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DEVELOPMENT OF PRECONSTRUCTION CHANGE ORDER PREVENTION STRATEGIES FOR REDUCING DESIGN ERRORS AND OMISSIONS IN UNIVERSITY PROJECTS

presented by

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has been accepted towards fulfillment
of the requirements for the

M.S. degree in Construction Management

Major Professor's Signature

8/2/2005

Date

DEVELOPMENT OF PRECONSTRUCTION CHANGE ORDER PREVENTION STRATEGIES FOR REDUCING DESIGN ERRORS AND OMISSIONS IN UNIVERSITY PROJECTS

By

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A THESIS

Submitted to
Michigan State University
in partial fulfillment of the requirements
for the degree of

MASTER OF SCIENCE

Construction Management Program

2005

ABSTRACT

DEVELOPMENT OF PRECONSTRUCTION CHANGE ORDER PREVENTION STRATEGIES FOR REDUCING DESIGN ERRORS AND OMISSIONS IN UNIVERSITY PROJECTS

By

Vijay Yelakanti

This research focused on developing strategies to prevent change orders caused by design errors and omissions during the preconstruction stage of a project. The study examines a database of change orders from 16 Michigan State University (MSU) construction projects. The researcher analyzed 1,372 change order items to identify recurring causes of change orders. Change order items were analyzed quantitatively based on Construction Specification Institute (CSI) divisions. Keyword searches were run on narrative descriptions of change order items in the database to isolate recurring causes. Additionally, interviews were conducted of contractors, subcontractors, architects as well as university construction administrators from five universities to gain their perspectives on change order causes and processes. The research showed that 42% of change orders resulted from design errors and omissions, and identified a number of recurring design and plan coordination causes of change orders. The results from the quantitative analysis, keyword searches, interview data, and literature review were used to develop a plan review checklist, and recommended strategies for reducing design errors and omissions, which are suitable for use by universities and similar institutional organizations.

To My Beloved Family

ACKNOWLEDGEMENTS

I'd like to acknowledge the contributions of many people who have helped to complete this research thesis. Professor Tim Mrozowski, for his outstanding motivation, guidance and assistance throughout the work on the thesis. Dr. Tariq Abdelhamid for his valuable guidance on design related change order issues. Dr. William McCarthy for sharing his MS Access expertise. I also thank my friends Pooja Mechanda and Shashikanth Manikonda who always boosted my morale throughout the course of the research thesis.

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CHAPTER 1

CHAPTER 1: INTRODUCTION

1.0. Introduction

Change refers to any event that results in a modification of the original project scope, execution time, or cost of work (Bridgers et.al, 2001). A procedure for requesting a change via a written document to add, delete, or modify the work on a construction project is referred to as a change order.

A change order is typically requested to improve project value, but it may lead to cost overruns and time delays as a result of uncompetitive pricing, increased general conditions, and overhead costs. Change orders can significantly affect the budget and schedule of a project. In 1995 the Construction Industry Dispute Avoidance Task Force (DART) reported that more than $60 billion annually were spent on change orders in the United States (Ibbs, 1997). In a study of change orders at Michigan State University, it was found that more than 10 million dollars were spent for change orders on a group of sixteen projects with a total starting value of 133 million dollars (Mrozowski, 2004). Although the percentage of change orders (percentage increase in budget of a project, and number of change orders) varies depending upon the nature of a project, several authors have offered opinions regarding change order percentages. O'Brien reports increases in project costs due to change orders average approximately 5 percent of the initial cost (O'Brien, 1998).

The number of change orders is a concern for building owners and contractors. In an attempt to reduce cost overruns, time delays, and disputes in projects, some researchers have examined change order management practices and developed recommendations regarding the management of change orders during construction. Little

research however has addressed preconstruction activities which can decrease the number of change orders on a project.

This research addresses preconstruction activities for reducing change orders in university construction. In this research, Michigan State University was used as a case study organization to determine the causes and impacts of change orders. The research led to the development of a plan review checklist, and to recommendations and strategies for reducing change orders caused by design errors and omissions. Additional recommendations are also made for other preconstruction activities which impact change orders and include functional briefing, scope definition, and communication between project participants (architects, engineers, owners, contractors and sub contractors).

1.1. Need

The cost of projects within major universities can be significant, for example at MSU, according to a December 2002 report, released by the MSU Physical Plant there were 66 active projects equaling 199 million dollars (Mrozowski, 2004). Due to the number and value of projects built, the cumulative effect of change orders can be significant within a university construction system. Therefore reducing change orders before they occur through a variety of preconstruction activities could decrease cost overruns.

Diekman and Nelson (1985) have identified and classified causes of change orders as: (1) design errors and omissions, (2) scope changes, and (3) unforeseen conditions. These researchers reported that 65 percent of change orders were generated by design errors and omissions, 30 percent from scope changes, and the remaining 5 percent from unforeseen conditions (Diekman, et.al., 1985). In *Contractors Guide to*

Change Orders (Civitello, 2002), Civitello classified the sources of change orders as predesign, plans and specifications, and site. Civitello identified plans and specifications as common generators of change orders. Consequently, cost overruns and time delays could be reduced by minimizing design errors and omissions, which lead to change orders.

1.2. Goals and objectives

1.2.1. Goals

The goals of this research were to identify potential areas of change orders caused by design errors and omissions, and to develop preconstruction change order prevention strategies, along with recommendations and instruments for reducing design errors and omissions for university construction projects.

1.2.2. Objectives

The objectives of this research were to develop a plan review checklist in order to reduce change orders caused by design errors and omissions, and to formulate recommendations for preconstruction activities, such as functional briefing, scope definition, and communication between project participants, which can reduce the number of change orders.

1.3. Methodology

This research was accomplished using the nine steps identified below. The research methodology is explained in detail in Chapter 3.

1) Review of literature.

2) Development of questionnaires for architects, contractors, subcontractors, and university construction personnel which sought information on change order management practices and causes of change orders.

3) Review and analysis of a database of MSU construction projects, which included: CSI[1] division quantitative analysis, analysis of narrative descriptions of change order items, and comparison with Civitello's (2002) change order discovery checklist.

4) Interviews with outside designers, contractors, and subcontractors.

5) Interviews with construction personnel of five research intensive universities.

6) Comparison of the data obtained from the interviews and database in order to identify the sources of change orders.

7) Interviews with MSU construction personnel in order to gain their perspective on plan review processes and for the development of a plan review checklist.

8) Development of preconstruction change order prevention strategies including:

   a. Plan review checklist.

   b. Recommendations for programming and functional briefing, scope definition and communication between project participants.

9) Interviews with MSU construction personnel in order to gain feedback regarding the use of the plan review checklist.

1.4. Deliverables

The completion of this research led to the development of a plan review checklist which is designed to help identify potential design errors and omissions.

[1] The Construction Specifications Institute, a professional organization of construction specifications writers. (www.aiapvc.org/glossary.htm) date visited: 10/15/2004

Recommendations were also made related to coordination issues among design disciplines for reducing design errors and omissions in CSI divisions 15 and 16, as well as for programming and functional briefing, scope definition and prequalification of architects appropriate for large universities.

1.5. Validation

Interviews were conducted with construction administrators of the case study university in order to obtain their views regarding the use of the proposed plan review checklist and its potential for preventing change orders caused by design errors and omissions.

1.6. Case Study University

MSU has over 40,000 students on a campus of over 5000 acres; A December 2002 report, released by the MSU Physical Plant, noted that there were 66 active projects equaling 199 million dollars, 37 different prime contractors were employed, and 10 MSU project managers were assigned. Projects released for construction in 2002-2003 totaled 178, and were valued at 84 million dollars (Mrozowski, 2004).

This research focuses on preconstruction change order prevention strategies, and is part of a broader research project: the Michigan State University Change Order Management Project (referred to as the umbrella project) (Mrozowski, 2004). That project addressed strategies for change order management practices on MSU projects. As a part of the umbrella project, 16 MSU construction projects, 19 contracts, 159 change orders, and 1,675 change order items were analyzed to find the major causes of change orders. For this research 1,372 change order items with complete information were used. Additionally, construction professionals were interviewed to gain an insight into change

order management practices in industry. The case study database analysis and interviews were correlated to find the sources of change orders, and to develop preconstruction change order prevention strategies.

