Identifying potential delay situations in advance to define construction contract obligations of public buildings

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During the execution of construction project, project completion on time was commonly considered the key of project's success. Project time can be evaluated as the vital factor in project management point of view because it affects directly on the profit of project if project time delay happens. Because of the many sources and causes of construction project delays, it is often difficult to analyze the ultimate liability in delay claims. During a construction projects, delays may result from many circumstances. Act of GOD, the Employer, the Engineer, the Contractor, or a third party may cause delays. Delays are one of the biggest problems that construction firms face. They can lead to many negative effects such as lawsuits between Employers and Contractors, increased costs, loss of productivity and revenue, and contract termination. The aim of this paper is to identify the main causes and consequences of delay in public building projects and their impact. By applied Spearman coefficient in this study, it was found that the degree of agreement among the parties of the project is high. In addition, the Engineer has an intermediate position from both the Employer and the Contractor. The significance of Spearman correlation coefficient values was checked and it was found that we can be 99.9% confident the correlation has not occurred by chance, and the results can be dependable.

Keywords: Construction delay, contract, and spearman correlation

1. Introduction

Construction delays are often the result of miscommunication between Contractors, subcontractors, and property employers. These types of misunderstandings and unrealistic expectations are usually avoided through the use of detailed critical path schedules, which specify the work, and timetable to be used, but most importantly, the logical sequence of events which must occur for a project to be completed. Delays in construction projects are frequently expensive, since there is usually a construction loan involved which charges interest, management staff dedicated to the project whose costs are time dependent, and ongoing inflation in wage and material prices. However, in more complex projects, problems will arise that are not foreseen in the original contract, and so other legal construction forms are subsequently used, such as change orders, lien waivers, and addenda. In construction projects, as well in other projects where a schedule is being used to plan work, delays happen all the time. It's what is being delayed that determines if a project, or some other deadline such as a milestone, will be completed late.

The state of construction projects in Developing countries exposed to different types of delays, therefore, the construction industry need to determine the most important causes that lead to these delays. Many previous studies have been working to identify the most important factors of delays in construction projects and try to reduce and mitigate their effects and determine the responsibility of each party to the project and its contribution in these delays. This study relied on previous studies in extracting the most important factors that fit and compatible with the construction projects that are supervised by the Directorate of Housing and Utilities in Alexandria as an example of a government construction projects. Delays occur in every construction project and the magnitude of these delays varies considerably from project to project. Some projects are only a few days behind the schedule; some are delayed over a year. So it is essential to define the actual causes of delay in order to minimize and avoid delays in any construction project. Delay is generally acknowledged as the most common, costly, complex and risky problem encountered in construction projects. Because of the overriding importance of time for both the Employer (in terms of performance) and the Contractor (in terms of money), it is the source of frequent disputes and claims leading to lawsuits. To control this situation, a contract is formulated to identify potential delay situations in advance and to define and fix obligations to preclude such controversies.

There is a wide range of views for the causes of time delays for engineering and construction projects. Some are attributable to a single party, others can be ascribed to several quarters and many relate more to systemic faults or deficiencies rather than to a group to group. The successful execution of construction projects and keeping them within estimated cost and prescribed schedules depend on a methodology that requires sound engineering judgment.

Circumstances play a great deal in determining which clause(s) will be applied to a particular delay claim. Also, contract law encompasses concepts of reasonableness and fair dealing, implied obligations and warranties, constructive acceleration, etc. A good general understanding of the principles involved and the operation of the applicable clauses are essential to help make appropriate decisions and take the proper action in those delay situations.

The objective of this study is to determine and identify the main causes of delay of public building construction projects which are under supervision of the directorate of Housing and Utilities. This study used a compiled list which was formed from a number of lists used in previous studies and have been modified to be appropriate for the public building construction projects in Developing countries.

2. Types of construction delay

Before determining the impact of a delay on the project, it must be determine whether the delay is critical or non-critical. Additionally, all delays are either excusable or non-excusable. Both excusable and non-excusable delays can be defined as either concurrent or non-concurrent. Delays can be further broken down into compensable or non-compensable delays. There are four basic ways to categorize delays, which will be defined as follows:

2.1 Non-excusable Delays

Non-excusable delays are delays, which the Contractor either causes or assumes the risk for. These delays might be the results of underestimates of productivity, inadequate scheduling or mismanagement, construction mistakes, weather, equipment breakdowns, staffing problems, or mere bad luck. Such delays are inherently the Contractor's responsibility and no relief is allowed. These delays are within the control of the Contractor or are foreseeable; however; it is not necessary that they be both.

