A STUDY OF DELAYS AND COST OVERRUNS IN CONSTRUCTION PROJECTS

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Master of Science

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by

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In construction projects, changes are very common and likely to occur at any stage of the project. Construction project is a complex process, which requires close cooperation and coordination among the stakeholders. The process also consists of various stages, which ultimately make it more complicated and difficult to manage. Therefore, proper planning is necessary to enhance value generation, reduce dispute and improve the workflow. Even with a good plan, there are tendencies for design changes to creep in during various phases of a project. These changes can take place right from the drawing phase up until the construction phase. The later the changes are made, the more it affects the project. Such changes may occur due to the needs to satisfy the new or modified requirements specified by the stakeholder, to reduce project cost, or to rectify existing design mistakes. To make things worse many of the changes are made during the construction phase. These generate change orders, contractual disputes, cost overruns, time delays, compromises on quality and poor management overall. This research has compiled

data on various types of construction projects, and reviewed causes, effects, and control procedure for changes and management of change orders. A classification schema is presented to group different types of delays in well-defined categories, and the impact of these delays on the project costs is investigated. Furthermore, an in-depth case study of an ongoing construction project is performed.

The outcome of this review may help the engineers and contractors to improve productivity, to enhance the effective change management process and initiate further research in this field.

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Chapter 1 Introduction

1.1 Background

One of the most important problems in the construction industry is variations. They occur in every construction project and the magnitude of these variations varies considerably from project to project. Hence, the change orders bear significant importance right from the design to completion in the construction industry. Construction industry is often described as a volatile industry, which can be true in implementing a project. Construction itself is more often unpredictable due to the different situations a project may face. Changes may occur in the preparation, during construction and even upon completion of the project. Due to the inconsistent nature of any construction project implementation, effective change management procedures must be considered to minimize the effects particularly to project cost, time schedule and overall quality of the project. Change orders can occur and are often unavoidable during the construction process, which can lead to delays. A change order is work that is added or removed from the original scope of work and as a result, the original contract amount or completion date of the project is modified. Despite the best efforts to avoid changes during construction, they are mostly unavoidable. There are many reasons changes can occur such as unknown field conditions, design changes or stakeholder requests.

1.2 Purpose of study

The cost of a construction project is one of the most crucial factors in the construction industry. Due to many reasons, the total cost of a project can significantly vary from the initial estimated cost. The reasons could be changes in scope of work, specifications, or any other contract documents. In the construction industry, change orders are created when changes occur. It is an official document that states the changes made into the original agreement between the

client and the contractor. When a change order is created, it brings several negative effects to both the client and the contractor (Halwatura and Ranasinghe, 2013). Not only that the changes in order affects the construction, it also has an impact on the design professionals and the stakeholders. Change in orders can be broadly characterized depending on the way they are addressed in a contract. Moreover, there are several types of change orders based on the kinds of changes made in contracts. The impact and causes of change orders on various phases of construction need to be studied. The other types of change in orders are differing site conditions, acceleration of work, weather conditions, non-design related change order, design-related change order. There is also the emergency field condition change orders and a donation or contribution that could contribute in changing of orders.

According to Mechanda (2005), the change of orders can increase the cost of the project. Therefore, it is advisable that when there is a change order in a project it is wise to plan for a 5-10% contingency to handle these items to avoid going over budget. This way if changes occur, they will not exceed the initial forecasted budget. When a change is required, it is best to notify the project team immediately. This way the issue can be discussed, and a solution developed. Many times, the changes can require the architect or engineer to revise the project drawings or make permitting changes and then additional work must be priced for the stakeholder's acceptance (Mechanda, 2005. Pg6). Depending on the magnitude of the change, the project schedule may be extended, or completion of certain work could be delayed.

The timing of changes can also have varying effects on construction. According to A.R. Brouwer Company (2016), changes can result in a several weeks delay as the trickle-down effect of one change impacts other progress. If changes are significant throughout the duration of the project, contingency budgets could be exceeded.

In this study, we reviewed several construction projects in order to perform an in-depth study of the major reasons for construction project delays and their impact on the project costs.

1.3 Research Objective

The four important objectives of this research are:

- To compile data on several types of construction projects.
- To study and classify main reasons for construction project delays.
- To study how the variations of changes in orders affect project costs.
- To perform a case study of an ongoing construction project.

1.4 Definition of Terms

Change Order: "Variation or change order is the deviation experienced in any project from base contract or work scope mutually agreed at contracting time. It is a written agreement between the contracting parties that represent an addition, deletion, or revision to the contract documents, identifies the change in price and time and describes the nature of the work involved" (Keane, 2010). Variation orders arise for a variety of causes, of which some causes are foreseeable, and others are not.

Stakeholders: A person with a significant interest in the project.

Cost overrun: Cost overrun occurs when the actual cost for the project is more than the initial estimated cost.

Time overrun: When an activity faces a delay resulting into a late start or late finish of the previous activity, therefore causing extra time to the project. So, this usually occurs when a project is finished later than the initial estimated competition time.

Pareto Chart: Pareto chart is a statistical technique in decision-making used for the selection of a limited number of causes that produce significant overall effect. It uses the Pareto Principle, which states that approximately 80% of the effects come from 20% of the causes for many events. Pareto chart is also referred as the Pareto diagram or Pareto analysis,

Pie Chart: A pie graph is a specialized graph used in statistics in which the relative proportions of parts of a whole are shown as distinct size pieces of a pie shape.

1.5 Summary

Chapter one introduced the topic of the thesis. The general area of concern was identified. After stating the problem, the significance of the study was addressed, followed by the main objectives of the research. Last, several commonly used terms were defined.

Chapter 2 Literature Review

2.1 Background

This research compiles data on several construction projects in order to perform an in-depth study of the major reasons for construction project delays and their impact on the project costs. According to Fritz (1994), few items in a project manager's busy schedule cause disproportionately more work and anxiety than do change orders. The change orders reflect flaws in the planning, design, or execution of the project. In most cases, they increase the cost of the project. They also result in a heavy managerial load due to additional review, discussion, and tracking requirements (Vandenberg, 1996).

Many researchers have identified various causes of delays such as Randolph (1987), Hale (2009), Lee (2008) and Roth (1995). They all concluded that cost overruns were correlated with the name of the contractor, type of work, project size and that cost overruns and time overruns were also correlated with design errors and changes, changed site conditions, contract conflicts, and weather influenced delays.

2.2 Reasons for Project Delays

The change of a schedule during the construction phase can result into major reallocation of resources. Thus, the contractor will be required to either provide additional resources or preserve some resources to remain idle. Another main reason why there are delays in construction is the change of plan or scope that usually results in inadequate planning at the defining stage because of lack of interest or involvement of the stakeholder during the design phase. Stakeholder’s financial issues can also affect the progress of the project. Financial issues often lead to change in the work schedules and specifications, which then results in affecting the

quality of the project (Clough and Sears, 1994; O'Brien, 1998). Careless decision-making process is another reason why they are delays. Failure to make decision efficiently may result in delays causing rising project costs.

