Analyses of Performance Indices in the Construction of Steel Structures

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Abstract

Time, safety and economy constitute the three main factors in a construction project, of which time plays a significant role in construction. Delay in any task or operation is a time overrun which influences the completion of the work. A cost overrun, also known as a cost increase, underrated or budget overrun, involves unexpected costs incurred in excess of budgeted amounts due to an underestimation of the actual cost during budgeting. Accident don't just happen, they are caused by unsafe acts, unsafe conditions or both. Most accidents result from a combination of contributing causes and one or more unsafe acts and unsafe condition. This study was based on a list of construction problems, causes retrieved from literature reviews. The feedback of construction experts was obtained through interviews. Subsequently, a questionnaire survey was prepared. The questionnaire was distributed to construction experts who represent owners, consultants, and contractor's organizations. A case study was analyzed and compared with the most important problems causes in the research. Recommendations was made in order to reduce the problems in constructions.

Keywords- Safety, Cost Overrun, Delay, Survey

I. INTRODUCTION

Because of the advantage of steel structure, widely used in bridges, industrial plants, high-rise buildings and other modern buildings. In a lot of the construction process, the steel structure also exposed many quality defects. A typical construction project suffers from high risks associated with schedule delays and time-based disputes, since time is one of the main essence of the construction contract.

II. OBJECTIVE OF THE STUDY

The key objectives of the project are listed below:

1) To understand and evaluate the various challenges faced in the construction of multi storeyed projects at all stage of project life cycle.
2) To assess the frequently occurring problem which will affect the projects.
3) To identify significant reasons for problem involved in construction projects.
4) To provide response strategies and actions towards the identified critical problems.

III. RESEARCH METHODOLOGY

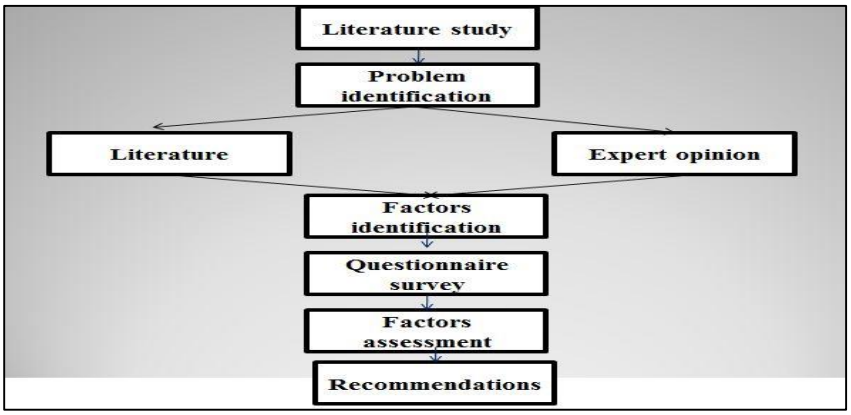

Fig. 1: Methodology

IV. DATA COLLECTION

A. Interview

Personal interviews were carried out with construction experts to get baseline information about the various problems faced in each projects. The semi- structured interview focused on factors which effected project performance criteria (Cost, Time and Safety). The response collected helped in identifying various factors of problem prominent in the projects. Based on the information collected during interview factors in various sectors of construction field were identified.

B. Factors Identification

The aim of this step is to generate a comprehensive list of problems based on those events that might create, enhance, prevent, degrade, accelerate or delay the achievement of objectives. Comprehensive identification is critical, because a risk that is not identified at this stage will not be included in further analysis.

C. Questionnaire Survey

A questionnaire survey has been carried out as the next stage of research. This method of data collection is quite popular. It is being adopted by private individuals, research workers, private and public organizations. In this method a questionnaire is given to the person concerned, with a request to answer the questions and return the questionnaire and by mails. A questionnaire consists of a number of questions printed or typed in a definite order on a form or set of forms. The questionnaire is mailed to respondents who are expected to read. And understand the questions and write down the reply in the space meant for the purpose in the questionnaire itself. The respondents have to answer the questions on their own.

