

Examining Delay Causes Using Anova Statistics

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Abstract: Construction projects are suffered by delays. If something goes wrong, it affects the project completion date. In such situation attempts are made to identify the causes of delay and its solution, and schedules of completion of project are revised. Most of the construction delays can be minimized by identifying its causes on construction site. Most of the time construction delays are result of miscommunication between contractors, sub-contractors, suppliers, owners and consultants. We can avoid such kind of unforeseen exceptions by applying efficient and perfect planning mechanisms through specification of work and its timetable. Delays in construction project may result in severe damages. Apart from the above example there are so many realistic as well as unrealistic factors which are responsible for project delays. There are many techniques to identify the cause of delays. An Anova technology is one of them. It is helpful to find out the contradicting variance as well as the causes where there is negligible variance in the causes. The significance of a survey or experiment results are found by using an anova test. Improvement needs by way of incorporating these issues in the analysis and focusing on them in future research work are the key recommendations of the study.

IndexTerms - Construction Delays, delay analysis techniques, minimize delays, Anova technology.

I. INTRODUCTION

Construction projects are affected by the weather, soil conditions, availability of labour, material and plant, disputes, etc. These uncertainties usually cause delays in project programmes. The delay results in unimaginable extra cost being incurred by both contractors and clients. For contractors it is in the form of liquidated or actual damages, extended labor, material and equipment costs, additional head and field office overheads and inefficiency cost. For clients, it may include loss of profit, revenue, opportunity costs, legal and consulting costs. (Trauner 1990). The research to date (Akintoye and Skitmore, 1991; Lewis and Athereley, 1996) suggests that cost caused by delays are highly significant. Hence, every party are interested in reducing the delays and its effects. Even minor advances in recovery delayed schedule can have major impact on the typical financial returns of the parties involved. Delay analysis is a method to determine the respective delay liabilities of the client and the contractor. Construction delay analysis is classified in the broad categories based on present research. The first category includes the study aimed at identifying the nature and causes of delays from their composition and importance. It includes the work of Majid and McCaffer's (1998) on the identification of factors for delay and ranking of their significance in delay prevention strategies. Lewis and Athereley's (1996) examination of cost and time implication of delays; and Ogunlana et al's (1996) relationships between delay factors and economic growth in developing countries. The second category comprises the study aimed at analyzing the effects of delays on project completion time (Scott, 1993). It concentrates on developing the schedule of the project for use in preparing delay claims (Alkass et al, 1996; Bordoli; and Baldwin, 1998; yogeshwaran et al, 1998) and apportioning delays in a fair way between different parties (Arditi and Patel, 1989; Chehayeb et al, 1995).

II. DEFINITION

What Does “One-Way” or “Two-Way Mean?”

One-way or two-way refers to the number of independent variables (IVs) in your Analysis of Variance test. One-way has one independent variable (with 2 levels) and two-way has two independent variables (can have multiple levels). For example, a one-way Analysis of Variance could have one IV (brand of cereal) and a two-way Analysis of Variance has two IVs (brand of cereal, calories).

What are “Groups” or “Levels”?

Groups or levels are different groups in the same independent variable. In the above example, your levels for “brand of cereal” might be Lucky Charms, Raisin Bran, Cornflakes — a total of three levels. Your levels for “Calories” might be: sweetened, unsweetened — a total of two levels.

III. TYPES OF TESTS

There are two main types: one-way and two-way. Two-way tests can be with or without replication.

- **One-way ANOVA** between groups: used when you want to test two groups to see if there's a difference between them.
- **Two-way ANOVA** without replication: used when you have one group and you're double-testing that same group. For example, you're testing one set of individuals before and after they take a medication to see if it works or not.
- **Two-way ANOVA** with replication: Two groups, and the members of those groups are doing more than one thing. For example, two groups of patients from different hospitals trying two different therapies.

3.1 ONE WAY ANOVA

A one way ANOVA is used to compare two means from two independent (unrelated) groups using the F-distribution. The null hypothesis for the test is that the two means are equal. Therefore, a significant result means that the two means are unequal.

