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Delay Analysis and Mitigation Strategies in Urban Infrastructure Projects

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To

the APJ Abdul Kalam Technological University

in partial fulfillment of the requirements for the award of the Degree

of

Master of Technology

In

Structural Engineering and Construction Management

Department of Civil Engineering

Indira Gandhi Institute of Engineering & Technology

Kothamangalam

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DECLARATION

I undersigned hereby declare that the project report "Delay Analysis and Mitigation Strategies in Urban Infrastructure Projects", submitted for partial fulfillment of the requirements for the award of degree of Master of Technology of the APJ Abdul Kalam Technological University, Kerala is a bonafide work done by me under supervision of Geethika G Pillai (Project guide).This submission represents my ideas in my own words and where ideas or words of others have been included, I have adequately and accurately cited and referenced the original sources. I also declare that I have adhered to ethics of academic honesty and integrity and have not misrepresented or fabricated any data or idea or fact or source in my submission. I understand that any violation of the above will be a cause for disciplinary action by the institute and/or the University and can also evoke penal action from the sources which have thus not been properly cited or from whom proper permission has not been obtained. This report has not been previously formed the basis for the award of any degree, diploma or similar title of any other University.

Kothamangalam

06.12.2025 Manna Jose

CERTIFICATE

This is to certify that the report entitled **'Delay Analysis and Mitigation Strategies in Urban Infrastructure Projects'** submitted by **Manna Jose** to the APJ Abdul Kalam Technological University in partial fulfillment of the requirements for the award of the Degree of Master of Technology in Civil Engineering is a bonafide record of the project work carried out by her under my/our guidance and supervision. This report in any form has not been submitted to any other University or Institute for any purpose.

Internal Supervisor(s)
Geethika G Pillai

External Supervisor(s)
(if any)

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ABSTRACT

Delays are a persistent and detrimental challenge in urban infrastructure projects, often leading to increased costs, contractual disputes and significant socio-economic impacts. This project presents a comprehensive delay analysis to identify and quantify the primary causes of delays in urban infrastructure projects, focusing on typical projects such as multi story commercial and residential projects. The research employs a mixed methods approach, integrating a review of established literature, analysis of project case studies and quantitative survey data from project stakeholders (contractors, consultants, owners etc.). Key delay factors are categorized and analyzed across various dimensions, including planning and design, procurement, site management, resource availability and external factors. The findings pinpoint the most critical and frequently occurring delay root causes, such as slow decision making, design changes/errors, inadequate resource allocation and complex approval processes. Based on this, the project develops a set of proactive and reactive mitigation strategies. These strategies focus on improving contractual clarity, implementing advanced project management techniques, enhancing collaboration among stakeholders, and establishing robust risk management protocols. The resulting framework provides project managers, policy makers and industry practitioners with a practical guide to effectively predict prevent and manage delays, ultimately aiming to improve the delivery efficiency and success rate of critical urban infrastructure projects.

ABBREVIATIONS

PPP	Public Private Partnership
UIP	Urban Infrastructure Projects
EOT	Extension Of Time
LD	Liquidated Damages
SI	Severity Index
GSI	Group Severity Index

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CHAPTER 1

INTRODUCTION

1.1 GENERAL BACKGROUND

The rapid pace of urbanization across the globe, particularly in developing nations, necessitates a massive investment in urban infrastructure projects. India's construction sector is expanding very quickly. Construction projects are one of the most important factors in supporting the socio-economic development of the country. The project delay is a pervasive and critical challenge facing by the construction industry. The project delay can be defined as the difference between the planned and actual completion dates. Anyhow delays in infrastructure projects have severe consequences like economic impact, social impact and contractual impact.

1.1.1 Economic Impact

The economic consequences of project delays are typically the most tangible and easily quantifiable which are causing a direct drain on public funds and hindering economic growth. The most immediate impact is cost overruns and budget strain. Delays extend the project duration, increasing overhead costs for the contractor and the owner. This includes extended rental for equipment, site facilities, insurance, salaries for supervisory staff, and general administration expenses.

Inflation and material price escalation is another economic impact. A longer project lifecycle means purchasing materials and labor at future, inflated prices. For large projects spanning several years, this can dramatically increase the total cost beyond the original budget, leading to significant cost variances.

The lost opportunity cost is the cost to the economy from the delayed use of the infrastructure. For instance, a delayed metro line means delayed passenger revenue, a delayed highway means continued traffic congestion and reduced logistics efficiency for businesses, and a delayed water treatment plant means delayed health benefits and lost capacity.

Reduced investor confidence is also one of the economic impacts. Chronic delays and cost overruns in public projects can signal poor governance and inefficiency, deterring private sector investment (both domestic and foreign) in future Public-Private Partnership (PPP) projects or other sectors.

Financial burden on tax payers is indirect but a severe impact on economy. Ultimately, increased project costs are covered either by reallocating funds from other essential services (like health or education) or by raising taxes or borrowing, directly impacting the citizens.

1.1.2 Social Impact

The social consequences affect the quality of life, public perception, and overall well-being of the urban population. These impacts are often less quantifiable but have a profound effect on the community.

Disruption to daily life: Prolonged construction (e.g., road closures, noise, dust, detours) disrupts commutes, business operations, and general urban mobility for an extended period. This leads to increased travel time, traffic congestion, and fuel consumption.

Delayed access to essential services: The primary purpose of UIPs is to deliver services (e.g., clean water, sanitation, power, efficient transport). Delays postpone the realization of these benefits, negatively affecting public health, safety and productivity.

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Erosion of public trust: When public funds are spent on projects that are perpetually behind schedule and over budget, it generates public dissatisfaction, heightens political discontent, and severely damages the credibility and reputation of the government or implementing agencies.

Safety and environmental issues: Incomplete construction sites pose safety hazards to the public. Furthermore, dragging out construction can increase noise and air pollution for a longer duration than originally planned.

1.1.3 Contractual Impact

This category focuses on the legal and relational consequences among the parties involved in the project (Owner/Client, Contractor, and Consultant).

Disputes and litigation: Delays are the primary cause of disputes in the construction industry. Parties will argue over who is responsible for the delay (e.g., owner-caused, contractor-caused, or force majeure), which leads to costly and time-consuming arbitration or litigation.

Extension of time (EOT) claims: The contractor submits a formal request to extend the contractual completion date due to excusable and sometimes compensable delays.

Compensation claims: The contractor seeks financial recovery for time-related costs incurred during owner-caused compensable delays.

Imposition of liquidated damages (LDs): If the delay is deemed the contractor's responsibility (inexcusable delay), the owner is entitled to charge predetermined daily or weekly penalties (Liquidated Damages) to compensate for the delayed usage of the facility.

Strained relationships and loss of profit: Disputes inevitably damage the working relationship between the client and the contractor, affecting collaboration on the current project and future contracts. The contractor faces a reduction in profit margin due to extended duration and increased overheads.

Project Abandonment/Termination: In severe cases of persistent delay and contractual breach, the client may terminate the contract, leading to a long, drawn-out process of re-tendering, which can lead to total project abandonment or further significant time loss.

Empirical evidence consistently shows that a majority of large-scale infrastructure projects do not meet their original time schedules. Understanding the root causes of these delays is therefore paramount to improving project delivery performance. For this project, a rigorous and systematic analysis of the causes and effects of delays in urban infrastructure projects are conducting and subsequently trying to develop robust, practical and effective mitigation strategies.

