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Delay Analysis in Industrial Projects by using Relative Importance Index Method

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Abstract:
One of the most common problems in the industrial project is delay. Delay in a construction project can be defined as the late completion of works as compared to the planned schedule or contract schedule. Construction projects can be delayed due to so many factors. It may be due to consultant, contractor, material, equipment, finance etc related factors. The aim of this paper to identifying the causes and effects of delays in industrial projects. This has been achieved by undertaking a critical analysis of the literature and carrying out a questionnaires survey. The twenty questionnaire surveys were completed by taking interviews of the respondent, i.e., consultants and contractors who works on industrial projects. Then the causes of delay assessed using Relative Importance Index (RII) so as to rank the factors .Also use the Spearman's Rank Correlation Coefficient test to determine significant correlation between contractors and consultants perspective. The most significant factors of construction delays were identified as: (1) Local political interference; (2) Inadequate fund allocation; (3) Improper project planning and scheduling; (4) Delay in progress payments by client; (5) Escalation of material prices. Also major effects of delay were identified that are (1) Time overrun; (2) Cost overrun; (3) Disputes. The results also include the most effective methods for minimizing construction delays.

Keywords: Industrial projects, Delay, Relative importance index, Spearman's rank, Correlation coefficient

I. INTRODUCTION

The construction industry is a very important sector for the development and economic growth of developing country (Haseeb et al., 2011). A construction project is commonly acknowledged as successful, when it is completed on time, within budget and in accordance with the specifications (Murat Gunduz et al., 2013). Over many years, delay has been a popular topic in construction management research, and various delay studies have been carried out for different purposes (Abdullah AlSehaimi et al., 2013). Construction projects in India are infamous for delays and cost overruns. Very few projects get delivered within time and within cost. The delays and cost overruns have become hallmark of construction project in India. Bandra-Worli Sea Link was planned as a Rs. 300 Crore project to be completed by 2004; but its actual cost is Rs. 1,600 crore along with five years delay. Indeed, very few projects get delivered in time and on cost. Delays on construction projects are a universal phenomenon. They are almost always accompanied by cost and time overruns (Sadi Assaf and Sadiq Al-Hejji, 2006). Project delays have a debilitating effect on all 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 (Abd. Majld and Ronald McCaffe, 1998). Several factors can contribute to delays on a project and analyzing the causes of delays is an essential task for ameliorating any potential conflicts or claims (Muhwezi and Otim, 2014). The study is to identify the major causes of delays in construction projects in construction industry through a survey and to find the perception of the different parties towards the problem, what their responsibilities are and how they carry them out. It is expected that this study will provide some good empirical data on the extent and type of delays in construction projects.

II. LITERATURE REVIEW

Several articles have discussed causes of delay in construction projects in numerous manners; some studies identified the main causes of delay in several countries and various project types, while other studies discussed the delay analysis methods and the proposed ways to mitigate it. The study of Baldwin *et al.* (1971) was carried out to determine the causes of delay in the construction process in the United States. Mansfield *et al.* (1992) which investigated the causes of delay and cost overruns that affect completed highway projects in Nigeria. Murat Gunduz *et al.* (2013) identified the total 83 different delay factors and addressed the most significant factors and groups of causes of delays through ranking results. Sadi Assaf *et al.* (2006) identified seventy three causes of schedule delay exist in Saudi construction projects. They found that the most important causes of schedule delay as seen by contractors were: delay in progress payments by owner, late approving design documents by owner, change orders by owner during construction. Abd El-Razek *et al.* (2008) identified the thirty two causes of delay in construction projects in Egypt. The overall results indicated that the most important causes are: financing by contractor during construction, delays in contractors payment by owner and non utilization of professional contractual management. Muhwezi *et al.* (2014) studied the effects of delays on building construction projects in Uganda, using Kampala as the case study so as appropriate mitigation measures are put in place to ameliorate the effects of delay. Abdullah Al Sehaimi *et al.* (2013) studied simple analysis and evaluation of the findings and recommendations

of published studies of construction delay in developing countries.