Design changes are usually frequent especially when the construction starts before the final design is finalized thus affecting the project in several ways depending on the timing of the change. The design plays a major significant role in construction so when there is a complex design it requires unique skills and construction methods. The complexity of the design affects the flow of construction activities whereas simpler construction designs are easier to handle. Drawing details must be accurate and clear because inadequate drawing details can result in misinterpretation of the actual requirements for the project. Another major reason for delays is the conflict between contract documents that could result in misapprehension of what is required of the project. Hence, it is apparent that the contract documents should be clear and precise. Insufficient details in the contract documents can result in complications thus causing delays and cost overrun.

Scarcity of equipment and lack of skilled manpower can negatively affect projects, especially technological projects. Defective workmanship may lead to annihilation and rework in construction projects. Lastly but not the least is the contractor's financial difficulties. Construction is a labor driven industry. Whether the contractor has been paid on time or not, the wages of the workers must still be paid timely. Hence, financial difficulties faced by the contractor can result into scarce resources and project delays.

Many times during the project implementation, minor issues identified by the architect, engineer, and contractor can eventually lead to change orders. Regardless of its origin, a change order is issued by the stakeholder. Change orders cover a multitude of items such as design

developments, scope changes, recognition of actual site condition. An example could be soil conditions that were not known with a sufficient degree of certainty until excavated or exposed can lead to changes in original plan (Owalabi, et al., 2014).

2.3 Effects of Project Delays

Delays in projects can strain the relationship between the stakeholders, engineers, contractors and others involved during the construction process as well as add cost overrun. Not only does the workflow get disrupted but also trying to get quick responses, drawings and other things required to get back to schedule to cause strain on a working relationship. Abdul-Rahman et al. (2008) identified important causes and important impacts of construction project delays. It is concluded that the stakeholder is usually the most responsible party for the delay. The study found out that the overall average increase in total costs are 11.3% when a change of order is made in a project. The research also concluded that when there is change of the scope of the project due to the requirements of the stakeholder it leads to major cost overruns. The project costs and time overrun were found to be the two main effects of the changes made to a project. The change of plans by the stakeholders is the main source of delays and another important source is design errors.

Increase in project cost is regarded as the most common effect of variations in a project implementation plan. Any adjustment or addition to the design during execution of the project may results in annihilation or rework of any project component which could eventually increase the project cost (Clough and Sears, 1994). Ehrenreich-Hansen (1994) reported that delay in projects are usually 9% of the original scheduled time duration for projects.

Normally, a contingency amount is assigned to help provide for possible changes in the project and resulting minor cost overruns. Hence, projects require processing procedures, paper work and reviews before they can be implemented. This process may lead to expenses for all the parties concerned. Normally these expenses are provided from the contingency fund allocated for the project. With all the delays and changes, the quality of work is frequently affected. This effect is still expected even if the project changes occur after the majority of construction is already completed. Though it may not require any rework or demolition on the sites, it still leads to cost overrun. Another effect is logistic delays, which involves the use of new or additional amount of material and equipment. This is mentioned by researchers as among the significant effects of project change in construction projects. These logistic delays could include the delay in receiving material or tools, which then puts the work on hold.

To conclude, making changes especially in a construction project can cause a major dispute between the stakeholder and the contractor. This type of effect is never the best and it is usually the most significant. Most people try to avoid this because it could lead to law suits, disputes, lots of breach of codes and contract disputes amongst stakeholders and contractors. Therefore, making it impossible for the work to be done resulting in further delays and cost overruns. Figure 2.1 shows some of the major effects of delay in construction projects.

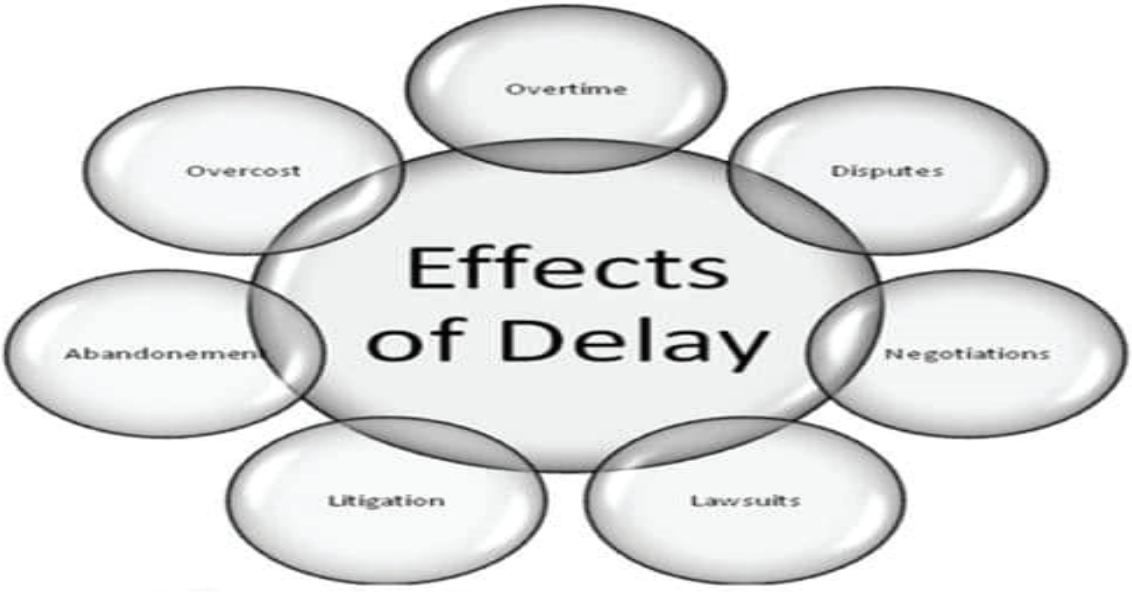

Figure 2.1 Major effects of delays in construction projects (Retrieved from *theconstructor.org/construction/delays-construction-projects*)

Chapter 3 Methodology

This research methodology consists of the following four phases:

- Collection of data on selected projects
- Identifying and classifying the reasons for project delays
- Statistical analysis to explore the relationship between time delays and cost overruns.
- A descriptive case study on a selected project, where the researcher had access to the project site, and could conduct in-person interviews.

3.1 Data Collection

In this study, the data on twenty-nine construction projects was collected. The researcher used several data sources including literature reviews (Ahbad and Changiz, 2012; Ismail, 2014), interviews with construction project managers, documents provided by these managers, etc. Initially, the researcher looked at 35 projects, but could not get all the necessary information. Thus, the final selected projects consisted of only 29 projects. These projects were implemented in countries like Nepal, India, Iran, Nigeria, Bangladesh, Turkey, China, and America. Evaluation of project completion reports was conducted, and post evaluation results were the core data for this study. Summarized data of collected information was obtained by focusing on the factors influencing time delays, overall project costs, and cost overruns of these projects. Table 3.1 shows the comprehensive data of the selected projects including the type of project such as road, sewage, etc. The category “others” describe other types of construction projects such as oil refineries, etc. Project names were anonymized and replaced by project identifiers, such as A1, A2, etc.

