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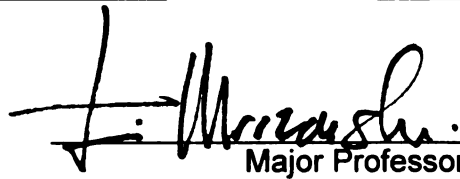
**IMPACT OF CHANGE ORDERS ON OVERALL PROJECT
BUDGET WITHIN UNIVERSITY PROJECTS**

presented by

Kenneth James Gottschalk

has been accepted towards fulfillment
of the requirements for the

M.S. degree in Construction Management


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**IMPACT OF CHANGE ORDERS ON OVERALL PROJECT
BUDGET WITHIN UNIVERSITY PROJECTS**

By

Kenneth James Gottschalk

A THESIS

**Submitted to
Michigan State University
In partial fulfillment of the requirements
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ABSTRACT

IMPACT OF CHANGE ORDERS ON OVERALL PROJECT BUDGET WITHIN UNIVERSITY PROJECTS

By

Kenneth James Gottschalk

This project sought to reduce reoccurring change order items on university construction projects caused by errors and omissions, field conditions, and scope changes and was part of a broader three-phase umbrella project that identified and analyzed change order items in an attempt to reduce both cost and time associated with changes on projects. The research presented here focuses on the creation of a database of change order items for Michigan State University (MSU) construction projects. Results are generalized to other universities and major owners who procure outside construction services. Nineteen recently completed construction contracts with 159 change orders and in excess of 1675 change order items were analyzed through this research. Statistical analyses were conducted to identify which Construction Specifications Institute (CSI) Divisions contained the greatest number of changes while highlighting those divisions that require further attention. The research indicated that although Division 15 was the largest by contract dollar volume, it was not the greatest contributor to change order costs. In addition to the database approximately forty construction professionals were interviewed as part of the project in order to establish the current change order environment. The results indicate the need to reduce design errors and omissions as a means to reduce change orders and made recommendations for providing adequate time for document review and coordination.

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TABLE OF CONTENTS

LIST OF TABLES	xiii
-----------------------------	-------------

LIST OF FIGURES	ix
------------------------------	-----------

CHAPTER 1

OVERVIEW AND INTRODUCTION

1.1 Introduction	2
1.1.1 Change order effects on project and parties	3
1.2 Change order definition	5
1.3 Change order causes	6
1.4 Problem statement	9
1.5 Overview of umbrella project case study	10
1.5.1 Case study construction overview	14
1.5.2 Project oversight committee	14
1.5.2.1 Oversight committee project selection	15
1.6 Research objectives	15
1.7 Deliverables	16
1.8 Chapter summary	16
1.9 Organization of the thesis	17

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction	19
2.2 Predicting change orders	19
2.3 Change order compensation	20
2.4 Change order effects on productivity	21
2.5 Cost and time associated with change	22
2.6 Why changes cost more	24
2.7 Reducing change orders before design	25
2.8 Reducing change orders during construction	27
2.9 Industry change order rates	29
2.10 Reducing change order claims	30
2.11 Similar studies	30
2.11.1 Effective project management	31
2.11.2 Cumulative impacts of change orders	32
2.11.3 Circumventing claims	33
2.11.4 Accuracy and contingency	33
2.12 Summary	34

CHAPTER 3

METHODOLOGY

3.1 Introduction.....	38
3.2 Literature review.....	39
3.3 Creation of the database	39
3.4 Database development.....	40
3.5 Project costs.....	41
3.6 Change order form.....	42
3.6.1 Section 1	44
3.6.2 Section 2.....	44
3.6.3 Section 3	45
3.7 Database analysis.....	47
3.7.1 Reason codes.....	49
3.7.2 Change timelines.....	49
3.7.3 Construction type.....	49
3.7.4 CSI Division.....	50
3.7.5 Macro and micro analysis	50
3.8 Interviews.....	52
3.9 Integration of data	53
3.10 Summary.....	54

CHAPTER 4

DATA ANALYSIS

4.1 Introduction.....	56
4.2 Project information.....	57
4.2.1 Project types.....	57
4.2.1.1 New construction	57
4.2.1.2 Renovation.....	58
4.2.1.3 Infrastructure	59
4.2.2 Location.....	60
4.3 Data Analysis.....	60
4.4 Quantifying change order reasons.....	66
4.5 Change order item relationships to point of project completion.....	67
4.6 Construction specifications institute (CSI) Divisions.....	68
4.7 Database project values by CSI Division.....	69
4.8 Reason codes vs. project time	73
4.9 Dollar amount per grouped reason codes	75
4.10 Divisional costs and time occurrence	76
4.11 Reason codes vs. project time	76
4.12 Dollar amount vs. time	79
4.13 Reason codes – Division specific.....	81
4.14 Chapter summary.....	91

CHAPTER 5

INDUSTRY INTERVIEWS

5.1 University interviews	96
5.2 General construction data	96
5.3 Construction analysis	97
5.4 Change order classification	98
5.5 Change order prediction	98
5.6 Change order histories	100
5.7 Contract document review	100
5.8 Partnering / commissioning	102
5.9 CSI Division impact	103
5.10 Summary	103

CHAPTER 6

INDUSTRY RELEVANCE

6.1 Introduction	106
6.2 Industry change order rates	106
6.3 Project type change order rates	107
6.4 Change order causes	108
6.4.1 Documents errors & omissions	109
6.5 CSI Divisional change orders	110
6.6 Recommendations	111
6.7 Conclusion	112
6.8 Summary	113

CHAPTER 7

SUMMARY

7.1 Introduction	116
7.2 Research objectives	116
7.3 Conclusion	117
7.3.1 Change order reasons	118
7.3.2 CSI Division costs	119
7.3.3 Changes associated with time	121
7.4 Limitations of the research	123
7.4.1 Project time vs. work in place	123
7.5 Future areas of research	124
7.6 Final comments	126

REFERENCES	128
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APPENDICES

APPENDIX I Data entry point definitions.....	132
APPENDIX II CSI Division analysis - Tables.....	136
APPENDIX III CSI Division analysis - Graphs.....	153
APPENDIX IV Project descriptions.....	186
APPENDIX V University interview questionnaire.....	193
APPENDIX VI Projects original scheduled value and contract percentage.....	202

LIST OF TABLES

3.1	Database projects with initial and ending project costs.....	41
3.2	Construction specifications institute (CSI) Divisions.....	46
3.3	Change order items reason codes.....	48
4.1	Database projects.....	56
4.2	Database projects classified as new.....	62
4.3	Database projects classified as renovations.....	64
4.4	Database projects classified as infrastructure.....	65
4.5	Schedule of values for all database projects.....	70

LIST OF FIGURES

3.1	MS Access change order form.....	43
3.2	Macro-analysis illustrating reason code items over project time.....	51
3.3	Micro-analysis illustrating CSI Division 2 total database dollar amounts per grouped reason code.....	52
4.1	Change order amount showing initial project cost.....	61
4.2	Number of change order items per specified grouped reason codes.....	67
4.3	Number of items per percent project completion.....	68
4.4	Total dollar amount per CSI Division.....	71
4.5	Number of changes per CSI Division.....	73
4.6	Dollar amount per grouped reason codes.....	75
4.7	Grouped reason code with time for entire database.....	77
4.8	Total Division 12 dollars spent per project percent complete.....	78
4.9	Total dollars spent per percentage grouping for the entire database.....	80
4.10	Total dollar amount per percentage grouping for CSI Division 1.....	81
4.11	Number of items per percentage grouping for CSI Division 1.....	82
4.12	Number of items per percentage grouping for CSI Division 2.....	82
4.13	Total dollar amount per percentage grouping for CSI Division 6.....	83
4.14	Number of items per percentage grouping for CSI Division 6.....	84
4.15	Number of items per percentage grouping for CSI Division 7.....	85
4.16	Total dollar amount per percentage grouping for CSI Division 9.....	85

4.17 Total dollar amount per percentage grouping for CSI Division 10.....86

4.18 Number of items per percentage grouping for CSI Division 11.....87

4.19 Number of items per percentage grouping for CSI Division 12.....88

4.20 Grouped reason code with time for Division 15.....89

4.21 Number of items per percentage grouping for CSI Division 16.....90

CHAPTER 1

INTRODUCTION

1.1 Introduction

Construction change orders are an unwanted, but inevitable, reality of construction (O'Brien, 1998). There is a body of literature which addresses change orders during construction projects and a common theme expressed in virtually all of this literature is that during complex construction projects, change orders are inevitable. Project complexity, project uniqueness, site conditions, varying expertise of designers and competitive market forces which require contractors to bid "lean" all contribute to the generation of change orders. In 1995, the Construction Industry Dispute Avoidance Task Force (DART) reported that more than \$60,000,000,000 annually was spent on change orders in the United States (Ibbs 1997).

While the magnitude of change orders on any given project varies with many factors, several authors have offered opinions about average change order rates. James Obrien, in his text "Construction Change Orders", suggests that experienced owners expect to pay more than the initial contract price and acceptable cost increases range around 5% (Obrien 1998). In a study of 35 organizations and 104 private sector projects, Ibbs found that cost increases due to design and construction changes averaged 5 % (Ibbs, 1997).

Change orders are believed to have a premium attached to them because they originate in an uncompetitive environment. When changes on a project are initiated, regardless of the source, the owner loses the ability to competitively bid the work and thus may have to accept quotes that are higher than would be expected if they had been included in the initial

stages of the bidding process. This research was targeted toward determining the cost impact of change orders, their causes, and point in the projects schedule in which they occur.

1.1.1 Change Order Effects on Project and Parties

The words “change order” conjure up strong feelings of negativity for all involved in construction projects. Owners do not like them because they generally feel they are paying for others’ mistakes. Contractors say change orders disrupt project flow and require additional paperwork and time to price and track. Architects, contractors, and owners agree they would prefer projects that didn’t require change orders. Change orders strain the relationships of the owners, architects, contractors, subcontractors, and others involved in the construction process as well as add cost and schedule delay.

Changes on one project can also affect other unrelated projects by tying up resources that are committed elsewhere. Negative relationships between the parties are another by-product of changes on a project. Not only is workflow disrupted, but also trying to get quick responses to RFI’s, quotes, shop drawings, and many other things required to get back on schedule causes a strain on working relationships.

Another impact of changes is the potential for cost overruns. If too many changes occur on a project and any/all contingency money is consumed, then projects budgets are depleted prematurely. Owners must closely monitor construction budgets and track construction

changes. Some projects may require administrative approval if they exceed budgets which may cause additional delay. Changes on the United Spirit Arena constructed by Texas Tech in 1999 forced Tech leaders to seek funding re-approval from both the university's agents and the Higher Education Coordinating Board (Altenbaumer, 1999). The excessive cost overages on this project may have been substantially reduced by initially producing better plans and specifications.

Change orders require a substantial amount of time to investigate, track, review, and approve. Obviously construction projects could be better served if there were no changes involved but this is an unrealistic viewpoint even though it represents how most parties involved on a project feel about change orders.

Each player in a project has his/her own belief about how long it should take to approve/process changes in a project and these opinions are usually very diverse. Although some of this diversity can be minimized by agreeing about processing times for paperwork in the pre-construction phase, compromise is inevitable so some parties will disagree. This can create far-reaching consequences for the project schedule and budget and possibly even contaminate working relationships between trades as they fight over space.

It is the contractor's responsibility to prove the merits and quantum of the claim (Harmon, 2001). Contractors spend a great deal of time requesting, reviewing, handling, and accounting for changes on a project and many feel that markup allowances on change orders

do not adequately compensate for actual field overhead costs, and do not provide for home office overhead completely or, in some cases, at all (Fayek, 2002). There is more to estimating the cost of a change order than plugging in some labor, material, and subcontractor costs and applying markups (McCally, 1997). Researching the legitimacy of each item a contractor or their subcontractor initiates requires a substantial amount of time for what sometimes equates to a trivial markup.

Loss of worker productivity is another harmful side effect of changes on a project. The effects of change orders on productivity is discussed in further detail in Chapter 2. When a schedule has been established and personnel are committed to work in certain areas of the job, the work needs to be available. When trades become stacked and many people are trying to work in the same space, production is lost.

1.2 Change Order Definition

A change order is the vehicle used to compensate a contractor for additional costs on a construction project. A change order is an instrument prepared by the architect and signed by the owner, contractor, and architect, each stating their agreement to any/all of the following: change(s) in work; the amount of the adjustment, if any, in the contract sum; and the extent of the adjustment, if any, in the contract time (AIA, 1997). There are two types of changes identified by A201 which include change orders and minor changes. The architect's authority to order change is limited to minor changes which by definition do not have any impact on price or time.

All changes under the A201 process begin with Construction Change Directives (CCD's) which may be used to direct the contractor to execute a change in the project. The contractor must perform the directed work under this process even if there is disagreement on price or time. Upon full agreement between the owner, contractor, and architect as evidenced by their signing, the CCD is converted to a change order. Aggregate changes require supplemental documents such as bulletins describing the project change, subcontractor quotes and negotiating to obtain agreement between the parties.

A change order may also be viewed as procurement without competitive bid (Wallwork, 2001). In some instances an owner at bidding may choose to defer a planned item until later in the project when confidence in project cost and progress is gained. A change may be executed to increase the scope of the project at this time.

1.3 Change Order Causes

Changes can originate from a number of sources, including the owner, Architect, or the contractor, as well as from the project itself. Construction project complexity, a lack of coordination between design professionals, and misinterpreted design programs are the leading causes of change orders.

Numerous authors have also identified and categorized potential causes of change orders. Diekman and Nelson (1985), Jacobs and Richter (1978) and Clark (1990) classified change orders into three main categories: design errors and omissions, scope changes and unforeseen

conditions. They also suggest that design errors and omissions account for 65% of changes, design changes (scope changes) account for 30% and unforeseen conditions account for 5% (Ibbs 1997). Civetello, in his book "Contractor's Guide to Change Orders", identifies many detailed causes of change orders and dedicates an entire chapter to "prospecting" for change orders (Civetello 2002).

According to Fayek, the majority of change orders result from errors or omissions in original contract documents (Fayek, 2002). Sufficient time is not often given to engineers and architects to review historical data and develop construction documents, and therefore often resulting in errors and/or omissions. Although human error cannot be entirely eliminated from the process, significant reductions in inaccuracies are possible. Changes made on the drawing board and in the design office are a lot cheaper and less time consuming to implement than those made in the field (Ehrenreich, 1994).

Owners often issue bid package addenda when responding to formal questions from bidders (McCally, 1997). Current practice is to address or solve issues with addenda or during the construction phase in lieu of during the design phase. This slows the project and distracts the parties from concentrating on the end goal and forces them to deal with the changes at hand, which is commonly referred to as "putting out fires". Contractors and designers are so preoccupied with making corrections and tweaking designs; they spend much of their time concentrating on the pieces of a project and lose sight of the project as a whole.

In current practice, architects and engineers rely on general notes in the contract documents to cover unanticipated changes which may lead to damages or delays sustained by the contractor who may misinterpret the contract documents (Kirsch, 2000). Though generalized notes will always be included in contract documents, reducing the number of vague statements could reduce the number of claims they cause.

It is common practice for owners to make scope changes toward the end of a project. If a project has had few changes and contingency monies are available, these excess monies may be used to add furnishings or other amenities toward the end of the project. These scope changes represent a significant source of change orders when owners decide, for a variety of reasons, to change the original design intent of the project. Scope changes can be as simple as changing the color of the carpet or as extensive as adding another story to the building. Early project communication between the owner and its architect, and accurate budgeting, can alleviate most of these issues.

Stakeholders in the project need to communicate constantly during the design phase in order to reduce the number of elements which cause change orders. The architect needs to fully understand the owner's scope and how the space will be utilized in order to reduce the number of changes during construction. A breakdown in communication during the planning stages may mean an owner initially pays for an item, and then is subsequently charged again for its removal and replacement.

Finally, field changes also are a significant cause of change orders. Field changes result from differing site conditions which are physical conditions that differ in some material respect other than weather, climate, or act of God discovered on or affecting a construction site, from what reasonably was anticipated (Cushman, 1992). This definition primarily represents those conditions discovered underground but the broad category field condition also includes, for example, building interior conditions where covered walls may hide asbestos containing materials or the discovery of lead paint post-bid.

1.4 Problem Statement

Developing a database to address the above objectives provides a foundation upon which recommendations are made in order to reduce change order costs. The projects in this research had original contract costs of \$133,000,000 and change orders totaling an additional \$10,836,044. These dollar amounts validate the need for a comprehensive examination for reducing change order items on future projects. If the recommendations presented in this research are followed, change order costs could be significantly reduced, in addition to a decrease in the time spent monitoring and processing them.

By assigning reasons as to why changes occur on a project one can begin to recognize their origins. If a standardized system for assigning reasons to change order items is established changes can be categorized and sub-categorized in order to better understand them. When changes occur in the project schedule is also an area of interest and can further lend insight into ways to reduce the impact of change order items on construction projects. Discovering

where the greatest numbers of changes occur will further narrow the focus and assist in designing preventive measures for reducing their impact on future construction projects.

Recognizing why changes occur on a construction project is needed in order to implement measures for their reduction. This research evaluates sixteen construction projects with nineteen separate contracts implemented on the campus of Michigan State University for purposes of assessing problem areas and determining common issues that need to be considered by architects and engineers when producing contract documents. The problem areas presented here can be tested against other universities and owners who procure construction on an ongoing basis.

1.5 Overview of Umbrella Project Case Study

This thesis developed a statistical database of change orders for a case study university and was part of a larger umbrella research project, conducted at Michigan State University (MSU) during 2004. Funding for the research was provided by MSU's Office of the Vice President for Finance and Operations, the Physical Plant, Engineering and Architectural Services (EAS), Campus Park and Planning (CPP), and Housing and Food Services Construction, Maintenance & Interior Design (CMID).

The overall research goal was to develop strategies for reducing the impact and cost of construction change orders at MSU and other large universities, through prevention of change orders and effective change order management.

The research led to the development of a statistical database for use in benchmarking and analysis, recommendations for MSU, a preconstruction plan review checklist, process maps outlining change order processes for procuring departments, a suggested alternative process map and three Masters level theses which included:

- Statistical Analysis of MSU Change Orders (Gottschalk 2006)
- Development of Pre-construction Strategies for Reducing Design Errors and Omissions Leading to Change Orders (Yelakanti 2005)
- Development of a Framework for Reducing Change Order Processing Time in University Construction Projects. (Mechanda 2005)

The primary project activities in the overall umbrella project consisted of review of relevant literature, development and analysis of a change order database for sixteen recent MSU construction projects and development and administration of an interview process of industry firms and other universities.

In developing the database, data was collected on over 1675 change order items listed on a total of 159 change orders. Change order information was analyzed on a project, change order and item basis. Statistical analysis was conducted on the data base which included general statistical reporting, analysis of change orders by Construction Specification Institute Divisions, and analysis by reason codes assigned by CGA. Keyword analysis was conducted on narrative descriptions included in the database in order to review causes of change orders within CSI Divisions and for comparisons of checklists prepared by Civettelo (2002) and the

University of Notre Dame.

The interview process consisted of interviews designed to gather information about change order perspectives and management practices of other organizations. The researchers conducted open-ended interviews of MSU personnel, outside architects, contractors, subcontractors and construction administrators from four Division One Universities. The University of Minnesota, University of Wisconsin, Purdue University and the University of Notre Dame were included in the study. More than 40 experienced construction professionals from these organizations were interviewed. Data from the interviews was paraphrased and tabulated in order to assess general themes expressed by the interviewees. A number of interview questions regarding change order rates, causes, tracking methods, and technical divisions involved were developed by this research and included in the interview. The thesis methodology is discussed in detail in Chapter 3.

In order to study change order management practices and seek opportunities for reducing change order processing times, current processes of EAS, CPP and CMID were mapped. MSU construction administrators and staff were interviewed to learn about current practices. The interview data was integrated with published MSU information on change order practices including the MSU Construction Standards, supplementary Conditions and Division 1 General Requirements.

The researchers applied Graham Flow Chart analysis techniques to the current change order process map for the EAS Formal Process in order to break down current processes and uncover opportunities for improvement. The data and analysis led to the development of a proposed process model and specific recommendations for managing change orders. Upon completion the proposed process map and pre-construction plan review checklists, were presented to MSU construction administrators for review and feedback. This feedback was used to make appropriate adjustments to the process map and checklists.

The goal of this research, and ultimately of the larger umbrella project at MSU, is to significantly reduce the number and impact of change orders on construction projects within universities. This thesis presents the data analysis of change order items from the case study university and is supplemented by interviews of outside parties familiar with MSU construction projects and processes. In addition four other universities were interviewed as well. In excess of 1,675 individual change items were evaluated. Each of these items was analyzed to determine their CSI divisional origins and where they occur in the project schedule. This information, along with 29 other characteristics of each change order item, was entered into a database to conduct various analyses.

Additionally, a review of relevant literature was conducted to gather information on, and experiences from, universities, major owners, and the general industry environment on various aspects of change order causes and management practices. This information was used along with the case study database and interview responses in order to form a

conclusion regarding the predominate causes of change orders within university settings and generalize the results to other institutions.

1.5.1 Case Study Construction Overview

Construction projects at Michigan State University typically total between \$60,000,000-\$100,000,000 annually. Overall, the projects in the database totaled \$133,355,273 at contract start and had ending costs of \$144,191,317 for a total increase by change order of \$10,836,044 or 8.1% from starting contract price. Projects selected for the database ranged from the approximate \$71,148,082 new Bio-physical Sciences Building (Cd#4) to a \$242,500 contract for the site work on the Intercollegiate Athletics New Track and Field Phase I project. Projects which were predominately new buildings or substantial additions were classified as new buildings. Projects which consisted mostly of renovation work were classified as renovations. The database consists of eleven contracts classified as new buildings and eight contracts classified as renovations. Projects were generally completed during the last three years.

1.5.2 Project Oversight Committee

An Oversight Committee comprised of MSU administrators from the Physical Plant, EAS, CPP, CMID, and CGA was created at the inception of the research project. The Oversight Committee met to define the scope of the project and to make recommendations regarding MSU projects to be included in the database. Additionally, the Oversight Committee suggested appropriate industry firms which provide services for MSU including architects,

contractors, and subcontractors and other universities which could be included in the interview process.

1.5.2.1 Oversight Committee Project Selection

The committee suggested that construction projects varying in size, cost, and complexity be studied. Projects ranging from under \$100,000 and in excess of \$1,000,000 were recommended. Construction projects that were in, or are currently in, litigation were purposely not included in this study. The group also agreed to choose projects that represented a good cross-section of campus construction. This included various types of construction including classrooms, offices, laboratories, sports arenas, and parking lots. New construction, renovations, and infrastructure were the three main categories in which the projects were classified.

1.6 Research Objectives

The goals of this research were to determine the cost impacts of changes and their causes on university projects. The specific objectives of this study are identified below:

1. Ascertain the patterns and causes of change orders to determine their relative impact on university construction projects.
2. Conduct detailed analysis of change order items to assess the impact of specific CSI divisions on change orders.

1.7 Deliverables

This research created a database containing information for use on the umbrella project. The information contained in the database allowed further research on the subjects of time and cost associated with change order items. Additionally, each change order item was categorized using reason codes which determined the root cause of each change and assisted in the creation of recommendations for minimizing their reoccurrence on future projects. The information was further used to develop and interpret which CSI Divisions had the greatest number of changes and the costs associated with them.

1.8 Chapter Summary

Through this project the researchers have analyzed over 1675 change order items, classified them by Construction Specification Institute (CSI) specification divisions, determined their cause and proportional impact on projects, as well as provided recommendations for preventing a variety of recurring types of change orders. This detailed look and reporting by technical category is a unique aspect of this research. The research establishes the foundation for specific processes which are applicable to university construction projects.

The industry recognizes the need to further understand change orders and why they occur on construction projects. The creation and analysis of a database produced from a wide range of projects offers insight into the sources of change order items and their root causes. The project timeline is also considered to identify when and what types of changes occur at the various stages of project completion. Interviews were conducted of industry professionals

and the general consensus is that reducing change orders is considered a top priority to streamlining the construction process.

1.9 Organization of the Thesis

This thesis is organized into seven chapters and appendices. The first chapter provides an introduction to change orders, an overview of the research, provides background on the case study, and describes the research objectives. The second chapter presents the literature review and provides an understanding of current industry trends regarding change orders and systems for identifying, monitoring, and processing change orders. The third chapter discusses the methodology used to perform the work associated with this research. It includes how the database was created and how it is part of a larger umbrella project that examines various aspects of change orders.

The fourth chapter presents the data analysis and describes the database in detail. New construction, renovations, and infrastructure projects are included with time, cost and relevant CSI divisions investigated. Chapter five reports the interview data and chapter six relates the change order database to the literature review and interviews in order to generalize the results and recommendations to other institutions. The seventh chapter consists of the summary, conclusions, and limitations of the research, as well as opportunities for future research.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

As part of this study on change orders, literature was reviewed in order to locate other studies which address changes on construction projects. The literature review focused on costs and time associated with these changes and their impact on productivity, schedule, and monetary impacts. The literature review was also done in an attempt to determine if change orders can be predicted prior to bidding or from the range of bids on a project.

2.2 Predicting Change Orders

The most logical approach to minimizing the impacts of change orders is to not allow them. Although it is impossible to eliminate all change orders on construction projects, steps can be taken to reduce their quantity. Whether or not change orders can be predicted based upon bids received by an owner is discussed by John Farbarik in his thesis "Evaluation of the Efficiency of Using Bid Data to Predict Construction Cost Overruns" (Farbarik, 1994). In Farbarik's study, various influences of change orders, such as the economy, number of bids, and the construction estimate, were examined to determine if they can be used to predict future changes on a project. One hundred sixty two governmental projects from the Army, Navy, and Coast Guard were evaluated and included in the database created in this study.

Farbarik attempted to determine if change order rates could be predicted by statistically analyzing the data using regression, chi-squared, and model utility tests. The results were inconclusive, inconsistent, or contrary to studies on the subject previously undertaken by others. Farbarik found that the only predictor that was useful in determining the amount

of change orders on governmental projects was historical data.

Military construction spending and the type of facility being constructed were the only predictors in trying to determine change order rates on Army, Navy, and Coast Guard government projects. Too many known and unknown variables exist for accurate predictions to be made at the time of bid.

2.3 Change Order Compensation

Construction projects are bound to generate change orders (Ehrenreich, 1994). One way a contractor recoups his/her overhead and profit is by markups on change orders. There is little agreement between contractors and owners as to what is an equitable markup. Cheryl Semple's thesis "Construction Change Order Impacts" (Semple, 1996) investigates change order markup values on construction projects in Canada to determine what is considered acceptable (defined as meaning fair to the owner, contractor, and subcontractors). Her conclusion is that there is disagreement on both sides as to what is fair and reasonable when pricing change orders. She discovered that contractors would like larger percentages of the changes in order to cover processing costs and also to provide some level of profit; owners likewise would like to see smaller markups.

The study concentrated on the cost and time aspects of change orders. To a lesser degree, other factors such as complexity, timing, material/labor ratios, relationships, quality, and terms of the contract were also investigated. Data was gathered by utilizing the existing literature, developing a survey, and then by formation of a panel of construction experts.

By these methods it was determined that the Canadian construction industry does not agree on a fair and reasonable markup for indirect costs and overhead, however, there is some agreement that a 7-8 % markup is fair for profit. It was also found that set values for indirect and overhead costs are not appropriate for all cases and that a tiered or sliding-scale system for markups is more suitable. Results indicate that processing time for change orders could have been improved between 45% and 114% for those items in the study that experienced problems or unusual delays. Although there is disagreement on the markup values for indirect costs and overhead, Semple discovered there is reasonable agreement with respect to contractor profit and that reducing the time it takes to process change orders is beneficial to both parties.

2.4 Change Order Effects on Productivity

Change orders disrupt project flow and negatively affect worker morale. Trades may have to relocate to different areas until the disposition for proposed changes is determined. This may result in the stacking of trades in certain project areas or the removal and replacement of work in place. Losses in productivity attributed to change orders were studied in detail by Assem of Concordia University over a six month period at Revay and Associates Limited in Montreal, Canada, a firm that assists in dispute resolutions (Assem, 2000).

In Assem's thesis he wanted to quantify how change orders impact productivity on construction projects. He developed computer models to measure the adverse impact that change orders have on construction productivity and this study lends insight to how

disruptive change orders are to construction projects. Thirty three work packages were studied on 117 completed projects and models were created. He statistically analyzed cases to correlate productivity loss against variables. The impacts of Change Orders on productivity were quantified by: 1) type of impact, 2) intensity of the Change Orders, 3) work type, and 4) the stage in the project when issues occurred.

Assem's case study provides data that model the adverse effects of timing and work types on change orders. Ten data sets were formed and used to model the impacts of timing and work type of change orders. He developed a software program named "ChangeOrders.E" (Change Orders Estimator) utilizing Microsoft™ Visual Basic to estimate the impacts of change orders. This program successfully predicted productivity loss due to the impact from change orders. His thesis findings support that change orders negatively impact construction projects and that errors and omissions during the design phase contribute to change orders and ultimately have adverse effects on projects. Change orders also negatively affect work flow and can result in stacking of trades, remobilization, and various other ripple effects not directly related to the change.

