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Examining Change Order Reasons for Non-Structural Utility Support Projects in Healthcare Facilities

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Abstract: Although issuing change orders is a common practice in the construction phase of any project, non-structural utility subcontractors are struggling and seek to find a way to reduce change orders. Therefore, this paper presents the analysis results on change orders to cultivate possible suggestions and solutions on how to reduce or minimize change orders in mechanical, electrical, and plumbing (MEP) works. Change orders in non-structural utility works are analyzed based on six categories such as rerouting and change of location, changes in weight, rejected design by Office of Statewide Health Planning and Development, District Structural Engineer, or the Structural Engineer of Record, unforeseen conditions, changed equipment, and owner-initiated change. The analysis findings showed that rerouting and changing location is the most significant cause, followed by unforeseen conditions. The results not only contribute to the existing body of knowledge on change order research area, but also help MEP contractors reduce the time and cost of change orders.

Key words: Change Order, Risk Management, Contract, Project Management, Health Facilities

1. INTRODUCTION

Health facility projects are high-profile projects in the design and construction industry. Just by looking at the International Building Code alone, “hospitals and other health care facilities having surgery or emergency treatment facilities” are classified with an importance category of III (IBC 2018). An importance category of I is the lowest importance and that of IV is the highest importance. In California, healthcare facility projects have to not only abide by the state building codes (CBC 2019), but they also have to be approved by California’s Office of Statewide Health Planning and Development (OSHPD 2022). One of OSHPD’s responsibilities is to observe the construction, renovation, and seismic safety of hospitals. The District Structural Engineer (DSE) oversees the design and construction documents before construction starts. The DSE keeps track, oversees, and approves the design and any changes it goes through. Not only does the DSE follow building code, but the DSE also emphasizes on the safety of the people utilizing the building.

Mechanical, electrical, and plumbing (MEP) systems play a very significant role during the construction of new and existing healthcare facilities. These MEP works are the fundamental components for operation and maintenance for the facilities. Designers and contractors shall abide by California code standards as well as the OSHPD for health facilities located in California. These MEP components and utilities are expected to be properly installed to confirm that the flow of building operation runs to perfection. However, change orders occur during the construction process and take up about 5% of the budget.

Nonstructural utilities or MEP works also play a very crucial role in the operation and maintenance of buildings, especially healthcare facilities. Nonstructural utilities include mechanical, electrical, plumbing, HVAC, piping, and more. By being the meat of the body of the structure, it is expected that these components and utilities are to be properly supported because that is where non-structural utility support subcontractors come into play.

In California, utility seismic support and bracing is strictly enforced by OSHPD. This form of nonstructural utility support is becoming largely known not only in California but is also being enforced in other states as well as a standard to ensure safety at all costs. Since investors of healthcare facilities are willing to put safety as a priority, the operation and maintenance of the building have to run smoothly throughout the building's lifetime with the design of a smooth operation that comes a lot of risks and risk management. This is where changes occur during design and construction in MEP projects. With changes in the design, change orders need to be issued. However, change orders in MEP projects tend to occur more often than others.

In this study, the change orders for non-structural utility support projects of healthcare facilities are examined. The change orders are sorted into categories that were found to be the most common among non-structural utility support projects, and then analyzed as to what kind of change order occurs the most often and costs the most amount of money. This study aims to investigate these change orders to cultivate possible suggestions and solutions on how to reduce or minimize change orders in future MEP projects that could be utilized in the design and construction world.