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CHAPTER 2

OBJECTIVES

The main goal of this project is to develop a robust framework for identifying, analyzing and mitigating delays in complex urban infrastructure projects. The specific objectives of the study are

- To identify and classify the major factors contributing to delays in selected urban infrastructure projects using a combination of literature review, surveys and case studies.
- To assess the relative significance of these identified delay factors through quantitative analysis.
- To apply advanced delay analysis techniques to a selected project case study to establish the critical path and determine the liability.
- To propose a comprehensive framework of practical and implementable mitigation strategies, incorporating technological tools and best management practices.

CHAPTER 3

SCOPE

3.1 PROJECT TYPE

This project focuses on certain urban infrastructure projects within a specified geographical area. The projects include residential buildings, commercial buildings, road & bridge construction and high way construction.

3.2 TIME SCOPE

Analysis will cover project delays that occurred during the execution phase and up to the completion or current stage of the project.

3.3 DATA FOCUS

Data collection will center on contractual, managerial, design and regulatory factors influencing delays. Technical construction methods will be considered only insofar as they relate to mismanagement or planning delays.

3.4 CASE STUDY DEPTH

The study will involve detailed analysis of 5-6 selected projects. Any one project from these will be selected for deep quantitative delay analysis while the other projects will provide input for qualitative and mitigation strategy development.

3.5 MITIGATION AND STRATEGY DEVELOPMENT

The study will be ended by proposing effective and possible mitigation strategies to the delay causes. This may include management methods or introduction of any software.

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CHAPTER 4

METHODOLOGY

The methodology presents major process used in this project.

4.1 DATA COLLECTION

The processes of data collection and the design of the questionnaire start with the development of sample questionnaire with an intensive review of literature. A detailed study on literature reviews has been done to select the significant causes of delay. Based on the study, a 0-5 scale questionnaire with 30 statements has been designed. The data were collected from 30 experienced participants from four major districts in Kerala. The major steps of the data collection include:

(1) Selecting significant causes of delay

(2) Preparing the questionnaire

(3) Selecting different kinds of construction works from various places across Kerala and sorting them into groups

(4) Assessing and collecting the data using a questionnaire survey

4.2 ANALYSIS AND RANKING

The analysis of survey data from 30 participants has been done on the basis of ranking for each statement in the questionnaire. After the manual computation of the ranking for each 30 statements, the data were analyzed using Microsoft Excel and following charts are prepared; (1) bar chart of ranking data, (2) percentage base pie chart of first six ranks and (3) area base pie chart of survey.

4.3 RESEARCH METHODOLOGY

This research is on the basis of a survey designed to gather all necessary information in an effective way. The survey presents 30 delay causes generated on the basis of related research work on construction delay together with input, revision, and modifications by some construction parties (Table 4.1). A questionnaire was developed to evaluate the severity of the identified causes.

Simple random sampling was used to select the participants from an available list. Data were gathered through a survey and analyzed by using a severity index, taking in view of contractors and consultants. Agreement on the ranking of the severity of the causes of delay between the contractors and consultants was also tested. Recommendations for minimizing delay in construction projects were emphasized in view of the results of the study.

Table 1.1 Lists of Delay Causes and Related Group

Main Group	Causes under each group
1. Consultant / Client group	(a) Delay in obtaining approval documents / permits from concerned authority (b) Disputes with other parties (c) Satisfaction in selecting the contractor (d) Poor competence level of key staff from consultant group (e) Poor decision making by the consultant (f) Legal or industrial disputes between various parties
2. Contractor group	a) Poor experience of contractor b) Poor decision making by the contractor c) Planning and scheduling before project preceding d) Up to date planning and scheduling by contractor for

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	ongoing projects e) Poor site management and supervision by contractor f) Not strictly following the structural designs by contractor g) Poor financing by contractor during construction h) Productivity level and perfection of work i) Faulty work by contractor j) Handling multiple projects at a time k) Poor perfection in estimation practices
3. Material& Equipment group	a) Late procurement of materials b) Delay in delivery of materials c) Change in material type and specification during construction d) Availability of equipment e) Breakdown of equipment
4. Labour group	a) Lack of equipment operator's skill b) Dispute between labours in site c) Level of equipment operator's skill d) Availability of labours e) Absenteeism of labours f) Poor productivity of labours g) Labour strike /union issues
5. Finance	a) Global financial crisis b) Poor financial capability of consultant c) Financing by consultant during construction d) Poor quality of cost controlling system
6. External	a) Changes in government regulations and law b) Effects of social and cultural factors c) Unavailability of utilities in site (water, electricity etc) d) Weather conditions e) Accidents or mistakes during construction f) Disturbance to public activity g) Poor communication

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CHAPTER 5

LITERATURE REVIEW

1. Rashmi. M. Bijwar and Prof. Dr. A. B. More: The thesis on 'Delay analysis in construction of redevelopment residential project' concentrated on investigation of centre components that are bringing about deferrals and breaking down the everyday records to limit delays. The study has undertaken on Construction of High rise residential building project in Andheri, Mumbai. The project was reconstruction of G+13 floor High rise Residential Building and was scheduled to complete in 47 Months including all sanctioning and redevelopment processes. The study conducted on various factors that were causing the delays in project. The causes, resources and the discrete methods on nonetheless to derogate the delays in the ordering locality were noted down regularly. The day-to-day data was regularly collected from site. Beginning time, completing time, Also span was recorded over misundertaking differentiating undertaking. A questionnaire was arranged with weightage for each general component. A web document is created for this questionnaire.

   Those reactions gathered starting with the respondents made it obvious that very nearly the sum parties holds almost equivalent obligation to the delays clinched alongside project. They concluded that delays in installments i.e, payments leads to delays in construction. Poor co-ordination from contractor's side, absence of qualified labour, supplies and material when necessary. Overall time overrun for above project was 369 days from the planning of the project. From box plot analysis it shows most significant delays from constructors for poor communication and from low productivity labours i.e. 3.9. Maximum delays was appeared in government sanctioning process i.e. receiving of commencement certificates up to 4th floor and delay was 4 months, for 6th floor delay was 4 months, for 7^{th}floor delay was calculated as 4 months and for 9th floor it was 3 months.

2. Surbhi Singh: In this research study questionnaire-based survey was conducted in which, data had been collected from various construction sites. The questionnaire designed in such a ways that respondents could give their answers based on their opinions and their analysis, for which RII method (relative important Index) was adopted in which the comparison was done between the views of respondents that are contractors, engineers and project manager on the basis of certain parameters. Finally, interpretation of findings was represented in a tabulated form which is easy to understand. This research helps to figure out the critical causes of the construction delay and present data into meaningful form that was in the descending order which depends upon their RII value.
3. Ahmed El Sayed: In this study, they look into the causes of construction project delays in Bosnia and Herzegovina and assess their importance. This study examines how management software is used during the project planning and execution phases, as well as how precisely inputs are determined.
4. TsegayGebrehiwet and Hanbin Luo: This study involves the analysis of the delay and its causes at different stages of construction in the Ethiopian city. In this, it involves the questionnaire with 52 causes and 5 Effects of delay and data were collected from 77 participants from different organization. This study involves the method of Relative importance index and post construction sequentially.
5. Jawad A. Alsuliman: The author conducted a survey on delay faced in Saudi Arabia. He has included 50 delay factors and 211 participants were considered and responses were collected. In this top 20 causes were identified and final

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simplified formula was developed to calculate the effect of each cause of delay onsite. This study mainly considered the part of the government work and was awarded with ranking.

6. Dixit and Kudari et al. (2021): They addressed delay issues prevalent in the construction industry over several decades. They advocated for enhanced project and technical management, as well as the integration of modern technologies. Their study involved a survey-based assessment, categorizing delay factors into seven groups and comparing them based on impact severity.

