This identifies a clear need for focused research on the success factors and performance factors of the Indian construction industry, aiming to bridge this significant gap.

2.6 Summary:

This chapter provides a comprehensive review of the literature on success and performance factors, as well as the challenges faced within the construction industry. It defines success in the construction sector, explores global methodologies, and highlights key research findings. Additionally, it identifies a research gap, emphasizing the need for further study on industry-level success factors in India. The discussion concludes by summarizing the identified success and performance attributes.

Chapter 3

Research Methodology

3.1 Introduction:

The literature review in the previous chapter reveals that success factors at the project and organizational levels in the construction industry have been extensively studied. However, there is a noticeable gap in research focusing on these success factors at the industry level within the Indian context. Consequently, the research objectives for this study were established as outlined in Chapter 1. This chapter details the research methodology employed to meet these objectives, which is comprised of two main steps:

1. Data collection through questionnaire surveys
2. Data analysis of responses using descriptive analysis, univariate analysis (factor analysis) and multivariate analysis (regression analysis).

3.2 Development of questionnaire for first stage:

A questionnaire with 30 success attributes and 15 performance attributes was developed. The questionnaire is divided into 5 sections 1) Section-1 Question related to success attributes for the construction industry 2) Section-2 Question related to performance attributes for the construction industry 3) Section-3 Comments or Suggestions 4) Section-4 Respondent's Organization details 5) Section-5 Respondent's details. A pilot survey was then conducted to test the questionnaire's wording and comprehension, and any necessary changes were made to the questionnaire as there were no major suggestions for improvement given by the respondents after the pilot survey the questionnaire was set aside for the final survey (Tabish & Jha 2011, Tripathi & Jha 2019). The pilot survey was conducted by three experts with a minimum experience of over 20 years in the construction industry.

Since Likert scale-based questionnaires are quick and simple to complete, they are ideal for surveys because the responses provide precise data based on the respondent's individual experiences (Datta et al. 2023). In this study, a 5-point Likert scale was used in this study rather than a 7-point Likert scale since it reduces respondent frustration and increases response rate and quality (Tripathi & Jha 2019). A 5-point Likert scale was used to measure the degree of effect of the success attributes and the degree of importance of the performance attributes. The success attributes were rated on a Likert scale from 1 for "very low effect," 2 for "low effect," 3 for "moderate effect," 4 for "high effect," and 5 for "very high effect.". Similarly, performance attributes were rated on a Likert scale from 1 for "very low importance," 2 for "low importance," 3 for "moderate importance," 4 for "high importance," and 5 for "very high importance". Table 3.1 shows the extract of part 1 of the questionnaires. The questionnaire utilized in the first stage of the study is provided in Appendix A.

Table 3.1: Extract of part 1 of the questionnaire

Part-1		Please rate the following parameters which affect the success of the construction industry on a 5-point Likert scale.				
Sr. No.	Success Attributes	Very Low Effect = 1	Low Effect = 2	Moderate Effect = 3	High Effect = 4	Very High Effect = 5
1	Favorable taxation system applicable to the construction industry					
2	Efficient registration system (firms and professionals)					
3	Attributes as given in Table 2.3					

3.3 Sample selection:

The selection of the sample comes next after the attributes have been determined. This research's sample selection involved three critical groups within the construction sector. These included 209 members affiliated with the Builders Association of India (BAI), 840 members affiliated with the Ahmedabad Municipal Corporation (AMC), and 1080 affiliated with the Ahmedabad Urban Development Authority (AUDA), all operating in the state of Gujarat, India. This research used a random sampling method to select a diverse group of participants from the Indian construction industry, including contractors, clients, and engineers. This approach was designed to ensure the sample's homogeneity and reliability. Each selected respondent had experience in managing large-scale construction projects within India. The sample size was calculated using the formula given under Equation 3.1 and 3.2 (Tripathi & Jha 2018*a*).

$$n = \frac{n'}{1 + \frac{n'}{N}} \tag{3.1}$$

where,

$$n' = \frac{pq}{v^2} \tag{3.2}$$

Where,

$n =$ The required sample size

$n' =$ The first estimate of sample size

$N =$ The population size

$p =$ The proportion of the characteristic being measured in the target population

$q = 1 - p$

$v =$ Standard error of the sampling population

The values of p and q were assumed to be 0.5 to obtain the maximum sample size. The sample size was determined using a standard error of 5%, with a maximum permitted standard error of 10% (Tripathi & Jha 2018*a*). The formula above indicated that 96 was the necessary sample size. However, this study collected a sample size of 129 responses.

3.4 Respondent's profile:

In this study, data was collected by a survey using a questionnaire. There are several methods to conduct a questionnaire survey, such as web-based surveys, in-person interviews, and postal mail (Mengistu & Mahesh 2020). Two methods were used to collect data from the respondents in this study. 1) In-person interviews; and 2) Via Email. In this survey, in-person interviews were the main method used for collecting data. In this survey the stakeholders selected for the Indian construction industry are divided into three groups 1) Contractor 2) Client and 3) PMC.

A total of 129 responses were collected from various stakeholders out of which 120 were collected by face-to-face interview and 9 were collected by email. A questionnaire survey was conducted using Google Forms, and the survey link was sent to 14 individuals. Out of these, 9 responses were received, resulting in a response rate of 64.28%. This rate exceeds 50%, which according to Tripathi & Jha (2019) is deemed an acceptable response rate in the construction industry. A collection of responses were carried out for different types of projects. In total, 67 responses (51.94%) were collected for the contractor, 48 responses (37.21%) for the client, and 14 responses (10.85%) for the PMC. The number of respondents from the PMC group was lower compared to contractors and clients because, in India, it is common for clients to utilize their staff for project management tasks. Only a few of them use a third party for project management tasks (Tripathi and Jha, 2017). Out of the total, Seventy-nine (61.24%) had less than 10 years of experience, twenty-six (20.16%) had experience ranging from 10 to 20 years, sixteen (12.40%) had experience ranging from 20 to 30 years, and eight (6.20%) had over 30 years of experience. There were about 18 (13.95%) organizations with less than 10 years of experience, 34 (26.36%) organizations had 10 to 20 years of experience, 31 (24.03%) organizations had 20 to 30 years of experience, and 46 (35.66%) organizations had more than 30 years of experience. The survey was conducted between August 2023 to October 2023. Table 3.2 illustrates the demographics of the respondents.

Table 3.2: Respondent profile

Group	**Total**	**Percentage (%)**
Category of organization		
Client	48	37.21
Contractor	67	51.94
PMC	14	10.85
Respondent's years of experience (In years)		
1-10	76	58.91
10-20	29	22.48

Continued on next page

Table 3.2 – continued from previous page

Group	**Total**	**Percentage (%)**
20-30	16	12.40
Above 30	8	6.20
Organization's total years of experience (In years)		
1-10	17	13.18
10-20	35	27.13
20-30	33	25.58
Above 30	44	34.11
Category based on project cost (In millions dollars)		
Less than 500	19	38.77
500-1000	11	22.44
1000-10000	16	32.65
Above 10000	3	6.122

3.5 Descriptive analysis:

Descriptive analysis is a method that focuses on summarizing data using a single variable. Typically, this analysis presents data through charts such as bar charts, pie charts, and histograms and tables for clear data illustration. This analysis commonly includes metrics such as percentile values (including cut points, quartiles, and percentile), measures of central tendency (mean, median, mode, and sum), and measures of dispersion (standard deviation, variance, range, minimum, and maximum values), along with distribution characteristics like skewness and kurtosis. The mean value was used to analyze the responses collected on success and performance attributes, with the mean value for each attribute calculated to determine its significance within the dataset.

3.5.1 Ranking of success and performance attributes:

In this research, a 5-point Likert scale was adopted for this questionnaire survey. The success and performance attributes were ranked based on questionnaire responses. Data gathered from a questionnaire employing a Likert scale is typically classified as ordinal and nonparametric. According to Datta et al. (2023), non-parametric data usually does not follow a normal distribution. So, the approach of using mean value and standard deviation was applied to the ranking of attributes (Tripathi & Jha 2019). When multiple attributes shared the same mean value, the one with the smaller standard deviation received a higher ranking. The process for calculating the mean of each rating on a five-point Likert scale involved counting the number of responses as follows (Tripathi & Jha 2019). Equation 3.3 was use for calculating ranking of different group.

$$\text{Mean} = \frac{\sum_{i=1}^{n} R_i F_i}{n} \tag{3.3}$$

Where,

R_i = The rating is given using the 5-point Likert scale, which ranges from 1 to 5.

F_i = The number of responses received for each rating.

n = Total number of responses received.

3.5.2 Spearman's rank corelation coefficient (SRCC):

To assess the degree of concurrence in the rankings of success and performance attributes between the two survey groups, the SRCC test was employed. This correlation method, which relies on medium instead of mean, can be used to reduce the impact of outliners' errors in the data set. Being a non-parametric test, it does not depend on the uniformity of variance (Datta et al. 2023). The Spearman correlation ranges from -1 to 1, where 1 indicates a positive correlation, 0 indicates no correlation, and -1 indicates a negative correlation between groups (Datta et al. 2023, Tripathi & Jha 2019). According to Datta et al. (2023), if the correlation coefficient 'R' reaches statistical significance at an accepted level, like 5%, then it is possible to reject the null hypothesis. This hypothesis asserts that there is not a significant correlation in the rankings between the two survey groups. The constant, referred to as rho, is denoted by r_s. SRCC can be calculated using the following Equation 3.4 and 3.5 (Tripathi & Jha 2018*b*, Datta et al. 2023):

Equation for data with not having tied rank (Ingle et al. 2021):

$$r_s = 1 - \frac{6\sum d^2}{N(N^2-1)} \tag{3.4}$$

Where,

$$d = \text{Represents the difference in ranks between pairs of observations}$$
$$N = \text{The number of pairs}$$

Equation for data with tied ranks (Tripathi & Jha 2018*b*):

$$R = 1 - \frac{\sum(x_i-\bar{x})(y_i-\bar{y})}{\sqrt{\sum(x_i-\bar{x})^2\sum(y_i-\bar{y})^2}} \tag{3.5}$$

Where,

$$i = \text{Indicates the rank of each observation}$$
$$x_i \& y_i = \text{The rank values for two variables}$$
$$\bar{x}, \bar{y} = \text{The mean rank values}$$

3.5.3 Categories of Attributes:

The mean value derived from the descriptive statistical analysis of the responses did not correspond to a whole number as specified in the questionnaire. Therefore, it is likely that the attributes related to success and performance in the construction industry are positioned between two adjacent scales (Tripathi & Jha 2019).

Table 3.3: Categories of attributes

Sr. No.	Mean Value (µ)	Degree of Effect	Degree of Importance
1	µ >4.5	Very high effect	Very high importance
2	4.5 >µ >3.5	High effect	High importance
3	3.5 >µ >2.5	Moderate effect	Moderate importance
4	2.5 >µ >1.5	Low effect	Low importance

Continued on next page

Table 3.3 continued from previous page

Sr. No.	Mean Value (µ)	Degree of Effect	Degree of Importance
5	1.5 >µ	Very low effect	Very low importance

3.5.4 One-sample T-Test:

To assess the statistical significance of attributes at a specific mean value, researchers can utilize various tests, including the parametric one-sample t-test, the non-parametric one-sample Sign test, or the one-sample Wilcoxon test (Tripathi & Jha 2019). Since the data was free from outliners and followed a normal distribution, the identification of significant attributes was conducted through a parametric one-sample T-test, with a mean value set at 3.5 and a confidence interval of 95% (Mengistu & Mahesh 2020, Tripathi & Jha 2019). A mean value of 3.5 (moderate or higher effect) is used as a threshold for further consideration of attributes based on the questionnaire's scale and the study's context. By focusing on these attributes, researchers can prioritize the most crucial attributes for the success and performance of the construction industry.

3.6 Factor analysis:

Factor analysis, a statistical tool used for identifying latent variables, was employed in this study (Yap et al. 2019). Numerous researchers commonly use this data reduction method to identify the number of factors responsible for the majority of the observed variance across several attributes (Tripathi & Jha 2019). For the factor analysis of the collected responses, SPSS 21 software was utilized.

Multiple methodologies exist for factor extraction in statistical analysis, including Principal Components Analysis (PCA), Principal Axis Factoring (PAF), Image Factoring, Maximum Likelihood, Alpha Factoring, Unweighted Least Squares, Generalised Least Squares, and Canonical methods (Taherdoost et al. 2022, Tripathi & Jha 2018*a*). Each approach offers a unique mechanism to identify underlying factors within a dataset, catering to different types of data structures and research objectives. The selection of an extraction method becomes particularly critical in scenarios involving small sample sizes and limited variables. PCA is commonly the preferred method in factor analysis (Fox & Skitmore 2007). In PCA, the extraction process initiates by identifying a linear combination that accounts for the highest variance within the original variables. This method proceeds to discover additional components that account for the maximal portion of the variance left unexplained by the preceding components while ensuring orthogonality (no correlation) among them. This iterative procedure continues until the number of extracted components equals the count of original variables (Fox & Skitmore 2007, Taherdoost et al. 2022, Tripathi & Jha 2019). In most statistical software packages, PCA is the default option. PCA is recommended for scenarios lacking a theoretical framework or prior model, ideally suited for situations where there is minimal pre-existing knowledge about the potential clusters or relationships within the dataset (Fox & Skitmore 2007, Taherdoost et al. 2022).

For enhancing factor analysis interpretability, axis rotation is essential, as it improves interpretability without compromising the solution's fit. Among the primary rotation methods are varimax, equimax, and quartimax, of which the varimax rotation is preferred as it stands out for its efficiency in yielding a more straightforward, more interpretable solution. This technique effectively minimizes the number of variables with significant factor loadings on multiple factors, thereby allowing the distinction between each variable's factor loadings (Fox & Skitmore 2007). Deciding on the number of factors to extract is crucial, with various literature available. A widely used method is the minimum eigenvalue criterion, which selects factors based on their principal component's eigenvalues. Specifically, eigenvalues are ranked from highest to lowest, and those with a value greater than one are selected for the number of factors to be included in the analysis(Fox & Skitmore 2007).

Kaiser Meyer Olkin (KMO) and Bartlett's tests of sphericity: Numerous preliminary tests are available to assess the sample's characteristics and ensure precise factor analysis. Among these, the KMO measure stands out for evaluating the adequacy of the sample size. This test is crucial for determining if the sample is suitable for conducting factor analysis, ensuring that the results derived are statistically significant and reliable (Fox & Skitmore 2007, Taherdoost et al. 2022). The value of KMO ranges from 0 to 1.0. Closer to the value of 1.0 is better. For a factor analysis to be successful, the overall KMO needs to be 0.60 or higher. Similarly, another test known as the Barlett Test of Sphericity serves as a statistical test used to detect if there are any relationships between different variables (Tabish & Jha 2011). The correlation matrix demonstrates that all variables should be significant ($p<0.05$) for factor analysis to be suitable.

Another way of measuring sample adequacy is subject to a variable ratio (STV), which is 5.86 (129/22) for the success attributes and 10.75 (129/12) for the performance attributes which is greater than the required minimum value of 2 (Tripathi & Jha 2019). In this case-to-variable, the performance attributes are 10.7:1, the success attributes are 5.8:1, and the case-to-variable ratio that was recommended was 5:1 for factor analysis (Fox & Skitmore 2007, Tabish & Jha 2011).

3.6.1 Reliability test:

In quantitative research, reliability refers to the extent to which a measurement tool consistently captures the attribute it is intended to measure (Ingle & Mahesh 2022). In this study, Cronbach's alpha ($C\alpha$) measure was utilized to evaluate the internal consistency of all attributes that passed the one-sample t-test. Cronbach's alpha values range from 0 to 1, where values closer to 1 indicate greater internal consistency or inter-criteria correlations and vice versa among the measured variables. A Cronbach's alpha ($C\alpha$) >0.7 is typically regarded as the minimum acceptable level for reliability, suggesting that measures above this value demonstrate sufficient consistency for research purposes (Ingle & Mahesh 2022, Tripathi & Jha 2018*a*).

3.6.2 Pearson correlation coefficient:

To confirm whether attributes classified under a single factor in factor analysis are related to the same measure, it is recommended to test this using (1) Pearson's correlation coefficient, (2) Kendall's tau-b, and (3) SRCC (Tripathi & Jha 2018*a*). Pearson's correlation coefficient is the most commonly used test to assess the strength of the relationship between variables. It is assumed in this test that the variables have a normal distribution and a linear relationship. On the other hand, Kendall's tau-b is a non-parametric test that evaluates the degree of association between two variables (Tripathi & Jha 2018*a*). To evaluate the degree of concurrence between two variables, SRCC test can be utilized. As a non-parametric test, it does not depend on the uniformity of variance (Datta et al. 2023). These tests determine the extent to which two variables are correlated. In this study, Pearson's correlation test is used to calculate the coefficients, demonstrating how attributes grouped under a factor correlate with each other.

3.7 Regression analysis:

The method of regression analysis is repetitive in nature (Tabish & Jha 2011). Among the various types, multiple linear regression analysis is the most popular (Gunduz & Abdi 2020). For identifying CSFs, stepwise regression analysis is a highly recommended technique (Ingle et al. 2021). In this study, stepwise regression analysis was utilized as the primary technique to assess the criticality of success factors, which were identified through factor analysis against various performance factors. During the regression analysis, factor scores for both the success and performance factors were computed. This method shows the relationship between the dependent and independent variables (Gunduz & Abdi 2020). Performance factors are taken individually as dependent variables, while success factors are collectively considered as independent variables.

As there were initially too many attributes and a small sample size, the attributes were grouped using factor analysis before performing regression analysis (Ingle et al. 2021, Tabish & Jha 2011). Including too many variables in regression analysis can create ambiguity regarding their relative importance. To enhance the model's performance, it is important to exclude variables that do not significantly impact the outcome. Stepwise regression systematically selects or excludes variables based on their significance, as measured by the coefficient of determination (R^2), which evaluates the model's fit (Lema 1996, Tabish & Jha 2011).

A regression model is considered effective if it has a high R^2, representing the percentage of variance explained by the independent variables in the dependent variable (Tabish & Jha 2011). R^2 values range from 0 to 1, with higher values indicating a better model fit. However, as more independent variables are added, R^2 inevitably rises. Adjusted R^2 provides a more accurate measure of the model's fit. In comparison to R^2, it does not increase abruptly with the increase in the number of independent variables (Tabish & Jha 2011). The regression analysis approach involves minimizing model variances, maximizing R^2 values, and including only variables that have proven statistically significant through stepwise selection procedures and T-tests. Independent variables are considered at the 5% level of significance ($p < 0.05$) (Gunduz & Abdi 2020, Tabish & Jha 2011). The regression model is stated as the following Equation 3.6 (Ingle et al. 2021).

$$Y = B_0 + B_1X_1 + B_2X_2 + B_3X_3 + \ldots + B_nX_n + e \tag{3.6}$$

Where,

$$Y = \text{The dependent variables}$$
$$X_i = \text{The independent variables}$$
$$B_i = \text{Beta coefficient}$$
$$i = 1,\ 2,\ 3 \ldots\ \text{n}$$
$$e = \text{Error term}$$

The analysis investigates the influence of each independent variable (X_i) on the dependent variable (Y) by utilizing the results of the t-test applied to the coefficient (B_i) associated with each independent variable. If a coefficient is found to be significant at a 5% level or lower, this suggests that there is less than a 5% chance that the coefficient is zero, leading to the conclusion that the independent variable significantly impacts the dependent variable (Gunduz & Abdi 2020). A positive coefficient signifies a positive influence on the dependent variable, and conversely, a negative coefficient indicates a negative effect.

3.8 Summary:

This chapter outlines the research methodology used to explore critical success factors at the industry level within the Indian construction sector. The methodology consists of two primary steps: data collection through structured questionnaire surveys and detailed data analysis. The survey utilized a 5-point Likert scale to assess 30 success and 15 performance attributes. Data analysis included descriptive analysis, factor analysis, and regression analysis were factor analysis helped in identifying latent variables, while regression analysis evaluated the impact of these factors on various performance factors.

Chapter 4

Success and Performance Factors for the Construction Industry

4.1 Introduction:

This chapter concentrates on analyzing the responses collected from Stage-1 questionnaires, which explore the attributes crucial for evaluating the success and performance of the construction industry. The primary objective is to identify the key success and performance factors, with a particular focus on identifying the CSFs for the industry which are essential for driving the construction sector forward.

Various statistical analysis methodology, such as descriptive analysis, factor analysis and regression analysis was employed. Additionally, numerous tests were conducted to verify the reliability and validity of the results.

The objectives outlined in this chapter are presented below:

- To evaluate the various attributes of success and performance in the construction industry.
- To determine the success and performance factors for the construction industry.
- To determine the critical success factors (CSFs) for the construction industry.

4.2 Evaluation of success and performance attributes:

As discussed in Section 3.5.1 of chapter 3, success and performance attributes were ranked based on responses from a questionnaire. The data collected through this questionnaire were analyzed by calculating the mean value and standard deviation to rank the attributes (Tripathi & Jha 2019). The mean was calculated using Equation 3.3.

Table 4.1 displays the overall ranking of the success attributes, including a breakdown of rankings by different respondent groups. Similarly, Table 4.2 presents the overall ranking of the performance attributes, also including a breakdown of rankings by various respondent groups.

