Causes of delays in construction industry and comparative delay analysis techniques with SCL protocol

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Abstract

Purpose – The purpose of this paper is to reveal the main causes of delays in the projects are from the client (relative importance index (RII) = 0.716), labor and equipment (RII = 0.701) and contractor (RII = 0.698). Hence determining the contractual responsibility of delay is the most likely source of dispute in construction projects and many techniques have been used in the courts to demonstrate the criticalities of a delay event on the project schedule. Therefore, authors try to investigate all process-based techniques of delay claims and evaluated and conformed them with principles by Society of Construction Law (SCL) protocol and Association for the Advancement of Cost Engineering International (AACEI) in order to choose the best techniques based on the specific circumstances of each project.

Design/methodology/approach – This section is divided into two distinct parts: refers to the methods used to assess the perceptions of clients, consultants, and contractors on the relative importance of causes of delay in construction industry; and refers to advantages and disadvantages of various techniques used to analyze delays and their conform with SCL protocol. A questionnaire was developed to assess the perceptions of clients, consultants, and contractors on the relative importance of causes of delay in Iranian construction industry. The respondents were asked to indicate their response category on 78 well-recognized construction delay factors identified by authors.

Findings – In total, 78 causes of delay were identified through research. The identified causes are combined into seven groups. The field survey included 58 contractors, 55 consultants, and 62 client. Data collected were analyzed by RII and Statistical Package for Social Sciences (SPSS). The authors identified main causes of delay and ten most important causes, according to Table AII, from the perspective of three major groups of participants (clients, consultants and contractors). The ranking of categories of causes of delay, according to Table I, were: client-related causes (RII = 0.716); labor and equipment category causes (RII = 0.701); contractor-related causes (RII = 0.698); material-related causes (RII = 0.690); design-related causes (RII = 0.666); external causes (RII = 0.662); and consultant-related causes (RII = 0.662). But according to the discussions and given that determining the contractual responsibility of delay is the most likely source of dispute in construction industry and many techniques have been used in the courts to demonstrate the criticalities of a delay event on the project schedule.

Originality/value – All process-based techniques of delay analysis have been present in this paper and categorized in 11 groups. In order to understand the advantages and disadvantages of them by clients, contractor and consultant, a thorough review conducted to reveal the nature of techniques. In the next step, given that selecting the most appropriate technique based on constraints and specific conditions of each

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project is one of the most important steps to carry out a successful delay analysis. The authors conformed, all process-based techniques of delay analysis, by SCL protocol and AACEI principles. Finally, the result of this match was brought in order to choose the best technique based on the specific circumstances of each project.

Keywords Scheduling, Project management, Methodology

Paper type Technical paper

Introduction

In construction, delay could be defined as the time overrun either beyond completion date specified in a contract or beyond the date that the parties agreed upon for delivery of a project. 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.

Therefore, 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 and it is necessary that a detailed assessment be conducted and calculates the loss resulted from delays on both parties in the projects with time required for the extension of projects time if the project is delayed.

A lot of research efforts have been made to study delay causes in different countries. For example, Odeh and Battaineh (2002), Vilventhan and Kalidindi (2016) showed that owner interference, inadequate contractor experience, financing and payments, labor productivity, slow decision making, improper planning, and sub-contractors are among ten top most important factors causing delay in Jordan; Maura *et al.* (2007) discovered that design errors, client liability, project specification and direct change order by the client are the major factors that cause the time and cost overrun in Portuguese; Abdul-Rahman *et al.* (2006) conducted a study on delay mitigation in the Malaysian construction industry; they proved that a financial problem is confirmed by the survey as the main causes of delay.

Hence, one of the most important problems in the construction industry is delay and it is essential to define the actual causes of delay in any construction project. So choosing an appropriate delay analysis method is an important part of construction industry. The famous process-based methods include the global impact, net impact, adjusted as-built CPM, as-planned expanded, but-for, snapshot, time impact, windows and isolated delay type techniques (Yang *et al.*, 2006; Yang and Kao, 2007). These techniques are applied to prepare the logical basis to persuade their claims concerning the extension of time and financial burden but each delay analysis method adopts a different approach to identify delay impacts and may yield different results.

But in Iran, there is not a comprehensive and practical package for delays analysis techniques to determine which one is appropriate in accordance with the feature of the project. So the authors examine all delay analysis techniques that are frequently used in the construction project in Iran in order to determine which delay analysis techniques is appropriate for each construction project.

In this paper the main causes of delays in Iranian construction projects have been determined and the aim of this study is to operate a method based on which one could select the delay analysis techniques appropriate to the nature of the projects that what is needed to implement this method is to analyze the Society of Construction Law (SCL) protocols and analytical delay techniques and then to implement standards of protocol with delay analysis techniques.

Literature review

Many researchers have studied the causes of delay and delay analysis techniques in the construction industry. We have broken the studies into two parts: studies on causes of delay; and studies on delay analysis techniques.

Studies on causes of delay

Delay in construction is a global phenomenon affecting not only the construction industry but the overall economy of countries as well (Sambasvian and Soon, 2007; Parchamijalal and Shahsavand, 2016). Delays in construction are caused by several factors. Ahmed *et al.* (2003) grouped delays into two categories – internal causes and external causes. Internal causes arise from the parties to the contract (e.g. contractor, client, and consultant). External causes, on the other hand, arise from events beyond the control of the parties. These include the act of God, government action, and material suppliers. Sweis *et al.* (2008) studied the causes of delay in residential projects in Jordan and concluded that financial difficulties faced by the contractor and too many change orders by the owner are the leading causes of construction delay. Abd El-Razek *et al.* (2008) in a similar study in Egypt found that the most important causes of delay are financed by contractor during construction, delays in contractor's payment by owner, design changes by owner or his agent during construction, partial payments during construction, and non-utilization of professional construction/contractual management. Sambasvian and Soon (2007) identified the delay factors and their impact on project completion in the Malaysian construction industry. The results indicated that the ten from a list of 28 different causes of delay were: contractor's improper planning; contractor's poor site management; inadequate contractor experience; client's inadequate financial resources and payments for completed work; problems with subcontractors; shortage in material; labor supply; equipment availability and failure; lack of communication between parties; and mistakes during the construction stage. Assaf and Al Hejji (2006) conducted a survey on time performance of large construction projects in Saudi Arabia. The survey had 73 different causes of delay. He studied the importance of various causes from the viewpoint of contractors, consultants, and owners. The most common cause of delay identified by all the parties was "change order." He also found that about 70 percent of the projects experienced time overruns.

The previously mentioned studies were generally focused on finding causes of delays. Some of these studies identified very limited (lacking) factors or ignored some important groups. This may be misleading or may result in wrong analysis. In this paper, through a comprehensive literature review and interviews with highly experienced construction professionals, the authors attempted to use the relative importance index (RII) method in the quantification of the relative importance of a comprehensive list of delay factors in construction projects in Iran.

Studies on delay analysis techniques

Project managers and schedule (timing) analysts do often face with the problem of how to analyze the complicated delays and resolve the claims resulted from it. In addition, in most of the contracts of construction, it is not specified which method would be used to evaluate and analyze delays. On the other hand, the contractor and client have different views against analysis and determination of responsibility for delay. As a result, calculating delays and determination of responsibilities of each of the party is an important issue. Therefore, project managers must have a systematic approach for analyzing delays and allocation of responsibilities. Since there are different methods to analyze delays such as: pervasive influence technique, Bar chart or Gant chart technique, collapse technique or (but because), critical path method, time impact technique, global impact technique, net impact technique, impacted as-planned technique, collapsed as-built technique, sectional technique or snapshot technique, isolated delay type technique. So choosing an appropriate delay analysis technique for calculation of the effects of delay on project is a critical decision that is discussed in this paper (Hoshino and Livengood, 2011).

SCL has identified some factors that should be considered in choosing the method of delay analysis that includes the conditions related to the contracts, nature of causal events, value of claims, time in hand, recorded information, information of the existing time plan and planner's experience on the project (Braimah, 2013; Yangand Kao, 2012). SCL protocol is intended to act as an aid to the interpretation of the delay and disruption provisions contained in standard of civil engineering and building contracts and to act as a guide to the manner in which the managers ought to properly prepare delay and disruption claims and how adjudicators, arbitrators and judges ought to properly determine them. The protocol does not fully reflect the provisions concerning delay and disruption contained in certain standard forms and is not intended to have contractual status, it is believed that it is at least a useful guidance document.

Arditi and Pattanakitchamroon (2006) discussed selecting a suitable delay analysis method and concluded that the most appropriate analysis method depends on information available, time of analysis and capabilities of the method, as well as time, funds and effort allocated to the analysis. Bubshait and Cunningham (1998) proposed an approach for selecting one suitable method among the as-planned method, the as-built method, and the modified as-built method. Their approach consists of four scenarios, each comprising various approved schedules (network or bar chart) with different evidence and progress reports. They concluded that method selection depends on the time and resources available, and on the accessibility of project control documentation. Mohan and Al-Gahtani (2006) discussed ten delay analysis techniques in analysis flow and compared them in resolving the issues of real time delay, concurrent delay and pacing delay. Based on study results, Mohan and Al-Gahtani proposed a desirable delay analysis system consisting of 11 requirements, such as the requirement for the project schedule to be updated every day, taking account of all delays and changes in total floats.

Methodology

This section is divided into two distinct parts: refers to the methods used to assess the perceptions of clients, consultants, and contractors on the relative importance of causes of delay in construction industry; and refers to the nature of process-based techniques used to analyze delays and their conformity with SCL protocol.

Experts' perception of causes of delay

A questionnaire was developed to assess the perceptions of those in the Iranian construction industry on the relative importance of causes of delays. Then the questionnaire was filled out by highly experienced construction professionals including project managers, site managers, technical office managers, technical office engineers, procurement managers, and technical consultants. The collected data were analyzed through the RII method. RII or weight is a type of relative importance analyses. RII was used for the analysis because it best fits the purpose of this study. The analysis included ranking the different causes according to the relative importance indices. The analysis revealed the factors and groups that contribute most to delays.

