AN EMPIRICAL STUDY ON THE DELAYS IN CONSTRUCTION PROJECTS IN INDIA

Submitted By

Dev Patel

22MCLT08

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INSTITUTE OF TECHNOLOGY
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AN EMPIRICAL STUDY ON THE DELAYS IN CONSTRUCTION PROJECTS IN INDIA

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Submitted By

Dev Patel

(22MCLT08)

Guided By

Dr. Kamalendra Kumar Tripathi

DEPARTMENT OF CIVIL ENGINEERING

INSTITUTE OF TECHNOLOGY

NIRMA UNIVERSITY

AHMEDABAD-382481

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Certificate

This is to certify that the major project entitled **"An empirical study on the delays in construction projects in India"** submitted by **Dev Patel (Roll No: 22MCLT08)**, towards the partial fulfilment of the requirements for the award of degree of Master of Technology in Civil Engineering (Construction Technology and Management) of Nirma University, Ahmedabad, is the record of work carried out by him under my supervision and guidance. In my opinion, the submitted work has reached a level required for being accepted for examination. The results embodied in this major project part-I, to the best of my knowledge, haven't been submitted to any other university or institution for 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 (CTM)
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, **Dev Patel**, Roll. No. **22MCLT08**, give undertaking that the Major Project entitled "**An empirical study on the delays in construction projects in India**" submitted by me, towards the partial fulfillment of the requirements for the degree of Master of Technology in **Civil Engineering (Construction Technology and Management)** of Institute of Technology, Nirma University, Ahmedabad, contains no material that has been awarded for any degree or diploma in any university or school in any territory to the best of my knowledge. It is the original work carried out by me and I give assurance that no attempt of plagiarism has been made.It contains no material that is previously published or written, except where reference has been made. I understand that in the event of any similarity found subsequently with any published work or any dissertation work elsewhere; it will result in severe disciplinary action.

Signature of Student
Date:
Place: Ahmedabad

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

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- Dev Patel

22MCLT08

Abstract

Construction projects are complex and frequently impacted by several variables that could delay their completion and the need for a systematic analysis of the reasons for delays and developing a clear understanding of the industry professionals is highly crucial. This study aims to identify and evaluate the delay factors in construction projects in India and their effects on project performance. Through a detailed literature review, 42 attributes were identified–31 related to project delays and 11 to their effect. A first-stage questionnaire was designed based on these attributes and a total of 129 stakeholders in the Indian real estate industry from 50 different organizations were included in the survey. Descriptive analysis, exploratory factor analysis, regression analysis, and structural equation modelling were utilized to analyze the respondents' viewpoints.

Exploratory factor analysis extracted seven delay factors: poor stakeholder coordination; delays in availability of materials; contractor's performance; unfavourable government regulations; poor site management; quality and safety risks; and inefficient construction method and equipment. Similarly, three effect factors: ethical and social impact; cost and time overrun; and contract dissolution were extracted. Notably, quality and safety risks emerged as the most significant delay factor, as indicated by regression analysis and structural equation modelling. To obtain a better understanding of the factors, it is essential to determine their relative significance in comparison to one another, for which a second-stage questionnaire survey was conducted and 20 highly experienced construction professionals from different construction organizations participated in the survey via personal interviews. The relative weights of each delay and effect factor and their attributes were assigned using a fuzzy preference relation.

Due to the complexity of the construction industry, this study's scope was restricted to real estate projects in Gujarat, India. However, given the broad engagement of these companies nationwide, the study's findings should be applicable across the nation. Previous studies primarily identified the delay factors and their effects without indicating their interdependencies. However, in the present study, the authors have tried to elaborate on the interdependencies between delay and effect factors, highlighting their influences on construction projects. The study's findings will help professionals in the construction management field by allowing them to concentrate on a smaller number of factors in-

stead of dealing with a lot of factors to achieve the best outcome. This insight enables the stakeholders to reduce delays and improve their understanding of construction project management in India, enabling more effective strategies for mitigating delays and optimizing project success.

Abbreviations

AHP	Analytical Hierarchy Process
AMOS	Analysis of Moment Structure
BAI	Builders Association of India
CAGR	Compounded Annual Growth Rate
CFI	Comparative Fit Index
CREDAI	Confederation of Real Estate Developers Association of India
CFPR	Consistent Fuzzy Preference Relation
CB	Covariance Based
DF	Delay Factor
EF	Effect Factor
ECVI	Expected Cross Validation Index
FPR	Fuzzy Preference Relation
GDP	Gross Domestic Product
GFI	Goodness of Fit Index
GOF	Goodness of Fit
IBEF	India Brand Equity Foundation
IFI	Incremental Fit Index
KMO	Kaiser-Meyer-Olkin
MOSPI	Ministry of Statistics and Programme Implementation
MPR	Multiplicative Preference Relation
MMDA	Municipal and District Assembly
PMC	Project Management Consultants
RII	Relative Important Index
RMSEA	Root Mean Squared Error of Approximation
SEM	Structural Equation Modeling
SRCC	Spearman's Rank Correlation Coefficient
TLI	Tucker-Lewis Index
USD	United States Dollar
VB	Variance Based

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Chapter 1

Introduction

1.1 General:

The population of the world is increasing at a rapid pace in the twenty-first century. The present growth trend is expected to result in a world population of 9 billion by 2050. The demand for infrastructure would naturally be impacted by this rapid and ongoing population growth(Ametepey et al. 2018). The construction industry is a vital sector that plays a significant role in the economic development of countries worldwide. It has a substantial impact on the economy of all nations and is a major contributor to the growth of other industries. The productivity of other sectors is significantly influenced by the construction industry, making it a key player in economic growth (Sha et al. 2017).

Over the last few decades, the Indian economy has been driven forward by the Indian construction industry, becoming a crucial component of the nation's socioeconomic progress. After agriculture, The construction industry in India is the second-largest sector in terms of economic contribution, accounting for 6-9% of the country's GDP over the past 5 years. This sector has experienced an average annual growth rate of 8-10% (Doloi, Sawhney, Iyer & Rentala 2012).

Infrastructure development is the backbone of a developing country. Its development implies growth in all sectors of the economy. The infrastructure market in India is projected to grow from $USD 186.24 billion in 2023 to $USD 294.12 billion by 2028, with a compound annual growth rate (CAGR) of 9.57%. In order to achieve its goal of US$ 5 trillion in economic development by 2025, India plans to improve its infrastructure. Infrastructure capital investment in Budget 2023-24 is being increased by 33%, reaching

Rs. 10 lakh crore (US$122 billion)., or roughly three times the amount invested in 2019–20 (India Brand Equity Foundation 2023)(IBEF) According to the "Ministry of Statistics and Programme Implementation (MOSPI)" December 2023 status report, which tracks infrastructure projects costing Rs 1500 million or more, 431 of the 1,820 projects revealed cost overruns and 848 projects were delayed (The Economic Times 2023).

1.2 Need of the Study:

Construction project delays are a frequent problem that occurs around the world (Sambasivan & Soon 2007). These delays are the elements that can make a project successful or unsuccessful. Construction projects are complex and frequently impacted by several variables that could delay their completion. Effectively minimizing, alleviating, and eliminating delays in construction projects requires understanding and detecting the underlying reasons for these delays (Zidane & Andersen 2018).

This study aims to identify and evaluate the factors significantly impacting project timelines and outcomes in the Indian context. By employing a methodology that integrates insights from industry experts in India. While existing literature has extensively explored delay factors in construction projects worldwide, focusing on nations such as European countries, the United States of America, and the United Arab Emirates, very little attention has been directed toward the Indian construction market. Therefore, this study aims to bridge this gap by examining the unique characteristics of delays in Indian construction projects and understanding the relationship between delay and effect factors. By identifying these critical delay factors, this research seeks to enhance the understanding of construction project management in India, facilitating more effective strategies for mitigating delays and optimising project success.

1.3 Objectives:

This research has the following objectives:

- To determine the delay and effect factors for construction projects.
- To analyse the relationship between delay and effect factors to determine the critical delay factors for construction projects.
- Development of a model to measure the delay in construction projects.
- To test the hypothesis that delay factors influence the effects of delays in construction

projects.

• To assign relative weight to attributes and factors of delay and the effect of delay in construction projects.

1.4 Organization of thesis:

The thesis is presented in seven chapters. The remaining six chapters of the thesis are organized as follows.

In Chapter 2, the literature review regarding the topic of the present study is presented. This research focuses on the analysis of construction project delays, which includes identifying delay factors and effect factors in construction projects. The delay attributes and effect attributes are identified through a literature review. through a literature review.

In Chapter 3, The development of the questionnaire, the selection of respondent groups, data collection via the questionnaire survey, and the analysis of the data in the study using a variety of statistical tools and techniques such as descriptive statistical analysis, factor analysis and regression analysis are explained and discussed.

In Chapter 4, the delay and effect factors of delay in construction projects are discussed. The delay and effect attributes of delay in construction projects were evaluated using descriptive statistical analysis and delay and effect factors were extracted from the delay and effect attributes using factor analysis. Critical delay factors corresponding to each effect factor were identified using multiple regression analysis. The most critical delay factor of all the delay factors was also identified.

In Chapter 5, the hypothesis that the delay factors influence the delay in construction projects was tested using structural equation modeling (SEM).

In Chapter 6, relative weights were assigned to each of the delay attributes, delay factors, effect attributes, and effect factors using the consistent fuzzy preference relation technique (CFPR).

Finally, in Chapter 7, the chapter concludes by emphasizing the contributions made to knowledge, discussing the study's shortcomings, and suggesting ideas for further research.

1.5 Summary:

This chapter has examined the significance of the construction sector and its contribution to the nation's development, serving as the foundation for this research. The objectives set for the current study, scope of work and the organization of the thesis to achieve these objectives have also been briefly outlined. In the next chapter, the literature review is presented and the gaps in the previous research work have been identified to set out the objectives for the current study.

Chapter 2

Literature Review

2.1 General:

This chapter includes a literature study conducted to understand the present state of research on the critical delay factors of construction projects. Delay is a global phenomenon that impacts the performance of construction projects worldwide (Sambasivan & Soon 2007). Construction project delays have been studied for many years. In general, research in this field is conducted in two ways: one focusing on factors that lead to project delays and the other on delay analysis (Durdyev et al. 2017). For this research, the first method is more relevant to this study and focuses on delay and effect factors.

2.2 Delay in construction projects:

A delay is a situation where the completion of a project goes beyond the agreed finish date (Durdyev et al. 2017). According to Javed et al. (2022), Durdyev & Hosseini (2020), delays can be classified into different categories such as critical and non-critical delays, as well as concurrent, compensable, and excusable delays. Critical and non-critical delays affect the scheduled project finish date. The simultaneous occurrence of two or more independent delays is known as a concurrent delay. Unforeseen delays can be classified as compensable or excusable due to circumstances outside of the contractor's control, whereas non-excusable delays are caused by circumstances under the contractor's control. Project and project management are impacted by different types of delays. Whereas third parties engaged in the project delivery process are the causes of external delays, project stakeholders are the cause of internal delays.

Construction projects frequently experience slower-than-anticipated progress and delays throughout implementation (Sha et al. 2017). According to Sambasivan & Soon (2007), delays are a worldwide occurrence that has an impact on how well construction projects and related businesses function. Most delays are the result of faulty management of several variables involving important stakeholders like clients, contractors, consultants, labour, equipment, and materials needed for projects. Project cost overruns, disputes, litigation, arbitration, and time overruns are all effects that are regularly experienced in the construction industry as a result of the causes of project delays outlined above (Rashid 2020). The following section briefly discuss several studies investigating the delay and its effects on construction projects in various countries.

2.3 Existing studies:

Research across various geographies, including India, has revealed many factors influencing project timelines. Doloi, Sawhney, Iyer & Rentala (2012) identified the factors causing delays in the construction industry in India, using a questionnaire survey and conducting in-depth interviews, a total of 77 valid responses were obtained from various stakeholders engaged in construction projects. Regression modelling and factor analysis were both utilized to assess the delay factors' importance. Based on the factor analysis, the following were the most important causes of construction delays: inadequate planning, poor coordination, ineffective site management, unclear project scope, poor communication, and subpar contracts. Based on the regression model, the project's overall delay was mainly caused by the owner's slow decision-making, low labour efficiency, and the architects' resistance to change and rework due to construction errors. Further extending the study, Doloi, Sawhney & Iyer (2012) employed a theoretical structural equation model to investigate the influence of four latent variables on project delays in the construction sector in India. The results of the structural equation model suggest that the impact of the client had the greatest influence on-time performance on Indian projects, which shows that the second study examines the direct and relative effects of these factors on time delay, whereas the first study merely looked at a few of the distinctive characteristics of the aspects influencing time performance in the Indian construction scenario.

To address the causes and effects of construction delays, Sambasivan & Soon (2007) created an integrated strategy in Malaysia. Out of the 28 indicated components, they were able to isolate 10 important factors and the consequences of six key delays using the relative importance index and Spearman rank correlation. A similar study was conducted by Hisham & Yahya (2016) on the causes and effects of delays in Malaysia's construction industry. In which a correlation was established between the delays' causes and their effects. The data was collected using a questionnaire that utilized a Likert scale, and the RII was used for analysis. The study discovered that subcontractors, site management, and owner interference are the top three reasons for delays, according to all respondents. Time overrun, cost overrun and total abandonment are the top three most significant effects.

Assaf & Al-Hejji (2006) conducted a survey on different construction projects in Saudi Arabia to determine the causes of delays and their perceived importance by the contractor, owner, and consultant. During the investigation, 73 reasons for delays were found. "Change orders" have been noted by all three parties as the most frequent reason for delays. According to surveys, 45 out of 76 projects that were taken into consideration were delayed, and 70% of projects ran over their allotted time. A new survey was published by Alajmi & Ahmed Memon (2022) that includes all relevant variables from prior research, Assessing both the present magnitude of delays and the feasibility of implementing improvements. In this paper, an overview of the Saudi Arabian construction industry as well as the construction sector in general has been provided. The main reasons behind the delays in the construction industry have been determined, along with their consequences, based on the review of the literature. Several common causes have been identified, including inadequate planning, issues with administration, challenges with financing, a shortage of experienced personnel, and inadequate communication. It was recommended that the major players in the construction industry use the right strategies to carry out preventative measures to minimise the effects when completing construction projects.

Based on a thorough assessment of the literature and actual data from significant Norwegian projects, Zidane & Andersen (2018) determined the causes of delay using open-ended survey questions. The findings identify specific factors that contribute to delays in the Norwegian construction sector, such as inadequate planning, sluggish decision-making, a lack of resources, poor communication, and design modifications. The survey also lists the top ten universal delay causes, including design modifications, payment delays, inadequate site management, and problems with worker productivity. The research offers useful insights for project managers and policymakers to minimize delay concerns and enhance project performance.

The following study's respondents were chosen using a purposive sampling strategy. The primary causes of project delays in Ghana, according to Amoatey et al. (2015) are variation orders, a weak financial and capital market, price fluctuations and inflation, increases in material prices, and delays in paying suppliers and contractors. Delays have serious effects, including overspending, time and money overruns, lawsuits, client discontinuity, and arbitration. They mostly examined the reasons for construction project delays in state housing projects. In contrast, Ametepey et al. (2018) conducted a study that specifically examined construction projects carried out by Metropolitan, Municipal and District Assemblies (MMDAs) in Ghana. The study also established a clear connection between the factors that cause delays and their resulting effects. Through a study, the main reasons for schedule delays were found to be material delivery delays, construction-related modification orders, delays in running bill payments, contractors' financial challenges with the project, and unanticipated site conditions. It was observed that delays led to disputes, time and cost overruns, contractor loan payback delays, and subpar work.

To identify and analyze the causes of delays in these large-scale projects in Oman Oyegoke & Al Kiyumi (2017) used a combination of literature review and interviews with industry professionals. Causes of project delays include inadequate planning, poor communication, design revisions, financial constraints, and external pressures. The research also investigates the substantial effects of project delays on project cost, schedule, and overall project success. To reduce delays and improve project performance, mitigation strategies such as competent project management, stakeholder participation, risk management, and advanced planning approaches are recommended. In a similar kind of research, Javed et al. (2022) focus on the building sector in Oman. The study reveals 60 delay causes, three of which are client-related (design changes, decision delays, and scope adjustments). This research also investigated the consequences and mitigation of typical delays as well as those caused by Covid-19. Effective project time and budget control systems are critical for minimizing construction delays.

Choong Kog (2018) did a thorough examination of 13 studies undertaken in Portugal, the United Kingdom, and the United States revealing the top 10 construction delay factors. The major delay factors for each country were presented in this paper, along with preventive methods for each factor. A similar study was done by Kog (2019) in which 6, 15, 3, and 5 studies indicate the top delay factors in the literature for Indonesia, Malaysia, Vietnam, and Thailand, respectively. To determine the respective top delay reasons for Malaysia, Indonesia, Vietnam, and Thailand, a review of these 29 papers was done. Mitigation strategies were also provided for each significant cause of delay to minimize construction delays.

Pourrostam & Ismail (2012) in this paper prioritises 10 major causes and 6 effects out of 28 causes and various effects in construction projects in Iran through a questionnaire survey. The ranking is done by the relative importance index. The top 10 causes include problems like clients not paying on time, clients initiating change orders during construction, poor site management, clients making slow decisions, contractors' financial difficulties, clients delaying the review and approval of design documents, Clients facing issues with subcontractors, contractors' poor project planning and scheduling, errors in design documents, and unfavourable weather conditions. Time overruns, cost overruns, disputes, project abandonment, arbitration, and litigation are the six main effects that have been identified. A similar study was done in Bangladesh by Hoque et al. (2023) who reported that among the 40 delay factors in Bangladesh, "Delays in progress payments," "rework due to mistakes during construction," "lack of skilled labour," "poor monitoring and control of activities," and "delays in the making of a decision" are listed as the top five variables that have the greatest impact on delays. The ten adverse consequences of construction delays are ranked as follows: "time overrun," "cost overrun," "disputes," "arbitration," and "litigation" are the five most detrimental. Table 2.1 shows several other studies worldwide that determined the delay and effect factors.

