



Correlation Between the Factors of Causes of Delay in Strengthening Projects

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Abstract

One of the delays which engineers are facing is related to strengthening projects. The aim of this study was to investigate the causes of delay in strengthening projects and examine the correlation between the factors of time overrun by using statistical analysis software (SPSS). To achieve this objective, a list of subjects representing strengthening delays based on available information in the literature and interview with strengthening experts was obtained. A field survey was conducted through a structured questionnaire including owners, contractors, university's professors who have a PhD degree in structural or earthquake engineering, consultant engineers, and supervisor engineers in Mazandaran and Tehran. About 174 respondents participated in the survey. The factors was analyzed by using Relative Importance Index (RII). Ranking of factors and categories was demonstrated according to their importance level on delay. Ten most important causes from a list of 36 different causes of delay were: (1) delay in finance and payments of completed work by owner, (2) unrealistic contract duration planning, (3) shortage of labor skill, (4) perception of strengthening methods differ amongst stakeholders, (5) inadequate modern equipment, (6) ineffective planning and scheduling of project, (7) inadequate contractor experience, (8) cost of strengthening, (9) contract problems, and (10) unclear strengthening standards criteria. The correlation results showed that generally there is a relation between different causes of delay in strengthening project.

Keywords: Construction, Strengthening, Delay, Correlation

Introduction

Time performance of a project is generally the most important consideration for the owner and the contractor. Often, the most troublesome construction disputes are over delay and failure to complete the works in a timely manner. Time of delivery of a project is a key factor to the owner in terms of cost, and it is important also to the contractor (Marzouk and El-Rasas 2014).

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. Delay was also defined as an act or event which extends required time to execute or complete work of the contract manifests itself as additional days of work (Marzouk and El-Rasas 2014).

To the owner, delay means losing revenue through lack of production facilities and rent-able space or a dependence on present facilities. In some cases, in contractor's point of view, delay means higher overhead costs because of longer work period, higher material costs through inflation, and due to labor cost increases (Assaf and Al-Hejji 2006).

One of the main objectives of construction industry is to upgrade strengthening projects performance, through reduction of costs, completion of the projects within their assigned budget and time constraints, and improvement of quality. Execution time is one of performance measures of a construction project, which are time, cost, and quality. Project success is measured by these factors, showing the performance of the construction parties involved, primarily the owner and contractor. All the parties look for project completion by a specified time. The duration of contract performance directly effects the profitability of construction projects from the perspective of all stakeholders (Alkass, Mazerolle et al. 1996)

Completing projects on time shows how efficient a project is, but the construction process is subject to many variables along with some unpredictable factors, which result from many sources. An event of delay may occur from any of the factors related to the performance of parties, resources availability, environmental conditions, and involvement of other parties, and contractual relations which may affect adversely by causing disruption of work, loss of productivity, time loss, cost overruns, claims or sometimes termination of contracts. However, it hardly ever happens that a project is completed within the specified time (Sweis, Sweis et al. 2008), (Gardezi, Manarvi et al. 2014).

This research is an attempt to study the delay problem in strengthening through a structured questionnaire. Relative Importance Index technique (RII) was used to analyze data to determine the importance index and ranking of the causes. It identify the correlation between causes of delay in this type of project to give the necessary precautions to control and avoid those causes for future improvement in the performance of strengthening projects.

Problem statement

Construction delays have become an inseparable part of the project's construction life. Even with today's highly developed technology, and management understanding of project management techniques, construction projects continue to suffer delays and project completion dates still get pushed back (Gardezi, Manarvi et al. 2014). This makes problems that could obstruct the progress and cause delay in strengthening project. Delay means time which directly equals cost. A delay is a real cost item. It usually produces a costly situation for any project. The delay problem is considered as one of the critical problems in the construction process, since it may lead to claims and disputes between the owner and the contractor (Brimah 2013). Delay is experienced in strengthening projects. Strengthening authorities who suffer from delays in these projects, need to recognize the causes of delay and their relations. The main objectives of the study can be summarized in the following points:



1. Identify the importance of the causes of delay in construction of strengthening projects based on the relative importance index.
2. Examine the relation between the factors affecting construction time.

Then, this will help these authorities to take necessary precautions to control those causes in the early planning and design of the project, and improve their involvement in the strengthening by shear wall and steel bracing, to avoid the causes of delay that may occur during construction of strengthening projects.

