

Change Order Causation; Who is the Guilty Party?

Darren Olsen, Roger Killingsworth and Brandon Page
Auburn University
Auburn, Alabama

Change orders are an all too common part of construction projects. They can be extremely expensive and may negatively impact a project's schedule. All project stakeholders benefit when changes orders are limited. In addition to affecting costs and increasing the time, they can potentially sour the business relationships on a project. It is a desirable outcome for most project participants to reduce the occurrence of avoidable change orders.

This research seeks to determine the most common causes of change orders and to uncover which divisions of work are most susceptible to the greatest number of changes. The research concludes that the majority of changes result from plan errors and omissions and further that as a division of work mechanical, electrical and plumbing (MEP) systems are most susceptible to changes. By defining these and other problems, it is anticipated that future research will build off this work and provide solutions to reduce the number of changes orders on construction projects.

Key Words: Change Orders, Causation, Design Errors, MEP Systems

Introduction

The aim of this research is to discover the most common causes of change orders, and further which divisions of work are most susceptible to change orders. While there is a significant body of knowledge in this area it is important to provide an update which would reflect the current state of the industry. A construction change order by definition is a modification to the work described in the contract documents (Webster, 1997). While every construction project is unique, all share many similarities in their materials, methods and processes with other construction projects and face many of the same challenges. This paper is based on the working hypothesis that the causation behind most change orders relate to common challenges which can be targeted with specific solutions.

Past researchers who have analyzed change order causations have first developed classifications and then sorted actual change order records by those classifications to determine their frequency of occurrence. The same methodology was followed in this study using the previous work as a starting point to develop the classification system. In *Construction Change Orders: Impact, Avoid, Documentation*, James J. O'Brien lists six typical causes of change orders:

- Unforeseen conditions
- Plans and/or specifications
- Scope change (additional or enhancement) by owner
- Value engineering
- Force majeure
- Acceleration

O'Brien defined *unforeseen conditions* as conditions in the field that do not match the contract documents. The example given is underground conditions such as uncharted utilities, uncharted existing foundations, rock or other strata at a higher elevation than expected, high ground water, etc., differing materially from document depictions.

Regarding *plans and/or specifications,* O'Brien states, "During implementation it is discovered that, if done per contract plans and or specifications, the work cannot be installed, or if installed, will not operate." These changes result from mistakes made during the design process. *Scope change by owner* could arise when additional funding becomes available from unexpected sources and/or favorable bids that may entice the owner to expand the project's scope. *Value engineering* is a change proposed by the contractor that will improve the project and result in savings that is shared with the owner. A *force majeure* change order is for time delays due to forces beyond the control of the contractor. O'Brien list as examples accident, fire, flood, strikes, and severe weather. The sixth and final cause is *acceleration.* Acceleration refers to an owner initiated change order that is an attempt to expedite completion to a date earlier than agreed upon or regain time previously lost through no fault of the contractor.

For their paper, *Taxonomy for Change Causes and Effects in Construction Projects*, Sun and Meng conducted a literature review of 101 sources relating to change order cause and effect on construction projects. They developed five major classifications through grouping previously identified causes of change from existing studies. The categories are:

- Project-related causes
- Client-related causes
- Design-related causes
- Contractor-related causes
- External causes

Sun and Meng say, "Project-related causes come from the complexity of a construction project." The more complex a project is the more likely there is a chance for change. The underlying problem that produces project-related causes is the temporary nature of the team that is assembled for the project duration and their failure to communicate and collaborate properly throughout its entire duration. This break down is caused by design changes and chain reaction delays. Unforeseen site conditions, safety and security issues, and other restrictions are all issues that fall under Sun and Meng's project-related cause classification.

The next classification, *client-related causes* are very common and easily identifiable because they are always client initiated. Client-related causes often happen in the design stage and occur as a result of unrealistic expectations, the constant need of requirement updates, budget reductions, acceleration of schedule and other such issues.

Design-related causes are the third classification and usually come in the form of errors and omissions. These causes are the sole responsibility of the design team. These causes can be derived from the designers misunderstanding of the client's desires, inadequate preparation, not staying up to date with the latest code requirements, or site and ground conditions and can completely undermine an entire design if not tested.