Table 3.1 Summary data for the selected projects

Project Identifier	Location	Type of Project	Delay (months)	Initial Cost (millions)	Final Cost (millions)
A1	Paraguay	Road	24	$90.00	$136.29
A2	Pakistan	Others	25	$143.00	$155.10
A3	Cambodia	Road	23	$87.00	$87.00
A4	Kazakhstan	Road	22.5	$77.00	$78.00
A5	Republic of Honduras	Road	18	$106.80	$118.20
A6	Kingdom of Swaziland	Others	29	$99.60	$110.38
A7	Turkey	Road	6	$480.00	$750.00
A8	Timor-Leste	Road	15	$9.29	$9.58
A9	Kazakhstan	Road	29	$123.00	$131.00
A10	Lesotho	Road	17	$4.25	$5.00
A11	Republic of Korea	Sewage	18	$272.10	$278.60
A12	Philippines	Building	56	$105.41	$121.41
A13	Nepal	Road	30	$59.14	$59.14
A14	Republic of Iran	Sewage	24	$341.45	$359.22
A15	India	Others	37	$503.70	$480.50
A16	Mongolia	Road	10	$20.00	$23.74
A17	Republic of Mozambique	Road	13	$38.27	$48.82
A18	Lao People's Democratic Rep	Road	49	$64.50	$60.74
A19	Bangladesh	Railway	35	$269.00	$365.00
A20	Bangladesh	Bridges	14	$170.00	$196.30
A21	China	Road	44	$757.50	$965.50
A22	Kyrgyz Republic	Road	36	$50.00	$57.00
A23	Afghanistan	Road	39	$76.60	$80.00
A24	Republic of Nicaragua	Road	18	$88.70	$88.70
A25	Cote D'Ivoire	Road	12	$230.00	$313.00
A26	India	Road	24	$385.30	$417.99
A27	Nigeria	Others	110	$217.00	$287.33
A28	Bangladesh	Bridges	6	$696.00	$753.70
A29	USA	Building	3	$39.00	$42.00

3.2 Method of Analysis

Once the data was collected, several statistical measures were used to determine what factors cause the most delays in construction projects. The researcher was also able to look at how these projects were affected financially, therefore resulting in some cases, a major cost overrun. The descriptive statistical tools used include Pie charts and Pareto charts. The fishbone diagram is also used in the case study to outline the main causes of the time delays.

Several **Pie charts** are used to categorize and breakdown the projects by various regions, and constructions types. The causes of project time delays are classified in major categories and appropriately displayed on a pie chart.

A **Pareto analysis** tool is used to further analyze causes of project time delays and to show the delta percentage increase in the total cost from the initial projected cost. The following formula can be used to determine the delta percentage increase in the total cost:

% delta increase in the cost **= (Final cost - initial cost) / initial cost** * 100

The Pareto analysis also categorizes and helps appraise the reasons for the delays and types of projects using the 80/20 rule.

A **Bar graph and Histogram frequency** statistical standard procedures are used to measure and determine what factors cause the most delays in construction and the relationship between the initial and cost and cost overruns.

Chapter 4 Data Presentation and Analyses

This chapter contains statistical analyses of the data presented in the previous chapter. This includes a graphical description of the data using appropriate histograms and pie charts. Then finally, the Pareto charts are used to analyze the project time delays, classification of the delays, cost overruns, etc.

4.1 Graphical Analysis

The data for graphical analysis in this section is taken from Table 3.1 in Chapter 3. Table 4.1 below groups the selected projects in different continents based on their actual locations. Figure 4.1 shows the distribution of selected projects by continents in a pie chart.

Table 4.1 Distribution of the selected projects by continents in which they were located

Continent	Number of Projects
Africa	6
South America	3
South Asia	12
Asia (North and Middle East)	7
North America	1

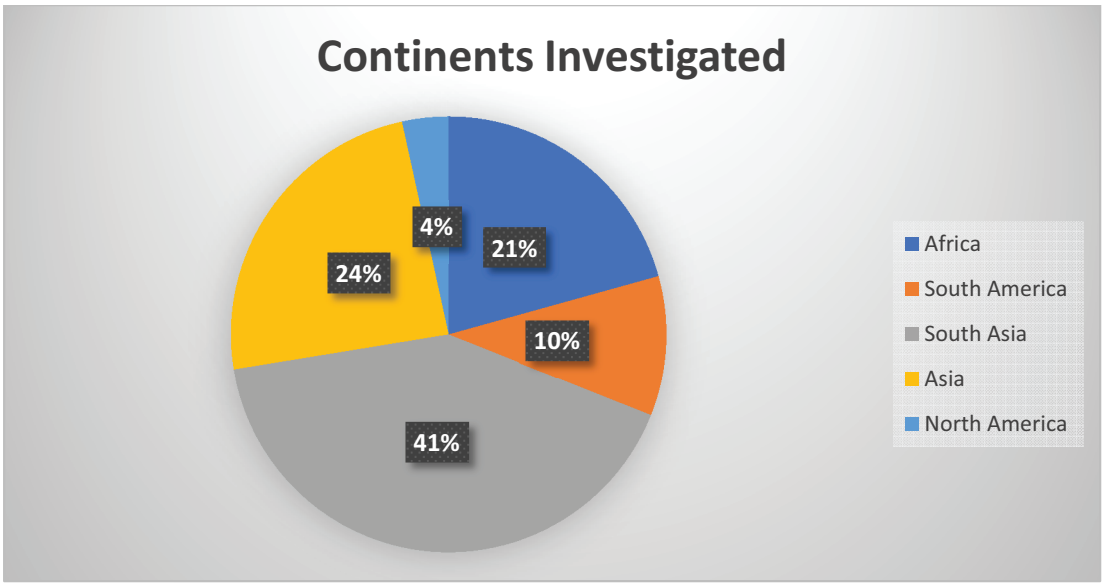

Figure 4.1 Distribution of selected projects by continents

Next, the projects are classified in six several types of construction work: roads, buildings, sewage, bridges and others. Table 4.2 shows the distribution of the selected projects based on the description on construction work.

Table 4.2 Distribution of selected projects based on the type of construction work

Type of construction work	Number of projects
Roads	19
Sewage	2
Building	2
Railway	1
Bridges	2
Others	3

A pie chart displaying the distribution of selected projects by type of construction work is shown in Figure 4.2. This shows that the majority of the projects (66%) were Roads construction projects.

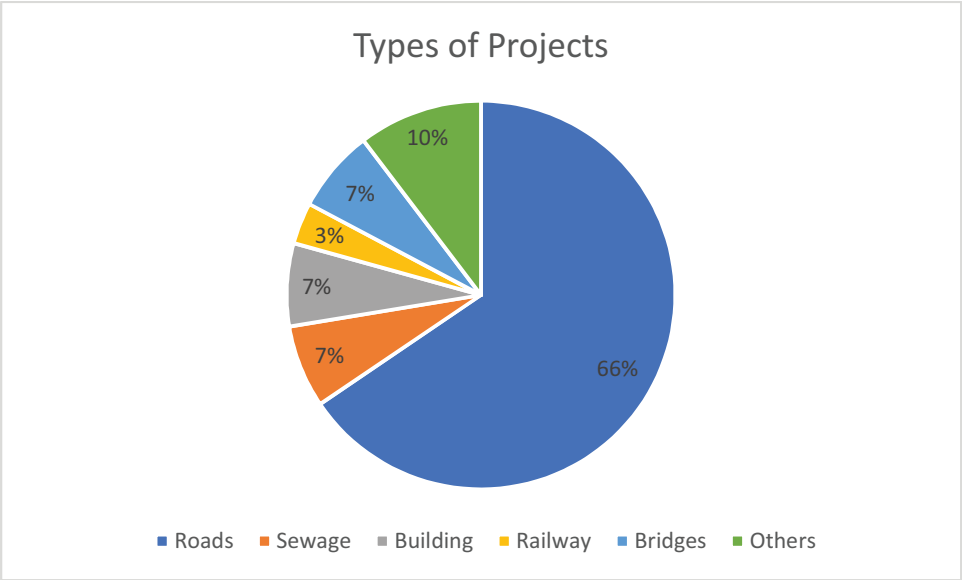

Figure 4.2 Distribution of the selected projects by type of construction work

Next, the reasons for project delays are categorized into the following groups:

- **Design issues** reflects that the design errors surfaced during the project implementation.
- **Weather** could be heavy rain and heavy snow.
- **Contract disputes** describes were the stakeholders and contactors had disagreements over contracts that resulted in contract disputes.
- **Government** issues, defined as the countries either having some political instability or there was a war in the country during that period.
- **Funds shortage** describes when either a government or stakeholder decides to not fund the necessary funds to continue the project on a timely basis.