Literature review

Delays frequently happen in construction projects, whether simple or complex. Construction delay could be defined as the time overrun either further than the contract date or beyond the date that the parties agreed upon for delivery of a project (Assaf and Al-Hejji 2006).

Several studies and reports have been reviewed, which present the delay in construction projects, specifically the causes and types of delay in public projects.

(Al-Momani 2000) conducted a quantitative analysis on construction delays in Jordan. The result of his study proved that the major causes of delay in construction of public projects were related to designers, user changes, weather, site conditions, late deliveries, economic situation and increase in quantity.

(Sambasivan and Soon 2007) investigated the causes and effects of delays facing with the Malaysian construction industry. They identified main causes of delay and ten (10) most important causes were as in the following: (1) contractor's inappropriate planning, (2) contractor's poor site management, (3) inadequate contractor experience, (4) inadequate owner's finance and payments for completed work, (5) problems with subcontractors, (6) shortage in material, (7) labor supply, (8) equipment availability and failure, (9) lack of communication between parties, and (10) mistakes during the construction stage.

(Mansfield, Ugwu et al. 1994) studied the delay causes and cost overrun in construction projects in Nigeria. They identified sixteen (16) major factors. Based on their findings, the most significant factors were as follows: (1) financing and payment for completed works, (2) poor contract management, (3) changes in site conditions, and (4) shortage of materials and improper planning. From existing literature on the construction industry in Nigeria, it was possible to identify certain major effects of delay on project delivery.

(Assaf, Al-Khalil et al. 1995) studied the delay causes in large building construction projects in Saudi Arabia. They identified fifty-six (56) delay causes and grouped them into nine (9) major categories. They concluded that the most significant delay factors were as in the following: (1) approval of shop drawings, (2) delays in payment to contractors resulting from cash problems throughout construction, (3) design changes, (4) conflicts in work schedules of subcontractors, (5) slow decision making and executive bureaucracy in owner's organizations, (6) design errors, (7) labor shortage, and (8) inadequate labor skills.

(Chan and Kumaraswamy 1997) conducted a study to evaluate the relative importance indices of eighty-three (83) potential delay factors that were grouped into eight (8) major categories in Hong Kong construction projects. The results of their research showed that the five (5) principal and common causes were as follows: (1) poor site management and supervision, (2) unforeseen ground condition, (3) low speed of decision making involving all projects team, (4) owner initiated variations, and (5) necessary variation of works.

(Fugar and Agyakwah-Baah 2010) studied on delays for constructing building projects in Ghana. The study showed that all the three groups of respondents generally agreed that out of thirty-two (32) factors the top ten influencing factors in causing delay arranged in descending order of importance were as follows: (1) delay in honoring certificates, (2) underestimation of the costs of projects, (3) underestimation of the complexity of projects, (4) difficulty in accessing bank credit, (5) poor

supervision, (6) underestimation of time for completion of projects by contractors, (7) shortage of materials, (8) poor professional management, (9) fluctuation of prices/rising cost of materials, and (10) poor site management.

(Mezher and Tawil 1998) carried out a survey on the causes of delay in the construction industry in Lebanon. The survey included sixty-four (64) delay causes, grouped into ten (10) main categories. Based on their findings, (1) financial issues, (2) contractors regarded contractual relationship, and (3) project management issues were the most important delay causes.

(Aiyetan, Smallwood et al. 2008) point out that the three most important factors that adversely impact construction project delivery time performance are: quality of management throughout construction, quality of management during design, and design coordination.

(Pourrostan, Ismail et al. 2011) identified the causes and effects of delay in construction projects in IAU-Shuster Branch in Iran. From the analysis of the results, it was found that from 27 factors that were responsible for causing delay, inadequate contractor experience, financial difficulties by contractor and change orders by employer during construction were ranked high by respondents.

(Abbasnejad and Moud 2013) showed the main causes of delay in construction projects of Iran were insufficient familiarity of involved organizations with the nature of project.

In general, the literature reviewed did not present any specific studies concerning the delay in strengthening projects, but the studies reviewed presented considerable data for the causes of delay for the purpose of this research.

Seismic retrofit and challenges in strengthening projects

Seismic retrofitting of existing vulnerable buildings is one of the means of reducing hazards during an earthquake, therefore, it is an essential activity in any earthquake-prone region. In fact Seismic retrofit is one of the means of reducing hazards during an earthquake with a primary objective of reducing injury or loss of life, property and ensuring business continuity in an incident of an earthquake. There are several techniques to retrofit and strengthen buildings with inadequate stiffness, strength and/or ductility (Egbelakin and Wilkinson 2008).

