

Investigating Causes of Delay in U.S. Construction Projects

Mohammadsoroush Tafazzoli Ph.D. Candidate, LEED AP, and Pramen P. Shrestha Ph.D., PE
University of Nevada, Las Vegas
Las Vegas, Nevada

Delays in construction projects is a global problem that causes considerable losses for many economies. Due to the complexities in standardizing construction projects, efforts to mitigate risks of delay have not been adequately successful. A rudimentary step to prevent delays involves identifying the main potential causes, which may be different in each region. This paper is a result of a survey that was conducted in the United States, targeting experienced experts in the construction industry to assess the criticality of potential causes of construction delay. In this study, the most common causes were identified first by means of a comprehensive literature review. Then, a nationwide survey was conducted to assess the relative criticality of causes of delay. Analysis of the collected data revealed that change orders, time-consuming decision making by the owner, and design errors were the most important causes of construction delays in the U.S. Using the relative importance index method, the relative criticality of the other 27 causes also was calculated. The findings of the research can be used as an informative tool to invest budget and time efficiently in mitigating the main causes of delay, decreasing the risk of delay in U.S. construction projects.

Keywords: construction delay, relative criticality ranking, construction projects, causes of delay

Introduction

On-time completion of the projects is an indicator of efficiency. Requiring any time more than what is actually needed to complete a project should be considered as a delay. However, under field conditions, many tasks cannot be completed in the minimum required time due to unforeseen events, the interconnectivity of tasks, and other factors. The schedule of a construction project has a significant role in a project's success (Luu et al., 2009); therefore, in project scheduling, estimators try to consider these factors to provide a practical, and not idealistic, estimated time needed to complete an activity, and in general, the time that is needed to substantially finish the project. At the same time, this estimation should encourage the team to prevent wasting time and actively move the project towards its completion. Although the deterrent factors of the smooth progress of a project are, to some extent, taken into consideration in scheduling, statistics indicate that a considerable amount of construction projects fail to finish on time (Majid et al., 1998; Odeh et al., 2002; Duran, 2006).

Delays during construction is a global phenomenon that has imposed immense costs on the construction industry. Some of the consequences of delay in construction projects are lawsuits between house owners and contractors, exaggerated prices, loss of productivity and revenue, and contract termination (Megha et al., 2013). It should be noted that late completion also indirectly causes such costs as the late opening of projects, and these losses may not always be easy to claim and compensate. Aggressive schedules, which are used as a common remedy to get a project back on track, are costly, and may affect the quality of work by increasing disturbance of work and loss of productivity (Cerpa et al., 2009). Since the

construction industry is one of the most important elements of the economy in most countries (Lange et al., 1979), losses caused by construction delays can affect the entire economy. Therefore, it is essential to come up with ways to minimize construction delays.

Although science and engineering have been applied in the construction industry to make processes more standardized, repeatable, and predictable, the complexity of construction projects still seems to make delays unavoidable. One challenge when introducing a universal prescription to prevent or handle delays in construction projects involves the uniqueness of construction projects in terms of size, duration, objectives, environment, complexity, deadlines, finances, and organization structures (Zou et al. 2007; Keung and; Shen 2013; Puspasari 2006) as well as personnel, delivery methods, and payment methods. This amount of variation does not allow for constant variables so that the process might become fully formulated and controlled.
Despite substantial advances in many different industries in minimizing the amount of waste and increasing productivity (Fulford et. al., 2014), the construction industry has not been as successful and quick in moving towards efficiency as other industries. When compared to other industries, such as manufacturing, the construction industry shows lower rates of risk control, minimizing waste, and maximizing productivity. In fact, the key to making the construction industry more standardized, and therefore controllable, is to try to implement processes similar to other manufacturing industries. (Forbes et al., 2010)

When controlling the occurrence of delays, the essential step is to investigate their roots. In other words, the events that may contribute to delay, which are called 'potential causes of delay' in this paper, should be identified. Based on this, this research aimed to achieve the three following goals:

1) Identify the main causes of construction delays by a comprehensive review of construction-delay research that have been carried out worldwide;

2) Conduct a nationwide survey to identify the main causes of construction delays in the United States from the perspective of experts; and

3) Define the relative criticality of all potential causes, and provide a sorted list of causes of delay according to the experts' responses.