The fourth classification is *contract-related causes.* Sun and Meng blame this type of cause on the contractor's lack of experience, poor workmanship, poor scheduling, inadequate managerial skills and similar issues. The primary cause for schedule delay is mismanagement of the job-site and poor supervision. This may be due to inadequate managerial skills or lack of experience. Scheduling of different subcontractors may become a cause for delay, as well as having to replace a subcontractor completely.

Sun and Meng's final classification *external causes* relates to occurrences outside of the project and project team.

In, *Construction Jobsite Management*, Minks & Johnston's give eight reasons for project change:

- Owner Directed Change of Scope
- Constructive Change
- Consequential Change

- Differing Site Conditions
- Jobsite Discovery of Hazardous Materials
- Code Revision
- Vendor Coordination
- Product Substitution

The first cause defined, *owner directed change of scope,* is when extra work is added or deducted from the projects original scope. *Constructive change* as defined by Minks & Johnston is when "The architect or owner's representative causes the contractor to perform work outside their contract. This change could occur from a simple defective specification to a directed change in the contractor's method of accomplishing the work at hand. Construction document errors and omissions can fall into this category." A *consequential change* is a direct result of the previous two situations. It represents the impact costs that arise from the other work being performed. Often this is seen in delays, rescheduling, re-work, and the rise in overhead costs to facilitate these extra activities. *Differing site conditions* include sub-surface issues and existing conditions in renovation projects where the designer does not have all of the previous construction details and plans of the original project that existed prior to the redesign. Therefore, either latent conditions in a renovation project or unforeseen site conditions on a new construction project may result in contract change. *Jobsite Discovery of Hazardous Materials* is a change related to the abatement and remediation of hazardous materials. *Code revision* describes an event that occurs after the construction contract has been awarded and signed, but the local building code authority has not reviewed the project. If the reviewing agencies require changes to be made to the original scope in order for the project to comply with current building codes, then change orders will need to be issued for the contract modifications. *Vendor Coordination* is listed as a separate cause because, when a project nears completion, special coordination is needed for the supply and installation of certain equipment. An extremely common change is *product substitution* and can occur for many reasons, but it is usually when a product specified is not researched by the architect and is no longer available. Non-availability of original product can occur for many reasons; regardless a substitution must be found.

After careful review of the available literature, the researchers selected six causation classifications for cataloging change orders. The classifications which were chosen are most similar to those used by O'Brien. The goal of this research is to define the causations which were resulting in change orders, so in assessing the different classification systems we were looking for one which would reduce overlap and limit the discretion of the researchers when sorting the data. The following is a list of the major classifications used in this research:

- **Unforeseen/Existing Conditions --** Unforeseen conditions are defined as conditions in the field that do not match the expected conditions.
- **Plans and/or Specifications Errors and Omissions --** This cause relates to items that were either omitted, improperly drawn or improperly coordinated by the design team.
- **Owner Directed Scope Change (additions/deletions) --** An owner directed scope change can occur due to unexpected needs, change of business, purpose of project, acquisition of more capital, or the depletion of expected available funds.
- **Value Engineering --** A substitution resulting in the same or improved function for a reduced cost.
- **Force Majeure --**Time delays due to forces beyond the control of the contractor.
- **Acceleration/Delay --** Acceleration in project schedule occurs when the contract duration is shortened.

Prior research which explored similar issues suggests that design errors were a primary source for changes (Josephson & Harmmarlund, 1999). As the construction environment is constantly changing this research seeks to establish a current view of change order causation.

Methodology

Sun and Meng defined change order causation as conditions or events that either directly trigger or contribute to a change in construction project. Through their literature review, it was discovered that the numerous studies conducted on causation could be classified into three groups: questionnaire surveys, review of project records, and case studies. This paper incorporates two of the data collection methods listed here: questionnaire surveys and the review of project record data. Sun and Meng found through their research that questionnaire surveys are best when used to collect opinions from a large sample of people in a specific industry. The only drawback is that opinions can be biased based on their position within the industry. To counteract this perceived bias the decision was made to use the survey combined with hard data collected from different construction projects to verify our results.

Data was collected from eight different commercial projects, included 145 contract changes. All of the projects were located within Georgia and Alabama. The projects range in value from $800,000 to $20,000,000 and were constructed between the years of 2007 and 2011. Two different contractors completed these eight projects and participated in supplying the change order data used in this research. Seven different design firms were used across the eight different projects. Each project had a different owner, consisting of state municipalities, energy companies, private developers, medical professionals, and the Federal Aviation Administration.