- **Poor-site management,** defined as a mis-management that lead to poor site management.

Below table 4.3 displays the frequency distribution of these delay reasons across the selected projects.

Table 4.3 Frequency distribution of delay reasons across the selected projects

Project Identifier	Delay (months)	Reasons for Delay					
		Design issues	Government	Contract Disputes	Weather	Funds shortage	Poor site Management
A1	24	X					
A2	25		X				
A3	23			X		X	
A4	22.5			X	X	X	
A5	18	X					
A6	29			X			
A7	6					X	
A8	15		X		X		
A9	29	X					X
A10	17			X	X		
A11	18		X				
A12	56	X			X		X
A13	30		X				
A14	24					X	
A15	37	X			X		
A16	10			X	X		
A17	13	X		X	X		
A18	49				X		X
A19	35			X			X
A20	14				X		
A21	44	X					
A22	36					X	
A23	39		X		X		X
A24	18		X		X	X	
A25	12					X	
A26	24	X		X			
A27	110			X			
A28	6	X		X		X	
A29	3	X					

The data in Table 4.3 is further summarized in table 4.4 below.

Table 4.4 Displays the frequency for delay reasons

Delay Categories	Delay Frequencies
Design issues	10
Weather	11
Contract disputes	10
Government	6
Funds shortage	8
Poor site management	5

Figure 4.3 shows distribution of delay categories and associated delay frequencies in a pie chart. Based on the pie chart analysis, it is clear that weather is one for the main causes of the delay in construction projects (22% of the selected projects). The contract disputes and design errors both came second sharing 20% each of the pie chart.

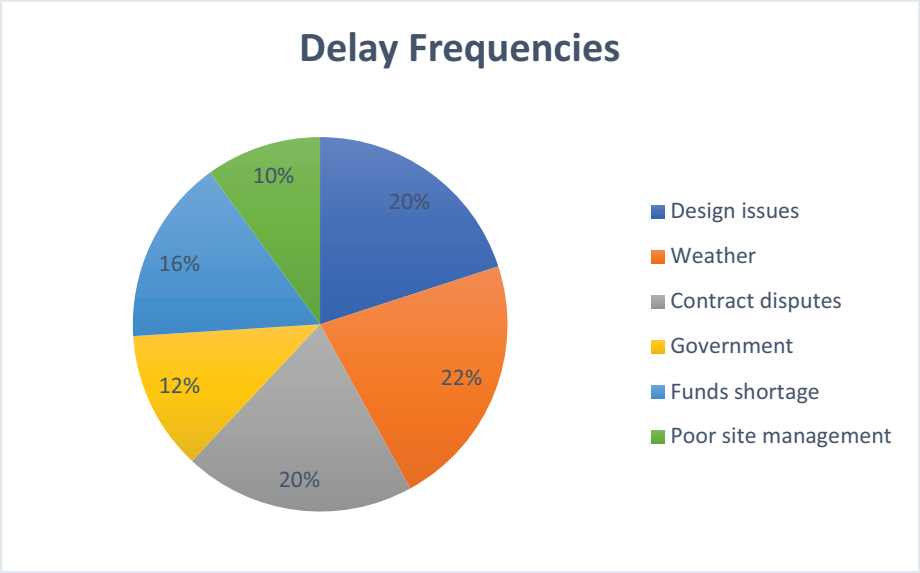

Figure 4.3 Distribution of selected projects by main causes for the project delays

Figure 4.4 illustrates the Pareto analysis of delay categories and associated delay frequencies.

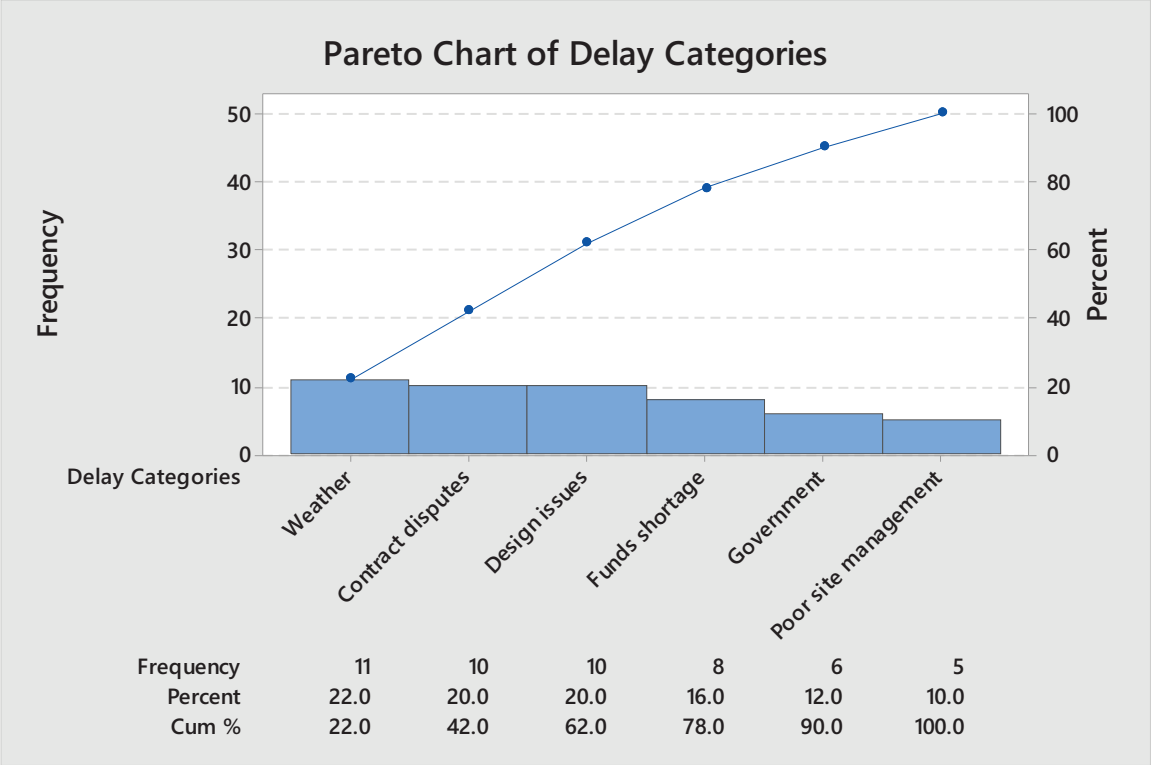

Figure 4.4 Pareto analysis of the main reasons for the project delays

The project delays in actual months for the selected projects are displayed in Figure 4.5. The longest delay (110 months) was for the A27 project that was constructed in Nigeria. The second project with a long time overrun is the A12 (56 months).

