Investigating delay factors in construction industry: A Korean perspective

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Abstract

Construction projects are facing delay problems. Delays in construction have been immense effect on performance or satisfactory delivery of the project. Delays have been causing project cost overrun as well as it is a source of dispute hence damaging the relationship between the project participants. The purpose of this study was to explore the causes of delay risk through a field survey study. Data were collected from construction professionals working in owner, consultant and contractor organizations. All together 208 questionnaire instruments were used and analyzed by employing statistical tools (SPSS computer program). 19 delay factors were identified by this study, out of which following factors were critical: Frequent interruptions from public (local people, pressure group etc.), changed site condition, failure to provide required construction site, unrealistic project time estimation and design errors.

Key Words : Construction projects, delay factors, Project participants, Project matter.

1. Introduction

The construction industry is subject to more risk and uncertainty than other industries. Construction projects involve complex and time-consuming design. The processes of construction are also characterized by unforeseen circumstances. As a result effect risk management has become a major problem that confronts the industry (Santoso, Ogunlana and Minato, 2003). Construction delay has been considered as a major risk (problem) as well as sources of disputes in various literature (Al-Hamad, 1993; Ogunlana et al., 1996; Aibinu and Jagboro, 2002; Long et al., 2004; Koushki et al., 2005), therefore, knowledge and understanding of risk of delay is important to help identify and manage effectively and systematically to achieve the project objectives of time, cost and quality. The six most effects of delay are: cost overrun, time overrun, dispute, arbitration, total abandonment and litigation (Aibinu et al., 2002).

Delay is a serious problem in the construction industry and can affect each party's contractual obligations. Time is an integral part of every construction plan, therefore, delay will be costly for both owner and contractor. The owner loses by missing out on the potential revenues from the use of the project and by increased overhead cost for contract administration and supervision. The contractor also loses due to increased costs in overhead and tied-up capital. Contractor's losses may include lost opportunities for new projects because of diminished financial capabilities. In public projects, the public may also be affected by the delay in the utilization of the facilities and by the extended inconveniences such as traffic disturbances (Al-Khalil and Al-Ghafly, 1999). In this regard, Foreman (1999) argued that the contractor has the right to dictate the methods and sequence used to achieve the results required by the contract; therefore, the contractor must zealously guard the time needed to complete the work. Regardless of who causes the

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problems, disruptions can wound and sometimes kill a project.

According to Arditi and Pattanakitchamroon (2005) delays in construction can cause a number of changes in a project such as late completion, lost productivity, acceleration, increased costs, and contract termination. However, the authors also have argued that a delay caused by a party may or may not affect the project completion date and may or may not cause damage to another party. Aibinu et al. (2002) have identified and assessed the impact of delays on the delivery of 61 building construction projects. Time and cost overruns were found to be frequent effects of delay. The authors were able to estimate a mean percentage cost overrun of 17.34%. This is 7.34% more than usual practice of 10% of contingency estimate.

The purpose of this study was to explore the causes of delays in construction industries, so the study will focus to get answers of the following research questions:

(1) What is the current delay situation in the construction industry?

(2) What are the critical delay factors in construction projects?

The scope of the study is delimited to identify delay factors and their sources (originality) during construction phase. Construction phase is defined as the period which starts after signing the contract with contractor to build something and continues till the structure is handed over to the owner. During this phase, various stakeholders or participants might be involved, however this research have collected data from only three major participants namely, the owner, the consultant and the contractor.

2. Construction delays and its classification

Construction delay is generally acknowledged as the most common, costly, complex and risky problem encountered in construction projects. Because of the overriding importance of time for both the owner and the contractor, it is the source of frequent disputes and claims leading to lawsuits (Ahmad et al. 2003; Norfleet, 2004).

Delays do not always result from a single catastrophic event. They frequently develop slowly during the course of work. To determine the critical delay, we have to compare as-planned and as-built schedules (Last, 1997). Delays can cause substantial damages to an owner. The delay in public construction works has immensely affected the cost of the project.

According to Chevalier (2001) success of project that is, timely completion depend upon the three Cs: (i) capacity (ii) collaboration and (ii) coordination. Here, capacity deals with the ability of those involved in construction process to contribute in accordance with their professional role, collaboration is involved with constructive relations among key players in the project; and coordination involve the managing the flow of project tasks and events. The proper mixture of these three factors contributes to reduce the construction delays.

Aibinu et al. (2002) have defined delay as a situation when the contractor and the project owner jointly or severally contribute to the non-completion of the project within the original or the stipulated or agreed contract period. Usually, a delay of an activity on the critical path delays the completion of the project. Mathematically, construction delay is the difference of time between actual completion date and contract completion (planned) date. Figure 1 shows a project has been delayed by 15 calendar months.

This project delay is not the result of one factor, various causes interplay to affect the delays. A delay can be caused by more than one party; however, it can also be caused by none of the parties (such as unusually severe weather conditions). Following sections describe the various types of delays and their classifications according to various aspects.

2.1 Classification of delays

This construction delay could be the result of different factors. In this order, construction delays can be classified according to their origin and timing as well as their compensability (Kartam, 1999; Aftuck, 1999). Construction delays occurred by principal participants (owner or designer or supervising consultant or contractor) of project are owner caused delays (OCD) and contractor caused delays (CCD). However, some delays are neither party's sole responsibility; therefore they are called third party (including natural factor) caused