3.1.1 WHEN TO USE A ONE-WAY ANOVA

Situation 1: You have a group of individuals randomly split into smaller groups and completing different tasks. For example, you might be studying the effects of delay on construction and form three groups: contractor, owner, consultant.

Situation 2: Like situation 1, but in this case the individuals are split into groups based on an attribute they possess. For example, you might be studying compressive strength of cube according to weight. You could split participants into shape categories (normal, cut off edges and cracks) and measure their compressive strength on a testing machine.

3.1.2 LIMITATIONS OF ONE WAY ANOVA

A one-way ANOVA will tell you that at least two groups were different from each other. But it won't tell you what groups were different. If your test returns a significant f-statistic, you may need to run an ad hoc test (like the Least Significant Difference test) to tell you exactly which groups had a difference in means.

III. METHODOLOGY

Based on the results of all the reviewed studies, specially the Indian ones, we develop a list of factors, which might affect the delays in the Indian private projects and categorized them into three main groups. A questionnaire was developed to evaluate the frequency of occurrence and importance of the identified causes. The design of the questionnaire has been based on Assaf and Al-Hejji (2006) and Sweis (2008) references, and the study questionnaire is based on Open Conversion System proposed by Drewin. According to Drewin the construction process influenced by technologies and both external and internal environments. Therefore, a combination between Drewin's open conversion system and delay causes identified in previous studies results in 45 potential delay factors were summarized into three major categories:

- Production Elements (PE) includes: Labor (L), Materials (M) and Equipment (E) related factors.
- Internal Environment (IE) includes: Consultant, Contractor and Owner related factors.
- External Environment (EE) includes: Weather, Government Regulations and Other reasons.

Then the questionnaire was distributed by hand. Therefore, a sample consists of 5 consultants, 5 contractors, and 5 owners selected (many residential and trade buildings have the same owner- organization). Responses to the questionnaire were then collected and analyzed. The responses consisted of 5 consultants, 5 contractors, and 5 owners. They were asked to grade each delay cause from a scale of 1 to 5 in which number 5 indicates a very strong affecting cause on the construction projects and number 1 indicates a minor cause of delays in the construction projects.

IV. DATA ANALYSIS & RESULTS

The delay causes were ranked by taking the average of the respondents for each individual group/participant (consultant, contractor, owner), then the average of the three groups were calculated separately. The resulting averages were ranked in descending order according to the highest average in the group response.

Table 1: RANKING FOR CONSULTANT

Reason	Category	Avg. Rate
Manpower shortage	Labour	3.7
Shortage of Material	Materials	3.4
Relation between different subcontractor's schedules	Contractor	3.2

Table 2: RANKING FOR OWNER

Reason	Category	Avg. Rate
Manpower shortage	Labour	2.9
Shortage of Material	Materials	3.9

Relation between different subcontractor's schedules	Contractor	3.7
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Table 3: RANKING FOR CONTRACTOR

Reason	Category	Avg. Rate
Manpower shortage	Labour	3.8
Shortage of Material	Materials	3.5
Relation between different subcontractor's schedules	Contractor	2.8

