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Analyzing delay causes in Egyptian construction projects



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ABSTRACT

Construction delays are common problems in civil engineering projects in Egypt. These problems occur frequently during project life-time leading to disputes and litigation. Therefore, it is essential to study and analyze causes of construction delays. This research presents a list of construction delay causes retrieved from literature. The feedback of construction experts was obtained through interviews. Subsequently, a questionnaire survey was prepared. The questionnaire survey was distributed to thirty-three construction experts who represent owners, consultants, and contractor's organizations. Frequency Index, Severity Index, and Importance Index are calculated and according to the highest values of them the top ten delay causes of construction projects in Egypt are determined. A case study is analyzed and compared to the most important delay causes in the research. Statistical analysis is carried out using analysis of variance ANOVA method to test delay causes, obtained from the survey. The test results reveal good correlation between groups while there is significant difference between them for some delay causes and finally roadmap for prioritizing delay causes groups is presented.

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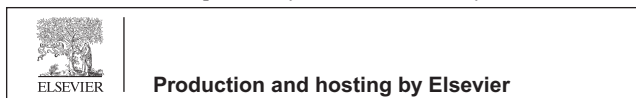
Introduction

Construction delay means a time overrun either beyond the contract date or beyond the date that the parties have agreed upon for the delivery of the project. In both cases, a delay is usually a costly situation [1]. Delay was also defined as an act or event which extends required time to perform or complete work of the contract manifests itself as additional days of work [2]. Poor site management can cause project delay

and affect productivity [3]. A lot of research efforts have been made to study delay causes in different countries [4–15]. For example, material-related delay is the main cause of project delays in Saudi Arabia [16]. Bordoli and Baldwin [17] examined the causes of delays in building projects in the United States. Weather, labor supply, and sub-contractors were found to be the major causes of delays. Poor risk management, poor supervision, unforeseen site conditions, slow decision making involving variation, and necessary variation works are the principle delay factors in Hong Kong [18]. Unforeseen soil condition, poor site supervision, low speed of decision making involving all project teams, client initiated variations, necessary variations of work, and inadequate contractor experience are the six significant factors contributing to delays in building and civil engineering works [19]. Materials-, equipment-, and labor-related delays were identified as major causes of contractors' performance delays [20]. Design changes, poor labor

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productivity, and inadequate planning and resources were found to be responsible for delays in Indonesia [21]. In Saudi Arabia, contractor performance, owner's administration, early planning and design, government regulation, site and environment conditions, and site supervision were found to be the important causes of delay [22]. Whereas, the financing and payment for completed works, poor contract management, change in site conditions, and shortages of materials were found the most important items of delay causes in Nigeria [23]. Odeyinka and Yusuf [24] studied client-, contractor-, and consultant-caused delays in housing projects in Nigeria. Variation orders, slow decision making, and cash flow problems were found as client-caused delays. Financial difficulties, material management problems, planning and scheduling problems, inadequate site inspection, equipment management problems and shortage of manpower were found as contractor-caused delays. Incomplete drawing, slow response by consultant, variation orders, late issuance of instruction, and poor communications were classified as consultant-caused delays. Inclement weather, act of God, labor dispute, and strikes were found to be extraneous factors responsible for delays. Bramble and Callahan [25] studied owner-, designed-, contractor-, and others-related delays in U.S.A. Late release of site to the contractor, late approval, financial difficulties, contract administration responsibilities, change orders, and interference were found to be owner-caused delays. Design defects, slow correction of design errors, tardy shop drawings review, and delays due to test and inspection were considered to be designed-caused delay. Failure to evaluate the site and design, construction defects, contractor management problems, and inadequate resources were found to be contractor-related delays. Weather, act of God, strikes, and labor disputes were found to be delays not caused by the design and construction parties. In Egypt, Amer [26] studied the major delay causes for construction projects which they are: poor contract management, unrealistic scheduling, lack of owner's financing/payment for completed work, design modifications during construction, and shortages in materials such as cement and steel. Abd El-Razek et al. [27] considered several delay causes in construction projects in Egypt which are: financing 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. Marzouk et al. [28] studied delays that are related to engineering factors which arise due to design development, workshop drawings, and change then he developed a knowledge based expert system for assessing the engineering related delay claims. Kazaz et al. [29] conducted a study on the causes of time extensions in the Turkish construction industry and levels of their importance, considering 34 factors. A questionnaire survey was conducted with 71 construction companies in Turkey, and the outcomes were evaluated by means of statistical analyses.