7. BhataleSomajJayawant and Prof. Shashank U Vanakudari: They conducted the study to determine the major causes of the delay and divide them in to several categories, to analyses the causes of the delay due to contractor, consultant or owner's own mistakes and priorities and to study and understand the effects and change the scheduling in the execution phase. They conducted the study from the earlier studies by the researchers on delay analysis with its effects and causes in the execution phase. Questionnaires were prepared by contacting the people of experienced one's and was taken into Google forms as survey, responses were collected from contractors, consultants, students and clients. The responses collected were then analyzed and given a rank with the help of RII.
8. Sharmila et al. (2024): Conducted an extensive investigation into the causes of delays in construction projects. Their study highlights key issues in project planning and scheduling that often contribute to time overruns. Using pre structured questionnaire surveys and statistical techniques, the authors analyzed on-site conditions to identify critical delay factors and suggested that proper assessment of these elements is crucial for effective project management.
9. Mohamed M. Marzouk and Tarek I. El-Rasas: The main purpose of this study is to identify the delays in construction projects in Egypt. He stated that the problems occur due to disputes and litigation with different parties. The feedback of the construction experts was obtained through interviews, subsequently a questionnaire was prepared. The survey was carried out from 33 experts who represent owner, consultants and contracting organization. He used frequency index, security index and importance index were calculated.
10. N. Hamzah, M. A. Khoiry, I. Arshad, N. M Tawil and A.I. Che Ani: In this study it has been discussed about construction delay in Malaysia. They have given delay definition as time overrun or extension of time to complete the project. It has been summarized as delay is a situation which actual construction project is slower than the planned schedule. It involved the category of two types, excusable and non-excusable delay. Further ranks were given to the factors with the help of Relative importance index (RII).

11. Ibrahim Mahamid, Amund Bruland, and Nabil Dmaidi: In this paper the researcher referred the delay in Road projects. Surveys were collected from professionals such as contractors, clients and consultants. The survey obtained is then analyzed using relative importance index (RII). The top groups affecting the delay in construction are: equipment, design, contractor, material, contract and lastly awarding the tender to the lowest bid price.
12. Mr. Vinay Nahire and Prof. Ashish Pruthviraj Wagmare: This research aimed to examine the effectiveness of various strategies employed to prevent or minimize delays in large bridge construction projects. These strategies included advanced project planning, use of modern scheduling tools, risk assessment frameworks, early stakeholder engagement, contractual mechanisms such as incentives and penalties, and the application of technologies like Building Information Modeling (BIM).By analyzing case studies, conducting interviews with industry professionals and reviewing existing

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literature, this study seeks to identify which strategies are most effective under different conditions and why. Understanding the critical success factors behind timely project delivery can offer valuable insights for policymakers, engineers, and project managers seeking to enhance efficiency, reduce risk, and ensure the successful completion of large-scale bridge projects.

13. Shreyash D. Desai and Renuka R. Purohit: In order to determine the impact of several factors on delay in the Indian construction sector, a questionnaire survey approach had used for this research, based on the numerous overseas researchers previously mentioned. A survey of industry experts representing different stakeholders in construction projects in India was carried out. The adopted methodology included the stages like problem identification, study through various literature papers, determination of delay factor, preparation of questionnaire, data collection through questionnaire survey, data analysis and results and discussion. After Literature Review, Site visits, and brainstorming, 23 Delay attributes under 5 broad categories namely (Man power, Equipment, Material, Architectural/Structural, Owner) have been found as most common in small residential building construction projects. The results received from Google survey forms and RII analysis revealed that owner related delays have maximum impact among all delays.
14. Amin Sherif et al. (2023): Categorized delay occurrences into three major project phases: mobilization, construction and closeout. They reviewed several delay analysis techniques and identified Time Impact Analysis (TIA) as the most effective method. TIA's forward looking approach allows project managers to better predict and mitigate the impact of delays based on their timing and context.
15. Zayyanu Mohammed et al. (2022): Presented a systematic literature review encompassing 51 peer-reviewed journal articles. The research classified studies by geography, methodology and thematic focus, revealing that Asia contributed the most literature on this topic. The authors called attention to gaps in current research and emphasized the need for improved methodologies to address delay causes more comprehensively.
16. Paray and Kumar et al. (2021): Identified 46 delay causes from a thorough literature review, narrowing down to five highly severe ones. Their findings underscore the importance of early identification and prioritization of critical delay factors that negatively influence project performance.
17. Majnoor and Joy et al. (2020): Focused on two case studies—a healthcare facility and an infrastructure project. Their study stressed the importance of efficient planning and scheduling to reduce costs, avoid disputes, and maintain workflow continuity. They highlighted the need for technological and human resource improvements in today's competitive construction environment.
18. Tosniwal et al. (2018): Examined the effects of delays on cost and schedule performance. The research identified major contributors such as poor planning, labor shortages, and procurement delays. Data from experienced engineers helped to validate these findings, reinforcing the need for better resource and schedule management.
19. Meena and Babu et al. (2015): Found recurring delay causes such as labor shortages, external disruptions, and financial issues. Their analysis revealed that contractors contribute most significantly to delays, followed by clients and consultants. The study highlighted resource allocation as a key area for schedule optimization.

20. Ade Asmi, Muhammad Geri Rahmadi and Aurino Djamaris: This study adopted a descriptive qualitative approach to investigate the root causes of delays in a high-rise school building construction project in Indonesia. The methodology combines primary data collection with established analytical tools to identify and evaluate key risk factors affecting

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project timelines. This study explored the dominant factors contributing to delays in the construction of a high-rise school building project in Indonesia using a risk-based framework. The findings highlight that financial instability due to material price fluctuations and contractor cash flow issues are the most significant causes of delay. Other major contributors include frequent design revisions, inadequate labor management, and extreme weather conditions. Through the integration of the Fishbone Diagram and the Probability-Impact Matrix, the study has systematically identified and prioritized key delay risks. Such an approach allows for more structured mitigation planning and aligns with globally accepted project risk management practices.

21. Dilip Kumar E and Manishankar S: This study aimed to analyze the delays in a construction project by detailed literature study, site activities etc. the methodology included collection of literatures, selection of study area, field investigation, study on BOQ &drawings, study on labour productivity, data entry in primavera, setting of baselines, tracking of schedule, comparison of original with baseline schedule and obtaining results. Based on their case study, the Construction started in February 2016, and the duration of the Project as per the baseline Schedule is 988 days. Tracking till April 2019 revealed 99% completion of foundation and substructure work and 100% casting of precast segments, and 64% erection of segments, overall completion of the project is 58%. Causes of delay in their project were identified by a direct site visit and predict the project's approximate date. In their case study, the most important causes of delays in bridge project are Traffic permission/diversion delays because this project is located at five road junction to bus stand, delay in utility shifting/diversion, delay in design works, shortage of resources, and land acquisition delay.
22. Mate and Hinge et al. (2015): Used Primavera to compare planned and actual schedules. They found that delays often stemmed from indecisive management during construction. The study recommended that mitigation strategies be developed collaboratively by all stakeholders to reduce risks during the project lifecycle.
23. Kolhe et al. (2014): Analyzed time and cost overruns in residential projects, noting that larger budgets often experience more significant delays. Their findings linked delay to increased financial claims and fluctuation-related expenses, stressing the economic implications of inefficient time management.

CHAPTER 6

DELAY AND DELAY ANALYSIS

6.1 DELAY

At its core, a delay in infrastructure construction is the unintended expansion of the project’s lifecycle, occurring when the actual progress of works lags behind the contractually agreed-upon schedule. It represents a breakdown in the synchronization between resource allocation, environmental conditions, and administrative approvals. Delay can be of either external or internal. For an example, an unexpected labour strike in a working day is an internal delay cause while if the strike is a type of state-wide harthal or something like that, it can be considered as an external delay cause. Delay in construction can have a number of consequences in a project, such as late completion, lost productivity, acceleration, consequential damages, increased cost and contract termination. The party experiencing damages from delays needs to be able to recognize the delays and the parties responsible for them in order to recover time and cost.