2.5 Cost and Time Associated With Change

Requests for additional cost and/or time are almost always a part of change orders because they require the contractor to recreate the construction schedule to incorporate the change(s). Trades must reorganize to incorporate changes and also adhere to the original construction schedule. Owners are usually reluctant to give time extensions, regardless of the justification (O'Brien, 1998).

How change orders impact the construction schedule was researched by John Kuprenas in his thesis "Use of Influence Diagrams to Assess the Cost and Schedule Impact of Construction Changes" (Kuprenas, 1988). He looked at the development and testing of influence diagrams to determine the cost and schedule impacts of change orders on construction projects. Influence diagrams provide a structure by which complex decisions with uncertainty can be understood. Impacts can be entered into the diagram and an expected value can be obtained. A model was created to forecast direct, indirect, and consequential impacts of change orders to construction projects. Kuprenas developed a Change Order Management Procedure (COMP) model to understand direct and indirect impacts. This COMP model was developed as a change management tool to investigate deficiencies in current pricing techniques.

Two case studies were used to test his model, a sprinkler project as well as an insulation project. The sprinkler project study shows that a change negatively impacted productivity, resulting in increased labor and rental costs for equipment, in addition to a delay in the completion date. The insulation installation project study also confirms that change orders negatively impact construction projects and, in this case, decreased productivity up to 50% while increasing labor costs and therefore extending the completion date.

Kuprenas's thesis findings reinforce Assem's discoveries that change orders negatively impact construction projects by disrupting flow and increasing labor costs to complete projects. Kuprenas's case studies prove that change orders require crews to move to

different work areas, rework existing work in place, and/or demobilize until a solution can be discovered. Contractors do not account for the costs of worker disruption downstream because they do not understand it or they are dictated by a contract that only allows what equates to time and materials plus a specified mark-up for overhead and profit to the individual issue at hand.

Consideration may or may not be given with respect to time, however, project flow is already disrupted and the contractor has to rely on experience to get the crews back into a rhythm. The stop and go fallout from change orders on construction projects also increases tension between the owner, architect, contractor, and lower tier contractors and decreases worker morale. Kuprenas's thesis reinforces Assem's assessment on how change orders negatively affect construction projects.

2.6 Why Changes Cost More

Change orders disrupt project completion and require owners, contractors, and subcontractors to spend additional money to implement them. Owners rarely turn to the architect/engineer for relief. Changes during construction can require rework and force the contractor to remove and install the change. This can result in out-of sequence work in which laborers must perform future activities ahead of schedule. This often is the result of having to wait for materials to arrive or forcing separate subcontractors to work together in available work areas on a project. If stacking trades proves to be impossible, contractors may be forced to demobilize until work becomes available.

Changes to the project may also require additional materials, some of which may be long-lead items. Even when the materials are readily available, workers may still have to wait to receive new materials before proceeding, or may be forced to perform piece meal work. Workers will also have to re-familiarize themselves with a task if reassigned to other work areas for a period of time or may even have to demobilize to a different project, which is even more detrimental.

The processing time for change orders is another reason why changes cost more. A contractor should not be expected to finance changes to the work and should be allowed compensation for that service (McCally, 1997). Contractors should be paid quickly and equitably in order to maintain good working relations.

2.7 Reducing Change Orders before Design

The contract documents are a culmination of work done by many people from various disciplines that form a temporary team in order to accomplish a construction project. Very few projects are implemented without any changes to the original scope of work and, therefore, construction projects are bound to encounter change orders. Changes made on the drawing board and in the design office are a lot cheaper and less time consuming to implement than those made in the field (Ehrenreich, 1994)

Because numerous people from so many different areas are involved in gathering the information and interpreting it, human error is a common problem. Significant amounts of project information must be known by each design discipline so that quality

construction documents are released for bidding/construction. Contractors typically do not include contingencies in their bids to cover errors or omissions on the part of the architect and they play a role in making the pre-bid period an opportunity to reduce the need for later change orders (McCally, 1997). A competitive environment does not allow for this when a contractor desires to win a bid. Contractors who identify defects usually do one of two things: either they notify the architect so an addendum can be issued to help equalize the bidding environment, or they take notes for future potential claims against the owner.

All too often, bidders do not review documents that are referenced in the bid documents, only to later discover problems that could have been anticipated (Harmon, 2001). Some contractors believe this is one way an architect forcibly induces a contractor to include things because he/she does not have time to research all of the referenced documents, thereby causing inadequate preparation time and information for the contract documents to be assembled. Contractors believe that by doing this the architect is shifting the workload to them.

Standard notes on drawings are another way this is believed to shift responsibility and cover-all notes on the prints such as “per industry standard” and “coordinate with other trades” are other examples. Architects, engineers, and owners need to continuously communicate when creating contract documents. Contractors and sub-contractors assume these to be free of defects and damages or delays sustained by the contractor often are the result of misrepresentation or inaccuracies in the contract documents

(Kirsch, 2000). Contractors and their subs can only bid what is in the documents. While nothing is black and white, there are many gray areas that are open to interpretation and thereby cause change orders to originate.

2.8 Reducing Change Orders During Construction

Defeis (1986) believes that an effective and efficient change order process is imperative in order to minimize costs. In order to achieve this he recommends the use of standardized forms and procedures which allows team members to concentrate on the issues rather than the processes. In addition, accurate records can be retrieved at a later date to assist in defending a dispute or claim. Documentation of meetings, conversations, work performed, equipment on site, daily labor reports, photographs, and correspondence, as they relate to a change, should be kept. These records can assist in determining both cost and schedule impacts.

Jacob and Richter (Jacob, 1978)^b also agree that the best way to avoid or minimize claims is a thorough understanding of the obligations of all parties involved in the contract. They also believe timeliness in discovering and notifying those affected is crucial to settling early. All too often, bidders do not review documents that are referenced in the bid documents, only to later discover problems they could have anticipated (Harmon, 2001). Failure of a contractor to give proper notice may result in a claim denial and generally contractors are required to continue working during the claim process. Throughout the claims process it is imperative that the contractor keep detailed records to support their claim. Written direction from the owner on how to proceed

during an event can help to support claim.

When evaluating design errors or omissions it is the contractor's responsibility to prove that his/her interpretation of the documents was reasonable in order for a claim to be defensible. However, the contract carries an implied warranty that the specifications are free from design defects (Secretary, 2002). As shown in this thesis, design errors and omissions represent the greatest number of change order items on projects contained in the database. The burden of proof is on the contractor to prove he/she erroneously relied upon the contract documents. The contractor has an obligation to present evidence to support his/her claim. Richter's advice to contractors is that one should prepare each claim completely and carefully and recommends accepting a fair and reasonable settlement, even if low, in order to resolve an issue. The longer the process lasts, the harder it is to resolve because of the amount of time that has passed and the loss of institutional memory (Angelo, 2003).

On average, three hours are spent in administering a change before work even commences on the change (Fayek, 2002). It is in the contractor's best interest to resolve disputes early so they can be reimbursed quickly. Other team members such as the owner, architect, and subcontractor also have additional time involved in researching these changes and these increases in workloads for all involved parties can be reduced with better pre-bid planning when drafting the contract documents. Change orders can take days, months, or even years to assemble and process. The contractor should not be expected to finance changes to the work but rather should be allowed compensation for

that service (McCally, 1997). When most contractors submit a quote for additional work they use “today’s dollars”. They don’t expect the architect to take any significant amount of time to resolve an issue. Many times it is the fault of the owner, not the architect. Government agencies and other large owners, such as universities and corporations, have enormous chains of command in which a change order must circulate before finally being approved.

2.9 Industry Change Order Rates

A statistical review of construction projects, such as refineries, manufacturing, petroleum/natural gas, and pharmaceutical/chemical, which range from \$3,900,000 to \$1,200,000,000, had an average change order rate of 5% (Ibbs, 1997). These projects were mostly from the private sector and typically used the design-build and design-bid-build project delivery methods. Ibbs’s study also shows that productivity suffered due to changes. He looked at changes separately during the design phase and the construction phase.

Diekmann & Nelson reviewed twenty-two federal projects to determine the associated change order rates (Diekmann, 1995). These projects ranged in construction costs of \$200,000 to \$20,000,000. There were 427 claims for change orders with strikes and weather being the biggest contributors to time extensions. They also determined that there was no correlation between the size of claim requested by a contractor and the contractor’s company size. The largest reason for change order items (46%) was

attributed to design errors. Scope changes were the second most common cause and resulted in 26% of the claims.

Change order rates on the above projects averaged 5% for projects that were designed by commercial (outside) designers and 10% for in-house designers. The average change order percentage for all twenty-two construction projects is 6% with 72% of this rate attributed to designer errors or owner initiated changes.

2.10 Reducing Change Order Claims

The number of construction cases in litigation has increased four-fold over the past ten years (Borg, 2004). Contractors are better educating themselves about the process of documenting changes and the importance of understanding the contract. In a 1978 study, Jacob and Richter stress the importance of reading the contract and understanding the obligations of each party. Furthermore, they stress the importance of identifying problems early, bringing it to the attention of the owner, and resolving the issue quickly. This is everyone's best interest in order to adhere to the time limits outlined in the contract as well as to resolve the issue while it is still fresh in the minds of the team members. If a contractor waits too long before submitting written notice, or performs work on a verbal approval from the owner, he/she may be barred from recovering restitution.

2.11 Similar Studies

Individual change items on a project can cause ripple effects throughout the project. The

cumulative effect of multiple changes can negatively influence the project and may lead to claims. Effective project management is seen as one method for controlling these effects. Various studies address reducing change orders through effective project management. Reported below are summaries of several relevant studies.

2.11.1 Effective Project Management

Clark examined effective project management tools for controlling schedule and cost on public works projects through interviews of project administrators, project managers, architects and engineers (Clark, 1990). The study concentrated on saving time and money and conducted interviews of personnel who consistently achieved superior project cost and schedule control to identify effective approaches. The various phases of construction were separated in order to be reviewed independently and included project planning, consultant selection, construction contract documents, agency review, and construction phase. The project planning phase discussed the importance of having a detailed project scope when planning a project. As part of the consultant selection phase, Clark & Mosher suggest that the number of design firms interviewed should be limited to two or three.

Clark & Mosher also indicate that selection of the consultant should not be decided on the basis of low bid. They believe project costs are greater when consultants are hired based solely on cost. Also, that the owner should provide a single set of coordinated review documents to the consultant to ensure they do not conflict with previous information provided to the consultant prior. In the construction phase, they also suggest

that quick resolutions to change orders, settlements, timely issuance of payments, and communication are critical to a successful project. Effective project management that focuses on cost control and schedule adherence is the best improvement that can be made to projects. Their emphasis is on project management techniques in order to reduce costs and improve schedule.

2.11.2 Cumulative Impacts of Change Orders

A study by Reichard examined the cumulative impact of change orders on projects that exceeded planned labor hours by more than 10-15% (Reichard, 2001). When this amount is exceeded, the contractor experiences a productivity loss on the changed work as well as the unchanged work and is entitled to additional compensation. Information on how to price cumulative change orders comes from published sources such as the National Electrical Contractor Association (NECA), Mechanical Contractors Association of America (MCAA), and the US Army Corps of Engineers.

Reichard's study presents four methods for calculating additional costs due to cumulative change order impacts. Researchers utilized an existing study of 84 building and industrial facilities totaling in excess of \$220,000,000 (Leonard, 1988). It was determined that the amount of additional work hours required by a subcontractor to complete his work to be within 2% of the actual hours expended. This study suggests that change orders have ripple effects on projects that are not always considered when pricing change orders.

2.11.3 Circumventing Claims

A study by Clark concluded that when changes exceed 10% of the original allocated workhours, construction schedule and cost are impacted (Clark, 1990). The reasons why changes occur include engineering, dates, specifications, clients, and environmental conditions. Clark's study also suggests that to avoid change orders sufficient time must be given to ensure the scope of the project is understood by the client. Shop drawing review and answering questions are equally important to mitigating changes on a construction project. Quick responses to both are essential to keep the project on schedule as well as minimizing costs associated with delay. Regardless of the contract type, each party is responsible for ensuring the other is informed.

2.11.4 Accuracy and Contingency

The final cost of a project includes all changes and events that occurred during the project (Rapier, 1990). Rapier's study examined cost estimate accuracy utilizing statistical evaluation and analysis. An estimate classification system was developed for use in dealing with accuracy and contingency. By use of interviews and check lists for the design team, members provide personal ownership of the project. Utilizing estimate simulation programs assisted in discovering deficiencies in design. The better a project cost estimate could be determined, the closer the final design was to being completed.

Contingencies are sums of money set aside on a project to cover unforeseen costs. These costs originate out of errors and omissions, scope changes, or field conditions. Rapier believes every project should have a contingency and it should be quantified as a function

of accuracy, anticipated, and planned for. It is inevitable that projects will encounter additional costs regardless of how well the design is assembled. In addition to design, scope, and field conditions, changes Rapier presents execution and estimating changes. Execution changes are those that are associated with the schedule, contract, site, business conditions, or labor. Estimating changes are inadequacies due to the estimate assembled by the design team. These changes should be tracked and added to the internal historical data in order that they may be incorporated into future designs.

2.12 Summary

This thesis seeks to minimize the impacts of change orders by going to the source of the problems. This will reduce the development of change orders by creating an understanding of how change orders originate and how to reduce them during the design stage. This will also help to minimize the number of change order items, hence minimizing productivity losses commonly associated with them. Change orders cannot be predicted at bid time and owners can only rely on historical data when establishing contingency budgets on construction projects.

Contractor markup for overhead and profit on change orders was examined and it was determined that markup values on indirect costs could not be reached, but that some agreement was reached on a 7-8% markup for profit. Reducing the processing time of change orders could be greatly improved and is beneficial to both parties. Change orders themselves negatively impact construction projects by disrupting project flow and can result in stacking of trades or remobilization. This forces the contractor to reconfigure

the project schedule to incorporate this work and get subcontractors to agree. Changes also negatively effect project morale and increase tension between the involved parties.

Change orders require additional money in order to implement, most of which does not add value. In the cases of scope changes, some value is added but not necessarily at the best price. These changes also typically negatively impact the construction schedule and require trades to coordinate their implementation. Availability of materials to incorporate a change(s) may delay the completion of certain areas or require remobilization.

The most opportune and beneficial time to reduce change orders is during the design phase of construction. Architects, engineers, and owners need to communicate effectively during this phase in order to help minimize errors and omissions. When changes occur in the construction phase, the contractor must document the reasons and circumstances surrounding an issue in order to support additional costs and schedule impacts. It is imperative to have quick resolution to change issues so they can be closed; allowing the parties to concentrate on the project and not on the change

U.S. industry construction projects typically exhibit change order rates around 5% (O'Brien, 1998) (Ibbs, 1997). Other industry projects experience change order percentages similar to those found by O'Brien and Ibbs. Diekmann's study of a 22 project database had an average change order rate of 6%. A Taiwan metropolitan public works project reported a higher average change order rate of 10-17%. This higher rate is the result of earth moving activities and could possibly be attributed to the nature of

unknown soil conditions. Elsewhere, The Construction Industry Development Agency in Australia (CIDA, 1995) reported an average change order rate of 10% on construction projects.

CHAPTER 3

METHODOLOGY

3.1 Introduction

This chapter describes the methodology used for this thesis. Literature review was conducted to examine existing research. A case study university was selected, and project data was obtained. A database was created to investigate where, why, and how changes occurred on 16 recently completed construction projects at the case study university, as well as, the costs associated with them. Microsoft™ Access and Excel were utilized to sort and group the data for statistical analysis. Linked tables and relationships were also utilized to tie the data together and are useful for further analysis.

Interviews of construction administrative personnel were conducted at MSU and four other research universities. To obtain information about change orders, interviews were also held with outside architects, contractors, and subcontractors previously or currently contracted by the case study university. This information served as a basis for the current change order environment and assisted in revealing several areas of opportunity. Recommendations using the data gathered in this study are provided and can be incorporated into current systems in order to reduce the impact of change orders on construction projects.

This thesis is one part of a three part umbrella project that analyzed completed MSU construction projects. Herein change orders are analyzed at the item level to determine their origins and the CSI divisions involved with each change. Part two of the umbrella project interprets the change order route and the times associated with the process of each. Part three discusses preconstruction prevention strategies and offers recommendations to reduce change

orders on construction projects

3.2 Literature Review

The literature review presents many of the issues that are common to each project. No comprehensive database was found to exist addressing the reasons why changes occur, where or when in the project schedule they occur, or the costs associated with them. Although each construction project is unique in both the design and the personnel team, there are reoccurring issues that are redundant in the studied projects. Differing site conditions and hazardous material abatement, along with space coordination between trades, are a couple of examples. Incomplete or deficient plans and specifications were found to be another significant source for change orders.

3.3 Creation of the Database

An MSU case study was selected for this project because this researcher is an employee and had direct access to all records, approval for the study, and financial support from the university. The researcher also had good working relationships with personnel in obtaining and duplicating the necessary documents. Because MSU is publicly funded this information could still be obtained, and the study duplicated, through a Freedom of Information Act (FOIA) request. All of the staff pledged their full support in both time and accessibility. The other research universities included in this study were in close geographic proximity to MSU and existing relationships with them were utilized in obtaining their participation.

An oversight committee was established consisting of top personnel from the offices of Contracts & Grant Administration, Physical Plant, Campus Park & Planning (CP&P), and Construction Maintenance & Interior Design (CM&ID). The committee assisted in the selection of the construction projects for this study with careful consideration to ensure each discipline was fairly represented. For example, CP&P included a parking lot while CM&ID included a residence hall renovation. Projects involved in litigation were not included in this project list. This committee also assisted in overseeing the research.

3.4 Database Development

The database is comprised of 16 recently completed construction projects with nineteen separate contracts. The projects contain a total of 159 change orders with 1675 individual items (Table 3.1). The change orders were retrieved in hard copy from MSU's Physical Plant archives, which is the central location for all project data relating to construction projects that go through the Physical Plant. This historical data is stored in many forms such as hard copies, microfiche, as well as electronically. Other records that didn't employ the services of the Physical Plant were obtained from CP&P's archives for those projects. All records were reproduced into hard copy form to simplify data entry and for future reference.

Project ID	Project Name	Initial Cost	Ending Cost
0365	Hannah Administration	\$849,000.00	\$925,818.13
1707	Agriculture Hall Annex Renovation and Window replacement	\$6,260,300.00	\$6,605,238.00
3482	Jenison Fieldhouse Locker Room Renovation and Addition	\$6,394,000.00	\$6,931,214.96
2474A	MSU Bio-Physical Science Bld.	\$1,647,000.00	\$2,886,756.00
2474B	MSU Bio-Physical Science Bld. Cd#2	\$4,522,200.00	\$4,698,577.00
2474D	MSU Bio-Physical Science Bld. Cd#4	\$71,148,082.00	\$74,777,169.40
2124	Nisbet Building Chiller Installation	\$385,000.00	\$396,501.34
3067	Spartan Stadium-East Concourse Restoration	\$2,565,000.00	\$4,955,991.54
3119	Breslin Center - Berkowitz Addition	\$6,136,953.00	\$6,498,546.64
3147	Chemistry Building Renovations	\$931,889.00	\$991,284.00
3158	Wilson Hall Alterations	\$313,000.00	\$312,208.00
3282	Life Sciences Alterations	\$420,531.00	\$469,489.92
3347	Spartan Child Development Center	\$2,035,000.00	\$2,324,281.03
3496	Campus Fiber-Optic System Phase VIII	\$1,995,000.00	\$2,028,923.06
3981	MSU Cyclotron Building Office Expansion	\$3,205,108.00	\$3,533,998.09
02140A	Intercollegiate Athletics New Track and Field Facility Phase I	\$242,500.00	\$265,776.80
02140B	Intercollegiate Athletics New Track and Field Facility Phase II	\$2,547,000.00	\$2,572,226.80
0584	Food Safety/ Tox Lab	\$18,737,710.00	\$19,241,573.00
99072	Parking Lot #89 Expansion	\$3,020,000.00	\$3,775,743.12
Totals		\$133,355,273.00	\$144,191,316.83

Table 3.1. Database projects with initial and ending project costs

3.5 Project Costs

Project costs range from \$242,500 for the site work on the Intercollegiate Athletics New Track and Field Facility Phase I project to \$71,148,082 for the Bio-Physical Science Building (Cd#4). The total initial contract cost for all projects in this data set is \$133,355,273 with an additional \$10,836,044 in change orders. The projects include infrastructure, renovations, additions, and new buildings. Project descriptions for each of the projects are listed in Appendix IV.

3.6 Change Order Form

A change order form was created in Microsoft™ Access to include sixty-plus data entry points for each change order item (Figure 3.1) and is divided into three main sections. The definition for each of the data entry points is found in Appendix I. Linked tables for projects, change orders, and change order items were also utilized in order to tie the tables together. Relationships between these tables can be seen and a snapshot of the raw data in Microsoft™ Excel is also included. The change order form was created and all information was entered for use in the umbrella project. Statistical analysis of the data utilized Microsoft™ Excel.

The database was also constructed so that key word searches could be run, which allows change order items with the same key word, such as “duct” or “piping”, to be sorted and further examined. Other researchers under the umbrella project performed keyword search analyses as part of their research. Fellow researchers also used this information to provide additional detailed analysis and recommendations. When reviewed as a whole, patterns or problems areas emerged and allowed for a more detailed analysis where conclusions could be made to reduce their impact on future projects.

Change Order Form

New Project

Project ID: 3482

Project Name: Jensen Fieldhouse Locker Room Renovation and Addition

Project Desc: Partial renovation of 5 floors and electrical room and penthouse additions.

Architect: Rossetti Architect

MSU Project Manager: Ken Gottschalk

Contractor: Kares Constructive

Contract Date: 7/2/2001

Change Order No: 3

Initiation Date: 11/19/2001

Reason Code: Documents

Bulletin: 0

CCD: 8.0

Others: QFC # 23

Item Desc: ASL#4 Various mechanical and locker color change.

☐ CSI 1 ☒ CSI 2 ☐ CSI 3 ☐ CSI 4 ☒ CSI 5 ☐ CSI 6
 \$0.00 \$11,166.29 \$0.00 \$12,156.00
☐ CSI 7 ☐ CSI 8 ☐ CSI 9 ☒ CSI 10 ☐ CSI 11 ☐ CSI 12
 \$0.00 \$0.00 \$0.00 (\$1,000.00)
☐ CSI 13 ☐ CSI 14 ☒ CSI 15 ☐ CSI 16 ☒ O and P Amount
 \$6,201.23 \$0.00 \$4,739.08 \$32,363.35

Item Initiation Date: 8/29/2001

Project Progress: 16%

New Item

Record: 14 of 10

Previous Contract Sum: \$5,484,447.88

New Contract Sum: \$5,533,428.63

Change Contract Sum: \$48,980.75

Days Effected: 0

Athd Architect: Rossetti Architects

Architect Athn Date: 11/19/2001

Athd Contractor: Kares Construction Co.

Contractor Athn Date: 11/21/2001

MSU Authorization: Contracts and Grants

MSU Athn Date: 12/12/2001

Next change order

Record: 14 of 3 of 11

Record: 14 of 3 of 19

Figure 3.1. Microsoft™ Access Change Order Form

3.6.1 Section 1

The first section of the data entry form includes general project information such as assigned project number and official project name. Project names typically included the building name along with a brief synopsis of what work was performed, i.e. “Jenison Fieldhouse Locker Room Renovation and Addition”. Along with the project name, a project description was provided to assist the reader and researchers to better understand the extent of the project. For example, “Partial renovations to 5 Floors, installation of new elevator, construction of a new penthouse and electrical room addition”. The project architect of record, MSU project manager, and general contractor or construction manager were included as well. Additionally, the contract date was integrated to identify the date the parties entered into the agreement.

3.6.2 Section 2

The second section identified the change order number and the date it was written. Included is detailed information such as previous contract sum, individual change order amount(s), and the sum of the two for the new contract sum. Any addition or reduction in days was also listed. The authorizing parties for the architect, contractor, and MSU, along with signature dates, were also included in this section for concurrent studies of processing time by fellow researchers of the umbrella project.

3.6.3 Section 3

Individual change order item information is found in the third and final section. A detailed description of each item listed on the change order was also provided. Whether the item originated as a contractor quote, Construction Change Directive, Bulletin, or some form thereof, is also indicated. Each item was separated and classified into the corresponding Construction Specifications Institute (CSI) divisions (Table 3.2) and is identified, along with the corresponding dollar amount attributed to the divisions affected by that change. For example, a Division 15 HVAC duct may need to be replaced and require additional Division 9 ceiling work to be performed. The corresponding overhead and profit for each change order item was also tracked by the researcher and is included on the form.

The initiation date for each item was exhaustively researched to find the point in time when it was first discovered. This date could originate from a variety of sources such as Request For Information (RFI's), Bulletins, CCD's, memos, e-mails, etc. A project progress field on the form identifies, in percentages, when each item occurred in relation to the original/contractual specified construction schedule.

1. General Requirements
2. Site Work
3. Concrete
4. Masonry
5. Metals
6. Carpentry
7. Thermal and Moisture Protection
8. Doors and Windows
9. Finishes
10. Specialties
11. Equipment
12. Furnishings
13. Special Construction
14. Conveying Systems
15. Mechanical (Includes HVAC, Plumbing and Fire Suppression Systems)
16. Electrical
17. Profit and Overhead (Created by the researcher)

Table 3.2. Construction Specifications Institute (CSI) divisions

3.7 Database Analysis

Design Error, Scope Change, Field Condition, and Reason Not Specified are four “Reason Code” categories used to assign responsibility for each change item (Table 3.3). Reason Codes were created by MSU Contracts and Grants Administration office as a way of tracking changes on construction projects. Reason Code designations were assigned by the MSU architect on each project and the Reason Code, when it existed, were included in the database.

1. Design Errors and Omissions

D1	Construction Standards	Change required because original design did not include an MSU standard
D2	Code Compliance	Corrects for a local, state or national code deficiency
D3	Constructability	Portion of work is not buildable as designed
D4	Errors	Portion of work will not achieve objective as designed or is missing relevant information
D5	Other	Other design related error or omission not described above

2. Field Conditions

F1	Environmental	A regulated hazard is discovered: asbestos, pcb, etc
F2	Soils	Poor soils are discovered
F3	Hidden condition	A hidden existing condition is discovered
F4	Allowance adjustment	Allowance is adjusted to reflect actual cost
F5	Change in code	A local, state or national code is changed during construction
F6	Other	Other field changes not described above

3. Scope

S1	Customer Scope	Customer changes scope for any reason
S2	Physical Plant Scope	Physical Plant changes scope for any reason
S3	CP&P Scope	CP&P changes scope for any reason
S4	Value engineering	Value engineering changes contract price
S5	Other	Other scope changes not included in above

4. Reason Not Specified

Category created to classify items not given an above Reason Code designation

Table 3.3. Change Order item Reason Codes

3.7.1 Reason Codes

Design Errors are mistakes that designers make from either a lack of coordination with other trades, insufficient field visits, and/or improper review of historical data as well as a myriad of other reasons. Scope Changes are modifications initiated by the owner and sometimes result from miscommunication between themselves and the architect but can also result from a change in owner criteria. Field Conditions are circumstances that are discovered after a project begins. An example of this would be asbestos insulation hidden in a wall and not discovered until demolition begins. This change would be documented as occurring “early” in the project whereas relocation of an exterior light pole base due to a conflict with an existing ductbank would be documented as “late” because this typically occurs toward the end of a project. The category of “Reasons Not Specified” includes issues that are not otherwise categorized or are missing in the data set (Table 3.3).

3.7.2 Change Timelines

Changes were categorized by quartile of project completion to determine when the majority of the changes occurred in the project set. The researcher was interested in concentrating on change orders by completion point.

3.7.3 Construction Type

Whether the construction project was an addition, renovation, or new was also determined to assist in identifying the types of projects that need to carry a higher contingency. The database was categorized based on project type.

3.7.4 CSI Division

An objective of this research was to classify all change order items into their respective Construction Specifications Institute (CSI) divisions. Items that involve multiple divisions per item are separated into their respective divisions and an additional division was created to monitor overhead and profit. Once the sources were discovered, recommendations for preventive measures were developed to reduce the impact of change orders on future construction projects.

3.7.5 Macro and Micro Analysis

Upon completion of database acquisition the data was exported to MS Excel and the following nine forms of macro and micro analysis was conducted:

MACRO-ANALYSIS:

1. Change Order Rates
2. Impact of New vs. Renovation
3. Occurrence in Project Time
4. Reason Code Identification
5. Source of Item (RFI, Bulletin, CCD, etc.)

MICRO-ANALYSIS:

6. Items Divided Into Corresponding CSI Divisions
7. Break-out of Overhead & Profit for Each Item
8. Number of Items Per Reason Code
9. Number of Dollars Per Reason Code

Macro analysis was conducted in order to determine broad change order rates for the database projects. Comparison of project types was also investigated to verify which project type, new, renovation, or infrastructure, is more susceptible to change orders. Where

changes occur in the project schedule can also be useful for budgeting changes as the project progresses (Figure 3.2). Understanding the reasons why changes occur and whether they originate from a contractor as an RFI, an architect as part of a Bulletin, or from the owner as part of a Construction Change Directive (CCD) offers opportunities for their reduction on future projects.

