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AN ANALYSIS OF CHANGE ORDERS IN PUBLIC SCHOOL PROJECTS

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Abstract: In the construction phase of Design-Bid-Build projects, change orders are among the important aspects that can affect the success of the projects. Change orders in any project adversely affect the project cost and schedule performance. Therefore, change orders should be controlled in order for greater success of the project. It is very important to determine change order costs in new and modernization projects as well as the association between the change orders cost and construction cost growth and schedule growth. This study statistically compared change orders for 171 modernization projects and 98 new projects in public schools built by the Clark County School District (CCSD) of Nevada and constructed from 2001 to 2009. The study collected the total cost of change orders, bid cost, final construction cost, bid duration, and final completion duration of modernization and new school projects. The analysis of variance (ANOVA) and Pearson Correlation tests were used to determine the statistical difference in change order costs and also the association between change order costs and both the construction cost and schedule growth of these projects. The findings of this study are presented in this paper.

Key Words: Design-Bid-Build, change orders, public school projects, new construction projects, modernization projects

1 Introduction

Both the public sector as well as private owners are equally involved in the construction projects. Infrastructural projects seem to heavily dominate the public sector; private owners are more involved in the construction of industrial, commercial, and residential buildings. In spite of differences in the client demand and the construction environment, the ultimate goal of both types of construction work is to complete the project on time and within budget. In the process of doing that, various factors affect the performance of the construction projects, among which the most important is change order.

1.1. Definition of Change Order

According to Scott (1999), “A change order is a change for work not included in a contract's scope of work.” This particular definition of a change order includes the condition during the time when the scope of the work changes. But in general, change orders are not limited to this requirement. For example, in the case of building construction, codes issues can be a cause of the change order; in such cases, the scope of project remains intact.

Jackson (2004) defined a change order as “Once the contract is signed, both parties must live with the terms of the contract, and any flaws, errors, or omissions in the plans and specifications will result in a change order.” However, this definition does not consider any kind of unforeseen conditions that might be a source of the change order.

According to White (2007), “The term ‘change order’ refers to the formal method by which contract documents for a construction project are modified.” In reality, however, some conditions occur for which a change order is issued without any modification in the original contract. Sun and Meng (2009) state that, “In construction projects, a change refers to an alteration to design, building work, project program or other project aspects caused by modifications to pre-existing conditions, assumptions or requirements.” The authors limit the term ‘pre-existing conditions’ to conditions that are already known, and do not mention anything about unforeseen conditions.

This paper defines a change order as any cost or time regarded as an addition, a subtraction, or an alteration by the parties involved in the contract during the duration of the project. Change orders caused by reasons beyond the scope of the above definitions have not been used in the analysis.

1.2. Quantification of Change Order

The quantification process is one way to take a closer look at change orders. The common quantification methods usually employed in analysis are direct impact and cumulative impact (Ibbs et al. 2007). It is clear that the cumulative effect of change orders is always greater than the direct individual impact (Dunn III 1999; Hanna et al. 2002; Ibbs and McEniry 2008). When a change order occurs during the construction phase, it is quantified by calculating how much money it will take and how long it will take to incorporate the changes compared to the original target. As the change order might change both the cost and time or either one of them, the current condition of the project also changes with the new conditions. It is difficult for anybody to quantify the new conditions due to a change order before it occurs. Therefore, cumulative analysis is indispensable for any project involving change orders.

The effect on time of a change order can be analyzed based on its effect on the schedule of the project. In most cases, the schedule is determined by Critical Path Method (CPM). Unless the change order affects the critical path, it is difficult to analyze the overall performance of the project. In most cases, the schedule change is not recorded unless it impacts the critical path. Also impacted by change orders is productivity. When new and unforeseen conditions are induced by change order, the project conditions become more aggravated. Therefore, quantification of the change order should be done accurately in terms of the effect on schedule and labor productivity.