The respondents were asked to indicate their response category on 78 well-recognized Construction delay factors identified by authors. These causes were categorized into the following seven major groups. Client-related causes (with 19 factors); contractor-related causes (with 13 factors); consultant-related causes (with 9 factors); design-related causes (with 8 factors); material-related causes (with 8 factors); labor and equipment category causes (with 8 factors); and external causes (with 13 factors). A five-point Likert scale ranging from 1 (very low) to 5 (very high) was adopted to capture the importance of causes of delays. Before distributing the questionnaires, a small interview with industry professionals was conducted that includes a 15 clients, 15 consultants and 15contractors. The basic purpose of this interview was to verify the completeness of the questionnaire in capturing the factors relevant for Iran. All the respondents agreed that the questionnaire was sufficient to capture the causes of delays. We distributed the questionnaires through our co-workers in Public Works Department of Iran, developers, consultants and construction firms. Our co-workers in turn distributed to their friends. This sampling method enabled us to obtain a large number of completed questionnaires quickly and economically. In total, 250 sets of questionnaires were distributed to the potential respondents at all levels in the organizations within the construction industry. In all, 100 sets were distributed to clients, 70 sets to consultants and 80 sets to the contractors. Of the 250 questionnaires, 175 sets (70 percent) were returned and there were 62 sets (62 percent) from clients, 55 sets (79 percent) from consultants and 58 sets (73 percent) from contractors.

The nature of process-based techniques

All process-based techniques of delay analysis have been present in this paper and categorized in 11 groups. In order to understand the pros and cons of them, a thorough review conducted with the participation of clients, contractor and consultant to reveal the nature of these techniques. The results of this review on techniques have been obtained based on several years' experiences of the client, consultant and contractor and studies that have been done by authors .In the next step, the most appropriate technique has been selected based on constraints and specific conditions of each project, which is one of the most important steps to carry out a successful delay analysis. The authors conformed, all process-based techniques of delay analysis, by SCL protocol and Association for the Advancement of Cost Engineering International (AACEI) principles. The SCL protocol recommends that wherever possible, an appropriate method should be agreed and adopted by the parties before retrospective delay analysis is carried out. The protocol gives guidance on the appropriateness, or otherwise of different types of retrospective delay analysis to different evidential situations. The protocol suggests that if the method is not agreed between the parties, then this failure to agreement should be taken into consideration by the arbitrator, or judge when awarding the costs of the dispute. Finally, the result of this match was brought in order to choose the best technique based on the specific circumstances of each project.

Data analysis

Kometa *et al.* (1994) and Sambasvian and Soon (2007) used the RII method to determine the relative importance of the various causes of delays. The same method was adopted in this study. RIIs are calculated for each factor as in the following equation:

$$(\text{RII}) = \frac{\sum w}{AN} = \frac{5_{n5} + 4_{n4} + 3_{n3} + 2_{n2} + 1_{n1}}{5N} \tag{1}$$

where RII is the relative importance index; W the weighing given to each factor by respondents (ranging from 1 to 5); A the highest weight (i.e. 5 in this case); and N the total number of respondents. The RII value had a range of 0 to 1 (0 not inclusive); the higher the RII, the more important was the cause of delays. The causes were ranked based on RII values. From the ranking assigned to each cause of delays, we were able to identify the most important factors or causes of delays in Iranian construction industry. For more information about the list of causes of delays categorized into seven groups refer to Table AI.

In Table AII, the main causes of delays in each category specified and have been ranked based on RII. For more information on the way of ranking and 78 causes of delays from experts' views refer to Table AII (Table I).

No.	Client	RII	Contractor	RII	Consultant	RII	Overall	RII
1	Delays in sub-contractors work	0.77	Inadequate definition of substantial completion	0.82	Delay to furnish and deliver the site to the contractor by owner	0.79	Change orders by owner during construction	0.90
2	Poor site management and supervision by contractor	0.76	Change orders by owner during construction	0.80	Change orders by owner during construction	0.78	Underestimation of time for completion	0.88
3	Difficulties in financing project by contractor	0.75	Underestimation of time for completion	0.79	Underestimation of time for completion	0.78	Underestimation of cost of projects	0.87
4	Unqualified workforce	0.75	Effects of subsurface conditions (e.g. soil, high water table, etc.)	0.79	Underestimation of cost of projects	0.77	Delay to furnish and deliver the site to the contractor by owner	0.87
5	Change orders by owner during construction	0.74	Delay to furnish and deliver the site to the contractor by owner	0.77	Late in revising and approving design documents by owner	0.77	Effects of subsurface conditions (e.g. soil, high water table, etc.)	0.87
6	Underestimation of cost of projects	0.73	Insufficient Feasibility studies and survey before investment	0.76	Difficulties in financing project by contractor	0.77	Inadequate definition of substantial completion	0.86
7	Poor qualification of the contractors technical staff	0.73	Delay to furnish and deliver the site to the contractor by owner	0.74	Slow decision making	0.76	Insufficient Feasibility studies and survey before investment	0.84
8	Effects of subsurface conditions (e.g. soil, high water table, etc.)	0.73	Underestimation of cost of projects	0.74	Delays in sub-contractors work	0.76	Unqualified workforce	0.84
9	Underestimation of time for completion	0.71	Unqualified workforce	0.74	Inadequate definition of substantial completion	0.75	Delay in obtaining permits from municipality	0.84
10	Delay in obtaining permits from municipality	0.70	Low productivity and efficiency of equipment	0.74	Poor communication and coordination by owner and other parties	0.75	Slow decision making	0.83

Table I.
Importance of delay causes

Table II, summarizes RII and ranking of the categories of causes of delay as perceived by all respondents.

Analysis of variance (ANOVA)

ANOVA is used to get the average scores obtained by construction industry experts given to each of the causes of delay (i.e. RII) and every seven fold causes has been rated using these scores and the rate of their being under the effect on the projects has been prioritized.

According to Levene's test, the significance of this test is more than 0.05 and parametric tests such as ANOVA can be used. ANOVA is a collection of statistical models used to analyze the differences among group means. In the ANOVA setting, the observed variance in a particular variable is partitioned into components attributable to different sources of variation. Factorial ANOVA can be balanced or unbalanced (Gelman, 2005; Armstrong *et al.*, 2002). This is to say, you can have the same number of subjects in each group (balanced) or not (unbalanced). The results shown in Table III indicate that the data were balance and there is no significant difference among respondents' data, at the community.

Pearson's correlation

Data normality test (one sample K-S test) clarifies that the calculated p-value is greater than the significant level which is equal to 0.05 (p-value $>$ 0.05). This in turn denotes that data follows normal distribution and we can use Pearson's correlation test.

In order to test the degree of agreement between the three groups of respondents, a correlation analysis was done using Pearson's correlation coefficient. Table IV gives the results of this analysis. Based on this test, view point of clients and contractors are not the same as consultants and have different opinions from each other. On the other hand, view point of Clients and the contractor were nearly identical to rank of delay factors.

Category	Clients		Consultants		Contractors		Overall	
	RII	Rank	RII	Rank	RII	Rank	RII	Rank
Client-related causes	0/563	5	0/634	2	0/651	1	0/716	1
Contractor-related causes	0/654	1	0/639	1	0/501	7	0/698	3
Consultant-related causes	0/601	2	0/480	7	0/572	6	0/645	7
Design-related causes	0/561	6	0/567	6	0/585	4	0/666	5
Material-related causes	0/566	4	0/596	3	0/613	3	0/690	4
Labor and equipment category causes	0/599	3	0/571	4	0/632	2	0/701	2
External causes	0/546	7	0/569	5	0/584	5	0/662	6

Table II. RII and ranking of categories of causes of delay

	Sum of squares	df	Mean square	F	Sig.
Between groups	0.009	6	0.001	0.685	0.665
Within groups	0.030	14	0.002		
Total	0.039	20			

Table III. Analysis of variance (ANOVA)

	Clients	Consultants	Contractors
Clients			
Pearson correlation	1	0.135	−0.672
Sig. (2-tailed)		0.773	0.028
N	7	7	7
Consultants			
Pearson correlation	0.135	1	−0.002
Sig. (2-tailed)	0.773		0.997
N	7	7	7
Contractors			
Pearson correlation	−0.672	−0.002	1
Sig. (2-tailed)	0.028	0.997	
N	7	7	7

Table IV. Pearson's correlation

So based on the perceptions of clients, consultants, and contractors on the relative importance of causes of delay in Iranian construction industry and data analysis using Statistical Package for Social Sciences (SPSS), we found that clients (with 19 subcategories and RII = 0.716); labor and equipment (with 8 subcategories and RII = 0.701) and contractors (with 13 subcategories and RII = 0.698), respectively, have the highest impact in construction industry.

In this paper, at first all the delays have been identified and ranked and validated from client, contractors and consultants, viewpoint three factors of ten causes that lead to delays and are of main causes have been identified in Table AI. Then, in Table II, based on the opinions of clients, contractors, consultants and all the three, the index of relative importance and ranking have been ranked in seven categories in which delays had been examined. In the following, in order to lower or remove those after interviewing with experts, 40 alternative have been extracted and presented in Table AIII that performing this task could prevent delays emergence in next projects.

Given that delays are an integral part of construction industry. Therefore, the authors in second part of this paper discussed the pros and cons of all process-based techniques of delay claims and compared the versatility of each of them with SCL protocol.