6.2 DELAY ANALYSIS

The suggested delay causes in infrastructure projects are ranked by the measurement of the severity index. The following formula is used to rank them on the basis of impact level as identified by the participants:

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$$\text{Severity Index}(\%) = \sum a\left(\frac{n}{N}\right) * \left(\frac{100}{5}\right) \quad (1)$$

Where,

a = constant expressing weighting given to each response, which ranges from 0 for no influence up to 5 for very high

n = frequency of the responses

N = total number of responses

Accordingly, if all participants answer one cause to be no influence, then the severity index is 0, meaning that this cause is not relevant and the last in rank. Conversely, if all answer very high influence, then the severity index is 100, meaning that this cause is very highly relevant and is the first in rank. Table 3.1 shows the possible ranges for the severity index and the corresponding impact level.

The severity index for each cause was calculated according to Eq. (1) from contractor's, consultant's, and combined view. The group index was calculated by using the average of the severity indexes of the causes under each group such that,

$$\text{Group Severity Index}(\%) = \sum_{i=1}^{n}\left(\frac{Xi}{n}\right) \quad (2)$$

Where,

Xi = severity index of cause i under the group

n = number of causes under the group

The Spearman rank correlation is used to measure the degree of correspondence between the two lists of ranks of the sample observation. This test is used to find and compare how well the contractors and consultants agree on the severity of the delay causes. A perfect positive correlation (r_s ¼ +1) indicates that the two samples rank each object identically, whereas a perfect negative correlation (rs ¼ -1) indicates that the ranks of the two samples have an exactly inverse relationship. It might be said then that sample estimates of correlation close to unity in magnitude imply good correlation, whereas values near 0 indicate low or no correlation.

The following formula is used for calculation of the Spearman rank correlation:

$$r_s = 1 - [\,6 * \sum d2 / (n3 - n)] \quad (3)$$

Where,

r_s= Spearman rank correlation coefficient between two parties

d = difference between ranks assigned to variables for each cause

n = number of pairs of rank

Table 1.2 Severity Index Scale and Corresponding Impact Level

Range (%)	Impact Level
0	No Influence
0-20	Very Low
20-40	Low
40-60	Moderate
60-80	High
80-100	Very High

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CHAPTER 7

QUESTIONNAIRE

7.1 QUESTIONNAIRE ANALYSIS

A questionnaire is a research instrument consisting of a series of questions and other prompts for the purpose of gathering information from respondent. Although they are often designed for statistical analysis of the responses, this is not always the case. When developing a questionnaire, items or questions are generated that require the respondent to respond to a series of questions or statements. Participant responses are then converted into numerical form and statistically analyzed. These items must reliably operationalize the key concepts detailed within specific research questions and must in turn, be relevant and acceptable to the target group. There are a range of scales and response styles that may be used when developing a questionnaire. Within researches Likert-type or frequency scales are most commonly used. These scales use fixed choice response formats and are designed to measure attitudes or opinions.

7.2 QUESTIONNAIRE DESIGN

The questionnaire is divided into two main parts. Part I includes the list of the identified causes of delay and delays faced by the contractor during the construction works. Part II is related to general information for contractors by consultant about their work and experience. Both the contractors and consultants were further requested to answer questions pertaining to their experience in the construction fields and their opinions about the average time overrun in construction projects that they have experienced. These causes are classified into six groups according to the source of delay: consultant or client group, contractor group, material &equipment group, labour group, finance and external. For each cause a question was asked: What is the degree of severity of this cause on project delay? The severity was categorized on a six-point scale as follows: very high, high, moderate, low, very low, and no influence on a 5 to 0 point scale. The questionnaire so designed in a way that it includes the name and address details of the contractor as well as the consultant. The questionnaire in google form had shared with many contractors, consultants and engineers so that they can participate in the survey from any distance without any hassle. Signature and official seal of the contractor or their corresponding engineer was included in the questionnaire which can be filled by the Contractors, consultants, site engineers in nearest places. Also name, type and location of the project along with the project duration like expected date, starting date and completion date which is being considered in the survey. The designed questionnaire is given in the appendix A.

CHAPTER 8

SELECTION OF RESPONDENTS

The survey data were collected from 30 experienced participants from 4 major districts in Kerala. The places include Alappuzha, Ernakulam, Thrissur and Kozhikode. The participants were registered builders, associates, companies, PWD engineers etc. For the comfortable and easy surveying, the selected areas were sorted into 5 groups as follows.

Group 1: Alappuzha

Group 2: Ernakulam

Group 3: Thrissur

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Group 4: Malappuram

Group 5: Kozhikode

CHAPTER 9

SURVEY DATA ANALYSIS

9.1 NUMERICAL ANALYSIS

The analysis of survey data from 30 participants has been done on the basis of choice of agree to each statement in the questionnaire. After the manual computation of the choice of agree for each out of a total of 30 statements in which 20 are contractor's and 10 are consultant's, the data were analyzed using Microsoft Excel and a bar chart is generated for the ranking of data.

9.2 MICROSOFT EXCEL

Microsoft Excel is a spreadsheet developed by Microsoft for Windows, macOS, Android and iOS. Microsoft Excel has the basic features of all spreadsheets, using a grid of cells arranged in numbered rows and letter-named columns to organize data manipulations like arithmetic operations. It has a battery of supplied functions to answer statistical, engineering and financial needs. In addition, it can display data as line graphs, histograms and charts, and with a very limited three-dimensional graphical display. The bar chart generated using Microsoft Excel for ranking the data is given below.