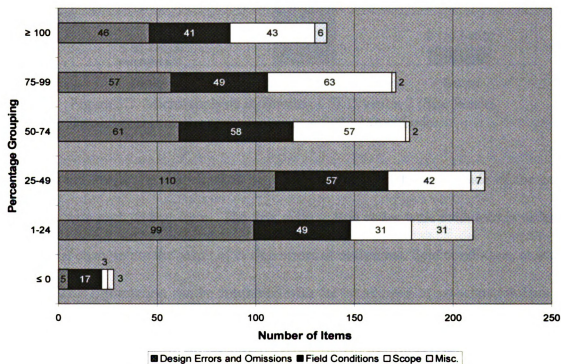


Figure 3.2. Macro-analysis illustrating Reason Code items over project time

Micro analysis delved into which Construction Specifications Institute (CSI) Divisions witness the greatest number of changes and how many involve multiple divisions. Further analysis looked at determining the dollar amounts attributable to each Reason Code category for every CSI Division. An example of Division 2 (Site Work) is shown in Figure 3.3.

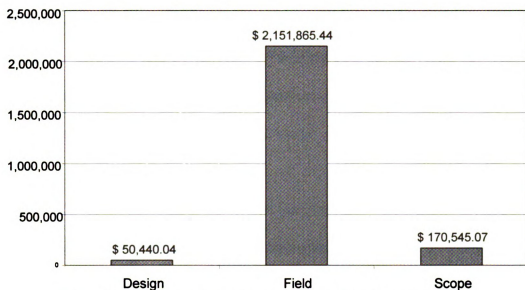


Figure 3.3. Micro-analysis illustrating CSI Division 2 (Site Work)
Total database dollar amounts per grouped Reason Code

Overhead and Profit was also tracked in order to determine the magnitude of the costs associated with each change item. The four main reason codes were evaluated in order to determine if changes are the result of design errors or omissions, field conditions, or scope changes. This information can be combined with the breakdown of associated dollars for each reason code and be utilized to reduce future change orders.

3.8 Interviews

Various parties involved in construction projects at the case study university, as well as construction personnel from four other research universities, were interviewed as part of the umbrella project. Approximately 40 individuals were interviewed including general contractors, subcontractors, external design firms, and universities. Researchers conducted the outside interviews in order to avert unbiased feedback. The initial, internal

questionnaires consisted of 45 open and closed-ended questions and are included in Appendix V. Questions developed by this researcher were combined with those of the other researchers to create the final questionnaire. Participation in the interviews was voluntary. A coding system was set up to ensure privacy and each interviewee had the right to refuse to answer any question without penalty.

Included in this research are 29 of the 45 total questions that were relevant to this part of the umbrella project. These questions included background information on change order rates, analysis, monitoring, and standardization of change items currently being tracked internally. The types of changes typically seen on projects and information on contingency allocations and the number of changes throughout a project were also included. The researcher also asked about unspent contingency funds during and after project completion in order to determine whether these funds are used for scope changes or returned to the university.

3.9 Integration of Data

Through the interviews and the literature review it was determined that there is agreement throughout the industry with regard to the types of common changes seen on construction projects. Both interviewees and the literature reported design errors are the dominant cause for change orders. They also concur that CSI Division 15 (Mechanical) is responsible for the greatest number of changes on projects. The change order rates of 3-10% expressed through the interviews matches studies performed in the industry.

3.10 Summary

This chapter identified the creation of the case study university database of sixteen recently completed construction projects with nineteen separate contracts. A form was created to track the various aspects of change orders which contained in excess of sixty data entry points for each individual change item. Reason Codes were reviewed along with when changes occurred in the project schedule and the costs associated with them. New, renovation, and infrastructure projects were included in the case study in order to provide an accurate cross-section of the different types of projects seen in the industry.

Interviews of more than 40 construction professionals including the case study university, four additional research universities, architects, contractors, and subcontractors were conducted as part of the larger umbrella project. The information received from these interviews was then combined with the literature review to convey the current change order environment. This information was then compared against the database in order to draw conclusions about change orders.

CHAPTER 4

DATA ANALYSIS

4.1 Introduction

The database used for this study consists of sixteen recently completed construction projects with nineteen separate contracts that took place on the campus of Michigan State University (Table 4.1). Due to the size, complexity, and short time schedules, two projects had multiple contracts. The Bio-Physical Science Building had four separate contracts consisting of the site work, steel erection, chiller equipment purchase, and balance of project. The Intercollegiate

Project ID	Project Name	Initial Cost	Final Cost
365	Hannah Administration	\$849,000.00	\$925,818.13
1707	Agriculture Hall Annex Renovation and Window Replacement	\$6,260,300.00	\$6,605,238.00
3482	Jenison Fieldhouse Locker Room Renovation and Addition	\$6,394,000.00	\$6,931,214.96
2474A	MSU Bio-Physical Science Bldg.	\$1,647,000.00	\$2,886,756.00
2474B	MSU Bio-Physical Science Bldg. Cd#2	\$4,522,200.00	\$4,698,577.00
2474D	MSU Bio-Physical Science Bldg. Cd#3	\$71,148,082.00	\$74,777,169.40
2124	Nisbet Building Chiller Installation	\$385,000.00	\$396,501.34
3067	Spartan Stadium - East Concourse Restoration	\$2,565,000.00	\$4,955,991.54
3119	Breslin Center - Berkowitz Addition	\$6,136,953.00	\$6,498,546.64
3147	Chemistry Building Renovations	\$931,889.00	\$991,284.00
3158	Wilson Hall Alterations	\$313,000.00	\$312,208.00
3282	Life Sciences Alterations	\$420,531.00	\$469,489.92
3347	Spartan Child Development Center	\$2,035,000.00	\$2,324,281.03
3496	Campus Fiber-Optic System Phase VIII	\$1,995,000.00	\$2,028,923.06
3981	Cyclotron Building Office Expansion	\$3,205,108.00	\$3,533,998.09
02140A	Intercollegiate Athletics New Track and Field Facility Phase I	\$242,500.00	\$265,776.80
02140B	Intercollegiate Athletics New Track and Field Facility Phase II	\$2,547,000.00	\$2,572,226.80
584	Food Safety / Toxicology Laboratory	\$8,737,710.00	\$9,241,573.00
99072	Parking Lot #89 Expansion	\$3,020,000.00	\$3,775,743.12
Total		\$133,355,273.00	\$144,191,316.83

Table 4.1. Database projects

Athletics New Track and Field Facility consisted of two packages, site work and the balance of the project. The total contract cost for these two projects is \$77,317,282 and \$2,789,500 respectively. Original contract amounts for all sixteen projects totaled \$133,355,273 with final construction costs of \$144,191,317 as a result of change orders totaling \$10,836,044.

4.2 Project Information

All construction projects were constructed on the campus of MSU located in East Lansing, Michigan. Individual project costs ranged from \$242,500 for the site work on the Intercollegiate Athletics New Track and Field Facility Phase I project to \$71,148,082 for the Bio-Physical Science Building (Cd#4).

4.2.1 Project Types

The construction projects included in this database are listed in one of three categories: new construction, renovation, or infrastructure. New construction consisted of ten projects while renovations and infrastructure projects numbered seven and two respectively. Although the number of projects in each category differs, this author believes this to be a fair representation of typical construction projects that occur on university projects annually. The Oversight Committee assisted in the selection of the construction projects.

4.2.1.1 New Construction

The ten new construction projects consisted of the following projects:

- 1) Agriculture Hall Annex Renovation and Window Replacement
- 2) MSU Bio-Physical Science Building
- 3) MSU Bio-Physical Science Building Cd#2

- 4) MSU Bio-Physical Science Building Cd#4
- 5) Breslin Center – Berkowitz Addition
- 6) Spartan Child Development Center
- 7) MSU Cyclotron Building Office Expansion
- 8) Intercollegiate Athletics New Track and Field Facility – Phase I
- 9) Intercollegiate Athletics New Track and Field Facility – Phase II
- 10) Food Safety / Toxicology Laboratory

The above projects represented new buildings or major additions sharing a wall or connected by a wing to an existing building. The ten construction projects classified as new had an original contract amount totaling \$116,481,853 and a final contract amount of \$123,404,143. This equated to \$6,922,290 in change orders for projects classified as new.

The ten “new” projects included buildings housing offices, laboratories, classrooms, and athletic spaces. The largest project contained in this section was the Bio-Physical Science Building, which had original contract amounts in excess of \$77,000,000. The smallest project classified as new was the site work performed in preparation for the Intercollegiate Athletics New Track and Field Facility. This original contract amount totaled \$242,500. The total average change order rate for these ten projects was 5.65% (Table 4.2)

4.2.1.2 Renovations

The renovation project list consisted of seven projects as follows:

- 1) Hannah Administration
- 2) Jenison Fieldhouse Locker Room Renovation and Addition
- 3) Nisbet Building Chiller Installation
- 4) Spartan Stadium – East Concourse Restoration
- 5) Chemistry Building Renovations
- 6) Wilson Hall Alterations
- 7) Life Sciences Alterations

These projects mainly consisted of renovations to existing spaces and included miscellaneous abatement and upgrades to mechanical, electrical, and communication systems. New partitions were built dividing the spaces and structural strength was increased as part of the design. For example, field conditions on the Spartan Stadium project resulted in a considerable amount of the \$2,390,992 in change orders to be spent due to unsound concrete and changes resulting from an unknown original monolithic concrete pour method.

Seven of the nineteen contract databases were classified as renovations. These seven projects mostly consisted of renovations to existing buildings on campus and included room alterations/renovations and also the restoration of Spartan Stadium. The room renovations are typical of those found at a 100+ year old campus and include the demolition and upgrading of the electrical, mechanical, and fire sprinkler/alarm systems. Asbestos containing materials were abated when encountered, typically by way of change order (i.e. hidden condition).

4.2.1.3 Infrastructure

The two infrastructure projects included the following:

- 1) Campus Fiber-Optic System Phase VIII
- 2) Parking Lot # 89 Expansion

The total original cost for these two projects was \$5,015,000 with the final costs tallying at \$5,804,666. This equated to \$789,666 in change orders or a 13.6 % increase to the original contract amounts.

4.2.2 Location

All construction projects included in this database were located on the main campus of Michigan State University in East Lansing, Michigan. MSU, founded in 1855, is a land grant Division One research institution. The campus encompasses over 5000 acres with 680 buildings containing over twenty-one million square feet of space. There is a diversity of building types, vintage, and construction and numerous academic, research, and support departments are housed within these buildings. MSU also has an extensive infrastructure and operates a co-generating power plant that supplies electricity, and heating and cooling to the entire campus. Steam, chilled water, electrical, and various other utility lines are all buried underground throughout the campus.

4.3 Data Analysis

The sixteen-project/nineteen-contract database consisted of 159 change orders containing in excess of 1,675 individual change order items. The total original contract amounts for these projects were valued at \$133,355,273 and at project completion totaled \$144,191,317. This is an increase of \$10,836,044 as a result of change orders and equates to an 8.13% increase from the original contract amounts (Figure 4.1). For scaling purposes, project number 2474D (Bio-Physical Science Building – Cd#4) was not included and had an original contract amount of \$71,148,082 and a final contract amount of \$74,777,169.

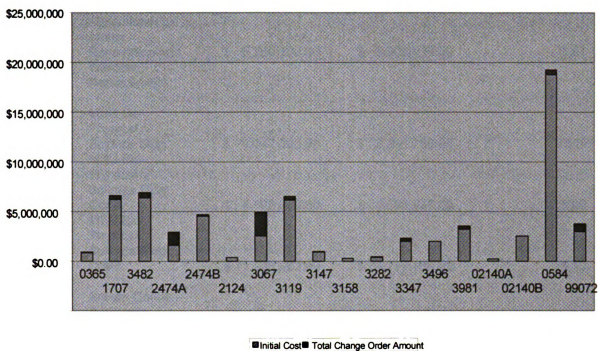


Figure 4.1. Change Order Amount Showing Initial Project Cost

Interviews conducted at four additional research universities self-reported the following change orders rates: Notre Dame: 3% for new buildings; Purdue: 3% for new buildings; Minnesota: 5-10%; and Wisconsin: 7-10%. Based on these interviews it appears the change order rate on the case study projects is in line with averages of other similar universities.

Project ID	Project Name	Initial Cost	Final Cost	% Change
1707	Agriculture Hall Annex Renovation and Window Replacement	\$ 6,260,300.00	\$ 6,605,238.00	5.51
2474A	MSU Bio-Physical Science Bldg.	\$ 1,647,000.00	\$ 2,886,756.00	75.27
2474B	MSU Bio-Physical Science Bldg. Cd#2	\$ 4,522,200.00	\$ 4,698,577.00	3.90
2474D	MSU Bio-Physical Science Bldg. Cd#3	\$ 71,148,082.00	\$ 74,777,169.40	5.10
3119	Breslin Center - Berkowitz Addition	\$ 6,136,953.00	\$ 6,498,546.64	5.89
3347	Spartan Child Development Center	\$ 2,035,000.00	\$ 2,324,281.03	14.22
3981	Cyclotron Building Office Expansion	\$ 3,205,108.00	\$ 3,533,998.09	10.26
02140A	Intercollegiate Athletics New Track and Field Facility Phase I	\$ 242,500.00	\$ 265,776.80	9.60
02140B	Intercollegiate Athletics New Track and Field Facility Phase II	\$ 2,547,000.00	\$ 2,572,226.80	0.99
584	Food Safety / Toxicology Laboratory	\$ 8,737,710.00	\$ 19,241,573.00	2.69
Total		\$116,481,853.00	\$123,404,142.76	Average % Change 13.34
Total Project % Change				5.65

Table 4.2. Database projects classified as new

The largest of the renovation projects was the Jenison Fieldhouse Locker Room Renovation and Addition with an original contract amount of \$6,394,000 and a final contract amount of \$6,931,215, which equated to an 8.4% change order rate. The smallest project contained in this section was the Wilson Hall Alterations project with an original contract amount of \$313,000 and a final contract amount of \$312,208. This lower, final contract amount is attributed to the installation of a 2-1/2" galvanized rigid conduit for the new chiller power supply in lieu of the original 4" specified. This therefore resulted in a single deductive change order with a corresponding rate of -0.25%.

These seven projects had a total project change order rate of 20% (Table 4.3). This rate was heavily influenced by the Spartan Stadium–East Concourse Restoration Project which had a change order rate of 93.22%. This high percentage was due to unsound concrete conditions discovered during demolition, which resulted in additional concrete removal, replacement, and supplementary reinforcement. This extra work was performed on a time and material basis. By performing removal and replacement under this method, MSU lost the ability to competitively bid the work, which may have resulted in higher costs. If this item is removed from the data set, the change order rate is 6.37% for renovation projects.

Project ID	Project Name	Initial Cost	Final Cost	% Change
365	Hannah Administration	\$ 849,000.00	\$ 925,818.13	9.05
3482	Jenison Fieldhouse Locker Room Renovation and Addition	\$ 6,394,300.00	\$ 6,931,214.96	8.40
2124	Nisbet Building Chiller Installation	\$ 385,000.00	\$ 396,501.34	2.99
3067	Spartan Stadium – East Concourse Restoration	\$ 2,565,000.00	\$ 4,955,991.54	93.22
3147	Chemistry Building Renovations	\$ 931,889.00	\$ 991,284.00	6.37
3158	Wilson Hall Alterations	\$ 313,000.00	\$ 312,208.00	(0.25)
3282	Life Sciences Alterations	\$ 420,531.00	\$ 469,489.92	11.64
Total		\$11,724,720.00	\$14,666,530.93	Average % Change 18.77
Total Project % Change				20

Table 4.3. Database projects classified as renovation

The final two projects were classified as infrastructure. These two projects were the Campus Fiber-Optic System Phase VIII and the Parking Lot #89 Expansion. The fiber-optic project involved the excavation and installation of underground communication duct lines, encased in concrete and are located throughout campus and used to house fiber optic cables. This project had an original contract amount of \$1,995,000 and a final contract amount of \$2,028,923 which equated to a 1.7% change order rate (Table 4.4).

Project ID	Project Name	Initial Cost	Final Cost	% Change
3496	Campus Fiber-Optic System Phase VIII	\$1,995,000.00	\$2,028,923.06	1.70
99072	Parking Lot #89 Expansion	<u>\$3,020,000.00</u>	<u>\$3,775,743.12</u>	<u>25.02</u>
Total		\$5,015,000.00	\$5,804,666.18	Average % Change 3.82
				Total Project % Change 13.6

Table 4.4. Database projects classified as infrastructure

The second of the two projects was the Lot #89 Expansion, which added approximately 800 new parking spaces adjacent to an existing lot. Work included grading, pavement, drainage, curb and gutter, sidewalks, site lighting, and bus shelter installations. The original contract amount for this project was \$3,020,000 and the final contract amount totals \$3,775,743. The change order rate for this project was 25.02%. A significant amount of poor soils were discovered, which required additional excavation and fill, and soil borings were performed. When asked why a large amount of poor soils were discovered so late, the Project Representative responded by saying the poor soil conditions were located between the test borings and therefore not known prior to construction.

Because of the prevalence of a myriad of unknown conditions experienced while performing underground work, any good contract written by an owner will include unit prices for various conditions expected during construction. This simplifies change order verification processes. Quantities are simply tracked and the unit prices are applied to them. This streamlines the

process and minimizes the amount of time necessary to review change order item costs by the owner/engineer and can also assist the contractor in receiving quicker payment.

4.4 Quantifying Change Order Reasons

The reasons change orders occur on a project were also studied as part of this project. “Reason Codes” were developed by CGA to assist in assigning a narrowed cause for why a change occurs. The Reason Codes were divided into four basic groups: 1) design errors and omissions; 2) field conditions, 3) scope, and 4) reason not specified (refer to Table 3.3 in chapter 3 for a complete description). The reasons not specified category was created for those items that are either missing a reason code or for projects that were completed before the implementation of the reason code designations.

There are 936 items that were classified as design errors or omissions, field conditions, or scope using the CGA designation system. Of these, 394 were design errors or omissions, constituting 42% of the “classified” change order items contained in this study and representing the leading group of reason codes. The design error and omissions group resulted in roughly \$1,800,000 in contingency monies used. Next, at 31%, were field conditions. This category includes 286 items, accounting for close to \$2,200,000 in change orders. The final group includes 256 items related to scope, which represented 27% of the change order items contained in this study (Figure 4.2). These changes accounted for nearly \$2,000,000 in spent contingency. The data presented here shows considerable areas for improvement in the assembling of contract documents before sending a project out to bid.

Figure 4.2 is based on 1375 items (for this graph items without narrative descriptions were eliminated).

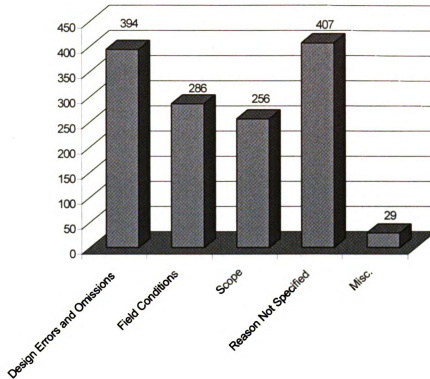


Figure 4.2. Number of Change Order Items per Specified Grouped Reason Codes

4.5 Change Order Item Relationships to Point of Project Completion

Change order items in the entire database were graphed against time to determine what phase, if any, was prone to the greatest number of changes (Figure 4.3). If changes before and after the contracts start and completion dates are ignored, changes were consistent throughout the project progress with only slightly more occurring in the first half. Even looking at changes after the completion dates, the number of items was consistent with items from the start of the projects. However, preconstruction changes accounted for less than 3%

of all changes that occurred in the database. One reason for this is that construction teams are newly assembled and unfamiliar with the project and its difficulties. Also, contract documents (drawings and specifications) have not had extensive contractor review because of the newness of the project. There were also a minimum number of scope changes at this point because little, if anything, has been constructed that would indicate to a client a need for a change.

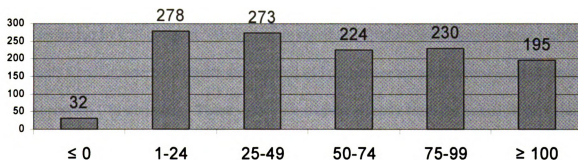


Figure 4.3. Number of Items per Percent Project Completion

4.6 Construction Specifications Institute (CSI) Divisions

There are currently sixteen CSI divisions in use today (refer to Table 3.2 in chapter 3). All change order items in this study were examined in detail and quotes were reviewed in order to assign dollars applicable to each CSI division. For example, the addition of a door and frame on the Food Safety & Toxicology Building project resulted in changes to three CSI divisions. Division 4 (Masonry) changes resulted in additional costs totaling \$1,877 while Divisions 8 (Doors and Windows) and 9 (Finishes) resulted in costs of \$1,443 and \$205 respectively. A separate Division 17 was established to track overhead and profit for each item and, in this example, resulted in \$697, or a total for this one change order item of \$4,223. Overhead and profit for this one item consisted of 17% of the total cost. MSU

contractually sets the O&P amounts for change orders at a 15% mark-up on self-performed work and 5% on subcontracted work. The reason this change order item amount is above the 15% maximum is attributed to the mark-ups from subcontractors in addition to the general contractor's mark-up.

4.7 Database Project Values by CSI Division

In order to ascertain the effect of change order items within each CSI division the database was separated by CSI division. An aggregate schedule of values indicating contract starting amounts for all nineteen contracts was created and proportionate costs were assigned to each of the sixteen CSI divisions. These values were taken directly from the Schedule of Values for each individual project. Four columns were created: The first designates the assigned CSI division number; the second specifies the name of each division; the third column indicates the dollar amount attributed to each specific division, that is the total of all the original contract amounts for each division; and the fourth column shows the percentage for each division and how they relate to the original contract amount for the entire database (Table 4.5).

	CSI Division	Division Amount	%
1	General Conditions	\$ 8,609,625.00	6%
2	Site Work	\$ 12,418,425.00	9%
3	Concrete	\$ 9,642,198.00	7%
4	Masonry	\$ 10,388,214.00	8%
5	Metals	\$ 8,626,550.00	6%
6	Wood & Plastics	\$ 2,537,656.00	2%
7	Thermal & Moisture	\$ 4,147,514.00	3%
8	Windows & Doors	\$ 5,766,195.00	4%
9	Finishes	\$ 7,038,028.00	5%
10	Specialties	\$ 718,515.00	1%
11	Equipment	\$ 7,322,868.00	5%
12	Furnishings	\$ 318,157.00	0%
13	Special Construction	\$ 1,226,832.00	1%
14	Conveying Systems	\$ 1,186,312.00	1%
15	Mechanical	\$ 39,156,403.00	29%
16	Electrical	\$ 14,114,828.00	11%
	TOTAL	\$133,218,320.00	100%

Table 4.5. Schedule of Values for All Database Projects

As shown in Table 4.5, Division 15 (Mechanical) stands out immediately as the largest dollar amount at \$39,156,403 of the \$133,218,320 database or 29% of the total contract amounts in the database. Although Division 15 represents nearly a third of the original contract costs in the database it accounted for only 15% of the costs of change orders (Figure 4.4). Site Work, Division 2, had an original contract amount of \$12,418,425 and accounted for 30% of the costs associated with change orders (Figure 4.4). However, Division Two was heavily skewed by a pre-construction scope change on the Bio-Physical Science Building, which resulted in a single \$1,000,000 change. If this single change is removed, results are in line with the proportionate Schedule of Values.

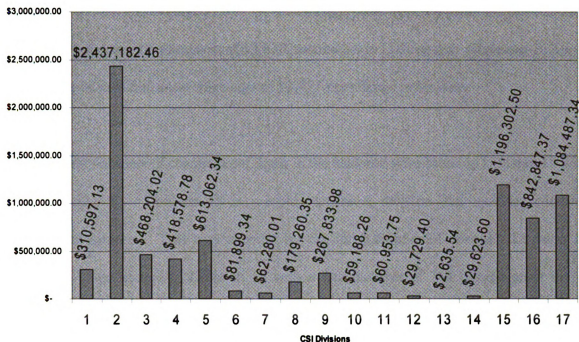


Figure 4.4. Total Dollar Amount per CSI Division

Interviews conducted as part of the research suggested that most agree the greatest number of changes occur in Division 15 and the data supports this view. However, interviewees also believed Division 15 accounted for the greatest costs increase on change orders but that is not supported by the data (Figure 4.4). Division 2 had 100 fewer change order items than Division 15 but resulted in more than twice the total dollar value (Figure 4.5). Based upon this finding, the average cost per item in Division 2 was \$11,717 compared to an average cost of \$3,884 for each individual Division 15 item.

Division 7 (Thermal & Moisture Protection) had the least cost per change order item at \$1,271 with 49 items and a total cost of \$62,280. Divisions 13 (Special Construction) and 14 (Conveying Systems) had the least number of items at 2 and 3 respectively. Division 13

costs total \$2,636 and average \$1,318 for each change order item. Division 14 had total costs of \$29,624 and an individual cost of \$9,875, second behind Division 2. Divisions 1, 3-6, 8-12, and 16 in total had an average cost of \$3,471 per change order item.

The greatest numbers of change order items in the database were found in Division 15 with 308 (Figure 4.5). Division 15 is a highly technical division that includes complex mechanical systems. This may account for the large number of changes. Division 16 (Electrical) was second to Division 15 with a total number of 267 change order items. Division 2 was next with 208 change order items. Division 9 (Finishes) had 148 items and Division 5 (Metals) had 112.

Divisions 2, 15, and 16 had an average of 261 items with an average cost of \$1,492,111 and represented the largest contributing divisions to change order costs in both the number of items and total cost.

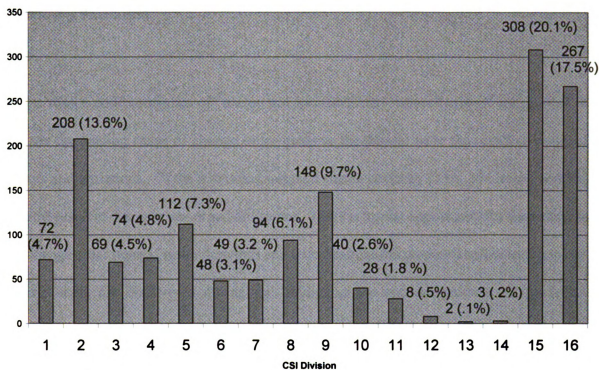


Figure 4.5. Number of Changes per CSI Division

4.8 Reason Codes vs. Project Time

The CGA office at MSU developed a Reason Code system (Reason Codes are discussed in Chapter 3) in which change order items could be categorized by the reason of origination. As discussed previously there are three categories in which change order items were assigned: design errors and omissions, field conditions, and scope. As part of this study these three categories were included, along with two additional (Figure 4.6). Some items in the database were not assigned a reason code by CGA either because the projects were complete prior to the coding system or for some other reason. This group was given the designation of “Reason Not Specified”. A fifth group, known as miscellaneous, was also developed by this

researcher for those items that have a reason code different from the four categories previously mentioned.

If the reason code categories of “reason not specified” and “miscellaneous” are ignored, it shows the leading cause of change order items in the dataset were the result of designer errors and omissions. Of the 936 items assigned reason codes by CGA, 394 items, or 42%, are the result of designer errors and omissions. There is a great opportunity for the reduction of change order items if better drawings and specifications are produced before letting to bid. Some items are discovered during the bidding phase and addendums are produced. Addendums do not catch every detail, as the data here represents, and owners are left paying for changes in an uncompetitive setting.

Field conditions were the second leading cause of change order items at 286 items, or 31%, and are generally discovered during construction as a result of site conditions being different than the plans or specifications indicate. Scope changes are changes that add value to the project, but for one reason or another were not included in the original program. Scope changes were responsible for 256 items or 27% of the reason code designations. The reasons not specified group contains 407 items without a reason code designation assigned to them. It is expected that if they had been assigned reason codes the spread in the three CGA categories would be similar. The miscellaneous group contains 29 items and is considered insignificant.

4.9 Dollar amount Per Grouped Reason Codes

When costs are graphed in the five categories of design errors and omissions, field conditions, scope, reasons not specified, and miscellaneous, field conditions account for slightly higher costs although, as shown in Figure 4.6, it represented only 30% of the items categorized in CGA's three categories as compared to design errors and omissions which accounted for 42%. Here again is another example showing that field conditions generally cost more than those categorized as design errors or omissions.