In Table V, all the strengths and weaknesses of delay analysis techniques are studied in detail, and it should be noted that none of these methods are not preferred over one another and according to the conditions of project and available documentation; one of this methods can be used in the project. Therefore, among them and with regard to the specific and better features that some of these techniques have than others, in terms of complexity, they can be separated into two levels, namely:

(1) The first level that is shown in Table V (Items 4, 6 and 7), represents a simple method that a major problem in view of the simplification in these techniques is that they do not have a mechanism for exact determination of the types of delays, as a result, those delays that should not be applied in the analysis, are considered and therefore unrealistic and exaggerated results are obtained. In addition, these techniques consider the timing schedule only once (primary schedule) and assume that the critical path is fixed for the entire project. This makes the delays in contrast to what has really happened, potentially be considered as critical and also global impact technique, against two other techniques, has another weakness that has not the ability to consider the delays at the same time.

(2) The second level shows the detailed procedure, which includes the techniques that have been identified with number 2, 5, 8, 9, 10 and 11, in Table V. These techniques offer convenient and reliable methods for analyzing delays. At the same time enhancing and mitigation methods with analysis, define the type of delay. Increasing and decreasing methods while doing the analysis, identify the type of delay, too. Of course, the main problem is that these two techniques are applied only once to the scheduled timing and thus no change in the critical paths during the project implementation is accepted and also, simultaneous delays are not considered, of all the methods, both time impact technique and snapshot technique, because of considering the impact of delays during project and CPM scheduling, are known as systematic and reliable methods for quantifying delays in construction projects. The biggest problem with these techniques is that during the analysis none of them identify the delay type accurately and a series of other analyses to determine the contribution of the employer and the contractor of the delay is necessary. Another disadvantage of time impact technique is that the delay activities has been analyzed and examined separately and the impact of simultaneous delays is not specified during the analysis and due to a number of delayed events in the project,

Table V. Type of delay analysis techniques and explanation of pros and cons of each method

A variety of delay analysis techniques

Techniques type	Techniques description	Pros of the technique	Cons of the technique
1. Pervasive influence Technique	A simple method for analysis	When the calculation is not accurate, it has many applications	1. Ignoring simultaneous time delays 2. Rights resulted from delays are shown with great exaggeration 3. It has many opponents
2. Bar chart or Gant chart technique (Clark, 2006; Alkass *et al.*, 1996)	It identifies critical activities implemented in its time table and compares them with critical activities in planed schedule	1. Assesses delays impact on overall project 2. It indicates the cause and responsibility for the delays that effect on the completion date of the project 3. In the case of availability of planned and real schedule, it is cheap method	1. Because the schedule program is not based on CPM calculation, this method does not include information like use of flotation, and changes of project schedule and also changes made in the critical path 2. The method is time consuming and should be done based on judgment, research and professional evaluation
3. Collapse technique or (but because) (Clark, 2006; Alkass *et al.*, 1996)	It uses CPM format and so the result is the difference between the time completion of the construction and modified schedule This technique is applicable at the end of the project, when there is no other possibility for delay compensation	1. This is the best method when the delay analysis needs to be revised 2. This technique is very good for projects that are linear in nature and structure and the events are considered in As built schedule instead of planned schedule 3. Simplicity of comparison is the advantage of this method to project manager's presentations	1. There is no possibility of implementing the As built program as predicted 2. In complex situations where many events occur simultaneously in project or As Built schedule in detail not available, this method does not show the required efficiency
4. Critical path method and adjusted as built CPM technique	This technique uses the CPM, and development As Built schedule This technique is similar to the Net Impact Technique, for Both techniques show only the net effect of all the claimed delay in projects time completion	This technique is better than Net Impact Technique and if there is information, such as As-Built program, analysis of the mentioned technique, could be done easily	1. Delays types are not be checked carefully 2. There is no possibility for analyzing the delays at the same time 3. Delay events that cause claim in the project may be show in the schedule but most likely is not clear and not be on the critical path
5. Time impact technique (Clark, 2006; Alkass *et al.*, 1996)	In this technique the principles of Critical Path Method are used and the effects of delays in the project schedule are evaluated through periodic and usually every day analysis. This technique	This technique provides a systematic and scientific method to quantify the impact of delays in project	1. It is the most time consuming and most expensive method 2. If the information is invalid, the results of the analysis may be very different from reality

(*continued*)

Table V.

A variety of delay analysis techniques

Techniques type	Techniques description	Pros of the technique	Cons of the technique
	is similar to Snapshot analysis, by this difference that Time Impact Technique focuses on the delay or delay certain events, not a period of time including all delays. This technique is an advanced mode of Impacted As-planned Technique		3. It has not the ability to determine the exact type of delay, before the analysis completion 4. Delay activity is analyzed separately and therefore, the impact of simultaneous delays in project, when analysis is done is not traceable and these attitudes are unrealistic 5. The accuracy of this method is subjected to the number of analysis that can be done, and if there are a lot of events that cause delays in the analysis, the use of this technique is very difficult and time consuming
6. Global impact technique (Kartam, 1999)	In this technique, the whole projects delay is achieved by collecting all delays which are applied in completion of activities	Simplicity of the analysis and not requiring for activities and relationships in the schedules are the notable advantages of this technique	1. Ignoring the simultaneous delays 2. The lack of accurate determination of delays and the inability to determine the critical path and float activities
7. Net impact technique (Stumpf, 2000)	This technique only manifests the whole claimed delays through bar graph. In this technique, all the activities with delays are being considered, but only net effect of created delays in the activities, by considering the delays being simultaneous are applied	1. Using this technique, all the delays, non-consistency in performing activities, work orders and suspensions are drown in As Built scheduling and just net effect of all delays is calculated 2. Consider the simultaneous delays	1. It has not ability to exact determination of the types of delays 2. As long as the networks facility is not used, the real impact of delay on the full completion of the project is difficult to determine
8. Impacted as-planned technique (Keane and Caletka, 2008)	This technique uses CPM scheduling model and only includes delays that are related to one of the parties (Depending on whether the delays analyst, from which side)	1. This technique offers a relatively good method that with limited information collected from the beginning of the project is able to analyze the occurred delay 2. One of the major advantages of this technique that can be noted is to determine the type of delays during analysis which performed simply and at high speed	1. This technique is not considered change in CPM scheduling, during project execution and delays in As-planned scheduling in one step are applied which leads to achieve unrealistic results, because probably the critical path changes during project execution 2. This technique cannot be considered as an impartial analysis

(*continued*)

A variety of delay analysis techniques

Techniques type	Techniques description	Pros of the technique	Cons of the technique
9. Collapsed as-built technique (Keane and Caletka, 2008)	Like impacted As-planned technique, this technique uses CPM scheduling model and in order to overcome some shortcomings, when doing analysis, it uses As Built schedule, therefore at first, it is necessary that all delays caused by the parties involved in the project, be identified and applied	This method is selected when the contractor has not an acceptable schedule (during project execution) or when any pre-programmed schedule in the contract is not needed	1. No change in the CPM scheduling, during project execution 2. Delays related to one of the parties involved in the project that have taken place, altogether and in one step removed from the As Built schedule that would cause to achieve unrealistic results 3. This technique has not any reliance and dependence on As-planned schedule as the basis for analysis
10. Sectional technique or timeframe or snapshot technique	In this technique, independent and consecutive time periods in As-planned schedule (Primary Schedule) are used for imposing delays, based on what actually happened, in each of the above-mentioned periods. This technique is formed on the basis of As-planned schedule, As Built schedule and any other review schedule that is created during the projects execution	This technique proposes a systematic, impartially and fairly accurate way for the quantification of the delays in the project, which is moving, on an ongoing basis (based on As-planned schedule) This method considers simultaneous delays and indicated the impact of delays on the basis of time and CPM schedule based on what has really happened at that time period and it has been known as a complete and accurate technique for analyze delays	1. The types of delay is not clear in this technique and it is necessary to do other analyses on the results in order to identify the share of each party of delays 2. This technique is very time consuming
11. Isolated delay type technique	This technique, tries to consider all three principles (Categorization of delays, considering simultaneous delays, analysis of delays in real-time), in the way of performed analysis which require the presence of an event log and accurate documentation of information system from the beginning of the project. Albeit, the accuracy of this analysis is subjected to the number of performed analyses		

Table V.

the analysis may be very time consuming. Accuracy of both time impact technique and snapshot technique is a function of the number of intervals between analyses that occur during the project from beginning to end. Isolated delay type technique relying on the strengths of previous techniques, provide a practical method for analyzing delays. The mentioned technique showed that in the case of reliable information and reports available in the project, it is superior to the other techniques. Isolated delay type techniques study the delays during the analysis process and therefore it reduces time needed for delay analysis and so the expense is decreased. This technique considers the simultaneous delays in various activities.

The SCL protocol has been prepared by the SCL for determining extensions of time and compensation for delay and disruption. It exists to provide guidance to all parties in the construction process when dealing with delay and disruption matters. It recognizes that transparency of information and methodology is central to both dispute prevention and dispute resolution.

The object of the protocol is to provide useful guidance on some of the common delays and disruption issues that arise in construction projects. The purpose of the protocol is to provide a means by which the parties can resolve these matters and avoid unnecessary disputes. A focus of the protocol therefore is the provision of practical and principled guidance on proportionate measures for dealing with delay and disruption issues that can be applied in relation to all projects, regardless of complexity or scale, to avoid disputes and where disputes are unavoidable to limit the costs of those disputes. Users of the protocol should apply its recommendations with common sense. The protocol is intended to be a balanced document reflecting equally the interests of all parties to the construction process.

Given that the delays occur in every construction project and the significance of these delays varies considerably from project to project, hence identifying the type of delay analysis techniques and selecting the most appropriate technique based on constraints and specific conditions of each project is one of the most important steps to carry out a successful delay analysis. But unfortunately in Iran, because of the lack of accurate knowledge on a variety of techniques all parties cannot use the most suitable delay analysis techniques for each project and this leads to create a lot of disputes and claims in projects. Hence the delay analysis techniques for further investigation are evaluated and conformed with principles which have been released in Table VI by SCL and (AACEI. Finally, the result of this match, the rate of using each of these techniques in various stages of construction projects, the plausibility of each of these techniques in court, the level of expertise needed to experts analyst delays and the amount of time required for the analysis depends, the use of each of these techniques in large and complex projects, that regarding the mentioned items, each technique could be selected with respect to the kind of project regarding the feature it has. The information needed to be analyzed the delay, etc. have been shown in Table VI.