D. Preparation of Questionnaire

The questionnaire is prepared based on the identified factors and analyzed using method of factors assessment. A qualitative analysis of factors assessment by Frequency Index Method is proposed for assessment. Thus the questionnaire formulated to extract data for this technique. The questionnaire consists of Likert scale questions with a 5-point scale. A total of 112 questions are formulated.

E. Selection of Sample Size

The questionnaire was distributed to firms mainly under geodesic techniques. A total population of 50 is being observed. The size of the sample required from the targeted population i.e. Respondents was determined statistically.

The sample size required for the Questionnaire survey is determined from Taro Yamane Sample size Formula given by $n = z\propto 2 \times p \times (1-p) \times N / Z\propto \times p \times (1-p) + N \times e2$

N – Sample Size

P – Proportion of favorable result in the population (0.5), E – Standard error (0.1), N – Population (50), Zα -Critical Value of desired confidence level (95%), thus the sample size required for the survey is set at 20 Samples

F. Pilot Survey

The formulated questionnaire (Appendix -A) is aimed to priorities various causes according to their occurrence and impact in the projects. Before using the questionnaire, a 'pilot study' (Pilot Survey) had been conducted for testing the questionnaires. Pilot survey is in fact the replica and rehearsal of the main survey. Such a survey, being conducted brings to the light the weaknesses (if any) of the questionnaires and also of the survey techniques. From the experience gained in this way, improvements can be made. The questionnaire is circulated among technical experts in the field and contractors. A total sample size of 7 is considered for the pilot survey. The response was appreciable as no confusion existed among the respondents about the questions and also obtained remarks that all the sections of construction sector was included in the questions.

Reliability test for Questionnaire is conducted with the pilot survey response. Cronbach's Alpha is the most common measure of internal consistency or reliability. It is most commonly used when there are multiple Likert questions in a survey/questionnaire that form a scale and to determine the reliability of the scale. Cronbach's Alpha will generally increase as the inter-correlations among test items increase, and is thus known as an internal consistency estimate of reliability of test scores. Generally, a questionnaire with $\alpha > 0.7$ is considered reliable.

The test is conducted with the help of SPSS software, the Cronbach's Alpha value – 0.941 is obtained which is well above 0.7.

Reliability

[DataSet2] E:\AAKASH\MTECH\PROJECT RESULTS\chronbchs test.sav

Scale: ALL VARIABLES

Case Processing Summary

		N	%
Cases	Valid	7	100.0
	Excluded[a]	0	.0
	Total	7	100.0

a. Listwise deletion based on all variables in the procedure.

Reliability Statistics

Cronbach's Alpha	N of Items
.941	42

Fig. 2: The output of reliability test performed in SPSS

Thus the questionnaire is proved to be reliable.

G. Questionnaire Response

The questionnaire survey has been conducted by personally and through online mode also. The questionnaire response were collected from technical expert's i.e. technical staffs in the company (Regional Manager, Assistant Engineer, Project Engineer, Assistant Project Engineer, and Site in charge), technical staffs in client department, project engineers and site engineers on contract side.

Based on the response data individual assessment of each question has been carried out.

H. Response Assessment

Response assessment is the next stage of research which provides critical causes. A qualitative analysis of response assessment is carried out after the Questionnaire survey. The main aim is to prioritize potential threats in order to identify those of greatest impact on the project. The response assessment was done by Qualitative analysis method. The technique used for assessment under qualitative analysis is Frequency Index (F.I), Severity Index (S.I) and Importance Index Method (I.I.M).

