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Change Order Management System for Charter School Construction Projects

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Abstract This study develops a change order management system to decrease change management issues for charter school construction. A literature review of change orders causes, categorization, and change management practices were first conducted. A large set of change order data was compiled from several Texas Charter schools including five ground-ups, seventeen remodels and six capital improvements. A root cause analysis and a correlation analysis was conducted to better understand the recurring issues and the project correlated parameters that increase change order percentages and cause delays. The analysis of previous project change order data and best management practices were used to control, manage, and reduce change order percentages. Because of time limitation, 90% of the proposed change management practices were applied to one ground-up and three remodeling projects that were completed in August 2016. With the help of the proposed change management practices, all of these projects were successfully completed on time. Moreover, 21% and 24% reductions in change order percentages were achieved for ground-up and remodeling projects, respectively.

Keywords Change order management, Charter schools, Case study data, School construction

1. Introduction

The Texas Charter School Association defines public charter schools as tuition-free, open enrollment public schools that have the flexibility to adapt to the educational needs of individual students. These schools are also held to strict state academic and financial accountability standards (Texas Character Schools Association 2013). The National Alliance for Public Charter Schools, the enrollment in public charter schools has increased six times during a period of 15 years (National Alliance for Public Charter Schools 2016). The high demand for charter schools in the U.S has increased the need to construct new facilities and renovate existing ones. One of the largest Texas charter schools has completed 6 ground-up, 20 remodeling & expansion, and 6 capital improvement projects in the last four years to accommodate the high demand for charter schools.

It is inevitable that construction projects experience change orders that cause delays and cost overruns. A change order is a "formal directive change to a construction contract that typically includes a modification in work scope, an adjusted contract price, and any changes to the time to perform the work" (O'Brien, 1998). According to the Construction Industry Institute(CII), change orders may interrupt work flow, create delays, cause schedules to slip, inflate costs, lead to missed commitments, generate claims, result in costly litigation, impact productivity and morale, cause the loss of future opportunities (CII 2015). Moreover, one of the biggest change order causes is the unsuccessful project scope in terms of development, documentation, and controlling (CII 1995). That's why CII (2015) reported the following best practice: "Placing an early and comprehensive focus on developing a project's scope, followed by establishing and following a disciplined procedure for controlling scope changes will significantly reduce the number of changes during project execution." One important impact of change orders is construction inflated costs that directly affect the financial standing of charter schools. The change order percentages for the case study charter school construction projects were 15.33%, 11.71%, and 16.03% for the academic years 2014-15, 2013-14, and 2012-13, respectively. Another important impact of change is construction delays that may cause schools to open late and student enrollment number to decrease. Since the number of students is directly related to the funds that are provided by the state. Therefore, losing students will cause a reduction in state funding.

Researchers have highlighted the importance of developing better change order management systems to mitigate the negative impacts of change orders. Karim and Adeli (1999) have developed an object-oriented change management system to continually monitor, analyze, and approve change orders. Park and Pena-Mora (2003) have

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developed a model-based change management system to analyze change impact on project performance according to change characteristics, discovery status, and time. Love et al. (2002), Chan and Leung (2004), and Chen (2008) have developed other change order management methods and systems. While significant contributions were made in the area of change management research area, there has been little or no reported research focusing on charter school construction projects.

The lack of effective change management systems and clear understanding of the impact of change orders can be detrimental to charter schools. The objective of this paper is to develop and implement a change order management system for charter schools to reduce the number and impact of change orders in their construction projects. This paper contributes to the development of effective change order management systems for charter schools using data analysis of change orders from previous construction projects and proven change management practices. The developed change order management system was implemented and validated using 32 projects (6 ground-up, 20 remodeling and extension, and 6 capital improvement).

2. Background

Change Order Causes and Categorizations

Project changes are inevitable even if all project documents are complete and without errors. The main causes for change orders were reported as owner directed changes, unforeseen conditions, design errors/omissions, code requirements, and value engineering. The Construction Industry Institute (CII 2015) reported that the root causes of construction changes are classified into two categories, namely, Project Development Changes (PDC) and Scope Changes (SC). A PDC represents a change to the original work scope or process basis as defined by the owner. On the other hand, a SC refers to the changes in the base work scope or process basis as defined by the owner. Moreover, a SC can be mandatory or discretionary. The mandatory scope changes represents the modifications to comply with regulatory, safety, or legal requirements and meet owner's requirements (CII 2015). On the other hand, a discretionary change is non-mandatory one that alters the premise, process, capacity, location, or schedule. It can also be a contract strategy change to more effectively implement the work plan.

Owner-directed changes

Owner-directed changes can be defined as project scope changes. Gunhan et al. (2007) reported that owner-directed changes are the most straightforward to process because they do not lead to a dispute about their necessity. However, change orders have impacts on the project schedule, logistics, finance, and design. These issues should be considered before approving the changes (Gould and Joyce 2009). To make the right decision, project managers should check if the requested scope change is mandatory or discretionary. If it is mandatory, it should be approved. If the change order is discretionary, a Return on Investment (ROI) analysis should be performed to determine whether the change is desirable or not.

Unforeseen Conditions

Unforeseen conditions change orders occur due to discovered or previously undisclosed existing conditions such as unexpected soil variations or uncovered conditions during alteration to an existing structure (Doyle et al. 2008). Hsieh et al. (2004) reported that unforeseen conditions result from "insufficient site investigation by the design party, or additional requirements for underground improvements or enhancement of underground monitoring/sensing, and differing underground condition or underground seepage after excavation".

Design Errors/Omissions

Design errors/omissions type change orders are due to omissions in the contract documents or design features (Stone et al. 2011). Hsieh, et al. (2004) reported that the responsibility for design errors/omissions type change orders normally falls on the side of the planning and design party. Moreover, Gunhan et al. (2007) reported that change orders resulting from improper design are due to the failure of the designer to adequately specify all project components to an acceptable level so that the contractor can proceed with construction.

Code requirements

City or County inspectors may request design changes due to code violations once they have inspected the building (Stone et al. 2011). Hsieh et al. (2004) reported that public works often endure an extensive schedule for planning, design, and construction. The longer the project's duration, the more likely it is susceptible to changes related to work rules and regulations. The work rules or regulations in force during the initial planning and design periods may be revised by the governing agency later during the construction stage.

Change Order Impacts

Gunhan et al. (2007) reported that projects with change orders are usually prone to delays, cost increases, and reduced labor productivity. Change orders have in most cases negative impacts. Moreover, change orders may interrupt the work flow, create delays, cause schedule slips, increase costs, result in costly litigation, reduce labor productivity, and lead to loss of future opportunities (CII 2015). Gunhan et al. (2007) reported that increased costs cause conflicts between the parties ending up in costly disputes. Change orders affect project duration especially if they are directly related to the activities on the schedule critical path. The project planned date will slip if the extra work extends or postpones the completion of critical activities. However, the completion date of the project does not change if the additional work is not found critical (Bolin 2017). CII (1995) reported that there is a significant

correlation between the amount of project changes and labor productivity during the design and construction phases.

Change Order Management Practices

The AIA and CII change order management systems were reviewed to understand how the change order process starts and how it is processed.