Table VI. Factors influencing on choosing a suitable method to analyze delay, according to SCL protocol and AACEI RP-FSA

AACEI RP-FSA	SCL protocol
Contract requirements	Conditions of contract
Analysis purposes	Nature of the causal relations of the events in log project
The availability and reliability of data sources	The rate of claims value
The complexity of the claims	Existing time to analyze
Time and budget available to analyze	Access to records
Access to experts of timing legal analysis	Access to scheduling information
Legal services of the voting	The planner's skills and familiarity with project
Previous methods of parties	
Legal requirements	

By examinations carried out and interviews with the experts, the Iranian project have been divided into three groups from magnitude perspective and into 6 categories from delay rates perspective that regarding their features and the results obtained from complete comparison of the methods of delays analysis (Tables V and VII) a proper method to examine delay in six above classes are suggested as the following table.

Conclusion

(1) Construction projects often suffer from delays due to a wide variety of reasons, which can have severe financial impact on the project. As a result, delay claims may be filed. But delays can be avoided or minimized when their causes are clearly identified. However, in case of delays the analysis of its impact, the causes, and effects of the delaying activities is one of the most complicated types of claims analysis. The aim of this paper is to identify the delay factors in construction projects and introduction type of delay analysis techniques for applying more reliable and precise techniques in order to reduce the frequency and to mitigate the severity of disputes and litigation due to delay claims because delays are considered to be a serious problem in the construction industry.

    Hence through a detailed literature review and interviews with experts from the Iranian construction industry, a total of 78 different delay factors were identified and categorized into seven groups the field survey included 58 contractors, 55 consultants and 62 clients. Data collected were analyzed by RII and SPSS. We identified main causes of delay and ten most important causes, according to Table AI.

(2) According to the discussions and given that determining the contractual responsibility of delay is the most likely source of dispute in construction industry and many techniques have been used in the courts to demonstrate the criticalities of a delay event on the project schedule, the authors discussed the pros and cons of all process-based techniques of delay claims and compared the versatility of each of them with SCL protocol in order to choose the best techniques based on the specific circumstances of each project.

(3) The Iranian projects have been classified from magnitude perspective into three categories and from the perspective of emergence of delays; they have divided into six groups. Several methods of analyzing delays have been compared from different dimension (Tables V-VII). So regarding the features of projects one could select the most suitable methods kind based on Table VIII. For example, for those mega projects with many delays, i.e. 6th class, the methods of analysis of delays has been selected as the most suitable method.

In this paper, by providing all the causes of delays in Iranian construction projects, all parties can be familiar with the variety of delays and implementation of solutions which are presented in Table AIII in appendixes, they can decrease the causes of delays in projects. But delay cannot be controlled from time to time and occurs in every construction project and the significance of this delay varies considerably from project to project. Unfortunately in Iran, there is not a comprehensive and practical package for delays analysis techniques to determine which technique is appropriate for each project. So the implications of this paper could be used as a complete package, in order to select the appropriate delays analysis techniques according to the circumstances of each project. Hence, by the use of SCL protocol guidance and according to the circumstances of each project the authors show on which basis choose the best delay analysis technique to reduce the confusion and disputes arising from the delays in construction projects.

Table VII. Accommodation and evaluation of Tables V and VI

Techniques type	The rate of use in complicated and valuable financial claims		Requires the time and budget available to analyze project		Requires the sources of information and records of the project to analyze		Rate of acceptance from the legal services of the voting court			Possibility of using simultaneous delay	Analysis based on CPM	Analysis based on several schedule program			Rate of acceptability regarding its use	
	High	Low	High	Low	High	Low	High	Low	Description			As-Planned Schedule	As-Built Schedule	As-Projected Schedule	High	Low
1. Pervasive influence technique		*		*		*		*	This method is simple and ignores simultaneous delays and exaggerates in showing them and it has many opponents			*				*
2. Bar chart or Gant chart technique		*	*			*		*	This technique is not aware of those events occurring during the project like flooted consumption, scheduling changes and critical path and so it has problem in needed accuracy	*	*	*	*	*		*
3. Collapse technique or (but because)		*		*	*			*	In complex conditions in which so many events have occurred simultaneously in		*			*		*

(*continued*)

Techniques type	The rate of use in complicated and valuable financial claims High	Low	Requires the time and budget available to analyze project High	Low	Requires the sources of information and records of the project to analyze High	Low	Rate of acceptance from the legal services of the voting court High	Low	Description	Possibility of using simultaneous delay	Analysis based on CPM	Analysis based on several schedule program: As-Planned Schedule	As-Built Schedule	As-Projected Schedule	Rate of acceptability regarding its use High	Low
									the project and or as built schedule is not available with details, this method will not have necessary efficiency							
4. Critical path method and adjusted as built CPM technique								*	Delay events that caused claim, may not be shown in scheduling, but they are more likely not clear and definite and may not be on critical path	*	*	*	*			*
5. Time Impact technique	*		*		*		*		This method is systematic, unbiased and relatively accurate and the analysis is severely made the influence of the basic program and programmer skill	*	*	*			*	

(*continued*)

Table VII.

Table VII.

Techniques type	The rate of use in complicated and valuable financial claims High	Low	Requires the time and budget available to analyze project High	Low	Requires the sources of information and records of the project to analyze High	Low	Rate of acceptance from the legal services of the voting court High	Low	Description	Possibility of using simultaneous delay	Analysis based on CPM	Analysis based on several schedule program: As-Planned Schedule	As-Built Schedule	As-Projected Schedule	Rate of acceptability regarding its use High	Low
									with the project. The accuracy of this method is subjected to the number of performed analysis and in the case of the presence of high amount of events causing delay in this analysis, use of this technique is so difficult and time consuming							
6. Global impact technique		*		*		*		*	The lack of accurate determination of created delayed and disability in determining the critical path and contentment activities and				*			*

(*continued*)

Techniques type	The rate of use in complicated and valuable financial claims		Requires the time and budget available to analyze project		Requires the sources of information and records of the project to analyze		Rate of acceptance from the legal services of the voting court			Possibility of using simultaneous delay	Analysis based on CPM	Analysis based on several schedule program			Rate of acceptability regarding its use	
	High	Low	High	Low	High	Low	High	Low	Description			As-Planned Schedule	As-Built Schedule	As-Projected Schedule	High	Low
									exaggeration in displaying delay and rejection of this method from the court							
7. Net impact technique		*		*		*		*	Though it uses simultaneous delays, but it has not the ability to follow the delay accurately and the delay is being exaggerated and when the network is not being used, determination of delay on project completion time properly is hard	*			*			*
8. Impacted as-planned technique		*	*		*				In this method, the analyst can add just one side of contract delays to schedule program			*		*	**	

(*continued*)

Table VII.

Table VII.

Techniques type	The rate of use in complicated and valuable financial claims High	Low	Requires the time and budget available to analyze project High	Low	Requires the sources of information and records of the project to analyze High	Low	Rate of acceptance from the legal services of the voting court High	Low	Description	Possibility of using simultaneous delay	Analysis based on CPM	Analysis based on several schedule program: As-Planned Schedule	As-Built Schedule	As-Projected Schedule	Rate of acceptability regarding its use High	Low
									in any step and examine its impact, therefore it is unfair method							
9. Collapsed as-built technique		*	*		*		*		Regarding that this method does not consider those delays done in project administration and change in resource allocation and schedule steps, the analyses could sometimes lead to unacceptable results					*	*	
10. Sectional technique or timeframe or snapshot technique	*		*		*		*		This technique proposes a systematic, unbiased, and relatively exact method to quantify performed delays	*	*	*	*	*	*	

(continued)

Techniques type	The rate of use in complicated and valuable financial claims		Requires the time and budget available to analyze project		Requires the sources of information and records of the project to analyze		Rate of acceptance from the legal services of the voting court			Possibility of using simultaneous delay	Analysis based on CPM	Analysis based on several schedule program			Rate of acceptability regarding its use	
	High	Low	High	Low	High	Low	High	Low	Description			As-Planned Schedule	As-Built Schedule	As-Projected Schedule	High	Low
									in the project and is considered as a complete and accurate technique for delays but is so time consuming							
11. Isolated delay type technique	*		*		*		*		This technique proposes a systematic, unbiased, and relatively exact method to quantify performed delays in the project and is considered as a complete and accurate technique for delays but is so time consuming	*	*	*	*	*	*	

Table VII.

