Quantification of Delay Factors Using the Relative Importance Index Method for Construction Projects in Turkey

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Abstract: Construction delays are common in construction industry and create major concerns for project performance. Construction delays are caused by many factors. The aim of this paper is to identify delay factors on construction projects and analyze these factors with the relative importance index method. For this purpose, 83 different delay factors were identified, categorized into nine major groups, and visualized by the Ishikawa (fishbone) diagram through detailed literature review and interviews with experts from the construction industry. The relative importances of these delay factors were quantified by the relative importance index method. The ranking of the factors and groups were demonstrated according to their importance level on delay. According to the case study results, the factors and groups contributing the most to delays (those needing attention) were discussed, and some recommendations were made to minimize and control delays in construction projects. **DOI: 10.1061/(ASCE)ME.1943-5479.0000129.**

CE Database subject headings: Construction management; Scheduling; Turkey; Delay time.

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Introduction

A construction project is commonly acknowledged as successful when it is completed on time, within budget, in accordance with the specifications, and to stakeholders' satisfaction (Majid 2006). In the construction industry, contractors tend to maximize their profit to increase market share. To achieve this aim, it is crucial for contractors to carefully identify the factors that affect the success of a project and estimate their impacts before the bidding stage. Construction projects may differ in size, duration, objectives, uncertainty, complexity, deadlines, and some other dimensions. Delay means noncompletion of the project within the specified duration agreed on in the contract. It is widely accepted that the schedule of a construction project plays a key role in project management due to its influence on project success (Luu et al. 2009). Delays are common in various construction projects and cause considerable losses to project parties. The common results of delays are late completion of the project, increased cost, disruption of work, loss of productivity, third-party claims, disputes, and abandonment or termination of contracts. Therefore, delays in construction projects give rise to dissatisfaction to all parties involved (Majid 2006).

This research aimed to (1) identify the delay factors in construction projects, (2) categorize the delay factors in construction projects, (3) quantify the relative importance of delay factors and to demonstrate the ranking of the factors and groups according to their importance with respect to delays, (4) address the factors and groups contributing most to delays, and (5) make recommendations in order to minimize or control delays in construction projects.

Literature Review

The construction industry has a very poor reputation for coping with delays. Delay analysis is either ignored or done subjectively by simply adding a contingency. As a result many major projects fail to meet schedule deadlines (Duran 2006). In Indonesia, Trigunarsyah (2004) reported that only 47% of projects were completed within schedule, 15% were completed ahead of schedule, and 38% were behind schedule.

Previous Studies

As the process of construction project development is very complicated and combines various parties' agendas, comprise many stages of work, and entail a long period until completion (Puspasari 2006), many factors contribute to delays in construction projects. Various researchers have examined and identified the causes of delays in construction projects. Some of these studies are presented below.

Baldwin and Manthei (1971) investigated the reasons for delays in building projects in the United States. They indicated 17 delay factors. Their study concluded that weather, labor supply, and subcontractors are the three major causes of construction delays.

Arditi et al. (1985) studied the reasons for delays in publicly funded construction projects for the period 1970–1980 in Turkey. They concluded that 23 reasons accounted for the construction delays. Their findings indicated that the delays were due to a shortage of materials, difficulties in receiving payments from agencies, contractor difficulties, and organizational characteristics of contracting companies and public agencies. Ubaid (1991) discussed the performance of contractors as one of the major causes of delays. He related 13 major delay factors to contractor resources and capabilities.

The causes of delays and cost overruns were studied by Mansfield et al. (1994) in regard to construction projects in Nigeria. The researchers identified 16 major factors. According to their

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findings, the most significant factors were financing and payment for completed works, poor contract management, changes in site conditions, shortage of materials, and improper planning.

In their study, Assaf et al. (1995) examined the causes of delays in large building construction projects in Saudi Arabia. They identified 56 causes of delays and grouped them into 9 major categories. They concluded that the most significant delay factors were the approval of shop drawings, delays in payment to contractors and the resulting cash flow problems during construction, design changes, conflicts in subcontractor work schedules, slow decision making and executive bureaucracy in owners' organizations, design errors, labor shortages, and inadequate labor skills.

