

Critical Success Factors and Strategies for Sub-contractor Management in Infrastructure Projects

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Abstract - With complexities involved in construction projects continuously on a rise, the role of subcontractors has become crucial for the successful execution of these projects. This paper tries to examine the current subcontractor management system adopted by general contractors. A case study approach was adopted for the same and 3 projects based upon contract value are selected. In the second phase, through literature review and expert opinions, critical factors affecting the performance of subcontractors were identified and ranked based on their relative importance. Lastly, interviews with experts working as industry leaders were conducted to understand the various strategies which can be adopted to improve the performance of subcontractors in a project.

Key Words: Vendor Management, Supply Chain Management, Construction Management, Sub-contractor Management.

1. INTRODUCTION

Each construction project possesses a unique characteristic in terms of engineering and construction. To deal with the arising complexities of projects, general contractors must either develop in-house expertise for each construction activity or sub-let the work to a sub-contractor. The option of sub-contracting generally emerges to be more profitable and sustainable in the market. While the general contractor is responsible for the overall success or failure, sub-contractors are deployed to perform specific tasks under the supervision of the general contractor without any obligation to the client. In countries like Hong Kong, United Kingdom researchers have arrived at a consensus that sub-contracting of activities in a project helps the general contractors to reduce the cost and resources required [1]. However, sub-contracting, in certain cases has also proved to be fatal in the success of a project. According to [2], poor subcontractor performance is a major reason for delays and poor quality of work in construction projects. In Malaysia and UAE, poor subcontracting is found to be among the top five reasons contributing to project delays [3]. With global spending in the construction sector projected to reach \$17.5 Trillion by 2030, it becomes important for the general contractors to maximize the performance of sub-contractors in a project. In order to achieve the same general contractors, need to focus on factors or uncertainties that might impact the

performance of a sub-contractor. Along this line, the objective of this study is to:-

- To understand the sub-contractor management system adopted by general contractors in construction projects.
- Identify the critical factors affecting performance of sub-contractors in construction projects.
- To statically analyse the identified factors and rank the factors based upon their impact on sub-contractor performance.
- To identify the strategies which can be adopted in the industry to counter the challenges encountered in management of sub-contractors.

2. RESEARCH METHODOLOGY

A mixed research methodology was adopted to conduct the study. The study was conducted in four phases. Firstly, a literature review was conducted to identify the factor's affecting performance of sub-contractors in construction projects. In the second phase, a qualitative research technique was adopted to understand the applicability of identified factors. In this direction, five infrastructure projects were shortlisted. The criteria for selection of projects are mentioned below:-

- The Project has major amount of work being carried out by sub-contractor

Value of the project is greater than 500 Cr. In the third phase of the study, interviews were conducted with the relevant professionals from the projects. The objective of these interviews was to understand the sub-contractor management system adopted by the stakeholders and applicability of the identified factors in context of Indian construction industry. (Patton, 2002) suggested that sample size in qualitative research should be determined by the concept of saturation and can be limited to between five to fifty interviews depending upon the interview content. In the present study to avoid biased results from the interviews representatives from the side of General contractor, Sub-contractor and Client were interviewed. Saturation was observed in the Tenth interview, further one more interview was carried out. 4 General contractors, 4 Subcontractors, and 3 clients were interviewed. The

selection was made based on position in the organization and experience of the individual in project management. The interviews were carried out personally and the duration of each interview varied from 45 minutes to 1 hour.

Further to quantitatively assess the identified factors, a questionnaire approach was adopted. The questionnaire designed for this study had 2 sections. 1st section included questions related to demographic information of the respondent. The 2nd section of the questionnaire included questions related to identified factors affecting performance of subcontractors in a project. The experts were asked to rate the impact of a factor on the performance of sub-contractor on a scale of 1-5. The scale was defined as follows:

Table-1: Definition of rating scale adopted in the study

Rating	Meaning
1: Very Low	The given factor has a negligible impact on performance of the sub- contractor in the project.
2: Low	The given factor has a slightly significant impact on performance of the sub-contractor in the project.
3: Moderate	The given factor has a significant impact on performance of the sub-contractor in the project.
4: High	The given factor has a remarkable impact on performance of the sub-contractor in the project.
5: Very High	The given factor has a consequential impact on performance of the sub-contractor in the project.

In total 150 questionnaires were floated, and 88 responses were received from industry professionals.