III. RESEARCH METHODOLOGY

The research methodology will explain how the objectives of this study can be achieved. Firstly, questionnaire was divided into two main parts. Part A includes the details of the respondents and organizations in order to get the information about the respondents details and organization as well. Part B includes three sub-sections, Section I includes the questionnaire of factors causing delay, Section II includes the questionnaire of effects of delay and section III includes the questionnaire of method of minimizing delay. In Section I, seventy six factors causing delay were identified from in-depth literature studies and discussing with some construction practitioners. These factors then grouped into eight major groups which are Material related delays, Labour related delays, Equipment related delays, Contractor related delays, Consultant related delays, Client related delays, Finance related delays and External related delays. Material related group includes ten factors which are: Shortage of construction material in market, Late delivery of materials, Changes in material specification during construction, Poor procurement of construction materials, Imported of construction materials, Delay in manufacturing materials, Unreliable suppliers, Damage of sorted materials, Poor quality of construction materials and Escalation of material prices. Labour related group includes eight factors which are: Strike, Labor supply, Personal conflicts among labour, Labour productivity, Shortage of skill labour, Slow mobilization of labour, Low motivation and Absenteeism. Equipment related group includes seven factors which are: Insufficient numbers of equipment, Equipment allocation problem, Inadequate modern equipment, Improper equipment, Frequent equipment breakdown, Slow mobilization of equipment and Shortage of equipment parts. Contractor related group includes thirteen factors which are: Inadequate contractor experience, Inappropriate construction methods, Poor site management and supervision, Site management, Improper technical studies by the contractor during the bidding stage, Improper project planning and scheduling, Incompetent project team, Delays in sub- contractors work, Poor communication and coordination with other parties, Rework due to errors, Inaccurate time estimate, Inaccurate cost estimate and Obsolete technology.

Consultant related group includes eight factors which are:

Lack of experience of consultant in construction projects, Poor design and delays in design, Delay in approving major changes in the scope of work by consultant, Slow response and poor inspection, Inaccurate site investigation, Incomplete drawing/detail design, Poor communication and coordination with other parties and Inadequate project management assistance. Client related group includes ten factors which are: Slow decision making by client, Change orders by the owner during the construction, Delay in progress payments, Conflicts between joint-ownership, Lack of experience of client in construction, Client interference, Delay in site delivery, Lack of capable representative, Lack of communication and coordination and Improper project feasibility study. Finance related group includes seven factors which are: Inadequate fund allocation, High interest rate, Monthly payment difficulties, Delay payment to suppliers/subcontractors, Unreasonable constraints to client, Client's financial difficulties. Finance related group includes thirteen factors which are: Local political interference, Weather condition, Changes in government regulations and laws, Loss of time by traffic control and restriction at job site, Natural disasters (flood, hurricane, earthquake), Accidents during construction, Unexpected geological condition (Such as high water table, etc.), Inflation/Prices fluctuation, Delay in providing services from utilities (such as water, electricity), Slow site clearance, Conflict, war and public enemy, Problem with neighbors and Unforeseen ground condition.

Section II of B questionnaire included the six effects of delays which are:

Time overrun, Cost overrun, Dispute, Arbitration, Litigation and Total abandonment. Section III of B questionnaire included the total thirty two methods of minimizing construction delays which are: Competent D Capable project manager, Ensure adequate and available source of finance, Multidisciplinary/competent project team, Availability of resources, Commitment to projects, Adopting a new approach to contract award procedure by giving less weight to prices and more weight to the capabilities and past performance of contractors, Complete and accurate project feasibility study and site investigation, Acceleration of site clearance, Comprehensive contract documentation, Frequent progress meeting, Awarding bids to the right/experience consultant and contractor, Use up to date technology utilization, Use of experienced subcontractors and suppliers, Complete and proper design at the right time, Competent personnel of consultant/ designer, Competent and capable of client's representative, Site management and supervision, Use of proper and modern construction equipment, Proper project planning and scheduling, Accurate initial cost estimates, Use of appropriate construction methods, Proper material procurement, Effective strategic planning, Systematic control mechanism, Perform a preconstruction planning of project tasks and resources needs, Absence of bureaucracy, Allocation of sufficient time and money at the design phase, Accurate initial time estimates, Frequent coordination between the parties involved, Developing human resources in the construction industry through proper training, Clear information and communication channels and Project management assistance. These questionnaires were based on the Likert Likert's scale of five ordinal measures from 1 to 5 (very low effect to very high effect) according to level of contributing.