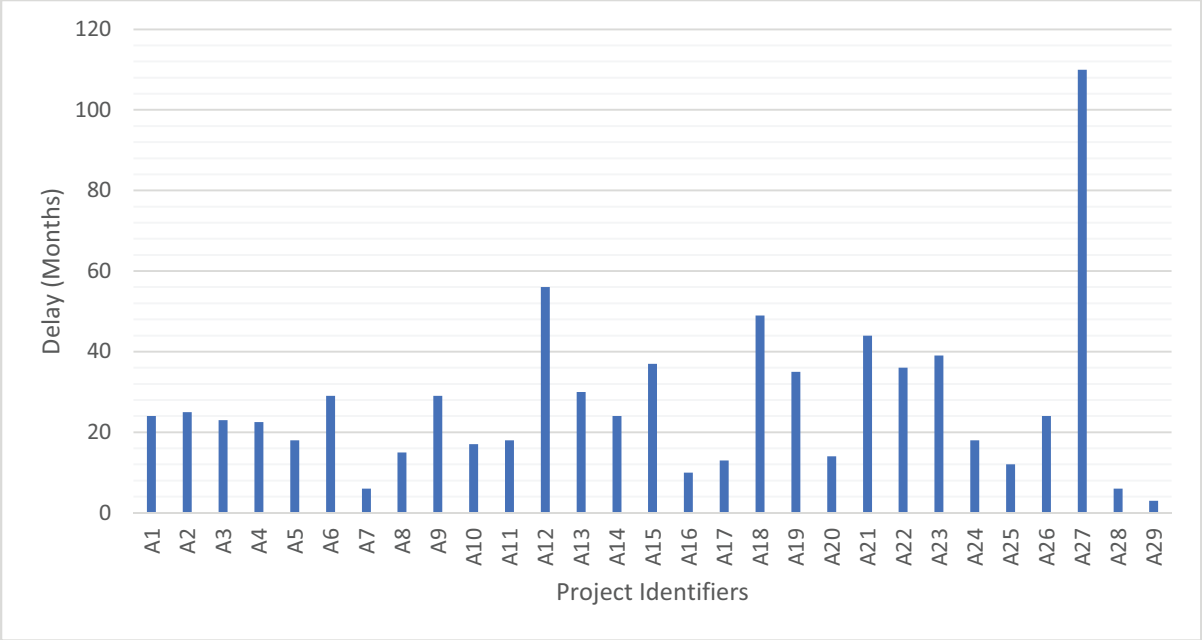

Figure 4.5 A bar graph of time overruns for the selected projects.

Figure 4.6 shows histogram of the frequency of project delays for selected projects. It can be seen from the figure that the mean time overrun for selected project is 27.12 months.

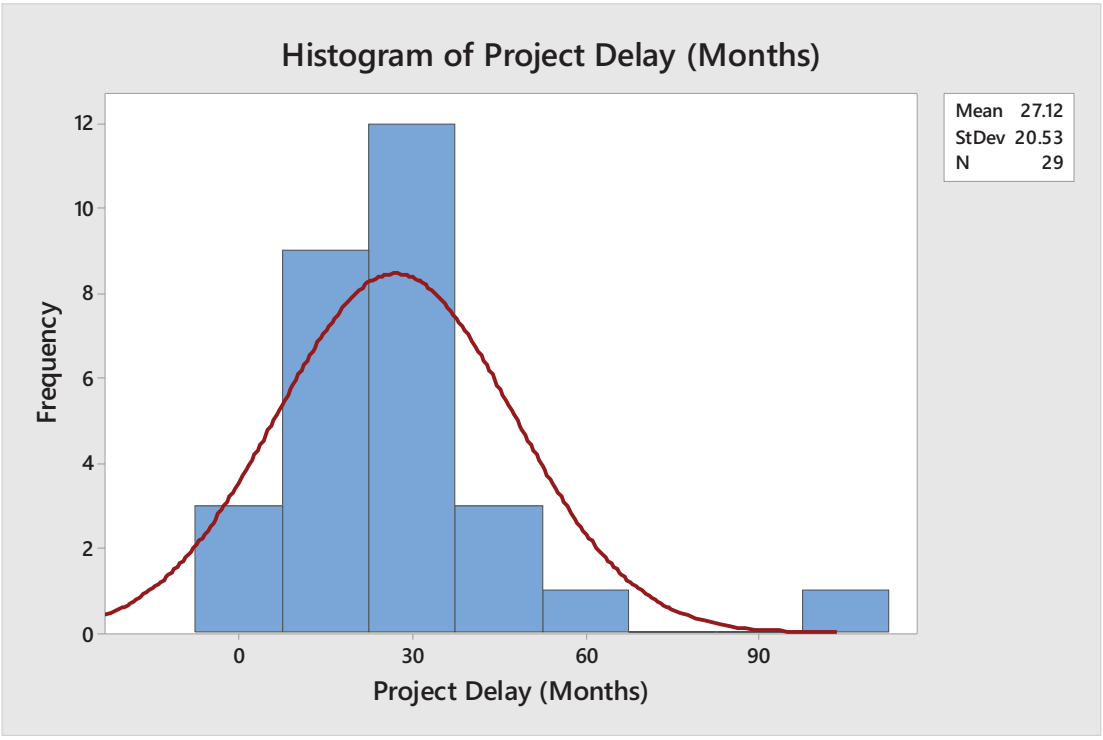

Figure 4.6 Histogram showing the frequency of project delays for selected projects

Figure 4.7 shows the comparison of initial projected cost and final cost for the selected projects.