Table 4.1: Ranking of success attributes

Sr No	Success Attributes	Id	Client		Contractor		PMC		Overall	
			Mean	Rk	Mean	Rk	Mean	Rk	Mean	Rk
1	Availability of equipment materials and workforce	SA-13	4.396	1	4.507	1	4.429	2	4.457	1
2	Availability of easy finance	SA-17	4.292	2	4.403	2	4.357	3	4.357	2
3	Higher productivity of the workforce	SA-26	4.208	4	4.388	3	4.214	5	4.302	3
4	Availability of qualified professionals in the industry	SA-16	4.125	6	4.284	4	4.500	1	4.248	4
5	Availability of physical infrastructure such as rail, road, telecom, etc.	SA-14	4.000	7	4.269	5	4.000	11	4.140	5
6	Transparency in the industry	SA-9	3.875	10	4.254	6	4.143	6	4.101	6
7	Favorable rules and regulations	SA-10	4.000	8	4.104	9	3.929	12	4.047	7
8	Appropriate training and education	SA-29	3.813	16	4.164	7	4.286	4	4.047	8
9	Low-interest rate on finance	SA-18	4.271	3	3.851	16	4.071	8	4.031	9

Continued on next page

Table 4.1 – continued from previous page

Sr No	Success Attributes	Id	Client		Contractor		PMC		Overall	
			Mean	Rk	Mean	Rk	Mean	Rk	Mean	Rk
10	Favorable government policy in supporting capacity building of organizations	SA-3	4.146	5	3.896	12	4.143	7	4.016	10
11	Growing GDP of the country	SA-5	3.813	15	4.119	8	3.857	14	3.977	11
12	Favorable market conditions	SA-19	3.875	9	3.896	14	3.786	15	3.876	12
13	Collaborative culture in the industry i.e., relationships among key stakeholders	SA-27	3.688	20	3.970	10	4.000	10	3.868	13
14	Standardized bye-laws and codes	SA-12	3.833	12	3.910	11	3.786	17	3.868	14
15	Good image of the industry in terms of employment opportunities business opportunities etc.	SA-8	3.813	13	3.896	13	3.857	13	3.860	15
16	Low accident rate, fatality rate, etc.	SA-25	3.563	24	3.881	15	4.000	9	3.775	16
17	Availability of foreign direct investment and foreign aid	SA-6	3.854	11	3.701	20	3.646	24	3.752	17
18	Favorable external environment (social political factors)	SA-7	3.708	18	3.776	17	3.643	23	3.736	18

Continued on next page

Table 4.1 – continued from previous page

Sr No	Success Attributes	Id	Client		Contractor		PMC		Overall	
			Mean	Rk	Mean	Rk	Mean	Rk	Mean	Rk
19	Positive impact on society	SA-22	3.688	19	3.716	18	3.786	16	3.713	19
20	Level of competition among industry players	SA-28	3.625	22	3.701	19	3.643	20	3.667	20
21	Favorable taxation system applicable to the construction industry	SA-1	3.813	14	3.567	25	3.643	25	3.667	21
22	Investment and encouragement in research and development	SA-30	3.625	23	3.642	21	3.571	26	3.628	22
23	Availability of the latest technologies such as automation, robotics, 3D printing, etc.	SA-15	3.521	26	3.597	24	3.786	18	3.589	23
24	Certification by various agencies (ISO, PMI, ISI, MSME, etc.)	SA-11	3.521	25	3.612	23	3.500	27	3.566	24
25	Government promoting labour-intensive schemes to create employment	SA-4	3.646	21	3.448	26	3.643	21	3.543	25
26	Efficient registration system (firms and professionals)	SA-2	3.792	17	3.358	28	3.500	28	3.535	26
27	Favorable weather conditions	SA-23	3.417	27	3.627	22	3.429	29	3.527	27

Continued on next page

Table 4.1 – continued from previous page

Sr No	Success Attributes	Id	Client		Contractor		PMC		Overall	
			Mean	Rk	Mean	Rk	Mean	Rk	Mean	Rk
28	Positive impact on the environment	SA-21	3.375	28	3.418	27	3.643	22	3.426	28
29	Low waste production and recycling	SA-24	3.333	29	3.239	29	3.786	19	3.333	29
30	Low fluctuation in the currency exchange rate	SA-20	2.542	30	2.657	30	2.786	30	2.628	30

Table 4.2: Ranking of performance attributes

Sr No	Performance Attributes	Id	Client		Contractor		PMC		Overall	
			Mean	Rk	Mean	Rk	Mean	Rk	Mean	Rk
1	Qualified professionals in the industry	PA-9	4.396	1	4.507	1	4.429	2	4.457	1
2	Technological development of industry	PA-7	4.292	2	4.403	2	4.357	3	4.357	2
3	Annual growth rate of the industry	PA-3	4.208	4	4.388	3	4.214	5	4.302	3
4	Labour productivity	PA-14	4.125	6	4.284	4	4.500	1	4.248	4
5	High annual construction demand/Market share	PA-1	4.000	7	4.269	5	4.000	11	4.140	5
6	Employment opportunities in the construction industry	PA-10	3.875	10	4.254	6	4.143	6	4.101	6
7	Stakeholder satisfaction	PA-15	4.000	8	4.104	9	3.929	12	4.047	7

Continued on next page

Table 4.2 – continued from previous page

Sr No	Performance Attributes	Id	Client		Contractor		PMC		Overall	
			Mean	Rk	Mean	Rk	Mean	Rk	Mean	Rk
8	High profitability ratio (Industry generating profit)	PA-2	3.813	16	4.164	7	4.286	4	4.047	8
9	Safety (Accident rate, Fatality, etc.)	PA-6	4.271	3	3.851	16	4.071	8	4.031	9
10	Positive impact on society	PA-4	4.146	5	3.896	12	4.143	7	4.016	10
11	Construction Research and Development (Innovative material, Technique, number of patent registers, etc.)	PA-8	3.813	15	4.119	8	3.857	14	3.977	11
12	Higher wages of employees	PA-13	3.875	9	3.896	14	3.786	15	3.876	12
13	Human resource training and development	PA-11	3.688	20	3.970	10	4.000	10	3.868	13
14	Positive impact on the environment	PA-5	3.833	12	3.910	11	3.786	17	3.868	14
15	Low staff turnover	PA-12	3.813	13	3.896	13	3.857	13	3.860	15

4.3 Spearman's rank corelation coefficient (SRCC):

As extensively covered in section 3.5.2 of Chapter 3, the SRCC test was employed to assess the degree of agreement in the rankings of success and performance attributes between the two survey groups. The Spearman correlation ranges from -1 to 1, where 1 indicates a positive correlation, 0 indicates no correlation, and -1 indicates a negative correlation between groups (Datta et al. 2023, Tripathi & Jha 2019). The SRCC was calculated using Equation 3.4 and 3.5. The results are displayed in Table 4.3 shows the results of SRCC for success and performance attributes.

Table 4.3: Spearman's rank correlation test on success and performance attributes

Sr no	Comparison of rankings between groups of respondents	SRCC, R (Success attributes)	SRCC, R (Performance attributes)	Significance level, p	Conclusion
1	Contractor ranking vs Client ranking	0.782	0.839	0.000	Reject H0 at p = 5%
2	Contractor ranking vs Project management consultant ranking	0.867	0.868	0.000	Reject H0 at p = 5%
3	Project management consultant vs Client ranking	0.710	0.743	0.000	Reject H0 at p = 5%

4.4 Categories of attributes:

he mean value derived from the descriptive statistical analysis of the responses did not correspond to a whole number as specified in the questionnaire. Therefore, it is likely that the attributes related to success and performance in the construction industry are positioned between two adjacent scales (Tripathi & Jha 2019). Table 4.4 illustrates that attributes can be classified according to their mean values.

Table 4.4: Categories of attributes of success and performance attributes

Sr. No.	Mean Value (µ)	Degree of Effect	Success Attributes	Degree of Importance	Performance Attributes
1	$\mu > 4.5$	Very high effect	Nil	Very high importance	Nil

Continued on next page

Table 4.4 continued from previous page

Sr. No.	Mean Value (µ)	Degree of Effect	Success Attributes	Degree of Importance	Performance Attributes
2	4.5 >µ >3.5	High effect	SA-1 to SA-19, SA-22, SA-23, SA-25 to SA-30	High importance	PA-1 to PA-15
3	3.5 >µ >2.5	Moderate effect	SA-20, SA-21, SA-24	Moderate importance	Nil
4	2.5 >µ >1.5	Low effect	Nil	Low importance	Nil
5	1.5 >µ	Very low effect	Nil	Very low importance	Nil

4.5 One-sample T-Test:

A mean value of 3.5 (moderate or higher effect) is used as a threshold for further consideration of attributes based on the questionnaire's scale and the study's context. By focusing on these attributes, researchers can prioritize the most crucial attributes for the success and performance of the construction industry. In detailed one-sample t-test is elaborated upon in Section 3.5.4 of Chapter 3.

The results of the one-sample t-test show eight attributes linked to success; efficient registration system (firms and professionals); government promoting labor-intensive schemes to create employment; certification by various agencies (ISO, PMI, ISI, MSME, etc.); availability of the latest technologies such as automation, robotics, 3d printing, etc.; positive impact on the environment; favorable weather conditions; low waste production and recycling; investment and encouragement in research and development. Similarly, the results of the one-sample t-test show three performance attributes: positive impact on the environment, human resource training and development, and higher wages of employees.

The significance level is below 0.05, indicating that the attributes did not pass the one-sample t-test with a test value of 3.5. This points out that these success and performance attributes are not significantly affected or essential to the construction industry.

Hence, only 22 of the 30 success attributes and 12 of the 15 performance attributes that demonstrated significant effect and importance for the construction industry's success and performance were selected for further analysis. The Table 4.5 shows the results of one-sample T-test on success attributes. Similarly, Table 4.6 shows the results of one-sample T-test on performance attributes

Table 4.5: One-sample T-Test on success attributes

ID	Success Attributes	t	df	Sig. (2-tailed)
SA-1	Favorable taxation system applicable to the construction industry	2.054	128	.042
SA-2	Efficient registration system (firms and professionals)	.409	128	.683
SA-3	Favorable government policy in supporting capacity building of organizations	6.497	128	.000
SA-4	Government promoting labour-intensive schemes to create employment	.484	128	.629
SA-5	Growing GDP of the country	6.038	128	.000
SA-6	Availability of Foreign Direct Investment and Foreign Aid	2.883	128	.005
SA-7	Favorable External Environment (Social Political Factors)	2.964	128	.004
SA-8	Good image of the industry in terms of employment opportunities	5.478	128	.000
SA-9	Transparency in the industry	7.892	128	.000
SA-10	Favorable rules and regulations	7.254	128	.000
SA-11	Certification by various agencies (ISO, PMI, ISI, MSME, etc.)	.732	128	.465
SA-12	Standardized bye-laws and codes	4.623	128	.000
SA-13	Availability of equipment, materials, and workforce	14.702	128	.000

Continued on next page

Table 4.5 continued from previous page

ID	Success Attributes	t	df	Sig. (2-tailed)
SA-14	Availability of physical infrastructure such as rail, road, telecom, etc.	8.157	128	.000
SA-15	Availability of the latest technologies such as automation, robotics, 3D printing, etc.	.971	128	.333
SA-16	Availability of qualified professionals in the industry	12.010	128	.000
SA-17	Availability of easy finance	14.258	128	.000
SA-18	Low-interest rate on finance	7.279	128	.000
SA-19	Favorable market conditions	5.401	128	.000
SA-20	Low fluctuation in the currency exchange rate	-9.900	128	.000
SA-21	Positive impact on the environment	-.989	128	.325
SA-22	Positive impact on society	2.982	128	.003
SA-23	Favorable weather conditions	.332	128	.740
SA-24	Low waste production and recycling	-1.756	128	.081
SA-25	Low accident rate, fatality rate, etc.	3.305	128	.001
SA-26	Higher productivity of the workforce	12.767	128	.000
SA-27	Collaborative culture in the industry	4.761	128	.000
SA-28	Level of competition among industry players	2.446	128	.016
SA-29	Appropriate training and education	6.963	128	.000
SA-30	Investment and encouragement in research and development	1.581	128	.116

Table 4.6: One-sample T-Test of performance attributes

ID	Performance Attributes	t	df	Sig. (2-tailed)
PA-1	High annual construction demand/Market share	7.966	128	.000

Continued on next page

Table 4.6 continued from previous page

ID	Performance Attributes	t	df	Sig. (2-tailed)
PA-2	High profitability ratio (Industry generating profit)	6.423	128	.000
PA-3	Annual growth rate of the industry	9.583	128	.000
PA-4	Positive impact on society	3.086	128	.002
PA-5	Positive impact on the environment	-1.456	128	.148
PA-6	Safety (Accident rate, fatality, etc.)	4.374	128	.000
PA-7	Technological development of industry	9.656	128	.000
PA-8	Construction research and development (innovative material, technique, number of patent registers, etc)	2.093	128	.038
PA-9	Qualified professionals in the industry	11.327	128	.000
PA-10	Employment opportunities in the construction industry	7.666	128	.000
PA-11	Human resource training and development	-0.435	128	.664
PA-12	Low staff turnover	-4.237	128	.000
PA-13	Higher wages of employees	1.534	128	.127
PA-14	Labour productivity	9.423	128	.000
PA-15	Stakeholder satisfaction	6.084	128	.000

4.6 Factor analysis:

Addressing all 22 success attributes and 12 performance attributes simultaneously would be very challenging for the construction industry in terms of achieving and evaluating success. Nevertheless, this obstacle can be overcome with the help of success factors and performance factors. In this study, factor analysis is performed on all 22 success attributes and 12 performance attributes. In detailed factor analysis is elaborated upon in Section 3.6 of Chapter 3.

Kaiser Meyer Olkin (KMO) and Bartlett's sphericity tests: The KMO measure stands out for evaluating the adequacy of the sample size. The value of KMO ranges from 0 to 1.0. Closer to the value of 1.0 is better. For a factor analysis to be successful, the overall KMO needs to be 0.60 or higher. The value of KMO value was 0.792 (>0.6) for success and 0.704 (>0.6) for performance attributes, which showed that the sample is adequate for performing factor analysis (Fox & Skitmore 2007, Taherdoost et al. 2022). Similarly, another test known as the Barlett Test of Sphericity serves as a statistical test used to detect if there are any relationships between different variables (Tabish & Jha 2011). The results from Bartlett's Test of Sphericity, indicate chi-square values of 648.414 and 272.555 for success and performance attributes respectively, with a significance level of 0.000 for both, which means the correlation matrix is not an identity matrix. Figures 4.1 and 4.2 show the results of factor analysis of success and performance attributes.

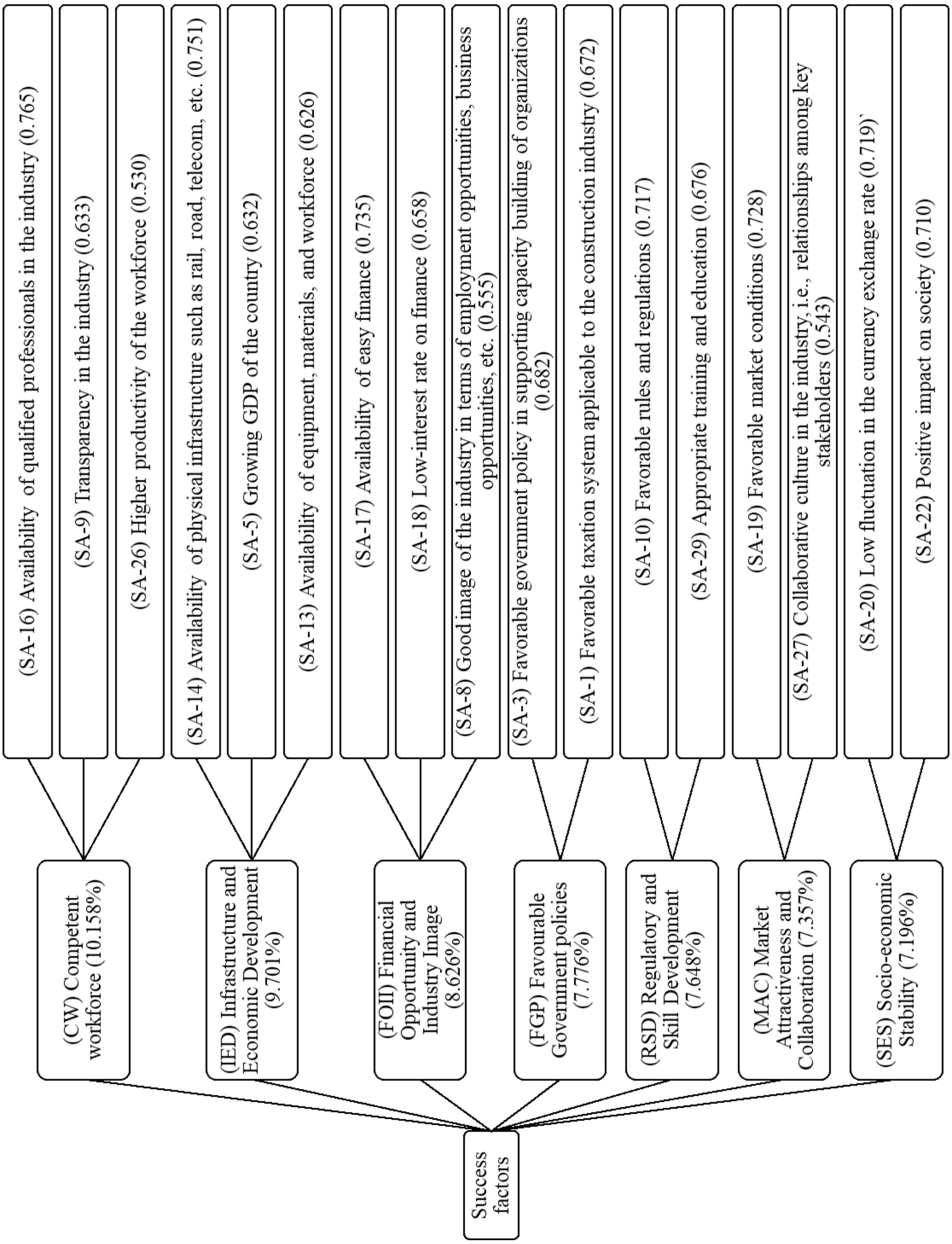

Figure 4.1: Factor analysis of success attributes

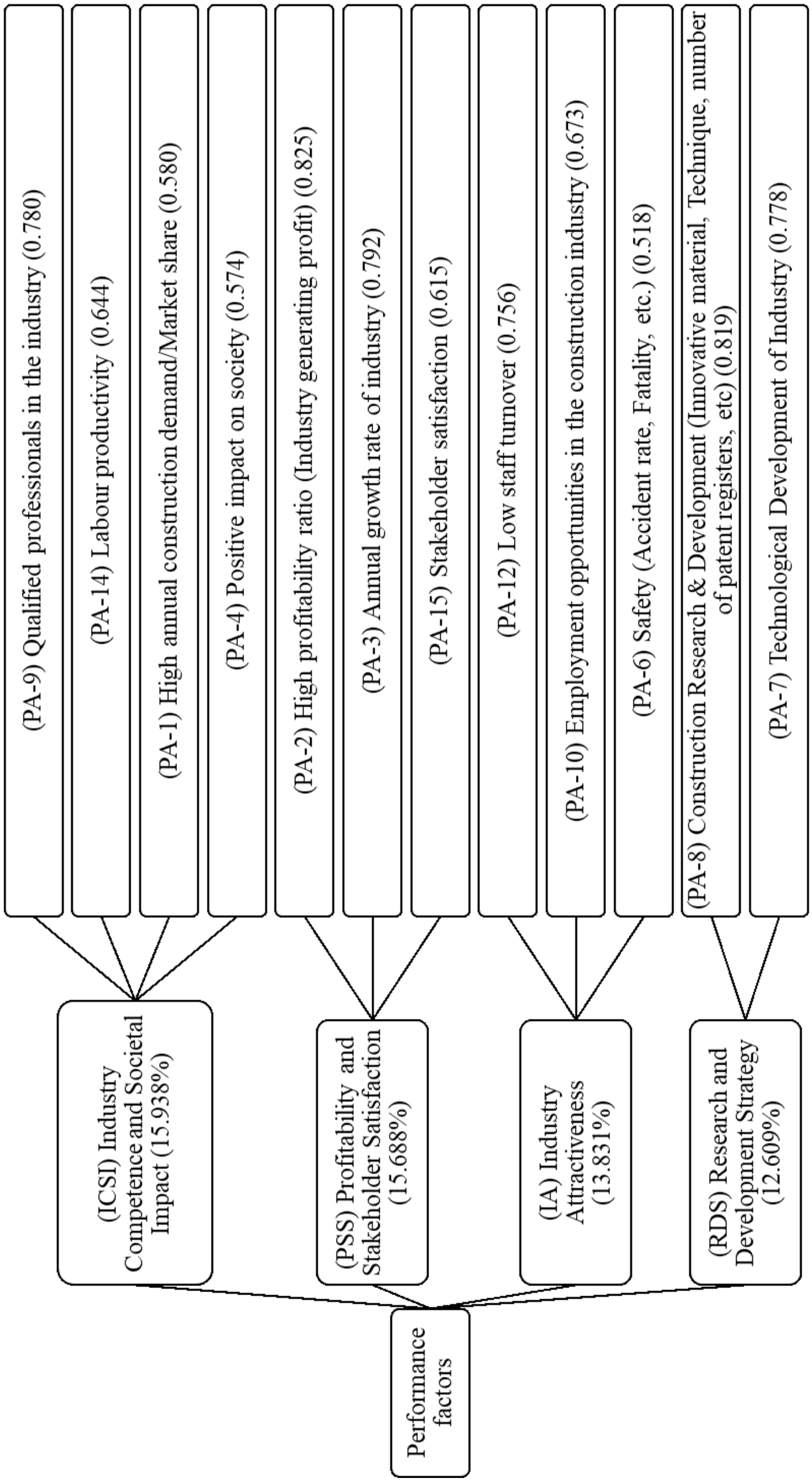

Figure 4.2: Factor analysis of performance attributes

4.6.1 Reliability Test:

In this study, Cronbach's alpha ($C\alpha$) measure was utilized to evaluate the internal consistency of all attributes that passed the one-sample t-test. Cronbach's alpha values range from 0 to 1, where values closer to 1 indicate greater internal consistency or inter-criteria correlations and vice versa among the measured variables. A Cronbach's alpha ($C\alpha$) >0.7 is typically regarded as the minimum acceptable level for reliability, suggesting that measures above this value demonstrate sufficient consistency for research purposes (Ingle & Mahesh 2022, Tripathi & Jha 2018*a*). In this study, Cronbach's alpha ($C\alpha$) is **0.840** for success attributes and **0.734** for performance attributes, indicating high internal consistency.