Type of project	The rate of delays	The volume of available documentation	Time duration of dealing with delay	Expense of dealing with delay	The proposed method for the analysis of delays
Classification of delayed projects in construction industry of Iran					
Small projects: Implementation: in less than one year amounted to less than 30 million dollars	Low to moderate High (The rate of delays More than 30 percent of the project) High (The rate of delays up to 30 percent of the project)	Low (simplified)	Low	Low to moderate	1. Pervasive influence Technique 4. Critical path method and adjusted as-built CPM technique
Medium projects: Implementation: 1 to 3 years amounted to between 30 and 50 million dollars	Low to moderate (The rate of delays up to 30 percent of the project) High (The rate of delays More than 30 percent of the project)	Low to moderate	Moderate (less than 6 months)	High	2. Bar chart or Gant chart technique 5. Time impact technique 6. Global impact technique 7. Net impact technique
Large-scale projects: Implementation: over three years amounted to more than 50 million dollars	Low to moderate (The rate of delays up to 30 percent of the project) High (The rate of delays More than 30 percent of the project)	A lot of (complicated) over 50 Ledger	High (more than 6 months to one year)	Very high	3. Collapse technique 8. Impacted as-planned technique 9. Collapsed as-built technique 10. Sectional technique 11. Isolated delay type technique

Table VIII.
The method of choosing the most appropriate technique based on the nature of project and the value of delays

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Appendix

No.	Case of delay	Group
1	Change orders by owner during construction	Client
2	Underestimation of time for completion	Client
3	Underestimation of cost of projects	Client
4	Delay to furnish and deliver the site to the contractor by owner	Client
5	Inadequate definition of substantial completion	Client
6	Insufficient feasibility studies and survey before investment	Client
7	Slow decision making	Client
8	Poor communication and coordination by owner and other parties	Client
9	Late in revising and approving design documents by owner	Client
10	Type of project bidding and award (negotiation, lowest bidder)	Client
11	Type of construction contract (Turnkey, construction only)	Client
12	Suspension of work by owner	Client
13	Ineffective delay penalties by owner	Client
14	Unavailability of incentives for contractor for finishing ahead of schedule	Client
15	Delay in approving shop drawings and sample materials	Client
16	Delay in finance and payments of completed work by owner	Client
17	Poor supervision	Client
18	Low bid	Client
19	Delays in inspection and testing of work	Client
20	Difficulties in financing project by contractor	Contractor
21	Delays in sub-contractors work	Contractor
22	Poor qualification of the contractors technical staff	Contractor
23	Poor site management and supervision by contractor	Contractor
24	Rework due to errors during construction	Contractor
25	Ineffective planning and scheduling of project by contractor	Contractor
26	Inadequate contractor experience	Contractor
27	Frequent change of sub-contractors because of their inefficient work	Contractor
28	Poor communication and coordination by contractor with other parties	Contractor
29	Conflicts in sub-contractors schedule in execution of project	Contractor
30	Improper construction methods implemented by contractor	Contractor
31	Conflicts between contractor and other parties (consultant and owner)	Contractor
32	Delay in site mobilization	Contractor
33	Inadequate experience of consultant	Consultant
34	Delay in performing inspection and testing by consultant	Consultant
35	Poor communication/coordination between consultant and other parties	Consultant
36	Delay in approving major changes in the scope of work by consultant	Consultant
37	Inflexibility (rigidity) of consultant	Consultant
38	Late in reviewing and approving design documents by consultant	Consultant
39	Conflicts between consultant and design engineer	Consultant
40	Unclear and inadequate details in drawings	Consultant
41	Quality assurance/control	Consultant
42	Mistakes and discrepancies in design documents	Design
43	Delays in producing design documents	Design
44	Complexity of project design	Design
45	Insufficient data collection and survey before design	Design
46	Unclear and inadequate details in drawings	Design
47	Misunderstanding of owner's requirements by design engineer	Design
48	Inadequate design-team experience	Design
49	Un-use of advanced engineering design software	Design
50	Shortage of construction materials in market	Material

(*continued*)

Table AI. List of causes of delay categorized into seven groups

No.	Case of delay	Group
51	Delay in material delivery	Material
52	Changes in material types and specifications during construction	Material
53	Damage of sorted material while they are needed urgently	Material
54	Delay in manufacturing special building materials	Material
55	Late procurement of materials	Material
56	Late in selection of finishing materials due to availability of many types in market	Material
57	Escalation of material prices	Material
58	Unqualified workforce	Labor and equipment
59	Low productivity level of labors	Labor and equipment
60	Shortage of labors	Labor and equipment
61	Low productivity and efficiency of equipment	Labor and equipment
62	Equipment availability and failure	Labor and equipment
63	Low level of equipment-operator's skill	Labor and equipment
64	Personal conflicts among labors	Labor and equipment
65	Lack of high-technology mechanical equipment	Labor and equipment
66	Effects of subsurface conditions (e.g. soil, high water table, etc.)	External factor
67	Delay in obtaining permits from municipality	External factor
68	Effect of social and cultural factors	External factor
69	Weather effect (hot, rain, etc.)	External factor
70	Changes in government regulations and laws	External factor
71	Unavailability of utilities in site (such as, water, electricity, telephone, etc.)	External factor
72	Traffic control and restriction at job site	External factor
73	Accident during construction	External factor
74	Differing site (ground) conditions	External factor
75	Delay in providing services from utilities (such as water, electricity)	External factor
76	Fluctuations in cost/ currency	External factor
77	Delay in performing final inspection and certification by a third party	External factor
78	Force majeure as war, revolution, riot, strike, and earthquake, etc.	External factor

Table AI.

Table AII. The main causes of delays in each category specified and have been ranked based on RII

Delay group	No.	Factor of delay	Criteria weights V.L 1.	L 2.	M 3.	H 4.	V.H 5.	RII	Rank
		Client comments							
1. Employer delays	1/1	Change orders by owner during construction	4	8	12	16	22	0/74	1
	2/1	Underestimation of time for completion	3	12	13	16	18	0/71	3
	3/1	Underestimation of cost of projects	5	6	14	18	19	0/73	2
	4/1	Delay to furnish and deliver the site to the contractor by owner	9	8	13	15	17	0/67	5
	5/1	Inadequate definition of substantial completion	8	13	10	15	16	0/66	8
	6/1	Insufficient feasibility studies and survey before investment	6	12	13	17	14	0/67	6
	7/1	Slow decision making	7	10	16	14	15	0/66	7
	8/1	Poor communication and coordination by owner and other parties	5	11	13	17	16	0/69	4
	9/1	Late in revising and approving design documents by owner	9	16	14	11	12	0/6	10
	10	Type of project bidding and award (negotiation, lowest bidder)	9	14	13	15	11	0/62	9
	11/1	Type of construction contract (Turnkey, construction only)	14	12	15	12	9	0/57	11
	12	Suspension of work by owner	15	19	13	7	8	0/52	13
	13/1	Ineffective delay penalties by owner	14	22	7	10	9	0/53	12
	14/1	Unavailability of incentives for contractor for finishing ahead of schedule	18	24	9	6	5	0/46	14
	15/1	Delay in approving shop drawings and sample materials	22	25	5	4	6	0/43	15
	16/1	Delay in finance and payments of completed work by owner	30	19	5	4	4	0/38	16
	17/1	Poor supervision	31	20	6	3	2	0/36	17
	18/1	Low bid	29	26	4	2	1	0/34	18
	19/1	Delays in inspection and testing of work	30	27	2	1	2	0/34	19
2. Contractor delays	2/1	Difficulties in financing project by contractor	5	6	9	20	22	0/75	3
	2/2	Delays in sub-contractors work	4	7	8	19	24	0/77	1
	2/3	Poor qualification of the contractors technical staff	6	8	9	18	21	0/73	4
	2/4	Poor site management and supervision by contractor	4	5	10	24	19	0/76	2
	2/5	Rework due to errors during construction	6	9	12	18	17	0/7	5
	2/6	Ineffective planning and scheduling of project by contractor	7	9	13	17	16	0/68	6
	2/7	Inadequate contractor experience	8	13	10	16	15	0/65	9
	2/8	Frequent change of sub-contractors because of their inefficient work	6	11	14	17	14	0/67	7
	2/9	Poor communication and coordination by contractor with other parties	5	10	19	16	12	0/66	8
	2/10	Conflicts in sub-contractors schedule in execution of project	10	11	17	14	10	0/61	10
	2/11	Improper construction methods implemented by contractor	16	14	12	11	9	0/55	11

(*continued*)

Table AII.

Delay group	No.	Factor of delay	Criteria weights V.L 1.	L 2.	M 3.	H 4.	V.H 5.	RII	Rank
	2/12	Conflicts between contractor and other parties (consultant and owner)	17	24	6	8	7	0/48	12
	2/13	Delay in site mobilization	17	23	10	6	6	0/47	13
3. Consultant delays	3/1	Inadequate experience of consultant	7	9	13	15	18	0/69	1
	3/2	Delay in performing inspection and testing by consultant	9	10	11	17	15	0/66	2
	3/3	Poor communication/coordination between consultant and other parties	10	11	9	15	17	0/66	3
	3/4	Delay in approving major changes in the scope of work by consultant	12	10	11	14	15	0/63	4
	3/5	Inflexibility (rigidity) of consultant	13	9	10	16	14	0/63	5
	3/6	Late in reviewing and approving design documents by consultant	11	14	9	15	13	0/62	6
	3/7	Conflicts between consultant and design engineer	15	18	8	10	11	0/55	7
	3/8	Unclear and inadequate details in drawings	17	20	8	9	8	0/51	8
	3/9	Quality assurance/control	18	24	7	7	6	0/47	9
4. Design delays	4/1	Mistakes and discrepancies in design documents	8	9	12	17	16	0/68	1
	4/2	Delays in producing design documents	8	11	10	18	15	0/67	2
	4/3	Complexity of project design	9	10	13	16	14	0/65	3
	4/4	Insufficient data collection and survey before design	16	12	10	13	11	0/57	5
	4/5	Unclear and inadequate details in drawings	12	15	14	11	10	0/57	4
	4/6	Misunderstanding of owner's requirements by design engineer	19	17	9	8	9	0/51	6
	4/7	Inadequate design-team experience	21	23	5	7	6	0/45	7
	4/8	Un-use of advanced engineering design software	28	22	3	5	4	0/39	8
5. Material delays	5/1	Shortage of construction materials in market	7	7	13	17	18	0/7	1
	5/2	Delay in material delivery	9	11	12	14	16	0/65	2
	5/3	Changes in material types and specifications during construction	12	9	10	17	14	0/64	3
	5/4	Damage of sorted material while they are needed urgently	16	15	6	12	13	0/57	4
	5/5	Delay in manufacturing special building materials	16	17	8	11	10	0/54	5
	5/6	Late procurement of materials	20	17	5	11	9	0/51	6
	5/7	Late in selection of finishing materials due to availability of many types in market	18	20	6	10	8	0/5	7
	5/8	Escalation of material prices	25	23	5	4	5	0/41	8
6. Labor and equipment delays	6/1	Unqualified workforce	4	7	11	19	21	0/75	1
	6/2	Low productivity level of labors	6	12	7	18	19	0/7	2
	6/3	Shortage of labors	7	15	6	16	18	0/67	3
	6/4	Low productivity and efficiency of equipment	14	14	7	12	15	0/6	4

(*continued*)

Table AII.

