To Analysis Effect of Subcontracting in Infrastructure Projects with Descriptive statistics, Inferential statistics

[1]Mr. V.P. Kakade, [2]Dr.S.S.Deshmukh , [3]Mr. K.H. Ghorpade

[1] Student, [2] Professor, [3] Assistant Professor
[1]Civil Engineering Department,
[1]Trinity Academy of Engineering, Pune, India
[1] Vaibhavkakde530@gmail.com

***Abstract*—The Subcontracting has become a prevalent strategy in the execution of infrastructure projects, offering potential benefits in terms of cost efficiency, flexibility, and access to specialized skills. However, its impact on overall project performance remains a subject of critical analysis. This study aims to investigate the effect of subcontracting on key performance indicators—namely cost, time, quality, and risk—within infrastructure projects, using descriptive statistical methods. Data was collected through structured surveys and project records from a sample of ongoing and completed infrastructure projects. The analysis focuses on identifying trends, patterns, and relationships between subcontracting practices and project outcomes. Findings reveal that while subcontracting can contribute positively to quality and schedule adherence when managed effectively, it also introduces risks related to coordination, communication, and cost overruns when oversight is weak. The results underscore the importance of robust subcontractor management and strategic planning. This study provides valuable insights for project managers, policymakers, and construction firms aiming to optimize subcontracting practices for improved infrastructure delivery.**

***Index Terms*—Construction management, Subcontractors, Main contractors, Subcontracting, Infrastructure.**

I. INTRODUCTION

Infrastructure projects are complex undertakings that require the coordination of various disciplines, resources, and stakeholders to achieve successful delivery. As the demand for large-scale infrastructure continues to grow—particularly in sectors such as transportation, energy, and public utilities—project owners and main contractors increasingly rely on subcontracting as a strategic approach to manage scope, time, and expertise constraints. Subcontracting enables project teams to access specialized skills, reduce fixed costs, and enhance operational flexibility.

Despite these advantages, the practice of subcontracting presents a set of challenges that, if not properly managed, can hinder project performance. Issues such as poor coordination, communication breakdowns, scope ambiguity, and lack of oversight often result in cost overruns, schedule delays, and compromised quality. The impact of subcontracting is therefore not inherently positive or negative, but highly dependent on how it is implemented and managed.

This study aims to analyze the effects of subcontracting on infrastructure project performance using descriptive statistical methods. By examining real-world data from ongoing and completed infrastructure projects, the research seeks to identify patterns, correlations, and potential areas of concern related to subcontracting practices. The analysis focuses on four key dimensions of project performance: cost, time, quality, and risk.

The findings are expected to offer practical insights for project managers, contractors, and policymakers who are involved in the planning and execution of infrastructure projects. By shedding light on the role subcontracting plays in shaping project outcomes, this study contributes to the broader effort to improve efficiency, accountability, and success rates in infrastructure development.

II. LITERATURE REVIEW

Descriptive statistics is a fundamental tool in empirical research used to summarize, organize, and interpret raw data in a meaningful way. It plays a crucial role in identifying trends, central tendencies, variability, and distribution patterns, particularly in studies involving large datasets. In the context of construction and infrastructure project management, descriptive statistics provides valuable insights into project performance metrics such as cost, time, quality, and risk—allowing researchers and practitioners to make data-driven decisions.

descriptive statistics offer a preliminary understanding of the structure and patterns within a dataset, serving as a foundation for more complex inferential analysis. Measures such as mean, median, mode, standard deviation, and frequency distribution allow for a clear understanding of general project behavior and performance outcomes. highlights that descriptive analysis is especially useful in applied research fields like engineering and construction management, where the goal is often to understand real-world issues and provide practical recommendations. In infrastructure projects, descriptive statistics have been used to examine aspects such as cost overruns, schedule delays, contractor performance, and safety incidents.

For instance, applied descriptive methods to study labor productivity in subcontracted construction works in Uganda. Their analysis of frequency and percentage distributions revealed common causes of inefficiency, such as poor supervision and lack of materials. used mean ranking and standard deviation to assess risk factors contributing to project delays in the UK, allowing stakeholders to prioritize risk mitigation strategies.

Furthermore, descriptive statistics have been used in benchmarking studies. evaluated cost performance of construction projects in Malaysia using average cost deviations and frequency analysis, offering insights into common budgetary challenges across multiple projects. These types of analyses are essential in identifying recurring patterns and deviations from expected outcomes.

However, despite the usefulness of descriptive statistics, literature also notes its limitations. As pointed out by, while descriptive statistics are excellent for summarizing data, they do not allow for generalization or hypothesis testing beyond the sample unless

followed by inferential techniques. Therefore, many researchers advocate for a combined approach where descriptive statistics provide the initial understanding, which is then expanded upon through regression, correlation, or other inferential analyses.