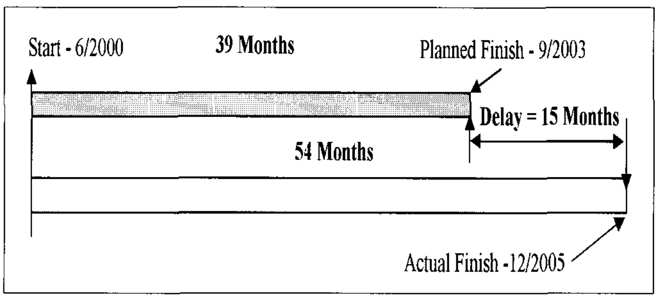
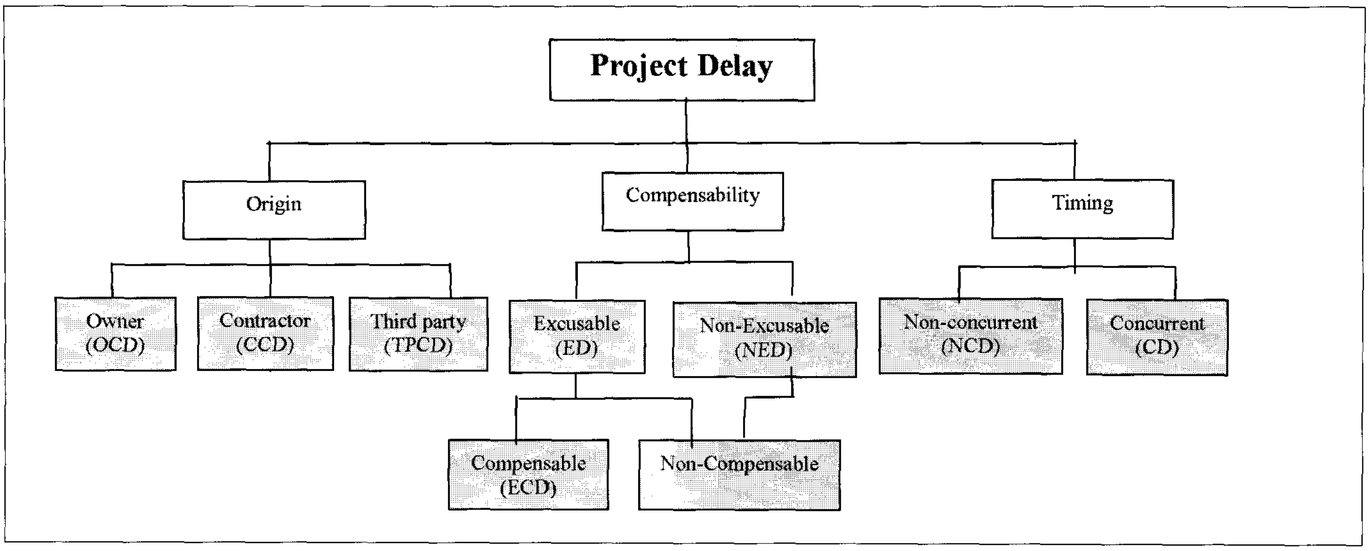


Figure 1. Graphical explanation of construction delay



Source: Adapted from kartam(1999)

Figure 2. Delay types

Table 1. Delay types

Delays types	Source	Explanation
Owner caused delays (OCD)	Participants' activities based	Owner and consultant activities
Contractor caused delay (CCD)		Owing to contractor activities
Third-party caused delays (TPCD)		Owing to other causes rather than project participants' activities
Concurrent (dependent) delays (CD)	Time of activities based delays	Delays due to effect of one activity to other
Non-concurrent delay (NCD)		Delays due to independent activities
Excusable delay (ED) with compensation	Extension of time (EOT) and financial compensation based	EOT and financial compensation granted for delay
Excusable delay (ED) with non-compensation		Only EOT granted (no financial compensation)
Non-excusable delay (NED)		No compensation for either financial or EOT.

delays (TPCD).

The timing of a delay is crucial to determining whether the delay is compensable or not. Delays can either occur concurrently or nonconcurrently. Concurrent delays (CD) are those delays that occur when more than one delay that is caused by different parties coincide. For example, CD occurs when OCD and CCD coincide in time. On the other hand, nonconcurrent delays (NCD) are those delays that occur alone at the time in which the delay took place.

Delays are also classified according to their compensability: excusable delays (ED) and non-excusable delays (NED). EDs are those delays in which the contractor is excused from their sole responsibility. It is further divided into compensable delays and non-compensable delays. OCD and TPCD include in this category of delay. In the case of NED, contractor is not excused in part of their delays, hence not compensated. This category includes CCD, in which the contractor is the sole responsible party for the delay. Delay types with explanation is provided in table 1 and illustrated in figure 2.

Several researchers have classified the construction delays according to the sources of delays activities e.g. owner, contractor, material caused, labor caused etc. The various categories of delays with researchers adopted to classify are illustrated in table 2.(Next page)

A five-prong source of delay as shown in figure 3 was identified and construction delays were categorized accordingly.

2.1.1 Owner caused delays (OCD)

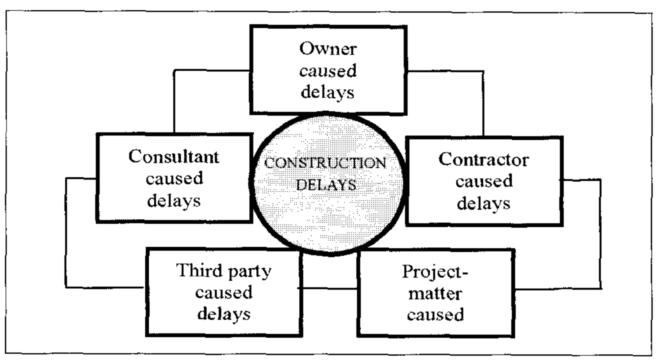


Figure 3. Source of delays

Table 2. Category of delay as adopted by various researchers

Category of delay	Assaf (1995)	Ogunlana et al (1996)	K'swamy et al (1997)	Odeh (2002)	Frimpong (2003)	Fereig et al (2005)	Nkado (2005)	Fong (2006)	This study (2006)
Client/Owner caused	-	√	√	√	-	-	√	√	√
Contractor caused	-	√	√	√	-	-	√	√	√
Consultant/Design team caused	-	√	√	√	-	-	√	√	√
Design-related	-	-	-	-	-	√	-	-	-
Construction-related	-	-	-	-	-	√	-	-	-
Management/administrative	-	-	-	-	-	√	-	-	-
CM or Inspector	-	√	-	-	-	-	-	-	-
Resource suppliers	-	√	-	-	-	-	-	-	-
Financial/Economic factors	-	-	-	-	√	√	-	-	-
Changes related	√	-	-	-	-	-	-	-	-
Material related	√	-	√	√	√	-	-	√	-
Labor and equipment related	-	-	-	√	-	-	-	√	-
Labor/Manpower related	√	-	√	-	√	-	-	-	-
Plant/Equipment related	√	-	√	-	√	-	-	-	-
Contract related	-	-	-	√	-	-	√	-	-
Contractual relationships related	√	-	-	√	-	-	-	-	-
External factors related	-	-	√	√	√	-	√	√	-
Project related	-	-	√	-	-	-	√	-	√
Project financing related	√	-	-	-	√	-	-	-	-
Natural conditions related	-	-	-	-	√	-	-	-	-
Environment related	√	-	-	-	-	-	-	-	-
Others	-	√	-	-	-	-	-	-	-
Third party caused	-	-	-	-	-	-	-	-	√
Government relations related	√	-	-	-	-	-	-	-	-
Scheduling and controlling	√	-	-	-	-	-	-	-	-
Code-related	-	-	-	-	-	√	-	-	-

Owner is the main party of the construction project, because this party initiates and spends money in the project. Therefore, owner has authority to say much in the project, that is why change of scope of the project, change orders etc. are by far the most frequent activities and cited cause of construction delay. Some change orders can be large magnitude changes requiring extensive redesign. Slow decision making and late payment are other activities of owner often faced by contractor.