Methodology

Delay causes survey

The questionnaire designed for use in the survey comprised demographic information about respondents and 43 delay causes which were grouped to seven categories: owner related,

consultant related, contractor related, material related, labor and equipment related, project related, and external related (see Table 1). The respondents were requested to choose one degree of frequency for each delay cause which is rarely, sometimes, often, or always. Also they were requested to choose one degree of severity which is low, moderate, high, or extreme.

The questionnaire was distributed only to owners who are representatives of large investment projects and affiliated to first class of consultants who are classified as house of expertise in the Egyptian Syndicate of Engineers as well as to contractors who are representatives to high class companies registered in the Egyptian Federation for Construction and Building Contractors (EFCBC). Total of 33 experts responded. The experts were divided into three groups each group consists of eleven experts the first group represents owners and the second represents consultants while the third represents contractors. All respondents hold senior positions with related working experience and the majority of them had practiced in the field for 20–30 years.

The size of the sample required from the targeted population, i.e. 33 respondents was determined statistically [30]. The results suggested that the minimum sample size required was:

$$n_0 = \frac{p * q}{v^2} \quad (1)$$

$$n = \frac{n_0}{1 + \frac{n_0}{N}} \quad (2)$$

where n_0 is the first estimate of sample size. p the proportion of the characteristic being measured in the target population. q the complement of p or $1-p$. v the maximum standard error allowed. N the population size. n is the sample size.

The total number of contractors registered the Egyptian Federation for Construction and Building Contractor (EFCBC) in 2011 are 58991 and the first class contractor are 1716. Then, N is 58991 and p is $1716/58991 = 0.0291$. To account for the possible error in the qualitative answers from the questionnaire, the maximum standard error V was set as 10%. Substituting in Eqs. (1) and (2), the minimum sample required is $2.8 \approx 3$.

It is obvious that this number of required sample is less than the number of respondents who provided their feedback (i.e., 33 respondents). Since the number of contractor companies in Egypt is more than the number of consultant companies and owner representatives, therefore, it is sufficient to utilize the same sample size for owner and consultant representatives as for contractor. A detailed questionnaire comprises 43 delay causes were prepared and presented to construction experts. The respondents were asked to determine the frequency of occurrence of each cause as follows: *Rarely* (R) = 1, *Sometimes* (S) = 2, *Often* (O) = 3, *Always* (A) = 4. To determine the degree of severity of that cause, the following levels are considered: *Low* (L) = 1, *Moderate* (M) = 2, *High* (H) = 3, *Extreme* (E) = 4.

The Frequency Index (F.I), Severity Index (S.I), and Importance Index (IMP.I) are calculated using Eqs. (3)–(5) respectively as stated in Assaf and Al-Hejji [31].

$$\text{Frequency Index (F.I)}(\%) = \sum_{i=1}^4 \frac{a_{if} * n_{if}}{4 * N} \times 100 \quad (3)$$

$$\text{Severity Index (S.I)}(\%) = \sum_{i=1}^4 \frac{a_{is} * n_{is}}{4 * N} \times 100 \quad (4)$$

Table 1 Delay causes of construction projects.