Seismic retrofitting of buildings is a novel activity for most structural engineers. The retrofitting of a building entails an appreciation for the technical, economic and social aspects of the issue in hand. Changes in construction technologies and innovation in retrofit technologies present added challenge to engineers in selecting a technically, economically and socially acceptable solution (Cheung, Foo et al. 2000).

The selection of the most suitable retrofit strategy for a particular structure may be not straightforward as in several applications, there is no alternative which clearly emerges among others as the best one considering all the above mentioned criteria (ElGawady, Lestuzzi et al. 2004).

The field of hazards mitigation, most especially seismic retrofits encounters with a series of issues and challenges relating to implementation. Some of these challenges are lack of enough knowledge of available systems, cost of strengthening, regulatory constraints, perception of earthquake occurrence and risks (Egbelakin and Wilkinson 2008).

Retrofit cost is a significant economic driving force affecting the decision to adopt risk reduction measures. The cost involved in seismic retrofitting can vary widely making it difficult to adequately guess the total amount of cost that might be involved in retrofitting, which could be a constraint in seismic retrofit decisions (K. Ahadzie, A. Ankrah et al. 2014).

The economical characteristics of the retrofitting schemes are also among the most vital parameters, more specifically for the clients who should consider selecting the best retrofitting option. This cost is usually in comparison with the replacement cost of the building to assess the retrofitting scheme (Azmoodeh and Moghadam 2011).

(Hopkins 2005) pointed out that buildings owners usually adopt cheaper cost options without considering the necessary level of strengthening.

Most stakeholders in the market have almost little or no knowledge about seismic retrofit performance standards, legal compulsions and potential liabilities which relates to earthquake risks. A considerable challenge connected with earthquake mitigation decision making relates to how perception of earthquake risk differs amongst stakeholders. Uncertainty about earthquake occurrence, severity and potential mitigation cost can create disparity of opinion among stakeholders regarding the level of acceptable risks (K. Ahadzie, A. Ankrah et al. 2014).

In strengthening projects, the project management unit is weak and do not have the capacity to launch and evaluate bids for the procurement of the vehicles, prepare the training program proposal and to effectively follow-up the implementation of the ongoing consultancy contract and computerization program resulting in implementation delays and the project was also affected by the management changes (Manyong 2005).

The most difficult and also the most significant problem is the lack of standards for repair or strengthening of damaged buildings. A lack of repair standards criteria for strengthening creates controversy and denied owners use of their buildings. Conservative standards may delay the economic recovery of the community (Avramidou 2003).

Resources are actually the absent guest in all tables where the issue is to define the safety level to be met when designing and constructing new structures, and much more so when the issue is reducing vulnerability in existing constructions (Calvi 2013).

Social sciences and arts are often disregarded in seismic retrofitting management, the focus being mostly on technical aspects. But the research on the influences is important to facilitate appropriate implementation through transferring research knowledge to decision makers (Dan, Armaş et al. 2014).

Instrumental measures and tests may be needed, both in order to quantify the level and the character of damage and to complete the information regarding the condition of the building before any repair and/or strengthening work. Research procedures and guidelines for in situ and laboratory surveys must be defined so that all the data collected can be used for damage evaluation and as input data for structural analysis and control models. Nonetheless, it is often very difficult to elaborate and interpret the results of the investigation; this situation is particularly common when the designer is not skilled enough (Gesualdo and Monaco 2011).

Through the literature review, many interviews, studying nature of strengthening projects and discussions with some professionals in this field, thirty-six (36) potential causes identified.

Methodology

A questionnaire was developed to assess the perceptions of owners, contractors, university's professors who have a PhD degree in structural or earthquake engineering, consultant engineers, and supervisor engineers in Mazandaran and Tehran on the relative importance of causes of delay in strengthening projects. The questionnaire was divided into two parts. The first part requested background information about the respondents. The second part of the questionnaire focused on 36 recognized strengthening delay factors. Those causes were combined in seven major groups as: owner related, contractor related, consultant related, material related, labor and equipment related, project related and external related factors. Table 1 shows the framework of the causes in strengthening project.