Table 2.1: Summary of literature review on delay factors

Researchers Name	Tool Used	Country	Delay attributes/ factors Identified
Santoso & Soeng (2016)	Importance index	Cambodia	Frequent equipment breakdowns, poor site management and supervision, inexperienced contractor, late progress payments, low productivity of labor.
Khair et al. (2016)	RII	Sudan	Contractor, client, consultant, material and external.
Sha et al. (2017)	RII	Nepal	Contractor, client, consultant, material, equipment, finance, labor and external.
Durdyev et al. (2017)	RII	Cambodia	Shortage of materials on site, late delivery of material, shortage of skilled labor, design changes, delay by subcontractor.
Khatib et al. (2018)	Delay factor index	Saudi Arabia	Labor productivity, providing alternative safe access, site conditions and constraints, the design constructability and modification.
Rashid (2020)	SEM	Pakistan	Contractor, client, consultant, material and equipment.

Continued on next page

Table 2.1 – continued from previous page

Researchers Name	Tool Used	Country	Delay attributes/ factors Identified
Vacanas & Danezis (2021)	Descriptive statistics	Cyprus	Changes by the owner, difficulties in financing of the works by the contractor, low productivity by contractor, payments delay by owner, bad communication between the parties, low productivity of labor.
Bagaya & Song (2016)	Descriptive statistics	Burkina Faso	Financial capability of contractor, slow payments of completed work, inadequate planning and scheduling, poor site management and supervision, slow decision making from owner.
Abbasi et al. (2020)	Descriptive statistics	Iran	Contractor, owner, architect, procurement and miscellaneous.
Akogbe et al. (2013)	Descriptive statistics	Benin	Contractor, owner, design, consultant and external.
Hussain et al. (2018)	RII	Pakistan	Contractor, project, external, equipment, owner, material, design, labor.
Viles et al. (2020)	Quantitative analysis	Spain	Changes during construction, poor construction management, construction errors, financial constraints, conflicts, lack of experience, low productivity.

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Table 2.1 – continued from previous page

Researchers Name	**Tool Used**	**Country**	**Delay attributes/ factors Identified**
Islam & Suhariadi (2018)	Descriptive statistics	Bangladesh	Lack of experienced construction managers, owners' fund shortage, lack of proper management by the owners, improper planning and scheduling, lack of skilled workers, contractors' financial problems.
Kim et al. (2016)	Factor analysis	Vietnam	Financial difficulties to owner, change design by owner, incompetence contractor, inadequate contractor experience.
Gunduz et al. (2015)	Fuzzy modeling	Turkey	Contractor, project, external, equipment, owner, material, design, labor.
Koshe & Jha (2016)	Factor analysis	Ethiopia	Difficulties in financing project by contractor, escalation of materials price, ineffective project planning, delay in progress payments for completed works, lack of skilled professionals.
Mpofu et al. (2017)	Descriptive statistics	United Arab Emirates	Clients, designers, project managers, contractors, labor, finance, communication and information, government authorities.

Continued on next page

Table 2.1 – continued from previous page

Researchers Name	Tool Used	Country	Delay attributes/ factors Identified
Gündüz et al. (2013)	RII	Turkey	Inadequate contractor experience, poor site management and supervision, design changes by owner, late delivery of materials, change orders, delay in progress payments.
McCord et al. (2015)	Factor analysis	United Kingdom	Client, consultant, contractor, design, equipment, external, labor, management, material, project.
Yang & Ou (2008)	SEM	Taiwan	Contract, management, human, non-human, design, finance.
Faridi & El-Sayegh (2006)	RII	United Arab Emirates	Preparation and approval of drawings, slowness of the owner's decision-making process, non-availability of materials on time, obtaining approval from different government authorities, financial problems of contractor.
Wang et al. (2018)	Descriptive statistics	China	Changes of scope, delay in progress payments, late procurement of materials, inexperienced contractor, poor planning and scheduling by contractor.

2.4 Identification of delay and effect attributes:

This study systematically reviews the literature to determine the delays and effects of construction projects in India. The delays and effects of construction delays have already

Table 2.2: List of delay attributes and their sources

Sr.no.	Delay Attributes	Sources
1	Delay in material supplied by vendors	Assaf and Al-Hejji, 2006; Doloi, Sawhney, Iyer & Rentala 2012; Doloi, Sawhney & Iyer 2012; Durdyev et al., 2017; Oyegoke and Al Kiyumi, 2017; Choong Kog, 2018; Kog, 2019; Abbasi et al., 2020; Rashid, 2020; Hoque et al., 2021
2	Delay in material to be supplied by the owner	Iyer and Jha, 2005; Assaf and Al-Hejji, 2006; Doloi, Sawhney, Iyer & Rentala 2012; Pourrostam and Ismail, 2012; Durdyev et al., 2017; Oyegoke and Al Kiyumi, 2017; Ametepey et al., 2018; Choong Kog, 2018; Kog, 2019; Abbasi et al., 2020; Rashid, 2020; Vacanas and Danezis, 2020; Hoque et al., 2021; Alajmi and Ahmed Memon, 2022
3	Delay in material procured by contractor	Iyer and Jha, 2005; Assaf and Al-Hejji, 2006; Doloi, Sawhney, Iyer & Rentala 2012; Doloi, Sawhney & Iyer 2012; Durdyev et al., 2017; Choong Kog, 2018; Zidane and Andersen, 2018; Kog, 2019; Abbasi et al., 2020; Rashid, 2020; Hoque et al., 2021
4	Price escalation of goods and services	Sambasivan and Soon, 2007; Doloi, Sawhney, Iyer & Rentala 2012; Doloi, Sawhney & Iyer 2012; Akogbe et al., 2013; Amoatey et al., 2015; Bagaya and Song, 2016; Khair et al., 2016; Durdyev et al., 2017; Oyegoke and Al Kiyumi, 2017; Khatib et al., 2018; Zidane and Andersen, 2018; Abbasi et al., 2020
5	Improper storage of materials leading to damage	Iyer and Jha, 2005; Assaf and Al-Hejji, 2006; Doloi, Sawhney, Iyer & Rentala 2012; Khair et al., 2016

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Sr.no.	Delay Attributes	Sources
6	Poor site management and supervision	Iyer and Jha, 2005; Assaf and Al-Hejji, 2006; Sambasivan and Soon, 2007; Doloi, Sawhney, Iyer & Rentala 2012; Doloi, Sawhney & Iyer 2012; Pourrostam and Ismail, 2012; Akogbe et al., 2013; Bagaya and Song, 2016; Khair et al., 2016; Santoso and Soeng, 2016; Durdyev et al., 2017; Oyegoke and Al Kiyumi, 2017; Ametepey et al.,2018; Choong Kog, 2018; Khatib et al., 2018; Zidane and Andersen, 2018; Kog, 2019; Abbasi et al., 2020; Hoque et al., 2021; Alajmi and Ahmed Memon, 2022
7	Poor labour productivity	Sambasivan and Soon, 2007; Doloi, Sawhney, Iyer & Rentala 2012; Doloi, Sawhney & Iyer 2012; Pourrostam and Ismail, 2012; Amoatey et al., 2015; Khair et al., 2016; Santoso and Soeng, 2016; Durdyev et al., 2017; Oyegoke and Al Kiyumi, 2017; Ametepey et al.,2018; Khatib et al., 2018; Zidane and Andersen, 2018; Abbasi et al., 2020; Rashid, 2020; Vacanas and Danezis, 2020; Alajmi and Ahmed Memon, 2022
8	Financial constraints of contractors	Assaf and Al-Hejji, 2006; Sambasivan and Soon, 2007; Doloi, Sawhney, Iyer & Rentala 2012; Pourrostam and Ismail, 2012; Akogbe et al., 2013; Amoatey et al., 2015; Bagaya and Song, 2016; Santoso and Soeng, 2016; Oyegoke and Al Kiyumi, 2017; Ametepey et al.,2018; Khatib et al., 2018; Zidane and Andersen, 2018; Kog, 2019; Abbasi et al., 2020; Vacanas and Danezis, 2020

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Sr.no.	Delay Attributes	Sources
9	Inadequate experience of contractor	Sambasivan and Soon, 2007; Doloi, Sawhney, Iyer & Rentala 2012; Doloi, Sawhney & Iyer 2012; Pourrostam and Ismail, 2012; Bagaya and Song, 2016; Khair et al., 2016; Santoso and Soeng, 2016; Oyegoke and Al Kiyumi, 2017; Ametepey et al.,2018; Choong Kog, 2018; Khatib et al., 2018; Zidane and Andersen, 2018; Kog, 2019; Abbasi et al., 2020; Hoque et al., 2021; Alajmi and Ahmed Memon, 2022
10	Lack of motivation for contractors for early finish	Sambasivan and Soon, 2007; Doloi, Sawhney, Iyer & Rentala 2012; Doloi, Sawhney & Iyer 2012
11	Frequent change of contractors and sub contractors	Iyer and Jha, 2005; Sambasivan and Soon, 2007; Doloi, Sawhney, Iyer & Rentala 2012; Doloi, Sawhney & Iyer 2012; Pourrostam and Ismail, 2012; Akogbe et al., 2013; Khair et al., 2016; Santoso and Soeng, 2016; Ametepey et al.,2018; Zidane and Andersen, 2018; Kog, 2019; Hoque et al., 2021
12	Delay in running bill payments to the contractor	Iyer and Jha, 2005; Assaf and Al-Hejji, 2006; Doloi, Sawhney, Iyer & Rentala 2012; Pourrostam and Ismail, 2012; Akogbe et al., 2013; Amoatey et al., 2015; Bagaya and Song, 2016; Khair et al., 2016; Santoso and Soeng, 2016; Durdyev et al., 2017; Oyegoke and Al Kiyumi, 2017; Ametepey et al.,2018; Zidane and Andersen, 2018; Kog, 2019; Vacanas and Danezis, 2020; Hoque et al., 2021
13	Improper planning of project by contractor	Sambasivan and Soon, 2007; Doloi, Sawhney, Iyer & Rentala 2012; Pourrostam and Ismail, 2012; Khair et al., 2016; Oyegoke and Al Kiyumi, 2017; Ametepey et al.,2018; Khatib et al., 2018; Zidane and Andersen, 2018; Kog, 2019; Alajmi and Ahmed Memon, 2022

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Sr.no.	Delay Attributes	Sources
14	Conflict between owners and other parties	Iyer and Jha, 2005; Sambasivan and Soon, 2007; Doloi, Sawhney, Iyer & Rentala 2012; Pourrostam and Ismail, 2012; Bagaya and Song, 2016; Khair et al., 2016; Santoso and Soeng, 2016; Durdyev et al., 2017; Oyegoke and Al Kiyumi, 2017; Ametepey et al.,2018; Khatib et al., 2018; Rashid, 2020
15	Poor coordination among various stakeholders	Iyer and Jha, 2005; Assaf and Al-Hejji, 2006; Sambasivan and Soon, 2007; Doloi, Sawhney, Iyer & Rentala 2012; Doloi, Sawhney & Iyer 2012; Pourrostam and Ismail, 2012; Akogbe et al., 2013; Amoatey et al., 2015; Bagaya and Song, 2016; Khair et al., 2016; Santoso and Soeng, 2016; Durdyev et al., 2017; Oyegoke and Al Kiyumi, 2017; Ametepey et al.,2018; Choong Kog, 2018; Khatib et al., 2018; Zidane and Andersen, 2018; Kog, 2019; Rashid, 2020; Vacanas and Danezis, 2020; Hoque et al., 2021; Alajmi and Ahmed Memon, 2022
16	Slow decisions from owner	Assaf and Al-Hejji, 2006; Doloi, Sawhney, Iyer & Rentala 2012; Pourrostam and Ismail, 2012; Akogbe et al., 2013; Bagaya and Song, 2016; Khair et al., 2016; Santoso and Soeng, 2016; Oyegoke and Al Kiyumi, 2017; Ametepey et al.,2018; Khatib et al., 2018; Zidane and Andersen, 2018; Kog, 2019; Abbasi et al., 2020; Hoque et al., 2021; Alajmi and Ahmed Memon, 2022
17	Frequent change of design by owner/ architect/ consultant	Iyer and Jha, 2005; Sambasivan and Soon, 2007; Doloi, Sawhney, Iyer & Rentala 2012; Khair et al., 2016; Oyegoke and Al Kiyumi, 2017; Khatib et al., 2018; Rashid, 2020

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Sr.no.	Delay Attributes	Sources
18	Delay in approval of completed work by client (i.e. stage passing)	Iyer and Jha, 2005; Doloi, Sawhney, Iyer & Rentala 2012; Doloi, Sawhney & Iyer 2012; Pourrostam and Ismail, 2012; Santoso and Soeng, 2016; Durdyev et al., 2017; Ametepey et al.,2018; Kog, 2019; Abbasi et al., 2020
19	Bureaucracy in client's organisation	Iyer and Jha, 2005; Doloi, Sawhney, Iyer & Rentala 2012; Amoatey et al., 2015; Zidane and Andersen, 2018
20	Delay in obtaining permission from government authorities	Iyer and Jha, 2005; Doloi, Sawhney, Iyer & Rentala 2012; Pourrostam and Ismail, 2012; Akogbe et al., 2013; Bagaya and Song, 2016; Santoso and Soeng, 2016; Durdyev et al., 2017; Oyegoke and Al Kiyumi, 2017; Ametepey et al.,2018; Choong Kog, 2018; Khatib et al., 2018; Zidane and Andersen, 2018; Kog, 2019; Rashid, 2020
21	unfavourable changes in government regulations and laws	Iyer and Jha, 2005; Doloi, Sawhney, Iyer & Rentala 2012; Pourrostam and Ismail, 2012; Santoso and Soeng, 2016; Oyegoke and Al Kiyumi, 2017; Ametepey et al.,2018; Choong Kog, 2018; Khatib et al., 2018; Kog, 2019
22	Unfavourable external environment (political and social)	Doloi, Sawhney, Iyer & Rentala 2012; Amoatey et al., 2015; Santoso and Soeng, 2016; Khatib et al., 2018; Zidane and Andersen, 2018
23	Rework due to error in execution	Assaf and Al-Hejji, 2006; Sambasivan and Soon, 2007; Doloi, Sawhney, Iyer & Rentala 2012; Doloi, Sawhney & Iyer 2012; Akogbe et al., 2013; Bagaya and Song, 2016; Khair et al., 2016; Santoso and Soeng, 2016; Durdyev et al., 2017; Khatib et al., 2018; Kog, 2019; Abbasi et al., 2020; Rashid, 2020; Hoque et al., 2021; Alajmi and Ahmed Memon, 2022

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Sr.no.	Delay Attributes	Sources
24	Unfavourable weather conditions	Doloi, Sawhney, Iyer & Rentala 2012; Doloi, Sawhney & Iyer 2012; Pourrostam and Ismail, 2012; Akogbe et al., 2013; Amoatey et al., 2015; Bagaya and Song, 2016; Santoso and Soeng, 2016; Durdyev et al., 2017; Oyegoke and Al Kiyumi, 2017; Ametepey et al.,2018; Choong Kog, 2018; Khatib et al., 2018; Zidane and Andersen, 2018; Rashid, 2020; Vacanas and Danezis, 2020)
25	Restricted access at site	Doloi, Sawhney, Iyer & Rentala 2012; Amoatey et al., 2015; Santoso and Soeng, 2016; Vacanas and Danezis, 2020; Alajmi and Ahmed Memon, 2022
26	Unforeseen ground conditions	Doloi, Sawhney, Iyer & Rentala 2012; Pourrostam and Ismail, 2012; Akogbe et al., 2013; Amoatey et al., 2015; Bagaya and Song, 2016; Durdyev et al., 2017; Oyegoke and Al Kiyumi, 2017; Ametepey et al.,2018; Choong Kog, 2018; Khatib et al., 2018; Zidane and Andersen, 2018
27	Delay in handing over of site by client to contractor	Iyer and Jha, 2005; Doloi, Sawhney, Iyer & Rentala 2012; Khair et al., 2016; Oyegoke and Al Kiyumi, 2017; Khatib et al., 2018; Zidane and Andersen, 2018
28	Site accidents due to lack of safety measures or negligence	Doloi, Sawhney, Iyer & Rentala 2012; Doloi, Sawhney & Iyer 2012; Santoso and Soeng, 2016; Ametepey et al.,2018; Vacanas and Danezis, 2020)
29	Ambiguity in specifications and conflicting interpretation by parties	Assaf and Al-Hejji, 2006; Sambasivan and Soon, 2007; Doloi, Sawhney, Iyer & Rentala 2012; Doloi, Sawhney & Iyer 2012; Santoso and Soeng, 2016; Oyegoke and Al Kiyumi, 2017; Ametepey et al.,2018; Khatib et al., 2018; Hoque et al., 2021; Alajmi and Ahmed Memon, 2022

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Sr.no.	Delay Attributes	Sources
30	Use of improper or obsolete construction methods	Assaf and Al-Hejji, 2006; Sambasivan and Soon, 2007; Doloi, Sawhney, Iyer & Rentala 2012; Amoatey et al., 2015; Khair et al., 2016; Santoso and Soeng, 2016; Durdyev et al., 2017; Oyegoke and Al Kiyumi, 2017; Ametepey et al.,2018; Khatib et al., 2018
31	Inefficient use of equipments because of unskilled operator	Iyer & Jha 2005; Sambasivan and Soon, 2007; Doloi, Sawhney, Iyer & Rentala 2012; Doloi, Sawhney & Iyer 2012; Akogbe et al., 2013; Khair et al., 2016; Santoso and Soeng, 2016; Durdyev et al., 2017; Ametepey et al.,2018; Vacanas and Danezis, 2020

been the subject of extensive research, and a well-established set of attributes that have undergone peer review is available in the literature Doloi, Sawhney, Iyer & Rentala (2012). While the attributes were being compiled, it became apparent that various researchers had cited many of the attributes for construction project delays in various contexts. Only attributes two or more researchers mentioned were considered to limit the list of attributes. As much as possible, the attributes cited in a single study were grouped with similar attributes (Tripathi & Jha 2019). The systematic literature review resulted in the identification of 31 delay attributes and 11 effect attributes. Tables 2.2 and 2.3 show the complete list of delay and effect attributes and their sources.

