CAPITAL UNIVERSITY OF SCIENCE AND TECHNOLOGY, ISLAMABAD

# Data Driven Decision-making Model for Fast-track High-rise Buildings using Structural Equation Modelling

by

Mustafa Sultan

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in the

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By

Mustafa Sultan

(DCE 203002)

**Dr. Syed Mahmood Ahmed, Professor**

**Mississippi State University, USA**

**(Foreign Evaluator 1)**

**Dr. Yuting (Tina) Chen, Assistant Professor**

**University of North Carolina at Charlotte, USA**

**(Foreign Evaluator 2)**

**Dr. Ishtiaq Hassan**

**(Research Supervisor)**

**Dr. Syed Shujaa Safdar Gardezi**

**(Co-supervisor)**

**Dr. Majid Ali**

**(Head, Department of Civil Engineering)**

**Dr. Imtiaz Ahmad Taj**

**(Dean, Faculty of Engineering)**

**DEPARTMENT OF CIVIL ENGINEERING**

**CAPITAL UNIVERSITY OF SCIENCE AND TECHNOLOGY**

**ISLAMABAD**

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*Dedicated to my beloved parents Sher Sultan &
Tahira Batool*

CAPITAL UNIVERSITY OF SCIENCE & TECHNOLOGY
ISLAMABAD
Expressway, Kahuta Road, Zone-V, Islamabad
Phone:+92-51-111-555-666 Fax: +92-51-4486705
Email: info@cust.edu.pk Website: https://www.cust.edu.pk

# CERTIFICATE OF APPROVAL

This is to certify that the research work presented in the dissertation, entitled "**Data Driven Decision-making Model for Fast-track High-rise Buildings using Structural Equation Modelling**" was conducted under the supervision of **Dr. Ishtiaq Hassan**. No part of this dissertation has been submitted anywhere else for any other degree. This dissertation is submitted to the **Department of Civil Engineering, Capital University of Science and Technology** in partial fulfillment of the requirements for the degree of Doctor in Philosophy in the field of **Civil Engineering.** The open defence of the dissertation was conducted on **January 31, 2025**.

**Student Name :** Mustafa Sultan (DCE203002)

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The Examination Committee unanimously agrees to award PhD degree in the mentioned field.

**Examination Committee :**

| | | | |
|---|---|---|---|
| (a) | External Examiner 1: | Dr. Khurram Iqbal Ahmad Khan<br>Associate Professor<br>NICE, NUST, Islamabad | |
| (b) | External Examiner 2: | Dr. Jawad Hussain<br>Associate Professor<br>UET Taxila | |
| (c) | Internal Examiner : | Dr. Majid Ali<br>Professor<br>CUST, Islamabad | |

**Supervisor Name :** Dr. Ishtiaq Hassan, Professor, CUST, Islamabad

**Name of HoD :** Dr. Majid Ali, Professor, CUST, Islamabad

**Name of Dean :** Dr. Imtiaz Ahmed Taj, Professor, CUST, Islamabad

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Registration No: DCE203002

Dated: 31 January, 2025

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# *List of Publications*

It is certified that following publication(s) have been made out of the research work that has been carried out for this dissertation:-

1. **Sultan, M.**, Hassan, I., and Gardezi, S. S., "Identification and Prioritization of Decision-Making Aspects on High-Rise Fast-track Buildings A Pilot Study," *Power System Technology, vol. 47(4) 448-474, 2023.*

2. **Sultan, M.**, Hassan, I., and Gardezi, S. S., "A Decision-Making Model for Fast-Track High-Rise Buildings Using Structural Equation Modelling," *Power System Technology, vol 48(1), 1654-1685, 2024.*

**(Mustafa Sultan)**
Registration No: DCE203002

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# Abstract

In the fast-paced landscape of the construction industry, the timely completion of projects stands as a paramount concern, particularly in the realm of high-rise building construction. The urgency of completing high-rise projects on time cannot be overstated. Delays not only incur substantial financial costs but also hinder economic growth and societal development. Moreover, in the competitive global market, meeting project deadlines is often the differentiating factor in securing contracts and maintaining a favourable reputation within the industry. In order to meet the project deadlines, the Project Management Institute mentions fast-track as a schedule compression technique used to address time constraints and schedule overrun on construction projects. One of the major impediments in the application of the fast-track technique in construction industry is the lack of a comprehensive decision-making model. This research has three objectives i.e., identification and ranking the decision-making aspects on fast-track projects, developing a decision-making model for fast-track projects and identifying the impediments hindering the application of fast-track technique in Pakistan's construction industry. However, the specific goal of this research is to develop a comprehensive decision-making model for fast-track high-rise building construction that can highlight the impact of each decision-making aspect on its relevant project success indicator i.e., time variance (TV), cost variance (CV), quality variance (QV) or scope variance (SV) and the impact of cost, quality, and scope variances on time variance. Structural equation modelling (SEM) was used to develop this model. After an extensive literature review, delphi technique and pilot survey were conducted, after which 47 decision-making aspects on fast-track projects were identified which were used to develop a survey questionnaire. The questionnaire was based on a 5-point Likert scale which was used to collect data from 159 construction industry professionals. Data was analysed using Relative Importance Index (RII) and smart PLS-4 software. RII was used for ranking the decisions on fast-track high-rise projects which revealed that early contractor involvement, scope freeze approach, project delivery method selection, early procurement of long-lead-time items and over-designing the facility were the 5 most important decisions on fast-track construction from the viewpoint of client, contractors, and consultants. In the SEM analysis, 7 research hypotheses were developed and tested, all the hypotheses were statistically significant. Further, the hypothesis results showed that 1-unit change in project cost or project scope will change the project duration by 0.569 units and 0.799 units signifying a large impact whereas with 1-unit variation in project quality, the project duration changes by 0.241-units implying a low impact. The mediation analysis showed that the cost variation mediates a high impact between variations in project scope duration whereas the mediating impact is weak between variations in project quality and duration. The $R^2$ values of the model revealed that on a high-rise fast-tracking project, 64.4% of the variance in project cost is attributed to variations in project scope and quality whereas 62.1% variations in project duration are attributed to variations in scope, quality and cost. The $f^2$ values revealed that scope variance has a large effect on variations in project budget (1.771) and project duration (0.387) implying that variations in project scope must be evaluated for its impact on project success. Moreover, the proposed model has high out-of-sample predictive ability making it a universally applicable decision-making model. Importance Performance Map Analysis (IPMA) results showed that for fast-track projects, scope variance has the greatest impact on time variance whereas quality variance has the least impact. Early scope freeze, early involvement of the contractor in design phase and early procurement of long-lead-time items are the most important decisions on fast-track projects whereas quality optimization decisions have an adverse impact on project duration. Lastly, through unstructured interviews, the construction industry professionals assisted in identifying 19 most critical fast-track implementation barriers in Pakistan which were discussed in detail to facilitate the stakeholders for seamless fast-track application in Pakistan's construction industry and to assist the policymakers in creating an investment friendly environment for the stakeholders which is the need of the hour for Pakistan's turbulent economy.

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# Abbreviations

| | |
|---|---|
| **AVE** | Average Variance Extracted |
| **BIM** | Building Information Modelling |
| **CBA** | Cost-Benefit Analysis |
| **CB-SEM** | Covariance based Structural Equation Modeling |
| **CEO** | Chief Executive Officer |
| **CFA** | Confirmatory Factor Analysis |
| **CII** | Construction Industry Institute |
| **CM** | Construction Management |
| **CMB** | Common Method Bias |
| **CSFs** | Critical Success Factors |
| **CVPAT** | Cross Validation Predictive Ability Test |
| **CV** | Cost Variance |
| **CWP** | Construction Work Packages |
| **DB** | Design-build |
| **DBB** | Design-Bid-Build |
| **df** | Degree of Freedom |
| **DWP** | Design Work Packages |
| **ECI** | Early Contractor Involvement |
| **EPC** | Engineering Procurement Construction |
| **FEED** | Front-end-engineering-design |
| **FEP** | Front-end-planning |
| **GDP** | Gross Domestic Product |

| | |
|---|---|
| **GFI** | Goodness Fitness Index |
| **HTMT** | Heterotrait-Monotrait |
| **IPMA** | Importance Performance Map Analysis |
| **IPD** | Integrated Project Development |
| **IR** | Industrial Revolution |
| **LM** | Linear Model |
| **MAE** | Mean Approximate Error |
| **MnDOT** | Minnesota Department of Transportation |
| **MV** | Manifest Variables |
| **NFI** | Normal Fit Index |
| **O&M** | Operational and Maintenance |
| **OPS** | Overall Project Success |
| **PLS-SEM** | Partial Least Squares - Structural Equation Modeling |
| **PMBOK** | Project Management Body of Knowledge |
| **PMI** | Project Management Institute |
| **QV** | Quality Variance |
| **RFP** | Request for Proposal |
| **RII** | Relative Importance Index |
| **RMSE** | Root Mean Square Error |
| **SRMR** | Square Root Mean Residual |
| **SV** | Scope Variance |
| **TV** | Time Variance |
| **VIF** | Variance Inflation Factor |
| **VM** | Value Management |
| **3C's** | Client, Contractors, and Consultants |

# Symbols

| | |
|---|---|
| $A$ | Highest possible score that can be assigned to a decision-making aspect |
| $\alpha$ | Cronbach's Alpha |
| $f^2$ | F-Square |
| $N$ | Total Number of respondents |
| $w$ | Weight assigned by each respondent to a particular decision-making aspect |
| $x$ | Number of respondents assigning a particular weight to a decision-making aspect |
| $\beta$ | Path Coefficients |
| $p$ | Number of manifest variables |
| $q$ | Number of latent variables |
| $Q^2$ | Q-Square |
| $R^2$ | Coefficient of Determination |
| $\rho_c$ | Composite Reliability |

# Chapter 1

# Introduction

## 1.1 Background

The dawn of the $21^{st}$ century has ushered in an era marked by unprecedented challenges and opportunities across various spheres of human endeavor. In the domain of academia, the pursuit of knowledge has evolved to address complex and multifaceted issues faced by mankind. This dissertation embarks on a journey into the complex scenarios faced by the global construction sector in general and Pakistan's construction sector in particular, diving into unexplored territories and seeking to contribute meaningfully to the existing body of knowledge. This chapter initiates a comprehensive exploration of the research problem, research questions, research objectives, significance of this research and brief methodology within the broader academic and industrial context. At the heart of this research is the overwhelming research problem of the absence of a comprehensive decision-making model for fast-track high-rise building construction that is consultant, contractor and client focused. This issue has emerged as a critical concern due to the major delays faced by construction projects worldwide and client's demand for timely completion of their projects for early revenue generation.

Present research seeks to address this gap by unraveling the complexities inherent in fast-track construction, with the ultimate goal of identifying and ranking the decision-making aspects on fast-track projects and developing a comprehensive model for decision-making on fast-track high-rise construction along with identification of the impediments involved in implementation of the fast-track approach in Pakistan's construction industry. The rationale for undertaking this research rooted in the belief that addressing the decision-making problem on fast-track projects is not only academically enlightening but also holds profound implications for the clients, contractors, and the consultants. This research provides a new perspective that contributes meaningfully towards academic discourse and has practical implications for the global construction industry already employing or seeking to employ the fast-track approach.

The construction industry in Pakistan plays a pivotal role in shaping the country's economic landscape, contributing significantly to its GDP and providing employment opportunities. As of the latest available data, the construction sector constitutes a substantial portion of Pakistan's economy, accounting for approximately 9% of the country's GDP. This highlights the construction sector's importance as a major catalyst for economic growth and development. Arefazar et al. [1] reported that the frequency of construction and infrastructure projects in a country is a key indicator of its economic expansion. The residential construction segment, in particular, has experienced substantial growth due to the increasing population and urbanization trends in the country. As cities expand and the demand for housing rises, the construction industry has responded by undertaking large-scale residential projects, contributing to both economic growth and improved living standards. Infrastructure development also constitutes a significant part of Pakistan's construction sector.

The government has been actively investing in infrastructure projects, such as roads, bridges, and energy facilities, to address the country's infrastructure deficit and enhance connectivity. These investments not only stimulate economic activity directly within the construction sector but also have a ripple effect on other industries, fostering a more robust and interconnected economy. The construction industry's impact on employment is noteworthy, with millions of Pakistanis finding employment opportunities within the sector. From skilled laborers and engineers to project managers and administrative staff, the industry provides a diverse range of jobs, contributing to poverty alleviation and socio-economic development. This employment effect extends beyond the construction sites to various ancillary industries, including manufacturing and services, further amplifying the industry's role in job creation.

Despite its significant contributions, the construction industry in Pakistan faces several challenges that merit attention. One notable concern is the informal nature of a substantial portion of the construction sector, leading to issues including labor rights violations, poor safety standards, and a lack of regulatory oversight. Efforts to formalize and regulate the industry are essential to ensure the well-being of workers and the sustainability of the sector. Furthermore, the construction industry is sensitive to external influences such as political instability, economic fluctuations and global events. Economic downturns can impact investment in construction projects, leading to a slowdown in the industry. Political instability and policy uncertainties also pose risks to the sector's growth, as they may deter both domestic and foreign investors from committing to long-term construction projects.

In recent years, the Government of Pakistan has taken steps to address some of these challenges and promote sustainable growth in the construction industry. Initiatives such as the Prime Minister's Housing Program aims to facilitate affordable housing for low-income families, providing a boost to the residential construction segment. Additionally, regulatory reforms and increased transparency efforts seek to formalize the sector and create a more conducive environment for investment. Looking forward, the construction industry in Pakistan is poised for continued growth, driven by the country's demographic trends, urbanization, and the need for expanded infrastructure. The government's commitment to addressing regulatory challenges and promoting sustainable development will play a crucial role in shaping the industry's trajectory. Strategic partnerships with the private sector, foreign investors, and international development organizations can further contribute to the industry's resilience and long-term success. In short, the construction industry in Pakistan stands as a vital pillar of the country's economy, making substantial contributions to GDP, employment, and infrastructure development.

According to the council of tall buildings and urban habitat, a building higher than 50 meters is a high-rise, a 300 meter or higher is a supertall, and the one higher than 600 meters is a megatall building. High-rise buildings enable the concentration of diverse functions within a confined footprint, reducing the strain on urban infrastructure and mitigating the need for horizontal sprawl, which often encroaches upon valuable agricultural land. Additionally, high-rise constructions contribute to the creation of vibrant urban centers that foster economic growth and innovation. The vertical stacking of residential, commercial, and recreational spaces within a single building or complex promotes mixed-use developments, encouraging a dynamic and interconnected urban environment. This, in turn, enhances the efficiency of resource utilization, reduces commuting times, and fosters a sense of community by bringing diverse activities into close proximity.

The economic benefits of high-rise construction extend beyond efficient land use. The development of tall buildings serves as a catalyst for economic activity, generating employment opportunities and attracting investments. The construction phase itself creates jobs for a diverse range of skilled and unskilled labor, while the completed structures often become hubs for businesses, retail, and hospitality, further stimulating economic growth. Moreover, the imperative for high-rise construction in Pakistan is accentuated by the need to address housing shortages in urban areas. Rapid urbanization has led to an escalating demand for affordable housing, and vertical construction provides a viable solution to accommodate a large number of residents within a limited space. Initiatives like the Prime Minister's Housing Program, which aims to build affordable housing units, can benefit from the vertical expansion of residential spaces, optimizing the use of available land and addressing the critical issue of housing scarcity in urban centers. While the imperative for high-rise construction is evident, it is essential to address the associated challenges and considerations. Additionally, stringent building codes and safety standards are paramount to counter the risks linked with tall structures, ensuring the well-being of occupants and the resilience of buildings in the face of natural disasters.

The construction sector is a complex and multifaceted industry that relies on the collaboration of various stakeholders to bring projects from conception to completion. A construction project's success hinges on the effective coordination and cooperation of the stakeholders. Construction industry stakeholders can be broadly categorized into three key groups: clients, contractors and consultants. Clients, who initiate and fund projects, set the vision and objectives. Contractors, responsible for executing the physical construction, bring these visions to life. Consultants, including architects and engineers, provide expertise in design and project management. Contractor, consultant and the client are the three key stakeholders which primarily manage any construction endeavor [2].

The client is the prime mover of the project whereas consultants are architects of client's vision and contractors make that vision a reality. The interdependence among clients, contractors, and consultants is a cornerstone of successful construction projects. Effective collaboration ensures that the project aligns with the client's vision while meeting technical and safety standards. Clients communicate their expectations, budget constraints, and desired outcomes to contractors and consultants. Contractors, in turn, work closely with consultants to translate these expectations into plans. Moreover, consultants bridge the communication gap between clients and contractors, providing technical expertise and design modifications as needed. This collaborative approach fosters a holistic understanding of project requirements, promotes transparency, and mitigates the risk of misunderstandings that can lead to project delays and disputes.

Construction projects are inherently risky, involving various uncertainties such as weather conditions, material availability, and unforeseen technical challenges. Clients, contractors, and consultants each play a crucial role in risk management and decision-making throughout the project lifecycle. Clients must make informed decisions about project scope, budget, and timelines, considering potential risks and uncertainties. Contractors are responsible for identifying, assessing, and mitigating risks related to construction activities, ensuring that the project progresses smoothly. Consultants contribute by providing expert advice on potential challenges and proposing solutions that align with the project's goals.

Summarily, the construction industry is a dynamic ecosystem shaped by the collaboration of diverse stakeholders. While clients set the vision and fund projects, contractors bring these visions to life through physical construction, and consultants provide the technical expertise and design insight essential for project success. The interplay between clients, contractors, and consultants is pivotal for effective project management, risk mitigation, and decision-making. As the construction industry continues to evolve, recognizing and optimizing the roles of these key stakeholders will be essential for delivering sustainable, efficient, and successful construction projects.

## 1.2 Research Motivation and Problem Statement

In 1968, only after 21 years of its independence, Pakistan had built the tallest building in South Asia (Habib Bank tower, Karachi,101 m) and which remained the tallest in South Asia till 1972, whereas at that time the tallest building in the world was the Empire State Building (381 m). Presently, a 593-meter high-rise

(Port Tower Complex, Karachi) is in its conceptual stage. There are several already constructed skyscrapers in Pakistan with Bahria Icon tower, Lahore (272.8 meters, topped-out in 2017) being the tallest building in Pakistan and it remained the tallest building in South Asia between 2017 and 2018. Similarly, there are several 200 meter and higher buildings which are under construction in Karachi, Lahore, and Islamabad. The preceding statistics reflect Pakistans ever-growing desire to go vertical despite the uncertain economic turmoil. The imperative for high-rise construction in Pakistan is rooted in a confluence of demographic, economic, and urbanization factors that necessitate innovative solutions to address the challenges posed by rapid urban growth. Pakistan, like many developing nations, is experiencing a surge in population and urbanization. With a population surpassing 220 million people, the demand for urban housing, commercial spaces, and infrastructure has escalated dramatically. The existing urban fabric, characterized by sprawling developments and horizontal expansion, is proving insufficient to accommodate this expanding population. As a result, the need for high-rise construction has become imperative to optimize land use efficiently and cater to the growing demand for space.

The construction industry in Pakistan has traditionally relied on conventional approaches, leading to significant challenges in the execution of mega projects. One notably underutilized technique is fast-tracking, a method that has been globally employed since the 1960s but has not found widespread adoption in Pakistan. The reluctance to embrace fast-tracking in the country is primarily attributed to a lack of understanding of the scientific principles underpinning this approach. Despite a few instances of successful rapid project completion, the construction industry in Pakistan has not recognized fast-tracking as a key success tool. The prevailing construction practices in Pakistan remain rooted in conventional methodologies, leading to major cost overruns, time delays, and compromises in project quality. Although a few projects in the country have been executed in a short time frame, but without incorporating the scientific and technical advancements embraced worldwide for similar endeavours.

As the global construction landscape advances into the era of Industrial Revolution 5.0 (IR 5.0), it becomes imperative for Pakistan to evolve its construction procedures accordingly. One prominent aspect of modern construction project management is the fast-track project delivery approach, which is predominantly client-contractor-consultant oriented on a global scale. However, the global construction industry lacks a decision-making model which is specifically tailored for fast-track high-rise projects that caters the perspectives of the clients, contractors, and the consultants. This decision-making model aims not only to streamline the decision-making process but also to evaluate the feasibility of fast-tracking a specific project from the standpoint of clients, contractors, and consultants.

In the realm of project delivery, the fast-track approach stands out as an effective strategy. However, its successful implementation requires a client, contractor, and consultant-centric perspective, recognizing the pivotal role these stakeholders play. The time-constrained nature of fast-track projects emphasizes the criticality of an objective decision-making process. However, the absence of a comprehensive decision-making model compounds the challenges faced by the industry. The lack of such a model not only hinders the identification of decision-making aspects but also prevents their correlation with globally accepted project success indicators, including time, cost, quality, and scope. This dearth of a decision-making framework specifically tailored for high-rise fast-track projects contributes to the reluctance of construction industry professionals to adopt this approach. Currently, the absence of a decision-making model tailored to clients, contractors, and consultants hinders the implementation of the fast-track methodology in Pakistan.

In conclusion, the proposed research addresses an essential gap in the global construction industry by developing a client, contractor, and consultant focused decision-making model for fast-track high-rise building construction. By understanding and incorporating the unique perspectives of each stakeholder group, the research aims to propel the industry towards more efficient, timely, and quality-driven project delivery in alignment with global standards. Through a systematic methodology that includes literature review, stakeholder interactions, and case studies, the research endeavors to provide actionable insights and practical solutions for the challenges faced by the construction industry. In contrast to the limited adoption of fast-tracking in Pakistan, worldwide construction projects often employ the fast-track project delivery approach. Recognizing the need for a paradigm shift in the Pakistani construction industry, there is a call not only to formulate a decision-making model for construction projects but also to ensure its orientation towards clients, contractors, and consultants. The purpose of this endeavour is to assess the feasibility of the fast-track method from the perspective of all the stakeholders.

## 1.3 Research Questions

The following research questions aim to comprehensively explore the various dimensions of decision-making in fast-track high-rise building construction, from model development and stakeholder perspectives to the influence of cultural factors and the integration of technology.

a. What is the impact of variations in cost, quality and scope on project duration on fast-track projects?

b. What are the key decisions that govern the successful implementation of fast-track construction?

c. What is the importance/ priority of the decisions made by the clients, contractors and consultants on fast-track projects?

d. What is the impact of each decision on variations in time, cost, quality and scope for project that is on fast-track schedule?

e. What are the barriers that impede the successful application of fast-track technique in Pakistan's construction industry?

## 1.4 Overall Research Goals and Objectives

Research objectives are foundational components of any scholarly investigation, serving as key signposts that guide the researcher throughout the research journey. These objectives represent the specific goals and aims that the researcher seeks to accomplish through the systematic inquiry into a particular problem. These objectives act as a roadmap, providing a structured pathway for the research process, delineating the focus of this research, and setting the parameters for investigation. Crafting the objectives of research requires meticulous consideration of the research questions and the gaps identified in the existing literature. One primary purpose of research objectives is to offer clarity regarding the specific outcomes the researcher aims to achieve. The formulation of research objectives often begins with a thorough review of existing literature, which helps identify gaps, controversies, or areas that require further exploration within the chosen field of study. Research objectives therefore emerge as responses to these identified gaps, aiming to contribute new knowledge, insights, or solutions to the academic discourse. Through this process, the researcher positions his work within the broader context of existing scholarly work, ensuring that the study is both informed by and contributes to the ongoing academic conversation. For this research, under mentioned objectives have been identified after identifying the research gap through extensive literature review.

a. To identify the most critical decision-making aspects on fast-track high-rise projects.

b. To develop a 3C's (Clients, Contractors, and Consultants) oriented decision-making model for fast-track high-rise buildings using Structural Equation Modeling (SEM).

c. To identify the impediments involved in implementation of fast-track approach in Pakistan's construction industry.

## 1.5 Scope of Work and Study Limitations

The primary objective of this research is to develop a decision-making model for fast-track high-rise building construction utilizing Structural Equation Modeling (SEM). The research aims to develop a universally applicable model while also addressing the specific decision-making aspects and implementation barriers within Pakistan's construction industry. The scope of this work encompasses the following key elements:

**a. Model Development:**

i. Utilize SEM to construct a decision-making model tailored for fast-track high-rise building projects.

ii. Ensure the model is robust, comprehensive, and capable of being globally accepted and implemented.

**b. Identification of Decision-Making Aspects:**

i. Identify and categorize critical decision-making aspects that influence the success of fast-track high-rise construction projects.

ii. Analyze these factors within the context of Pakistan's construction industry to highlight any unique challenges or requirements.

**c. Evaluation of Implementation Barriers:**

i. Investigate the impediments that hinder effective implementation of fast-track technique in Pakistan.

ii. Focus on aspects such as regulatory constraints, cultural practices, technological limitations, and resource availability.

**d. Data Collection and Analysis:**

i. Collect empirical data from key stakeholders in Pakistan's construction industry, including clients, contractors, and consultants.

ii. Employ surveys, interviews, and existing literature to gather comprehensive data.

iii. Use this data to validate the SEM model and rank the identified decision-making aspects.

**e. Model Validation and Refinement:**

i. Validate the decision-making model through rigorous statistical analysis.

ii. Refine the model based on feedback and data analysis to ensure accuracy and reliability.

**f. Recommendations for Practice:**

i. Provide actionable recommendations for stakeholders in the construction industry to improve decision-making processes in fast-track projects.

ii. Suggest strategies to overcome identified implementation barriers, enhancing the feasibility and efficiency of fast-track construction projects in Pakistan.

**g. Contribution to Knowledge:**

i. Contribute to the academic and practical understanding of decision-making in fast-track high-rise building projects.

ii. Offer insights that can be leveraged by construction professionals globally, with a particular focus on adapting these insights to the Pakistan's context.

**h. Relevance with Sustainable Development Goals (SDGs):**

The United Nations Sustainable Development Goals (SDGs) are a set of 17 global objectives adopted by all United Nations Member States in 2015 as part of the 2030 Agenda for Sustainable Development. These goals are aimed at addressing the worlds most pressing challenges, such as poverty, inequality, environmental degradation, and peace and justice, with the ultimate goal of creating a more equitable, sustainable, and prosperous world for all. This research directly relates with the 9th goal that aims to build resilient infrastructure, promote inclusive and sustainable industrialization, and foster innovation, all of which are crucial for modern urban development. In the context of this research, the development of a sophisticated decision-making framework that utilizes real-time data and SEM can significantly enhance the efficiency and sustainability of high-rise building projects. Fast-tracking high-rise construction while ensuring safety, quality, and sustainability is a challenge that requires innovative technological solutions and data-driven approaches to reduce delays, cost overruns, and resource waste. The application of SEM, which captures complex relationships between various variables such as project duration, cost, scope variance and quality variance, can lead to more informed decision-making that optimizes resource allocation, project planning, and risk management. This research can thus contribute directly to SDG 9 by advancing infrastructure systems that are not only resilient but also sustainable, fostering the adoption of innovative construction methodologies that promote smarter urban development. The fast-tracking of high-rise buildings is an example of leveraging advanced technologies and data analytics to meet the growing demand for urbanization while minimizing environmental impacts. As cities continue to expand, building high-rise structures becomes essential for accommodating a growing population in a limited space. By utilizing data-driven models, this research can contribute to the development of a new paradigm in construction that minimizes inefficiencies, reduces material waste, and enhances project delivery times without compromising safety or quality.

However, this research has certain limitations. This model is only applicable to fast-track high-rise building construction and does not provide decision-making support for other facilities such as roads, dams, bridges, etc. While the research aims to cover a broad range of decision-making aspects, it is possible that some relevant factors might be overlooked or underrepresented. The identification of implementation barriers might not account for all possible challenges, especially those that are less apparent or emerging. Solutions and recommendations provided might be difficult to implement in practice due to entrenched industry practices, resistance to change, or financial constraints.

## 1.6 Novelty of Work/ Research Significance

The blooming landscape of Pakistan's construction industry, coupled with the pressing challenges of rapid urbanization and population growth, has spurred a critical need for innovative approaches. In this context, this research with special emphasis on Pakistan's construction industry, stands as a beacon of transformative potential. The study's main contribution lies in the creation of a comprehensive decision-making model tailored for high-rise fast-track projects. This model not only sheds light on the interrelationships between crucial project parameters such as time, cost, quality, and scope but also integrates the often-overlooked dimensions of decision-making aspects. The implications of this research extend beyond theoretical advancements; they have the potential to instill confidence among construction industry professionals and propel Pakistan's construction practices into the realm of global competitiveness. At the core of this research is a commitment to empirical rigor.

By meticulously examining the dynamics of high-rise fast-track projects, this study provides tangible evidence of the interconnections between key project success parameters. The interrelationships between time variance, cost variance, quality variance, and scope variance are unearthed, offering a nuanced understanding of how alterations in one aspect can reverberate throughout the project. This empirical foundation not only enhances the academic discourse surrounding construction management but also offers a practical guide for professionals navigating the complexities of fast-tracked high-rise construction in Pakistan. While traditional project management models often focus on quantifiable parameters, this research opens a new dimension by incorporating decision-making aspects into the equation. Success of a fast-track project is heavily dependent on decision-making, and recognizing its role is paramount. The model considers the impact of decisions on project outcomes, providing a more holistic perspective for industry professionals. This integration acknowledges the multidimensional nature of decision-making on fast-track construction, where factors such as decision outcome predictability, stakeholder engagement, and strategy adaptability play pivotal roles. Fast-track construction methodologies have been a cornerstone of success in the developed world for over half a century. However, their adoption in developing nations like Pakistan has not been materialized. The decision-making model developed in this research serves as a catalyst for change by offering a structured approach to fast-track projects. By providing empirical evidence and a comprehensive understanding of the intricacies involved, the model becomes a valuable tool for professionals seeking to adopt and implement fast-track approaches with confidence. One of the overarching goals of this research is to bridge the gap between construction practices in Pakistan and those in developed nations.

The decision-making model, inspired by success stories from around the globe, acts as a conduit for the transfer of knowledge and best practices. As construction professionals in Pakistan gain confidence in fast-track methodologies, the industry stands to benefit from the wealth of experience accumulated by the developed world. This bridge facilitates a more seamless integration of globally proven strategies into the local context, fostering a construction sector that can compete on an international scale. Looking beyond immediate applications, the research anticipates a transformative long-term impact on Pakistan's construction industry. The adoption of the decision-making model for high-rise fast-track projects is poised to bring about efficiency, innovation, and resilience. By empowering professionals with a tool that addresses the unique challenges of fast-track construction, the industry can witness sustained growth. This, in turn, has far-reaching consequences, including economic development, job creation, and the establishment of robust infrastructure that meets the needs of a rapidly evolving society. Impediments associated with fast-tracking will be analyzed through a combination of literature review, stakeholder interviews, and case studies. The goal is to categorize and prioritize these impediments based on their impact on project outcomes.

In conclusion, the research contributions extend beyond the confines of academic inquiry; it is a roadmap for industry professionals navigating the complexities of high-rise construction in Pakistan. By providing empirical evidence, integrating decision-making aspects, and instilling confidence in the fast-track approach, this research sets the stage for a new era in construction practices.

## 1.7 Brief Methodology

The following paragraphs outline the brief methodology adapted to attain the research objectives.

**Literature Review:** A comprehensive literature review was conducted to identify the research gap and the decision-making aspects on fast-track projects which further assisted in setting the objectives of this research.

**Latent Variables and Manifest Variables:** Time, cost, quality and scope variances were selected as the latent variables in the model, whereas 47 decision-making aspects identified from the literature were included in the model as the manifest variables.

**Data Acquisition:** Data used in developing the decision-making model and ranking the decision-making aspects was acquired through a questionnaire prepared on

5-point Likert scale. The respondents included clients, contractors and consultants from Pakistan's construction industry having experience on fast-track projects.

**Statistical Analysis:** The decision-making aspects were ranked using RII whereas SEM was used to study the impact of cost, quality and scope variances on time variance. Moreover, SEM was also used to study the association between the manifest variables and their parent latent constructs. Seven hypotheses were also developed and tested.

**Implementation Barriers:** Unstructured interviews with the construction industry experts were conducted to identify the barriers involved in the application of the fast-track technique in Pakistan's construction industry.

**Conclusions and Recommendations:** Based on the statistical analysis and interactions with the construction industry experts, conclusions and recommendations were drawn.

## 1.8 Dissertation Layout

The dissertation unfolds across 6 chapters as shown in figure 1.1, each carefully crafted to contribute a unique facet to the overarching research problem. Chapter 1 provides a brief introduction to the construction industry and its stakeholders, fast-track technique, and need for a decision-making model, research significance, research problem , research questions, research scope and limitations. Chapter 2 conducts a comprehensive review of the existing literature, mapping intellectual terrain thereby identifying the gaps that motivate the current research. Building upon this foundation, Chapter 3 delineates the research methodology employed to address the research problem. Chapters 4 present the statistical analysis of the data and reports the results. Chapter 5 outlines the barriers to the implementation of the fast-track technique in Pakistan's construction industry. Chapter 6 synthesizes the insights, draws conclusions and recommendations, and discusses future directions.

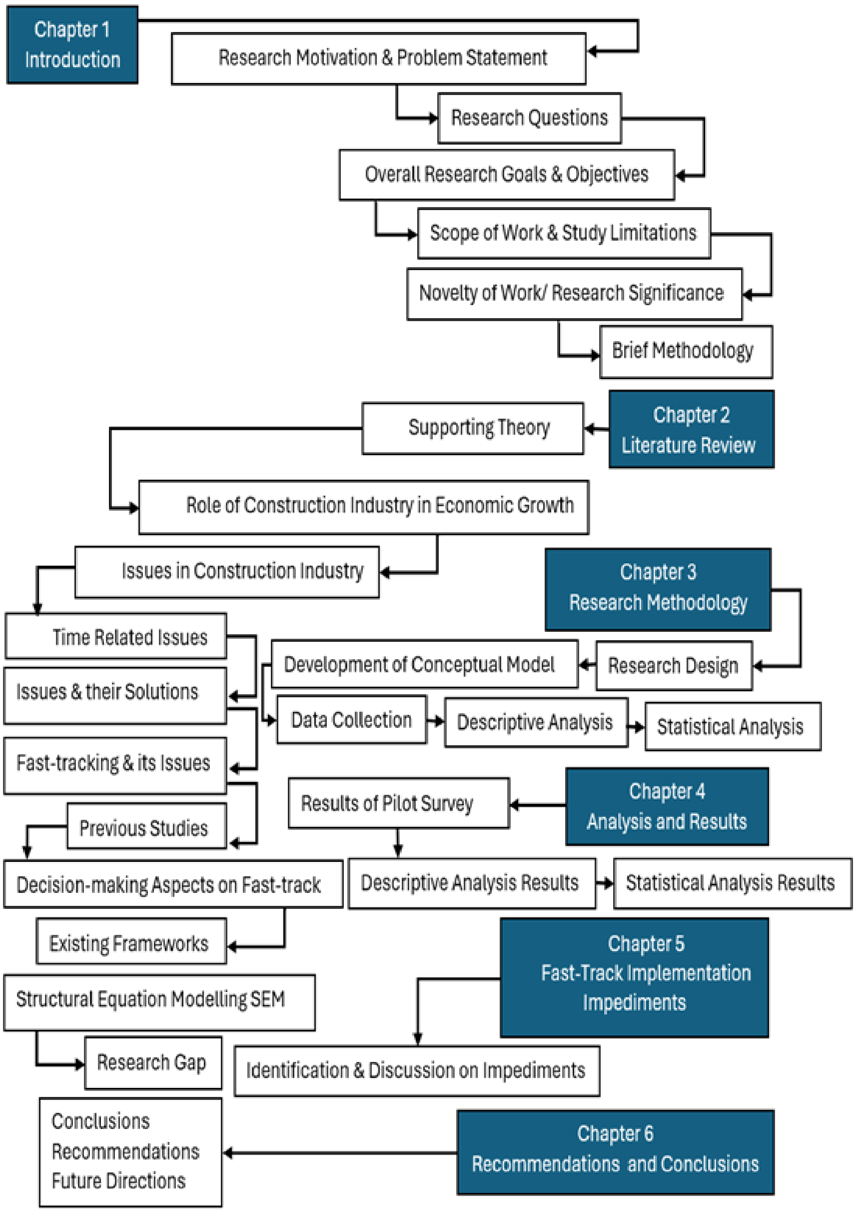



FIGURE 1.1: Dissertation Layout

# Chapter 2

# Literature Review

## 2.1 Background

This chapter serves as the review of existing literature on fast-track decision-making model development using structural equation modeling (SEM). Literature review in research serves as a critical and detailed analysis of existing scholarly works pertaining to the research topic. It is an integral component that outlines and evaluates the key theories, concepts, methodologies, and findings in the chosen field of study. The primary purpose of a literature review is to provide a solid foundation for the research by showcasing the existing knowledge and highlighting the areas where further investigation is warranted. One of the key benefits of literature review is its role in establishing the rationale for the research. By reviewing and synthesizing existing literature, researchers can identify the gaps and unanswered questions in their field of research, thus justifying the need for their study. Additionally, literature review helps researchers refine their research questions, hypotheses, and methodologies by learning from the successes and shortcomings of previous studies. It also aids in the identification of key concepts and variables, contributing to the conceptual framework of the research. Moreover, a well-conducted review of exiting literature enhances the credibility of research work by showcasing the researcher's familiarity with relevant field of research. It serves as a tool for critical analysis, enabling researchers to evaluate the weaknesses and strengths of various methodologies, identify patterns and trends, and assess the overall quality of existing research. Furthermore, literature review can contribute to the development of theoretical frameworks, allowing researchers to build on existing theories and propose new conceptual models based on the synthesis of existing knowledge. In essence, literature review is an indispensable component of research, playing a pivotal role in shaping the research process and contributing to the advancement of scholarly understanding in a certain field. With above in view, following aspects of fast-track construction and decision-making model using structural equation modeling have been explored.

## 2.2 Supporting Theory

The literature reveals that construction professionals apply a number of theories in the construction industry which include cognitive competence theory (CCT), competency based management theory (CBM) [3], theory of waste behavior [4], conservation of resources theory (COR) [5], theory of constraints (TOC), contingency theory, theory of project management [6, 7], construction management theory [8], data driven network theory [9], lifecycle cost theory [10], generative learning theory [11], lean construction theory [12], path-goal theory [13]. Among all these theories, the concept of fast-tracking has been taken from the theory of construction management. Construction management theory is based on the process of managing the design and construction of a project on behalf of a client [14]. Theory of construction management is needed to ensure that the specialist actions needed to produce modern buildings and all parts of our incredibly complex physical infrastructure can be undertaken efficiently [8].

## 2.3 Role of Construction Industry in Economic Growth

Globally, the construction industry significantly influences the built environment, driving social development, environmental sustainability and economic growth.

Beyond economic factors, it facilitates societal functioning and ensures the efficient movement of goods and people [15]. By 2030, it is estimated that the global construction industry will attain a value of 15.5 trillion USD, signifying major economic growth worldwide and this value will be equal to approximately 14.7% of the world's GDP, reflecting the significant addition to the global economy [16, 17]. Antoniou and Tsioulpa [18] observed that the construction sector in Greece underwent a significant decline following the fiscal crisis of 2008, after the downward trajectory of GDP and the ensuing financial and banking crisis. Norouzi et al. [19] reported that the building and construction sector is a key area that has significant impacts on the economy and environment. This sector contributes to the economy (about 9% of the EU's Gross Domestic Product (GDP)), provides direct and indirect job opportunities (18 million direct jobs at the EU) and satisfies the people's needs for buildings and facilities.

## 2.4 Issues in Construction Industry

Cost overruns and time delays have been the primary sources of criticism in project delivery, also they are often cited as the most significant issues undermining the efficiency and project success [20]. Ameh and Ogundare [21] conducted a research on the effect of delays in the construction industry, the results showed that in the construction sector of Nigeria, 70% of projects related to construction get delayed in execution. Bajere et al. [22] while evaluating the factors contributing to delays in project completion, found that, 190 out of 196 projects, suffered an average delay of more than 450%. Mamman et al. [23] evaluated the completion cost of public sector construction projects, and the results showed that 76.5% of the selected projects experienced 43.3% cost overrun. Antoniou and Tsioulpa [18] reported that the Greek construction industry like all other construction industries worldwide, is also afflicted with cost and time overruns that irrevocably results in disputes and claims which, mostly lead to litigation, which unavoidably cost extra money to both the parties in dispute. The extension of a project's timeline often leads to adverse effects on the initial objectives and accomplishments [24].