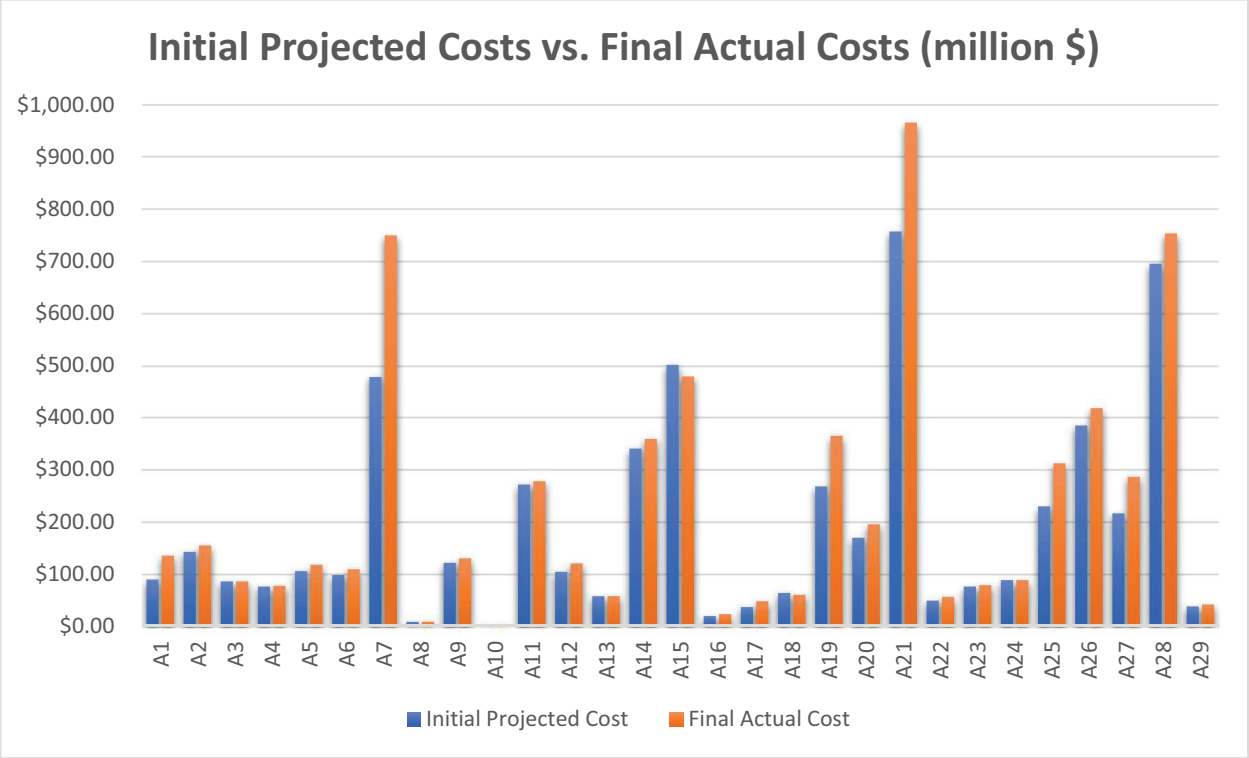

Figure 4.7 Comparison between the initial projected cost and the final cost for selected projects

Next, the percentage delta increase in the cost was calculated using the following formula.

% delta increase in the cost = **(Final cost - initial cost) / initial cost** * 100

Table 4.5 lists initial project costs, final costs, cost overruns, and % delta increase for the selected projects.

Table 4.5 Initial projects costs, final costs, cost overruns, and % delta increase for selected projects

Project Identifiers	Initial Projected Cost (millions)	Final Actual Cost (millions)	Cost Overrun (millions)	% Delta Increase
A1	$90.00	$136.29	$46.29	51.43%
A2	$143.00	$155.10	$12.10	8.46%
A3	$87.00	$87.00	$0.00	0.00%
A4	$77.00	$78.00	$1.00	1.30%
A5	$106.80	$118.20	$11.40	10.67%
A6	$99.60	$110.38	$10.78	10.82%
A7	$480.00	$750.00	$270.00	56.25%
A8	$9.29	$9.58	$0.29	3.12%
A9	$123.00	$131.00	$8.00	6.50%
A10	$4.25	$5.00	$0.75	17.65%
A11	$272.10	$278.60	$6.50	2.39%
A12	$105.41	$121.41	$16.00	15.18%
A13	$59.14	$59.14	$0.00	0.00%
A14	$341.45	$359.22	$17.77	5.20%
A15	$503.70	$480.50	-$23.20	-4.61%
A16	$20.00	$23.74	$3.74	18.70%
A17	$38.27	$48.82	$10.55	27.57%
A18	$64.50	$60.74	-$3.76	-5.83%
A19	$269.00	$365.00	$96.00	35.69%
A20	$170.00	$196.30	$26.30	15.47%
A21	$757.50	$965.50	$208.00	27.46%
A22	$50.00	$57.00	$7.00	14.00%
A23	$76.60	$80.00	$3.40	4.44%
A24	$88.70	$88.70	$0.00	0.00%
A25	$230.00	$313.00	$83.00	36.09%
A26	$385.30	$417.99	$32.69	8.48%
A27	$217.00	$287.33	$70.33	32.41%
A28	$696.00	$753.70	$57.70	8.29%
A29	$39.00	$42.00	$3.00	7.69%

The largest total cost project investigated is a road project in China (A21 in table 4.5) with actual cost of 965.5 million dollars with an overrun of 208 million dollars, a 27.46% of cost overrun. The second largest project is a bridge project (A28 in Table 4.5) in Bangladesh with a

total cost of $753.73 million dollars and with $57.70 million dollars cost overrun, which is 8.3% over the estimated cost of the project. The third largest project is a road project (A7 in table 4.5) in Turkey with total cost of 750 million dollars and $270 million dollars of cost overrun, which is equal to 56.25% over the predicted total cost of the project.

Figure 4.8 shows the distribution of the delta percentage increase in initial project costs for the selected projects. It is clear from the figure that the worst project in terms of cost overrun factor is the road project in Turkey (A7) with more than 50% increase based on table 4.5.

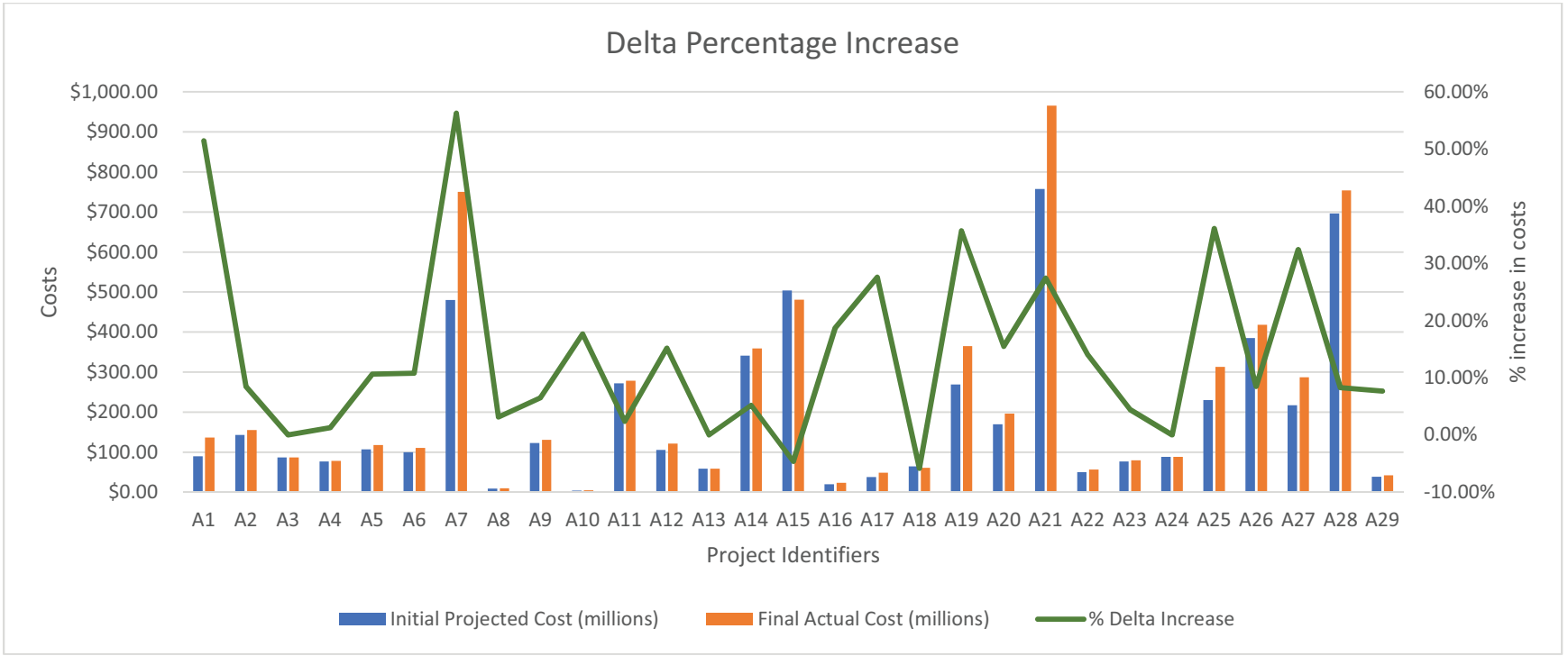

Figure 4.8 The delta percentage increase in initial project costs for selected projects

Next, average costs associated with each delay category for the selected projects were calculated and shown in Table 4.6 below. For calculations purposes, when a project had more than one type of delay, the cost overrun for that project was assumed to be equally divided among the different delay types associated with the project.