Delay group	No.	Factor of delay	Criteria weights V.L 1.	L 2.	M 3.	H 4.	V.H 5.	RII	Rank
	6/5	Equipment availability and failure	13	17	6	14	12	0/58	5
	6/6	Low level of equipment-operator's skill	16	19	8	9	10	0/53	6
	6/7	Personal conflicts among labors	18	21	6	8	9	0/5	7
	6/8	Lack of high-technology mechanical equipment	24	19	5	6	8	0/45	8
7. External delays	7/1	Effects of subsurface conditions (e.g. soil, high water table, etc.)	7	6	10	19	20	0/73	1
	7/2	Delay in obtaining permits from municipality	6	9	11	18	18	0/71	2
	7/3	Effect of social and cultural factors	11	8	10	17	16	0/66	3
	7/4	Weather effect (hot, rain, etc.)	8	9	16	15	14	0/66	4
	7/5	Changes in government regulations and laws	12	14	11	12	13	0/6	5
	7/6	Unavailability of utilities in site (such as, water, electricity, telephone, etc.)	14	15	12	11	10	0/56	6
	7/7	Traffic control and restriction at job site	16	14	12	9	11	0/55	7
	7/8	Accident during construction	15	19	11	7	10	0/53	8
	7/9	Differing site (ground) conditions	17	21	8	7	9	0/5	9
	7/10	Delay in providing services from utilities (such as water, electricity)	21	23	8	6	4	0/44	10
	7/11	Fluctuations in cost/currency	25	23	7	4	3	0/4	11
	7/12	Delay in performing final inspection and certification by a third party	28	22	5	3	4	0/38	12
	7/13	Force Majeure as war, revolution, riot, strike, and earthquake, etc.	25	27	4	3	3	0/38	13
		Consultant comments (55)							
1. Employer delays	1/1	Change orders by owner during construction	2	7	5	21	20	0/78	2
	2/1	Underestimation of time for completion	3	6	4	23	19	0/78	3
	3/1	Underestimation of cost of projects	4	7	4	18	22	0/77	4
	4/1	Delay to furnish and deliver the site to the contractor by owner	2	4	10	19	20	0/79	1
	5/1	Inadequate definition of substantial completion	4	6	8	20	17	0/75	7
	6/1	Insufficient Feasibility studies and survey before investment	5	7	9	15	19	0/73	9
	7/1	Slow decision making	3	4	11	19	18	0/76	6
	8/1	Poor communication and coordination by owner and other parties	4	7	9	16	19	0/74	8
	9/1	Late in revising and approving design documents by owner	3	6	7	20	19	0/77	5
	10	Type of project bidding and award (negotiation, lowest bidder)	4	8	11	16	16	0/72	10
	11/1	Type of construction contract (Turnkey, construction only)	8	10	9	13	15	0/66	11
	12	Suspension of work by owner	9	13	8	14	11	0/62	12
	13/1	Ineffective delay penalties by owner	11	15	6	11	12	0/59	13

(*continued*)

Table AII.

Delay group	No.	Factor of delay	Criteria weights V.L 1.	L 2.	M 3.	H 4.	V.H 5.	RII	Rank
	14/1	Unavailability of incentives for contractor for finishing ahead of schedule	12	21	9	7	6	0/51	14
	15/1	Delay in approving shop drawings and sample materials	17	20	3	6	9	0/49	15
	16/1	Delay in finance and payments of completed work by owner	21	15	6	7	6	0/46	16
	17/1	Poor supervision	22	20	7	3	3	0/4	17
	18/1	Low bid	24	21	5	3	2	0/37	18
	19/1	Delays in inspection and testing of work	26	21	4	2	2	0/36	19
2. Contractor delays	2/1	Difficulties in financing project by contractor	3	4	10	19	19	0/77	1
	2/2	Delays in sub-contractors work	3	5	9	20	18	0/76	2
	2/3	Poor qualification of the contractors technical staff	4	6	11	15	19	0/74	3
	2/4	Poor site management and supervision by contractor	3	11	5	21	15	0/72	4
	2/5	Rework due to errors during construction	5	9	12	15	14	0/69	5
	2/6	Ineffective planning and scheduling of project by contractor	7	14	9	13	12	0/63	7
	2/7	Inadequate contractor experience	10	14	8	12	11	0/6	9
	2/8	Frequent change of sub-contractors because of their inefficient work	8	12	11	14	10	0/62	8
	2/9	Poor communication and coordination by contractor with other parties	8	10	10	16	11	0/64	6
	2/10	Conflicts in sub-contractors schedule in execution of project	17	9	7	13	9	0/56	11
	2/11	Improper construction methods implemented by contractor	18	6	10	11	10	0/56	10
	2/12	Conflicts between contractor and other parties (consultant and owner)	20	8	9	9	9	0/52	12
	2/13	Delay in site mobilization	17	18	6	7	7	0/49	13
3. Consultant delays	3/1	Inadequate experience of consultant	10	11	15	9	10	0/59	2
	3/2	Delay in performing inspection and testing by consultant	12	10	8	12	13	0/61	1
	3/3	Poor communication/coordination between consultant and other parties	15	14	7	10	9	0/54	3
	3/4	Delay in approving major changes in the scope of work by consultant	16	12	12	7	8	0/52	5
	3/5	Inflexibility (rigidity) of consultant	15	12	13	7	8	0/53	4
	3/6	Late in reviewing and approving design documents by consultant	24	15	9	4	3	0/41	6
	3/7	Conflicts between consultant and design engineer	25	17	6	3	4	0/4	7
	3/8	Unclear and inadequate details in drawings	26	19	5	3	2	0/37	8
	3/9	Quality assurance/control	26	22	4	2	1	0/35	9
4. Design delays	4/1	Mistakes and discrepancies in design documents	5	7	13	16	14	0/7	1
	4/2	Delays in producing design documents	6	9	12	15	13	0/67	2
	4/3	Complexity of project design	9	10	10	14	12	0/64	3

(*continued*)

Table AII.

Delay group	No.	Factor of delay	Criteria weights V.L 1.	L 2.	M 3.	H 4.	V.H 5.	RII	Rank
	4/4	Insufficient data collection and survey before design	16	9	9	10	11	0/57	5
	4/5	Unclear and inadequate details in drawings	14	12	7	12	10	0/57	4
	4/6	Misunderstanding of owner's requirements by design engineer	15	17	7	9	7	0/51	6
	4/7	Inadequate design-team experience	17	20	6	7	5	0/47	7
	4/8	Un-use of advanced engineering design software	19	24	5	4	3	0/41	8
5. Material delays	5/1	Shortage of construction materials in market	4	7	13	14	17	0/72	1
	5/2	Delay in material delivery	4	10	9	17	15	0/71	2
	5/3	Changes in material types and specifications during construction	8	11	7	15	14	0/66	3
	5/4	Damage of sorted material while they are needed urgently	7	17	7	14	10	0/61	5
	5/5	Delay in manufacturing special building materials	9	11	9	12	14	0/64	4
	5/6	Late procurement of materials	16	12	7	9	11	0/55	6
	5/7	Late in selection of finishing materials due to availability of many types in market	16	17	6	9	7	0/51	7
	5/8	Escalation of material prices	24	21	4	4	2	0/38	8
6. Labor and equipment delays	6/1	Unqualified workforce	9	7	10	14	15	0/67	1
	6/2	Low productivity level of labors	7	14	7	13	14	0/65	2
	6/3	Shortage of labors	8	16	8	11	12	0/61	3
	6/4	Low productivity and efficiency of equipment	14	14	8	9	10	0/55	6
	6/5	Equipment availability and failure	12	16	5	13	9	0/57	4
	6/6	Low level of equipment-operator's skill	11	18	4	14	8	0/56	5
	6/7	Personal conflicts among labors	16	17	5	8	9	0/52	7
	6/8	Lack of high-technology mechanical equipment	19	21	4	6	5	0/44	8
7. External delays	7/1	Effects of subsurface conditions (e.g. soil, high water table, etc.)	5	6	12	14	18	0/72	2
	7/2	Delay in obtaining permits from municipality	6	6	11	15	17	0/71	3
	7/3	Effect of social and cultural factors	5	4	9	19	18	0/75	1
	7/4	Weather effect (hot, rain, etc.)	8	6	11	14	16	0/69	4
	7/5	Changes in government regulations and laws	11	8	9	14	13	0/64	6
	7/6	Unavailability of utilities in site (such as, water, electricity, telephone, etc.)	7	9	10	15	14	0/67	5
	7/7	Traffic control and restriction at job site	13	11	9	12	10	0/58	7
	7/8	Accident during construction	15	17	6	9	8	0/52	8
	7/9	Differing site (ground) conditions	18	16	8	6	7	0/48	9
	7/10	Delay in providing services from utilities (such as water, electricity)	21	19	6	5	4	0/43	10

(*continued*)

Table AII.