In this study, the term *delay* refers to an extension of time that is decided upon for the substantial completion of a construction project. The types of projects investigated in this study were not limited to a certain type of construction.

Background

Because of the high frequency of construction delays and their extensive consequences, many studies have been conducted to investigate the various aspects of construction delays. Some of the findings of these studies in minimizing construction delays are provided in this section.

Frimpong et al. (2003) named three main criteria for the success of a construction project, which is 1) it is completed on time, 2) it is finished within budget, and 3) it is consistent with the specifications. Based on this concept, a delayed project is an unsuccessful project. Luu et al. (2009) and Gunduz et al. (2013) emphasized the importance of predicting the probability of delays. In preventing delays, the most effective solution that has been emphasized in the literature was to identify the main causes and then find solutions to mitigate the risk of their occurrence. Based on this, various researchers have attempted to investigate the causes of delay in certain regions. Examples of such studies are:

- Chan et al. (1997), who conducted a survey and evaluated the relative importance of 83 potential delay factors in Hong Kong;
- Al-momeni (2000), who investigated eight causes of delays on 130 public projects in Jordan;
- El Razek et al. (2008), who investigated the main causes of delay from the viewpoints of contractors, consultants, and owners in Egypt; and
- Kazaz et al. (2012), who investigated the main causes that effected project durations in Turkey with regard to seven categories.

Another category of delay analysis in the literature focuses on methods for analyzing delays. One example is a study by Bubshait et al. (1998), in which three delay-measurement processes were evaluated to measure the effects of delays, utilizing computerized critical path method (CPM) analysis. Some other techniques that have been used are the global-impact method, the net-impact technique, adjusted as-built CPM techniques, the 'but for' or collapsing technique, the snapshot technique, and time-impact techniques (Alkass et al., 1991, 1993; Wickwire et al., 1991; Reams; 1990; Leary and Bramble, 1988). Other construction delay studies focused on developing data collection tools to prevent delays. An image-processing system that integrates pictorial and voice information with project control data in support of performance evaluation and delay management was developed by Abu-Dayyeh in 1997.

The findings of these studies, conducted in different regions, indicate that criticality of the various causes might depend on the area where the project was carried out. For example, Ubaid (1991) determined that the performance of contractors was the major cause of delays in Saudi Arabia. Also in Saudi Arabia, delays in payments was found to be the major cause by Assaf et al. (1995). In Nigeria, financing and payment for completed works and poor contract management were found to be the most significant factors. In Hong Kong, the results of a comprehensive study on construction delays by Chan and Kumaraswamy (1997) revealed that poor site management and supervision, unforeseen ground conditions, and slow decision making were the three top causes. One of the oldest studies conducted about the reasons of that delays that occur in the U.S. was by Baldwin and Manthei in 1971. They investigated 17 different reasons for delays, and identified weather, labor supply, and subcontractors as the three major causes of construction delays.

In this research, the method used for analysis was the relative importance index. This method has been used before in similar studies. For example, Gunduz et al. (2013) used this index to quantify delay factors

for construction projects in Turkey. Chan et al. (1997) used the same method to study potential delay factors in Hong Kong construction projects.

Research Method

As mentioned earlier, the first step in preventing a delay is to identify its causes, and the causes depend on the characteristics of the area in which projects are being carried out. Rules and regulations as well as the way that delay penalties are decided or enforced can influence the factors that may cause construction delays. The method used in this study to determine the causes of delay in the construction industry of the Unites States is as follows.

Step 1: Selecting Potential Causes of Construction Delays for Evaluation

To begin with, it was necessary to come up with a list of the most critical causes of construction delays. Due to the fact that the number of personnel, equipment, and materials involved in most construction projects are large – and also because most construction projects have long durations with numerous activities – a large number of issues can negatively affect the smooth progress of construction projects. For most of these causes, this could lead to postponing the dates for completing tasks on the jobsite or, if the causes accumulate over time, to delay the intended substantial completion date of projects.

