Statistical Analysis of Delay Factors and Success Factors on Building Construction Projects

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Abstract— Not all the projects finish on time and within given budget. Delays and changes occur during construction that impact the schedule, consequently impacting the project in its completion. Delay in construction projects is defined as late completion of project as compared to the planned schedule. Delays in construction projects are quite expensive; sometimes they may result in severe damages to involved parties. The time and cost for the performance of project are usually important to the employer and contractor. Time overruns always contributed as expensive to all parties. The purpose of this research is to identify critical success and delay factors which can help project parties to reach their intended goals with greater. Totally Twenty Eight delay factors & seven success factors were shortlisted to be made part of the questionnaire survey. According to the case study results, the most contributing factors and categories (those need attention) were discussed, some recommendation were made in order to minimize and control delays in construction projects. Also this project can serve as guide of all construction parties with effective management in construction projects to achieve a competitive level of quality and a time effective project. Statistical Prediction model for estimating actual project duration with delay was implemented on a real case study & tested the accuracy of prediction model.

Key words: Delay Factors, Success Factors, Construction Planning, Construction Costs, Project Management, Forecasting, Statistical Models

I. INTRODUCTION

The delay problem in the construction industry is a worldwide phenomenon. Delays occur in most building construction projects, either simple or complex. In construction, delay can be defined as the extension of time in the completion of project. In short delay means failure to complete project in targeted time & budgeted cost as agreed in contract. Construction delay and their claims are an integral part of construction. Construction delay is considered to be one of the recurring problems in the construction industry and it has an adverse effect on project success in terms of time, cost and quality. To the owner, delay means loss of revenue through lack of production facilities and rentable space or a dependence on present facilities. In some cases, to the contractor, delay means higher overhead costs because of longer work period, higher material costs through inflation, and due to labor cost increases.

Completing projects on time is an indicator of efficiency, but the construction process is subject to many variables and unpredictable factors, which result from many sources. These sources include the performance of parties, resources availability, environmental conditions, involvement of other parties, and contractual relations. However, it is rarely happen that a project is completed within the specified time. The building Construction project is large, volatile, and requires tremendous capital outlays. Typically, the work offers low rates of return in relation to the amount of risk involved. Delays on construction projects are a universal phenomenon. They are almost always accompanied by cost and time overruns. Construction project delays have an adverse effect on parties (owner, contractor, and consultant) to a contract in terms of a growth in adversarial relationships, distrust, litigation, arbitration, cash-flow problems, and a general feeling of apprehension towards each other. So, it is essential to define the actual causes of delay in order to minimize and avoid the delays in any construction project. The purpose of this research is to identify critical success and delay factors which can help project parties to reach their intended goals with greater efficiency and to study the different delay analysis techniques.

II. PROBLEM STATEMENT

From scheduling standpoint, the goal of every project is to be delivered on time and within budget, with desired functionality and acceptable quality level. The common results of delays are increases cost, late completion of project, loss of productivity, third party claims, conflicts abandonment and termination of contract. When projects are delayed, the extension of time invite additional cost. This result in conflict between parties (owner, Contractor and/or third party) in regards to claims for extra compensation or extra time to complete a project. To recover the damages caused by delays, the parties responsible for the occurrence should be identified. Most of the time more than one party is responsible for project delay therefore multiple delays may occur concurrently. Hence it is important to analyze causes of construction delay and schedule impact analysis techniques.

III. THEROTICAL CONTENTS

A. Delay Factors

1) Client related Causes

- Finance and payments of completed work Owner interference
- Slow decision making
- Unrealistic contract duration and requirements imposed

2) Contractor related causes

- Subcontractor performance
- Site management
- Construction methods
- Inadequate planning
- Mistake during construction stage
- Inadequate Contractor experience

3) Engineer/consultant related causes Contract management
- Preparation and approval of drawings
- Quality assurance/control
- Waiting time for approval of tests and inspection

4) Material related causes
- Quality of material Change
- Shortage of material

5) Labor and equipment category causes
- Labor supply
- Labor productivity
- Equipment availability and failure

6) Contract related Causes
- Change orders
- Mistakes and discrepancies in contract document

7) Contract relationships related causes
- Major disputes and negotiations
- Inappropriate overall organizational structures
- Lack of communication between the parties

8) External causes
- Weather conditions
- Regulatory changes
- Problem with neighbors
- Unforeseen ground condition's

B. Success Factors
- Project managers capabilities and experience
- Use of control system
- Project manager's goal commitment
- Organizational planning
- Clarity of project scope and work definition
- Safety precautions and applied procedures
- Project team's motivation and goal orientation

IV. DELPHI ANALYSIS

The Delphi technique is a widely used and accepted method for gathering data from respondents within their domain of expertise. The technique is designed as a group communication process which aims to achieve a convergence of opinion on a specific real-world issue. The Delphi process has been used in various fields of study such as program planning, needs assessment, policy determination, and resource utilization to develop a full range of alternatives, explore or expose underlying assumptions, as well as correlate judgments on a topic spanning a wide range of disciplines.

The Delphi technique is well suited as a method for consensus-building by using a series of questionnaires delivered using multiple iterations to collect data from a panel of selected subjects. Subject selection, time frames for conducting and completing a study, the possibility of low response rates, and unintentionally guiding feedback from the respondent group are areas which should be considered when designing and implementing a Delphi study.