4.6.2 Pearson correlation coefficient:

Pearson's correlation coefficient is the most commonly used test to assess the strength of the relationship between variables. It is assumed in this test that the variables have a normal distribution and a linear relationship. In this study, Pearson's correlation test is used to calculate the coefficients, demonstrating how attributes grouped under a factor correlate with each other. Table 4.7 and 4.8 demonstrate that the success attributes under each success factor, from CW to SES, were positively correlated within a range of 0.243 to 0.412. Similarly, Table 4.9 and 4.10 show that the performance attributes under each performance factor, from ICSI to RDS, exhibited positive correlations ranging from 0.222 to 0.475.

Table 4.7: Pearson correlation coefficients for success attributes from CW to FOII

	CW			**IED**			**FOII**		
SA	SA-16	SA-9	SA-26	SA-14	SA-5	SA-13	SA-17	SA-18	SA-8
SA-16	1								
SA-9	.380**	1							
SA-26	.376**	.330**	1						
SA-14				1					
SA-5				.376**	1				
SA-13				.412**	.334**	1			

Continued on next page

Table 4.7 – continued from previous page

	CW			IED			FOII		
SA-17							1		
SA-18							.381**	1	
SA-8							.236**	.285**	1

*Correlation is significant at the 0.05 level (2-tailed).

Table 4.8: Pearson correlation coefficients for success attributes from FGP to SES

	FGP		**RSD**		**MAC**		**SES**	
SA	SA-3	SA-1	SA-10	SA-29	SA-19	SA-27	SA-20	SA-22
SA-3	1							
SA-1	.354**	1						
SA-10			1					
SA-29			.325**	1				
SA-19					1			
SA-27					.393**	1		
SA-20							1	
SA-22							.243**	1

*Correlation is significant at the 0.05 level (2-tailed)

Table 4.9: Pearson correlation coefficients for performance attributes from ICSI to PSS

	ICSI				**PSS**		
PA	PA-9	PA-14	PA-1	PA-4	PA-2	PA-3	PA-15
PA-9	1						
PA-14	.351**	1					
PA-1	.280**	.242**	1				
PA-4	.379**	.224*	.222*	1			
PA-2					1		
PA-3					.475**	1	
PA-15					.388**	.433**	1

*Correlation is significant at the 0.05 level (2-tailed)

Table 4.10: Pearson correlation coefficients for performance attributes from IA to RDS

	IA			RDS	
PA	PA-12	PA-10	PA-6	PA-8	PA-7
PA-12	1				
PA-10	.236**	1			
PA-6	.308**	.241**	1		
PA-8				1	
PA-7				.401**	1

*Correlation is significant at the 0.05 level (2-tailed)

4.7 Success attributes and factors:

This section explains top three success attributes and seven success factors extracted using factor analysis.

4.7.1 Success attributes:

Availability of equipment, materials, and workforce emerged as the most critical success attribute for the construction industry, with a mean value of 4.457. The construction industry's success hinges on the ready availability of equipment, materials, and workforce, that directly influence the project timeline, budget, and overall quality. Every construction project and organization's success and functioning depend on these three factors. Easy access to modern and properly maintained equipment not only increases productivity but also allows activities to be completed on time and at under-budgeted costs. Similarly, the easy availability of materials for the market improves the supply chain of the project and organization, which ensures cost savings and timely completion. However, the availability of skilled manpower is the most critical factor for any industry to grow and succeed. Equipment and materials have been determined as critical factors for the success of construction projects (Barajei et al. 2023).

The availability of easy finance is the second most critical success attribute for the construction industry, with a mean value of 4.357. For the completion of any project, sufficient finance is required to purchase materials, employ a skilled workforce, and invest in the latest technologies and machinery. For a construction firm to thrive, it must have working capital and liquidity, which provide the necessary accessible funds to cover essential expenses (Tripathi & Jha 2019). These financial resources are vital in supporting operational activities and enabling the completion of projects within the construction industry. This shows the direct link between a company's financial management and the successful execution of projects in the construction field.

Higher productivity of the workforce is essential for the success of any industry. However, as the construction sector relies heavily on the workforce, it became particularly vital, with a mean value of 4.302. High productivity of the workforce ensures that resources are used effectively, which reduces workforce costs, which directly or indirectly affects a significant portion of construction budgets, and ensures that projects are completed within the assigned budgets and schedule time. A motivated and skilled workforce can complete tasks faster and with greater quality, which reduces the need for rework and ensures standards are met.

4.7.2 Success factors:

Competent Workforce (CW): Factor analysis revealed that a competent workforce is characterized by skilled professionals, high productivity, and transparency that underpins the industry's efficiency and innovation. The construction industry relies heavily on such a workforce with the necessary technical knowledge, experience, and qualifications to ensure high standards in planning, execution, safety, and quality, reducing disputes and improving schedule, cost, and quality management (Mengistu & Mahesh 2020, Tripathi & Jha 2019). Transparency in the industry can strengthen trust and accountability, leading to a reduction in risks and disputes (Fox & Skitmore 2007). Effective workforce utilization maximizes output and minimizes waste. However, higher productivity is achieved through proper planning, training, and technology use, which results in cost savings and timely completion. Improved corporate management and governmental policies on social responsibility, employee satisfaction, and individual respect correlate with increased workforce productivity, boosting overall industry productivity (Deng et al. 2013). This factor explains 10.158% of the total variance.

Infrastructure and Economic Development (IED): This factor encompasses the availability of equipment, materials, and workforce; availability of physical infrastructure such as rail, road, and telecom; and the growing GDP of the country, each contributing to the sector's robust development. The availability of equipment and materials ensures the timely and efficient completion of projects, and the proper workforce is essential for the construction. According to Tripathi & Jha (2019), an organization's success in the construction industry depends on providing the necessary equipment, materials, and labor for a project. Similarly, having a well-established infrastructure network like rail, road, and telecom leads to the easy transfer of goods and services, expanding the country's economy and industry. Efficient rail, road, and telecom infrastructure facilitates the smooth transportation of materials and personnel, which reduces time and cost and improves the supply chain. A growing GDP indicates a robust economy, typically resulting in increased investment in public and private construction projects. This economic growth creates an excellent environment for the construction industry, allowing it to grow and take on bigger and more challenging projects. The total variance explained by this factor is 9.701%.

Financial Opportunity and Industry Image (FOII): This factor covers three key attributes: availability of easy finance, the low interest rate on finance, and good industry image, collectively shaping the sector's attractiveness and growth potential. So, as per the factor loading, it is named "FOII." The ability to secure financing easily is essential for initiating and executing construction activities, enabling firms to manage cash flow, invest in necessary resources, and mitigate financial risks (Tripathi & Jha 2019). The sector's growth is facilitated by easy access to finance, which guarantees that projects can proceed without undue delays caused by financial constraints. A positive image for the construction industry is defined by good job prospects, company growth, and ethical practices crucial for attracting talent, investment, and business opportunities from stakeholders like potential employees, investors, and clients. Fox & Skitmore (2007) claim that demonstrating a positive image through improved practices and ethical behavior enhances the industry's ability to attract financial resources. Most research found that these contractors faced ongoing financial difficulties due to either exceptionally high interest rates from lenders or significant client payment delays (Fox & Skitmore 2007). The role of low-interest rates on financing is also significant since they lower the cost of capital, stimulate investment, and create an atmosphere favorable to economic growth. The total variance explained by this factor is 8.626%.

Favorable Government Policies (FGP): Government policies are decisive in shaping the construction industry's landscape. This factor includes favorable government policy supporting organizations' capacity building and a favorable taxation system applicable to the construction industry. A favorable taxation system for construction could involve tax incentives for infrastructure development, reduced rates for importing essential materials and equipment, or tax credits for projects that meet specific environmental or social criteria (Mengistu & Mahesh 2020). Such measures can significantly reduce the financial burden on construction projects, enhance their viability, and encourage industry growth by allowing more investment in quality and innovation. Fox & Skitmore (2007) highlight the need for governmental support for the construction industry in developing countries, where local contractors are frequently viewed as less competent and incapable, leading to the selection of foreign contractors for complex projects. They suggested that to strengthen private sector organizations, the government should implement strategic policies and supportive measures such as funding for technology upgrades, training programs to improve workforce skills, and incentives for adopting sustainable construction practices. This factor explained 7.776% of the total variance.

Regulatory and Skill Development (RSD): Navigating regulatory challenges and advancing skill development is pivotal for the industry's adaptability and compliance, fostering a safer and more innovative environment. This factor includes favorable rules and regulations and appropriate training and education. So, as per the factor loading, it is named "RSD." Favorable rules and regulations are those that not only ensure safety, quality, and environmental protection but also facilitate project approval processes, land acquisition, and the procurement of materials and labor (Sawhney et al. 2014). A supportive regulatory framework can significantly reduce bureaucratic hurdles and project delays, enhancing construction projects' overall efficiency and success rate. Appropriate training and education in technical skills, project management, sustainability, and safety are critical for meeting complex construction project demands. According to Loganathan et al. (2017), emphasizing practical learning and training in lean construction and Building Information Model (BIM) technologies enhances workforce capabilities, ensuring innovation, quality, and efficiency in project implementation, thereby driving industry success. This factor explained 7.648 % of the total variance.

Market Attractiveness and Collaboration (MAC): This factor, known as "MAC," is defined by two key attributes: favorable market conditions and collaborative culture in the industry, i.e., relationships among key stakeholders. This factor explained 7.357% of the total variance. Several factors can contribute to favorable market conditions, including a strong economy, high demand for construction, easy access to financing, and supportive government policies. Projects thriving in favorable market conditions will likely attract resources and investment, boosting their success rate. The industry's success depends on solid relationships between suppliers, clients, contractors, and government bodies. A collaborative culture within the industry enhances effective communication, problem-solving, and innovation, all essential for construction projects to run efficiently and effectively. To achieve better project outcomes, stakeholders must foster a spirit of partnership and mutual respect. This collaborative approach enables them to navigate challenges more efficiently and work towards shared goals.

Socio-economic Stability (SES): Under this factor, there are two success attributes: low fluctuation in the currency exchange rate and positive impact on society. So, as per the factor loading, it is named "SES." Currency stability is vital for managing the costs of imported materials, equipment, and foreign labor in projects, ensuring predictable project costs, and aiding in accurate financial planning (Barajei et al. 2023). It is especially critical for long-term projects to mitigate financial risks caused by exchange rate volatility. Exchange rate stability, alongside the monetary and credit ratings of the host country, is vital for international stakeholders, influencing their firm's strategic decisions by signifying the regional investment environment's stability and indirectly indicating market and political stability (Gao et al. 2021). Prioritizing social impacts in construction projects can improve community relations and public welfare through community engagement, environmental sustainability, and workforce development; all benefit societal well-being while enhancing the industry's public image and contributing to socioeconomic growth. This factor explained 7.196 % of the total variance.

4.8 Performance factors:

This section explains four performance factors extracted using factor analysis.

Industry Competence and Societal Impact (ICSI): Under this factor, there are four performance attributes: qualified professionals in the industry, labour productivity, high annual construction demand/Market share and positive impact on society. So, as per the factor loading, it is named "ICSI." Qualified professionals significantly impact the construction industry's performance by enhancing project outcomes, efficiency, and innovation through adherence to best practices and advanced technologies. Ofori (2001) highlighted the importance of assessing qualified professionals in the construction industry, focusing on the categorization and specialization of professionals and technicians, including the annual output of graduates in these fields. According to Ofori (2001) in developing countries, despite a large workforce, construction labour productivity remains a critical concern. Labour productivity can be analyzed at various levels: the industry level (overall output per worker), the project level (duration required to complete a unit area of construction), and the level of individual trades (output per person for different tasks). Similarly, the annual demand in the construction sector serves as a crucial performance metric, particularly for developing countries, highlighting the industry's financial health and its ability to sustain itself over time (Chan 2009). However, organizations within the construction industry should act as responsible corporate entities adhering to regulatory and social norms, and fostering a positive ecosystem through eco-friendly practices (Chan & Hiap 2012). This factor explained 15.938 % of the total variance.

Profitability and Stakeholder Satisfaction (PSS): This factor, known as "PSS," is defined by three key attributes: profitability ratio (industry generating profit), annual growth rate of industry and stakeholder satisfaction. This factor explained 15.688 % of the total variance. According to Tripathi & Jha (2018*a*), profitability is the most important financial indicator for measuring the performance of an industry. Higher profitability indicates the industry's capacity to generate profit, which is a direct indicator of its financial health and operational efficiency. A strong profitability ratio indicates a healthy sector that can sustain operations, invest in growth, and deliver value to its stakeholders. The annual growth rate of the industry showcases its growth and highlights its capacity to adapt to market shifts and maintain a steady demand for its services. This growth rate is essential for drawing investments, generating jobs, and driving further progress in the sector. In the construction industry, stakeholder satisfaction serves as measuring performance. Prioritizing the interests of end users, developers, investors, and governments is key to long-term success. However, client dissatisfaction is a frequent issue. Addressing these concerns is critical for improving a company's reputation and value, as satisfaction across the project lifecycle significantly impacts the success of both projects and organizations.

Industry Attractiveness (IA): This factor encompasses the low staff turnover; employment opportunity in the construction industry; and safety (accident rate, fatality, etc.), each contributing to increase the sector's attractiveness.So as per the factor loading it is named Industry Attractiveness. Staff turnover is the rate at which employees leave the industry within a year. High turnover, is often caused by factors like poor working conditions, inadequate pay, insufficient benefits, and employee dissatisfaction. High Staff turnover incurs additional costs and time for hiring and training replacements. High Staff turnover reduces morale and increases stress among the remaining staff (Tripathi & Jha 2018*a*). A stable workforce is indicative of a positive working environment and job satisfaction, making the industry more appealing to potential employees. The availability of jobs and career prospects within the construction sector plays a vital role in its attractiveness. The promise of employment opportunities attracts talent and encourages career development within the industry. Safety measures, such as reducing accidents and fatalities, are crucial for the construction industry's appeal by ensuring regulatory compliance and enhancing worker well-being. Despite this, the sector struggles with health and safety issues, including illness, injury, and poor facilities, causing absenteeism and turnover, particularly in indian projects. Addressing these challenges requires increased owner accountability for fair wages, improved living and working conditions, awareness of worker compensation and insurance, and reform labour laws to safeguard worker welfare and dignity (Loganathan et al. 2017, Sawhney et al. 2014). Such improvements are vital for the industry's long-term sustainability and attractiveness. The total variance explained by this factor is 13.831 %.

Research and Development Strategy (RDS): Research and Development (R&D) play a crucial role in enhancing the performance of the construction industry. This factor includes construction research and development (innovative material, technique, number of patent registers, etc.) and technological development of industry. So, as per the factor loading, it is named "RDS." Technological developments like BIM have profoundly transformed the construction industry in terms of managing stakeholders, the design phase, and project scheduling and management, resulting in cost and time savings. The use of prefabricated, precast technologies, and automation has lowered both direct and indirect expenses while enhancing construction speed as well as quality, which is critical for developing industrial abilities and performance. The total variance explained by this factor is 12.609 %.

4.9 Critical success factors:

Stepwise regression analysis was utilized as the primary technique to determine the criticality of success factors identified through factor analysis against various performance factors. Factor scores for all the success and performance factors were calculated during the regression analysis. The performance factors (ICSI to RDS) were taken one at a time as dependent variables, and the success factors (CW to SES) all together as independent variables. Table 4.11 shows the results of the regression analysis.

The study shows that the success factors - CW, IED, FOII, and MAC are critical for the performance factor – ICSI, which includes performance attributes such as 1) Qualified professionals in the industry, 2) Labour productivity, 3) High annual market demand/Market share, 4) Positive impact on society. The beta value of CW ($\beta = 0.322$) is the highest when compared to the other success factors, IED ($\beta = 0.284$), FOII ($\beta = 0.200$), and MAC ($\beta = 0.191$), indicating that CW is the more critical for ICSI.

According to the findings, the success factors - MAC and CW are critical for the performance factor PSS, which includes performance attributes such as 1) High profitability ratio (Industry generating profit), 2) Annual growth rate of the industry, and 3) Stakeholder satisfaction. Compared to CW ($\beta = 0.225$), the beta value of MAC ($\beta = 0.310$) is high, indicating that MAC is more critical for PSS.

The results of the study show that the success factors - SES and CW are critical for the performance factor IA, which includes performance attributes such as 1) Low staff turnover, 2) Employment opportunity in the Construction industry, and 3) Safety (Accident rate, Fatality, etc.). Compared to SES ($\beta = 0.239$), the beta value of CW ($\beta = 0.218$) is low, indicating that SES is more critical for IA.

According to the findings, the success factor - IED is critical for the performance factor RDS, which includes performance attributes such as 1) Construction research and development (Innovative material, Technique, number of patents registered, etc) and 2) Technological Development of industry. The factor IED ($\beta = 0.245$) indicates that it is critical for RDS.

The regression analysis revealed that FGP did not emerge as critical to any performance factors. These findings are depicted in Table 4.12, where the success factors are

Table 4.11: Stepwise Regression Analysis Results

Performance Factor (Dependent)	**Success Factor (Independent)**	**B (Unstandardised Coefficients)**	**Std. Error**	**T-Value**	**Standardized β Coefficients**	**Sig. (p)**	**R^2/Adjusted R^2**
Industry Competence and Societal Impact (ICSI)	Constant	0.000	0.077	0.000	0.000	1.000	0.261/0.237; Durbin-Watson = 1.927
	Competent Workforce (CW)	0.322	0.077	4.175	0.322	0.000	
	Infrastructure and Economic Development (IED)	0.284	0.077	3.672	0.284	0.000	
	Financial Opportunity and Industry Image (FOII)	0.200	0.077	2.587	0.200	0.011	
	Regulatory and Skill Development (RSD)	0.191	0.077	2.479	0.191	0.015	
Profitability and Stakeholder Satisfaction (PSS)	Constant	0.000	0.082	0.000	0.000	1.000	0.147/0.133; Durbin-Watson = 1.601
	Market Attractiveness and Collaboration (MAC)	0.310	0.082	3.772	0.310	0.000	
Industry Attractiveness (IA)	Constant	0.000	0.084	0.000	0.000	1.000	0.105/0.090; Durbin-Watson = 2.037
	Socio-economic Stability (SES)	0.239	0.084	2.838	0.239	0.005	
	Competent Workforce (CW)	0.218	0.084	2.582	0.218	0.011	
Research and Development Strategy (RDS)	Constant	0.000	0.086	0.000	0.000	1.000	0.060/0.053; Durbin-Watson = 1.963
	Infrastructure and Economic Development (IED)	0.245	0.086	2.846	0.245	0.005	

positioned along the horizontal axis and the performance factors on the vertical axis. Tick marks on the chart denote a statistically significant correlation between success and performance factors. In contrast, blank spaces signify an absence of a significant relationship between the success factors and performance factors.

From Table 4.12, it is clear that the success factor CW affected as many as three performance factors- ICSI, PSS, and IA; hence, it can be considered the most critical success factor for the overall success of the construction industry. IED was the second most critical success factor, which affected two performance factors- ICSI and RDS.

Table 4.12: Tick mark of Critical Success Factors

	CW	IED	FOII	FGP	RSD	MAC	SES
Industry competence & societal impact (ICSI)	✓	✓	✓		✓		
Profitability and stakeholder satisfaction (PSS)	✓					✓	
Industry attractiveness (IA)	✓						✓
Research and development strategy (RDS)		✓					

4.10 Summary:

This chapter systematically analyzed the success and performance attributes in the construction industry using data from Stage-1 questionnaires. Statistical methodologies, including descriptive analysis, SRCC, and one-sample T-test, were employed. Factor analysis identified key success and performance factors: Competent workforce, Infrastructure and economic development, Financial opportunity and industry image, Favorable government policies, Regulatory and skill development, Market attractiveness and collaboration, and Socio-economic stability. These performance factors encompass industry competence and societal impact, profitability and stakeholder satisfaction, industry attractiveness, and research and development strategies.

Stepwise regression analysis was employed to identify CSFs for the construction industry. This analysis clarified how these success factors influence different performance metrics. For example, a competent workforce emerged as a critical element influencing several performance factors, highlighting the importance of skilled personnel in driving industry competence and societal impact. Similarly, Infrastructure and Economic Development supported research and development strategies, highlighting the interdependencies between infrastructure, economic growth, and innovation in construction.

Chapter 5

Assessing Success and Performance Factors using Structural Equation Modeling (SEM)

5.1 Introduction:

This chapter explores the relationships between success and the performance factors in the construction industry using SEM. The primary objective is to test the hypothesis that success factors significantly influence the success of construction industry.

The objectives outlined in this chapter are presented below:

- To test the hypothesis that success factors significantly influence the success of construction industry.
- To investigate the relative impact of the success factors in the success of the construction industry measured against various performance factors.