Chan and Kumaraswamy (1997) conducted a survey to evaluate the relative importance of 83 potential delay factors, which were grouped into 8 major categories in Hong Kong construction projects. The results of their research indicated that the five principal and common causes were poor site management and supervision, unforeseen ground conditions, low speed of decision making involving all projects teams, client-initiated variations, and necessary variation of work.

Kaming et al. (1997) examined 31 high-rise projects in Indonesian construction projects. They identified 11 variables related to delays. According to their findings, the most important factors were design changes, poor labor productivity, inadequate planning, and resource shortages.

Mezher and Tawil (1998) carried out a survey about the causes of delays in the construction industry in Lebanon. The survey included 64 causes of delay, which were grouped into 10 major categories. According to their findings, financial issues, the way in which contractors regarded the contractual relationship, and project management issues were the most important causes of delays.

Assaf and Al-Hejji (2006) studied the causes of delays in large construction projects in Saudi Arabia. In their study, they identified 73 causes of delay in Saudi construction projects. Delay factors were grouped into nine major categories with different levels of importance for different parties. The most common cause of delay identified by all three parties was change orders.

Han (2005) and Dikmen et al. (2007) assumed that a total number of 23 risk factors stemming from project and country levels led to cost overrun risk. According to their risk model, 9 factors affected country risk, and 14 factors caused project risk. They proposed a fuzzy risk assessment methodology to quantify cost delay risk in construction projects and developed a tool to implement the proposed methodology. A computer program was developed for an international construction company, and the applicability of this system during risk assessment at the bidding stage was tested using real company and project information.

Identification and Categorization of Delay Factors by Synthesis of Existing Literature (in Alphabetical Order)

- Consultant-related factors. These were identified as one of the groups of causes of delays in construction projects. Several studies have identified consultant-related factors as causing delays. (Odeh and Battaineh 2002; Long et al. 2004; Assaf and Al-Hejji 2006). Based on these studies, the author identified eight factors of consultant related delays.
- Contractor-related factors. These factors comprised a second group of causes of delay. Several studies have identified contractor-related factors as the cause of delays (Chan and Kumaraswamy 1997; Ogunlana et al. 1996; Majid and McCaffer 1998; Odeh and Battaineh 2002; Long et al. 2004; Assaf and Al-Hejji 2006). Based on these studies, the author identified 10 factors of contractor-related delays.
- Design-related factors. These were identified as another group of causes of delays. Several studies have identified design-related factors as causing delays (Chan and Kumaraswamy 1997; Assaf and Al-Hejji 2006; El Razek et al. 2008). Based on these studies, the author identified nine factors of design-related delays.
- Equipment-related factors. This group of factors was identified as a fourth group of causes of delay. Several studies have identified equipment-related factors as causing delays (Chan and Kumaraswamy 1997; Ogunlana et al. 1996; Majid and McCaffer 1998; Odeh and Battaineh 2002; Long et al. 2004; Assaf and Al-Hejji 2006). Based on these studies, the author identified seven factors of equipment-related delays.
- Externality-related factors. These were identified as another group of causes of delays. Several studies have identified external factors as causing delays (Ogunlana et al. 1996; Al-Momani 2000; Odeh and Battaineh 2002; Long et al. 2004; Wiguna and Scott 2005; Assaf and Al-Hejji 2006). Based on these studies, the author identified 14 factors of externality-related delays.
- Labor-related factors. These factors were identified as a sixth group of causes of delays. Several studies have identified labor-related factors as causing delays (Ogunlana et al. 1996; Chan and Kumaraswamy 1997; Majid and McCaffer 1998; Odeh and Battaineh 2002; Assaf and Al-Hejji 2006). Based on these studies, the author identified eight factors of labor-related delays.
- Material-related factors. These were identified as another group of causes of delays. Several studies have identified material-related factors as causing delays (Chan and Kumaraswamy 1997; Majid and McCaffer 1998; Odeh and Battaineh 2002; Frimpong et al. 2003; Koushki et al. 2005; Wiguna and Scott 2005; Assaf and Al-Hejji 2006). Based on these studies, the author identified nine factors of material-related delays.
- Owner-related factors. This category was identified as an eighth group of causes of delays. Several studies have identified owner-related factors as causing delays (Ogunlana et al. 1996; Odeh and Battaineh 2002; Long et al. 2004; Koushki et al. 2005; Assaf and Al-Hejji 2006). Based on these studies, the author identified 12 factors of owner-related delays.
- Project-related factors. These were identified as a ninth and final group of causes of delays. Several studies have identified project-related factors as causing delays (Chan and Kumaraswamy 1997; Han 2005; Assaf and Al-Hejji 2006; Dikmen et al. 2007). Based on these studies, the author identified six factors of project-related delays.