IV. DATA ANALYSIS AND DISCUSSION

The procedure used in analyzing of data was aimed at establishing the relative importance of the various factors that contribute to causes of delays, effects of delays and methods of minimizing construction delays. There are three steps used in analyzing the data: calculating the relative importance index; ranking of each factors based on relative importance index, and to determine degree of correlation on ranking the factors among the two groups.

4.1 Relative Importance Index

The contribution of each of the factors to overall delays was examined and the ranking of the attributes in terms of their criticality as perceived by the respondents was done by use of Relative Importance Index (RII) which was computed using equation and the results of the analysis are presented in Tables 1 to 3. To determine the ranking of different factors from the

viewpoint of contractors and consultants, the Relative Importance Index (RII) was computed using RII Equation (Abdalla Odeh and Hussein Battaineh, 2002; Murat Gunduz *et al.*, 2013; and Muhwezi and Otim, 2014).

Table.1. Most Important Factors Causing Delays

Most Important Factors Causing Delays				
Causes of Delay	Contractor	Consultant	Over All	
	RII	RII	Mean RII	Rank
Local political interference (External)	0.9	0.72	0.81	1
Inadequate fund allocation (Finance)	0.8	0.72	0.76	2
Improper project planning and scheduling (Contractor)	0.78	0.68	0.73	3
Delay in progress payments (Client)	0.74	0.72	0.73	4
Escalation of material prices (Material)	0.7	0.74	0.72	5
Weather condition (External)	0.78	0.64	0.71	6
Delay payment to suppliers/subcontractors (Finance)	0.66	0.74	0.7	7
Insufficient numbers of equipment (Equipment)	0.74	0.64	0.69	8
Incomplete drawing/detail design (Consultant)	0.8	0.58	0.69	9
Natural disasters-flood, hurricane, earthquake (External)	0.74	0.64	0.69	10

RII = W/(A x N)
Where
W = Weight age given to each factor by the respondents
A = Highest weight (i.e., 5 in this case) N = the total number of respondents

Table 1 shows the ranking of top ten factors that causes delay from seventy six delay factors. That means these ten factors causing delay are more contributing into the industrial projects. Table 2 shows the ranking of various effects of delay. Top effects indicate very high frequency of occurrence in industrial projects. Bar Chart 1 shows the time overrun is the top most significant effect of delay among six effects of delay.

Table.2. The Common Effects of Delays

The Common Effects of Delays				
Effects of Delay	Contractor	Consultant	Over All	
	RII	RII	Mean RII	Rank
Time overrun	0.9	0.8	0.85	1
Cost overrun	0.86	0.72	0.79	2
Dispute	0.76	0.58	0.67	3
Litigation	0.64	0.56	0.6	4
Arbitration	0.62	0.54	0.58	5
Total Abandonment	0.56	0.58	0.57	6

It also indicates the cost overrun and disputes are also major effects of delay. Table 3 shows the ranking of the relative importance of top ten methods of minimizing construction delays from total thirty two methods. It indicates that these ten methods are more effective methods for minimizing construction delay

Table.3. Methods of Minimizing Construction Delays

Methods of Minimizing Construction Delays				
Methods of minimizing construction delays	Contractor	Consultant	Overall	
	RII	RII	Mean RII	Rank
Competent/ Capable project manager	0.82	0.76	0.79	1
Perform a preconstruction planning of project tasks and resources needs	0.8	0.74	0.77	2
Accurate initial cost estimates	0.82	0.72	0.77	2
Ensure adequate and available source of finance	0.74	0.76	0.75	4
Multidisciplinary/ competent project team	0.78	0.72	0.75	5
Use of proper and modern construction equipment	0.78	0.72	0.75	6
Proper project planning and scheduling	0.76	0.74	0.75	7
Use of appropriate construction methods	0.8	0.7	0.75	8
Use of experienced subcontractors and suppliers	0.74	0.76	0.75	9
Site management and supervision	0.74	0.72	0.73	10