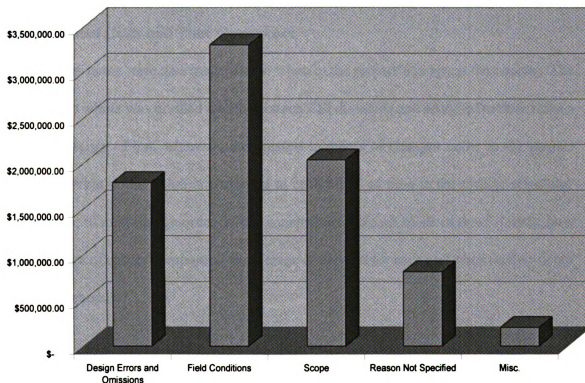


Figure 4.6 Dollar Amount per Grouped Reason Codes

Design errors and omissions include 394 change order items and were valued at \$1,790,336. This equated to an average cost of \$ 4,544 for each individual item. Field conditions contained 286 items valued at \$2,202,527 and had an average change order item cost of

\$7,701. This was a 69% higher cost per change order item than those classified as design errors or omissions. The scope category, with a cost of \$2,039,145 and 256 change order items, had an average value of \$7,965. This equated to a 75% higher cost per item than design errors or omissions. However, the reasons not specified category, which contained 407 change order items, accounted for only \$811,883 with an individual item cost of \$1,995. Finally, the miscellaneous category with 29 change order items totaled \$204,275 with an individual cost of \$7,044.

4.10 Divisional Costs and Time Occurrence

Change order items were also tracked as to when in the project's progress they occur. The database as a whole was divided into the sixteen CSI divisions and analyzed to determine a number of things. First, where do the greatest numbers of changes occur in the project schedule? What dollar value is attributed to each block of time in the project schedule? What percent of total change order dollars are attributed to each block of time? Lastly, how do the number of entries compare to the average dollar cost for each and when do they occur during the schedule?

4.11 Reason Codes vs. Project Time

Reason Codes varied depending on when change order items occur in the project schedule (Figure 4.7). When reviewing just the reason code designations design errors & omissions, field conditions, and scope in the database, 68% of preconstruction changes were attributed to field conditions. These are changes that were discovered post-bid and prior to the contract start date.

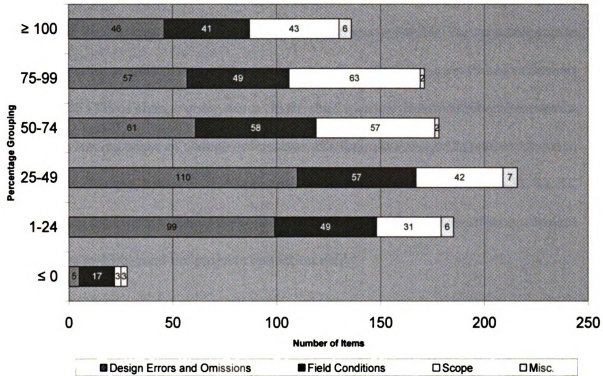


Figure 4.7. Grouped Reason Code with Time for Entire Database

At MSU, the Board of Trustees must approve any projects that are valued at \$100,000 and above and the Board of Trustees only meets nine times a year. Time is of the essence on all construction projects and Letters of Intent are often issued to the contractors telling them to proceed with the project pending Board approval. This could explain the large number of change order items before the contract start date.

When looking at the first quarter of the database, ignoring the reason code “reasons not specified”, it can be seen that most change order items were attributed to design errors and omissions (Figure 4.7). In fact, 55% of the items in the database indicate such. During this period the contractor and subcontractors become intimately familiar with the contract

documents while the project schedule and shop drawings are being prepared and errors or omissions in the drawings or specifications are realized and corrected. This trend appears to continue into the second quarter of the database timeline with design errors and omissions consisting of 53% of change order items. In the third quarter, design errors and omissions still are the leading cause of change order items, but their percentage is greatly reduced to 35%. Scope changes, however, rise from three items during preconstruction to 31, 42, 57, and 63 during the four quarters of the construction schedule. The number of scope changes then reduces to 43 beyond the project completion date.

As clients become comfortable with project progress and completion nears, contingency monies that have gone unspent tend to be used for furnishings in Division 12 (Figure 4.8). One way to reduce change order costs on construction projects is to eliminate scope changes. Scope changes sometimes add value and, thus, in some cases are acceptable. However, in order to reduce overall change order costs these changes need to be minimized and in order to offer better cost control, further approval should be sought before proceeding.

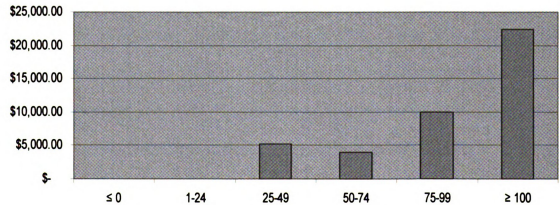


Figure 4.8. Total Division 12 dollars spent per project percent complete

4.12 Dollar Amount vs. Time

As shown in Figure 4.3, changes that occurred in the range from the project start date to the completion date were fairly level with slightly more occurring during the first half. When the total dollar amount per percentage grouping is evaluated it indicated a spike in total costs in the first quarter (Figure 4.9). This could be attributed to a significant number of errors and omissions in the contract documents being discovered early on, as shown in Figure 4.7.

During the second quarter of the project minimal work was in place and this may explain why changes during this time require less money to correct due to the modest amount of rework required. Conversely, the total dollar amount spent on change order items gradually increased in the last half of the project. Figure 4.9 shows a modest increase in the third quarter of the project schedule and an even larger increase in the final quarter.

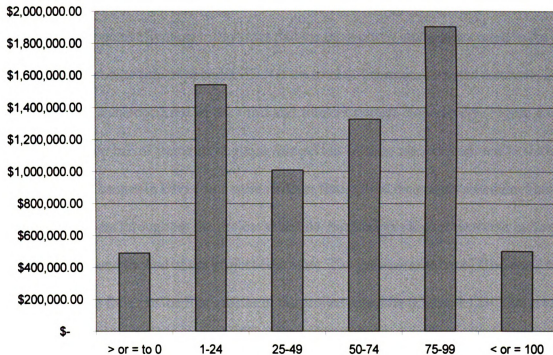


Figure 4.9. Total dollars amount per percentage grouping for entire database

Analysis of the database shows that changes that occurred near project completion were costlier and may be explained by the amount of work in place and the extent of rework that needed to be done. Numerous change order items in the database contained changes that affected multiple CSI Divisions. For example, towards the end of the Jenison Fieldhouse project, Room 215 had no supply or return air ducts installed to condition the space. At this point the lay-in ceiling and light fixtures were already installed. The contractor had to remove and reinstall the ceiling (CSI Division 9), the light fixtures (CSI Division 16), and install the mechanical components (CSI Division 15) to correct this deficiency. This resulted in a higher cost to the client which could have been reduced had this error been discovered earlier.

4.13 Reason Codes – Division Specific

General Requirements Division 1 illustrates that the most costly changes occurred in the last half of the project schedule (Appendix III). Of the total dollar amounts in the database, 29% and 45% of the costs occurred in the third and fourth quarters respectively (Figure 4.10). However, the number of items throughout this period of time ranged from ten to thirteen (Figure 4.11). Changes in Division 1 were uniform throughout the project schedule. Having consistent numbers throughout the project schedule, but having a higher total cost indicated that changes toward the end of the project cost more. The greatest number of Division 2 Site Work items were found in the first quarter of the project schedule (Figure 4.12). This is to be expected because a significant portion of the site work division needs to occur before most construction can begin.

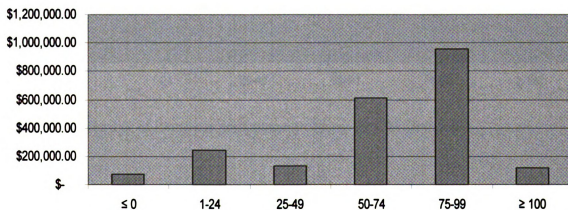


Figure 4.10. Total dollar amount per percentage grouping for CSI Division 1

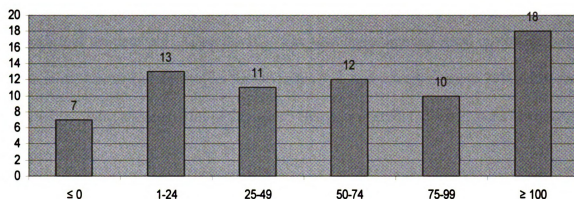


Figure 4.11. Number of items per percentage grouping for CSI Division 1

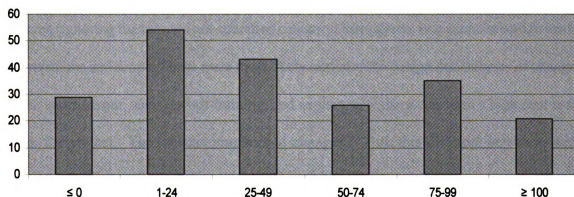


Figure 4.12. Number of items per percentage grouping for CSI Division 2

In the database the average cost per entry item was \$2,122 for first quarter changes and \$15,913 for those changes that occurred in the fourth quarter of the project (Appendix III). This again shows that changes late in the project schedule tend to cost more to implement than those that are made early on. Of the total dollar amount, 66% of the costs attributed to CSI Division 2 items occurred in the last half of the project schedule. Concrete, Masonry, and Metals, CSI Divisions 3, 4, and 5 have similar trends as those found in Divisions 1 and

2. The average cost per change order item was greatest in the fourth quarter for Divisions 1 through 5 of the database (Appendix III). The total dollar amount spent on change order items in the last half of the project for Divisions 3, 4, and 5 were equal to 79%, 62%, and 51% respectively, although 41% of Division 5 change order costs occurred in the last quarter. (Appendix III).

Division 6, Wood & Plastics, encompassed only 48 individual change order items in the database. Here, 62% of the total cost spent on change order items occurred in the first quarter (Figure 4.13). When evaluating the reason codes for these items a total of four reasons (ignoring the reasons not specified category) were given, two each for design errors or omissions and scope. These were most likely attributed to design deficiencies or changes in the space layout, such as wall framing, and explain why there was such a high cost early on in the project. The greatest numbers of changes (17) in this division, however, were found in the final quarter of the project (Figure 4.14).

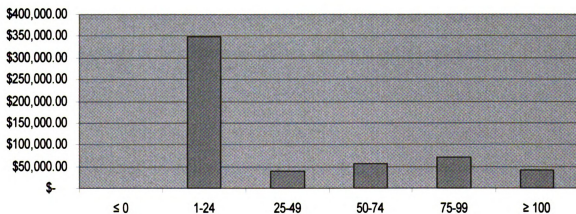


Figure 4.13. Total dollar amount per percentage grouping for CSI Division 6

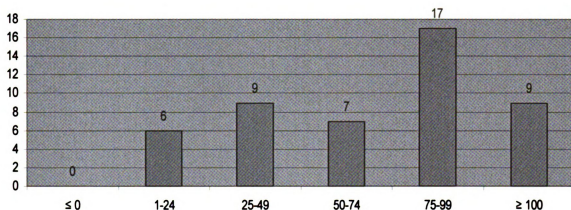


Figure 4.14. Number of items per percentage grouping for CSI Division 6

Thermal and Moisture Protection, Division 7 had the greatest number of changes occurring in the second quarter (41%) when ignoring pre- and post-construction change items (Figure 4.15). However, 71% of the total change order costs for this division were found in the second half with 44% alone in the fourth quarter (Appendix III). The first quarter of Division 8, Doors & Windows, had the largest cost increase of \$260,431 with a total of 24 items and an average cost of \$10,851. Exactly half of the 94 total items were attributed to the reason code designation of design errors or omissions. This offers a great opportunity for cost savings if the quality of the contract documents sent out to bid is improved.

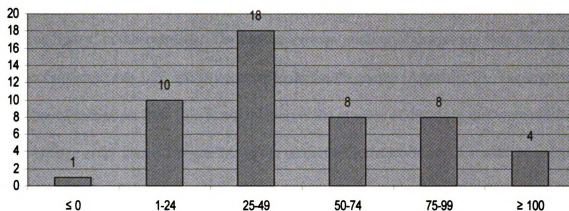


Figure 4.15. Number of items per percentage grouping for CSI Division 7

The largest cost of changes in Division 9, Finishes, were found in the first and fourth quarters of the project schedule and equated to \$597,642 (58%) of the \$1,034,189 total costs (Figure 4.16).

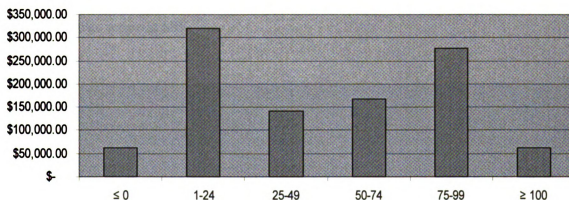


Figure 4.16. Total dollar amount per percentage grouping for CSI Division 9

Each change order item was separated by cost into the corresponding CSI divisions involved in the change. For example, an item that contained painting and electrical work would have

costs attributable to Divisions 9 (Finishes) and 16 (Electrical). Each instance is referred to here as “entry” in this research. The highest average number of entries per item during the project schedule was 3.27, which occurred in the fourth quarter (Appendix II). The larger the number of entries per item is in direct relation to the number of divisions that were affected by a change order item. Changes late in the project affected work in place and had a ripple effect on other trades and therefore drove up costs.

Division 10, Specialties, had 58% of the change order items occur in the last quarter and post-construction (Appendix III). However, 78% of the total dollar amount for this division occurred in the first quarter (Figure 4.17). The average cost per item in the first quarter was \$12,327 and consisted of five items and 25 entries, which equated to the highest average number of entries per item of five in this division (Appendix II). In other words, these changes affected many other CSI divisions. The reason code most responsible for change order items was scope at 60%.

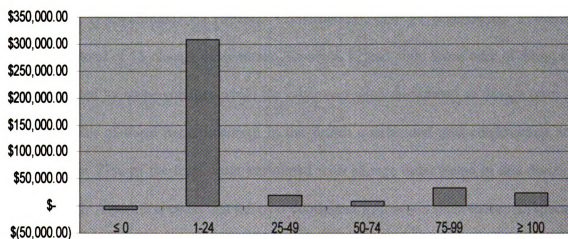


Figure 4.17. Total dollar amount per percentage grouping for CSI Division 10

Equipment, Division 11, had the greatest number of changes occur past the halfway point in the database with 64% of the items caused by scope changes (Figure 4.18). This is yet another example of contingency monies being spent toward the end of the project to add equipment. Of the \$206,098 total costs associated with Division 11 in the database, \$133,378 was attributed to change order items that occurred after the project halfway point (Appendix III).

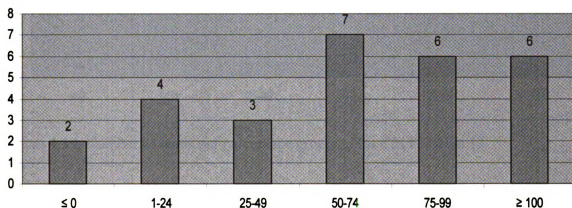


Figure 4.18. Number of items per percentage grouping for CSI Division 11

Division 12 (Furnishings), 13 (Special Construction), and 14 (Conveying Systems), contained a total of 13 change order items. Division 12 had eight items and, of these, six were attributed to scope changes while the other two were designated as design error or omission. Six of these items occurred in the fourth quarter and post-construction and accounted for 77% of the total costs associated with change order items in this division (Figure 4.19). Again, it appears that left over contingency money is spent to furnish spaces. Divisions 13 and 14 had two and three change order items respectively. Both Division 13 changes occurred in the first quarter of construction and total \$3,623. Division 14 had two

changes occur in the first quarter and one occurred in the third quarter and totaled \$51,490 (Appendix III). Two of the items were classified as scope and the third was reason not specified. These three items had an average cost of \$17,163 (Appendix II).

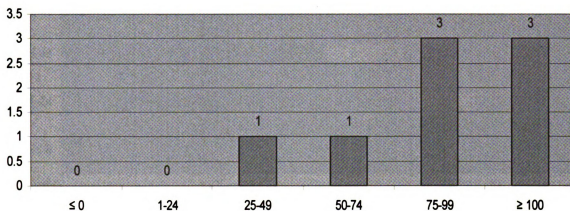


Figure 4.19. Number of items per percentage grouping for CSI Division 12

Division 15 (Mechanical), contained 308 change order items and accounted for 20% of the total items in the entire database (Figure 4.4). A significant number of changes were recorded but, as shown earlier in Table 4.5, Division 15 was responsible for 29% of the original project costs in the database yet it caused only approximately 15% of the change order costs. The largest contributor to Division 15 change order items was the result of design errors or omissions at 119 items or 39% (Figure 4.20).

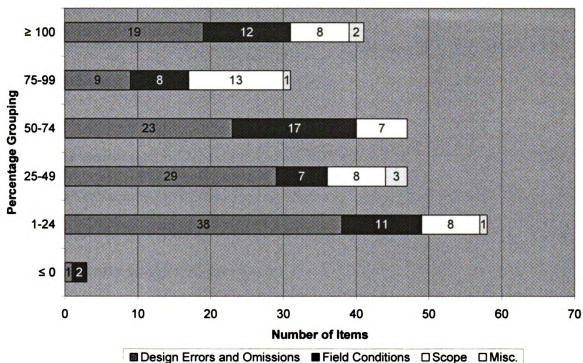


Figure 4.20. Grouped Reason Code with Time for CSI Division 15

Design errors and omissions also accounted for \$627,892 (67%), three times that of scope, and nearly seven times that of the field conditions for this division (Appendix II). Following behind design errors or omissions were field conditions with 19% and scope at 14%. Mechanical changes in the database occurred equally throughout the project schedule with slightly more occurring in the first quarter and only four occurring preconstruction. The first quarter also had the largest total dollar amount with \$953,672 and equaled 36% of all dollars spent in Division 15. The largest average cost per item for changes was \$11,921 and was attributed to the first quarter (Appendix II).

One explanation for the large number of design errors or omissions in Division 15 is that Division 15 is a very technical division and contains extremely complex systems. Designers

and engineers when working together on a construction project must give significant thought to all disciplines and constant communication and coordination are imperative in order to minimize change order items in this and all divisions.

Reviewing change order items for Division 16 showed that 69% of all changes occurred in the last half of the project including post-construction (Figure 4.21). Scope changes were the leading cause for change orders in Division 16 and 74% of them occurred past the halfway point for the entire database. Scope change costs accounted for 52% of the items and equaled \$339,529 (Appendix II). These figures show that as a project moves toward completion clients begin to spend contingency money more readily for scope changes. Similar to the findings for Divisions 11 (Equipment) and 12 (Furnishings), scope changes again appear to be used to enhance the spaces. Even though this type of change is seen as value adding, it is priced by the contractor in a non-competitive environment and may result in higher end costs to the owner.

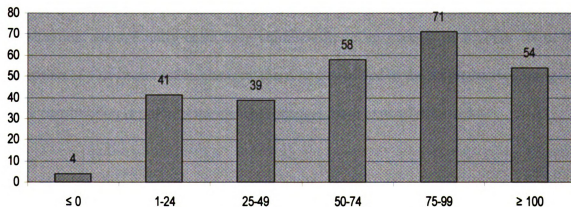


Figure 4.21. Number of items per percentage grouping for CSI Division 16

Design errors and omissions accounted for 33% of Division 16 changes. Unlike scope changes that occurred mostly in the second half of the project, design errors and omissions in Division 16 were consistent throughout the project schedule and Divisions 2, 5, and 7 design errors or omissions changes occurred in the first half of the project schedule. Electrical work is installed throughout the project and may explain why Division 16 design errors seem to be evenly distributed throughout project phases.

There were 183 change order items, which in total cost \$2,224,889 or 81% of the total change item cost in the database for Division 16 which occurred in the second half of the project. This figure includes costs for the third and fourth quarters, as well as post-construction costs. The highest average cost per entry of \$7,124 was attributed to four pre-construction changes, which contained a total of ten entries (Appendix II). The first quarter of Division 16 entries were significantly lower with an average entry cost of \$1,528. Each subsequent quarter has an increase in this average entry cost with the second, third, and fourth quarters having average costs of \$2,763, \$5,820, and \$6,506 respectively. Post-construction average entry costs drop significantly to an average of \$1,249. With the exception of post-construction changes, this data shows that as the project moves along and more construction is put in place changes become more expensive to make.

4.14 Chapter Summary

Of the sixteen project/nineteen contract database of recently completed construction projects on the campus of MSU, included are ten new construction projects, seven renovations, and two infrastructure projects, with average change order rates of 5.65%, 20%, and 13.6%

respectively. Original (\$133,355,273) and final (\$144,191,317) contract amounts totaled \$10,836,044 in changes, with an overall change order rate increase of 8.13% for all contracts in the database. Based on interviews it appears the change order rate on MSU projects is in line with averages found at other research universities.

Reason Codes for design errors or omissions, field condition, or scope were developed by CGA to assist in assigning specific groups of causes to changes which occur on a construction project. Design errors or omissions are the leading cause of changes in the database and account for 42% of the change order items. Field conditions are the second leading cause of change order items at 31% followed by scope change at 27%.

Change order items arise consistently throughout the schedule when all projects are reviewed as a whole although slightly more occurred in the first half of the schedule and only 3% of all change order items occurred in pre-construction. The total dollar costs associated with these changes greatly increased in the first quarter from pre-construction and dropped in the second quarter. The third quarter showed a modest increase with an even larger increase in the fourth quarter. Numerous change order items in the database contained changes that affect multiple CSI divisions and resulted in higher costs. These higher costs can partially be attributed to the rework necessary in order to incorporate the change into a project. Overhead and profit were also added by each individual subcontractor and again by the general contractor.

All change order items in this study were examined in detail and their quotes reviewed in order to assign dollars to each specific division of the current 16 CSI divisions involved for each change order item. Additionally, a Division 17 was created by this researcher to track overhead and profit for each change order item. The original contract amounts for the 19 contracts were separated into the sixteen CSI divisions based on their Schedule of Values listed on the payment applications.

Divisions 2, 15, and 16 were the greatest contributors to the database of both number and cost. Division 2 represented 9% of the original contract amounts but accounted for 30% of the costs associated with change order items. Original contract costs for Division 15 accounted for 29% of the total dollars in the database and, although it contained the greatest number of changes in the database, it also represented only 15% of the total change order costs. In the first quarter, Division 15 accounted for 36% of change order cost and had the highest average cost per item at \$11,921. This illustrates that most changes in Division 15 which occur early are expensive. However, Division 15 appears to have a change order rate less than expected when compared to its original scheduled value cost.

Division 16 represented 11% of the total starting project costs and was the second leading contributor to change order items. The change order costs in the database represented 10% of the total and were also proportional to the original contract amount. However, when Divisions 6-8 and 10-14 when combined, accounted for only 13% of the change order items in the entire database and only 6% of the total change order costs.

Lastly, the data shows that change order items occur on a consistent basis throughout the project schedule and although some divisions have a greater number of changes in certain timeframes, there is no one point in a project that an owner can feel comfortable spending contingency monies for extras such as furnishings and equipment.

CHAPTER 5

INDUSTRY INTERVIEWS

5.1 University Interviews

As discussed in chapter 3, interviews were conducted with construction administrators at four research intensive universities in addition to the case study university as part of the umbrella project. 29 of the 45 questions were relevant to this thesis and are reported below. The five universities procure between \$39,000,000 and \$300,000,000 in construction projects annually and report change order rates between 3% and 10%. All indicate contingencies are established on a project-by-project basis utilizing historical data with excess monies spent at project completion or returned to the department. Four of the five universities allow unconsumed contingency to be used for scope changes.

5.2 General Construction Data

The first five questions asked general information about the respondents position within the university and whether an organizational chart exists which outlines the construction project management parties and their responsibilities. All respondents had considerable experience and responsibility for project management and administration.

When asked if they conducted any analysis or review of their construction project management processes, one interviewee indicated they did not while the others stated they conduct some type of analysis. Two of the universities indicated their processes are heavily dictated and monitored by state processes who conduct periodic financial audits. Another outlined a very in depth detailed process that included required signature sheets at the various levels of conceptual, schematic, and construction designs, as well as an extensive budget tracking system utilizing Microsoft Excel Macro. A close-out form was also employed to

further track the success of each project.

5.3 Construction Analysis

Four of the five universities had an informal post-construction analysis process with respect to budget, schedule, change orders, or party performance. No formal records were kept. In the case of one university, the “formal” process consisted of a project close-out form that indicated whether the project was under or over budget. They reported that all of this information went into a database and included elements such as client satisfaction, warranty, and an evaluation of the architect. The importance of the development and maintenance of project records cannot be overstated (DeFeis, 1986). It is imperative that lessons learned on construction projects be recorded so that others can utilize these lessons through the historical data.

One interviewee stressed the importance of timely issuance of change orders and employed a system of issuing them, at a minimum, on a monthly basis. This assisted in resolving issues quickly and, more importantly, allowed the contractor to bill and be paid faster. This does not require the contractor to finance project changes. This same university had a change order authorization process that consisted of a two-tiered signature system. The executive Vice President could authorize change order amounts up to \$250,000. For change orders that exceeded \$250,000, a signature from the Vice President of Business Operations was required.

Another university reported that a lengthy signature or approval process is required on all

changes and that at least eight people signed-off or handled them, with as many as fourteen signatures required throughout the entire change order process. This significantly impacted the processing time for changes and delayed payments to contractors.

5.4 Change Order Classification

Four of the five universities indicated they had a standardized system for classifying the causes of change orders. Categories ranged from six to sixteen, with the three main categories being design errors and omissions, unforeseen condition, and scope changes. Design errors and omissions contain elements such as code deficiencies, missing information, and incorrectly designed details. Unforeseen conditions are usually hidden and can include poor soils and/or hazardous materials (i.e., asbestos/lead/PCB). The last of the three main categories is scope changes. These are changes to the original contract documents and can be initiated by a number of sources. These changes are typically seen as value adding and can originate from the building occupants, maintenance personnel, or even the landscapers. All four universities concurred that these three categories are the dominant causes of change orders on university construction projects and believe that a lack of coordination played a major role.

5.5 Change Order Prediction

The universities interviewed confirmed that no analysis had been conducted to assist in predicting change order rates for construction projects. One of the five indicated experience was their only guide when establishing contingencies for construction projects. They also indicated change order rates had been increasing since they hired new architects/designers.

This exemplifies how knowledgeable owners have distinct and different sets of construction standards that have been assembled over decades based upon their past experience and historical data. New architects and engineers need to familiarize themselves, in what many believe to be a short amount of time, with these construction standards and accurately incorporate them into the contract documents in.

When the respondents were asked if they have drawn any conclusions to the dominant causes of change orders four of the five listed errors and omissions as the leading cause. Two universities indicated poor coordination as the probable reason why this occurs. The fifth university responded by saying scope changes were the leading cause and proceeded to rate errors and omissions as second followed by field conditions.

When asked which project type encountered the greatest number of change orders two of the five responded by saying significant renovations to buildings such as classroom/offices or dormitories and indicated change order rates of 10%. One responded by saying change order rates were less than 3%. The fourth interviewee responded by saying change order rates were 5% on Construction Management projects, and 7% on lump sum. The fifth interviewee did not provide a response. When asked if these rates were acceptable, two responded by saying they are and one indicated they have actually increased due to the hiring of different A/E's than they currently use. A third interviewee indicated changes are inevitable and the change order numbers are in line. The last two respondents did not provide an answer.

When university personnel were asked if they believed there is a difference in change order

rates between in-house designs and those that use outside design firms, three of the four responded by saying they do not design projects themselves. One indicated they do very little in-house design and do not have information available to determine if there is a difference. The fifth indicated they do design in-house but had no formal statistics to determine if change order rates differ.

5.6 Change Order Histories

The number of construction cases has increased four-fold over the past ten years (Borg, 2004). Contractors are willing to invest the resources necessary in pursuing and collecting amounts due from change orders. When the universities were asked about whether change order histories of general contractors were used in determining if a contractor is qualified, all responded by saying no, that contracts were awarded based upon the lowest competent bid. Public monies were used in four of the five universities and state governments dictated the award process. One university indicated general contracting was the best project delivery method for minimizing change order rates (for general buildings). Another responded by saying the project delivery method is not as important as the project team members. The other two answered by saying selecting the best construction manager was the best way to minimize change order rates. Overhead and markup rates on changes orders vary from 5% to 15%, depending upon if the work was self-performed or a pass-thru markup for handling.

5.7 Contract Document Review

The interviewees at each university stated that contract documents are reviewed to some degree before being released for construction. This internal review consisted of input from

various maintenance and shop personnel, along with senior staff. Outside design consultants also assist in the review process providing an invaluable third-party perspective. So why is it that so many projects are released with numerous design errors and omissions? This question was posed to the interviewees and they responded that although there is a process in place for reviews to occur at various stages of design completion, it is very difficult for maintenance staff to step away from their daily duties to perform the reviews. This is equally true for architects and engineers who must maximize output with minimal staffing.

It appears that insufficient time is being spent on design review by team members. The majority of change orders result from errors or omissions in the original contract documents (Fayek, 2002). The industry, as a whole, is more competitive than ever and this may also lead to designing specialties in-house that would normally be outsourced to more specialized consultants in an effort to maximize profits.

Prebid meetings and walk-thru's were performed on all the interviewed university construction projects. One respondent indicated this process was mandatory, while another stated it was only done for renovation projects, and the other three did not require contractor attendance. One of the universities that do not require a contractor to attend the prebid meeting or walk-thru indicated they only hire pre-qualified contractors and that they had an existing relationship with certain contractors and each was familiar with their standards and expectations on construction projects.