Table 2.3: List of effect attributes and their sources

Sr.no.	Effect Attributes	Sources
1	Cost overrun	Sambasivan and Soon, 2007; Pourrostam and Ismail, 2012; Amoatey et al., 2015; Khair et al., 2016; Gebrehiwet and Luo, 2017; Oyegoke and Al Kiyumi, 2017; Sha et al., 2017; Ametepey et al.,2018; Rashid, 2020; Hoque et al., 2021; Alajmi and Ahmed Memon, 2022; Javed et al., 2022
2	Dispute	Sambasivan and Soon, 2007; Pourrostam and Ismail, 2012; Khair et al., 2016; Oyegoke and Al Kiyumi, 2017; Sha et al., 2017; Ametepey et al.,2018; Hoque et al., 2021; Alajmi and Ahmed Memon, 2022; Javed et al., 2022
3	Litigation	Sambasivan and Soon, 2007; Amoatey et al., 2015; Khair et al., 2016; Gebrehiwet and Luo, 2017; Oyegoke and Al Kiyumi, 2017; Sha et al., 2017; Ametepey et al.,2018; Rashid, 2020; Hoque et al., 2021; Alajmi and Ahmed Memon, 2022; Javed et al., 2022
4	Termination of contract	Amoatey et al., 2015; Gebrehiwet and Luo, 2017; Oyegoke and Al Kiyumi, 2017; Hoque et al., 2021
5	Time overrun	Sambasivan and Soon, 2007; Pourrostam and Ismail, 2012; Amoatey et al., 2015; Khair et al., 2016; Gebrehiwet and Luo, 2017; Oyegoke and Al Kiyumi, 2017; Sha et al., 2017; Ametepey et al.,2018; Rashid, 2020; Hoque et al., 2021; Alajmi and Ahmed Memon, 2022; Javed et al., 2022

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Sr.no.	Effect Attributes	Sources
6	Arbitration	Sambasivan and Soon, 2007; Pourrostam and Ismail, 2012; Amoatey et al., 2015; Khair et al., 2016; Gebrehiwet and Luo, 2017; Oyegoke and Al Kiyumi, 2017; Sha et al., 2017; Ametepey et al.,2018; Hoque et al., 2021; Javed et al., 2022
7	Total abandonment	Sambasivan and Soon, 2007; Pourrostam and Ismail, 2012; Amoatey et al., 2015; Khair et al., 2016; Oyegoke and Al Kiyumi, 2017; Sha et al., 2017; Ametepey et al.,2018; Rashid, 2020; Hoque et al., 2021; Alajmi and Ahmed Memon, 2022; Javed et al., 2022
8	Reduction in project quality	Oyegoke and Al Kiyumi, 2017; Ametepey, Gyadu-Asiedu and Assah-Kissiedu, 2018; Hoque et al., 2021
9	Negative reputation	Ametepey et al.,2018; Hoque et al., 2021
10	Loss of revenue	Ametepey et al.,2018; Hoque et al., 2021
11	Impact on society	Ametepey et al.,2018; Hoque et al., 2021

2.5 Research gap:

The ultimate goal of construction projects is successful completion, just like in any other business (Tripathi & Jha 2018*c*). However, construction projects frequently experience slower-than-anticipated progress and delays throughout implementation, and it is challenging to succeed in such circumstances (Sha et al. 2017). Therefore, many delay and effect factors are available in the literature. However, because of their limited resources, stakeholders in construction projects find it extremely difficult to focus on too many factors at once. Hence, it is essential to identify those factors that are highly significant for delay in construction projects and to concentrate on a limited number of factors rather than focusing on an excessive number of factors.

From the literature review, to determine the reasons for delays, a great deal of study has been done in developed countries like European countries, the United States of America, the United Arab Emirates, etc. with most studies being conducted with a specific location or nation in mind (Hoque et al. 2023), but very few of them have tried to focus their attention on the Indian market. The delay factor of a construction project in one country may or may not be critical in another country. Most studies have primarily focused on identifying the cause and effect of delays. However, there is a need for further investigation into the relationship between the different causes and effects of delays on Indian construction projects to determine the critical factors causing delays.

2.6 Summary:

In this chapter, various research works carried out worldwide in the area of delay factors and effect factors of construction projects were reviewed to identify the research gaps, and accordingly, research objectives were set. Along with studying literature delay and effect attributes were also identified. In the following chapter, the research methodology used to achieve the study's objectives will be explained.

Chapter 3

Research Methodology

3.1 Introduction:

The literature review conducted in the previous chapter has revealed studies from different countries on the identification of factors responsible for the delay and the effect of delay in construction projects. Findings indicate that most of the earlier research has been conducted in the context of European nations, the United Arab Emirates, the United Kingdom, etc., with relatively few studies published in the context of nations like India. The research objectives for the present study are established in Chapter 1. This chapter outlines the research methodology employed to accomplish the research objectives. The research method broadly involves the following two steps.

Step 1: Data collection using questionnaire surveys.

Step 2: Data analysis of responses using descriptive analysis, and multivariate analysis.

3.2 First stage questionnaire preparation:

The delay and effect attributes identified were used to design the questionnaire. To confirm the comprehension and grammar of the questionnaire, a pilot survey was conducted, and necessary adjustments were made (Oyegoke & Al Kiyumi 2017). A questionnaire was created in 4 parts; an extract of part 1 is shown in Table 3.1. The 31 delay attributes were listed in the first part. The second part of the questionnaire contained 11 effect attributes. The third part contains information about organisations, including the name of the organisation, its category, and the overall number of years the company has been in the construction industry. The fourth part contains information about respondents, including their name, email address, and the total number of years the respondent has worked in the construction industry. Based on their knowledge and experience, respondents were asked to rank the questions on a five-point Likert scale from 1 (very low) to 5 (very high). The questionnaire used for the first stage of the study is provided in Appendix A.

Table 3.1: Extract of Part 1 of the questionnaire

PART-1	**Please put a tick mark or highlight the relevant cell to rate the following parameters (on a five-point Likert scale from very low effect = 1 to very high effect = 5) with respect to the extent to which they can delay the construction projects.**					
Sl. No.	Delay attributes	Very low effect	Low effect	Moderate effect	High effect	Very high effect
1	Delay in material supplied by vendors					
2	Delay in material to be supplied by the owner					
3	- - Attributes as given in Table 2.2					

3.3 Sample Selection:

The selection of the sample comes next after the attributes have been determined. Every construction company in India is registered with many government departments or independent groups founded with support from the Indian government. The sources for the sample selection 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. To choose participants from a wide pool of professionals working in the Indian construction industry, this study used a random sampling technique, including contractors, clients, and project management consultants (PMC). Professionals were chosen in a manner that maximised sample uniformity and reliability. Every respondent had prior experience with significant engineering construction projects within the Indian context. The following formula was used to get the sample size that represented the population (Tripathi & Jha 2018*a*).

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

Where,

$$n' = \frac{p * q}{v^2} \tag{3.2}$$

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 sampling population

To get the maximum sample size, it was assumed that p and q were equal to 0.5. The sample size was determined using a standard error of 5%, with a maximum permitted standard error of 10%. The formula above indicated that 96 was the necessary sample size.

3.4 Respondent's Profile:

A total of 129 responses were gathered from 50 companies that consisted of PMCs, contractors, and clients. The respondent's profile is shown in Table 3.2.

Table 3.2: Respondent's profile

	Group	**Total count**	**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	79	61.24
	11-20	26	20.16
	21-30	16	12.40
	Above 30	8	6.20
Organization total years of experience (in years)	1-10	18	13.95
	11-20	34	26.36
	21-30	31	24.03
	Above 30	46	35.66
Category based on project cost (in millions dollar)	Less than 500	19	38.77
	500-1000	11	22.44
	1000-10000	16	32.65
	Above 10000	3	6.122

3.5 Data Analysis:

3.5.1 Ranking of delay and effect attributes:

The 5-point Likert scale was used to rank the delay and effect attributes. The standard deviations and mean values of each attribute were obtained using every collected response. If two or more attributes had the same mean value, the attribute with the lower standard deviation was ranked higher (Tripathi & Jha 2018*a*). The data was analysed using Microsoft Excel 2016.

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

R_i=rating using the 5-point Likert scale (1 to 5),

F_i = number of responses received for the rating,

n= the number of responses

3.5.2 Rank correlation coefficient test:

A correlation between the selected attributes is assessed using Spearman's rank correlation coefficient (SRCC) (Doloi, Sawhney, Iyer & Rentala 2012). A perfect positive association is represented by a correlation coefficient value of +1, and a perfect negative relationship is represented by a correlation coefficient value of -1. Accordingly, sample estimates of correlation that are close to unity in magnitude suggest a strong correlation, whereas values that are close to zero suggest little to no correlation (Pourrostam & Ismail 2012). The null hypothesis, which asserts that there is no significant correlation between the two groups' rankings, can be rejected if the statistical measure R is found to be significant at a 5% significance level (Islam & Suhariadi 2018). This study employs Spearman's rank correlation coefficient, which is widely used, to assess the degree of agreement between two survey groups regarding their rankings (Tripathi & Jha 2019). The Spearman's rank correlation coefficient, R is calculated using Equations 3.4 and 3.5.
(1) When data do not have tied ranks

$$\text{R} = 1 - \frac{6 \sum d_i^2}{n(n^2 - 1)} \tag{3.4}$$

Where, di = difference in paired ranks and

n = number of cases

(2) When data have tied ranks

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

Where, i = rank

3.5.3 Categorizing attributes based on their mean value

The mean value obtained from the descriptive statistical analysis does not align with the whole numbers specified in the questionnaire, which utilised a five-point Likert scale. Thus for interpretation, the various attributes of delay and effect in construction projects may be considered to fall somewhere between two adjacent scales as shown in Table 3.3 (Tripathi & Jha 2018*a*).

Table 3.3: Categories of attributes

SI.no.	Mean value(µ)	Degree of effect/ importance
1	µ >4.5	Very high
2	4.5 >µ >3.5	High
3	3.5 >µ >2.5	Moderate
4	2.5 >µ >1.5	Low
5	1.5 >µ	Very low

3.5.4 Statistical significance test:

There are three tests that can be used to determine the statistical significance of attributes at a specific mean value: the one-sample Wilcoxon test, the non-parametric one-sample sign test, or the parametric one-sample t-test (Tripathi & Jha 2019). The present study employed the parametric one-sample t-test to analyse the data, which exhibited a normal distribution without any outliers. This test aims to ascertain whether there exists a significant disparity between the mean of the sample and the mean of the population (Tripathi & Jha 2018*a*, Ofori et al. 2000).

3.5.5 Factor analysis:

Factor analysis's primary goal is to simplify more observed attributes into a few factors that explain most of the observed variance (Doloi, Sawhney, Iyer & Rentala 2012). The current study uses factor analysis on delay attributes and effect attributes to determine the fundamental factors that explain the observed correlation patterns within the collection of attributes. Statistical Package for Social Sciences 27 (for Windows) was used to perform factor analysis on all responses.

Factor extraction can be done using different methods, including principal components, unweighted least squares, generalised least squares, maximum likelihood, principal axis factoring, etc. This study employed the principal components method of extraction, which is widely used, along with varimax rotation. Varimax rotation aims to maximise the variance of the squared loading for each factor. (Tripathi & Jha 2019). The principal component analysis is one of the oldest and most well-known methods of analysis (McCord et al. 2015). The first step in the principal components extraction method is finding a linear combination of a component that best explains the variation in the original attributes that is expressed in scores and loadings. It then looks for another component uncorrelated with the previous component and can explain as much of the remaining variation as possible; this process is repeated until the number of components equals the number of original attributes. Most of the variance is typically explained by a few components, which can be utilised to substitute the original attributes.

Factor rotation is used to determine how variables are related to the identified factors. Rotation techniques are classified into two types: orthogonal and oblique rotation. Uncorrelated factors are orthogonally rotated (e.g., Varimax), while correlated factors are obliquely rotated (e.g., Promax). Varimax rotation is a technique that aims to maximise the variance of the squared loadings for each factor. This method results in clear and easily interpretable factor loadings (Tripathi & Jha 2019). The Kaiser Meyer Olkin (KMO) and Bartlett's sphericity tests were employed to assess the suitability of the survey data for factor analysis (Kim et al. 2016).

3.5.6 Reliability test:

After factors have been extracted, the factor analysis's applicability must be verified, and an internal consistency test called a reliability test must be carried out (Javed et al. 2022). The reliability of data for the application of factor analysis can be checked in various ways. The Cronbach's alpha test is of great importance as it quantifies the internal consistency of attributes by assessing the average correlation among them and the total number of attributes in the sample (Doloi, Sawhney, Iyer & Rentala 2012).

The internal consistency of the attributes is explained by the reliability coefficient, which has a "very high," "high," and "moderate" effect on each attribute, as shown in Table 3.3. The internal consistency was evaluated using Cronbach's alpha test (Cα) varying between the range of 0 to 1. A larger value indicates more internal consistency and vice versa. Generally, a Cα >0.7 is acceptable (Doloi, Sawhney, Iyer & Rentala 2012).

3.5.7 Correlation coefficient test:

To determine whether the attributes grouped together in factor analysis collectively explain the same measure, one can assess this using Pearson's correlation coefficient, Kendall's tau-b, and Spearman's correlation coefficient. The Pearson bivariate correlation test is commonly employed to quantify the extent of the association between variables. This test assumes that the variables follow a normal distribution and have a linear relationship (Tripathi & Jha 2019). All these tests determine the degree of correlation between the two variables. This study employs Pearson's correlation test to calculate the coefficients that indicate the correlation between the attributes grouped under a factor. This test validates that all the attributes categorised under the factors show a positive correlation.

3.5.8 Multiple linear regression:

Multiple regression analysis is employed to evaluate the correlation between independent and dependent variables across multiple observations. The regression model is represented by the following equation Doloi, Sawhney, Iyer & Rentala (2012).

$$Y = a_0 + a_1X_1 + a_2X_2 + a_3X_3 + \cdots + a_nX_n + e \tag{3.6}$$

In the above equation,
Y = dependent variable,
X_i = independent variables, where, i =1, 2 ... n,
a_i = coefficients, where, i= 0, 1 ... n, and
e = error term.

To determine the criticality of delay factors corresponding to different effect factors, a stepwise regression is used. Regression was performed using the factor scores for each of the delay factors and effect factors. One by one, the effect factors were considered dependent variables, and all of the delay factors were considered independent variables (Tripathi & Jha 2019).

A regression model that exhibits a high coefficient of determination (R^2) is considered to be good. The value of R^2 indicates the proportion of the variance in the dependent variable that can be accounted for by the independent variables. The value of R^2 ranges from 0 to 1. However, when more independent variables are introduced into the model, R^2 automatically increases. For a better estimate of the goodness of fit adjusted R^2 is calculated. Unlike R^2, It measures the percentage of variance explained by only those independent variables that impact the dependent variable.

3.5.9 Summary:

In this chapter, the first stage of questionnaire survey preparation, sample selection, and various statistical tools such as descriptive statistical analysis, factor analysis, and multiple regression analysis, were discussed in detail. The results of various statistical analyses have been presented in the respective chapters. The next chapter discusses the analysis of responses of the first stage questionnaire on delay and effect attributes for determining the delay in construction projects.

Chapter 4

Delay factors and effect factors of construction projects

4.1 Introduction

The previous chapter provided a detailed discussion of the research methods employed to accomplish the objectives of this study. This chapter focuses on the analysis of the responses obtained from the first stage questionnaire. The following objectives are to be discussed in this chapter.

(a) To evaluate delay attributes and effect attributes for construction projects, and

(b) To identify delay factors (DFs) and effect factors (EFs) for construction projects.

4.2 Evaluation of delay and effect attributes

As stated in section 3.5.1 of Chapter 3, the delay and effect attributes identified in the study were assessed using a five-point scale in the questionnaire. The attributes were ranked based on the mean values and standard deviations of the responses. The mean was calculated using Equation 3.3. When two or more attributes had the same mean value, the attributes with a lower standard deviation were given a higher ranking (Tripathi & Jha 2019). The ranking of delay and effect attributes based on responses of all respondent groups is shown in Table 4.1 and 4.2 respectively.