Delay group	Causes
1. Owner related	1.1 Slow decision making 1.2 Suspension of work 1.3 Late in revising and approving design documents by owner 1.4 Delay to furnish and deliver the site to the contractor 1.5 Delay in finance and payments of completed work by owner 1.6 Variation orders/changes of scope by owner during construction 1.7 Type of project bidding and award (negotiation, lowest bidder) 1.8 Unrealistic contract duration 1.9 Ineffective delay penalties 1.10 Owner interference
2. Consultant related	2.1 Inadequate experience of consultant 2.2 Delay in approving shop drawings and sample materials 2.3 Mistakes and discrepancies in design documents 2.4 Unclear and inadequate details in drawings 2.5 Quality assurance/control
3. Contractor related	3.1 Difficulties in financing project by contractor 3.2 Poor site management and supervision 3.3 Ineffective planning and scheduling of project 3.4 Rework due to errors during construction 3.5 Delays in sub-contractors work 3.6 Inadequate contractor experience 3.7 Delay in site mobilization 3.8 Delay in preparation of shop drawings and material samples
4. Material related	4.1 Shortage of construction materials in market 4.2 Delay in material delivery 4.3 Changes in material types and specifications during construction
5. Labor & equipment related	5.1 Shortage of labors 5.2 Unqualified workforce 5.3 Low productivity level of labors 5.4 Equipment availability and failure
6. Project related	6.1 Effects of subsurface conditions (e.g., soil, high water table, etc.) 6.2 Traffic control and restriction at job site 6.3 Unavailability of utilities in site or Delay in providing services from utilities such as (water, etc.) 6.4 Accident during construction 6.5 Problem with neighbors
7. External related	7.1 Weather effect (hot, rain, etc.) 7.2 Environmental restrictions 7.3 Changes in government regulations and laws 7.4 Slow permit by government/municipality 7.5 Delay in performing final inspection and certification by a third party 7.6 Lack of communication between the parties 7.7 Fluctuations in cost/ currency 7.8 Force Majeure as war, revolution, riot, strike, and earthquake, etc.

$$\text{Importance Index (IMP.I)}(\%) = \frac{F.I * S.I}{100} \quad (5)$$

where a_{if} and a_{is} are numbers of respondents who choose certain frequency and severity degree respectively, n_{if} and n_{is} are degrees of frequency and severity respectively (1 or 2 or 3 or 4), N is total number of respondents. Average values for Frequency and Importance Indexes for all respondents are shown in Fig. 1. The top ten delay causes that are ranked according to Frequency Index (F.I), Severity Index (S.I), and Importance Index (IMP.I) are listed in Tables 2–4, respectively.

Case study

A contract was signed between the claimant (contractor) and the defendant (owner) to construct 16 residential buildings

including utilities and landscape in 6 October city – Egypt. The duration of the contract was 24 months and the contract amount was 62.25 million pounds. The project was delayed for the following reasons:

- Strike of drivers and tractors sub-contractors (Reason A) which delays reaching required material to site. The contractor notified the owner and the consultant that this event delayed the project one month.
- Revolution of 25 January and its effects, security chaos, curfew, closure of banks and material factories, departure of labor to their towns to secure their families (Reason B). The contractor notified the owner and the consultant that this event delayed the project from 25 January 2011 until that event was finished.

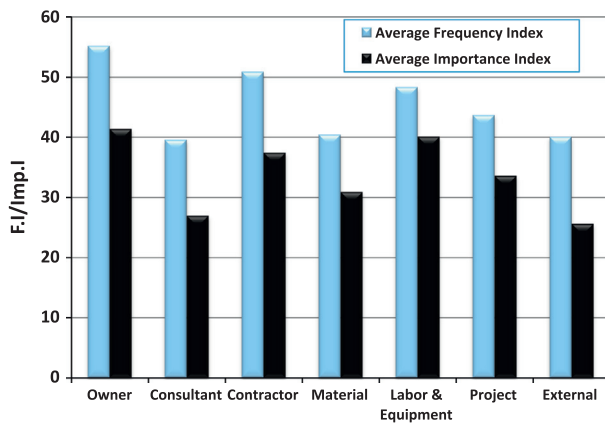


Fig. 1 Average of Frequency and Importance Index for all respondents.

- Execution of upper semells due to increase height of the ground floor (Reason C). The contractor notified the owner and the consultant that this event delayed the project for four months.
- Official holidays (Reason D). The contractor notified the owner and the consultant that this event delayed the project for 180 days.