In order to conduct a criticality assessment, the causes to be selected for assessment needed to be determined. In order to identify the causes that should be assessed, a comprehensive literature search was conducted. The outcome was a list of 59 factors that cause delays. From these 59 factors, those that were repeated in two or more studies were evaluated. Additionally, by rewording, similar factors were identified and grouped under the same title. For instance, instead of considering three different factors that might cause a contractor's inefficiency in handling labor, equipment and materials, all three could be summarized in one factor, i.e., 'contractor's inefficiency in handling and managing resources'. Another example for grouping the factors is categorizing delays caused by different types of permits (environmental, building, right of way, utilities, etc.) as one factor. Similarly, the causes of delay related to poor quality control by the contractor that were identified in other studies under various different terms in other studies were grouped under one factor in this study. Although this approach might have reduced the accuracy of the results, it made it possible to conduct the survey, since too many questions may overwhelm the respondents and cause them not to provide precise responses. The results of narrowing down the number of factors to a list of 30 potential causes of construction delays are shown in Table 1.

Table 1

The potential causes of construction delays based on the responsible party for doing the analysis

The potential cause of delay	Index
Unrealistic schedule (bid duration is too short)	C1
Ineffective delay penalties provisions in contract	C2
Errors in contract documents	C3
Selecting inappropriate project delivery method	C4
Excessive change orders by the owner during construction	C5
Delayed payments by the owner	C6
Delay in approving design documents by the owner	C7
Time consuming decision making process of the owner	C8
Unnecessary interference by the owners	C9
Delay to furnish and deliver the site to the contractor	C10
Poor communication and coordination of the owner with designer and/ or contractor	C11
Poor Quality Assurance (QA) plan of the owner	C12
Lack of management staffs of the owner	C13
Inappropriate construction methods	C14
Contractor inefficiency (in providing the labor, equipment and material and handling sub-contractors)	C15
Poor communication and coordination of the contractor with owner and/ or designer	C16
Inadequate contractor experience	C17
Financial difficulties and mismanagement by the contractor	C18
Poor site management and Quality Control (QC) by the contractor	C19
Legal disputes between designer and the owner	C20
Design errors	C21
Complexities and ambiguities of project design	C22
Delays in providing the design documents by the designer	C23
Inadequate experience of the designer	C24
Inadequate site assessment by the designer during design phase	C25
Misunderstandings between owner and designer about scope of the work	C26
Financial difficulties with the designer	C27
Poor communication and coordination of the designer with owner and/ or contractor	C28
Legal disputes between designer and the owner	C29
Delay in getting permits and acquisitions (Environmental, building, right of way, utilities, etc.)	C30

Step 2: Assessment Survey for Construction Delays Nationwide

In the next step, a survey was designed to assess the criticality of the factors that cause construction delays. To do this, an online questionnaire was designed. Respondents were asked to rate each potential

cause of delay with a number between '1' to '5', where '1' indicated the least and '5' indicated the most level of criticality. None of the questions were forced responses in order to maintain the quality of responses; therefore, a different number of responses were collected for different questions. In addition, this survey tool made it possible to check how much time the respondent spent in answering the survey; this allowed the administrator to eliminate responses that were generated too quickly.

The invitation to fill out the survey was sent to a list of construction experts, who were identified by using the LinkedIn® database. The research team was attempted to find potential respondents in all the 50 states in order to have a quality sample representing the experts in the United States.

Step 3: Criticality Ranking of Factors that Cause Delays

One of the most important things that the survey aimed to measure was the effectiveness of the 30 factors in causing delays. The respondents were asked to evaluate the effectiveness of each of the causes by selecting a number between '1' to '5', in which '1' indicated the least effective and '5' indicated the most effective. The results of the survey for this question were analyzed using the relative importance index (RII) method. The reason that the RII method was selected for the analysis was that this method helped determine the contribution that a particular variable makes to the prediction of a criterion variable, both by itself and in combination with other predictor variables. (Johnson et al., 2004). RII is expressed as:

$$RII = \frac{\sum W}{A \times N} \qquad (0 \leq RII \leq 1) \qquad (1)$$

where: W = The weight given to each factor by respondents and ranges between 1 and 5
A = The highest weight (in this case, 5) and;
N = The total number of respondents

Step 4: Analyzing the Data and Interpreting the Results

After the data were analyzed and the criticality ranking determined, the results of this survey were compared with similar surveys in order to arrive at conclusions and make recommendations.