Table 4.1: Ranking of cause attributes

Sr. no.	Cause attributes	ID	Client		Contractor		PMC		Overall	
			Mean	Rank	Mean	Rank	Mean	Rank	Mean	Rank
1	Slow decisions from owner	DA16	3.917	5	4.164	1	4.143	6	4.070	1
2	Poor labour productivity	DA7	3.979	2	4.015	2	4.286	2	4.031	2
3	Improper planning of project by contractor	DA13	3.979	1	3.955	4	3.929	9	3.961	3
4	Frequent change of contractors and subcontractors	DA11	3.917	4	3.955	6	4.071	7	3.953	4
5	Frequent change of design by owner/ architect/ consultant	DA17	3.813	7	3.985	3	4.143	5	3.938	5
6	Poor site management and supervision	DA6	3.938	3	3.910	7	3.929	10	3.922	6
7	Financial constraints of contractors	DA8	3.729	8	3.955	5	4.429	1	3.922	7
8	Inadequate experience of contractor	DA9	3.875	6	3.851	8	4.143	4	3.891	8
9	Delay in material procured by contractor	DA3	3.604	11	3.731	10	4.214	3	3.736	9

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Table 4.1 – continued from previous page

Sr. no.	Cause attributes	ID	Client		Contractor		PMC		Overall	
			Mean	Rank	Mean	Rank	Mean	Rank	Mean	Rank
10	Delay in obtaining permissions from government authorities	DA20	3.667	9	3.597	12	3.643	14	3.628	10
11	Conflict between owners and contractors	DA14	3.625	10	3.537	16	4.000	8	3.620	11
12	Delay in running bill payments to the contractor	DA12	3.188	20	3.761	9	3.643	15	3.535	12
13	Delay in material supplied by vendors	DA1	3.458	14	3.567	13	3.571	19	3.527	13
14	Unfavourable changes in government regulations and laws	DA21	3.542	13	3.343	20	3.714	12	3.457	14
15	Inefficient use of equipments because of unskilled operator	DA31	3.563	12	3.418	18	3.214	25	3.450	15
16	Delay in approval of completed work by client (i.e. stage passing)	DA18	3.063	26	3.657	11	3.571	18	3.426	16

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Table 4.1 – continued from previous page

Sr. no.	Cause attributes	ID	Client		Contractor		PMC		Overall	
			Mean	Rank	Mean	Rank	Mean	Rank	Mean	Rank
17	Delay in material to be supplied by the owner	DA2	3.271	17	3.537	14	3.286	20	3.411	17
18	Poor coordination among various stakeholders	DA15	3.271	16	3.433	17	3.786	11	3.411	17
19	Delay in handing over of site by client to contractor	DA27	3.125	24	3.537	15	3.214	24	3.349	19
20	Rework due to error in execution	DA23	3.146	22	3.358	19	3.571	17	3.302	20
21	Site accidents due to lack of safety measures or negligence	DA28	3.250	18	3.254	22	3.643	13	3.295	21
22	Price escalation of goods and services	DA4	3.396	15	3.179	25	3.143	25	3.256	22
23	Use of improper or obsolete construction methods	DA30	3.208	19	3.119	27	3.571	22	3.202	23

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Table 4.1 – continued from previous page

Sr. no.	Cause attributes	ID	Client		Contractor		PMC		Overall	
			Mean	Rank	Mean	Rank	Mean	Rank	Mean	Rank
24	Unfavourable external environment (political and social)	DA22	3.167	21	3.224	24	3.143	26	3.194	24
25	Bureaucracy in client's organisation	DA19	3.125	23	3.164	26	3.286	21	3.163	25
26	Unforeseen ground conditions	DA26	3.063	25	3.104	28	2.929	29	3.070	26
27	Unfavourable weather conditions	DA24	2.813	29	3.254	21	2.643	31	3.023	27
28	Restricted access at site	DA25	2.771	30	3.224	23	2.929	30	3.023	28
29	Improper storage of materials leading to damage	DA5	2.813	28	3.045	30	3.071	28	2.961	29
30	Lack of motivation for contractors for early finish	DA10	3.021	27	2.866	31	3.143	27	2.953	30

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Table 4.1 – continued from previous page

Sr. no.	Cause attributes	ID	Client		Contractor		PMC		Overall	
			Mean	Rank	Mean	Rank	Mean	Rank	Mean	Rank
31	Ambiguity in specifications and conflicting interpretation by parties	DA29	2.604	31	3.045	29	3.214	23	2.899	31

Table 4.2: Ranking of effect attributes

Sr. No.	Effect Attributes	ID	Client		Contractor		PMC		Overall	
			Mean	Rank	Mean	Rank	Mean	Rank	Mean	Rank
1	Time overrun	EA2	4.104	1	4.194	1	4.500	2	4.194	1
2	Cost overrun	EA1	3.979	3	3.955	2	4.571	1	4.031	2
3	Loss of revenue	EA10	4.042	2	3.761	3	3.857	3	3.876	3
4	Negative reputation	EA9	3.875	4	3.552	6	3.429	6	3.659	4
5	Reduction in project quality	EA8	3.500	7	3.627	4	3.500	5	3.566	5
6	Total abandonment	EA7	3.542	5	3.612	5	3.357	11	3.558	6
7	Dispute	EA3	3.500	6	3.254	8	3.714	4	3.395	7
8	Termination of contract	EA6	3.375	9	3.358	7	3.429	7	3.372	8
9	Impact on society	EA11	3.438	8	3.194	9	3.071	10	3.271	9
10	Litigation	EA5	2.958	10	2.791	10	3.214	8	2.899	10
11	Arbitration	EA4	2.854	11	2.731	11	3.143	9	2.822	11

4.2.1 Understanding the responses from different respondent's groups

The respondents who participated in the survey were from three different groups of organizations. These are construction contractors, real estate developers, and project management consultants. To understand the level of agreement between various respondent groups on the rankings of delay and effect attributes, the mean values of all attributes for responses of each respondent's group were calculated separately. The ranking of performance attributes by various respondent groups is shown in Tables 4.1 and 4.2.

The agreement between different respondent groups was assessed using the Spearman's rank correlation coefficient (R) test, as described in section 3.5.2 of Chapter 3. Using equations 3.4 and 3.5 the values of Spearman's rank correlation coefficient (R) are calculated as shown in Tables 4.3 and 4.4, The values show that there was a significant agreement among the different groups of respondents regarding the ranking of delay and effect attributes.

Table 4.3: Spearman's rank correlation test among various groups of respondents on delay attributes

SI. no.	Comparison of ranks	Spearman's rank correlation coefficient, R	Significance level, p	Conclusion
1	Contractor vs Client	0.799	0.000	Reject H0 at $p = 5\%$
2	Contractor vs PMC	0.797	0.000	Reject H0 at $p = 5\%$
3	Client vs PMC	0.840	0.000	Reject H0 at $p = 5\%$

Table 4.4: Spearman's rank correlation test among various groups of respondents on effect attributes

SI. no.	Comparison of ranks	Spearman's rank correlation coefficient, R	Significance level, p	Conclusion
1	Contractor vs Client	0.891	0.000	Reject H0 at p = 5%
2	Contractor vs PMC	0.845	0.001	Reject H0 at p = 5%
3	Client vs PMC	0.809	0.003	Reject H0 at p = 5%

4.3 Identification of delay and effect factors

An organisation aspiring to achieve success in the construction industry would face significant challenges in effectively implementing all 31 delay attributes and 11 effect attributes mentioned earlier. In this study, factor analysis was used on delay and effect attributes to identify the underlying factors that explain the pattern of correlations among a set of observed attributes. All responses were factor analysed using SPSS 27 (for Windows) (Koshe & Jha 2016).

4.3.1 Categorization of delay and effect attributes

The mean obtained from the descriptive statistical analysis is not a whole number, as stated in section 3.5.3 of chapter 3. Thus, the different attributes of delay and effect in construction projects may fall somewhere between two adjacent scales, depending on how they are interpreted as shown in Tables 4.5 and 4.6.

Table 4.5: Categories of cause attributes

SI.no.	Mean value(µ)	Degree of effect	Cause attributes
1	µ >4.5	Very high effect	Nil
2	4.5 >µ >3.5	High effect	DA1, DA3, DA6-DA9, DA11-DA14, DA-16, DA17, DA-20
3	3.5 >µ >2.5	Moderate effect	DA-2, DA-4, DA-5, DA-7, DA-8, DA-10, DA-15, DA-18, DA-19, DA-21-DA-31
4	2.5 >µ >1.5	Low effect	Nil
5	1.5 >µ	Very low effect	Nil

Table 4.6: Categories of effect attributes

SI.no.	Mean value(µ)	Degree of effect	Effect attributes
1	µ >4.5	Very high effect	Nil
2	4.5 >µ >3.5	High effect	EA1, EA2, EA7-EA10
3	3.5 >µ >2.5	Moderate effect	EA3-EA6, EA11
4	2.5 >µ >1.5	Low effect	Nil
5	1.5 >µ	Very low effect	Nil

4.3.2 Statistical significance of delay and effect attributes

As mentioned in section 3.5.4 of chapter 3, one sample t-test was conducted on attributes with a mean value of 3.0 (moderate effect) or higher and was considered for further study because these attributes were considered to be more significant in explaining construction project delays. The one-sample t-test result shows the delay attributes - improper storage of materials leading to damage (DA5), lack of motivation for contractors for the early finish (DA10), bureaucracy in the client's organisation (DA19), the unfavourable external environment (political and social) (DA22), unfavourable weather conditions (DA24), restricted access at the site (DA25), unforeseen ground conditions (DA26), ambiguity in specifications and conflicting interpretation by parties (DA29), had a significance level of >0.05, hence they did not pass the one-sample t-test at a test value of 3.0. Similarly, effect attributes - arbitration (EA4) and litigation (EA5) did not pass the one-sample t-test at a test value of 3.0. The results of the one-sample t-test are shown in Tables 4.7 and 4.8. This shows that these delay and effect attributes did not significantly impact the delay of construction projects and were not considered for further analysis. Therefore, only 23 of the 31 delay attributes and 9 of the 11 effect attributes, respectively, demonstrated "very high", "high", and "moderate" effects on the delay of construction projects.

Table 4.7: One sample T-test for cause attributes

Cause attributes	ID	Test Value = 3		
		t	df	Sig. (2-tailed)
Delay in material supplied by vendors	DA1	5.642	128	.000
Delay in material to be supplied by the owner	DA2	4.381	128	.000
Delay in material procured by contractor	DA3	8.673	128	.000
Price escalation of goods and services	DA4	2.877	128	.005
Improper storage of materials leading to damage	DA5	-0.420	128	.675
Poor site management and supervision	DA6	11.342	128	.000
Poor labour productivity	DA7	13.975	128	.000
Financial constraints of contractors	DA8	10.119	128	.000
Inadequate experience of contractor	DA9	10.524	128	.000
Lack of motivation for contractors for early finish	DA10	-0.537	128	.592
Frequent change of contractors and sub contractors	DA11	11.390	128	.000
Delay in running bill payments to the contractor	DA12	5.537	128	.000
Improper planning of project by contractor	DA13	14.891	128	.000
Conflict between owners and contractors	DA14	6.292	128	.000
Poor coordination among various stakeholders	DA15	4.962	128	.000
Slow decisions from owner	DA16	12.635	128	.000
Frequent change of design by owner / architect/ consultant	DA17	11.625	128	.000
Delay in approval of completed work by client (i.e. stage passing)	DA18	4.284	128	.000
Bureaucracy in client's organisation	DA19	1.746	128	.083
Delay in obtaining permissions from government authorities	DA20	6.585	128	.000
Unfavourable changes in government regulations and laws	DA21	4.675	128	.000
Unfavourable external environment (political and social)	DA22	1.944	128	.054
Rework due to error in execution	DA23	3.293	128	.001
Unfavourable weather conditions	DA24	0.276	128	.783
Restricted access at site	DA25	0.267	128	.790
Unforeseen ground conditions	DA26	0.878	128	.382
Delay in handing over of site by client to contractor	DA27	3.508	128	.001
Site accidents due to lack of safety measures or negligence	DA28	3.023	128	.003
Ambiguity in specifications and conflicting interpretation by parties	DA29	-1.088	128	.279
Use of improper or obsolete construction methods	DA30	2.461	128	.015
Inefficient use of equipments because of unskilled operator	DA31	5.108	128	.000

Table 4.8: One sample T-test for effect attributes

Effect attributes	ID	Test Value = 3.0		
		t	df	Sig. (2-tailed)
Cost overrun	EA1	14.466	128	0.000
Time overrun	EA2	15.809	128	0.000
Dispute	EA3	4.870	128	0.000
Arbitration	EA4	-1.601	128	0.112
Litigation	EA5	-0.945	128	0.346
Termination of contract	EA6	3.732	128	0.000
Total abandonment	EA7	5.378	128	0.000
Reduction in project quality	EA8	6.435	128	0.000
Negative reputation	EA9	7.287	128	0.000
Loss of revenue	EA10	10.635	128	0.000
Impact on society	EA11	2.832	128	0.005

4.3.3 Factor analysis

In accordance with section 3.5.5 of chapter 3, the Kaiser Meyer Olkin (KMO) and Bartlett's sphericity tests were employed to assess the suitability of the survey data for factor analysis (Kim et al. 2016). The factor analysis findings revealed that Bartlett's test of Sphericity for delay attributes was 1016 with a significance level of less than 0.01. For effect attributes, it was 362 with a significance level of less than 0.01. This indicates that the correlation matrix was not an identity matrix (Tripathi & Jha 2019). For delay attributes, the Kaiser Meyer Olkin value was 0.793 (>0.5) and for effect attributes, it was 0.792 (>0.5). These findings indicate that the sample size for factor analysis is appropriate (Koshe & Jha 2016). This study only included attributes with a factor loading greater than 0.5 (Tripathi & Jha 2018*a*). Using the principal components method of extraction along with varimax rotation in Statistical Package for Social Sciences 27 (for Windows), seven delay factors (DFs) and three effect factors (EFs) with eigenvalues larger than one were identified. DFs and EFs explained 68.005% and 64.021% of the total variance, respectively. Figures 1 and 2 show the results of factor analysis.