BAR CHART FOR SEVERITY INDEX OF VARIOUS DELAY FACTORS CONSIDERING CONSULTANT'S RESPONSES

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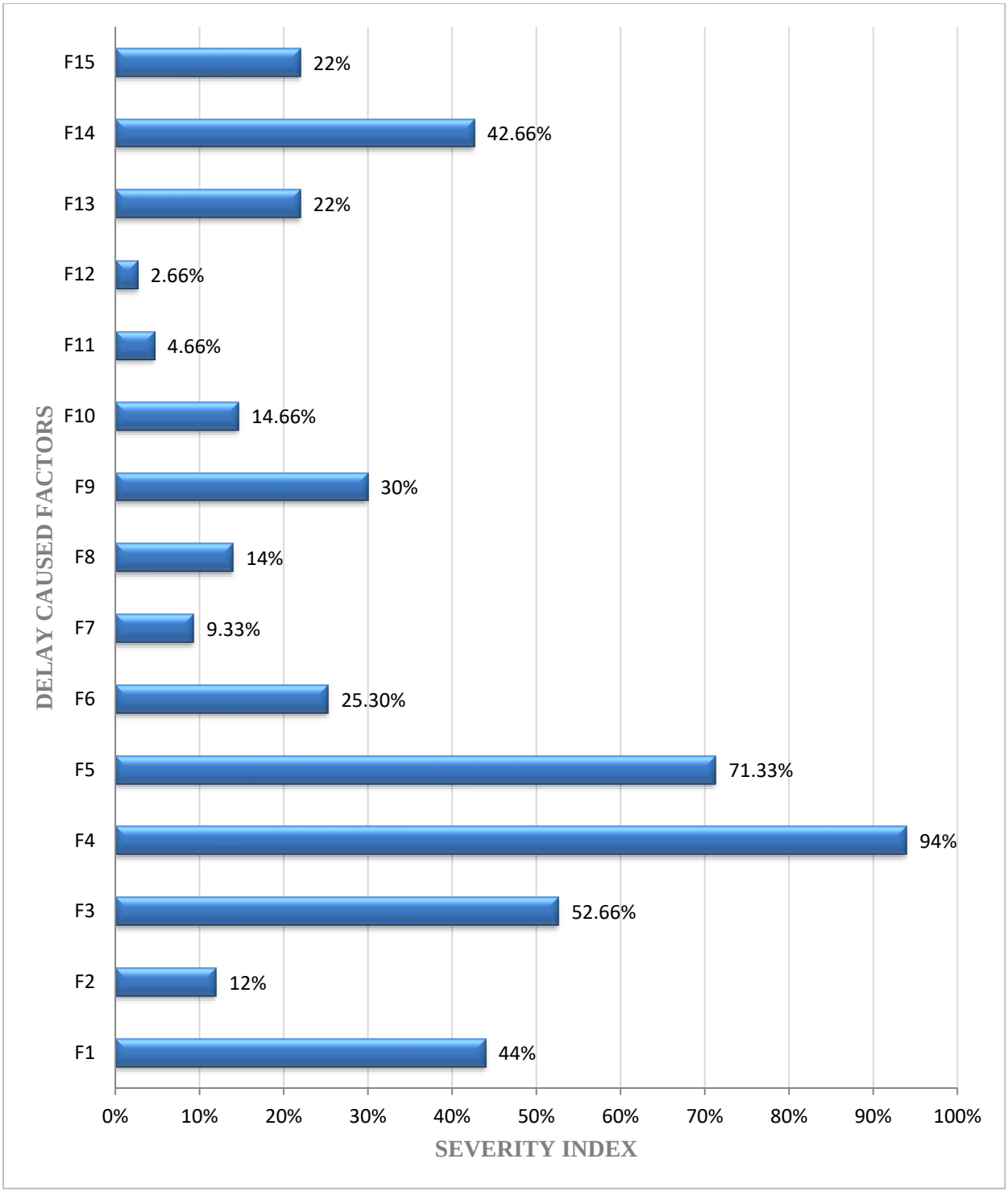

Fig 1.1 Bar chart for Severity Index of delay factors of Consultant's response

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BAR CHART FOR SEVERITY INDEX OF THE MOST DELAYED FACTORS CONSIDERING CONTRACTOR'S RESPONSES

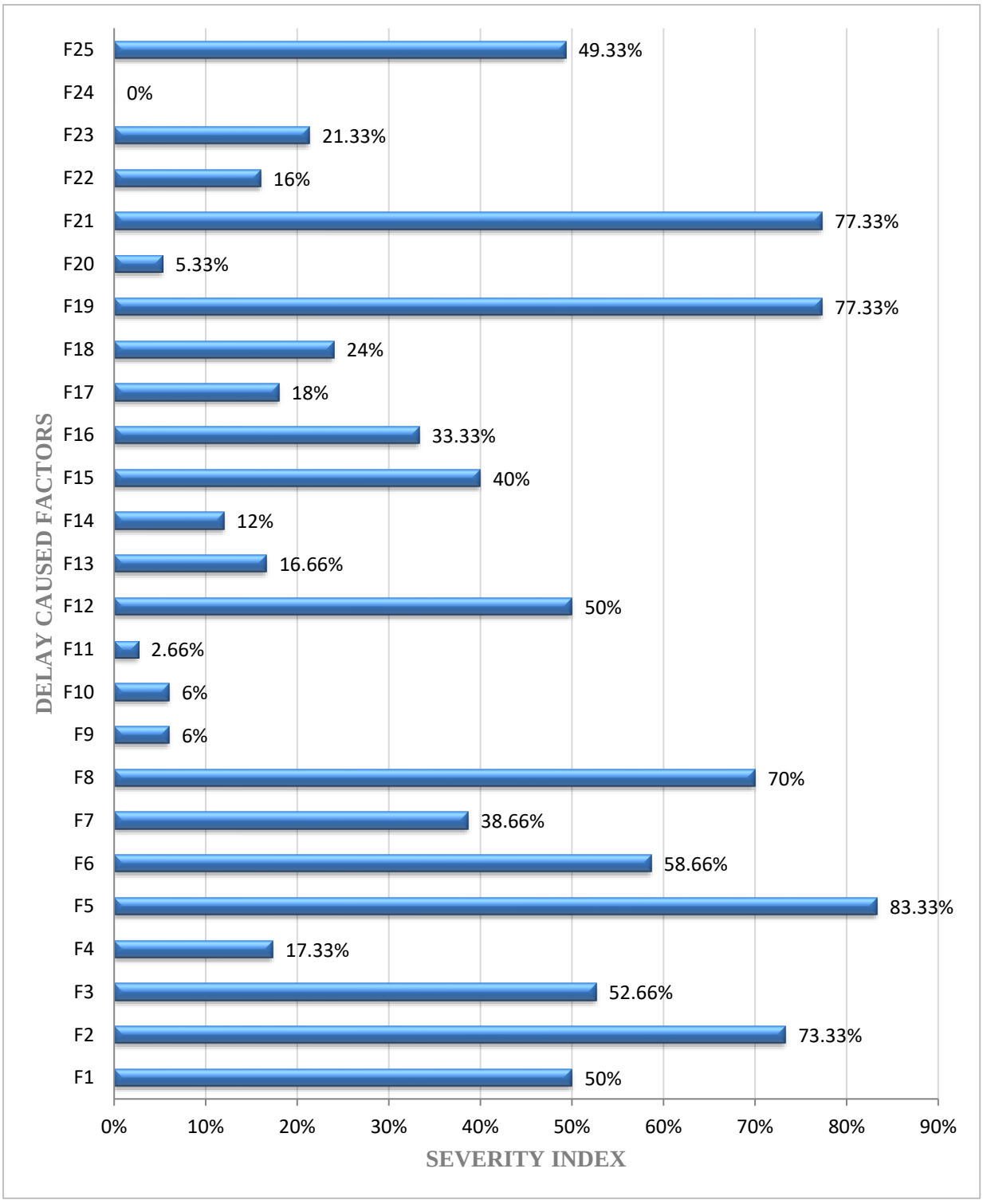

Fig 1.2 Bar chart for Severity Index of delayed factors of Contractor's response

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CHAPTER 10

RANKING OF DATA

10.1RANKING OF DETAILS

Ranking based on the severity index of various delay factors of contractors and consultants are given in the following tables:

Table 1.3 Ranking details of survey of Contractor

Sl. No	Delay Factors	Severity Index	Rank
1.	Competence level of key staff from consultant group	50%	17
2.	Decision making by the consultant	73.33%	22
3.	Financing by consultant during construction	52.66%	19
4.	Dispute between labours in site	17.33%	9
5.	Multiple projects at a time	83.33%	25
6.	Procurement of materials in advance	58.66%	20
7.	Delivery of materials	38.66%	14
8.	Changes in material type and specification during construction	70%	21
9.	Availability of equipment	6%	4
10.	Breakdown of equipment	6%	5
11.	Level of equipment operator's skill	2.66%	2
12.	Availability of labours	50%	18
13.	Absenteeism of labours	16.66%	8
14.	Productivity of labours	12%	6
15.	Labour strike/Union issues	40%	15
16.	Perfection of estimation practices	33.33%	13
17.	Quality of cost controlling system	18%	10
18.	Changes in government regulations and law	24%	12
19.	Effects of social and cultural factors	77.33%	23
20.	Unavailability of utilities in site (water, electricity etc)	5.33%	3
21.	Weather conditions	77.33%	24
22.	Accidents or mistakes during construction	16%	7
23.	Legal or industrial disputes between various parties	21.33%	11
24.	Disturbance to the public activity	0%	1
25.	Effective communication	49.33%	16