In conclusion, descriptive statistics is a widely accepted and effective method for analyzing project-related data. In the study of subcontracting in infrastructure projects, its application provides a strong basis for identifying trends, evaluating performance metrics, and supporting managerial decisions. Despite its limitations, it remains an indispensable tool in construction research, particularly when reliable, accessible, and interpretable data analysis is required.

III. Selection of Method for Analyzing Quantitative Data from a Closed-End Survey

When analyzing quantitative data from a closed-ended questionnaire, the appropriate statistical methods depend on the type of data, research objectives, and scale of measurement (e.g., Likert scale). In your case, since the data involves Likert-scale responses (1–3)

The research aimed to identify critical success factors in subcontracting for infrastructure projects using data collected from a closed-ended Likert-scale survey. Given the nature of the data and the research objectives, it was important to select statistical methods that could accurately summarize responses and assess their reliability. The analysis methods chosen are appropriate and justified as follows:

Table 1 Assessment of Statistical Methods for Likert-Scale Data Analysis

Method	Purpose	Suitable for Likert-Scale Data?	Why It's Not Appropriate Here
Descriptive Statistics (Central Tendency)	Summarize responses (Mean, Median, Mode)	✓ Yes	Most appropriate for showing response trends
Inferential Statistics (Confidence Intervals)	Estimate range of true population mean	✓ Yes	Best for assessing reliability and generalizability
Regression Analysis	Predict outcome based on variables	✗ No	Goal is evaluation, not prediction
T-Test	Compare means between two groups	✗ No	No Grouping variable in study
ANOVA	Compare means across 3+ groups	✗ No	Not comparing groups
Chi-Square Test	Test relationships between categorical variables	✗ No	Not analyzing associations or dependencies
Factor Analysis / PCA	Reduce dimensions, discover underlying factors	✗ No	Already have predefined factors; sample size likely too small
Correlation (Pearson/Spearman)	Assess relationships between two variables	✗ No	Not studying relationships between factors
Multivariate Analysis (MANOVA, MLR)	Complex modeling, multiple variables	✗ No	Overly complex for the study's scope

Best Fit:

- Descriptive Statistics (Central Tendency)
- Inferential Statistics (Confidence Intervals)

These methods are the most appropriate, efficient, and interpretable for your survey data focused on ranking and evaluating critical success factors.

The use of descriptive statistics and Inferential Statistics (Confidence Intervals) was both justified and effective for analyzing closed-ended survey data in this study. These methods offered a balance of clarity and statistical robustness for identifying and ranking critical success factors.

IV. RESEARCH METHODOLOGY

General

Subcontracting in infrastructure projects in India has a mixed impact, offering benefits like cost reduction and specialized expertise while also presenting challenges like communication breakdowns and potential delays. Effective management of

subcontractors, including clear contracts, efficient communication, and trust-based relationships, is crucial for mitigating risks and maximizing the positive effects of subcontracting.

Benefits of Subcontracting:

- **Cost Reduction:**

Subcontracting allows businesses to leverage specialized expertise and skills without the overhead costs associated with hiring full-time employees, like benefits, training, and equipment.

- **Specialized Expertise:**

By outsourcing specific tasks or projects, main contractors can access specialized labor and resources, potentially improving the quality and efficiency of the work.

- **Flexibility:**

Subcontracting provides flexibility in managing workloads and adapting to project changes, as contractors can scale their workforce up or down as needed.

Challenges of Subcontracting:

- **Communication Issues:**

Breakdowns in communication between the main contractor and subcontractors can lead to delays, cost overruns, and even safety hazards.

- **Payment Disputes:**

Delays in payments to subcontractors can create financial difficulties and strained relationships, impacting project performance.

- **Quality and Safety Concerns:**

Lack of oversight and inconsistent quality control by subcontractors can lead to problems that impact project outcomes and safety.

- **Scheduling Conflicts:**

Coordination challenges between different subcontractors on a project can cause delays and disrupt the workflow.

Recommendations for Effective Subcontracting:

- **Clear Contracts:**

Establish well-defined contracts that outline the scope of work, responsibilities, timelines, and payment terms for all parties involved.

- **Effective Communication:**

Develop clear communication channels and procedures to facilitate information sharing and address issues promptly.

- **Trust-Based Relationships:**

Foster a collaborative environment with subcontractors by building trust, promoting open communication, and working together to achieve project goals.

- **Strong Project Management:**

Implement robust project management practices to monitor progress, manage risks, and ensure timely completion of the project.

- **Focus on Quality and Safety:**

Establish clear quality standards and safety protocols, and provide adequate training and supervision to subcontractors to ensure adherence.

By addressing the challenges and implementing best practices, the positive aspects of subcontracting can be maximized, contributing to the successful execution of infrastructure projects in India.

Expert Consultation for Developing a Comprehensive Survey

To prepare a questionnaire survey on the impact of subcontracting in infrastructure projects, discuss with industrial experts Mr. Subodh Mule, Mr. Promadh Deshpande, Mr. Vishal Phulpager to identify key areas of interest, ensure a comprehensive understanding of the issues, and refine the questionnaire for clarity and relevance. Focus on aspects like communication, payment issues, safety, productivity, and the impact on project outcomes.