The AIA best practices (AIA 2007) reported two ways to process change orders, namely, Proposed Change Order (PCO) and Construction Change Directive (CCD). PCO is a tool for tracking on-site changes that document the process thoroughly. PCO helps to prevent late or unforeseen claims and maintains open communication (AIA 2007). The Request For Information (RFI) becomes a PCO when a change in the project cost or duration is required. Moreover, the contractor needs to send the PCO to the subcontractors that are affected by this change. When the proposed change affects the cost and duration of any subcontractor, the contractor collects all documentations and prepares and submits for review a change proposal with all backup documents to the architect and owner. Backup documents include RFI, subcontractor backup documents, and a price quotation breakdown showing unit prices, extended prices, fees, and markups. The architect examines the PCO to see if it affects the work scope and if its price is fair. After the review process, the architect accepts the PCO "as-is" or requests its revision. Finally, the PCO is sent to the owner if the architect approves it "as-is". If he does not approve it, the architect requests that the contractor modifies the PCO or provides more information.

Project managers should be involved in the PCO process at an early phase, instead of reviewing the change order after it has been submitted. If the RFI requires a change, the owner's project manager may request from the architect other solutions that will not affect the project's schedule and cost. However, eliminating the change may not always be possible. If the change occurs, the owner representative and the architect may discuss and come up with a solution on how to minimize the cost, delay, and side impacts.

The Construction Change Directive (CCD) is used when the change order will delay the project completion time, and the team agrees on the necessity of its modification. The GC submits a CCD request instead of an RFI. At that time, the architect and owner discuss the importance of the change and come up with a solution if they agree on the CCD. The contractor completes the change order and submits the cost when the CCD is approved. The architect modifies or cancels the CCD when the owner does not approve the CCD (AIA 2008).

On the CCD document, the owner may request the GC to include unit prices for the required work scope and get these unit prices reviewed and agreed upon. If there is any unknown scope in a specific part of the required additional work, the owner's project manager may request the GC to include it not exceeding the allowance for that specific job portion. That way, the owner's project manager can be more comfortable to sign CCD with less unexpected costs.

According to CII Best Practices, changes can be managed by implementing a disciplined and formal change management process that follows five principles, namely, promote a balanced change culture, recognize change, evaluate change, implement mandatory and desirable project changes, and continuously improve through lessons learned (CII 2015).

At CII's change management model, the process starts with promoting a balanced change culture: "A balanced change culture exists where beneficial changes are encouraged, and detrimental changes are discouraged". The change order itself is not a bad thing but the disturbance comes from the change cause issues. The changes that can be made without disturbance can be useful.

The CII process continues with recognizing the change. Project owners should be educated to acknowledge the difference between mandatory and discretionary changes. Applying specific and disciplined processes is crucial for managing change. The RFI process should be explained, and official documents should be prepared. RFI tracking, review, and resolution process have to be followed. After the RFI is recognized as a change, the standard documentation must be prepared and shared with each stakeholder (CII 2015).

After recognizing the change, the process continues with its evaluation. At this phase, a change order should be classified as required and discretionary. Required changes are the ones that comply with the city codes and regulations or safety reasons. Discretionary changes are the ones that are not mandatory and could be done if the return on the investment is satisfactory. A detailed evaluation of the change must be accomplished by the given schedule changes. The involvement of all stakeholders is required for the timely and precise estimation of the impact of the changes. After evaluating the change decision on the formal approval or disapproval of the change should be made. Before implementing the change, the authorization of the change should be mandatory, timely, decisive, and documented.

The CII change management model continues with implementing the change phase that necessitates the use of a formal management process with standardized procedures. Based on the project-specific requirements, these procedures should be modified, and all project participants should get used to these procedures. The project participants should be flexible given the unique demands of the situation. Common sense, good faith, honesty and consideration of change impacts should be used. Well documented change evaluation, recording and authorizing the change punctually is crucial for the project success. Project managers should not expect for changes to be resolved on their own; they should be proactive and decide on authorization to proceed (O'Brien 2008).

According to the CII Change management final phase, the system should constantly be improved through lessons learned. Lessons learned discussion and documentation should be implemented at the end of each step of the project lifecycle. At least, a close-out critique of the project should be executed to evaluate changes and their impact on design,

construction, start-up and operating performance cost and schedule. The goal of the lesson learned process is to enhance a culture of continuous improvement in the organization. Therefore, future projects will not have to deal with similar project change disruptions (O'Brien 2008).

Change Order Management Processes and Systems

Zhao et al. (2009) reported that change order management systems are developed to resolve problems when changes occurred in a project or minimize changes that may occur and disrupt the progress of the project. These systems forecast possible changes, identify changes that have already occurred, plan for preventive measures, and coordinate changes across the entire project among all stakeholders. Besides addressing the impact of changes, an effective change management should also look into the cost, time and quality considerations for the project.

Motawa et. al. (2007) reported that inconsistent management of the change process can result in many disruptive effects. Moreover, major source of contract disputes arise lif changes are not resolved through a formalized change management process, which may lead to project failure. Hwang & Low (2012) reported that a change management process conists of four basic principles: (1) identify changes; (2) evaluate changes; (3) implement changes; and (4) learn from past experiences. These four principles work together to achieve the objective of an effective change management system.

Motawa et al. (2007) reported that the development of change management systems needs to include various factors such as project processes and all the internal and external factors that influence project changes. Sun et al. (2006) proposed a change management toolkit for construction projects, which include a change dependency framework and change prediction and workflow tools. On the other hand, Lee and Peña-Mora (2005) and Motawa et al. (2007) established a system dynamics integrated change management systems that can evaluate negative impacts of errors and changes on construction performance. Moreover, Charoenngam et al. (2003) developed a management system with a change order procedure that involves workflows, documents, records keeping, and a centralized database. Similarly, Isaac and Navon (2008) devloped a model that identifies and quantifies possible impact of change orders on building construction projects. Lastly, Zhao et al. (2009) proposed a simulation method using Dependency Structure Matrix (DSM) to predict changes in construction projects, which identifies the sources of changes and verifies the effectiveness of the DSM model.

3. Methodology

As shown in Figure 1, the research methodology includes three main goals, namely, (1) analyze previous projects change orders data and current change management practices, (2) develop the best change management system for charter school construction projects, and (3) implement & document the impact of the developed system in reducing change order issues.