Results

The survey was conducted in 96 days. It was sent by a link sent electronically to potential respondents nationwide throughout the U.S. A total of 11000 invitations were sent, and 219 experts completed the survey. Results of this survey, which investigated the most important factors that cause delays in construction projects, are described as follows.

Average Years of Experience of the Respondents

The average years of experience of the respondents was 27.9 years. This is a high number to be involved in construction projects, and could be considered as one of the strengths of the sample population because it likely results in more reliable data than might be gained with a lower average years of experience.

Respondents' Background

The respondents were asked to share the type of project, the ownership, the party they worked for, and the type of delivery method they used, as shown in Table 2. The respondents might have a history of being involved in more than a single project type, project delivery method, project ownership, or they could have worked for different types of parties (e.g., owner, designer, or contractor); therefore, they were allowed to have more than one choice when answering these questions. As a result, the sum of the percentages are not 100.

Table 2

Respondents' Background

Type of Projects					Type of Project Delivery Method			
Building	**Highway**	**Infrastructure***	**Other**		**Design-bid**	**Design-bid-build**	**CMAR****	**Other**
87.74%	**13.86%**	**22.64%**	**6.13%**		**66.03%**	**67.94%**	**39.23%**	**12.92%**
Type of Ownership					**The Party Respondents Have Worked For**			
Public	**Private**	**Public-Private**	**Others**		**Owner**	**Designer/consulting firm**		**Contractor**
48.83%	**86.85%**	**17.84%**	**1.41%**		**82.55%**	**31.13%**		**37.74%**

Criticality Ranking of Delay Causes

The RII method was used to determine the criticality of factors that cause delays. Figure 1 shows the RII values of the 30 factors that were ranked by the respondents. The higher the RII values, the more critical was the factor. The results showed that excessive change orders and time-consuming decision processes taken by the owners were the two main factors; both had a value greater than 0.70.