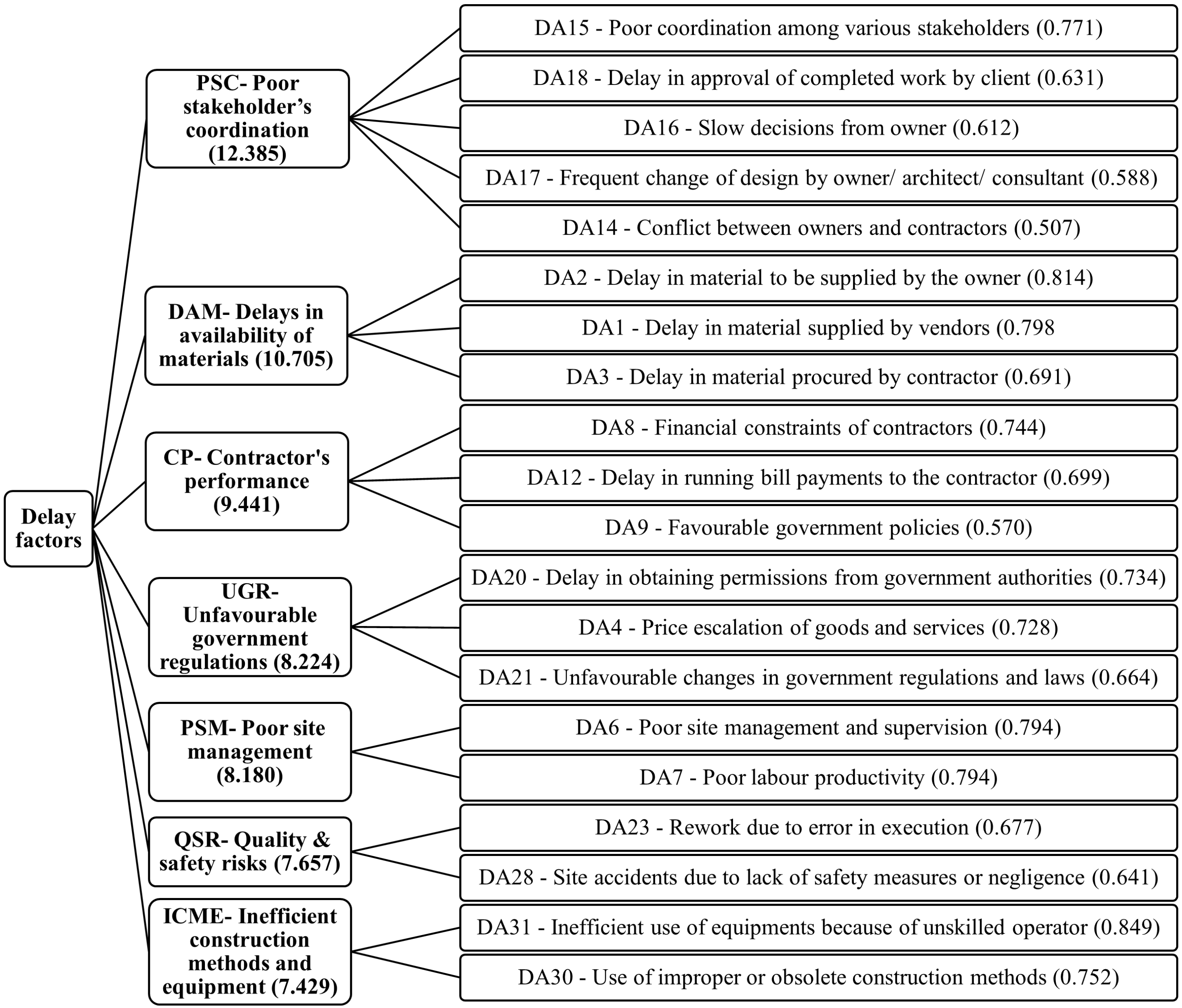

Figure 4.1: Delay factors

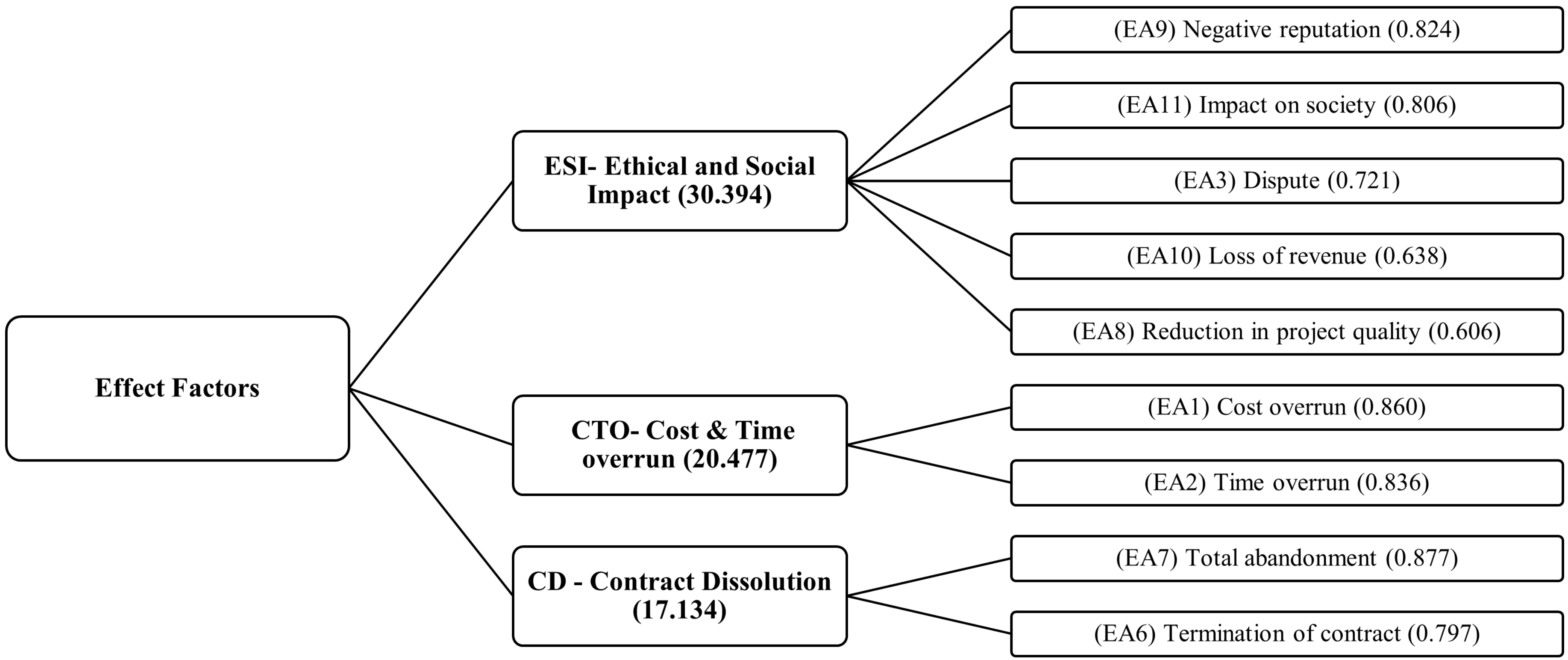

Figure 4.2: Effect factors

4.3.4 Reliability test

A reliability test, specifically measuring internal consistency, was conducted to assess the suitability of factor analysis. In order to assess the internal consistency, a Cronbach's alpha (Cα) test was conducted on all the attributes that had 'very high' and 'high' effects, as indicated in Table 4.2. The analysis revealed a Cα value of 0.873, indicating a high level of internal consistency for the attributes. As stated in the research methodology, a Cα value greater than 0.70 is considered acceptable (Tripathi & Jha 2018*a*).

4.3.5 Correlation coefficient test:

A Pearson bivariate correlation test was used to examine whether the attributes categorised under a factor in the factor analysis collectively explain the same measure (Tripathi & Jha 2019). Tables 4.9, 4.10, 4.11 and 4.12 show the attributes under each factor showed a positive correlation in the range of 0.203–0.662 for DFs and EFs in the range of 0.356–0.576. Pearson bivariate correlations are mostly greater than 0.3 among various attributes. Based on these findings, we can ensure that factors created through factor analysis contain related attributes.

Table 4.9: Correlation coefficient of attributes within the factors DF1

		DF1				
		DA14	DA15	DA16	DA17	DA18
DF1	DA14	1				
	DA15	.439**	1			
	DA16	.388**	.409**	1		
	DA17	.358**	.410**	.422**	1	
	DA18	.320**	.392**	.432**	.546**	1

Table 4.10: Correlation coefficient of attributes within the factors DF2, DF3, and DF4

		DF2			**DF3**			**DF4**		
		DA1	DA2	DA3	DA8	DA9	DA12	DA4	DA20	DA21
DF2	DA1	1								
	DA2	.616**	1							
	DA3	.496**	.479**	1						
DF3	DA8				1					
	DA9				.580**	1				
	DA12				.443**	.203*	1			
DF4	DA4							1		
	DA20							.295**	1	
	DA21							.264**	.662**	1

Table 4.11: Correlation coefficient of attributes within the factors DF5, DF6, and DF7

		DF5		**DF6**		**DF7**	
		DA6	DA7	DA2	DA28	DA30	DA31
DF5	DA6	1					
	DA7	.528**	1				
DF6	DA2			1			
	DA28			.322**	1		
DF7	DA30					1	
	DA31					.490**	1

Table 4.12: Correlation coefficient of attributes within the factors EF1, EF2, and EF3

		EF1					**EF2**		**EF3**	
		EA3	EA8	EA9	EA10	EA11	EA1	EA2	EA6	EA7
EF1	EA3	1								
	EA8	.391**	1							
	EA9	.531**	.479**	1						
	EA10	.483**	.427**	.509**	1					
	EA11	.484**	.483**	.573**	.356**	1				
EF2	EA1						1			
	EA2						.576**	1		
EF3	EA6								1	
	EA7								.481**	1

4.3.6 Delay factors

The seven delay factors extracted from factor analysis are explained below.

1) Poor Stakeholder's Coordination (PSC):

the first factor has five attributes that account for 12.385% of the total variance. Every stakeholder must work together to complete a project successfully (Doloi, Sawhney, Iyer & Rentala 2012). The first attribute is 'poor coordination among different stakeholders' resulting from a lack of cooperation across all project stakeholders. The second attribute, 'delay in approval of completed work by client', is because of improper coordination between the owner, engineer, and contractor, resulting in delayed contractor's payment, ultimately delaying the project. The third attribute, 'slow decisions from the owner', is because the owner, consultant, and contractor did not properly coordinate with each other. This study highlights that slow decision-making by owners is a primary cause of construction project delays in India. This happens when a consultant or contractor does not fully explain to the client how urgently a decision needs to be taken or when an owner's decision is not properly communicated to everyone concerned. The fourth attribute is 'frequent change of design by owner/ architect/ consultant', which is very common in construction projects due to the client's inability to make the correct decision at the required time regarding the project. The fifth attribute is 'conflict between owners and contractors', which is also very common in construction projects in India. The reason for such occurrences is often rooted in the divergent viewpoints of the owners and clients.

2) Delays in availability of materials (DAM):

The second factor, comprising three attributes, accounts for 10.705% of the total variance. According to Sambasivan & Soon (2007), among the most critical causes of project delays in Malaysian construction projects is the delay in material delivery. This study has highlighted the importance of this factor in the Indian context. The first attribute, 'delay in material to be supplied by the owner', is a lack of understanding regarding material procurement between the contractor and owner. The second attribute is a delay in 'material supplied by vendors', usually due to market shortages or inflated prices. The third attribute, 'delay in material procured by contractor', is due to impractical scheduling or a problem with not comprehending the time it takes for materials to be delivered. Additionally, contractors only pay suppliers when payment has been received from the client. Liquidity concerns make it difficult for contractors to acquire supplies because suppliers are reluctant to provide materials on credit.

3) Contractor's performance (CP):

The third factor has three attributes, accounting for 9.441% of the total variance. To ensure that the project is successful, the contractor's performance is essential. The first attribute, 'financial constraints of contractors', was also found to be among the top five causes of delays in several research investigations (McCord et al. 2015). Poor financial management by contractors can lead to insufficient funds, a major cause of financial difficulties (Koshe & Jha 2016). The second attribute is 'delay in running bill payments to the contractor.' Project funding from owners guarantees progress payments for finished work throughout construction. Contractor liquidity, cash flow, and, eventually, worker and supplier payments can all be impacted by payment delays. The third attribute is 'inadequate experience of contractor'. A less experienced contractor could find it difficult to keep up with the work's advancement or not completely appreciate the project's complexity, which could cause misunderstandings and confusion. Time overruns and poor site management may arise from the contractor's inexperience.

4) Unfavourable government regulations (UGR):

the fourth factor, comprising three attributes, accounts for 8.224% of the total variance. The first attribute is 'delay in obtaining permissions from government authorities', caused due to unfavourable government regulations. It may be due to the complexity of applying for permission or the misinterpretation of applied permission to local authorities. Not getting permission from the local authorities can delay the work and possibly lead to legal problems that prolong the delay (Doloi, Sawhney, Iyer & Rentala 2012). The second attribute is that the 'price escalation of goods and services' is usually due to inflation; as this factor is beyond the control of project parties, they can only minimise project delays to minimise cost overruns caused by this factor. The third attribute is 'unfavourable changes in government regulations and laws', which can result in delays, increased costs, and operational challenges for construction firms. Uncertainty from regulatory changes can discourage investments, disrupt project schedules, and impact project feasibility.

5) Poor site management (PSM):

The fifth factor, which has two attributes, is called and accounts for 8.180% of the total variance. Effective site supervision and management are crucial factors in achieving success. The first attribute is 'poor site management and supervision', which emphasises how different stakeholders in the Indian construction industry do not coordinate with one another. Effective site management and supervision are essential components of project success. The second attribute, 'poor labour productivity', results from hiring unskilled labour, unfavourable climatic conditions, labour shortage, etc. In case a skilled workforce is unavailable, unskilled labour should be trained.

6) Quality and safety risks (QSR):

The sixth factor, comprising two attributes, accounts for 7.657% of the total variance. The first attribute, 'rework due to error' in execution, indicates rework resulting from project management's ignorance of the project's scope or design. The rework process can cause delays as it requires additional time and resources. The second attribute is 'site accidents due to lack of safety measures or negligence' because the project's stakeholders have not committed enough. Site accidents cause injuries, financial losses, and property damage and considerably decrease worker productivity. It can be prevented if the parties involved are dedicated to implementing the proper safety procedures at the location.

7) Inefficient construction method and equipment (ICME):

The seventh factor consists of two variables, which account for 7.429% of the total variance. Obsolete construction methods and equipment can compromise structural integrity and safety standards, posing risks to workers and end-users. The first attribute is 'inefficient use of equipment because of unskilled operators', which arises when resources are idle due to improper equipment mobilisation. In addition, the issue worsens when no skilled workers are available. The second attribute is the 'use of improper or obsolete construction methods'. An improper construction method can hurt project completion and even result in financial losses by compromising safety and quality standards, affecting resource productivity and the project schedule.

4.3.7 Effect factors

The three effect factors extracted from factor analysis are explained below.

1) Ethical and Social Impact (ESI):

The first factor has five attributes, accounting for 30.394% of the total variance. The first attribute is the 'negative reputation', which can significantly affect India's construction industry. Investors, clients, and the general public may lose faith in a company with a damaged reputation. This damaged reputation may hinder future collaborations and business opportunities. The second attribute, 'impact on society', will negatively impact society due to increased costs, daily life disruptions, and rising environmental impact issues. The third attribute is 'dispute', resulting from poor project management, problems with quality, or delays that may become disputable, further straining the project's finances and schedule. The fourth attribute, 'loss of revenue', results in financial losses due to poor project management in construction projects. The fifth attribute is 'reduction in project quality', which is due to negligence or inefficiencies that compromise the quality of a project and can put public safety at risk, impacting not just stakeholders but the entire community.

2) Cost and time overrun (CTO):

The second factor has two attributes and accounts for 20.477% of the total variance. The first attribute is 'cost overrun', caused by several variables, such as unforeseen rises in labour and material costs and project scope modifications. This may burden the project participants' financial resources and possibly spark disputes. The second attribute is 'time overrun', which impacts the project's overall financial rewards and causes delays in project delivery. All the causes of delay mentioned by various researchers can result in project time overrun. When combined, cost and time overruns can damage investor returns, undermine stakeholder confidence, and prevent essential projects from being finished on time.

3) Contract Dissolution (CD):

The third factor comprises two attributes, accounting for 17.134% of the total variance. The first attribute is ‘total abandonment’, which happens when work stops without being finished. The second attribute, ‘termination of contract’, implies the legal termination of a contract for violation or other predefined reasons. Delays, legal disputes, and significant financial losses are possible outcomes of both scenarios. Penalties could be imposed on contractors, and the owner might have to devise alternative ways to finish the construction.

4.3.8 Critical delay factor

In factor analysis, variables were grouped under different factors based on the degree of correlation between them. However, it did not highlight how important these elements are to find the critical delay factor. As mentioned in section 3.5.8 of chapter 3 a stepwise regression analysis was used to determine the criticality of DFs corresponding to different EFs. The relative significance of each element was determined. Regression analysis was then carried out utilising the factor scores of DFs and EFs. One by one, the EFs were considered dependent variables, and all DFs were considered independent variables. Table 4.9 presents a summary of the regression results.

From Table 4.9, it can be seen that the DFs –poor stakeholder coordination (PSC), quality and safety risks (QSR), inefficient construction methods and equipment (ICME), unfavourable government regulations (UGR) – are critical for the EF ‘ethical and social impact (ESI)’. Compared to the other three factors, the higher β value for poor stakeholder coordination (β =0.380) shows that the ‘ethical and social impact’ was more affected by poor stakeholder coordination.

The DFs –contractor’s performance (CP) and QSR – are critical for the EF ‘cost & time overrun (CTO)’. Compared to the quality and safety risks, the higher beta value for the contractor’s performance (β =0.228) shows that the cost and time overrun’ were more affected by the contractor’s performance.

Table 4.13: Stepwise Regression Analysis Results

Sr. No.	Effect factors (Dependent)	Delay Factors (Independent)	Unstandardized Coefficients		t	Standardized Coefficients	Sig.	$R^2/Adjusted R^2$
			B	Std. Error		Beta		
1	(EF1) Ethical and Social impact	(Constant)	0.000	0.071	0.000		1.000	0.378/0.358 Durbin-Watson =1.735
		(DF1) Poor Stakeholder's Coordination	0.380	0.071	5.359	0.380	0.000	
		(DF6) Quality & Safety Risks	0.296	0.071	4.181	0.296	0.000	
		(DF7) Inefficient construction method and equipments	0.292	0.071	4.128	0.292	0.000	
		(DF4) Unfavourable Government regulations	0.246	0.071	3.480	0.246	0.001	
2	(EF2) Cost & Time overrun	(Constant)	0.000	0.084	0.000		1.000	0.102/0.088 Durbin-Watson = 2.015
		(DF3) Contractor's Performance	0.228	0.084	2.696	0.228	0.008	
		(DF6) Quality & Safety Risks	0.224	0.084	2.653	0.224	0.009	
3	(EF3) Contract Dissolution	(Constant)	0.000	0.082	0.000		1.000	0.155/0.135 Durbin-Watson = 1.626
		(DF7) Inefficient construction method and equipments	0.309	0.082	3.757	0.309	0.000	
		(DF4) Unfavourable Government regulations	0.182	0.082	2.213	0.182	0.029	
		(DF6) Quality & Safety Risks	0.163	0.082	1.981	0.163	0.050	

The DFs – ICME, UGR, QSR– are critical for the EF 'contract dissolution (CD)'. Compared to the other two factors, the higher beta value for inefficient construction methods and equipment (β =0.309) shows that the contract dissolution' was more affected by inefficient construction methods and equipment.

The results of the regression analysis that have been presented earlier are conveniently summarised in Figure 4.3. The DFs and EFs are displayed along the horizontal and vertical axes, respectively. The tick marks indicate the statistically significant correlation between the effect and delay factors. The blank space signifies the lack of a statistically significant correlation between the effect and delay factors. From Figure 4.3, it is clear that the delay factor QSR affected all EFs: ESI, CTO and CD; hence, it can be considered the most critical delay factor (CDF) for delays in construction projects in India. The second most important CDF is ICME, and UGR affected two EFs: ESI and CD.

Effect factors \ Delay factors	Poor Stakeholder's coordination (PSC)	Delays in availability of materials (DAM)	Contractor's performance (CP)	Unfavourable government regulations (UGR)	Poor site management (PSM)	Quality & safety risks (QSR)	Inefficient construction method and equipment (ICME)
Ethical and social impact (ESI)	√			√		√	√
Cost & time overrun (CTO)			√			√	
Contract dissolution (CD)				√		√	√

Figure 4.3: Critical delay factors

4.3.9 Summary

In this chapter, the 31 delay attributes and 11 effect attributes identified in Chapter 2 were evaluated using descriptive statistical analysis. Based on this analysis, seven delay factors and three effect factors have emerged. These are poor stakeholder coordination, delays in availability of materials, contractor's performance, unfavourable government regulations, poor site management, quality and safety risks, and inefficient construction method and equipment. Similarly, three effect factors, ethical and social impact, cost and time overrun, and contract dissolution were extracted. Notably, quality and safety risks emerged as the most significant delay factor, as indicated by regression analysis. The viewpoints of various respondent groups on the rankings of delay and effect attributes were also discussed. It was found that there was a significant agreement between the various groups of respondents on the ranking of delay and effect attributes. The next chapter discusses the hypothesis that delay factors influence the effects of delay in construction projects, which will be tested using structural equation modelling.

Chapter 5

Structural equation model

5.1 Introduction:

In the previous chapter, the identification of delay factors and effect factors has been discussed. This chapter will test the hypothesis that the delay factors influence the occurrence of delays in construction projects using structural equation modelling. The objective to be discussed in this chapter is given below.
(1) To test the hypothesis that delay factors influence the effect of delays in construction projects.

5.2 Development of the Hypothesized Model:

Structural equation modelling (SEM) is a methodology primarily created by sociologists and psychologists. SEM is a statistical method used to quantitatively estimate a set of interrelated relationships among latent or independent variables (Doloi, Sawhney & Iyer 2012). SEM is a statistical technique that consists of a measurement component and a structural component. The measurement component evaluates the extent to which observed variables accurately measure latent variables and verifies their reliability and validity. On the other hand, the structural component establishes the connection between latent variables (Yang & Ou 2008).