2.2 Non-compensable Excusable Delays

When a delay is caused by factors that are not foreseeable, beyond the Contractor's reasonable control and not attributable to the Contractor's fault or negligence, it may be "excusable". This term has the implied meaning that neither party is at fault under the terms of the contract and has agreed to share the risk and consequences when excusable events occur. Contractor will not receive compensation for the cost of delay, but he will be entitled for an addition time to complete his work and is relieved from any contractually imposed liquidated damages for the period of delay.

2.3. Compensable Excusable Delays

In addition to the compensable delays that result from contract changes by Change Notice, there are compensable delays that can rise in other ways. Such compensable delays are excusable delays, suspensions, or interruptions to all or part of the work caused by an act or failure to act by the Employer resulting from Employer's breach of an obligation, stated or implied, in the contract. If the delay is compensable, then the Contractor is entitled not only to an extension of time but also to an adjustment for any increase in costs caused by delay.

2.4. Concurrent Delays

Concurrent delays occur when both Employer and Contractor are responsible for the delay. Generally, if delays are inextricably intertwined, neither the Contractor can be held responsible for the delay (forced to accelerate, or be liable for liquidated damages) nor can he recover the delay damages from the Employer.

3. Background

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 following articles were incorporated in this study to compile a list of delay causes.

Economic historian Robert E. Wright argues that construction delays are caused by bid gaming, change order artistry, asymmetric information, and post contractual market power. Until those fundamental issues are confronted and resolved, many custom construction projects will continue to come in over budget, past due, or below contract specifications, he claims

The study of Baldwin et al. (1971) was carried out to determine the causes of delay in the construction process in the United States of America.

Mansfield et al. (1992) investigated the causes of delay and cost overruns that affect completed highway projects in Nigeria.

Construction delay problems in Developing countries were discussed by Amer (1994) via studying and analyzing the causes that contribute to construction delays in order to improve the ability to implement construction projects without delays. Results of this study indicated that the major causes of delay in construction projects in Developing countries are: (a) poor contract management, (b) unrealistic scheduling, (c) lack of Employer's financing and/or payment for completed work, (d) design modifications during construction, and (e) shortages in materials such as cement and steel.

In Saudi Arabia, Assaf et al. (1995) studied the main causes of delay in large building projects. The survey covered a random sample of Contractors, Engineers, and Employers.

As a case study regarding the Nontaburi bypass road project, Noulmanee et al. (2000) discussed the internal causes of delay in a highway construction project in Thailand.

Ahmed et al. (2003) carried out a study to identify the major causes of delays in building construction in Florida, and then allocated the responsibilities and types of delays for each cause, regarding commercial construction projects.

Choudhury and Phatak (2004) studied the causes that affect time overrun.

Mobarak, M. (2008) discussed the role of consultancy in minimizing the delays of large projects and showed possible categorizations of causes of delay such as internal and external, Financial and nonfinancial.

4. Methodology and Objectives

Even though various studies have been considered into the causes affecting delays, these studies seldom discuss common and general causes of delays in construction of public building projects. Also, the previous studies in Developing countries were conducted over one decade ago and the nature of the construction industry in Developing countries has changed and rapidly developed ever since. Many multinational firms have expanded their operations in Developing countries, in addition to a noticeable improvement in construction management practices in large projects. Due to the influence of multinational firms, the initial compilation of delay causes list depended on international studies and was further compared against the causes identified by studies in developing countries and checked for appropriateness to developing countries within the expert interviews.

5. Questionnaire Design

A list of delay factors has been derived from the lists used in previous studies after deleting repeated factors, as well as the factors that rule out the occurrence in the projects under study. Some were taken from experts in this field who represent one of the parties of the project such as Engineers who deal with the Directorate of Housing or project managers who run the project as representatives of the Directorate of Housing. Considering the appropriate list, a questionnaire of 41 factors of delays was formed; the 41 factors were grouped according to the different responsibilities (Contractor, Engineer, Employer and shared responsibility). This questionnaire used in a survey which includes 64 participants who gave each factor a degree of importance (very important, important, somewhat important and not important). A questionnaire survey was conducted to quantitatively confirm the derived list of causes and identify the most important causes of delay.

The questionnaire was divided into two parts: Part One participant's personal information (e.g., position, experience; and level of education); and Part Two — project information (e.g., measurement of the importance of the causes of delay).