Abdallah et al. [25] mentioned that among the many challenges that the industry is facing are communication problems between construction participants. It is stated that one out of five projects end up being unsuccessful due to communication being ineffective. Moreira et al. [26] mentioned in their research that construction industry is a globally recognized industry with a high incidence of workplace accidents and fatalities. According to International Labour Organization - ILO (2021), the direct and indirect costs of occupational diseases and accidents cost on average, 3.94% of global GDP each year. In Brazil, approximately 18.77 billion dollars were spent on accidental benefits from 2012 to 2020, taking into account all manufacturing sectors. Soni and Smallwood [27] highlighted corruption as a dominant problem in the construction industry as it persistently overwhelms the basic contributions of the construction industry, preventing the infrastructure services to be delivered with desired quality and specifications. Maqbool et al. [28] mentioned that a skilled workforce is essential for producing high quality construction work, efficiently and effectively however in UK's construction industry the shortage of skilled workers has put contractors in a tough position in terms of the availability of the necessary skills in the labour market. This resulted in a significant investment of time and resources in selecting the competent individuals for training to address the problem of skilled labour shortage.

## 2.5 Time Related Issues (Stats)

Delays are inevitable in construction projects, and they mostly result in disputes between contractor and employer because they impact the project completion date, which could lead to extension of time and monetary compensation claims or exposure to liquidated damages [29]. A number of construction projects suffer delays, which are frequently associated with the dynamic, complex, uncertain nature of the construction sector [30]. Worldwide, construction delays are a conspicuous event in the construction sector. Internationally, over 85% of the mega projects are not completed within their planned timeline [31]. Approximately 60% of the projects worldwide are delayed at least by 2 months and 14% of them get delayed by a year. Delays to large-scale construction projects have more than doubled during the Covid-19 pandemic, according to new data released by machine learning company nPlan. Analysis of pre- and mid-pandemic projects suggests that nearly nine in ten large-scale construction projects (85.5%) are delivered late - nearly two-thirds of them (59.4%) by at least two months [32]. According to the United States Government Accountability Office, 14 to 74 months of delays have been experienced by the Department of Veteran Affairs in their huge medical center construction projects. Similarly, a report by European Court of Auditors [33] addressed that the average delay in the completion of eight huge transportation projects was 11 years, endangering the European transport networks.

In the UAE, half of the construction projects suffer from delays [34], while nearly 17.3% of the government projects in Malaysia experienced project delays of more than three months [35]. According to the study of Assaf and Al-Hejji [36], more than four-thirds of the contractors in Saudi Arabia indicated that they have experienced 10-30% delays compared to the original project duration. Moreover, in the study conducted by Paramasivam et al. [37], they reported that tight deadlines set by the owners are also a reason for workplace stress for the project team. In the research conducted by Rantsatsi [38], he mentioned that pressure to meet tight deadlines may lead to shortcuts being taken with safety protocols or procedures.

## 2.6 Issues and their Solution

For addressing the time overrun and tight deadlines' issue in the construction sector, the Project Management Institute outlines crashing and fast-tracking as the two most employed schedule compression techniques. Verocha and Negara [39] reported in their research that the fast track and crashing methods can be used as schedule acceleration tools to overcome delays and meet the tight project deadlines, but in financing, the fast-track method is more cost-effective while the crashing method has additional costs. Prawirawati et al. [40] mentioned that fast-track, crashing and what-if, all can reduce project delays. The costs incurred by the fast-track method is less than the what-If method and what-if method was cheaper that crashing. In order to achieve a competitive advantage among their competitors, the clients decide to fast-track their projects. Clients want their projects to be delivered quicker than normal, while maintaining the desired quality standards [41].

## 2.7 The Concept of Fast-tracking

Many researchers have defined the fast-track approach in their own words, however the main concept is the same as outlined by the project management institute (PMI), fast-track is a schedule compression technique in which activities or phases normally done in a sequence are performed in parallel for at least a portion of their duration [42] in other words, the activities are overlapped [43, 44]. The manual for fast-track construction defined the fast-track approach as compressing the project schedule to the bare minimum practically possible and this is the dominant driving force for several stages of the project [45]. Fazio et al. [46]; Clough and Sears [47]; Williams [48]; Songer et al. [49] defined fast tracking as the compression of the design and/or construction schedule through overlapping of activities or reduction in activity durations [50]. Kasim et al. [51] and Cho et al. [50] described that fast-track is the compression and overlapping of the various project activities of preliminary design, construction and procurement phases so as to deliver the project faster and within the planned budget [52].

Fast-tracking is, starting construction before the completion of the 100% design [53]. A fundamental idea of fast-tracking technique is the execution of construction and design phases of the project simultaneously or concurrently [51]. Squires and Murphy [54] defined fast-track as a method of construction by which actual construction is commenced prior to the completion of all design, planning, bidding and subcontracting stages in order to alleviate the effects of inflation and achieve time saving. Williams [48] defined fast-track projects as those projects which are delivered within 70% of the duration it takes to deliver a project through "sequential" construction. On fast-track schedule, the projects do not have the flexibility of time to deal with all the protocol, procedures, methods and standards which are usually required during traditional construction. Kalirajan and Sivagnana [55] stated that fast-tracking compresses the project schedule by integrating progressive design and construction phases that proceed concurrently, along with simultaneous site preparation and procurement of major long-term deliveries. It is noteworthy that traditional construction projects typically adhere to a predetermined sequence, progressing through conceptual development, schematic design, design development, creation of construction documents, and then construction administration.

Conversely, the fast-track technique overlaps these activities to ensure that the construction can start earlier and can progress at a quicker rate [56]. A widely recognized principal about fast-tracking is that if construction phase begins with less than 50% of the designs and specifications finished, the project can be termed as a fast-track project [54]. Fast-track projects exhibit a higher level of uncertainty and unpredictability due to their intensified concurrent activities and overlapping phases involving scope definition, engineering, procurement, and construction [57] The sole purpose of fast-tracking is to cut down on time and money by project schedule reduction [58]. In comparison to traditional construction methods, which follow a sequential and linear approach, fast-track construction employs parallelism in project activities, allowing for overlapping of design, procurement, and construction phases as shown in figures 2.1 and 2.2 [59]. Fast-track construction methodology emerged as a response to the significant challenges posed by high costs of financing and rapidly escalating inflation in construction expenses, aiming

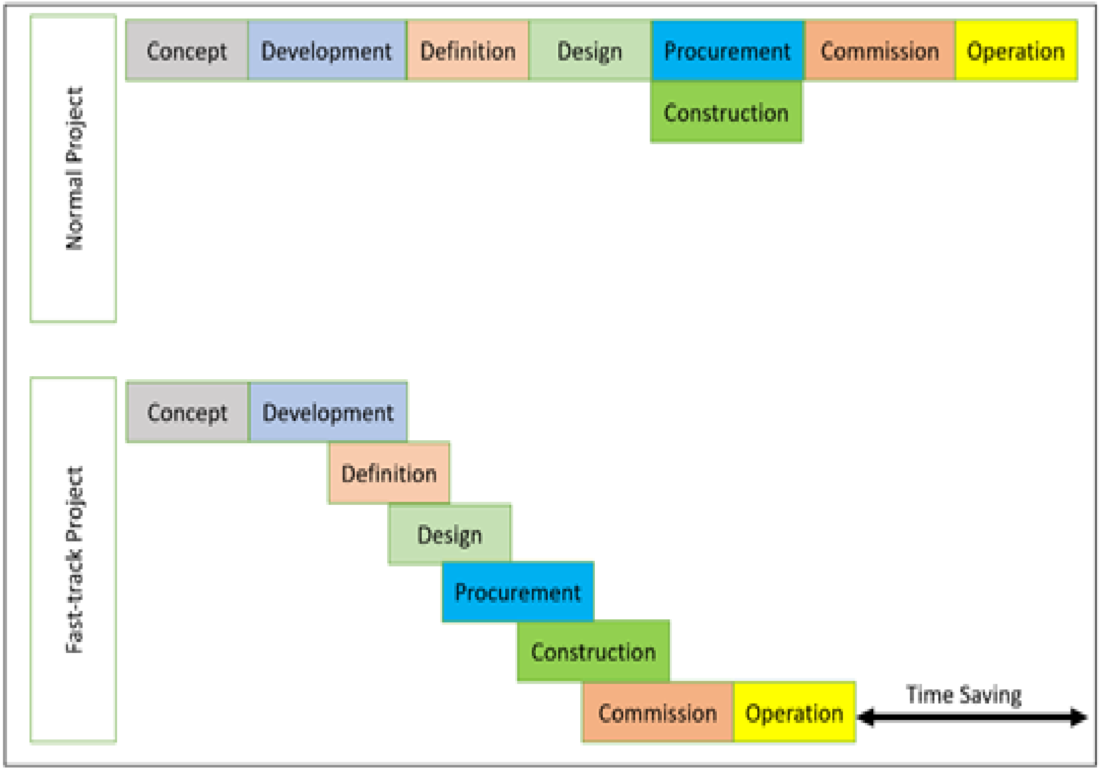



FIGURE 2.1: Comparison of Normal and Fast-track Projects [59]

to minimize the overall construction duration for specific projects [54]. Kwakye [60]; Squires and Murphy [54] reported that the fast-track approach shares similarities with concurrent engineering (CE), which is commonly employed in the manufacturing and engineering sectors to expedite production schedules by integrating design, development, and manufacturing processes simultaneously [52]. Huovila et al. [61] pointed out in their study, which compared fast-tracking with the concurrent engineering approach, that fast-tracking is a project delivery method primarily grounded in practical application rather than being rooted in a firm conceptual or theoretical foundation.

Alhamodi et al. [45] concluded that beside other factors, the basic purpose of fast-tracking a project can be achieved successfully by abstaining from aggressive overlapping, using an experienced and knowledgeable project team, and establishing effective project coordination and communication. Egbelakin et al. [52] identified the challenges and opportunities linked with fast-track construction in Qatar. The research highlighted four crucial categories of challenges: scope related, equipment and material related, contractual related and design and coordination-related challenges. Furthermore, methodologies such as the use of an effective change control system, early involvement of operations and maintenance personnel, constructability assessment and accurate information have been proposed to deal effectively with the challenges identified in the research. Kim et al. [62] concluded that in the fast track method, the proper division of construction phases is an important issue in determining the overall project timeline. To address this issue, they presented a rational phase division method that can be applied when a construction project with complex structures is carried out on fast-track. A fast-track project delivery strategy is designed to leverage the ability to execute the design, procurement, and construction phases simultaneously to substantially reduce the overall project duration [63].

Khoramshahi [64]; Cho et al. [50]; Eastham [65] concluded that the success of fast-track projects is not attributed to its tendency to challenge traditional construction procedures and manage the extra risks introduced, rather also because they do the normal things well, including being proactive in seeking regulatory approvals, holding decision-focused meetings, making timely and well-informed decisions and paying on time. According to Dainty and Brooke [66], construction organizations functioning in competitive environments in the UAE frequently adopt the fast-track technique without detailed planning and adjustments to their policies and standard operating procedures, which could lead to subpar project performance. A significant increase in adoption rates among certain UAE countries, coupled with a limited conceptual grasp of the inherent challenges associated with fast-tracking, poses potential risks to the long-term sustainability of the construction industry [52].

Alsharef et al. [67] reported that in addition to the negative impacts of the COVID-19 pandemic, several new opportunities emerged. These opportunities encompassed projects focusing on the expedited construction of medical facilities, the recruitment of skilled laborers, transportation-related initiatives and the development of residential buildings. Dehghan and Ruwnapura [44] developed a trade-off model between overlapping and rework of design activities. The model illustrates the process of analyzing multipath networks by introducing the concept of the multi-predecessor effect. It also outlines methods for analyzing concurrent overlapping by introducing the cascade effect. Pea-Mora and Li [68]; Fazio et al. [46] mentioned that the implementation of fast-track technique has the potential to lead to a notable reduction in the overall project schedule duration and reduce inflation and interest costs. Park [69] reported that effective management of resources, including materials and equipment, performs a pivotal role in influencing productivity outcomes of projects that are on fast-track.

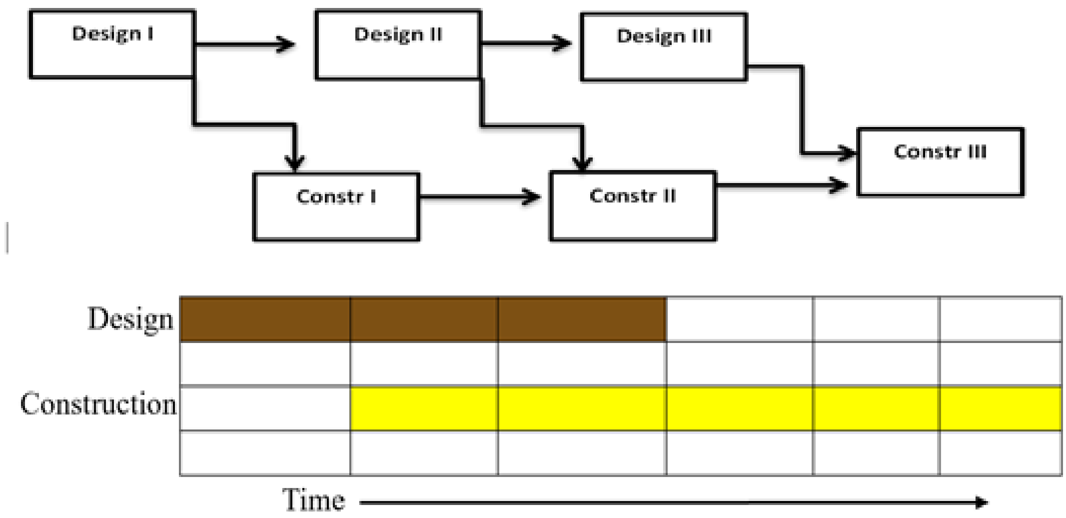



FIGURE 2.2: Fast-track Overlapping Mechanism [74].

Today, fast tracking has become a prevalent project delivery system across various industries. The faster development of project markets such as industrial, engineering, procurement, construction, and information technology (IT) over the recent decades has intensified the need to shorten project durations. This trend often results in increased project complexity, posing significant challenges for project teams to navigate [45]. Duggan [70]; Knecht [71] and Elvin [72] reported that fast-tracking has firmly established itself as a standard practice within the construction industry. Reports indicate that a considerable number of projects now incorporate elements of fast tracking or concurrent design and construction strategies to expedite project timelines. According to Ballesteros-Perez [73], fast-tracking is recognized as one of the prevalent techniques used to accelerate projects. Fazio et al. [46]; Huovila et al. [61]; Eastham [65] argued that with the increasing client's demands for adoption of this fast-track delivery approach, construction and engineering organizations adopting this approach are considered to have a strategically competitive advantage over other competitors or emerging similar projects [52].

## 2.8 Issues in Fast-tracking

Accelerating a project through fast-track is a major decision, and construction professionals are often not aware of its implications [46]. On a fast-track project, the overlapping decision is basically a trade-off between time savings and increased cost [75]. Egbelakin et al. [52] reported that while the fast-track project delivery method offers numerous advantages and disadvantages, it may not be suitable for every project therefore it is a critical decision whether to go or not to go for fast-track construction. Cho et al. [50] reported that delays in owner's decision-making is an important factor in successful completion of fast-track projects. Fast-track requires project owners to take complex decisions and exhibit firm discipline [76]. Tengler [77] reported that within the next few years, the only restraint on fast-track projects may well be the prospective owner's decision-making capability. Eldin [78] and Attar et al. [79] concluded that the construction industry was missing a denite model and a computer tool for making overlapping decisions [80].

## 2.9 Previous Studies

Zaki [81] mentioned that fast-track projects are challenging for the project management team as it requires additional measures to deal with challenges regarding time, quality and cost. Rasul et al. [82] concluded that the primary project objectives - time, cost, and quality - are intricately interconnected, and any variation in one objective can significantly impact the others. When utilizing fast-tracking to accelerate, overlap, or compress project schedules, it can influence the project's predictability and its ability to meet the decided objectives of time, quality and cost. Fast-tracking can create complexities and challenges that may affect the overall success of achieving these key goals [45]. Many researchers like El-Far et al. [83] and others have used time, cost, quality and scope as project success indicators in their study on fast-track projects. Alhamodi et al. [45] reported that fast-track projects are similar to traditional projects with regards to measuring project success against time, cost, and quality objectives. They reported that no existing research has directly explored the relationship between fast-tracking and the predictability of a project's objectives. Their investigation focused on the connection between fast-tracking and the predictability of achieving success in meeting the project's planned objectives. They emphasized the necessity for further research into the relationship between the fast-tracking technique and the project's predictability indices, such as cost variance, time variance, and quality variance. Additional research is essential to gain a deeper understanding of the relationship and to enhance the predictability of fast-track projects.

### 2.9.1 Impact of Fast-track on Time Variance

On fast-track projects, time serves as the principal performance indicator [82]. Alhamodi et al. [45] characterized time variance as the discrepancy between the total actual time taken to complete a project and the initially planned time. This metric is a crucial measure of predictability for fast-track initiatives. In other words, time slippages or delays represent deviations from the project's original deadline. The primary objective of employing fast-tracking techniques is to shorten or reduce the overall project duration. However, the extent of these time savings can differ significantly depending on the specific details and requirements of each project [83]. An important aspect of fast-tracking technique is to shorten or reduce the project timeline. The primary motivation for applying fast-tracking in government sector is its ability to significantly reduce project durations, particularly when traditional delivery methods are insufficient for meeting tight schedules. In essence, reducing the project schedule becomes the foremost criterion for measuring project success in these scenarios. Consequently, the fast-track approach is adopted to ensure that time constraints are effectively managed, and deadlines are met [50]. The magnitude of schedule reductions may differ depending on project characteristics [45]. Bent and Humphreys [84] reported that this fast-track approach ensures that each phase of the project is expedited efficiently, leading to a significantly reduced overall project timeline while maintaining economic viability [50]. Jergeas [85] proposed that on fast track projects the total construction duration is cut-down by 10 - 30%. El-Far et al. [83] reported that a few researchers like Kasim et al. [51] and Alhomadi et al. [86] believe that fast-track projects can be completed in 50-70% of the time required for conventional projects whereas researchers like Fazio et al. [46]; Pena-Mora and Park [87] believe that fast-track execution can lead to communication problems, design flaws, omissions, and more design and construction changes than the sequential method, causing delays which can cancel out the time savings gained by increased overlapping.

### 2.9.2 Impact of Fast-track on Cost Variance

On fast-track projects, cost variance is a predictability indicator [83]. Researchers vary in their opinions with regards to the impact of fast-track approach on cost. Jergeas [88] highlighted that the application of fast-tracking strategy is a significant contributor to cost overruns. These overruns can be substantial, potentially escalating to as much as 100% of the project's initial budget. Cho et al. [50] suggested that for fast-track projects, the overall project costs could potentially rise by approximately 10-20%. Moazzami et al. [89]; Knecht [71]; Park [69] contended that although fast-track project delivery offers numerous benefits, it also involves greater risks and challenges as compared to various procurement methods, and it has its own drawbacks. One major issue is that overlapping activities with insufficiently defined scopes can lead to several negative consequences. These include significant cost overruns, an increased frequency of rework, numerous change orders, and a variety of contract-related issues. When employing a business-as-usual approach, fast-tracking projects can result in increased overall costs due to the inherent unpredictability and complexities associated with this method [57]. Pedwell et al. [90] reported that greater the overlap, the greater are the cost overruns. They collected data from 16 projects, each with an average project cost of 80 million USD and reported that the projects that began overlapping early, had the greatest cost overruns of 27%. On the other hand, the projects that began overlapping late had lesser cost overruns with only 11%. Michalak [91] concluded that an aggressively scheduled project (overlapped, accelerated or compressed schedule), the project cost overrun might increase unreasonably from 40% to 50% or even greater. The impact of fast-track technique on cost is two-fold, on one hand the unique time saving advantage allows reduced payback period, tax reductions, reduced time to market, earlier operation, increased prestige, earlier income, and increased market share, however, on the contrary, the major issue exists in additional risks created, with the rework risk being the most crucial. Rework increases the project length and expenditure of the project's construction phase [44]. Researchers such as Lalu et al. [92] and Kasim et al. [51] opined that fast-track projects may result in unforeseen additional cost in the project budget that can increase up to 40-50% and even more whereas Pena-Mora and Park [87] concluded that fast-track may not result in more costly construction.

Moreover, Pena-Mora and Park [87] stated that fast-track projects are much cheaper than the conventionally delivered projects. Performing activities that are typically carried out sequentially in an overlapping manner can greatly shorten project delivery times. However, this overlapping of tasks must be approached methodically to minimize associated risks and costs [93]. Although the literature highlights that the fast-track projects can lead to cost overruns however this overrun can be mitigated by offsetting reduced land tax, recurring inflation and interest costs and benefiting from returns on investment through the facility's use on or before the scheduled completion time [52]. Conventional wisdom suggests that constructing facilities in a significantly reduced timeframe leads to increased costs. This belief is based on the understanding that there is less opportunity for optimization and a higher likelihood of rework due to the compressed schedule. However, experience has shown that, depending on various factors such as the size and complexity of the project, the level of overhead costs, the expected duration, and the proficiency of the project team, fast-track projects can potentially be more cost-effective. In some cases, the advantages of accelerated timelines may outweigh the disadvantages, resulting in overall lower project costs [48]. The ultimate cost of a fast-track project can vary significantly, either being much higher or lower than traditional methods. However, when considering the value generated by the product produced within the reduced timeframe, the overall cost of constructing a fast-track facility often turns out to be considerably lower. By factoring in the economic benefits gained from the expedited completion and earlier utilization of the facility, the investment in fast-track construction frequently proves to be more cost-effective in the long run [48].

Fast-track construction enables the commencement of building activities before the design phase is completed [94]. This approach can lead to significant cost savings, primarily through the reduction of overhead expenses. Additionally, it allows for the early realization of project benefits, as the facility can be put to use sooner. This early start often translates to improved overall project efficiency and financial advantages, making fast-track construction a highly effective strategy for timely project delivery [82]. Cho and Hastak [95] reported sizeable time and cost savings of 40.48% and 4.48% respectively, from fast-track project delivery. Harthi [96] reported that one of the key advantages of employing fast-tracking, when feasible, is that it can significantly contribute to the reduction of overhead costs. This can be achieved by reducing the number of days dedicated to construction and associated activities. El-Far et al. [83] found that fast-track construction cost must not exceed 100-120% of conventional construction technique. The fast-tracking methodology is especially utilized in the public sector for emergency rebuilds, hospitals, schools and infrastructure projects [57] where early project delivery is required owing to political advantages and social pressure. Contrary to it, in private sector, early project delivery provides the opportunity to produce positive cash flows for the owner [95].

### 2.9.3 Impact of Fast-track on Quality Variance

Quality, alongside cost and time, serves as a metric of success in fast-track projects. Predictability regarding quality variation can be assessed through factors such as the frequency of changes, reworks, deviations, omissions, or defects. The accelerated pace of fast-tracking and limited time can potentially impact project quality [45]. Rasul et al. [82] found that while fast-track projects may achieve shorter timelines, they often experience increased costs and compromise on quality as a result. El-Far et al. [83] concluded in their study that quality on fast-track projects should not deteriorate below 90% of the traditional projects which shows that fast-track projects suffer from quality degradation as compared to traditional projects. It is commonly debated that delivering something in half the usual time often involves sacrificing some quality. In fast-track projects, there is minimal opportunity for optimization. The facility is designed to meet specific product criteria, and once these criteria are satisfied, further work ceases [48]. Due to the priority placed on completing the project rapidly and undertaking multiple tasks concurrently, fast-tracking disregards quality criteria [83].

In addition, Moazzami et al. [89] reported that insufficient time and information can lead to a less than optimal design. Abdelbary et al. [43] reported that the projects rushed without adequate planning may necessitate management adjustments in response. However, these adaptations often result in greater rework and reduction in overall project quality due to subsequent revisions. El-Far et al.

[83] additionally noted that in fast-track projects, designs may suffer from either under-design or overdesign issues, necessitating rework to address deviations from the original design. According to Lalu et al. [92], inadequate clarity in defining the final product significantly contributes to challenges during the design phase of fast-track initiatives. A case study revealed that the design impacts of fast-track projects necessitate greater effort and rework compared to traditional projects, primarily due to more frequent and substantial interruptions. In terms of ensuring quality and minimizing maintenance costs on fast-track projects, prioritizing high-quality project completion is preferred to extend maintenance intervals and consequently reduce overall maintenance expenses [83].

Emuze & Oladokun [56] reported that quality management methods often conflict with the need for speed, which is a fundamental requirement in fast-track construction projects. Fazio et al. [46], in a case study, discovered that during the tendering process, numerous addenda were issued, and a substantial number of drawings were revised, added, or removed. These changes and deletions contribute to the compromised quality of design stage deliverables, subsequently impacting the quality and completeness of procurement phase deliverables [86]. On the research conducted by Emuze and Oladokun [56], some interviewees expressed the view that maintaining quality in fast-track construction is highly challenging, particularly because construction begins before the design phase is complete. They also emphasized that establishing and upholding high quality standards in fast-track projects can present significant difficulties. Another interviewee emphasized the importance of having a quality control plan for construction managers. Emuze & Oladokun [56] further concluded that among the quality management methods employed by contractors in fast-track construction, key strategies included the use of quality control plans, design-build approaches, checklists, and the Plan-Do-Act-Check method. They emphasized that implementing a fast-track construction approach can facilitate timely project completion without compromising the standards of quality.

### 2.9.4 Impact of Fast-track on Scope Variations

Deshpande [97] pointed out that a significant challenge in fast-track projects is effectively managing scope changes. Handling these scope adjustments and associated rework poses inherent risks to fast-track projects that are not sufficiently planned for. Properly addressing and managing scope changes is crucial to mitigating potential disruptions and ensuring the successful execution of fast-track initiatives. Al-Dubaisi [98] observed that in fast-track projects, heightened scope variations often stem from insufficient preplanning during the design and conceptual phases. This deficiency frequently leads to inaccurate cost estimations, unexpected project delays, and challenges in managing project quality. Addressing these issues through thorough preplanning in the initial phases is critical to mitigating risks and ensuring smoother execution of fast-track projects [52].

### 2.9.5 Decision-Making Aspects on Fast-track Projects

In the dynamic realm of fast-track high-rise construction projects, effective decision-making stands as a cornerstone for success, demanding a symphony of collaboration and foresight among key stakeholders - clients, contractors, and consultants. Fast-track construction projects present intricate systems governed by interconnected project performance indicators, posing a significant project management challenge for decision-makers. These projects require careful navigation of interdependencies among various performance metrics, making strategic decision-making crucial to achieving successful outcomes within accelerated timelines [82].From the literature, 47 decision-making aspects on fast-track high-rise building construction were identified which were made part of the final questionnaire. The succeeding paragraphs will highlight these decision-making aspects.

#### 2.9.5.1 Communication Mechanism

Koskela et al. [99]; Nicolini et al. [100]; Anumba and Evbuomwan [101] emphasized that enhancing communication between design and field activities is crucial when overlapping these phases. Many researchers suggest early communication and forming multidisciplinary teams early in the project to improve scope management [102]. Robertson [53] emphasized that early and proactive communication with facility owners enables the architect-engineer and contractor to make fast-tracking possible. One of the interviewees reported that success of fast-track approach depends heavily on collaboration and communication between the parties [56]. Williams [48] argued that designing a multi-million-dollar industrial facility hinges on effective communication among the individuals. Memos, drawings, and specifications are crucial in communication, but significantly more information is communicated when informal channels are utilized and promoted. Fast-track projects require better communication and trust. Specifically, it is vital to encourage continuous, detailed, relevant, and focused communication among parties on a fast-track project. Such projects cannot afford communication breakdowns with the "freezing" of the project schedule; communication must be ongoing, informal and prompt.

Squires and Murphy [54] also supported the idea that for projects anticipating numerous changes, such as fast-track projects, rapid and clear communication channels should be supplemented by swift change and claim processing procedures. Communication between project team members plays a critical role in the performance of how scope changes are identified, documented, and managed on a fast-tracked project [103]. Effective communication is explained as the exchange of information to control the risk by discussing its nature, cause, magnitude and impacts. For the successful risk management, the communication must be two ways to maximize the input and communication level [81].

#### 2.9.5.2 Change Management Plan

In the fast-track methodology, the construction and the design activities sequentially overlap hence change orders and design errors critically impact the project's success. If change orders and design errors occur, they must be addressed promptly by the supplier and the design team, who must be present onsite, to minimize potential delays [50]. A major difficulty for most construction projects today is to manage changes, which often result from unexpected situations and unforeseen circumstances. Change orders comprise the single major source of delays and cost overruns for projects of any kind [104]. Proper management of design changes is critical to the efficient delivery of construction projects; this requires a timely identification and coordination of changes and a proper analysis of their impacts [105].

In this regard, Deshpande et al. [106] reported that in an organization, change management is integrating a balanced change culture of planning, recognition and evaluation of project changes in order to manage the changes in an effective manner. If not properly managed, changes may disrupt workflow and lead to cost inflation, schedule delays, and potentially expensive litigation [107]. Park [69] reported that in fast-track projects, contractual challenges often include an increased number of change orders for modifications and rework, as well as claims for delay damages. Design changes are commonly encountered on fast-track construction projects [105]. Changes in a project are inevitable, they can occur at any stage of the project, because of a wide range of reasons, they vary from being small change to a large one [108]. However, what is important, is to determine whether the change has a small impact on project performance or severe [109]. Sun and Meng [110] reported that changes may have a direct or indirect impact on various aspects of a project. While some may be positive and benefit the project, most changes cause interruptions to the work as well as time and cost overruns. Proper management of design changes is critical to the efficient delivery of construction projects; this requires a timely identification and coordination of changes and a proper analysis of their impacts [105].

The effect of changing or refining anything in the design has a significant ripple effect. Very quickly this can have an impact on the overall cost and schedule of the project. The project team must comprehend the ripple effect of design alterations and its effect on the overall project to act appropriately thus maximizing value [48]. Robertson [53] stated that on all projects with early involvement of the contractor, the change orders should be quantified with respect to cost and quantity. Managing the change orders significantly influences the chances of project success under fast-track approach.

Squires & Murphy [54] reported that in fast-track projects, the likelihood of encountering a significant volume of change orders and disputes increases with the incompleteness of plans and specifications, whether in general or for specific subcontracts or prime contracts. Incomplete plans and specifications inherently lead to changes and revisions; however, the exact extent and volume of these changes and revisions remain unpredictable. Thus, while some level of change is anticipated, the full impact and number of these changes are not foreseeable. Salem and Miller [111]; Eastham [65] reported that an effective change management plan facilitates early payment for additional and altered work, thereby reducing commercial constraints and enabling the project team to focus on their tasks [57]. Egbelakin et al. [52] advocated that on fast-track projects, implementing systematic change management from the project's outset and securing agreement from all team members can mitigate the impacts of increased scope changes.

#### 2.9.5.3 Building Information Modeling - BIM

Liu et al. [112] defined Building Information Modeling (BIM) as a digital representation of the physical and functional characteristics of a building or infrastructure. It is a collaborative process that utilizes a 3D model to integrate information about the design, construction, and operation of a facility. Fan et al. [113] mentioned that on projects that are fast-tracked, where time is of the essence, BIM acts as linchpin in enhancing efficiency and minimizing errors. BIM's proactive approach helps prevent delays and rework, which are particularly detrimental in fast-track projects with tight schedules. Mcneil-Ayuk and Jrade [114] concluded that with the ability to simulate and analyze various design scenarios, BIM enables teams to make informed decisions about construction sequencing, resource allocation, and potential risks. This predictive capability is invaluable in a fast-track environment where quick and well-informed decisions are essential to maintain the project's momentum. Han [115] proposed that advancements in information technology, such as project management software and computer-aided design tools, are transforming delivery of construction projects to enhance flexibility. Cheung et al. [116] reported that technological advancements in information flow like BIM can mitigate project risks and enhance project quality.

#### 2.9.5.4 Lean Construction

Elmalky et al. [117] mentioned in their research that evidence showed that the integration of lean construction (LC) concepts and tools into construction management not only addresses challenges but also generates a synergistic impact on project quality. They further added that applying LC methods will enhance the implementation of fast-track projects with high quality, less cost and time. Mbachu et al. [118] reported that increased rework and changes on fast-track projects can result in plenty of non-valued added alterations on the project, which leads to greater wastage in the project execution phase, in order to reduce wastage, lean construction is desirable. Stracusser [119] reported that the construction sector has seen various efforts to enhance productivity, including initiatives like lean construction. Lean construction focuses on reducing waste. Austin et al. [57] reported that among the many successful fast-track projects like the new state of the art steel processing facility (Hot Dip Galvanizing Line in Thyssen Krupp) in Alabama, also implemented lean construction methodology which paved path for its success. Collaborating fast-track and lean construction will definitely increase the profit and productivity of an organization [120].

#### 2.9.5.5 Appropriate Contractual Strategy

Moazzami et al. [121] reported that the clauses and contract forms applied on fast-track projects critically impact project delivery and performance. Contracts are legal documents or mechanisms used to allocate project risks and liabilities between the contracting parties. Dhanushkodi [122] mentioned that due to the unique challenges and accelerate timelines associated with fast-track projects, adopting an appropriate contractual strategy becomes critical. A clear and comprehensive contractual strategy helps establish the roles, responsibilities, and expectations of all project stakeholders, including clients, contractors, and consultants. This clarity is crucial in fast-track projects where quick decision-making is essential. Lee et al. [123] mentioned that with a defined contractual framework, parties involved can better navigate the fast-track complexities, reducing the likelihood of disputes and delays. Cho et al. [50] highlighted in their study that specific guidelines for fast-track applications are lacking. Egbelakin et al. [52] mentioned that, while this research was being conducted, no published contractual frameworks or documents existed in the literature or in practice specifically for implementation on fast-track construction projects. The lack of contractual framework leads to inequitably risk allocation among the contracting parties. Inequitable risk apportionment between contracting parties is the main source of legal problems on fast-track projects. Mendis et al. [124] also reported that the primary sources of contractual disputes between contracting parties in the fast-track project delivery method are the inequitable allocation of risks, ambiguous contract clauses, and the use of inappropriate contract forms.

Equitable risk distribution throughout the contract's duration keeps all parties engaged and reduces the likelihood of adversarial relationships during the execution phase [53]. Squires and Murphy [54] concluded that in fast-track projects, the incompleteness of plans and specifications for subcontract work can lead to specific tasks being overlooked. This occurs when one subcontractor assumes that another overlapping subcontractor is responsible for a particular task, and vice versa. To prevent this, every party involved in a fast-track project must be fully aware of their responsibilities. Therefore, the contract documents should clearly outline the extent of design completion, not only for the entire project but also for each individual subcontractor work package.

Alhomadi et al. [45]; Foster [125]; Eastham [65] and Bynum [126] stated that on fast-track projects, clear and specific scope requirements, appropriate risk allocations, and sufficient funding are fundamental contractual considerations and are of increased importance. An interviewee reported that on a fast-track project the contractor provides the owner with a guaranteed maximum cost [56]. Park [127] identified that a cost reimbursement strategy is generally more suited to fast-track projects than lump sum strategies. The changing and uncertain nature of fast-track projects requires flexible strategies, such as cost reimbursement, to effectively manage changes and additional costs. Bernstein [128]; Cleves and Meyer [129]; Sakal [130]; Ashcraft [131]; Rahman and Kumaraswamy [132] reported that standard construction contracts, typically cost-focused and risk-averse, are inconsistent with the uncertainty and collaboration needs of fast-tracking projects.

#### 2.9.5.6 Client Authorizing Extras

Squires & Murphy [54] advocated that fast-track construction frequently involves overlapping design and construction phases, leading to incomplete plans and specifications. Consequently, there is a higher likelihood that a diligent subcontractor will perform tasks not explicitly detailed in the plans and specifications but deemed reasonably necessary to execute them as provided. Typically, the owner must authorize any "extras." Changes, extras, and delays translate to additional costs for both general contractors and subcontractors. This scenario underscores the importance of clear communication and detailed documentation to manage exceptional scenarios and financial implications effectively. Vanhoucke [133] concluded that the authorization of extras by the client becomes a critical factor in mitigating the impact of these unforeseen circumstances. Without a clear mechanism for approving additional work, subcontractors may be hesitant to undertake tasks they believe are necessary but are not explicitly outlined in the original plans. This hesitancy could potentially lead to delays, disputes, or compromised project quality. Caplicki [134] mentioned in his research that the change' provision necessitates the contractor to obtain an authorization from the client, prior to proceeding with the work for that extra work. In Caldwell village of Seneca Valley, a contractor who did not obtain the appropriate written authorization before executing additional work was not compensated in terms of finances and time for that extra work. Where time is of the essence as in fast-track projects, the importance of authorizing extras by the client becomes particularly pronounced.

#### 2.9.5.7 Organizational Restructuring (Experienced Team)

According to Smith et al. [135], the fast-track delivery approach may conflict with existing organizational standards and operating principles, particularly if the organization lacks experience with this method. Alp and Stack [103] reported that the structure of a project organization can significantly affect the performance of the project team, especially on a fast-track project. Austin et al. [57] found that successful fast-tracking hinges on planning, execution, and organizational practices. Williams [48] found that experienced design-build teams characterized by mutual respect, effective communication and trust can construct fast-track projects more cost-effectively than teams lacking any of these ingredients. Jeffery [136]; Miles [137]; Gehrig et al. [138]; Carroll et al. [139] reported that successful fast-track projects employ technically proficient and self-motivated team players who are expected to proactively find solutions to problems. An interviewee reported that employing a well experienced project team to supervise each task on project site is the most critical quality management practice in fast-track construction [56]. Top fast-track stakeholders understand that there is minimal margin for error when preparing for fast-tracking [57]. Fast-track construction, by virtue of its inherently risky nature, requires cooperation by each team member at each phase of the project. If the participants in this process are compelled to allocate excessive resources to shield themselves from liability, they will struggle to find the will or time necessary to ensure the project's success. This diversion of focus and effort away from collaboration can significantly hinder the effective completion of the project [54].

#### 2.9.5.8 Front End Planning (FEP)

Fast tracking projects without proper planning may lead to multiple changes as a management reaction to rectify the problem. However, this change would cause subsequent changes adding more work and lower quality [69]. Fast-track projects that begin with insufficient front-end planning make it even more challenging to execute the design within budget and schedule constraints [63]. Projects rushed without adequate planning may resort to change management as a response to the situation. However, such adjustments often lead to increased scope variations and compromised quality due to subsequent revisions [43]. The reduced duration of the project does nothing but increases the importance of careful and thorough planning [48]. There are certain researchers like Williams [48] and Miles [137] who reported that fast-track schedules are dynamic, and the planning process remains continuous as the project evolves. Deshpande [63] concluded that the fast-track approach is often marked by incomplete scope definition during the conceptual and design phases and insufficient duration for thorough front-end planning, in contrast to various project delivery methodologies. Eldin [140]; Miles [137] reported that in fast-track projects, shortened timelines and heightened concurrent activities underscore the critical need for meticulous, comprehensive, and innovative planning approaches. According to Deshpande et al. [63], front-end planning is crucial for gathering strategic information that enables owners to mitigate risks and make informed resource commitments to enhance project success. Regrettably, many fast-track projects prioritize starting work quickly over thorough front-end planning.

#### 2.9.5.9 Scope Freeze Approach

Bogus et al. [93] argued that early freezing of design criteria enables transfer of upstream information to downstream activities prior to upstream design phase completion. This strategy necessitates early commitment to specific design criteria by project participants. While early scope freezing reduces uncertainty for downstream designers, it comes with trade-offs. Freezing the upstream design removes the possibility of alterations in upstream activities following the commencement of downstream activities. Early scope freezing may increase project costs due to limited design optimization opportunities. Austin et al. [57] reported that according to the Construction Industry Institute, clearly defining design freeze points, establishing early scope locks, and implementing design criteria and standards at an early stage are crucial aspects of fast-track projects.