Profession of respondents	No. of respondents
Contractors	11
Engineers	19
Total	30

Table 1: No. of respondents

Years of experience	No. of respondents
1 to 5 years	1
5 to 10 years	6
10 to 15 years	9
Above 15 years	14

Table 2: Respondents years of experience

A. Analysis

For the Analysis of questionnaire survey Relative Importance Index (RII) is used. In this method all the factors/questions from the questionnaire are ranked on the basis of their Importance.

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

W= Weighting given to each statement by respondent from 1 to 4

Ranking: Scale(1 to 4)
- Not Important
- Slight Important
- Moderate Important
- Important

A= Higher response (i.e 4 in this case)

N=Total no. of respondents

Sample Example of Inadequate Planning

RII= 106/4*30= 0.88

No.	Causes of delay	Rank
1	Inadequate planning	1
2	Labour productivity	2
3	Site management	3
4	Construction methods	4
5	Sub-contractor performance	5
6	Shortage of material	5
7	Labour supply	5
8	Preparation & approval of drawings	6
9	Mistakes and discrepancies in contract document	7
10	Inappropriate overall organizational structures	7
11	Lack of communication between the parties	7
12	Owner interference	8
13	Unrealistic contract duration and requirements imposed	8
14	Change orders	8
15	Mistakes and discrepancies in contract document	9
16	Inadequate Contractor Experience	9
17	Waiting time for approval of tests and inspection	10
18	Quality of material	10

Table 3: Most Important causes of delay as per ranking

The above analysis shows the delay factors rated by the experts and their ranking. It can be seen that in above ranking Inadequate Planning has the highest RII and has been ranked first in the table. Similarly top ten ranking factors from above analysis can be considered as most important factors which should be mostly considered during the execution of work.

No.	Success factors	Rank
1	Project manager's capabilities and experience	2
2	Use of control system	1
3	Project manager's goal commitment	3

4	Organizational planning	5
5	Clarity of project scope and work definition	4
6	Safety precautions and applied procedures	6
7	Project team's motivation and goal orientation	4

Table 4: Overall ranking of success factors

The above analysis shows that the success factors rated by the experts and their ranking. It can be seen that in above ranking "Project manager's capabilities and experience" has the highest RII and has been ranked first in the table and other factors also arranged as per their ranking in this table.

V. PREDICTION MODEL

The data collection helps us to gather the information regarding current scenario, so that we can analyze the variables of our interest and reach to a conclusion and carry our research in the particular area. From previous analysis of collected data from construction projects field, the planner can predict approximately the construction actual time of any new construction project before construction using the following equation:

$$DC=1+\sum_{j=4}^{j=1}(dj \times ERIIj)/\sum_{j=4}^{j=1}(ERIIj)$$

$$PAD= DC \times PSD$$

Where DC is the project Delay Coefficient; ERIIj (%) is the Equivalent weighted average percentage of Relative Importance Index per category; dj is the percentage of each category impact ranged between (0.00–1.00), PAD is the total Predicted Actual Duration of the studied project; and PSD is the total Planned Scheduled Duration before constructing the studied project.

Where, $ERIIj\ (\%) = \sum_{n=1}^{n=N}(Pn \times ORIIn)/\sum_{n=1}^{n=N}(Pn)$

Where ERIIj (%) is the Equivalent weighted average percentage of Relative Importance Index per category; ORIIn (%) is the Overall weighted average percentage of Relative Importance Index per factor of specific category, which is calculated based upon total years of experiences of all respondents; n is the number represents the factor number in the related category (from first factor of category n = 1 to from last factor of category n = N); and Pn is the priority weight of the studied factor. It is clear that the results of studied factor.

No.	Category Items	ERII	Dj
1	contractor related causes	79.14	35
2	labor and equipment	79	35
3	Client related causes	68.125	40
4	Contract relationships related causes	67	37
5	Material related causes	66.67	43
6	Contract related causes	66.67	33
7	Engg/Consultant related causes	66.3	30
8	External Causes	52.2	66

Table 5: Equivalent average relative importance index of category & Percentage of each category impact

Calculation of Delay coefficient

$$DC= 1+\sum_{j=4}^{j=1}(dj \times ERIIj)/\sum_{j=4}^{j=1}(ERIIj) = 1+ 0.37 = 1.37$$

In case study it was found that total planned project duration before start date was 445 working days, while total actual project duration after completion was 586 working days. While total actual project duration before constructing the studied project can be predicted from the following formulas

$$DC= 1.37$$

$$PAD= 1.37*445= 611 \text{ Days}$$

A. Case Study Conclusion

From studying and analyzing the previous project, it was found that there is variation in total project duration as actual duration increased from the planned project duration by 30 % and the predicted actual project duration increased from the planned project duration by 35 % with accepted variance +15 days.

VI. CONCLUSION

To improve control in building construction projects, the influence of the main factors affecting it must be identified and recognized. This research has identified and based on the quantified relative importance indices, determined the influence ranks of twenty eight factors causing delay in construction projects. The explored factors were classified under the following eight primary classifications: 1. Client related causes 2. Contractor related causes 3. Engineer/ consultant related causes 4. Material related causes 5. Labor and equipment related causes 6. Contract related causes 7. Contract relationships related causes 8. External causes. Then quantified relative importance indices of delay factors and demonstrated the ranking of the factors according to their importance level of delay. Delphi method also used to rank the most needed critical success factors for building construction. These success factors can be used to avoid the delay factors. Prediction model for estimating actual project duration was implemented; a real case study tested the accuracy of prediction model. This statistical method could assist the decision makers in identifying factor causing delay and complete the project on planned schedule time.

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