After negotiation, the consultant recommended time extension of 132 days as follows: 21 days for Reason A, 75 days for Reason B, 36 days for Reason C, and no time extension for Reason D. By comparing the above delay causes with delay causes listed in questionnaire, these causes are equivalent respectively to the following causes:

- Force Majeure as war, revolution, riot, strike, and earthquake, etc. (Cause 7.8).
- Shortage of construction materials in market (Cause 4.1).
- Shortage of labors (Cause 5.1).
- Variation orders/changes of scope by owner during construction (Cause 6.1).

Statistical analysis

Data are analyzed using Statistical Package for Social Sciences (SPSSs). Numerical data were expressed as median and range to compare between the three groups of respondents (owners, consultants, and contractors) using Kruskal–Wallis test (non-parametric ANOVA), and post-Hoc “Scheffe test” on ranks by performing pair-wise comparison. A P -value < 0.05 was considered significant. According to subjective meaning of gathered data from questionnaire which is ordinal data and express of experts’ opinions, therefore, median values were utilized to indicate the frequency of delay causes and the major difference between respondents’ opinions for values of $P < 0.05$.

Table 5 illustrates median and range for delay causes as well as P value (probability of error) is presented in the table for each cause which indicate to major difference between respondents opinions for values of $P < 0.05$. It is clear from the table that there are no differences in opinions among opinions of experts for the three groups of owners, consultants, and contractors in total and for each delay causes group. This means there is good correlation between respondents with regard to delay causes groups in general. Table 6 lists the median and range for each delay cause as well as P value which indicate

Table 2 Top ten delay causes ranked according to Frequency Index.

Delay group	Cause	F.I
Owner related	1.7 Type of project bidding and award (negotiation, lowest bidder)	68.94
Contractor related	3.3 Ineffective planning and scheduling of project	68.94
Owner related	1.6 Variation orders/changes of scope by owner during construction	66.67
Owner related	1.3 Late in revising and approving design documents by owner	65.15
Owner related	1.5 Finance and payments of completed work by owner	64.39
Contractor related	3.2 Poor site management and supervision	64.39
Labor & equipment	5.3 Low productivity level of labors	64.39
Contractor related	3.1 Difficulties in financing project by contractor	63.64
Project related	6.1 Effects of subsurface conditions (e.g., soil, high water table, etc.)	62.12
Owner related	1.1 Slow decision making	57.58

Table 3 Top ten delay causes ranked according to Severity Index.

Delay group	Cause	S.I
Material related	4.1 Shortage of construction materials in market	93.9
External related	7.7 Fluctuations in cost/currency	91.7
Owner related	1.5 Finance and payments of completed work by owner.	90.9
Project related	6.1 Effects of subsurface conditions (e.g., soil, high water table, etc.)	90.9
Labor & equipment	5.1 Shortage of labors	88.6
Consultant related	2.1 Inadequate experience of consultant	86.4
Contractor related	3.1 Difficulties in financing project by contractor	86.4
Labor & equipment	5.3 Low productivity level of labors	86.4
Labor & equipment	5.2 Unqualified workforce	85.6
Owner related	1.6 Variation orders/changes of scope by owner during construction	84.8

Table 4 Top ten delay causes ranked according to Importance Index.

Delay group	Cause	Imp.I
Owner related	1.5 Finance and payments of completed work by owner	58.54
Owner related	1.6 Variation orders/changes of scope by owner during construction	56.57
Project related	6.1 Effects of subsurface conditions (e.g., soil, high water table, etc.)	56.47
Labor & equipment	5.3 Low productivity level of labors	55.61
Contractor related	3.3 Ineffective planning and scheduling of project	55.36
Contractor related	3.1 Difficulties in financing project by contractor	54.96
Owner related	1.7 Type of project bidding and award (negotiation, lowest bidder)	53.27
Material related	4.1 Shortage of construction materials in market	51.24
Owner related	1.3 Late in revising and approving design documents by owner	50.84
Labor & equipment	5.2 Unqualified workforce	48.64

Table 5 Median and range of frequency for delay causes groups.