2.1.2 Consultant caused delays (CoCD)

Most technical problems are originated from the consultants. The majority of delays are traced to inconsistent detailing of drawings, frequent revision of design due to errors, unqualified site personnel, uncomprising attitude of supervisors etc. Rather than plan inspection in accordance with the sequence of work, construction management staff and inspection teams are in habit of waiting to be approached to approve works. Last minute disapproval causes delays and waste contractors' resources (Ogunlana et al., 1996).

2.1.3 Contractor caused delays (CCD)

The blame for most project delays is laid on the contractor. Whole management of construction works comes under the responsibility of the contractor. In the construction process, owner explains only his requirements and pays for the work completed, consultant prepares the plan and design of the owner's requirement and contractor needs to transform the requirements, plans and designs to the reality. In this process, a contractor needs to carry out following activities: manage finance, work planning and scheduling, site organization, materials management, equipment management, coordination between workers etc. so, any mismanagement in above activities will be the source of construction delay.

2.1.4 Third party caused delays (TPCD)

All other sources of delays which are not the fault of either principal project participants or occurred not of consequence of project related matter have been considered as third party caused delays. Some of examples are material shortage, change of codes, unusual rain/other natural calamities etc.

2.1.5 Project matter caused delays (PMCD)

This category contains all factors causing delays which are out of control of owner, contractor, consultant and third parties including natural calamities and also related with more than one party. Some of examples of this category delay factors are: remoteness of site, social and cultural differences, disputes, accidents etc.

2.3 Previous studies: delay causes

Many studies have been carried out to assess the causes of delays

Table 3. Previous researches about causes of construction Delays

Research	Project	Causes of delays
Majid (1992)*	UK, Two office blocks	Shortages of plants, general workers, materials and finance; equipment breakdown, delay by subcontractors, slow mobilization, deficiency in control and supervision
Yates (1993)*	USA, 50 Army corps and 10 district offices	Equipment, labor, and material shortages
Elinwa et al. (1993)*	10 building contracts	Subcontractor delays, and material shortages
Assaf et al. (1995)*	48 Organizations	Materials related delays, labor related delays, equipment delays
Assaf, Al-Khalil and Al-Hazmi (1995),	Saudi Arabia, Large public building projects, Empirical	Financing, material, contractual relationships, changes and scheduling and controlling were the top 5 delays.
Ogunlana, Promkuntong and Jearkjirm (1996)	Thailand, 12 high rise building projects, empirical	Material (supply of resources) shortages, problems caused by clients and consultants, contractors incompetence/inadequacies
Kumaraswamy and Chan (1997)	Hong Kong, buildings and civil engineering projects, empirical	Top five delay factor categories are: contractor related, design team related, labor related, external factors, and project related
Kumaraswamy and Chan (1998)	Hong Kong, buildings and civil engineering projects, empirical	Unforeseen ground conditions, poor site management and supervision, low speed of decision making involving all project teams, client-initiated variations, necessary variations of works, inadequate contractor experience.
Al-Khalil and Al-Ghafly (1999)	Saudi Arabia, Utility projects, empirical	Financial difficulties (inadequate capabilities of contractor and delay by the owner in making progress payments), difficulties in obtaining government work permit, lowest bidder, underestimate of project duration.
Al-Momani (2000)	Jordan, Public building projects, empirical	Poor design and negligence of owner, change orders, weather condition, site condition, late delivery, economic conditions, and increase in quantities.
Elinwa and Joshua (2001)	Nigeria construction industry, empirical	Mode of financing and payment (94%), improper planning (80%), underestimation of time/duration of projects (79%), frequent changes in materials and designs (79%), noncompliance with the conditions of the contract (72%), poor site management (69%), government policy (68%), choice of material not readily available (64%), preparation and approval of variation orders (56%), lack of coordination between the contractor and design team (56%), mistakes during construction (53%).
Ellis and Thomas (2002)	USA, Highway projects, empirical	Business practices, procedures, utilities unidentified or delays in the relocation, differing site condition, inadequate scheduling and planning by contractor and owner, lacking constructability, and design errors and omissions.
Odeh and Battaineh (2002)	Jordan, traditional type construction (civil engineering), empirical	Owner interference, inadequate contractor experience, financing and payments, labor productivity, slow decision-making, improper planning and subcontractor
Frimpong and Oluwoye (2003)	Ghana, Ground water projects, Empirical	Project-financing, economic, natural conditions and materials
US Department of Transportation (2003)	USA, Highway projects, Empirical	Programming of funds, difficult public sector coordination, difficult utility relocation, poor coordination with utility companies
Koushki, Al-Rashid and Kartam (2005)	Kuwait, private residential projects, empirical	Number of change orders, financial constraints, and owner's lack of experience in construction.
Fong, Wong and Wong (2006)	Hong Kong, building construction projects, Empirical	Improper site co-ordination and management, lack of timely decision making of the client, defects in finished work
Rahman et al. (2006)	Malaysia, Construction projects	Most delays occur in construction phase, financial problems, manpower shortage and changes in the project requirement are main causes of delays.
Nirmal et al. (2006)	Nepal, building construction projects	Seasonal unavailability of construction material and unskilled workers, frequent strikes, road blockades, lack of use of modern construction equipment, severe weather, 배가 벼무샤쇼 increased excessively than bill of quantities, low bidding of contractor, slow work of contractor, scope and master plan changed.

Note: *Referred from Majid and McCafer(1998)

in construction projects. Table 3 provides summary of previous studies about delays in construction field. The table gives information of previous studies after 1990 year only. From the study of table, delay causes and sources of delays found to be widely different as per the specific local condition.

3. Research Methodology

Figure 4 illustrates the method employed to collect the data. As the purpose of the research was to collect causes of delays occurring in construction field from the experience of professionals field survey research method was employed. From extensive literature study, 85 delay items were sorted out and two parts consisted survey questionnaire was prepared. Part one seek the demographic information of respondents and part 2 provided 85 instruments of delay factors. The respondents were asked to rate the occurrence and significance of delay in 5-point Likert scale. The scale was calibrated into 1 to 5; where 1 represented as 'not significant' and 5 represented as 'very significant'.