1.3. Change Orders in Clark County School District

The working definition of a change order in the context of the CCSD office from which data was collected for this study is as follows: “A change order is a written document signed by all parties to the construction contract indicating agreement on a change in the scope of work, any adjustment to the contract amount, and/or any adjustment to the contract duration.” CCSD office classified the change orders under five categories, namely a) unforeseen conditions, b) requirements levied by government agencies, c) value-added design deficiencies, d) no-value-added design deficiencies, and e) owner requested. The total change orders were calculated by the summation of the amount of changes due to these five categories.

‘Unforeseen conditions’ covers all the change orders for adjustments identified during the construction phase due to new situations in the construction environment. Any rerouting or repairing of underground utilities; and unanticipated conditions identified inside walls and ceilings are few examples of this kind of change orders. The ‘requirement levied by government agencies’ are change orders introduced during the approval of the permit or installation of underground utilities. ‘Value-added design deficiency change orders’ include mistakes, oversights, or inconsistencies in the design drawings or specifications that would result in additional work/days when incorporated in the contract document. ‘No-value-added design deficiency change orders' are caused by same reasons and situations, but do not result in additional work/days. 'Owner requested change orders' are those changes introduced in the project because of a new requirement by the owner during construction. Normally in any kind of project, 10% contingencies are provided for in order to support any unforeseen expenses in the project. Therefore, the cost of a change order can be compensated by using the contingency fund.

1.4. Objectives of the Study

Despite the great effort from the public sector to avoid change orders and utilize public money spent in school construction projects efficiently and effectively, change orders are inevitable. The main objectives of this paper are as follows:

a) To statistically compare the amount of change orders that have occurred in new and modernization construction projects for public schools, and
b) To correlate the change orders with the construction cost and schedule growth in new projects.

2 Literature Review

Various researches had been conducted related to causes, impacts and remedies of the change orders. Table 1 describes the major findings of the studies related to the impacts of change orders on cost and schedule overrun.

Table 1: Brief Summary of the literature overview

Researchers	Sample Size	Project types	Major Findings
Ndihokubway and Haupt (2008)	2	Apartments Complexes	This case study of two projects showed that the change orders impacted the schedule of the projects. The first project had 7.1% change orders, and it overran the schedule growth by about 33%. The second project had 3.3% change orders, and the project schedule growth was about 9%.
Randa et al. (2009)	22	Large building constructions	The survey results from 11 contractors and 11 consultants revealed that the cost and the schedule were the top two performance metrics impacted by change orders.
Alnuaimi et al. (2010)	4 projects and 43 respondents	Water transmission, building, road and port projects	The analysis of water transmission, buildings, roads, and port projects showed that the owner's modification and the design change were the main reasons for the majority of the change orders. The survey responses from owners, consultants, and contractors showed that schedule delay, disputes, and cost overruns were the top three ranked effects of change orders.

3 Methodology

To achieve the objectives mentioned above, the required data for new school construction and modernization of existing schools were collected and analyzed statistically. The data were analyzed using statistical tests called Analysis of Variance (ANOVA) and Pearson Correlation Test. Details of the data collection process as well as the analysis of these data are described as follows.

3.1 Hypothesis

Shrestha et al. (2012) found a significant correlation between the amount of change orders and the types of projects (new and reconstruction). Also, several studies showed that the change orders impacted the cost and schedule of the projects (Ndihokubway and Haupt, 2008; Randa et al., 2009; Alnuaimi et al., 2010). Based on these findings, the following hypotheses were developed for this research.

a) Research Hypothesis 1: The mean total change order in new projects is significantly different than the mean total change order in modernization projects.
b) Research Hypothesis 2: The mean number of days added in new projects is significantly different than the mean number of days added in modernization projects.
c) Research Hypothesis 3: There is a significant correlation between the total change order and cost and schedule performance of new projects.

These research hypotheses were converted into null hypotheses to conduct the statistical tests. For each and every hypothesis mentioned above, a null hypothesis was generated. In each null hypothesis, the mean values for different data series were considered to be equal. For null hypothesis to be false, the p-value should be less than or equal to 0.05.

4. Data Collection

The data required for the analysis were obtained from CCSD in southern Nevada. The data collected were for the modernization of the existing schools and the construction of new schools. Modernization projects included upgrading the plumbing, the heating, ventilation, and air conditioning (HVAC) systems, lights, and fire alarms. Also categorized under modernization were asphalt, concrete, and drainage projects as well as upgrading the various school facilities, such as athletic courts. New school projects involved any new facility construction that did not have an existing structure prior to the project.