Delay causes group	Owner respondents	Consultant respondents	Contractor respondents	P value
Owner related	21(12–31)	24(11–28)	24(15–31)	0.369
Consultant related	6(5–11) ^a	7(5–10) ^a	10(6–13) ^b	0.024
Contractor related	18(12–24) ^a	17(12–23) ^a	15(8–19) ^b	0.059
Material related	5(3–7)	5(3–7)	4(3–7)	0.925
Labor & equipment related	8(5–10)	8(5–11)	7(4–11)	0.368
Project related	9(5–11)	10(6–12)	9(5–14)	0.891
External related	13(9–18)	12(8–17)	12(8–20)	0.764
Total	80(51–112)	83(50–108)	81(49–115)	0.966

Notes: The respondents group which has a different superscript b is significantly different from the other two respondents groups which have superscript a (e.g. Causes group 2).

Table 6 Median and range of severity for delay causes groups.

Delay causes group	Owner respondents	Consultant respondents	Contractor respondents	P value
Owner related	28(18–36) ^a	28(18–37) ^a	36(23–38) ^b	0.065
Consultant related	13(7–17)	12(9–17)	15(11–17)	0.502
Contractor related	22(15–27)	25(17–30)	23(16–29)	0.670
Material related	7(5–10) ^b	10(7–12) ^a	9(6–11) ^a	0.005
Labor & equipment related	14(9–16)	15(10–16)	11(9–15)	0.307
Project related	14(8–17)	17(11–19)	16(10–18)	0.237
External related	20(14–26) ^a	19(14–24) ^a	24(16–28) ^b	0.022
Total	118(76–149)	126(86–155)	134(91–156)	0.401

Notes: The respondents group which has a different superscript b is significantly different from the other two respondents groups which have superscript a (e.g. Causes group 1).

Table 7 Median and degrees of Frequency Index and Severity Index.

Delay causes group	Frequency			Severity		
	Median	%	Degree	Median	%	Degree
Owner related	23	28.28	V.H	30.67	24.34	V.H
Consultant related	7.67	9.43	L	13.33	10.58	L
Contractor related	16.67	20.49	H	23.33	18.51	H
Material related	4.67	5.74	V.L	8.67	6.88	V.L
Labor & equipment related	7.67	9.43	L	13.33	10.58	L
Project related	9.33	11.47	L	15.67	12.44	L
External related	12.33	15.16	M	21	16.67	M
Total	81.34	100	—	126	100	—

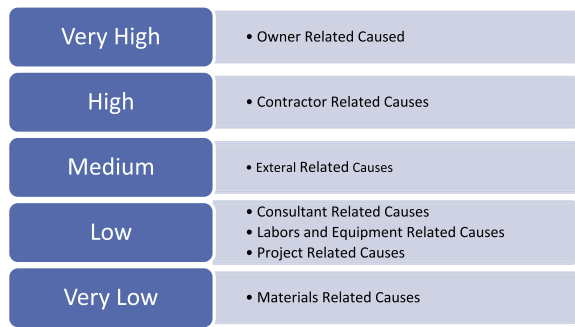


Fig. 2 Prioritizing delay causes groups roadmap.

to major difference between respondents' opinions considering $P < 0.05$. The results reveal that there are no differences in opinions among opinions of experts for the three groups of owners, consultants, and contractors in total and for each delay causes group which indicates that there is good correlation between respondents with regard to delay causes groups in general.

Table 7 lists the median values of Frequency Index and Severity Index for each delay causes group. They are classified according to its percentage as *Very Low (V.L)*, *Low (L)*, *Medium (M)*, *High (H)*, and *Very High (V.H)*. The table indicates that the frequency scores are in compliance with severity where owner related delay causes has degree *Very High* and contractor related delay causes has degree *High* while external related delay causes has degree *Medium* but delay causes related to consultant, labor and equipment, and project have degree *Low* while material related delay causes has degree *Very Low*. Fig. 2 depicts the findings regarding the most important delay causes groups of construction projects in Egypt. These causes are prioritized regarding significance to five levels *Very High*, *High*, *Medium*, *Low*, and *Very Low*.