#### 2.9.5.10 Risk Management Plan

Park [69] reported that fast-track projects frequently face numerous project risks. Those who manage projects on fast-track, are often tasked with making decisions aimed at efficiently minimizing and managing these risks through the implementation of formal guidelines and standards for proactive management of risks. The complexities inherent in fast-track construction necessitate adopting systematic and risk management techniques [82]. Huovila et al. [61] concluded that effective risk management in fast-track projects can substantially mitigate risks and challenges, while simultaneously maximizing opportunities. Efficient management of risks is crucial for maintaining control in fast-track projects. It is essential to introduce risk registers early and utilize them consistently throughout the project duration [45, 65, 89, 141, 142]. According to the European Construction Institute Fast-Tracking Manual, two-thirds of interviewed project managers implemented a risk management process to address penalties arising from fast-tracking, while the remaining third reported cost increases due to additional design, redesign, and rework [45]. Cho and Hastak [95] and Moazzami et al. [89] reported that fast-track projects are highly vulnerable to failure unless proactive risk management strategies are implemented.

Dehghan et al. [143]; Hossain and Chua [144]; Khoueiry et al. [145] mentioned that accelerating projects with incomplete design information introduces complexities that amplify project risks, including increased design errors, change orders and reworks. The heightened exposure to risks on fast-track construction, compared to conventional projects, underscores the need for a thorough examination of their risk profile [82]. Wang and Yuan [146] mentioned that achieving optimal outcomes in fast-tracking requires not only selecting the right materials, methods, and accurate designs but also ensuring effective risk management [82]. Eriksson et al. [147] reported that previous research has shown that inadequate risk management strategies contribute to the failure of many high-budget projects.

In their study, Rasul et al. [82] highlighted that current risk assessments often treat risks as isolated, singular events, neglecting their interdependencies and cumulative impact on project controls. This oversight significantly increases the vulnerability of fast-track projects to failure, as it fails to account for the complex interplay of risk impacts that are inherent in such projects. Therefore, robust and dependable methodical instruments and procedures for risk analysis are essential for effective risk management. This approach contrasts with the reliance on the experience and intuition of project managers, which is common in many developing countries but may not adequately address the multifaceted challenges posed by fast-track project environments. Perera et al. [148] mentioned risk management is a course of identifying, assessing risks, and application of methods to decrease them to a tolerable degree. Dey [149] reported that the projects on fast-track schedule are highly dynamic, and they derive significant advantages from dynamic risk management strategies.

#### 2.9.5.11 Modularization and Pre-fabrication

Aziz et al. [150] mentioned that the strategic embrace of modularization and prefabrication is not merely an option but a crucial decision in fast-track construction, offering a transformative approach that amalgamates speed, efficiency, and quality in a harmonious construction process. Williams [48] & Eastham [65] reported that to ensure success on fast-track projects, latest proven methods and technical improvements like pre-fabrication and time-saving modularization are used to pace up the project execution. Adopting pre-fabrication and modularization is a crucial decision in fast-track construction projects, offering several benefits that contribute to efficiency, cost-effectiveness, and timely project completion. A study on construction practices conducted by an electrical power research institute reported that modular construction created enormous opportunities for time and cost savings [151]. Modularization involves breaking down a project into smaller, manageable modules that can be constructed simultaneously. These modules are then assembled on-site. This parallel construction approach significantly reduces project timelines compared to traditional linear construction methods. The decision to adopt modularization and pre-fabrication is of paramount importance in fast-track projects due to their direct contributions to time efficiency, quality control, and cost savings [65]. Tighe [141] suggested that pre-fabrication allows manufacturing components in a controlled factory setting allowing for rigorous quality control measures, resulting in standardized, high-quality products. Pre-fabrication and modularization are most beneficial once such decisions are taken earlier in the project. In the shipbuilding industry, 60% to 80% schedule compression has been achieved through modularization of huge parts like whole sections of the ship and engine rooms [57].

#### 2.9.5.12 Early Contractor Involvement (ECI)

Robertson [53] mentioned that it has now been universally acknowledged that early involvement of the contractor in project execution can result in fruitful consequences. Further, Robertson [53] concluded that commonly the greater the complexity of the project, the sooner the contractor must be engaged. Moreover, depending on the complexity of the project, the contractor must be involved at

25% to 35% of design phase. Vorster et al. [152] showed that the early engagement of the suppliers and the contractors during the planning phase produced up to 19% time savings and 18% cost savings as contrast to conventional procedures. Kwakye [153] suggested that in the management of fast-track construction projects, the building contractors should be engaged in both design and construction stages. Cho et al., [50] mentioned that experiences on fast-track projects advocate that the execution of antecedent design packages once the design of the subsequent packages is incomplete, bears the risk of construction delays and increased construction cost because of variation orders. Hence, under prevailing fast-tracking procedures, the absence of contractor's involvement during the designing stage is highly perilous.

In the research conducted by Emuze and Oladokun [56], one of the interviewees reported that on fast-track projects, the contractor is engaged prior to the start of other project phases in such a manner that the contractor provides input to the development of design and then bids for the project prior to design completion. Cho et al. [50] reported that the risk of variation orders increase because of design omissions or various design management related issues incase design packages are evolved without getting input from the contractor. Due to the greater contractor engagement and coordination during the initial stages of design, fast-track projects are best suited to ECI approach [53].

#### 2.9.5.13 Owner's Financial Capacity

Cho et al. [50]; Eastham [65]; Miles [137]; Kumaraswamy et al. [154] reported that for successful completion of fast-track projects, clients must have plenty of resources at his disposal and organizational strength [57]. On fast-track projects executed in Korean construction industry, it was reported that the client's financial strength and organizational stability are the highly significant success factors [50]. Zaki [81] reported that the financial capacity of the owner/client is the most relevant indicator of success with regards to fast-track project execution methodology, exerting a profound influence on the project's success and viability. The accelerated timelines characteristic of fast-track projects necessitate substantial upfront financial commitments to meet the demands of rapid construction schedules. Owners/clients with robust financial capabilities can readily allocate the necessary funds for expedited procurement of materials, skilled labor, and cutting-edge technologies. This financial strength facilitates the seamless execution of concurrent project activities, reducing the risk of delays associated with funding shortages. Moreover, a well-capitalized client can absorb unforeseen costs and navigate potential financial challenges that may arise during the accelerated construction process. Naji et al. [155] advocated that financial stability also enables owners/clients to secure favorable lending terms and engage in strategic partnerships, further bolstering the project's financial resilience. In contrast, a client with limited financial capacity may struggle to keep pace with the demands of fast-track projects, leading to compromised quality, delays, and potential cost overruns. Therefore, the owner/client's financial strength is not just a facilitating factor but a foundational cornerstone that underpins the entire fast-track construction endeavor, ensuring the availability of resources essential for meeting aggressive timelines and overcoming the inherent challenges of expeditious project delivery. Thus, the financial capacity of the owner/client is a decisive factor that can determine the feasibility, success, and ultimate outcome of fast-track construction projects.

#### 2.9.5.14 Relational Approaches

Cho et al. [50]; Walker and Hampson [156]; Asmar et al. [157] mentioned that procurement practices based on innovative relationship are considered as an important improvement to conventional procurement methods, which are contemplated as being inconsistent with the inherent complexities of fast-track technique. As per those researchers who advocate relational contracting procedures such as alliance and partnering, contracts with more risk sharing assist in aligning project stakeholders with objectives of the project thus increasing commitment from all stakeholders towards project success [57]. Cho et al. [50] reported that results of the survey verified that chances of success on fast-track projects increase once partnering is applied.

According to Deshpande et al. [63], as in alliance, partnering is a long-term commitment among two or more individuals or companies or it can be applied for lesser durations such as till completion of project. Partnering aims at attaining particular business goals by optimizing the impact of resources contributed by all stakeholders [158]. Deshpande et al. [63] mentioned in their study that partnering effectively removes the adversarial aspects of relationships among project participants and foster a collaborative teamwork environment. This involves transforming conventional relationships into a collaborative culture that disregards organizational boundaries. Such relationship relies upon commitment towards shared objectives, trust and mutual understanding of each other's values and personal expectations. Hence, application of partnering idea can enhance the efficiency of fast-track methodology through establishing a more cooperative environment and improved communication. Cho et al. [50] in their study of applying partnering on fast-track projects observed a significant correlation between fast-tracking and partnering, suggesting that integrating partnering could enhance the success of fast-track projects.

Austin et al. [57] concluded that relational agreements such as alliance, resemble those in the DB projects, but offer greater flexibility in managing project risks and the capacity to adapt or modify the project course as needed. Alliance approach features a culture of accountability without blame, shared project risks, and integrated project teams chosen based on the most suitable individuals for each role. Gehbauer [159] contended that an emerging project delivery process is the Integrated Project Delivery (IPD) that engages main stakeholders collaboratively at the outset of the project. IPD and alliance have several commonalities, alliance contracts emphasize on team input and promotes client values while IPD utilizes lean project delivery methods to facilitate collaborative project execution.

#### 2.9.5.15 Commercial Buildings rather than Residential

Cho et al. [50] mentioned that fast-track methodology is commonly utilized in the commercial sector when reduced timeline can result in increased profits. This occurs when completing the project early enables it to generate positive cash flow sooner. Owing to such reasons, fast-track technique can be utilized for construction of hotels, large retail stores and other rapid income-generation infrastructures. Cho and Hastak [95] concluded that irrespective of the contract type, high-profit projects, such as emergency rebuild and critical time to market projects, are the best candidates for fast tracking. Fazio et al [46] argued that the preference for applying fast-track construction methodologies to commercial building projects over residential ones is often grounded on several factors related to project complexity, financial considerations, and the nature of the construction industry. Commercial projects typically involve higher profit margins compared to residential projects. The larger financial capacity associated with commercial developments allow for more flexibility and investment in the strategies required for fast-track construction, such as parallel processing, off-site fabrication, and expedited procurement. Deshpande [97] mentioned that industrial projects often have more intricate designs, intricate systems, and specialized requirements than residential structures.

Fast-track construction is better suited to projects with complex timelines and multiple phases, where the ability to overlap design and construction phases becomes a significant advantage. Commercial developments are typically seen as higher-return investments, justifying the additional effort and cost associated with fast-track construction. The quicker completion of a commercial project allows for a faster realization of profits, making it more attractive to investors and stakeholders. Fast-track construction allows developers to bring their projects to market more quickly, gaining a competitive edge and responding to dynamic market conditions. The application of fast-track construction to commercial building projects is supported by the financial capacity of the commercial sector, the complexity and scale of commercial developments, and the need for a rapid return on investment. The advantages of fast-track construction align with the dynamics of the commercial real estate market, making it a strategic and valuable decision for high-profit projects.

#### 2.9.5.16 Complex High-Rise buildings

According to Vidal et al. [160], project complexity refers to 'the characteristic of a project that makes it challenging to comprehend, predict, and maintain control over its overall environment, even if reasonably comprehensive information about the project is provided. Alp and Stack [103] mentioned that a number of complex construction projects are executed on a fast-tracked design and construction schedule. Recently, as the scale of a construction project has become larger and more complicated, there are many cases where construction projects with complex structures are carried out in a fast-track method to save construction duration. Kim et al. [62] reported that the application of fast-track construction to complex buildings is essential for managing the unique challenges posed by intricate designs and specialized requirements, ensuring a more adaptive and efficient construction process. Fast-track's importance lies in its capacity to deliver complex projects within compressed timelines without compromising quality, providing a strategic advantage in meeting the demands of traditional construction practices.

#### 2.9.5.17 Optimal Degree of Overlap

Bogus et al. [93] mentioned that by synchronizing activity characteristics and overlapping strategies, project managers can optimize decisions on the timing and the extent of overlap between sequentially arranged project phases, hence decreasing the project duration. Dehghan et al. [161] highlighted that the distinct benefit of activity overlapping is the reduction in timeline it creates in the project, leading to a host of benefits including faster time to market, increased revenue, shorter payback period, tax reductions, earlier operation, enhanced prestige and greater market share. The primary issue is the additional risks introduced, with rework related risk being the most significant. Reworks might raise costs and prolong the project's execution time. Hence, a trade-off is needed to be established among risks and costs of overlapping on one side and the time-saving benefits of overlapping on the other side in order to evaluate the most optimum degree of overlapping.

Bogus et al. [93] argued that the decision to overlap is essentially a compromise between greater reworks (increased costs) and time-savings. The extent to which dependent activities can be overlapped is governed by the type of information exchange among the activities. Most favorable overlapping scenario takes place when the successor activity is less sensitive, and the predecessor activity evolves quickly. Dehghan and Ruwnapura [44] showed 25% was the optimum degree of overlap as it resulted in the maximum net benefit.

#### 2.9.5.18 Critical Path rather than Non-critical

Dehghan and Ruwnapura [44] mentioned that project schedule compression is achieved by overlapping dependent activities on the critical path whereas overlapping the activities that are not on the critical path do not compress the schedule rather it escalates the project costs. Pena-Mora and Li [68] reported that after the detailed plan is generated, the construction schedule can be fast-tracked by applying the concept of concurrent engineering. In this phase, the characteristics of the critical activities will determine if fast-tracking the project is appropriate and realistic. The activities that should be analyzed include the ones that are on the critical path, have a high criticality index, or are constrained by a high resource and duration variance. These are the activities that have the most significant impact on the project schedule if their work duration can be reduced. If the two overlapped activities are either on the critical path or have high criticality indices, then overlapping the two can effectively shorten the project schedule. Bogus et al. [93] argued that overlapping the activities on the critical path result in significant time savings. After identifying the critical path activities, the next phase is to identify sensitivity characteristics and evolution of each critical path activity. The subsequent step in the decision algorithm is identifying the potential overlapping schemes for pairs of inter-dependent activities on critical path.

#### 2.9.5.19 Project Delivery Method

Laryea and Watermeyer [162] reported that the choice of project delivery method is a critical decision that determines how many contracts are required to be procured and overseen along with required capabilities and the capacity of the owner. According to Robertson [53], project delivery method is defined as assigning the responsibilities to various project stakeholders engaged to form a methodology for procurement, design and construction. Ahmed and El-Sayegh [163] referred to selection of the project delivery method as a crucial success factor for any project. For effective implementation of fast-track approach, combining it with an individual contract form like Engineering-Procurement-Construction (EPC) delivery systems, Construction-Management (CM) or Design-Build (DB) [164], can enhance collaboration among constructors and designers, leading to improved design efficiency. DB projects are executed on fast-track timeline to attain optimum project schedule.

Cho et al. [50] proposed that DB is the alternate method for project delivery which incorporates both construction and design in one contract. DB method is selected by the clients mainly because it has potential of reducing project timeline. Pena-Mora and Park [87] reported that DB projects supports delivery of fast-track projects. An interviewee reported that design-build (DB) project delivery method is used for fast-track construction. They further stated that attaining success in fast-track technique is more effective when the contractor and the designer work together as a single entity. Emuze and Oladokun [56] concluded that DB projects

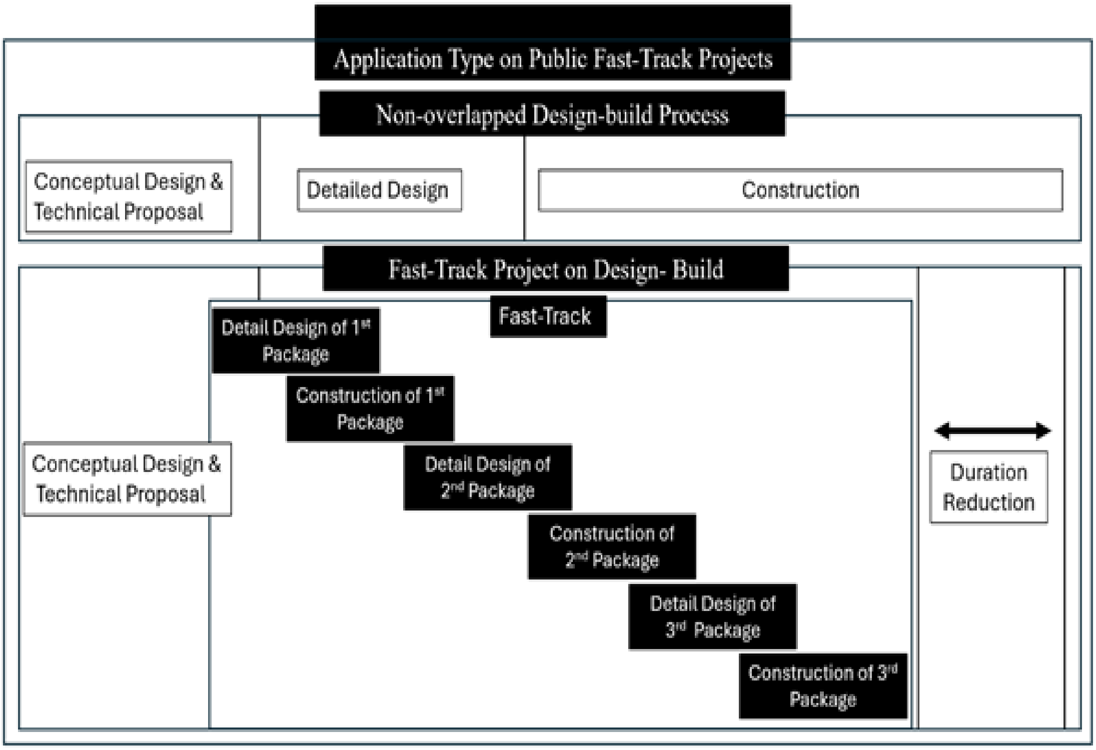



FIGURE 2.3: Design-Build and Fast-track Design-Build Model [50].

do not require the construction documents to be completed before construction can begin. As per them, this not only improves flexibility for alterations during the project, it also significantly reduces construction duration, which is the basic principle of the fast-track methodology. The DB contract fosters increased co-ordination among the constructor and the designer and DB projects are mostly expedited as project execution can start prior to completion of design [165]. The fast-track coupled with DB method can substantially compress project duration to 50%, based on the type of project [166]. This timeline reduction is attained through schedule compression by executing construction and design activities concurrently [71]. DB application has increased many folds from the beginning 1990s owing to the benefits it has over conventional methods of project delivery specifically with regards to reducing the project timeline [50].

#### 2.9.5.20 Contingency Allocations

Egbelakin et al. [52] in their research on management of fast-track construction highlighted some barriers that impede the fast-track performance and suggested that on fast-track projects, contingency allocation are must hence should be abundantly available to accommodate uncertainties and risks inherent to this type of project delivery methodology. Moazzami et al. [121] and Mendis et al. [124] argued that on fast-track projects, the probable result of the unbalanced allocation of liabilities and risks are linked to the use of greater percentages of premiums and contingencies by the engineers, project architects and contractors in the bid price, which eventually leads to increase in project cost and, expensive litigations in some cases. Williams [48] reported that while executing fast-track technique, the project team accounts for all potential scenarios and allocates a budget for these contingencies, by doing so they reduce unexpected issues and facilitate their resolution.

#### 2.9.5.21 Design Optimization

Williams [48] mentioned that with a reduced schedule as in case of fast-track projects there is no time to optimize every design as many customers and engineers alike have grown accustomed to doing. Deshpande et al. [63] reported that in fast-track projects, designers are required to make decisions based on incomplete information, and the design is swiftly implemented on-site. Due to limited time and insufficient information, optimizing the design is challenging. Williams [48] concluded that fast-track projects are comparable to traditional ones, but they involve more one-on-one communication, fewer iterations and a higher level of assumptions. A huge amount of resources and time is wasted in the conventional accurate, iteration based design procedure. With the advance softwares, engineers devote so much time to optimizing and minimizing the design that it eventually becomes waste of time which the fast-track projects cannot afford. Bogus et al.

[93] advocated that overlapping dependent activities requires that work on the downstream activity starts before the required upstream information is finalized. Therefore, the downstream activity must begin with incomplete, non-optimal, or non-final information. Bogus et al. [93] further proposed that by limiting optimization or iterations in a gradually evolving activity, accelerates the communication of enabling information to the downstream activities quicker than planned. This strategy is relevant to activities that evolve naturally at a slow pace, where optimization or iteration hinders information exchange for downstream activities. According to this approach, there will be restrictions on the frequency of iterations permitted before particular information must be transferred to activities in the downstream. The choice to restrict the iteration process applies to upstream activities characterized by slow evolution.

#### 2.9.5.22 Over-design Approach

Deshpande et al. [63] reported that on fast-track projects, the design team is compelled to over-design and make sure that sufficient capacity is available. For instance, structural systems and foundations are built in initial project phases, however essential information regarding the forces and loadings is usually unavailable. Under this scenario, design optimization is not possible, hence structural system and foundations are usually designed for a greater load-bearing capacity. Williams [48] mentioned that on a fast-track project while designing the project, due to the less information exchange, for example either the structural steel framing or the foundations of a facility will usually be oversized. Using conservative assumptions or over-designing in downstream activities, enables work to commence prior to the completion of upstream design. According to Bogus et al. [93] by adopting conservative assumptions regarding the strength or size of project elements, designers can initiate the downstream activities before completion of the upstream activities, and in certain instances, even prior to the commencement of upstream activity. El-Far et al. [83] mentioned that overdesign poses the risk that assumptions about upstream activities might not be sufficiently conservative, potentially necessitating reconstruction or redesign of subsequent activities. As this happens, all the time-saving advantages are lost, and probability of additional cost increases. Therefore, striking the right balance among enhancing the conservatism of assumptions and upholding a reasonable project budget is crucial. Overdesign stemming from insufficient knowledge, also influences other disciplines to elevate their design assumptions. Williams [48] suggested that as the number of assumptions on fast-track projects increase, it is better to overdesign rather than under designing a building foundation and let them fail under overloads, for which the consequences are dire.

#### 2.9.5.23 Incentive for Early Completion and Penalty for Delays

Williams [48] concluded that in fast-track projects, implementing robust incentive and penalty clauses - potentially amounting to as much as 50% of the purchase order's value - can significantly motivate suppliers to actively participate as integral members of the design-build team. Such contractual measures aim to enhance supplier commitment and collaboration, thereby fostering project success through timely and effective contributions. Mubarik [74] reported a case study that on 17 Jan 1994, a 6.7 magnitude earthquake caused several casualties and inflicted heavy damages in North ridge, California. In order to reopen this highway in the busiest region of America, a 14.7 Million USD contract was signed with C.C. Meyers. As per the contract, the contractor was supposed to complete the project in 140 days. The contract also had a liquidated damages clause of 200,000 USD per one day delay and same bonus amount was set for each day of early completion. The contractor completed the project in just 66 days and earned a bonus of US$ 14.8 M. On this fast-track project, this early finish was attributed to the bonus and penalty clause in the contract. Austin et al. [57] reported a case study of a Hot Dip Galvanizing Line (HDGL # 2) costing 32 M USD, the project had a construction schedule of nine months. The project had significant penalties in case of its failure to meet the specified nine months contractual timeline. Inclusion of damages clause particularly and other factors in general made it possible to complete the project in 6.5 months with a lesser cost compared to another 38 M $ HDGL # 1 project.

#### 2.9.5.24 Front-End-Engineering Design (FEED)

Deshpande et al. [63] mentioned in their study that successfully completing the designing phase on fast-track endeavors presents a significant challenge, primarily because simultaneous construction and design activities disrupt the iterative characteristics inherent in the designing process. The FEED process form the basis for the detailed design which mostly follows in the succeeding stages of the project. Thorough documentation of the project and design scope is crucial for the successful execution of design in fast-track construction. This process entails the exchange of information among different engineering disciplines, including mechanical design (equipment design), piping design, process design, electrical and instrumentation design. Utilizing front-end engineering design can help anticipate and minimize the potential for significant future changes in the design particularly in fast-track projects hence enhancing the quality considerations.

#### 2.9.5.25 Safety Regulations

Rasul et al. [82] reported that increased accidents on project site directly diminish project productivity. Consequently, decreased productivity translates into reduced schedule feasibility, ultimately resulting in project time overruns. This cause-and-effect relationship underscores the critical importance of maintaining safety to ensure project efficiency and timely completion. Koehn et al. [167] concluded that in fast-track construction, safety is given the minimum importance specifically in the construction sector of under-developed countries. Austin et al. [57] while discussing the best practices on fast-track projects with a panel of industry experts reported that the experts emphasized on not compromising safety during the execution phase of the project. Kazi and Parker [168] reported that no common safety culture is practiced by contractors in case of traditional projects whereas fast-track projects are more concerned to safety policies followed on their site. Harthi [96] mentioned that lack of safety considerations is one of the barriers in implementation of fast-track construction.

#### 2.9.5.26 Early Contract Award

Early contact award is an important decision, Robertson [53] found that on ECI (Early Contractor Involvement) projects, the client did not contractually engage the contractor until more than half of the design phase was complete due to which the project underwent redesign delays that could potentially have been prevented if the contract had been signed earlier, allowing for earlier contractor input. The field offices indicated that factors such as scale of the project, source of funding, location, project complexity and timelines influence the timing for awarding the early contract. However, there was general consensus that delaying the contract award beyond 35% design completion stage diminishes the advantages of ECI. This observation aligns with recommendations consistently highlighted in the literature review. Similarly, Skaik [169] reported that on high-rise fast-track projects, the employers tend to award shoring and piling contracts to enabling contractors on design and build basis once conceptual design is completed. The target was to make sure that the enabling work scope is finished latest by the award of main contract to maximize the efficiency of fast-tracking. In this way, the shoring system and piling are likely to be procured firstly on a design-build contractual basis where the winning enabling contractor can commence construction at a very early stage of design development.

#### 2.9.5.27 'Fast-track' Decision Stage and Why?

Cho et al. [50] reported that as per the USACE's Design-Build Contracting, the client decides at the pre-design stage whether the fast-track approach is necessary or not. During this phase, the client determines the requirements for fast-track technique and communicates them to the consultant and the contractor through the request for proposal (RFP) and then the consultant and the contractor prepares the documents based on these requirements. Austin et al. [57] conducted a survey in which the interviewees were asked about the project stage at which the decision to fast-track was made and what were the reasons for fast-tracking the project? Russell and Ranasinghe [170] reported that interestingly, for most of the projects described in the literature, the decision to follow a fast-track schedule was not part of the original plan but a subsequent one. However, the existing literature reflects that the decision to fast-track a project is available at any state of the project, depending on whether the purpose is to meet the tight project deadlines set by the client or to overcome project delays/ time overrun. If the purpose of fast-track is to meet the deadlines, then this option is availed at the early stages of the project and if the purpose is to overcome the delays, then it can be adopted at any stage of the project experiencing delays.

#### 2.9.5.28 Early Permits/ Approvals

Cho et al. [50] in their research mentioned delays in securing permits and authorizations as one of the most crucial aspect of fast-track success. Skaik [169] reported that on a 340 m (81-storey) super tall building in United Arab Emirates, the enabling contractor was appointed before obtaining authorities approval of preliminary design. The design was eventually rejected due to insufficient number of lifts which hindered the commencement of shoring works on site. After lengthy debate and discussion with authorities and specialist designers, the building was redesigned to accommodate additional lifts. The work was resumed on site in August 2009 and completed in June 2011 resulting in an overall project delay of 15 months. Similarly, Austin et al. [57] reported that one factor among the many factors leading to successful termination of I-35, Saint Anthony Falls Bridge reconstruction on fast-track schedule was the decision to secure early site access permits. In this regard, the Minnesota Department of Transportation (MnDOT) was able to obtain eight permits within two weeks of the bridge collapse.

#### 2.9.5.29 Acceptable Quality Compromise on Fast-Track Projects

Many researchers like Abdelbary et al. [43], Alhomadi et al. [45] and Williams [48] have concluded in their research that quality compromise is an inherent part of fast-track methodology because of the limited time available for optimizing the planning, design and construction phases. El-Far et al. [83] while conducting research on strategies for controlling time, cost and quality variables and minimizing the rework on fast-track projects limited the acceptable quality compromise on fast-track construction projects to 10% which means that the quality standards on fast track construction projects must not degrade below 90% as compared to the traditional construction projects which was also concluded in the research.

#### 2.9.5.30 Interface Management Plan

Bogus et al. [171] mentioned that fast-tracking is the practice of overlapping the phases which are conventionally planned in a sequence. The extent to which these phases, either construction or design, can be overlapped depends on the rate of information exchange among them. This information exchange requires dynamic interface between design and construction and the key to reducing project delivery time is the management of the interface between design and construction. According to de la Garza et al. [172] and Hastak et al. [173], the construction industry views design and construction as separate entities with no or little coordination among designers and builders, which is counter-productive to any attempt to minimize the overall project delivery time. Hence the construction industry must move towards an integrated design-construction interface. Cho et al. [50] emphasized that to minimize design error and defects, designers across various disciplines -

such as architectural, structural, mechanical, and electrical - must strive to minimize omissions by utilizing shared design information. To reduce scope changes and errors in design, design interface management must be implemented prior to the completion of each design sub-phase.

#### 2.9.5.31 Constructability Review

Smock [151] and Eastham [65] reported that all fast-track projects which were successful, they commenced with a proactively involved client, who should be an integral part of project contracting, engineering and design and his concern for constructability should start at the planning stage of the project. Arditi et al. [174] argued that even if the design package has been awarded to one contractor and the construction to another; errors can be minimized by adopting the philosophy of constructability. Such philosophy helps the designers see through a model as if it is real, at site, to reflect on their work which leads to a higher quality of design. Arditi et al. [174] further reported that around only 50% of engineering firms have adopted constructability concept, and that led to decrease in number of design errors [109]. Cho et al. [50] argued that the contractors must review the construction drawings with regards to the design's constructability. Examining the design of fast-track projects, they highlighted that constructability is one of the most critical factor influencing fast-track success.

#### 2.9.5.32 Time Saving vs Additional Reworks

Khoueiry et al. [145] advocated that while making overlapping decisions, the project manager is left with the task of assessing whether the value of the potential time savings is higher than the expected amount of rework. Love et al. [175] reported that fast-tracking the projects by overlapping the succeeding activities related to construction with unfinished design information from preceding design stages can significantly shorten project timelines. However, this approach comes with the risk of potential rework due to the incomplete information available at the start of construction. The key hurdle lies in determining the most effective overlapping strategy that can meet project deadlines without leading to excessive rework. Rework, in this context, refers to any unnecessary work or effort undertaken to correct or redo the execution of a task due to initial errors or incomplete information. Hwang et al. [176] reported that design errors are the primary contributors to the highest rework costs in construction projects. Similarly, Han et al. [177] reinforced these findings, indicating that design errors account for approximately 78% of the total rework costs [144]. El-Far et al. [83] reported that fast-track construction projects that begin with inadequate design information have become more common in response to a rising construction industry demand. Fast-tracking shortens project duration while increasing rework. Srour et al. [80] noted that on fast-track schedule, downstream processes commence with incomplete information from upstream phases and in case the initial incomplete information alters, there exists a major risk of rework. Abdelbary et al. [43] conducted research on client related reworks on fast-track projects, they identified and also assessed the impact of reworks on project performance criteria, primarily time, cost, and quality. According to Dehghan and Ruwanpura [44], if two activities on the project critical path overlap, the actual time saving is equal to the difference between overlapping period and rework period.

#### 2.9.5.33 Scope Management Plan

Alp and Stack [103] conducted research to determine existing efficiencies and deficiencies for scope management of large and complex projects on a fast track schedule. They reported that it is the scope of the project (and changes to) that the three pillars, cost, schedule, and quality are dependent upon hence within the project management it is the scope management that requires the most attention. The cost, schedule, and quality of a project will vary (positively and negatively) according to the defined scope of work. Thus, poor management of the project scope can have detrimental effects on the overall outcome of the project.

#### 2.9.5.34 Cost-Benefit Analysis (Financial Feasibility)

Khatale and Aher [178] described cost-benefit analysis (CBA) as a detailed outline of the potential risks and gains of a projected venture. Many factors are involved, including some abstract considerations, making the creation of a CBA more of an art than a science, though a quantitative mindset is still a must-have. A CBA is useful for making many types of business and personal decisions, especially ones with a potential for profit. Moreover, by comparing the financial feasibility of fast-track construction over the conventional method and calculating the risks associate with fast track construction provides better decision-making opportunities. Baker and Boyd [179] conducted research on the fast-track construction of nuclear power plants, cost-benefit analysis was an integral part of the client's technical review in the change control/ approval process. In this change control process, a change is not implemented until it has a positive cost-benefit analysis.

#### 2.9.5.35 Value Engineering

Hendrickson et al. [180] stated that value engineering may be broadly defined as an organized approach in identifying unnecessary costs in design and construction and in soliciting or proposing alternative design or construction technology to reduce costs without sacrificing quality or performance requirements. It usually involves the steps of gathering pertinent information, searching for creative ideas, evaluating the promising alternatives, and proposing a more cost-effective alternative. This approach is usually applied at the beginning of the construction phase of the project life cycle. Khadim et al. [181] reported that value engineering is highly relevant to quality-cost trade-off and was found to be highly effective in construction projects. Laryea and Watermeyer [182] carried out research on managing uncertainty in fast-track construction projects. The research was motivated by an observation on an approximately 100 million USD New Universities fast-track project in South Africa which was successfully delivered under the estimated project cost despite that 73% of the project scope was uncapable of being estimated by the contractor once the construction started. The analysis of the project documents and client delivery-management team member's interviews revealed that out of all the practices and procedures, continued value engineering was the main client oriented management methodology employed to manage the uncertainty and to successfully handover the project that too under the project budget. The design teams were required to work collaboratively with the contractors, where design solutions during the construction phase resulted in cost increases, trade-offs were sought in order to bring the cost back to the agreed target price without compromising quality, which reflected a culture of continuous value engineering.

#### 2.9.5.36 Retain Design and Interface Management Responsibilities

Watermeyers [183] reported that on projects funded by the client rather than the market, a decision needs to be made regarding the allocation of design and interface management responsibilities between the parties to a contract. A client can retain the design and interface management responsibilities in which as the contractor undertakes construction on the basis of production information issued by the client, the client is responsible for the planning and managing of all post contract activities for work packages which have dependencies due to interfaces. In this case the client needs to appoint professional service providers to undertake design and interface management responsibilities which it has retained, where he lacks in-house professional expertise to assume these responsibilities. Laryea and Watermeyer [182] reported that on the fast-track construction of the New Universities project in South Africa, a decision was taken early-on in the project for the client to retain rather than transfer design and interface management responsibilities to the contractor. This decision was taken with the view that such an approach would provide more flexibility given the uncertainties in requirements and enable the use of expertise to ensure that the designs of the teaching spaces are aligned with current and future best practice. The project team was also of the view that such a strategy would better serve the design competition approach adopted to create a superior design that would not only be responsive to spatial requirements but also result in architectural landmarks symbolic of intellectual aspiration.

#### 2.9.5.37 Quality Management Plan Submission

Emuze and Oladokun [56] reported that the quality management methods on fast-track projects are not handled the same manner as in traditional projects. Traditional projects have extra room for mistakes compared to fast track projects. Quality management on fast-track projects, as opposed to traditional construction has a detailed and a unique method for approval. The contractor is intimated at the bidding stage regarding the quality requirements and is expected to have a full-time quality assurance manager and quality management plans ready. Moreover, the sub-contractors are required to fill-in the inspection test plans. After every inspection the concerned stakeholders initial the documents which shows that the quality is approved prior to entering the subsequent phase. An interviewee working for the contractor reported that on fast-track projects in order to achieve quality, they have to deposit a quality management plan to the client which is the Department of Human Settlements (DoHS), prior to the design phase.

#### 2.9.5.38 Contractor Pre-Qualification

On construction projects in general and fast-track projects in particular, contractor pre-qualification now forms part of the initial investigations thereby permitting time savings and realistic evaluations of construction and contract strategy [184]. The contractor's pre-qualification positions the owner such that he can better assess the contractor's ability to perform the work within the accelerated time frame. The advance knowledge about the contractor's capability can be used in an optimal manner to further compress the project schedule. The prequalification of the contractor assists in building owner's confidence well before the start of the construction phase [185]. Dey [149] conducted research on managing fast-track projects in which they reported that on fast-track projects, contractors are selected from a pre-qualified pool by examining their present commitment.

#### 2.9.5.39 Dispute Resolution Technique

Kasim et al. [51] reported that in fast-track construction, it is essential to manage disputes with effective resolution strategies during the execution phase to achieve better outcomes. On fast-track projects, there is no room for turf wars or politics moreover there is less time for petty disputes and indecisiveness [48]. Moazzami et al. [89] investigated the contractual risks associated with disputes, claims, and legal issues in fast-track projects. Since on fast-track projects, the scope, specifications and the design keeps changing during execution phase therefore it turns difficult to estimate the accurate project budget and duration which consequently becomes the basis of legal issues. The use of inappropriate contract form, unclear contract clauses, and inequitable allocation of risks constitute the main reason of contractual issues among contracting parties in fast-track project delivery technique [52]. U.S. Federal Facilities Council (2007) reported that 33% of fast-track projects have claims as compared to 7% of conventionally scheduled projects [169].

#### 2.9.5.40 Prototyping

Elvin [72] mentioned that on fast-track projects rapid on-site prototyping may also be cost effective means of generating valuable ideas and information. As Lee

Trimble of Mancini and Duffy explained, We had a client who developed a full scale mock-up of their space  we called it a design lab  and we really pulled it apart in terms of design, usability and constructability. The cost was far offset by the savings achieved by correcting things early as opposed to after we had built it in the field.

Bogus et al. [93] stated that prototyping is the technique of rapidly assembling initial design concepts into a functional model of the final system. Once working model is completed, prototyping enables execution activities to commence, although the design process is not yet finalized. Prototyping is akin to the early exchange of initial information; however, it pertains to complex systems where numerous pieces of information must be communicated to downstream activities. Ruvald & Askling [186] advocated that in the context of building construction, prototyping refers to the creation of a physical prototype of a structure before the actual construction begins. This process allows architects, engineers, and other stakeholders to visualize, test, and refine the design before committing to full-scale construction. Prototyping is a valuable tool in the construction industry for several reasons, such as visualization, design validation, client communication, innovation, and regulatory compliance.

#### 2.9.5.41 Early Scope Definition

The most frequent reasons for risks in fast-tracking are incomplete scope of work and design package at the bidding stage [187]. Alp and Stack [103]reported that apart from change control and management performance, poor project scope definition leads projects into budget overruns and late finishes. Scope definition is a process that relies on a collection of dynamic project inputs, (i.e. owner requirements, regulatory requirements, design specifications, construction methodologies, etc.), that formulate a defined and quantified itemization of the required functional and technical work efforts to execute the project. The scope definition activity should be performed by the project team which ideally collects input from all project stakeholders (owner, design, and construction) that can identify and quantify the project's purpose, goals, and requirements into packages of executable specific information, or more simply stated work packages. Research results have indicated that greater pre-project planning and scope definition efforts, lead to improved performance on industrial projects in cost, schedule and operations [103].

As time is of the most critical aspect of fast-track projects, therefore elevated degree of concurrency among engineering, construction, procurement and early scope definition are the characteristics of such projects [188]. Al-Saeedi and Karim [109] found that undefined scope of project is the main source of design changes in oil and gas projects in Canada. If the scope is incomplete or vague or generic for that matter, the design team will tend to guess how a particular package should be designed. Then later on, the client comes in and suggests that this is not what is wanted, therefore early scope definition is imperative to project success.

#### 2.9.5.42 Resource Management Plan

Taghaddos et al. [189] mentioned that efficient resource allocation for large-scale industrial projects is challenging due to their size and complexity, especially with fast-track contracts, which often lack detailed information during the early planning phase. Das [190] reported that resource management is the process of planning the resources necessary to meet the objectives of the project, and to satisfy the client's requirements. Without proper resource management, projects can fall behind schedule, or can become unprofitable. Egbelakin et al. [52] mentioned in their research that efficient management of equipment and material can impact the productivity of fast-track projects. Furthermore, when construction activities are performed concurrently, then resources not needed for an activity can be deployed to the other activity. Materials management is particularly problematic on fast-track projects where design and procurement decisions are made concurrently with construction activities [51]. Emuze and Oladokun [56] conducted research on quality management practices which contractors employ on fast-track projects and emphasized that the contractors must apply efficient resource management on fast-track projects. Vijayan and Johny [120] concluded that lack of efficient resource management is amongst the three strategies which cause delays in fast-track construction.