1.7. Scope and Limitations

Strategies and recommendations were developed, which can reduce the number of change orders caused by design errors and omissions. This research did not addresses change order processing, or change order management strategies during project progress. The limitations of the research were:

1) The sample of projects used for data analysis was from only one university, which can limit generalization of recommendations to other universities.
2) The interviews were conducted with Michigan based firms; practices and procedures of firms from other regions may vary.

1.8. Summary and organization of the thesis

This chapter introduces some of the causes of change orders, and stresses the importance of preconstruction activities in reducing the number of change orders. There is a need for research on the development of strategies to reduce change orders related to errors and omissions in the design process. This research is intended to improve construction within universities by identifying the sources of change orders and providing recommendations for reducing design errors and omissions which frequently are the root cause of change orders.

This thesis is organized into seven chapters with appendices. The first chapter establishes the need for the research, and defines the research objectives, methodology and expected deliverables. The second chapter presents the literature review. The third

chapter explains the methodology, database and interview processes. The fourth chapter presents the data, database analysis, interview responses, and feedback. The fifth chapter describes development of the plan review checklist. The sixth chapter presents recommendations for reducing change orders that result from design errors and omissions, as well as on other preconstruction concepts. The seventh chapter consists of the summary, conclusions and limitations of the research, followed by discussion of future research areas.

CHAPTER 2

CHAPTER 2: REVIEW OF EXISTING LITERATURE

2.0. Introduction

This chapter presents a summary of literature addressing the areas influencing change orders. The focus of the literature review was on change orders generated by design errors and omissions. Additionally, the researcher reviewed literature on related factors that influence change orders, such as the selection process of architects/engineers, prequalification of contractors, bid evaluation strategies, partnering, and communication between project participants, and how they can add or reduce the number of change orders on a project. Refer to Figure 2.1 for the organization of the literature review.

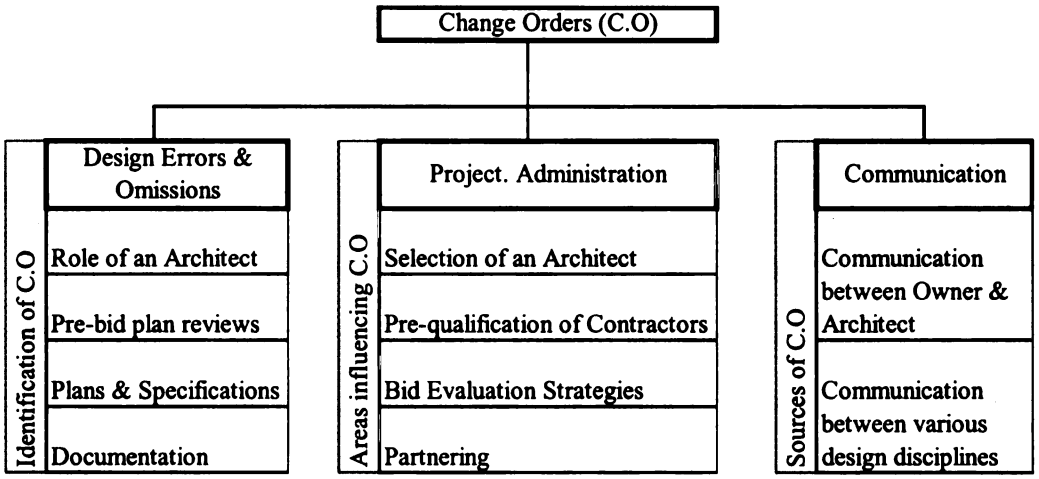


FIGURE 2.1. ORGANIZATION OF LITERATURE

2.1. Design Errors and Omissions

In this section, the researcher identified and discussed issues which can be effective in reducing change orders due to design errors and omissions; they are: (1)

architect's role in reducing design errors and omissions, (2) pre-bid plan review and (3) documentation.

(a) The Role of an Architect

In Civitello's publication, *Contractor's Guide to Change Orders* (Civitello, 2002), the responsibilities of the architect from preconstruction to closeout are clearly defined and include: (1) production and coordination of plans and specifications, where architects hold responsibility for generating complete and clear plans with accurate specifications, (2) technical accuracy of all documents, (3) workability of the design (the designer is ultimately responsible for project design and the ability of systems to function and perform in the manner and to the extent intended), and (4) code compliance (the designer is assumed to be responsible for specifying technical specifications in compliance with codes unless specific engineering activity is introduced in subcontracting agreements).

In addition to the architect's review of plans, third party plan reviews may be conducted prior to construction to identify potential problems. Plan reviews can help to reduce the number of change orders caused by design errors and omissions and are discussed below.

(b) Pre-bid plan reviews - third party plan review process, constructability

The quality of design documents has a direct influence on the number of change orders. The better the design documents, the fewer the change orders (O'Brien, 1998). Changes identified during the later stages of a project may have more impact than those identified in earlier project stages. Changes identified early in a project are easier to handle (O'Brien, 1998). Identification of possible change orders prior to construction can

be achieved by the process of third party reviews, and constructability reviews. In a paper titled "The Constructability Review Process: A Constructor's Perspective" by Mendelson, "constructability" is defined as "the integration of construction expertise into the planning and design of a project so that construction forces have the maximum opportunity to deliver the project in conformity with the cost, quality, schedule, and safety objectives of the project's stakeholders." The constructability reviewer is defined as a construction expert who can incorporate construction expertise into the design process, so that all criteria are met, from aesthetics to proper construction (Mendelson, 1997).

Mendelson identifies two elements which are considered to be the source of potential problems: (1) plans and specifications, and (2) contract language, including the general, supplementary and special provisions. He also suggests that there are advantages in having the constructability reviewer at the preliminary design phase assess the potential design and determine the requirements necessary to handle the project. These procedures promote a cooperative team atmosphere regarding the project.

Constructability during design phase - In a research paper related to constructability, titled "Improving Constructability During Design Phase," Glavinich (1995) explains the importance of constructability with respect to problems related to scheduling and the time delays caused by design errors and omissions (Glavinich, 1995). Glavinich indicates that no matter who bears the responsibility, ignoring constructability during the design phase may lead to conflicts during the project, which in turn may lead to delays, inefficient use of resources, and out of sequence work. These issues impact major participants of the project with contractors being the first to experience it.

Glavinich also indicates that problems may arise during the pre-bid stage. He emphasizes that bidding periods are short and may not allow contractors to review plans and specifications completely and accurately. Thus, it is the duty of Architects/Engineers (A/E) to check the quality of design documents at the pre-bid stage. Glavinich recognizes problems with coordination issues and quality of design documents, and cites them as major causes of delays and project disruptions. In considering the constructability of a project, several issues were identified that included: avoiding activities that delay the progress of a project, eliminating use of unusual equipment or materials, avoiding the use of exotic state-of-the-art technologies, and specifying obsolete materials, equipment and construction techniques.

(c) Plans and specifications

Civitello's publication *"Contractor's Guide to Change Orders"* (2002) is used extensively for data analysis in this thesis and is cited several times in this chapter. Civitello identifies issues related to the sources of change orders and provides detailed descriptions of plan areas where potential change orders can be found. A broad representation of a change order discovery checklist developed by Civitello is illustrated in Table 2.1.

In his discussion of design related issues, Civitello indicates that the designer has to coordinate drawings and specifications among the various design disciplines and that a lack of design follow-up and accurate information can lead to change orders. Civitello identifies certain telltale phrases in construction plans that reflect a lack of design follow-up such as, "As Shown," "See Structural," "See Plans." Rather than using such phrases,

Civitello suggests providing precise references such as "See Section 0344" instead of "See Specs," and "See 2/S4" instead of "See Structural."