Identify Key Areas of Focus:

- **Communication:**

Discuss challenges in communication between main contractors and subcontractors, including language barriers and information flow.

- **Payment Issues:**

Explore concerns about timely payments, payment methods, and the impact on subcontractors' financial stability.

- **Safety:**

Examine safety protocols, potential hazards, and the effectiveness of safety training for subcontractors.

Productivity:

Investigate productivity levels, factors affecting productivity, and the impact of subcontracting on overall project timelines.

- **Project Outcomes:**

Discuss the overall impact of subcontracting on project cost, time, quality, and stakeholder satisfaction. To effectively discuss questionnaire preparation with industry experts, focus on defining clear research objectives, identifying the target audience, developing a well-structured questionnaire, and ensuring clarity and validity of the questions. Consider piloting the questionnaire with a small group before full deployment.

V. PREPARE THE QUESTIONNAIRE

General

Creating a questionnaire to study the effect of subcontracting in infrastructure projects involves focusing on how subcontracting impacts factors like cost, quality, time, safety, selection of Sub-contractors, Payment, terms & conditions.

This questionnaire consists of closed-ended questions that are designed for quick and objective responses.

Here's a sample questionnaire structure.

Questionnaire survey

Name of contractor >

Type of contractor > A) Main Contractor B) Sub contractor

Rating of questions

A) Never =1mark out of 3	B) Sometime =2 mark out of 3	C)Always =3 mark out of 3

Click on the box for Answer the questions

Q.1) Is the sub-contractor selected from their previous work experience?

A) Never	B) Sometime	C)Always

Q.2) Main contractor checking the financial ability of sub- contractor?

A) Never	B) Sometime	C)Always

Q.3) Is the Selection of sub-contractor with lower bids?

A) Never	B) Sometime	C)Always

Q.4) Is advance is paid to the Subcontractor before starting the work?

A) Never	B) Sometime	C)Always

Q.5) Is the billing period of sub-contractor as per contract agreement between main contractor & sub-contractor?

A) Never	B) Sometime	C)Always

Q.6) Main contractor has paid the billing amount to sub-contractor as per contract agreement between main contractor & sub-contractor?

A) Never	B) Sometime	C)Always

Q.7) Is Main contractor holding some % of amount from bill of sub-contractor as a security deposit?

A) Never	B) Sometime	C)Always

1

Questionnaire survey

Name of contractor >

Type of contractor > A) Main Contractor B) Sub contractor

Rating of questions

A) Never =1mark out of 3	B) Sometime =2 mark out of 3	C)Always =3 mark out of 3

Click on the box for Answer the questions

Q.8) Do Sub-contractor submits the project schedule to main contractor before start the work?

A) Never	B) Sometime	C)Always

Q.9) Is the appointment of sub-contractor is reducing the cost of project?

A) Never	B) Sometime	C)Always

Q.10) Has Sub -contractor completed the project with in time frame?

A) Never	B) Sometime	C)Always

Q.11) Is Sub- contractor maintaining the standards of safety during work?

A) Never	B) Sometime	C)Always

Q.12) Is Sub- contractor maintaining the standards of quality during work?

A) Never	B) Sometime	C)Always

Q.13) Does appointment of Sub-contractor reduces the work load from main contractor?

A) Never	B) Sometime	C)Always

Q.14) Does appointment of sub-contractor to project increases the efficiency of work?

A) Never	B) Sometime	C)Always

Q.15) Is the coordination between sub- contractor & main contractor is good?

A) Never	B) Sometime	C)Always

2

Questionnaire survey

Name of contractor >

Type of contractor > A) Main Contractor B) Sub contractor

Rating of questions

A) Never =1mark out of 3	B) Sometime =2 mark out of 3	C)Always =3 mark out of 3

Click on the box for Answer the questions

Q.16) Appointment of sub-contractor is reducing the administrative cost of main contractor for employment permanent labour cost & supervision cost?

A) Never	B) Sometime	C)Always

Q.17) There should be Any Penalty to sub-contractor for incompletions of work as per Project schedule submitted by sub-contractor?

A) Never	B) Sometime	C)Always

Q.18) Shall sub-contractor submit the credential certificate?

A) Never	B) Sometime	C)Always

Q.19) is the sub-contractor submit their organogram to main Contractor?

A) Never	B) Sometime	C)Always

Thank you for answering my questions promptly,

3

VI. PREPARE THE QUESTIONNAIRE

General

Data collection was a crucial phase aimed at gathering first-hand information from professionals involved in infrastructure projects to analyze the impact of subcontracting on various project performance parameters such as Payment, cost, time, quality, Safety, Terms and conditions.