Demographic information about respondents is summarized below: -

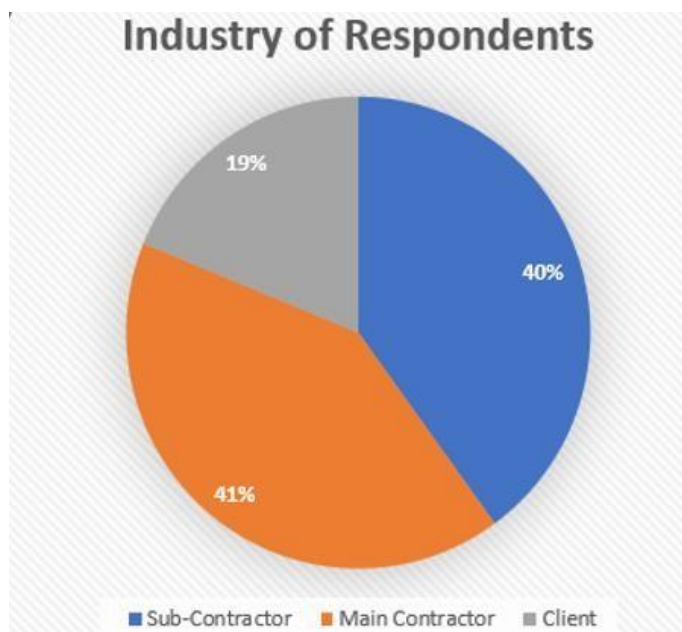
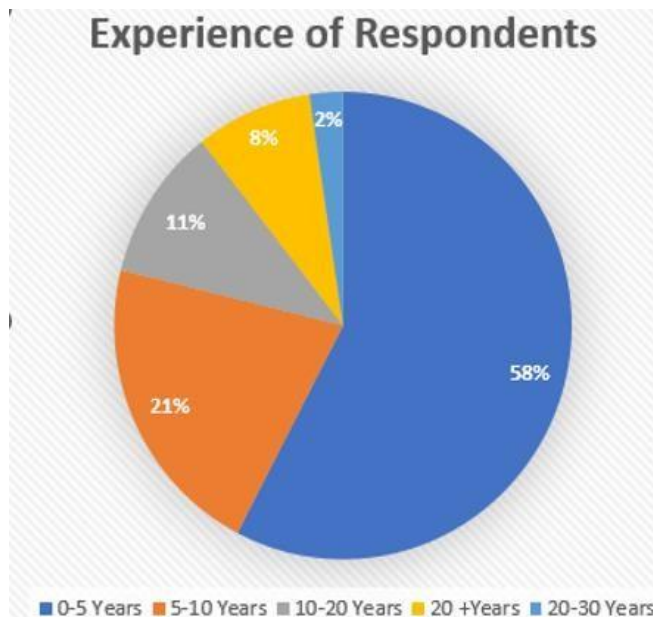


Figure-1: Demographic information about respondents

The data collected was analyzed in MS Excel and Python. The RII (Relative Importance index) method was used to rank the factors affecting the subcontractor’s performance. The relationship for computing RII is depicted below:-

$$\sum W / (A * N)$$

$\sum W$ = The weighting given to each factor by the respondent.

A= The highest weight N= Sample Number

To check the internal consistency of the data, the Cronbach Alpha test was conducted. Alpha = 0.85 was obtained. The relation between Coefficient of Cronbach alpha and Reliability level of data is summarized below:

Table-2: Relation between Cronbach Alpha and Reliability Level of the data

Coefficient of Cronbach Alpha	Reliability Level
More than .90	Excellent
0.80- 0.89	Good
0.70- 0.79	Acceptable
0.60- 0.69	Questionable
0.50- 0.59	Poor
Less than 0.49	Unacceptable

Further, to understand the variation between responses received from Sub-Contractors and Main- Contractors, two variance test was conducted. The hypothesis assumed for Two variance tests are mentioned below: -

Null Hypothesis: General contractor and Sub-Contractor had same notion for a given factor.

Alternate Hypothesis: General contractor and Sub-Contractor had a different notion for a given factor.

For all the factors shortlisted in the study, the f value obtained in two variance tests was within permissible limits to accept the null hypothesis with a 95% confidence interval. In the last phase of the study, structured interviews were conducted with professionals from leading construction firms to identify the strategies that can be adopted to nullify these challenges.