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Table 1.4 Ranking details of survey of Consultant

Sl. No	Delay Factors	Severity Index	Rank
1.	Issuing of approval documents / obtaining permits from concerned authority on time	44%	12
2.	Experience of contractor	12%	4
3.	Decision making by Contractor	52.66%	13
4.	Planning and scheduling by contractor before project preceding	94%	15
5.	Up to date planning and scheduling by contractor for ongoing projects	71.33%	14
6.	Site management and supervision by contractor	25.30%	9
7.	Strict following of structural designs without any malpractices by the Contractor	9.33%	3
8.	Financing by contractor during construction	14%	5
9.	Productivity level and perfection of work	30%	10
10.	Faulty work by contractor	14.66%	6
11.	Disputes with other parties	4.66%	2
12.	Level of equipment operator's skill	2.66%	1
13.	Global financial crisis	22%	7
14.	Financial capability of consultant	42.66%	11
15.	Satisfaction in selecting the contractor	22%	8

10.2RESULT AND ANALYSIS

The main points from the ranking details were as follows. Among the 30, majority of construction sites are facing schedule delays in almost every ways. The most delay causing factor is lack of planning before project proceeding. Ranking given as 0 or 1 represents no influence or very low influence when compared to higher influences. The less delay causing factor is disturbance to the public activity. The most delay causing factors from the contractor's responses apart from handling of multiple projects at a time are poor weather conditions, social and cultural factors and delay in decision making. From consultant's responses, the most delayed factor is lack of planning and scheduling before project proceeding and up to date planning and scheduling of ongoing projects.

10.3CONTRACTOR'S VIEW

10.3.1 Reasons for first 10 factors

F1- Multiple projects handling at a time

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- Inexperience and problems related to supervisors and contractors.

F2- Poor weather conditions

- Unpredictable climatic changes, inefficient qualitative analysis on geographic factors.

F3- Social and cultural factors

- Majority of labors are from North India and they have to attend the regional rituals and celebrations results in continuous leave.

F4- Delay in decision making by consultant

- Lack of knowledge, increased no. of participants in decision making committee and Political influence.

F5- Changes in material type and specification during construction

- Unexpected but frequent changes in material type and specification hinder the contractor from purchasing of the material in advance.

F6- Procurement of materials in advance

- Multiple works, lack of supervision and resource management.

F7- Financing by consultant during construction

- Multiple works and rolling of cash

F8- Availability of labors

- Multiple works and poor site management by supervisor

F9- Competence level of key staff from consultant group

- Delay in finding solutions for problems and delay in decision making

F10- Effective communication

- Lack of knowledge regarding technical terms and improper communication

10.3.2 Remedial measures

- Efficient planning using management software and selection of efficient managers in each sector.
- Punishments for irresponsible staffs and rewards for good performance.
- Proper planning and designing from the beginning.
- Collection of sinking fund.
- Efficient supervision on resource management.
- Appointing efficient no. of participants in the decision-making committee.
- Proper planning and supervision
- Punctual, skilled and experienced labors.
- Relaying weather forecasting.

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10.4CONSULTANT'S VIEW

10.4.1 Reasons for first 5 factors

F1- Planning and scheduling by contractor before project proceeding

- Inexperience and problems related to supervisors

F2- Up to date planning and scheduling by contractor for ongoing projects

- Inexperience and problems related to supervisors

F3- Decision making by contractor

- Lack of knowledge, increased no. of participants in decision making committee and Political influence.

F4- Issuing of approval documents/obtaining permits from concerned authority on time

- Irresponsibility of authority

F5- Financial capability of Consultant

- Multiple works and rolling of cash

10.4.2 Remedial Measures

- Efficient planning using management software and selection of efficient amanagers in each sectors.
- Proper planning and designing.
- Punishments for irresponsible staffs and reward for good performance.
- Choosing an experienced contractor and efficient pre-planning and pre scheduling in case of multiple projects.
- Collection of sinking fund

CHAPTER 11
ANALYSIS OF PIE CHARTS

11.1 AREA BASED PIE CHART OF SURVEY

The pie chart shows the percentage level of survey done in all the five districts. Out of the 30, maximum questionnaire collection is done in Thrissur (9/30) and Ernakulam (7/30). Minimum questionnaire were collected from Malappuram (4/30). Questionnaire collected from Alappuzha and Kozhikode are of 5 each.

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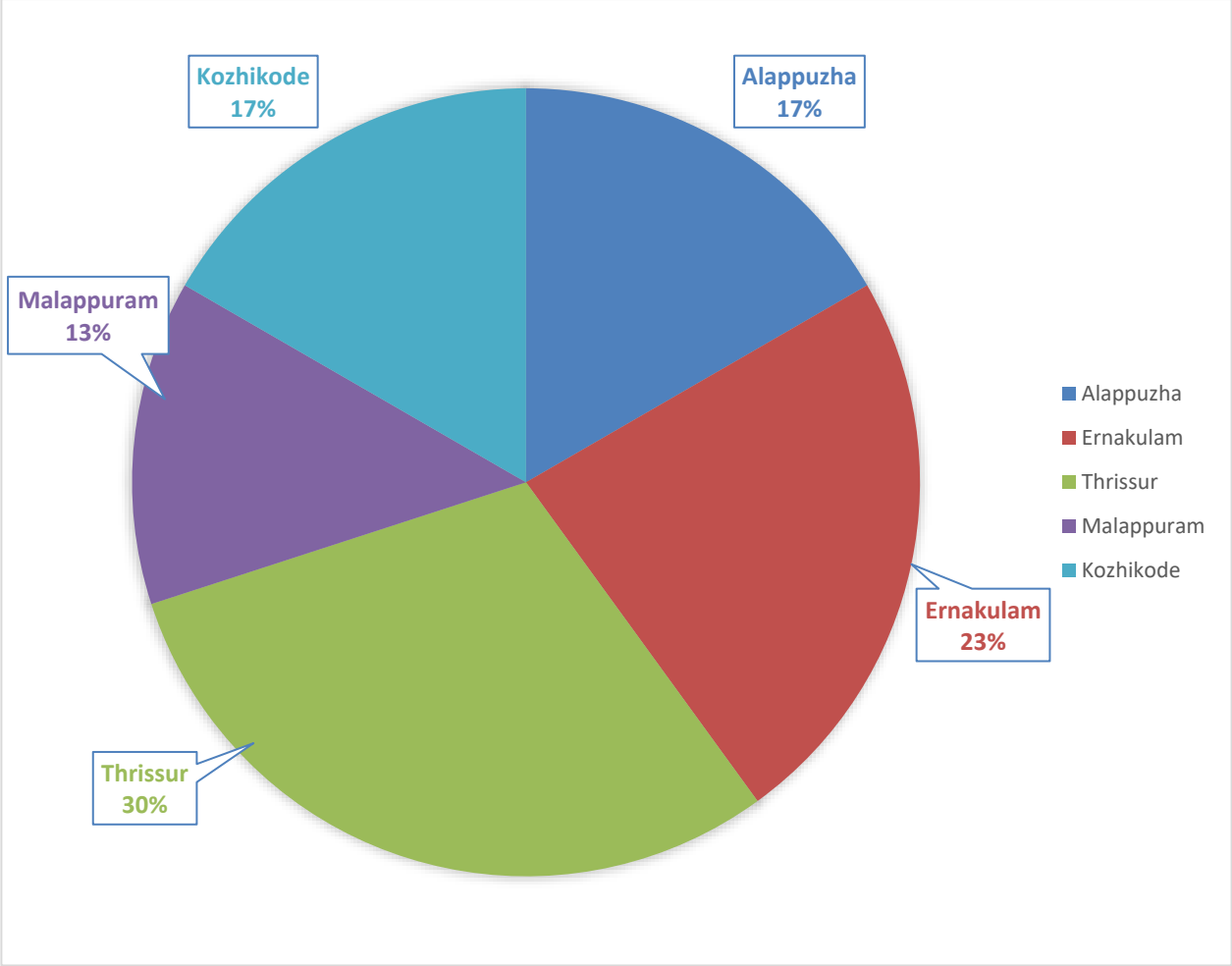

Fig 1.3 Area based Pie chart of Survey

CHAPTER 12

RESULT ANALYSIS

12.1 SEVERITY INDEX OF FACTORS IN CONTRACTOR'S VIEW

Using Eqn (1) values calculated as percentage is given in the following tables.