PREDESIGN
Adjacent Properties
Boring (Subsurface Data)
Building Code Compliance
Easements/Rights of Way
Special Agency Approvals
Interference From Utilities Not Properly Shown
Plan Approvals (Building Permit)
Temporary Utilities – Availability Within the Contract Limit Lines
CONTRACT AND BID DOCUMENTS
Award Date
Named Subcontractors
(Price/Bid) Allowances
Contract Time
PLANS AND SPECIFICATIONS
"As Indicated"
Ceiling Spaces (Conflicts)
Changed Existing Conflictions
Column and Beam Locations
After Reviewing the Architectural, Plumbing, H.V.A.C, and Electrical Plans
Design Changes Telltales
Design Discipline Interfaces
Duplication of Design
In a Review of Relevant Contracts, Plans, and Specifications
Objectively Analyze Each Duplication
Is There A Preferred Solution?
"Fat" Specifications
Finish Schedule vs. Specifications Index
Inadequate Level of Detail
Light Fixture Locations
Match Lines and Plan Orientations
Mechanical, Electrical
Numerous Details and Dimensions Strings
Performance and Procedure Specifications
Proprietary Restrictions (Public)
Specifications Section "Scopes"
SITE
Grades, Elevations, and Contours

TABLE 2.1.
BROAD OVERVIEW OF CIVITELLO'S CHANGE ORDER DISCOVERY CHECKLIST (Modified into tabular format) (Civitello, 2002)

In another recommendation, Civitello specifically discusses change orders caused by last minute design changes. These may be identified in plans and specification

sections that have been rewritten, in design details that have been changed, or in materials and equipment added or deleted at the last minute. Although this practice of adding details is not considered to be wrong, these changes are sometimes made after drawings and specifications have passed final checks.

Changes made at this stage should be coordinated with all affected disciplines; failure of coordination can lead to change orders and errors. Civitello identifies the following telltale signs to look for in the documents: a different style type on the plans, handwriting in the specifications, hand-drawn details on computer-generated plans, out-of-sequence reference marks and details, out-of-sequence or inserted pages in the specifications and details, different handwriting on plans, and inconsistent use of language (inconsistent ways of saying the same thing may lead to a variety of interpretations).

Civitello identifies specifications as a potential area for generating change orders. A thick set of specifications that develop over a period of time at an architect's office are referred to as "fat" specifications. "Every year more projects are completed, more battles are won and lost, more arbitrations occur, and more change orders are reluctantly given up. Each subsequent specification then attempts to "benefit" from the experience," (Civitello, 2002). In the process of lessons learned from the above, specifications are continuously developed that eventually become "fat" specifications, resulting in complicated, cryptic, and confusing specifications that lead to change orders. Civitello recommends that being cautious about these kinds of specifications can help avoid potential change orders.

In a section on "Inadequate Level of Design," Civitello discusses change orders that occur due to lack of information and inadequate level of detail. Examples cited by Civitello include: missing mounting or fastening details, insufficient dimensions, and vague descriptions of special shapes, angles, and etc.

In discussion related to match lines and plan orientation, Civitello mentions that in large projects improper match lines and plan orientations can play a role in generating change orders.

In a final important recommendation for avoiding change orders caused by numerous details and dimension strings, Civitello suggests that providing correct information the least number of times will be to everyone's advantage.

(d) Documentation

Historical project documentation can provide base knowledge helpful in identifying the sources of problems which lead to cost overruns and time delays in future projects. Unfortunately, not much importance is given to historical documentation in the industry. "Generally, lessons learned during the construction phase of a project are not effectively incorporated into the design and construction phases of other projects" (Kartam, 1995). Good documentation helps to compare current work with that of previous work, and thus helps to detect problems in advance. The main method for testing a design is by a process of comparison. "Compare and contrast is the underlying name of the game" (Brown, 2001). In a paper related to documentation (Brown, 2001), the author identified benefits of knowledge acquisition from the construction process and also the lessons learned are presented. Brown's research used a survey and interview processes, and determined that although many organizations have a formal or informal

method for obtaining and sharing the data, the main focus is on design aspects rather than construction. While organizations may use a method to acquire and share data, it is limited to very few people in the organization.

2.2. Project administration

(a) Selection of an Architect - *"Selection of the design professional should be pragmatic even if the design professional is MICHELANGELO reincarnate"* (O'Brien, 1998).

The major participants in a project, the owner, designer, and contractor have common project objectives, and an important part of project planning is the selection of design professionals and contractors (Crowley et.al., 1995). "Selection and retaining design professionals and constructors is a vital step in producing a quality product" (Potter et al., 1995).

Depending upon the design needs and scope of a project, architects are hired on the basis of their specializations and expertise. "The strategic interests of design purchasers who seek specialized knowledge from their consulting professionals have motivated many architects to specialize by building type" (Gutman, 1988). As the design of a project plays a vital role in its success, developing a good scope for a project is crucial and requires high technical and design knowledge on the part of the architect. In a paper addressing the designer's construction knowledge and its effects, Battersby and Yates (2003) summarized research which indicated that designers have limited knowledge of the construction process.

Selection processes for design professionals based on qualification criteria are currently used in the industry. One such system is Qualification-based selection[2] (QBS). QBS is addressed in a report titled Qualification-Based Selection of Design Professionals. QBS is a flexible procedure for obtaining architectural, engineering, land surveying, and other related professional design services on public projects. This system assists the owner in selecting design professionals based on quality, rather than price.

(b) Prequalification of Contractors – Does it makes a difference?

The selection of contractors also influences project quality and administration. This process involves multiple steps, including prequalification and bidding. Based on prequalification criteria, contractors are evaluated to determine eligibility for bid participation. Issues related to selection of contractors are discussed below.

Financial and technical capabilities of contractors are assessed before they are invited to make a formal bid. This process of evaluation is referred to as "prequalification process of contractors" (Alsugair, 1999). It is considered to be one of the most important aspects in project decision making, because it helps to eliminate unqualified contractors. This decreases cost overruns, time delays, disputes and substandard work (Hatush et.al., 1997).

In research related to owner-contractor relationships, titled "More STable Owner-Contractor Relationships" (Dozzi et.al., 1996), construction professionals were asked about selection criteria for architects, engineers, and contractors. Most of the owner and consultant (engineer and architect) respondents indicated that they use some form of

[2] The Michigan QBS Coalition was formed in 1984. The purpose of the coalition is to enhance the public safety by providing a vehicle for the education and assistance of public officials and public owners toward the qualifications-based selection approach of design professionals and design professional services. In 1987 it undertook the charge by the Michigan Legislature in House Concurrent Resolution 206 to provide a documented process.

prequalification or screening in selecting a contractor. This process included: previous performance, location, financial measures, technical capabilities, safety record or safety program, project team expertise, working relationships, shared understanding of goals, objectives and interests, quality assurance, execution plan, company culture, management philosophy, labor relations, and specific environment programs. Dozzi et.al., (1996) showed that prequalification of the contractor is effective and contributes to the success of the project.

Many factors are considered during the prequalification process of a contractor. Researchers Hatush et.al., (1997) list the following factors that can be utilized during the contractor prequalification process (Table 2.2).

Past Failures	Management Safety Accountability
Management Personnel	Experience Modification Rate
Financial Status	Length of Time in Business
Bank Arrangements	Safety Performance
Ability	OSHA Incidence Rate
Management Knowledge	Owner/ Contractor Relationship
Project Management Organization	Credit Rating
Experiences	Financial Stability
Other Relations	Technical Support
Past Performance	Plant and Equipment

TABLE 2.2
CONTRACTOR SELECTION CRITERIA
(Source: Hatush et.al., 1997)

(c) Bid Evaluation Strategies - *Does the lowest bidder always offer the best bid?*

The selection of a bidder (contractor) has a tremendous impact on the quality of a project. "Owners should use sound discretion in evaluating the qualifications of low bidders" (Civitello, 2002). Many professionals generally do not consider the practice of accepting the low bid as a healthy sign for a project's success. It often raises many questions such as, "Has a mistake been made in the low bid?" (Crowley et.al., 1995). If a

contract is awarded to an unqualified bidder, there may be errors in estimation which would affect the progress of the project, and consequently lead to change orders.

Researchers Crowley et.al., (1995) proposed a quantitative evaluation method to select the best bidder that is consistent with the low bid philosophy. In this method, emphasis is given to lowest bids, which are termed as "discordant bids," and are identified using a series of implementation steps. In identifying discordant bids, statistical procedures are used and are elaborated in five implementation steps: (1) identifying an exploratory sample from available bids, (2) identifying a suiTable transformation, (3) testing for homogeneity of variance, (4) estimating the scale of bids, and (5) selecting the discordant threshold.