Table 1. Classification of causes of delay

| No. | Causes of delay | Group |
|-----|--|--------------|
| 1 | Type of project bidding (lowest bidder) | Owner 1-6 |
| 2 | Insufficient data collection and survey before design | |
| 3 | Variation orders/changes of scope by owner during construction | |
| 4 | Owner interference | |
| 5 | Delay in finance and payments of completed work by owner | |

| | | |
|----|---|---------------------------------|
| 6 | Unrealistic contract duration | Contractor 7-11 |
| 7 | Inadequate contractor experience | |
| 8 | Ineffective planning and scheduling of project | |
| 9 | Difficulties in fulfilling reporting requirements during project | |
| 10 | Difficulties in financing project by contractor | |
| 11 | Poor site management and supervision | Consultant 12-16 |
| 12 | protracted contract negotiations with the consultant | |
| 13 | Lack of consultant experience in construction projects | |
| 14 | Mistakes and delays in producing design documents by consultant | |
| 15 | Unclear and inadequate details in drawings | |
| 16 | Quality assurance/control | Project 17-25 |
| 17 | Unclear strengthening standards criteria | |
| 18 | Limitation of Engineering System | |
| 19 | Perception of strengthening methods differ amongst stakeholders | |
| 20 | Management changes | |
| 21 | Cost of strengthening | |
| 22 | Lack of communication between the parties | |
| 23 | Slow decision making for selecting method of strengthening | |
| 24 | Seismic retrofitting of buildings is a new activity for most structural engineers | |
| 25 | Architectural problems | |
| 26 | Improper equipment | Labor and Equipment 26-28 |
| 27 | Inadequate modern equipment | |
| 28 | Shortage of labor skill | |
| 29 | Changes in material types and specifications during construction | Materials 29-32 |
| 30 | Delay in material delivery | |
| 31 | Shortage of construction materials on decision making by consultant | |
| 32 | The type of concrete used | |
| 33 | Problem with neighbors | External 33-36 |
| 34 | Fluctuations in cost/ currency | |
| 35 | Weather effect (hot, rain, etc.) | |
| 36 | Road traffic control | |

A five-point Likert scale ranging from 1 (never) to 5 (always) was adopted to capture the importance of causes of delays.

Since the population size is unknown and no information about the variance of the population is available, the sample size is calculated using the following formula:

$$\sigma = \frac{\max(x_i) - \min(x_i)}{6} \quad (1)$$

$$n = \left(\frac{z_{\alpha/2} * \sigma}{\varepsilon} \right)^2 \quad (2)$$

$Z_{\alpha/2}$ amount is a fixed value which depends on the confidence interval and error level. Usually the error is considered to be zero which has been obtained based on the previous researches. Therefore,

the confidence level will be equivalent to 95%. So the value of $Z_{\alpha/2}$ will be 1.96 based on the statistical table. Therefore n is the Sample size, z is the amount of standard probability for a 95 percent confidence level (i.e. 1.96), α is the error level (i.e. 5%), σ is the standard deviation and ϵ is the estimation accuracy (i.e. 10% in this case). Moreover, as a questionnaire with 5-point Likert scale has been used, the highest value will be 5 and the lowest will be 1. Therefore, its standard deviation is equal, a value of 0.66 can be used. This value is the maximum standard deviation. With replacing the above values in the noted equation (2), the value of sample size (n) equals to 170.

So according to the above formula, the required sample size is 170 questionnaires. Considering the possibility of a complete lack of responsiveness, 250 questionnaires were distributed among the five agencies. Over a period of four (4) months later, the researcher collected one hundred and seventy four (174) responses from 2 hundred and fifty (250); this means the rate of response was 69.6 %.

Calculation of relative importance of factors

(Kometa, Olomolaiye et al. 1994) used the Relative Importance Index method to determine the relative importance of the various causes and effects of delays. The same method is going to be adopted in this study within various groups (i.e. owners, consultants, university's professors, supervisors and contractors). The five-point scale ranged from 1 (never) to 5 (always) for causes and effects of delay will be adopted and will be transformed to relative importance indices (RII) for each factor as follows:

$$RII = \frac{\sum W}{A * N} \quad (3)$$

Where W is the weighting given to each factor by the respondents (ranging from 1 to 5), A is the highest weight (i.e. 5 in this case), and N is the total number of respondents. The RII value had a range from 0 to 1 (0 not inclusive), higher the value of RII, more important was the cause of delays. The RII was used to rank (R) the different causes. These rankings made it possible to cross compare the relative importance of the factors as perceived by the five groups of respondents.