The advantages of using SEM are that Structural equation models analyse relationships of direct, indirect, and correlative effects, unlike standard regression models. Structural Equation Modelling (SEM) also includes measuring errors in estimating external variables and their corresponding latent variables (Doloi, Sawhney & Iyer 2012).

Covariance-based SEM (CB-SEM) and variance-based SEM (VB-SEM) are the two types of SEM. This research was designed to be used with the covariance-based structural equation model, with the maximum likelihood method being the most prevalent approach for calculating covariance in SEM (Tripathi & Jha 2018*c*).

SEM has been applied in diverse areas of construction management owing to the above benefits, such as, to establish a relationship between success factors that influence the success of the construction organizations (Tripathi & Jha 2018*c*), investigating factors affecting delay in Indian construction projects (Doloi, Sawhney & Iyer 2012), causes and effects of delays on construction projects executed in Pakistan (Rashid 2020), among key causes of delay in construction (Yang & Ou 2008), risk analysis of schedule delays in international highway projects in Vietnam (Vu et al. 2017), and impacts of financial risks on schedule delays (Vu et al. 2018). Therefore, the existing literature provides evidence for the validity and practicality of Structural Equation Modelling (SEM).

Figure 5.1 illustrates the different stages of the SEM development process (Tripathi & Jha 2018*c*).In the development of a model for this study the analysis of moment structure (AMOS) version, 27 was used which is used for CB-SEM.

After grouping the delay and effect attributes, using factor analysis discussed in Chapter 4, a hypothesized model was developed to test the relationship between delay factors in construction projects against various effect factors as shown in Figure 6.1. The structural equation model represents independent variables or observed variables (attributes) as rectangles, dependent variables or latent variables (factors) as ellipses, and measurement errors as circles. The arrows indicate the direction of the effect. The figures above the arrows terminating to the latent variables indicate path coefficients whereas figures above the arrows originating from the latent variable and terminating to observed variables indicate factor loadings.

5.3 Validation of The Hypothesized Model:

The SEM model is tested by evaluating its appropriateness. The model's adequacy is evaluated by analysing the covariance structure and assessing the goodness-of-fit (GOF) indices. If its appropriateness is inadequate then it needs revision. Several scholars in the field of structural equation modelling (SEM) have put forward diverse criteria for assessing the adequacy of a given model's fit. Various GOF indices assess the suitability

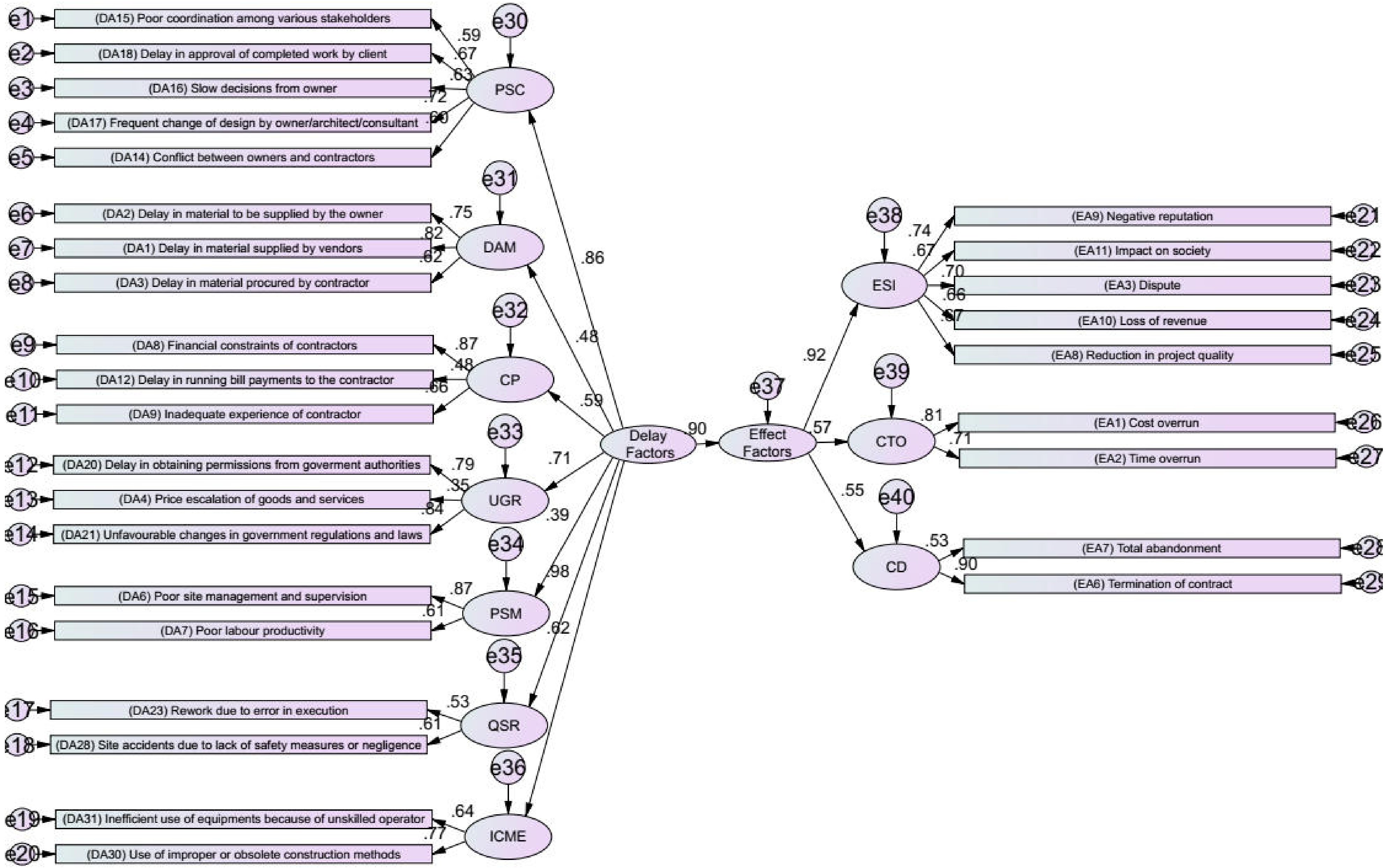

Figure 5.1: Hypothesized model

of a model from different perspectives(Doloi, Sawhney & Iyer 2012). To test the assumed correlation between delay factors and effect factors in construction projects, the following GOF measures were chosen for this study (Tripathi & Jha 2018*c*).

(1) The ratio of the Chi-square (x^2) to the degree of freedom (df): The observed covariance matrix is compared to the covariance matrix estimated under the assumption that the tested model is accurate (Doloi, Sawhney & Iyer 2012).

(2) The goodness of fit index (GFI) measures the extent to which observed data matches the expected data in a statistical model. The fit index is a precise measure that indicates the degree to which the hypothesized theory aligns with the data. The metric is influenced by the size of the sample and ranges from 0 to 1, with larger samples resulting in higher values (Tripathi & Jha 2018*c*).

(3) The Incremental Fit Index (IFI) is an indicator that compares the Chi-square value of the tested model to the Chi-square value of the hypothesized model. It indicates the extent to which the model performs better than a statistical baseline model (Yang & Ou 2008).

(4) Tucker-Lewis index (TLI): It examines the relationship between the complexity of a model and the size of the sample (Vu et al. 2017).

(5) The Comparative Fit Index (CFI) measures the extent to which the hypothesized model fits better than alternative models, it considers the sample size and performs effectively even when the sample size is limited. (Tripathi & Jha 2018*c*).

(6) The root-mean-squared error of approximation (RMSEA) is used to assess the accuracy of an approximation. It quantifies the disparity between the observed and estimated covariance matrices in relation to the unit degree of freedom (Vu et al. 2018).

(7) ECVI (Expected Cross-Validation Index): The purpose of this test is to assess the stability of the model's results. (Doloi, Sawhney & Iyer 2012).

The required level of these measures is provided in Table 5.1 (Tripathi & Jha 2018*c*, Vu et al. 2017). The results of the goodness-of-fit measures for the hypothesised model are presented in Table 5.1. The χ^2/df value of 1.465, along with GFI=0.788, IFI=0.865, TLI=0.846, CFI=0.861, RMSEA=0.060, and ECVI=5.267, suggests that the hypothesised model is not adequately suitable for explaining the relationships between delay factors and the effect factor. So, the proposed model was modified. The approach employed in this study to modify the model entails removing the path that exhibits a weak causal

Table 5.1: Goodness of Fit (GOF) measure

Sr. No.	**Goodness of fit (GOF) measure**	**Recommended level of GOF measures**	**Values obtained in hypothesized model**	**Values obtained in revised model**
1	Chi-square/degree of freedom (χ^2/df)	1 to 2	1.465	1.359
2	Goodness of fit index (GFI)	0 (no fit) -1 (perfect fit)	0.788	0.833
3	Incremental fit index (IFI)	0 (no fit) -1 (perfect fit)	0.865	0.913
4	Tucker-Lewis index (TLI)	0 (no fit) -1 (perfect fit)	0.846	0.898
5	Comparative fit index (CFI)	0 (no fit) -1 (perfect fit)	0.861	0.91
6	Root mean square error of approximation (RMSEA)	<0.05 (very good) - 0.1 (threshold)	0.060	0.053
7	Expected cross validation index (ECVI)	Lower value is better fit	5.267	3.471

relationship, as indicated by low path coefficients or low factor loading. The proposed model underwent several iterations until it indicated satisfactory performance according to the goodness-of-fit (GOF) criteria and fulfilled the theoretical expectations. DAM and PSM were not found significant ($p > 0.01$), and it was removed from the analysis. Several attributes, including DA1, DA2, DA3, DA6, and DA7, were excluded from the analysis because they had low path coefficients. This was done to obtain a more accurate and appropriate model.Figure 5.2 displays the final, revised model.

5.4 Results of the Structural Equation Modeling:

The level of appropriateness of the revised model improved significantly to χ^2/df =1.359; GFI =0.833; IFI = 0.913; TLI =0.898; CFI = 0.910; RMSEA = 0.053 and ECVI = 3.471, as shown in the last column of Table 5.1. The GOF measures indicate that the revised model better explains the relationships between delay factors and the effect factors of construction projects. Therefore, the model is acceptable for interpretation.

Table 5.2 presents the unstandardized path coefficient (B), standardised path coefficient (β), significance level (P), standard error (ϵ), and t-value. All of the standardized path coefficients are positive and statistically important. A higher path coefficient indicates a greater significance of the attribute or factor as an indicator of the delay.

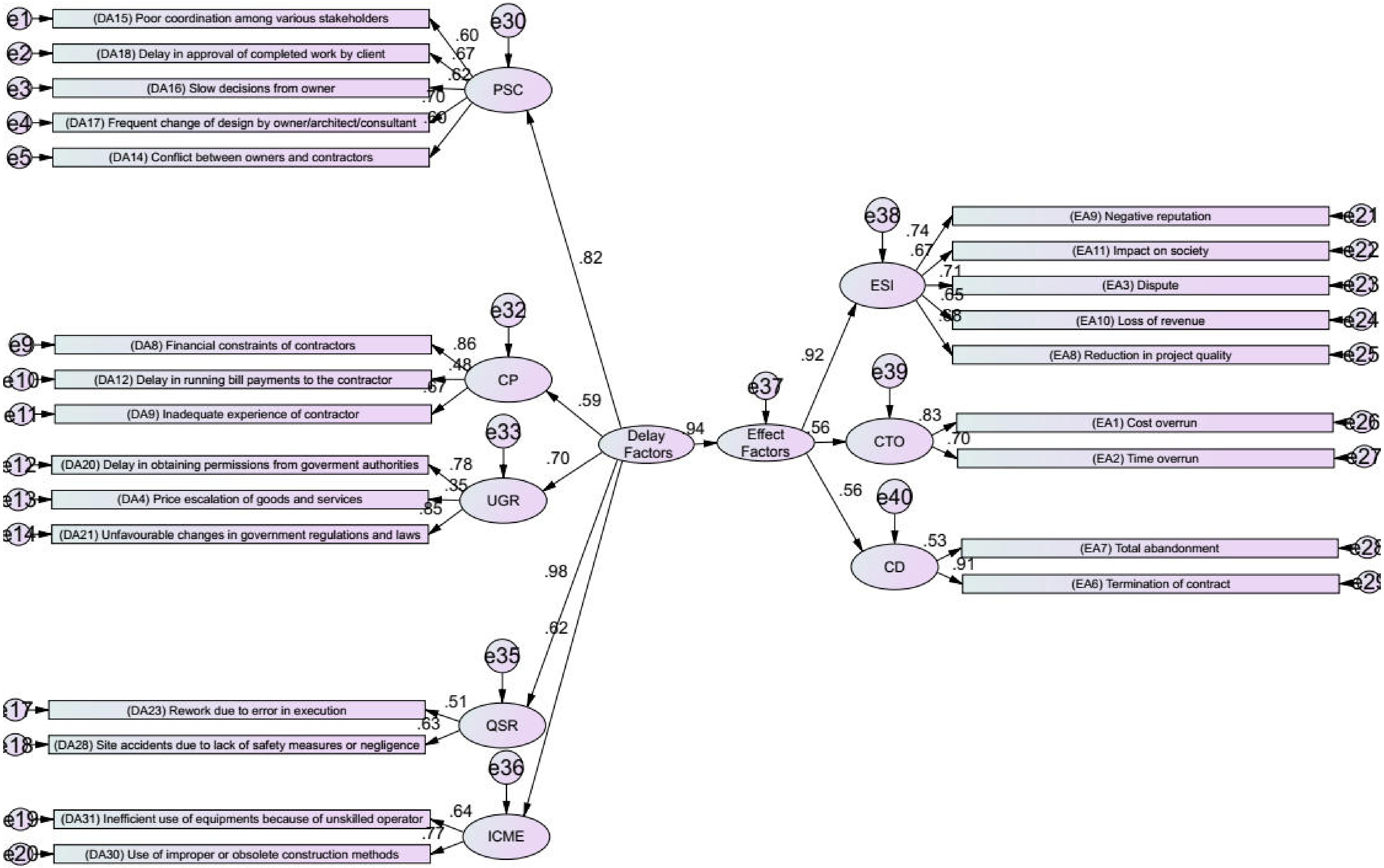

Figure 5.2: Revised Hypothesized model

Accordingly, quality and safety risks (QSR) as the most critical delay factor with a (path coefficient of 0.982), followed by poor stakeholder coordination (PSC) (path coefficient = 0.819), Unfavourable government regulations (UGR) (path coefficient = 0.702), Inefficient construction method and equipment (path coefficient = 0.616), and contractors performance (CP) (path coefficient = 0.594) are the significant delay factors. Similarly, contract dissolution (CD) (path coefficient = 0.767), ethical and social impact (ESI) (path coefficient = 0.639), and cost and time overrun (CTO) (path coefficient = 0.630) for effect factors. The hypothesis, which assumes that delay factors have a substantial influence on the effect of delay on construction projects, is confirmed as the path coefficient of 0.942 is statistically significant at a significance level of 0.01.

Table 5.2: Path Coefficients

Paths	**B**	β	**P**	ϵ	**t-value**
Delay factors→ Effect factors	0.554	0.942	0.005	0.197	2.813
Delay factors→ PSC	0.784	0.819	***	0.168	4.668
Delay factors→ CP	0.899	0.594	***	0.196	4.577
Delay factors→ UGR	1.000	0.702			
Delay factors→ QSR	0.885	0.982	***	0.199	4.438
Delay factors→ ICME	0.666	0.616	***	0.18	3.697
PSC→ DA15 Poor coordination among various stakeholders	1.000	0.558			
PSC→ DA18 Delay in approval of completed work by client	1.348	0.916	***	0.233	5.786
PSC→ DA16 Slow decisions from owner	1.057	0.558	***	0.193	5.471
PSC→ DA17 Frequent change of design by owner or architect or consultant	1.141	0.602	***	0.192	5.95
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Table 5.2 – continued from previous page

Paths	B	β	P	ϵ	t-value
PSC→ DA14 Conflict between owners and contractors	1.194	0.675	***	0.223	5.351
CP→ DA8 Financial constraints of contractors	1.000	0.622			
CP→ DA12 Delay in running bill payments to the contractor	0.585	0.705	***	0.126	4.632
CP→ DA9 Inadequate experience of contractor	0.716	0.603	***	0.122	5.885
UGR→ DA20 Delay in obtaining permissions from government authorities	1.000	0.864			
UGR→ DA4 Price escalation of goods and services	0.423	0.477	***	0.116	3.651
UGR→ DA21 Unfavourable changes in government regulations and laws	1.116	0.666	***	0.15	7.432
QSR→ DA23 Rework due to error in execution	1.000	0.778			
QSR→ DA28 Site accidents due to lack of safety measures or negligence	1.311	0.353	***	0.272	4.81
ICME→ DA31 Inefficient use of equipment because of unskilled operator	1.000	0.846			
ICME→ DA30 Use of improper or obsolete construction methods	1.117	0.51	***	0.257	4.341
Effect factors → CTO	1.079	0.63	0.007	0.396	2.721
Effect factors → ESI	2.003	0.639	0.003	0.674	2.973

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Table 5.2 – continued from previous page

Paths	B	β	P	ϵ	t-value
Effect factors → CD	1.000	0.767			
ESI→ EA9 Negative reputation	1.000	0.739			
ESI→ EA11 Impact on society	0.955	0.667	***	0.135	7.062
ESI→ EA3 Dispute	0.861	0.709	***	0.115	7.506
ESI→ EA10 Loss of revenue	0.804	0.652	***	0.116	6.913
ESI→ EA8 Reduction in project quality	0.889	0.676	***	0.124	7.162
CTO→ EA1 Cost overrun	1.000	0.829			
CTO→ EA2 Time overrun	0.888	0.695	***	0.191	4.65
CD→ EA7 Total abandonment	1.000	0.528			
CD→ EA6 Termination of contract	1.661	0.912	***	0.484	3.433

Note: where, Unstandardized Estimate (B), Standardized Estimate (β), Significance (P), Standard error (ϵ).