In the same paper, public policy implementation of this bid evaluation procedure is explained in detail, followed by differentiation of alternative procurement procedures and the proposed bid evaluation procedure. The major drawback discussed is the lack of professionalism, where the contract award becomes a lottery, rather than a testimony of managerial skill, construction talent or innovation.

(d) Partnering – Will this really help?

Partnering is a relatively new project administration tool, which can encourage a cooperative atmosphere on projects. "Partnering is typically defined in one of two ways: by its intended attributes such as trust, mutual goals, long-term commitment; or by the process where partnering is seen as a verb, as in developing a mission statement, agreeing on goals, etc." (Crowley et.al., 1995)

Partnering develops a mutual understanding between the project participants before the project starts, and this may have a positive impact on project success. By

addressing the goals and interests in the early stage of a project, potential problems may be identified and resolved in advance. "Partnering offers a challenge to the stakeholders to find mutual advantages in addressing change orders" (O'Brien, 1998).

A research study on owner-contractor relationships utilized a survey, which included questions on partnering (Dozzi et.al., 1996). The study found projects that used partnering most, often yielded successful results. Sixty nine projects initially started with formal partnering continued their relationship until the end maintaining Table relationship compared with projects without formal partnering. Reasons for declining and improving relationships found in the study listed in Table 2.3.

N	Declining Relationships	N	Improving Relationships
21	Unclear contract/litigation	25	Trust/positive relationship
20	Change in scope/schedule	20	Shared goals
12	Personnel	9	Teamwork/communication
7	Failure to perform	6	Personal changes
7	Lack of trust	3	Clear contract
6	Underbid		

N = Number of respondents.

TABLE 2.3
REASONS FOR CHANGES IN OWNER-CONTRACTOR WORKING RELATIONSHIPS
(Source: Dozzi et.al., 1996)

2.3. Communication between project participants

In all phases of a project's life-cycle, communication between project participants plays a vital role in its success. Effective communication between the administrative division (owner), design function (architect), and the construction force (contractor) is vital. Lack of communication between these three creates potential for misunderstandings that eventually lead to change orders causing time delays and cost overruns (Civitello, 2002).

In the predesign phase the architect is involved with the owner in project scope definition; in the design phase, he/she generates plans and specifications and communicates with other designers, and during the construction phase he/she communicates with the construction team. "The architect has a responsibility to satisfy him/herself that the work is being performed in accordance with the design, as well as within applicable workmanship standards" (Civitello, 2002). Communication between the owner and an architect, and communication between architect and other designers heavily influences project quality.

(a) Communication between the owner and an architect

"In situations where the ultimate users are not construction-knowledgeable, such as universities or hospitals, users should be included in the programming process" (O'Brien, 1998). Effective programming is essential in determining project scope. (Programming may also be referred by some authors as functional briefing or needs briefing and are used interchangeably in this thesis).

Communication between the owner and an architect in determining project scope can have a tremendous influence on project success. The Construction Best Practice Program (CBPP)[3] (1998) defined briefing as "the process by which the client's requirements are investigated, developed and communicated to the construction industry" (CBPP, 1998, Hassanen; et al., 2000). A proper functional brief can be instrumental in developing a preferred design and can help to avoid potential change orders.

[3] The Construction Best Practice Program (CBPP) is a program which is aimed at developing an understanding and explanation of the benefits of best practices and providing guidance to UK client organizations to make them available with skills which can support implementation of any new changes. This program is supported by Environment Transport and Regions and the Construction Industry Board.

In a paper titled "Improving Construction Client Satisfaction Through Functional Briefing" (Seay et.al., 2003) issues related to the importance of Functional Briefing (FB) are addressed. In this paper, the authors indicate that although FB occupies a significant place in project planning, the function of the brief is not well understood by all participants. A brief allows an owner to explicitly indicate project requirements and goals to an architect.

This clear definition of a project at its outset facilitates the smooth flow of a project and helps eliminate any major changes. Inadequate time and thought at an early stage of a project is considered to be a major cause of poor definition of projects. (Kamara, et al., 2002).

Due to variations in projects and a lack of standard procedures for briefing, a check list was developed by the authors for use by designers during the early stages of project planning. Figure 2.2 illustrates a summary checklist for briefing.

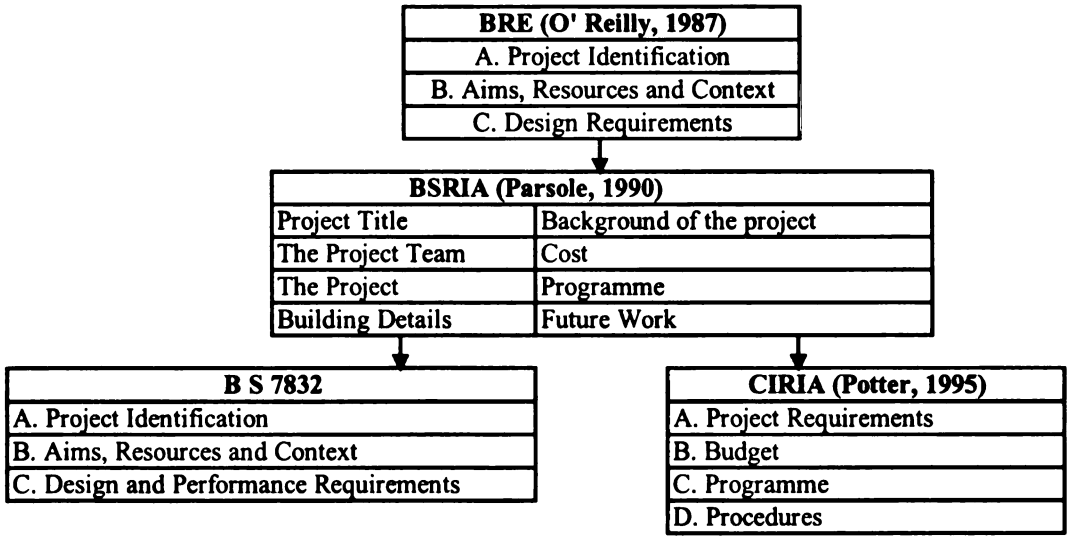


FIGURE 2.2

SUMMARY OF THE DEVELOPMENT OF A CHECKLIST FOR BRIEFING

(Source: Cheong, Anumba, Hill and Bouchlaghem, 2003)

As a part of this research Seay et.al., (2003) conducted a survey in the United Kingdom to identify perceptions on FB. Industry practitioners, consisting of clients, consultants and contractors, were surveyed. The survey found that 64 percent of the respondents use a standard methodology in briefing, and the remaining 36 percent do not follow any standard methodology (Seay et.al., 2003).

(b) Communication between design disciplines

A project team is comprised of various design professionals who work on the single objective of successful project completion. "All systems, structural, mechanical, electrical, site, architectural, and many specialty systems, must satisfy their own respective requirements while keeping within the grand scheme of the project" (Civitello, 2002). Due to so many project participants and lack of coordination between them, there is possibility for error. Lack of coordination between project participants can lead to many problems in a project. "Some of the most significant areas in which the risks of error and oversight are extremely high are the points where the various design disciplines interface with each other" (Civitello, 2002).

In a paper related to design coordination for building projects, Tarek et.al., (2000) indicated that the management of changes is crucial, since changes made in one discipline will have effects on other disciplines. The authors of this study stress the need for documentation of a design rationale, which is helpful in avoiding problems which flow from lack of coordination among design disciplines.

2.4. Summary

The literature review addressed various causes of change orders along with activities conducted prior to construction which influence the quantity of change orders.