Correlation between causes of time overrun

Since the data collected in this study were meant for nonparametric analysis using ordinal variables, the suitable rank correlation method for determining the relation among the delay factors concerned in this study is Spearman's correlation. Spearman's rank correlation coefficient is a nonparametric measure of statistical dependence between two variables. This method of correlation was performed to examine the relation between the factors affecting construction time by SPSS. The correlation coefficient (r) varies between a value of +1 and -1, where +1 implies a perfect positive relationship (agreement), while -1 results from a perfect negative relationship (disagreement) (Walpole, Myers et al. 1993).

Analysis of data

The demographic characteristics of the respondents are given in Table 2.

Table 2. Demographic characteristics of the respondents

| Demographic characteristics | Frequency | Percent |
|-----------------------------|-----------|---------|
| Sex | | |
| Male | 154 | 88.5 |
| Female | 20 | 11.5 |
| Age | | |
| 20-30 | 0 | 0 |



| | | |
|-------------------|-----|------|
| 30-40 | 99 | 56.9 |
| 40-50 | 70 | 40.2 |
| More than 50 | 5 | 2.9 |
| Job | | |
| consultant | 35 | 20.1 |
| supervisor | 37 | 21.3 |
| owner | 22 | 12.6 |
| PhD | 40 | 23.0 |
| Contractor | 40 | 23.0 |
| Education | | |
| Bachelor degree | 65 | 37.4 |
| Master degree | 57 | 32.8 |
| PhD | 52 | 29.9 |
| Experience | | |
| <10 | 3 | 1.7 |
| 10-20 | 130 | 74.7 |
| 20-30 | 36 | 20.7 |
| >30 | 5 | 2.9 |

Ranking of causes of delay

The data collected from the second part of the questionnaire (i.e. causes of delay) was analyzed from the perspective of owners, contractors, university's professors who have a PhD degree in structural or earthquake engineering, consultant engineers, and supervisor engineers. Each individual cause's RII perceived by all respondents was computed for overall analysis. The relative importance index, RII, was determined for each cause to identify the most important causes. The causes were ranked based on RII values. From the ranking related to each cause of delays, the most important causes of delay were identified in strengthening projects. The results of the ranking are presented in Table 3.

Table 3. Ranking of causes

| Q | Causes of delays | 1 | 2 | 3 | 4 | 5 | RII | Ran k |
|-----|--|-----|------|------|------|------|-------|----------|
| | Owner related causes | | | | | | | |
| Q8 | Type of project bidding (lowest bidder) | 0.0 | 3.4 | 27.0 | 50.0 | 19.5 | 0.653 | 24 |
| Q13 | Contract problems | 0.0 | 1.1 | 31.6 | 55.7 | 11.5 | 0.754 | 9 |
| Q18 | Variation orders/changes of scope by owner during construction | 0.0 | 20.1 | 48.9 | 29.3 | 1.7 | 0.625 | 28 |
| Q19 | Owner interference | 1.1 | 28.2 | 33.9 | 31.6 | 5.2 | 0.623 | 29 |
| Q20 | Unrealistic contract duration | 0.0 | 0.0 | 0.6 | 78.2 | 21.3 | 0.842 | 2 |
| Q21 | Delay in finance and payments of completed work by owner | 0.0 | 1.7 | 13.2 | 31.6 | 53.4 | 0.872 | 1 |
| | Contractor related causes | | | | | | | |
| Q5 | Inadequate contractor experience | 0.0 | 0.0 | 14.9 | 73.0 | 12.1 | 0.794 | 7 |
| Q14 | Ineffective planning and scheduling of project | 0.0 | 0.6 | 28.2 | 39.1 | 32.2 | 0.806 | 6 |
| Q15 | Difficulties in fulfilling reporting requirements during project | 0.0 | 7.5 | 53.4 | 33.9 | 5.2 | 0.673 | 19 |
| Q16 | Poor site management and supervision | 0.0 | 25.3 | 52.3 | 17.2 | 5.2 | 0.604 | 30 |
| Q25 | Difficulties in financing project by contractor | 0.0 | 17.2 | 32.8 | 47.1 | 2.9 | 0.671 | 20 |
| | Consultant related causes | | | | | | | |
| Q4 | Lack of consultant experience in construction projects | 2.3 | 19.0 | 28.2 | 44.3 | 6.3 | 0.667 | 21 |
| Q11 | protracted contract negotiations with the consultant | 0.0 | 0.6 | 35.1 | 57.5 | 6.9 | 0.742 | 12 |
| Q22 | Mistakes and delays in producing design documents by consultant | 0.0 | 5.2 | 46.6 | 44.3 | 4.0 | 0.694 | 17 |
| Q23 | Unclear and inadequate details in drawings | 0.0 | 31.6 | 25.3 | 36.8 | 6.3 | 0.635 | 26 |
| Q24 | Quality assurance/control | 2.9 | 21.3 | 54.0 | 17.8 | 4.0 | 0.597 | 31 |
| | Material related causes | | | | | | | |
| Q26 | Delay in material delivery | 0.0 | 5.7 | 39.7 | 48.9 | 5.7 | 0.709 | 14 |