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 64 different highly experienced construction professionals, the author 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 Turkey.

Research Methodology

The research methodology can be summarized as follows: 83 different delay factors were identified and categorized into 9 major groups and visualized using the Ishikawa (fishbone) diagram through a detailed literature review and interview with experts in the construction industry. An interview questionnaire was developed to assess the perceptions of those in the Turkish construction industry on the relative importance of causes of delays. Then the

questionnaire was filled out by 64 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. 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.

Interview on the Causes of Delay

The interview focused on the causes of delay in construction projects. The interviewees were asked to check the questionnaire form about delay factors and groups prepared through a detailed literature review, cite additional factors if necessary, and complete the questionnaire form by assigning values to the factors ranging from 1 (very low important) to 5 (very high important) considering their relative importance. It was assured that interviewees had significant information about delay factors in construction projects, allocated necessary time to performing required tasks, and were experts on construction projects.

The Ishikawa (fishbone) diagram was utilized to demonstrate the factors that may cause delays in construction projects. The Ishikawa diagram, also known as the fishbone diagram or cause-and-effect diagram, is a tool used for systematically identifying and presenting all the possible causes of a particular problem in graphical format. The possible causes are presented at various levels of detail in connected branches, with the level of detail increasing as a branch goes outward, i.e., an outer branch is a cause of the inner branch it is attached to. Thus, the outermost branches usually indicate the root causes of the problem. The Ishikawa (fishbone) diagram of categories and factors that cause delays in this paper were shown in Fig. 1.

The interviewees checked and evaluated the 83 well-organized delay factors (Table 1) based on their professional judgment considering the consultant-, contractor-, design-, equipment-, external, labor-, material-, owner-, and project-related delay factor groups.

Data Analysis

Kometa et al. (1994) and Sambasivan 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 Eq. (1):

$$\text{RII} = \frac{\sum W}{(A * N)} \tag{1}$$

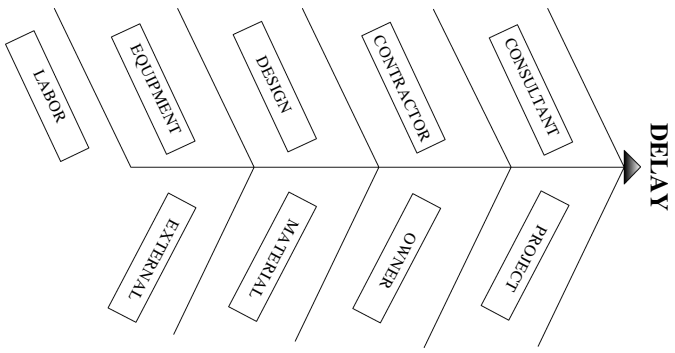

Fig. 1. Categories and factors that cause schedule delays (Ishikawa diagram)

where RII = relative importance index; W = weighting given to each factor by respondents (ranging from 1 to 5); A = highest weight (i.e., 5 in this case); and N = 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 RIIs were then ranked, and the results are shown in Table 1. Calculating the average RIIs of the causes in each group gives the RIIs of the mean groups. The mean RIIs and the ranking of all groups are shown in Table 2.