5.2 Overview of SEM:

SEM has emerged as one of the most valuable statistical analysis methods in the social sciences over the past few decades (Sinesilassie et al. 2019). SEM is a comprehensive technique that simultaneously examines and analyzes the interdependent relationships among measured variables (independent variables or observed variables) and constructs (dependent variables or latent variables) (Alaloul et al. 2020, Sinesilassie et al. 2019).

Data from observed variables is directly measured, while data from latent variables is not directly observed and must be represented through models based on the observed variables (Chen, Chen, Sheng Lu & Liu 2012). SEM integrates parts of CFA as a measurement model with regression or path analysis into the structural model (Sinesilassie et al. 2019). While the structural model develops a relationship between latent variables, A measurement model evaluates he validity and reliability of observed variables in relation to latent variables (Tripathi & Jha 2018*c*). The maximum likelihood technique is the method commonly employed to determine the covariance in SEM.

There are two primary approaches to SEM: covariance-based structural equation modeling (CB-SEM) and variance-based structural equation modeling (VB-SEM). Typically, CB-SEM is performed using Analysis of Moment Structures software (AMOS), while VB-SEM is performed using the PLS algorithm (Gao et al. 2021, Tripathi & Jha 2018*c*). CB-SEM is based on the covariance matrices that describe the connection between observed and latent variables and validate the model's theoretical assumptions. On the other hand, VB-SEM determines the relationships among latent variables by quantifying the variance explained. The primary objective of CB-SEM is to validate theories by evaluating the model's ability to calculate the covariance matrix from the sample data, whereas VB-SEM operates similarly to multiple regression analysis (Tripathi & Jha 2018*c*).

Due to the previously mentioned advantages, SEM has been particularly well-suited and widely used in various domains of construction engineering and management research. Examples include studying the relationships among success variables in construction partnering (Chen, Chen, Sheng Lu & Liu 2012), identifying CSFs for small and medium-sized enterprises (Al-Tit et al. 2019), examining success factors for construction organizations (Tripathi & Jha 2018*c*), analyzing performance factors for construction organizations (Tripathi et al. 2020), exploring critical factors affecting contractors' coopetition relationships (Gao et al. 2021), investigating the interrelationships among CSFs of construction projects (Chen, Zhang, Liu & Mo 2012), assessing success factors for public construction projects (Sinesilassie et al. 2019), understanding disputes in construction contracts (Molenaar et al. 2000), and evaluating construction project performance based on coordination factors (Alaloul et al. 2020). The literature study highlights the wide range of applications for SEM. In addition to its advantages and adaptability in investigating relationships across several domains, SEM facilitates the visual and systematic identification of complex relationships. It is especially useful for understanding performance processes, making SEM an excellent tool for identifying the underlying relationships between critical factors (Sinesilassie et al. 2019).

In this research, success attributes previously identified in Chapter 4 were organized into seven latent success factors. These success factors were subsequently combined to explain the success of the construction industry. Likewise, performance attributes previously identified in Chapter 4 were also categorized into four latent performance factors, which were then used to measure the success of the construction industry.

5.3 Need for SEM:

Even though standardized multivariate regression analysis methods have proven to be highly valuable in the past, they possess a significant drawback. These fundamental regression methods assume that the independent variables are measured without error, which is typically not the case. For instance, some variables are not directly measurable and are usually assessed using surrogate variables. However, since these surrogate variables may not accurately measure the primary variable of interest, leading to technical issues in model estimation and reducing the capacity to perform statistical inference with a standard regression model.(Molenaar et al. 2000)

SEM can be viewed as an advanced form of standard regression modeling that is specifically designed to address the issue of poorly measured independent variables. SEM effectively handles measurement errors and allows for the accurate estimation of relationships between latent variables and observed variables, providing a more reliable and comprehensive analytical framework (Molenaar et al. 2000).

5.4 Sample size for SEM:

A crucial decision prior to data collection and analysis is determining a suitable sample size for testing the proposed model. It is generally advised to have a sample size of at least 100 to ensure reliable results. However, a sample size of 200 is recommended, as smaller sample sizes increase the risk of non-normality, thereby potentially compromising the accuracy of the results (Xiong et al. 2015). According to Tripathi & Jha (2018*c*), an adequate and appropriate sample size for SEM falls within the range of 100 to 400. Therefore, the sample size of 129 used in the present study can be considered sufficient.

5.5 Development of Hypothesis Model:

After grouping the attributes, a model was developed to investigate the relationship between success factors and the performance factors of the construction industry, as illustrated in Figure 5.1. The proposed model was analyzed using AMOS 21 software, which supports CB-SEM. For this investigation, the maximum likelihood estimate approach was used (Tripathi & Jha 2018*c*). The dependent variables, or latent variables, or factors are represented by ellipses in the proposed model, the measurement errors are represented by circles, and the independent variables, or observed variables or attributes are represented by rectangles. The arrows indicate the direction of the effect. The directional arrow from "CW" to "SA-16" suggests that the success attribute "SA-16" influences the success factor "CW". The numbers above the arrows leading to the latent variables represent path coefficients, while the numbers above the arrows that start from latent variables and end at observed variables denote factor loading's.

Based on the research model, the hypothesis asserting that success factors exert a significant positive impact on the performance of the construction industry was evaluated using the following hypotheses:

- **Null Hypothesis (H_0)**: The path coefficient linking success factors to the success of the construction industry is not significantly different from zero.
- **Alternative Hypothesis (H_a)**: Success factors significantly and positively influence the performance of construction industry.

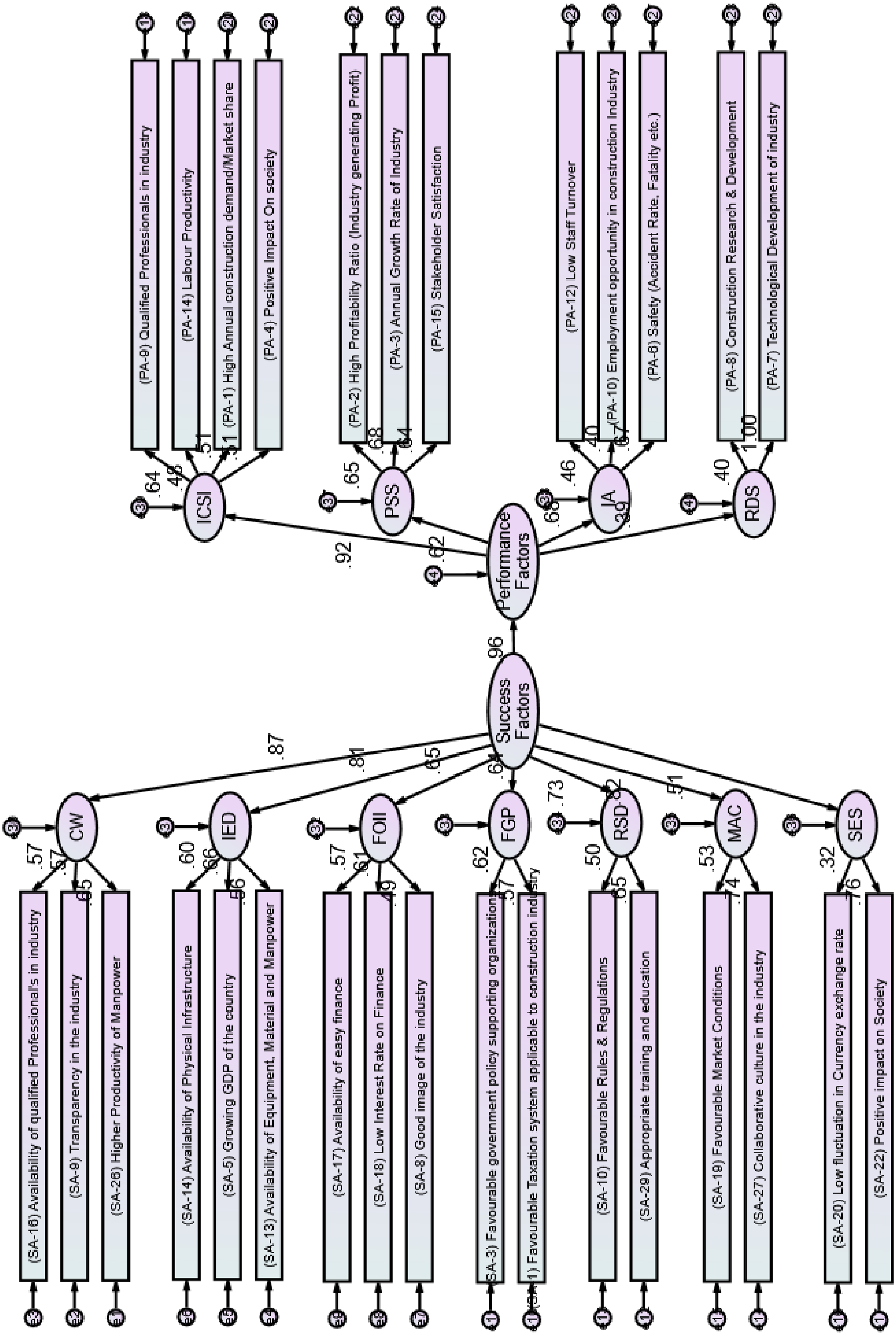

Figure 5.1: Hypothesis model of the study

5.6 Validation of Hypothesis Model:

The appropriateness of the SEM is assessed by examining the results from the covariance structural analysis, as indicated by the goodness-of-fit (GOF) indices. If the SEM is found to be inappropriate, it necessitates further development and revision to enhance its fit (Chen, Zhang, Liu & Mo 2012). Various researchers working on SEM have suggested different criteria for evaluating the GOF of specified models. These GOF indices assess the suitability of a model from diverse perspectives (Tripathi & Jha 2018*c*). For this study, a selection of GOF measures was chosen from those available in the SEM literature to validate the hypothesized relationships between success factors and the performance of the construction industry (Chen, Zhang, Liu & Mo 2012, Tripathi & Jha 2018*c*, Sinesilassie et al. 2019, Chen, Chen, Sheng Lu & Liu 2012, Gao et al. 2021).

- The **chi-square to degrees of freedom ratio** (χ^2/**df**) is an index used to compare the observed covariance matrix to the covariance matrix estimated under the assumption that the proposed model is correct (Chen, Zhang, Liu & Mo 2012).

- The **Tucker-Lewis Index (TLI)**, also known as the non-normal fit index (NNFI), accounts for the relationship between the complexity of the model and the sample size (Sinesilassie et al. 2019).

- The **Comparative Fit Index (CFI)** measures the proportional improvement in fit by comparing the hypothesized model to a baseline model. This index is adjusted for sample size, ensuring reliable performance even with smaller datasets (Chen, Zhang, Liu & Mo 2012).

- The **Goodness of Fit Index (GFI)** is an absolute fit index that shows the extent to which the proposed model fit with the observed data. This index is influenced by sample size, with values ranging from 0 to 1, and tends to increase as the sample size grows (Tripathi & Jha 2018*c*).

- The **Root-Mean-Square Error of Approximation (RMSEA)** measures the difference between the observed and the estimated covariance matrices versus the unit degree of freedom (Chen, Zhang, Liu & Mo 2012).

- The **Incremental Fit Index (IFI)** evaluates the improvement in fit of a tested model by comparing its chi-square value to that of a hypothesized baseline model, indicating the relative enhancement in model fit (Tripathi & Jha 2018*c*).

- The **Expected Cross-Validation Index (ECVI)** is used to assess the stability and reliability of a model's outcomes by evaluating its predictive accuracy across different samples (Sinesilassie et al. 2019).

The recommended level of these measures is given in Table 5.1 (Tripathi & Jha 2018*c*, Molenaar et al. 2000, Chen, Zhang, Liu & Mo 2012, Sinesilassie et al. 2019, Gao et al. 2021)

Table 5.1: Goodness of fit measures for the hypothesized and revised models

Sr no.	**Goodness of Fit Measure (GOF)**	**Recommended Level of GOF Measures**	**Values in Hypothesized Model**	**Values in Revised Model**
1	Chi-square/degree of freedom (χ^2/df)	1 to 2	1.356	1.396
2	Goodness of Fit Index (GFI)	0 (no fit) to 1 (perfect fit)	0.792	0.799
3	Incremental Fit Index (IFI)	0 (no fit) to 1 (perfect fit)	0.833	0.830
4	Tucker-Lewis Index (TLI)	0 (no fit) to 1 (perfect fit)	0.804	0.799
5	Comparative Fit Index (CFI)	0 (no fit) to 1 (perfect fit)	0.824	0.821
6	Root Mean Square Error of Approximation (RMSEA)	$<$0.05 (very good) to 0.1 (threshold)	0.053	0.056
7	Expected Crossvalidation Index (ECVI)	Lower value is better fit	4.953	4.428

Table 5.1 presents the GOF measures for the hypothesized model. The values obtained $\chi^2/\text{df} = 1.356$, GFI = 0.792, IFI = 0.833, TLI = 0.804, CFI = 0.824, RMSEA = 0.053, and ECVI = 4.953 suggest that the hypothesized model was not entirely adequate for explaining the interrelationships between success and performance factors. Consequently, the model was revised.

Typically, two approaches are employed to modify a model. The first approach involves eliminating paths with weak causal relationships, such as those with low path coefficients or factor loadings. The second approach adds causal relationships to strengthen the model (Molenaar et al. 2000, Tripathi & Jha 2018*c*, Chen, Zhang, Liu & Mo 2012).

In this study, the first approach was utilized. The initial hypothesized model underwent multiple revisions, adjusting it each time to improve its alignment with both the GOF metrics and theoretical expectations until satisfactory results were achieved (Tripathi & Jha 2018*c*).

5.7 Results of SEM:

RDS was removed from the analysis due to a low path coefficient to get the better fit model. The final revised model is shown in Figure 5.2. Table 5.1 presents the GOF measures for the revise model. The values obtained χ^2/df = 1.396, GFI = 0.799, IFI = 0.830, TLI = 0.799, CFI = 0.821, RMSEA = 0.056, and ECVI = 4.4283 suggested that the revised model provides a better explanation of the interrelationships between success and performance factors. Consequently, this model is deemed suitable for interpretation.

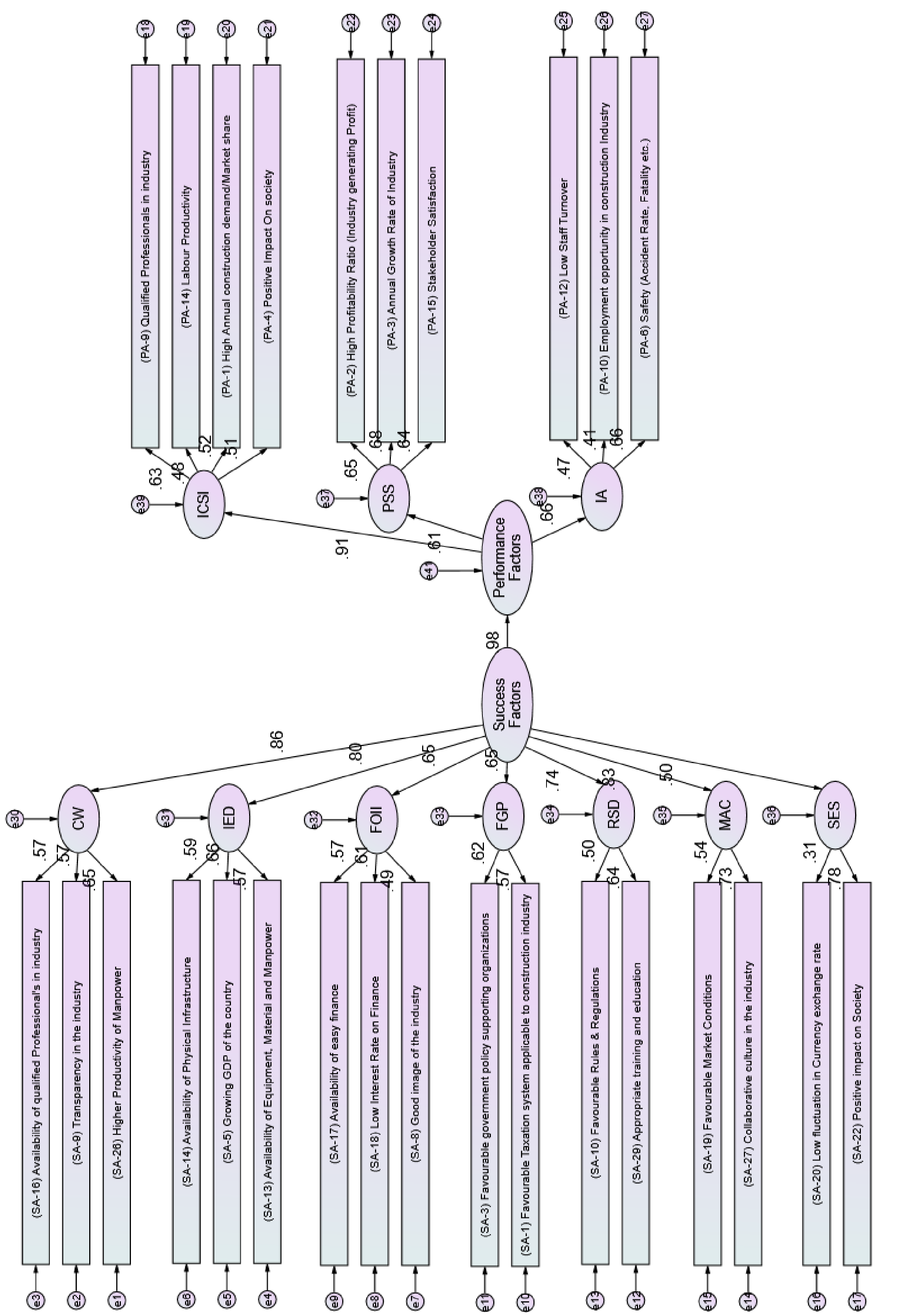

Figure 5.2: Revise model of the study

Table 5.2 presents the unstandardized path coefficients (USE), standardized path coefficients (SE), significance levels, standard errors, and t-values. All standardized path coefficients are positive and statistically significant, as indicated by t-values greater than 1.67, suggesting meaningful relationships. A larger path coefficient suggests a stronger influence of the attribute or factor as an indicator of success. Specifically, CW is identified as the most critical success factor with a path coefficient of 0.857, followed by MAC at 0.831, IED at 0.802, RSD at 0.739, FOII at 0.654, FGP at 0.650, and SES at 0.504. Additionally, ICSI, with a path coefficient of 0.915, IA at 0.662, and PSS at 0.612, are also significant performance factors. The hypothesis H_a, which posits that success factors significantly and positively impact the success of construction industry, is supported by the significant path coefficient of 0.976 at the 0.0001 significance level.

Table 5.2: Path coefficient for the Revised model

Paths	**USE (B)**	**SE (β)**	**Sig. (p)**	**Standard error (ϵ)**	**T-value**
Performance factors ← Success factors	0.549	0.976	0.001	0.170	3.233
CW ← Success factors	0.751	0.857	***	0.146	5.129
IED ← Success factors	0.636	0.802	***	0.142	4.484
FOII ← Success factors	0.448	0.654	***	0.129	3.489
FGP ← Success factors	0.645	0.650	***	0.178	3.620
RSD ← Success factors	0.797	0.739	***	0.178	4.472
MAC ← Success factors	1.000	0.831			
SES ← Success factors	0.598	0.504	***	0.158	3.796
ICSI ← Performance factors	1.486	0.915	0.001	0.461	3.226
PSS ← Performance factors	1.166	0.612	0.003	0.398	2.928
IA ← Performance factors	1.000	0.662			
(SA-26) Higher productivity of the workforce ← CW	1.000	0.653			
(SA-9) Transparency in the industry ← CW	1.063	0.574	***	0.213	5.003
(SA-16) Availability of qualified professionals in industry ← CW	0.862	0.568	***	0.174	4.968

Continued on next page

Table 5.2 Continued from previous page

Paths	USE (B)	SE (β)	Sig. (p)	Standard error (ϵ)	T-value
(SA-13) Availability of equipment, material, and workforce ← IED	1.000	0.571			
(SA-5) Growing GDP of the country ← IED	1.399	0.658	***	0.288	4.864
(SA-14) Availability of physical infrastructure such as rail, road, telecom, etc. ← IED	1.255	0.595	***	0.272	4.620
(SA-8) Good image of the industry in terms of employment, business opportunity ← FOII	1.000	0.488			
(SA-18) Low interest rate on finance ← FOII	1.383	0.609	***	0.378	3.660
(SA-17) Availability of easy finance ← FOII	1.059	0.566	***	0.295	3.588
(SA-1) Favorable taxation system applicable to the construction industry ← FGP	1.000	0.572			
(SA-3) Favorable government policy supporting capacity building of organizations ← FGP	1.058	0.619	***	0.303	3.494
(SA-29) Appropriate training and education ← RSD	1.000	0.644			
(SA-10) Favorable rules and regulations ← RSD	0.753	0.505	***	0.207	3.641
(SA-27) Collaborative culture in the industry, relation among stakeholders ← MAC	1.000	0.729			
(SA-19) Favorable market conditions ← MAC	0.665	0.539	***	0.143	4.642
(SA-22) Positive impact on Society ← SES	1.000	0.777			
(SA-20) Low fluctuation in Currency exchange rate ← SES	0.495	0.312	0.099	0.300	1.649
(PA-9) Qualified professionals in industry ← ICSI	1.000	0.635			
(PA-14) Labour productivity ← ICSI	0.676	0.478	***	0.154	4.385

Continued on next page

Table 5.2 Continued from previous page

Paths	**USE (B)**	**SE (β)**	**Sig. (p)**	**Standard error (ϵ)**	**T-value**
(PA-1) High annual construction demand/Marketshare ← ICSI	0.835	0.521	***	0.178	4.702
(PA-4) Positive impact on society ← ICSI	0.973	0.510	***	0.211	4.620
(PA-2) High profitability ratio (Industry generating profit) ← PSS	1.000	0.655			
(PA-3) Annual growth rate of industry ← PSS	0.885	0.682	***	0.169	5.227
(PA-15) Stakeholder satisfaction ← PSS	1.064	0.640	***	0.208	5.108
(PA-12) Low staff turnover ← IA	1.000	0.468			
(PA-10) Employment opportunity in construction industry ← IA	0.696	0.406	0.004	0.240	2.901
(PA-6) Safety (Accident rate, Fatality, etc.) ← IA	1.419	0.657	***	0.416	3.410

5.8 Summary:

This chapter evaluates the hypothesis that success factors significantly impact the performance of the construction industry. The hypothesis positing that success factors have a considerable positive effect on industry success is supported by a path coefficient of 0.98, which is statistically significant at the 0.01 level.