2. EXISTING STUDIES

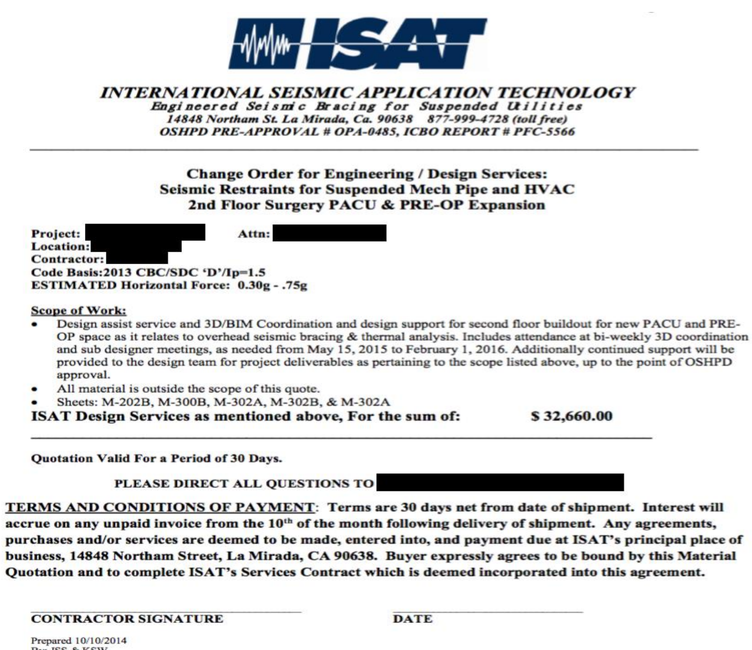
Thomas et al. (1991) discussed the legality of oral change orders. Although they are common in the design and construction industry, there should be certain precautions that all parties involved need to act on before oral change orders cause chaos such as misunderstanding the new scope of work or if the owner refuses to pay for the changes. The study recommended that (1) relevant and specific questions need to be asked to clearly define what extra work needs to be done, (2) reducing oral directions and putting them in writing with documentation of what was discussed and placed in a proper job folder, (3) for meeting minutes to be recorded, (4) to document all changes and revisions made to design, calculations and drawings, and (5) to clearly establish the line of authority. Hanna et al. (1999) evaluated how changes impact costs and found that changing the project scope will increase the amount of time to plan and replan. Efficiency will go down when there is an "interruption, interference, lack of availability of tools, labor and materials to meet the requirements of the changes." Change orders also make it much harder to adjust how to break down the total change order cost to the parties affected. Thus, changes will need to include the cost of project management and supervision, plus other overhead costs to accommodate the changes. As the nature of change orders means that the process needs to be expedited, the schedule will be compressed, which means that labor will increase either by adding more workers or paying overtime.

Gunhan et al. (2007) evaluated causes of change orders in construction and renovation of school buildings. The study found that management practices can differ among different project managers. Some project managers have different priorities on what should be an acceptable change order, and some will issue change orders for everything, even if they are unnecessary. Some managers will give strict orders in minimizing different types of change orders, specifically owner-initiated changes. Du et al. (2015) presented that change orders cause interruptions in the planned work schedule. The consequences of altering the planned work schedule are increased costs through rework of the design, and most likely installation and construction, and decreased efficiency to the base contract work in every kind and size of construction projects. By improving the management of projects from the very beginning and applying careful risk management all throughout the project duration, changes can be speculated better, which will, in turn, reduce costs. Some of the examples are using progress reports and investigating similar projects. Kim et al. (2020) analyzed change orders data from 27 renovation projects to compare the cost impact of change orders by focusing on unforeseen circumstances.

3. RESEARCH OBJECTIVE AND METHOD

3.1. Research Objective

The objective of this paper is to analyze the common change orders that occur during non-structural utility support projects. The change orders considered in this paper are obtained from three health facilities. The change orders are evaluated with respect to its occurrence, reasoning, and cost. The change order, billing, and contract data were provided by the project management department server. The database tracks billing, purchase orders, quotes, change orders, RFIs, specifications, schedule, hours, material orders and other business-related paperwork. Figure 1 shows the example of change order contract document. Each change order contains the project information, contractor involved, discipline, code basis and seismic information, the new scope of work, terms and conditions of the change order, breakdown of cost for services and material.