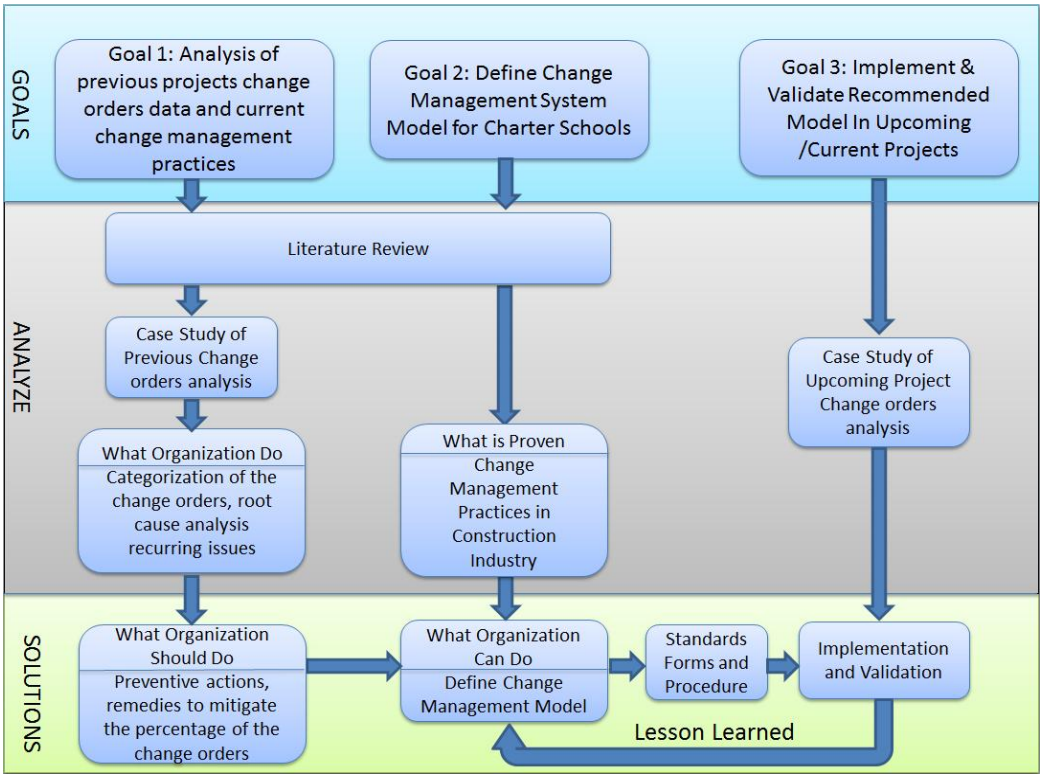


Figure 1. Research Methodology

Table 1. Change Order Collection Projects

	Change order data analysis				Change management system validation	
Project Type	**2012-13**	**2013-14**	**2014-15**	**Sub-Total**	**2015-16**	**Total**
Ground-up	0	3	2	5	1	6
Remodel	5	6	6	17	3	20
Capital Improvement	6	0	0	6	N/A	6
Total number of projects						**32**

A literature review was first conducted to investigate change order causes, impacts, and categorizations to gain a better understanding of the problem. Then, 212 change orders were collected from 28 charter public school construction projects, namely, 5 ground-up, 17 remodel and 6 capital improvement. It is worth noting that these projects have been completed between 2012 and 2015 as shown in Table 1. The collected data was analyzed to gain a better understanding of the recurring issues causing change orders in charter public school construction projects. A correlation analysis of the change orders was then conducted to find out if there is any correlation between change order amounts and contract prices, project sizes, project durations, and design durations.

These studies enabled to understand the major problems facing charter school construction projects and the corrective actions to mitigate them.

Moreover, a comprehensive literature review was conducted to gain a better understanding of proven change management practices in the construction industry. A change management system was developed for charter school construction projects based on the knowledge gained from the analysis of previous project's change order data and proven industry best practices. Finally, the developed change order management system was implemented and validated using one ground-up and three remodeling projects. The change order management system implementation lead to learning the pros and cons of the system and provided lessons learned metrics for its continuous improvement.

4. Data Collection and Analysis

Data Collection and General Data Analysis of All Projects

The first step was to gather, organize, and analyze the data that was taken from Texas Public Charter School projects that occurred during the time period between 2012 and 2015. The collected change order data included the following data: Project year, project name, project type, project size, contract amount, change order quantity, change order amount, change order percentage (i.e., change amount/ contract amount), project planing start date (i.e., architect agreement date), design duration, project start date, construction duration, delayed time, completion date, change order description, change order cause sub-classification, change order cause main-classification. Table 2 shows that the main change order causes were: owner request with 42.52% of grand total of change orders, code requirements with 27.43%, unforeseen conditions with 23.03%, city plan revisions with 12.71%, A/E/C requests with 6.03%, design errors and omissions with %1.27, and value engineering with -%12.99.

The total budget for all the projects was $40,461,588. Figure 2 shows that the total budget of the five ground-up projects was $23,920,101 (i.e., 59% of the total budget). The total budget of the seventeen remodel projects was $15,175,277 (i.e., 38% of the total budget). Finally, the total budget for the six capital improvement projects was $1,366,209 (i.e., 3% of the total budget).

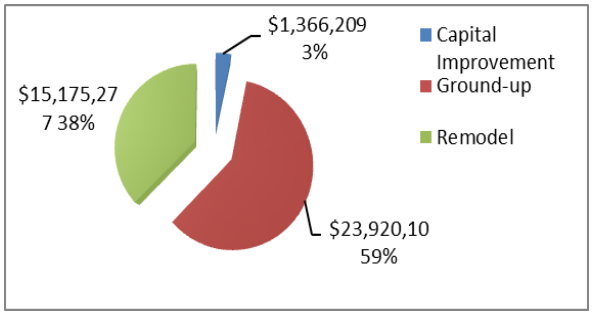


Figure 2. Total Project Amount Percentages

Table 2. Change Order Data Analysis Results

Project Types vs Change Order Reasons (COR)	A/E/C Requested	City Plan Revisions	Code Requirements	Design Error/Omission	Owner Request	Unforseen	Value Engineering	Grand Total of CO (GTCO)	Grand Total of CA (GTCA)
Capital Improvement			$ 259,612.00			$ 46,312.00		$ 305,924.00	$ 1,366,209.63
Ground-up	$ 205,209.86	$ 639,501.07	$ 1,042,708.62	$ 28,647.86	$ 663,777.78	$ 590,100.99	$ (6,045.00)	$ 3,163,901.18	$ 23,920,101.00
Remodel	$ 110,152.64	$ 25,883.00	$ 133,296.74	$ 37,710.00	$ 1,561,684.62	$ 568,951.45	$ (673,874.77)	$ 1,763,803.68	$ 15,175,277.85
Total COR	**$ 315,362.50**	**$ 665,384.07**	**$ 1,435,617.36**	**$ 66,357.86**	**$2,225,462.40**	**$1,205,364.44**	**$ (679,919.77)**	**$ 5,233,628.86**	**$ 40,461,588.48**
Percentage of COR/GTCO	6.03%	12.71%	27.43%	1.27%	42.52%	23.03%	-12.99%	**100.00%**	**N/A**
Percentage of COR/GTCA	0.78%	1.64%	3.55%	0.16%	5.50%	2.98%	-1.68%	**12.93%**	**N/A**

**CO: Change Order
**COR: Change Order Reason
**GTCO: Grand Total of Change Order
**GTCA: Grand Total of Contract Amount

Change Order Data Analysis

The analysis of the collected data showed that the main change order causes were: owner requests, code requirements, unforeseen, city plan revisions, A/E/C requests, design errors and omissions, and value engineering.

A root cause analysis was conducted for Owner Requested Changes. The analysis showed that the main causes of owner requested changes were insufficient early planning and the need for expedited construction and material. It also showed that the local admininstration request for modifications happened because of their limited involvement in the planning phase and their lack of construction knowledge. The root causes for the changes related to new scope additions were the cost to expedite the schedule due to the limited time to school opening. They were also due to the discovery of scope additions late during the construction phase. These changes can be reduced with early project scope development and standardization. They can also be reduced by considering in the scope of new projects the additions that were requested in previously completed projects.

The root causes for Owner Requested Expediting Fees were the limited time that was allocated to charter school construction projects to avoid missing opportunities to buy or lease good facilities and previous success on fast track projects. Moreover, construction and construction expediting is required to compensate for unexpected bad weather conditions and unpredicted longer city approval processes. Allocating longer time for construction, city approval process, and adding rainy days into the owner-contractor agreement would reduce the risk of not completing projects before the critical school opening deadline.