#### 2.9.5.43 Early Engagement of O&M Team

Pishdad-Bozorgi et al. [58] conducted research on readiness assessment of fast-track projects using analytic hierarchy process (AHP) in which they mentioned the engagement of O&M teams early in the project as one of the leading best practices on fast-track projects. de la Garza and Pishdad-Bozorgi [188] formalized a re-engineered workflow process for successful fast-tracking, abbreviated as cPEpC (c for collaborative and committed participation of downstream stakeholders right from the start of the project, P for procurement of long lead items, E for engineering, p for procurement of remaining equipment and material, and C for construction). cPEpC model standardizes the dedicated involvement of facilities managers and operators at the onset of the project. In the nutshell, this framework allows an operation and maintenance (O&M) driven and construction-driven design philosophy in which design is developed by infusing in it, at the outset, experience and knowledge regarding the means and methods of construction and considerations for O&M. The main distinctive part of cPEpC is the significance of the collaborative and committed engagement of important downstream stakeholders, for example O&M personnel are engaged at the onset of defining the project scope, prior to starting any key engineering design, procurement and construction activities. The cPEpC model allows the application of a O&M-driven and construction-driven philosophy of design that is crucial for the success of fast-track approach. The O&M-driven and construction-driven designs developed through cPEpC enhance the productivity of construction processes by overpowering the common issues often faced in traditional project delivery strategies.

#### 2.9.5.44 Delegate Authority to Project Level

Austin at al. [57] conducted research on identifying and prioritizing the best practices for achieving success on fast-track projects in which they recommended delegating decision-making authority to the lowest project level, as the staff nearest to the work have the required viewpoint to make high quality and timely decision at the project level. Pishdad-Bozorgi et al. [58] carried out research on readiness assessment of fast-track projects in which they defined 47 essential fast-track practices out of which authority delegation to project level was ranked amongst the top ten best practices for successful fast-tracking. Moreover, these 47 fast-track practices were used by de la Garza and Pishdad-Bozorg [188] in their research to develop workflow process model for fast-track projects in which authority delegation to project level was used as a tier-1 practice.

#### 2.9.5.45 Limiting the Cost Impact of Fast-Track Approach

El-Far et al. [83] conducted research on controlling the cost, quality and time variables on government funded construction projects that are executed on fast-track. The research limited the cost variance to a maximum of 20% increase on fast-track projects as compared to traditional construction methods as this proportion is considered to be ideal and preferred setting for achieving shortest duration for construction projects with highest quality. The research strongly concluded that the cost impact of implementing fast-track technique should not exceed 120% of conventional methods. Similarly, Das [190] while conducting research on strategies for fast-track mode of construction concluded that the fast-track approach increases the project cost to 128.38% as compared to the traditional sequential construction which is less than 130% which is an acceptable cost overrun value in the construction industry.

#### 2.9.5.46 Long-Lead-Time Items

Cho et al. [50] mentioned that through the procurement of long-lead items at an early stage, sufficient manufacturing duration is guaranteed. If long-lead items such as elevators, curtain walls, major equipment, etc., are determined early, there will be less interference in the construction work. Because interference frequently occurs during the construction of the structure, long-lead item suppliers have to be involved at the design phase. Cho et al. [50] found that among the factors related to procurement, selection and procurement of long-lead-time items is a crucial factor while deciding the fast-track project's success. Moreover, long-lead items are identified early to avoid delays in their procurement and availability on project site. Dey [149] also concluded that a major reason for time overrun were the delays in material supply, inferring that delays in material availability were a crucial reason for delays on construction projects. Williams [48] reported that earliest identification and procurement of long-lead-time items is a very important aspect as delay in procuring and delivering such items on a fast-track schedule can be detrimental. Austin et al. [57] mentioned identification and procurement of long-lead-time items as the top ranked practice on fast-track projects.

TABLE 2.1: Frequency Analysis of Decision-making Aspects

| **Decision-Making Aspects (Indicators)** | **References** |
|---|---|
| Decide between the potential time savings due to overlapping and the amount of expected reworks | [43, 44, 80, 83, 144, 145, 175–177] |
| Adopt Relational Approaches | [50, 57, 63, 156–159] |
| Implement an effective Change Management Plan | [1, 48, 50, 52, 57, 65, 69, 104–111] |

| **Decision-Making Aspects (Indicators)** | **References** |
|---|---|
| Implement design & construction interface management plan | [50, 171–173] |
| Implement Front-End-Engineering Design (FEED) | [63] |
| Early scope definition at conceptual or design stage | [103, 109, 187, 188] |
| Early involvement of the contractor in design phase | [50, 53, 56, 152, 153] |
| Adopt scope freeze approach at early design stage | [57, 93] |
| Over-designing the facility | [48, 63, 83, 93] |
| Early Procurement of Long-Lead-Time Items | [48, 50, 57, 149] |
| Adopt an appropriate contractual strategy | [45, 50, 52, 53, 56, 65, 121–132] |
| Implement an effective resource management plan | [51, 52, 56, 120, 189, 190] |
| Implement Value Engineering | [180–182] |
| Implement an effective Risk Management Plan | [45, 61, 65, 69, 82, 89, 95, 141, 142] |
| Limit the cost impact due to fast-track to 120% compared to traditional construction | [83, 190] |
| Use prototyping (Scaled-down models of complex buildings) | [72, 93, 186] |
| Sufficient contingency allocations by the clients | [48, 53, 121, 124] |
| Conduct Cost/Benefit analysis (Financial Feasibility) | [178, 179] |
| Apply fast-track to commercial building (which are time critical & High profit) rather than residential | [50, 95] |
| Adopt BIM based Fast-track Approach | [112–116] |
| Owner's financial capacity (Ensuring no resource constraint) | [50, 65, 137, 154, 159] |

| **Decision-Making Aspects (Indicators)** | **References** |
| --- | --- |
| Retain Design and Interface Management Responsibilities | [182, 183] |
| Decide the acceptable quality compromise extent on fast-track project preferably not less than 90% | [43, 45, 48, 83] |
| Limit the design optimization/ iteration process | [48, 63, 93] |
| Delegate Authority to Project Level | [57, 58, 188] |
| Implement Lean Construction | [57, 117–120] |
| Adopt contractor pre-qualification Strategy | [149, 184, 185] |
| Quality Management Plan submission in pre-design stage | [56] |
| Conduct constructability review during planning or design phase | [50, 65, 109, 151, 174] |
| Early engagement of O&M team in the design process | [58, 188] |
| Implement effective communication mechanism | [48, 53, 54, 56, 81, 99–103] |
| Organizational restructuring (Experienced Team) | [48, 54, 56, 57, 103, 135–139] |
| Implement Front-End-Planning (FEP) | [43, 48, 63, 69, 137, 140] |
| Adopt Pre-fabrication and Modularization | [48, 57, 65, 141, 150, 151] |
| Adopting Fast-track on complex high-rise buildings | [54, 62, 103, 160] |
| Compliance with site safety regulations | [57, 82, 96, 167, 168] |
| Project stage at which the decision to fast-track is made | [50, 57, 170] |
| Adapting an effective dispute resolution technique | [48, 51, 52, 89, 169] |
| Securing Early Permits/ Approvals | [48, 51, 51, 89, 169] |

| **Decision-Making Aspects (Indicators)** | **References** |
|---|---|
| Decide the optimal degree of overlap between activities | [44, 93, 161] |
| Selecting the most suited project delivery method (DB, CM, EPC) | [50, 53, 56, 71, 87, 162–166] |
| Announce incentives/ bonus for early completion | [48, 57, 74] |
| Impose damages/ penalties for delays | [48, 57, 74] |
| Early contract award for enabling works | [53, 169] |
| Apply Fast-track to Critical Path rather than non-critical | [44, 68, 93] |
| Implement an effective Scope Management Plan | [103] |
| Client Authorizing Extras | [133, 134] |

## 2.10 Existing Frameworks for Fast-tracking

A few decision support tools for fast-track projects were found in the literature, but they only focused on a specific aspect of fast-track approach and lacked comprehensiveness. Khoueiry et al. [145] presented a decision support tool which was based on activity schedule optimization for fast-track projects. Russell & Ranasinghe [176] presented a deterministic analysis framework that permits the computation of an upper bound on the constant dollar expenditure that should be made to fast-track a project to achieve a specified duration. Hossain & Chua [144] proposed an optimization methodology for design and construction overlap employing the ideas of downstream sensitivity and upstream evolution features and formulated the simulation model to determine performance of the project with regards to expected amount of rework and total project duration. Bogus et al. [93] proposed a framework for overlapping dependent design activities on a fast-track project which can assist the project managers in making better decisions on when and how much to overlap the sequential activities.

The decision-making model proposed by Cho & Hastak [95] fails to provide a detailed insight into the real-life decision-making aspects on fast-track projects. The model only considers the design and construction work packages, ignoring other decision-making dimensions such as contracting, procurement, economic feasibility, management, finances etc. Moreover, the model does not clearly identify the design and construction work packages and randomly terms them as $\text{DWP}_k$ and $\text{CWP}_{nm}$ which does not provide a clear insight on the real decision-making scenarios encountered by the stakeholders. All these decision frameworks focus only on one aspect of fast-tracking, either its information flow, overlapping design activities, reducing reworks or financial considerations.

Austin et al. [57] proposed a model that evaluated the trade-offs among cost and time. The model showed that identification of long lead-time items, a focus on construction-driven milestones, scheduling, standardizations and detailed critical path planning showed high correlations with outcomes of successful fast-track. Cho et al. [50] formulated a unique fast-track partnering process model (FTPPM) for implementation on design-build projects in public sector. The model was founded on the analysis of the variables that impact the fast-track methodology success. They used factor analysis to discover the seven key success variables. FTPPM comprises of the fast-track workshop stage, preparatory stage and the construction and detailed design stage. They concluded that FTPPM will reduce the risks during the entire fast-track process owing to procurement delays and errors in design. Moreover, it is believed that delays in construction can be avoided, and success of the project can be ensured.

## 2.11 SEM and its Applications in Construction Industry

Structural Equation Modelling (SEM) emerged as a powerful 2nd generation multivariate statistical technique [191], Dash and Paul [192] used SEM for experimental, non-experimental research, cross-sectional and longitudinal data. SEM transcends traditional linear regression models, providing a comprehensive framework to analyse complex relationships among variables. This sophisticated methodology combines elements of path analysis, factor analysis, and regression to elucidate intricate causal relationships and dependencies, making it particularly apt for examining multifaceted phenomena within various industries. Its applications in various industries have been increasing since its introduction in the 1980s [193]. SEM can be used for advance risk analysis, optimized decision support systems, model predictions, and other applications [194]. SEM describes and tests relationships between the latent variables and the observed variables [195].

Variance-based SEM (PLS-SEM) and covariance-based SEM (CB-SEM) are the two main methods [196]. SEM analysis consists of the measurement model and the structural model. The measurement model is used to study the relationships between the constructs (latent variables) and their indicators (observed variables) whereas the structural model enables the analysis of interrelationships between the constructs [197]. In measurement model, we assess the convergent and discriminant validity. The degree of agreement between two or more manifest variables used in the model to define a construct is called convergent validity [198]. Discriminant validity refers to the extent to which a construct is distinct and differs significantly from other constructs [199]. Collinearity means that two or more indicators in a model are highly correlated triggering type II errors (i.e., false negatives) [200]. Xiong et al. [193] used chi-square/df (degrees of freedom), goodness-of-fit index (GFI), standardized root-mean squared residual (SRMR) and normed fit index (NFI) to assess the model fit in their study. A crucial aspect of evaluating

PLS-SEM is assessing the $R^2$ value for endogenous variables [201]. $R^2$ represents the variance in the endogenous variables that can be attributed to the exogenous variables attached to them [202, 203]. $f^2$ is used to ascertain the impact of the removed exogeneous construct on the endogenous constructs [204]. Predictive validity assessment is an essential part of any structural model [205]. Al-Khatib and Ramayah [206] assessed the out-of-sample prediction of their model with the PLSpredict algorithm (cross-validation procedure) using Q2, RMSE and MAE.

As the industry grapples with increasingly complex and interconnected challenges, SEM emerges as a valuable analytical tool, empowering researchers, and practitioners alike to unravel the nuanced dynamics that underlie the successful execution of construction endeavors. The application of SEM in construction industry has grown over the years [207]. Chinda and Mohamed [208] conducted research on construction safety culture using SEM, they developed and empirically test the model. A significant contribution of the model is that it unfolds the association between the safety culture goals (what the organization aims to achieve) and safety culture enablers and the relationship between those enablers (what the organization is doing) with regards to the Thailand's construction sector.

Al-Zwainy & Al-Marsomi [209] used SEM to model the priority of CSFs of program management under four categories (program planning, strategy of the organization, stakeholders, and construction program performance) associated with regional development programs RDPs in Iraqi provinces. Olanrewaju et al. [210] used SEM to model the relationship between barriers to Building Information Modelling (BIM) implementation, its awareness and usage throughout the building project lifecycle. The results of the model indicated that the most critical barriers to BIM implementation are processes and economics, technology and business, training and people and cost and standards which should be avoided. Moreover, the predictions made by the model disclosed that removing BIM barriers has a limited effect on achieving sufficient knowledge throughout project lifecycle of the building.

Hauashdh et al. [211] utilized SEM to construct a hypothetical structural model for assessing the factors influencing the success of building maintenance. The model incorporates 34 attributes distributed among six confirmatory factors which include, financial, technical, human resource, building user, organizational and building maintenance success (BMS). The data collected through a case study in the Indonesian construction sector was used, the results of the model analyzed the influence of the above mentioned variables on BMS. With a thorough grasp of the importance of the variables in achieving building maintenance success, such findings could aid in refining maintenance organization procedures to improve current building maintenance practices for successful implementation.

Kineber et al. [212] employed SEM to construct project success model (OPM) by exploring the effects of mediation of implementing value management (VM) between VM critical success factors (CSFs) and OPM with the effects of moderation of VM CSFs between VM application and OPM. The study modeled the relationship between VM application, CSFs and OPS employing partial least square structural equation modeling (PLS-SEM). The results indicated a significant indirect positive correlation between the variables. The predictive analysis of the model also revealed a significant effect of 61% on OPM when incorporating implementation of VM as mediator variable and 63% while considering VM CSFs as moderation variable.

Kineber et al. [213] used SEM to develop a model for supporting the decision enhancing application of cloud computing through evaluation of the relationship among construction activities and drivers of cloud computing in Nigerian infrastructure development sector. The model revealed that there exists a significant relationship between the application of cloud computing drivers and construction activities. A weak relationship was also revealed through the findings of the research among construction activities and implementation of cloud computing, with a 7.9% effect. Moreover, the findings suggest that user contentment is the primary variable impacting cloud computing implementation, proceeded by client consent, industry-related and organizational variables.

Almakayeel et al. [214] employed SEM to model the barriers that impede the implementation of sustainable construction projects in Iraq. The findings suggest that sustainable construction practices can also help improve quality of life. Rosli et al. [213] modeled the influence of acceptability and suitability of lean principles in the domain of waste management on performance of construction related projects using SEM in Malaysian construction industry. Results show that three variables in lean principles, namely operation in the flow of waste management, employee involvement in the flow of waste management, and continuous flow of waste management, support construction project performance. Ali et al. [215] used SEM to establish a model for modular construction (MC) adoption in developing nations by examining the link between critical success factors (CSFs) and overall sustainable success (OSS) for residential projects. The findings revealed that the seven CSFs have a substantial impact on the OSS of residential projects, influencing it by 27.4%. Kineber et al. [216] using SEM examined the association among value management (VM) application and (VM) application impediments in Egypt's construction industry. The results of the suggested model revealed that surmounting the VM impediments significantly influences VM implementation success.

Le and Sutrisna [217] developed a project cost control system (PCCS) for projects related to construction for assessing its present level of maturity in cost control, measuring the relationship among components within PCCS processes and identifying areas requiring improvement using SEM. It was confirmed through the PLS-SEM based data analysis that all latent variables have significant and positive relationships among each other. The proposed system suggested that communication, skills and experience, systematic cost analysis reports, top management's support, and defining roles and responsibilities must be the top preference for enhancing the PCCS in a much befitting way.

Kineber et al. [218] studied the impact of overcoming BIM implementation barriers on sustainable building project success using SEM. The results showed that BIM adoption attributed 41% towards long-term sustainability of the project, which demonstrated a strong relationship. Attia et al. [204] used SEM to examine the effect of sustainable construction supply chains (SCSC) on overall sustainable success (OSS) during the entire life of the project in less developed economies. Study findings revealed that adoption of SCSC has a major impact ranging from medium to high on OSS during the execution of the project. The analysis results revealed significant findings which will assist the policymakers in developing economies, as the results highlighted the significance of overcoming impediments to SCSC adoption and further enhancing these drivers to ensure that the project is completed successfully.

Ghafourian et al. [219] empirically investigating demolition waste management (SCDWM) and sustainable construction by analyzing the effects of variables that contribute towards sustainability of construction and demolition waste management (CDWM) on waste management hierarchy (WMH), comprising of recycle, reuse, reduce and disposal methodologies. Outcome of the analysis showed that the public environment contamination due to illegal waste dumping (minor group) and economic aspect of CDWM (major group) were highly significant variables in SCDWM in Malaysian construction industry.

Lin and Chen [220] through structural equation modeling, developed a risk analysis model that takes a different perspective and considered the occurrence probability of risk events and the extent to which these events affect a project. For achieving success in sustainable operation of the construction projects and saving resources, this proposed model can be used as a benchmark by the managers in making effective decisions about the risks involved in the projects. Rani et al. [221] employed SEM to develop the competitiveness framework of local contractors in the Malaysian construction industry towards globalization and liberalization comprising of five factors. The four factors namely, competitiveness factors, competitive awareness and drivers of competitiveness directly impacted, whereas challenges of competitiveness had an indirect impact on competitive strategy. Memon et al. [194] developed a model using SEM, to demonstrate how construction resources affect cost overrun. Analysis outcome revealed that approximately 50% increase in cost was linked with variables related to resources. The model highlighted that effective financial management can significantly improve the project's success and help in reducing the cost overrun.

Ali et al. [222] proposed a SEM based model which will improve modular construction adoption (MCA) by studying the association among critical success factors (CSFs) and their enablers, for building projects in under-developed nations to be benefitted from modular construction. The research found that the CSFs had a moderate effect on MCA that is more than 60%. The proposed model provides project stakeholders and policymakers with a framework for applying MC in developing nations. Seo et al. [223] established relationships between the individual and organizational factors that affect temporary workers' safety behaviors using SEM. The model highlighted that personal traits had a partial influence on job related stress and direct influence on safety culture. Personal traits and job related stress had a direct influence on self-perceived fatigue. Moreover, safety culture and personal traits had a direct effect on safety climate. Lastly, safety culture and personal traits did not have direct influence on safety behavior, rather the influence was indirect. Safety climate as well had a major influence.

Tripathi and Jha [224] used SEM to examine the hypothesis that success factors impact the success of an organization liked to construction and to analyze the impact of these success variables on the success of the organization. The results of the study highlighted that top management competence is the most crucial factor succeeded by performance and experience. Durdyev et al. [225] formulated a conceptual framework to study the effect of six key factors on labor productivity in the construction sector and their association to labor productivity performance. SEM was used to analyze the data collected via questionnaire survey. The outcomes of SEM analysis confirmed the significance of management team competency level and workforce quality in enhancing labor productivity. Li et al. [226] studied diffusion prediction of prefabricated construction technology under multi-factor coupling. The importance of impacting factors of prefabricated construction technology diffusion was investigated via an experimental method stemming on PLS - SEM. Results revealed that both knowledge sharing and perceived superiority have positive impact on prefabricated construction technology diffusion, and these both variables have a mediating role between organizational climate and prefabricated construction technology diffusion.

Waqar et al. [205] employed SEM to construct a model involving success factors for superhydrophobic coatings in the oil and gas construction industry of Malaysia. The significance value for all constructs was below 0.05, affirming the robust relationships between these constructs and the pivotal success of superhydrophobic coatings in the oil and gas sector. Chandra et al. [227] assessed the factors that affect construction equipment productivity using SEM. This research identified and measured the connections among different constraints on construction equipment productivity, aiming to enhance experts' and specialists' understanding of overcoming delays caused by idle time and improving overall construction equipment productivity. Eybpoosh et al. [228] employed SEM to illustrate that causal relationships exist among multiple risk factors, emphasizing the need to highlight the risk paths instead of single risk factors during the assessment of construction risks. Findings from SEM indicate that each risk path originates from a particular vulnerability factor within the project environment, with contractor-specific vulnerabilities exerting the most significant influence on project cost overruns.

Ali et al. [229] used SEM to determine the barriers and examine the relationships between overcoming modular construction adoption barriers (MCABs) and overall sustainable success (OSS). The results indicated a moderate association, with addressing the MCABs contributing 44.7% to the OSS of the residential projects. Li et al. [230] used SEM to build a comprehensive decision support methodology for bidding decision on construction projects. The results revealed that the decision to bid is a multi-stage decision-making process carried out in the following order: risk vulnerability of the country, performance capability, vulnerability to project risks, profit generation and chances of success. Zhao et al. [231] identified, classified, and assessed the impacts of the factors affecting project cost in New Zealand construction industry using SEM. The results of the analysis showed that market and industry conditions factor has the most significant effect on project cost, while regulatory regime is the second-most significant influencing factor, followed by key stakeholders' perspectives.

## 2.12 Research Gap

The implementation of the fast-track project delivery method in Pakistan's construction industry mirrors global trends. However, there is a discernible lack of understanding among clients, contractors, and consultants regarding the scientific underpinnings of the managerial aspects of fast-tracking. The literature review and interviews with industry professionals have unveiled that as of now, a significant research gap exists in the global construction industry as there is no decision-making model available that adequately addresses the needs of clients, contractors, and consultants for making informed, correct, and confident decisions regarding fast-track projects. The current state of research reveals a substantial gap in the absence of a dedicated fast-track decision-making model or framework. While countermeasures for risks are explored, there is a dearth of a structured approach that can assist clients, contractors, and consultants in making well-informed decisions tailored to the complexities of fast-track construction. The domain of fast-tracked construction in the construction industry is marked by its inherent risks and unpredictability, garnering significant attention from the research community. Existing literature predominantly delves into the risks and uncertainties faced by the clients, contractors, and consultants in fast-tracked projects, offering insights into countermeasures to mitigate adverse effects.

However, a noteworthy gap exists in the literature concerning the client, contractor and consultant's perspective on the decision-making process who are crucial stakeholders in the construction industry. Hence, there exists a compelling need to develop a decision-making model that not only facilitates contractors and consultants but also streamlines the decision-making process for clients. This study endeavors to bridge this gap by focusing on the impediments associated with fast-tracking in the Pakistan's construction sector. Additionally, this research focuses on identify and prioritize the decision-making aspects from of clients, contractors, and consultant's perspective, concerning the adaptability of the fast-track technique in the context of high-rise building construction and seeks to bridge this gap by delving into the impediments associated with fast-track implementation in Pakistan and exploring the perspectives of clients, contractors, and consultants regarding the adaptability of the fast-track approach in the local context.

The feasibility of adopting the fast-track approach for a particular project emerges as a critical consideration that significantly influences the decision-making process. However, there is currently no established framework for systematically assessing the feasibility of fast-track projects in Pakistan. Clients, guided by input from consultants and contractors, make pivotal decisions regarding the implementation of the fast-track technique. This underscores a significant gap in the existing body of knowledge. A crucial research gap exists in ensuring that the decisions made by clients, contractors and consultants are not arbitrary but informed. The absence of a dedicated decision-making model for fast-track construction projects poses a risk of clients, contractors and consultants making decisions without a comprehensive understanding of the associated risks, benefits, and implications. Addressing these research gaps holds substantial significance for the global construction industry. Fast-tracking has become integral to construction methodologies worldwide, and its successful implementation requires a comprehensive understanding and collaboration among all stakeholders.

In conclusion, the identified research gap in the fast-track project delivery approach in construction industry underscore the need for a dedicated focus on decision-making models, identification and prioritizing the decision-making aspects, and impediments in implementation of fast-track approach in Pakistan's construction industry. The proposed research aims to address these gaps through a systematic and comprehensive approach, contributing valuable insights that can transform the way high-rise fast-track projects are conceptualized and executed in the country. By considering the perspectives of clients, contractors, and consultants, the research seeks to foster a collaborative and informed decision-making process that aligns with global best practices.

## 2.13 Summary of the Chapter

This chapter provides a comprehensive literature review, starting with the construction management theory that supports the fast-track technique. It then examines the crucial role of the construction industry in economic growth, emphasizing its impact on GDP, job creation, and infrastructure development. The chapter identifies prevalent issues in the construction sector, with a focus on time-related challenges supported by statistical data. Solutions to these issues are discussed, particularly within the context of fast-tracking, moreover, focusing on technique's associated problems. Previous studies and existing frameworks on fast-tracking are reviewed, followed by an exploration of Structural Equation Modeling (SEM) and its applications in the construction industry. The chapter concludes by identifying research gaps, setting the stage for the subsequent chapters of the dissertation.

# Chapter 3

# Research Methodology

## 3.1 Background

This chapter discusses the methodology adopted for this research. Research methodology is a systematic and structured framework that guides the entire research process, from the formulation of research questions to the interpretation and presentation of results. It serves as the roadmap for researchers, providing a clear and organized approach to investigate the research gap and answer the research queries. A fundamental element of research methodology is the research design, which outlines the overall strategy, and the methods employed. Whether qualitative or quantitative, experimental or observational, the design dictates the path researcher takes in collecting and analyzing data. Sampling is another crucial component, it involves the selection of a representative subset of respondents from a larger population, ensuring that findings can be inferred to the population. Ethical considerations are paramount, necessitating the protection of respondents' rights, confidentiality, and the minimization of potential harm. The literature review establishes the theoretical foundation by identifying gaps in existing knowledge. Researchers employ various data collection methods, such as surveys, experiments, or interviews, choosing research instruments that align with their objectives and ensuring reliability and validity. Research methodology also requires meticulous planning of the timeframe and budget to ensure efficient resource utilization. As a dynamic and iterative process, research methodology allows for adjustments based on emerging insights and challenges. Ultimately, a well-constructed methodology enhances the credibility and robustness of research, contributing valuable knowledge to the exiting body of knowledge and practical realms.

## 3.2 Research Design

Research design is a systematic and structured plan that outlines the procedures, methods, and techniques for conducting a research study. It serves as the blueprint for the entire research process, guiding researchers in addressing their research hypotheses effectively. Research design has an important role in shaping the quality and reliability of study outcomes. A well-crafted research design ensures that the study is conducted with precision, rigor, and coherence, contributing to the credibility of the findings. Deciding on a research design involves careful consideration of various aspects. First and the foremost, researchers must clearly define the research problem and the purpose and also outline the specific objectives they aim to achieve. They need to review existing literature to understand the current state of knowledge and identify research gaps.

The choice of research type, whether qualitative, quantitative, or mixed methods, depends on the nature of the research questions. Defining the population and selecting an appropriate sampling strategy are crucial steps, ensuring the generalizability of the findings. Identifying the variables, selecting data collection methods, and deciding data analysis techniques require thoughtful consideration to align with the research objectives. Ethical considerations, such as participant confidentiality and informed consent, should be integrated into the design. Finally, creating a realistic timeline and allocating resources effectively contribute to the successful execution of the research design. A well-considered research design empowers researchers to conduct studies with clarity, purpose, and methodological diligence, thereby enhancing the overall quality of research. This research used the quantitative approach aided by a cross-sectional questionnaire [199]. The research design has been outlined in figure 3.1.

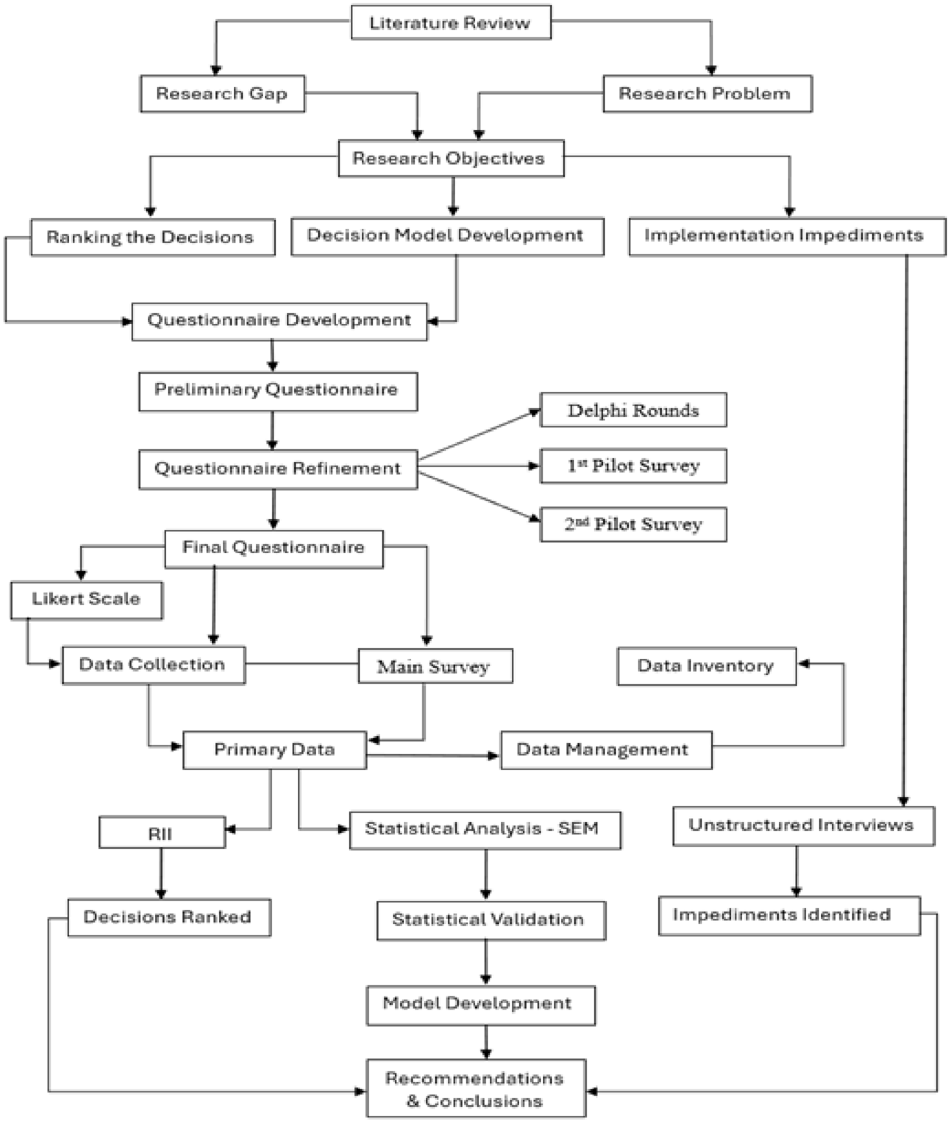



FIGURE 3.1: Flow Chart Research Methodology

## 3.3 Development of the Conceptual Model

The literature reviewed resulted in the development of a conceptual model between the decision-making aspects (indicators) on fast-track projects and the four latent constructs i.e., TV, CV, QV and SV as shown in figures below. The conceptual model consists of a network of constructs and indicators that provides a detailed understanding of how the exogenous constructs could influence the endogenous constructs. A conceptual model is a simplified representation or framework that abstracts the key elements, variables, relationships, and processes within a specific phenomenon. It serves as a theoretical blueprint, providing a structured and organized way to understand, analyze, and communicate complex phenomena. The steps involved in developing a conceptual model include defining the research problem, extensive literature review, identify key variables (latent variables and manifest variables), establish relationships, construct diagrams and define hypotheses. From the conceptual model, seven hypotheses were developed. Out of these seven, 5 have direct relationship and 2 have indirect relationship involving mediation analysis. The model in figure 3.2 shows QV and TV in a direct hypothesis relation. The model uses 26 manifest variables to study both latent variables.

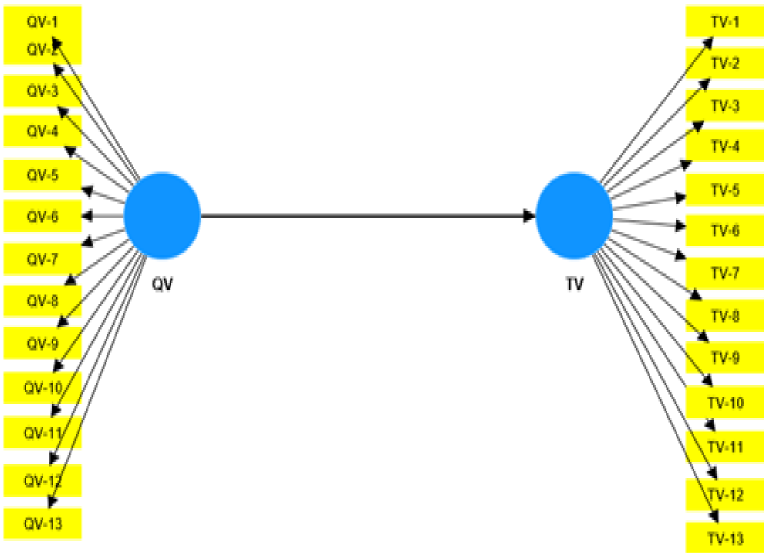



FIGURE 3.2: Model 1. QV-TV Latent Construct

The model in figure 3.3 will be used to study the direct relation between CV and TV. CV will be assessed using the 11 manifest variables whereas 13 manifest variables will explain TV.

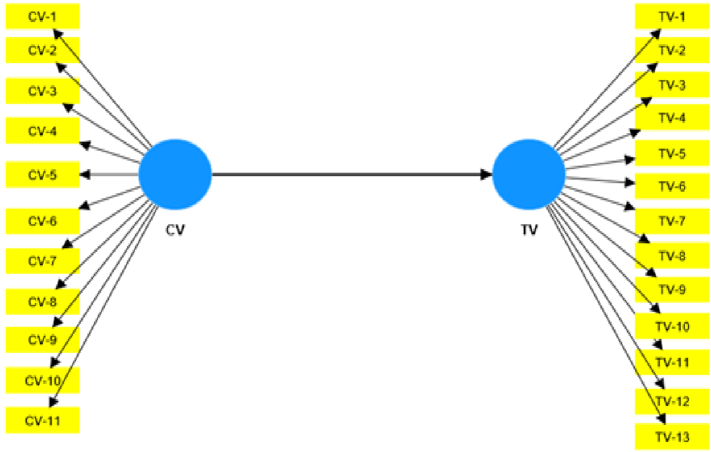



FIGURE 3.3: Model 2 CV-TV Latent Construct

Model 3 in figure 3.4 is a direct association hypothesis between SV and TV. 10 manifest variables will help in studying SV and 13 manifest variables will explain TV and its association with SV.

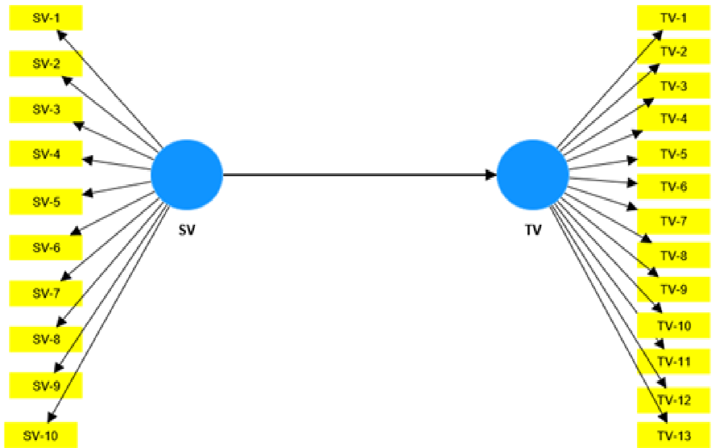



FIGURE 3.4: Model 3 SV-TV Latent Construct

Model 4 in figure 3.5 presents a direct hypothesis interaction between QV and CV. QV is studied using the 13 manifest variables and CV is explained by its relevant 11 manifest variables. The model in figure 3.6 is a direct association hypothesis among SV and CV. SV is explained by its associated manifest variables whereas 11 manifest variables are used in the model to study CV. Further SVs impact on CV is also studied. The model in figure 3.7 is a mediation analysis model in which CV acts as a mediating variable between QV and TV. All three latent variables are explained by their associated manifest variables as shown in the figure. Figure 3.8 also shows a mediation analysis model in which CV is the mediating variable

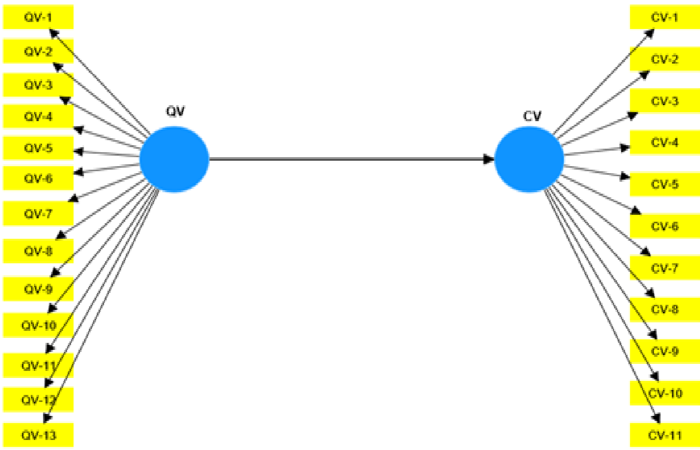



FIGURE 3.5: Model 4 QV-CV Latent Construct

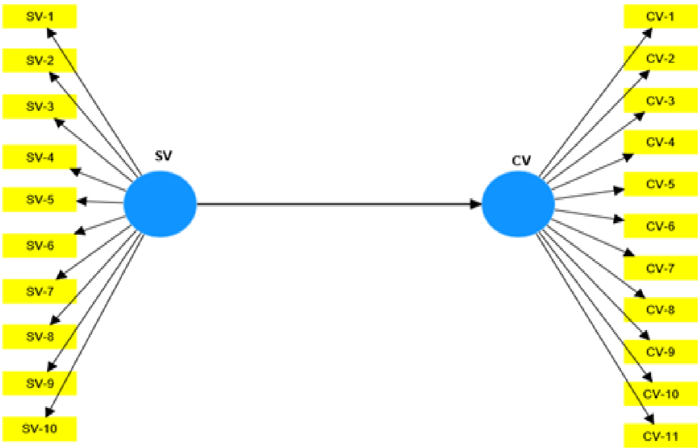



FIGURE 3.6: Model 5 SV-CV Latent Construct

between SV and TV. This model will assist in studying the impact of SV on TV through CV. The associated manifest variables as shown in the figure will help in studying the three latent variables. Figure 3.9 is a combination of all the individual model shown above. This model represents the conceptual model of this research.