| | | | | | | | | |
|-----|---|------|------|------|------|------|-------|----|
| Q27 | Shortage of construction materials | 1.7 | 11.5 | 21.8 | 62.6 | 2.3 | 0.704 | 15 |
| Q28 | Changes in material types and specifications during construction | 0.0 | 21.3 | 40.2 | 31.6 | 6.9 | 0.648 | 25 |
| Q36 | The type of concrete used | 0.0 | 0.0 | 27.0 | 73.0 | 0.0 | 0.746 | 11 |
| | Labor and equipment related causes | | | | | | | |
| Q6 | Shortage of labor skill | 0.0 | 0.0 | 8.0 | 65.5 | 26.4 | 0.836 | 3 |
| Q29 | Improper equipment | 0.0 | 0.6 | 70.7 | 27.0 | 1.7 | 0.659 | 23 |
| Q30 | Inadequate modern equipment | 0.0 | 0.0 | 5.2 | 81.0 | 13.8 | 0.817 | 5 |
| | Project related causes | | | | | | | |
| Q12 | Cost of strengthening | 0.0 | 1.1 | 29.9 | 50.0 | 19.0 | 0.773 | 8 |
| Q2 | Unclear strengthening standards criteria | 0.0 | 0.0 | 26.4 | 73.0 | 0.6 | 0.748 | 10 |
| Q3 | Limitation of Engineering System | 45.4 | 34.5 | 12.6 | 6.3 | 1.1 | 0.365 | 36 |
| Q7 | Slow decision making for selecting method of strengthening | 0.0 | 7.5 | 47.7 | 33.9 | 10.9 | 0.696 | 16 |
| Q9 | Lack of communication between the parties | 0.0 | 10.3 | 48.3 | 32.8 | 8.6 | 0.679 | 18 |
| Q10 | Perception of strengthening methods differ amongst stakeholders | 0.0 | 0.0 | 3.4 | 75.9 | 20.7 | 0.834 | 4 |
| Q1 | Seismic retrofitting of buildings is a new activity for most structural engineers | 0.0 | 5.7 | 33.9 | 50.0 | 10.3 | 0.729 | 13 |
| Q17 | Management changes | 2.3 | 48.9 | 26.4 | 16.1 | 6.3 | 0.550 | 34 |
| Q35 | Architectural problems | 0.0 | 54.6 | 37.4 | 6.9 | 1.1 | 0.509 | 35 |
| | External related causes | | | | | | | |
| Q31 | Weather effect (hot, rain, etc.) | 0.6 | 9.2 | 51.1 | 33.9 | 5.2 | 0.666 | 22 |
| Q32 | Problem with neighbors | 0.0 | 44.2 | 27.6 | 16.1 | 12.1 | 0.592 | 32 |
| Q33 | Road traffic control | 0.0 | 12.6 | 60.9 | 24.1 | 2.3 | 0.631 | 27 |
| Q34 | Fluctuations in cost/ currency | 0.0 | 39.1 | 34.5 | 17.8 | 8.6 | 0.591 | 33 |

Based on ranking, the ten most important causes of delay in strengthening project were: (1) delay in finance and payments of completed work by owner (RII=0.872), (2) unrealistic contract duration planning (RII=0.842), (3) shortage of labor skill (RII=0.836), (4) perception of strengthening methods differ amongst stakeholders (RII=0.834), (5) inadequate modern equipment (RII=0.817), (6) ineffective planning and scheduling of project (RII=0.806), (7) inadequate contractor experience (RII=0.794), (8) cost of strengthening (RII=0.773), (9) contract problems (RII=0.754), and (10) unclear strengthening standards criteria (RII=0.748).