As shown in Figure 3, the code requirements related change orders occurred because of inspector requests and code changes during the project life cycle. When they inspect ongoing construction projects, city inspectors may find items that do not meet the code even though the city plan reviewer has already approved the drawings. At the final inspection, the fire marshals may require additional emergency lights, fire alarm strobes, and additional fire caulking because of safety concerns. Construction building codes or regulations met during the initial period of planning and design may be revised at a later construction stage by the governing agency. Code and regulations changes are more critical to the project during construction late stages. If they have good communications with the city officials and inspectors at the planning phase, the design team members might learn the expectations and possible code changes during the construction phase. As a result, the design team can include all code required items in the project drawings and decrease the possibility of receiving code requirement changes.

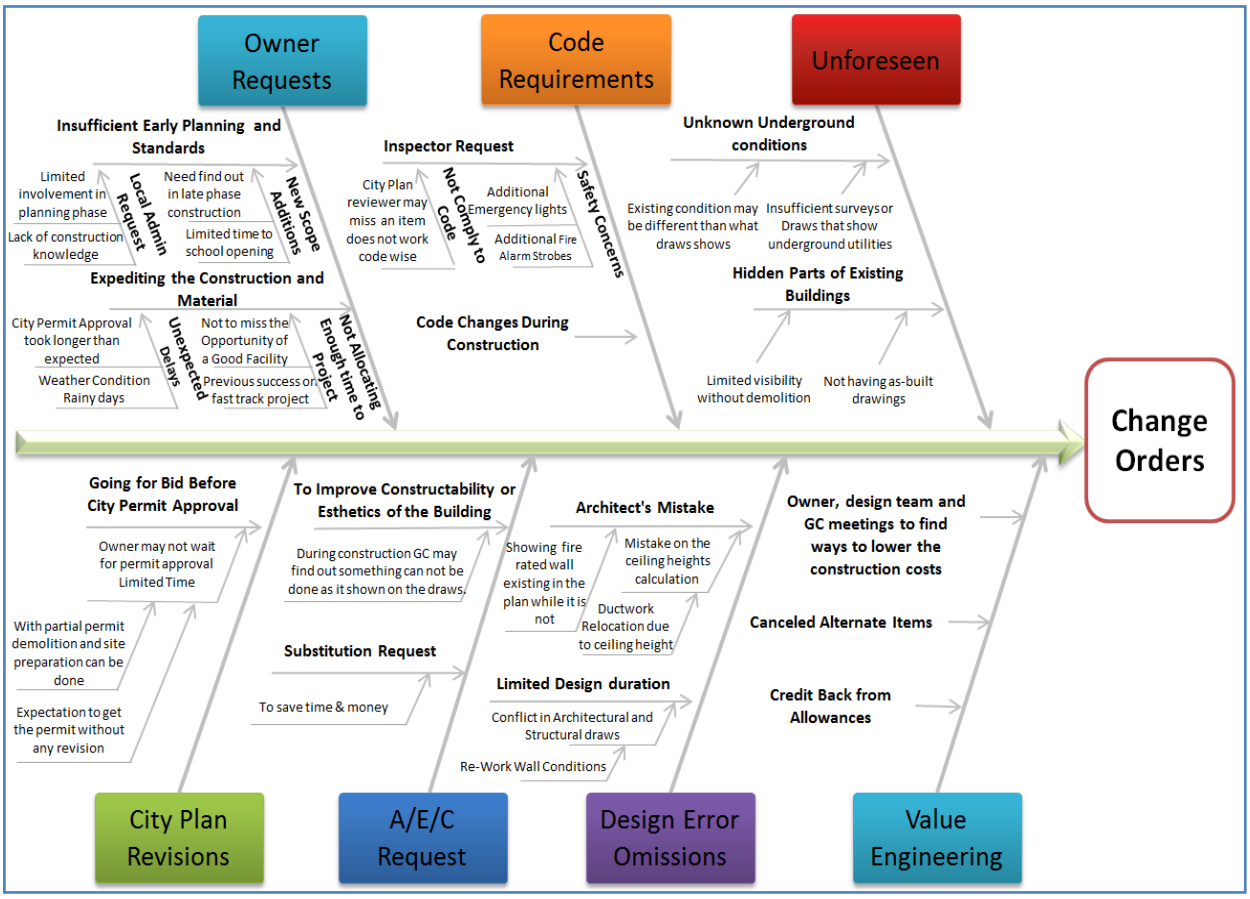


Figure 3. Recurring Change Order Root Cause Analysis

Unknown underground conditions and hidden parts of existing buildings may result in unexpected change orders. In the case study, unknown underground conditions occurred mostly in the ground-up project because existing conditions were different from what the drawings reflected. Inaccurate surveys and drawings that show the underground utilities may also result in change orders. For the remodeling projects, unforeseen change orders occurred due to lack of as-built drawings and limited visibility of the building parts when demolition is needed. For this reason, project architects could not include the necessary specifications in the drawings. To reduce the percentage of change orders, owners may request the design team to investigate the site to provide all needed surveys including, geotechnical reports, topographic surveys, and underground utilities surveys. If there are unknown sanitary/sewer lines underground, a camera review may be conducted to discover how these lines are routed. These additional surveys would reduce the risk of encountering unforeseen underground conditions.

City plan related change orders occurred because bid procedures were initiated before obtaining city permit approvals. The Charter School Facility and Construction Department should initiate bidding procedures after the submission of the drawings to the city by the architects because of the limited time allocation to projects. The department always hopes to obtain the permit without any city revision requests. Furthermore, after the submission of the projects to the city, the contractor would get a partial permit from the city because demolitions and site preparation can be done with partial permits.

On future projects, which lasts for 17 to 20 months instead of 11 to 13 months, city plan change orders were not an issue because the bidding process was initiated after obtaining city permit approvals. When the bidding is done after the permit approval, all the required changes on the drawings are done by architects during the city review process in order to comply and avoid potential change orders.

As shown in Figure 3, change orders occur due to A/E/C modification to improve constructability or esthetics of the building. During the construction phase, the general contractor may find out something cannot be done as it shown on the drawings. After they review the issue, the architect and engineer recommend a solution to the issue. Another reason for A/E/C change orders is a general contractor's request for a material substitution during the construction phase. In order to save time on long lead materials, these material substitution requests are submitted. Moreover, these requests are also submitted to exchange the material with a better quality substitute and also save money. These changes can be reduced by conducting a constructability review of drawings before signing a contract with the general contractor.

Design error/omission change orders had the lowest cost impact in the case study projects. A common example of an architectural mistake is the miscorrelation between fire rated walls identified and ceiling height calculations, which result in ductwork relocation. Due to the limited design time, architects may not have enough time to eliminate all conflicts related to architectural and structural correlations that cause wall related change orders. Design error/omission change order percentages can be reduced for future projects by documenting lessons learned and by preparing a drawing review checklist.

Contrary to other change orders, value engineering change orders provide credit to the owner. That's why, value engineering change orders are desirable changes at any given time. The analysis of the case study projects showed that value engineering change orders occurred when discussing the possible savings with the awarded bidder before signing the contract. Canceling alternate items and getting credit back from the allowance items are also another saving method. These change orders are beneficial to the project. That's why, owners should promote value engineering.