The 41 causes of delay were grouped according to responsibility' (Contractor, Engineer, Employer, and common responsibility) then they are categorized into several categories under each group. Two extra blank rows were provided to give the participant a chance to add any further causes, and thus confirm the list of delay causes. Each cause of delay was measured on a Likert scale using four options: very important: important somewhat important; and not important.

Under the responsibility of the Contractor there were selected causes which summarized in the following table.

Table 1: Selected delay under the Contractor's Responsibility

#	Delay cause
1	Shortage in construction materials
2	Slow delivery of construction materials.
3	Shortage in labor.
4	Poor labor productivity.
5	Unqualified workforce.
6	Shortage in equipments
7	Unskilled operators.
8	Poor equipment productivity
9	Financing by Contractor during construction
10	Preparation of shop drawings and material samples.
11	Errors committed due to the lack of experience
12	Accidents during construction
13	Controlling subcontractors by Contractor in the execution
14	Frequent change of subcontractors because of their inefficient work.
15	Improper construction methods implemented by Contractor
16	Ineffective planning and scheduling of project by Contractor
17	Unavailability of utilities in site (such as, water, electricity, telephone, etc.)

Under the responsibility of the Engineer there were selected causes which summarized in the following table.

Table 2: Selected delay under the Engineer's Responsibility

#	Delay cause
18	Changing materials types and specification during construction.
19	Design changes by Employer or his representative during construction.
20	Design errors and/or incomplete made by designers
21	Unexpected foundation conditions encountered in the site.
22	Mistakes in soil investigation
23	Waiting for approval of shop drawings and material samples.
24	Inspection and testing procedures used in the project.
25	Inadequate experience of the Engineer.

Under the responsibility of the Employer there were selected causes which summarized in the following table.

Table 3: Selected delay under the Employer's Responsibility

#	Delay cause
26	Delays in Contractor's payments by Employer
27	Cash problems during construction
28	Obtaining permits from municipality.
29	Excessive bureaucracy in project employer operation
30	Delay to furnish and deliver the site to the Contractor by the Employer.
31	Slowness of the Employer decision-making process
32	Ineffective delay penalties

Under the shared responsibility there were the following selected causes which summarized in the following table.

Table 4: Selected delay under the Employer's Responsibility

#	Delay cause
33	Application of quality control based on foreign specifications.
34	The conflict in point of view between Contractor and Engineer
35	Unavailability of professional construction and/or contractual management.
36	The relationship between different subcontractors' schedules.
37	Poor organization of the Engineer or the Contractor.
38	Difficulty of coordination between construction contract parties.
39	Weather effect.
40	Traffic control and restriction at construction site.
41	Change in government regulations and laws.

6. Psychometric scale

A psychometric scale commonly involved in research that employs questionnaires as Likert scale (1932). It is the most widely used approach to scaling responses in survey research, such that the term is often used interchangeably with rating scale, or more accurately the Likert-type scale, even though the two are not synonymous. The scale is named after its inventor, psychologist Rensis Likert. Likert distinguished between a scale proper, which emerges from collective responses to a set of items (usually eight or more), and the format in which responses are scored along a range. Technically speaking, a Likert scale refers only to the former. The difference between these two concepts has to do with the distinction Likert made between the underlying phenomenon being investigated and the means of capturing variation that point to the underlying phenomenon. When responding to a Likert questionnaire item, respondents specify their level of agreement or disagreements on a symmetric agree-disagree scale for a series of statements. Thus, the range captures the intensity of their feelings for a given item, while the results of analysis of multiple items (if the items are developed appropriately) reveals a pattern that has scaled properties of the kind Likert identified.

7. Results Analysis

A total of 64 questionnaires representing 64 participants were involved in this study. These participants were distributed as follows:

Table 5: Participant's categories

Categories	Number of Participants
Employer / Representative	25
Engineer / Representative	21
Contractor / Representative	18
Total	64

The majority of Engineer participants were having experience more than 20 years in the construction industry. It was decided to avail from each participant in contacting with more participants. The gathered data are analyzed using a similar methodology used by Assaf et al. (1995). The methodology was to calculate the "Importance Index" which gives each delay factor a degree of importance. The Importance Index was calculated using the following formula:

$$I = \frac{a \cdot x}{3}$$

Where

I = Importance Index for certain cause

a_i = Weight of response

x_i = Frequency of response

i = Response category index

A response of “very important” was given a weight of response 3, “important” was given a weight of 2, “somewhat important” was given a weight of 1, and “not important” a weight of 0.