According to Welman and Kruger (1999, cited in Coetzee, 2005), no matter what size the population is, 500 unit of data will be enough for analysis, based on this 510 questionnaires were distributed to the

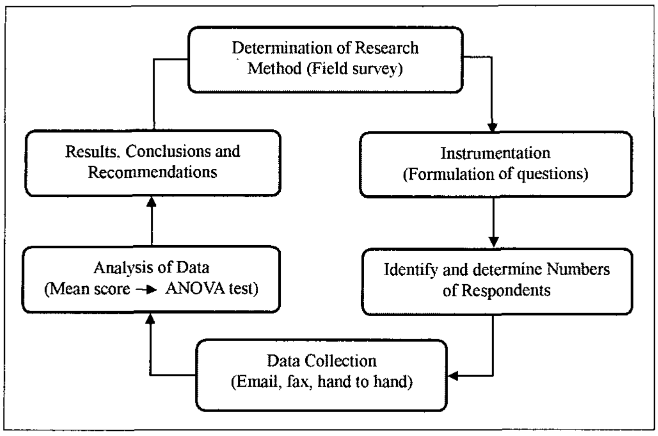


Figure 4. The research process

population of this study. As mentioned in scope of this study, population of this study are professionals working for owner, consultant and contractor in construction field. The questionnaire was distributed through emails, faxes and in personal basis (hand to hand), and consequently the responses were received also by all means of delivery system e.g. return email, ordinary post mail, faxes and in person.

The survey data have been analyzed through descriptive as well as comparative and associational measures. Mean score as descriptive measure was used to obtain the importance and ranking of delay items. In this study, ranges of acceptance level of delay factors according to mean values have been followed as per table 4. One way ANOVA and Pearson correlation at 5% significant level were employed to compare the association of variables with different

Table 4. Category of acceptance of variables

Mean value	Acceptance level
1.0 - 2.5	Not accepted
2.5 - 3.0	Moderate (not decided, but not positive)
3.0 - 3.5	Moderate (not decided, but positive)
3.5 - 5.0	Accepted

(Source: Adapted from Awakul et al., 2002)

Practical difference (d) for ANOVA case

$$= \mid Mean_A - Mean_B \mid \div \text{Pooled SD}$$

Figure 4. Practical significance formula
(Source: Adapted from Coetzee, 2005)

demographic domains. The differences detected by ANOVA were further looked for whether they are practically significant or not. Practical significant is reported by the effect sizes. The formula used to determine the effect size (d) is illustrated in fig. 5. Cohen (1988, cited in Coetzee, 2005) has recommended 0.50 value as cutoff point for practical differences between means. Hence, in this study, the practical difference of statistical significant relations having less than 0.50, d value will be considered as no difference in the means.

Factor analysis was performed to reduce the data by clustering the number of correlated factors. The varimax orthogonal rotation of principal component analysis was used to interpret the components. SPSS 12 statistical computer program was used to analyze the data.

4. Survey response and characteristics of respondents

Total of 510 numbers of questionnaire were distributed through various means of delivery as described in previous section. Out of those, 220 responses were received, thus giving 43% response rate, however after checking the responses, only 208 numbers were found to be usable for further analysis. The eliminated responses were either partially responded or not suitable to use (probability of being outlier). Table 5 provides detail information about respondents. According to the table, respondents from the owner, consultant and contractor organizations constitute this survey as 42%, 22%, and 36% respectively.

5. Analysis and findings

Table 5. Characteristics of respondents

Number of Response	Experience	Project types	Mgmt. position	Project nature	Project delivery	Project duration	Project ownership	Project delay
Owner =88 (42%)	< 5yrs = 12%	Building = 15%	Top = 24%	New = 83%	Traditional = 65%	<12 mth = 8%	Government = 43%	No delay = 29% Early complete=6 %
Consultant =45 (22%)	6-10 yrs = 26%	Road = 35%	Middle = 51%	Extension = 13%	Design/build = 26%	12-24 mth. = 12%	Public = 39%	< 10% =7% 11-25% = 15%
Contractor = 75 (36%)	11-15 yrs = 26%	Railway =28%	Lower = 25%	Renovation = 1%	BOT/BOOT = 5%	24-36 mth. = 31%	Private = 17%	26-50% = 23% > 50% = 20%
Total = 208	16-20 yrs = 13%	Water related = 5%		Others = 3%	Others = 4%	36-48 mth. = 20%	Others = 1%	
	>20 yrs = 23%	Others = 17%				>48 mth = 29%		

Analysis and findings of this study have been arranged in focusing answering the three research questions.

5.1 Construction project delays

This study has revealed that the average original construction duration of 128 studied projects is 43.3 months and they were extended averagely by13.10 months, which is 30.2% of original stipulated time. This time overrun result is somewhat less than the study of Elinwa and Joshua (2001) in Nigeria, which was 44%. Tables 6 to 10 provide delays in different characteristics of projects.

According to table 6, not all projects are delayed, about 29% projects were also completed without delay and 5.5% projects were completed even before planned finish date. Table 7 (shaded portion) shows that projects having construction time period between 24-36 months and > 48 months categories are suffered most delays. Out of 128 studied projects 21% (after eliminating no delay and early finish counts) of 36-48 month and 20% of > 48 months category projects were delayed, out of which some projects were delayed even more than 100%.

5.2 Delays by project characteristics

5.2.1 Types of project

Table 6. Extension of time category

Total extended time	Frequency	Percent
No delay	37	28.9
Early finish	7	5.5
<12 months	48	37.5
12-24 months	16	12.5
24-36 months	10	7.8
36-48 months	2	1.6
> 48 months	8	6.3
Total	128	100

Table 7. Original project period * Delay category cross tabulation

Project period (months)	Delay category						Total
	No delay	0 - 10%	11-25%	26 - 50%	>50 %	Early finish	
< 12	6	0	0	3	1	0	10
12-24	6	2	1	3	4	0	16
24-36	8	4	6	11	6	4	39
36-48	8	1	5	6	5	1	26
> 48	9	2	7	7	10	2	37
Total	**37**	**9**	**19**	**30**	**26**	7	**128**

Table 8. Delay category * Project category cross tabulation

Delay category	Project category						Total
	1	2	3	4	5	6	
No delay	14	4	8	1	1	9	37 (29.1%)
<10%	5	2	2	0	0	0	9 (7.1%)
11-25%	2	7	5	1	0	4	19 (15%)
26-50%	3	10	10	2	1	3	29 (22.8%)
>50 %	0	11	10	0	1	4	26 (20.5%)
Early completion	1	0	2	0	2	2	7 (5.5%)
Total	**25**	**34**	**37**	**4**	**5**	**22**	**127**

Note: 1-Building, 2-Road, 3-Railways, 4- Water supply, 5-Dams/harnor, 6-Others

Table 9. Delay category * Project nature cross tabulation

Delay category	Project Nature				Total
	1	2	3	4	
No delay	35	0	0	2	37 (28.9%)
<10%	8	0	0	1	9 (7.0%)
11-25%	17	2	0	0	19 (14.8%)
26-50%	28	2	0	0	30 (23.4%)
>50 %	15	10	0	1	26 (20.3%)
Early completion	5	1	1	0	7 (5.5%)
Total	**108**	**15**	**1**	**4**	**128**

Note: 1- New construction, 2- Extension/expansion, 3- Renovation, 4- Others.