Research Findings and Results

Based on the ranking in Table 1, the mean RIIs and the ranking of all groups are shown in Table 2, the top 15 most important factors causing delays are shown in Table 3, and the 15 least important factors causing delays are shown in Table 4. According to the ranking of the groups, the three factors of each group that contribute most to delays are discussed in what follows.

Contractor (RII = 0.773)

The contractor-related group of delay factors was the most important group to cause delays. This was mainly due to the factors inadequate contractor experience (RII = 0.863), ineffective project planning and scheduling (RII = 0.844), and poor site management and supervision (RII = 0.844).

Owner (RII = 0.730)

The second most important group was the owner-related group, whose most significant factors were change orders (RII = 0.778), delay of onsite delivery (RII = 0.778), and slowness in decision making (RII = 0.775).

Consultant (RII = 0.723)

After the owner-related group, the consultant-related group of delay factors came in as the third most important group. The significant factors were delay in performing inspection and testing (RII = 0.784), poor communication and coordination with other parties (RII = 0.756), and conflicts between consultant and design engineer (RII = 0.741).

Design (RII = 0.704)

Following the consultant, the design-related group of delay factors ranks as the fourth most important group. The notable factors were design changes by owner or his agent during construction (RII = 0.813), design errors made by designers (RII = 0.750), and lack of experience of design team in construction projects (RII = 0.741).

Material (RII = 0.692)

The fifth most important group was the material-related group. The prominent factors were late delivery of materials (RII = 0.803), poor procurement of construction materials (RII = 0.744), and shortage of construction materials (RII = 0.731).

Equipment (RII = 0.683)

After the material, the equipment-related group of delay factors was the sixth most important group. The significant factors were improper equipment (RII = 0.709), shortage of equipment (RII = 0.700), and low efficiency of equipment (RII = 0.691).

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Table 1. RII and Ranking of Delay Factors, Respondent Scores

Factor group	Number	Factors causing delays	Respondent scores					RII	Rank
			1: Very low importance	2: Low importance	3: Medium importance	4: High importance	5: Very high importance		
Consultant-related factors	1	Lack of experience of consultant in construction projects	0	7	18	27	12	0.738	28
	2	Conflicts between consultant and design engineer	1	7	22	14	20	0.741	26
	3	Delay in approving major changes in scope of work by consultant	1	12	32	15	4	0.628	66
	4	Delay in performing inspection and testing	0	1	19	28	16	0.784	7
	5	Inaccurate site investigation	2	6	23	27	6	0.691	46
	6	Inadequate project management assistance	0	9	18	25	12	0.725	33
	7	Late in reviewing and approving design documents	2	6	17	28	11	0.725	33
	8	Poor communication and coordination with other parties	0	5	17	29	13	0.756	14
Contractor-related factors	1	Frequent change of subcontractors	2	11	8	25	18	0.744	24
	2	Inadequate contractor experience	0	4	5	22	33	0.863	1
	3	Inappropriate construction methods	2	6	15	23	18	0.753	18
	4	Incompetent project team	1	2	23	22	16	0.756	14
	5	Ineffective project planning and scheduling	0	0	11	28	25	0.844	2
	6	Obsolete technology	6	9	24	21	4	0.625	67
	7	Poor communication and coordination with other parties	0	2	25	22	15	0.756	14
	8	Poor site management and supervision	0	2	8	28	26	0.844	2
	9	Rework due to errors	2	7	15	22	18	0.747	22
	10	Unreliable subcontractors	1	1	15	28	19	0.797	6
Design-related factors	1	Complexity of project design	3	8	33	16	4	0.631	65
	2	Design changes by owner or his agent during construction	0	2	15	24	23	0.813	4
	3	Design errors made by designers	1	4	24	16	19	0.750	21
	4	Insufficient data collection and survey before design	2	5	15	33	9	0.731	29
	5	Lack of experience of design team in construction projects	0	9	14	28	13	0.741	26
	6	Mistakes and delays in producing design documents	1	3	29	21	10	0.713	38
	7	Misunderstanding of owner's requirements by design engineer	3	6	21	28	6	0.688	49
	8	Poor use of advanced engineering design software	11	6	32	13	2	0.566	77
	9	Unclear and inadequate details in drawings	1	10	20	20	13	0.706	43
Equipment-related factors	1	Equipment allocation problem	2	7	29	17	9	0.675	55
	2	Frequent equipment breakdowns	4	4	26	20	10	0.688	49
	3	Improper equipment	2	10	15	25	12	0.709	40
	4	Inadequate modern equipment	4	8	23	21	8	0.666	57
	5	Low efficiency of equipment	0	7	26	26	5	0.691	46
	6	Shortage of equipment	2	10	14	30	8	0.700	45
	7	Slow mobilization of equipment	3	9	25	23	4	0.650	61
Externality-related factors	1	Accidents during construction	5	20	19	14	6	0.588	72
	2	Changes in government regulations and laws	4	22	21	15	2	0.566	77
	3	Conflict, war, and hostilities	13	10	6	10	25	0.675	55
	4	Delay in obtaining permits from municipality	4	3	19	16	22	0.753	18
	5	Delay in performing final inspection and certification by a third party	1	9	29	19	6	0.663	59
	6	Delay in providing services from utilities (such as water, electricity)	5	12	26	9	12	0.634	64
	7	Global financial crisis	2	13	10	21	18	0.725	33