Correlation test

Spearman correlation test was performed to examine the relation between the seven major groups of causes of delay. Results are presented in Table 4 from output of SPSS and it can be considered that owner related factors has a moderate correlation with project related factors with correlation value of 0.369.

Contractor related factors has a moderate correlation with consultant related factors. There is high correlation between material related factors and external related factors with correlation of 0.502. Owner and contractor related factors has a poor correlation with external related factors (0.264, 0.231).

Table 4. Correlation between the seven major groups

| | | Owner | contractor | Consultant | Labor | Material | Project | External |
|------------|-------------------------|-------|------------|------------|-------|----------|---------|----------|
| Owner | Correlation Coefficient | 1.000 | -.012 | .024 | .053 | .239** | .369** | .264** |
| | Sig. (2-tailed) | . | .872 | .749 | .483 | .001 | .000 | .000 |
| contractor | Correlation Coefficient | -.012 | 1.000 | .332** | -.055 | .149* | .011 | .231** |
| | Sig. (2-tailed) | .872 | . | .000 | .474 | .050 | .883 | .002 |
| Consultant | Correlation Coefficient | .024 | .332** | 1.000 | .178* | .084 | .231** | .131 |
| | Sig. (2-tailed) | .749 | .000 | . | .018 | .271 | .002 | .085 |

| | | | | | | | | |
|----------|-------------------------|--------|--------|--------|-------|--------|--------|--------|
| Labor | Correlation Coefficient | .053 | -.055 | .178* | 1.000 | -.037 | -.083 | .039 |
| | Sig. (2-tailed) | .483 | .474 | .018 | . | .629 | .274 | .605 |
| Material | Correlation Coefficient | .239** | .149* | .084 | -.037 | 1.000 | .173* | .502** |
| | Sig. (2-tailed) | .001 | .050 | .271 | .629 | . | .022 | .000 |
| Project | Correlation Coefficient | .369** | .011 | .231** | -.083 | .173* | 1.000 | .209** |
| | Sig. (2-tailed) | .000 | .883 | .002 | .274 | .022 | . | .006 |
| External | Correlation Coefficient | .264** | .231** | .131 | .039 | .502** | .209** | 1.000 |
| | Sig. (2-tailed) | .000 | .002 | .085 | .605 | .000 | .006 | . |

**Correlation is significant at the 0.01 level (2-tailed).

*Correlation is significant at the 0.05 level (2-tailed).

Conclusion

Delays in strengthening projects can be minimized when their causes are identified. Knowing the cause of any particular delay in a construction project would help avoiding the same. This project was therefore, aimed at identifying the major causes of delays in strengthening projects through a survey. 36 Causes of delay combined into seven major groups related to their sources as: (1) consultant related delay factors, (2) contractor related delay factors, (3) owner related delay factors, (4) labor and equipment related delay factors, (5) external related delay factors, (6) material related delay factors, and (7) project related delay factors. Based on the quantified relative importance indices, the ten most important causes of strengthening delays were identified as: (1) delay in finance and payments of completed work by owner (RII=0.872), (2) unrealistic contract duration planning (RII=0.842), (3) shortage of labor skill (RII=0.836), (4) perception of strengthening methods differ amongst stakeholders (RII=0.834), (5) inadequate modern equipment (RII=0.817), (6) ineffective planning and scheduling of project (RII=0.806), (7) inadequate contractor experience (RII=0.794), (8) cost of strengthening (RII=0.773), (9) contract problems (RII=0.754), and (10) unclear strengthening standards criteria (RII=0.748). There is a correlation between seven major groups of cause of delay. External related factors has highly correlated with material related factors. While contractor related factors was moderately correlated with consultant related factors. It means any causes of delay can lead to another delay.

Recommendation

- Owners should pay the finances in time to the contractors.
- A detailed analysis of the repair strengthening should be design by a licensed professional engineer and the acceptance by an appropriate authority.
- An effective strengthening program should have certain specifications and the cost of implementation of retrofit measures should not be restrictive.
- Paying more consideration to capabilities of contractor than the lowest bidder.
- Hiring high quality labors, developing human resources in strengthening industry through proper training programs

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