5.8 Partnering / Commissioning

Partnering is a team based approach to getting things done on a construction project with the intention of improving effectiveness and resolving differences in a civil friendly environment. When asked if Partnering had been effective in reducing change order rates, two respondents indicated they have had success in reducing claims with this type of agreement. One indicated they use a modified version but had little success in reducing change order rates and also indicated it takes too much of one's time. With reduced funding throughout the industry, university construction administrators are required to manage the same amount of projects with reduced staff. One interviewee saw no improvement and the last had only used partnering one time.

Each university was asked if their organization utilized commissioning services. Three indicated they do and indicated it as helpful, but also that the A/E should already be doing the work that a commissioning engineer typically performs. One of the respondents who does commission utilizes in-house staff to conduct the procedure. Another indicated they do not use commissioning to its fullest extent and but have still avoided problems. They went on to say they do not believe commissioning has been effective in reducing change order rates. One reason for this could be as systems are commissioned, design defects and short-comings are realized and typically need additional funding to be corrected. If installed correctly and the design is insufficient the contractor, in some cases, is not responsible to correct the change without compensation. The last respondent indicated they have not utilized commissioning services to date.

5.9 CSI Division Impact

When asked which CSI divisions caused the greatest number of changes on projects, all responded by saying Division 15 – Mechanical. Although none had data to support this claim, their construction experience provided them with this knowledge. Three of the five went on to include CSI Division 16 – Electrical – as another area susceptible to a large change order rate. This information correlates with the data presented in the database that the greatest numbers of change occur in CSI Divisions 15 and 16. These are highly complicated divisions and include significant amounts of information. Complex designs and systems that must occupy the same coveted space on a construction project cause complications. When asked which design professions caused the most change orders on a project, all responded by unanimously that it was Mechanical.

Lastly, the five universities were also asked for suggestions that could be employed to reduce change order frequency and their impacts. Some suggestions were to require a minimum 30 day review period before releasing projects to bid, holding people accountable for errors and omissions in the contract documents, as well as using repeat work as an incentive to minimize oversights was another. One university suggested that the designer coordinate with a general contractor or construction manager to assist in document review before going to bid. All agree that improving the contract documents was the best way to minimize change orders and their impacts on construction projects.

5.10 Summary

This chapter summarized results of the interviews conducted of university administration and

staff from four universities in addition to the case study university. In general the universities were similar to the case study university in project type and scale. Change order rates were self-reported as 3-10% which is consistent with the database analyses of the case study university.

CHAPTER 6

INDUSTRY RELEVANCE

6.1 Introduction

Various research was conducted in order to understand the current change order environment. This included interviews of major universities who procure tens of millions of dollars in construction annually which allowed the researcher to gauge the change order environment from owners with experience in the construction process. Procedures from those universities were also examined and are discussed in further detail below. The industry as a whole was reviewed via published literature on the topic of change orders. The information contained is from previous studies of change orders and their results are also included below. Using this information, recommendations were developed that could be implemented in order to reduce change orders on many construction project types and throughout the industry.

6.2 Industry Change Order Rates

The average change order percentage of 8% presented as part of this research appears to be consistent with other universities and published data. The researcher wanted to determine if this was seen as an acceptable rate. Based upon the interviews conducted of four other research universities and literature review, it appears that this research results are similar to those results obtained from the interviews and through literature review. The universities interviewed as part of this study self-reported rates of as little as 3% for new buildings and others reported as much as 10% (Chapter 5). At a Construction Owners Association of America (COAA) conference the State of Michigan reported an estimated change order rate of between 5-10%. Interviews of several Michigan architects, contractors, and subcontractors self-reported average change order rates ranging from 5-10 % (Mechanda, 2005). Another

study of 22 federally funded construction projects had an average change order rate of 6% (Diekmann, 1985). U.S. industry construction projects typically exhibit change order rates around 5% (O'Brien, 1998) (Ibbs, 1997).

In order to test the validity of these change order rates from the U.S., consideration was given to studies undertaken in Taiwan and Australia. A statistical analysis of change orders in Taiwan metropolitan public works projects demonstrated an average change order rate between 10-17% (Hsieh, 2004). These projects consisted mostly of roadway, bridge, and subway tunnel construction and due to the very nature of underground work and hidden conditions may help explain this higher rate. The Construction Industry Development Agency in Australia (CIDA, 1995) reported an average change order rate of 10% which is only slightly higher than the data results reported in this study. These studies also show that change orders are an international issue within the construction industry.

6.3 Project Type Change Order Rates

Change order rates were further examined in order to determine which types of construction projects are more susceptible to increased or decreased change order rates. The three basic categories of new, renovation, and infrastructure were used. The research obtained as part of the MSU database indicates new projects had an average change order rate of 5.65%. Interviews of the various universities reported change order rates of 3-5% for new construction. It would appear the results of this study are similar, but on the high end, of those self-reported elsewhere in the industry. Also note the information obtained from the

interviews was based on perception rather than statistical or quantifiable data.

When reviewing the change order rates for renovations the study of MSU projects experienced an average change order rate of 20% however this was heavily skewed by unsound concrete conditions discovered on a stadium renovation and when this project is removed from the database the remaining projects had a change order rate of 6.37%. When the universities interviewed were asked their opinion on change order rates for renovations they responded by saying 10% was the average. Here, the MSU study appears to be doing better on renovation projects than what the other universities self-reported.

Change order rates for infrastructure projects was also considered. The MSU study reported an average change order rate of 13.6% for its two infrastructure projects. Only one university responded to this question and stated they believe their change order rate to be 5%. Again, this is based on perception and not quantitative data.

6.4 Change Order Causes

The causes of change orders were also examined in order to determine their root cause. This researcher utilized the existing coding system utilized by MSU for classifying the causes of change orders. As part of this research it was discovered that 42% of all changes are the result of design errors or omissions. Diekmann, in his study reports design errors resulted in 46% (Diekmann, 1985). This is similar to the results from the MSU study. Diekmann additionally reported scope changes accounted for 26% of the changes in his study. The MSU study

reported a 27% change order rate for scope changes. This further lends support to the results of this study. Field conditions were the last category used to track change order items. The MSU results were 31% and the Diekmann study reported 28%. The Diekmann study included delay, differing site conditions maladministration, etc as part of their reported percentage. Various other versions of the classification exist in the industry. Hsieh et al., (2004) in their study identify 35 change order causes and Rapier (1990) outlines six. Jacob and Richter (1978) indicate four while Defeis (1986) identifies 13 causes of change orders.

6.4.1 Document Errors & Omissions

With document errors and omissions representing the most common source of change order items from the literature further investigation was done in order to determine if these rates were seen as normal. Through the interviews it was discovered that four of the five interviewed indicated their experience with change orders has shown that design errors and omissions are the most significant cause. Three of the four indicated this was primarily due to poor coordination. One indicated scope changes were their biggest contributor to change order items.

Clark also identified design errors and omissions as the primary cause for change order items and indicated they result from producing design documents by computer and not checking them (Clark, 1990). Love indicated most changes are initiated by the client and errors and omissions were found to be the primary causes (Love, 2000). Hsieh et al. found in public works projects that most changes arise from problems in planning and design (Hsieh, 2004).

Ehrenreich agrees that the design phase of construction should allow for several scheduled reviews in order to minimize change order items from occurring during construction (Ehrenreich, 1994).

6.5 CSI Divisional Change Orders

The most common CSI divisions involved in change orders as part of this study are found in Divisions 2, 15, & 16. In fact, 51% of the change orders in the database involved these three divisions. Division 2 - Site Work consisted of 14% followed by Division 15 – Mechanical 20% and finally Division 16 at 17%. This researcher did not find any literature to substantiate the number or percentages of change order items per CSI division. However, information obtained through the interviews indicates that all interviewees concur that most changes on a project involve Division 15 items. Three of the five went on to say that Division 16 is another area susceptible to a higher number of change orders. This is consistent with what was discovered through the case study database analysis.

Division 15 was determined to be associated with the greatest number of changes followed by Division 16. Division 15 represents 29% of the project costs in this study however only represented 15% of the change orders costs. RSMeans 2005 estimated that mechanical and electrical combined to account for 31.50% of the total building costs under the section of Colleges-Science, Engineering, and Laboratories (RSMeans 1, 2005). When evaluating cost estimates per square foot, RSMeans “Square Foot Costs” which indicates for Colleges-Laboratory that plumbing, HVAC, and electrical account for 17.3%, 16.9%, and 10.7% of

project costs respectively (RSMeans 2, 2005). When added together, the total cost for mechanical and electrical equals 44.9%. The combined Mechanical and Electrical percentages in this study was equal to 40% of the total original costs and appear to be in line with the industry accepted averages according to RSMeans. Although there are many changes as a result of Division 15, it would be expected considering that it made up nearly a third of the total project costs in the database. However, although there are more changes related to mechanical the total costs for these changes were less proportionally.

6.6 Recommendations

Increasing the amount of time architects and engineers have during the design phase will greatly reduce the number of errors and omissions in the contract documents. Changes made in the design phase are easily corrected as compared to those during construction. Scope changes could also be reduced if during pre-bid the owner can explain how the space will function and be utilized. Rework is costly to both the schedule financially and also disrupts worker productivity.

Communication is important between the parties in order to reduce and address issues as they arise. Many design disciplines are assembled for a project and all try to occupy valuable space with their designs. Constant communication is necessary in order to minimize conflicts in the design. Regular meetings are necessary where people can explain how each system is expected to work and discuss compromises for solutions prior to getting the contractor involved. Changes at this stage are easily corrected and do not have the domino effect as it

would during construction. If architects and engineers are given adequate time and resources and maintain communication between themselves and the owner, construction projects can be released for construction with minimal errors or omissions.

6.7 Conclusion

On average, three hours are spent in administering a change before work even commences on the change (Fayek, 2002). This is a significant amount of wasted time for items that can be easily identified and corrected pre-bid. This time can also be significantly reduced during construction if standard forms are used to process change requests. Each party would then know exactly what needs to be provided with a request such as back-up, signed time sheets, breakdowns, and additional documentation. Correctly identifying each party's obligation in the contract can help to reduce processing time for change orders as well.

Change orders are one of the most common sources of waste and fraud during a project (Klepal, 2000). Because most projects are hard-bid, there is little room to make additional profit. The only other way to receive additional compensation from an owner is with change orders. Because there is no longer a competitive environment in which a contractor and his subcontractor need to compete, there is little incentive to give the owner a fair market price.

University interviews were conducted to gauge the current environment and determine current change order monitoring practices. These universities self-reported poor coding systems for tracking change orders are currently being utilized. Opinions suggest errors and omissions as

the predominant cause for additional project costs.

Change orders can have ripple effects on construction projects. Studies have been conducted and presented in this thesis that identifies their negative impacts. All the studies included in this research indicate that most change orders are attributed to errors or omissions in the contract documents. Reducing these during the design phase offers the greatest opportunity to minimize the number of change order items on construction projects. Litigation for designer errors has increased in recent years and although it will never be eliminated, it has the possibility of being reduced.

6.8 Summary

This research utilized a database of change orders for a case study university, interviews, and existing published literature on the subject of change order causes and percentage rates. This chapter presented information and opinions from other universities, U.S. industries, and included international studies from Taiwan and Australia. Through the database analysis and interviews of university construction administrators, local architects, contractors, and subcontractors as well as literature review it was determined that change order rates in the industry typically range from 5-10%, depending on a significant number of variables such as project type, design team, or location. The data presented in this study had an average change order rate of 8% and included various project types.

Design errors or omissions were the most commonly seen category for classifying change

orders and accounted for 42% of the change order items as part of the university case study presented here. This is closely followed by field conditions and scope changes at 31% and 27%. Industry reports averages of 46%, 28%, and 26% respectively for the three listed categories, although other variations for classifying change orders exist.

CSI Division 15 reported the greatest number of changes in the database as well as through the interviews and literature review. Division 15 constituted 29% of the total project costs in the database and would therefore be expected to have a larger number of changes. The change order rates for Divisions 15, 16, & 2 accounted for change order percentages of 18%, 16%, and 12% of the change order items in the database.

The database results presented in this thesis are consistent with industry opinions and through existing published studies on the subject of change orders. This study found similar results to existing literature and provided additional reasons as to how changes originate on construction projects. Through understanding how change orders originated and the corresponding CSI Divisional cost associated with each offers areas of opportunity that can be explored for reducing the impacts of change orders.

CHAPTER 7

SUMMARY

7.1 Introduction

This thesis focuses on the creation and statistical database analysis of a case study university to identify the causes of change orders on construction projects. The causes were categorized into three main types including 1) design errors and omissions, 2) field conditions, and 3) scope. In addition to determining the origination of each change item, the costs associated with each entry were separated into the affected CSI divisions and then analyzed. This chapter provides the results of this study as well as recommendations, conclusions, limitations of the research, and suggestions for future areas of research.

7.2 Research Objectives

The goal of this thesis was to find ways to reduce the number and impact of change orders on construction projects by determining the sources and causes. Herein, 159 change orders, with a total in excess of 1,675 change order items from a sixteen project/nineteen contract database, are analyzed. Each item is categorized into its main cause and is separated by the contributing dollar amount into the respective CSI division involved in the change. Overhead, profit, time, and point in project completion are also examined.

A 60+ data entry point change order form was created in MS Access for use in evaluation of each of the 1,675 change order items. Linked tables for projects, change orders, and items were used to tie the tables together and to create relationships. The raw data for the tables is tracked utilizing MSTM Excel.

Interviews of construction administrators were conducted at four additional research universities. These universities procured between \$39,000,000 and \$300,000,000 annually in construction projects. Three of the four universities are public institutions while the fourth is private.

Literature review was conducted to locate existing research addressing change orders and bid data analyzed to predict changes, mark-up values, and effect(s) on project productivity, as discussed in chapter two. Various trade articles and books were also consulted to assist in determining the industry change order environment. This information, along with the database created in this thesis, indicate change items for certain CSI divisions consistently account for a larger quantity and cost, as well as negative time impacts on projects.

7.3 Conclusion

The original construction cost for the case study sixteen project/nineteen contract database was \$133,355,273 with an ending cost of \$144,191,317. This resulted in a net increase of \$10,836,044 from the base bids for these contracts and represented an 8.13% cost increase on construction projects ranging from \$242,000 to \$71,148,082.

The database consisted of ten new construction projects, seven renovations, and two infrastructure projects. With a 5.61% increase for new construction and 6.37% increase for renovations after outliers are removed. Two infrastructure projects average 13.6% cost increase by change orders.

Through the interviews and the literature review it was determined that the average change order rate of 8% is in line with industry averages. Two universities self-reported estimates of 3% for new buildings. One university, as well as the State of Michigan (COAA, 2004), report their change order rate to be between 5 and 10%. One university also self-reports a change order rate between 7 and 10%.

7.3.1 Change Order Reasons

Three change order reason codes are presented and discussed in this thesis in order to classify the origins of changes on construction projects. These include design errors and omissions, field conditions, and scope. Those classified as design errors and omissions consist of 394 items at a cost of approximately \$1,800,000. This represents 42% of the known changes classified (does not include the category of reason not specified). This is the largest percentage of the three and offers the greatest opportunity for improvement. As discussed throughout this thesis, improving communication and lengthening the amount of time spent for design offers the best chance in reducing additional costs, delays, and clashes during construction.

Field Conditions represent 31% of the change order items in the database and occurred 286 times requiring approximately an additional \$2,200,000. Field conditions are changes discovered in the field during construction, some of which could have been anticipated during the design process by a more thorough review of the historical records and/or exploratory demolition to see, for example, how buildings to be renovated are constructed and if there are

any hidden conditions. Additional testing could also be provided for such things as asbestos, lead, or additional soil borings.

Scope changes are almost as common as field conditions in that their percentages are close with scope changes making up 27% of the known changes. These changes are a result of owners either changing or adding items. Scope changes can and do occur from pre-construction to post-construction. Some changes may even require the removal and replacement of work in place or be as simple as adding finishes. These changes are typically seen as value adding and therefore not always perceived as harmful. However, some scope changes can be avoided through better communication with the architects and engineers during the design phase. It is critical that the design team be cognizant of the users' intent and have a clear "needs brief" established.

The design phase offers significant opportunities for reducing the number and amount of change orders on construction projects. This is applicable to all types of construction projects, whether large or small, no matter where they are located. The documented reasons for changes on construction projects are consistent with owners and contractors across the U.S. and the world. There are limitations to this research and those will be discussed later in this chapter.

7.3.2 CSI Division Costs

In order to determine time and costs associated with each division, this research separates the

individual costs for each of the sixteen Construction Specifications Institute (CSI) Divisions for each of the change orders items and includes as many as 80,000 data points. A seventeenth division was created by this researcher in order to track overhead and profit.

The greatest numbers of change order items in the database are attributed to Division 15 with a total of 308 at a cost of \$1,196,303. This is consistent with the interviews conducted as part of this research, with all interviewees agreeing that Division 15 contains the greatest number of changes. However, those interviewed also suggest that this division also generates the greatest cost increases associated with change orders. The data presented negates that assumption. Division 2 actually leads to the greatest cost increase when comparing change order amounts and how they relate to original contract percentages.

Division 15 accounts for 29% of the total cost of the original contract amounts in the database, but only caused 15% of the change order costs. Division 16 is second to Division 15 with a total of 267 change order items and accounts for 10% of the change order costs. Division 2, with 208 change items, totals in excess of \$2,400,000 in change order costs which represents 23% of the total change orders in the database.

Divisions 15 and 16 are highly technical while Division 2 involves site conditions. Again, communication is essential during the design phase to ensure these complicated systems that vie for the same space can fit and that adequate exploration of the site conditions occurs. The contract carries an implied warranty that the specifications are free from design defects (ENR,

2002). It is essential for team members to coordinate the installation of systems and to ensure that contract documents are released with minimal errors and omissions. This will assist in reducing the number of change orders on projects and has the added benefit of maintaining construction flow without delays in correcting design deficiencies.

The average cost per Division 15 item is \$3,884 and the average cost per item in Division 16 is \$4061.75. Division 7 had the least average cost per item at \$1,271 and consists of 49 items.

Divisions 12, 13, and 14 have a total number of 13 items and average \$3,716, \$1,318, and \$9,875 respectively. The remaining divisions (1, 3-6, and 8-11) have a combined total of 685 items with an average cost of \$3,591.

The researcher assembled the central causes of change order items along with the associated costs and number of instance for each CSI Division in the database. These together form the basis of this research. The CSI Division primarily responsible for each change initiation was not specifically studied.

7.3.3 Changes Associated with Time

Construction changes occur consistently throughout a project's duration. Changes are evaluated and categorized into whether they occurred pre-construction, post-construction or in which quarter during actual construction. The timeline defined as under construction shows minimal variation with an average of 251 per quarter with only slightly more occurring in the first half of the projects in the database. Pre-construction changes total only 32 while post-

construction (changes occurring after the scheduled completion date) saw 195. That was slightly less than during construction averages but significantly more than before construction started. This could be attributed to the parties being unfamiliar with the project in the beginning and then closing items out at the end of a project.

When the reasons for changes are charted, it shows a significant increase in design errors and omission in the first half of the project. Again this may be attributed to the team's unfamiliarity with the prints and specifications. This is also the period the contractor is assembling shop drawings and producing a project schedule. Scope changes also steadily increase in number every quarter of the project and only fall slightly post-construction, although, the most costly scope changes occur post-construction. This may be attributed to the clients' comfort with the budget near project completion and then designating the monies remaining for such things as furnishings and equipment. In fact, six of the eight items in Division 12 from the entire database are scope changes that occur in the fourth quarter and consume 77% of the total cost increases in that division.

Analysis of the database indicates that changes are more costly to make as project schedule progresses. This may be attributed to the amount of work in place that affects multiple CSI Divisional work to be removed, altered, and/or replaced. The sooner changes are discovered the less expensive they are in terms of both schedule and cost.

7.4 Limitations of the Research

The research herein consists of a number of change orders items and subsequently an even greater amount of CSI Divisional analysis. This research is limited to the dataset with limitations as summarized below:

1. The construction projects included in this research occur on only one Michigan campus.
2. The total number of construction contracts analyzed consists of nineteen.
3. University interviews include research universities located in the Midwest portion of the U.S.
4. Categorization or classification of change order items may differ throughout the industry.
5. Only three of the nineteen projects utilize a Construction Management delivery method while all others are General Contractor.

The researcher attempted to generalize this study for use by other universities. The results obtained are believed to be beneficial to research universities and may be applied to the industry in general.

7.4.1 Project Time vs. Work in Place

Activities typically occur at different times during the project schedule. For example, when constructing new building, activities such those that occur in Site Work (Division 2) are usually performed ahead of most other work at the onset of a project. However, Finishes (Division 9) typically occur at the end of the projects schedule to complete other work in

place. Therefore the percent complete for each of these example CSI divisions would differ in percent complete when compared against the entire project schedule. This research studied *project* percent complete when comparing the data and not necessarily the amount of work in place for each corresponding CSI Division.

7.5 Future Areas of Research

This research concentrates on the reasons, costs, and time associated with construction changes. This research does not involve projects in excess of \$100,000,000 or other types of projects such as those found in the petroleum, housing, or manufacturing industries. Reason codes on many industry projects could be tracked and analyzed for comparison with this study. The findings in this research could be used to compare other change orders across the industry. In addition, areas of concentration for improvement are identified and further research can be conducted to reduce their impact on change orders.

Further research can also be conducted to determine if the project delivery method has any effect on change orders. Are design/build and construction management projects more or less susceptible to change orders than those that are awarded to general contractors? Construction projects utilizing these project delivery methods could be studied to show their effect on change orders.

One theory is that design/build projects experience minimal change orders due to the fact they are designed in-house and communication between the team members (design team and

constructor) is easier. Is this the case though? Are design/build projects less likely to encounter change orders? One would also have to take into account that if change orders are encountered how would they be classified? Who assigns the classification of design error, field related, or scope changes? This area of study offers an interesting and challenging analysis.

What would be discovered if projects administered by Construction Managers were studied? In this project delivery method the Construction Manager acts as manager/advisor to the owner and protects his/her interest in the construction project. Here the Construction Manager controls most of the construction project by managing the schedule and the subcontractor contracts. They are an experienced professional who understands the construction process and is in the position to mitigate construction changes. Does this reduce the number of change orders? Does it increase the number of change orders? What effect does this project delivery method have on changes?

A checklist could be created to improve communication between the client and the design teams to ensure the needs of all parties are being considered. Further investigation of architects and engineers and their hiring methods could be conducted based upon their past performance records for errors, omissions, and change orders. Do they have a system for tracking and reducing them on current and future projects? Do mandatory pre-bid meetings and walk-thru's reduce change order claims on projects? This is another area for exploration that could help determine if getting contractors involved in asking questions prior to bidding

would reduce the number of claims during a project.

Through the interviews conducted with owners it was concluded that reducing change orders in the industry would have a positive effect on time and cost, as well as the added benefit of maintaining good relationships with the team members. Most contractors agree that they would like to see fewer change orders on construction projects. Changes are very disruptive to work flow and, in most cases, owners and consultants question each and every cost (Fayek, 2002). Therefore it is imperative to find a way in which to reduce change order frequency and impact through better design and investigation.

7.6 Final Comments

This thesis centers on developing a database for categorization and investigation into reasons why changes occur on construction projects and at which point during the project schedule they are most likely to occur. This was tracked by dividing the project schedule into quarters and tracking the outliers of changes that occurred either pre- or post-construction. Costs associated with each change are compared to both the schedule and corresponding CSI divisions to identify areas conducive to further investigation.

Change orders are one of the most common sources of waste and fraud during a project (Klepal, 2000). Reducing change orders should be an incentive for the owner and design team to allow adequate time during the design phase to improve communication between team members. One reason for so many change orders is that most construction starts before all

documents are completed (Janecke, 2002). Many changes can be eliminated before construction starts by concentrating efforts on the design portion and ensuring the contract documents are not released until they are ready. There is an obvious need to reduce change order costs and occurrences. Changes extend completion dates, cost additional money, and strain relations between those involved in the construction process. By working together a significant improvement can be realized if team members are committed to continued education and communication.

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APPENDIX I

Data Entry Point Definitions

Data Entry Point Definitions

Project Table Information

Project ID	MSU Project Number assigned to all MSU projects
Project Description	Project name assigned to project
MSU Project Manager	MSU project manager assigned as owner's representative
Contractor	General contractor or construction management firm
Architect	Architect or designer
Contract Date	Date of the original contract agreement

Change Order Table Information

Change Order ID	Change order code included in the database
Project ID	MSU Project Number assigned to all MSU projects
Change Order Number	Number of change order in sequence for a particular project
Contractor	General contractor or construction management firm
Initiation Date	Initiation of change order
Contract Date	Date of the original contract agreement
Previous Contract Sum	Original contract amount or subsequent totals after prior change orders
New Contract Sum	Contract price after adjustments for change orders to date

Change Contract Sum	Net increase or decrease resulting from change orders
Time	Increase or decrease of contract extension due to a change order
Authorization	MSU authorization
Attention Date	Date of MSU authorization
Architect	Architect or designer
Authorization Architect	Architect authorizing the change order
Architect Authorization Date	Date of the architect's authorization
Authorization Contractor	General contractor or construction management firm authorizing the change order
Contractor Authorization Date	Date of general contractor or construction management firm authorizing the change order

Change Order Item Table Information

Change Order Item ID	Change order item code in the database
Change Order ID	Date base change order code of which the item is a subset
Change Order Number	Number of change order in sequence for a particular project of which the change order item is a subset
Reason Code	The reason category for the item using a MSU Contracts and Grants coding system. Reason codes are discussed below in detail
Item Initiation Date	The initiation date for the change order item
Change Order Item Description	Narrative description of the change order item

CSI Section	Construction Specification Institute Divisions indicating work categories for a change order item. Division 17 was added for profit and overhead
CSI Section Code	Construction Specification Institute Divisions indicating work categories for a change order item. Division 17 was added for profit and overhead
Change Order Amount	Total contract adjustment due to the change order
CCD	Project Construction Change Directive number
Bulletin Number	Project bulletin number
Others	Change orders initiated administratively rather than from a bulletin or construction change directive
CSI Divisions 1-16	Construction Specification Institute Divisions impacted by the change order item. (See discussion below)
Division 17(Profit and Overhead)	Division created for profit and overhead
CSI Division (1-16 + Division 17)	Cost amounts assigned to each of the CSI divisions for a particular change order item
CSI Division Cost amounts	Proportionate amount of change order assigned to each CSI Division for a change order item
% Project Progress	% of project completed at Initiation of the change order Item

APPENDIX II

CSI Division Analysis - Tables

Division 1 Analysis with Respect to Time

Project Progress Analysis					
Zones	# Of Items	\$ Total	# of Entries	Average \$ per Entry	Entry:Item Ratio
≤ 0	7	\$ 71,838.85	19	\$ 3,780.99	2.71
1-24	13	\$ 243,027.77	42	\$ 5,786.38	3.23
25-49	11	\$ 128,999.90	34	\$ 3,794.11	3.09
50-74	13	\$ 611,823.33	33	\$ 18,540.10	2.54
75-99	10	\$ 956,966.86	42	\$ 22,784.93	4.20
≥ 100	18	\$ 117,570.58	46	\$ 2,555.88	2.56

Break Down of Project Progress: CSI 1-- Items						
Reason Code	≤ 0	1-24	25-49	50-74	75-99	≥ 100
D1			1			
D2			1			
D3						
D4		1				
D5						
Documents	2		1	1		4
F1						
F2						
F3						
F4						
F5						
F6				2		1
Field	1	2	2	4	3	3
S1		1	1	1	1	3
S2		1	2			
S3						
S4	1	1				
S5						
Scope				1		
Site Scope				1	1	
Misc	1	3			1	1
RNS	2	4	3	2	4	6
Total	7	13	11	12	10	18

Categories For Reason Codes	≤ 0	1-24	25-49	50-74	75-99	≥ 100
Design Errors and Omissions	2	1	3	1	0	4
Field Conditions	1	2	2	6	3	4
Scope	1	3	3	3	2	3
Reason Not Specified	2	4	3	2	4	6
Misc.	1	3	0	0	1	1
Total	7	13	11	12	10	18

Division 2 Analysis with Respect to Time

Project Progress Analysis					
Zones	# Of Items	\$ Total	# of Entries	Average \$ per Entry	Entry:item Ratio
≤ 0	29	\$ 468,236.03	43	\$ 10,889.21	1.48
1-24	54	\$ 267,331.04	126	\$ 2,121.67	2.33
25-49	43	\$ 238,592.29	104	\$ 2,294.16	2.42
50-74	26	\$ 657,003.60	69	\$ 9,521.79	2.65
75-99	35	\$1,177,577.75	74	\$ 15,913.21	2.11
≥ 100	21	\$ 36,328.04	46	\$ 789.74	2.19