4.2The Spearman's Rank Correlation Coefficient Test

The Spearman rank correlation is used to know whether there is disagreement or agreement between the two groups on ranking factors. This test is used to find and compare how well the contractors and consultants agree on the relative importance of the delay causes. A perfect positive correlation ($r_s = +1$) indicates that the two samples rank each object identically, whereas a perfect negative correlation ($r_s = -1$) indicates that the ranks of the two samples have an exactly inverse relationship. It might be said then that sample estimates of correlation close to unity in magnitude imply good correlation, whereas values near 0 indicate low or no correlation (Sadi Assaf *et al.*, 1995; Sadi Assaf and Sadiq Al-Hejji, 2006; and Abdullah AlSehaimi *et al.*, 2013).

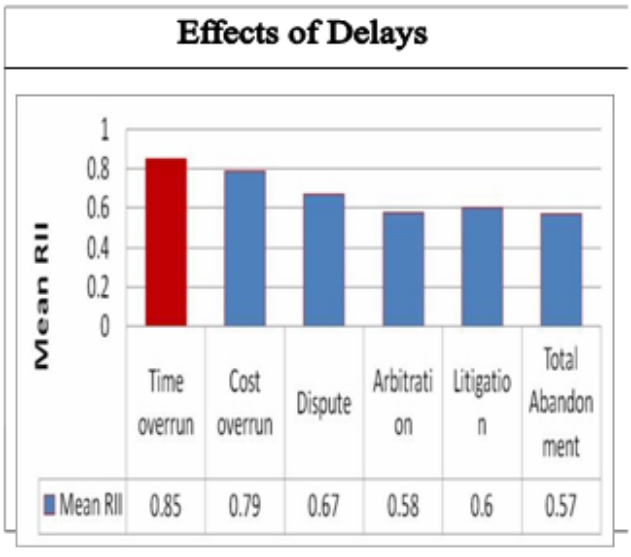

Figure.1. Effects of Delays

In order to determine there is significant correlation of the ranking of factors that causes delays, effects of delays, and methods of minimizing construction delays between

contractors and consultants perspective, the Spearman's Rank correlation coefficient was computed as following equations and the results of the analysis are presented in Table 4 (Abdalla Odeh and Hussein Battaineh, 2002; Abd El-Razek *et al.*, 2008; and Ibrahim Mahamid *et al.*, 2012):

$rs = 1 - [(6 \Sigma d2)/(N3 - N)]$

rs = Spearman's Rank correlation coefficient

d = the difference in ranking between the contractors and consultants

N = the number of variables

This calculated value of rs is compared with critical value of rs from the standard table for n samples.

Null hypothesis: Ho: No significant agreement in the rankings among the two groups.

Alternative hypothesis: H1: Agreement in rankings among the two groups.

Compare the value against the critical value. Reject the null hypothesis, if rs is greater than the critical value.

Table.4. Results of Spearman's Rank Correlation Coefficient Test

Results of Spearman's Rank Correlation Coefficient Test			
Groups	Spearman's Rank Coeff. r_s (Calculated)	Spearman's Rank Coeff. r_s (Critical)	Results
1) Material	0.824	0.648	Ho is rejected
2) Labour	0.440	0.738	Ho is accepted
3) Equipment	0.554	0.786	Ho is accepted
4) Contractor	0.577	0.560	Ho is rejected
5) Consultant	0.655	0.738	Ho is accepted
6) Client	0.709	0.648	Ho is rejected
7) Finance	0.804	0.786	Ho is rejected
8) External	0.577	0.560	Ho is rejected

Table 4 shows the results of tests of Spearman's Rank Correlation Coefficient for different groups of construction delay. This Table 4 indicates Material, Contractor, Client, Finance and External related delay groups agree on the ranking given by both contractors and consultants.