INTERNATIONAL SEISMIC APPLICATION TECHNOLOGY
Engineered Seismic Bracing for Suspended Utilities
14848 Northam St. La Mirada, Ca. 90638 877-999-4728 (toll free)
OSHPD PRE-APPROVAL # OPA-0485, ICBO REPORT # PFC-5566

Change Order for Engineering / Design Services:
Seismic Restraints for Suspended Mech Pipe and HVAC
2nd Floor Surgery PACU & PRE-OP Expansion

Project: [redacted] **Attn:** [redacted]
Location: [redacted]
Contractor: [redacted]
Code Basis: 2013 CBC/SDC 'D'/Ip=1.5
ESTIMATED Horizontal Force: 0.30g - .75g

Scope of Work:
- Design assist service and 3D/BIM Coordination and design support for second floor buildout for new PACU and PRE-OP space as it relates to overhead seismic bracing & thermal analysis. Includes attendance at bi-weekly 3D coordination and sub designer meetings, as needed from May 15, 2015 to February 1, 2016. Additionally continued support will be provided to the design team for project deliverables as pertaining to the scope listed above, up to the point of OSHPD approval.
- All material is outside the scope of this quote.
- Sheets: M-202B, M-300B, M-302A, M-302B, & M-302A

ISAT Design Services as mentioned above, For the sum of: $ 32,660.00

Quotation Valid For a Period of 30 Days.

PLEASE DIRECT ALL QUESTIONS TO [redacted]

TERMS AND CONDITIONS OF PAYMENT: Terms are 30 days net from date of shipment. Interest will accrue on any unpaid invoice from the 10th of the month following delivery of shipment. Any agreements, purchases and/or services are deemed to be made, entered into, and payment due at ISAT's principal place of business, 14848 Northam Street, La Mirada, CA 90638. Buyer expressly agrees to be bound by this Material Quotation and to complete ISAT's Services Contract which is deemed incorporated into this agreement.

CONTRACTOR SIGNATURE DATE

Prepared 10/10/2014
By: JSS & KSW

Figure 1. Example of a Change Order Contract

3.2. Research Method and Data Collection

The change order information gathered was logged into a spreadsheet, classified by reason, filtered by category, discipline, and change order cost. The data is then broken down into percentages to see which type of change orders happen more often for non-structural utility support projects. The costs for change orders are also compared with the contract value, as a total value, and per project. Furthermore, the total cost of the change orders per category is compared.

Change order data are collected from three non-structural utility support projects in healthcare facilities. *Project 1* is an existing non-profit multi-specialty hospital. The utility support is mostly for the rerouting of electrical to account for the upgrade of the building. Even though it is an existing building, the new utility support design has to abide by new OSHPD rules and regulations.

Project 2 is a hospital that houses the largest emergency room and trauma center. The hospital itself is an existing hospital built in 1901, but the owner invested $363 million for a 250,000 square-foot, seven-story expansion building to further serve the residents of the regions. The expansion building will have a new patient tower, hospital laboratory, food service areas, four new operating rooms, 3-floor medical office, 5-level parking garage, medical imaging department, as well as seismic retrofit to the existing tower. With this expansion, and this being located in California, rules for seismic stability especially for utilities are stricter than the California Building Code. All utility support design has to be approved by OSHPD in terms of safety and constructability.

Project 3 is an existing medical center that serves the military. Similar to Project 2, Project 3 is also building a 1.3M square-foot medical facility, however, not to expand the existing building, but to replace it. The facility has a main hospital, inpatient and outpatient clinics, administration building, research building, central utility plant, two access control points, and surface parking. With this, new utilities will be installed, which will need utility supports for the whole building. The utility supports were designed under seismic and wind conditions as a new standard of safety.