Qualitative data was collected to help support the lack of quantitative data used during the research. Of the 176 surveys sent out, 21 were completed and sent back. The group of respondents consisted of owners, architects, and contractors with the overwhelming majority being contractors. Out of the 21 industry professionals who completed the survey, six had worked on jobs throughout the U.S. and the other 15 were primarily stationed in the Southeast. All but one of the 21 respondents had more than fifteen years of construction experience.

Results and Analysis

The key question presented at the beginning of this research was, "What is the causation of most contract changes?" The authors analyzed the 145 change order records received and then cataloged them through our classification system. Of the changes included in the study a review of the project record data showed more than 52% were caused by plans and/or specification errors and omissions, 32% were owner directed changes, and 9% resulted from unforeseen/existing conditions. The occurrences of the remaining causations sharply drop off in the order of value engineering, acceleration/delay, and force majeure (see table 1).

Table 1

(Project Data) Change Order Classifications

Classification	**Number of Changes**	**% of Total Changes**
Plans and/or Specification Errors & Omissions	76	52%
Owner Directed Change(Additions, Deletions)	48	33%
Unforeseen/Existing Conditions	13	9%
Value Engineering	5	3%
Acceleration/Delay	2	1%
Force Majeure	1	1%
Other	0	0%
TOTAL	145	100%

To verify the quantitative data shown above we ask essentially the same question in our survey, "On Average, what percentage of change orders is produced by each change causation?" Table 2, below shows the results gathered from that question. The results produced from the qualitative survey data support the quantitative data. In terms of ranking the causations are placed in the same order as they were as a result of the quantitative spreadsheet.

Table 2

(Survey Data) Change Order Classifications

Classification	**% of Total Changes**
Plans and / or Specification Errors & Omissions	29%
Owner Directed Scope Change (Additions, Deletions)	26%
Unforeseen Conditions	16%
Value Engineering	13%
Acceleration / Delay	10%
Force Majeure	6%
TOTAL	100%

To ensure that the results are consistent, the question of what are the leading causes of change orders is evaluated by probing for the answer by asking for similar information different ways. We asked our respondents "in your experience on a number of different projects and project types, which of the following causes typically results in the most change orders?" The results of this question further confirm our prior findings (see table 3). The preponderance of respondents identify plans and/or specification errors and omissions as the leading cause of contract change and owner directed scope change (additions/deletions) as the second prominent cause.

Table 3

(Survey Data) Which of the following causes result in the most change orders?

Classification	**Respondents**	**Overall Percentage**
Plans and/or Specification Errors & Omissions **-** During implementation it is discovered that, if done per contract plans and/or specifications, the work cannot be installed, or if installed, will not operate as intended.	9	43%
Owner Directed Scope Change (Additions/Deletions) **-** Any deviation to the original contract documents per the owners request.	7	33%
Value Engineering **-** Adjustment of original contract documents in order to reduce cost without affecting the function.	3	14%
Unforeseen/Existing Conditions **-** Conditions in the field do not match the contract documents (i.e., plans & specifications).	1	5%
Force Majeure **-** a change to contract documents because of a time delay due to forces beyond the control of the contractor. These might include accident, fire, flood, strikes, severe weather beyond average, acts of God, etc.	1	5%
Acceleration **-** Change order initiated by the owner to either expedite an earlier completion date or regain all or part of lost time.	0	0%
Total	21	100%

The same survey asked a more pointed question related to both the data sets above, "Which of the primary stakeholders in a typical construction project do you consider responsible for the majority of change orders?" The results to this question are located below (see table 4). In context these results are not surprising since the majority of respondents were contractors; however, it does agree with the results above.

Table 4

(Survey Data) Which of the primary stakeholders to a typical construction project do you consider responsible for the majority of change orders?

	Respondents	**Overall Percentage**
Designer	14	67%
Owner	6	29%
Contractor	1	5%
Total	21	100%

The second key question considered in this research is, "Which groups of trades throughout the construction process are the most susceptible to changes/modifications in their division of work?" Again the 145 change orders were sorted and cataloged into separate divisions of work based on the primary purpose of the change. They were then totaled and are listed below (see table 5).

Table 5

(Project Data) Which divisions of work are the most susceptible to changes?