The data for this research was collected through a structured questionnaire survey, which is a common and effective method for collecting standardized information from a 27 number of respondents,

The target population included professionals directly or indirectly involved in infrastructure projects, such as:

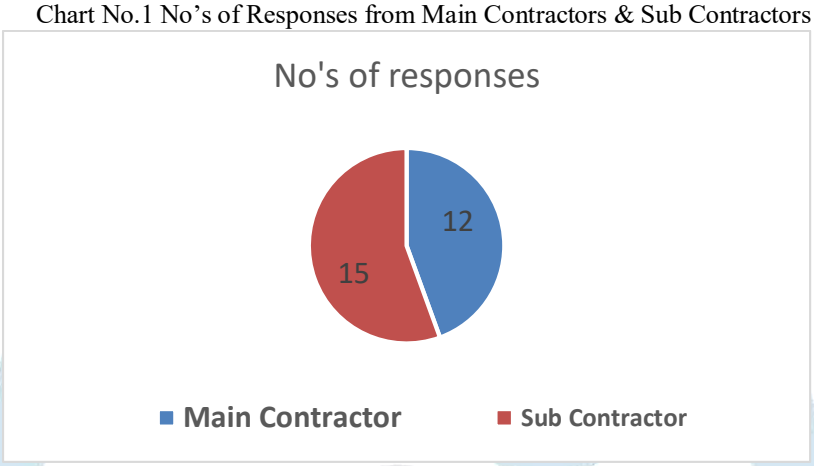
Project Managers

Subcontractors

Main Contractors

A non-probability purposive sampling technique was adopted to reach respondents who have practical knowledge and experience with subcontracting. The selection focused on ensuring diversity across sectors, project types, and experience levels.

Chart No.1 No's of Responses from Main Contractors & Sub Contractors



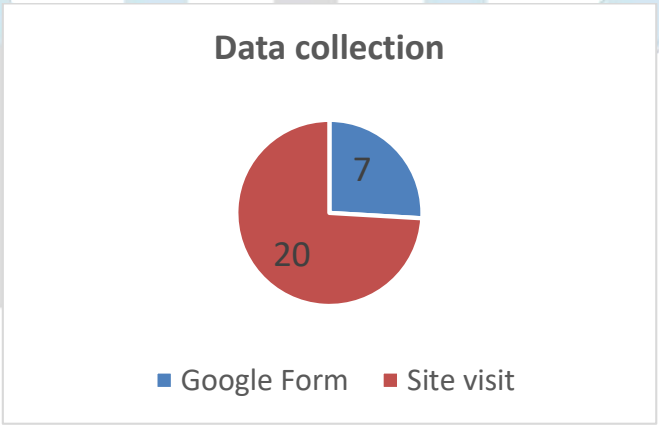
Mode of collection of data

Data collection is a fundamental phase in any research project, serving as the bridge between theoretical concepts and practical findings. In the context of this study, data collection was conducted to gather first-hand, reliable, and relevant information regarding the impact of subcontracting on infrastructure projects.

Online Survey Tools (e.g., Google Forms, Microsoft Forms) were used to distribute the questionnaire electronically. Email and WhatsApp Sharing: The survey link was circulated through professional networks, LinkedIn groups, and WhatsApp communities related to construction and infrastructure.

Site Visits (where possible): Some responses were collected during personal site visits and interviews to enhance response depth and clarity. factors like cost, quality, time, safety, selection of Sub-contractors, Payment, terms & conditions.

Chart No.2 Data collection



The primary objective was to obtain a comprehensive understanding of how subcontracting practices influence key aspects of project performance—namely cost, time, quality, safety, Selection of subcontractors terms and conditions as perceived by professionals working in the field. To achieve this, a quantitative research approach was adopted using a structured questionnaire survey.

By using online survey tools i.e. Google form 7 no's data collected & visited various project site 20 no's data collection from main contractors & subcontractors.

VII. TO ANALYSIS THE COLLECTED DATA

Analyzing closed-ended survey data involves two primary statistical approaches: descriptive statistics, which summarize the data, and inferential statistics, which allow for generalizations beyond the sample. Here's a comprehensive guide to both:

Questionnaire survey divided into following groups.

1. Cost: Questions related to budgeting, expenses, and financial aspects.
2. Time & Schedule: Questions about timelines, schedules.
3. Quality & Safety: Questions regarding standards, protocols, and measures to ensure quality and safety.
4. Payment: Questions about payment terms, methods, and schedules.
5. Selection of Subcontractors: Questions about the process of selecting and working with subcontractors.
6. Coordination, Terms & Conditions: Questions about project coordination, contractual agreements, and terms and conditions.

Descriptive Statistics (Central tendency)

Descriptive statistics help summarize and describe the main features of a dataset. For closed-ended survey responses, especially those using Likert scales or multiple-choice formats, the following measures are commonly used:

• Mean (Average): Calculated by summing all response values and dividing by the number of responses. Suitable for interval or ratio-scale data.

• Median: The middle value when responses are ordered. Useful for ordinal data or when the data distribution is skewed.