Tha

cau

rev

sc

us

The literature review helped to provide a basic understanding of issues that influence the causes and prevention of change orders. Several related topics addressed in the literature review include: design errors and omissions, architect selection, functional briefing, scope definition, pre-bid issues and contract documents/bid strategies. The literature was used by the researcher in formulating strategies for reducing of change orders

CHAPTER 3

CHAPTER 3: METHODOLOGY

3.0 Introduction

This section presents the methodology used for this research, and briefly introduces the umbrella project. The methodology is outlined below and is presented graphically in Figure 3.1. The broad methods used for this study include:

1) Literature review.
2) Analysis of the MSU project database.
3) Development of questionnaires for architects, contractors, subcontractors, and university construction personnel, which sought information on change order management practices and causes of change orders.
4) Interviews with outside architects, contractors, and subcontractors.
5) Interviews with construction personnel of five universities.
6) Comparison of the data obtained from interviews, with the literature review and the database, to find correlations and to identify sources of change orders.
7) Interviews with construction personnel of a case study university, to gain their insight regarding plan review processes and on the development of a plan review checklist.
8) Development of preconstruction change order prevention strategies which include:
    a. Development of a plan review checklist.
    b. Development of recommendations for preconstruction activities, including selection of architects, project communications and functional briefing.
9) Validation of the checklist through interviews with three MSU construction personnel.

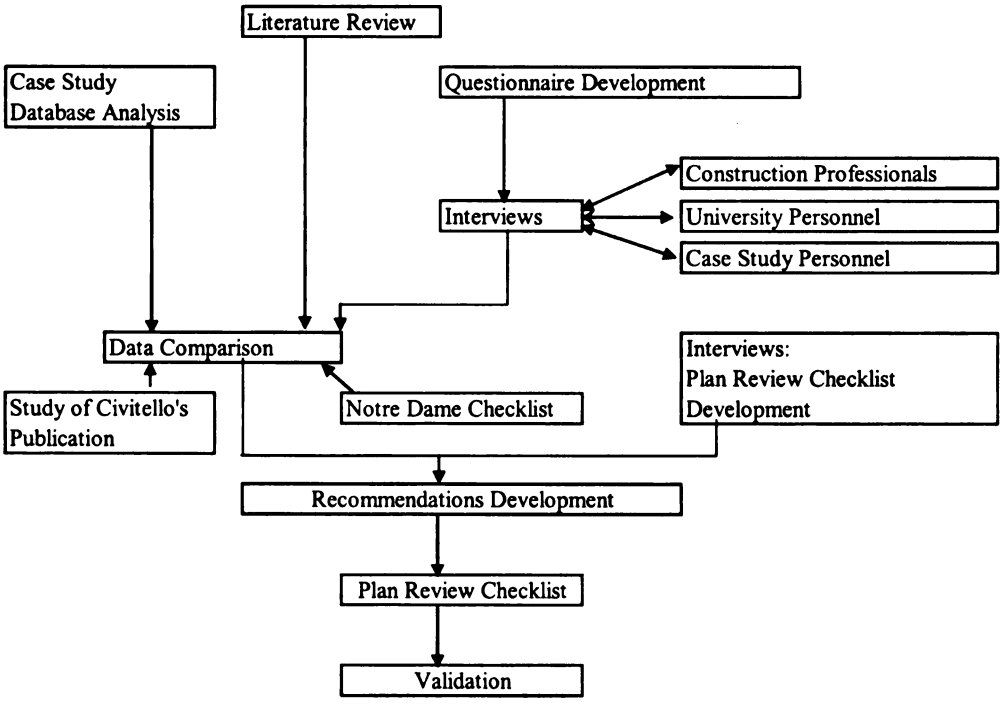


FIGURE 3.1 METHODOLOGY

3.1. Literature Review

Literature and research which addressed design errors and omissions, selection of architects, scope definition, functional briefing, contractor prequalification and selection, pre-bid plan reviews, commissioning, and partnering, was reviewed and summarized. An overview of the literature review was presented in chapter 2.

3.2. MSU Database Analysis

As a part of the umbrella project, a database was created from MSU construction projects files. Data was collected on 1,675 change order items listed on a total of 159 change orders for 19 contracts and 16 projects. Data contained a variety of variables including change order code (COID), change order item code (CIID), change order item

description, projects, and CSI divisions (the cost per CSI division associated with each COID). Table 3.1 lists the variables included in the database, which were used for this thesis.

Project Table Information	
Project ID	MSU Project Number assigned to all MSU projects
Project Description	Project name assigned to project
Change Order Table Information	
Change Order ID (COID)	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
Previous Contract Amount	Original contract amount or subsequent totals after prior change orders
New Contract Amount	Contract price after adjustments for change orders to date
Change Contract Sum	Net increase or decrease resulting from change orders
Change Order Item Table Information	
Change Order Item ID (CIID)	Change order item code in the database
Reason Code	The reason category for the item using a MSU Contracts and Grants coding system.
Change Order Item Description	Narrative description of the change order item
Change Order Amount	Total contract adjustment due to the change order

TABLE 3.1 VARIABLES OF THE DATABASE

The MSU Contract and Grant Administration (CGA) has developed standard definitions referred to as "reason codes," which are used to classify the causes of change order items. The CGA system includes 20 codes, and for this thesis, these reason codes were grouped into broad categories including: (1) design (change order items related to design errors and omissions), (2) field (change order items related to field changes), and (3) scope (change order items related to scope changes). Approximately one quarter of the change order items in the database had reason codes previously assigned by CGA. For items not previously classified, the researchers assigned reason codes using CGA standard definitions when possible. Paper files, including correspondence, bulletins, and other documentation for each item, were reviewed to determine reason codes when they

had not been previously specified. Refer to Appendix I for a complete description of CGA reason codes. Where reason codes did not exist or could not be assigned for some change order items they were left as unspecified.

3.2.1. Analysis

The analyses performed in this research are reported below. The steps used were organization of the data, development of a format for analysis, sorting of the data per analysis requirements, and development of final recommendations.

The project database was developed using MS Access software. Figures 3.2 and 3.3 below show the conceptual structure of the database; Data was exported into MS Excel for analysis, categorization, sorting and retrieval. (Refer to Figure 3.4).