Delay group	No.	Factor of delay	Criteria weights V.L 1.	L 2.	M 3.	H 4.	V.H 5.	RII	Rank
	7/11	Fluctuations in cost/ currency	21	20	6	5	3	0/41	11
	7/12	Delay in performing final inspection and certification by a third party	26	18	5	3	3	0/38	12
	7/13	Force Majeure as war, revolution, riot, strike, and earthquake, etc.	25	21	3	4	2	0/37	13
		Contractor comments (55)							
1. Employer delays	1/1	Change orders by owner during construction	3	6	5	19	25	0/8	2
	2/1	Underestimation of time for completion	4	5	8	14	27	0/79	3
	3/1	Underestimation of cost of projects	6	7	5	19	21	0/74	6
	4/1	Delay to furnish and deliver the site to the contractor by owner	3	6	9	18	22	0/77	4
	5/1	Inadequate definition of substantial completion	1	3	9	22	23	0/82	1
	6/1	Insufficient feasibility studies and survey before investment	4	8	5	20	21	0/76	5
	7/1	Slow decision making	6	11	3	22	16	0/71	8
	8/1	Poor communication and coordination by owner and other parties	8	12	6	16	16	0/67	10
	9/1	Late in revising and approving design documents by owner	6	10	3	20	19	0/72	7
	10	Type of project bidding and award (negotiation, lowest bidder)	7	12	6	15	18	0/69	9
	11/1	Type of construction contract (Turnkey, construction only)	5	16	12	10	15	0/65	11
	12	Suspension of work by owner	13	13	9	11	12	0/59	12
	13/1	Ineffective delay penalties by owner	14	15	11	13	5	0/53	15
	14/1	Unavailability of incentives for contractor for finishing ahead of schedule	22	8	4	14	10	0/54	14
	15/1	Delay in approving shop drawings and sample materials	17	17	6	8	10	0/52	17
	16/1	Delay in finance and payments of completed work by owner	9	24	7	8	10	0/55	13
	17/1	Poor supervision	11	21	11	8	7	0/53	16
	18/1	Low bid	15	16	14	7	6	0/51	18
	19/1	Delays in inspection and testing of work	15	17	15	8	3	0/49	19
2. Contractor delays	2/1	Difficulties in financing project by contractor	16	9	12	6	15	0/58	2
	2/2	Delays in sub-contractors work	14	13	18	3	10	0/54	6
	2/3	Poor qualification of the contractors technical staff	12	13	11	14	8	0/58	3
	2/4	Poor site management and supervision by contractor	18	14	13	5	8	0/5	7
	2/5	Rework due to errors during construction	16	11	12	11	8	0/54	5
	2/6	Ineffective planning and scheduling of project by contractor	16	10	7	12	13	0/59	1
	2/7	Inadequate contractor experience	17	9	9	12	11	0/57	4
	2/8	Frequent change of sub-contractors because of their inefficient work	23	9	11	6	9	0/49	8

(*continued*)

Delay group	No.	Factor of delay	Criteria weights V.L 1.	L 2.	M 3.	H 4.	V.H 5.	RII	Rank
	2/9	Poor communication and coordination by contractor with other parties	28	18	3	3	6	0/4	12
	2/10	Conflicts in sub-contractors schedule in execution of project	16	25	4	5	8	0/48	9
	2/11	Improper construction methods implemented by contractor	17	27	3	6	5	0/44	10
	2/12	Conflicts between contractor and other parties (consultant and owner)	20	22	12	1	3	0/41	11
	2/13	Delay in site mobilization	28	16	7	3	4	0/39	13
3. Consultant delays	3/1	Inadequate experience of consultant	7	10	4	18	19	0/71	2
	3/2	Delay in performing inspection and testing by consultant	11	9	5	18	15	0/66	4
	3/3	Poor communication/coordination between consultant and other parties	5	9	11	14	19	0/71	1
	3/4	Delay in approving major changes in the scope of work by consultant	6	14	8	15	15	0/67	3
	3/5	Inflexibility (rigidity) of consultant	13	18	6	9	12	0/56	5
	3/6	Late in reviewing and approving design documents by consultant	18	20	5	9	6	0/48	7
	3/7	Conflicts between consultant and design engineer	15	18	13	8	4	0/49	6
	3/8	Unclear and inadequate details in drawings	19	20	10	5	4	0/44	8
	3/9	Quality assurance/control	23	18	8	5	4	0/42	9
4. Design delays	4/1	Mistakes and discrepancies in design documents	12	12	6	11	17	0/63	3
	4/2	Delays in producing design documents	17	5	6	10	20	0/64	2
	4/3	Complexity of project design	17	12	2	11	16	0/59	4
	4/4	Insufficient data collection and survey before design	5	8	13	15	17	0/71	1
	4/5	Unclear and inadequate details in drawings	19	10	3	10	16	0/58	5
	4/6	Misunderstanding of owner's requirements by design engineer	15	17	3	10	13	0/56	6
	4/7	Inadequate design-team experience	15	19	4	7	13	0/54	7
	4/8	Un-use of advanced engineering design software	27	13	7	4	7	0/43	8
5. Material delays	5/1	Shortage of construction materials in market	8	8	6	16	20	0/71	3
	5/2	Delay in material delivery	9	6	7	14	22	0/72	2
	5/3	Changes in material types and specifications during construction	5	12	9	15	17	0/69	4
	5/4	Damage of sorted material while they are needed urgently	9	3	9	18	19	0/72	1
	5/5	Delay in manufacturing special building materials	14	15	7	12	10	0/56	6
	5/6	Late procurement of materials	9	18	10	12	9	0/58	5
	5/7	Late in selection of finishing materials due to availability of many types in market	15	21	7	6	9	0/51	7
	5/8	Escalation of material prices	28	15	5	4	6	0/41	8
6. Labor and equipment delays	6/1	Unqualified workforce	4	10	8	13	23	0/74	1

(continued)

Table AII.

Table AII.

Delay group	No.	Factor of delay	Criteria weights V.L 1.	L 2.	M 3.	H 4.	V.H 5.	RII	Rank
	6/2	Low productivity level of labors	9	6	9	13	21	0/71	3
	6/3	Shortage of labors	12	3	5	19	19	0/7	4
	6/4	Low productivity and efficiency of equipment	7	1	11	23	16	0/74	2
	6/5	Equipment availability and failure	11	9	10	14	14	0/64	5
	6/6	Low level of equipment-operator's skill	20	2	7	15	14	0/6	6
	6/7	Personal conflicts among labors	20	11	5	11	11	0/54	7
	6/8	Lack of high-technology mechanical equipment	26	16	10	5	1	0/39	8
7. External delays	7/1	Effects of subsurface conditions (e.g. soil, high water table, etc.)	2	4	10	21	21	0/79	1
	7/2	Delay in obtaining permits from municipality	4	6	11	18	19	0/74	2
	7/3	Effect of social and cultural factors	4	8	10	19	17	0/73	3
	7/4	Weather effect (hot, rain, etc.)	7	11	7	14	19	0/69	4
	7/5	Changes in government regulations and laws	9	8	8	15	18	0/69	5
	7/6	Unavailability of utilities in site (such as, water, electricity, telephone, etc.)	18	13	4	8	15	0/56	6
	7/7	Traffic control and restriction at job site	16	22	2	8	10	0/51	8
	7/8	Accident during construction	16	13	10	8	11	0/55	7
	7/9	Differing site (ground) conditions	18	17	8	8	7	0/49	9
	7/10	Delay in providing services from utilities (such as water, electricity)	22	17	6	7	6	0/46	12
	7/11	Fluctuations in cost/ currency	15	24	5	6	8	0/49	10
	7/12	Delay in performing final inspection and certification by a third party	12	29	6	7	4	0/47	11
	7/13	Force Majeure as war, revolution, riot, strike, and earthquake, etc.	20	25	5	4	4	0/42	13
		Total views (175) of all three factors (62 clients, 55 consultants, 58 contractors)							
1. Employer delays	1/1	Change orders by owner during construction	9	21	22	56	67	0/90	1
	2/1	Underestimation of time for completion	10	23	25	53	64	0/88	2
	3/1	Underestimation of cost of projects	15	20	23	55	62	0/87	3
	4/1	Delay to furnish and deliver the site to the contractor by owner	14	18	32	52	59	0/87	4
	5/1	Inadequate definition of substantial completion	13	22	27	57	56	0/86	5
	6/1	Insufficient feasibility studies and survey before investment	15	27	27	52	54	0/84	6
	7/1	Slow decision making	16	25	30	55	49	0/83	7
	8/1	Poor communication and coordination by owner and other parties	17	30	28	49	51	0/82	8
	9/1	Late in revising and approving design documents by owner	18	32	24	51	50	0/81	9
	10	Type of project bidding and award (negotiation, lowest bidder)	20	34	30	46	45	0/78	10

(*continued*)

Delay group	No.	Factor of delay	Criteria weights V.L 1.	L 2.	M 3.	H 4.	V.H 5.	RII	Rank
	11/1	Type of construction contract (Turnkey, construction only)	27	38	36	35	39	0/73	11
	12	Suspension of work by owner	37	45	30	32	31	0/67	12
	13/1	Ineffective delay penalties by owner	39	52	24	34	26	0/64	13
	14/1	Unavailability of incentives for contractor for finishing ahead of schedule	52	53	22	27	21	0/58	14
	15/1	Delay in approving shop drawings and sample materials	56	62	14	18	25	0/56	15
	16/1	Delay in finance and payments of completed work by owner	60	58	18	19	20	0/54	16
	17/1	Poor supervision	64	61	24	14	12	0/50	17
	18/1	Low bid	68	63	23	12	9	0/47	18
	19/1	Delays in inspection and testing of work	71	65	21	11	7	0/46	19
2. Contractor delays	2/1	Difficulties in financing project by contractor	24	19	31	45	56	0/82	1
	2/2	Delays in sub-contractors work	21	25	35	42	52	0/81	2
	2/3	Poor qualification of the contractors technical staff	22	27	31	47	48	0/80	3
	2/4	Poor site management and supervision by contractor	25	30	28	50	42	0/77	4
	2/5	Rework due to errors during construction	27	29	36	44	39	0/75	5
	2/6	Ineffective planning and scheduling of project by contractor	30	33	29	42	41	0/74	6
	2/7	Inadequate contractor experience	35	36	27	40	37	0/71	7
	2/8	Frequent change of sub-contractors because of their inefficient work	37	32	36	37	33	0/70	8
	2/9	Poor communication and coordination by contractor with other parties	41	38	32	35	29	0/66	9
	2/10	Conflicts in sub-contractors schedule in execution of project	43	45	28	32	27	0/64	10
	2/11	Improper construction methods implemented by contractor	51	47	25	28	24	0/60	11
	2/12	Conflicts between contractor and other parties (consultant and owner)	57	54	27	18	19	0/55	12
	2/13	Delay in site mobilization	62	57	23	16	17	0/53	13
3. Consultant delays	3/1	Inadequate experience of consultant	24	30	32	42	47	0/78	1
	3/2	Delay in performing inspection and testing by consultant	32	29	24	47	43	0/75	2
	3/3	Poor communication/coordination between consultant and other parties	30	34	27	39	45	0/75	3
	3/4	Delay in approving major changes in the scope of work by consultant	34	36	31	36	38	0/71	4
	3/5	Inflexibility (rigidity) of consultant	41	39	29	32	34	0/67	5
	3/6	Late in reviewing and approving design documents by consultant	53	49	23	28	22	0/59	6
	3/7	Conflicts between consultant and design engineer	55	53	27	21	19	0/56	7
	3/8	Unclear and inadequate details in drawings	62	59	23	17	14	0/52	8
	3/9	Quality assurance/control	67	64	19	14	11	0/48	9

(*continued*)

Table AII.