Mode: The most frequently occurring response.

Cost

Cost is one of the most critical components in the successful delivery of infrastructure projects. To evaluate how subcontracting affects project costs, data was collected through structured questionnaires targeting key stakeholders involved in infrastructure projects (e.g., contractors, project managers, and engineers). The collected responses were analyzed using descriptive statistical methods to understand cost-related trends, variations, and perceptions.

Table No.2. Calculation by Descriptive Statistics (Central tendency) for cost

Variables	Mean	Median	Mode
Is the appointment of sub-contractor is reducing the cost of project?	2.30	2.00	2
Does appointment of Sub-contractor reduces the work load from main contractor?	2.78	3.00	3
Appointment of sub-contractor is reducing the administrative cost of main contractor for employment permanent labour cost & supervision cost?	2.41	3.00	3

Time & Schedule

Time management is one of the key pillars of successful project execution, particularly in infrastructure projects where delays can lead to significant cost overruns and reputational damage. This section analyzes the impact of subcontracting on time and schedule performance using data collected through a structured questionnaire survey. Descriptive statistics were applied to interpret the trends, perceptions, and experiences of stakeholders regarding project timelines.

Table 3. Calculation by Descriptive Statistics (Central tendency) for Time & Schedule

Variables	Mean	Median	Mode
Do Sub-contractor submits the project schedule to main contractor before start the work?	2.30	2.00	2
Has Sub -contractor completed the project with in time frame?	2.19	2.00	2
Does appointment of sub-contractor to project increases the efficiency of work?	2.85	3.00	3

Payment

In infrastructure projects, financial arrangements between the main contractor and subcontractors are crucial for ensuring project continuity and contractor confidence. Two common practices advance payments and security deposit retention significantly impact cash flow and risk sharing. This section analyzes the frequency and perception of these practices using data collected from industry stakeholders via a questionnaire survey. Descriptive statistical methods are used to evaluate the responses.

Table No.5 Calculation by Descriptive Statistics (Central tendency) for payment

Variables	Mean	Median	Mode
Is advance is paid to the Subcontractor before starting the work?	2.26	2.00	2
Is Main contractor holding some % of amount from bill of sub-contractor as a security deposit?	2.44	3.00	3

Selection of Subcontractors

The selection of subcontractors plays a pivotal role in the success of infrastructure projects. A poor choice can lead to delays, cost overruns, and quality issues. This section explores the key criteria used by main contractors when selecting subcontractors, based on data collected via structured questionnaires. Descriptive statistical methods are used to analyze practices like preference for experience, financial vetting, cost competitiveness, and submission of credentials.

Table No.6 Calculation by Descriptive Statistics (Central tendency) for Selection of Subcontractors

Variables	Mean	Median	Mode
Is the sub-contractor selected from their previous work experience?	2.74	3.00	3
Main contractor checking the financial ability of sub- contractor?	2.48	2.00	3
Is the Selection of sub-contractor with lower bids?	2.48	3.00	3
Shall sub-contractor submit the credential certificate?	2.15	2	3

Coordination, Terms & Conditions

Effective coordination and clear contractual terms between main contractors and subcontractors are essential for timely project execution and minimizing disputes. This section evaluates how well-defined agreements are implemented in practice, how subcontractors align with project plans, and how responsibilities are coordinated. The data is collected through structured questionnaires and analyzed using descriptive statistical methods to draw insights into industry practices.

Table No.7 Calculation by Descriptive Statistics (Central tendency) for Coordination, Terms & Conditions

Variables	Mean	Median	Mode
Is the billing period of sub-contractor as per contract agreement between main contractor & sub-contractor?	2.74	3.00	3
Main contractor has paid the billing amount to sub-contractor as per contract agreement between main contractor & sub-contractor?	2.85	3.00	3
Do Sub-contractor submits the project schedule to main contractor before start the work?	2.30	2.00	2
Is the coordination between sub- contractor & main contractor is good?	2.78	3	3
There should be Any Penalty to sub-contractor for incompletions of work as per Project schedule submitted by sub-contractor?	2.04	2	2.00
is the sub-contractor submit their organogram to main Contractor?	2.19	2	2.00

Inferential Statistics: Confidence Intervals

Inferential statistics allow you to make predictions or inferences about a population based on your sample data. A common method is constructing **confidence intervals (CIs)**, which estimate the range within which a population parameter lies, given a certain level of confidence (typically 95%).

Steps to Calculate a Confidence Interval for the Mean:

1. Compute the Sample Mean ($\bar{x}$): Average of your sample data.
2. Calculate the Standard Deviation (s): Measures the dispersion of your data points.
3. Determine the Sample Size (n): Total number of observations in your sample.
4. Calculate the Standard Error (SE): $SE = s / \sqrt{n}$
5. Find the Critical Value (z or t):
   - Use z-score for large samples ($n \geq 30$).
   - Use t-score for small samples ($n < 30$). t Score = (T.INV.2T(0.05, n-1))
6. Compute the Margin of Error (ME): ME = Critical Value × SE
7. Construct the Confidence Interval: $CI = \bar{x} \pm ME$

Cost

Table No. 8 Calculation by Inferential Statistics (Confidence Intervals) for cost.