Change Order Data Analysis for Each Project Type

Ground-up Projects

First, the major causes of change orders for ground-up projects were mainly caused by city traffic light addition, fire Marshall's requests during the final inspection due to safety concerns, fire code compliance, and additional work for power connection, water line & meter installations. Owner requested change orders in ground-up projects were due to the need for expediting the project and adding new scope during the pre-planning phase. The city plan change orders occurred due to the fact that project bidding was done before city permit approvals.

The biggest issue on ground-up projects is construction delays due to change orders. Sixty percent of the projects were completed after the school opening date. Two of the projects were completed right before the school opening date.

The owner requested expediting project costs can be reduced by increasing the duration of future projects from 11 - 13 months to 17 - 20 months. Plan revision related change orders can be reduced by conducting project bidding after city permit approval.

Remodeling Projects

First, the major change order causes in the remodeling project were: owner requests, unforeseen, and value engineering. The owner requested change orders were the largest in remodeling projects. The main causes of the owner requested change orders were: new scope additions during the construction phase, project acceleration fees, finishing material changes, soccer fields, and roof renovations. The root causes of the unforeseen change orders were: limited visibility of the existing building without demolition, unavailability of as-built drawings, existing air conditioning units that could not repaired due to the unavailability of electrical power, and additional plumbing work due to unknown underground piping locations. The owner requested change orders can be reduced with early project scope development and standardization.

Capital Improvement Projects

Capital improvement project change order data was very limited compared to that of remodeling and ground-up projects. The total number of change orders was only 5. The change orders were received on 2 projects out of 6. An 84.9% of change orders were code requirement related while the remaining 15.1% were unforeseen related.

Code requirement change orders were the largest in capital improvement projects. An 81% of the change orders in capital improvement projects were related to air conditioning and roof renovation. The city requested HVAC roof screening that resulted in a change order that costed $249,162.00. There were two unforeseen conditions related change orders. One consisted of replacing all existing refrigerant piping to accommodate a new chiller per manufacturer specs. On the other hand, the second change order consisted of adding 5 water pumps to replace worn out pumps.

The data analysis showed that capital improvement project change orders were very rare. The change orders occurred due to code requirements and unforeseen modification reasons. The owner should allocate contingency budget to mitigate any unanticipated changes

Change Order Regression Analysis

The correlation analysis results of all project change orders shows a relatively strong positive correlation (R^2 = 49.2%) between project budget (amounts between one and seven million US Dollars) and change order percentage. Therefore, a change management system is needed to control, manage, and reduce change orders especially for projects with budgets over one million US Dollars. The results also indicates that there is a moderate positive correlation between project size (less than or equal to 50,000 ft^2) and change order percentage. This shows that the percentage of change orders increases with the project size. The correlation analysis results for ground-up and remodeling projects show a strong positive correlation (R^2 =64.5% and R^2=55.2%) between change order percentage and project budget and duration, respectively.This is an indication that the change order percentage increases with project size and budget. Moreover, there is a strong positive correlation (R^2 =42.84%) between project duration and time overrun. Therefore, more attention should be given to ground-up projects with longer project durations to reduce change order percentages. Lastly, there is a negative strong correlation (R^2 =55.96%) between design duration and time overrun. This means that design errors and omissions that causes change orders are reduced when more time is allocated to the design phase. For that reason, the charter school facility and construction department should allocate sufficient time for the design phase of the project.

The regression analysis of remodeling projects shows that there is a moderate negative correlation between change order percentage with contract amount (R^2 =17.52%), project duration (R^2 =33.08%), and design duration (R^2 =23.38%). These correlations indicate that for the remodeling project, when the contract amount and project duration are low, the change order percentage is high. For this reason, at smaller remodeling projects, the charter school organization should look for ways to lower the change order percentage. However, when the design team is given more time, change order percentage is lower, which means that when design team has more time to prepare the drawings, they make sure drawings are complete and do not have any mistakes or errors. For that reason, when sufficient design duration allocated to the design team, change order percentage will be reduced.

5. Change Management System Development

As reported by previous research studies, change order management systems can control, manage, and reduce the number of CO. A significant reduction in CO can be achieved by establishing a detailed project scope in the early project phase to prevent random and individual changes to the project scope.

Pre-planning planning phase

Figure 4 shows the pre-planning planning phase change management system. The standard documents and best practices have been developed to control the project scope and timeline requirements.

The pre-project planning phases consist of business planning, project planning, and project scope definition. In the business planning phase, project requests are made by campus principals and cluster superintendents to the charter school facility and construction department before the deadlines. For each project type, there are specific timeline requirements that have been estimated based on previous project experience and architect recommendations. For ground up projects, the case study data analysis showed that the main issue was insufficient time allocation to projects. This issue postponed three school openings between 2012 and 2015. This issue was resolved for projects that started in 2015 and 2016 by allocating durations of 17 to 20 months instead of those selected for previously completed ground-up projects. The first week of January is the new ground-up project submission deadline to have the building ready by mid-June or July of the following year.

In addition to a time period of 6 to 8 weeks as a cushion time, it was decided to include of a rainy day period of 6 to 8 weeks in the agreements. The submission for the Brownsville Middle and High School ground-up project was done before January 2016 and the architect agreement was signed on January 11, 2016. Per the agreement, the project completion date was set for June 20, 2017 and 70 rainy days were included. Therefore, the general contractor will not be able to request any delays due to rainy days if the total number of rainy days during the construction period does not exceed 70 days.