The importance indices were calculated for all delay causes and the delay causes were ranked accordingly. For illustration, 64 responses were received of which for a first delay cause" Shortage in construction materials" : 41 responded by “very important”; 19 responded by “important,” 2 responded by “somewhat important,” and 2 responded by “not important,” then the importance index for this delay cause would be calculated as shown in the following Equation.

$$I = \frac{3*42 + 2*29 + 1*2 + 0*2}{3} = 54.33$$

Table 8: Importance Index for delay causes due to the Contractor's Responsibility

Cause ID	3	2	1	0	Important Index, I
1	41	19	2	2	54.33
2	27	33	2	2	49.67
3	28	22	11	3	46.33
4	19	23	19	3	40.67
5	15	22	20	4	39.33
6	27	26	7	4	46.67
7	17	27	14	6	39.67
8	14	24	21	5	37.00
9	44	17	2	1	56.00
10	25	24	13	2	45.33
11	16	28	18	2	40.67
12	8	21	27	8	31.00
13	14	29	18	3	39.33
14	22	21	19	2	42.33
15	26	25	11	2	37.67
16	35	20	7	2	50.67
17	32	18	12	2	48.00

The previous table shows the ranked delay causes and their corresponding importance index due to the Contractor's responsibility. The most important causes identified by, and based on overall results, were financing by Contractor during construction.

Table 7: Importance Index for delay causes due to the Engineer's Responsibility

Cause ID	3	2	1	0	Important Index, I
18	21	32	7	12	44.67
19	29	32	3	0	51.33
20	36	17	8	3	50.00
21	19	30	15	0	44.00
22	37	17	9	1	51.33
23	17	32	14	1	43.00
24	12	39	11	2	41.67
25	28	20	16	0	46.67

The previous table shows the ranked delay causes and their corresponding importance index due to the Engineer's responsibility. The most important causes identified by, and based on overall results, were mistakes in soil investigation.

Table 6: Importance Index for delay causes due to the Employer's Responsibility

Cause ID	3	2	1	0	Important Index, I
26	44	15	5	0	55.67
27	35	21	8	0	51.67
28	32	21	10	1	49.33
29	21	29	11	3	44.00
30	26	25	11	2	46.33

31	26	34	3	1	49.67
32	13	31	16	4	39.00

The previous table shows the ranked delay causes and their corresponding importance index due to the Employer's responsibility. The most important causes identified by, and based on overall results, were delays in Contractor's payments by Employer.

Table 9: Importance Index for delay causes due to the Shared Responsibility

Cause ID	3	2	1	0	Important Index, I
33	12	35	12	5	39.33
34	11	33	19	1	39.33
35	28	26	9	1	48.33
36	15	29	19	1	40.67
37	12	32	18	2	39.33
38	27	23	14	0	47.00
39	8	16	34	6	30.00
40	4	28	28	4	32.00
41	7	23	24	10	30.33

The previous table shows the ranked delay causes and their corresponding importance index due to the shared responsibility. The most important causes identified by, and based on overall results, were unavailability of professional construction and/or contractual management.

The previous analysis shows the most important causes identified by, and based on overall results, were financing by Contractor during construction.

8. Degree of agreement

The agreement between parties or survey respondents has been addressed by Spearman rank correlation coefficient among ranks. In statistics, Spearman's rank correlation coefficient or Spearman's rho, named after Charles Spearman is a non-parametric measure of statistical dependence between two variables. It assesses how well the relationship between two variables can be described using a monotonic function. If there are no repeated data values, a perfect Spearman correlation of (+1) or (−1) occurs when each of the variables is a perfect monotone function of the other.

Spearman's coefficient can be used when both dependent (outcome; response) variable and independent (predictor) variable are ordinal numeric, or when one variable is a ordinal numeric and the other is a continuous variable. However, it can also be appropriate to use Spearman's correlation when both variables are continuous.