## 3.4 Data Collection

The research data is either primary or secondary in nature. This research utilized primary data, which was collected from clients, contractors and consultants working in the construction sector on a 5-point Likert scale whereas secondary data is

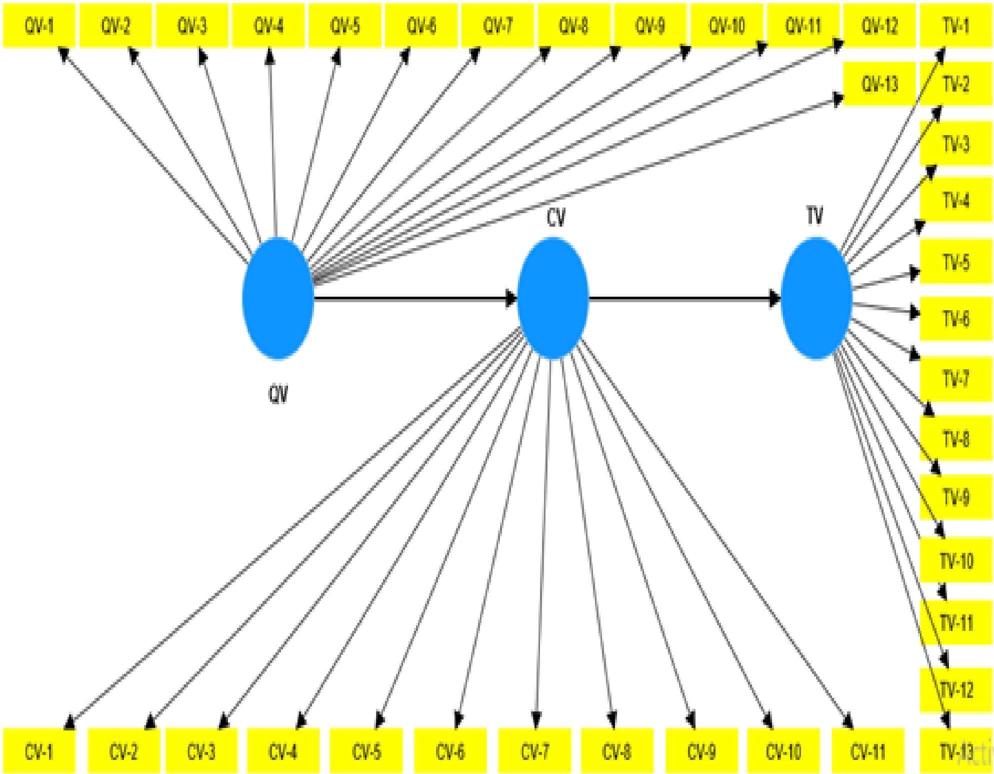



FIGURE 3.7: Model 6 QV-CV-TV Latent Construct

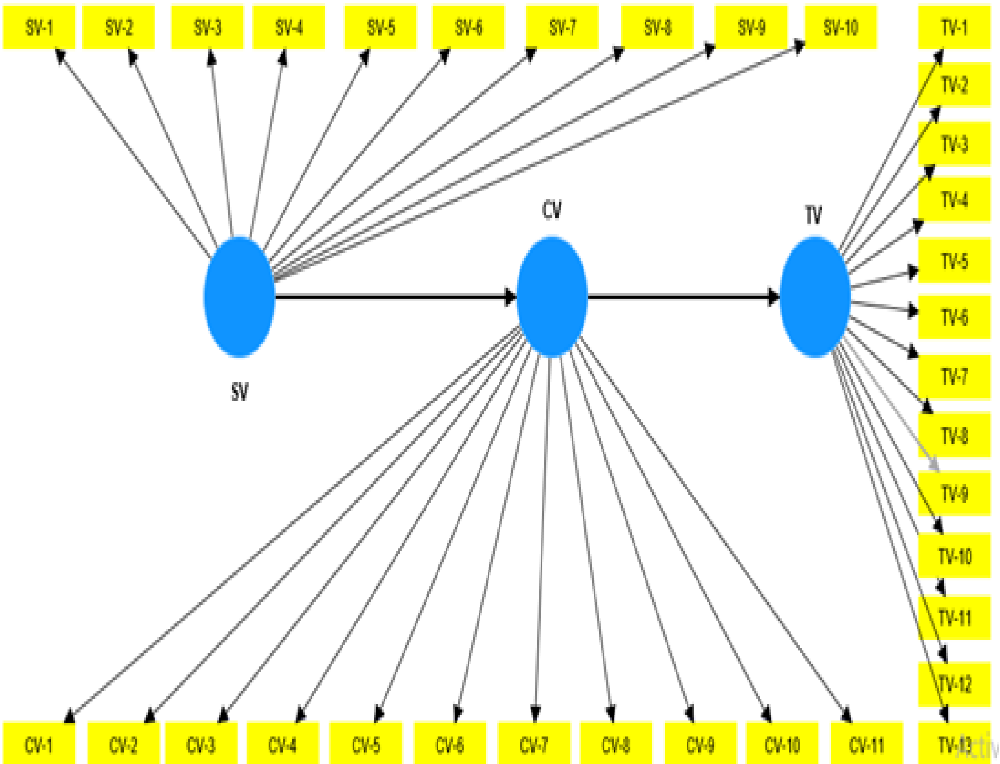



FIGURE 3.8: Model 7 SV-CV-TV Latent Construct

derived from the primary data which is collected by some other researcher.

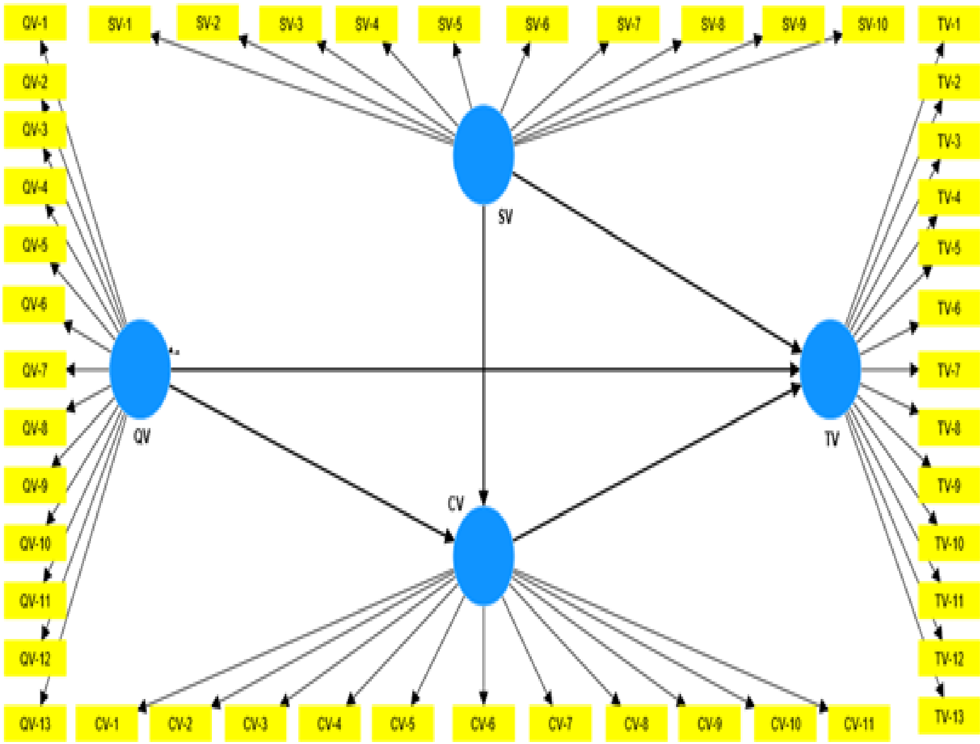



FIGURE 3.9: Combined Conceptual Model for Fast-Track High-Rise Projects

### 3.4.1 Sample Size

Sample size in research refers to the number of individuals or observations selected from a larger population to participate in a study. The selection of an appropriate sample size is a critical aspect of research design, as it directly impacts the reliability and generalizability of study findings. The most appropriate sample size depends on the research objectives, the variability of the population, and the desired level of statistical precision. A good sample size is characterized by being large enough to detect meaningful effects or differences with sufficient statistical power, yet small enough to be practical and manageable within resource constraints. It should strike a balance between precision and feasibility. In general, a larger sample size increases the likelihood of obtaining results that are representative of the population, leading to more robust and reliable conclusions. Researchers often use statistical calculations and considerations of the study's design and objectives to determine an optimal sample size that minimizes bias and enhances the validity of the study's findings.

The sample size for SEM lacks consensus among the researchers. Some researchers suggest that the sample size should be between 100 to 400 whereas studies in construction management have used smaller sample sizes (Molwus et al. [197]. Yin [232] suggested that sample size for SEM must not exceed 100. This study used Daniels Priori online calculator [233] to find the minimum sample size required against 95% confidence interval, 0.3 effect size and 80% statistical power. The minimum sample size calculated by the calculator was 137.

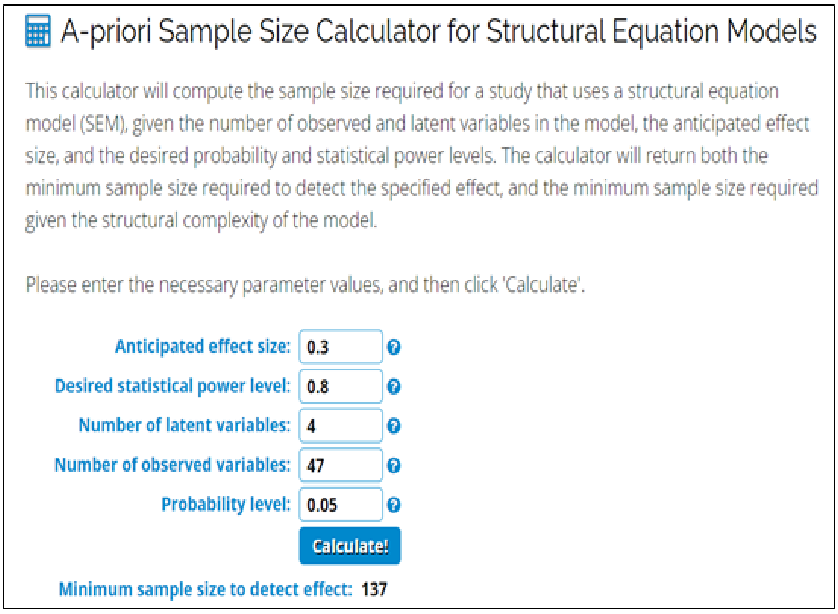



FIGURE 3.10: SEM sample size calculator

## 3.4.2 Questionnaire Development

Literature review provides a conceptual/ hypothesized basis and research gap identification for further exploration. When reviewing literature for research, the researcher should thoroughly understand the existing body of knowledge related to the research topic, identifying seminal works, theories, and gaps in existing research. The researcher should critically evaluate the credibility and reliability of the sources, considering the rigor of research methodologies, content, tools/ techniques, and the publication offices. Furthermore, recognizing the historical context and evolution of ideas in the field is crucial for providing a solid foundation for the study. Comparing and contrasting findings from different studies helps to highlight past trends, patterns, and areas that require further investigation. Additionally, the researcher should stay updated on recent publications to ensure the literature review reflects the most current state of knowledge. Finally, synthesizing the information gathered, identifying themes, and conceptualizing how the literature enlightens the researcher on the research questions are essential for framing the research study within the vast scholarly discourse.

In this regard, this research first identified the articles related to the research scope, and then filtered them thus narrowing down to the most relevant ones. Initially, an extensive literature review was conducted: more than 500 research papers from google scholar and internet sources were reviewed, out of which 245 have been included in this research. 54 decision-making aspects were initially identified from the literature.

#### 3.4.2.1 Preliminary Questionnaire

A preliminary questionnaire is a survey instrument designed to collect initial information from respondents in the early stages of a research. This tool serves as an essential component of the research planning phase, aiming to gather baseline data and insights that can assist in the development of subsequent research instruments. The preliminary questionnaire is needed to achieve several key objectives. Firstly, it helps researchers identify and refine the key variables and factors relevant to the research. By posing a set of initial questions, researchers can gauge the respondents' perspectives, experiences, and attitudes related to the research topic, providing valuable insights into the research topic. Secondly, a preliminary questionnaire aids in the design and construction of more comprehensive and focused questionnaire for data collection during final survey. It allows researchers to identify any ambiguities or potential issues in the survey questions, ensuring clarity and relevance in the final data collection tool also known as the research instrument. Additionally, the preliminary questionnaire helps the researchers identify suitable participants for the study based on the responses to the initial set of questions. Preliminary questionnaire lays the groundwork for the entire research process by guiding the formulation of research questions, hypotheses, and survey instruments. Through the early collection of data, researchers can refine their approach, ensuring that the subsequent phases of the study are grounded in a clear understanding of the target population. The preliminary questionnaire acts as a diagnostic tool, enabling researchers to identify any unforeseen biases that may arise during the data collection process. Ultimately, the insights gained from the preliminary questionnaire enhance the overall quality and validity of the research by contributing to the development of a valid and a reliable final questionnaire. Basing on a comprehensive review of the existing literature, a preliminary questionnaire was designed which contained 54 decision-making aspects also known as indicators in the SEM model and four latent variables i.e., Time Variance (TV), Cost Variance (CV), Quality Variance (QV) and Scope variance (SV).

#### 3.4.2.2 Delphi Technique

Delphi technique is a qualitative research method that seeks to obtain a consensus opinion from a group of experts through a series of carefully designed questions and controlled feedback. The process typically involves multiple rounds of surveys where experts anonymously provide their opinions on a particular issue or problem. After each round, the results are aggregated and presented to the participants, allowing them to adjust their opinions in light of the group's feedback. This iterative process continues until a consensus is reached or until the researchers achieve a predetermined level of stability in the responses. Keeney et al. [234] reported that the Delphi technique is a research method that uses anonymous opinions and feedback from a group of experts to achieve consensus on a topic. The importance of the Delphi Technique in research lies in its ability to harness the collective knowledge and expertise of a diverse group of individuals, especially when faced with complex or uncertain issues. By maintaining anonymity, this method minimizes the influence of dominant personalities and allows participants to express their views freely. This is particularly valuable in fields where consensus is crucial, such as policy planning and decision-making. The Delphi technique is especially useful when dealing with topics where there is a lack of empirical evidence, as it provides a systematic way to explore and integrate expert opinions. Delphi technique offers a structured approach to handling ambiguity and uncertainty, enabling the synthesis of expert insights into a coherent and informed consensus. Overall, the Delphi technique serves as a powerful tool for tapping into the collective wisdom of experts, facilitating informed decision-making and strategic planning in the face of complexity and uncertainty in research. In this research, four rounds of Delphi technique were conducted, 10 anonymous respondents were asked to furnish their expert opinion on the preliminary questionnaire. The preliminary questionnaire was refined basing on the expert opinion of the respondents and in the fourth round, the respondents reached consensus on the structure and contents of the preliminary questionnaire. The number of decision-making aspects were reduced to 50, four decision-making aspects were removed from the questionnaire based on the opinion of the experts. The preliminary questionnaire was ready for the pilot survey. Table 3.1 shows the qualifications and experience of the experts and figure 3.11 explains the delphi process adopted in this research

#### 3.4.2.3 Pilot Survey

A pilot survey is a small-scale, preliminary study conducted before the main research to test and refine the research instruments, procedures, and methodologies. Its primary purpose is to identify and address potential issues that may arise during the full-scale data collection phase. During a pilot survey, researchers typically administer the research instruments, such as questionnaires or interviews, to a small sample of participants who share similarities with the target population. The goal is to assess the validity, clarity, effectiveness, and appropriateness

Table 3.1: Frequency Analysis of Delphi Experts with Experience in Fast-tracking

| **Respondents** | **Qualification** | **Experience** |
|---|---|---|
| Project Manager | BE (Civ) | 16 Yrs |
| Project Manager | MS (PM) | 13 Yrs |
| Construction Manager | BE (Civ) | 27 Yrs |
| Structural Engineer | MS (Structures) | 19 Yrs |
| Construction Manager | MS (CE&M) | 16 Yrs |
| Project Manager | MS (PM) | 14 Yrs |
| Architect | MS (Architecture) | 15 Yrs |
| Project Planner | BE (Civ) | 25 yrs |
| Construction Manager | MS (CE&M) | 18 Yrs |
| Structural Engineer | MS (PM) | 19 Yrs |

of the survey tools and to identify any problems. The data collected during the pilot survey are not included in the final analysis but are instead used to make necessary adjustments to the research instrument, ensuring that the main study is well-designed and capable of yielding reliable and valid results. Pilot survey serves as a critical step in the research process, offering researchers the opportunity to refine their methodologies and address any unforeseen issues prior to the main survey. By identifying and resolving potential problems early on, a pilot survey enhances the reliability and validity of the research findings. Moreover, it helps researchers refine their data collection instruments, ensuring that questions are clear, unbiased, and relevant to the research objectives. The pilot survey also allows researchers to assess the feasibility of their data collection procedures, from potential respondent identification to data analysis, and to make any necessary adjustments. In summary, a pilot survey is an valuable tool that contributes to the overall quality of the research by minimizing errors, enhancing the research design, and ultimately increasing the credibility of the researchs findings. In this research two pilot surveys were conducted. During the pilot surveys, following aspects were considered:

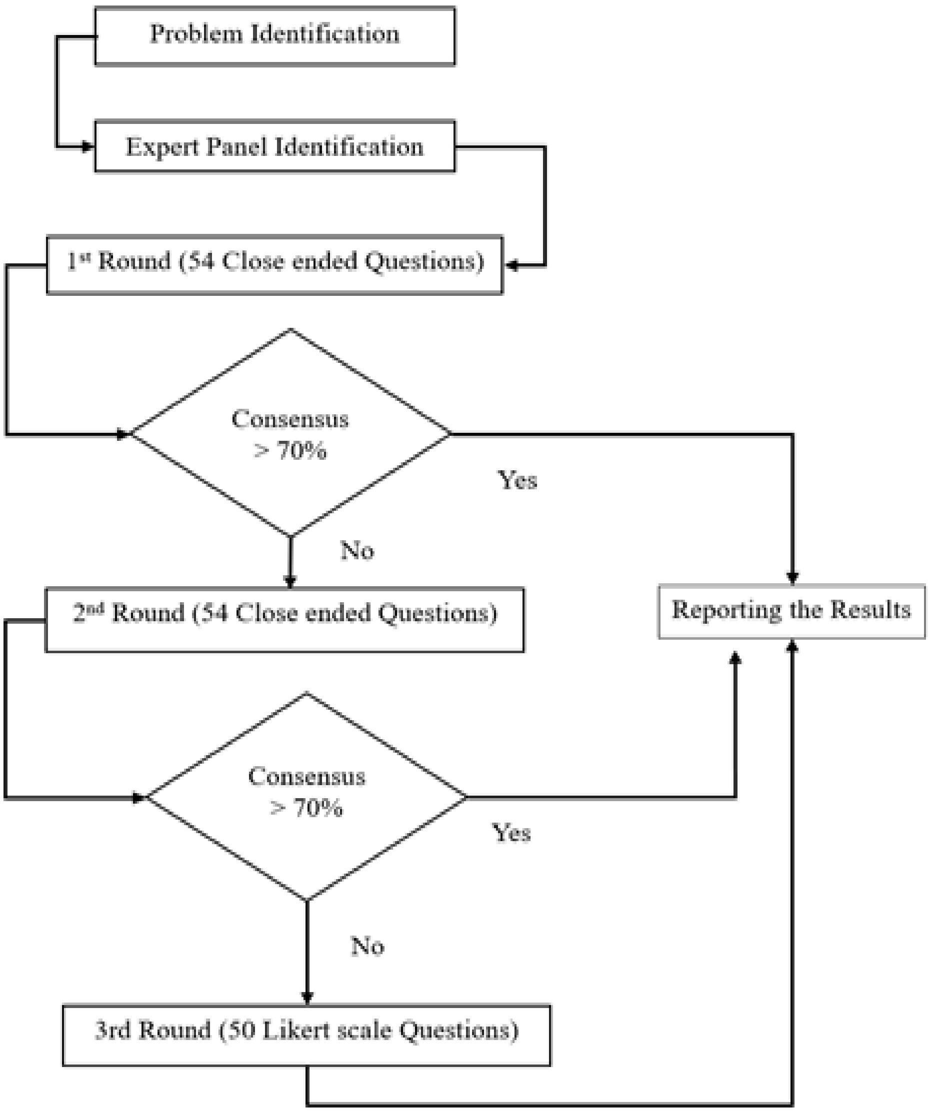



FIGURE 3.11: Delphi Process

a. The professionals should have adequate experience on projects related to the study.

b. It was preferred that the experts were currently executing a relevant project.

c. The expert panel should be a blend of various industry stakeholders i.e., clients, contractors, and consultants.

d. The experts should have adequate qualification related to the field of this study.

e. Face to face interviews/ discussions were a key aspect.

On the basis of the above key considerations, the input received from the experts should be adequate in number to earmark the deficiencies and improvements needed for refinement of the questionnaire.

#### 3.4.2.4 Final Questionnaire

The final questionnaire is a refined and definitive version of a survey instrument used in research. It represents the culmination of the questionnaire development process, incorporating feedback from pilot surveys, expert reviews, and any necessary revisions. The final questionnaire serves as the tool for collecting data from study participants and is carefully crafted to ensure clarity, relevance, and reliability of the information gathered. Its importance in research cannot be overstated as it directly influences the quality of data collected and the validity of study outcomes. A well-constructed final questionnaire helps researchers achieve their specific objectives by eliciting accurate and meaningful responses from participants. It also ensures consistency in data collection across different respondents, facilitating reliable comparisons and analyses. The clarity of questions, appropriate response options, and the overall structure of the questionnaire contribute to minimizing bias and enhancing the overall rigor of the research study. The final questionnaire is a key element in the empirical research process, playing a pivotal role in generating reliable data for analysis and interpretation.

The final questionnaire was refined on the basis of the two pilot surveys which was used further for the data collection process. This final questionnaire has removed the anomalies as highlighted by the experts. The final questionnaire consists of three parts i.e., part-I relates to the demographic information of the respondents, part-II pertains to respondents general familiarization with fast-track technique and part-III contains a 5-point Likert scale based data collection procedure. Each of the 47 identified decision-making aspects identified through literature review and validated through the pilot surveys were separately assigned to a specific latent variable either to time variance, cost variance, quality variance or scope variance.

#### 3.4.2.5 Coding Scheme

A coding scheme is required for feeding the latent and the manifest variables to the SEM software. Table 3.2 shows the coding used for representing the latent and the manifest variables.

TABLE 3.2: Coding Scheme for Latent and Manifest variables

| **Latent Variable** | **Decision-making Aspects (Indicators)** | **Code** |
|---|---|---|
| **Cost Variance (CV)** | Decision on Owners financial capacity (Ensuring no resource constraint) | **CV-1** |
| | Early Procurement of Long-Lead-Time Items | **CV-2** |
| | Adopt an appropriate contractual strategy | **CV-3** |
| | Limit the cost impact due to fast-track to 120% compared to traditional construction | **CV-4** |
| | Use prototyping (Scaled-down models of complex buildings) | **CV-5** |
| | Organizational restructuring (Experienced Team) | **CV-6** |
| | Over-designing the facility | **CV-7** |

| Latent Variable | Decision-making Aspects (Indicators) | Code |
| --- | --- | --- |
| | Implement an effective Resource Management Plan | **CV-8** |
| | Sufficient contingency allocations | **CV-9** |
| | Implement an effective Risk Management Plan | **CV-10** |
| | Conduct Cost/Benefit analysis (Financial Feasibility) | **CV-11** |
| **Quality Variance (QV)** | Adopt BIM based Fast-track Approach | **QV-1** |
| | Delegate Authority to Project Level | **QV-2** |
| | Retain Design and Interface Management Responsibilities | **QV-3** |
| | Decide the acceptable quality compromise extent on fast-track project preferably not less than 90% | **QV-4** |
| | Limiting the design optimization process | **QV-5** |
| | Implement Value Engineering | **QV-6** |
| | Implement Lean Construction | **QV-7** |
| | Decide between the potential time savings due to overlapping and the amount of expected reworks | **QV-8** |

| **Latent Variable** | **Decision-making Aspects (Indicators)** | **Code** |
|---|---|---|
| | Quality Management Plan submission in pre-design stage | **QV-9** |
| | Early engagement of O&M team in the design process | **QV-10** |
| | Implement Front-End-Engineering Design (FEED) | **QV-11** |
| | Conduct constructability review during planning or design phase | **QV-12** |
| | Adopt contractor pre-qualification Strategy | **QV-13** |
| **Time Variance (TV)** | Early contract award for enabling works | **TV-1** |
| | Adopt Pre-fabrication/ Modularization | **TV-2** |
| | Adopting Fast-track on complex buildings | **TV-3** |
| | Apply Fast-track to Critical Path rather than non-critical | **TV-4** |
| | Project stage at which the decision to fast-track is made | **TV-5** |
| | Adapting an effective dispute resolution technique | **TV-6** |

| **Latent Variable** | **Decision-making Aspects (Indicators)** | **Code** |
|---|---|---|
| | Securing Early Permits/ Approvals | **TV-7** |
| | Adopt Relational Approaches | **TV-8** |
| | Impose penalties for delays | **TV-9** |
| | Decide the optimal degree of overlap between activities | **TV-10** |
| | Compliance with site safety regulations | **TV-11** |
| | Selecting the most suited project delivery method (DB, CM, EPC) | **TV-12** |
| | Announce incentives for early completion | **TV-13** |
| **Scope Variance (SV)** | Implement an effective Change Management Plan | **SV-1** |
| | Client Authorizing Extras | **SV-2** |
| | Early scope definition at conceptual or design stage | **SV-3** |
| | Apply fast-track to commercial building (which are time critical & High profit) rather than residential | **SV-4** |
| | Implement effective communication mechanism | **SV-5** |

| Latent Variable | Decision-making Aspects (Indicators) | Code |
|---|---|---|
| | Implement Interface Management Plan | **SV-6** |
| | Implement an effective Scope Management Plan | **SV-7** |
| | Implement Front-End-Planning (FEP) | **SV-8** |
| | Early involvement of the contractor in design phase | **SV-9** |
| | Adopt scope freeze approach at early design stage | **SV-10** |

#### 3.4.2.6 Main Survey

A main survey, also known as a full-scale survey, is a comprehensive research method used to collect data from a large and representative sample of a population. This type of survey involves the administration of a structured questionnaire or set of questions to a diverse group of respondents, aiming to gather detailed information on the variables of interest. The importance of a main survey in research lies in its ability to provide a comprehensive and accurate understanding of a population's characteristics, attitudes, behaviors, or opinions. By employing rigorous sampling techniques and standardized data collection methods, main surveys ensure that findings can be generalized to the broader population, enhancing the external validity of the research. This method allows researchers to draw robust conclusions, identify trends, and make informed decisions based on a thorough analysis of the collected data. Additionally, main surveys are valuable for exploring the relationships between variables, testing hypotheses, and allowing evidence-based informed decision-making. Overall, main surveys are a cornerstone of empirical research, providing a structured and systematic approach to gather meaningful insights from a diverse and representative sample. The final questionnaire was distributed amongst the respondents for full scale survey. Respondents for the full scale survey were selected through random sampling, to be true representative of the target population. The final questionnaire was self-administered to 217 construction industry professionals in Lahore, Karachi, Islamabad, and Rawalpindi (being the hub of high-rise construction in Pakistan). Moreover, one-to-one meetings with project directors in Islamabad and Lahore were also conducted. 176 questionnaires were received, indicating a response rate of 81.1%. Keeping in view the respondents familiarity with fast-track concept (identified in part 2 of the questionnaire), only 159 questionnaires were made part of this research.

## 3.5 Descriptive Analysis Method

Descriptive analysis in research refers to the process of summarizing and interpreting data to provide a clear and concise overview of the phenomena being studied. It involves employing statistical techniques and tools to describe the basic features of the data in a study, offering insights into patterns, trends, and relationships without making inferences or predictions beyond the data at hand. Descriptive analysis is the foundational step in data analysis that helps researchers and analysts to grasp the essence of their data, making it easier to communicate findings and support decision-making processes. This research used graphs to represent the distribution of the respondents in the construction industry basing on their qualification, experience, designation and role in the construction industry.

## 3.6 Statistical Analysis Method

Statistical analysis is a methodological approach used in research to analyze and interpret data, providing meaningful insights and drawing conclusions from the information gathered. It involves the use of various statistical techniques to identify patterns, trends, and relationships within datasets. The primary goal of statistical analysis is to make inferences about a population based on a sample of data, allowing researchers to draw generalizations and assess the reliability of their findings. In research, statistical analysis plays a crucial role in quantifying the uncertainty associated with data, testing hypotheses, and making informed decisions. It helps researchers to accept or reject the hypotheses, assess the significance of observed effects, and ensure that the conclusions drawn are not merely due to chance. Ultimately, statistical analysis enhances the rigor and objectivity of research, providing a systematic framework for making sense of complex data and contributing to the robustness of scientific knowledge. In this research, the conclusions were drawn using statistical analysis, facilitating decision-making and future predictions based on past trends.

### 3.6.1 Relative Importance Index (RII)

The Relative Importance Index (RII) is a statistical tool employed by researchers to assess and prioritize the significance of different factors or variables within a study. This index plays a crucial role in various fields, including social sciences, marketing, and business, where understanding the relative impact of multiple factors is essential for decision-making. The calculation of RII involves surveying the participants and asking them to rate the importance of various factors on a numerical scale. RII is calculated using the following equation 3.1:

$$\text{RII} = \frac{\sum w \cdot x}{N \cdot A} \tag{3.1}$$

where,

w = weight assigned by each respondent to a particular decision-making aspect

x = Number of respondents assigning a particular weight to a decision-making aspect

N = Total Number of respondents

A = Highest possible score that can be assigned to a decision-making aspect

Researchers turn to RII for several reasons, with one of its primary purposes being the prioritization of factors. By utilizing RII, researchers can identify and focus on the most influential aspects among a set of variables, enabling them to make informed decisions. This prioritization is particularly valuable when faced with limited resources, as it guides researchers in directing their efforts where they are likely to have the most significant impact. Researchers leverage this index to compare the relative importance of different factors within a study, offering insights into the factors that contribute most significantly to the observed outcomes. This comparative aspect allows for a detailed knowledge of the research dynamics, aiding in refining of theories and the development of more targeted strategies. The ability to quantify and compare the relative importance of factors provides a valuable framework for decision-makers seeking to navigate complex scenarios.

One of the primary benefits of RII is its role in decision-making processes. As a tool that highlights the relative significance of various factors, RII assists decision-makers in focusing on critical aspects that drive specific outcomes. Whether formulating policies, designing marketing strategies, or allocating resources, decision-makers can leverage RII to optimize their efforts. The efficiency in resource allocation is a tangible advantage of using RII, as it guides decision-makers toward areas where their interventions are likely to yield the most substantial returns. By providing a numerical measure of the relative importance of factors, RII offers a standardized way to interpret and communicate research findings. This quantification not only enhances the clarity of communication but also facilitates comparisons across different studies or contexts. Researchers and decision-makers alike benefit from this standardized approach, as it streamlines the interpretation of results and supports evidence-based decision-making.

Despite these advantages, researchers must exercise caution when utilizing RII. The method heavily relies on participant perceptions and subjective judgments, which may introduce biases. The choice of variables, scales, and weights can significantly impact the results, necessitating careful consideration during the study design phase. Additionally, the context of the research should be taken into account when interpreting RII findings to ensure the relevance and applicability of the results. In conclusion, the Relative Importance Index serves as a valuable tool for researchers and decision-makers, offering a systematic and a quantitative approach to assess and prioritize factors within a study, ultimately contributing to more informed and effective decision-making processes.

### 3.6.2 Structural Equation Modeling (SEM)

This study used smart PLS4 SEM software for statistical analysis (figure. 3.12). PLS-SEM was preferred over CB-SEM as PLS-SEM performs better for predicting purposes [235]. PLS-SEM does not require large sample size as required in CB-SEM [236]. When hypotheses are to be tested with comparatively small sample size, the PLS-SEM is preferred [237]. The SEM analysis is governed by the following set of equations:

#### a. Equations governing CFA

For each latent variable (factor) $\eta_j$ with observed indicators $y_i$:

$$y_i = \lambda_{ij}\eta_j + \epsilon_i \tag{3.2}$$

where:

$y_i$ is the $i$-th observed indicator.

$\lambda_{ij}$ is the factor loading of $y_i$ on $\eta_j$.

$\eta_j$ is the latent variable.

$\epsilon_i$ is the measurement error term for $y_i$.

Similarly, for latent variables $\xi_j$ with observed indicators $x_i$:

$$x_i = \lambda_{ij}\xi_j + \delta_i \tag{3.3}$$

where:

$x_i$ is the i-th observed indicator.

$\lambda_{ij}$ is the factor loading of $x_i$ on $\eta_j$

$\eta_j$ is the latent variable. $\delta_i$ is the measurement error term for $x_i$

**b. Equation governing Path Analysis**

For endogenous latent variables $\eta$:

$$\eta = B\eta + \Gamma\xi + \zeta \tag{3.4}$$

where:

$\eta$ is a vector of endogenous latent variables.

$B$ is a matrix of coefficients relating endogenous latent variables to each other.

$\Gamma$ is a matrix of coefficients relating exogenous latent variables $\xi$ to endogenous latent variables $\eta$.

$\xi$ is a vector of exogenous latent variables.

$\zeta$ is a vector of disturbance terms (errors in the equations for $\eta$).

**c. Combined Measurement and Structural Models**

The overall SEM model can be represented by combining the measurement and structural models:

$$y = \Lambda_y \eta + \epsilon \tag{3.5}$$

$$x = \Lambda_x \xi + \delta \tag{3.6}$$

where:

$y$ is a vector of observed endogenous variables.

$\Lambda_y$ is a matrix of factor loadings for $y$.

$\epsilon$ is a vector of measurement errors for $y$.

$x$ is a vector of observed exogenous variables.

$\Lambda_x$ is a matrix of factor loadings for $x$.

$\delta$ is a vector of measurement errors for $x$.

#### 3.6.2.1 Confirmatory Factor Analysis (CFA)

CFA is used to assess the measurement model which this research assessed the internal consistency of the indicators and reliability of the scale using Cronbachs Alpha and composite reliability, for which the values should be $\geq 0.7$ and convergent validity was assessed using average variance extracted (AVE) for which the AVE values should be $\geq 0.5$ [192]. To establish the discriminant validity, Heterotrait-Monotrait ratio (HTMT) and Fornell and Larcker Criterion were used [205]. The HTMT value should be $< 0.85$ and Fornell & Larcker criterion requires that the square root of the average variance extracted by a construct must be greater with itself than any other construct. Moreover, indicators with outer loading $< 0.7$ were eliminated from the model [238]. Before conducting the path analysis, variance inflation factor (VIF) was used to rule-out multi-collinearity, the VIF values should be $< 3.5$ [205]. After assessing the internal consistency and validity, the model fit was assessed [192]. To establish model fit, the ideal square root mean residual (SRMR) cut-off is 0.08 [239], normal fit index (NFI) value should be $\geq 0.8$ [240], Chi-square/df should be $\leq 3$ [192] and Goodness of fit index (GFI) $\geq 0.1$ is considered small, $\geq 0.25$ is moderate, while $\geq 0.36$ is good [241]. Degrees of freedom (df) and GFI for this model were calculated using equation 3.7 [193] and equation 3.8 [240] respectively, where p represents number of manifest variables and q represents number of latent variables in equation 3.7.

$$\text{df} = \frac{p(p+1)}{2} - q \tag{3.7}$$

$$\text{GFI} = \sqrt{\text{Avg.AVE} \cdot R^2} \tag{3.8}$$

#### 3.6.2.2 Explanatory Power of the Model

The explanatory power of the model was assessed using $R^2$ (Coefficient of Determination) and $f^2$ [204, 219]. The values of $f^2 \geq 0.02$, $\geq 0.15$, and $\geq 0.35$ indicate small, medium, and enormous impact of the exogenous constructs on the endogenous construct [242].

#### 3.6.2.3 Path Analysis (Structural Model)

Path Analysis was used to assess the structural model. The structural model consists of the interaction among the latent constructs. In path analysis, a bootstrapping procedure was used to conduct hypothesis testing, which provided the p-values and path coefficients ($\beta$) required for testing the hypothesis. $\beta < 0$ indicates a direct and positive relationship, whereas $\beta > 0$ indicates a direct and adverse relationship, and zero indicates that there is no relationship between the variables [204]. Moreover, a $\beta$-value between 0.1 and 0.3 shows weak impact, between 0.3 and 0.5 moderate impact, and 0.5 to 1.0 strong influence [242], while the p-value for a 95% confidence level should be $< 0.05$.

#### 3.6.2.4 Predictability of the Model

The out-of-sample predictability of the model was assessed with the PLSpredict algorithm (cross-validation procedure) using $Q^2$, RMSE and MAE [206]. The key criterion for assessing the predictive relevance of the model is $Q^2 > 0$ [243]. Cross-validated predictive ability test (CVPAT) is an alternative to PLSpredict for prediction-oriented assessment of PLS-SEM model. CVPAT uses indicator average (IA) and liner model (LM) as a benchmark for comparing the average loss values of PLS-SEM. The difference of average loss values should be significantly less than zero to substantiate better predictive capabilities of the model and p-value $< 0.05$ to support the hypothesis that predictive ability of PLS-SEM is better than IA and LM.

#### 3.6.2.5 Important Performance Map Analysis

IPMA was initially developed by Martilla and James in 1977. It provides understanding about the indicators that should be given priority in order to obtain superior levels of a target construct. IPMA output has two axes, for which a cutoff score is specified to divide each axis in a high and a low segment hence splitting the matrix in 4 quadrants. Drivers in the first quadrant (Keep up the good work) are characterized by high performance and importance level. These indicators show opportunities for achieving a superior quality of the target construct. The indicators in the second quadrant termed as Concentrate here are main elements for enhancement and improvement, as the respondent consider these indicators as significant, while the perceived level of performance leaves things to be desired. The next two quadrants of the matrix have low importance level. Therefore, if we assume equal investment, these indicators are expected to provide the lowest ROI. The third quadrant consists of low importance with low performance. Indicators in third quadrant do not require additional effort or extra attention. Lastly, the fourth quadrant (Possible overkill) signifies indicators for which the respondents do not consider them important but perceive a high performance. Also, third quadrant indicators do not signify feasible alternatives for improving the performance of the target construct. Therefore, to avoid the chance of possible overkill, it is better to employ the resources somewhere else rather than committing to these indicators. From a practical point of view, IPMA contributes to more rigorous management decision-making [244]. Importance-performance map analysis (IPMA) combines PLS-SEM estimates, indicating the importance of an exogenous constructs influence on another endogenous construct of interest, with an additional dimension comprising the exogenous constructs performance in a two-dimensional map. Importance Performance Map Analysis (IPMA) was used to rank and assess the performance of each indicator and each construct (SV, CV, and QV) on the target variable (TV). IPMA broadens the finds of PLS-SEM by evaluating the performance of the exogeneous latent variables and indicators on the target latent variable. The twofold assessment of importance and performance in IPMA is critical for decision making [204].

## 3.7 Summary of the Chapter

This chapter focuses on the research methodology, encompassing the development of the conceptual model, research design, and data collection procedures. This chapter details the steps taken to construct a robust conceptual framework that underpins the study's hypotheses and objectives. The research design is meticulously outlined, highlighting the techniques and approaches employed to ensure the validity and reliability of the data. The data collection methods are described, including the development and administration of the questionnaire, designed to gather pertinent information from the study's target population. Relative Importance Index (RII) and Structural Equation Modeling (SEM) techniques also explain descriptive and statistical analyses. These analyses will provide insights into the data, enabling the examination of relationships among variables and the testing of the proposed hypotheses, thus contributing to the overall findings, recommendations and conclusions of the research.