3.3. Change Order Types of Non-Structural Utility Support Projects

The authors found six common change order categories in non-structural utility projects, including rerouting and change of location, changes in weight, rejected design by OSHPD or the DSE or the SEOR, unforeseen conditions, changed equipment, and owner-initiated changes. The brief explanation for each of the six change order categories is summarized as follows:

A. *Rerouting and Change of Location*: During the construction phase, when components are being built, sometimes there are circumstances where there is a space limitation and a pipe, a conduit or an equipment doesn't fit in the space indicated in the plans like it should. Sometimes, the contractor will decide to move equipment or utilities around to try to save material and labor cost. As a result, the original non-structural utility support design will need to be altered and a change order will be needed to complete the new or modified design.
B. *Changes in Weight*: Although material or equipment cut sheets are provided by the manufacturer, weights are outdated or not accurate. Sometimes, only the shipping and empty weights are indicated, but not the operating weight. So, when the support is under designed for a lower weight, the design must be modified with a change order in line.
C. *Rejected Design by OSHPD or the DSE or the SEOR*: There is a plethora of reasons for the District Structural Engineer (DSE) or the Structural Engineer of Record (SEOR) to reject a utility support design. One main important reason is safety. The inspecting structural engineer focuses on providing a safe and strong facility to ensure that the occupants aren't harmed at an event of a tragedy like an earthquake. In the case of non-structural utility support projects, the DSE will ensure that non-structural components such as pipes, tanks, or fans are properly supported in the building. For example, in California, it is required for

these components to be properly supported for seismic. A change order is usually requested when the support doesn't meet proper code standards for support. On the other hand, the SEOR may reject the design if the design cannot be supported by the structural skeleton of the building, including girts, beams, columns, concrete decks, etc. It could also be required to be changed if the material used is not approved or recommended per specifications.

D. *Unforeseen Conditions*: Unforeseen conditions can be anything from needing vibration isolation or flexes that was not disclosed before to changing the material of the support to accommodate the material of the component that needs supporting or weather conditions. For instance, they include stainless steel materials for outdoor supports and neoprene to attach galvanized steel to fiberglass.
E. *Changed Equipment*: A change order is initiated when an equipment is replaced and requires a brand-new support design. Equipment and components are usually replaced as a result of changed conditions. One example could be that a water heater can't handle the amount of water that goes in and out of the heater. Another one could be a space limitation issue to where an equipment doesn't fit the area where it's supposed to be installed.
F. *Owner-Initiated Change*: An owner-initiated change would be any job or task that the owner would like to add and assign the designer that is out of the original scope and contract.

4. FINDINGS AND ANALYSIS

The total contract value of the three projects is $6,336,504.05. A total of 81 change orders were analyzed at a total value of $2,563,506.12, which is 40.46% of the total contract value as shown in Figure 2. Figure 3 shows the comparison of the contract values with change order values per project. The percentages of the change order value out of the contract values are 23.77%, 51.86%, and 37.83% for Project 1, Project 2, and Project 3, respectively. Table 1 tabulates the values for each category of change orders and the percentages from the total change order values. By observing the data collected, it appears that the most common change order type for non-structural utility projects is the rerouting and change of location of components. It also appears that this category has the biggest financial impact at 52.25%.