The final SEM model reveals that the competent workforce, market attractiveness and collaboration, infrastructure and economic development, regulatory and skill development, financial opportunity and industry image, favorable government policies, and socio-economic stability. Additionally, industry competence and societal impact, industry attractiveness, and profitability and stakeholder satisfaction are the significant performance factors. These success factors directly impact the construction industry's success, whereas the success attributes indirectly influence it through these factors.

Chapter 6

Analysis of Success and Performance Factors through Fuzzy Synthesis Evaluation

6.1 Introduction:

The chapter explores the application of FSE in assessing key success and performance factors within the construction industry. Utilizing survey data from industry experts, the methodology calculates weightings for success attributes and performance factors. These weightings are crucial as they determine the relative importance of each attribute and factor. These weighted factors are integrated into the FSE model to develop the Construction Industry Success Index (CISI) and Construction Industry Performance Index (CIPI).

The objectives outlined in this chapter are presented below:

- To develop a success and performance model using the fuzzy synthetic evaluation (FSE) approach.

6.2 Overview of Fuzzy Synthesis Evaluation:

FSE is a technique based on fuzzy set theory that has been developed and widely used in a variety of disciplines to handle complex, multi-level evaluations involving multiple criteria and attributes (Deng et al., 2021; Wuni et al., 2022). It is especially well-suited for decision-making processes that involve the assessment of multiple attributes, making it an effective tool for quantifying various judgments in a variety of areas (Xu et al., 2010).

Evaluation of success and performance attributes by professionals involves the use of linguistic variables, where 1 indicates a very low effect and 5 signifies a very high effect for success attributes, and 1 indicates a very low importance and 5 signifies a very high importance for performance attributes. This form of assessment is inherently subjective and prone to uncertainties. Given that the evaluation depends on professionals judgment, it exhibits a fuzzy nature. Research has shown that fuzzy set theory is particularly well-suited for analyzing data marked by such fuzziness. Therefore, this study applied FSE to examine the key success and performance factors within the construction industry. FSE, as a component of fuzzy set theory, employs weightings and membership functions to facilitate an objective evaluation of the professionals judgments.

Based on the results of the factor analysis, three levels of FSE for key success and performance factors in the construction industry are derived. At the third level, the evaluation focuses on the criticality of success and performance attributes within each respective factor. The second level assesses the criticality of the success and performance factors themselves. The overall success and performance index (first level) for the construction industry is then calculated based on the criticality assessments of the individual success and performance factors. This method represents a multi-factor and multi-level FSE of the key success and performance factors for construction industry. The systematic execution of this multi-level FSE is depicted in Figure 2.

FSE offers several advantages that make it particularly well-suited for construction engineering and management research. One of its primary strengths lies in its ability to handle the inherent uncertainty and subjectivity associated with assessing complex, multi-criteria decision-making problems. By converting qualitative judgments into quantitative values, FSE provides a structured and systematic approach to evaluate various factors simultaneously. Additionally, FSE's flexibility and adaptability make it applicable across diverse contexts, including comprehensive risk assessment models for green building projects (Nguyen & Macchion 2023), risk assessment in Singapore's green projects (Zhao et al. 2016), and risk exposure assessments for infrastructure mega-projects (Chan et al. 2018). FSE has also been applied in evaluating operational management success factors for PPP infrastructure projects (Osei-Kyei et al. 2017), financial risk management strategies for PPP projects in Ghana (Akomea-Frimpong et al. 2024), and critical success factors for PPP sustainability in China (Deng et al. 2021) and developing risk assessment models for PPP projects in China (Xu et al. 2010). Other applications include safety technology adoption decision-making tools (Nnaji et al. 2020), heritage building maintenance challenges (Adegoriola et al. 2023). Furthermore, FSE has been used for modeling and evaluating critical risk factors in modular integrated construction projects (Wuni, Shen, Osei-Kyei & Agyeman-Yeboah 2022, Wuni, Shen & Osei-Kyei 2022).

The literature review highlights the extensive applications of FSE in various domains. In this study, the FSE technique was utilized to determine the criticality of each success and performance factor within the construction industry. This approach was instrumental in developing the CISI and CIPI equation models. By focusing on CISI and CIPI, decision-makers can significantly improve the overall performance of the industry, ensuring a more comprehensive and effective evaluation process.

6.3 Steps of Fuzzy Synthesis Evaluation:

Step 1: Determining weighting functions for success and performance factors and their attributes:

According to Akomea-Frimpong et al. (2024) and Wuni, Shen, Osei-Kyei & Agyeman-Yeboah (2022) state that the overall effectiveness of the FSE model depends heavily on the accuracy of the weightings allocated to each success attribute and factors for the construction industry. There are multiple methods available for precisely computing the weightings from survey data gathered using a Likert scale, including the tabulated judgment method, direct point allocation, unit weighting, analytic hierarchy process, and normalized mean approach (Akomea-Frimpong et al., 2024; Wuni et al., 2022).

This research adheres to the recommendations set forth by Akomea-Frimpong et al. (2024) by employing the mean value approach, which utilizes the overall mean value. This methodology was selected for its ability to transform and enhance the stability of test data and the model. The weightings for the success attributes and factors were determined according to Equation (6.1).

$$w_i = \frac{MV_i}{\sum_{i=1}^{5} MV_i}, \quad 0 < w_i < 1, \quad \sum_{i=1}^{n} w_i = 1 \tag{6.1}$$

Where,

$$W_i = \text{The weighting function of each attribute and factor related to the success.}$$
$$MV_i = \text{The mean value of each attribute and factor related to the success.}$$
$$i = \text{Ranges from 1 to 5 based on the 5-point Likert scale}$$

A sample calculation for the weighting of success attribute is illustrated below. As indicated in Table 6.1, the mean value for SA-26 is 4.302, and the mean value for SF-1 is 12.651. The weighting for SA-26 is calculated using Equation (6.1). In a similar manner all other success attributes calculation was performed, with the results shown in Table 6.1.

$$w_{\text{SA-26}} = \frac{4.302}{4.302 + 4.248 + 4.101} = \frac{3.80}{12.651} \approx 0.340$$

A sample calculation for the weighting of success factor is illustrated below. As indicated in Table 6.1, the mean value for the success factors (SF1 = 12.651, SF2 = 12.574, SF3 = 12.248, SF4 = 7.682, SF5 = 8.093, SF6 = 7.744, and SF7 = 6.341) sum up to 67.333. The weighting for SF-1 is calculated using Equation (6.1). In same manner the calculation for all other success factors was performed with the results shown in Table 6.1.

$$w_{\text{SF-1}} = \frac{12.651}{12.651 + 12.574 + 12.248 + 7.682 + 8.093 + 7.744 + 6.341} = \frac{12.651}{67.333} \approx 0.188$$

The weighting function is given as follows:

$$W_i = \{w_1, w_2, w_3, w_4, \ldots, w_n\} \tag{6.2}$$

The normalized weighting function should satisfy the criteria specified in Equation (6.1) which is the sum of the normalized weightings for all the success attributes under each success factor should equal 1. For example, the normalized weighting function for SF-1 is given as follows:

$$\sum_{i=1}^{3} W_i = 0.340 + 0.336 + 0.324 = 1.000$$

This example demonstrates how the weighting functions are standardized to sum to one, ensuring they meet the defined requirements.

Similarly, the sum of normalized weightings function for the all the SFs should equal 1.The weightings for each attribute and factor provide the foundation for calibrating the membership functions in the subsequent section. For example, the normalized weighting function for SF-1 is given as follows:

$$\sum_{i=1}^{7} W_i = 0.188 + 0.187 + 0.182 + 0.114 + 0.120 + 0.115 + 0.094 = 1.000$$

Table 6.1: Mean Value and Weightage of success attributes and success factors

Id	Success attributes (SA)/Success factors (SF)	Mean value for SA	Mean value for SF	Weighting for each SA	Weighting for each SF
SF-1	**(CW) Competent workforce**	-	12.651	-	0.188
SA-26	Higher productivity of the workforce	4.302	-	0.340	-
SA-16	Availability of qualified professionals in the industry	4.248	-	0.336	-
SA-9	Transparency in the industry	4.101	-	0.324	-
SF-2	**(IED) Infrastructure and Economic Development**	-	12.574	-	0.187
SA-13	Availability of equipment, materials, and workforce	4.457	-	0.355	-
SA-14	Availability of physical infrastructure such as rail, road, telecom, etc.	4.140	-	0.329	-
SA-5	Growing GDP of the country	3.977	-	0.316	-
SF-3	**(FOII) Financial Opportunity and Industry Image**	-	12.248	-	0.182
SA-17	Availability of easy finance	4.357	-	0.356	-
SA-18	Low-interest rate on finance	4.031	-	0.329	-
SA-8	Good image of the industry in terms of employment opportunities, business opportunities, etc.	3.860	-	0.315	-
SF-4	**(FGP) Favorable Government Policies**	-	7.682	-	0.114

Continued on next page

Table 6.1 continued from previous page

Id	Success attributes (SA)/Success factors (SF)	Mean value for SA	Mean value for SF	Weighting for each SA	Weighting for each SF
SA-3	Favorable government policy in supporting capacity building of organizations	4.016	-	0.523	-
SA-1	Favorable taxation system applicable to the construction industry	3.667	-	0.477	-
SF-5	**(RSD) Regulatory and Skill Development**	-	8.093	-	0.120
SA-10	Favorable rules and regulations	4.047	-	0.500	-
SA-29	Appropriate training and education	4.047	-	0.500	-
SF-6	**(MAC) Market Attractiveness and Collaboration**	-	7.744	-	0.115
SA-19	Favorable market conditions	3.876	-	0.501	-
SA-27	Collaborative culture in the industry, i.e., relationships among key stakeholders	3.868	-	0.499	-
SF-7	**(SES) Socio-economic Stability**	-	6.341	-	0.094
SA-22	Positive impact on Society	3.713	-	0.586	-
SA-20	Low fluctuation in the currency exchange rate	2.628	-	0.414	-

Step 2: Deriving membership functions for success attributes and factors:

FSE employs grading alternatives to establish membership functions (MFs) for success attributes and success factors (Wuni, Shen & Osei-Kyei 2022). The MF for each success attribute is derived from the percentage responses of experts (Wuni, Shen, Osei-Kyei & Agyeman-Yeboah 2022). Based on the study's objectives, FSE membership functions are typically generated at two or three levels, demonstrating the process of first deriving an MF for a subset (Level 2) before developing one for the entire set (Level 1). In this study, Level 1 corresponds to the MF for success factors, while Level 2 pertains to the MF for success attributes. The MF for each success factor (Level 1) is subsequently derived from the MF of the success attribute (Level 2) within each respective factor grouping. The Level 2 MF is calculated from the distribution of expert responses using the previously described 5-point Likert scale, ranging from 1 ("very low effect") to 5 ("very high effect"). A membership function is a numerical value between 0 and 1, representing the degree to which an element belongs to a fuzzy set (Nnaji et al. 2020).

To calculate the MF for each success attribute, it is necessary to determine the percentage responses from experts using the 5-point Likert scale, defined as $E = (1, 2, 3, 4, 5)$, where E_1 represents very low effect (VLE), E_2 represents low effect (LE), E_3 represents moderate effect (ME), E_4 represents high effect (HE), and E_5 represents very high effect (VHE). Based on the expert's responses, the MF for each success attribute is computed as follows:

$$\text{MF}_{u_{in}} = \frac{X_{1u_{in}}}{E_1(1)} + \frac{X_{2u_{in}}}{E_2(2)} + \frac{X_{3u_{in}}}{E_3(3)} + \frac{X_{4u_{in}}}{E_4(4)} + \frac{X_{5u_{in}}}{E_5(5)} \tag{6.3}$$

In this equation, u_{in} denotes the nth success attribute in a given success factor. The variable $X_{ju_{in}}$ (where $j = 1, 2, 3, 4, 5$) denotes the percentage of experts who rated the effect of the success attributes with a grade j, which reflects the degree of membership. The term $\text{MF}_{u_{in}}$ represents the MF of a specific success attributes. The ratio $X_{ju_{in}}/E_j$ represents the relationship between the percentage response and its corresponding grade alternative. Using Equation 6.4, the MF for a specific success attributes can be expressed as follows:

$$\text{MF}_{u_{in}} = \left(X_{1u_{in}}, X_{2u_{in}}, X_{3u_{in}}, X_{4u_{in}}, X_{5u_{in}}\right) \tag{6.4}$$

The MFs were derived from the collective assessment of success attributes by the experts using Equation (5). For instance, the data analysis indicates that 0.00% of the experts rated “Higher productivity of workforce (SA-26)” as having a very low effect, 2% rated it as having a low effect, 10% rated it as having a moderate effect, 45% rated it as having a high effect, and 43% rated it as having a very high effect. Consequently, the membership function for SA-26 is computed as follows:

$$\text{MF}_{SA-26} = \frac{0.00}{\text{VLE (1)}} + \frac{0.02}{\text{LE (2)}} + \frac{0.10}{\text{ME (3)}} + \frac{0.45}{\text{HE (4)}} + \frac{0.43}{\text{VHE (5)}} \tag{6.5}$$

Thus, the membership function of CRF1 can be expressed otherwise as (0.00, 0.02, 0.10, 0.45, 0.43). The membership functions of the rest of the CRFs are computed using the same approach as shown in Table. The membership functions (Level 2) of the individual attributes form the basis for computing the membership functions (Level 1) of the success factors. However, the computations of the membership functions of the success factor require the fuzzy evaluation matrix.

$$R_i = \begin{bmatrix} \text{MF}_{u1} \\ \text{MF}_{u2} \\ \text{MF}_{u3} \\ \vdots \\ \text{MF}_{un} \end{bmatrix} = \begin{bmatrix} X1_{u11} & X2_{u11} & X3_{u11} & \cdots & Xn_{u11} \\ X1_{u12} & X2_{u12} & X3_{u12} & \cdots & Xn_{u12} \\ X1_{u13} & X2_{u13} & X3_{u13} & \cdots & Xn_{u13} \\ \vdots & \vdots & \vdots & \ddots & \vdots \\ X1_{uin} & X2_{uin} & X3_{uin} & \cdots & Xn_{uin} \end{bmatrix}$$

Table 6.2: Mean value and weightage of performance attributes and performance factors

Id	Performance attributes (PA)/Performance factors (PF)	Mean Value of PA	Total Mean Value of PF	Weightage of PA	Weightage of PF
PF-1	**(ICSI) Industry Competence and Societal Impact**	-	16.132	-	0.342
PA-9	Qualified professionals in the industry	4.264	-	0.264	-
PA-14	Labour productivity	4.070	-	0.252	-

Continued on next page

Table 6.2 continued from previous page

Id	Performance attributes (PA)/Performance factors (PF)	Mean Value of PA	Total Mean Value of PF	Weightage of PA	Weightage of PF
PA-1	High annual construction demand/Market share	4.047	-	0.251	-
PA-4	Positive impact on society	3.752	-	0.233	-
PF-2	**(PSS) Profitability and Stakeholder Satisfaction**	-	12.124	-	0.257
PA-2	High profitability ratio (Industry generating profit)	3.992	-	0.329	-
PA-3	Annual growth rate of industry	4.124	-	0.340	-
PA-15	Stakeholder satisfaction	4.008	-	0.331	-
PF-3	**(IA) Industry Attractiveness**	-	11.039	-	0.234
PA-12	Low staff turnover	3.140	-	0.284	-
PA-10	Employment opportunities in the construction industry	4.023	-	0.364	-
PA-6	Safety (Accident rate, Fatality, etc.)	3.876	-	0.351	-
PF-4	**(RDS) Research and Development Strategy**	-	7.814	-	0.166
PA-8	Construction Research & Development (Innovative material, Technique, number of patent registers, etc)	3.667	-	0.469	-
PA-7	Technological Development of Industry	4.147	-	0.531	-

Table 6.3: Membership Functions of the Performance Attributes and Performance Factors

Id	PA/PF	WA	MF of PA					MF of PF				
			1	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**
PF-1	(ICSI) Industry Competence and Societal Impact	-	-	-	-	-	-	0.00	0.03	0.20	0.46	0.31
PA-9	Qualified professionals in the industry	0.264	0.01	0.01	0.12	0.43	0.43	-	-	-	-	-
PA-14	Labour productivity	0.252	0.00	0.01	0.18	0.55	0.26	-	-	-	-	-
PA-1	High annual construction demand/Market share	0.251	0.00	0.01	0.26	0.42	0.32	-	-	-	-	-
PA-4	Positive impact on society	0.233	0.01	0.09	0.26	0.43	0.22	-	-	-	-	-
PF-2	(PSS) Profitability and Stakeholder Satisfaction	-	-	-	-	-	-	0.01	0.03	0.23	0.39	0.34
PA-2	High profitability ratio	0.329	0.01	0.02	0.26	0.38	0.33	-	-	-	-	-
PA-3	Annual growth rate of industry	0.340	0.00	0.02	0.17	0.49	0.33	-	-	-	-	-
PA-15	Stakeholder satisfaction	0.331	0.01	0.05	0.26	0.31	0.38	-	-	-	-	-
PF-3	(IA) Industry Attractiveness	-	-	-	-	-	-	0.02	0.09	0.29	0.37	0.24

Continued on next page

Table 6.3 continued from previous page

Id	PA/PF	WA	MF of PA					MF of PF				
			1	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**
PA-12	Low staff turnover	0.284	0.02	0.25	0.38	0.26	0.09	-	-	-	-	-
PA-10	Employment opportunities	0.364	0.00	0.01	0.26	0.43	0.30	-	-	-	-	-
PA-6	Safety (Accident rate, etc.)	0.351	0.03	0.04	0.24	0.40	0.29	-	-	-	-	-
PF-4	(RDS) Research and Development Strategy	-	-	-	-	-	-	0.00	0.04	0.27	0.40	0.28
PA-8	Construction Research and Development	0.469	0.00	0.09	0.37	0.33	0.21	-	-	-	-	-
PA-7	Technological Development of Industry	0.531	0.01	0.00	0.18	0.47	0.35	-	-	-	-	-

Step 4: Calculating the criticality index for success factors and overall criticality:

The criticality index for the success factors was calculated using the grade alternatives on the Likert scale used in the study, along with the membership function of the success and performance factors. The criticality index of the success and performance factors were derived using the following Equation 6.6.

$$\text{Criticality Index} = \sum_{i=1}^{5}(D_i * E_i) \tag{6.6}$$

Where Di denotes the fuzzy evaluation matrix of a given PSF and Ei denotes the grade alternatives of the 5-point rating scale. From Table 6.3, the following outcomes can be derived:

$$\begin{aligned}
\text{ICSI} &= (0.00, 0.03, 0.20, 0.46, 0.31), \\
\text{PSS} &= (0.01, 0.03, 0.23, 0.39, 0.34), \\
\text{IA} &= (0.02, 0.09, 0.29, 0.37, 0.24), \\
\text{RDS} &= (0.00, 0.04, 0.27, 0.40, 0.28)
\end{aligned}$$

Hence, the criticality index of the Performance factors are computed as follows:

$$\begin{aligned}
\text{ICSI} &= (0.00, 0.03, 0.20, 0.46, 0.31) \cdot (1, 2, 3, 4, 5) \\
&= (0.00 \cdot 1 + 0.03 \cdot 2 + 0.20 \cdot 3 + 0.46 \cdot 4 + 0.31 \cdot 5) \\
&= 0.00 + 0.06 + 0.60 + 1.84 + 1.55 = 4.05, \\
\text{PSS} &= (0.01, 0.03, 0.23, 0.39, 0.34) \cdot (1, 2, 3, 4, 5) \\
&= (0.01 \cdot 1 + 0.03 \cdot 2 + 0.23 \cdot 3 + 0.39 \cdot 4 + 0.34 \cdot 5) \\
&= 0.01 + 0.06 + 0.69 + 1.56 + 1.70 = 4.02, \\
\text{IA} &= (0.02, 0.09, 0.29, 0.37, 0.24) \cdot (1, 2, 3, 4, 5) \\
&= (0.02 \cdot 1 + 0.09 \cdot 2 + 0.29 \cdot 3 + 0.37 \cdot 4 + 0.24 \cdot 5) \\
&= 0.02 + 0.18 + 0.87 + 1.48 + 1.20 = 3.75, \\
\text{RDS} &= (0.00, 0.04, 0.27, 0.40, 0.28) \cdot (1, 2, 3, 4, 5) \\
&= (0.00 \cdot 1 + 0.04 \cdot 2 + 0.27 \cdot 3 + 0.40 \cdot 4 + 0.28 \cdot 5) \\
&= 0.00 + 0.08 + 0.81 + 1.60 + 1.40 = 3.89.
\end{aligned}$$