2. LITERATURE REVIEW

When a general contractor is awarded a project, the first step is to decide the packages in the project which must be outsourced. So as to support general contractors in their selection of packages, [6] devised a decision support system to identify the works that must be subcontracted based upon the given constraints (Maximum units of work that can be assigned to a sub-contractor). Attempting to understand the existing subcontractor management processes adopted by general contractors to manage subcontractors working is a project, [7] conducted a study, ultimately identifying strategies for mitigating the issues encountered in sub-contractor management. The study concluded that relevant pre-qualification criteria, warning systems for sub-contractor performance can be viable solutions for

the same. [8] conducted research to understand the perception of general contractors towards development of long-term relations with Sub-contractors. The research concluded that competitive advantage in the market is a major factor that promotes establishment of long terms relations between the general contractor and subcontractor. The key strategies that can be adopted to achieve the same include open communication, top management commitment, and proportionate risk distribution. Further,[9] identified conflicts between

individual personalities as a major challenge for efficient sub-contractor management in construction industry. Extending the research on this line [10] developed a model based upon social exchange theory, examining the relation between justice perception of a subcontractor in previous works with a particular general contractor and their willingness to corporate in present job. [11] identified that lack of integrity respect and fairness, and unwillingness to negotiate the risk and price as the major factors for prevalence of poor relationship between general contractors and general contractors. Addressing the issue of non-compliance to contractual clauses by Subcontractors in the United Kingdom [12] conducted thematic interviews with sub-contractors. The findings of these interviews led to the conclusion that subcontractors generally have limited knowledge about the contractual clauses they are entering into. Thus, in addition to understanding the pricing of contract, the top management of subcontractors must also focus upon the contractual clauses.

Based on the literature review conducted, the factors identified in the study are listed below:-

Factor	Source
Sub-Contractor Selection process	(Li, Weifang, 2018); (Ashraf M. Elazouni and Fikry G.Metwally, 2000)
Sub-Contractor Bid Price	(Li, Weifang, 2018)
Distribution of Risk Between General contractor and Sub-Contractor	(Loosemore Martina, Lim Benson, 2021); (Assbeihat J.M, 2019)
Cash Flow Management of Sub-Contractor	(Loosemore Martina, Lim Benson, 2021); (Jianga, 2014)
Impact of Regular Performance Monitoring of Sub-Contractor	(Temitope Seun Omotayo et.al ,2022), (Arditi, 2005)
The ambiguous contractual agreement between Sub-contractor and General contractor	(Temitope Seun Omotayo et. al ,2022) ; (LIM, Patrick X.W. ZOU, Benson T.H., 2014)

Table-3: Factors Identified from Literature Review

3. Case Study

A detailed review of sub-contract documents and interviews with multiple stakeholders involved in the projects selected for case studies were conducted to understand how sub-contractors are managed in a project.

The same has been summarized below in a phase-wise manner.

Pre-Award Phase : Detailed discussions are carried out within various stakeholders of the general contractor to understand the major benefits and consequences of subletting a particular package and not doing the works inhouse. In coordination with the project team a detailed scope matrix, resource requirement and a pre-qualification criterion for the works is prepared. Further market research is carried out to identify the major sub-contractors carrying the similar works.

Award phase: The identified sub-contractors are asked to share their company profile, turnover information, and relevant information for pre-qualification criteria evaluation. Detailed drawings, BOQ, designs and site related details are shared with sub-contractors. Multiple rounds of negotiations and technical evaluation offers received from sub-contractors in carried out. Based upon the score in prequalification criteria, methodology of the work and most importantly the final price received, work is awarded to the suitable sub-contractor and LOI is issued.

Execution phase: In this phase, kick off meeting is conducted between the site team of general contractor and sub-contractor to ascertain the work plan and mobilization schedule for the work. Bills for the works certified by the general contractor are booked and submitted to the clients for further certification and invoicing. Regular review meetings between the top management of both the stakeholders are carried out to track the progress of the work.

Closure phase: In this phase, final certification of the sub-contractor's work is done, the sub-contractor is issued completion certificate, maintenance of the finished services as per the contract document is carried out by the sub-contractor. All the retentions and other withheld amounts are released as per the agreed schedule.

4. RESULTS

5.1 Relative Importance Index Test:-

As per the responses received to the questionnaire, RII was calculated to understand the relative importance of the factors.