	Is the appointment of sub-contractor is reducing the cost of project?	Does appointment of Sub-contractor reduces the work load from main contractor?	Appointment of sub-contractor is reducing the administrative cost of main contractor for employment permanent labour cost & supervision cost?
Mean	2.30	2.78	2.41
Standard Deviation	0.67	0.51	0.64
Sample Size (n)	27.00	27.00	27.00
T -Score	2.06	2.06	2.06
Margin of Error (MOE)	0.26	0.20	0.25
Confidence interval lower limits	2.03	2.58	2.16
Confidence interval Upper limits	2.56	2.98	2.66

Time & Schedule

Table No. 9 Calculation by Inferential Statistics (Confidence Intervals) for Time &Schedule

	Do Sub-contractor submits the project schedule to main contractor before start the work?	Has Sub -contractor completed the project with in time frame?	Does appointment of sub-contractor to project increases the efficiency of work?
Mean	2.30	2.19	2.85
Standard Deviation	0.61	0.40	0.36
Sample Size (n)	27.00	27.00	27.00
T -Score	2.06	2.06	2.06
Margin of Error (MOE)	0.24	0.16	0.14
Confidence interval lower limits	2.06	2.03	2.71
Confidence interval Upper limits	2.54	2.34	3.00

Quality & Safety

Table No. 10 Calculation by Inferential Statistics (Confidence Intervals) for Quality & Safety

	Is Sub- contractor maintaining the standards of safety during work?	Is Sub- contractor maintaining the standards of quality during work?
Mean	2.74	2.85
Standard Deviation	0.45	0.36
Sample Size (n)	27.00	27.00
T -Score	2.06	2.06
Margin of Error (MOE)	0.18	0.14
Confidence interval lower limits	2.56	2.71
Confidence interval Upper limits	2.92	3.00

Payment

Table No. 11 Calculation by Inferential Statistics (Confidence Intervals) for Payment

	Is advance is paid to the Subcontractor before starting the work?	Is Main contractor holding some % of amount from bill of sub-contractor as a security deposit?
Mean	2.26	2.44
Standard Deviation	0.66	0.70
Sample Size (n)	27.00	27.00
T -Score	2.06	2.06
Margin of Error (MOE)	0.26	0.28
Confidence interval lower limits	2.00	2.17
Confidence interval Upper limits	2.52	2.72

Selection of Subcontractors

Table No. 12 Calculation by Inferential Statistics (Confidence Intervals) for Selection of Subcontractors

	Is the sub-contractor selected from their previous work experience?	Main contractor checking the financial ability of sub-contractor?	Is the Selection of sub-contractor with lower bids?	Shall sub-contractor submit the credential certificate?
Mean	2.74	2.48	2.48	2.15
Standard Deviation	0.45	0.51	0.58	0.72
Sample Size (n)	27.00	27.00	27.00	27.00
T -Score	2.06	2.06	2.06	2.06
Margin of Error (MOE)	0.18	0.20	0.23	0.28
Confidence interval lower limits	2.56	2.28	2.25	1.86
Confidence interval Upper limits	2.92	2.68	2.71	2.43

Coordination, Terms & Conditions

Table No. 13 Calculation by Inferential Statistics (Confidence Intervals) for Coordination, Terms & Conditions

	Is the billing period of sub-contractor as per contract agreement between main contractor & sub-contractor?	Main contractor has paid the billing amount to sub-contractor as per contract agreement between main contractor & sub-contractor?	Do Sub-contractor submits the project schedule to main contractor before start the work?	Is the coordination between sub-contractor & main contractor is good?	There should be Any Penalty to sub-contractor for incompletions of work as per Project schedule submitted by sub-contractor?	is the sub-contractor submit their organogram to main Contractor?
Mean	2.74	2.85	2.30	2.78	2.04	2.19
Standard Deviation	0.45	0.36	0.61	0.42	0.65	0.68
Sample Size (n)	27.00	27.00	27.00	27.00	27.00	27.00
T -Score	2.06	2.06	2.06	2.06	2.06	2.06
Margin of Error (MOE)	0.18	0.14	0.24	0.17	0.26	0.27
Confidence interval lower limits	2.56	2.71	2.06	2.61	1.78	1.92
Confidence interval Upper limits	2.92	3.00	2.54	2.95	2.29	2.45

VIII. RESULT & RECOMMENDATION.

Result

The study's results, based on Descriptive Statistics (Central Tendency method) and Inferential Statistics (confidence intervals), highlight key critical success factors with subcontracting in infrastructure projects.