Frequency Index rating is performed based on individual assessment of questions in the questionnaire. For each question the weighted average of the 20 response is calculated to get the average frequency of occurrence. Similarly the weighted average is calculated for all 112 delays.

$$\text{Frequency Index (F.I)} = \sum_{i=1}^{5} \frac{a_{if} * n_{if}}{5 * N}$$

$$\text{Importance Index (IMP.I)}(\%) = \frac{\text{F.I} * \text{S.I}}{100}$$

$$\text{Severity Index (S.I)} = \sum_{i=1}^{5} \frac{a_{is} * n_{is}}{5 * N}$$

Where a_{if} and a_{is} are numbers of respondents who choose certain frequency and severity degree respectively, n_{if} and n_{is} are degrees of frequency and severity respectively (1or2or3or4or5), N is total number of respondents. Average values for Frequency and Severity Indexes for all respondents are shown in fig.1 to fig.17. The top ten delay causes that are ranked according to Frequency Index (F.I), Severity Index (S.I), and Importance Index (IMP.I) are listed.

Table 1: Top Ten accident causes according to Importance index

Accident group	*Accident causes*
Unsafe method	*Knowledge level*
Unsafe equipment	*Equipment without safety devices*
Human element	*Negligence*
Human element	*Experience*
Job site conditions	*Poor site management*
Management	*No warning system*
Management	*No education provided to the workers*
Management	*Poor inspection program*
Unique nature of the industry	*Work at high elev.*
Job site conditions	*Poor illumination*

Table 2: Top Ten delay causes according to Importance index

Delay group	*Delay causes*
Owner related	*Schedule*
External factors	*Strikes*
Owner related	*Delay in transportation*
Contractor related	*Poor Efficiency of labour*
External factors	*Local permits*
Contractor related	*Schedule*
Owner related	*Disputes in contracts*
External factors	*Change in law*
Contractor related	*Failure of Subcontractor default*
External factors	*Unavailability of staff*

Table 3: Top Ten cost overrun causes according to Importance index

Cost overrun group	*Cost overrun causes*
External factors	*Site worker strikes, vendor strikes / working to rule issues.*
External factors	*The requirements to work overtime or multiple shifts,*
Contractor related	*Removal of unsatisfactory subcontractors from site and locating new subcontractors.*
Owner related	*An unrealistic schedule dictated by the Owner*
External factors	*Accidents at the site, accidents to major equipment & materials in transit to the construction site.*
Contractor related	*Inexperienced Project Managers, Estimators and Planners that rely too much on computerized estimating programs*
External factors	*Shortages of key engineered materials such as some exotic steel / alloy products.*
Contractor related	*Lack of understanding by the contractor / subcontractors in this particular*
External factors	*Disputes between Unions and Open shop contractors.*
Owner related	*Engineering delays many time caused by Owners R&D / Process Group*

V. RECOMMENDATIONS TO ACCOMPLISH DELAY REDUCTION

- Specification of a realistic duration in the contract for the contractor to execute the project.
- Having sufficient time to prepare feasibility study for the project, as well as the preparation of a comprehensive financial plan and cash flow.
- Obtaining the required approvals for the project from the relevant authorities and ensure the availability of the necessary funding.
- Choosing a consultant to the project with sufficient experience in the field of work and has a good reputation.
- Making sure tender documents are complete, clear and free of errors and/or contradiction.
- Payment of the dues to the contractor for the work being carried as well as the payments of finished items according to terms of the contract.
- Hiring an experienced contractor in the field of work who has a good reputation.
- Avoiding delaying the response to contractor's queries as well as the approval the submitted submittals and shop drawings.
- Establishment of a control system to handle, control, and evaluate variation orders, initiated by the owner.
- Development of a comprehensive financial plan and cash flow.
- Development of a monitoring and periodical reporting of critical and long lead items and periodically providing a narrative explanation of causes of any experienced delay.
- Choosing experienced subcontractors with good reputation.
- Development of a good system for site management and supervision also develops effective planning and scheduling for the project.
- Project parties should preview the site Due-Diligence Reviews and execution of necessary borings during the tender stage to make sure that the need for adjustments in design or make amendments if necessary before the issuance of notice to proceed.
- Formal relationships among project parties should be clearly identified, as well as roles and responsibilities