Similar previous studies used the Spearman rank correlation coefficient (Alwi and Harnpson 2003; and Assaf et al. 1995) to quantitatively measure the agreement between parties. Spearman rank correlation coefficient was calculated according to the following formula (Assaf and A1-Hejji 2006).

$$r = 1 - \frac{6\sum d}{n.(n - 1)}$$

Where:

r_s= Spearman rank correlation coefficient

d= difference between the ranks indicated by two parties

n= number of records (n=41 in this study)

Table 10:

ID	Rank (contractor)	Rank (consultant)	Rank (Employer)
1	6	1	2
2	14	4	3
3	9	5	13
4	16	15	11
5	18	11	16
6	9	7	11
7	12	12	21
8	16	18	18
9	3	2	1
10	11	6	12
11	12	9	21
12	15	20	24
13	9	18	20
14	13	10	15
15	12	6	9
16	7	7	3
17	12	4	6
18	9	12	11
19	4	6	4
20	6	5	6
21	10	9	16
22	5	3	5
23	10	11	16
24	9	17	15
25	10	11	8
26	1	2	4
27	2	9	7
28	5	4	10
29	8	12	14
30	8	11	9

31	3	8	8
32	16	14	19
33	13	17	17
34	15	16	15
35	7	8	7
36	13	13	17
37	15	14	17
38	9	6	10
39	19	19	23
40	17	19	22
41	18	20	23

The results of the correlation between (a) Contractor and Employer, (b) Employer and Engineer, and (c) Contractor and Engineer were 0.92, 0.94, and 0.94 respectively.

The Spearman rank correlation coefficient shows high agreement between the three parties involved in the project noticing that Spearman rank correlation coefficient show the same degree of agreement between Engineer and both Contractor and Employer, which reflects his intermediate position considering this party as possibly, having an impartial view between the differences among the Contractor and the Employer

In this study, the values of 0.92, 0.94, and 0.94 of Spearman correlation coefficient and degree of freedom equal to 39 give a significance level above 0.1% which means that we can be 99.9% confident the correlation has not occurred by chance, and results can be dependable.

Table 11: Significance of Spearman rank correlation coefficient

Parties	S	Significance level
Employer and Contractor	0.92	0.999
Employer and Engineer	0.94	0.999
Contractor and Engineer	0.94	0.999

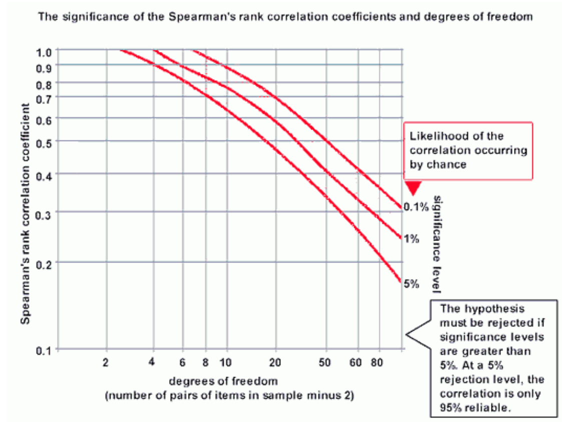

Fig 1: Significance of Spearman rank correlation coefficient

9. Conclusions

After analyzing the collected data, it was found that the most important factors causing delays in public building projects were the financial ones and factors that related to lack of construction material. The results were analyzed from the perspective of each party to the project to determine the most important reasons for the delay in the party saw all of them.

Spearman coefficient was applied to determine the degree of agreement among the parties of the project and it was found that the degree of agreement among the parties of the project is high, and that the Engineer has an intermediate position from both the Employer and the Contractor. The significance of Spearman correlation coefficient values was checked and it was found that we can be 99.9% confident the correlation has not occurred by chance, and results can be dependable.

Employers should give special attention to the following factors:

(a) Pay progress payments to the Contractor on time because it impairs the Contractor's ability to finance the work.
(b) Minimize order changing during construction to avoid delays.
(c) Avoid delay in reviewing and approving of design documents than the anticipated.
(d) Check for resources and capabilities, before awarding the contract to the lowest bidder.

Engineers should look to the following points:

(a) Reviewing and approving design documents: any delay caused by the Engineer in checking, reviewing and approving the design submittals prior to construction phase, could delay the progress of the work.

(b) Inflexibility: Engineers should be flexible in evaluating Contractor's works. Compromising between the cost and high quality should be considered.
(c) Mistakes and discrepancies in design documents: they are common reasons for redoing designs and drawings and may take a long time to make necessary corrections.

Contractors should consider the following factors:

(a) Shortage and low productivity of labor: enough number of labors should be assigned and motivated to improve productivity.
(b) Financial and cash flow problems: Contractor should manage his financial resources and plan cash flow by utilizing progress payments.
(c) Planning and scheduling: they are continuing processes during construction and match with the resources and time to develop the work to avoid cost overrun and disputes.
(d) Site management and supervision: administrative and technical staff should be assigned as soon as project is awarded to make arrangements to achieve completion within specified time with the required quality, and estimated cost.

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