Results and discussion

The results of questionnaire are analyzed to obtain the important causes of delays for owners, contractors, and consultants respondents. These causes of delays are listed in below subsections.

Owners respondents

The important causes are; ineffective planning and scheduling of project, difficulties in financing project by contractor, variation orders/changes of scope by owner during construction, poor site management and supervision, type of project bidding and award (negotiation, lowest bidder), low productivity level of labors, effects of subsurface conditions (e.g., soil, high water table, etc.), unqualified workforce, shortage of construction materials in market, and delays in sub-contractors work.

Contractors respondents

The important causes are; finance and payments of completed work by owner, late in revising and approving design documents by owner, owner interference, suspension of work, mistakes and discrepancies in design documents, shortage of construction materials in market, variation orders/changes of

scope by owner during construction, slow decision making, effects of subsurface conditions (e.g., soil, high water table, etc.), and type of project bidding and award (negotiation, lowest bidder).

Consultants respondents

The important causes are; effects of subsurface conditions (e.g., soil, high water table, etc.), low productivity level of labors, difficulties in financing project by contractor, ineffective planning and scheduling of project, poor site management and supervision, finance and payments of completed work by owner, type of project bidding and award (negotiation, lowest bidder), unqualified workforce, late in revising and approving design documents by owner, and variation orders/changes of scope by owner during construction. According to the considered case study, "variation orders/changes of scope by owner during construction" is the most frequent delay cause which is one of the top ten delay causes considered in the questionnaire. According to the findings of the questionnaire and case studies, it is recommended for all project parties to avoid occurrence of delay causes which lead to disputes.

The following recommendations might help accomplishing delay reduction in construction projects:

For owners

- Specification of a realistic duration in the contract for the contractor to execute the project.
- Having sufficient time to prepare feasibility study for the project, as well as the preparation of a comprehensive financial plan and cash flow.
- Obtaining the required approvals for the project from the relevant authorities and ensure the availability of the necessary funding.
- Choosing a consultant to the project with sufficient experience in the field of work and has a good reputation.
- Making sure tender documents are complete, clear and free of errors and/or contradiction.
- Payment of the dues to the contractor for the work being carried as well as the payments of finished items according to terms of the contract.
- Hiring an experienced contractor in the field of work who has a good reputation.

For consultants

- Avoiding delaying the response to contractor's queries as well as the approval the submitted submittals and shop drawings.
- Establishment of a control system to handle, control, and evaluate variation orders, initiated by the owner.

For contractors

- Development of a comprehensive financial plan and cash flow.
- Development of a monitoring and periodical reporting of critical and long lead items and periodically providing a narrative explanation of causes of any experienced delay.
- Choosing experienced subcontractors with good reputation.

- Development of a good system for site management and supervision also develops effective planning and scheduling for the project.

For all parties

- Project parties should preview the site Due-Diligence Reviews and execution of necessary borings during the tender stage to make sure that the need for adjustments in design or make amendments if necessary before the issuance of notice to proceed.
- Formal relationships among project parties should be clearly identified, as well as roles and responsibilities.

Conclusion

This paper analyzed causes of construction delays in Egypt. The feedback of construction experts was obtained through interviews and questionnaire surveys. Frequency Index, Severity Index, and Importance Index are calculated and according to the highest values of them the top ten delay causes of construction projects in Egypt are determined. Statistical analysis is carried out using analysis of variance ANOVA method to test delay causes, obtained from the survey. The most important delay causes groups of construction projects in Egypt are prioritized according to their significance to five levels *Very High, High, Medium, Low, and Very Low*. The survey results were discussed. Finally, recommendations have been made to construction projects' parties to accomplish delay reduction in construction projects.

Conflict of interest

The authors have declared no conflict of interest.

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