Table 1. (*Continued.*)

Factor group	Number	Factors causing delays	Respondent scores					RII	Rank
			1: Very low importance	2: Low importance	3: Medium importance	4: High importance	5: Very high importance		
	8	Loss of time by traffic control and restriction at job site	13	22	18	11	0	0.484	82
	9	Natural disasters (flood, hurricane, earthquake)	8	14	8	13	21	0.678	54
	10	Price fluctuations	3	21	23	12	5	0.584	73
	11	Problem with neighbors	10	12	29	12	1	0.544	80
	12	Slow site clearance	15	19	20	10	0	0.478	83
	13	Unexpected surface and subsurface conditions (such as soil, hw table)	0	7	22	26	9	0.716	36
	14	Unfavorable weather conditions	4	9	20	18	13	0.684	52
Labor-related factors	1	Absenteeism	7	17	20	12	8	0.591	70
	2	Low worker motivation and morale	4	10	20	15	15	0.684	52
	3	Low worker productivity	2	4	21	25	12	0.728	31
	4	Personal conflicts among workers	7	20	27	10	0	0.525	81
	5	Labor shortage	4	5	11	25	19	0.756	14
	6	Slow mobilization of labor	6	10	23	23	2	0.616	69
	7	Strike	13	21	7	13	10	0.556	79
	8	Unqualified/inexperienced workers	0	3	13	34	14	0.784	7
Material-related factors	1	Changes in material types and specifications during construction	0	7	24	23	10	0.713	38
	2	Damage of sorted materials	3	10	22	25	4	0.653	60
	3	Delay in manufacturing materials	4	6	17	27	10	0.703	44
	4	Escalation of material prices	2	18	27	15	2	0.591	70
	5	Late delivery of materials	0	1	16	28	19	0.803	5
	6	Poor procurement of construction materials	1	5	19	25	14	0.744	24
	7	Poor quality of construction materials	9	10	15	24	6	0.625	67
	8	Shortage of construction materials	2	8	10	34	10	0.731	29
	9	Unreliable suppliers	2	5	29	26	2	0.666	57
Owner-related factors	1	Change orders	2	6	13	19	24	0.778	9
	2	Conflicts between joint owners	2	10	16	23	13	0.709	40
	3	Delay in approving design documents	0	4	14	32	14	0.775	11
	4	Delay in progress payments	0	4	15	30	15	0.775	11
	5	Delay in site delivery	0	5	13	30	16	0.778	9
	6	Improper project feasibility study	1	6	18	29	10	0.728	31
	7	Lack of capable representative	5	10	21	20	8	0.650	61
	8	Lack of experience of owner in construction projects	4	4	19	25	12	0.716	36
	9	Lack of incentives for contractor to finish ahead of schedule	3	17	33	5	6	0.581	74
	10	Poor communication and coordination with other parties	0	7	16	28	13	0.747	22
	11	Slowness in decision making	0	3	18	27	16	0.775	11
	12	Suspension of work by owner	1	11	13	16	23	0.753	18
Project-related factors	1	Project complexity	5	17	22	20	0	0.578	75
	2	Inadequate definition of substantial completion	4	18	23	19	0	0.578	75
	3	Ineffective delay penalties	1	16	23	15	9	0.647	63
	4	Legal disputes between project participants	3	7	25	16	13	0.691	46
	5	Shortness of original contract duration	4	10	14	26	10	0.688	49
	6	Unfavorable contract clauses	2	8	20	21	13	0.709	40