Break Down of Project Progress: CSI 2-- Items						
Reason Code	≤ 0	1-24	25-49	50-74	75-99	≥ 100
D1						
D2						
D3						
D4		3	5		2	
D5						
Documents	3	6	1	1	3	4
F1						
F2			1			
F3			1			
F4						
F5						
F6			1			2
Field	21	21	21	11	21	5
S1	1					1
S2						
S3			1	1		
S4						
S5						1
Scope	3	2	4	3	2	2
Site Scope				3	2	
Misc	1		2	1		1
RNS		21	6	6	5	5
Total	29	54	43	26	35	21

Categories For Reason Codes	≤ 0	1-24	25-49	50-74	75-99	≥ 100
Design Errors and Omissions	3	9	6	1	5	4
Field Conditions	21	21	24	11	21	7
Scope	4	3	5	7	4	4
Reason Not Specified	0	21	6	6	5	5
Misc.	1	0	2	1	0	1
Total	29	54	43	26	35	21

Division 3 Analysis with Respect to Time

Project Progress Analysis					
Zones	# Of Items	\$ Total	# of Entries	Average \$ per Entry	Entry:Item Ratio
≤ 0	5	\$ 217,717.25	20	\$ 10,885.86	4.00
1-24	18	\$ 49,778.83	48	\$ 1,037.06	2.67
25-49	12	\$ 113,165.25	48	\$ 2,357.61	4.00
50-74	16	\$ 686,256.65	55	\$ 12,477.39	3.44
75-99	10	\$ 851,483.31	36	\$ 23,652.31	3.60
≥ 100	8	\$ 12,267.71	20	\$ 613.39	2.50

Break Down of Project Progress: CSI 3- Items						
Reason Code	≤ 0	1-24	25-49	50-74	75-99	≥ 100
D1						
D2						
D3		1				
D4		5	1	1		
D5						
Documents	1	1		1		1
F1						
F2			1			
F3						
F4						
F5						
F6						1
Field	2	2	2	6	4	4
S1		1				
S2				1		
S3			1			
S4	1		1			
S5			1			
Scope			2	3	2	1
Site Scope		1		3	2	
Misc	1	1	1			
RNS		6	2	1	2	1
Total	5	18	12	16	10	8

Categories For Reason Codes	≤ 0	1-24	25-49	50-74	75-99	≥ 100
Design Errors and Omissions	1	7	1	2	0	1
Field Conditions	2	2	3	6	4	5
Scope	1	2	5	7	4	1
Reason Not Specified	0	6	2	1	2	1
Misc.	1	1	1	0	0	0
Total	5	18	12	16	10	8

Division 4 Analysis with Respect to Time

Project Progress Analysis					
Zones	# Of Items	\$ Total	# of Entries	Average \$ per Entry	Entry:Item Ratio
≤ 0	1	\$ 61,345.68	8	\$ 7,668.21	8.00
1-24	11	\$ 406,226.86	47	\$ 8,643.12	4.27
25-49	20	\$ 100,621.55	62	\$ 1,622.93	3.10
50-74	20	\$ 72,554.21	48	\$ 1,511.55	2.40
75-99	18	\$ 907,504.05	80	\$ 11,343.80	4.44
≥ 100	4	\$ 24,224.83	19	\$ 1,274.99	4.75

Break Down of Project Progress: CSI 4-- Items						
Reason Code	≤ 0	1-24	25-49	50-74	75-99	≥ 100
D1						
D2						
D3			1	1		
D4		3	3			
D5					1	
Documents		1	6	10	4	1
F1						
F2						
F3						
F4						
F5						
F6						
Field			1	2	2	
S1		1			3	1
S2		4	2	1		
S3						
S4	1	1				
S5				1		
Scope			1			
Site Scope				3	1	
Misc			1	1	1	1
RNS		1	5	1	6	1
Total	1	11	20	20	18	4

Categories For Reason Codes	≤ 0	1-24	25-49	50-74	75-99	≥ 100
Design Errors and Omissions	0	4	10	11	5	1
Field Conditions	0	0	1	2	2	0
Scope	1	6	3	5	4	1
Reason Not Specified	0	1	5	1	6	1
Misc.	0	0	1	1	1	1
Total	1	11	20	20	18	4

Division 5 Analysis with Respect to Time

Project Progress Analysis					
Zones	# Of Items	\$ Total	# of Entries	Average \$ per Entry	Entry:Item Ratio
≤ 0	7	\$ 163,156.10	20	\$ 8,157.81	2.86
1-24	31	\$ 565,999.34	86	\$ 6,581.39	2.77
25-49	53	\$ 181,442.28	122	\$ 1,487.23	2.30
50-74	12	\$ 187,067.25	35	\$ 5,344.78	2.92
75-99	6	\$ 788,696.66	24	\$ 32,862.36	4.00
≥ 100	3	\$ 1,287.49	7	\$ 183.93	2.33

Break Down of Project Progress: CSI 5-- Items						
Reason Code	≤ 0	1-24	25-49	50-74	75-99	≥ 100
D1						
D2						
D3			2			
D4	1	9	16		1	
D5		1				
Documents	2	4	11	4	1	1
F1						
F2			1			
F3			1	2		
F4						
F5						
F6			1			1
Field	1	13	11	2	1	
S1				1		
S2		1	1			
S3						
S4	1	1	1			
S5						
Scope						1
Site Scope				1	1	
Misc	1		1			
RNS	1	2	7	2	2	
Total	7	31	53	12	6	3

Categories For Reason Codes	≤ 0	1-24	25-49	50-74	75-99	≥ 100
Design Errors and Omissions	3	14	29	4	2	1
Field Conditions	1	13	14	4	1	1
Scope	1	2	2	2	1	1
Reason Not Specified	1	2	7	2	2	0
Misc.	1	0	1	0	0	0
Total	7	31	53	12	6	3

Division 6 Analysis with Respect to Time

Project Progress Analysis					
Zones	# Of Items	\$ Total	# of Entries	Average \$ per Entry	Entry:Item Ratio
≤ 0	0	\$ -	0	\$ -	0.00
1-24	6	\$ 347,365.86	24	\$ 14,473.58	4.00
25-49	9	\$ 38,458.90	33	\$ 1,165.42	3.67
50-74	7	\$ 56,039.38	25	\$ 2,241.58	3.57
75-99	17	\$ 71,603.16	52	\$ 1,376.98	3.06
≥ 100	9	\$ 42,531.23	23	\$ 1,849.18	2.56

Break Down of Project Progress: CSI 6-- Items						
Reason Code	≤ 0	1-24	25-49	50-74	75-99	≥ 100
D1						
D2						
D3						
D4		1	2			1
D5						1
Documents		1	3	2	3	
F1						
F2						
F3						
F4						
F5						
F6					1	3
Field					3	
S1				1	2	
S2						
S3						
S4		2				
S5						
Scope				1	4	
Site Scope						
Misc			1		1	
RNS		2	3	3	3	4
Total	0	6	9	7	17	9

Categories For Reason Codes	≤ 0	1-24	25-49	50-74	75-99	≥ 100
Design Errors and Omissions	0	2	5	2	3	2
Field Conditions	0	0	0	0	4	3
Scope	0	2	0	2	6	0
Reason Not Specified	0	2	3	3	3	4
Misc.	0	0	1	0	1	0
Total	0	6	9	7	17	9

Division 7 Analysis with Respect to Time

Project Progress Analysis					
Zones	# Of Items	\$ Total	# of Entries	Average \$ per Entry	Entry:Item Ratio
≤ 0	1	\$ 61,345.68	8	\$ 7,668.21	8.00
1-24	10	\$ 431,363.86	40	\$ 10,784.10	4.00
25-49	18	\$ 52,686.55	51	\$ 1,033.07	2.83
50-74	8	\$ 498,581.27	27	\$ 18,465.97	3.38
75-99	8	\$ 801,874.44	28	\$ 28,638.37	3.50
≥ 100	4	\$ (1,862.69)	10	\$ (186.27)	2.50

Break Down of Project Progress: CSI 7-- Items						
Reason Code	≤ 0	1-24	25-49	50-74	75-99	≥ 100
D1						
D2						
D3						
D4		2	3	2		
D5					1	
Documents		3	3		1	
F1						
F2						
F3						
F4						
F5						
F6			1			
Field			1	1	3	1
S1		1				1
S2			1			
S3						
S4	1	1	2			1
S5						
Scope				2		1
Site Scope					2	
Misc			1			
RNS		3	6	3	1	
Total	1	10	18	8	8	4

Categories For Reason Codes	≤ 0	1-24	25-49	50-74	75-99	≥ 100
Design Errors and Omissions	0	5	6	2	2	0
Field Conditions	0	0	2	1	3	1
Scope	1	2	3	2	2	3
Reason Not Specified	0	3	6	3	1	0
Misc.	0	0	1	0	0	0
Total	1	10	18	8	8	4

Division 8 Analysis with Respect to Time

Project Progress Analysis					
Zones	# Of Items	\$ Total	# of Entries	Average \$ per Entry	Entry:Item Ratio
≤ 0	1	\$ 61,345.68	8	\$ 7,668.21	8.00
1-24	24	\$ 260,431.33	78	\$ 3,338.86	3.25
25-49	21	\$ 67,320.30	57	\$ 1,181.06	2.71
50-74	10	\$ 15,466.00	18	\$ 859.22	1.80
75-99	29	\$ 163,637.81	101	\$ 1,620.18	3.48
≥ 100	9	\$ 32,679.05	28	\$ 1,167.11	3.11

Break Down of Project Progress: CSI 8-- Items						
Reason Code	≤ 0	1-24	25-49	50-74	75-99	≥ 100
D1						
D2						
D3					1	
D4		9	4	1	1	1
D5					1	
Documents		4	7	4	11	3
F1						
F2						
F3						
F4						
F5						
F6						
Field		1	4		1	1
S1		1	1	3	5	4
S2		4	1	1	1	
S3						
S4	1					
S5						
Scope			2		1	
Site Scope						
Misc			1		1	
RNS		5	1	1	6	
Total	1	24	21	10	29	9

Categories For Reason Codes	≤ 0	1-24	25-49	50-74	75-99	≥ 100
Design Errors and Omissions	0	13	11	5	14	4
Field Conditions	0	1	4	0	1	1
Scope	1	5	4	4	7	4
Reason Not Specified	0	5	1	1	6	0
Misc.	0	0	1	0	1	0
Total	1	24	21	10	29	9

Division 9 Analysis with Respect to Time

Project Progress Analysis					
Zones	# Of Items	\$ Total	# of Entries	Average \$ per Entry	Entry:Item Ratio
≤ 0	2	\$ 62,910.98	9	\$ 6,990.11	4.50
1-24	27	\$ 320,187.94	83	\$ 3,857.69	3.07
25-49	24	\$ 142,330.86	72	\$ 1,976.82	3.00
50-74	22	\$ 168,163.54	55	\$ 3,057.52	2.50
75-99	48	\$ 277,454.51	157	\$ 1,767.23	3.27
≥ 100	25	\$ 63,141.45	65	\$ 971.41	2.60

Break Down of Project Progress: CSI 9– Items						
Reason Code	≤ 0	1-24	25-49	50-74	75-99	≥ 100
D1						
D2						
D3					1	
D4		5	5	2	2	1
D5						
Documents	1	4	5	3	6	4
F1						
F2						
F3						
F4						
F5						
F6						2
Field			3	7	10	1
S1			1	4	6	8
S2		3			1	
S3						
S4	1	1				
S5				1		1
Scope			4	1	4	1
Site Scope				1	1	
Misc			1		2	
RNS		14	5	3	15	7
Total	2	27	24	22	48	25

Categories For Reason Codes	≤ 0	1-24	25-49	50-74	75-99	≥ 100
Design Errors and Omissions	1	9	10	5	9	5
Field Conditions	0	0	3	7	10	3
Scope	1	4	5	7	12	10
Reason Not Specified	0	14	5	3	15	7
Misc.	0	0	1	0	2	0
Total	2	27	24	22	48	25

Division 10 Analysis with Respect to Time

Project Progress Analysis					
Zones	# Of Items	\$ Total	# of Entries	Average \$ per Entry	Entry:item Ratio
≤ 0	1	\$ (6,000.00)	1	\$ (6,000.00)	1.00
1-24	5	\$ 308,182.45	25	\$ 12,327.30	5.00
25-49	5	\$ 20,422.55	15	\$ 1,361.50	3.00
50-74	6	\$ 8,635.24	16	\$ 539.70	2.67
75-99	13	\$ 32,305.92	34	\$ 950.17	2.62
≥ 100	10	\$ 24,808.71	18	\$ 1,378.26	1.80

Break Down of Project Progress: CSI 10-- Items						
Reason Code	≤ 0	1-24	25-49	50-74	75-99	≥ 100
D1						
D2						
D3						
D4						
D5						
Documents		4		2	1	3
F1						
F2						
F3						
F4						
F5						
F6						
Field				1		1
S1					4	4
S2			2	1		1
S3						
S4		1				
S5						
Scope			2	2	6	
Site Scope					1	
Misc	1					
RNS			1		1	1
Total	1	5	5	6	13	10

Categories For Reason Codes	≤ 0	1-24	25-49	50-74	75-99	≥ 100
Design Errors and Omissions	0	4	0	2	1	3
Field Conditions	0	0	0	1	0	1
Scope	0	1	4	3	11	5
Reason Not Specified	0	0	1	0	1	1
Misc.	1	0	0	0	0	0
Total	1	5	5	6	13	10

Division 11 Analysis with Respect to Time

Project Progress Analysis					
Zones	# Of Items	\$ Total	# of Entries	Average \$ per Entry	Entry:item Ratio
≤ 0	2	\$ 28,059.00	2	\$ 14,029.50	1.00
1-24	4	\$ 7,836.72	8	\$ 979.59	2.00
25-49	3	\$ 36,824.52	17	\$ 2,166.15	5.67
50-74	7	\$ 101,274.16	25	\$ 4,050.97	3.57
75-99	6	\$ 8,445.08	10	\$ 844.51	1.67
≥ 100	6	\$ 23,658.97	13	\$ 1,819.92	2.17

Break Down of Project Progress: CSI 11-- Items						
Reason Code	≤ 0	1-24	25-49	50-74	75-99	≥ 100
D1						
D2						
D3						
D4		1	1			
D5						
Documents				2	2	
F1						
F2						
F3						
F4						
F5						
F6						
Field					1	
S1					1	
S2				1		
S3						
S4						
S5						
Scope		2		1	2	2
Site Scope						
Misc	1		1			
RNS	1	1	1	3		4
Total	2	4	3	7	6	6

Categories For Reason Codes	≤ 0	1-24	25-49	50-74	75-99	≥ 100
Design Errors and Omissions	0	1	1	2	2	0
Field Conditions	0	0	0	0	1	0
Scope	0	2	0	2	3	2
Reason Not Specified	1	1	1	3	0	4
Misc.	1	0	1	0	0	0
Total	2	4	3	7	6	6

Division 12 Analysis with Respect to Time

Project Progress Analysis					
Zones	# Of Items	\$ Total	# of Entries	Average \$ per Entry	Entry:Item Ratio
≤ 0	0	\$ -	0	\$ -	0.00
1-24	0	\$ -	0	\$ -	0.00
25-49	1	\$ 5,290.00	4	\$ 1,322.50	4.00
50-74	1	\$ 3,978.65	4	\$ 994.66	4.00
75-99	3	\$ 10,009.92	8	\$ 1,251.24	2.67
≥ 100	3	\$ 22,350.78	6	\$ 3,725.13	2.00

Break Down of Project Progress: CSI 12-- Items						
Reason Code	≤ 0	1-24	25-49	50-74	75-99	≥ 100
D1						
D2						
D3						
D4						
D5						
Documents			1		1	
F1						
F2						
F3						
F4						
F5						
F6						
Field						
S1				1	1	3
S2						
S3						
S4						
S5						
Scope					1	
Site Scope						
Misc						
RNS						
Total	0	0	1	1	3	3

Categories For Reason Codes	≤ 0	1-24	25-49	50-74	75-99	≥ 100
Design Errors and Omissions	0	0	1	0	1	0
Field Conditions	0	0	0	0	0	0
Scope	0	0	0	1	2	3
Reason Not Specified	0	0	0	0	0	0
Misc.	0	0	0	0	0	0
Total	0	0	1	1	3	3

Division 13 Analysis with Respect to Time

Project Progress Analysis					
Zones	# Of Items	\$ Total	# of Entries	Average \$ per Entry	Entry:Item Ratio
≤ 0	0	\$ -	0	\$ -	0.00
1-24	2	\$ 3,623.45	5	\$ 724.69	2.50
25-49	0	\$ -	0	\$ -	0.00
50-74	0	\$ -	0	\$ -	0.00
75-99	0	\$ -	0	\$ -	0.00
≥ 100	0	\$ -	0	\$ -	0.00

Break Down of Project Progress: CSI 13-- Items						
Reason Code	≤ 0	1-24	25-49	50-74	75-99	≥ 100
D1						
D2						
D3						
D4		1				
D5						
Documents						
F1						
F2						
F3						
F4						
F5						
F6						
Field						
S1						
S2						
S3						
S4						
S5						
Scope						
Site Scope						
Misc						
RNS		1				
Total	0	2	0	0	0	0

Categories For Reason Codes	≤ 0	1-24	25-49	50-74	75-99	≥ 100
Design Errors and Omissions	0	1	0	0	0	0
Field Conditions	0	0	0	0	0	0
Scope	0	0	0	0	0	0
Reason Not Specified	0	1	0	0	0	0
Misc.	0	0	0	0	0	0
Total	0	2	0	0	0	0

Division 14 Analysis with Respect to Time

Project Progress Analysis						
Zones	# Of Items	\$ Total	# of Entries	Average \$ per Entry	Entry:Item Ratio	
≤ 0	2	\$ 35,275.00	4	\$ 8,818.75	2.00	
1-24	0	\$ -	0	\$ -	0.00	
25-49	0	\$ -	0	\$ -	0.00	
50-74	1	\$ 16,215.00	4	\$ 4,053.75	4.00	
75-99	0	\$ -	0	\$ -	0.00	
≥ 100	0	\$ -	0	\$ -	0.00	

Break Down of Project Progress: CSI 14-- Items						
Reason Code	≤ 0	1-24	25-49	50-74	75-99	≥ 100
D1						
D2						
D3						
D4						
D5						
Documents						
F1						
F2						
F3						
F4						
F5						
F6						
Field						
S1		1		1		
S2						
S3						
S4						
S5						
Scope						
Site Scope						
Misc						
RNS		1				
Total	0	2	0	1	0	0

Categories For Reason Codes	≤ 0	1-24	25-49	50-74	75-99	≥ 100
Design Errors and Omissions	0	0	0	0	0	0
Field Conditions	0	0	0	0	0	0
Scope	0	1	0	1	0	0
Reason Not Specified	0	1	0	0	0	0
Misc.	0	0	0	0	0	0
Total	0	2	0	1	0	0

Division 15 Analysis with Respect to Time

Project Progress Analysis					
Zones	# Of Items	\$ Total	# of Entries	Average \$ per Entry	Entry:Item Ratio
≤ 0	4	\$ 3,443.59	11	\$ 313.05	2.75
1-24	80	\$ 953,672.18	206	\$ 4,629.48	2.58
25-49	56	\$ 324,667.36	126	\$ 2,576.73	2.25
50-74	63	\$ 738,451.62	151	\$ 4,890.41	2.40
75-99	42	\$ 470,388.64	123	\$ 3,824.30	2.93
≥ 100	63	\$ 207,419.44	136	\$ 1,525.14	2.16

Break Down of Project Progress: CSI 15-- Items						
Reason Code	≤ 0	1-24	25-49	50-74	75-99	≥ 100
D1						
D2						2
D3					1	
D4	1	28	19	7	2	1
D5			4	1		2
Documents		10	6	15	6	14
F1						
F2						
F3			3	1		5
F4						
F5						
F6				2	1	2
Field	2	11	4	14	7	5
S1					5	4
S2		5	1	3		
S3						
S4		2	1			
S5						
Scope		1	6	4	8	4
Site Scope						
Misc		1	3		1	2
RNS	1	22	9	16	11	22
Total	4	80	56	63	42	63

Categories For Reason Codes	≤ 0	1-24	25-49	50-74	75-99	≥ 100
Design Errors and Omissions	1	38	29	23	9	19
Field Conditions	2	11	7	17	8	12
Scope	0	8	8	7	13	8
Reason Not Specified	1	22	9	16	11	22
Misc.	0	1	3	0	1	2
Total	4	80	56	63	42	63

Division 16 Analysis with Respect to Time

Project Progress Analysis					
Zones	# Of Items	\$ Total	# of Entries	Average \$ per Entry	Entry:item Ratio
≤ 0	4	\$ 71,242.92	10	\$ 7,124.29	2.50
1-24	41	\$ 160,412.89	105	\$ 1,527.74	2.56
25-49	39	\$ 276,171.81	100	\$ 2,761.72	2.56
50-74	58	\$ 838,043.28	144	\$ 5,819.74	2.48
75-99	71	\$1,223,178.99	188	\$ 6,506.27	2.65
≥ 100	54	\$ 163,666.29	131	\$ 1,249.36	2.43

Break Down of Project Progress: CSI 16-- Items						
Reason Code	≤ 0	1-24	25-49	50-74	75-99	≥ 100
D1					1	
D2			1		1	
D3				1		
D4		5	2	3	2	2
D5			5		1	2
Documents	1	10	1	6	9	8
F1						
F2						
F3					1	3
F4						
F5						
F6			1			
Field	2	6	5	12	7	7
S1		1	3	3	10	8
S2		2	1	5	1	1
S3				1		
S4		1			1	
S5					1	
Scope	1	1	8	13	4	1
Site Scope				1	1	
Misc			2	1	1	3
RNS		15	10	12	30	19
Total	4	41	39	58	71	54

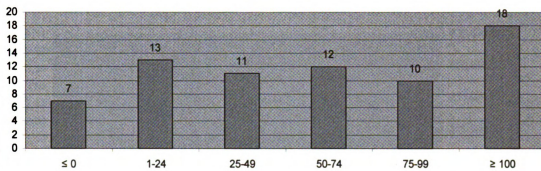
Categories For Reason Codes	≤ 0	1-24	25-49	50-74	75-99	≥ 100
Design Errors and Omissions	1	15	9	10	14	12
Field Conditions	2	6	6	12	8	10
Scope	1	5	12	23	18	10
Reason Not Specified	0	15	10	12	30	19
Misc.	0	0	2	1	1	3
Total	4	41	39	58	71	54

APPENDIX III

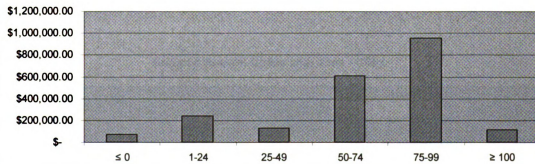
CSI Division Analysis - Graphs

CSI Division 1

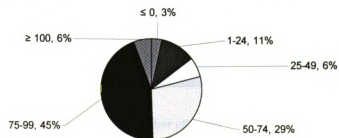
Number of Reason Codes per Percentage Grouping



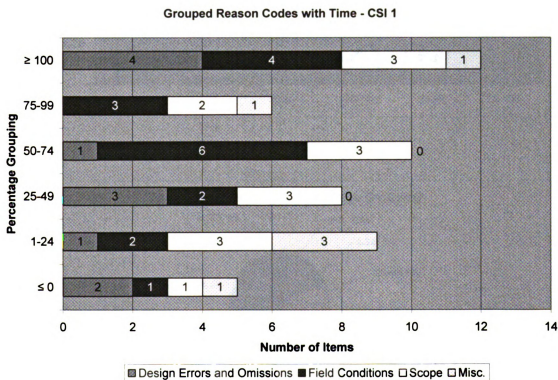
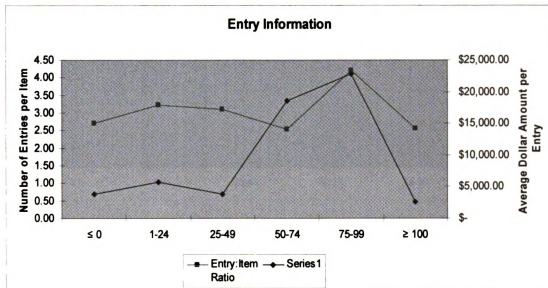
Total Dollar Amount per Percentage Grouping



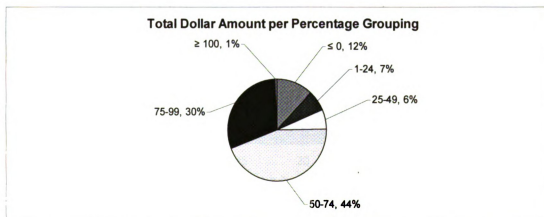
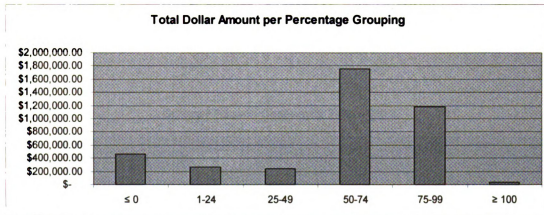
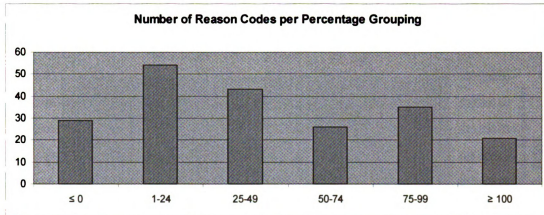
Total Dollar Amount per Percentage Grouping



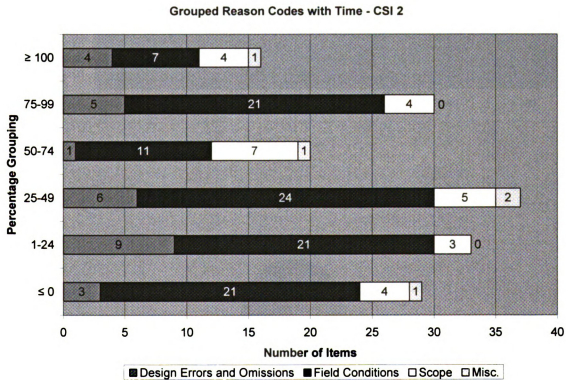
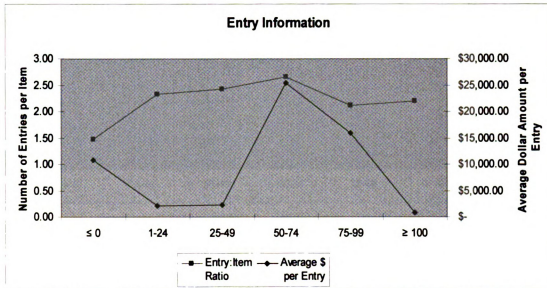
CSI Division 1



CSI Division 2

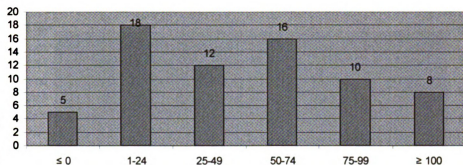


CSI Division 2

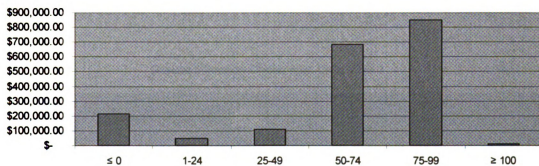


CSI Division 3

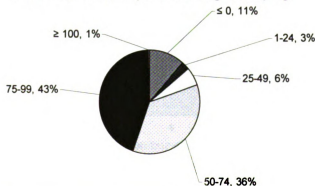
Number of Grouped Reason Codes per Percentage Grouping



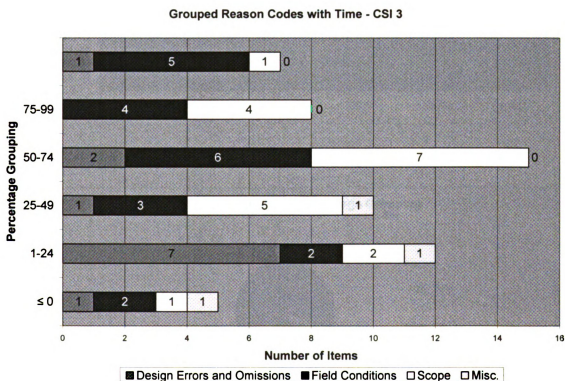
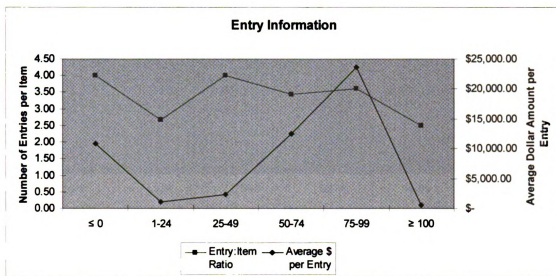
Total Dollar Amount per Percentage Grouping