A. Recommendations to Accomplish Cost Overrun Reduction

- The estimate / tender should include an allowance for Shortage of skilled and similar issues should also be discussed in the Risk Evaluation meeting.
- The Estimate / Tender should include an allowance for work overtime or multiple shifts possible situation.
- Ongoing communications are vital to the future success of construction project.
- Removal of unsatisfactory subcontractors from site and locating new subcontractors ,The Estimate / Tender should include an allowance for this possible situation

- Accidents at the site, accidents to major equipment & materials in transit to the construction site. The Estimate / Tender should include an allowance / fund for this possible situation, the correct insurance should be in place, which party is responsible for insuring goods in transit.
- Unavailability of skilled Engineering and Construction technical management personnel (home office engineers and site staff Shortages of key engineered materials such as some exotic steel / alloy products. : Senior Management should acknowledge this as a possibility and advise the Estimating Group on how to alleviate this issue.
- Site worker strikes, vendor strikes / working to rule issues. Disputes between Unions and Open shop contractors : Senior Management should recognize this as a possibility and endeavor to ensure this does not occur.
- usage plan and ensure construction equipment is at the construction site when required and is off hire /removed from site when specific activity is completed. A detailed Estimating Department review by discipline needs to be completed, with the Project Manager, Engineering Manager and Procurement Manager. Checklists need to be compiled to speed up this activity. Engineering discipline departments need to provide or agree to the quantities in the Estimate / Tender, sign off sheets need to be created to ensure all scope items are part of the Estimate / Tender.
- Discussions with the Owner by the Contractors Senior Management on the additional costs that will be required to achieve this fast track construction program is perhaps the best course of action on this item.
- The construction contract must have a comprehensive listing of all anticipate work items (Schedule of Rates & various multipliers) that were priced with the Estimate; these can be used to estimate the cost of the changes.
- The construction contract must have a comprehensive listing of all anticipate work items (Unit Prices / Schedule of Rates & various mark-up multipliers / uplifts) that were priced with the Estimate; these can be used to estimate the cost of the changes.
- A rigorous review of the contractor / subcontractors qualifications statements and an in depth check / questioning of their past customer.

B. Recommendations to Accomplish Accident Reduction

- By providing good training to your employees, you're helping them become more aware of the work environment and what they need to do to remain safe on the job site. Make fall training a required part of your training program.
- Safety harnesses and nets both help minimize the injuries that occur when a fall accident is unavoidable Make sure to regularly schedule inspections of workers' and business' safety equipment to ensure that it remains safe instead of failing when it's needed most.
- By blocking off potential fall sites in an obvious way, can physically reduce the risk of a fall while alerting workers to potential safety issues.
- Should not leave guard and mid rails off of scaffolding to allow better ease of movement, in addition, making sure that scaffolding will handle four times the weight of the maximum load, that planking is of sufficient quality and tightly placed and that the setup has been inspected by a qualified professional
- When construction workers are tired, whether from a crazy schedule on a fast-track project or because they're working in a tough environment, they have more accidents. Instead of working tired employees while paying overtime, look at hiring a few more employees for a big or tough job to create a second shift. The difference in cost is more than worth it when an accident means lowered production due to poor worker morale and higher insurance rates.
- Keep a Clean Work Site: designate a safety supervisor who takes a quick walk through the job site at least every couple hours to maintain a safe environment.
- Providing good lighting not only means quality construction, it can save lives as well.
- Adding traction in the form of sand, grip tape or similar formats helps prevent accidents by improving work site safety dramatically.
- Always inspect machine before use. Log and report faults to supervisor.
- Make sure staffs are trained and authorised to use the machine.
- Wear a harness when using the machine.
- Read operators manual for safe use.
- Beware of a wind funnelling effect between buildings.

VI. CONCLUSIONS

This study analyzed causes of construction delays, accidents and cost overruns. The feedback of construction experts obtained through interviews and questionnaire surveys were used for the study, to find most frequently, severally and important occurring causes of delays, accident and cost overruns in construction of steel structures in SOUTH INDIA. Study also provides recommendations to avoid these major causes of delay, accident and cost overrun in current and future projects.

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