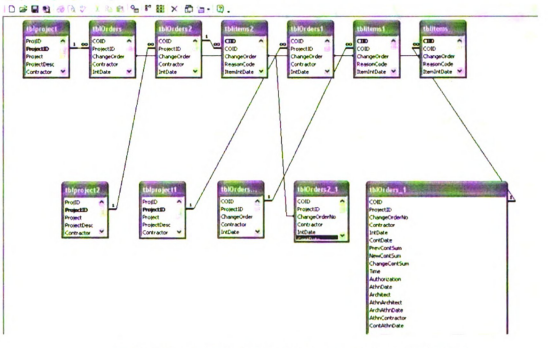


FIGURE 3.2 EXCERPT OF DATABASE SHOWING RELATIONSHIPS IN MS ACCESS

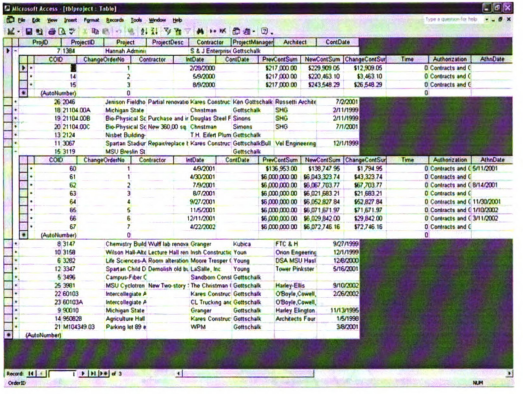
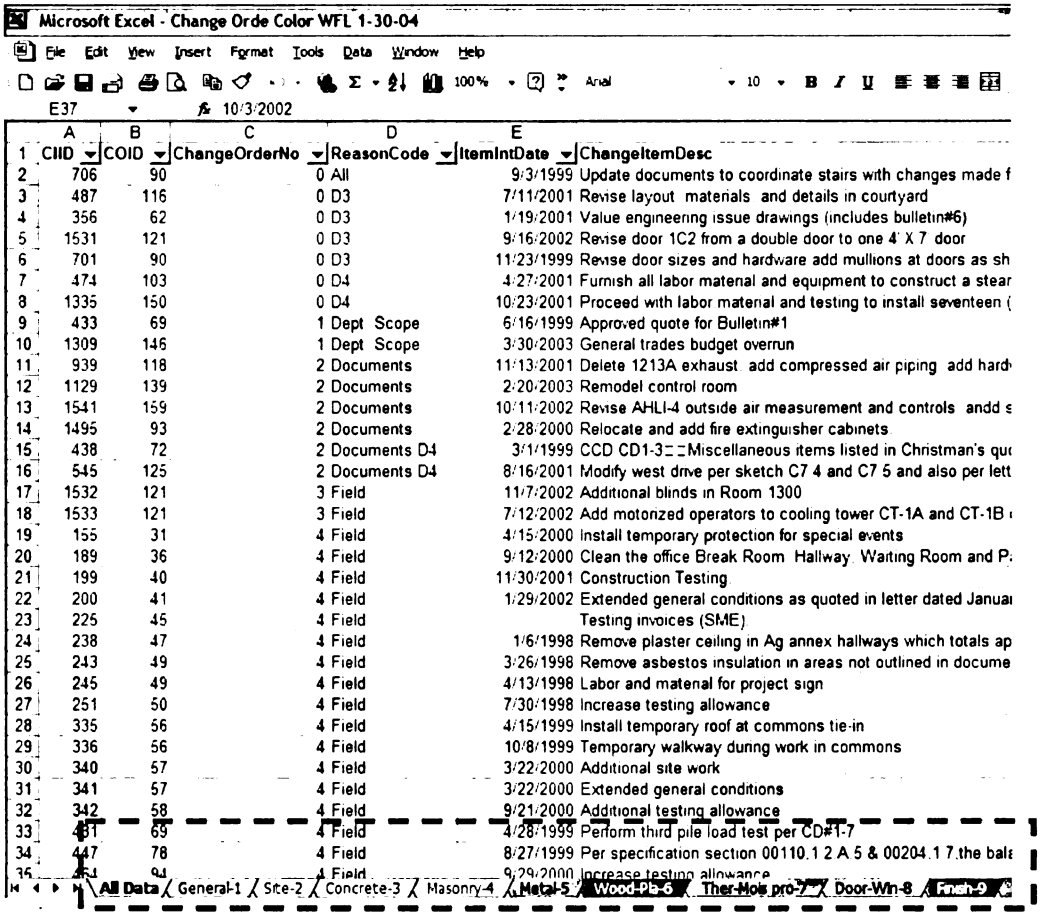


FIGURE 3.3 EXCERPT OF DATABASE SHOWING VARIOUS CHANGE ORDER VARIABLES IN MS ACCESS



	A	B	C	D	E	
1	CIID	COID	ChangeOrderNo	ReasonCode	ItemIntDate	ChangeItemDesc
2	706	90		0 All	9/3/1999	Update documents to coordinate stairs with changes made f
3	487	116		0 D3	7/11/2001	Revise layout materials and details in courtyard
4	356	62		0 D3	1/19/2001	Value engineering issue drawings (includes bulletin#6)
5	1531	121		0 D3	9/16/2002	Revise door 1C2 from a double door to one 4' X 7' door
6	701	90		0 D3	11/23/1999	Revise door sizes and hardware add mullions at doors as sh
7	474	103		0 D4	4/27/2001	Furnish all labor material and equipment to construct a stear
8	1335	150		0 D4	10/23/2001	Proceed with labor material and testing to install seventeen (
9	433	69		1 Dept Scope	6/16/1999	Approved quote for Bulletin#1
10	1309	146		1 Dept Scope	3/30/2003	General trades budget overrun
11	939	118		2 Documents	11/13/2001	Delete 1213A exhaust add compressed air piping add hard
12	1129	139		2 Documents	2/20/2003	Remodel control room
13	1541	159		2 Documents	10/11/2002	Revise AHLI-4 outside air measurement and controls andd s
14	1495	93		2 Documents	2/28/2000	Relocate and add fire extinguisher cabinets
15	438	72		2 Documents D4	3/1/1999	CCD CD1-3 Miscellaneous items listed in Christman's qu
16	545	125		2 Documents D4	8/16/2001	Modify west drive per sketch C7 4 and C7 5 and also per lett
17	1532	121		3 Field	11/7/2002	Additional blinds in Room 1300
18	1533	121		3 Field	7/12/2002	Add motorized operators to cooling tower CT-1A and CT-1B
19	155	31		4 Field	4/15/2000	Install temporary protection for special events
20	189	36		4 Field	9/12/2000	Clean the office Break Room Hallway Waiting Room and P.
21	199	40		4 Field	11/30/2001	Construction Testing
22	200	41		4 Field	1/29/2002	Extended general conditions as quoted in letter dated Januai
23	225	45		4 Field		Testing invoices (SME)
24	238	47		4 Field	1/6/1998	Remove plaster ceiling in Ag annex hallways which totals ap
25	243	49		4 Field	3/26/1998	Remove asbestos insulation in areas not outlined in docume
26	245	49		4 Field	4/13/1998	Labor and material for project sign
27	251	50		4 Field	7/30/1998	Increase testing allowance
28	335	56		4 Field	4/15/1999	Install temporary roof at commons tie-in
29	336	56		4 Field	10/8/1999	Temporary walkway during work in commons
30	340	57		4 Field	3/22/2000	Additional site work
31	341	57		4 Field	3/22/2000	Extended general conditions
32	342	58		4 Field	9/21/2000	Additional testing allowance
33	431	69		4 Field	4/28/1999	Perform third pile load test per CD#1-7
34	447	78		4 Field	8/27/1999	Per specification section 00110.1 2 A 5 & 00204.1 7.the bal
35	451	81		4 Field	9/29/2000	Increase testing allowance

FIGURE 3.4
ORGANIZATION OF CSI DIVISIONS IN MS EXCEL SPREAD SHEET

The data in MS Excel was organized on the basis of CSI divisions as shown in Figure 3.4. Change order items in the database were placed in 16 different MS Excel worksheets by CSI division. Additionally one worksheet, which included all data from all projects and CSI divisions, was created for analysis of the entire data set (referred to as All Data).

(a) Quantitative Analysis

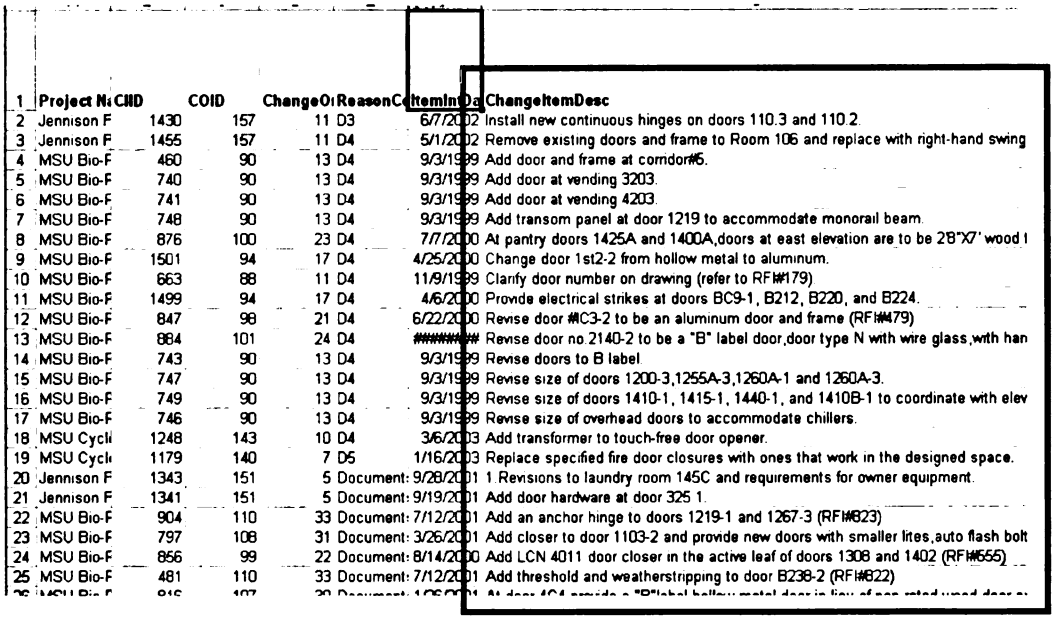
Quantitative analysis was run on each CSI division and on the entire data set to determine the causes of change orders associated with each individual CSI division, and their aggregate costs. After determining the number and costs of change orders by CSI divisions, all change order items were examined based on grouped reason codes (design errors and omissions, field, and scope). The "All Data" worksheet was analyzed in order to find the change order items generated and the cost associated with each grouped reason code.