Total Dollar Amount per Percentage Grouping

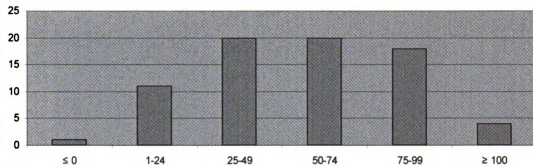


CSI Division 3

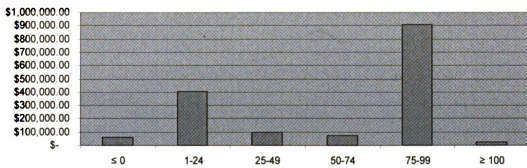


CSI Division 4

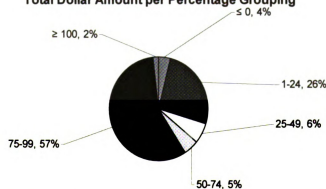
Number of Reason Codes per Percentage Grouping



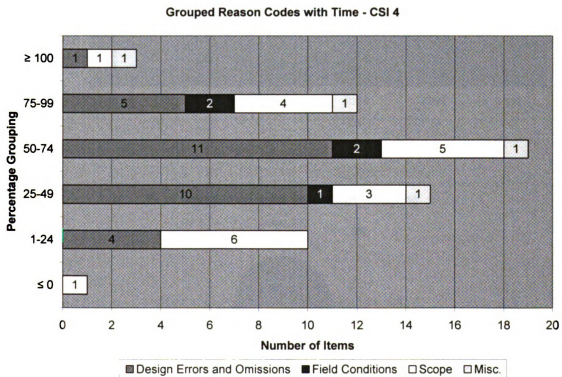
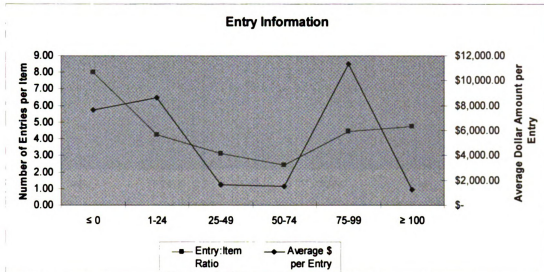
Total Dollar Amount per Percentage Grouping



Total Dollar Amount per Percentage Grouping

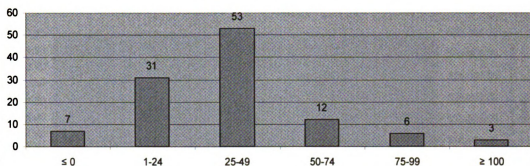


CSI Division 4

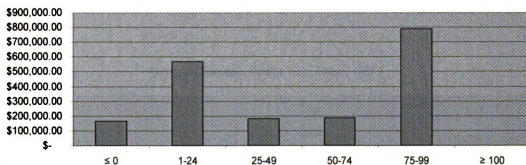


CSI Division 5

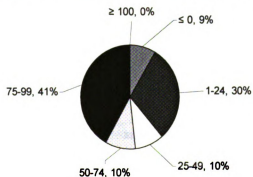
Number of Reason Codes per Percentage Grouping



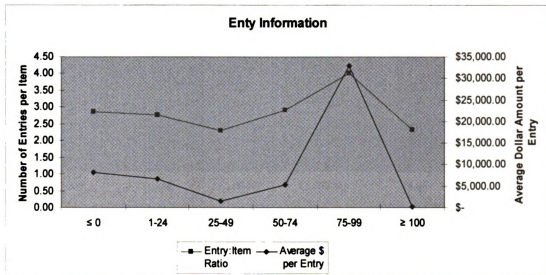
Total Dollar Amount per Percentage Grouping



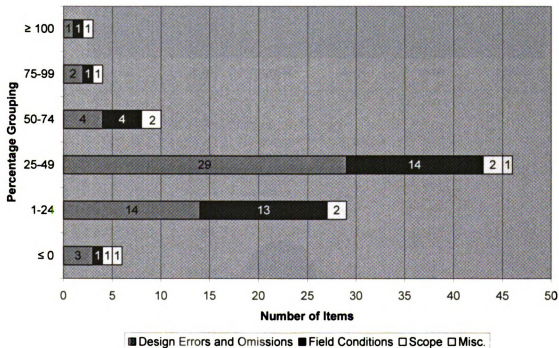
Total Dollar Amount per Percentage Grouping



CSI Division 5

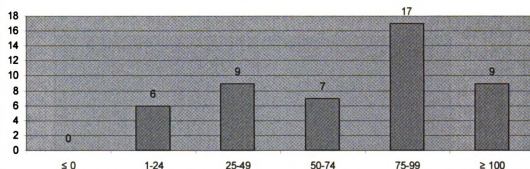


Grouped Reason Codes with Time - CSI 5

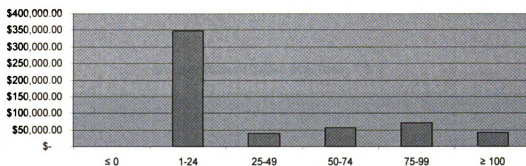


CSI Division 6

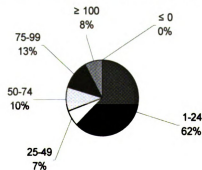
Number of Reason Codes per Percentage Grouping



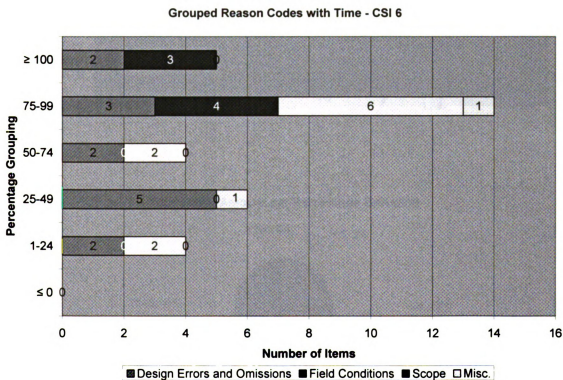
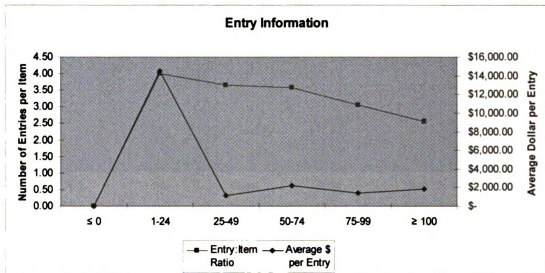
Total Dollar Amount per Percentage Grouping



Total Dollar Amount per Percentage Grouping

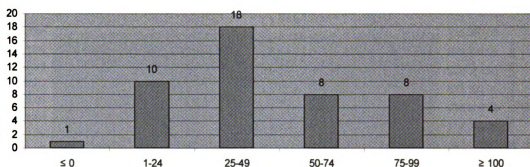


CSI Division 6

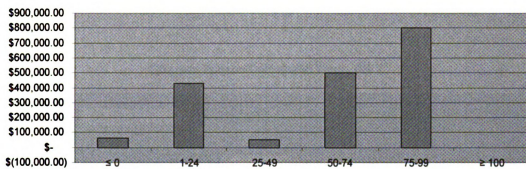


CSI Division 7

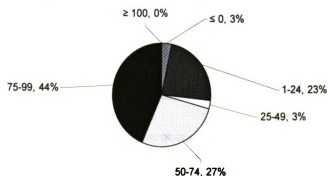
Number of Codes per Percentage Grouping



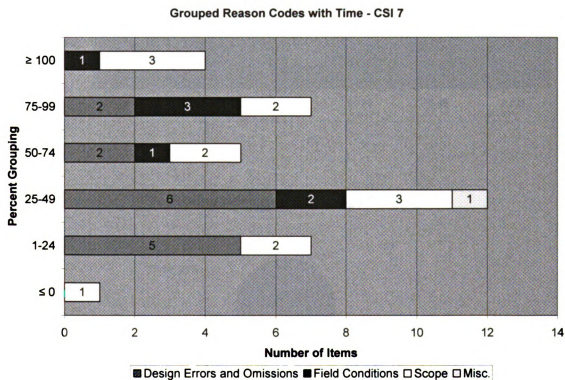
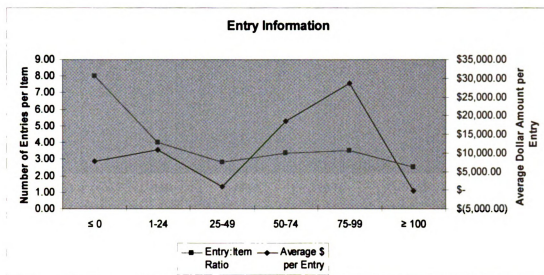
Total Dollar Amount per Percentage Grouping



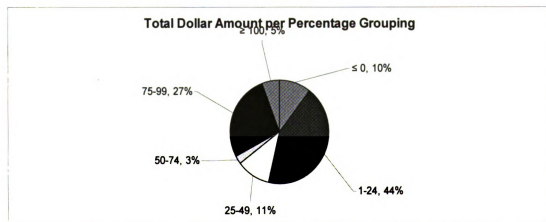
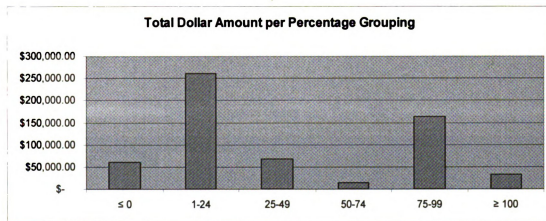
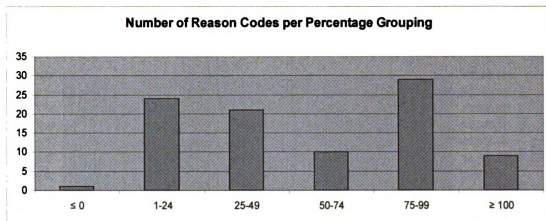
Total Dollar Amount per Percentage Grouping



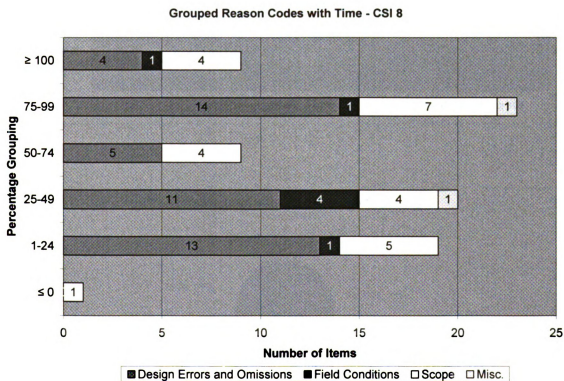
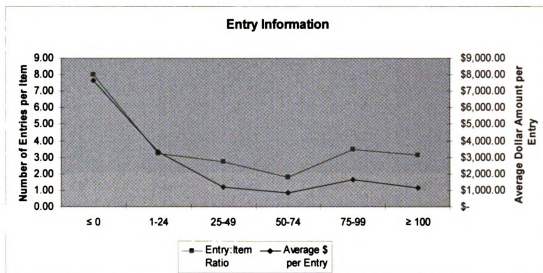
CSI Division 7



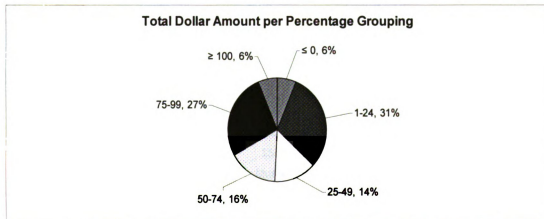
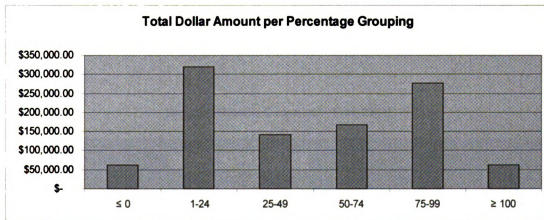
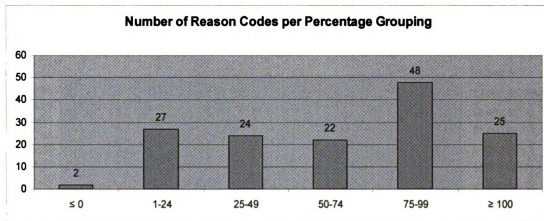
CSI Division 8



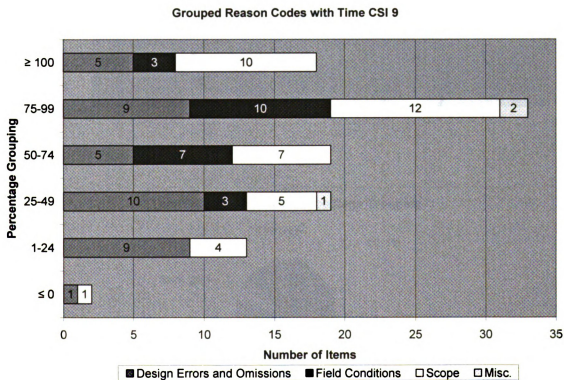
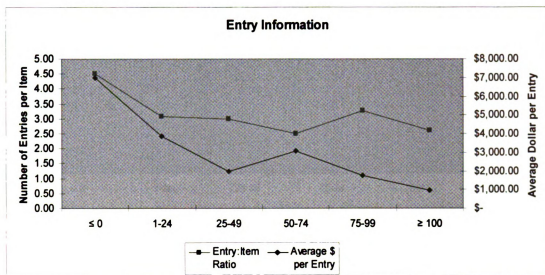
CSI Division 8



CSI Division 9

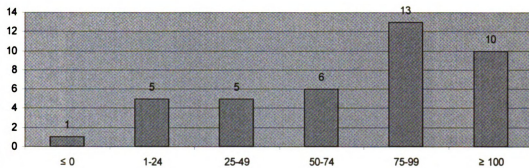


CSI Division 9

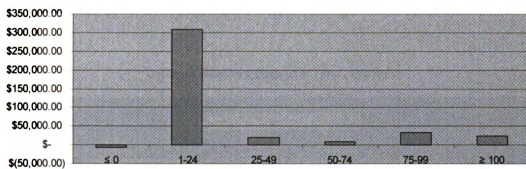


CSI Division 10

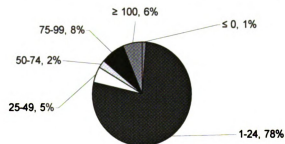
Number of Reason Codes per Percentage Grouping



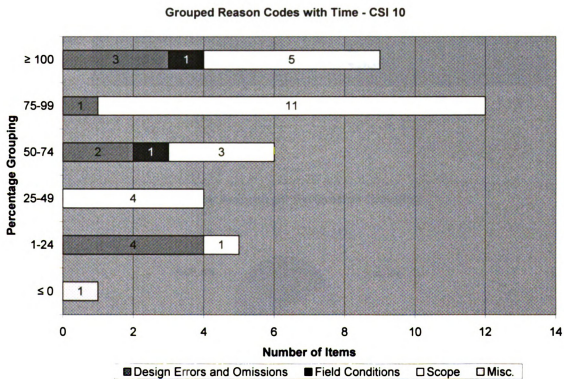
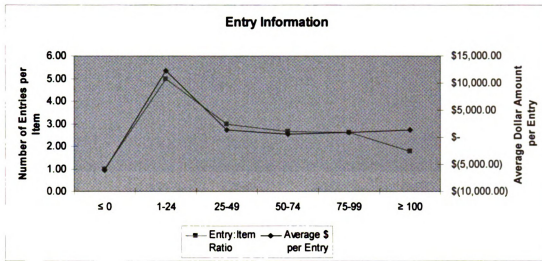
Total Dollar Amount per Percentage Grouping



Total Dollar Amount per Percentage Grouping

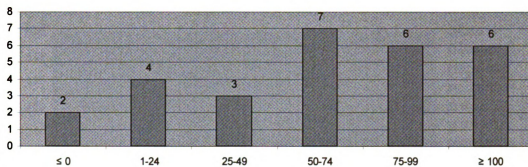


CSI Division 10

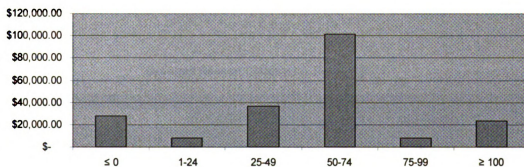


CSI Division 11

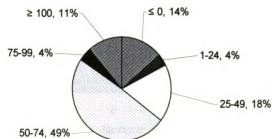
Number of Reason Codes per Percentage Grouping



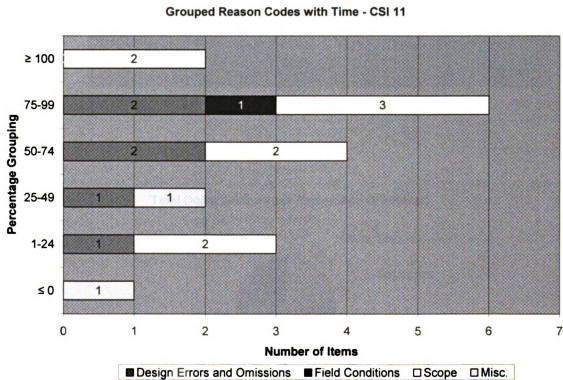
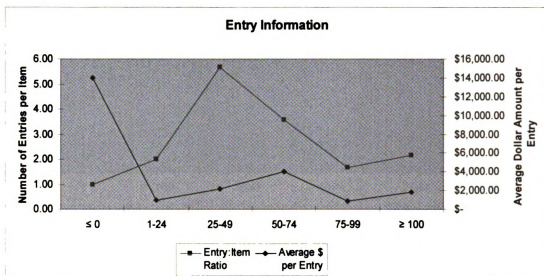
Total Dollar Amount per Percentage Grouping



Total Dollar Amount per Percentage Grouping

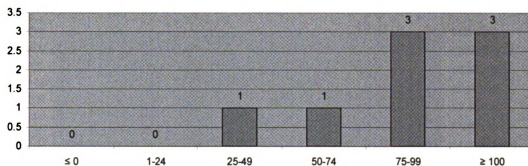


CSI Division 11

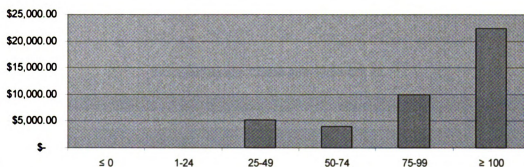


CSI Division 12

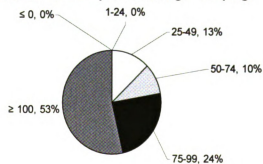
Number of Reason Codes per Percentage Grouping



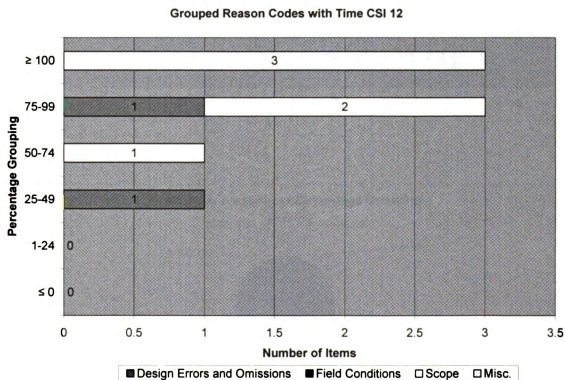
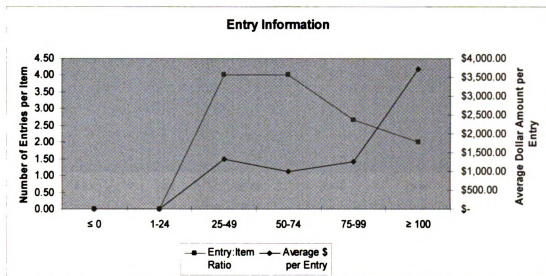
Total Dollar Amount per Percentage Grouping



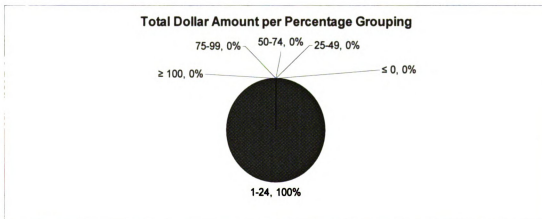
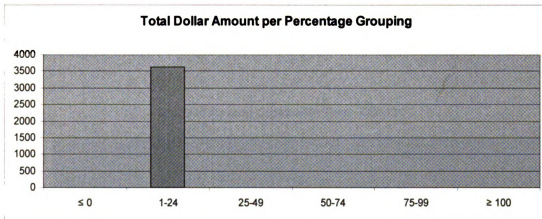
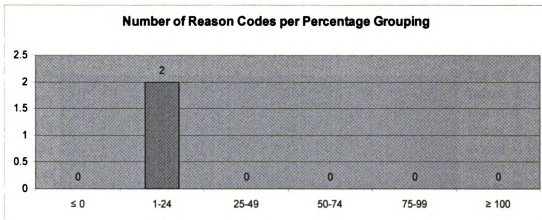
Total Dollar Amount per Percentage Grouping



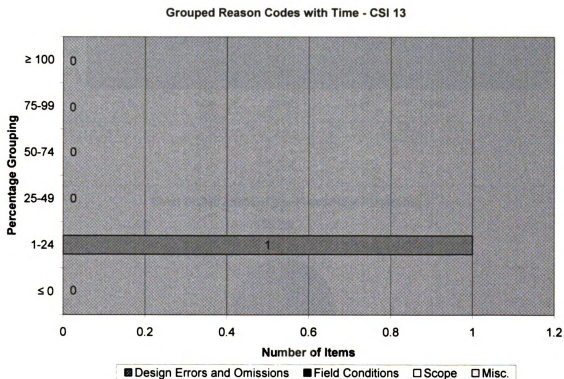
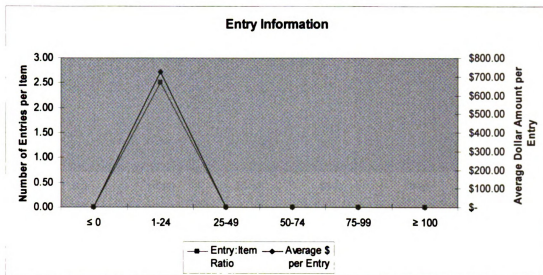
CSI Division 12



CSI Division 13

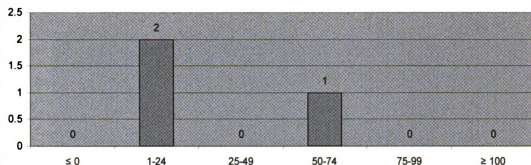


CSI Division 13

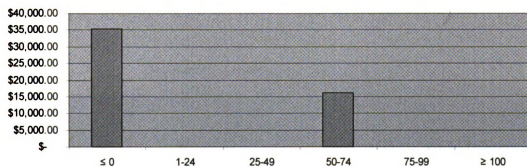


CSI Division 14

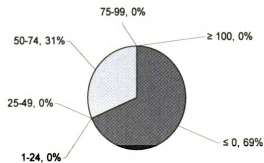
Number of Reason Codes per Percentage Grouping



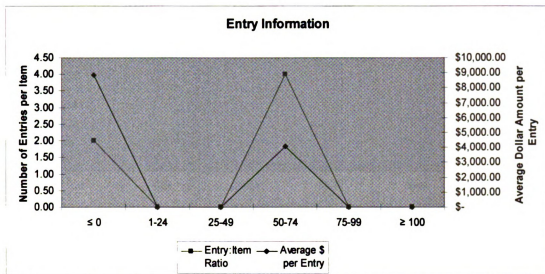
Total Dollar Amount per Percentage Grouping



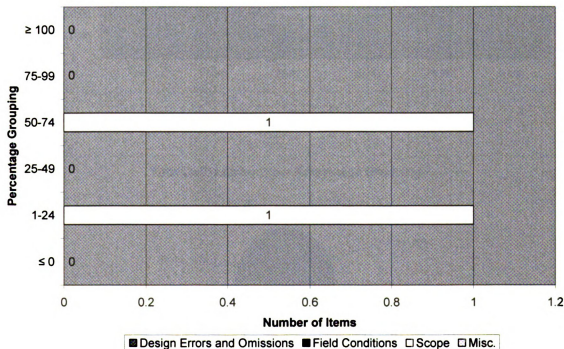
Total Dollar Amount per Percentage Grouping



CSI Division 14

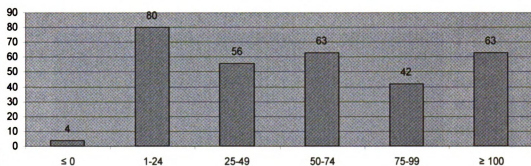


Grouped Reason Codes with Time - CSI 14

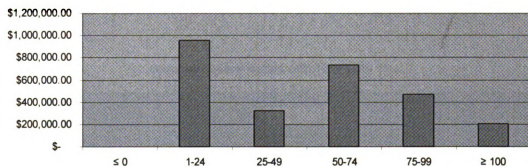


CSI Division 15

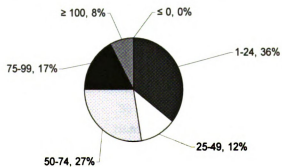
Number of Reason Codes per Percentage Grouping



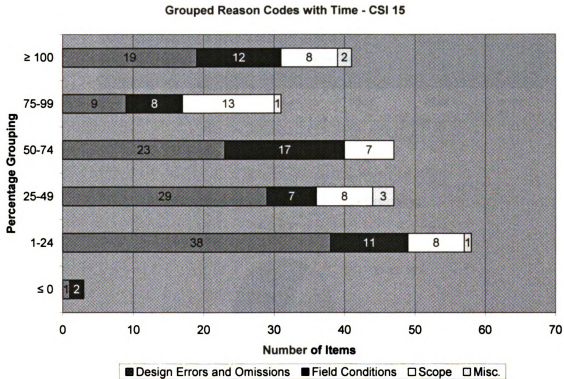
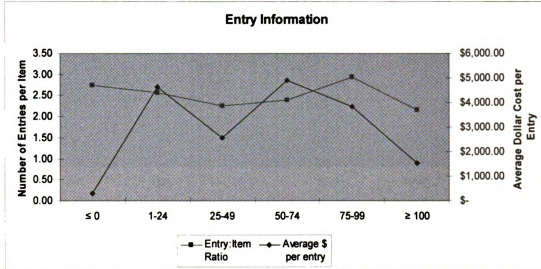
Total Dollar Amount per Percentage Grouping



Total Dollar Amount per Percentage Grouping

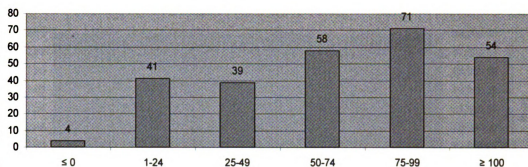


CSI Division 15

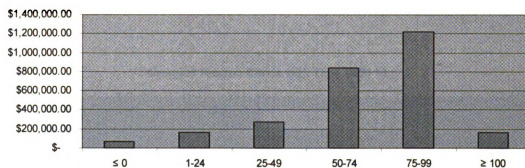


CSI Division 16

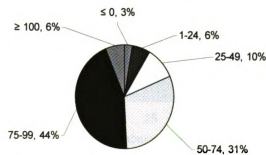
Number of Reason Codes per Percentage Grouping



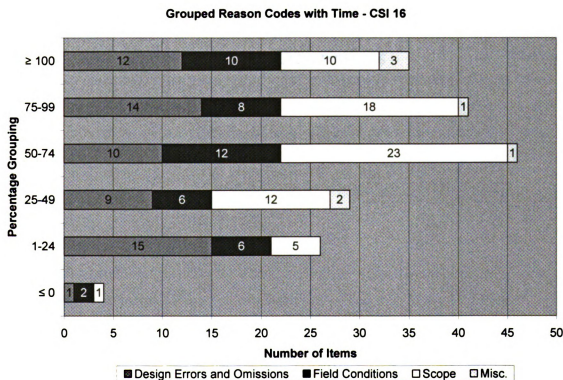
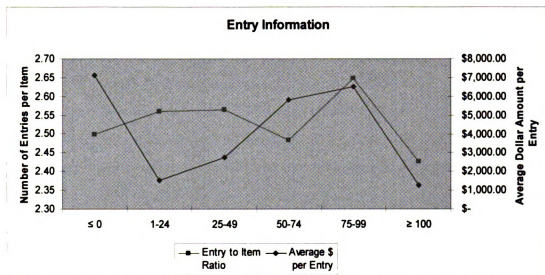
Total Dollar Amount per Percentage Grouping



Total Dollar Amount per Percentage Grouping



CSI Division 16



APPENDIX IV

Project Descriptions

Project Descriptions

1707 Agriculture Hall – Annex Replacement and Cook Hall Renovations

Construction of a new 3-Story, brick facade and limestone banded Annex building attached to the existing Agriculture Hall by an Atrium connector wing. The new Annex is entirely air-conditioned and contains typical electrical, mechanical, and communication services. The 2nd Floor has a removable brick panel for future Mechanical Room equipment replacement. Two classrooms in the existing building were renovated and converted into office spaces. The entire crawl space was also abated for asbestos, and all exterior windows were replaced. A new 2-course asphalt parking lot with concrete curb and gutter and classic lamps to match existing were also installed. Cook Hall is a fieldstone foundation, balloon framed, brick building. It was completely gutted and lead abatement was performed in the entire building. Cubicles were installed in the Basement for Graduate students while the 1st and 2nd Floors were converted into office spaces. An exterior emergency exit was added at the 2nd Floor level.