Table 1.5 Severity Index of delay factors in Contractor's view

Sl. No	Delay Factors	Severity Index
1.	Competence level of key staff from consultant group	50%
2.	Decision making by the consultant	73.33%
3.	Financing by consultant during construction	52.66%
4.	Dispute between labours in site	17.33%
5.	Multiple projects at a time	83.33%

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6.	Procurement of materials in advance	58.66%
7.	Delivery of materials	38.66%
8.	Changes in material type and specification during construction	70%
9.	Availability of equipment	6%
10.	Breakdown of equipment	6%
11.	Level of equipment operator's skill	2.66%
12.	Availability of labours	50%
13.	Absenteeism of labours	16.66%
14.	Productivity of labours	12%
15.	Labour strike/Union issues	40%
16.	Perfection of estimation practices	33.33%
17.	Quality of cost controlling system	18%
18.	Changes in government regulations and law	24%
19.	Effects of social and cultural factors	77.33%
20.	Unavailability of utilities in site (water, electricity etc)	5.33%
21.	Weather conditions	77.33%
22.	Accidents or mistakes during construction	16%
23.	Legal or industrial disputes between various parties	21.33%
24.	Disturbance to the public activity	0%
25.	Effective communication	49.33%

12.2 SEVERITY INDEX (SI) OF FACTORS IN CONSULTANT'S VIEW

Table 1.6 Severity index of delay factors by Consultant's view

Sl. No	Delay Factors	Severity Index
1.	Issuing of approval documents / obtaining permits from concerned authority on time	44%
2.	Experience of contractor	12%
3.	Decision making by Contractor	52.66%
4.	Planning and scheduling by contractor before project preceding	94%
5.	Up to date planning and scheduling by contractor for ongoing projects	71.33%

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6.	Site management and supervision by contractor	25.30%
7.	Strict following of structural designs without any malpractices by the Contractor	9.33%
8.	Financing by contractor during construction	14%
9.	Productivity level and perfection of work	30%
10.	Faulty work by contractor	14.66%
11.	Disputes with other parties	4.66%
12.	Level of equipment operator's skill	2.66%
13.	Global financial crisis	22%
14.	Financial capability of consultant	42.66%
15.	Satisfaction in selecting the contractor	22%

12.3 GROUP SEVERITY INDEX FOR FACTORS UNDER EACH GROUP IN CONSULTANT'S VIEW

Values calculated as percentage using Eqn (2) is given in the following table.

Table 1.7 Group Severity Index of grouped factors by Consultant's view

Group No	Delay Factors	Group Severity Index
1.	Consultant group	32.33%
2.	Contractors group	44.10%
3.	Material &equipment group	2.66%
4.	Labour group	22.33%
5.	Finance group	18%
6.	External group	24.33%

12.4 GROUP SEVERITY INDEX (GSI) FOR FACTORS UNDER EACH GROUP IN CONTRACTOR'S VIEW

Table 1.8 Group Severity Index of grouped factors by Contractor's view

Group No	Delay Factors	Group Severity Index
1.	Consultant group	61.67%
2.	Contractors group	58.33%
3.	Material &equipment group	27.33%
4.	Labour group	23.11%
5.	Finance group	35.33%

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6.	External group	37.85%

12.5 SPEARMAN COEFFICIENT

Table 1.9 Calculation of Spearman Coefficient

No.	Group	Contractor's GSI	Rank	Consultant's GSI	Rank	D	D^2
1.	G1	61.67	6	32.33	5	1	1
2.	G2	58.33	5	44.10	6	-1	1
3.	G3	27.33	2	2.66	1	1	1
4.	G4	23.11	1	22.33	3	-2	4
5.	G5	35.33	3	18	2	1	1
6.	G6	37.85	4	24.33	4	0	0
							$\sum D^2 = 8$

Where, GSI = Group Severity Index

D = Difference between ranks

12.5.1 Rank Calculation

Rank correlation, $r_s = 1-[(6*\sum D^2)/(n^3-n)]$

$= 1-[(6*8)/(6^3-6)]$

$= 0.8$

Since, Spearman's Rank Coefficient is a +ve value, there exists a +ve correlation between the two groups contractor's and consultant's. That is both groups are dependent and for the better and efficient completion of project both groups should perform efficiently simultaneously.

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CHAPTER 13

VISITED SITES

Fig 1.4: Commercial building for Hotel Sky at Chalakudy

Fig 1.5: Commercial building for Justin Alookaran at Thrissur

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Fig 1.6: Residential building for Mr. Rinto Moyalan at Ollur

Fig 1.7: Commercial building for Mr. Faby Varghese at Cherthala

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Fig 1.8: Commercial building for Mr Thankachan Kattakayam at Chalakudy

Fig 1.9: Construction of Subcenter at Melangady, Malappuram by HLL

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Fig 1.10: Construction of LP School at Vellayil, Kozhikode

CHAPTER 14

CASE STUDY

14.1 CASE STUDY OF CONSTRUCTION OF COMMERCIAL BUILDING AT CHALAKUDY

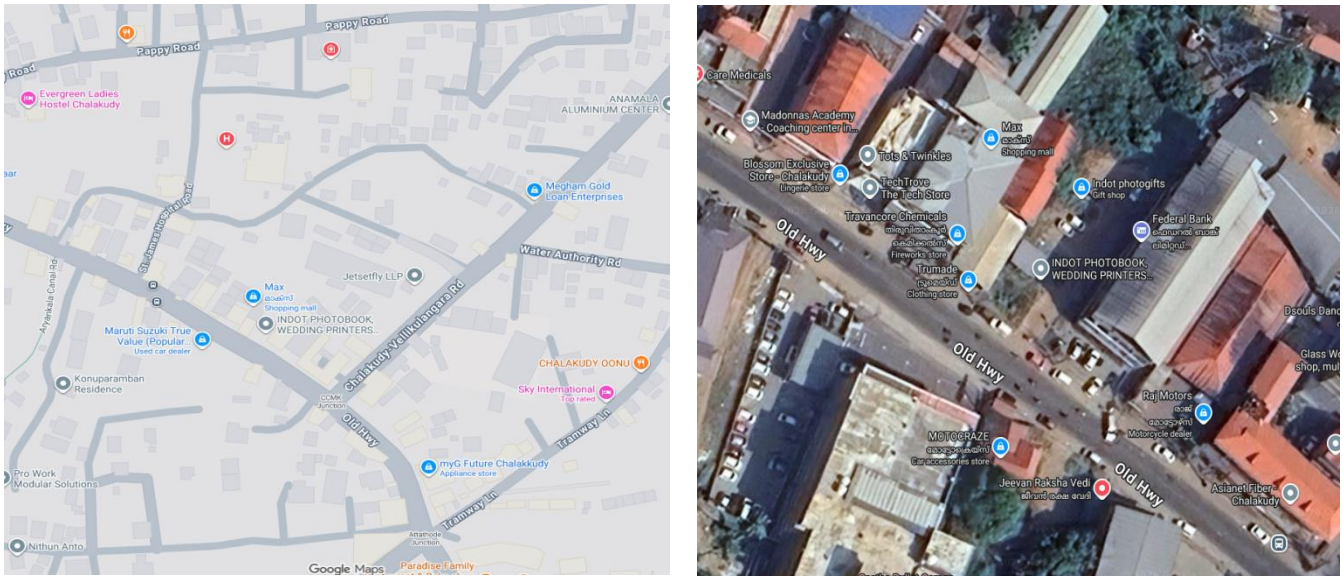

Fig 1.11: Location of site

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The study focuses on the different stages of construction from the procurement level to completion of the commercial building for Mr. Faby Varghese at Anamala. The site is located at Anamala opposite to the St. James Hospital, Chalakudy. The tender was quoted by Global Constructions, a construction firm owned by Mr. Biju Pereppadan in Chalakudy.