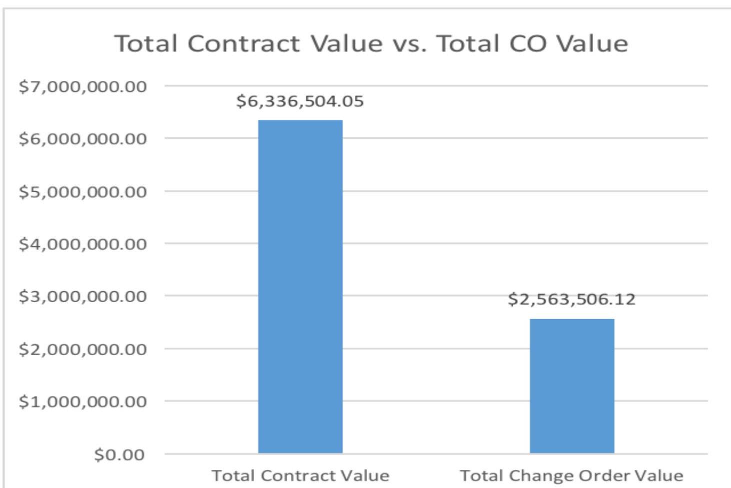


Figure 2. Total Contract Value vs. Total CO Value

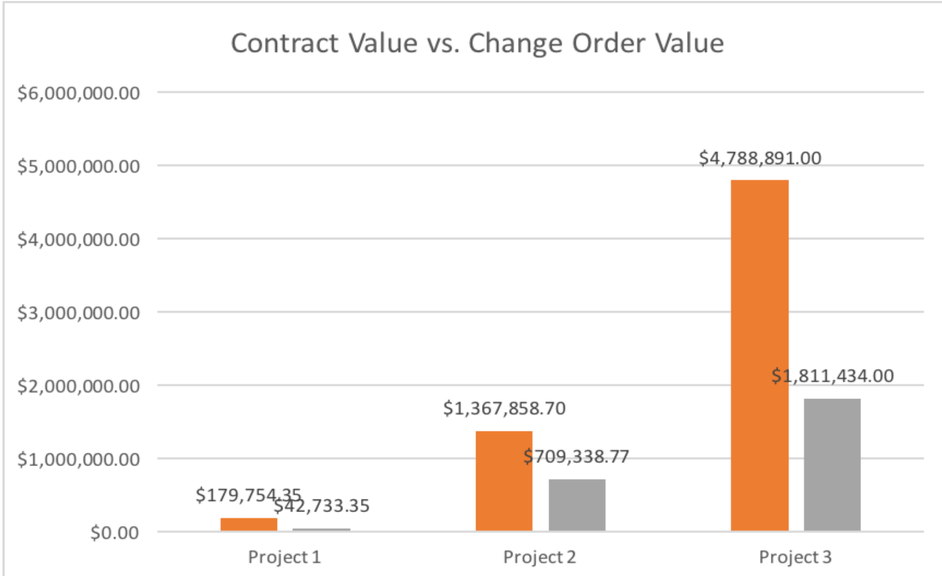


Figure 3. Contract Value vs. CO Value per Project

Table 1. Change Order Values and Percentages

Change Order Category	Change Order Value	Portion (%)
Rerouting and Changing Locations	$1,735,940.85	52.25%
Weight Changes	$159,395.00	4.80%
Rejected Design by DSE/SEOR	$375,531.66	11.30%
Unforeseen conditions	$646,902.00	19.47%
Changed equipment	$134,288.00	4.04%
Owner Initiated change	$270,355.61	8.14%

The change orders are made up 40.46% of the total contract value, which greatly exceeds the typical 5% construction standard. More than half of the total cost of change orders are caused by the rerouting and changing of locations, and the rest of the reasons are all under 20% of the total cost. By observation, there could be a few reasons why this category type is so common, and the cost is so high as follows:

- Changing the design could either be a minor change, or could change the entire design, which means that the designer would need to start again from scratch, or
- There is poor coordination and communication between the different disciplines and the contractors such as electrical, mechanical, plumbing, etc. that the plans don’t work as designed.

Another observation that’s intriguing is that about 2/3 of the amount of change orders gathered came from mechanical and electrical disciplines, which is about 1/3 for each discipline, as shown on Figure 4. This result could show a trend that these disciplines could have poor coordination and communication when it comes to design.