(b) Narrative Description Analysis

After completion of the quantitative analysis discussed above, the narrative descriptions of each change order item were evaluated using key words identified for each CSI division. The purposes of the keyword analyses were to correlate the causes of change orders with Civitello's change order discovery checklist, and to determine if common causes could be identified. Additional keywords were developed for the "All Data" worksheet as well. Refer to Figure 3.5 for an excerpt showing the narrative descriptions. As 334 items did not have narrative descriptions, only 1,341 change order items were used for analysis. Using a Keywords-In-Context (KWIC)[4] approach various key words were identified for frequency counts in respective CSI divisions; the search was performed using MS Excel software. Examples of identified key words in the database are duct, ceiling, beam and columns. Refer to Appendix II for complete list of

[4] Key-words-in-context (KWIC) is closely associated with indigenous categories. KWIC is based on a simple observation: if you want to understand a concept, then look at how it is used. In this technique, researchers identify key words and then systematically search the corpus of text to find all instances of the word or phrase. Each time they find a word, they make a copy of it and its immediate context. Themes get identified by physically sorting the examples into piles of similar meaning (Ryan et.al., 2003)

key words. All key words were documented with the number of occurrences in that particular CSI division. The same keywords were also used for the "All Data" worksheet, which acted as a supplement to the keyword search performed for each CSI division. The frequency of recurring words was recorded and the occurrences were checked on the basis of each project. Keywords that had lower rates of recurrence were compared with other analyses. For example, if a certain keyword had lower occurrences, then the same keyword was checked for reference in Civitello's checklist, the database analysis, a Quality Control Checklist (QCC) used by University of Notre Dame, and responses of interviews. If the keyword had been addressed in any of those comparisons, and found to be relevant, those items were included in the checklist. As searches were conducted some of the sources of change orders could be identified, which then were used as a basis for development of a plan review checklist and recommendations. Refer to Appendix II for the list of keywords identified in each CSI division.



	Project Na	CHD	COID	ChangeOr	ReasonC	ItemIn	Da	ChangeItemDesc
2	Jennison F	1430	157	11	D3	6/7/20	02	Install new continuous hinges on doors 110.3 and 110.2.
3	Jennison F	1455	157	11	D4	5/1/20	02	Remove existing doors and frame to Room 106 and replace with right-hand swing
4	MSU Bio-F	460	90	13	D4	9/3/19	99	Add door and frame at corridor#6.
5	MSU Bio-F	740	90	13	D4	9/3/19	99	Add door at vending 3203.
6	MSU Bio-F	741	90	13	D4	9/3/19	99	Add door at vending 4203.
7	MSU Bio-F	748	90	13	D4	9/3/19	99	Add transom panel at door 1219 to accommodate monorail beam.
8	MSU Bio-F	876	100	23	D4	7/7/20	00	At pantry doors 1425A and 1400A,doors at east elevation are to be 2'8"X7' wood l
9	MSU Bio-F	1501	94	17	D4	4/25/20	00	Change door 1st2-2 from hollow metal to aluminum.
10	MSU Bio-F	663	88	11	D4	11/9/19	99	Clarify door number on drawing (refer to RFI#179)
11	MSU Bio-F	1499	94	17	D4	4/6/20	00	Provide electrical strikes at doors BC9-1, B212, B220, and B224.
12	MSU Bio-F	847	98	21	D4	6/22/20	00	Revise door #C3-2 to be an aluminum door and frame (RFI#479)
13	MSU Bio-F	884	101	24	D4	########		Revise door no.2140-2 to be a "B" label door,door type N with wire glass,with han
14	MSU Bio-F	743	90	13	D4	9/3/19	99	Revise doors to B label
15	MSU Bio-F	747	90	13	D4	9/3/19	99	Revise size of doors 1200-3,1255A-3,1260A-1 and 1260A-3.
16	MSU Bio-F	749	90	13	D4	9/3/19	99	Revise size of doors 1410-1, 1415-1, 1440-1, and 1410B-1 to coordinate with elev
17	MSU Bio-F	746	90	13	D4	9/3/19	99	Revise size of overhead doors to accommodate chillers.
18	MSU Cycli	1248	143	10	D4	3/6/20	03	Add transformer to touch-free door opener.
19	MSU Cycli	1179	140	7	D5	1/16/20	03	Replace specified fire door closures with ones that work in the designed space.
20	Jennison F	1343	151	5	Document:	9/28/20	01	1 Revisions to laundry room 145C and requirements for owner equipment.
21	Jennison F	1341	151	5	Document:	9/19/20	01	Add door hardware at door 325 1.
22	MSU Bio-F	904	110	33	Document:	7/12/20	01	Add an anchor hinge to doors 1219-1 and 1267-3 (RFI#823)
23	MSU Bio-F	797	108	31	Document:	3/26/20	01	Add closer to door 1103-2 and provide new doors with smaller lites,auto flash bolt
24	MSU Bio-F	856	99	22	Document:	8/14/20	00	Add LCN 4011 door closer in the active leaf of doors 1308 and 1402 (RFI#555)
25	MSU Bio-F	481	110	33	Document:	7/12/20	01	Add threshold and weatherstripping to door B238-2 (RFI#822)

FIGURE 3.5 EXCERPT OF DATABASE SHOWING NARRATIVE DESCRIPTIONS

(c) Data Reporting

Three different reports were developed during the study, which included: (1) the CSI division quantitative analysis, (2) narrative descriptions of change order items, and (3) comparison of the Civitello change order discovery checklist with the MSU database. The CSI quantitative analysis report is included in Chapter 4, under the discussion of CSI division analysis (Refer to Appendix VI). The narrative description analysis and comparison to the Civitello's checklist is included in Chapter 5.

The results of the database analyses were integrated with information obtained from the interviews and literature review and together were used to develop the plan review checklist and preconstruction change order prevention strategies suiTable for MSU and for other large universities.

3.3. Interviews

As part of the umbrella project, researchers conducted interviews with ten MSU personnel from Physical Plant and Engineering/ Architectural Services (EAS), two architects, six contractors, four subcontractors, and construction personnel from Purdue University, University of Wisconsin, University of Notre Dame, and University of Minnesota.

Approximately 40 individuals in total were interviewed to gain the insights of construction professionals. A target list of interviewees was developed by a university Oversight Committee appointed for the umbrella project. The list included firms that had worked for MSU in the past. The researchers short-listed firms for confidentiality purposes and sought their participation in the study. Interviews were conducted by

faculty and graduate research assistants. The identification of the firms interviewed was not disclosed to the Oversight Committee.

The purposes of the interviews were: 1) to gather information regarding change order trends, 2) to identify existing change order management practices and 3) to gather information about the possibilities for improvements in the change orders process. The questionnaire was broadly categorized into seven sections: (1) background or demographic questions, (2) design services, (3) building and pre-bid plan reviews, (4) causes of change orders, (5) quality standards, (6) project delivery systems, and (7) documentation. Interviewees were contacted prior to the interview by telephone to determine their willingness to participate and to schedule the interviews. Interviews lasted approximately 60 minutes with the questionnaire presented to the interviewees at the time of the interview. The entire interviewing process was completed within one month. The questionnaire was submitted to the University Committee on Research Involving Human Subjects (UCRIHS) for approval prior to conducting the interviews.

Notes were taken during the open-ended interviews by the researchers and responses were paraphrased, tabulated, and aggregated. The data obtained from the interviews were managed in MS Excel software. Refer to Appendix III for the tabulated data of the interviews. This information was utilized to identify typical change order management practices and was useful in developing strategies for prevention of change orders.

3.4. Comparison of the Data to Identify Major Causes of Change Orders

The data obtained from the interviews was compared with the literature review and with the results of database analysis to check for correlation. Using this comparison,

sources of change orders related to design errors and omissions were identified, and recommendations were developed for reducing design errors and omissions which may lead to change orders.