An excel summary report prepared by CCSD for the Clark County Board of School Trustees was scrutinized to find the following information: a) project identification numbers, b) description of the projects, c) location of the projects d) contractors' names, e) the original contract amounts, f) the total amount of change orders due to all types of causes, and g) additional days added due to change orders. Despite a repeated effort to find data for original estimated costs and time schedules for modernizing schools, this data could not be collected. The data collected consisted of a total of 269 projects that had equal to or over a $500,000 award contract amount. Out of 269 projects, 98 were new projects and 171 were modernization projects.

5. Data Analysis

Descriptive statistics were used to show the variation of the total change order amounts between the two project groups. The percentage of total change orders with respect to contract amount was calculated, and the variation of total change orders between project groups were statistically tested using the ANOVA test. The Pearson correlation test was used to determine significant correlations between the total change orders and both cost performance and schedule performance. Because data was missing for the original estimated cost and time schedule for the modernization of the school projects, the correlation between the change orders and cost growth or schedule growth for these projects could not be performed.

The new projects were built between 1999 and 2009. About 84% of the projects were constructed in the years 2000 – 2006. The data showed that number of new projects started decreasing from 2005. The 'notice to proceed' for new school construction projects is shown in Figure 1.

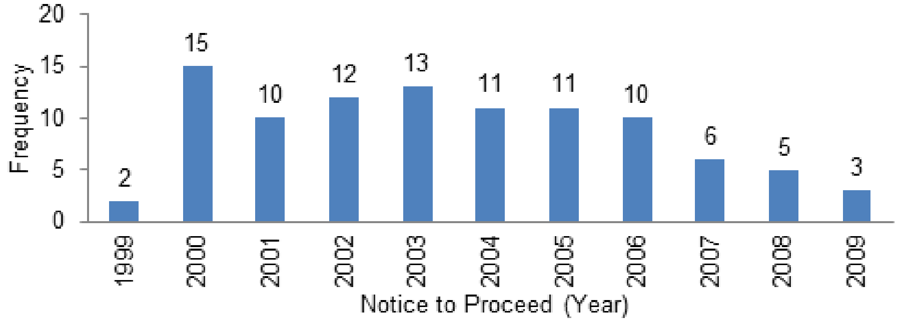

Figure 1: Histogram of the 'notice to proceed' year for new school building projects

Table 2 shows the total cost of construction – which is the cost of the project at its completion, including all the types of change orders – and the descriptive summaries of the two project categories.

Table 2: Descriptive Statistics of the Total Project Construction Cost

Descriptive Statistics	Total Project Construction Cost	
	New ($)	Modernization ($)
Minimum	668,288	526,178
Maximum	90,573,602	49,412,218
Median	17,898,509	2,000,000
Mean	22,041,767	4,600,197
Standard Deviation	18,314,025	7,829,897
Sample Size	98	171

The total construction cost for new schools ranged mostly between $5 million and $25 million (Figure 2). Only a few projects total cost was above $40 million. The project costs for the modernization of existing schools normally ranged from around $0.5 million to $5 million (Figure 2). The number of modernization projects whose cost ranged above $40 million was very small compared to projects costing below $5 million. Therefore, one conclusion was that because modernization projects did not involve new design and planning, the project cost of modernization projects were less than the project cost for new school construction.