Table AII.

Delay group	No.	Factor of delay	Criteria weights V.L 1.	L 2.	M 3.	H 4.	V.H 5.	RII	Rank
4. Design delays	4/1	Mistakes and discrepancies in design documents	25	28	31	44	47	0/78	1
	4/2	Delays in producing design documents	31	25	28	43	48	0/77	2
	4/3	Complexity of project design	35	32	25	41	42	0/73	3
	4/4	Insufficient data collection and survey before design	37	29	32	38	39	0/72	4
	4/5	Unclear and inadequate details in drawings	45	37	24	33	36	0/67	5
	4/6	Misunderstanding of owner's requirements by design engineer	49	51	19	27	29	0/61	6
	4/7	Inadequate design-team experience	53	62	15	21	24	0/57	7
	4/8	Un-use of advanced engineering design software	74	59	15	13	14	0/48	8
5. Material delays	5/1	Shortage of construction materials in market	19	22	32	47	55	0/83	1
	5/2	Delay in material delivery	22	27	28	45	53	0/81	2
	5/3	Changes in material types and specifications during construction	25	32	26	47	45	0/77	3
	5/4	Damage of sorted material while they are needed urgently	32	35	22	44	42	0/74	4
	5/5	Delay in manufacturing special building materials	39	43	24	35	34	0/68	5
	5/6	Late procurement of materials	45	47	22	32	29	0/64	6
	5/7	Late in selection of finishing materials due to availability of many types in market	49	58	19	25	24	0/59	7
	5/8	Escalation of material prices	77	59	14	12	13	0/47	8
6. Labor and equipment delays	6/1	Unqualified workforce	17	24	29	46	59	0/84	1
	6/2	Low productivity level of labors	22	32	23	44	54	0/80	2
	6/3	Shortage of labors	27	34	19	46	49	0/77	3
	6/4	Low productivity and efficiency of equipment	35	29	26	44	41	0/74	4
	6/5	Equipment availability and failure	36	42	21	41	35	0/70	5
	6/6	Low level of equipment-operator's skill	47	39	19	38	32	0/66	6
	6/7	Personal conflicts among labors	54	49	16	27	29	0/60	7
	6/8	Lack of high-technology mechanical equipment	69	56	19	17	14	0/50	8
7. External delays	7/1	Effects of subsurface conditions (e.g. soil, high water table, etc.)	14	16	32	54	59	0/87	1
	7/2	Delay in obtaining permits from municipality	16	21	33	51	54	0/84	2
	7/3	Effect of social and cultural factors	20	20	29	55	51	0/83	3
	7/4	Weather effect (hot, rain, etc.)	23	26	34	43	49	0/79	4
	7/5	Changes in government regulations and laws	32	30	28	41	44	0/75	5
	7/6	Unavailability of utilities in site (such as, water, electricity, telephone, etc.)	39	37	26	34	39	0/70	6
	7/7	Traffic control and restriction at job site	45	47	23	29	31	0/64	7

(*continued*)

Delay group	No.	Factor of delay	Criteria weights V.L 1.	L 2.	M 3.	H 4.	V.H 5.	RII	Rank
	7/8	Accident during construction	46	49	27	24	29	0/62	8
	7/9	Differing site (ground) conditions	53	54	24	21	23	0/58	9
	7/10	Delay in providing services from utilities (such as water, electricity)	64	59	20	18	14	0/51	10
	7/11	Fluctuations in cost/currency	61	67	18	15	14	0/51	11
	7/12	Delay in performing final inspection and certification by a third party	66	69	16	13	11	0/48	12
	7/13	Force majeure as war, revolution, riot, strike, and earthquake, etc.	70	73	12	11	9	0/45	13

Table AII.

No.	Category	Alternative of decrease and remove of delays
1.	Client-related causes	1. Accurate and realistic estimation of the time of the Project and the resources on hand (to decrease the causes of No. 2, 3, 5 in Table AI) 2. Sufficient studies before investment and evaluation of the project before start of it (to decrease the causes of No. 1, 3, 5, 6, 7, 10, 11, 12, 15, 17 in Table AI) 3. Lack of using poor executive principles due to hold low cost tenders (to decrease the causes of No. 14, 15, 17, 18, 19 in Table AI) 4. Removing conflict and lack of delay (to decrease the causes of No. 4 in Table AI) 5. Making correct decisions and in time (to decrease the causes of No. 4, 5, 7, 10, 12, 18 in Table AI) 6. Not to change and excessive involve in initial assumptions and scope of the project (to decrease the causes of No. 1, 9 in Table AI) 7. Reduce dispute among executive subordinates (to decrease the causes of No. 13, 14, 15, 17 in Table AI) 8. Predict alternative financing in the case of deficiency (to decrease the causes of No. 3, 16, 19 in Table AI)
2.	Labor and equipment category causes	9. Holding educational periods and safety justification in the workshop (to decrease the causes of No. 59, 63, 64 in Table AI) 10. The presence of incentive systems in the labor force 11. Allocation of skilled manpower and increase productivity (to decrease the causes of No. 58, 59, 60, 64 in Table AI) 12. Supply of new equipment and machinery (to decrease the causes of No. 62, 65 in Table AI) 13. Use of modern methods in the repair and maintenance of equipment during breakdowns and accidents (to decrease the causes of No. 65 in Table AI) 14. Considering standards in installation (to decrease the causes of No. 65 in Table AI) 15. Operating technology in mechanical devices and increasing the speed and efficiency and reduce errors (to decrease the causes of No. 61, 62, 63 in Table AI)
3.	Contractor-related causes	16. Selection of sub-contractors based on competence rather than on low prices (to decrease the causes of No. 21, 22, 23, 24, 26, 27 in Table AI) 17. Considering safety points and HSE in Project (to decrease the causes of No. 21, 22, 24, 32 in Table AI) 18. Non-weak contractors in developing executive alternative of coping with sever territories (to decrease the causes of No. 22, 26 in Table AI) 19. The technical study and design schedule and planning by the contractor during the tender stage (to decrease the causes of No. 23, 24, 27, 29 in Table AI) 20. Provide timely statements (to decrease the causes of No. 29, 31 in Table AI) 21. Sub-contractors following of schedule (to decrease the causes of No. 21, 29 in Table AI)
4.	Material-related causes	22. Timely selection in approval of resources of the materials and buying them (to decrease the causes of No. 52, 55, 56, 57 in Table AI) 23. Anticipation of the shortage of materials in the market and considering the solutions before the crisis and rising prices (to decrease the causes of No. 50, 55, 57 in Table AI) 24. Requesting a guideline formulated about the condition of maintaining the facilities and materials from manufacturers and suppliers (to decrease the causes of No. 51, 53, 54 in Table AI) 25. Prevention of crime and abuse of resources and materials while transit in workshop environment

(*continued*)

Table AIII.
Ranking the causes of delay and the ideas of decreasing and removing it

No.	Category	Alternative of decrease and remove of delays
5.	Design-related causes	26. Use of advanced software engineering and design (to decrease the causes of No. 42, 44, 46, 47, 49 in Table AI) 27. Provide timely execution plans to contractor (to decrease the causes of No. 45, 43 in Table AI)
6.	External causes	28. No deficiency would be in the formulating contracts (to decrease the causes of No. 67, 70 in Table AI) 29. Considering referee of resolving discrepancy among workforces (to decrease the causes of No. 67, 70 in Table AI) 30. Financial limitation faced due to lack of allocation budget by government in the projects (to decrease the causes of no. 76 in Table AI) 31. Anticipation of international situation and prolong the negotiations with builders and track orders (to decrease the causes of No. 78 in Table AI) 32. Anticipation of prolonging orders because of office bureaucracy (to decrease the causes of No. 67 in Table AI) 33. Study and anticipation of regional bad weather conditions (to decrease the causes of No. 69 in Table AI) 34. Study on inflation and market fluctuations and presenting alternatives (to decrease the causes of No. 76 in Table AI) 35. Exchange rate forecasting because of the political regional climate and gold and oil price impact on it (to decrease the causes of No. 76, 78 in Table AI) 36. Considering the conditions of societies and their cultures and preventing regional and labor strikes (to decrease the causes of No. 68, 78 in Table AI) 37. Paying attention to allocating credits in 2nd half of the year by the government on public projects (to decrease the causes of No. 76 in Table AI)
7.	Consultant-related causes	38. Accuracy in early studies and examining the feasibility of projects economic justification (to decrease the causes of No. 36, 41 in Table AI) 39. Timely providing design drawings and personating documents needed for next decision makings (to decrease the causes of No. 33, 34, 35, 38, 40 in Table AI) 40. High accuracy in evaluation and estimation of the volumes and work sums (to decrease the causes of No. 39, 40, 41 in Table AI)

Table AIII.

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