Table 4.6 Average costs associated with each delay category

Delay Categories	Average Cost Overrun (million)
Design issues	$30.55
Government	$3.31
Contract Disputes	$17.08
Weather	$2.32
Funds shortage	$49.67
Poor site Management	$11.32

As shown in Table 4.6, average cost overrun associated with the "Funds Shortage" related issues is $49.67 million. It can also be noted from Tables 4.3 and 4.4 that the frequency of "Funds shortage" issues is less as compared to other delay categories, but when funds shortage occurs, it can be expensive from the cost overrun perspective. Even though weather related delays are the most frequent occurrence, it can be noted from the Table 4.6 that the average cost associated with this category is the lowest. Figure 4.9 shows Pareto chart analysis of average cost overruns associated with individual delay categories. As can be seen from the figure, funds shortage and design issues are the two most important categories from the cost overrun perspective.

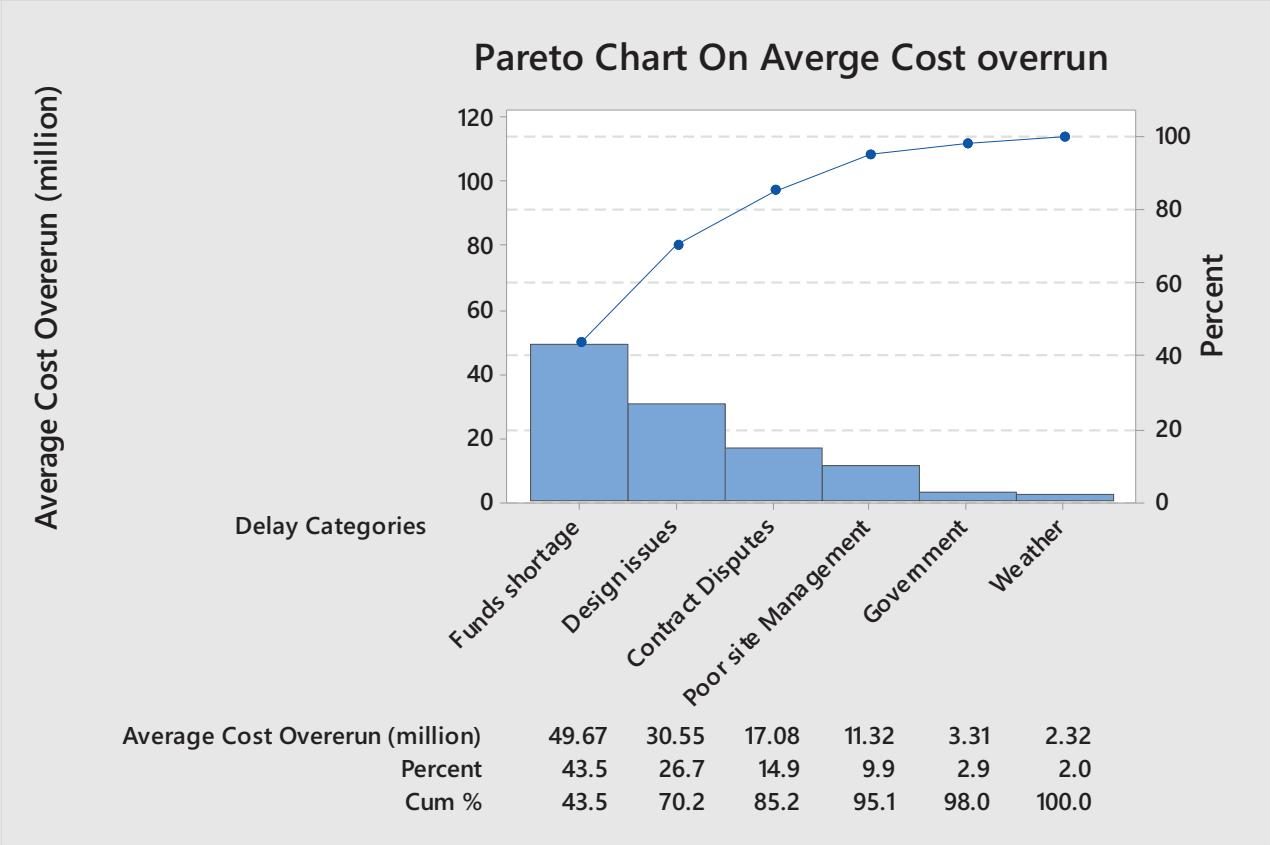

Figure 4.9 Pareto chart analysis of average cost overruns associated with individual delay categories

Chapter 5 Case Study

A specific project (Project A29 from Table 3.1) was selected and studied to validate the reasons identified in Chapter 4 for project delays. Project A29, chosen for the case study was an educational institution's *Student Center* construction project. Due to confidentiality reasons, the references to names of the project, the institute, and the location are withheld. This building on campus has been such a vital place for students. It was where the students came to eat, socialize and events were held inside the building. Due to capacity constraints and other limitations of the building, the university decided to renovate it based on student suggestions. This renovation would nearly double the size of the facility. It will offer more restaurant-style accommodations in a modern atmosphere. A fishbone diagram is used to determine main factors for the delay and cost overrun.

5.1 Background

A brief history of the project can help understand the current state of the project. The main objectives of this construction project were:

- To increase student services and amenities on campus.
- To offer a more restaurant style cafeteria on campus and more office spaces.
- To offer a better and more social environment for various campus activities.

The project implementation has experienced several changes including an administrative reshuffle, the state and the institute budget deficits, significant changes in the original plan, etc. The following sections analyzes these changes in detail.

5.2 Time Overrun

They were several reasons for delays in this project. The project was initially scheduled to be finished at the beginning of the fall semester (August, 2018). However, it was delayed for almost four months due to extreme and untimely weather. The project also had some design issues. Initially some rooms in the building were meant to have a vertical shutter, more specifically the kitchen area. However, a horizontal shutter was installed. Therefore, resulting to a vertical shutter that to be re-installed on the site costing some redesign on the 3rd floor of the building.

5.3 Cost Overrun

The cost overruns in this project came from extra spending on the shutters and reconstruction. Moreover, the project faced many other implementation issues that resulted in delays and cost overruns. The cost of temporarily relocated facility for student cafeteria due to construction work was initially miss-budgeted, but eventually costed approximately $500,000. To add to that, a lot more money was spent for ongoing maintenance of this temporary facility.