5.5 Summary

This chapter tests the hypothesis that delay factors have a significant impact on various effect factors in construction projects. The hypothesis is found to be supported with a path coefficient of 0.942 which is significant at a 0.01 significance level. The final SEM model reveals that quality and safety risks (QSR) as the most critical delay factor, followed by poor stakeholder coordination (PSC) and unfavourable government regulations (UGR) are the significant delay factors. Similarly, contract dissolution (CD), ethical and social impact (ESI), and cost and time overrun (CTO) are the significant effect factors. These delay factors have a direct implication on the effects of the construction projects. The results of regression analysis in Chapter 4 also revealed that the 'quality and safety risks (QSR)' is the most critical delay factor, which is the same as that of the results of structural equation modelling. In the next chapter, the weights of each significant delay and effect factor and their attributes will be assigned using consistent fuzzy preference relation (CPFR).

Chapter 6

Consistent fuzzy preference relation

6.1 Need for second stage questionnaire:

Many researchers have utilised a range of statistical tools, such as mean and standard deviation, RII, and SEM, to determine and evaluate various alternatives for delay and its effect on construction projects, However, only a limited number of researchers have tried to assign values to those different alternatives. Utilizing statistical analyses such as mean and standard deviation, RII, and others to rank alternatives is not effective unless the relative weights of the alternatives are known (Tripathi et al. 2021). To obtain a better understanding of the factors, it is essential to determine their relative significance in comparison to one another. A second-stage questionnaire was developed based on the delay factors and effect factors identified through factor analysis, as well as the attributes that emerged from those factors. The details of this questionnaire are described in the next section.

6.2 Second stage questionnaire preparation:

The questionnaire consisted of four parts: (1) questions on delay factors and their attributes, (2) questions on the effect factors and their attributes, (3) questions on respondents and their organisations and (4) questions on respondents and their organisations. The respondents were instructed to indicate their preference for each pair of attributes/factors using the following scale: equal, moderate, strong, very strong, and extremely important. These preferences were quantified using a 9-point scale. The questionnaire utilised for the second stage of the study is shown in Appendix B.

6.2.1 Sample selection and respondents profile

The sample selection for the second stage of the questionnaire survey was identical to that of the first stage questionnaire survey. Prior to carrying out the actual survey, a pilot survey was conducted to assess the wording and comprehension of the questionnaire (Tripathi et al. 2021). Minor corrections were carried out to improve the quality of the questionnaire, based on the feedback from the experts. In the second stage of the survey, a total of 20 construction professionals with extensive experience from various construction organizations took part in the survey through personal interviews. Out of the total of 20 professionals, 11 were contractors, 9 were developers, and 1 was a project management consultant. The average experience of the respondents in the survey was 20 years, while the average experience of the participating organisations was 25 years.

6.3 Data analysis:

The structure of criteria in the analytical hierarchy process (AHP) was utilised using the consistent fuzzy preference relation (CFPR) to facilitate the analysis of the responses obtained from the questionnaire. The CFPR method is utilised to find the relative weights and rankings of delay factors, effect factors, and their corresponding attributes.

6.3.1 Consistent fuzzy preference relation (CFPR)

To determine the best possible option from a group of competing objectives, one can employ multi-criteria decision-making (MCDM) methods like the analytical hierarchy process (AHP) (Tripathi & Jha 2018*b*). The Analytic Hierarchy Process (AHP) is a widely utilised technique in Multiple Criteria Decision Making (MCDM) processes. It involves comparing alternatives in pairs based on the expert's viewpoint (Tripathi et al. 2021). The advantage of utilising the Analytic Hierarchy Process (AHP) is its capability to facilitate both qualitative and quantitative evaluation. Thus, the goal of determining the relative weights of various factors was successfully accomplished using AHP. The consistent fuzzy preference relation (CFPR) technique enables the incorporation of both subjective and objective factors in the analysis. It also offers a versatile and simple approach to analysing subjective delay factors and effect factors.

Two prevalent statistical models are often used to evaluate the comparative significance of two or more alternatives in relation to their weight. The two types of preference relations are multiplicative preference relations (MPR) and fuzzy preference relations (FPR) (Tripathi et al. 2021). The Analytic Hierarchy Process (AHP) utilises the multiplicative preference relation (MPR) method, which requires numerous pairwise comparisons in order to construct a pairwise comparison matrix. As the quantity of attributes grows, the quantity of comparison questions also grows. As the frequency of comparison questions rises, the probability of respondents providing improper judgements also increases. The experts must review their choices using this method, which takes time. The utilisation of fuzzy preference relation (FPR) can effectively address the issue of inconsistency. The FPR significantly decreases the number of pair-wise comparisons to just (n-1) comparisons. Therefore, the process becomes more convenient and efficient, leading to faster decision-making for pairwise comparisons, requiring less time and effort (Patel et al. 2016). This study uses fuzzy preference relations (FPR) to apply the structure of criteria in the Analytic Hierarchy Process (AHP). Hence, CFPR appears suitable for this study to conduct pairwise comparisons of delay factors and effect factors, as well as their attributes, in order to ascertain their relative significance. Figure 3.2 illustrates the different steps of using consistent fuzzy preference (FPR) and will be further explained in the following section.

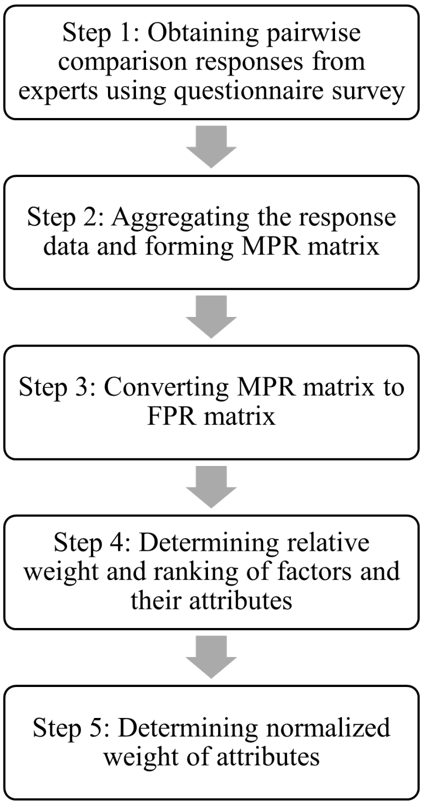

Figure 6.1: Steps of fuzzy preference relation (FPR)

6.3.2 Steps of consistent fuzzy preference relation (CFPR)

The different steps that are needed to use the CFPR are explained below.

1) Obtaining pairwise comparison responses using a questionnaire survey

In the stage II questionnaire, participants were instructed to express their preference for one criterion (factors/attributes) over another when comparing two criteria. This was done using a nine-point scale (Table 6.1) (Tripathi & Jha 2018*b*). A total of 20 highly experienced construction stakeholders from different construction projects participated in the survey via personal interviews.

Table 6.1: Nine-point scale of pairwise comparison

Sl. No.	Level of importance	Description
1	1	Equally important
2	3	Slightly more important
3	5	Strongly more important
4	7	Very Strongly more important
5	9	Most important
6	2, 4, 6, 8	For intermediate values

2) Forming multiplicative preference relation (MPR) matrix

Multiplicative preference relation matrices, $R = [r_{ij}]$ where $r_{ij} \in \left[\frac{1}{9}, 9\right]$, were prepared for factors and attributes of each factor. For n number of criteria (factors/attributes), only $(n-1)$ preferences such as $r_{12}, r_{23}, \ldots, r_{(n-1)n}$ were required. The responses of the experts were aggregated using the geometric mean as given in Equation 6.1 (Tripathi & Jha 2018*b*).

$$r_{ij} = (r_{ij1} \times r_{ij2} \times r_{ij3} \times \ldots \times r_{ijm})^{\frac{1}{m}} \tag{6.1}$$

where i, j $\in$ (1,2,3,... n)

In Equation 3.7, m represents the number of respondents and r_{ij} represents the evaluation of criteria i on criteria j by m^{th} respondent. The MPR matrics formed for delay and effect factors and attributes are shown in tables 6.2 to 6.13.

Table 6.2: MPR matrix for delay factors

	DF-1	**DF-2**	**DF-3**	**DF-4**	**DF-5**	**DF-6**	**DF-7**
DF-1	1.00	**4.40**					
DF-2		1.00	**0.75**				
DF-3			1.00	**2.30**			
DF-4				1.00	**1.05**		
DF-5					1.00	**1.15**	
DF-6						1.00	**0.95**
DF-7							1.00

Table 6.3: MPR matrix for attributes of DF1

	DA-1.1	**DA-1.2**	**DA-1.3**	**DA-1.4**	**DA-1.5**
DA-1.1	1.00	**0.50**			
DA-1.2		1.00	**0.26**		
DA-1.3			1.00	**1.10**	
DA-1.4				1.00	**2.05**
DA-1.5					1.00

Table 6.4: MPR matrix for attributes of DF2

	DA-2.1	**DA-2.2**	**DA-2.3**
DA-2.1	1.00	**0.55**	
DA-2.2		1.00	**0.75**
DA-2.3			1.00

Table 6.5: MPR matrix for attributes of DF3

	DA-3.1	**DA-3.2**	**DA-3.3**
DA-3.1	1.00	**1.95**	
DA-3.2		1.00	**0.60**
DA-3.3			1.00

Table 6.6: MPR matrix for attributes of DF4

	DA-4.1	**DA-4.2**	**DA-4.3**
DA-4.1	1.00	**3.00**	
DA-4.2		1.00	**0.72**
DA-4.3			1.00

Table 6.7: MPR matrix for attributes of DF5

	DA-5.1	**DA-5.2**
DA-5.1	1.00	**1.80**
DA-5.2		1.00

Table 6.8: MPR matrix for attributes of DF6

	DA-6.1	**DA-6.2**
DA-6.1	1.00	**0.41**
DA-6.2		1.00

Table 6.9: MPR matrix for attributes of DF7

	DA-7.1	**DA-7.2**
DA-7.1	1.00	**0.66**
DA-7.2		1.00

Table 6.10: MPR matrix for effect factors

	EF-1	**EF-2**	**EF-3**
EF-1	1.00	**0.95**	
EF-2		1.00	**1.80**
EF-3			1.00

Table 6.11: MPR matrix for attributes of EF1

	DA-1.1	**DA-1.2**	**DA-1.3**	**DA-1.4**	**DA-1.5**
DA-1.1	1.00	**0.50**			
DA-1.2		1.00	**0.26**		
DA-1.3			1.00	**1.10**	
DA-1.4				1.00	**2.05**
DA-1.5					1.00

Table 6.12: MPR matrix for attributes of EF2

	DA-2.1	**DA-2.2**	**DA-2.3**
DA-2.1	1.00	**0.55**	
DA-2.2		1.00	**0.75**
DA-2.3			1.00

Table 6.13: MPR matrix for attributes of EF3

	DA-3.1	**DA-3.2**	**DA-3.3**
DA-3.1	1.00	**1.95**	
DA-3.2		1.00	**0.60**
DA-3.3			1.00

3) Converting multiplicative preference relation (MPR) matrix into fuzzy preference relation (FPR) matrix

Multiplicative preference relation (MPR) matrix was converted to fuzzy preference relation (FPR) matrix $P = [p_{ij}]$ where $p_{ij} \in [0, 1]$, using Equation 6.2 (Tripathi et al. 2021).

$$p_{ij} = \frac{1}{2}\left(1 + \log_9(p_{ij})\right) \tag{6.2}$$

In Equation 6.2, $\log_9 p_{ij}$ is used as r_{ij} lies in the interval $\left[\frac{1}{9}, 9\right]$. If r_{ij} lies in the interval $\left[\frac{1}{n}, n\right]$, $\log_n p_{ij}$ will be used. As the fuzzy preference relation (FPR) matrix is based on additive transitivity, Equations 6.3, 6.4, and 6.5 were used to determine the remaining parts of the matrix.

$$p_{ij} + p_{ji} = 1, \quad \forall i, j \in \{1, 2, \ldots, n\} \tag{6.3}$$

$$p_{ij} + p_{jk} + p_{ki} = \frac{3}{2}, \quad \forall i < j < k \tag{6.4}$$

$$p_{i(i+1)} + p_{(i+1)(i+2)} + \ldots + p_{(i+k-1)(i+k)} + p_{(i+k)i} = \frac{k+1}{2} \quad \forall i < j \tag{6.5}$$

The FPR matrics formed for delay and effect factors and attributes are shown in tables 6.14 to 6.25.

Table 6.14: FPR matrix for delay factors

	DF-1	**DF-2**	**DF-3**	**DF-4**	**DF-5**	**DF-6**	**DF-7**
DF-1	0.50	0.84	0.77	0.96	0.97	1.00	0.99
DF-2	0.16	0.50	0.43	0.62	0.64	0.67	0.66
DF-3	0.23	0.57	0.50	0.69	0.70	0.73	0.72
DF-4	0.04	0.38	0.31	0.50	0.51	0.54	0.53
DF-5	0.03	0.36	0.30	0.49	0.50	0.53	0.52
DF-6	0.00	0.33	0.27	0.46	0.47	0.50	0.49
DF-7	0.01	0.34	0.28	0.47	0.48	0.51	0.50

Table 6.15: FPR matrix for attributes of DF1

	DA-1.1	**DA-1.2**	**DA-1.3**	**DA-1.4**	**DA-1.5**
DA-1.1	0.50	0.34	0.04	0.06	0.22
DA-1.2	0.66	0.50	0.19	0.22	0.38
DA-1.3	0.96	0.81	0.50	0.52	0.69
DA-1.4	0.94	0.78	0.48	0.50	0.66
DA-1.5	0.78	0.62	0.31	0.34	0.50

Table 6.16: FPR matrix for attributes of DF2

	DA-2.1	**DA-2.2**	**DA-2.3**
DA-2.1	0.50	0.36	0.30
DA-2.2	0.64	0.50	0.43
DA-2.3	0.70	0.57	0.50

Table 6.17: FPR matrix for attributes of DF3

	DA-3.1	**DA-3.2**	**DA-3.3**
DA-3.1	0.50	0.65	0.54
DA-3.2	0.35	0.50	0.38
DA-3.3	0.46	0.62	0.50

Table 6.18: FPR matrix for attributes of DF4

	DA-4.1	**DA-4.2**	**DA-4.3**
DA-4.1	0.50	0.75	0.68
DA-4.2	0.25	0.50	0.43
DA-4.3	0.32	0.57	0.50

Table 6.19: FPR matrix for attributes of DF5

	DA-5.1	**DA-5.2**
DA-5.1	0.50	0.63
DA-5.2	0.37	0.50

Table 6.20: FPR matrix for attributes of DF6

	DA-6.1	**DA-6.2**
DA-6.1	0.50	0.30
DA-6.2	0.70	0.50

Table 6.21: FPR matrix for attributes of DF7

	DA-7.1	**DA-7.2**
DA-7.1	0.50	0.41
DA-7.2	0.59	0.50

Table 6.22: FPR matrix for effect factors

	EF-1	**EF-2**	**EF-3**
EF-1	0.50	0.49	0.62
EF-2	0.51	0.50	0.63
EF-3	0.38	0.37	0.50

Table 6.23: FPR matrix for attributes of EF1

	EA-1.1	**EA-1.2**	**EA-1.3**	**EA-1.4**	**EA-1.5**
EA-1.1	0.50	0.54	0.52	0.27	0.11
EA-1.2	0.46	0.50	0.48	0.23	0.07
EA-1.3	0.48	0.52	0.50	0.25	0.09
EA-1.4	0.73	0.77	0.75	0.50	0.34
EA-1.5	0.89	0.93	0.91	0.66	0.50

Table 6.24: FPR matrix for attributes of EF2

	EA-2.1	**EA-2.2**
EA-2.1	0.50	0.43
EA-2.2	0.57	0.50

Table 6.25: FPR matrix for attributes of EF3

	EA-3.1	**EA-3.2**
EA-3.1	0.50	0.51
EA-3.2	0.49	0.50

4) Determining relative weight and ranking of factors and their attributes

The relative weight and rankings of the factors and their attributes were computed using Equation 6.6 (Tripathi et al. 2021).

$$W_i = \frac{\sum_{j=1}^{n} p_{ij}}{\sum_{i=1}^{n}\left(\sum_{j=1}^{n} p_{ij}\right)} \tag{6.6}$$

The relative weight and rankings of the delay and effect factors and the attributes were computed using Equation 6.6. These are shown in Table 6.26 to Table 6.37.