Sr No	Success Factors	Index	Criticality	Coefficients	Ranking
SF-1	Competent workforce	4.219	Very critical	0.154	1
SF-2	Infrastructure and Economic Development	4.201	Very critical	0.154	2
SF-3	Financial Opportunity and Industry Image	4.093	Very critical	0.150	3
SF-4	Favourable Government policies	3.849	Critical	0.141	6
SF-5	Regulatory and Skill Development	4.047	Very critical	0.148	4
SF-6	Market Attractiveness and collaboration	3.872	Critical	0.142	5
SF-7	Socio-economic Stability	3.078	Critical	0.112	7

Table 6.4: Success index for the construction industry

Sr No	Performance Factors	Index	Criticality	Coefficients	Ranking
PF-1	Industry Competence and Societal Impact	4.041	Very important	0.257	2
PF-2	Profitability and Stakeholder Satisfaction	4.042	Very important	0.257	1
PF-3	Industry Attractiveness	3.720	Important	0.237	4
PF-4	Research and Development Strategy	3.922	Important	0.249	3

Table 6.5: Performance index for the construction industry

Step 6: Developing the model for the construction industry success index (CISI):

To develop CISI model a linear additive approach was adopted. This study employed an additive model due to the lack of correlation between the attributes and among the factors, which is a fundamental prerequisite for linear models (Nnaji et al. 2020). Another reason for using a linear additive technique is because it is simple to understand and well-supported by the criticality index (Wuni, Shen, Osei-Kyei & Agyeman-Yeboah 2022). Additionally, previous research by Osei-Kyei & Chan (2017) and Wuni, Shen, Osei-Kyei & Agyeman-Yeboah (2022) used this methodology to develop a success index and risk assessment index utilizing FSE. Prior to the development of the CISI model, the criticality index for each success factor was normalized using an equation to derive their normalized weightings, ensuring that the sum of these weights equaled unity(Nnaji et al. 2020, Wuni, Shen, Osei-Kyei & Agyeman-Yeboah 2022). The calculations performed in step 5 gives the criticality index of CW, IED, FOII, FGP, RSD, MAC and SES are 4.219, 4.201, 4.093, 3.849, 4.047, 3.872 and 3.078 respectively. The co-efficient for each success factor was calculated using Equation 6.7

$$\text{Coefficient (CO)} = \frac{\text{Criticality index for each factor}}{\sum \text{Criticality index of all factors}} \tag{6.7}$$

The sample calculation of the co-efficient for CW is given below:

$$CO_{\text{CW}} = \frac{4.219}{4.219 + 4.201 + 4.093 + 3.849 + 4.407 + 3.872 + 3.078} = \frac{4.219}{27.358} \approx 0.154$$

Similarly, the co-efficient for each success factor was calculated as follows:

$$CO_{\text{IED}} = \frac{4.201}{27.358} \approx 0.154, \qquad CO_{\text{FOII}} = \frac{4.093}{27.358} \approx 0.150,$$
$$CO_{\text{FGP}} = \frac{3.849}{27.358} \approx 0.141, \qquad CO_{\text{RSD}} = \frac{4.047}{27.358} \approx 0.148,$$
$$CO_{\text{MAC}} = \frac{3.872}{27.358} \approx 0.142, \qquad CO_{\text{SES}} = \frac{3.078}{27.358} \approx 0.112$$

After get the co-efficient of each success factor the below given Equation 6.8 was prepared and used for the development of the model.

$$\begin{aligned} \text{SI} = {} & CO_{\text{CW}} \times \text{Value of CW} + CO_{\text{IED}} \times \text{Value of IED} \\ & + CO_{\text{FOII}} \times \text{Value of FOII} + CO_{\text{FGP}} \times \text{Value of FGP} \\ & + CO_{\text{RSD}} \times \text{Value of RSD} + CO_{\text{MAC}} \times \text{Value of MAC} \\ & + CO_{\text{SES}} \times \text{Value of SES} \end{aligned} \tag{6.8}$$

Using Equation 6.8, the linear additive model for the CISI for the construction industry was prepared and is presented below:

$$
\begin{aligned}
\text{Success Index (SI)} = {} & 0.154 \times (\text{Competent workforce}) + \\
& 0.154 \times (\text{Infrastructure and Economic Development}) + \\
& 0.150 \times (\text{Financial Opportunity and Industry Image}) + \\
& 0.141 \times (\text{Favourable Government Policies}) + \\
& 0.148 \times (\text{Regulatory and Skill Development}) + \\
& 0.142 \times (\text{Market Attractiveness and Collaboration}) + \\
& 0.112 \times (\text{Socio-economic Stability})
\end{aligned}
$$

Step 7: Developing the Construction Industry Performance Index (CIPI) Similar to step 6, the development of the CIPI model adopted a linear additive approach. Prior to the development of the CIPI model, the criticality index for each performance factor was normalized using an equation to derive their normalized weightings, ensuring that the sum of these weights equaled unity (Nnaji et al. 2020, Wuni, Shen, Osei-Kyei & Agyeman-Yeboah 2022). The calculations performed in step 5 gives the criticality index of ICSI, PSS, IA and RDS are 4.041, 4.042, 3.720 and 3.922 respectively. Similarly the co-efficient for each performance factor was calculated using Equation 6.7. The sample calculation of the co-efficient for ICSI is given below:

$$CO_{\text{ICSI}} = \frac{4.041}{4.041 + 4.042 + 3.720 + 3.922} = \frac{4.041}{15.725} \approx 0.257$$

Similarly, the co-efficient for each performance factor was calculated as follows:

$$CO_{\text{PSS}} = \frac{4.042}{15.725} \approx 0.257, \qquad CO_{\text{IA}} = \frac{3.720}{15.725} \approx 0.237,$$
$$CO_{\text{RDS}} = \frac{3.922}{15.725} \approx 0.249$$

After get the co-efficient of each performance factor the below given Equation 6.9 was used for the development of the model.

$$
\begin{aligned}
\text{Performance Index (PI)} = {} & 0.257 \times (\text{Industry Competence and Societal Impact}) + \\
& 0.257 \times (\text{Profitability and Stakeholder Satisfaction}) + \\
& 0.237 \times (\text{Industry Attractiveness}) + \\
& 0.249 \times (\text{Research and Development Strategy})
\end{aligned}
\tag{6.9}
$$

Chapter 7

Applying Consistent Fuzzy Preference Relations (CFPR) for Evaluating Success and Performance

7.1 Introduction

The objectives outlined in this chapter are presented below:

- To assign relative weights to the attributes and factors that contribute to the success of the construction industry.
- To assign relative weights to the attributes and factors that contribute to the performance of the construction industry.

7.2 Overview of Consistent Fuzzy Preference Relationship:

This research employs Consistent Fuzzy Preference Relations (CFPR), a methodological framework that has found application across diverse research domains. Notable applications include evaluating success factors in construction organizations (Tripathi & Jha 2018*b*), assessing quality of life through geometric Bonferroni mean (Alias et al. 2019), performance evaluation of construction organizations (Tripathi et al. 2021), and quality of life criteria assessment in Setiu Wetlands (Alias & Abdullah 2017). Further, CFPR has been effectively used in hazard assessment (Patel et al. 2016) and supplier selection processes (Chen & Chao 2012). The literature review reveals extensive utilization of CFPR across these studies underlines its broad applicability and validating its use in this research.

7.3 Need of second stage questionnaires:

The literature review reveals that numerous researchers have employed various statistical tools to identify and evaluate success and performance factors within the construction industry. Commonly used methods include simple statistical analysis (mean and standard deviation) (Barajei et al. 2023), RII (Datta et al. 2023), SMART (Arslan & Kivrak 2008), factor analysis (Mengistu & Mahesh 2020), regression analysis (Tripathi & Jha 2019), fuzzy synthesis (Adegoriola et al. 2023, Akomea-Frimpong et al. 2024), Delphi method (Sawhney et al. 2014), and SEM (Chen, Zhang, Liu & Mo 2012). Despite the extensive application of these methods, only a few studies (Tripathi & Jha 2018*b*, Tripathi et al. 2021, Patel et al. 2016) have made efforts to assign weights to these alternatives, highlighting a significant gap in the literature.

The existing methods primarily focus on ranking alternatives using statistical analyses like mean and standard deviation or RII is of limited value unless their relative weights are determined. These rankings merely indicate the order of preference among the alternatives but do not convey the degree of importance of one over the other. To gain a clearer understanding of the alternatives, it is crucial to evaluate their relative importance. Based on the success and performance factors identified through factor analysis, along with the associated attributes.

The use of CFPR for evaluating success and performance factors, along with their relative attributes, offers a promising avenue for addressing this gap. However, integrating CFPR with methodologies like mean and standard deviation, factor analysis, regression analysis, SEM, and fuzzy synthesis to create a comprehensive evaluation framework has not been fully realized. A second-stage questionnaire was developed, as detailed in the following section.

7.4 Development of questionnaires for second stage:

To evaluate the degree of importance of each success factor, performance factor, and their associated attributes, a second-stage questionnaire was designed. This questionnaire comprised six sections: 1) Section 1: Questions on success factors, 2) Section 2: Questions on success attributes, 3) Section 3: Questions on performance factors, 4) Section 4: Questions on performance attributes, 5) Section 5: Details of the respondent's organization, and 6) Section 6: Respondent's personal details. The questionnaire utilized in the second stage of the study is provided in Appendix B. Respondents were asked to indicate their preference for one criterion (factors/attributes) over another when comparing two criteria, using a nine-point scale. Below Table **??** shows the scale used for questionnaire survey (Tripathi & Jha 2018*b*, Tripathi et al. 2021).

1	Equally important
3	Slightly more important
5	Strongly more important
7	Very strongly more important
9	Most important
2, 4, 6, 8	Intermediate values between two adjacent judgments

Table 7.1: Relative Importance Scale

7.5 Sample selection:

The sample selection procedure for the second stage of the questionnaire survey was the same as in the first stage. Prior to the actual survey, a pilot survey was conducted to assess the questionnaire's wording and comprehension. Based on the feedback from the pilot survey, necessary adjustments were made. Since there were no major suggestions for improvement, the questionnaire was finalized for the main survey (Tabish & Jha 2011, Tripathi & Jha 2019).

The pilot survey involved three experts, each with over 20 years of experience in the construction industry. In total, 20 highly experienced construction professionals from 17 different construction organizations participated in the survey. The small sample size is not a significant concern for the application of the AHP methodology. All responses were collected through personal interviews.

7.6 Respondent profile:

In the second stage, 20 experienced construction professionals from 17 different construction organizations participated in the survey. All responses were collected through personal interviews. Of the 20 professionals, 8 (40%) were clients, 11 (55%) were contractors, and 1 (5%) was a project management consultant. The respondents had an average of 27 years of experience, while the participating organizations had an average age of 24 years.

Step 1: Forming multiplicative preference relation (MPR) matrix: Responses from experts in the construction industry were aggregated using Equation 7.1 to construct a multiplicative preference relation matrix $R = (r_{ij})$, where r_{ij} ranging from $\frac{1}{9}$ and 9 (Tripathi et al. 2021). The values of r_{ij} are derived from the geometric mean of the responses, as specified in the following equation (Patel et al. 2016, Tripathi et al. 2021, Tripathi & Jha 2018*b*):

$$r_{ij} = \left(r_{ij}^{1} \times r_{ij}^{2} \times \ldots \times r_{ij}^{m}\right)^{\frac{1}{m}}, \quad i, j \in \{1, 2, \ldots, n\} \tag{7.1}$$

Where "m" represents the total number of respondents, and r_{ij}^{m}, which denotes the dominance of the i-th factor or attribute over the j-th factor or attribute, is calculated based on the responses from each of the "m"-th respondents. For a set of n criteria (factors or attributes), only $n-1$ direct preferences are required, such as $r_{12}, r_{23}, \ldots, r_{(n-1)n}$, are needed and all diagonal elements are unity (Patel et al. 2016). The MPR matrix was constructed for both success and performance factors along with their respective attributes. The sample calculation of the element r_{12} of Table 7.2 is given below.

$$\begin{aligned} r_{12} &= (0.20 * 0.14 * 3.00 * 0.17 * 0.14 * 3.00 * 5.00 * 9.00 * 9.00 * 9.00 \\ &\quad *9.00 * 9.00 * 9.00 * 9.00 * 0.20 * 5.00 * 3.00 * 9.00 * 9.00 * 3.00)^{\frac{1}{20}} \\ &= 2.520 \end{aligned}$$

In a similar manner, the calculations for the remaining success factors and attributes were performed as shown from Table 7.2 to Table 7.9. The same procedure was applied to calculate the performance factors and attributes, as illustrated from Table 7.10 to Table 7.14.

Table 7.2: MPR matrix for success factors

Success factors	**CW**	**IED**	**FOII**	**FGP**	**RSD**	**MAC**	**SES**
(CW) Competent workforce	1.00	2.50					
(IED) Infrastructure and Economic Development		1.00	1.10				
(FOII) Financial Opportunity and Industry image			1.00	1.10			
(FGP) Favourable Government policies				1.00	1.62		
(RSD) Regulatory and Skill Development					1.00	1.50	
(MAC) Market Attractiveness and collaboration						1.00	1.20
(SES) Socio-economic Stability							1.00

Table 7.3: MPR matrix for attributes of CW

Success attributes of CW	**SA-16**	**SA-9**	**SA-26**
(SA-16) Availability of qualified professionals in the industry	1.00	2.22	
(SA-9) Transparency in the industry		1.00	0.71
(SA-26) Higher productivity of the workforce			1.00

Table 7.4: MPR matrix for attributes of IED

Success attributes of IED	**SA-14**	**SA-5**	**SA-13**
(SA-14) Availability of physical infrastructure such as rail, road, telecom, etc.	1.00	1.62	
(SA-5) Growing GDP of the country		1.00	0.25

Continued on next page

Table 7.4 continued from previous page

Success attributes of IED	**SA-14**	**SA-5**	**SA-13**
(SA-13) Availability of equipment, materials, and workforce			1.00

Table 7.5: MPR matrix for attributes of FOII

Success attributes of FOII	**SA-17**	**SA-18**	**SA-8**
(SA-17) Availability of easy finance	1.00	2.00	
(SA-18) A low interest rate on finance		1.00	1.50
(SA-8) Good image of the industry in terms of employment opportunities, business opportunities, etc.			1.00

Table 7.6: MPR matrix for attributes of FGP

Success attributes of FGP	**SA-3**	**SA-1**
(SA-3) Favorable government policy in supporting capacity building of organizations	1.00	2.97
(SA-1) Favorable taxation system applicable to the construction industry		1.00

Table 7.7: MPR matrix for attributes of RSD

Success attributes of RSD	**SA-10**	**SA-29**
(SA-10) Favorable rules and regulations	1.00	1.06
(SA-29) Appropriate training and education		1.00

Table 7.8: MPR matrix for attributes of MAC

Success attributes of MAC	**SA-19**	**SA-27**
(SA-19) Favorable market conditions	1.00	2.47

Continued on next page

Table 7.8 continued from previous page

Success attributes of MAC	**SA-19**	**SA-27**
(SA-27) Collaborative culture in the industry i.e. relationships among key stakeholders		1.00

Table 7.9: MPR matrix for attributes of SES

Success attributes of SES	**SA-20**	**SA-22**
(SA-20) Low fluctuation in the currency exchange rate	1.00	0.25
(SA-22) Positive impact on society		1.00

Table 7.10: MPR matrix for performance factors

Performance factors	**ICSI**	**PSS**	**IA**	**RDS**
(ICSI) Industry Competence and Societal Impact	1.00	2.10		
(PSS) Profitability and Stakeholder Satisfaction		1.00	1.80	
(IA) Industry Attractiveness			1.00	0.94
(RDS) Research and Development Strategy				1.00

Table 7.11: MPR matrix for ICSI

Performance Attributes of ICSI	**PA-9**	**PA-14**	**PA-1**	**PA-4**
(PA-9) Qualified professionals in the industry	1.00	1.33		
(PA-14) Labour productivity		1.00	0.57	
(PA-1) High annual construction demand/Market share			1.00	2.42
(PA-4) Positive impact on society				1.00

Table 7.12: MPR matrix for performance attributes of PSS

Performance attributes of PSS	**PA-2**	**PA-3**	**PA-15**
(PA-2) High profitability ratio (Industry generating profit)	1.00	0.75	
(PA-3) Annual growth rate of industry		1.00	1.19
(PA-15) Stakeholder satisfaction			1.00

Table 7.13: MPR matrix for performance attributes of IA

Performance attributes of IA	**PA-12**	**PA-10**	**PA-6**
(PA-12) Low staff turnover	1.00	0.33	
(PA-10) Employment opportunities in the construction industry		1.00	0.40
(PA-6) Safety (Accident rate, Fatality, etc.)			1.00

Table 7.14: MPR matrix for performance attributes of RDS

Performance Attributes of RDS	**PA-8**	**PA-7**
(PA-8) Construction Research & Development (Innovative material, Technique number, Patent registers, etc.)	1.00	1.85
(PA-7) Technological Development of Industry		1.00

Step 2: Converting multiplicative preference relation (MPR) matrix into fuzzy preference relation (FPR) matrix:

The transformation of the MPR matrix to a FPR matrix $P = [p_{ij}]$, where p_{ij} ranges between [0,1], was implemented using Equation 7.2 (Tripathi & Jha 2018*b*). This conversion utilizes the following transformation:(Patel et al. 2016, Chen, Chen, Sheng Lu & Liu 2012, Tripathi et al. 2021)

$$p_{ij} = \frac{1 + \log_9(r_{ij})}{2} \tag{7.2}$$

In Equation 7.2, $(\log_9(r_{ij}))$ is employed for r_{ij} values within the [1/9, 9] interval due to the specific range these values occupy. Similarly, for r_{ij} values within [1/7, 7], $(\log_7(r_{ij}))$ is applied. This method generalizes such that for r_{ij} within any [1/n, n] interval, $(\log_n(r_{ij}))$ is appropriately used (Chen & Chao 2012).

The consistency of the FPR matrix relies fundamentally on additive transitivity. Following the transformation of MPR matrix into the FPR matrix, Equations 7.3 to 7.5 are employed to ensure additive transitivity, thus facilitating the development of a fully CFPR. This approach ensures that the remaining elements of the matrix are computed to uphold the consistency criterion essential for FPR matrix (Tripathi & Jha 2018*b*, Patel et al. 2016, Chen & Chao 2012).

$$p_{ij} + p_{ji} = 1 \tag{7.3}$$

$$p_{ij} + p_{jk} + p_{ki} = \frac{3}{2} \quad \forall i < j < k \tag{7.4}$$

$$p_{i(i+1)} + p_{(i+1)(i+2)} + \cdots + p_{(i+k-1)(i+k)} + p_{(i+k)i} = \frac{(k+1)}{2} \quad \forall i < j \tag{7.5}$$

In certain instances of FPR, the derived values do not necessarily reside within the standard interval $[0,1]$. Occasionally, these values may span across the broader range $[-k, 1+k]$, where k >0 instead of the interval [0,1]. To address this, the FPR matrix is subjected to a transformation through a specific function $f : [-k, 1+k] \rightarrow [0,1]$. This function is designed to maintain both reciprocity and additive consistency throughout the matrix. The formula for this transformation is specified as follows (Chen & Chao 2012, Patel et al. 2016, Tripathi & Jha 2018*b*):

$$f : [-k, 1+k] \rightarrow [0,1], \quad f(p) = \frac{p+k}{1+2k} \tag{7.6}$$

The calculated value p may lie within the interval $[-k, 1+k]$. If these values exceed the standard range of $[0,1]$, the transformation serves as a normalization process. This process converts the values from $[-k, 1+k]$ to the normalized range of $[0,1]$ thus maintaining the functional integrity of the FPR (Chen & Chao 2012).