Labor (RII = 0.655)

Following the equipment-related group of factors, the labor-related group of delay factors ranked as the seventh most important group. The notable factors were unqualified/inexperienced workers (RII = 0.784), labor shortage (RII = 0.756), and low worker productivity (RII = 0.728).

Project (RII = 0.648)

The eighth most important group was the project-related group. The prominent factors were unfavorable contract clauses (RII = 0.709), legal disputes between project participants (RII = 0.691), and shortness of original contract duration (RII = 0.688).

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Table 2. Mean RII and Ranking of Groups of Delay Factors

Group of factors	RII	Rank
Contractor-related factors	0.773	1
Owner-related factors	0.730	2
Consultant-related factors	0.723	3
Design-related factors	0.704	4
Material-related factors	0.692	5
Equipment-related factors	0.683	6
Labor-related factors	0.655	7
Project-related factors	0.648	8
Externality-related factors	0.627	9

Externality (RII = 0.627)

The externality-related group of delay factors was the last and least important group. The notable factors were delay in obtaining permits from municipality (RII = 0.753), global financial crisis (RII = 0.725), and unexpected surface and subsurface conditions (such as soil, water table) (RII = 0.716).

Conclusions and Recommendations

Delays can be avoided or minimized when their causes are clearly identified. The aim of this paper was to identify the delay factors in construction projects because delays are considered to be a serious problem in the construction industry. Through a detailed literature review and interviews with experts from the Turkish construction industry, a total of 83 different delay factors were identified and categorized into nine groups in alphabetical order as follows: consultant-related delay factors, contractor-related delay factors, design-related delay factors, equipment-related delay factors, externality-related delay factors, labor-related delay factors, material-related delay factors, owner-related delay factors, and project-related delay factors. The demonstration of these groups of delay factors was achieved using the Ishikawa (fishbone) diagram because it is capable of showing factors, interrelations between different groups of factors, and consequences following from the factors. The paper then quantified the relative importance of delay factors and demonstrated the ranking of the factors and groups according to their importance level for delays. This objective was achieved through analysis of interview outcomes. According to the computed RIIs, all factors and groups were ranked. The paper addressed the most significant factors and groups of causes of delays. The most and least important factors and groups were achieved through ranking results.

According to the preceding findings, the following recommendations can be made as ways to minimize and control delays in construction projects:

1. Contractors should not be rewarded jobs for which they lack sufficient expertise. They should gain necessary experience before the bidding stage. Inadequate experience of contractors is the most important factor in causing delays. Contractors with inadequate experience cannot plan and manage projects properly, and this may result in deleterious consequences.