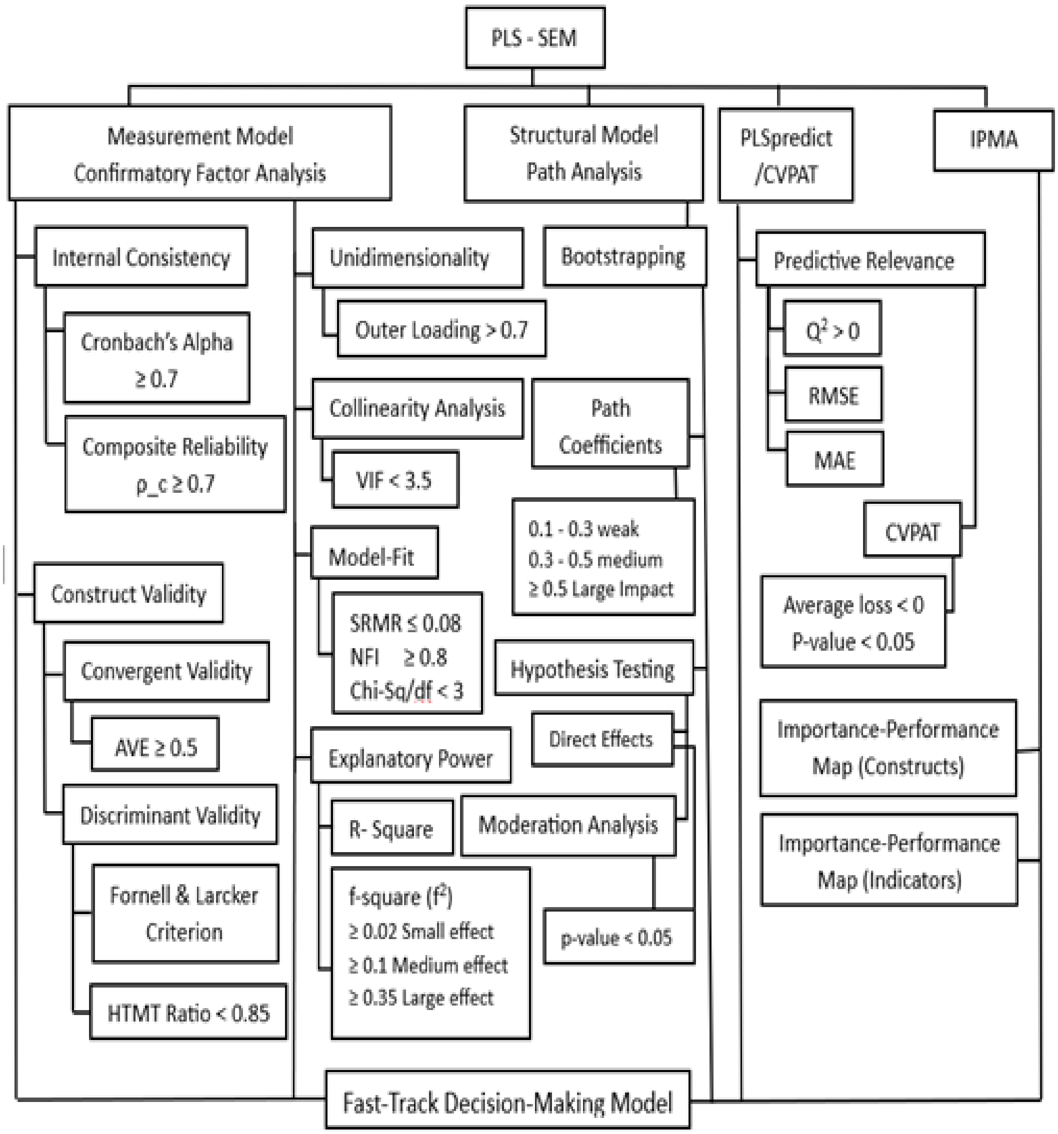



FIGURE 3.12: Statistical Analysis procedure - PLS-SEM

# Chapter 4

# Statistical Analysis, Results & Discussion

## 4.1 Background

This chapter explores the development of a decision-making model tailored for the complex domain of fast-track high-rise projects, employing the powerful framework of structural equation modelling (SEM). The chapter unfolds with a meticulous examination of the decision-making aspects through the lens of the Relative Importance Index (RII), a robust tool employed for ranking the decisions. Further this chapter transitions to the statistical analysis using SEM. The SEM analysis involves evaluation of fit indices, model parameters, and the intricate pathways connecting latent constructs. Another important part of this chapter is the testing of seven research hypotheses, each representing a critical conjecture about the relationships between key variables. This chapter transitions the theoretical aspirations into empirical realities. It offers a wide-ranging perspective of the decision-making phenomenon for fast-track high-rise projects, unveiling the hierarchies of importance and subjecting the model to rigorous statistical scrutiny. As the empirical procedure was employed with meticulous care, the results and discussions presented in this chapter stand as a testament to the scholarly rigor and shear commitment to reveal the complexities of decision-making in the dynamic domain of fast-track high-rise construction.

## 4.2 Results of the Pilot Survey

This research conducted two pilot surveys. In the first pilot survey the preliminary questionnaire was sent to 20 construction industry experts and three SEM professionals in USA and Pakistan. The construction industry experts and the SEM experts suggested few changes in the structure of the preliminary questionnaire and phrasing of the decision-making aspects. The preliminary questionnaire contained 6-point Likert scale with a 0 for the decision-making aspects not applicable to fast-track approach, the not applicable option was omitted from the questionnaire. Similarly, part II was added to the questionnaire which contained questions pertaining to respondent's general familiarity with the fast-track approach. The data collected through this preliminary questionnaire was not appropriate for feeding it to the SEM software therefore the SEM experts through e-mail conveyed to separately assign each decision-making aspect to a particular latent variable rather than grouping them all collectively under all four latent variables.

The 1st pilot survey resulted in changes in the structure of the preliminary questionnaire which required another pilot survey to establish the validity of the questionnaire for its application in Pakistan's construction industry and the structural equation modeling software. The refined questionnaire was dispatched to 11 construction industry experts and three SEM experts. The SEM experts approved the structure of the refined questionnaire thus validated the suitability and applicability of the data collected through this refined questionnaire in the SEM software. 6

out of the 11 construction industry experts suggested to remove 3 more decision-making aspects from the questionnaire being irrelevant to the fast-track approach. The 2nd pilot survey helped in establishing the validity and reliability of this research instrument. The feedback from the industry experts and the SEM experts revealed that the refinements suggested in the two pilot surveys have led to the development of a final questionnaire which will be used for the main survey.

## 4.3 Descriptive Analysis

The 159 respondents consist of construction industry professionals employed with clients (43), contractors (75), and consultants (41) as shown in figure 4.1. These respondents vary in experience and qualification however all of them have the experience of working on fast-track projects in either Dubai, Qatar, Saudi Arabia or in Pakistan. Figure 4.2 shows that most of the respondents have a bachelor's degree, 37% of the respondents hold a master's degree, 16% of the respondents have a diploma of associate engineer, 6 respondents have a PhD in civil engineering and 2 respondents were chartered accountants.

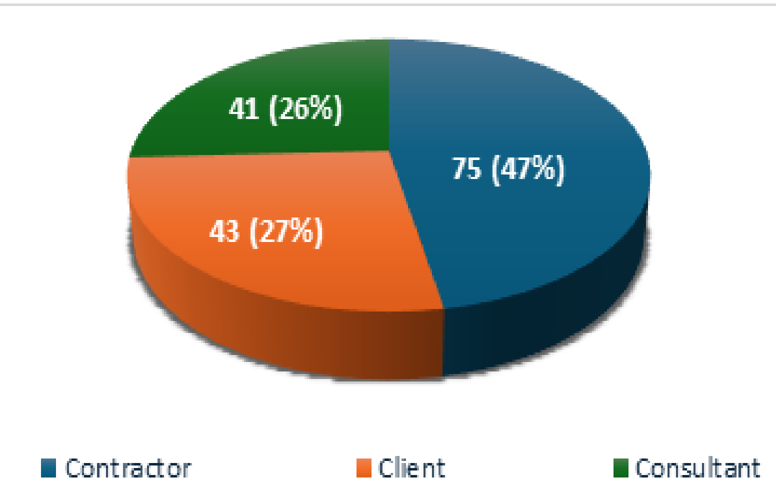



FIGURE 4.1: Type of Organizations

Figure 4.3 shows the experience of the respondents. 42 respondents had a vast experience of more than 20 years, and they provided valuable insight into the

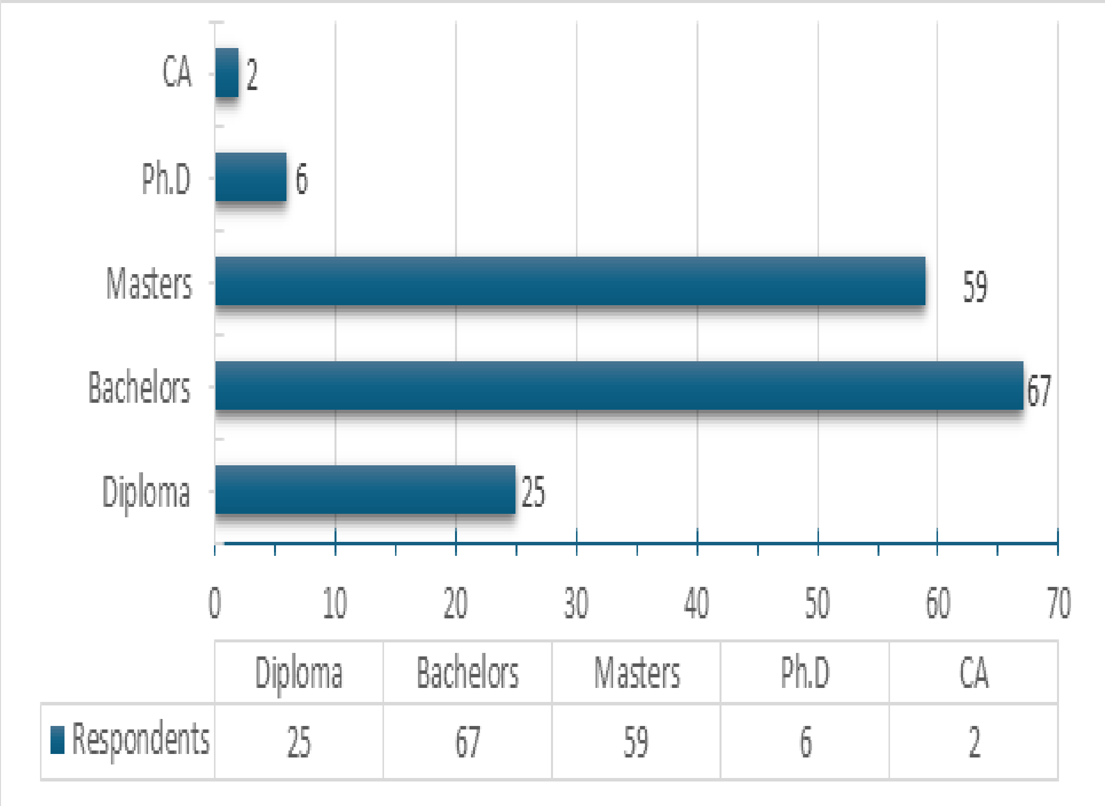



FIGURE 4.2: Qualification of the Respondents

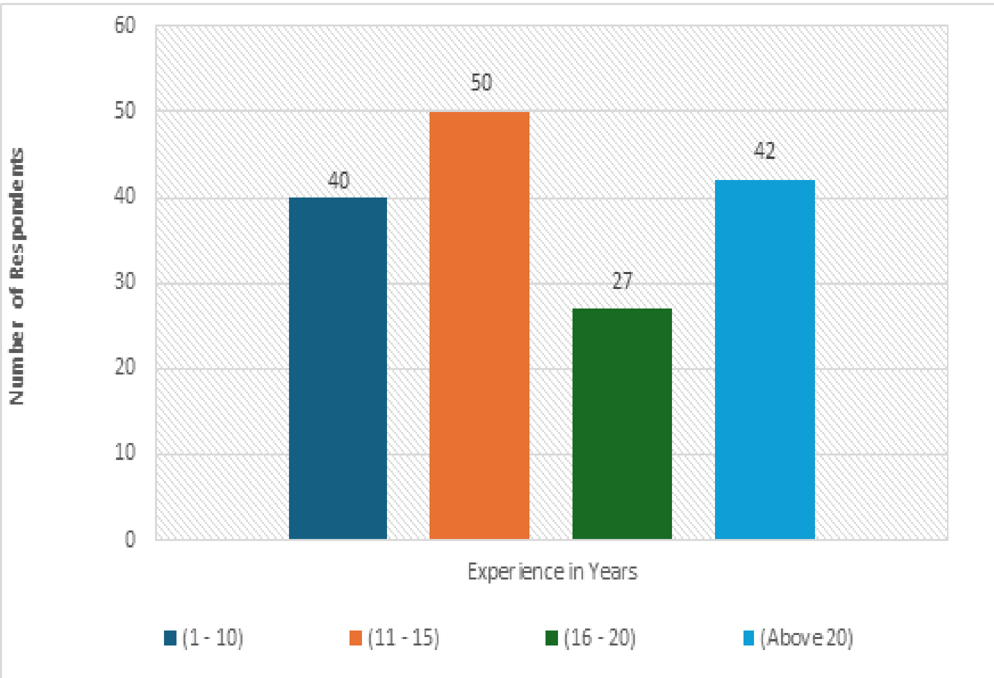



FIGURE 4.3: Respondent's Experience

decision-making aspects on fast-track projects and also highlighted the need for a comprehensive decision-making model. Figure 4.4 shows the distribution of respondents as per their role in the industry.

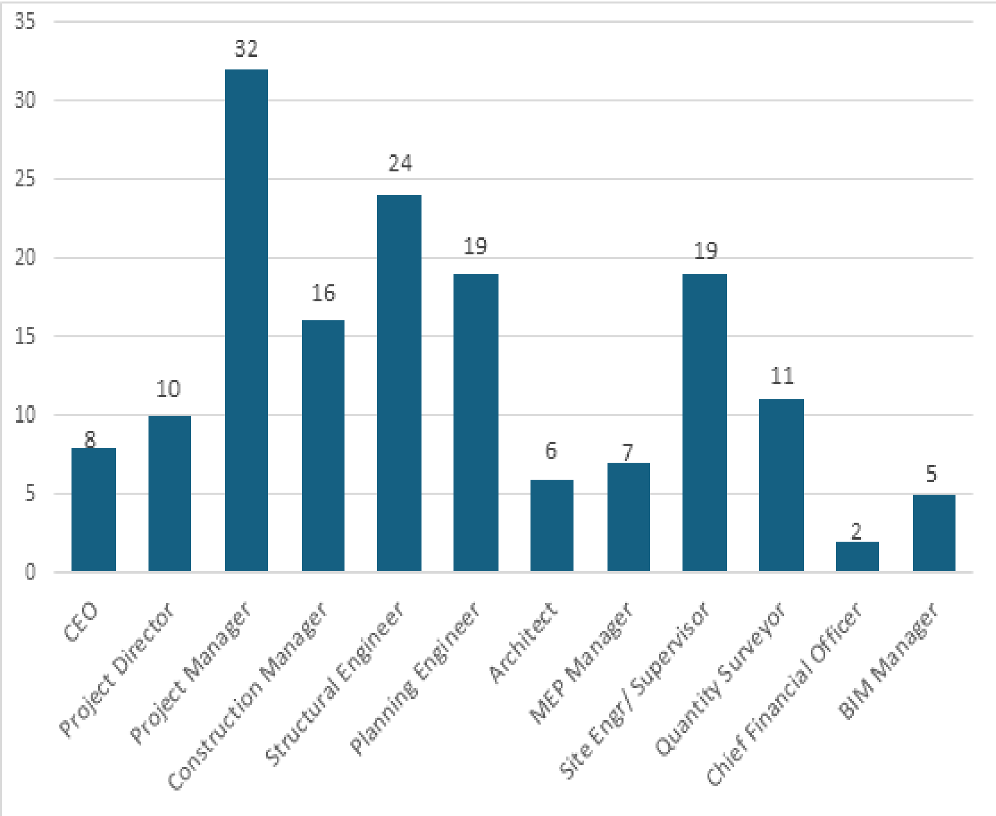



FIGURE 4.4: Distribution of respondents as per their role

## 4.4 Relative Importance Index (RII)

The relative importance index (RII) helped in ranking the decision-making aspects of fast-track high-rise construction in the context of a decision-making model from the perspective of the client, contractor, and the consultants. Table 4.1 shows the ranking of the all the 47 decision-making aspects identified from the literature. Figure 4.2 shows the top ten most critical decision-making aspects on high-rise fast-track projects.

TABLE 4.1: Ranked Decision-making aspects using RII

| **Decision-making Aspects** | **Number of Respondents** | | | | | **RII** | **Rank** |
|---|---|---|---|---|---|---|---|
| | **5** | **4** | **3** | **2** | **1** | | |
| Early involvement of the contractor in design phase | 115 | 37 | 7 | - | - | 0.94 | 1 |

| **Decision-making Aspects** | **Number of Respondents** | | | | | **RII** | **Rank** |
|---|---|---|---|---|---|---|---|
| | **5** | **4** | **3** | **2** | **1** | | |
| Adopting scope freeze approach at early design stage | 112 | 35 | 12 | - | - | 0.93 | 2 |
| Selecting the most suited project delivery method (DB, CM, EPC) | 107 | 38 | 13 | 1 | - | 0.92 | 3 |
| Early Procurement of Long-Lead-Time Items | 101 | 45 | 10 | 3 | - | 0.91 | 4 |
| Over-designing the facility | 98 | 49 | 10 | 2 | - | 0.91 | 5 |
| Client Authorizing Extras | 96 | 45 | 11 | 6 | 5 | 0.89 | 6 |
| Decide the optimal degree of overlap between activities | 93 | 44 | 15 | 7 | 6 | 0.89 | 7 |
| Implementing effective communication mechanism | 92 | 42 | 11 | 6 | 8 | 0.88 | 8 |
| Decision on Owner's financial capacity (Ensuring no resource constraint) | 90 | 46 | 9 | 8 | 7 | 0.86 | 9 |
| Organizational restructuring (Experienced Team) | 88 | 47 | 10 | 9 | 5 | 0.86 | 10 |
| Implement an effective Change Management Plan | 85 | 51 | 8 | 8 | 7 | 0.85 | 11 |
| Announce incentives for early completion | 81 | 54 | 9 | 7 | 8 | 0.84 | 12 |
| Adapting an appropriate contractual strategy | 79 | 51 | 12 | 8 | 9 | 0.83 | 13 |
| Early scope definition at conceptual or design stage | 77 | 52 | 13 | 9 | 8 | 0.83 | 14 |
| Conduct Cost/Benefit analysis (Financial Feasibility) | 72 | 55 | 14 | 11 | 7 | 0.80 | 15 |
| Implement an effective Scope Management Plan | 69 | 49 | 18 | 13 | 10 | 0.79 | 16 |

| Decision-making Aspects | Number of Respondents | | | | | RII | Rank |
|---|---|---|---|---|---|---|---|
| | 5 | 4 | 3 | 2 | 1 | | |
| Implement Front-End-Engineering Design (FEED) | 65 | 47 | 22 | 15 | 10 | 0.78 | 17 |
| Limit the cost impact due to fast-track to 120% compared to traditional construction | 62 | 45 | 24 | 16 | 12 | 0.76 | 18 |
| Implementing an effective Risk Management Plan | 56 | 49 | 27 | 13 | 14 | 0.75 | 19 |
| Implement Design & Construction Interface Management Plan | 52 | 47 | 34 | 16 | 10 | 0.74 | 20 |
| Apply fast-track to commercial building (which are time critical & High profit) rather than residential | 49 | 44 | 41 | 17 | 8 | 0.74 | 21 |
| Sufficient contingency allocations | 47 | 39 | 43 | 21 | 9 | 0.72 | 22 |
| Impose penalties for delays | 46 | 41 | 38 | 23 | 8 | 0.71 | 23 |
| Apply Fast-track to Critical Path rather than non-critical | 44 | 39 | 37 | 24 | 15 | 0.69 | 24 |
| Implement an effective Resource Management Plan | 43 | 38 | 36 | 25 | 17 | 0.68 | 25 |
| Implementing Value Engineering | 44 | 35 | 35 | 25 | 19 | 0.67 | 26 |
| Early contract award for enabling works | 42 | 33 | 37 | 26 | 21 | 0.66 | 27 |
| Adopt BIM based Fast-track Approach | 41 | 31 | 36 | 30 | 21 | 0.65 | 28 |
| Early engagement of O&M team in the design process | 39 | 31 | 35 | 31 | 23 | 0.64 | 29 |
| Quality Management Plan submission in pre-design stage | 38 | 29 | 34 | 35 | 23 | 0.63 | 30 |
| Delegate Authority to Project Level | 37 | 28 | 36 | 34 | 24 | 0.63 | 31 |
| Securing Early Permits/ Approvals | 35 | 30 | 37 | 31 | 26 | 0.62 | 32 |
| Conduct constructability review during planning or design phase | 36 | 27 | 35 | 33 | 28 | 0.61 | 33 |

| **Decision-making Aspects** | **Number of Respondents** | | | | | **RII** | **Rank** |
|---|---|---|---|---|---|---|---|
| | **5** | **4** | **3** | **2** | **1** | | |
| Adapting Relational Approaches (Partnering & Alliancing) | 34 | 26 | 34 | 36 | 29 | 0.60 | 34 |
| Adapting contractor pre-qualification Strategy | 35 | 24 | 32 | 35 | 33 | 0.59 | 35 |
| Compliance with site safety regulations | 34 | 22 | 33 | 36 | 34 | 0.58 | 36 |
| Implement Front-End-Planning (FEP) | 34 | 22 | 31 | 37 | 35 | 0.58 | 37 |
| Adopt Pre-fabrication/ Modularization | 32 | 21 | 29 | 41 | 36 | 0.56 | 38 |
| Decide between the potential time savings due to overlapping and the amount of expected reworks | 31 | 22 | 28 | 43 | 35 | 0.56 | 39 |
| Limiting the design optimization process | 29 | 23 | 30 | 42 | 33 | 0.56 | 40 |
| Implementing Lean Construction | 27 | 24 | 29 | 44 | 35 | 0.55 | 41 |
| Project stage at which the decision to fast-track is made | 25 | 22 | 31 | 45 | 36 | 0.54 | 42 |
| Adopting Fast-track on complex buildings | 24 | 21 | 30 | 46 | 38 | 0.53 | 43 |
| Decide the acceptable quality compromise extent on fast-track project preferably not less than 90% | 20 | 21 | 40 | 39 | 39 | 0.53 | 44 |
| Use prototyping (Scaled-down models of complex buildings) | 19 | 18 | 38 | 43 | 41 | 0.51 | 45 |
| Adapting an effective dispute resolution technique | 17 | 22 | 36 | 41 | 43 | 0.51 | 46 |
| Retain design and interface management responsibilities | 18 | 21 | 35 | 42 | 41 | 0.51 | 47 |

TABLE 4.2: Top Ten most critical decisions on Fast-track Projects

| **Decision-Making Aspects** | **RII** | **Latent Construct** |
|---|---|---|
| Early involvement of the contractor in design phase | 0.94 | **SV** |
| Adopting scope freeze approach at early design stage | 0.93 | **SV** |
| Selecting the most suited project delivery method (DB, CM, EPC) | 0.92 | **TV** |
| Early Procurement of Long-Lead-Time Items | 0.91 | **CV** |
| Over-designing the facility | 0.91 | **CV** |
| Client Authorizing Extras | 0.89 | **SV** |
| Decide the optimal degree of overlap between activities | 0.89 | **TV** |
| Implementing effective communication mechanism | 0.88 | **SV** |
| Decision on Owner's financial capacity (Ensuring no resource constraint) | 0.86 | **CV** |
| Organizational restructuring (Experienced Team) | 0.86 | **CV** |

## 4.5 Structural Equation Modeling (SEM)

### 4.5.1 Data Screening

Data screening is a crucial step in the statistical analysis process that involves inspecting, cleaning, and preparing the collected data before conducting further analysis. The basic purpose of data screening is to highlight and address issues or anomalies in the dataset that could potentially affect the validity and reliability of statistical results. This process ensures that the data meet the assumptions and requirements of the chosen statistical methods. All the observed values were as per the range of the Likert's scale, no outliers and missing values were observed. The skewness and kurtosis values were between -2 and +2 therefore the data was normally distributed [245]. All the values are given in Appendix-A.

### 4.5.2 Common Method Bias (CMB)

The results of Harman's one-factor test demonstrated that the first indicator accounted for 38.43% of the overall variance which is less than 50% hence CMB is not influencing the outcome of this study [246].

### 4.5.3 Measurement Model

#### 4.5.3.1 $1^{st}$ Order Construct - Confirmatory Factor Analysis (CFA)

Table 4.3 shows that all the values of Cronbach's Alpha ($\alpha$) and composite reliability ($\rho_c$) were greater than 0.7 thus establishing internal consistency and reliability. Average variance extracted (AVE) values of all the constructs were greater than 0.5 less quality variance which also improved after eliminating the indicators with factor loadings less than 0.7 thus convergent validity of the constructs was also established.

TABLE 4.3: Internal consistency and convergent validity

| **Constructs** | **Code** | **Cronbach's Alpha ($\alpha$)** | **Composite Reliability ($\rho$_c)** | **(AVE)** | |
|---|---|---|---|---|---|
| | | | | Initial | Modified |
| **Cost Variance** | **CV** | 0.864 | 0.902 | 0.581 | 0.647 |
| **Quality Variance** | **QV** | 0.928 | 0.939 | ***0.493*** | 0.69 |
| **Scope Variance** | **SV** | 0.915 | 0.936 | 0.658 | 0.747 |
| **Time Variance** | **TV** | 0.891 | 0.917 | 0.534 | 0.65 |

Table 4.4 shows that the values of correlation for a construct with itself are greater than other constructs thus establishing discriminant validity. Table 4.5 shows that all the HTMT values are $< 0.85$ implying that the constructs are empirically and statistically different thus establishing discriminant validity.

TABLE 4.4: Fornell & Larcker Criterion

| | **CV** | **QV** | **SV** | **TV** |
|---|---|---|---|---|
| **CV** | **0.804** | | | |
| **QV** | 0.115 | **0.831** | | |
| **SV** | 0.802 | 0.109 | **0.864** | |
| **TV** | 0.684 | 0.001 | 0.776 | **0.806** |

TABLE 4.5: Heterotrait-Monotrait Ratio

| | **HTMT** |
|---|---|
| **QV ↔ CV** | 0.113 |
| **SV ↔ CV** | 0.847 |
| **SV ↔ QV** | 0.12 |
| **TV ↔ CV** | 0.771 |
| **TV ↔ QV** | 0.074 |
| **TV ↔ SV** | 0.813 |

#### 4.5.3.2 $2^{nd}$ Order Construct

Table 4.6 shows that the VIF values for all the constructs are < 3.5 thus verifying that collinearity does not exist in the model.

TABLE 4.6: Variance Inflation Factor (VIF)

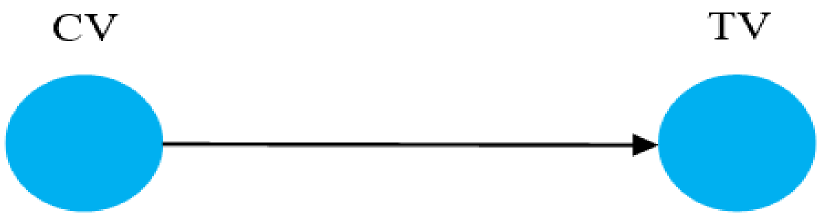
| | |
|---|---|
| CV ↔ TV | 2.808 |
| QV ↔ CV | 1.012 |
| QV ↔ TV | 1.014 |
| SV ↔ CV | 1.012 |
| SV ↔ TV | 2.804 |

#### 4.5.3.3 Model-Fit

The SRMR and NFI values of the model were 0.65 < 0.85 and 0.801 which is between 0.6 to 1.0 respectively and that of the GFI and chi-square/df were 0.651 > 0.36 and 2.16 < 3.0 respectively thus verifying a good model fit hence the model is appropriate for the next phase of statistical analysis i.e., path analysis.

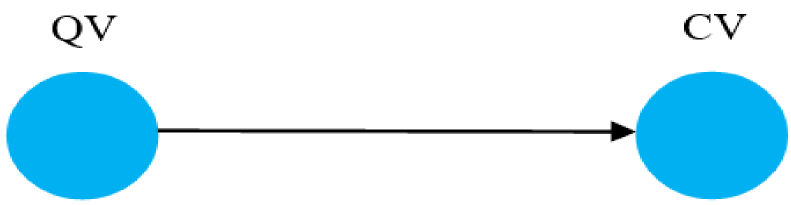
### 4.5.4 Path Analysis (Structural Model)

For testing the hypothesis in SEM, p-values and path coefficient ($\beta$) values are used. p-values assess the statistical significance of the estimated relationship. A p-value below a chosen significance level (e.g., 0.05) indicates that the relationship is statistically significant and is not a mere chance. The path coefficient values indicate the strength and direction of the relationships and provide information about the extent of change in the dependent variable for a one-unit change in the independent variable. The results of hypotheses testing in figure 4.6, tables 4.7 and 4.8 provide a useful insight into the decision-making process for high-rise fast-track projects which are discussed as follows. Figure 4.5 shows the significance values for structural and measurement model. As the significance values for all the indicators in the measurement model are less than 0.05, therefore all the indicators have a significant impact on their respective latent variable. However, the main focus of this research is to explore the relationship amongst the latent variables. The $\beta$ values are given in table 4.7 and 4.8 and in figure 4.6. Moreover, the model shown below represent individual research hypothesis.




**$H_1$:** The variation in project cost has a significant impact on project time variation

$\beta = 0.569$ and p-value $< 0.05$, indicates that there is a statistically significant relationship between project cost variation and project time variation and the hypothesis is accepted. The beta coefficient of 0.569 indicates a strong positive relationship between project cost variation and project time variation. This means that as project cost increases by 1-unit then the project duration also increases by 0.569. The construction industry stakeholders also revealed that increase in project cost creates cash flow problems which results in project suspension or even termination.




**$H_2$:** The variation in project quality has a significant impact on project cost variation

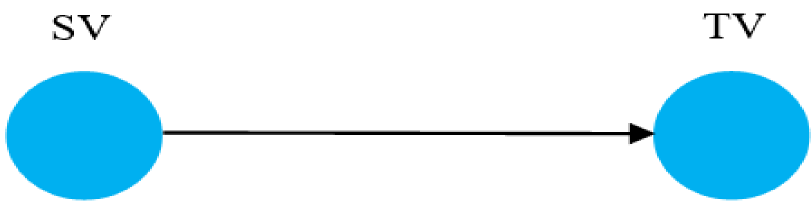
$\beta = 0.408$ and p-value $< 0.05$ reveal that variations in project quality have a statistically significant impact on variations in project cost hence the hypothesis is accepted. Beta coefficient of 0.408 suggests a moderately positive relationship between these two variables indicating that if the project quality deteriorates by 1-unit then the overall project cost increases by 0.408 units. The construction professionals do not encourage changes orders and reworks on fast-track project thus they are undesirable, only the very essential variations are made. As quality variations have significant impact on project cost therefore fast-tracking disregards quality criteria [83].


**$H_3$:** The variation in project quality has a significant impact on project time variation

$\beta = 0.241$ and p-value $< 0.05$, suggests that there exists a statistically significant relationship between the variations in project quality and project duration thus the hypothesis is accepted. The beta coefficient of 0.241 represents a weak positive relationship between the two variables, suggesting that when the project quality deteriorates by 1-unit, the duration of the project increases by 0.241-units. This hypothesis reveals that quality optimization decisions on fast-track projects will lead to project delays on fast-track projects. Hence, quality optimization on fast-track projects are not considered feasible.

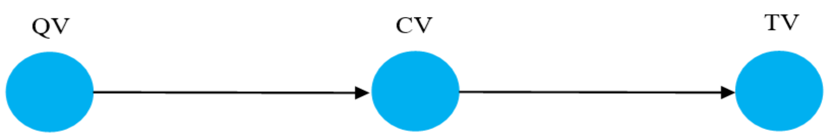
**$H_4$:** The variation in project scope has a significant impact on project cost variation

$\beta$ value (0.799) and p-value ($< 0.05$) suggest that that variations in project scope have a statistically significant on variations on project cost hence H4 is accepted. Beta coefficient of 0.799 suggests a strong positive relationship between these two variables. This means that if project scope increases by 1-unit then the overall project cost increases by 0.799-units. This finding is supported by literature and industry experience that with the increase in a project's scope, the project cost also increases drastically.



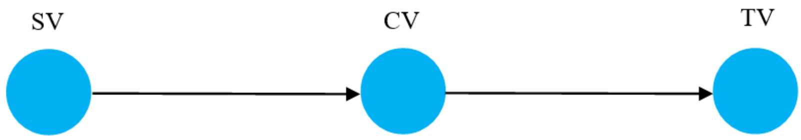

**$H_5$:** The variation in project scope has a significant impact on project time variation

The $\beta$ value (0.641) and p-value ($<0.05$) indicate that the variations in project scope have a statistically significant impact on variations in project duration thus H5 is accepted. The beta coefficient of 0.641 suggests a strong positive relationship between these two variables. This means that if project scope increases by 1-unit, the project duration increases by 0.641-units. This is a significant finding which is supported by industry experience that changes in project scope also strongly influences project duration. Hence adoption of scope-freeze approach is highly recommended on fast-track projects which is also strongly suggested by researchers and practitioners.



**$H_6$:** The variation in project cost mediates a significant impact between the variation in project quality and project duration

The $\beta$ value (0.214) and p-value ($< 0.05$) indicate that the variations in project cost significantly mediate the indirect impact of variations in project quality on variations in project duration thus the hypothesis is accepted. The Beta coefficient value (0.214) indicates a weak positive association between the changes in project quality and changes in project duration via variations in project cost. This suggests that variations in project quality influence project duration partially via their impact on project cost. The positive coefficient indicates that increases in quality variations are associated with longer project durations through increased project costs. The statistical significance of the mediation effect underscores the importance of considering project cost management in optimizing project duration, particularly in the context of varying project quality."




**$H_7$:** The variation in project cost mediates a significant impact between the variation in project scope and project duration

The $\beta$ value (0.602) and p-value ($< 0.05$) indicate that the variations in project cost significantly mediate the indirect impact of variations in project scope on variations in project duration thus the hypothesis is accepted. The Beta coefficient value (0.602) indicates a strong positive association between the changes in project scope and changes in project duration via variations in project cost. The findings of this hypothesis indicate that the increase in project scope increases the overall project cost which in turn increases the duration of the project. Moreover, this finding underscores the importance of considering project cost management in optimizing project duration, especially when dealing with variations in project scope.

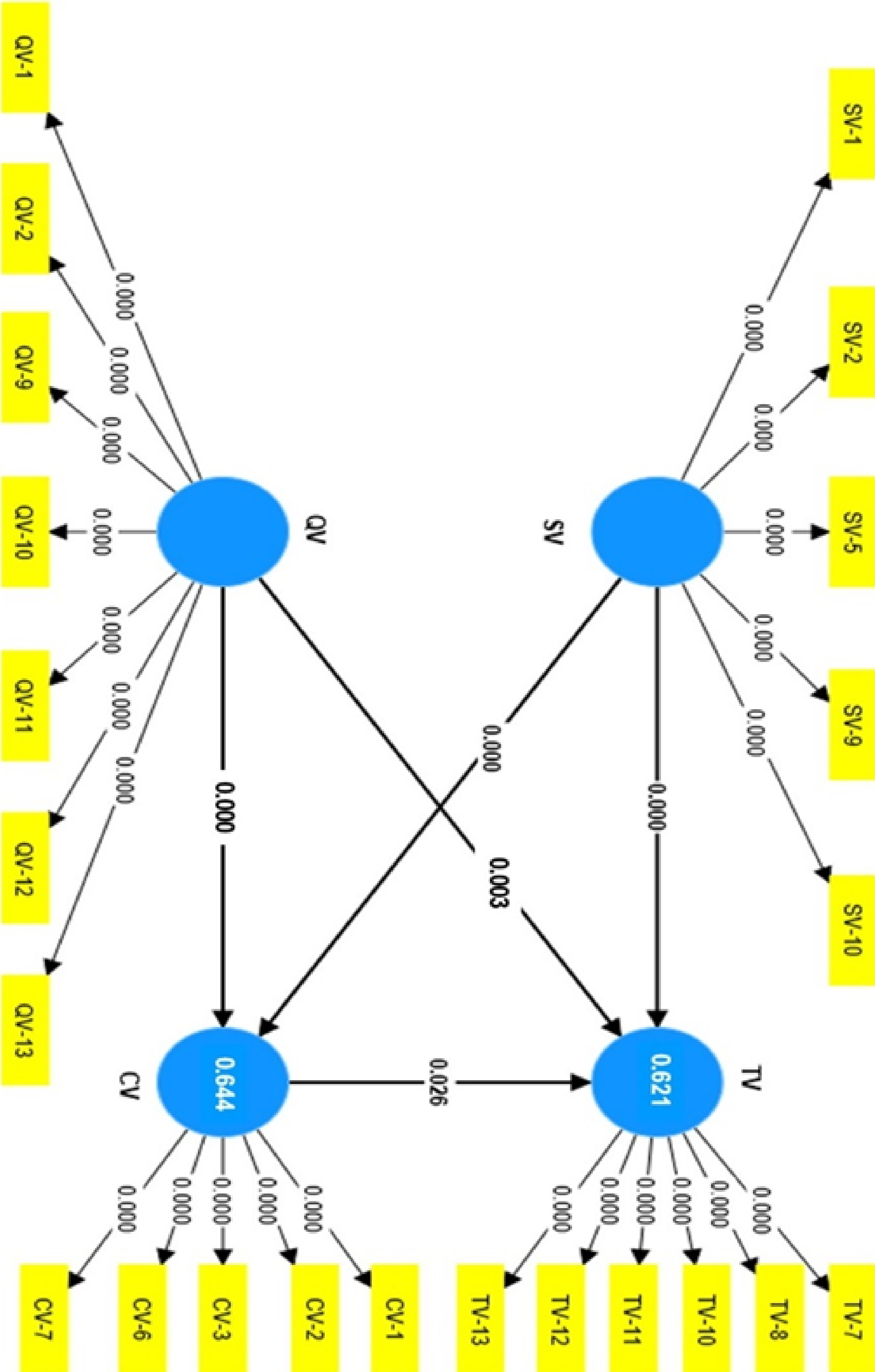



FIGURE 4.5: Modified model showing significance values (p-value) for measurement model and structural model

TABLE 4.7: Direct Effects

| | Original Sample (O) | **Sample Mean (M)** | **Standard Deviation (STDEV)** | **T Statistics (O/STDEV)** | **p-values** | **Decision** |
|---|---|---|---|---|---|---|
| **H1 CV↔TV** | 0.569 | 0.574 | 0.093 | 6.118 | 0.026 | ***Accepted*** |
| **H2 QV↔CV** | 0.408 | 0.502 | 0.054 | 7.555 | 0.299 | ***Accepted*** |
| **H3 QV↔TV** | 0.241 | 0.243 | 0.069 | 3.492 | 0.003 | ***Accepted*** |
| **H4 SV↔CV** | 0.799 | 0.799 | 0.024 | 33.291 | 0 | ***Accepted*** |
| **H5 SV↔TV** | 0.641 | 0.635 | 0.084 | 7.63 | 0 | ***Accepted*** |

TABLE 4.8: Specific Indirect Effects

| | **Original Sample (O)** | **Sample Mean (M)** | **Standard Deviation (STDEV)** | **T - Statistics (O/ STDEV)** | **p-value** | **Decision** |
|---|---|---|---|---|---|---|
| **H6 QV↔CV↔TV** | 0.214 | 0.618 | 0.011 | 19.454 | 0.01 | ***Accepted*** |
| **H7 SV↔CV↔TV** | 0.602 | 0.149 | 0.076 | 7.921 | 0.029 | ***Accepted*** |

### 4.5.5 Explanatory Power of the Structural Model

Figure 4.6 shows that $R^2$ for CV is 0.644 hence 64.4% of the variance in project cost is attributed to the variance in project scope and quality. Similarly, $R^2$ for TV is 0.621 hence 62.1% of the variance in project duration is attributable to variances in project scope, quality, and cost.

In this model, $f^2$ values indicate that scope variance has an enormous effect on cost variance (1.771) and time variance (0.387) whereas quality deterioration has moderate effect on time variance (0.22) and cost variance (0.19) which means eliminating the quality variance related aspects from the model will have moderate impact on cost variance and time variance respectively. Moreover, cost variance has a small effect (0.046) on time variance which seems contrary to industry practices, but it is supported by literature owing to the time-cost trade-off nature of fast-track projects.