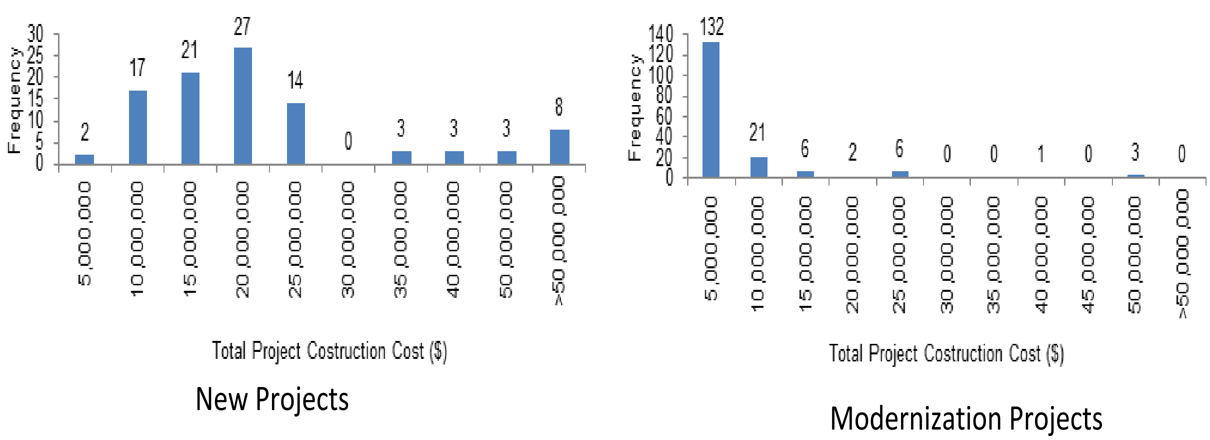

Figure 2: Total cost of new and Modernization projects

Based on detailed study of the data available for the number of additional days required to complete the project, regardless of the amount of change order, it became clear that a new construction project needed more additional days as compared to a modernization project. Similarly, the descriptive statistics of the total change orders in new and modernization projects, as shown in Table 3, indicates that the median and mean total change orders of new projects are higher than the median and mean of modernization projects.

Table 3: Raw Data for the Total Change Order

Descriptive Statistics	The Total Change Order	
	New Projects ($)	Modernization project ($)
Minimum	-58,897	1,334,605
Maximum	17,483,653	3,876,313
Median	637,148	45,051
Mean	1,238,600	231,641
Standard Deviation	2,036,962	565,825
Sample size	98	171

The total change order is expressed in a ratio between the cost for the total change orders and the total completion cost of the projects; this ratio is formulated in Equation 1:

$$\text{[1]} \qquad \text{Total Change Order (\%)} = \frac{\text{Total Change Order Cost}}{\text{Total Construction Cost}} * 100\ \%$$

Table 4 clearly depicts the descriptive statistics of the total change orders in new and modernization projects. Although the mean difference between new and modernization projects is small, the difference between the median values is large.

Table 4:1 Descriptive Statistics of the Total Change Orders

Descriptive statistics	Percentage of the total Change Order	
	New (%)	Modernization (%)
Minimum	-3.40	-25.8
Maximum	21.0	71.3
Mean	5.22	4.46
Median	3.83	2.61
Stand dev.	4.66	8.60
Sample size	98	171

5.1 Cost Performance Metrics Statistics

The cost performance metrics include percentages in terms of total cost, award cost, and estimated cost. These metrics are used to determine the cost variations due to each change order in the new construction projects. The contract award cost growth and total cost growth were computed by Equations 2 and 3, respectively.

[2] $$\text{Contract Award Cost Growth (\%)} = \frac{\text{Contract Award Cost} - \text{Estimated Cost}}{\text{Estimated Cost}} * 100\ \%$$

[3] $$\text{Total Cost Growth (\%)} = \frac{\text{Final Construction Cost} - \text{Estimated Cost}}{\text{Estimated Cost}} * 100\ \%$$

About 91% of the new projects had a contract award cost growth in the range of ±20% of the estimated cost (Figure 3). In some instances, the contract award cost growth was as high as 340% and as low as -90%. However, the percentage of these occurrences was within the 2% range of the total number of projects. The uniform variation between the positive and negative values of contract award cost growth indicates an absence of a specific trend in cost estimation either in favor of contractor or the owner. Similar statistics were found in an analysis of the total cost growth, as shown in Figure 3.