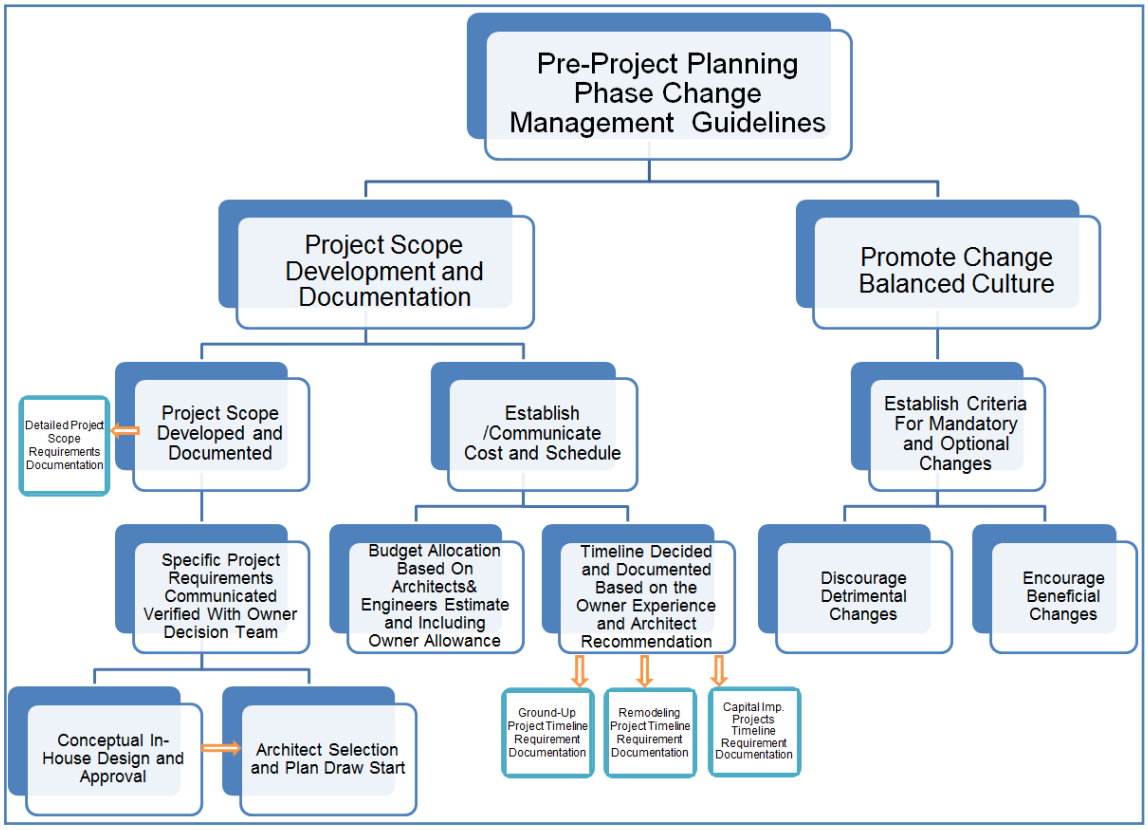


Figure 4. Pre-Project Planning Phase Change Management Guidelines

After its submission and approval, the basic project objectives are decided at the business planning phase. During the project planning phase, the initial project scope and conceptual scope of work such as facility size and project budget are decided. After gathering all of the project information, the project architect is selected.

In order to help reduce change order percentages, owner allowances are included in the projects. This allows for necessary changes to be made without causing any time delays as well.

The objective of the project scope definition phase is to address poor scope development, which is the major cause of change orders for the case study projects. A comprehensive project scope was developed on an excel document that was labeled using construction standards. The excel sheet consists of 5 sheets, namely, K-5 Setting, K-8 Setting, 6-8 Setting, 9-12 setting, and pre-construction planning checklist. The first four sheets represent the various school settings that are currently used in the charter school system. These sheets list the requirements for each room/area, which includes number, size, ceiling type & height, floor type, door type...etc. The minimum number for each room is also specified. Specific project requirements such as classroom number, may change from project to another. These quantities are verified by the area superintendent and the school principal.

In-house conceptual design plans are developed based on the construction standards identified in the excel document. After the in-house design team develops the conceptual plans, the area superintended, principal, facility and construction director and the owner's project manager meet to review and make a final approval. After this process, the project architect reviews the conceptual plans and make the necessary revisions to comply with city codes. The architect send back the plans to the owner's project manager after completing revisions to the conceptual plans. The owner's project manager then reviews the revisions and presents them to the project decision makers for another final approval.

On the other hand, during the pre-project planning phases, the charter school facility and construction department should promote a balanced culture among approval committee members by establishing criteria for mandatory and optional change orders. Thus, this approach encourages beneficial change orders and discourages detrimental ones.

Detailed Design Phase

After completing the project scope definition phase, the architect starts on the detailed design phase with drawings as shown in Figure 5. These drawings are sent to the owner's project manager for review at the 25, 50, 90, and 100 percent complete stages. For the case study projects, 125 out the 212 recorded change orders were related to scope while the remaining ones were related to development. At this stage, the design review the checklist of the changes that occurred in completed similar projects. The checklist should be improved and updated after the project completion by conducting lessons-learned meetings. It is worth noting that

the scope changes proposed by the architect did not cause any change order in the case study projects. This is due to the design-bid-build delivery method used by charter school facility and construction department. In order to eliminate city plan related change orders, the charter school organization decided not to open the bids until the city approves the construction permit. The bidding process is then completed and the construction phase can start.

Construction Phase

Change Order Recognition and Categorization

Scope and project development changes are proposed by multiple sources during the construction phase. The changes can be requested by the city inspector, owner, or contractor. The categorization of the change order should be done when the potential changes are identified. The charter school and facility construction department classifies the changes into two categories, namely, project development changes and scope changes, as recommended by CII (CII 2015). Since they are required to execute the original work scope, project development changes should be submitted for evaluation as change orders. On the other hand, scope changes can be either mandatory or discretionary. Mandatory changes are related to code requirement and safety and performance failure issues that have to be processed to prevent project termination. That's why, mandatory changes must be processed as quickly as possible. The owner allocated allowances should be used to cover for these changes. For discretionary/optional scope changes, a Return on Investment (ROI) analysis needs to be conducted to decide if these changes are desirable or undesirable. As shown in Figure 6, the optional changes that are proposed late into the construction phase must meet higher rate of return values. For this reason, the charter school facility and construction department should not approve discretionary changes if the changes do not meet higher rate of return thresholds. The possibility of changes during the construction phase starts with a request for information (RFI) that is sent from the general contractor to the architect. The charter school and facility construction department's project manager should be involved in the proposed change order (PCO) process at an early stage. After it is received from the general contractor, the request for information is reviewed by the architect, consultants, and engineers. If their response requires a change, the owner's project manager may request from the architect to find other solutions that will not impact the project's schedule and cost. However, eliminating the change may not be possible all the times. If the change occurs, the owner representative and architect need to discuss and come up with a solution to minimize the cost, delay, or side effects during the change order evaluation stage.