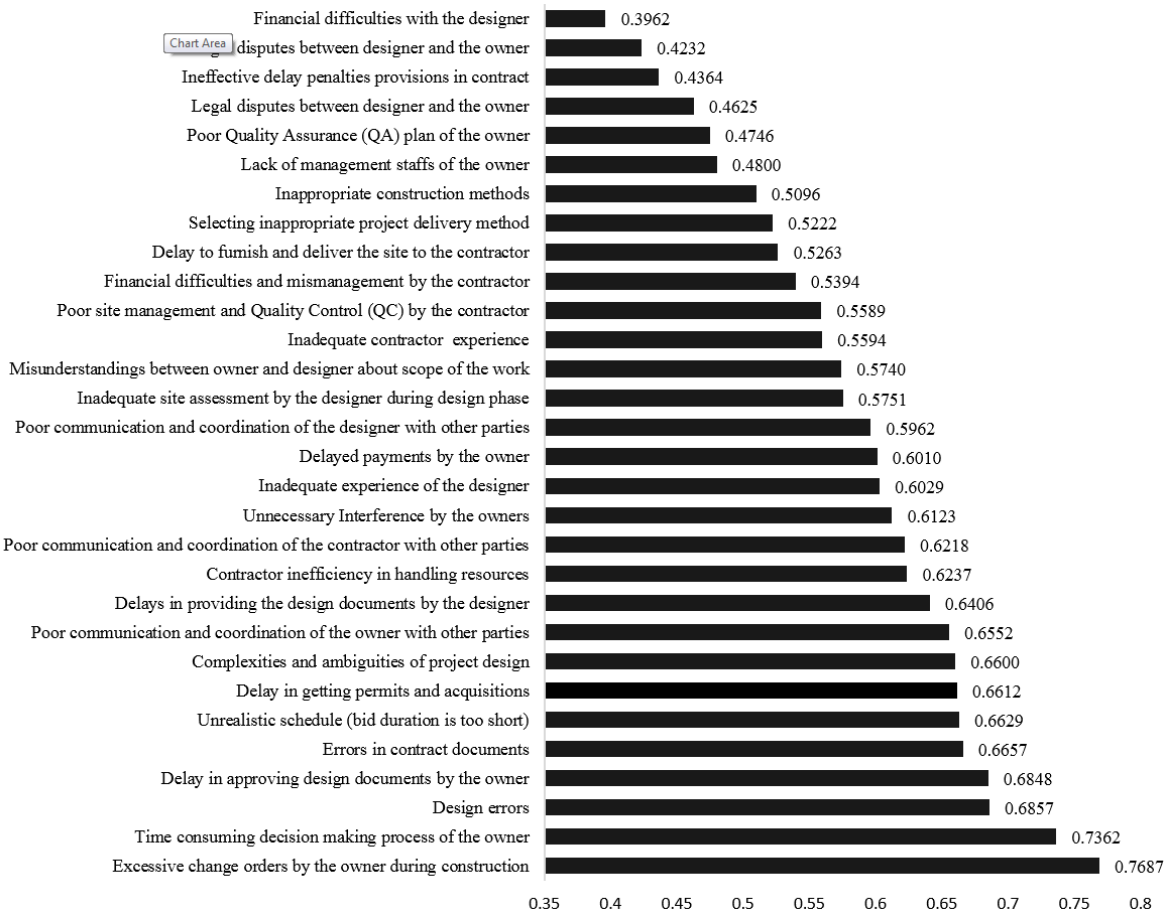

Figure 1: Results of the analysis for the Relative Importance Index.

Discussion and Recommendations

As it can be seen in Figure 1, the role of the owner was significant as a top factor in causing delays, and change orders were identified as the primary cause. In order to prevent change orders, two solutions are recommended:

1) Establish the client's needs and desires for the project in a clear way before the start of the design; this can be done by facilitating effective meetings between the two parties to make sure that the design meets the owner's expectations.

2) Ensure collaboration among the parties throughout the project by holding constant meetings. This allows for integrated decision making and planning on how to complete the deliverables by considering the interconnectivities among the tasks. This approach also lessens the potential of deviating from the intended budget and schedule as well as enhancing document management, particularly for the decisions made verbally during the meetings (Civitello et al., 2002).

It can be seen that issues related to design were among the most critical factors that cause delays. Design errors as well as design complexities and ambiguities has led to redesign, and the approval process is time consuming and costly. Some fundamental recommendations in preventing these errors are:

1) Hire designers with adequate experience in the type of target project, and hire high-profile designers for the more complex projects.

2) Allow sufficient time and resources to complete the design in order to avoid causing a rush in the design when trying to meet unreasonable deadlines.

3) Obtain peer reviews of the design by experienced reviewers.

Additionally, based on the results, improving communication and coordination between parties is essential in decreasing the risk of delays. Some recommendations are:

1) Precise and accurate language should be used, particularly for filed conversations, in a way that the message cannot be interpreted in different ways.

2) Project managers should facilitate effective communication by using a combination of clear speech, nonverbal signs and writing, and active listening in order to maximize the quality of interpersonal, group/ team, and organizational communications.

Conclusion

This paper explains why it is crucial to prevent the occurrence of delays in construction projects. It emphasized that two fundamental steps to mitigate the risk of delays are knowing the causes of delay and knowing the relative criticality of causes. The causes of delay may differ in various regions based on the characteristics of the construction industry and the rules and regulations in the region where a project is in progress.

Based on this, the causes of construction delays in the United Stated were investigated, using a national survey. The analysis of the data revealed that owner collaboration with the construction team, quality of design, and communication among parties were among the most significant factors regarding delays. The list of the most critical factors could be used by construction companies and project owners to maximize their budget planning to reduce or prevent delays.

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