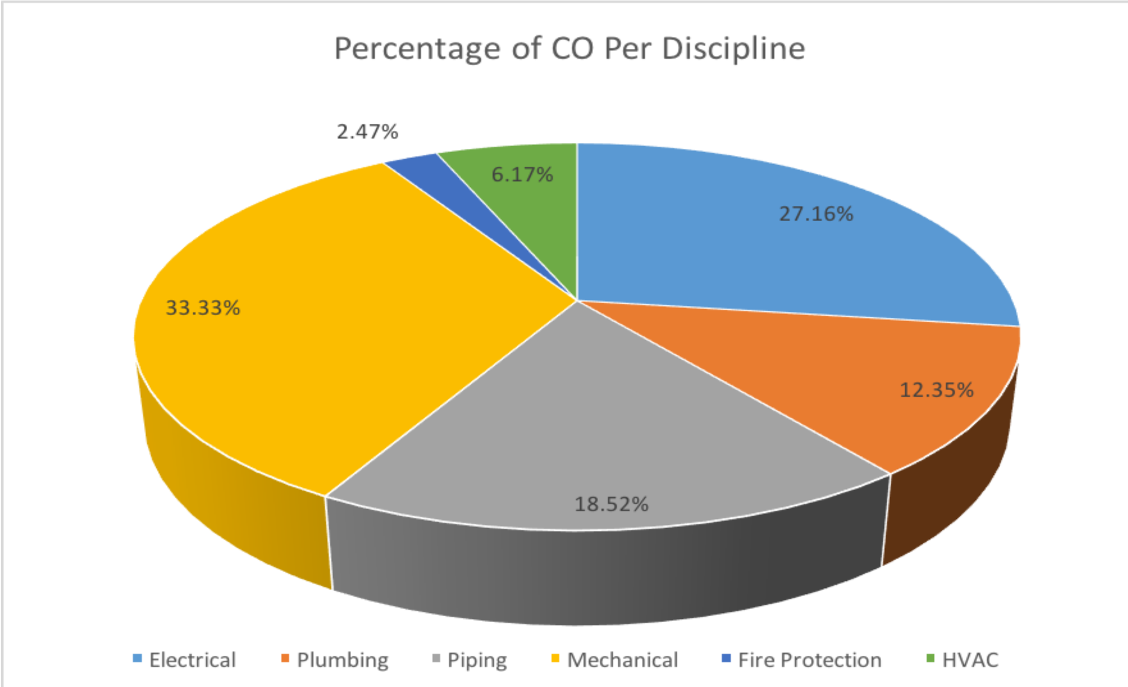


Figure 4. Distribution of CO per Discipline

5. CONCLUSIONS

The results of this analysis could be used as a tool to help MEP disciplines in the future in reducing the amount of change orders to be submitted to the client. Based on the common change orders from non-structural utility projects, some recommendations have been observed as probable solutions to minimize changes as follows:

- From the beginning, contractors and owners should initiate properly supporting all utilities.
- Different disciplines, subcontractors, contractors, and the owner should have constant communication and coordination between each other throughout the course of the project.
- Once changes have been indicated, other disciplines should be notified, or these changes should be discussed before moving forward.
- Problems should be identified early on the project by observing data from previous projects, as well as looking at the progress. This process will help to increase contingency to anticipate those unavoidable changes, as well as decrease owner-initiated changes.
- Constructability reviews should be conducted constantly to avoid wasting cost and schedule.
- Value engineering should be implemented.
- Site conditions have to be thoroughly and fully reviewed before submittal.
- The scope of work has to be properly detailed.
- The subcontractor has to communicate properly with the SEOR to receive approval or denial before submittal of the design. This process will ensure that the design isn't wasted when it is rejected, and all the labor hours have been burned.

Due to the smaller amount of data collected, there is a need to collect more data in increase the level of the accuracy of the findings. Had this study been continued, a larger pool of data could be gathered with more projects. Projects could be divided into new and existing building types for a comparison purpose. Even so, every project is different, and some change orders are unavoidable. For example, each DSE is different, and their method of inspection could either be very lenient or very strict. A design could be acceptable to one and under designed to another. If the aforementioned suggestions were applied in MEP projects, the amount of change orders can surely decrease or can be avoided. This could also increase productivity and reduce construction delays or reconstruction due to change orders.

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