Divisions of Work	**Number of Changes**	**% of Total Changes**
Systems (MEP, fire suppression, data communications)	66	46%
Envelope (veneer, windows, roofing)	25	17%
Finishes (flooring, partitions, ceilings, paint)	25	17%
Site (earthwork, pavers, landscape)	19	13%
Structure (concrete, structural steel, load bearing masonry)	10	7%
Total	145	100%

In order to gather the qualitative data for the support of the quantitative results in Table 5, a question in the survey asked, "In your past experience, which of the following areas of construction seem to be the most susceptible to changes/modifications?" The results of both data sets are similar and list the MEP systems as the division of work most susceptible to changes. The respondent's answers are listed below (see table 6).

Table 6

(Survey Data) In your past experience, which of the following areas of construction seem to be the most susceptible to changes/modifications?

Divisions of Work	**Respondents**	**Overall Percentage**
Systems (MEP, fire suppression, data communications)	8	38%
Structure (concrete, structural steel, load bearing masonry)	4	19%
Finishes (flooring, partitions, ceilings, paint)	4	19%
Site (earthwork, pavers, landscape)	3	14%
Envelope (veneer, windows, roofing)	2	10%
Total	21	100%

Conclusion

The first key question of this research was of the cause classifications defined, which one was most responsible for the majority of change orders. Both the qualitative and quantitative data clearly showed that design errors were responsible for the majority of changes. Design errors occur when the designers fail to properly coordinate different plan sets or leave information out of the design. When asked an open ended question concerning which causes they believed to frequently occur most among construction projects, the survey respondents gave responses including: .

- "Poor coordination of drawings during design process between the different design professionals' scope of work (architectural vs. MEP vs. site vs. structural)" was the primary reason for change."
- "poor design coordination"
- "lack of coordination between design disciplines"
- "in design/bid/build - poor design coordination between other disciplines."
- "Equipment associated with MEP is a major factor - usually the coordination of owner furnished equipment with the design"
- "poor coordination and lack of accurate determination of owner program and needs"

Finding solutions to the problem of design errors is essential to make the construction industry more efficient and responsive to the needs of all stakeholders in a given project. One possibility that may prove helpful in the coordination process, is a more wide spread use of Building Information Modeling (BIM). When projects are designed using BIM software, all disciplines are designed and coordinated in a three dimensional environment. The architect provides a design file, the structural engineer provides a structural design file, the mechanical engineer provides the MEP design file, and they are all combined into one model. Therefore, if there were any conflicts such as building items occupying the same space, they could be detected and eliminated in the office before they appear on the jobsite. Detecting these issues in the office, as opposed to in the field, can save a tremendous amount of time, money, and aggravation. Another idea to help mitigate design errors would be to involve the subcontractors in the design process. Their knowledge of the building components and process could be used to troubleshoot problems. Both of these solutions are being implemented and should improve this situation.

The second most avoidable change was determined to be owner directed changes. This should come as no surprise. After all, it is human nature to change one's mind. Unique interests, funding, or the scope of one's need may change during a project. Foreseeing the final product from what is represented on paper may prove daunting for some. It would be foolish to think that all owner changes can be completely eliminated, but they could be reduced. If the professionals hired to design, a building spent more time determining how best to satisfy the owner's needs and wants, it follows that owner directed changes could be greatly diminished. This is another situation whereby incorporating BIM into the design phase would help, as one respondent said, "sell" the owners. BIM allows the owner to virtually experience the building helping them achieve a better understanding of the buildings spaces and aesthetics.

Unforeseen/existing conditions, value engineering, force majeure, and acceleration/delay do not occur with the frequency of the two classifications mentioned above, some of these changes could also be classified as unavoidable (force majeure). The magnitude of these causations is not as significant as those previously mentioned.

The second key question raised in this thesis is which area of construction was most susceptible to change order causation. Conclusively, it was determined that change most often occurs within the systems grouping. The opinion of one industry professional is that, "complex MEP systems with more technology without sufficient coordination" are to blame. This sentiment appears to be shared throughout the industry, and it appears that some of the design deficiencies which were noted above may be related to these systems. A common solution to some of the coordination problems with MEP systems is using BIM modeling for clash detection. The old method of light boards and transparencies did not allow for precise coordination. Clash detection can be accomplished automatically within most BIM software suites.

It seems that although technology has evolved and processes have been improved, familiar change order causations and occurrences within divisions of work still persist in the industry. It is hoped that this paper will not only provide an updated look at these issues but will also direct future research into developing solutions.

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