Table 9 in shaded portion shows that projects like building (40%, 10nos.), road and highways (88%, 30 nos.) and railways (73%, 30 nos.) are delayed considerably. Highways and railway projects are most suffered from the delays. The delays are more than 50% and some of them are beyond 100%.

5.2.2 Project nature

Table 10 (shaded part) illustrates 55% (60 nos.) of new projects category are delayed more than 10% and some of them even have gone beyond 100%. Table 9 also shows that 67% (10 nos.) extension projects have faced delay problem.

5.2.3 Project ownership

Shaded portion in table 10 shows 73% (38nos.) government owned projects and 40% (21 nos.) public authority owned projects are delayed by 11 percent to more than 100 percent.

5.2.4 Project delivery methods

Shaded portion in table 11 shows 63% of traditional projects and 53% of design build projects have been suffered from delays more than 11%.

Table 10. Delay category * Project ownership cross tabulation

Delay category	Project Owner				Total
	1	2	3	4	
No delay	7	16	12	2	37 (28.9%)
<10%	3	4	2	0	9 (7.0%)
11-25%	7	10	2	0	19 (14.8%)
26-50%	12	15	3	0	30 (23.4%)
>50 %	19	6	1	0	26 (20.3%)
Early completion	4	1	2	0	7 (5.5%)
Total	**52**	**52**	**22**	**2**	**128**

Note: 1-Government, 2- Public, 3- Private, 4- Others

Table 11. Delay category * Project delivery method cross tabulation

Delay category	Project delivery method				Total
•	1	2	3	4	
No delay	25	8	0	3	36
<10%	2	4	1	0	7
11-25%	13	5	1	0	19
26-50%	20	8	0	1	29
>50 %	22	3	0	1	26
Early completion	5	2	0	0	7
Total	**87**	**30**	**2**	**5**	**124**

Note: 1-Traditional, 2- Design/build, 3- BOT/BOOT, 4- Others.

5.3 Over all mean score and ranking of delay factors

Reliability test of 85 items and 208 responses yielded Cronbach's alpha value of 0.982. This value indicates a high consistency of items related delay factors for further analysis. One sample test was conducted at 95% confidence levels of each individual item. The significance level of all 85 items were less than 0.05 (all p = 0.000) indicating that all items can be used as delay factors.

Tables 12 to 15 provide mean score results of construction delay factors. According to table 12, out of hypothesized 85 delay factors; 5 factors have been identified as very significant (all mean score >3.5) delay factors in construction sites. Five significant factors are (ranked in descending order according to the mean score): (i) Public frequent interruption (item no. 64, $\overline{x}$=3.73), (ii) Changed site condition (item no. 17, $\overline{x}$=3.54), (iii) Failure to provide required site (item no. 12, $\overline{x}$=3.53), (iv) Unrealistic project time estimation (item no. 5, $\overline{x}$=3.52) and (v) Design errors (item no. 14, $\overline{x}$=3.50).

Table 12. Very significant delay factors(Mean Score aboue 3.5)

S. N.	Item No.	Hypothesized delay factors	Mean	Std. Dev.
1	64	Public interruptions	3.73	1.13
2	17	Changed site conditions	3.54	0.98
3	12	Failure to provide required construction site	3.53	1.09
4	5	Unrealistic project time estimation	3.52	1.13
5	14	Design errors	3.50	1.06

(Total N=208)

According to criteria set out in chapter 3, these five delay factors will have substantial effect in total construction time and will also increase the total project cost. However, there is different perception between organizations about these five significant delay factors. Figure 3 shows that mean score of Owner group is well below and other three groups' mean score are above than average (except one case each for consultant and others). This result indicates that owner is reluctant to accepting these as delay factors.

Three factors (public interruptions, changed site condition and design errors) are also critical conflicting factors in construction industry as revealed by Acharya, Lee and Kim (2006). These two researches have proved that delay factors are the causes of conflict in construction sites.

Table 13 provides the list of moderate significant delay factors

Table 13. Moderate significant delay factors (Mean score between 3.0-3.5)

S. N.	Item No.	Hypothesized delay factors	Mean	Std. Dev.
1	18	Delay in design change decision	3.44	0.99
2	19	Excessive extra works	3.39	1.03
3	8	Inadequate early planning by owner	3.39	1.16
4	71	Time taking in obtaining permits from local authority	3.37	1.06
5	52	Subcontractor abandoned the project in the middle	3.34	1.12
6	39	Insufficient cash flows from contractor	3.30	1.26
7	6	Interruption by scope changes	3.23	1.06
8	15	Incomplete supply of drawings, specifications etc.	3.20	1.02
9	26	Rework due to wrong drawings etc.	3.18	1.22
10	73	Force meajure (acts of god)	3.14	1.19
11	84	Severe accidents	3.12	1.25
12	16	Excessive variations in work quantities	3.07	1.05
13	43	Work suspension for defects of contractor	3.07	1.12
14	25	Work suspension order due to design change compulsion	3.07	1.11
15	37	Lack or absenteeism of technical staff of contractor	3.04	1.16
16	4	Excessive bureaucracy (low decision making)	3.03	1.17
17	20	Changes in specifications	3.03	1.05
18	51	Poor quality of subcontractors' work	3.01	1.03
19	40	Inadequate experience of supervisors	3.00	1.10
20	38	Frequent change of contractor's technical staffs	3.00	1.13
21	83	Health hazardous things found during construction	3.00	1.31
22	70	Government authority's strict supervision	3.00	1.13

(Total N=208)

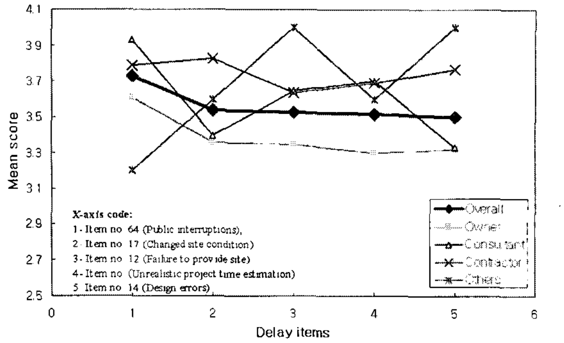


Figure 3. Mean score comparison of 5 critical delay factors with respect to organizational groups