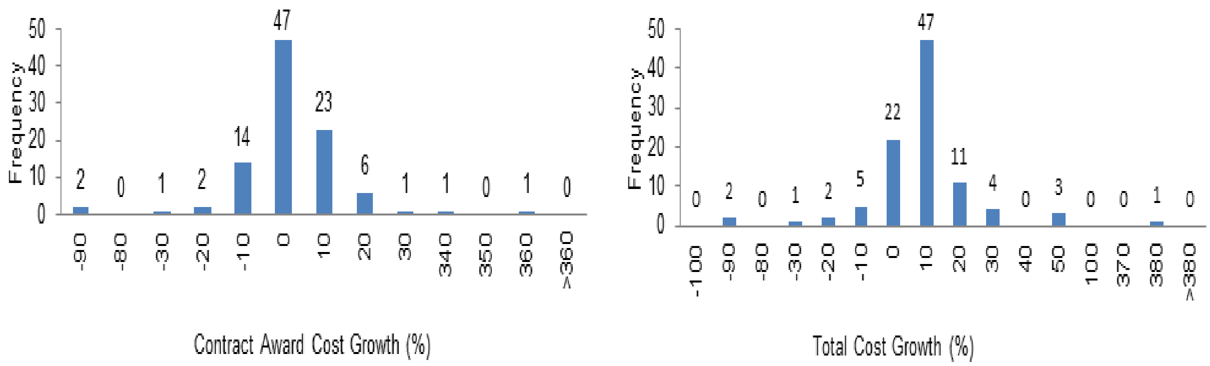

Figure 3: Contract award and total cost growth of new projects

5.2 Construction Schedule Metrics Statistics

Construction schedule growth is defined in Equation 4 as the percentage difference between the contract award duration and the final completion duration with respect to the contract award duration. The distribution of construction schedule growth of new projects is shown in Figure 4.

[4] $$\text{Total Schedule Growth (\%)} = \frac{\text{Final Completion duration} - \text{Contract award duration}}{\text{Contract Award duration}} * 100\ \%$$

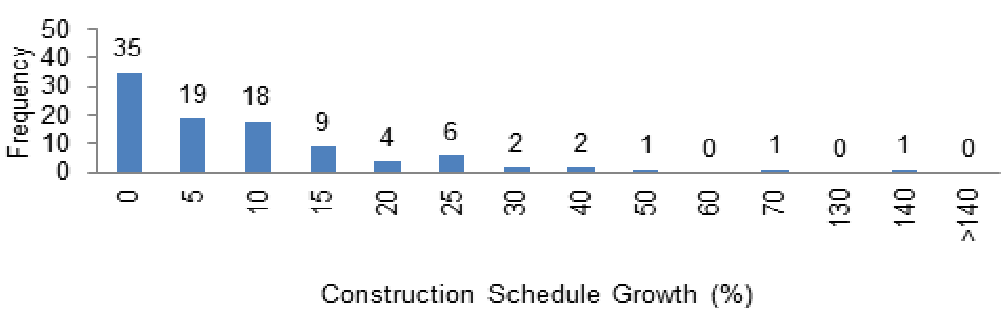

Figure 4: Construction schedule growth of new projects

5.3 Single Factor ANOVA test

To test the statistical differences between the total percentages of change orders for the two different types of projects, ANOVA analysis was used. The ANOVA result for the samples sizes 98 new and 171 modernization projects are given in Table 5. The results showed even though the change order is higher in new projects than in modernization projects, but it is not statistically significant at alpha level 0.05.

Table 5: ANOVA Results for Change Orders

Change order metrics	Mean		F Value	p Value	F Critical
	New (%)	Modernization (%)			
Total change order	5.52	4.45	0.668	0.41	3.877

As the number of days added to the projects was available for both types, an ANOVA test was completed. Table 6 shows result of the ANOVA test for the number of days added in both new and modernization projects. The results of the table show no statistically significant differences between the two project types at a significance level (α) equal to 0.05.

Table 2 ANOVA Results for Number of Days Added

Change order metrics	Mean		F Value	P Value	F Critical
	New (days)	Modernization (days)			
Number of additional days	31.48	24.94	0.732	0.39	3.877

A box plot shown in Figure 5 for the distribution of the number of days added in new and modernization projects indicated that modernization projects had many projects with more than 1.5 times the quartile range of additional days per project than new projects. This indicates a greater amount of uncertainty for the duration of modernization projects.