The total project cost at evaluation was supposed to be 39 million dollars, but with various project delays and cost overruns, the final project cost at completion was 42 million dollars. This is a 7.69% increase more than the appraisal prediction as indicated for project A29 in table 4.5.

5.4 Fishbone Diagram

Based on the classification schema for delay categories in chapter 4, the researcher conducted a fishbone diagram analysis to show the factors that caused time delays and cost overruns for project A29. The fishbone diagram can be used to optimize existing processes that

caused these critical delays and cost overruns during the construction of project A29. Particularly, Figure 5.1 (Fishbone diagram) displays the factors that affected the project such as weather, insufficient funds, administrative reshuffle, inaccurate design and improper planning.

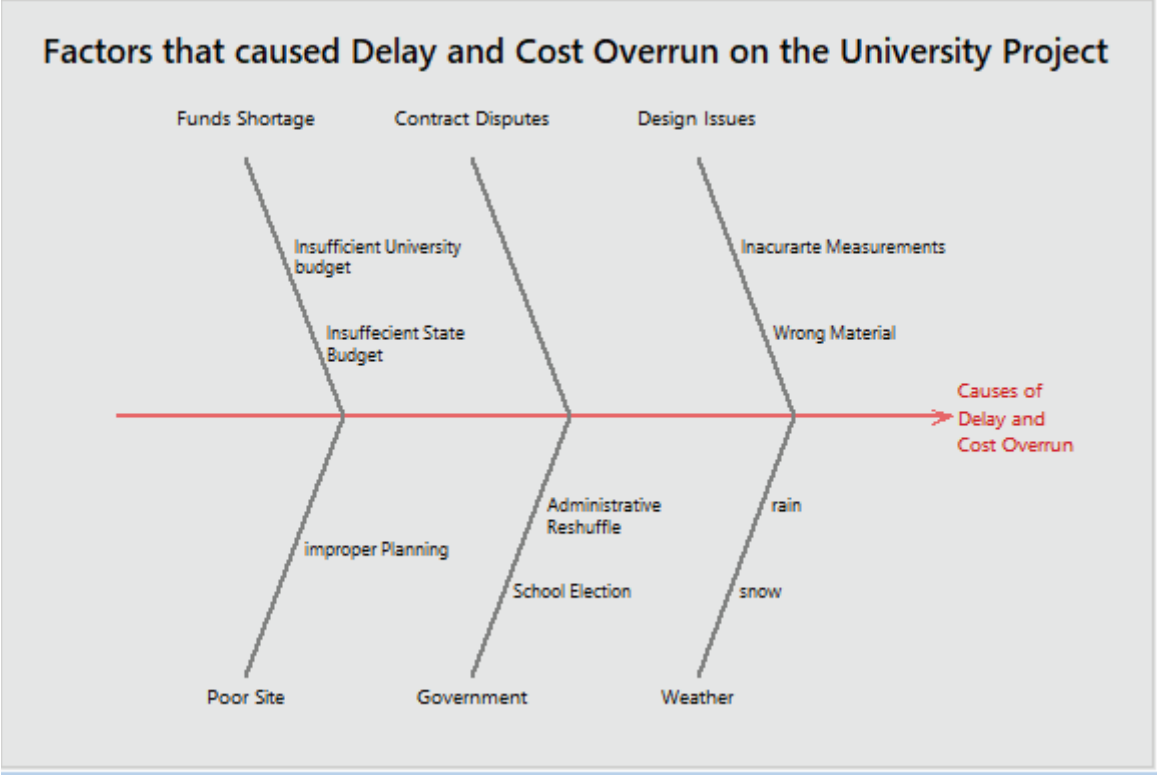

Figure 5.1 Fishbone diagram analysis for project A29

Chapter 6 Conclusions and Discussion

6.1 Overview

This research discussed the causes and effects of construction delays and has contributed to the understanding of how delays in a construction project can lead to cost overruns. The causes of delays and their effects on project cost and schedule are usually complex and influenced by numerous interrelated factors. The potential causes of changes as categorized in this research included lack of understanding and incorrect interpretation of customer's requirement such as poor technology, consultant-initiated changes, inaccurate information, inadequate resources, stakeholder's inconsistency, improper coordination, numerous construction projects going on simultaneously, complex design details, contract disputes, and contractor-initiated changes. The most frequent and severe effects of variation orders in construction projects are increase in construction costs, increase in construction time, stakeholder's dissatisfaction and sometimes, project failure.

Additionally, several projects were examined and studied to classify the project delay categories and to show the correlation between time delays and cost overruns. The researcher focused on 29 projects. Each project was unique and had a distinct time delay and cost overrun associated with it. Also, the analysis of differences between the initial projected costs and final costs for selected projects was presented. Finally, the researcher focused on a case study to demonstrate how delays and cost overrun affected a specific construction project from the selected list of projects.

6.2 How to Plan for Project Delays and Cost Overrun

In a study done by researchers it was concluded that the best way to manage change orders is to reach a negotiated solution between the different parties. So therefore, when a project change is initiated in a construction project it is a common perception that delays are undesirable and that the duration should be as close to zero as possible (Soares, 2012). However, a contractor should always expect possibility of a delay and should strive for an optimum number of project changes that will ensure that time and cost are met at the stakeholder's satisfaction. The project construction manager should always start planning early in the project since the planning stage is the most influential stage in the project life cycle from the cost, duration and quality of the project perspectives. All parties involved such as the engineering, cost and scheduling, procurement and logistics, maintenance, operation, and construction groups should prepare a detailed project plan in coordination with the project manager. The project plan should include some of the following topics listed below.

The project objective should be clearly identified and agreed upon by the stakeholder to avoid any confusion in future. The time schedule should allow for an orderly execution of the planning, design and construction phases required for the project. the design phase should allow for several scheduled reviews by the stakeholder to ensure that the objective is met. Another plan involves a risk plan that identifies the risk, evaluates the probability of their occurrence, and estimates the consequences. It should also address the time available for executing the project.

Cost plan is another plan that needs to be proposed before the start of a project. This plan should include a well-documented cash flow chart and initial cost estimate that includes allowances and possibilities based on the scope of work and reflecting the quality of information on which it is based. This plan usually involves refences to risks, whether they will be avoided,

or how it can be avoided. The cost of each risk item in this plan should also be distributed throughout the cost estimate spanned over the entire duration of the project. In addition, the management plan, this plan includes how the project will be managed. It also states who can initiate, review and approve changes during various phases of the project. A responsibility matrix and a flow chart usually illustrate this plan very well.

Lastly, researchers like Forbes and Ahmed (2011) have usually tried to identify ways that changes can be handled and planned as to avoid confrontation and disagreement. The causes of delays can result in a lot of discomfort, therefore the management should start working early on a detailed project plan that includes the items discussed above: a precise project objective, project scope of work, time plan, risk plan, cost plan, and lastly but not the least management plan. By proper implementation of this comprehensive project plan, a project can be completed more effectively within the budget, schedule, and scope requirements.

In conclusion, in today's construction marketplace, profit or loss is often dependent on how effectively the change order process is managed. Since changes in a construction project can lead to delays and cost overruns it is better for a construction management, stakeholders and all parties involved to have a well-organized plan. Thus, the early recognition of a project change is crucial to tackle the obstacles that come along.

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