Factor	Rank	RII	Mean
Sub-contractor bid price.	1	0.7106	3.55
Impact of regular performance monitoring of Sub-contractor.	2	0.6988	3.49
Sub-contractor selection process.	2	0.6988	3.49
Distribution of risk between General contractor and Sub-contractor.	3	0.6541	3.27
Cash Flow management of Sub-contractor.	4	0.6424	3.21
The ambiguous contractual agreement between Sub-contractor and General contractor.	5	0.6400	3.20

Table-4: Result for RII value

5.2 Two Variance Test

In addition to RII value, to understand the variance between notions of subcontractor's and general contractor about a particular factor, two variance test was conducted. The results of the same are tabulated below:-

Factor	Calculated F Value	F(5%)	F(95%)
Sub-Contractor Bid Price	0.84	1.81	0.54
Impact of Regular Performance Monitoring of Sub-Contractor	1.39	1.81	0.54
Sub-Contractor Selection process	1.09	1.81	0.54
Distribution of Risk Between General contractor and Sub-Contractor	0.93	1.81	0.54
Cash Flow Management of Sub-Contractor	0.87	1.81	0.54
Clarity of contractual agreement between Sub-contractor and General contractor	0.89	1.81	0.54

Table-5: Result for Two Variance Test

F value corresponding to 5% and 95% were taken from the relevant chart. The F value for the given factor was calculated by the formula:-

Variance of Sub-Contractor Responses / Variance Main Contactor Responses

From the above table, as the f value lies between the permissible interval of 95% confidence limit, it can be inferred that Main-Contractors and Sub-Contractors have a similar notion for every factor identified.

5. DISCUSSIONS

1. Sub-Contractor Bid Price

A subcontractor's ability to execute the work within the stipulated time and desired level of quality depends upon the price at which the firm acquires the job. Sometimes with an expectation of profits from following contracts, sub-contractor might underbid for a given contract and fail to execute it. In order to avoid such peculiar situations, general contractors must set a threshold price and not award the project below the same. Further, the general contractors should restrain from resorting to unethical practices like bid shopping during finalization of the contract. Although in the initial stage, it might improve the profit margins in the project, in long run it will hurt the quality of work, ruining the reputation of all the stakeholders involved. In line with the above facts, Sub-contractor bid price had an RII value of 0.7106 and was ranked as the most important factor affecting the performance of the sub-contractor.

2. Regular performance monitoring of Sub-Contractor

In large-scale construction projects, performance monitoring of sub-contractors working at a construction site is a challenging task and often a source of conflict between both parties. (Amin Mahmoudi, 2022) With an RII of 0.6988, regular performance monitoring emerged as the second most important factor in this study. In order to effectively deal with this issue, various researchers and industry professionals have stressed using drones for capturing real-time information from the project site. Further to ensure that desired level of progress, regular meetings between stakeholders involved are a viable solution.

3. Sub-contractor selection process

A rigorous sub-contractor selection process can prove to be successful in mitigating the risk associated with execution of the work. As per the responses received, the Sub-Contractor selection process had an RII score of 0.7106. Further

, discussions with industry professionals revealed that general contractors had a stringent pre-qualification criterion for selecting subcontractors, especially for specialized works. In order to assess the financial and technical capabilities of a sub-contractor, general contractors generally conducted a rigorous review of submitted documents and performance in similar works. However, in the case of routine works in a project like mix transportation, aggregate production etc, general contractors were more reliant on local contractors due to which pre-qualification criteria were often sacrificed. In such cases bid price was the main criterion for awarding the subcontract.

4. Distribution of risk between Sub-Contractor and General contractor: -

The distribution of risk and obligations between the general contractor and sub-contractor generally depends upon the contracting strategy adopted in the project. Scoring 0.6511 on RII scale, this factor was ranked as the fourth most important in the study. Previous studies revealed that contract clauses were designed to take advantage of the sub-contractor by shifting the risk into their scope. A review of various sub-contract documents validated the above fact. In most of the contract agreements, the local and financial risks were in the scope of the sub-contractor, without a proper mechanism for mitigation. Further, the various clauses like the scope of work, payment schedule, etc., were ambiguous and lacked clarity. Although during the execution phase of the project, all the stakeholders jointly resolved issues encountered, such arrangements were spontaneous and unplanned, resembling to exchange of services.

5. Cash Flow Management: -

As the cost of capital increases in the market, cashflow management is one of the major issues being faced by the stakeholders involved in construction projects. The clients have now shifted from monthly billing mode of payment to milestone-based payment in a project. Though this has motivated the general contractors to execute the works on a fast-track basis, on the other side it has created a significant cash lag. The general contractor generally adopts pay when paid and pay if paid strategies for billing of sub-contractor. This creates a peculiar situation for sub-contractors with 30-40% of their equity stuck up in a project. In the projects selected for study, numerous cases were observed where the sub-contractor didn't receive payment as per the agreed schedule. The interviews with various sub-contractors revealed that the payment cycle for an executed work spans between 45-60 days. In some cases, the performance bonds of sub-contractors were also not released after the completion of the works.