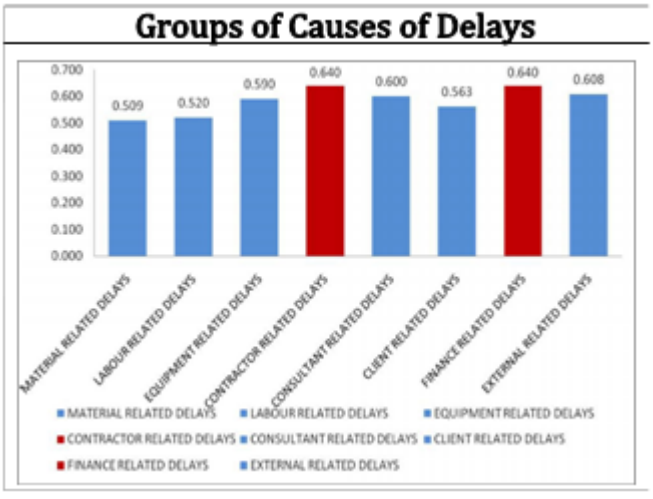

Figure.2. Groups of Causes of Delays

Contractor related group causing delay and finance related group causing delay are the top most significant group that contributed to causes of delays among eight groups shown in bar Chart 2.

V. CONCLUSION

In a construction project where time truly equals money, the management of time is critical, thus predicting the likelihood of schedule delay may play a key role towards project success. There existed a need to develop a probabilistic schedule delay analysis model in construction projects as a decision support tool for contractors before the bidding stage. From total seventy six factors causing delays, top ten most important factors have been identified which are: Local political interference, Inadequate fund allocation, Improper project planning and scheduling by contractor, Delay in progress payments by client, Escalation of material prices, Weather condition, Delay in payment to suppliers/subcontractors, Insufficient numbers of equipment, Incomplete drawing/detail design and Natural disasters (flood, earthquake, etc.).Total seventy six factors causing delay were identified and grouped into eight major groups. The major delays groups were identified are: Contractor related delays and Finance related delays. The major effects of delays have been identified which are: Time overrun, Cost overrun and Disputes. From total thirty two methods of minimizing construction delays, the top ten effective methods have been identified which are: Competent/Capable project manager, Perform a preconstruction planning of project tasks and resources needs, Accurate initial cost estimates, Ensure adequate and available source of finance, Multidisciplinary/competent project team, Use of proper and modern construction equipment, Proper project planning and scheduling, Use of appropriate construction methods, Use of experienced subcontractors and suppliers and Site management and supervision.

5.1Recommendations to Minimize Delays

Based on this study, some recommendations are given as follows: We divide the recommendations into three groups:

1. Recommendations for the clients,
2. Recommendations for the consultants, and
3. Recommendations for the contractors.

5.2Recommendations for the Clients

- Appropriate funding levels should always be determined at the planning stage of the project so that regular payment should be paid to contractors for work done. Therefore, clients should work closely with the financing bodies and institutions to release the payment on schedule.
- Clients should not interfere frequently during the execution and keep making major changes to the requirements. This can cause inordinate delays in the project.

While selecting the contractors, clients have to make sure that the contractors are not selected based only on the lowest bid. The selected contractor must have sufficient experience, technical capability, financial capability, and sufficient manpower to execute the project.

- Communication and Co-ordination should be proper with the other parties.
- Site should be delivered as soon as possible after project is awarded.

5.3Recommendations for the Consultants

- All working drawings must be clearly drawn indicating all the dimensions and scale so as to avoid ambiguity during construction.
- Avoid the redesign of the project once submitted.
- Accurate site investigation should be done in order to avoid errors in design.

- Establish control system to control and evaluate variation in orders initiated by owner
- Consultants should prepare and approve drawings on time.

5.4Recommendations for the Contractors

- Contractors should not take up the job in which they do not have sufficient expertise.
- Development of good system for site management and proper supervision develops project planning and scheduling.
- Initially calculate optimistic duration to execute the project.
- In order to improve contractors' managerial skills there is need for continuous work training programs to update their knowledge and be familiar with project management techniques and processes.
- Contractors should appoint experienced and reputed subcontractors.
- Contractors must plan their work properly and provide the entire schedule to the clients
- Proper work as per specification to avoid rework due to error.
- Contractors must make sure they have a sound financial backing

5.5Recommendations for Future Studies

More research on construction delays should be done in order to develop guidelines, or methods of minimizing construction delays. Furthermore, similar research should be performed in various provinces or cities of India. In order to providing more reliable data it is required to carry out studies for each specific type of construction projects, including highways, dam construction projects, utilities, etc. Surely, detailed surveys required to be performed to find out cash flow problems on delays in construction projects.

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