Table 3. 15 Most Important Factors Causing Delays

Number	15 most important factors causing delays	Factor group	RII	Rank
1	Inadequate contractor experience	Contractor related	0.863	1
2	Ineffective project planning and scheduling	Contractor related	0.844	2
3	Poor site management and supervision	Contractor related	0.844	2
4	Design changes by owner or agent during construction	Design related	0.813	4
5	Late delivery of materials	Material related	0.803	5
6	Unreliable subcontractors	Contractor related	0.797	6
7	Delay in performing inspection and testing	Consultant related	0.784	7
8	Unqualified/inexperienced workers	Labor related	0.784	7
9	Change orders	Owner related	0.778	9
10	Delay in site delivery	Owner related	0.778	9
11	Delay in approving design documents	Owner related	0.775	11
12	Delay in progress payments	Owner related	0.775	11
13	Slowness in decision making	Owner related	0.775	11
14	Poor communication and coordination with other parties	Consultant related	0.756	14
15	Unexpected surface and subsurface conditions (soil, hw t.)	External related	0.780	14

Table 4. 15 Least Important Factors Causing Delays

Number	Top 15 least important factors causing delays	Group of factor	RII	Rank
1	Slow site clearance	Externality related	0.478	83
2	Loss of time by traffic control and restriction at job site	Externality related	0.484	82
3	Personal conflicts among workers	Labor related	0.525	81
4	Problems with neighbors	Externality related	0.544	80
5	Strike	Labor related	0.556	79
6	Poor use of advanced engineering design software	Design related	0.566	77
7	Changes in government regulations and laws	Externality related	0.566	77
8	Project complexity	Project related	0.578	75
9	Inadequate definition of substantial completion	Project related	0.578	75
10	Lack of incentives for contractor to finish ahead of schedule	Owner related	0.581	74
11	Price fluctuations	Externality related	0.584	73
12	Accidents during construction	Externality related	0.588	72
13	Absenteeism	Labor related	0.591	70
14	Escalation of material prices	Material related	0.591	70
15	Slow mobilization of labor	Labor related	0.616	70

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2. Contractors should pay more attention to preparing effective planning and scheduling. During construction, planning and scheduling may be revised if necessary conditions occur. Only a project that is well planned and scheduled can be well executed.
3. Site management and supervision should be done correctly. Administrative staff should be assigned to make necessary arrangements to complete projects within the specified time while meeting quality and cost requirements.
4. Owners may demand design changes during construction, but only to the extent that no adverse effects occur with respect to mission-critical activities.
5. Delivery of construction materials to a site should not be late so that work may be executed in the planned order.
6. Generally, large projects may entail having many subcontractors working under main contractors. If a subcontractor is capable and reliable, the project can be completed on time as planned. If the subcontractor underperforms because of inadequate experience or capability, the project may face delays. The use of many subcontractors may lead to a high risk of delays.
7. Inspection and testing by consultants is an important activity during construction since poor quality inspection may result in lower quality of work.
8. The quality and experience of the labor force can have a major impact on projects. Unqualified workers may lead to inefficient work and cause accidents during construction.
9. A change order is work added to or deleted from the original scope of work of a contract, which may alter the original contract amount or completion date. Change orders often lead to claims and disruption of work due to inadequate analysis of the project in its initial stages. Also, contract conditions corresponding to change orders should be carefully understood.
10. Delays in deliveries to construction sites, approval of design documents, and progress payments are delay factors caused by owners. Sites should receive deliveries as soon as possible after a project is awarded. Design documents should be approved promptly; otherwise, work progress could be delayed. Progress payments should be made on time to contractors to finance the work.
11. Owners should make decisions as quickly as possible so as not to prevent projects from being completed on time.
12. Since many parties are involved in a project (client, consultant, contractor, and subcontractors), communication and coordination with other parties is a crucial factor in the timely completion of the project. Effective communication avoid most delays. Proper communication and coordination channels between the various parties should be established during each phase of construction. Problems with communication may result in misunderstandings and, therefore, delays in the execution of the project.

Finally, similar studies could be performed in specific types of construction projects, such as utility construction projects, pipeline construction projects, and dam construction projects. Detailed studies could be carried out to estimate the probability of delay (which is very important for project success and should be taken into account before the bidding stage) in construction projects by developing and utilizing the findings of this study.

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