6. Ambiguous contractual agreement between Sub-contractor and General contractor

A review of various sub-contract documents revealed that contractual agreements between general contractors and sub-contractors generally lack clarity in terms of the scope of work and obligations of both the parties. With an RII value of 0.6541, this factor emerged as the fourth most important factor affecting the performance of sub-contractors. Experts involved in the study stressed the fact that ambiguity of contractual clauses often leads to disputes among the stakeholders, ultimately delaying the progress of the project. To address this issue, various experts agreed that standard contract documents must be established by the general contractors with the contract document containing two parts, one including the general conditions and part two including the special site-specific conditions of the work. Further, with the complexity of projects on a rise, various researchers in past have suggested that clauses related to amendment of orders and management of claims in a project must be formulated in consultation with legal experts in a project.

7. STRATEGIES TO BE INCORPORATED IN TRADITIONAL SUB-CONTRACTOR MANAGEMENT FRAMEWORK:-

In order to identify strategies for factors identified in the study, interviews with industry leaders and consultants were conducted. These led to the identification of following strategies for improving sub-contractors' performance in the life cycle of a project.

1. Region-wise vendor redeployment, vendor consolidation: -

The strategy of region-wise vendor redeployment and vendor consolidation has been successfully adopted by general contractors in the procurement of raw materials. **Vendor consolidation** refers to a process in which all the vendors offering a particular material/ equipment in the given region are shortlisted. **Vendor Redeployment** refers to deploying the same vendor for the supply of a particular material/service at multiple sites. The general contractors should shortlist some good-performing sub-contractors based upon a set of pre-qualification criteria. Once the Sub-contractor has satisfied the Pre-qualification criteria, when a requirement for service is identified, the general contractor shall directly approach these sub-contractors for the services instead of searching the market again. The review of case studies revealed a high rate of vendor redeployment in case of purchase items but in the case of sub-contracting, the rate of vendor redeployment was very low. Discussion with the experts from the general contractor side revealed that redeploying a

particular sub-contractor for similar work at another project is attributed to his, willingness and capacity to execute the work.

2. Negotiation of Payment terms: -

During the finalization of contract, both the parties must understand the short-term and long terms implication of delayed payments on the project. To minimize the payment risk, the sub-contractors and general contractors must ensure that the payment terms agreed in the contract are adhered to strictly. In order to lure the general contractors for timely release of payments, dynamic discounts on net payable must be included in the payment terms. The prices of the contracts must be negotiated based on concepts such as Day sales outstanding. If the day sales outstanding is higher than initially agreed by both the parties, the total value of the contract must also increase proportionately and vice versa must also be applicable. Also, in order to improve the cash position in contracts various options like mobilization payment, and lower retained percentages can be beneficial in improving project finances and maximizing the final cash balance.

3. Inclusion of performance-based incentives in the contracts: -

Most of the experts agreed that to motivate the sub-contractors, performance-based incentive clauses must be introduced in the contract documents. These incentives can be in form of monetary incentives like Cost plus incentive fees, share-in-savings- incentive, and non-monetary such as an automatic extension of contracts in case of services. The strategy of monetary incentives was utilized in one project selected as a case study and yielded successful results. The sub-contractor completed the given scope of work one week ahead of the scheduled date of completion. To utilize such arrangements effectively more research needs to be carried out in terms of understanding the type of incentive to be used and the extent to which these incentives must be passed on along the supply chain.

8. CONCLUSION

The main objective of the study was to understand the traditional sub-contractor management strategy which is currently being adopted for execution of projects and various challenges encountered. It can be concluded that there is a wide spread of sub-contracting in construction industry. But the sub-contractor management strategies being utilized by various stakeholders are not being able to deliver the expected result. The sub-contractor selection process is not regulated through any statutory body. Lack of standardization in contractual terms and conditions has led to exploitation of sub-contractors in various cases. The pace at which sub-contractors execute the works has not been able to match the requirements of clients and general contractors. Cash flow management has also emerged as one

the critical issue in traditional sub-contractor management setup. To overcome all these issues various strategies which must be integrated with traditional sub-contractor management framework were identified and discussed in detail with experts. The utilization of these strategies can prove to be effective in improving the overall relationship between the stakeholders and enhancing the performance of subcontractors.

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