The MPR matrix of success and performance factors and the relative attributes were converted into FPR matrices $P = [p_{ij}]$ where $p_{ij} \in [0,1]$, using Equations 7.2 to 7.5. The FPR matrix for the success and performance factors along with their corresponding attributes, are detailed from Table 7.15 to Table 7.27. Within these matrix, the diagonal elements are consistently set at 0.5. Whereas the off-diagonal elements vary between 0 and 1. A sample calculation for the elements p_{12} and p_{21} of Table 7.15 is as follows:

$$p_{12} = \frac{1 + \log_9(2.5)}{2} = 0.71$$

$$p_{21} = 1 - p_{12} = 1 - 0.71 = 0.29$$

Table 7.15: FPR matrix for success factors

Success factors	**CW**	**IED**	**FOII**	**FGP**	**RSD**	**MAC**	**SES**
(CW) Competent Workforce	0.50	0.71	0.73	0.75	0.86	0.95	1.00
(IED) Infrastructure and Economic Development	0.29	0.50	0.52	0.54	0.65	0.75	0.79
(FOII) Financial Opportunity and Industry Image	0.27	0.48	0.50	0.52	0.63	0.72	0.77
(FGP) Favorable Government Policies	0.25	0.46	0.48	0.50	0.61	0.70	0.74
(RSD) Regulatory and Skill Development	0.14	0.35	0.37	0.39	0.50	0.59	0.63
(MAC) Market Attractiveness and Collaboration	0.05	0.25	0.28	0.30	0.41	0.50	0.54
(SES) Socio-economic Stability	0.00	0.21	0.23	0.26	0.37	0.46	0.50

Table 7.16: FPR matrix for attributes of CW

Success attributes of CW	**SA-16**	**SA-9**	**SA-26**
(SA-16) Availability of qualified professionals in the industry	0.50	0.68	0.60
(SA-9) Transparency in the industry	0.32	0.50	0.42
(SA-26) Higher productivity of the workforce	0.40	0.58	0.50

Table 7.17: FPR matrix for attributes of IED

Success Attributes of IED	**SA-14**	**SA-5**	**SA-13**
(SA-14) Availability of physical infrastructure such as rail, road, telecom, etc.	0.50	0.61	0.29
(SA-5) Growing GDP of the country	0.39	0.50	0.18
(SA-13) Availability of equipment, materials, and workforce	0.71	0.82	0.50

Table 7.18: FPR matrix for attributes of FOII

Success attributes of FOII	**SA-17**	**SA-18**	**SA-8**
(SA-17) Availability of easy finance	0.50	0.66	0.75
(SA-18) A low interest rate on finance	0.34	0.50	0.59
(SA-8) Good image of the industry in terms of employment and business opportunities	0.25	0.41	0.50

Table 7.19: FPR matrix for attributes of FGP

Success attributes of FGP	**SA-3**	**SA-1**
(SA-3) Favorable government policy in supporting capacity building of organizations	0.50	0.75
(SA-1) Favorable taxation system applicable to the construction industry	0.25	0.50

Table 7.20: FPR matrix for attributes of RSD

Success attributes of RSD	**SA-10**	**SA-29**
(SA-10) Favorable rules and regulations	0.50	0.51
(SA-29) Appropriate training and education	0.49	0.50

Table 7.21: FPR matrix for attributes of MAC

Success attributes of MAC	**SA-19**	**SA-27**
(SA-19) Favorable market conditions	0.50	0.71
(SA-27) Collaborative culture in the industry i.e., relationships among key stakeholders	0.29	0.50

Table 7.22: FPR matrix for attributes of SES

Success attributes of SES	**SA-20**	**SA-22**
(SA-20) Low fluctuation in the currency exchange rate	0.50	0.18
(SA-22) Positive impact on society	0.82	0.50

Table 7.23: FPR matrix for performance factors

Performance Factors	**ICSI**	**PSS**	**IA**	**RDS**
(ICSI) Industry Competence and Societal Impact	0.50	0.56	0.44	0.64
(PSS) Profitability and Stakeholder Satisfaction	0.44	0.50	0.37	0.57
(IA) Industry Attractiveness	0.56	0.63	0.50	0.70
(RDS) Research and Development Strategy	0.36	0.43	0.30	0.50

Table 7.24: FPR matrix for performance attributes of ICSI

Performance attributes of ICSI	**PA-9**	**PA-14**	**PA-1**	**PA-4**
(PA-9) Qualified professionals in the industry	0.50	0.56	0.44	0.64
(PA-14) Labour productivity	0.44	0.50	0.37	0.57
(PA-1) High annual construction demand/Market share	0.56	0.63	0.50	0.70

Continued on next page

Table 7.24 continued from previous page

Performance attributes of ICSI	**PA-9**	**PA-14**	**PA-1**	**PA-4**
(PA-4) Positive impact on society	0.36	0.43	0.30	0.50

Table 7.25: FPR matrix for performance attributes of PSS

Performance attributes of PSS	**PA-2**	**PA-3**	**PA-15**
(PA-2) High profitability ratio (Industry generating profit)	0.50	0.43	0.47
(PA-3) Annual growth rate of industry	0.57	0.50	0.54
(PA-15) Stakeholder satisfaction	0.53	0.46	0.50

Table 7.26: FPR Matrix for performance attributes of IA

Performance attributes of IA	**PA-12**	**PA-10**	**PA-6**
(PA-12) Low staff turnover	0.50	0.24	0.04
(PA-10) Employment opportunities in the construction industry	0.76	0.50	0.29
(PA-6) Safety (Accident rate, Fatality, etc.)	0.96	0.71	0.50

Table 7.27: FPR Matrix for performance attributes of RDS

Performance attributes of RDS	**PA-8**	**PA-7**
(PA-8) Construction Research & Development (Innovative material, Technique number, Patent registers, etc.)	0.50	0.64
(PA-7) Technological Development of Industry	0.36	0.50

Step 3: Relative weight and ranking of success and performance factors and their attributes

The relative weights and rankings for both the success and performance factors, along with their respective attributes, were determined using the equation 7.7. The calculations are displayed from Table 7.28 to Table 7.35 for success factors and attributes, and from Table 5 to Table 7 for performance factors and attributes.

$$w_i = \frac{\sum_{j=1}^{n} p_{ij}}{\sum_{i=1}^{n} \left(\sum_{j=1}^{n} p_{ij} \right)} \tag{7.7}$$

This equation (7.7) calculates the weight w_i based on the sum of the parameters p_{ij} over all indices j normalized by the total sum of all such parameters over all indices i and j.

Row average of CW: Row average of CW = 0.50 + 0.71 + 0.73 + 0.75 + 0.86 + 0.95 + 1.00 = 5.50

Similarly, the row averages for IED, FOII, FGP, RSD, MAC, and SES are calculated as:

$$\begin{aligned} \text{IED} &= 4.04, \\ \text{FOII} &= 3.89 \\ \text{FGP} &= 3.74, \\ \text{RSD} &= 2.97, \\ \text{MAC} &= 2.32, \\ \text{SES} &= 2.03. \end{aligned}$$

Sum of row averages = 24.50

Therefore, the weight of CW is calculated as follows:

$$\text{Weight of CW} = \frac{\text{Row average of CW}}{\text{Sum of row averages}} = \frac{5.50}{24.50} = 0.225 \tag{7.8}$$

Table 7.28: Relative weight and ranking of success factors

Success Factors	Row average	Weightage	Rank
(CW) Competent workforce	5.50	0.225	1
(IED) Infrastructure and Economic Development	4.04	0.165	2
(FOII) Financial Opportunity and Industry Image	3.89	0.159	3
(FGP) Favourable Government Policies	3.74	0.153	4
(RSD) Regulatory and Skill Development	2.97	0.121	5
(MAC) Market Attractiveness and Collaboration	2.32	0.095	6
(SES) Socio-economic Stability	2.03	0.083	7

Table 7.29: Relative weight and ranking of attributes of CW

Success Attributes of CW	Row average	Weightage	Rank
(SA-16) Availability of qualified professionals in the industry	1.78	0.396	1
(SA-9) Transparency in the industry	1.24	0.275	3
(SA-26) Higher productivity of the workforce	1.48	0.328	2

Table 7.30: Relative weight and ranking of attributes of IED

Success Attributes of IED	Row average	Weightage	Rank
(SA-14) Availability of physical infrastructure such as rail, road, telecom, etc.	1.40	0.312	2

Continued on next page

Table 7.30 continued from previous page

Success Attributes of SF-2	Row average	Weightage	Rank
(SA-5) Growing GDP of the country	1.07	0.239	3
(SA-13) Availability of equipment, materials, and workforce	2.02	0.449	1

Table 7.31: Relative weight and ranking of attributes of FOII

Success Attributes of FOII	Row average	Weightage	Rank
(SA-17) Availability of easy finance	1.91	0.424	1
(SA-18) A low interest rate on finance	1.43	0.319	2
(SA-8) Good image of the industry in terms of employment and business opportunities	1.16	0.257	3

Table 7.32: Relative weight and ranking of attributes of FGP

Success Attributes of FGP	Row average	Weightage	Rank
(SA-3) Favorable government policy in supporting capacity building of organizations	1.25	0.624	1
(SA-1) Favorable taxation system applicable to the construction industry	0.75	0.376	2

Table 7.33: Relative weight and ranking of attributes of RSD

Success Attributes of RSD	Row average	Weightage	Rank
(SA-10) Favorable rules and regulations	1.01	0.507	1
(SA-29) Appropriate training and education	0.99	0.493	2

Table 7.34: Relative weight and ranking of attributes of MAC

Success Attributes of MAC	Row average	Weightage	Rank
(SA-19) Favorable market conditions	1.21	0.603	1
(SA-27) Collaborative culture in the industry i.e., relationships among key stakeholders	0.79	0.397	2

Table 7.35: Relative weight and ranking of attributes of SES

Success Attributes of SES	Row average	Weightage	Rank
(SA-20) Low fluctuation in the currency exchange rate	0.68	0.341	2
(SA-22) Positive impact on society	1.32	0.659	1

Table 7.36: Relative weight and ranking of performance factors

Performance Factors	Row average	Weightage	Rank
(ICSI) Industry Competence and Societal Impact	2.76	0.345	1
(PSS) Profitability and Stakeholder Satisfaction	2.09	0.261	2

Continued on next page

Table 7.36 continued from previous page

Performance Factors	Row average	Weightage	Rank
(RDS) Research and Development Strategy	1.60	0.201	3
(IA) Industry Attractiveness	1.55	0.194	4

Table 7.37: FPR matrix for performance factors

Performance Factors	ICSI	PSS	IA	RDS
(ICSI) Industry Competence and Societal Impact	0.50	0.56	0.44	0.64
(PSS) Profitability and Stakeholder Satisfaction	0.44	0.50	0.37	0.57
(IA) Industry Attractiveness	0.56	0.63	0.50	0.70
(RDS) Research and Development Strategy	0.36	0.43	0.30	0.50

Step 4: Determining normalized weight of success and performance attributes

A comparison matrix of success and performance factors, along with their attributes was developed to calculate the normalized weights (W) of the success and performance attributes using the Equation 7.9 and is presented in Table 7.38 for success attributes and Table 7.39 for performance attributes (Tripathi & Jha 2018*b*).

$$W = W_i \times W_j \tag{7.9}$$

Where,

W_i = The weight of the success or performance factors.

W_J = The weight of the success or performance attributes

The success and performance attributes were ranked according to their normalized weights. For instance, the success attribute with the highest normalized weight, 0.095, received rank 1. Subsequently, the attribute with the next highest weight, 0.089, was assigned the second rank, and this pattern continued for the remaining attributes. Similarly, the performance attribute with the highest weight, 0.114, received rank 1, and the attribute with the next highest weight, 0.103, was assigned the second rank, and this pattern continued for the remaining attributes. A sample calculation for both success and performance attributes is shown below.

$$Normalized weight of SA16(W) = Weight of CW(W_i) \times Weight of SA16(w_j)$$
$$= 0.225 \times 0.396$$
$$= 0.089$$

$$Normalized weight of PA9(W) = Weight of ICSI(W_i) \times Weight of PA9(w_j)$$
$$= 0.345 \times 0.267$$
$$= 0.092$$

Table 7.38: Normalized weight of success attributes

Success factors	**Weight (Wi)**	**Rank of success factors**	**Success attributes**	**Weight (Wj)**	**Normalized weight (W=Wi*Wj)**	**Overall rank**
(CW) Competent Workforce	0.225	1	SA-16	0.396	0.089	2
			SA-9	0.275	0.062	6
			SA-26	0.328	0.074	4
(IED) Infrastructure and Economic Development	0.165	2	SA-14	0.312	0.051	12
			SA-5	0.239	0.039	15
			SA-13	0.449	0.074	3
(FOII) Financial Opportunity and Industry Image	0.159	3	SA-17	0.424	0.067	5
			SA-18	0.319	0.051	13

Continued on next page

Table 7.38 continued from previous page

Success factors	**Weight (Wi)**	**Rank of success factors**	**Success attributes**	**Weight (Wj)**	**Normalized weight (W=Wi*Wj)**	**Overall rank**
			SA-8	0.257	0.041	14
(FGP) Favourable Government Policies	0.153	4	SA-3	0.624	0.095	1
			SA-1	0.376	0.057	9
(RDS) Regulatory and Skill Development	0.121	5	SA-10	0.507	0.061	7
			SA-29	0.493	0.060	8
(MAC) Market Attractiveness and Collaboration	0.095	6	SA-19	0.603	0.057	10
			SA-27	0.397	0.038	16
(SES) Socio-Economic Stability	0.083	7	SA-20	0.341	0.028	17
			SA-22	0.659	0.055	11

Table 7.39: Normalized weight of performance attributes

Performance factors	**Weight (Wi)**	**Rank of Performance Factors**	**Performance attributes**	**Weight (Wj)**	**Normalized weight (W=Wi*Wj)**	**Overall rank**
(ICSI) Industry Competence and Societal Impact	0.345	1	PA-9	0.267	0.092	5
			PA-14	0.235	0.081	9
			PA-1	0.299	0.103	2
			PA-4	0.198	0.068	10
(PSS) Profitability and Stakeholder Satisfaction	0.261	2	PA-2	0.313	0.082	8
			PA-3	0.357	0.093	4
			PA-15	0.330	0.086	7
(IA) Industry Attractiveness	0.194	4	PA-12	0.174	0.034	12
			PA-10	0.344	0.067	11
			PA-6	0.483	0.094	3
(RDS) Research and Development Strategy	0.201	3	PA-7	0.570	0.114	1
			PA-8	0.430	0.086	6

7.7 Results:

Out Of the 17 identified success attributes, the top 10 alone account for a total weight of 0.693. Similarly, out of the 12 performance attributes, the top 5 contribute a combined weight of 0.496. Additionally, the top 5 success factors encompass a total weight of 0.823, while the top 2 performance factors have a combined weight of 0.606. Therefore, it is prudent to concentrate on these key success and performance attributes and factors, rather than distributing resources across all attributes and factors, to achieve optimal benefits from the available limited resources.

The SRCC test was performed to analyze the ranking results of the success and performance attributes using a fuzzy preference relation, compared to the results obtained from descriptive statistical analysis in the first stage questionnaire. The correlation coefficient R was calculated to be 0.684 for success attributes and 0.574 for performance attributes at a 0.05 significance level. Therefore, the strength of the correlation between the responses from the two groups of respondents is positive and statistically significant.

7.8 Summary:

The relative weights of each significant success and performance factor, along with their associated attributes, were identified in this chapter. To determine the level of agreement between two sets of respondents regarding the success and performance attributes, the SRCC was calculated. The correlation between the responses from the two groups was found to be strongly positive and statistically significant, indicating a high degree of consensus among the respondents.

Chapter 8

Summary and Conclusion:

This research identified and evaluated critical success factors for India's construction industry, highlighting the importance of seven pivotal factors: competent workforce, infrastructure and economic development, financial opportunity and industry image, favorable government policies, regulatory and skill development, market attractiveness and collaboration, and socioeconomic stability. Each factor's influence on various performance metrics within the industry underscores the interrelation of these factors and their collective impact on enhancing industry performance. Hence, by addressing these challenges, the construction industry in India can achieve substantial advancement, supporting broader economic development.

The study's findings highlight the paramount importance of a skilled and competent workforce, which is the foundation for achieving other success factors. This insight guides policymakers and industry leaders to prioritize education and training programs designed to meet the evolving needs of the construction sector. Additionally, the results indicate that infrastructure development plays a significant role, suggesting that investments in this area will likely lead to considerable improvements in industry productivity and growth. Based on the study's findings, it is recommended that stakeholders strengthen efforts to improve financial mechanisms within the industry to support small to large-scale firms. Developing a collaborative culture and integrating advanced technologies could enhance operational efficiencies and project outcomes.

This study significantly contributes to the strategic planning efforts required for sustainable growth and competitiveness by offering a nuanced understanding of the factors that drive success in the Indian construction industry. The development of a tailored framework for assessing and implementing these factors offers valuable insight for continuous improvement and adaptation in a rapidly evolving market. Looking ahead, the Indian construction industry is at a turning point in its development, and the strategic decisions made today will define its trajectory for decades to come. Implementing the insights from this study can catalyze a transformation that enhances economic output and contributes to the nation's socioeconomic well-being.

8.1 Limitation:

As the construction industry is very complex, the study was limited to the construction organizations involved only in the real estate business operating in India. Future research could extend this analysis to different markets, exploring the universality or specificity of the identified success factors.

Bibliography

Abraham, G. L. (2003), Critical success factors for the construction industry, *in* 'Construction Research Congress: Wind of Change: Integration and Innovation', pp. 1–9.

Adegoriola, M. I., Lai, J. H., Yung, E. H. & Chan, E. H. (2023), 'Development of a significant index model for assessing heritage building maintenance management challenges', *Engineering, Construction and Architectural Management* .

Akomea-Frimpong, I., Jin, X. & Osei-Kyei, R. (2024), 'Fuzzy analysis of financial risk management strategies for sustainable public–private partnership infrastructure projects in ghana', *Infrastructures* **9**(4), 76.

Al-Tit, A., Omri, A. & Euchi, J. (2019), 'Critical success factors of small and medium-sized enterprises in saudi arabia: Insights from sustainability perspective', *Administrative Sciences* **9**(2), 32.

Alaloul, W. S., Liew, M. S., Zawawi, N. A. W., Mohammed, B. S., Adamu, M. & Musharat, M. A. (2020), 'Structural equation modelling of construction project performance based on coordination factors', *Cogent engineering* **7**(1), 1726069.

Alias, F. M. A. & Abdullah, L. (2017), 'Consistent fuzzy preference relation method and its application to criteria assessment of quality of life among population of setiu wetlands', *Menemui Matematik (Discovering Mathematics)* **39**(2), 52–60.

Alias, F. M. A., Abdullah, L., Gou, X., Liao, H. & Herrera-Viedma, E. (2019), 'Consistent fuzzy preference relation with geometric bonferroni mean: a fused preference method for assessing the quality of life', *Applied Intelligence* **49**, 2672–2683.

Arslan, G. & Kivrak, S. (2008), 'Critical factors to company success in the construction industry', *World Academy of Science, Engineering and Technology* **45**(1), 43–46.

Asamoah, R. O., Baiden, B. K., Nani, G. & Kissi, E. (2019), 'Review of exogenous economic indicators influencing construction industry', *Advances in Civil Engineering* **2019**, 1–8.

Barajei, C., Kheni, N. A., Appiah-Kubi, E., Danso, H. & Iddrisu, A. W. (2023), 'Enhancing the success of ghanaian public road construction projects', *Cogent Engineering* **10**(1), 2199514.

Bullen, C. V. & Rockart, J. F. (1981), 'A primer on critical success factors'.

Cha, H. S. & Kim, C. K. (2011), 'Quantitative approach for project performance measurement on building construction in south korea', *KSCE Journal of Civil Engineering* **15**, 1319–1328.

Chan, A. P. & Chan, A. P. (2004), 'Key performance indicators for measuring construction success', *Benchmarking: an international journal* **11**(2), 203–221.

Chan, A. P., Osei-Kyei, R., Hu, Y. & Yun, L. (2018), 'A fuzzy model for assessing the risk exposure of procuring infrastructure mega-projects through public-private partnership: The case of hong kong-zhuhai-macao bridge', *Frontiers of Engineering Management* pp. 64–77.

Chan, A. P., Scott, D. & Chan, A. P. (2004), 'Factors affecting the success of a construction project', *Journal of construction engineering and management* **130**(1), 153–155.

Chan, T. K. (2009), 'Measuring performance of the malaysian construction industry', *Construction management and Economics* **27**(12), 1231–1244.

Chan, T. K. & Hiap, P. T. (2012), 'A balanced scorecard approach to measuring industry performance', *Journal of Construction in Developing Countries* **1**(2012), 23–41.

Chen, W. T., Chen, T.-T., Sheng Lu, C. & Liu, S.-S. (2012), 'Analyzing relationships among success variables of construction partnering using structural equation modeling: a case study of taiwan's construction industry', *Journal of Civil Engineering and Management* **18**(6), 783–794.

Chen, Y.-H. & Chao, R.-J. (2012), 'Supplier selection using consistent fuzzy preference relations', *Expert Systems with Applications* **39**(3), 3233–3240.

Chen, Y. Q., Zhang, Y. B., Liu, J. Y. & Mo, P. (2012), 'Interrelationships among critical success factors of construction projects based on the structural equation model', *Journal of management in engineering* **28**(3), 243–251.

Cox, R. F., Issa, R. R. & Ahrens, D. (2003), 'Management's perception of key performance indicators for construction', *Journal of construction engineering and management* **129**(2), 142–151.

Datta, S. D., Sobuz, M. H. R., Nafe Assafi, M., Sutan, N. M., Islam, M. N., Mannan, M. B., Akid, A. S. M. & Hasan, N. M. S. (2023), 'Critical project management success factors analysis for the construction industry of bangladesh', *International Journal of Building Pathology and Adaptation* .

Deng, B., Zhou, D., Zhao, J., Yin, Y. & Li, X. (2021), 'Fuzzy synthetic evaluation of the critical success factors for the sustainability of public private partnership projects in china', *Sustainability* **13**(5), 2551.

Deng, F., Liu, G. & Jin, Z. (2013), 'Factors formulating the competitiveness of the chinese construction industry: Empirical investigation', *Journal of Management in Engineering* **29**(4), 435–445.

Deng, F. & Smyth, H. (2013), 'Contingency-based approach to firm performance in construction: Critical review of empirical research', *Journal of construction engineering and management* **139**(10), 04013004.

Elkhalifa, A. & Shaddad, M. (2010), The construction and building materials industries in sudan, *in* 'W107-Special Track 18th CIB World Building Congress May 2010 Salford, United Kingdom', p. 97.

Fox, P. & Skitmore, M. (2007), 'Factors facilitating construction industry development', *Building Research and Information* **35**(2), 178–188.

Frank, K. (2023), 'Skilled employment in construction sector in india'. Accessed: 21 February 2024.
URL: *https://www.knightfrank.co.in/research2023*

Gao, L., Deng, X., Yang, W. & Chang, T. (2021), 'Exploring critical factors affecting contractors' coopetition relationship in international construction projects', *Advances in Civil Engineering* **2021**, 1–16.

Gudienė, N., Banaitis, A. & Banaitienė, N. (2013), 'Evaluation of critical success factors for construction projects–an empirical study in lithuania', *International journal of strategic property management* **17**(1), 21–31.

Gunduz, M. & Abdi, E. A. (2020), 'Motivational factors and challenges of cooperative partnerships between contractors in the construction industry', *Journal of Management in Engineering* **36**(4), 04020018.

Hardcastle, C., Edwards, P. J., Akintoye, A. & Li, B. (2005), 'Critical success factors for ppp/pfi projects in the uk construction industry: a factor analysis approach', *Construction management and economics* **23**(5), 459–471.