3119 Breslin Student Events Center – Alfred Berkowitz Basketball Complex

A new 16,500 sq. ft. one-story, brick-clad addition to the existing building with modifications to the existing parking and landscaping. The project also included a second sub-grade Auxiliary Gymnasium adjacent to the first, with training and coaching alcoves along the perimeter. The gyms are separated by a folding partition to allow for multiple uses. Two equally sized Suites of offices, reception, video and conference rooms, and support spaces for both Men's and Women's basketball programs were created. The main Lobby and common hallways were designed for the display of basketball history and triumphs. The existing mechanical, electrical, and telecommunication systems were also modified for the increased capacity. Furnishings were also provided as part of the project.

2474 Bio-Physical Science Building

Construction of a new 360,000 sq. ft. 6-story structure with links to two existing buildings through bridge and tunnel connections. The building has a steel frame with brick veneer and glazed curtain walls exterior and a skylit atrium in the center. The building contains a number of different uses including labs, lab support areas, offices, conference rooms, two lecture halls, and a research library. The project consisted of three different bid packages including site work, steel erection, and building construction. Site work included major footing excavation and the installation of the H-piles. The steel erection included the purchase and erection of the steel structure with the contract being absorbed into the building construction bid package in order to facilitate coordination.

3496 Campus – Fiber Optic System Phase XIII

The excavation and installation of a fiber optic system within new and existing communication ductlines, steam tunnels, and buildings. Terminal rooms were designated at existing locations or a new room was created by alteration. This work required minor demolition, electrical, mechanical, masonry, drywall, VCT flooring, and painting. A new 150 sq. ft. masonry wall, vinyl sided, asphalt shingled communication building was also constructed.

3147 Chemistry Building – Renovations to Rooms 529A, 529, 530, 531A, 532, & 533

Renovation of the 3900 sq. ft. Wulff lab on the 5th Floor that included demolition of the existing supply and exhaust ductwork and associated ductwork components. A window sill plenum partition in the wall between 529A and 529 as well as fume hoods and associated piping were removed. The new work included the installation of new supply and exhaust ductwork, a new window sill plenum partition, and the installation of a new space temperature sensor. New ductwork and piping was connected to new fume hoods and ventilated cabinets. Air and water testing was performed to ensure proper design flow rates and room

space pressurization relationships. Floor tile abatement was also performed during demolition.

0584 Food Safety Toxicology

The construction of a new 4-Story concrete framed building with basement. The exterior is brick-clad with limestone banding and contains windows on all floors. The building consists of offices, laboratories, and Clean Rooms for research. Hollow metal and aluminum doors and frames were installed throughout. Laboratory equipment and fixtures were also included. The building has a complete fire protection system. Heating, ventilating, and air conditioning systems were also installed. Mechanical and electrical systems typical for a laboratory research building were also built-in.

0365 Hannah Administration Building – Replace Absorption Chillers

Replacement of two existing absorption chillers and associated cooling towers, pumps, and piping with new. The existing cooling tower grillage and chilled water distribution center were also modified. The existing duplex PRV station was replaced with two new duplex stations and the existing AHU 3-way control valves with replaced with new 2-way. New controls and conversion of the existing controls were also performed. The existing mechanical room exhaust system and a portion of the mechanical room ceiling were removed and replaced to accommodate the removal and installation of the new chillers. A new condensate return pumping station was also installed. Associated asbestos containing materials were removed and disposed of when encountered.

3282 Life Science – Alterations to Rooms B107-109, B126-128, B130, & B145

Remodeled areas of the 1st Floor B-Wing for a new Nursing Skills Laboratory. The work included electrical, mechanical, plumbing, and communications required in a typical demolition and renovation of a laboratory setting. Significant sbestos abatement was required including plumbing and fireproofing materials. The existing floor was removed and replaced with VCT tile.

2124 Nisbet Building – Chiller Installation

Replace two existing condensing units and refrigerant coils with new air-cooled chillers and chilled water coils at two main air handling systems including associated piping and insulation. Modifications were made to the existing electrical system to incorporate the new design. The HWH coils were also replaced in the two existing units along with the bag filters as well as two sets of chilled water pumps. Modifications to the existing structural platforms and associated work were required for the new equipment.

3347 Spartan Child Development Center

Demolished and replace aging temporary facility and constructed a new 14,488 sq. ft. single story, slab on grade, wood framed, brick veneer, and asphalt shingled child care building with sprinkler fire protection throughout. The new building includes multi-purpose rooms, teacher rooms, classrooms, and a kitchen. Each classroom is served by its own restroom. There is room for 130 children with space for an additional 50 with planned future building expansion. Heat is provided by a HWH system which is derived from a central boiler. Unit ventilator A/C units with reheat coils are located in each room for local control. The infant and toddler rooms utilize floor radiant heating covered by carpeting and VCT tile. The exterior sidewalk has a snowmelt system and is handicap accessible. Two exterior playground areas surrounded by fencing were also installed.

3067 Spartan Stadium – East Concourse Restoration 2000

Full and partial depth concrete floor replacement, demolition, masonry, column and beam restoration, expansion joints, traffic coating, lighting, painting, handrails, doors, windows, and miscellaneous architectural, electrical, and mechanical work. Asbestos abatement was performed where encountered.

3158 Wilson Hall – Alterations in Room C102

Lecture hall renovation including removal of existing ceiling, diffusers, light fixtures, and seating. Floor preparation was also done for new seating that was installed by others. New construction included the installation of a new chiller, (2) circulating pumps, associated piping, ductwork, diffusers, acoustical ceiling, light fixtures, dimmer panel, speakers, exit lights, acoustical wall panels, and painting. Asbestos abatement was also performed.

3981 Cyclotron Building – Office Expansion

Demolition of an existing single story wing and the construction of a new 2-story addition consisting of a steel structure with brick veneer and a built-up coal-tar roof. Site utilities were installed for the new layout, which included storm water drainage, site concrete, pavement patching, and a new water main tie-in.

Windows were installed throughout and the front entrance consists of a glazed aluminum curtain wall system. The addition re-defines the main entry adding a reception space, conference rooms, and additional offices. The existing mechanical and electrical systems were upgraded with new added to support the new addition. A fire protection system was installed throughout the new addition and tied into the existing building.

3482 Jenison Fieldhouse – Locker Room Renovation and Addition

The complete demolition and renovation of the locker rooms on the First Floor as well as partial demolition and renovation of other areas on the Basement, Second, Third, Fourth, and Roof levels of the existing building. Asbestos abatement was performed in all areas affected by construction. A single-story brick addition was constructed to house the new upgraded electrical and fire suppression equipment. A new locker area was also constructed in the north end of the Third Floor gymnasium. The Fourth Floor weight room was expanded above the new Third Floor locker room space. The First Floor windows were replaced with glass block while the Third Floor Gymnasium windows were replaced with new. A new 6-

stop roped hydraulic elevator was also installed. A new mechanical Penthouse on the roof was created to house the new mechanical equipment and included a heat recovery unit. The fire alarm system for the entire building was also replaced. New supply and exhaust ductwork, electrical, communication, VCT flooring, carpeting, and painted were installed in all renovated spaces.

99072 Parking Lot No. 89 Expansion

Expansion of Parking Lot No. 89 to add approximately 800 new parking spaces and incorporate CATA Bus Service pick-up in the parking lot. Work includes grading, drainage, pavement, curb and gutter, sidewalk, bus shelters, storm water treatment, and lighting.

**02140 Intercollegiate Athletics New Track and Field Facility Ralph Young
Field**

Install new 8-lane NCAA regulation running track with new field hockey infield. Various other field event areas were also constructed including, shot-put, discus, and pole vault spaces. The project required site demolition, earthwork, storm drainage, utilities, paving, and fencing. A new brick storage building and bleachers were also installed.

APPENDIX V

University Interview Questionnaire

Interview Questionnaire

Development of a Change Order Management Practice for use on University Construction Projects

Strategies for Reducing the Impacts of Change Orders on Construction Projects at Michigan State University

University Construction Administrators

We are conducting research on change orders on Michigan State University construction projects and within similar universities. As part of this process we are trying to develop an understanding of how your university conducts its construction project management processes in general and with particular emphasis on change orders. We plan to visit or talk with three universities. Any information that you can provide regarding the following questions will be helpful. If your office is not directly involved with aspects of the questions asked, it will be helpful if you can direct us to an office that might have this information. We will be happy to furnish a copy of our final report to your university, upon request. We thank you in advance for taking your time to help us with our study.

1. What is the title of your position within your university?

2. Can you identify the offices or departments which procure construction services for your university (or department)?

3. Can your office provide general recent construction data for your university (or department) such as number of projects, annual dollar value and/or project profiles? If not where can we obtain this information?

4. Does an organizational chart exist which outlines your university's (or department) construction project management parties? If so can we obtain a copy of this chart? If not can you identify the offices which are involved?

5. What are the specific responsibilities of the offices or individuals involved in your construction project management process?

6. Has your office conducted any analysis or review of its construction project management processes? Can you describe this analysis process? Were recommendations made and implemented? Will you describe this process and its findings? Is a report available for review?
7. Do you conduct any formal post construction analysis of projects with respect to budget, schedule, change orders, or performance of the parties involved? Describe. Are findings or a report available for our review?
8. If an analysis has been conducted can you describe in general terms its findings?
9. To what extent does your office monitor change orders within your department or process? Are project records aggregated for the purposes of determining average change order rates? Are these change order rate statistics or analysis available for our review?
10. Has any analysis been undertaken to determine change order causes? Can you describe this process? What were its findings? Were recommendations made and implemented? Is a copy of the report available?
11. Have you standardized systems for classifying causes (such as scope, document error or field conditions)? Describe.
12. Have you drawn any conclusions with respect to the dominant causes of change orders? What are the dominant causes?

13. If you can either from statistical data or from your experience indicate the usual change order rate percentages of original project budget for some of the following project types?

	Percent and source
New building such as classroom/offices or dormitories	_____
New complex buildings such as science or laboratory buildings	_____
Significant renovations to buildings such as classroom/offices or dormitories	_____
Significant renovations to buildings such as science or laboratory buildings	_____
New infrastructure projects such as	_____
Electrical vaults	
Underground utility or distribution projects	
Physical plant improvements such as power plant extensions/chillers	
Significant Infrastructure renovation such as	_____
Electrical vaults	
Underground utility or distribution projects	
Physical plant improvements such as power plant extensions/chillers	

14. Has any analysis been conducted which helps you to predict change orders rates for projects? If so can you describe your process or methods? What are your change order rates?

15. Is that rate of changes orders seen as acceptable? Explain.

16. Are performance records of project parties monitored or tracked formally or informally with respect to change orders? If yes, can you describe how they are monitored for the following groups of project participants?

Architectural firms
Design engineers
General contractors
Construction managers
Individual subcontractors
University project managers

17. Please outline the process of receiving, reviewing and approving change orders within your organization.
18. What are the typical durations for processing change orders? Do these durations contribute to additional costs such as for extended general conditions, ripple effects or impact change orders?
19. How are project contingencies established for projects? What are typical rates?
20. What happens to unspent project contingencies as the project progresses? Are they generally available for use with the later project phases to allow for changes in scope?
21. Who determines the testing program for elements such as soils testing, environmental conditions or hazardous materials? How are they determined? Have testing programs generally been adequate or is this an area of concern or cause of change orders?
22. How are design professionals hired for projects? When selecting or considering design professionals are their performance records for errors, omissions and change orders considered? If they are considered when hiring, how is this information solicited?

23. When awarding construction contracts, are change order histories of general contractors considered in determining if they are "qualified" for the work. How is this information solicited?
24. In your opinion do construction, design or construction management firms which participate in ISO programs usually have reduced change order rates on projects undertaken for your university when compared to non ISO firms?
25. When awarding construction contracts or trade contracts, are change order histories of specific subcontractors or trade contractors considered in determining if they are "qualified" for the work. How is this information solicited?
26. How are construction managers hired for projects? When selecting or considering construction professionals are their performance records for errors, omissions and change orders considered?
27. Has your organization used design build firms for projects? If so describe frequency and project types?
28. Have you been generally satisfied with projects delivered through the design build project delivery method? Explain

29. Do you have any opinion or analysis on whether the project delivery method such as design build, construction management or general contracting influences change order rates? Explain.
30. Do you have any opinion on whether the spread (variation) of bids received influences change order rates? Are they a good predictor of change orders on a project?
31. Is the contractor's overhead and profit mark up typically contractually specified? What are the standard specified rates? If not how is overhead and markup incorporated into the contractor's change order pricing?
32. Has overhead and profit markup been a source of dispute on projects? Explain.
33. How are extended general conditions items or reduced productivity claims incorporated into change order pricing? Has this been a source of dispute on projects? Explain?
34. How are building programs (needs brief) established and documented? Are misunderstandings about program occasionally or commonly a cause of scope changes by the end user department? Describe.

35. Are construction documents formally reviewed by your organization in detail prior to bidding? Describe this process.
36. Does your organization have published construction standards or specifications which establish requirements for design and specification of projects by designers? Is failure to follow these standards by designers a frequent source of change orders? Explain.
37. Do you believe there is a difference in change orders rates designed within your organization when compared to when you use outside design firms? Explain.
38. Has your organization utilized commissioning services? Have these been effective in reducing change order rates?
39. If you have used "partnering" agreements on projects, have those projects typically experienced lower change order rates than others? Has partnering been effective in reducing change orders?

40. Are prebid meetings or wakthrus conducted for projects? Always? Describe?
41. Which CSI divisions cause the most change orders for your organization? Why do you think these divisions have the most change orders?
42. Which design professions cause the most change orders for your organization?
43. From your perspective do you have any suggestions that could be employed to reduce change orders frequency and their impact on projects?
44. What change order management process improvements could be made that would reduce the impact of change orders on projects? Either preconstruction or during construction contract administration?
45. Do you have any other comments regarding change orders that you would add?

APPENDIX VI

Projects Original Scheduled Value & Contract Percentage

1707 Agriculture Hall - Annex Replacement and Cook Hall Renovations

CSI Division	Scheduled Value	Percent of Contract
1	\$ 574,030.00	9.17%
2	\$ 476,305.00	7.61%
3	\$ 916,600.00	14.64%
4	\$ 855,371.00	13.66%
5	\$ 205,289.00	3.28%
6	\$ 99,000.00	1.58%
7	\$ 114,282.00	1.83%
8	\$ 715,821.00	11.43%
9	\$ 630,517.00	10.07%
10	\$ 30,497.00	0.49%
11	\$ -	0.00%
12	\$ -	0.00%
13	\$ -	0.00%
14	\$ 79,900.00	1.28%
15	\$ 888,688.00	14.20%
16	\$ 674,000.00	10.77%
TOTAL	\$ 6,260,300.00	100.00%

3119 Breslin Student Events Center - Alfred Berkowitz Basketball Complex

CSI Division	Scheduled Value	Percent of Contract
1	\$ 466,500.00	7.78%
2	\$ 512,970.00	8.55%
3	\$ 532,705.00	8.88%
4	\$ 540,000.00	9.00%
5	\$ 410,000.00	6.83%
6	\$ 299,300.00	4.99%
7	\$ 316,585.00	5.28%
8	\$ 278,281.00	4.64%
9	\$ 610,586.00	10.18%
10	\$ 77,721.00	1.30%
11	\$ 63,445.00	1.06%
12	\$ 66,360.00	1.11%
13	\$ -	0.00%
14	\$ -	0.00%
15	\$ 1,172,447.00	19.54%
16	\$ 653,100.00	10.89%
TOTAL	\$ 6,000,000.00	100.00%

2474 Bio-Physical Science Building – CD# 1

CSI Division	Scheduled Value	Percent of Contract
1	\$ 197,950.00	12.02%
2	\$ 1,417,050.00	86.04%
3	\$ -	0.00%
4	\$ -	0.00%
5	\$ -	0.00%
6	\$ -	0.00%
7	\$ 2,000.00	0.12%
8	\$ -	0.00%
9	\$ -	0.00%
10	\$ -	0.00%
11	\$ -	0.00%
12	\$ -	0.00%
13	\$ -	0.00%
14	\$ -	0.00%
15	\$ 2,500.00	0.15%
16	\$ 27,500.00	1.67%
TOTAL	\$ 1,647,000.00	100.00%

2474 Bio-Physical Science Building – CD# 2

CSI Division	Scheduled Value	Percent of Contract
1	\$ 362,400.00	8.01%
2	\$ -	0.00%
3	\$ -	0.00%
4	\$ -	0.00%
5	\$ 4,159,800.00	91.99%
6	\$ -	0.00%
7	\$ -	0.00%
8	\$ -	0.00%
9	\$ -	0.00%
10	\$ -	0.00%
11	\$ -	0.00%
12	\$ -	0.00%
13	\$ -	0.00%
14	\$ -	0.00%
15	\$ -	0.00%
16	\$ -	0.00%
TOTAL	\$ 4,522,200.00	100.00%

2474 Bio-Physical Science Building – CD# 4

CSI Division	Scheduled Value	Percent of Contract
1	\$ 4,011,673.00	5.64%
2	\$ 2,114,260.00	2.97%
3	\$ 3,648,200.00	5.13%
4	\$ 5,830,000.00	8.19%
5	\$ 2,523,949.00	3.55%
6	\$ 1,241,190.00	1.74%
7	\$ 2,503,138.00	3.52%
8	\$ 3,820,580.00	5.37%
9	\$ 3,782,397.00	5.32%
10	\$ 289,159.00	0.41%
11	\$ 5,032,672.00	7.07%
12	\$ 237,167.00	0.33%
13	\$ 1,007,912.00	1.42%
14	\$ 783,583.00	1.10%
15	\$ 25,856,071.00	36.34%
16	\$ 8,466,131.00	11.90%
TOTAL	\$ 71,148,082.00	100.00%

3496 Campus – Fiber Optic System Phase XIII

CSI Division	Scheduled Value	Percent of Contract
1	\$ 466,500.00	6.98%
2	\$ 512,970.00	48.51%
3	\$ 230,000.00	11.53%
4	\$ -	0.00%
5	\$ -	0.00%
6	\$ 299,300.00	3.71%
7	\$ -	0.00%
8	\$ -	0.00%
9	\$ -	0.00%
10	\$ -	0.00%
11	\$ -	0.00%
12	\$ -	0.00%
13	\$ -	0.00%
14	\$ -	0.00%
15	\$ -	0.00%
16	\$ 583,947.00	29.27%
TOTAL	\$ 1,995,000.00	100.00%

3147 Chemistry Building – Renovations to Rooms 529A, 529, 530, 531A, 532, & 533

CSI Division	Scheduled Value	Percent of Contract
1	\$ 191,896.00	20.59%
2	\$ 3,700.00	0.40%
3	\$	0.00%
4	\$ 37,200.00	3.99%
5	\$	0.00%
6	\$ 20,750.00	2.23%
7	\$	0.00%
8	\$	0.00%
9	\$ 48,476.00	5.20%
10	\$	0.00%
11	\$ 244,000.00	26.18%
12	\$ -	0.00%
13	\$ -	0.00%
14	\$	0.00%
15	\$ 355,207.00	38.12%
16	\$ 30,660.00	3.29%
TOTAL	\$ 931,889.00	100.00%

0584 Food Safety Toxicology

CSI Division	Scheduled Value	Percent of Contract
1	\$ 977,759.00	5.22%
2	\$ 998,000.00	5.33%
3	\$ 2,891,310.00	15.43%
4	\$ 2,320,233.00	12.38%
5	\$ 590,679.00	3.15%
6	\$ 103,000.00	0.55%
7	\$ 368,767.00	1.97%
8	\$ 373,600.00	1.99%
9	\$ 638,500.00	3.41%
10	\$ 62,000.00	0.33%
11	\$ 1,905,500.00	10.17%
12	\$ 12,000.00	0.06%
13	\$ -	0.00%
14	\$ 175,000.00	0.93%
15	\$ 5,613,862.00	29.96%
16	\$ 1,707,500.00	9.11%
TOTAL	\$ 18,737,710.00	100.00%

0365 Hannah Administration Building – Replace Absorption Chillers

CSI Division	Scheduled Value	Percent of Contract
1	\$ 20,000.00	2.36%
2	\$ 77,900.00	9.18%
3	\$ -	0.00%
4	\$ -	0.00%
5	\$ -	0.00%
6	\$ -	0.00%
7	\$ -	0.00%
8	\$ -	0.00%
9	\$ 38,000.00	4.48%
10	\$ -	0.00%
11	\$ -	0.00%
12	\$ -	0.00%
13	\$ -	0.00%
14	\$ -	0.00%
15	\$ 672,450.00	79.20%
16	\$ 40,650.00	4.79%
TOTAL	\$ 849,000.00	100.00%

3282 Life Science – Alterations to Rooms B107-109, B126-128, B130, & B145

CSI Division	Scheduled Value	Percent of Contract
1	\$ 33,556.00	7.98%
2	\$ 164,092.00	39.02%
3	\$ -	0.00%
4	\$ 8,800.00	2.09%
5	\$ 2,645.00	0.63%
6	\$ 1,500.00	0.36%
7	\$ 845.00	0.20%
8	\$ 13,290.00	3.16%
9	\$ 62,002.00	14.74%
10	\$ 19,318.00	4.59%
11	\$ -	0.00%
12	\$ -	0.00%
13	\$ -	0.00%
14	\$ -	0.00%
15	\$ 68,200.00	16.22%
16	\$ 46,283.00	11.01%
TOTAL	\$ 420,531.00	100.00%

2124 Nisbet Building – Chiller Installation

CSI Division	Scheduled Value	Percent of Contract
1	\$ 15,803.00	4.10%
2	\$ 3,422.00	0.89%
3	\$ 15,091.00	3.92%
4	\$	0.00%
5	\$ 11,988.00	3.11%
6	\$	0.00%
7	\$ 3,604.00	0.94%
8	\$	0.00%
9	\$	0.00%
10	\$	0.00%
11	\$ -	0.00%
12	\$ -	0.00%
13	\$ -	0.00%
14	\$ 4,010.00	1.04%
15	\$ 287,702.00	74.73%
16	\$ 43,380.00	11.27%
TOTAL	\$ 385,000.00	100.00%

3347 Spartan Child Development Center

CSI Division	Scheduled Value	Percent of Contract
1	\$ 371,450.00	18.25%
2	\$ 189,840.00	9.33%
3	\$ 134,795.00	6.62%
4	\$ -	0.00%
5	\$ 7,510.00	0.37%
6	\$ 290,447.00	14.27%
7	\$ 70,150.00	3.45%
8	\$ 125,180.00	6.15%
9	\$ 154,471.00	7.59%
10	\$ 5,575.00	0.27%
11	\$ 21,141.00	1.04%
12	\$ -	0.00%
13	\$ -	0.00%
14	\$ -	0.00%
15	\$ 524,991.00	25.80%
16	\$ 139,450.00	6.85%
TOTAL	\$ 2,035,000.00	100.00%

3067 Spartan Stadium – East Concourse Restoration 2000

CSI Division	Scheduled Value	Percent of Contract
1	\$ 261,819.00	10.21%
2	\$ 287,600.00	11.21%
3	\$ 979,096.00	38.17%
4	\$ 69,794.00	2.72%
5	\$ 77,900.00	3.04%
6	\$ 140,693.00	5.49%
7	\$ 427,493.00	16.67%
8	\$ 39,020.00	1.52%
9	\$ 29,585.00	1.15%
10	\$ -	0.00%
11	\$ -	0.00%
12	\$ -	0.00%
13	\$ -	0.00%
14	\$ -	0.00%
15	\$ 130,000.00	5.07%
16	\$ 122,000.00	4.76%
TOTAL	\$ 2,565,000.00	100.00%

3158 Wilson Hall – Alterations in Room C102

CSI Division	Scheduled Value	Percent of Contract
1	\$ 24,722.00	7.90%
2	\$ 37,074.00	11.84%
3	\$ 10,600.00	3.39%
4	\$ 14,146.00	4.52%
5	\$ 1,444.00	0.46%
6	\$ -	0.00%
7	\$ -	0.00%
8	\$ -	0.00%
9	\$ 26,660.00	8.52%
10	\$ -	0.00%
11	\$ -	0.00%
12	\$ -	0.00%
13	\$ -	0.00%
14	\$ -	0.00%
15	\$ 152,182.00	48.62%
16	\$ 46,172.00	14.75%
TOTAL	\$ 313,000.00	100.00%

3981 Cyclotron Building – Office Expansion

CSI Division	Scheduled Value	Percent of Contract
1	\$ 541,805.00	16.90%
2	\$ 186,691.00	5.82%
3	\$ 143,000.00	4.46%
4	\$ 259,170.00	8.09%
5	\$ 191,000.00	5.96%
6	\$ 92,737.00	2.89%
7	\$ 117,949.00	3.68%
8	\$ 174,900.00	5.46%
9	\$ 320,616.00	10.00%
10	\$ 12,628.00	0.39%
11	\$ -	0.00%
12	\$ 2,630.00	0.08%
13	\$ -	0.00%
14	\$ -	0.00%
15	\$ 946,775.00	29.54%
16	\$ 215,207.00	6.71%
TOTAL	\$ 3,205,108.00	100.00%

3482 Jenison Fieldhouse – Locker Room Renovation and Addition

CSI Division	Scheduled Value	Percent of Contract
1	\$ 141,946.00	2.22%
2	\$ 295,208.00	4.62%
3	\$ 105,516.00	1.65%
4	\$ 404,668.00	6.33%
5	\$ 441,463.00	6.90%
6	\$ 153,044.00	2.39%
7	\$ 205,842.00	3.22%
8	\$ 217,843.00	3.41%
9	\$ 695,755.00	10.88%
10	\$ 174,976.00	2.74%
11	\$ 56,110.00	0.88%
12	\$ -	0.00%
13	\$ -	0.00%
14	\$ 143,819.00	2.25%
15	\$ 2,470,444.00	38.64%
16	\$ 887,348.00	13.88%
TOTAL	\$ 6,394,000.00	100.00%

99072 Parking Lot No. 89 Expansion

CSI Division	Scheduled Value	Percent of Contract
1	\$ 140,000.00	4.64%
2	\$ 2,565,000.00	84.93%
3	\$ -	0.00%
4	\$ -	0.00%
5	\$ -	0.00%
6	\$ -	0.00%
7	\$ -	0.00%
8	\$ -	0.00%
9	\$ -	0.00%
10	\$ -	0.00%
11	\$ -	0.00%
12	\$ -	0.00%
13	\$ 75,000.00	2.48%
14	\$ -	0.00%
15	\$ -	0.00%
16	\$ 240,000.00	7.95%
TOTAL	\$ 3,020,000.00	100.00%

02140 Intercollegiate Athletics New Track and Field - Ralph Young Field Phase I

CSI Division	Scheduled Value	Percent of Contract
1	\$ 21,500.00	8.87%
2	\$ 221,000.00	91.13%
3	\$ -	0.00%
4	\$ -	0.00%
5	\$ -	0.00%
6	\$ -	0.00%
7	\$ -	0.00%
8	\$ -	0.00%
9	\$ -	0.00%
10	\$ -	0.00%
11	\$ -	0.00%
12	\$ -	0.00%
13	\$ -	0.00%
14	\$ -	0.00%
15	\$ -	0.00%
16	\$ -	0.00%
TOTAL	\$ 242,500.00	100.00%

**02140 Intercollegiate Athletics New Track and Field - Ralph Young
Field Phase II**

CSI Division	Scheduled Value	Percent of Contract
1	\$ 115,451.00	4.53%
2	\$ 1,900,607.00	74.62%
3	\$ 35,285.00	1.39%
4	\$ 48,832.00	1.92%
5	\$ 2,883.00	0.11%
6	\$ 21,995.00	0.86%
7	\$ 16,859.00	0.66%
8	\$ 7,680.00	0.30%
9	\$ 463.00	0.02%
10	\$ 346,641.00	1.83%
11	\$ -	0.00%
12	\$ -	0.00%
13	\$ 143,920.00	5.65%
14	\$ -	0.00%
15	\$ 14,884.00	0.58%
16	\$ 191,500.00	7.52%
TOTAL	\$ 2,547,000.00	100.00%

Total Project Costs

CSI Division	Division Amount	%
1 General Conditions	\$ 8,609,625	6%
2 Site Work	\$ 12,418,425	9%
3 Concrete	\$ 9,642,198	7%
4 Masonry	\$ 10,388,214	8%
5 Metals	\$ 8,626,550	6%
6 Wood & Plastics	\$ 2,537,656	2%
7 Thermal & Moisture	\$ 4,147,514	3%
8 Windows & Doors	\$ 5,766,195	4%
9 Finishes	\$ 7,038,028	5%
10 Specialties	\$ 718,515	1%
11 Equipment	\$ 7,322,868	5%
12 Furnishings	\$ 318,157	0%
13 Special Construction	\$ 1,226,832	1%
14 Conveying Systems	\$ 1,186,312	1%
15 Mechanical	\$ 39,156,403	29%
16 Electrical	\$ 14,114,828	11%
Total	\$ 133,218,320	100%

MICHIGAN STATE UNIVERSITY LIBRARIES



3 1293 02845 2542