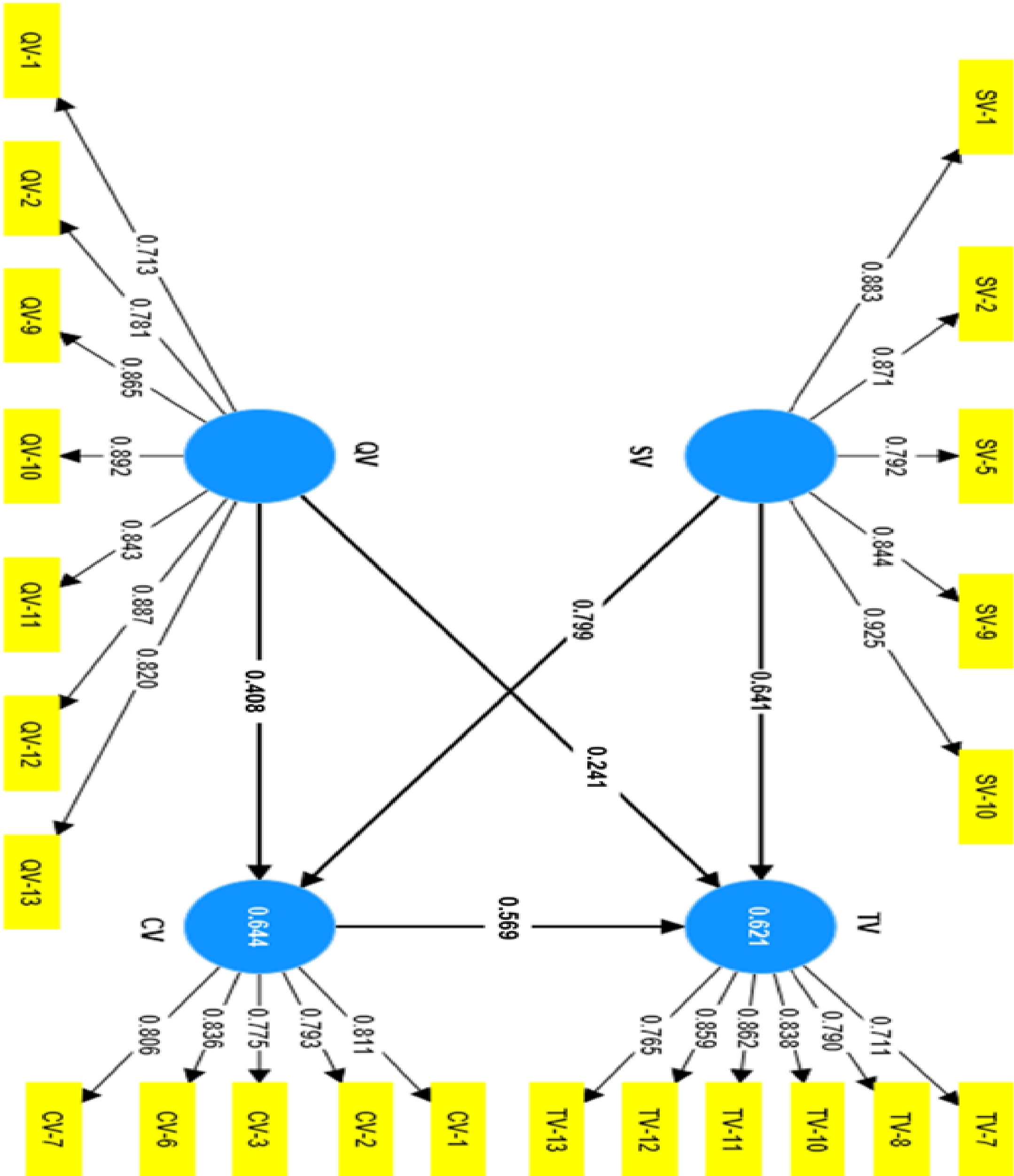



FIGURE 4.6: Hypothesized Model with outer Loadings, path coefficients and $R^2$ values

### 4.5.6 Predictive Relevance of the Structural Model

Tables 4.9 and 4.10 show that all the values of $Q^2$ are $> 0$ thus predictive relevance of the model is established. Similarly, all the PLS_RMSE and PLS_MAE values are less than LM_RMSE and LM_MAE values therefore the model has high out-of-sample predictability.

TABLE 4.9: Manifest Variable (MV) Prediction Summary

| | $Q^2$-predict | PLS-SEM_RMSE | PLS-SEM_MAE | LM_RMSE | LM_MAE |
|---|---|---|---|---|---|
| **CV-1** | 0.403 | 0.948 | 0.751 | 0.953 | 0.772 |
| **CV-2** | 0.572 | 0.898 | 0.712 | 0.916 | 0.731 |
| **CV-3** | 0.27 | 1.133 | 0.881 | 1.18 | 0.923 |
| **CV-6** | 0.372 | 1.121 | 0.898 | 1.144 | 0.915 |
| **CV-7** | 0.377 | 1.151 | 0.927 | 1.172 | 0.952 |
| **TV-10** | 0.341 | 1.064 | 0.903 | 1.118 | 0.916 |
| **TV-11** | 0.505 | 1.03 | 0.819 | 1.061 | 0.831 |
| **TV-12** | 0.475 | 1.038 | 0.807 | 1.065 | 0.815 |
| **TV-13** | 0.271 | 1.34 | 1.107 | 1.381 | 1.136 |
| **TV-7** | 0.335 | 1.043 | 0.838 | 1.071 | 0.857 |
| **TV-8** | 0.382 | 1.049 | 0.845 | 1.104 | 0.862 |

TABLE 4.10: . Latent Variable (LV) Prediction Summary

| | $Q^2$ predict | RMSE | MAE |
|---|---|---|---|
| **CV** | 0.632 | 0.612 | 0.493 |
| **TV** | 0.598 | 0.641 | 0.515 |

The CVPAT results in table 4.11 show that all the values of average loss difference are negative for both IA and LM moreover the p-values are $< 0.05$ which supports the hypothesis that predictive ability of PLS-SEM is better than IA and LM thus indicating high out-of-sample predictive power of the final modified decision-making model (Appendix-C).

TABLE 4.11: CVPAT-Difference of Average Loss values for PLS-SEM vs IA and LM

| | Indicator Average (IA) | | | Linear Model (LM) | | |
|---|---|---|---|---|---|---|
| | **Average loss difference** | **t value** | **p-value** | **Average loss difference** | **t value** | **p-value** |
| **CV** | -0.742 | 7.963 | 0 | -0.048 | 1.989 | 0.047 |
| **TV** | -0.776 | 7.277 | 0 | -0.052 | 2.023 | 0.029 |
| **Overall** | -0.761 | 8.932 | 0 | -0.05 | 2.148 | 0.033 |

## 4.6 Importance-Performance Map Analysis-IPMA

The IPMA results in figure 4.8 and table 4.12 show that SV has the highest performance (87.511%) and importance (0.759) which means that 1 unit improvement in SV will result in 0.759-unit improvement in TV. CV's performance is 38.117% and its impact is 0.695 which means that 1-unit improvement in CV will result in 0.695-unit improvement in TV. Although QV is performing well at 41.775% but its importance is -0.011 which is counter-productive, indicating that on fast-track projects efforts to improve the quality by 1-unit will result in adverse effects (-0.011) on project duration. These findings find strong support in the existing literature. Similarly, at the indicator level, IPMA helps a decision-maker in knowing which decision-making aspects require the most and the least attention. Figure 4.8 and table 4.13 clearly show that SV-10, SV-9, SV-2, SV-1, and SV-5 have the greatest impact on project duration whereas QV-9, QV-10, QV-12, QV-2, QV-13, QV-1 and QV-11 have counter-productive effects on project duration on fast-track projects.

In summary, the map analysis suggests that decisions related to scope variance are the most productive and a decision-maker must continue to allocate resources to scope related decisions to maintain competitive advantage in timely project delivery. The decision-maker needs to concentrate more on cost-related decisions as these indicators are considered crucial by stakeholders but are currently lacking in terms of performance. This misalignment between stakeholder expectations and actual performance can lead to dissatisfaction, erosion of trust, and potentially loss of business. Finally, the quality related decision on fast-track projects are counter-productive to timely project delivery, and they hold low priority while addressing the target construct that is project duration. The decision-maker should commit less resources to quality related decisions and focus more on cost related decisions as they hold priority for stakeholders.

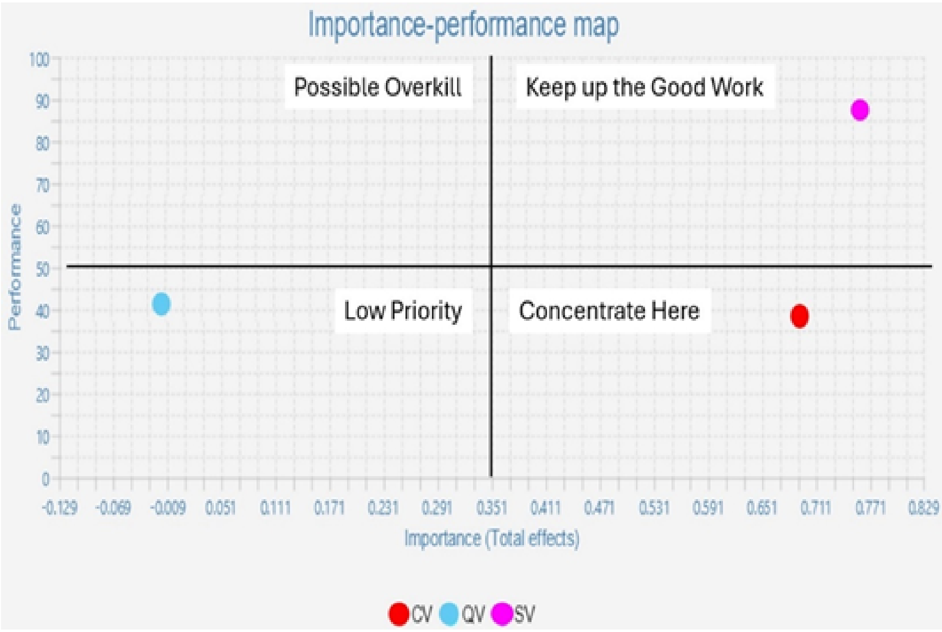



FIGURE 4.7: Importance-Performance Map Analysis-Constructs

TABLE 4.12: IPMA values - Constructs

| | Importance | Performance |
|---|---|---|
| **CV** | 0.695 | 38.117 |
| **QV** | -0.011 | 41.775 |
| **SV** | 0.759 | 87.511 |

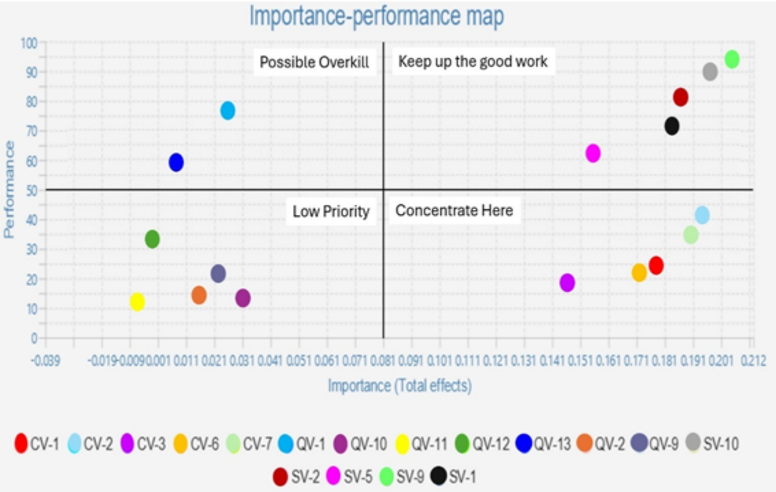



FIGURE 4.8: Importance-Performance Map Analysis-Indicators

TABLE 4.13: IPMA values - Indicators

| | **Importance** | **MV performance** |
|---|---|---|
| **CV-1** | 0.178 | 24.888 |
| **CV-2** | 0.193 | 42.111 |
| **CV-3** | 0.146 | 18.411 |
| **CV-6** | 0.172 | 22.381 |
| **CV-7** | 0.189 | 34.211 |
| **QV-1** | 0.025 | 76.611 |
| **QV-10** | 0.031 | 13.799 |
| **QV-11** | -0.007 | 12.111 |
| **QV-12** | -0.002 | 33.011 |
| **QV-13** | 0.007 | 58.777 |
| **QV-2** | 0.015 | 14.333 |
| **QV-9** | 0.023 | 22.013 |
| **SV-10** | 0.197 | 90.001 |
| **SV-2** | 0.186 | 81.999 |
| **SV-5** | 0.154 | 62.001 |
| **SV-9** | 0.204 | 93.777 |
| **SV-1** | 0.183 | 71.771 |

## 4.7 Summary of the Chapter

The chapter includes the results of RII along with descriptive analysis and statistical analysis. Top ten most important decisions on fast-track projects were identified and ranked using RII. The descriptive analysis included graphs showing the distribution of respondents in the construction industry as per their qualification, experience and designation. SEM analysis assisted in studying the latent variables and also aided in testing the research hypothesis. The hypothesis results showed that 1-unit change in project cost or project scope will change the project duration by 0.569 units and 0.799 units signifying a large impact whereas with 1-unit variation in project quality, the project duration changes by 0.241-units implying a low impact. The mediation analysis showed that cost variation mediates a high impact between variations in project scope duration whereas the mediating impact is weak between variations in project quality and duration. The R2 values of the model revealed that on a high-rise fast-tracking project, 64.4% of the variance in project cost is attributed to variations in project scope and quality whereas 62.1% variations in project duration are attributed to variations in scope, quality and cost. The f2 values revealed that scope variance has a large effect on variations in project budget (1.771) and project duration (0.387) implying that variations in project scope must be evaluated for its impact on project success. Moreover, the proposed model has high out-of-sample predictive ability making it a universally applicable decision-making model. Model's predictability was established after which IPMA was used to assess the performance and importance of each indicator and latent variable on the target variable.

The field interviews with 104 construction industry professionals in Pakistan revealed 19 key i mpediments to the successful implementation of fast-track construction techniques. These challenges encompass economic instability, project management issues, resistance to change, supply chain disruptions, lack of safety regulations, inadequate contractual frameworks, and pervasive corrupt practices.

Economic volatility, fluctuating inflation, and unpredictable market conditions exacerbate project financing and resource procurement. Project management deficiencies, such as poor planning, coordination, and a lack of skilled professionals, hinder the efficient execution of fast-track projects. Moreover, entrenched resistance to innovation, coupled with supply chain inefficiencies, delays, and unreliable material deliveries, further complicates project timelines. Additionally, the absence of robust safety regulations and tailored contractual frameworks creates a high-risk environment, while corruption undermines transparency, a ccountability, and investor confidence. Addressing these impediments is essential for creating a conducive environment for fast-track construction, fostering industry growth, and improving infrastructure quality in Pakistan.

# Chapter 5

# Fast-track Implementation Impediments and Proposed Solution

## 5.1 General

Chapter 5 of this dissertation focuses on the critical examination of the barriers that impede the successful implementation of fast-track construction practices within Pakistan's construction industry. Fast-track construction, characterized by aggressive project schedules and expedited timelines, presents a promising approach to meeting the country's growing infrastructure demands. However, the effective adoption of fast-track methods faces numerous challenges and complexities unique to the Pakistans context. This chapter aims to provide a comprehensive analysis of these barriers, ranging from regulatory complexities and infrastructure limitations to issues surrounding skilled labor shortages, financing constraints, and cultural factors. By examining these impediments in detail, this study aims to offer valuable insights and recommendations for policymakers, industry stakeholders, and practitioners seeking to navigate and overcome these challenges in order to promote efficient and effective fast-track construction practices in Pakistan. This chapter aims to provide a comprehensive analysis of these barriers, exploring their origins, implications, and potential solutions. By illuminating these barriers and their interconnections, this chapter aims to put forward a nuanced knowledge of the complexities surrounding fast-track construction implementation in Pakistan. By doing so, it seeks to inform policymakers, industry practitioners, and researchers about the multifaceted challenges that must be addressed to unlock the full potential of fast-track construction as a catalyst for sustainable development and economic growth in Pakistan's construction industry.

## 5.2 Implementation Impediments and Proposed Solution

The following sub-sections highlight the 19 impediments hindering the successful application of fast-track approach in Pakistans construction industry. These impediments were identified after conducting non-structured field interviews with 104 construction industry experts. These impediments and their solutions were extracted from the opinions of the construction industry stakeholders. Detailed discussion has been conducted on the impediments and their solutions which will prove to be a beacon of light for the future researchers to pave the path for further exploration into the dynamic nature of fast-track building construction.

I. **Regulatory Hurdles:** The regulatory hurdles in Pakistan present significant challenges that impede the successful application of fast-track construction techniques in Pakistans construction sector. These hurdles manifest in various ways, including complex and lengthy approval processes, ambiguities in building codes and standards, and inadequate regulatory enforcement mechanisms. Firstly, the cumbersome nature of obtaining permits and clearances poses a substantial barrier to fast-tracking construction projects in

Pakistan. The process of securing necessary approvals from multiple government departments and agencies is often delayed. Delays in obtaining permits for land acquisition, environmental clearances, and construction licenses can significantly hamper project commencement and subsequent progress. This bureaucratic inefficiency not only increases project costs but also undermines the feasibility of overlapping design and construction phases, which are essential components of fast-track methodologies aimed at compressing project schedules.

Furthermore, the regulatory landscape in Pakistan is characterized by jurisdictional overlaps and inconsistent interpretation of laws among different government bodies. This administrative fragmentation complicates the regulatory process, leading to confusion and delays in obtaining necessary approvals. The lack of coordination and collaboration between regulatory agencies further exacerbates administrative hurdles and impedes the efficient implementation of fast-track construction techniques. To address these regulatory challenges and facilitate the adoption of fast-track techniques, reforms are needed to streamline approval processes, enhance regulatory transparency, and strengthen enforcement mechanisms. Establishing clear permitting procedures will provide certainty and predictability to project stakeholders.

In conclusion, the regulatory hurdles in Pakistan's construction industry present formidable barriers to the successful implementation of fast-track construction techniques. By addressing regulatory complexities, enhancing transparency, and strengthening enforcement mechanisms, policymakers can create an enabling environment that incentivizes stakeholders to embrace innovative project delivery methods aimed at accelerating construction schedules and improving productivity in the construction sector.

II. **Absence of Standardized Building Codes:** The absence of standardized building codes and regulations for fast-track construction adds another layer of complexity to the regulatory landscape in Pakistan. Although, a building code has been published by Pakistan Engineering Council (PEC) but it overlook the managerial and technical aspects of fast-track construction. Furthermore, every region has its own building regulations like CDA, LDA, RDA, KDA, MDA etc. This lack of uniformity and clear guidelines create a number of challenges that undermine the efficiency and effectiveness of fast-tracking. Firstly, without standardized building codes, there is ambiguity and inconsistency in regulatory requirements across different regions and municipalities. This lack of uniformity complicates the planning and design phases of fast-track projects, as architects, engineers, and contractors encounter difficulties in interpreting and complying with varying regulations. The absence of clear guidelines lead to frequent revisions and modifications during the construction process, disrupting project timelines and increasing the risk of errors and rework. Consequently, the inability to rely on standardized codes hampers the seamless integration of design and construction activities, which are essential for achieving the accelerated timelines characteristic of fast-track construction.

Moreover, the absence of standardized building codes contributes to uncertainties in quality control and safety standards. Fast-track projects inherently operate under compressed schedules, which can compromise quality assurance processes. In the absence of clear benchmarks and performance criteria specified by standardized codes, there is a heightened risk of sub-standard construction practices and materials. This lack of regulatory oversight undermines the integrity and reliability of fast-track projects, as stakeholders may prioritize speed over adherence to established safety and quality protocols. Consequently, the absence of standardized building codes not only impedes the successful implementation of fast-track techniques but also jeopardizes the long-term durability and safety of constructed facilities. To address these challenges and facilitate the adoption of fast-track techniques, efforts are needed to establish and enforce comprehensive standardized building codes nationwide. This entails collaboration between government agencies, industry associations, and academia to develop robust regulatory frameworks that encompass the managerial and technical aspects of fast-track construction specifically.

In conclusion, the absence of standardized building codes in Pakistan poses significant barriers to the successful implementation of fast-track construction techniques. By prioritizing the development and enforcement of comprehensive and uniform building code, policymakers can create an enabling environment that supports innovation, fosters quality and safety standards, and facilitates the efficient execution of fast-track projects in the country's construction industry.

III. **Quality Control Concerns:** Fast-tracking may compromise quality control processes as there might be less time for thorough inspections and testing, potentially leading to safety issues and defects. In Pakistan, where the construction sector faces various challenges such as inconsistent regulatory frameworks, inadequate enforcement mechanisms, and a lack of standardized practices, ensuring stringent quality control becomes inherently challenging. One of the primary impacts of quality control concerns on fast-track construction implementation is the heightened risk of defects and deficiencies in the final deliverables. In an environment where quality oversight may be lax or inconsistent, there is a greater likelihood of substandard materials being used, workmanship errors going unnoticed, and crucial quality checkpoints being bypassed to meet tight deadlines. This not only compromises the structural integrity and safety of constructed facilities but also leads to increased maintenance costs and potential legal liabilities in the long run.

Moreover, the reputation of stakeholders involved, including contractors, developers, and regulatory bodies, can suffer irreparable damage if projects are marred by quality issues, further aggravating trust deficit within the industry. Additionally, the lack of standardized quality control protocols and the prevailing informal practices within Pakistan's construction sector hinder the effective implementation of fast-track construction methods. Without clear guidelines and benchmarks for quality assurance, stakeholders resort to ad-hoc measures, leaving room for ambiguity and inconsistency in decision-making processes. Furthermore, the absence of robust monitoring and evaluation mechanisms aggravates the challenge of maintaining quality standards throughout the project lifecycle. Without real-time feedback mechanisms and proactive quality assurance measures, deviations from specified standards may go undetected till it's too late to rectify them, leading to costly rework and project delays.

The inadequate capacity of local construction firms to invest in advanced technologies and specialized expertise for quality control further complicates matters. While fast-track construction relies heavily on efficient project management systems, cutting-edge construction methodologies, and advanced quality control tools, many firms in Pakistan lack the financial resources or technical capabilities to adopt such practices comprehensively. This creates a gap between the desired quality benchmarks and the actual implementation on the ground, undermining the feasibility and sustainability of fast-track construction projects in the long term. In conclusion, quality control concerns represent a significant barrier to the successful implementation of fast-track construction techniques in Pakistan's construction industry. Addressing these concerns requires a multi-faceted approach involving regulatory reforms, capacity-building initiatives, and industry-wide collaborations to foster a culture of quality consciousness and accountability across the construction industry. By prioritizing quality assurance alongside project speed, stakeholders can mitigate risks, enhance stakeholder confidence, and unlock the full potential of fast-track construction in Pakistan.

IV. **Lack of Experience and Expertise:** Limited experience and expertise in managing fast-track projects among local contractors and consultants can pose significant risks in terms of project coordination and delivery. A shortage of skilled labor and specialized construction workers can lead to inefficiencies during the construction phase, impacting the ability to meet compressed timelines. The lack of experience and expertise poses a formidable challenge to the successful implementation of fast-track construction techniques within Pakistan's construction industry. Fast-track construction demands a high level of proficiency in project management, engineering, and construction methodologies to effectively navigate tight timelines. However, in Pakistan, where the construction sector is characterized by limited access to formal training, and a shortage of experienced professionals, which significantly hampers the adoption and execution of fast-track projects. Without seasoned professionals who possess the necessary technical know-how and problem-solving skills, there is a heightened risk of project delays, cost overruns, and quality compromises.

Inexperienced project teams struggle to anticipate and mitigate potential risks, leading to errors in scheduling, resource allocation, and coordination, which can have cascading effects on project timelines and outcomes. Moreover, the lack of experienced personnel in key roles such as project management, site supervision, and quality control aggravates the challenge of ensuring adherence to project specifications and standards. In Pakistan, where construction projects often face regulatory hurdles, logistical constraints, and external uncertainties, the absence of seasoned professionals capable of making informed decisions and executing contingency plans further complicates matters. Without access to best practices and lessons learned from previous fast-track projects, construction firms in Pakistan may struggle to innovate and adapt to evolving project requirements. Additionally, the reliance on subcontractors and laborers with limited experience and training increases the risk of safety incidents and construction defects, undermining both the welfare of workers and the overall project outcomes.

In conclusion, the lack of experience and expertise represents a significant barrier to the successful implementation of fast-track construction techniques in Pakistan's construction industry. Addressing this challenge requires concerted efforts from stakeholders across the public and private sectors to invest in workforce development, promote knowledge transfer, and foster a culture of continuous learning and improvement.

V. **Infrastructure Constraints:** Insufficient infrastructure, such as transportation and utilities, can affect logistics and overall project efficiency, particularly in remote or underdeveloped areas. Infrastructure constraints present a significant impediment to the successful implementation of fast-track construction techniques within Pakistan's construction industry. Fast-track construction relies heavily on efficient logistics, reliable transportation networks, and robust infrastructure to ensure timely delivery of materials, equipment, and personnel to construction sites. However, in Pakistan, where infrastructural development has not kept pace with the demands of a rapidly growing population, the lack of adequate transportation, power, and communication networks poses challenges to fast-track projects. Insufficient road networks and congested traffic conditions impede the timely transportation of construction materials, leading to delays in project schedules and increased logistics costs.

Moreover, unreliable power supply and energy shortages disrupt construction activities, hampering productivity and over-shooting project timelines. The absence of modern telecommunications infrastructure further complicates coordination and communication among project stakeholders, undermining efficiency and worsening the risk of mismanagement and errors. Additionally, inadequate water and sanitation facilities pose health and safety risks to construction workers, further impeding project progress. The existence of infrastructural constraints not only increases project costs but also undermines the feasibility and viability of fast-track construction initiatives in Pakistan. Addressing these challenges requires concerted efforts from policymakers, investors, and industry stakeholders to prioritize infrastructure development, improve regulatory frameworks, and invest in innovative solutions. By overcoming infrastructural constraints, Pakistan can unlock the full potential of fast-track construction as a driver of economic growth, job creation, and sustainable development.

VI. **Cultural Factors:** Cultural norms impacting work practices, such as working hours and holidays, do not align with the demands of fast-track construction schedules. Cultural factors play a significant role in shaping the implementation of fast-track construction within Pakistan's construction industry. One of the key cultural factors impacting fast-track construction is the prevalent emphasis on hierarchical structures and traditional modes of authority within organizations. In many Pakistani construction firms, decision-making authority is concentrated at the top, leading to bureaucratic inefficiencies, delays in approvals, and a lack of empowerment among lower-level employees. This hierarchical culture can impede the swift decision-making and agile responsiveness required for successful fast-track projects, as initiatives get stuck in layers of approval processes and bureaucratic red tape.

Moreover, Pakistan's collectivist culture, which prefers consensus-building over individual initiative and innovation, hindering the adoption of new construction methodologies and risk-taking behaviors associated with fast-track construction. Pakistan operates on a flexible time orientation, where punctuality and adherence to schedules is viewed with less urgency compared to cultures with a more monochronic approach to time. This cultural mindset can lead to challenges in enforcing strict project timelines and deadlines, as stakeholders may be more tolerant of delays and disruptions. Furthermore, Pakistan's diverse cultural landscape, encompassing various ethnicities and languages, can present communication barriers and interpersonal challenges within multi-stakeholder construction projects. Differences in communication styles and cultural norms hinders effective collaboration and coordination among project teams, aggravating the complexities of fast-track construction implementation.

Moreover, cultural attitudes towards risk and uncertainty impacts stakeholders' willingness to embrace fast-track construction methodologies. In a risk-averse culture where failure is often stigmatized, stakeholders may be reluctant to deviate from traditional construction practices and embrace the inherent uncertainties associated with fast-track projects as in case of Pakistan. This aversion to risk-taking behavior can impede innovation and experimentation, suppressing the adoption of more efficient and expedited construction techniques. Addressing these cultural barriers requires emphasizing participatory decision-making, fostering open communication channels, and promoting a culture of accountability and transparency which will help mitigate the impact of cultural factors on fast-track construction implementation.

VII. **Political Instability:** Political instability and changes in government policies can create uncertainty in the construction industry, affecting project timelines and investments. Political instability represents barrier to the successful implementation of fast-track construction within Pakistan's construction industry. The construction sector is highly susceptible to fluctuations in political stability, as government policies and investment environment significantly influence project timelines and funds availability. In Pakistan, where political uncertainty and governance challenges are regular, the impact of political instability on fast-track construction is very high. Changes in government leadership, shifts in policy priorities, and disruptions in legislative processes can lead to delays in project approvals, changes in regulatory requirements, and uncertainties in project financing and land acquisition.

Moreover, political unrest, protests, and security threats disrupt construction activities, jeopardizing the safety of personnel and hinder progress on fast-track projects.

Moreover, corruption aggravated by political instability can further impede the implementation of fast-track construction. In an environment where transparency and accountability are compromised, project timelines may be extended due to delays in obtaining permits, inflated costs resulting from bribery. Furthermore, political instability discourages foreign investment and private sector participation in the construction industry which is essential for fast-track projects. Investors and developers adopt a cautious approach in the face of uncertain political conditions, delaying their investment plans.

The lack of long-term policy continuity aggravated by political instability also hinders progress towards achieving national development goals. Addressing the impact of political instability on fast-track construction requires concrete efforts from government stakeholders and construction industry to promote stability, transparency, and good governance. Strengthening institutions, enhancing regulatory frameworks, and fostering public-private partnerships can help mitigate the risks associated with political instability and create an enabling environment for fast-track construction projects.

VIII. **Technology Adoption:** Limited adoption of advanced construction technologies and tools may impede efficiency gains that are critical for fast-track construction schedules. The adaptation of technology represents a critical determinant of success in the implementation of fast-track construction techniques within Pakistan's construction industry. Rapid advancements in construction technology, such as Building Information Modeling (BIM), advanced construction materials, drone technology, and digital project management tools, offer immense potential to streamline processes, enhance efficiency, and accelerate project delivery timelines.

However, in Pakistan, where the construction sector traditionally lacks in technology adoption compared to global standards, the impact of technology on fast-track construction implementation is multi-fold. The reluctance to embrace innovative technologies stems from various factors, including limited awareness, perceived cost barriers, and resistance to change within the industry. Many construction firms in Pakistan operate with outdated methods and conventional practices, resulting in inefficiencies, rework, and delays in project timelines. Additionally, the absence of a supportive system for technology innovation, technical standards, and skilled labor, poses challenges to the widespread adoption of technology in fast-track construction projects. Without clear guidelines and incentives for technology integration, construction firms may hesitate to invest in new tools and processes. However, the potential benefits of technology adoption in fast-track construction are immense. Digital technologies enable real-time collaboration, data-driven decision-making, and remote monitoring, allowing project teams to overcome geographical barriers and coordinate activities more effectively.

Advanced construction materials and prefabrication techniques reduce construction time, minimize waste, and enhance the quality and durability of the facility. Moreover, technologies such as drones and 3D printing offer innovative solutions for site surveying, construction monitoring, and building fabrication, further expediting project delivery and reducing costs. The adoption of technology also enhances safety standards by automating hazardous tasks, implementing predictive maintenance programs, and providing real-time insights into potential risks and hazards. Moreover, technology-driven approaches to project management, such as agile methodologies and lean construction principles, enable greater flexibility, adaptability, and responsiveness to changing project requirements, which are essential attributes for successful fast-track construction implementation.

To benefit from the full potential of technology in fast-track construction, Pakistan must prioritize investment in digital infrastructure, promote technology literacy and capacity-building initiatives, and incentivize technology adoption through policy and financial incentives. By embracing technology, Pakistan can overcome barriers to fast-track construction implementation.

IX. **Project Complexity:** Complex projects involving multiple stakeholders, complex designs, and unique requirements may not be suitable for fast-track techniques due to increased coordination and execution challenges. Project complexity poses a significant challenge to the successful implementation of fast-track construction techniques in Pakistan's construction industry. Fast-track construction projects often involve tight schedules and simultaneous activities to expedite project completion. However, complex projects with complex designs, specialized requirements, or challenging site conditions can complicate the fast-track process. Such complexity may arise from factors like the need for advanced engineering solutions, coordination with multiple stakeholders.

In Pakistan, where infrastructure development often faces bureaucratic hurdles and regulatory red tape, navigating these complexities becomes even more difficult. Moreover, the scarcity of skilled labor and technical expertise further aggravate the challenges associated with complex projects, as it becomes difficult to find qualified professionals capable of executing complex tasks within tight timelines. Additionally, unforeseen complexities during construction, such as encountering unforeseen geological conditions or environmental issues, can disrupt project schedules and escalate costs. Furthermore, the lack of standardized practices and inadequate project management strategies aggravate the impact of project complexity on fast-track construction initiatives.

To address this barrier, it is crucial for stakeholders in Pakistan's construction industry to invest in advanced planning, risk management, and project coordination techniques. Embracing innovative technologies like Building Information Modeling (BIM) and adopting collaborative project delivery methods such as Integrated Project Delivery (IPD) can help streamline processes and enhance communication among project teams. Moreover, investing in skills development and training programs can enhance the workforce's capacity to tackle complex construction projects efficiently.

X. **Stakeholder Alignment:** Lack of alignment among project stakeholders, including clients, consultants, contractors, and suppliers, can lead to coordination issues and delays in decision-making. Stakeholder alignment plays a critical role in the successful implementation of fast-track construction techniques in Pakistan's construction industry. Fast-track construction projects often require close collaboration and coordination among various stakeholders, including the government, developers, contractors, subcontractors, suppliers, and local communities. However, achieving alignment among these diverse stakeholders can be challenging due to differing interests, priorities, and expectations.

In Pakistan, where the construction industry is characterized by fragmented regulatory frameworks, bureaucratic inefficiencies, and a lack of standardized practices, achieving stakeholder alignment becomes even more complex. Disagreements over project objectives, scope, budget, and timelines can lead to delays, conflicts, and cost overruns, disrupting the feasibility and effectiveness of fast-track construction. Moreover, issues related to land acquisition, permits, and regulatory approvals further complicate stakeholder alignment, as delays in obtaining necessary clearances can disrupt project schedules and escalate costs. Additionally, the lack of transparency and communication channels worsen the challenges of stakeholder alignment, as stakeholders may feel excluded from decision-making processes or uninformed about project developments. To overcome these barriers, it is essential for stakeholders in Pakistan's construction industry to prioritize open dialogue, transparency, and mutual cooperation. Establishing formalized communication channels, such as regular project meetings and progress reports, can facilitate information sharing and foster trust among stakeholders.

Moreover, involving stakeholders in the project planning and decision-making process from the outset can help address concerns, build consensus, and mitigate conflicts. Embracing collaborative project delivery methods, such as Integrated Project Delivery (IPD) or Public-Private Partnerships (PPPs), can also promote stakeholder alignment by incentivizing shared risks and rewards. Furthermore, investing in capacity building and skills development programs can enhance stakeholders' ability to contribute effectively to fast-track construction projects. By fostering alignment among stakeholders and promoting a culture of collaboration and transparency, Pakistan can overcome the barriers to implementing fast-track construction technique.

XI. **Security Risks:** Security concerns, and regional conflicts can disrupt construction activities and pose risks to project continuity and completion. Security risks present challenging barriers to the implementation of fast-track construction techniques in Pakistan's construction industry. The country's instable political landscape, with frequent changes in government, policy uncertainty, and bureaucratic inefficiencies, creates an unstable environment for construction projects. Security risks, including terrorism, insurgency, and civil unrest, pose significant threats to construction projects, especially in regions affected by conflict or instability. Security concerns not only jeopardize the safety of workers and project personnel but also disrupt transportation networks, hinder material deliveries, and impede construction activities. In addition, the threat of extortion, vandalism, and sabotage further heightens security risks for construction projects, deterring investors and developers from undertaking fast-track construction initiatives. Furthermore, security risks can impact project financing and insurance arrangements, as lenders and insurers may perceive higher levels of risk associated with projects in security-challenged environments. Consequently, securing funding and insurance coverage becomes more difficult, delaying project commencement or leading to the cancellation of projects altogether. To mitigate these risks, stakeholders in Pakistan's construction industry must engage in comprehensive risk assessments and adopt robust risk management strategies. This includes conducting thorough due diligence on project sites, assessing security conditions, and developing contingency plans to address security challenges. Moreover, fostering partnerships with local communities, government agencies, and security forces can enhance project security and mitigate risks. Investing in security measures, such as surveillance systems, security personnel, and secure transportation routes, can also help safeguard construction projects from security threats. Additionally, advocating for political stability, regulatory reforms, and the rule of law is essential to create a conducive environment for construction investment and development.

XII. **Financial Constraints:** Financial constraints represent a significant impediment to the successful implementation of fast-track construction techniques in Pakistan's construction industry. Fast-track construction projects often require substantial upfront investments to accelerate timelines, procure materials and equipment, and mobilize the contractor. However, the availability of financial resources is often limited in Pakistan, where economic challenges and limited access to financing sources exist. This shortage of financial resources constrains the ability of developers and contractors to undertake fast-track projects, as they may lack the necessary capital to fund project activities and cover operational expenses. Moreover, the high cost of borrowing, along with the perceived risks associated with construction projects in Pakistan, further aggravate financial constraints, making it difficult to secure affordable financing from banks. Additionally, currency fluctuations and inflationary pressures can negatively impact project budgets and increase the cost of imported materials, adding to the financial burden faced by construction firms. Furthermore, delays in project payments and disputes over contract terms can worsen cash flow challenges, hindering the timely completion of fast-track endeavors. As a result, developers and contractors may be forced to scale down project scopes, compromise on quality, or seek alternative financing arrangements, all of which undermine the feasibility and effectiveness of fast-track construction initiatives. To address financial constraints, stakeholders in Pakistan's construction industry must explore innovative financing mechanisms and investment models tailored to the unique challenges of fast-track construction projects. This includes undertaking public-private partnerships (PPPs) to mobilize funding from diverse sources. Moreover, incentivizing private sector participation through tax incentives, subsidies, and risk-sharing mechanisms can encourage greater investment in fast-track construction projects. Additionally, improving access to financing for small and medium-sized enterprises (SMEs) and promoting microfinance initiatives can empower local contractors and suppliers to participate in fast-track projects. Furthermore, enhancing transparency and accountability in project financing and procurement processes is essential to build investor confidence and attract foreign investment in Pakistan's construction sector.

XIII. **Economic Instability:** Economic instability poses a significant barrier to the successful implementation of fast-track construction techniques in Pakistan's construction industry. The country's economy is prone to volatility, with fluctuations in GDP growth, inflation rates, currency values, and interest rates. These economic uncertainties create a challenging environment for construction projects, particularly those employing fast-track techniques that require steady financing and predictable market conditions. Economic instability can lead to reduced investor confidence, making it difficult to secure funding for construction projects. Moreover, fluctuations in currency values can increase the cost of imported materials and equipment, adding to project expenses and having cash flow problems. Inflation further worsens the financial burden and diminishes the purchasing power of stakeholders. Additionally, economic instability often results in reduced government spending on infrastructure projects, leading to delays or cancellations of planned construction projects. This further worsens the hurdles confronted by the construction sector, hindering the implementation of fast-track techniques.

Furthermore, economic instability can impact the availability of skilled labor and resources, as workers migrate to more stable industries or regions in search of better opportunities. This labor shortage can delay project timelines and increase labor costs, affecting the overall efficiency of fast-track construction projects. To mitigate the impact of economic instability, stakeholders in Pakistan's construction industry must adopt proactive strategies to manage risks. This includes promoting stability through sound macroeconomic policies, fiscal reforms, and investment incentives can create a conducive environment for construction investment and development. Strengthening institutional frameworks, enhancing transparency and governance, and improving regulatory certainty can also build investor confidence and attract foreign investment in the construction sector. Additionally, investing in infrastructure resilience and disaster preparedness measures can help mitigate the impact of economic shocks on projects related to construction. By addressing the hurdles posed by economic instability and implementing measures to enhance resilience, Pakistan can utilize the full potential of fast-track construction to drive economic growth, create jobs, and improve infrastructure quality.

XIV. **Project Management Challenges:** Project management challenges represent a significant impediment to the successful implementation of fast-track construction in Pakistan's construction industry. Fast-track construction projects are characterized by compressed timelines, complex coordination requirements, and heightened risk, all of which demand robust project management capabilities. However, Pakistan's construction industry faces numerous challenges in this regard, including inadequate project planning and scheduling, poor risk management practices, and limited project oversight and control. Insufficient upfront planning often results in incomplete project scopes, ambiguous requirements, and inadequate resource allocation, leading to delays, cost overruns, and quality issues during project execution.