Table 15. Slightly significant delay factors

S. N.	Item No.	Hypothesized delay factors	Mean	Std. Dev.
1	46	Frequent breakdown of equipment	2.48	0.99
2	75	Disruption of power/water supplies	2.43	1.13
3	72	Time taking to obtain permit of foreign workers	2.39	1.05
4	31	Reluctance of consultant to work in extra days	2.39	1.09

having mean scores between 3.0 to 3.5. These delay factor will cause the delay in total construction time, however the delays could be managed through various corrective measures such as acceleration, close supervision, extra investment etc. According to table 13, twenty two (22) delay items come under this category. Top five items of this category are: delay in design change decision (I. No.18, $\bar{x}$=3.44), excessive extra work (I. No. 19, $\bar{x}$=3.39), inadequate early planning by owner (I. No. 8, $\bar{x}$=3.39), time taking in obtaining permission from local authority (I. No. 71, $\bar{x}$=3.37) etc.

Table 14 provides the delay items having mean scores between 2.5 to 3.0. There are 54 items in this category. These delay items contribute delays in work activities but not affect the total construction time. Some of items of this category are: frequent change of contractors' technical personals ($\bar{x}$= 2.98), government authority strict supervision ($\bar{x}$= 2.97), slow work of contractor ($\bar{x}$= 2.94) etc.

According to table 16, four factors do not contribute any delays in construction projects. Mean scores of those all four items are between 1.5 to 2.5.

Table 16. Mean and ANOVA results of 27 delay items

S. N.	I. N.	Hypothesized delay Items (Arranged in descending order as per over all mean)	Over all Mean	Owner		Consultant		Contractor		Others		*p*-value (ANOVA test)			
				Mean	R	Mean	R	Mean	R	Mean	R	Org.	Exp.	Proj. type	Method
1	64	Public interruptions	3.73	3.61	1	3.93	1	3.79	2	3.20	22	.333	.876	.054	.992
2	17	Changed site conditions	3.54	3.36	2	3.40	13	3.83	1	3.60	11	.017*	.583	.092	.829
3	12	Failure to provide site	3.53	3.35	3	3.65	4	3.64	6	4.00	5	.218	.290	.325	.300
4	5	Unrealistic time estimation	3.52	3.30	5	3.70	2	3.69	4	3.60	12	.102	.313	.768	.792
5	14	Design errors	3.50	3.32	4	3.33	15	3.77	3	4.00	6	.021*	.689	.203	.975
6	18	Delay in change decision	3.44	3.11	11	3.68	3	3.67	5	3.80	8	.001*	.790	.137	.736
7	19	Excessive extra works	3.39	3.18	9	3.55	8	3.53	8	3.80	9	.080	.117	.105	.503
8	8	Inadequate early planning	3.39	3.18	10	3.55	9	3.55	7	3.60	13	.167	.257	.534	.262
9	71	Time taking in obtaining…	3.37	3.23	8	3.48	11	3.45	9	3.60	14	.453	.495	.306	.817
10	52	Subcontractor abandoned...	3.34	3.24	7	3.63	7	3.29	14	3.60	15	.301	.184	.034*	.125
11	39	Insufficient cash flows…	3.30	3.27	6	3.65	5	3.16	18	3.20	23	.258	.204	.119	.055
12	6	Interruption by scope…	3.23	3.01	15	3.65	6	3.19	17	4.20	1	.002*	.345	.142	.089
13	15	Incomplete supply of …	3.20	3.05	12	3.20	22	3.39	12	3.20	24	.210	.255	.048*	.587
14	26	Rework…	3.18	2.90	23	3.28	19	3.44	10	3.40	19	.037*	.172	.765	.311
15	73	Force meajure (act of god)	3.14	3.01	17	3.05	27	3.27	15	4.20	2	.107	.925	.819	.246
16	84	Severe accidents	3.12	2.95	21	3.48	12	3.07	21	3.80	10	.095	.424	.561	.406
17	16	Excessive variations	3.07	2.98	18	3.10	26	3.09	20	4.20	3	.091	.565	.125	.419
18	43	Work suspension for…	3.07	3.02	14	3.30	16	2.93	22	4.00	7	.094	.901	.008*	.686
19	25	Work suspension due to…	3.07	2.69	26	3.30	17	3.35	13	3.60	16	.000*	.373	.130	.333
20	37	Lack or absenteeism of…	3.04	3.01	16	3.50	10	2.83	27	3.00	27	.031*	.135	.035*	.965
21	4	Excessive bureaucracy	3.03	2.56	27	3.30	18	3.44	10	3.20	25	.000*	.177	.171	.824
22	20	Changes in specifications	3.03	2.81	24	3.23	21	3.11	19	4.20	4	.007*	.937	.552	.170
23	51	Poor work of subcontractor	3.01	2.97	19	3.20	23	2.92	23	3.01	26	.172	.427	.020*	.810
24	40	Inadequate experience…	3.00	3.05	13	3.18	25	2.84	26	3.40	20	.339	.463	.029*	.571
25	38	Frequent change of staffs	3.00	2.97	20	3.28	20	2.87	24	3.40	21	.256	.492	.451	.596
26	83	Health hazardous	3.00	2.91	22	3.40	14	2.85	25	3.60	17	.105	.693	.144	.992
27	70	Government authority's …	3.00	2.70	25	3.20	24	3.20	16	3.60	18	.011*	.752	.191	.595

* The mean difference is significant at the 0.05 level. R = Rank.

5.4 ANOVA test for confirmation of delay items

ANOVA test at 0.05 significance level was performed to confirm the delay factors with respect to four population characteristics namely organization affiliation, years of working experience, working in types of project and project delivery methods. Table 17 provides the mean score, rank and p values (ANOVA test) of four population characteristics. The mean difference was considered to be significant, if p-value is less than 0.05. From this criteria different subgroups within organization and project type groups were found to be differ statistically ($p < 0.05$) as shown in table 16 with respect to organization in 10 numbers of item (12, 14,18, 6, 26, 25, 37, 4, 20 and 70), and project type in 6 items (52, 15, 43, 37, 51, and 40). There was no any significant difference (all $p > 0.05$) in mean scores of sub groups of working years of experience and project delivery categories.

Levene's test of homogeneity of variances was employed to decide on the post hoc multiple comparison tests. Table 17 provides the post hoc test necessary for each insignificant delay items with respect to organizational group and project type group.