We notice that the Shortage of labor (skilled, semiskilled, unskilled) were one of the first and the most often causes of delay in private projects in India from the view point of the consultants and contractors and it's the first according to the average of the three groups. For the owner, the shortage of materials was the most frequent cause, and it was one of the most important four causes for the three groups. The Indian construction industry suffers from the shortage of skilled man power because of the high wages demanded by the skilled foreign man power, and that is why the contractor depends on cheap, unskilled labor. Delay in the approval of contractor submissions by the engineer and that's a very important factor that the contractor complains from, and it's the second most important reason in the contractor points of view. In general, the contractor can't start any work or finish it without the approval of the engineer, so in general that process delays the project. In some cases, we notice that in some contracts the engineer got a specific time to give the approval to the contractor and that's cause a lot of delay in the project because the contractor can't work before getting that approval. And in some other cases the contractor starts his work without the engineer approval and in that case the engineer has the right to make the contractor does that work again. Shortage of materials is the third most frequent cause according to the point of view of the contractor consultant and owner and it's the most frequent reason among the owner's point of view. And the critical importance of this cause might come from a sudden increase in the cost of materials, and that might be a result of the increasing in demand on a specific material, monopoly of a specific material or import and export problems, so it's hard to get the enough quantity of that material. The relationship between different subcontractors' schedules was one of the most important delay causes according to the average of the three groups. The critical importance of this cause can be seen clearly by noticing that one of the most important delay causes by the consultant was "Insufficient coordination among the parties by the contractor", and by the owner was "The relationship between different subcontractors' schedules ". Therefore, both consultant and owner are blaming the contractor for his poor project implementation, coordination and planning. In addition, there is a strong agreement among the respondents on some of the lowest causes which are: "Accidents during construction", "Problem with neighbors "and" Changes in government regulations and laws". A one-way analysis of variance ANOVA was conducted among the means of responses from the three groups to check for any significant differences among the groups perceptions regarding the importance of the various delay causes. Factors Affecting Delays on Private Construction Projects. The mean values under the three groups, F statistics, and the P values at which hypothesis of equality of mean values across different groups could be rejected were calculated.

The tabular critical F value at the 0.05 level for 2° and 119° degree of freedom is approximately (3.094).

From the analysis, it was found that there were statistically non-significant differences among the respondent groups over the following sample of causes:

- Shortage in labor (F = 1.70, P = 0.184)
- Labor productivity (F = 1.89, P = 0.2)
- Shortage of materials (F = 0.07, P = 0.89)
- Delay in materials delivery (F = 2.3, P = 0.11)
- Specification changes (F = 0.5, P = 0.82)

The following causes have the highest F values which indicate a very strong agreement between the responses from the three groups on the following sample

of causes:

- Shortage of labor (skilled, semiskilled, unskilled labor), (F = 3.40, P = 0.040)
- Shortage of instruments (F = 5.8, P = 0.005)
- Disobeying safety rules by contractor organization (F = 4.52, P = 0.014)
- Untimely payments by contractor to subcontractor (F = 5.74, P = 0.003)
- Large number of players in project implementation (F = 4.2, P = 0.03).

V. CONCLUSION

The stated objective of this paper is to identify the causes of delay that produce the greatest effects and the extent to which these effects can be ameliorated in the private construction industry in Indian. A literature review was conducted to identify the causes of delay stipulated in the literature. The importance index of each cause is calculated as an average of the frequency indices of each cause. 44 causes of delay were identified through research. The identified causes are combined into three categories. The field survey included 5 consultants, 5 contractors, and 5 owners. Data then collected were analyzed by frequency and importance. However, the result of this study indicated that Shortage of manpower (skilled, semiskilled, unskilled labor), Delay in the approval of contractor submissions by the engineer, Shortage of materials and the relationship between different subcontractors' schedules are the major causes of delays in private projects in India. Owners specified that causes of delay are related to consultant and contractor; the consultants specified that the causes of delay are related to the contractor and the owners, and the contractors specified that the causes of delay are related to the consultants and owners, so we notice that each party of the project is blaming the other two parties. In general, two of the three parties (Consultant and Contractor) had an agreement over the most important cause which is Shortage of manpower (skilled, semiskilled, unskilled labor), and there was an agreement between two parties on the other top ranked causes. All parties agree that the following causes are the least important: accidents during construction and problems with neighbors. The following points can be recommended by all parties to minimize and control delays in construction projects:

Consultants should look to the following points:

- Should not be late in reviewing and approving the given documents and drawings.

Contractors should consider the following factors:

- Should try to increase the productivity of labor as far as possible and take efforts to motivate it.
- Efficient coordination between contractors and subcontractors is a must.
- Financial and cash flow problems should be managed by contractor with proper financial planning beforehand.

Owners should give special attention to the following factors:

- Avoiding too many changes after bidding of tender.
- Faster decision making on part of owners.
- Efficient cash flow to contractors on part of owner's responsibility.
- Check for resources and capabilities, before awarding the contract to the lowest bidder.

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