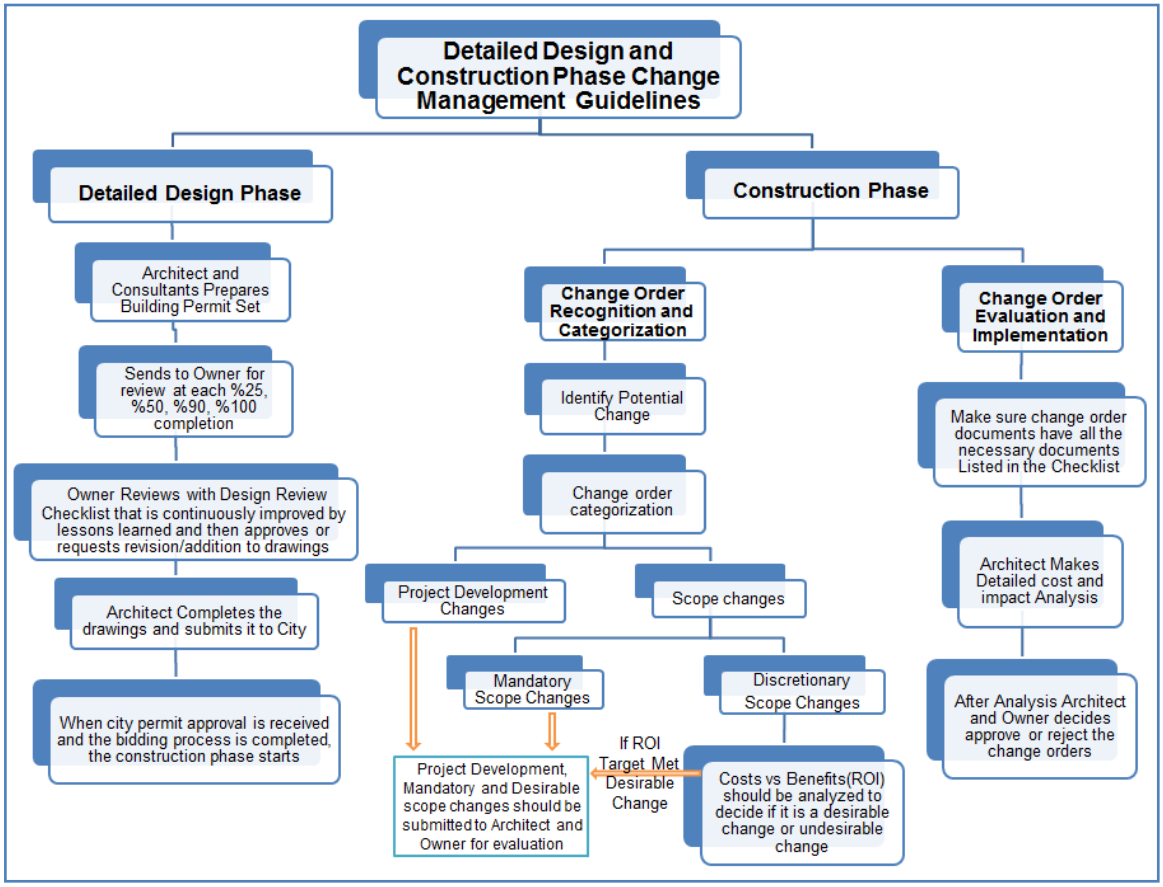


Figure 5. Detailed Design and Construction Phase Change Management Guidelines

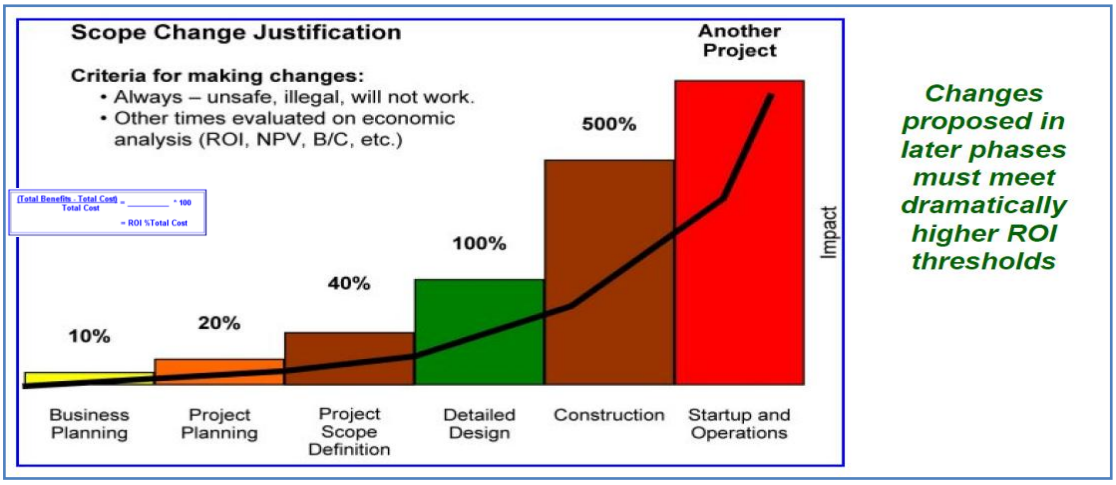
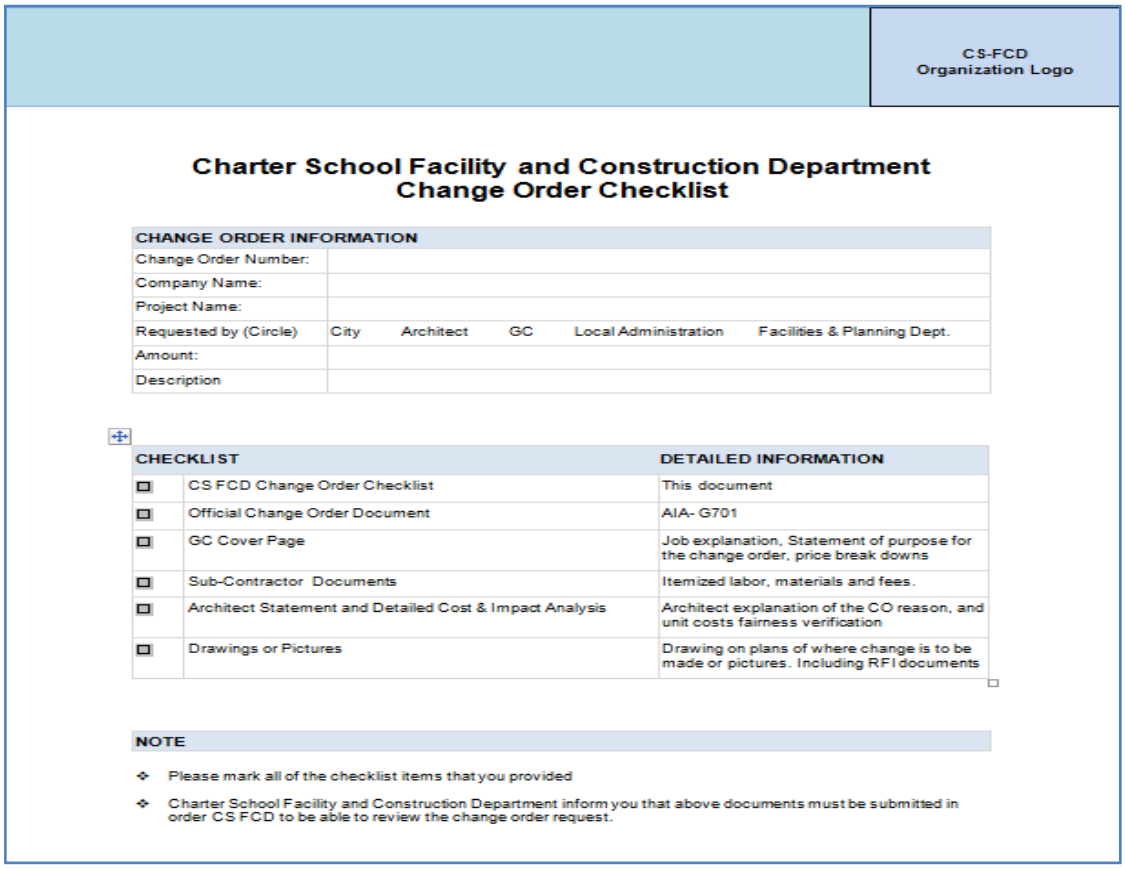


Figure 6. Scope Change Justifications (CII, 2015)



CS-FCD
Organization Logo

Charter School Facility and Construction Department
Change Order Checklist

CHANGE ORDER INFORMATION					
Change Order Number:					
Company Name:					
Project Name:					
Requested by (Circle)	City	Architect	GC	Local Administration	Facilities & Planning Dept.
Amount:					
Description					

CHECKLIST		DETAILED INFORMATION
☐	CS FCD Change Order Checklist	This document
☐	Official Change Order Document	AIA- G701
☐	GC Cover Page	Job explanation, Statement of purpose for the change order, price break downs
☐	Sub-Contractor Documents	Itemized labor, materials and fees.
☐	Architect Statement and Detailed Cost & Impact Analysis	Architect explanation of the CO reason, and unit costs fairness verification
☐	Drawings or Pictures	Drawing on plans of where change is to be made or pictures. Including RFI documents

NOTE

- Please mark all of the checklist items that you provided
- Charter School Facility and Construction Department inform you that above documents must be submitted in order CS FCD to be able to review the change order request.