5.4.1 Organization group

According to table 17, subgroups of organization differ statistically with respect to 10 numbers of delay items (4, 6, 14, 17, 18, 20, 25, 26, 37, and 70). Tukey's post hoc test was necessary with respect to 7 items to identify mean differences for particular two sub groups.

Tukey's test showed that except item no. 17 (changed site condition), mean score of owner sub-group differ statistically ($p < 0.005$) as well as practically ($d > 0.50$) with other categories. Regarding item no. 17, although the mean score difference of owner ($\bar{x}$ = 3.36) and contractor ($\bar{x}$ = 3.83) is statistically significant ($p = 0.014$), the difference is not of practical significance ($d = 0.47 < 0.50$).

Dunett's C test was employed for unequal mean variances detected by Levene's test. Table 18 provides the results of Dunett's post hoc HSD multiple comparison test of item nos. 14, 26 and 70. The table shows statistical significant differences between mean scores of owner with consultant and contractor. These differences however, are not of practical significance as all of the differences are less than cutoff value 0.50.

Table 17. Levene's test of homogeneity of variances

I. N.	Delay Items	Levene's statistic F	Levene's statistic Sig.	Post hoc HSD test
ORGANIZATION GROUP				
4	Excessive bureaucracy	0.526	0.665	Tukey
6	Interruption by scope changes	0.392	0.759	Tukey
14	Design errors	3.109	0.027 *	Dunett C's
17	Changed site conditions	2.147	0.095	Tukey
18	Delay in change decision	1.915	0.128	Tukey
20	Changes in specifications	0.343	0.794	Tukey
25	Work suspension order due to design change	2.038	0.110	Tukey
26	Rework	3.125	0.027 *	Dunett C's
37	Lack or absenteeism of technical staff of contractor	2.243	0.084	Tukey
70	Government authority's strict supervision	7.281	0.000 *	Dunett's C
PROJECT TYPES				
15	Incomplete supply of drawings etc.	2.946	0.014 *	Dunett's C
37	Lack or absenteeism of technical staff of contractor	0.862	0.507	Tukey's
40	Inadequate experience	1.877	0.100	Tukey's
43	Work suspension for defects of contractor	0.742	0.593	Tukey's
51	Poor quality of subcontractors' work	2.648	0.024 *	Dunett's C
52	Subcontractor abandoned the project in the middle	0.992	0.424	Tukey's

* Unequal variance ($p < 0.05$)

Table 18. Dunnett C multiple comparison test with respect to organizational groups

Dependent Variable	(I) Org.	(J) Org.	Mean diff. (I-J)	Pooled SD	Pract. sig. (d)
Item no.14	1	3	-0.455(*)	1.068	0.43
Item no. 26	1	3	-0.542(*)	1.229	0.44
Item no. 70	1	2	-0.495(*)	1.134	0.44
		3	-0.495(*)		0.44

* The mean difference is significant at the 0.05 level.
1-Owner, 2- Consultant, 3- Contractor, 4- Others

5.4.2 Years of work experience

According to table 16, mean scores of all five categories of years of working experience are significant (all $p > 0.05$) with respect to all 27 delay items. This result indicates that the perception towards delay factors is same regardless the years of working experience in construction site.

5.4.3 Project types

According to table 16, project type categories significantly differ with respect to 6 items (52, 15, 43, 37, 51 and 40). Levene's variance test result in table 17 indicates the types of post hoc test required for 6 items.

Table 19. Tukey HSD multiple comparison with respect to project types

Variable	(I) Types	(J) Types	Mean (I-J)	Pooled SD	Sig.	Pract sig.
Item No. 37	Road	Others	-0.747 *	1.167	0.018 *	0.64
Item No. 40	Road	Others	-0.706 *	1.106	0.018 *	0.64

* The mean difference is significant at the 0.05 level.
Harmonic mean size = 13.093

Table 20. Dunett's C HSD multiple comparison with respect to project types

Dependent Variable	(I) Types	(J) Types	Mean diff. (I-J)	Pooled SD	Pract. sig.
Item no 51	Building	Road	0.568 *	1.011	0.56
	Road	Others	-0.599 *	1.011	0.59

* The mean difference is significant at the 0.05 level.

According to table 19, Tukey HSD multiple tests detected significant differences between 'road' and 'others' subgroups with regard to item nos. 37 and 40 and those were also practically significance (d = 0.64, both cases). However, regarding 15, 43, 51 and 52, there is no statistical mean differences between the subgroups.

Dunett's C post hoc test was required with respect to item nos. 15 (incomplete supply of drawings etc.) and 51 (poor quality of subcontractors' work). Table 20 shows mean scores differ statistically ($p<0.05$) as well as practically ($d >0.05$) with respect to item no. 51; however, there is no statistical difference (not shown in table) in mean scores of subgroups within this category with respect to item no. 15.

5.3.4 Project delivery methods

According to table 16, mean scores difference of all four categories of project delivery methods are not significant (all p >

Table 21. Statistical and practical significance result for 27 delay items

Item No.	Delay items	Mean	Statistical significance				Pract. Sig.	Remarks	Classification of delay
			1	2	3	4			
64	Public frequent interruptions	3.73	0.333	0.876	0.054	0.992	-	**Critical Delay factor**	**TPCD**
17	Changed site conditions	3.54	0.017*	0.583	0.092	0.829	No	**Critical Delay factor**	**CoCD**
12	Failure to provide required construction site	3.53	0.218	0.290	0.325	0.300	-	**Critical Delay factor**	**OCD**
5	Unrealistic project time estimation	3.52	0.102	0.313	0.768	0.792	-	**Critical Delay factor**	**OCD**
14	Design errors	3.50	0.021*	0.689	0.203	0.975	No	**Critical Delay factor**	**CoCD**
19	Excessive extra works	3.39	0.080	0.117	0.105	0.503	-	Delay factor	**CoCD**
8	Inadequate early planning	3.39	0.167	0.257	0.534	0.262	-	Delay factor	**OCD**
71	Time taking in obtaining permits from local authority	3.37	0.453	0.495	0.306	0.817	-	Delay factor	TPCD
52	Subcontractor abandoned the project in the middle	3.34	0.301	0.184	0.034*	0.125	No	Delay factor	CCD
39	Insufficient cash flows from contractor	3.30	0.258	0.204	0.119	0.055	-	Delay factor	CCD
15	Incomplete supply of drawings...	3.20	0.210	0.255	0.048*	0.587	No	Delay factor	**CoCD**
26	Rework due to wrong drawings etc.	3.18	0.037*	0.172	0.765	0.311	No	Delay factor	**CoCD**
73	Force meajure (acts of god)	3.14	0.107	0.925	0.819	0.246	-	Delay factor	**PMCD**
84	Severe accidents	3.12	0.095	0.424	0.561	0.406	-	Delay factor	**PMCD**
16	Excessive variations in work...	3.07	0.091	0.565	0.125	0.419	-	Delay factor	**CoCD**
43	Work suspension for defects of contractor	3.07	0.094	0.901	0.008*	0.686	No	Delay factor	CCD
38	Frequent change of contractor's technical personal	3.00	0.256	0.492	0.451	0.596	-	Delay factor	CCD
83	Health hazardous found during construction	3.00	0.105	0.693	0.144	0.992	No	Delay factor	PMCD
70	Government authority's strict supervision	3.00	0.011*	0.752	0.191	0.595	No	Delay factor	TPCD
18	Delay in change decision	3.44	0.001*	0.790	0.137	0.736	Yes	-	-
6	Interruption by scope changes	3.23	0.002*	0.345	0.142	0.089	Yes	-	-
25	Work suspension order due to design change compulsion	3.07	0.000*	0.373	0.130	0.333	Yes	-	-
37	Lack or absenteeism of technical person of contractor	3.04	0.031*	0.135	0.035*	0.965	Yes	-	-
4	Excessive bureaucracy	3.03	0.000*	0.177	0.171	0.824	Yes	-	-
20	Changes in specifications	3.03	0.007*	0.937	0.552	0.170	Yes	-	-
51	Poor quality of subcontractors'	3.01	0.172	0.427	0.020*	0.810	Yes	-	-
40	Inadequate experience...	3.00	0.339	0.463	0.029*	0.571	Yes	-	-