The construction of building consists of Basement floor, Ground floor, First floor, Second floor and Terrace floor. The total built-up area of the building as per tender drawing is 44105 SqFt. The amount estimated for the construction works as per the architectural and structural tender drawings is 629,25,488.00 /-. The tender invitation received from the Client on 23/11/2022. As per the structural drawings, the foundation was designed with a pile foundation and the Slab and Beam were designed as post tensioning concrete structures. Normal reinforced cement concrete slabs and beams were also provided at the toilet areas. The post tensioning works didn't include in the scope of contractor's work. The tender put forward by the Contractor was accepted by the Client at a SqFt rate of 1426.72/- and site handed over to contractor on 15/12/2022. Piling works were started at site on 19/11/2022 after clearing the site. The duration for the project is 12 months. There was a slight delay for the commencement of works at the site even after the handover. This is due to the delay from Client side to clear the site. The work was expected to complete on or before 15/12/2023. But the work was actually completed on 02/08/2024 with a delay of 246 days. The construction works were completed on 18/04/2024 and site inspections, measurements checking, Billing and payment closing were completely done on 02/08/2024. So the actual construction delay was for 124 days and delay for 122 days were occurred for remaining documentation and other inspections.

The major cause of delay observed was the design change. A design change was introduced after starting the work. So the contractor was forced to pause the works since the design change will result a loss for the contractor. The PT slab was changed to normal RCC Slab. So there will be considerable decrease in the total amount quoted by the contractor. But there will be no change for labour and material cost for the work since the beams are PT. The concreting of slab and beams are possible to do together by ready mix. So this will result a huge loss for contractor. Many discussions were needed to conduct with the contractor, client and the consultant to solve the issue without a huge loss. In this period the work needed to be pause by the contractor. So the delay was occurred at the designing level and it may be eliminated without affecting the work duration if the contractor had a more perfect coordination among the designing team. Slight delays were occurred at the time of execution due to labour shortage. Hence it can be concluded that proper planning, scheduling and coordination among the entire team at different level is very important to mitigate the delay.

14.2 CASE STUDY OF CONSTRUCTION OF COMMERCIAL BUILDING FOR ALPHA PALIATIVE CARE AT CHALAKUDY

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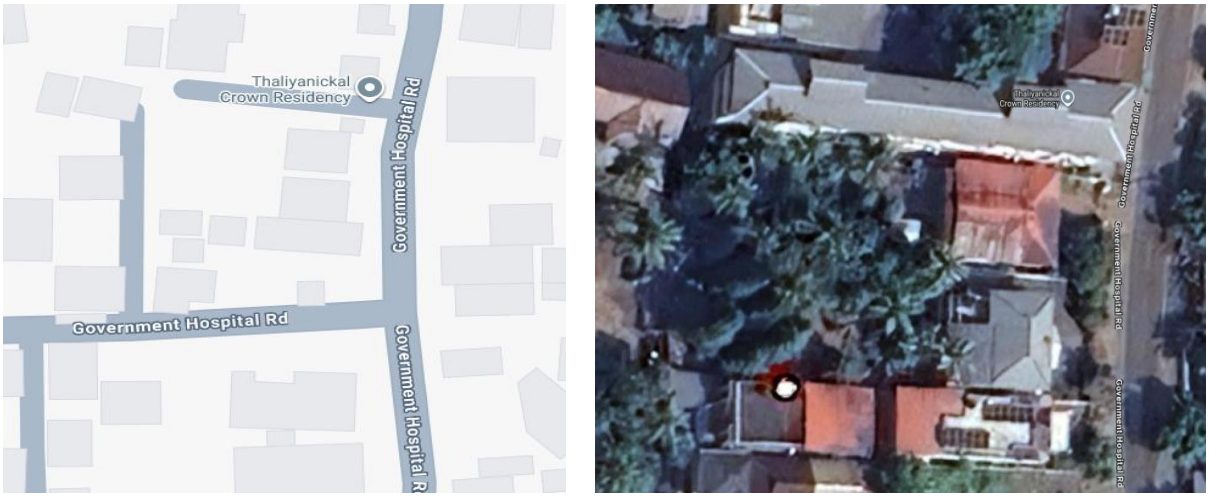

Fig 1.12: Location of site

The case study involves the construction of a building for Old Age Home by a charitable trust, Alpha Paliative Care in Chalakudy. The building is RCC framed structure with ground floor, first floor, second floor and terrace floor. Total built up area for the building is 5186 SqFt. The tender was quoted by the Global constructions, owned by Mr. Biju Pereppadan in Chalakudy. As per the agreement, the work was decided to finish in two stages. In first stage, RCC frame works were completed. All finishing works will be completed in the second stage. The first stage work was quoted by the contractor for a SqFt rate of 740/- and the total amount is 38,37,640.00/-. The second stage work is fixed for a SqFt rate of 1627/- and the amount is 84,37,622.00/-. The client was decided to execute the work in two stages due to the financial limitations. They had to fetch external financial support for the completion of the work. So, they had to split the work in to two stages to reduce the financial burden by the supporters. Also many organizations were refused to accept the work due to the huge amount. Thus, the budget for the first stage works were arranged by the client themselves with the help of various charitable trust, religious organizations etc. The charitable organization of BPCL was sanctioned the request for second stage fund by the Client.

The first stage works were started by the Contractor on 20/10/2024 and completed on 20/03/2025. The agreement for the first stage works was signed on 14/10/2024. First stage works were completed by the contractor without any delay. The second stage works were delayed for starting due to the financial issues. Agreement for second stage works was signed on 01/01/2026. The contractor started the works on 21/02/2026. The completion date for the work is 21/08/2026. There was a delay for starting the works by the contractor due to shortage of labors.

From this case study, it can be concluded that Project planning at all levels is very important for the effective completion of the works. It is better to implement any planning software in the firms which are handling multiple projects at various locations with limited resources.

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CHAPTER 15

CONCLUSION

The delay causes in urban infrastructure projects from five districts were discussed in this field survey. It studied the severity of the causes of delay from the contractor's and consultant's view. Through a detailed literature review, 40 causes of delay were identified. The identified causes were classified into six groups. The field survey included 30 contractors and 30 consultants each.

Planning and scheduling helps in forecasting the project. The cost of any individual can be known early along with its usage by using any planning and scheduling software like Primavera. Thus, decision can be made properly in managemental work. In multiple projects under same organization there is a chance of over allocation of resources, Primavera will be reduce this with proper resource optimization. Over allocation of resources can be seen in resource usage spreadsheet at the bottom of project window. Scheduling real time project can be done using Primavera software.

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