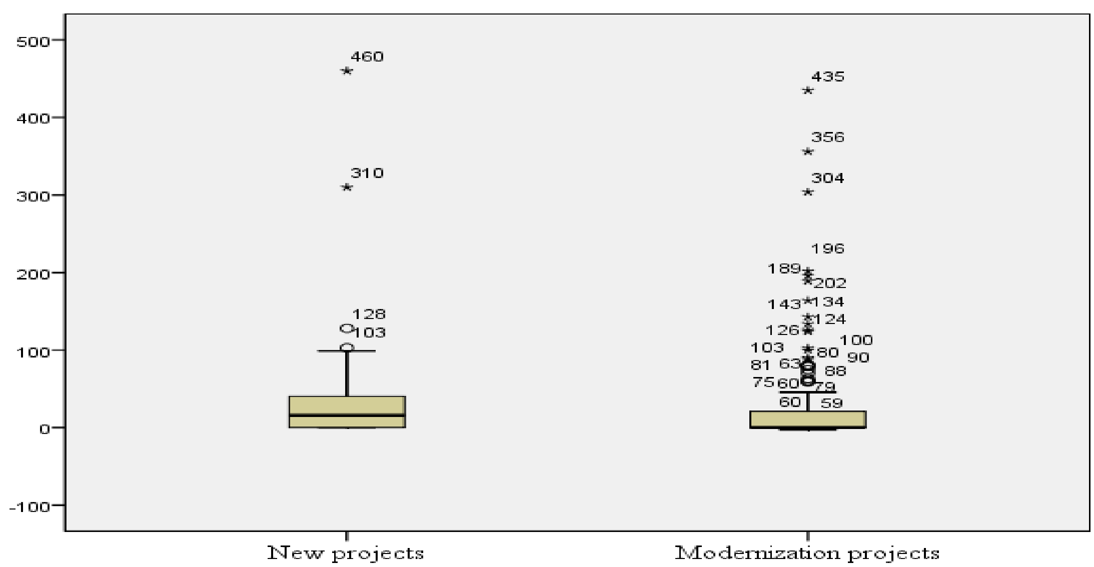

Figure 5: Box plot of number of days added

5.4 Pearson Correlation test

A correlation test was conducted to determine the correlation between total change order with award cost growth and total cost growth of new projects. Table 7 indicates that the total change orders are a random phenomenon, with no correlation between the award cost growth and the total cost growth. Due to data unavailability of estimated cost, this test was not conducted on the modernization projects.

Table 7:3 Results of Correlation between Change Orders and Cost Growth in New Projects

	Award cost growth		Total cost growth	
Independent variables	Pearson correlation coefficient	P-value	Pearson correlation coefficient	p-value
Total change orders	-0.004	0.971	0.125	0.222

Similarly, a correlation test between change orders and construction schedule growth was conducted of new projects. Table 8 shows that the total change orders has no correlation with the schedule growth and number of days added. This correlation could not be determined in modernization projects due to unavailability of estimated duration of those projects.

Table 8: Results of Correlation between Schedule Growth and Change Orders of New Projects

Independent Variables	Construction schedule growth		Number of days added	
	Pearson correlation coefficient	P-value	Pearson correlation coefficient	p-value
Total change orders	0.110	0.279	0.093	0.360

4 Conclusions

Based on the ANOVA tests, the change-order metrics of new and modernization projects showed no significant difference in the change order percentage between these two types of projects. Similarly, the mean number of days added in new and modernization projects was not significantly different between the project types at significance level (α) equal to 0.05. The results showed that even though new projects were larger in size when compared to modernization projects, the average days added in both types of projects were not statistically different. This may be explained by the fact that the time needed for amendments/revisions of design documents and drawings take same amount of time irrespective of the project size. The correlation test of new projects change order metrics with contract award cost growth and total cost growth showed no statistically significant correlation between these variables at α equal to 0.05. The absence of correlation of change order metrics with award cost growth negates the assumption that contractors try to compensate their low-bid price by generating more change orders during construction in public projects.

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