He, Q., Wang, T., Chan, A. P. & Xu, J. (2021), 'Developing a list of key performance indictors for benchmarking the success of construction megaprojects', *Journal of Construction Engineering and Management* **147**(2), 04020164.

Hillebrandt, P. M. et al. (2000), *Economic theory and the construction industry*, Springer.

IMD World Competitiveness Center (2024), 'World competitiveness ranking'. Accessed: 21 February 2024.
URL: *https://www.imd.org/centers/wcc/world-competitiveness-center/rankings/world-competitiveness-ranking/*

India Brand Equity Foundation (2023), 'Infrastructure sector in india industry report'. Accessed: 21 February 2024.
URL: *https://www.ibef.org/industry/infrastructure-sector-india*

Ingle, P. V. & Mahesh, G. (2022), 'Construction project performance areas for indian construction projects', *International Journal of Construction Management* **22**(8), 1443–1454.

Ingle, P. V., Mahesh, G. & MD, D. (2021), 'Identifying the performance areas affecting the project performance for indian construction projects', *Journal of Engineering, Design and Technology* **19**(1), 1–20.

Kabak, Ö., Ülengin, F., Çekyay, B., Önsel, Ş. & Özaydın, Ö. (2016), 'Critical success factors for the iron and steel industry in turkey: A fuzzy dematel approach', *International Journal of Fuzzy Systems* **18**, 523–536.

Khalid, G. (1996), 'An analysis of the malaysian construction industry-it's prospect and challenge', *CIB REPORT* pp. 511–522.

Kim, D., Oh, W., Yun, J., Youn, J., Do, S. & Lee, D. (2021), 'Development of key performance indicators for measuring the management performance of small construction firms in korea', *Sustainability* **13**(11), 6166.

Kulemeka, P. J., Kululanga, G., Morton, D. et al. (2015), 'Critical factors inhibiting performance of small-and medium-scale contractors in sub-saharan region: A case for malawi', *Journal of Construction Engineering* **2015**(927614).

Lema, N. M. (1996), Construction labour productivity analysis and benchmarking: the case of Tanzania, PhD thesis, © Ninatubu Mbora Lema.

Loganathan, S., Srinath, P., Kumaraswamy, M., Kalidindi, S. & Varghese, K. (2017), 'Identifying and addressing critical issues in the indian construction industry: Perspectives of large building construction clients', *Journal of Construction in Developing Countries* **22**, 121–144.

Mangla, S. K., Govindan, K. & Luthra, S. (2016), 'Critical success factors for reverse logistics in indian industries: a structural model', *Journal of cleaner production* **129**, 608–621.

Mellado, F., Lou, E. C. & Becerra, C. L. C. (2020), 'Synthesising performance in the construction industry: An analysis of performance indicators to promote project improvement', *Engineering, Construction and Architectural Management* **27**(2), 579–608.

Mengistu, D. G. & Mahesh, G. (2020), 'Challenges in developing the ethiopian construction industry', *African Journal of Science, Technology, Innovation and Development* **12**(4), 373–384.

Ministry of Finance, Government of India (2023), *Economic Survey 2022-23*, Government of India, New Delhi. Accessed: 21 February 2024.
URL: *https://www.indiabudget.gov.in/economicsurvey/*

Ministry of Housing and Urban Affairs, Government of India (2024), ‘Pradhan mantri awas yojana - mis’. Accessed: 21 February 2024.
URL: *https://pmaymis.gov.in/*

Ministry of Ports, Shipping, and Waterways, Government of India (2024), ‘Sagarmala programme’. Accessed: 21 February 2024.
URL: *https://sagarmala.gov.in/*

Molenaar, K., Washington, S. & Diekmann, J. (2000), ‘Structural equation model of construction contract dispute potential’, *Journal of construction engineering and management* **126**(4), 268–277.

Ngowi, A. (2002), ‘Challenges facing construction industries in developing countries’.

Nguyen, H. D. & Macchion, L. (2023), ‘A comprehensive risk assessment model based on a fuzzy synthetic evaluation approach for green building projects: the case of vietnam’, *Engineering, Construction and Architectural Management* **30**(7), 2837–2861.

Nnaji, C., Gambatese, J., Karakhan, A. & Osei-Kyei, R. (2020), ‘Development and application of safety technology adoption decision-making tool’, *Journal of construction engineering and management* **146**(4), 04020028.

Ofori, G. (2001), ‘Indicators for measuring construction industry development in developing countries’, *Building Research & Information* **29**(1), 40–50.

Osei-Kyei, R. & Chan, A. P. (2017), ‘Developing a project success index for public–private partnership projects in developing countries’, *Journal of Infrastructure Systems* **23**(4), 04017028.

Osei-Kyei, R., Chan, A. P. & Ameyaw, E. E. (2017), ‘A fuzzy synthetic evaluation analysis of operational management critical success factors for public-private partnership infrastructure projects’, *Benchmarking: An International Journal* **24**(7), 2092–2112.

Patel, D., Kikani, K. & Jha, K. (2016), ‘Hazard assessment using consistent fuzzy preference relations approach’, *Journal of Construction Engineering and Management* **142**(12), 04016067.

Rani, M. J. (2021), Indian construction industry progress since 1995, *in* 'Construction Industry Advance and Change: Progress in Eight Asian Economies Since 1995', Emerald Publishing Limited, pp. 43–62.

Rimbalová, J. & Vilčeková, S. (2013), 'The proposal of key performance indicators in facility management and determination the weights of significance', *Selected Scientific Papers-Journal of Civil Engineering* **8**(2), 73–84.

Sawhney, A., Agnihotri, R. & Kumar Paul, V. (2014), 'Grand challenges for the indian construction industry', *Built Environment Project and Asset Management* **4**(4), 317–334.

Sharma, S. & Goyal, P. K. (2022), 'Fuzzy assessment of the risk factors causing cost overrun in construction industry', *Evolutionary Intelligence* pp. 1–13.

Sinesilassie, E. G., Tripathi, K. K., Tabish, S. Z. S. & Jha, K. N. (2019), 'Modeling success factors for public construction projects with the sem approach: Engineer's perspective', *Engineering, Construction and Architectural Management* **26**(10), 2410–2431.

Sultan, B. & Kajewski, S. (2004), Local problems in the construction industry of yemen, *in* 'CIB W107 Globalization and Construction symposium', pp. 379–388.

Tabish, S. Z. S. & Jha, K. N. (2011), 'Identification and evaluation of success factors for public construction projects', *Construction management and economics* **29**(8), 809–823.

Taherdoost, H., Sahibuddin, S. & Jalaliyoon, N. (2022), 'Exploratory factor analysis; concepts and theory', *Advances in applied and pure mathematics* **27**, 375–382.

Thompson, M. W. (2000), 'Challenges of construction in emerging economies', *Journal of Corporate Real Estate* **2**(3), 250–259.

Tripathi, K. & Jha, K. (2018*a*), 'An empirical study on performance measurement factors for construction organizations', *KSCE journal of civil engineering* **22**(4), 1052–1066.

Tripathi, K. & Jha, K. (2019), 'An empirical study on factors leading to the success of construction organizations in india', *International Journal of Construction Management* **19**(3), 222–239.

Tripathi, K., Jha, K. & Jain, A. (2020), Determining criticality of performance indicators for a construction company, *in* 'ICSBE 2018: Proceedings of the 9th International Conference on Sustainable Built Environment', Springer, pp. 353–364.

Tripathi, K. K., Hasan, A. & Neeraj Jha, K. (2021), 'Evaluating performance of construction organizations using fuzzy preference relation technique', *International Journal of Construction Management* **21**(12), 1287–1300.

Tripathi, K. K. & Jha, K. N. (2018*b*), 'Application of fuzzy preference relation for evaluating success factors of construction organisations', *Engineering, construction and architectural management* **25**(6), 758–779.

Tripathi, K. K. & Jha, K. N. (2018*c*), 'Determining success factors for a construction organization: A structural equation modeling approach', *Journal of management in engineering* **34**(1), 04017050.

Tsiga, Z., Emes, M. & Smith, A. (2016), 'Critical success factors for the construction industry', *PM World Journal* **5**(8), 1–12.

Ugwu, O. & Haupt, T. C. (2007), 'Key performance indicators and assessment methods for infrastructure sustainability—a south african construction industry perspective', *Building and environment* **42**(2), 665–680.

Wells, J. (1984), 'The construction industry in the context of development: a new perspective', *Habitat International* **8**(3-4), 9–28.

Willis, C. J. & Rankin, J. H. (2012), 'The construction industry macro maturity model (cim3): theoretical underpinnings', *International Journal of Productivity and Performance Management* **61**(4), 382–402.

Windapo, A. O. & Cattell, K. (2013), 'The south african construction industry: Perceptions of key challenges facing its performance, development and growth', *Journal of construction in developing countries* **18**(2), 65.

Wong, J. M. & Ng, T. (2010), Company failure in the construction industry: A critical review and a future research agenda, *in* 'FIG International Congress'.

Wuni, I. Y., Shen, G. Q. & Osei-Kyei, R. (2022), 'Quantitative evaluation and ranking of the critical success factors for modular integrated construction projects', *International Journal of Construction Management* **22**(11), 2108–2120.

Wuni, I. Y., Shen, G. Q., Osei-Kyei, R. & Agyeman-Yeboah, S. (2022), 'Modelling the critical risk factors for modular integrated construction projects', *International journal of construction management* **22**(11), 2013–2026.

Xiong, B., Skitmore, M. & Xia, B. (2015), 'A critical review of structural equation modeling applications in construction research', *Automation in construction* **49**, 59–70.

Xu, Y., Yeung, J. F., Chan, A. P., Chan, D. W., Wang, S. Q. & Ke, Y. (2010), 'Developing a risk assessment model for ppp projects in china—a fuzzy synthetic evaluation approach', *Automation in construction* **19**(7), 929–943.

Yang, H., Yeung, J. F., Chan, A. P., Chiang, Y. H. & Chan, D. W. (2010), 'A critical review of performance measurement in construction', *Journal of Facilities Management* **8**(4), 269–284.

Yap, J. B. H. & Cheah, S. Y. (2020), 'Key challenges faced by chinese contractors in malaysian construction industry: Empirical study', *Journal of Engineering, Design and Technology* **18**(3), 705–726.

Yap, J. B. H., Chow, I. N. & Shavarebi, K. (2019), 'Criticality of construction industry problems in developing countries: Analyzing malaysian projects', *Journal of Management in Engineering* **35**(5), 04019020.

Yeung, J. F., Chan, A. P., Chan, D. W., Chiang, Y. H. & Yang, H. (2013), 'Developing a benchmarking model for construction projects in hong kong', *Journal of construction engineering and management* **139**(6), 705–716.

Zhao, X., Hwang, B.-G. & Gao, Y. (2016), 'A fuzzy synthetic evaluation approach for risk assessment: a case of singapore's green projects', *Journal of Cleaner Production* **115**, 203–213.

APPENDIX A

FIRST STAGE QUESTIONNAIRE

INSTITUTE OF TECHNOLOGY NIRMA UNIVERSITY
DEPARTMENT OF CIVIL ENGINEERING

CRITICAL SUCCESS FACTORS FOR CONSTRUCTION INDUSTRY IN INDIA

By Rushabh Parikh and Dr. K.K.Tripathi

<u>Questionnaire</u>

Part-1	**Please put a tick mark (√) or highlight the relevant cell to rate the following parameters (on five-point Likert scale from very low effect = 1 to very high effect = 5) which effects on the success of the Construction Industry.**					
Sr. No.	**Success attributes**	**Very low effect**	**Low effect**	**Moderate effect**	**High effect**	**Very high effect**
		1	**2**	**3**	**4**	**5**
1	Favourable taxation system applicable to construction industry					
2	Efficient registration system (firms and professionals)					
3	Favourable government policy in supporting capacity building of organizations					
4	Government promoting labour-intensive schemes to create employment					
5	Growing GDP of the country					
6	Availability of foreign direct investment & foreign aid					
7	Favourable external environment (Social, political factor)					
8	Good image of the industry in terms of employment opportunity, business opportunity etc.					
9	Transparency in the industry					
10	Favourable rules and regulations					
11	Certification by various agenices (ISO, PMI,ISI etc.)					

12	Standardized bye-laws and codes					
13	Availability of equipment, material, and workforce					
14	Availability of physical infrastructure such as rail,road, telecom etc.					
15	Availability of latest technologies such as automation, robotic, 3d printing etc.					
16	Availability of qualified professional's in industry					
17	Availability of easy finance					
18	Low Interest rate on finance					
19	Favourable market conditions					
20	Low fluctuation in currency exchange rate					
21	Positive impact on environment					
22	Positive impact on society					
23	Favourable weather conditions					
24	Low waste production & recycling					
25	Low accident rate, fatality rate etc.					
26	Higher productivity of workforce					
27	Collaborative culture in the industry, i.e. relationship among key stakeholders					
28	Level of competition among industry players					
29	Appropriate training and education					
30	Investment and encouragement on research & development					
Part-2	**Please put a tick mark (√) or highlight the relevant cell to rate the following parameters (on five-point Likert scale from very low importance = 1 to very high importance = 5) in terms of their importance in measuring success of the construction Industry.**					
Sr. No.	**Performance attributes**	**Very low Importance**	**Low Importance**	**Moderate Importance**	**High Importance**	**Very high Importance**
		1	**2**	**3**	**4**	**5**

1	High annual construction demand/ market share					
2	High profitability ratio (Industry generating profit)					
3	Annual growth rate of industry					
4	Positive impact on society					
5	Positive impact on Environment					
6	Safety (Accident rate, Fatality etc.)					
7	Technological development of industry					
8	Construction research & development (Innovative material ,technique, number of patent register etc)					
9	Qualified professionals in industry					
10	Employment opportunity in construction Industry					
11	Human resource training & development					
12	Low staff turnover					
13	Higher wages of employees					
14	Labour productivity					
15	Stakeholder satisfaction					
Part-3	**Please write any comments/feedback in the space provided below concerning the Success attributes and Performance attributes of the construction Industry. Please add any other Success attributes and Performance attributes if you feel that it is left in our list given above. Your feedback is highly valuable for our research work.**					
Part-4	**Organization's Information** ***(Please highlight the relevant cell)***					
1	Organization's name					
2	Organization's total years of experience in the construction business		1-10	10-20	20-30	Above 30
3	Category of organization		Contractor	Client	PMC	
Part-5	**Respondent's Information** ***(Please highlight the relevant cell)***					
1	Respondent's name					
2	Respondent's contact number					
3	Respondent's email id					
4	Respondent's total years of experience in the construction business		1-10	10-20	20-30	Above 30

APPENDIX B
SECOND STAGE QUESTIONNAIRE

INSTITUTE OF TECHNOLOGY NIRMA UNIVERSITY
DEPARTMENT OF CIVIL ENGINEERING

CRITICAL SUCCESS FACTORS FOR CONSTRUCTION INDUSTRY IN INDIA

By Rushabh Parikh and Dr. K.K.Tripathi

Questionnaire

Part-1A	Below, you will find pairs of success factors related to the construction industry. For each pair, please indicate which factor you believe is more important for the success of construction industry, using the provided scale: 1 (equally important), 3 (slightly more important), 5 (strongly more important), 7 (very strongly more important), and 9 (most important), with 2, 4, 6, and 8 as intermediate values.

Sr. No.	Success Factors	Importance	Success Factors	Importance	1	2	3	4	5	6	7	8	9
1	(SF-1) Competent workforce		(SF-2) Infrastructure and economic development										
2	(SF-2) Infrastructure and economic development		(SF-3) Financial opportunity and industry image										
3	(SF-3) Financial opportunity and industry image		(SF-4) Favourable government policies										
4	(SF-4) Favourable government policies		(SF-5) Regulatory and skill development										
5	(SF-5) Regulatory and skill development		(SF-6) Market attractiveness and collaboration										

6	(SF-6) Market attractiveness and collaboration		(SF-7) Socio-economic stability										
Part-1B	**Below, you will find pairs of success attributes related to the construction industry. For each pair, please indicate which attribute you believe is more important for the success of construction industry, using the provided scale: 1 (equally important), 3 (slightly more important), 5 (strongly more important), 7 (very strongly more important), and 9 (most important), with 2, 4, 6, and 8 as intermediate values.**												
Sr. No.	**Success Attributes**	**Importance**	**Success Attributes**	**Importance**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
1	**(SF-1) Competent workforce**												
	(SA-1.1) Availability of qualified professionals in the industry		(SA-1.2) Transparency in the industry										
	(SA-1.2) Transparency in the industry		(SA-1.3) Higher productivity of workforce										
2	**(SF-2) Infrastructure and economic development**												
	(SA-2.1) Availability of physical infrastructure such as rail, road, telecom, etc.		(SA-2.2) Growing GDP of the country										
	(SA-2.2) Growing GDP of the country		(SA-2.3) Availability of equipment, material, and workforce										
3	**(SF-3) Financial opportunity and Industry image**												
	(SA-3.1) Availability of easy Finance		(SA-3.2) Low-Interest rate on finance										

	(SA-3.2) Low-Interest rate on finance		(SA-3.3) Good image of the industry in terms of employment opportunities, business opportunities, etc.										
Sr. No.	**Performance Attributes**	**Importance**	**Performance Attributes**	**Importance**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
4	**(SF-4) Favourable government policies**												
	(SA-4.1) Favourable government policy in supporting capacity building of organizations		(SA-4.2) Favourable taxation system applicable to the construction industry										
5	**(SF-5) Regulatory and skill development**												
	(SA-5.1) Favourable rules & regulations		(SA-5.2) Appropriate training and education										
6	**(SF-6) Market attractiveness and collaboration**												
	(SA-6.1) Favourable market conditions		(SA-6.2) Collaborative culture in the industry, i.e., relationships among key stakeholders										
7	**(SF-7) Socio-economic stability**												
	(SA-7.1) Low fluctuation in the currency exchange rate		(SA-7.2) Positive impact on society										

Part-2A	Below, you will find pairs of performance factors related to the construction industry. For each pair, please indicate which factor you believe is more important for measurement of performance for construction industry, using the provided scale: 1 (equally important), 3 (slightly more important), 5 (strongly more important), 7 (very strongly more important), and 9 (most important), with 2, 4, 6, and 8 as intermediate values.													
Sr. No.	**Performance Factors**	**Importance**	**Performance Factors**	**Importance**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
1	(PF-1) Industry competence and societal impact		(PF-2) Profitability and stakeholder satisfaction										
2	(PF-2) Profitability and stakeholder satisfaction		(PF-3) Industry attractiveness										
3	(PF-3) Industry attractiveness		(PF-4) Research and development strategy										
Part-2B	**Below, you will find pairs of performance attributes related to the construction industry. For each pair, please indicate which attribute you believe is more important for measurement of performance for construction industry, using the provided scale: 1 (equally important), 3 (slightly more important), 5 (strongly more important), 7 (very strongly more important), and 9 (most important), with 2, 4, 6, and 8 as intermediate values.**												
Sr. No.	**Performance Attributes**	**Importance**	**Performance Attributes**	**Importance**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
1	**(PF-1) Industry competence and societal impact**												
	(PA-1.1) Qualified professionals in the industry		(PA-1.2) Labour productivity										
	(PA-1.2) Labour productivity		(PA-1.3) High annual construction demand/Market share										
	(PA-1.3) High annual construction demand/Market share		(PA-1.4) Positive impact on society										

2	**(PF-2) Profitability and stakeholder satisfaction**												
	(PA-2.1) High profitability ratio (Industry generating profit)		(PA-2.2) Annual growth rate of industry										
	(PA-2.2) Annual growth rate of industry		(PA-2.3) Stakeholder satisfaction										
3	**(PF-3) Industry attractiveness**												
	(PA-3.1) Low staff turnover		(PA-3.2) Employment opportunities in the construction Industry										
	(PA-3.2) Employment opportunities in the construction Industry		(PA-3.3) Safety (Accident rate, Fatality, etc.)										
4	**(PF-4) Research and development strategy**												
	(PA-4.1) Construction research & development		(PA-4.2) Technological development of industry										

Part-4	**Organisation's Information**				
1	Organisation's name				
2	Organisation's total years of experience in the construction industry	1-10	11-20	21-30	Above 30
3	Category of organization	Contractor	Client	PMC	
Part-5	**Respondent's Information**				
1	Respondent's name				
2	Respondent's contact number				
3	Respondent's email id				
4	Respondent's total years of experience in the construction industry	1-10	11-20	21-30	Above 30

LIST OF MANUSCRIPTS SUBMITTED FOR PUBLICATION

(1) Rushabh Parikh and Prof. Dr. Kamalendra Kumar Tripathi "Critical Success Factors for the Construction Industry in India" Emerald, *Engineering Construction and Architectural* Management (under review).

(2) Rushabh Parikh and Prof. Dr. Kamalendra Kumar Tripathi "Evaluating Key Performance Factors in the Construction Industry: A Comprehensive Approach Using Fuzzy Synthesis" ICCRIP 2024 (Abstract accepted).

Critical success factors

ORIGINALITY REPORT

8%	6%	8%	%
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

PRIMARY SOURCES

1	ascelibrary.org Internet Source	2%
2	www.tandfonline.com Internet Source	1%
3	www.researchgate.net Internet Source	1%
4	Ibrahim Yahaya Wuni, Geoffrey Qiping Shen, Robert Osei-Kyei. "Quantitative evaluation and ranking of the critical success factors for modular integrated construction projects", International Journal of Construction Management, 2020 Publication	1%
5	Ibrahim Yahaya Wuni, Geoffrey Qiping Shen, Robert Osei-Kyei, Stephen Agyeman-Yeboah. "Modelling the critical risk factors for modular integrated construction projects", International Journal of Construction Management, 2020 Publication	1%