Table 6.26: Relative weight and ranking of delay factors

Delay factors	Row average	Weightage	Rank
DF-1	6.04	0.246	**1**
DF-2	3.68	0.150	**3**
DF-3	4.14	0.169	**2**
DF-4	2.81	0.115	**4**
DF-5	2.73	0.112	**5**
DF-6	2.51	0.102	**7**
DF-7	2.59	0.106	**6**

Table 6.27: Relative weight and ranking of attributes of DF1

Attributes of DF-1	Row average	Weightage	Rank
DA-1.1	1.16	0.092	**5**
DA-1.2	1.94	0.156	**4**
DA-1.3	3.48	0.278	**1**
DA-1.4	3.37	0.270	**2**
DA-1.5	2.55	0.204	**3**

Table 6.28: Relative weight and ranking of attributes of DF2

Attributes of DF-2	Row average	Weightage	Rank
DA-2.1	1.16	0.258	**3**
DA-2.2	1.57	0.349	**2**
DA-2.3	1.77	0.393	**1**

Table 6.29: Relative weight and ranking of attributes of DF3

Attributes of DF-3	Row average	Weightage	Rank
DA-3.1	1.69	0.375	**1**
DA-3.2	1.23	0.274	**3**
DA-3.3	1.58	0.351	**2**

Table 6.30: Relative weight and ranking of attributes of DF4

Attributes of DF-4	Row average	Weightage	Rank
DA-4.1	1.93	0.428	**1**
DA-4.2	1.18	0.261	**3**
DA-4.3	1.40	0.311	**2**

Table 6.31: Relative weight and ranking of attributes of DF5

Attributes of DF-5	Row average	Weightage	Rank
DA-5.1	1.13	0.567	**1**
DA-5.2	0.87	0.433	**2**

Table 6.32: Relative weight and ranking of attributes of DF6

Attributes of DF-6	Row average	Weightage	Rank
DA-6.1	0.80	0.399	**2**
DA-6.2	1.20	0.601	**1**

Table 6.33: Relative weight and ranking of attributes of DF7

Attributes of DF-7	Row average	Weightage	Rank
DA-7.1	0.91	0.453	**2**
DA-7.2	1.09	0.547	**1**

Table 6.34: Relative weight and ranking of effect factors

Effect factors	Row average	Weightage	Rank
EF-1	1.61	0.358	**2**
EF-2	1.65	0.366	**1**
EF-3	1.24	0.276	**3**

Table 6.35: Relative weight and ranking of attributes of EF1

Attributes of EF-1	Row average	Weightage	Rank
EA-1.1	1.94	0.155	**3**
EA-1.2	1.74	0.139	**5**
EA-1.3	1.85	0.148	**4**
EA-1.4	3.08	0.246	**2**
EA-1.5	3.89	0.311	**1**

Table 6.36: Relative weight and ranking of attributes of EF2

Attributes of EF-2	Row average	Weightage	Rank
EA-2.1	0.93	0.464	**2**
EA-2.2	1.07	0.536	**1**

Table 6.37: Relative weight and ranking of attributes of EF3

Attributes of EF-3	Row average	Weightage	Rank
EA-3.1	1.01	0.506	**1**
EA-3.2	0.99	0.494	**2**

5) Determining the normalized weight of attributes

A comparison matrix of factors and their attributes was prepared to calculate the normalized weight of the delay and effect attributes (W) using Equation 6.7 (Tripathi & Jha 2018*b*).

$$W = W_i \times W_j \tag{6.7}$$

where,

W_i = weight of factors and

W_j = weight of attributes.

A comparison matrix of delay and effect factors and their attributes was prepared to calculate the normalized weight of the attributes using Equation 6.7 and is presented in Tables 6.38 and 6.39.

Table 6.38: Normalized weight of delay attributes

Delay factors	**Weight of delay factors (Wi)**	**Delay attributes**	**Weight of Delay attributes (Wj)**	**Normalised weight (Wi* Wj)**	**Overall rank**
DF-1	0.246	DA-1.1	0.092	0.023	**20**
		DA-1.2	0.156	0.038	**17**
		DA-1.3	0.278	0.068	**1**
		DA-1.4	0.270	0.066	**2**
		DA-1.5	0.204	0.050	**10**
DF-2	0.150	DA-2.1	0.258	0.039	**16**
		DA-2.2	0.349	0.052	**9**
		DA-2.3	0.393	0.059	**7**
DF-3	0.169	DA-3.1	0.375	0.063	**4**
		DA-3.2	0.274	0.046	**14**
		DA-3.3	0.351	0.059	**6**
DF-4	0.115	DA-4.1	0.428	0.049	**11**
		DA-4.2	0.261	0.030	**19**
		DA-4.3	0.311	0.036	**18**
DF-5	0.112	DA-5.1	0.567	0.063	**3**
		DA-5.2	0.433	0.049	**12**
DF-6	0.102	DA-6.1	0.399	0.041	**15**
		DA-6.2	0.601	0.061	**5**
DF-7	0.106	DA-7.1	0.453	0.048	**13**
		DA-7.2	0.547	0.058	**8**

Table 6.39: Normalized weight of effect attributes

Effect factors	**Weight of effect factors (Wi)**	**Effect attributes**	**Weight (Wj)**	**Normalised weight (Wi* Wj)**	**Overall rank**
EF-1	0.358	EA-1.1	0.155	0.056	**7**
		EA-1.2	0.139	0.050	**9**
		EA-1.3	0.148	0.053	**8**
		EA-1.4	0.246	0.088	**6**
		EA-1.5	0.311	0.111	**5**
EF-2	0.366	EA-2.1	0.464	0.170	**2**
		EA-2.2	0.536	0.196	**1**
EF-3	0.276	EA-3.1	0.506	0.140	**3**
		EA-3.2	0.494	0.136	**4**

A Spearman's rank correlation coefficient (SRCC) test was performed to analyse the ranking results of the delay and effect attributes. This was done by comparing the results of a fuzzy preference relation with the results of descriptive statistical analysis, as discussed in Chapter 4. The correlation coefficient R was calculated using Equation 3.4 and it was found to be 0.62 for delay attributes and 0.6 for effect attributes at a 0.05 significance level. Hence, the strength of correlation between the responses of the two groups of respondents is positive and can be considered statistically significant.

6.3.3 Summary

The relative weights of each significant delay and effect factor and their attributes are identified in this Chapter. Spearman's rank correlation coefficient was calculated to check the levels of agreement between two sets of respondents on the delay and effect attributes. The strength of the correlation between the responses of the two sets of respondents was found to be positive and statistically significant. The next chapter presents the conclusions of this study.

Chapter 7

Summary and Conclusion

7.1 conclusion

Construction projects often face delays, which can significantly impact the project timelines and budgets. Each year, many new projects are initiated with the aim of timely completion, but various factors often lead to delays, causing cost and time overruns and client dissatisfaction. Identifying and understanding the factors contributing to these delays is crucial for project managers and stakeholders. By regularly assessing the causes and effects of delays, construction organizations can implement strategies to mitigate these issues, ensuring projects stay on schedule and within budget, thereby enhancing their long-term success and reputation in the industry. Therefore, the identification of delay factors and effect factors of the construction projects should be addressed by the construction professionals engaged in this business.

Construction projects have many delay and effect factors. Due to resource constraints, organizations cannot focus on too many factors. Therefore, it is essential to identify the critical factors that contribute to delays in construction projects. A questionnaire survey approach was utilised to identify the factors. A total of 31 delay attributes and 11 effect attributes for delay in construction projects were identified from the literature. Factor analysis was applied to these attributes, resulting in the identification of seven delay factors and three effect factors. Regression and structural equation modelling (SEM) were used to determine that 'quality and safety risks' is the most critical delay factor causing construction project delays in India. To obtain a better understanding of the factors, it is essential to determine their relative significance in comparison to one another, for which a second-stage questionnaire survey was conducted and 20 highly experienced construction professionals from different construction organizations participated in the survey via personal interviews. The relative weights of each delay and effect factor and their attributes were assigned using a consistent fuzzy preference relation. This study has identified 'quality and safety risks' as the predominant factors contributing to construction project delays in India. This means that issues with ensuring good quality and safety standards during the project can cause significant delays and impact various aspects. These delays affect the construction timeline and have a widespread effect on ethical considerations, social impact, costs, and contracts. It highlights the importance of maintaining high-quality standards and safety measures throughout construction. These findings align with the global trend observed in developing countries, as highlighted by Doloi, Sawhney, Iyer & Rentala (2012) and Hoque et al. (2023), emphasising the universal importance of stringent quality and safety standards in the construction industry.

Addressing these issues requires a holistic management approach focused on mitigating delays and enhancing the construction project's overall success and sustainability. This involves strict quality control measures and thorough safety protocols. Managing and reducing these risks is crucial for efficient construction in India. Furthermore, the impact of quality and safety issues goes beyond just causing delays. It influences the broader field of project management and contributes to the project's long-term success by making it more reliable and durable. Focusing on safety protects the workers and aligns with ethical considerations, promoting social responsibility in the construction industry.

To tackle these challenges effectively, a proactive risk management strategy is needed. This includes identifying and addressing potential issues before they become problems, ensuring strong quality assurance, and promoting a safety-conscious culture throughout construction. Stakeholders can minimise disruptions by prioritising quality and safety. Additionally, a well-thought-out plan will be needed to manage these obstacles effectively. This entails identifying and resolving issues early on, guaranteeing high-quality standards, and integrating safety into the design process. In India's evolving construction landscape, stakeholders can ensure a smooth project implementation, enhance project performance, and develop robust, socially responsible construction practices by prioritising quality and safety.

7.2 Limitations

Every research study has limitations, and the current study is no different. In this study, efforts were made to reduce these limitations' impact wherever possible. This study has the following limitations.

This study was restricted to construction organisations involved in the real estate industry. However, it is important to note that the perspectives of construction organisations engaged in highways, railways, and urban infrastructure projects may vary. The study included respondents from different professional groups, specifically contractors, developers, and project management consultants. Due to their varied perspectives, their responses may be influenced by personal biases.

While this study's scope is restricted to real estate projects in the Gujarat region, the implications of its findings are potentially applicable nationwide, given the similarities in construction practices and economic conditions across India. It provides a valuable framework for improving construction project management across diverse regions, promoting a standardised approach to tackling challenges in the Indian construction industry.

7.3 Scope for further study

The responses obtained from the questionnaire surveys conducted in stage I and stage II were examined using a range of statistical methods in this study. These findings were analysed and appropriate conclusions were made. However, to verify the results of this study, alternative methods such as case studies and the stage III questionnaire survey can be employed.

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APPENDIX A

FIRST STAGE QUESTIONNAIRE

INSTITUTE OF TECHNOLOGY NIRMA UNIVERSITY
DEPARTMENT OF CIVIL ENGINEERING

EMPIRICAL STUDY ON DELAYS IN CONSTRUCTION PROJECTS IN INDIA

By Dev Patel and Dr. K.K.Tripathi

Questionnaire

PART-1	**Please put a tick mark (√) or highlight the relevant cell to rate the following parameters (on a five-point Likert scale from very low effect = 1 to very high effect = 5) which cause delays in the construction projects.**

Sr. No.	Delay attributes	Very low effect	Low effect	Moderate effect	High effect	Very high effect
		1	2	3	4	5
1	Delay in material supplied by vendors					
2	Delay in material to be supplied by the owner					
3	Delay in material procured by contractor					
4	Price escalation of goods and services					
5	Improper storage of materials leading to damage					
6	Poor site management and supervision					
7	Poor labour productivity					
8	Financial constraints of contractors					
9	Inadequate experience of contractor					
10	Lack of motivation for contractors for early finish					
11	Frequent change of contractors and sub contractors					

12	Delay in running bill payments to the contractor					
13	Improper planning of project by contractor					
14	Conflict between owners and other parties					
15	Poor coordination among various stakeholders					
16	Slow decisions from owner					
17	Frequent change of design by owner/ architect/ consultant					
18	Delay in approval of completed work by client (i.e. stage passing)					
19	Bureaucracy in client's organisation					
20	Delay in obtaining permission from government authorities					
21	unfavourable changes in government regulations and laws					
22	Unfavourable external environment (political and social)					
23	Rework due to error in execution					
24	Unfavourable weather conditions					
25	Restricted access at site					
26	Unforeseen ground conditions					
27	Delay in handing over of site by client to contractor					
28	Site accidents due to lack of safety measures or negligence					

29	Ambiguity in specifications and conflicting interpretation by parties					
30	Use of improper or obsolete construction methods					
31	Inefficient use of equipments because of unskilled operator					
PART-2	**Please put a tick mark (√) or highlight the relevant cell to rate the following effects of delay in construction projects on a five-point Likert scale from very low impact = 1 to very high impact = 5.**					
Sr. No.	**Effect attributes**	**Very low Impact**	**Low Impact**	**Moderate Impact**	**High Impact**	**Very high Impact**
		1	**2**	**3**	**4**	**5**
1	Cost overrun					
2	Time overrun					
3	Dispute					
4	Arbitration					
5	Litigation					
6	Termination of contract					
7	Total abandonment					
8	Reduction in project quality					
9	Negative reputation					
10	Loss of revenue					
11	Impact on society					
PART-3	**Organization's Information**					
1	Organization's name					
2	Organization'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-4	**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

APPENDIX B

SECOND STAGE QUESTIONNAIRE

INSTITUTE OF TECHNOLOGY NIRMA UNIVERSITY
DEPARTMENT OF CIVIL ENGINEERING

EMPIRICAL STUDY ON DELAYS IN CONSTRUCTION PROJECTS IN INDIA

By Dev Patel and Dr. K.K.Tripathi

Questionnaire

Part-1A	Among each pair of given delay factors, which is the more important factor for the delay of construction projects and how much more important? Please highlight the relevant cells. The scale used is 1 for equally important, 3 for slightly more important, 5 for strongly more important, 7 for very strongly more important, 9 for most important and 2,4,6 and 8 for intermediate values).

Sr. No.	Delay factors	Imp	Delay factors	Imp	1	2	3	4	5	6	7	8	9
1	Poor Stakeholder's Coordination (DF-1)		Delays in availability of materials (DF-2)										
2	Delays in availability of materials (DF-2)		Contractor's Performance (DF-3)										
3	Contractor's Performance (DF-3)		Unfavourable Government regulations (DF-4)										
4	Unfavourable Government regulations (DF-4)		Poor site management (DF-5)										
5	Poor site management(DF-5)		Quality & Safety Risks (DF-6)										
6	Quality & Safety Risks (DF6)		Inefficient construction methods and equipment (DF7)										

Part-1B	Among each pair of given delay attributes, which is the more important attribute for the delay of construction projects and how much more important? Please highlight the relevant cells. The scale used is 1 for equally important, 3 for slightly more important, 5 for strongly more important, 7 for very strongly more important, 9 for most important and 2,4,6 and 8 for intermediate values).												
Sr. No.	**Delay attributes**	**Imp**	**Delay attributed**	**Imp**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
1	**Poor Stakeholder's Coordination (DF-1)**												
	Poor coordination among various stakeholders (DA-1.1)		Delay in approval of completed work by client (DA-1.2)										
	Delay in approval of completed work by client (DA-1.2)		Slow decisions from owner (DA-1.3)										
	Slow decisions from owner (DA-1.3)		Frequent change of design by owner/ architect/ consultant (DA-1.4)										
	Frequent change of design by owner/ architect/ consultant (DA-1.4)		Conflict between owners and contractors (DA-1.5)										
2	**Delays in availability of materials (DF-2)**												
	Delay in material to be supplied by the owner (DA-2.1)		Delay in material supplied by vendors (DA-2.2)										
	Delay in material supplied by vendors (DA-2.2)		Delay in material procured by contractor (DA-2.3)										
3	**Contractor's Performance (DF-3)**												
	Financial constraints of contractors (DA-3.1)		Delay in running bill payments to the contractor (DA-3.2)										

	Delay in running bill payments to the contractor (DA-3.2)		Inadequate experience of contractor (DA-3.3)										
4	**Unfavourable Government regulations (DF-4)**												
	Delay in obtaining permissions from government authorities (DA-4.1)		Price escalation of goods and services (DA-4.2)										
	Price escalation of goods and services (DA-4.2)		Unfavourable changes in government regulations and laws (DA-4.3)										
5	**Poor site management (DF-5)**												
	Poor site management and supervision (DA-5.1)		Poor labour productivity (DA-5.2)										
6	**Quality & Safety Risks (DF-6)**												
	Rework due to error in execution (DA-6.1)		Site accidents due to lack of safety measures or negligence (DA-6.2)										
7	**Inefficient construction methods and equipments (DF-7)**												
	Inefficient use of equipment because of unskilled operator (DA-7.1)		Use of improper or obsolete construction methods (DA-7.2)										
Part-2A	**Among each pair of given effect factors, which is the more important that effects construction projects and how much more important? Please highlight the relevant cells. The scale used is 1 for equally important, 3 for slightly more important, 5 for strongly more important, 7 for very strongly more important, 9 for most important and 2,4,6 and 8 for intermediate values).**												
Sr. No.	**Effect factors**	**Imp**	**Effect factors**	**Imp**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
1	Ethical and Social Impact (EF-1)		Cost & Time overrun (EF-2)										

2	Cost & Time overrun (EF-2)		Contract Dissolution (EF-3)										
Part-2B	**Among each pair of given effect attributes, which is the more important that effects construction projects and how much more important? Please highlight the relevant cells. The scale used is 1 for equally important, 3 for slightly more important, 5 for strongly more important, 7 for very strongly more important, 9 for most important and 2,4,6 and 8 for intermediate values).**												
Sr. No.	**Effect attributes**	**Imp**	**Effect attributes**	**Imp**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
1	**Ethical and Social impact (EF-1)**												
	Negative reputation (EA-1.1)		Impact on society (EA-1.2)										
	Impact on society (EA-1.2)		Dispute (EA-1.3)										
	Dispute (EA-1.3)		Loss of revenue (EA-1.4)										
	Loss of revenue (EA-1.4)		Reduction in project quality (EA-1.5)										
2	**Cost & Time overrun (EF2)**												
	Cost overrun (EA-2.1)		Time overrun (EA-2.2)										
3	**Contract Dissolution (EF3)**												
	Total abandonment (EA-3.1)		Termination of contract (EA-3.2)										

Part-3	**Organization's Information**				
1	Organization's name				
2	Organization'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-4	**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) Dev Patel and Prof. Dr. Kamalendra Kumar Tripathi "An empirical study on the delays in construction projects in India" Emerald, *Engineering Construction and Architectural* Management (under review).

(2) Prof. Dr. Kamalendra Kumar Tripathi, Dev Patel, and Prof. Dr. Kumar Neeraj Jha "An empirical study on cause and effect of delay in construction projects in India" ARCOM Conference 2024 (Accepted with alteration).

(3) Dev Patel and Prof. Dr. Kamalendra Kumar Tripathi "Identification and Evaluation of Delay Factors in Construction Projects" ICCRIP 2024 (Abstract accepted).

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