Figure 7. Sample Change Order Checklist

Change Order Evaluation and Implementation

Whether it is a mandatory or desired change, the change order is sent by the general contractor s to the architect and the charter school facility and construction department. The architect and the charter school facility and construction department need to make sure that the change order documents have all the necessary backup documents. Since each contractor may have different documentation and understanding, the change order checklist cover page can be prepared by the charter school facility and construction department. This Checklist document can be included in the bid documents, or it may be given to the architect and the general contractor at the project kick-off meeting. As shown in Figure 7, the change order checklist of the charter school facility and construction department summarizes all required change order information such as change order number, company name, project name, requested by, amount, and description. Furthermore, the checklist provides more information suh as official change order document (AIA-G701), general cover page (job explanation, statement of

purpose for the change order, price breakdowns), sub-contractor documents (itemized labor, materials and fees), architect statement and detailed cost analysis(architect explanation of the change order cause, and unit costs fairness verification), drawings or pictures (drawings showing change is to be made or pictures), and RFI documents that need to be included in the submitted change order documentation.

The charter school facility and construction department can request from the architect to make a detailed cost analysis of the changer order and provide statements to the construction department. This would cause the architect to review the change order carefully and find any unfair costs requested by the general contractor. Other than the architect review, the charter school facility and construction department should review and double-check all the supporting documents to match the breakdown cost that has been provided in the general contractor cover pages. Each break-down cost should have the sub-contractor support document if the item is not being done directly by the general contractor. Moreover, Change order documents should not include any taxes since charter public schools are tax exempt organizations. After reviewing the change order, the architect and the charter school facility and construction department decide either to approve or reject the change order. Once approved, the charter school facility and construction department should submit the change order to get approval of the Board if there is no remaining allowance/contingency fund in the contract to cover the change order. After the change order approval process, the charter school facility and construction department should inform the general contractor to proceed with the work.

A change order may also start with construction change directive (CCD) when the project completion time is delayed and the actual cost of the work is hard to estimate because of unknown conditions. With these circumstances, if the change order is approved by the architect and the charter school facility and construction department, the general contractor submits a construction change directive. The general contractor is requested to submit the unit prices of the required work items and get them reviewed by the architect. The general contractor has also to agree on fair unit prices. After the approval of the construction change directive documentation, the general contractor completes the work as required by the change order and a job submits a payment request.

In order to avoid construction delays, it is very crucial to authorize and promptly execute the changes that occur during the construction phase. The project managers of the charter school facility and construction department should not expect differences regarding project changes to get resolved by themselves. They should take positive action to settle, authorize, and proceed.

Continuous Improvement through Lessons Learned

In order to improve the change management practices and enhance a culture of continuous improvement in the organization, charter school facility and construction departments should conduct a formal close out-critique at the end of each project by focusing on documenting lessons learned and evaluating the changes and their impacts on design, construction, start-up and operating performance, cost, and schedule. The design review checklist documentation should be also updated with the new lesson learned items and shared within the charter school facility and construction department. This would help project managers eliminate the issues that are causing change orders at the pre-project planning phase and therefore future project will not have to deal with similar project change disruptions.

6. Change Management System Implementation

A change management system for charter school facility departments was developed to control, manage, and reduce change orders. Because of the study time limitation, 90% of the developed change management system has been implemented in 4 projects (i.e., 1 ground up and 3 remodeling) that have been completed between 2015 and 2016. With the help of the developed change management system, these project were completed on time. The ground-up and remodeling projects achieved 21% and 23% change order reductions, respectively.

The West Houston ground-up project was allocated a duration of 20 months. It is worth noting that previous projects were allocated durations of only 11 to 13 months. This enabled more time to finish the project before the school opening deadline. Table 3 summarizes change order data comparison between West Houston project and five previously completed ground-up projects. The results show that the West Houston project had only 6 change orders for a total amount of $65,039.17, representing 1.15% of the total contract amount. They also show that the number of change orders and their total amount for the West Houston project were smaller than those of the other five projects. This finding shows that the use of the developed Change Management System allowed for the reduction of change orders and their total amount.

Three remodeling projects, named Alamo, Discovery, and Corpus Christi, have been completed between 2015 and 2016. Table 4 summarizes change order data comparison between the three remodeling projects and the ones that were previously completed during the period between 2012 and 2015. The results show that the three modeling projects had an average change order percentage (8.91%) lower than that of the remodeling projects that were completed between 2012 and 2015 (11.69%). This finding also shows that the use of the developed change management system allowed for the reduction of change orders and their total amount.

Table 3. Change Order Data Comparison for Ground-up Projects

Year	Project Name	Project Type	Project Size (sqft)	Contract Amounts	CO #	CO Amounts	Change Order Percentage (CO Amount/ Contract Amount)
2014-2015	Dallas Carrolton	Ground-up	45026	$6,951,854.00	16	$1,615,095.21	23.23%
2014-2016	Dallas Nature gym	Ground-up	7300	$2,157,777.00	5	$ 38,265.89	1.77%
2013-2014	Garland Phase 2	Ground-up	44795	$6,298,000.00	34	$ 618,868.57	9.83%
2013-2014	Ft Worth Phase 2	Ground-up	33315	$4,497,000.00	15	$ 369,920.64	8.23%
2013-2014	Rundberg	Ground-up	28480	$4,015,470.00	30	$ 521,750.87	12.99%
Average of Ground Up project 2012-2015			31783	$4,784,020.20	20	$ 632,780.24	11.21%
2015-2016	West Houston Phase 3	Ground-up	42130.00	$5,637,216.00	6	$ 65,039.17	1.15%

Table 4. Change Order Data Comparison for Ground-up Projects

Year	Project Name	Project Type	Project Size (sqft)	Contract Amounts (CA)	CO #	Total Change Order (TCO)	Change Order Percentage (TCO/CA)
2015-2016	Alamo Remodel	Remodel	2578.00	$ 170,193.00	6	$ 22,514.20	13.23%
2015-2016	Discovery Remodel	Remodel	10070.00	$ 662,801.00	16	$ 67,047.50	10.12%
2015-2016	Corpus Christi Remo	Remodel	16000.00	$ 688,680.00	18	$ 23,331.77	3.39%
Average of Remodel Projects 2015-2016 Including Used Allowance Amounts			9549	$ 507,224.67	13	$ 37,631.16	8.91%
Average of Remodel Projects 2012-2015			15167	$ 892,663.40	6.29	$ 50,078.29	11.69%

7. Conclusions

This paper discusses the development and implementation of a change order management system for charter schools to reduce the amount and impact of change orders. The system also provides charter school executives with a better understanding of the causes and impacts of change orders. A literature review was conducted to search for change order causes and categorizations, and change management practices. The change order data, which was collected from 5 ground-up, 17 remodeling, and 6 capital improvement projects, was analyzed and used to develop a change management system for charter school construction projects. The change order data from 4 additional projects were used to validate the results of the developed system and show its effectiveness to enhance project success. The developed change management system allowed these projects to be completed on time. The ground-up and remodeling projects achieved 21% and 23% change order reductions, respectively. The developed change management system model can be used by Charter Schools to reduce the number and impact of change orders in school construction projects. This new capability should prove useful to construction managers and charter school executives is expected to advance existing change order management practices for charter school construction projects.

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