Descriptive Statistics (Central Tendency) Summary

Table No. 14 Descriptive Statistics (Central Tendency) Summary

Factor	Mean	Mode	Median
Cost	2.49	3	3
Time, Schedule	2.44	2	2
Safety & Quality	2.80	3	3
Payment	2.35	NA	3
Selection of Subcontractors	2.46	3	2.5
Coordination, Terms & Conditions	2.48	3	2.5

Inferential Statistics (Confidence Intervals) Summary

Table No. 15 Inferential Statistics (Confidence Intervals) Summary

Factor	Mean	CI Lower	CI Upper	CI?
Safety & Quality	2.80	2.64	2.96	✓ (narrow, high)
Coordination & Terms	2.48	2.27	2.69	Moderate
Cost	2.49	2.25	2.73	Moderate
Selection of Subcontractors	2.46	2.24	2.69	Moderate
Time & Schedule	2.44	2.26	2.62	Moderate
Payments	2.35	2.08	2.62	✗ (widest CI)

• Safety & Quality has the highest lower bound (2.64) and highest upper bound (2.96) indicating high agreement and statistical confidence in its importance.

• Payments has the lowest mean and the widest CI (2.08–2.62), suggesting uncertainty and lower importance compared to others

Safety & Quality is the most critical success factor, supported by:

Highest Mean (2.80) in descriptive statistics.

Most consistent and narrow confidence interval (2.64 – 2.96) in inferential statistics.

Agreement across central tendency (mode and median = 3).

It demonstrates both strong perception and statistical reliability, making it the most decisive and impactful factor in successful subcontracting for infrastructure projects.

Recommendations

Based on the based on Descriptive Statistics (Central Tendency method) and Inferential Statistics (confidence intervals) the following recommendations are proposed to improve subcontracting outcomes in infrastructure projects:

• Prioritize Safety & Quality Management

Justification: This factor scored the highest mean (2.80) and had the tightest and highest confidence interval (2.64–2.96), indicating strong consensus and reliability.

Action:

1. Implement strict safety standards and quality assurance protocols for subcontractors.
2. Use prequalification criteria that emphasize previous safety performance and adherence to quality standards.
3.Provide continuous training on safety procedures and quality control for subcontractor staff.

• Enhance Coordination, Terms & Conditions

Justification: With a relatively high mean (2.48) and a strong CI (2.32–2.72), this factor reflects significant importance.

Action:

1. Develop clear, standardized contract templates to reduce ambiguity.
2. Ensure effective communication channels and reporting structures between main contractors and subcontractors.
3. Hold regular coordination meetings to address issues proactively.

• Strengthen Cost and Time Management Practices

Justification: Both cost (mean = 2.49) and time/schedule (mean = 2.44) were moderately important, but slightly below others.

Action:

1.Use cost control software and project tracking tools to monitor budget and timeline.
2.Encourage subcontractors to use detailed scheduling (e.g., Gantt charts, milestone tracking).
3.Include performance-based incentives or penalties in contracts to maintain time and budget targets.

•Review Payment Systems and Processes

Justification: Lowest mean (2.35) and widest confidence interval (2.08–2.62) indicate inconsistency and concern.

Action:

1.Reassess payment structures to ensure fairness and timeliness.
2.Introduce milestone-based payments to balance cash flow and work progress.
3.Increase transparency in billing and approval processes to reduce disputes.

• Improve Subcontractor Selection Criteria

Justification: While important (mean = 2.46), variability (CI: 2.24–2.69) suggests room for improvement.

Action:

1.Use a structured evaluation system during bidding that includes past performance, technical capability, and compliance history.
2.Mintain a qualified vendor list and conduct regular audits.
3.Promote competitive yet quality-focused tendering practices.

•Overall Recommendation

Safety & Quality is the top critical success factor, supported by strong agreement and reliable data. To ensure project success in subcontracting for infrastructure, safety and quality standards should be non-negotiable. Supporting this, improvements in contract clarity, coordination, payment practices, subcontractor selection, schedule control, and cost management will create a comprehensive and successful subcontracting environment

IX.CONCLUSION

The study utilized quantitative data collected through a closed-ended questionnaire survey to identify the critical success factors (CSFs) in subcontracting for infrastructure projects. The analysis was carried out using descriptive statistics (mean, median, and mode) and inferential statistics (confidence intervals), providing both a snapshot of respondents' perceptions and a statistical basis for drawing conclusions about the broader population.

Descriptive Statistics Insights

From the descriptive analysis:

•Safety & Quality emerged as the most critical factor with the highest mean score of 2.80, and both median and mode equal to 3, indicating that the majority of respondents agreed on its high importance.

•Cost (2.49) and Coordination, Terms & Conditions (2.48) also scored relatively high, showing that financial management and effective communication are perceived as essential.

•The lowest scoring factor was Payments (mean = 2.35), suggesting inconsistency or dissatisfaction with payment processes among subcontractors.