Note: 1- Organization, 2- Years of working experience, 3- Project types, 4- Project delivery methods.
(*) indicates statistical mean significant differences at 0.05 level. (-) indicates not necessary to test practical significance.

Table 22. Comparison of this study results with previous researches

This study (2006)	Kumaraswamy et al. (1998)	Al_khalil et al. (1999)	Al-Momani (2000)	Elinwa et al. (2001)	Ellis et al. (2002)	USDT (2003)
1. Interruptions from public	-	-	-	-	-	√
2. Change site condition	√	-	√	-	√	-
3. Failure to provide required construction site	-	-	-	-	-	-
4. Unrealistic project time	-	√	-	√	-	-
5. Design errors	-	-	√	-	√	-

0.05) with respect to all 27 delay items. This result indicates that the perception towards delay factors is same regardless the project delivery methods.

5.4 Identification of delay factors

Table 16 showed respondents from four population categories differ significantly with respect to 15 numbers of hypothesized delay items. As discussed in chapter three, the differences may be due to some chances as the significance varies with the numbers of respondents, therefore there is need to check whether these are practically significance or not. Tables 18 to 21 show the post hoc mean comparison HSD tests. These tests have provided whether the mean differences between subgroups are significant or not.

In some cases HSD multiple tests could not detect any statistical difference between the mean scores of groups, for which ANOVA have detected as statistical mean differences. Practical significance test as discussed in chapter three was employed and wherever 'd' value was found less than 0.50 for the mean difference, statistical significance if existed was nulled (cancelled). Table 21 shows the summary of statistical and practical significance out put result, which provides final result of delay factors.

According to table 21, eight items namely, "excessive bureaucracy in decision making (item no. 4)", "interruption by scope changes (item no. 6)", "delay in change decision (item no. 18)", "changes in specification during middle of the project (item no. 20)", "work suspension due to design change compulsion (item no. 25)", "lack or absenteeism or contractor's technical personals (item no. 37)", "inadequate experience of supervisors (item no.40)" and "poor quality of subcontractors' work (item no. 51)" are not the delay factors sorted out for practical testing. Table 21 also provides the list of final 19 delay factors ranked according to their mean score. Construction professionals involved in four categories e.g. organization, years of experience, project types and project delivery methods are unanimous that these 19 factors play significant role in delaying the construction projects.

Out of 19 identified delay factors, 3 factors (item nos. 5, 8 and 12) are related to owner caused (OCD), 6 factors (item nos. 14, 15, 16, 17, 19, and 26) are related to consultants caused (CoCD), 4 factors (item nos. 38, 39, 43 and 52) are related to contractor caused (CCD), 3 factors (64, 70 and 71) are related to third parties caused (TPCD), and 3 factors (73, 83 and 84) are related to project specific related (PMCD).

As five top delay items (interruptions from public, changes of site condition, failure to provide site, unrealistic project time and design errors) have mean score more than 3.5, these are considered as critical delay factors. These results are partly in line with various previous studies as shown in table 22. This indicates these factors are contributing construction delay significantly in globalwise.

6. Conclusion and recommendations

Delay in the construction work has many negative effects. So, the purpose of this paper was to identify the factors, which are contributing delays in the construction works. 85 different types of delay contributing items were collected through literature review, interviews and self experience of authors. 510 numbers of construction professionals working in owner, consultant and contractor organization were approached to ratify the cause factor of delay through field survey questionnaire. Statistical tools were used to analyze the delay causes.

According to mean score method, the respondent ratified only 27 factors that are contributing delays in construction works. ANOVA test at 5% was conducted to confirm whether all of respondents groups working in different organization and work types have same perception or not. According to ANOVA test, all of the respondents have same perceptions about only 19 factors. Out of these 19 factors, following five factors are critical as these factors have high agreement level: (i) frequent interruption from public (local people, pressure groups etc.) (ii) changed site condition (iii) failure to provide required construction site (iv) unrealistic project time estimation and (v) design errors.

These five causes of delay indicate third party, owner and consultant as the main sources of delay. If a contractor does not get a correct design, construction site, and a reasonable time, then it would be impossible to complete the project successfully within stipulated time. Again, if there are frequent interruptions from third parties in the name of protest and more benefit from the project, the possibility of project delay further increases.

The problem caused by contractor it self is not found to be critical in this study, though they are also some of good causes of delay. The delays incurred by contractors will make loss to themselves, so they certainly have to look at those things. No body will compensate for their own causes. Most of the delays which are due to owner and consultant however, are excusable and compensable. So, if the project is delayed, then the loss will be more, because the owner will loose money as well as fail to fulfill the objectives within time. For, a certain time bound projects (such as Olympic related infrastructures, conference hall etc.), it will be unbearable. The owner of the projects therefore, must consider these all delay factors during pre-planning of the project. A little time and money invested during preconstruction phase will save much more time and money during construction phase later. Hiring competitive not cheap consultants, involving all project stakeholders including user group, community affected by the project etc. in project planning phase, and setting a reasonable project time frame could help to finish the projects successfully without having any delays and other problems.

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