Moreover, the construction industry in Pakistan, with multiple stakeholders involved in project delivery, complicates project coordination and communication, making it difficult to ensure alignment of objectives, resolve conflicts, and maintain accountability. Additionally, the shortage of skilled project managers and professionals with expertise in fast-track construction methodologies further aggravates project management challenges, as it becomes challenging to effectively oversee and coordinate project activities within accelerated timelines. Furthermore, the lack of standardized project management processes and tools hampers efficiency and consistency across projects, leading to inefficiencies and missed opportunities for improvement. To address these challenges, stakeholders in Pakistan's construction industry must prioritize investment in project management capacity building, training, and professional development. This includes promoting the adoption of best practices, industry standards, and innovative project management techniques tailored to the unique requirements of fast-track construction projects.

Additionally, adopting technology solutions such as Building Information Modeling (BIM), project management software, and real-time monitoring tools enhances project visibility, communication, and decision-making, facilitating more effective project management and control. Moreover, fostering a culture of collaboration, teamwork, and continuous improvement within project teams can help overcome solo approaches and promote a more integrated and proactive project management approach. Strengthening regulatory frameworks, enhancing project governance, and improving transparency and accountability in project delivery processes are also essential to address project management challenges and foster a more conducive environment for fast-track construction initiatives.

XV. **Resistance to Change:** Resistance to change poses a significant barrier to the successful implementation of fast-track construction techniques in Pakistan's construction industry. Fast-track construction requires a deviation from traditional approaches and a willingness to adopt innovative methodologies, technologies, and project delivery methods to accelerate project timelines and improve efficiency. However, the construction industry in Pakistan is often characterized by resistance to innovation, and reluctance to embrace change. This resistance can stem from various factors, including fear of the unknown, skepticism about new technologies, and resistance stemming from established routines and processes.

Moreover, cultural factors, organizational hierarchies, and communication barriers can further increase resistance to change, making it difficult to adopt fast-track construction. Additionally, stakeholders may perceive fast-track construction as risky and unfamiliar, leading to skepticism about its feasibility and effectiveness. Resistance to change can exist at various levels within the construction industry, including among project owners, developers, contractors, subcontractors, suppliers, and laborers, further complicating efforts to implement fast-track construction initiatives. To address resistance to change, stakeholders must prioritize change management strategies that focus on building awareness and encourage a culture of innovation and continuous improvement. This includes engaging stakeholders early in the process, communicating the rationale and benefits of fast-track construction, and addressing concerns and misconceptions through open dialogue.

Moreover, providing training and capacity building opportunities to equip stakeholders with the skills and knowledge necessary to embrace new technologies and methodologies can help overcome resistance to change. Announcing incentives and rewards for adopting fast-track construction practices can also motivate stakeholders to embrace change and actively participate in implementation efforts. Strengthening leadership commitment, providing visible support from senior management, and leading by example are also essential to build confidence and inspire confidence in fast-track construction initiatives.

XVI. **Supply Chain Issues:** Supply chain issues pose significant challenges to the implementation of fast-track construction techniques in Pakistan's construction industry. The construction sector relies heavily on a complex network of suppliers, manufacturers, and distributors to procure materials and equipment necessary for project execution. However, in Pakistan, supply chain inefficiencies such as delays in material delivery, shortages, and unreliable transportation systems severely disrupt construction timelines and impede the rapid progress required for fast-track projects. Limited availability of specialized construction materials and reliance on imported goods further aggravate supply chain vulnerabilities, making projects susceptible to delays and cost overruns.

According to PCRA (Pakistan Credit Rating Agency), the machinery required for large construction projects is mostly imported. In 2022, due to the shortage of foreign currency reserves, the State Bank of Pakistan on the directions of the Government put a ban on the opening of LCs (Letter of Credit) thus curtailing the imports which led to supply chain issues in all sectors in general and the construction industry in particular. Moreover, bureaucratic red tape, customs clearance procedures, and infrastructure deficiencies contribute to logistical bottlenecks that hinder the timely delivery of materials to construction sites. Additionally, fluctuations in exchange rates and economic instability can impact the cost of imported materials, further complicating procurement processes and affecting project budgets. These supply chain challenges not only result in project delays but also increase construction costs, eroding profit margins and undermining the feasibility of fast-track construction initiatives.

Furthermore, supply chain disruptions can lead to subcontractor disputes, contractual disputes, and problems with clients, spoiling the reputation of construction firms and endangering future investment in the industry. To mitigate these barriers and facilitate the successful implementation of fast-track construction techniques, it is essential for Pakistan's construction industry to address supply chain issues through strategic planning and investment in infrastructure. The fast-track construction cannot afford such delays, due to which the local and the foreign investors are reluctant to invests in such finance intensive projects such as fast-track projects.

XVII. **Lack of Safety Regulations:** The lack of safety regulations presents a significant barrier to the successful implementation of fast-track construction techniques in Pakistan's construction industry. Without strict safety regulations in place, construction projects are prone to accidents, injuries, and even fatalities, leading to disruptions in project timelines and increased costs. Fast-track construction often involves accelerated schedules and simultaneous activities, which heightens the risk of accidents if proper safety measures are not enforced. The absence of comprehensive safety regulations not only jeopardizes the well-being of workers but also undermines the overall efficiency and productivity of construction projects.

Moreover, the lack of safety regulations shakes investor confidence and hinders foreign investment in the construction sector, as reputable firms may be reluctant to engage in projects in an environment where worker safety is not adequately protected. Additionally, the absence of safety standards lead to a higher occurrence of accidents and injuries, resulting in delays, legal disputes, and reputational damage for construction companies. Furthermore, the lack of safety regulations enforces a cycle of underdevelopment in the construction industry, as resources that could be allocated towards improving safety practices are instead diverted to address the consequences of accidents and injuries. This not only increases project costs but also undermines the overall competitiveness in the construction industry.

So as to overcome this barrier and facilitate successful implementation of fast-track construction techniques, it is imperative for Pakistan's construction industry to prioritize the establishment and enforcement of robust safety regulations. This includes investing in training programs, implementing safety protocols, and conducting regular inspections to ensure compliance with safety standards. By prioritizing worker safety and implementing comprehensive safety regulations, Pakistan can create a conducive environment for fast-track construction projects.

XVIII. **Lack of Contractual Framework:** Not only Pakistan but the construction industries worldwide suffer from lack of adequate contractual provisions that specifically deal with complex nature of fast-track projects. The absence of a robust contractual framework specifically tailored for fast-track construction projects significantly impedes the successful implementation of fast-track techniques in Pakistan's construction industry. A well-defined contractual framework is essential for mitigating risks, establishing clear project objectives, and facilitating effective collaboration among project stakeholders. Without such a framework, the unique challenges and complexities associated with fast-track projects, including accelerated timelines and overlapping design-construction phases, are not adequately addressed, leading to increased uncertainties and disputes.

One of the primary obstacles arising from the absence of a tailored contractual framework is the ambiguity in project scope and responsibilities.

In fast-track construction, project requirements and design specifications often evolve rapidly, necessitating flexibility and adaptability from all parties involved. Without a comprehensive contract that clearly delineates project scope, timelines, and deliverables, stakeholders encounter difficulties in managing and resolving conflicts related to scope changes and design modifications. This ambiguity can lead to inefficiencies, delays, and cost overruns, ultimately hampering the feasibility of fast-track implementation.

Furthermore, the absence of a specific contractual framework for fast-track construction increases the risks associated with project scheduling and coordination. Fast-track projects require close coordination and integration of design and construction activities to expedite project timelines effectively. However, without contractual provisions that address scheduling constraints, critical milestones, and coordination protocols, stakeholders struggle to synchronize their efforts and align project timelines. This can result in disruptions, conflicts, and delays, compromising the overall success of fast-track initiatives. Additionally, the absence of a tailored contractual framework hinders risk management and allocation strategies in fast-track projects. Fast-track construction inherently involves heightened risks due to compressed schedules, concurrent activities, and dependencies on timely material deliveries. A robust contractual framework should outline risk allocation mechanisms, dispute resolution procedures, and contingency plans to address unforeseen challenges and mitigate potential liabilities. Without such provisions, stakeholders may hesitate to embrace fast-track construction.

Moreover, the absence of a standardized framework for fast-track construction contracts undermines confidence and trust among project participants. Clear and enforceable contractual terms ensure transparency, accountability, and mutual understanding of project objectives and expectations. In the absence of a structured framework, stakeholders may resort to informal arrangements, leading to contractual disputes that impede project progress.

To overcome these challenges, efforts are needed to develop and implement a comprehensive contractual framework tailored specifically for fast-track construction projects in Pakistan. This framework should incorporate provisions that address the unique requirements and complexities of fast-track delivery methods. In conclusion, the absence of a robust framework for contractual obligations for fast-track construction projects poses significant impediments to the successful implementation of fast-track techniques in the construction sector of Pakistan. By prioritizing the development and adoption of tailored contractual frameworks, policymakers and industry stakeholders can enhance project efficiency, minimize risks, and promote confidence in adopting innovative and accelerated project delivery methods.

XIX. **Corrupt Practices:** Corrupt practices have long plagued Pakistan's construction industry, posing significant impediments to the successful implementation of fast-track construction techniques. The widespread nature of corruption within the construction industry undermines the efficiency, transparency, and effectiveness of project execution. One of the primary ways corruption hampers fast-track construction is through the distortion of procurement processes. Bribery, kickbacks, and favoritism often influence the selection of contractors and suppliers, sidelining those who may offer superior expertise or technology for rapid construction. Consequently, projects are awarded to incompetent or unqualified firms, leading to delays, cost overruns, and compromised quality. Moreover, corrupt practices inflate project costs as contractors factor in bribes and kickbacks into their bids, resulting in reduced project feasibility.

Additionally, corruption breeds a culture of exemption from punishment, where accountability mechanisms are weakened, and oversight bodies are susceptible to manipulation. This lack of accountability further encourages corrupt people to engage in fraudulent practices, aggravating the challenges faced in implementing fast-track construction projects. Furthermore, corruption undermines trust and confidence in the construction sector, stopping potential investors. This lack of trust hampers collaboration and innovation, which are essential for successful application of fast-track technology that requires close coordination and seamless integration of various stakeholders. Ultimately, the corrupt practices within Pakistan's construction industry not only impedes the adoption of fast-track construction but also encourages a cycle of inefficiency, distrust, and underdevelopment that hampers progress and hinders the country's socio-economic growth.

## 5.3 Summary of the Chapter

In conclusion, the implementation of fast-track construction techniques in Pakistan's construction industry faces a multitude of complex impediments that span regulatory, technical, financial, and cultural dimensions. These challenges collectively contribute to the reluctance and difficulty in adopting accelerated project schedules that overlap design and construction phases. Addressing these impediments requires a holistic approach that encompasses regulatory reforms, investment in human capital development, enhancement of infrastructure, and promotion of technology adoption. Streamlining regulatory processes, establishing clear and standardized building codes, and fostering a conducive business environment are imperative to incentivize stakeholders to embrace fast-track construction practices. Moreover, investing in skills development programs, promoting collaboration between academia and industry, and facilitating knowledge transfer will help bridge the skills gap and build a competent workforce capable of executing accelerated projects. In summary, while the concept of fast-track construction holds immense potential for expediting project delivery and enhancing productivity, its successful implementation in Pakistan's construction industry is contingent upon overcoming multifaceted impediments. By addressing regulatory, technical, financial, and cultural challenges through targeted interventions and collaborative efforts, stakeholders can pave the way towards a more efficient and resilient construction sector capable of meeting the evolving demands of urbanization and infrastructure development in Pakistan.

# Chapter 6

# Conclusions and Recommendations

## 6.1 General

The imperative to innovate and streamline processes has become increasingly paramount, particularly in the realm of fast-track high-rise building development. Throughout this dissertation, the research has explored the complex dynamics of the multifaceted domain of fast-track construction, navigating through the complexities inherent in decision-making processes. From the inception of this research endeavor, the goal has been to develop a robust decision-making model that not only addresses the exigencies of fast-track construction but also harnesses the power of Structural Equation Modelling (SEM) to furnish actionable insights and enhance project outcomes. At the culmination of this research, the final chapter serves as a synthesis of recommendation, conclusions and future directions, offering a a comprehensive section for concluding the analysis and empirical investigation. In this pivotal phase, this research document not only reflects upon the key insights garnered throughout this exploration but also elucidates avenues for future research and implementation. Through a comprehensive examination of the intricacies involved in fast-track high-rise building development, this chapter endeavors to distill actionable recommendations and logical conclusions that hold the potential to transform industry practices.

## 6.2 Conclusions

As the construction industry continues to evolve, fueled by technological innovation and shifting market dynamics, the need for adaptive and data-driven decision-making approaches have become increasingly pronounced. This research commenced with a thorough review of existing literature, which laid the foundation for understanding the complexities and challenges inherent to the decision-making process on fast-track high-rise construction projects. The literature review revealed that the construction industry lacks a comprehensive decision-making model for fast-track high-rise building construction which was later confirmed by field interviews with construction industry experts. Subsequently, this research identified key decision-making aspects, including project management practices, stakeholder engagement, technological integration, regulatory compliance, and fast-track strategies. The main aim of this research was to develop a decision-making model tailored specifically for fast-track high-rise building construction. Utilizing Structural Equation Modeling (SEM) as the methodological framework, this research endeavored to address three primary objectives: identifying and ranking critical decision-making aspects, developing a 3Cs oriented decision-making model, and uncovering the impediments to the implementation of the fast-track approach within Pakistan's construction industry. Through rigorous analysis and empirical validation, this research has yielded valuable insights that hold significant implications for practitioners, policymakers, and researchers within the construction sector. Further, this research sought to provide a comprehensive understanding of the intricate interplay between various decision-making aspects influencing the success and efficiency of fast-track projects in terms of time variance, cost variance, quality variance and scope variance which constituted the latent variables in the model with time variance as the target latent variable. 47 decision-making aspects were identified from the literature which constituted the observed variables in the model. 159 respondents took part in the survey. The demographic analysis revealed that the research participants were thoroughly abreast with the decision-making dynamics as well as the impediments of fast-track construction. Most of the participants were engaged with contractors and majority of the respondents had a bachelors degree in Civil Engineering with experience more than 10 years in fast-track construction in Pakistan and abroad. The 47 identified decision-making aspects were ranked using the Relative Importance Index (RII) as per the perception of the respondents. The results of RII showed that early contractor involvement, scope freeze approach, project delivery method selection, early procurement of long-lead-time items and over-designing the facility were the five most important decisions on fast-track construction from the viewpoint of client, contractors, and consultants.

Building upon the insights into the critical decision-making aspects, this research proceeded to develop a comprehensive decision-making model tailored to the unique context of fast-track high-rise projects in Pakistan. Central to this model was the integration of the 3C's framework, which emphasized the collaborative dynamics among Clients, Contractors, and Consultants. Through the application of SEM techniques, this research operationalized this framework, quantitatively assessing the causal relationships and interdependencies among various decision-making aspects influencing project success. Our model not only provided stakeholders with a systematic framework for decision-making but also enabled them to anticipate potential bottlenecks, optimize resource allocation, and ensure project success.

This novel decision-making model highlights the interplay between time, cost, quality and scope variances and also highlights the impact of each decision on time, cost, quality and scope variances on fast-track projects. By applying SEM to a rich dataset comprising of real-world project data, this research constructed a hypothesized model encapsulating the intricate relationships among the observed variables and the latent variables. 7 hypotheses were developed out of which 5 were direct hypothesis whereas two were indirect hypothesis (mediation analysis). All the hypotheses were statistically significant revealing that variations in cost, quality and scope have significant contribution towards variations in project duration. Moreover, variations in project scope and cost have direct, strong positive association with variations in project duration whereas deterioration in project quality has weak adverse relation with variations in project durations. The mediation analysis shows that variations in project cost mediate a significant impact of project scope and project quality variations on variations of project duration.

The outer loadings in the model reveal that how well a decision-making aspect loads on to its parent construct. The model output indicates that deciding the optimal degree of overlap between the activities, selecting the most suited project delivery method and compliance to safety regulations are most important decisions for shortening the project duration on fast-track projects. From project cost variation point of view, organizational restructuring and over-designing the facility are the decisions that effectively capture the underlying theoretical concepts. From scope variation point of view, adopting the scope freeze approach and early involvement of the contractor in the design phase are two most crucial decisions. Lastly, early engagement of O&M team and constructability review are the decisions that consistently reflects the underlying quality variation construct.

Moreover, the coefficient of determination in the SEM model revealed that 64.4% of the variance in project cost is attributed to the variance in project scope and quality and 62.1% of the variance in project duration is attributable to variances in project scope, quality, and cost. The predictive relevance of the model was established using $Q^2$, RMSE, MAE and CVPAT which revealed that the model has high out-of-sample predictability which makes it a universally applicable model. The IPMA results showed that scope variance related decisions have the highest importance and performance when it comes to reducing project duration and quality related decisions hold the least priority however, the decision-makers need to concentrate more on the project cost related decisions. The IPMA results show that the most important and highest performing decisions were early involvement of the contractor in design phase, adopting scope freeze approach at early design stage, early procurement of long-lead-time items and client authorizing Extras which are almost similar to RII results.

In addition to developing a decision-making model, this research sought to unpack the challenges and impediments hindering the widespread adoption of the fast-track approach within Pakistan's construction industry. Through in-depth interviews with key stakeholders, this research uncovered a myriad of obstacles spanning regulatory constraints, resource limitations, security concerns, financial and economic concerns, supply chain and contractual issues, corruption, technological issues, resistance to change, stakeholder alignment, political instability and cultural factors. These impediments not only underscored the complexity of the construction ecosystem but also highlighted the need for targeted interventions and policy reforms to facilitate the seamless implementation of fast-track methodologies.

The implications of this research extend beyond theoretical canvas, offering actionable insights for practitioners seeking to navigate the intricacies of fast-track high-rise projects in Pakistan. This decision-making model serves as a valuable tool for project managers, developers, and policymakers, providing them with a systematic framework for enhancing project efficiency and efficacy. By embracing the collaborative ethos of the 3Cs framework and leveraging the predictive capabilities of SEM, stakeholders can proactively identify potential challenges, optimize resource allocation, and foster a culture of transparency and accountability within project teams.

This model is a game-changer for Pakistan's construction industry, especially when it comes to building high-rise buildings faster and more efficiently. In simple terms, apart from client, contractors and consultants, it even assists the layman in making smarter choices to ensure that buildings are completed on time and within budget. In Pakistan, construction projects often face delays and cost overruns, which can be frustrating for everyone. This model offers a clear guide on how to avoid those problems by focusing on key decisions, such as choosing the right contractors early, deciding the project details in advance, and ensuring that materials are available when needed. It also helps identify common problems that slow down construction, such as poor planning or unexpected hurdles, and suggests ways to overcome them. By applying this model, Pakistans construction industry can build more quickly, reduce costs, and deliver better results, ultimately helping to meet the growing demand for buildings in cities across the country. This not only improves the construction process but also supports economic growth, as faster and more efficient buildings mean more job opportunities and better infrastructure for everyone.

Furthermore, the findings of this research have important implications for policymakers and researchers seeking to promote innovation and sustainability within Pakistan's construction industry. By addressing the systemic impediments hindering the adoption of fast-track methodologies, policymakers can create an enabling environment conducive to investment, innovation, and growth. Moreover, this research underscores the need for ongoing collaboration and knowledge exchange within the research community, fostering a culture of interdisciplinary inquiry and empirical validation to drive positive change within the construction sector. Findings underscored the pivotal role of effective project management practices in driving project success, highlighting the significance of clear communication, strategic planning, and proactive risk mitigation strategies. Furthermore, the integration of advanced technologies emerged as a critical enabler for enhancing project efficiency and reducing time-to-market.

In essence, this research serves as a beacon guiding practitioners and researchers towards a future where fast-track high-rise projects are not only feasible but thrive in an environment characterized by efficiency, sustainability, and excellence. The implications of our research extend beyond theoretical domain, offering tangible benefits for practitioners and industry stakeholders involved in fast-track high-rise construction projects. Our decision-making model serves as a valuable tool for guiding project managers, contractors, and developers in navigating the multi-faceted decision-making challenges inherent in such endeavors. From a practical standpoint, this research underscores the imperative of embracing technological innovations to augment project efficiency and ensure project success. By harnessing cutting-edge tools such as Building Information Modeling (BIM), stakeholders can unlock new opportunities for optimization and value creation throughout the project lifecycle. In conclusion, this research represents a significant contribution to the field of construction management by offering a robust decision-making model tailored specifically for fast-track high-rise building construction. By integrating insights from diverse disciplines and leveraging advanced analytical techniques, this research provided stakeholders with a powerful toolkit for navigating the complexities of decision-making in a rapidly evolving environment. Basics of the model are universally applicable which can be adapted to other regions to have the respective outcomes. The output of the model in this study will be applicable to construction industry of the developing countries.

## 6.3 Recommendations

Based on the insights extracted from the comprehensive investigation into the development of a decision-making model for fast-track high-rise buildings using Structural Equation Modelling (SEM), several recommendations emerge to guide practitioners, stakeholders, and researchers in the construction engineering domain. Firstly, it is imperative to foster a culture of collaboration and knowledge-sharing among all construction stakeholders. This collaborative culture serves as the bedrock for informed decision-making, ensuring that diverse perspectives are integrated into the process. Additionally, the integration of advanced technologies, such as Building Information Modeling (BIM) and data analytics, can augment the efficacy of decision-making models by providing real-time insights and predictive analytics. Moreover, this research underscores the importance of incorporating risk assessment and mitigation strategies into decision-making frameworks, thereby enhancing project resilience and mitigating potential setbacks. Furthermore, continuous monitoring and evaluation mechanisms should be instituted to assess the efficacy of decision-making models in real-world scenarios, facilitating iterative improvements and refinements. Lastly, it is recommended to dissemination of the findings of this research and the adoption of this decision-making model within the wider construction engineering community, fostering innovation and excellence in fast-track high-rise building development.

## 6.4 Future Directions

While this study represents a significant step forward in advancing the state of knowledge in fast-track high-rise construction projects in Pakistan, several avenues for future research warrant exploration. Firstly, longitudinal studies tracking the implementation and impact of this decision-making model on real-world projects could provide valuable insights into its efficacy and scalability over time. Additionally, further research into emerging technologies and their potential applications within the Pakistani construction industry could unlock new opportunities for innovation and optimization. Moreover, investigating the cultural and institutional factors shaping decision-making processes within project teams could deepen our understanding of the socio-cultural dynamics underpinning project success. Additionally, further investigation into emerging technologies and their potential applications within the construction industry could uncover new avenues for innovation and optimization. From the adoption of Artificial Intelligence (AI) and robotics to the integration of sustainable building practices, there exists a rich landscape of opportunities to enhance the resilience and sustainability of high-rise construction projects. Furthermore, exploring the influence of external factors such as socio-economic trends, geopolitical developments, and environmental regulations on project dynamics could enrich our understanding of the broader context within which these projects operate.

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# Appendix-A

| Name | No | Type | Missing Value | Mean | Median | Scale min | Scale max | Observed min | Observed max | Standard deviation | Excess kurtosis | Skewness | Cramér-von Mises p value |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SV-1 | 0 | MET | 0 | 3.61 | 4 | 1 | 5 | 1 | 5 | 1.288 | -0.942 | -0.523 | 0.00 |
| SV-2 | 1 | MET | 0 | 3.465 | 4 | 1 | 5 | 1 | 5 | 1.368 | -1.134 | -0.41 | 0.00 |
| SV-5 | 2 | MET | 0 | 3.352 | 4 | 1 | 5 | 1 | 5 | 1.313 | -1.238 | -0.221 | 0.00 |
| SV-9 | 3 | MET | 0 | 2.925 | 3 | 1 | 5 | 1 | 5 | 1.376 | -1.322 | -0.038 | 0.00 |
| SV-10 | 4 | MET | 0 | 3.314 | 4 | 1 | 5 | 1 | 5 | 1.388 | -1.154 | -0.365 | 0.00 |
| TV-7 | 5 | MET | 0 | 2.792 | 3 | 1 | 5 | 1 | 5 | 1.269 | -1.169 | 0.025 | 0.00 |
| TV-8 | 6 | MET | 0 | 2.673 | 2 | 1 | 5 | 1 | 5 | 1.325 | -1.069 | 0.326 | 0.00 |
| TV-10 | 7 | MET | 0 | 2.635 | 2 | 1 | 5 | 1 | 5 | 1.425 | -1.216 | 0.388 | 0.00 |
| TV-11 | 8 | MET | 0 | 3.025 | 3 | 1 | 5 | 1 | 5 | 1.453 | -1.418 | -0.019 | 0.00 |
| TV-12 | 9 | MET | 0 | 2.893 | 3 | 1 | 5 | 1 | 5 | 1.421 | -1.361 | 0.111 | 0.00 |
| TV-13 | 10 | MET | 0 | 2.579 | 2 | 1 | 5 | 1 | 5 | 1.56 | -1.477 | 0.385 | 0.00 |

| (Name | No | Type | Missing Value | Mean | Median | Scale min | Scale max | Observed min | Observed max | Standard deviation | Excess kurtosis | Skewness | Cramér-von Mises p value |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| QV-1 | 11 | MET | 0 | 3.447 | 4 | 1 | 5 | 1 | 5 | 1.528 | -1.33 | -0.453 | 0.00 |
| QV-2 | 12 | MET | 0 | 2.484 | 2 | 1 | 5 | 1 | 5 | 1.391 | -1.236 | 0.429 | 0.00 |
| QV-9 | 13 | MET | 0 | 2.906 | 3 | 1 | 5 | 1 | 5 | 1.453 | -1.344 | 0.091 | 0.00 |
| QV-10 | 14 | MET | 0 | 3.321 | 3 | 1 | 5 | 1 | 5 | 1.338 | -1.17 | -0.207 | 0.00 |
| QV-11 | 15 | MET | 0 | 3.182 | 3 | 1 | 5 | 1 | 5 | 1.378 | -1.198 | -0.216 | 0.00 |
| QV-12 | 16 | MET | 0 | 2.899 | 3 | 1 | 5 | 1 | 5 | 1.433 | -1.393 | -0.042 | 0.00 |
| QV-13 | 17 | MET | 0 | 3.39 | 4 | 1 | 5 | 1 | 5 | 1.336 | -1.025 | -0.377 | 0.00 |
| CV-1 | 18 | MET | 0 | 2.491 | 2 | 1 | 5 | 1 | 5 | 1.228 | -0.553 | 0.68 | 0.00 |
| CV-2 | 19 | MET | 0 | 3.182 | 3 | 1 | 5 | 1 | 5 | 1.364 | -1.244 | -0.14 | 0.00 |
| CV-3 | 20 | MET | 0 | 2.346 | 2 | 1 | 5 | 1 | 5 | 1.317 | -0.377 | 0.872 | 0.00 |
| CV-6 | 21 | MET | 0 | 2.931 | 3 | 1 | 5 | 1 | 5 | 1.406 | -1.293 | 0.097 | 0.00 |
| CV-7 | 22 | MET | 0 | 3.409 | 4 | 1 | 5 | 1 | 5 | 1.45 | -1.327 | -0.329 | 0.00 |

# Appendix-B

Appendix - B

Department of Civil Engineering

# 3C's Decision-Making Model for Fast-track High-Rise Buildings Using Structural Equation Modelling

(QUESTIONNAIRE)

Mustafa Sultan, Ph.D Scholar (DCE-203002)

Time is one of the most important indicator of project success. Worldwide consultants in general, and clients and contractors in particular endeavor to deliver the project in the least possible duration so that the commissioning phase can commence at the earliest. Early project completion is a requirement mostly set by the client which is made possible by the efforts of the project stakeholders. Although there are a number of ways to compress the project schedule, however, fast-track is a technique being widely implemented in the developed countries since 1960s. Fast-track technique is the overlapping of project activities/ phases that are normally/ traditionally performed in a sequence. The literature and the construction industry mostly suggest overlapping the design and construction phases however other phases can also be overlapped. According to the industry experts, the decision-making on fast-track projects is an aspect which becomes crucial under time constrained environment.

In this regard, I am conducting research in order to develop a decision-making model for the clients, contractors and the consultants (3 C's) on fast-track high-rise building projects in Pakistan. This decision-making model will be developed using a statistical technique called Structural Equation modeling which will confirm or reject the significance of each decision-making aspect on fast-track building projects on the global success indicators i.e time, cost, quality and scope variances. This research will contribute towards implementation of fast-track technique in Pakistan's construction industry.

With above in view, I am administering a research questionnaire which comprises of three parts i.e demographic information, general information and the decision-making aspects. The first part requires information about the respondent which will be used only for research purposes. The second part requires the respondent to give general information on their familiarity with fast-track technique and the third part consists of the fast-track decision-making aspects in which you are requested to rate the impact of each decision-making aspect on time, cost, quality and scope variances.

I shall be highly obliged if you can spare some time and share your valuable feedback on fast-tracking high-rise buildings in Pakistan.

**Part 1:** **DEMOGRAPHICAL DATA AND GENERAL INFORMATION:**

**Generic:**

1. **Name**……………………………………………………………………….(Optional)

2. **Gender**

o Male o Female

3. **Age**

o 20-30 o 31-40 o 41-50 o Above 50

4. **Qualification**

o Diploma (Civil) o BS Civil Engineering o Masters (Civil)
o PhD (Civil) o Others……………………………………. (Please Specify)

5. **Type of firm**

o Consultant o Contractor o Client o Other……...(Please Specify)

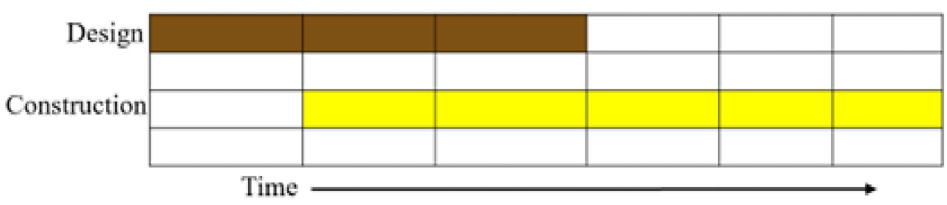
6. **Working experience**

o 1-10 years o 11-15 years o 16 -20 years o More than 20 years

7. **Designation**……………………………………………………….

**Part 2:**

**Fast-Track**. It is the process of overlapping two or more activities which traditionally follow a finish to start sequence. Activities that are normally executed in a sequence, are performed in parallel. In fast-tracking, the activities are overlapped such as design and construction rather than doing it in a sequence. The sole purpose of fast-tracking is to compress the project schedule to save time and meet the project deadlines.




1. Are you familiar with the concept of fast-tracking? Yes No
2. Have you ever done a project in which the design was incomplete, and construction was started? Yes No
3. In your opinion what %age of design should be complete before one can confidently allow the construction to start?___________________

4. How long does it take to completely design a 14 Storey or 50 Meters and above buildings? (Consultants only) ________________________________________

**Part 3:**

Keeping in view your experience please evaluate the impact of the following decision-making aspects on the success of fast-track approach in terms of cost variance, time variance, scope variance (change/ variation orders and addenda) and the impact of quality optimization decisions on quality variance (reworks etc ) by ticking the relevant box keeping in mind Pakistan's construction industry.
(5) represents **very high impact**, (4) represents **high impact**, (3) represents **Moderate impact**, (2) represents **Low impact**, (1) represents **very low impact**.

| **S/No** | **Fast-Track Decision-Making Aspects** | **Code** | **TIME VARIANCE** | | | | |
|---|---|---|---|---|---|---|---|
| | | | **5** | **4** | **3** | **2** | **1** |
| 1 | Early contract award for enabling works | **TV-1** | | | | | |
| 2 | Adopt Pre-fabrication/ Modularization | **TV-2** | | | | | |
| 3. | Adopting Fast-track on complex buildings | **TV-3** | | | | | |
| 4. | Apply Fast-track to critical path rather than non-critical | **TV-4** | | | | | |
| 5. | Project stage at which the decision to fast-track is made | **TV-5** | | | | | |
| 6 | Adapting an effective dispute resolution technique | **TV-6** | | | | | |
| 7 | Securing Early Permits/ Approvals | **TV-7** | | | | | |
| 8. | Adopt Relational Approaches (Partnering, IPD & Alliancing) | **TV-8** | | | | | |
| 9. | Impose penalties for delays | **TV-9** | | | | | |
| 10. | Decide the optimal degree of overlap between activities | **TV-10** | | | | | |
| 11. | Compliance with site safety regulations | **TV-11** | | | | | |
| 12. | Selecting the most suited project delivery method (DB, CM, EPC) | **TV-12** | | | | | |
| 13. | Announce incentives for early completion | **TV-13** | | | | | |
| | **Fast-Track Decision-Making Aspects** | | **COST VARIANCE** | | | | |
| | | | **5** | **4** | **3** | **2** | **1** |
| 1. | Decision on Owner's financial capacity | **CV-1** | | | | | |
| 2. | Early Procurement of Long-Lead-Time Items | **CV-2** | | | | | |
| 3 | Adopt an appropriate contractual strategy | **CV-3** | | | | | |
| 4 | Limit the cost impact due to fast-track to 120% compared to traditional construction | **CV-4** | | | | | |
| 5. | Use Prototyping (Scaled-down models) | **CV-5** | | | | | |
| 6. | Organizational restructuring (Experienced Team) | **CV-6** | | | | | |
| 7. | Over-designing the facility | **CV-7** | | | | | |
| 8 | Implement an effective Resource Management Plan | **CV-8** | | | | | |
| 9. | Sufficient contingency allocations | **CV-9** | | | | | |
| 10. | Implement an effective Risk Management Plan | **CV-10** | | | | | |
| 11. | Conduct Cost/Benefit analysis (Financial Feasibility) | **CV-11** | | | | | |

Appendix - B

| **S/No** | **Fast-Track Decision-Making Aspects** | **Code** | **QUALITY VARIANCE** | | | | |
|---|---|---|---|---|---|---|---|
| | | | **5** | **4** | **3** | **2** | **1** |
| 1. | Adopt BIM based Fast-track Approach | **QV-1** | | | | | |
| 2. | Delegate Authority to Project Level | **QV-2** | | | | | |
| 3. | Retain Design and Interface Management Responsibilities | **QV-3** | | | | | |
| 4. | Decide the acceptable quality compromise extent on fast-track project preferably not less than 90% | **QV-4** | | | | | |
| 5. | Limiting the design optimization process | **QV-5** | | | | | |
| 6. | Implement Value Engineering | **QV-6** | | | | | |
| 7. | Implement Lean Construction | **QV-7** | | | | | |
| 8. | Decide between the potential time savings due to overlapping and the amount of expected reworks | **QV-8** | | | | | |
| 9. | Quality Management Plan submission in pre-design stage | **QV-9** | | | | | |
| 10. | Early engagement of O&M team in the design process | **QV-10** | | | | | |
| 11. | Implement Front-End-Engineering Design (FEED) | **QV-11** | | | | | |
| 12. | Conduct constructability review during planning or design phase | **QV-12** | | | | | |
| 13 | Adopt contractor pre-qualification Strategy | **QV-13** | | | | | |
| | **Fast-Track Decision-Making Aspects** | | **SCOPE VARIANCE** | | | | |
| | | | **5** | **4** | **3** | **2** | **1** |
| 1. | Implement an effective Change Management Plan | **SV-1** | | | | | |
| 2. | Client Authorizing “Extras” | **SV-2** | | | | | |
| 3 | Early scope definition at conceptual or design stage | **SV-3** | | | | | |
| 4 | Apply fast-track to commercial building (which are time critical & High profit) rather than residential | **SV-4** | | | | | |
| 5. | Implement effective communication mechanism | **SV-5** | | | | | |
| 6. | Implement Interface Management Plan | **SV-6** | | | | | |
| 7. | Implement an effective Scope Management Plan | **SV-7** | | | | | |
| 8. | Implement Front-End-Planning (FEP) | **SV-8** | | | | | |
| 9. | Early involvement of the contractor in design phase | **SV-9** | | | | | |
| 10. | Adopt scope freeze approach at early design stage | **SV10** | | | | | |

Additional remarks (if any)

______________________________________________________________________

______________________________________________________________________

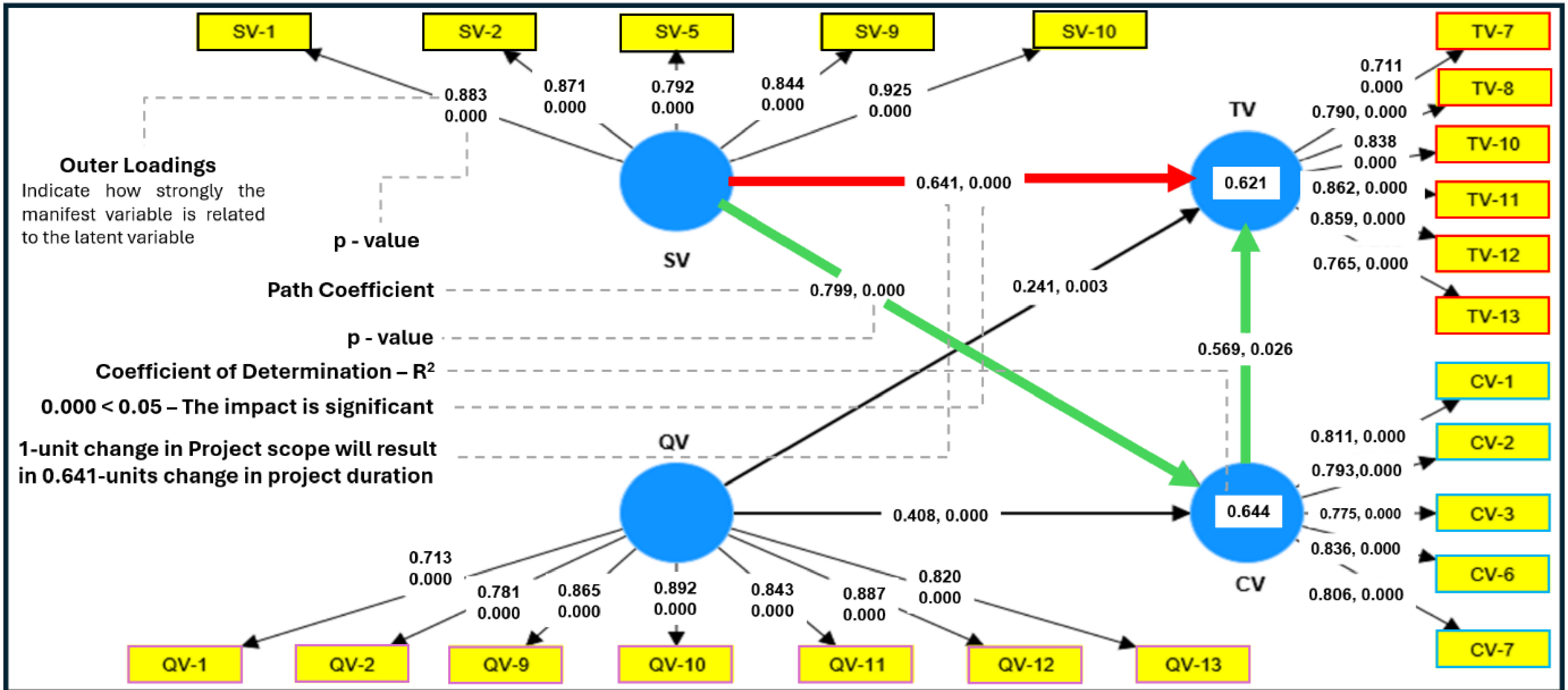
______________________________________________________________________

______________________________________________________________________

______________________________________________________________________

______________________________________________________________________

# Appendix-C




**LEGEND** **Final Modified Decision-making Model for Fast-track High-Rise Buildings**

**Latent Variables:**
TV – Time Variance QV – Quality Variance
SV – Scope Variance CV – Cost Variance

**Manifest Variables:** Decision-making aspects

**Hypothesis** (Direct Impact) SV – TV

**Mediation Analysis** (Indirect impact of SV on TV through CV)

Appendix - C