Inferential Statistics Insights

From the confidence interval analysis:

•Safety & Quality showed a narrow confidence interval (2.64–2.96), indicating high consistency and confidence in the data. This reaffirms it as the most statistically significant success factor.

•Other factors like Coordination & Terms (CI: 2.27–2.69) and Cost (CI: 2.25–2.73) also showed relatively tight intervals, signifying moderate importance with reasonable consistency.

•Payments again ranked lowest with the widest confidence interval (2.08–2.62), reflecting greater variation in respondent opinions and less confidence in its role as a consistent success factor.

Overall Conclusion

Based on both descriptive and inferential statistical methods, Safety & Quality stands out as the most critical success factor in subcontracting for infrastructure projects. It received the highest rating and exhibited the most reliable and consistent data across all respondents.

This clearly reflects industry stakeholders' prioritization of risk management, compliance, and performance reliability over other concerns such as cost or payment systems. In environments where multiple parties are involved and the margin for error is minimal, ensuring high safety standards and quality outputs is crucial for project success.

Meanwhile, coordination and clear contractual terms, as well as effective cost and time management, are also essential for supporting project delivery, though they are slightly less dominant. On the other hand, the variation in responses related to payments and subcontractor selection highlights areas that may require standardization, policy improvement, or better enforcement.

Implications for Practice

•Project managers and contractors should design subcontractor frameworks with a strong emphasis on safety and quality.

•Guidelines and training programs should focus on quality control, safety compliance, and risk mitigation.

•Coordination mechanisms and standardized contracts must be improved to ensure smooth execution.

•Payment practices and subcontractor selection processes must be reviewed to build trust and consistency.

REFERENCES

[1] Abdalla Odeh and Hussien Battauneh Paper on Causes of Construction delay: Traditional contracts by: International Journal of Project Management vol 20 (2002) 67-7019.www.elsevier.com

[2] Boston University, Boston, MA 02215, USA. Descriptive Statistics and Its Applications, Highlights in Science, Engineering and Technology. yihangd@bu.ed

[3] Creswell, J. W, Thousand Oaks, Research Design: Qualitative, Quantitative and Mixed Methods Approaches. Canadian Center of Science and Education, elt.cccse.net

[4] David Arditi and Ranon Chotibhongs in Journal of Management in Engineering. Issues in Subcontracting Practice DOI 10.1061/ASCE/733- 9364/2005/1318(866.www.asce.com

[5] Dalia A. Kshaf a,⇑ , Mohamed A. Mohamed b , Karim M. El-Dash The major problems between main contractors and subcontractors in construction projects in Egypt. Ain Shams Engineering Journal.www.sciencedirect.com.

[6] Henry Mwanaki Alinaitwe, Jackson A. Mwakali, Bengt Hansson, factor affecting the Productivity of building craftsmen – Studies of Uganda. http:/www.jcem.vgtu.lt

[7] Hyun-soo Lee1,Joon-oh Seo, M.S., Moonseo Park, M.ASCE, Han-guk Ryu, Ph.D and Soon-seok Kwon. Transaction-Cost-Based Selection of Appropriate General Contractor-Subcontractor Relationship Type. This paper is part of the Journal of Construction Engineering and Management, Vol. 135, No. 11, November 1, 2009. ©ASCE.www.asce.com

[8] Ismail Abdul Rahman, 1Aftab Hameed Memon, 2Ade Asmi Abdul Azis and 3Nor Hazana Abdullah. Modeling Causes of Cost Overrun in Large Construction Projects with Partial Least Square-SEM Approach: Contractor's Perspective. Research Journal of Applied Sciences, Engineering and Technology

[9] Jamie Hinze and Andrew Tracey. The Contractor-subcontractor Relationship: The Subcontractor's view published in the Journal of Construction Engineering and Management, Vol. 120, June 1994.www.asce.com

[10] Joseph R. Proctor Jr Golden Rule of Contractor - Subcontractor Relationships' February 1996 Practice periodical on structural design & construction of the ASCE.www.asce.com

[11] Mohan M. Kumaraswamy and Jason D. Matthews Improved Subcontractor Selection Employing Partnering Principles, a paper published in the Journal of Management in Engineering, Vol 16, May/June 2000.www. ascelibrary.org

[12] Parampreet Kaur, Jill Stoltzfus, Vikas Yellapu, Descriptive statistics IJAM International journal of academic medicine.

[13] Ting-Ya Hsieh A paper on 'Impact of subcontracting on site productivity: Lessons learned in Taiwan' from Journal of Construction Engineering and Management vol.124 no.2, March/ April 1998.www.asce.com

[14] Wei-Chih Wang and Jang-Jeng Liu Paper on Factor-based path analysis to support subcontractor management by: International Journal of Project Management vol 23 (2005) 109–120 www.elsevier.com

[15] Zhenzhen chen, Wanshaun Zhu, Prascale crama Subcontracting and rework cost sharing in engineering–procurement–construction projects. International journal of production economy.www.elsevier.com.