3.5. Interviews with Construction Personnel of the Case Study University

The researcher conducted interviews with five construction personnel of the case study university in order to gain their insights on plan review processes, and for development of a plan review checklist. The questionnaire addressed departmental plan review processes (if any), suggestions for a plan review checklist, and time period for plan review.

3.6. Development of Preconstruction Change Order Prevention Strategies

Development of Plan Review Checklist

Based on the results of the database analysis and the integration with the interview responses, literature review, and a checklist from the University of Notre Dame, potential areas of change orders were identified and a change order checklist was developed. This process is discussed in chapter 5. This checklist addresses the architectural, structural, mechanical, and electrical design disciplines. The checklist can aid in identifying sources of change orders related to design errors and omissions prior to construction, and can be implemented at four stages of the plan review process including: (1) conceptual level, (2) schematic level, (3) design development level, and (4) contract documents level.

Developing Preconstruction Change Order Prevention Strategies

From the literature review and interviews, the researcher developed additional strategies for reducing change orders caused due to design errors and omissions. The

recommendations include: aspects of functional briefing, recommendations related to CSI division 15 and 16, and selection of architects.

3.7. Validation

The plan review checklist was submitted for review to the construction personnel of Michigan State University in order to validate its effectiveness. Two MSU construction departments, Architectural and Engineering Services and Campus Park and Planning (CP & P), were chosen for validation.

3.8. Summary

This chapter introduced the methodology used for the thesis and provided a brief description of the database and its analyses, the interview process and the development of a plan review checklist.

CHAPTER 4

CHAPTER 4: DATA REPORTING

4.0. Introduction

This chapter presents the data used for this study, and its analysis. In this research, a quantitative analysis of CSI divisions was conducted and a narrative description analysis was performed using a keyword search approach referred to as KWIC (keywords-In-context). Additionally interviews were conducted with construction professionals to gain an insight into change order management practices in industry.

4.1. Data Collection

The MSU database was created from project files. Overall, the projects in the database totaled $133.35 million at contract start, and their ending cost was $144.19 million, the total increase by change order was $10.84 million, or 8.1 percent from starting contract price. Projects selected for the database ranged from approximately $90 million for a new project, to a $313,000 contract for renovations. Projects that were predominantly new buildings or substantial additions were classified as new buildings. Projects that consisted mostly of renovation work were classified as renovations. The database consisted of eleven contracts classified as new buildings and eight contracts classified as renovations. A breakdown of costs by CSI division for the entire project set was developed to determine the relative impact of cost of CSI divisions on a project, as shown in Table 4.1.

Total Costs		
CSI Division	**By Division**	**%**
1	$8,609,625	6 %
2	$12,418,425	9 %
3	$9,642,198	7 %
4	$10,388,214	8 %
5	$8,626,550	6 %
6	$2,537,656	2 %
7	$4,147,514	3 %
8	$5,766,195	4 %
9	$7,038,028	5 %
10	$718,515	1 %
11	$7,322,868	5 %
12	$318,157	0 %
13	$1,226,832	1 %
14	$1,186,312	1 %
15	$39,156,403	29 %
16	$14,114,828	11 %
TOTAL	**$133,218,320**	**100 %**

TABLE 4.1 SCHEDULE OF VALUES PER CSI DIVISION OF ALL PROJECTS IN THE DATABASE

Table 4.1 shows that CSI division 15 accounted for the greatest cost ($39 million, 29%) of the aggregate total cost of the project, followed by CSI division 16 ($14 million, 11%). CSI division 10 ($718,515, 1%), CSI division 13 ($1.2 million, 1%), CSI division 14 ($1.1 million, 1%), and CSI division 12 ($318,157) were small influencers with each division accounting for 1% of the total cost.

4.2. "All Data" Analysis

The data in the, "All Data" worksheet was analyzed using reason codes in order to find the general sources of change orders. The "All Data" worksheet was sorted on the basis of CSI divisions in order to find the number of change order items associated with each division (Refer to Figure 4.1) and the increase in contract amount (Refer to Figure 4.2).

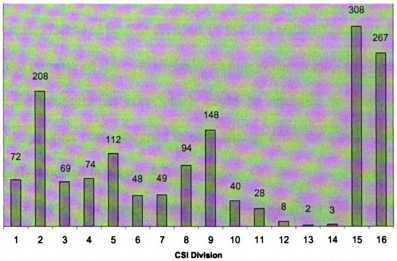


FIGURE 4.1. NUMBER OF CHANGE ORDER ITEMS PER CSI DIVISION

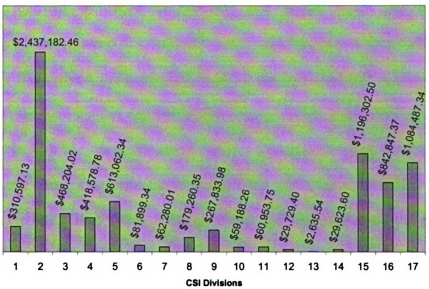


FIGURE 4.2
COST GENERATED BY CHANGE ORDER ITEMS PER CSI DIVISION

Figure 4.1 shows that CSI division15 (308) and division 16 (267) were involved in the greatest number of change order items, followed by divisions 2 (208) and division 9 (148). For this analysis 1341 change order items were used, but because some change order items involved more than one CSI division, the total numbers of CSI division citations are 1530.

Figure 4.2 shows that CSI division 2 ($2.437 million) is associated with the largest cost increase, followed by CSI division 15 ($1.196 million) and CSI division 16 ($ 842,847). For the purpose of the cost analysis, change order items were broken into CSI divisions, and the proportional cost which could be assigned to each division was determined. Change order costs assigned to each change order item were then aggregated to obtain the totals reported in Figure 4.2.

Figure 4.3 shows that design errors and omissions items (394) caused the most change order items in the database, followed by field conditions (286) and scope (256). However, when considering costs Figure 4.4 shows that field conditions accounted for $2,202,527, followed by scope ($2,039,145) and design errors and omissions ($1,790,336). As the reason codes, "miscellaneous", and "reason not specified" had not been used for the analysis, the number of change order items and cost increases do not correlate with the total number and cost of the grouped reason codes mentioned above. (Refer to Table 4.2). The researcher found that two change order items skewed the data and made scope changes the most costly reason code. These items were CIID 477 and CIID 487 of the MSU Bio-Physical Sciences project and were preplanned and generated approximately $880,000 in change cost. Similary, items CIID 474, 482 and 493 generated approximately $812,322, which heavily influenced the "field" grouped reason code.

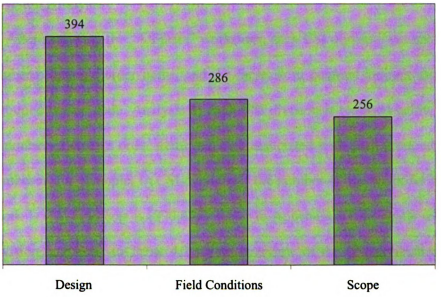


FIGURE 4.3

NUMBER OF CHANGE ORDER ITEMS PER GROUPED REASON CODES

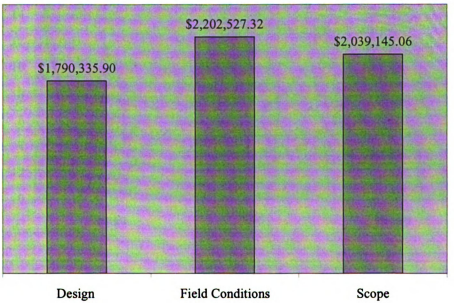


FIGURE 4.4

COST OF CHANGE ORDER ITEMS PER GROUPED REASON CODES

CSI Division Analysis

After analyzing the "All Data" worksheet, each CSI division was analyzed to find the number of change order items, and the increase in contract amount associated with each grouped reason code. Analysis of each CSI division is reported below by referring to the number of change order items and cost associated with each grouped reason code in parentheses, for example: In CSI division 1, the number of change order items of field conditions is (18), and cost is ($90,835). Refer to Appendix VI for charts related to each CSI division, and refer to Table 4.2 for an overview of the CSI division change order item analysis. Figures 4.5 and 4.6 are included below as examples, showing charts of CSI division 1.

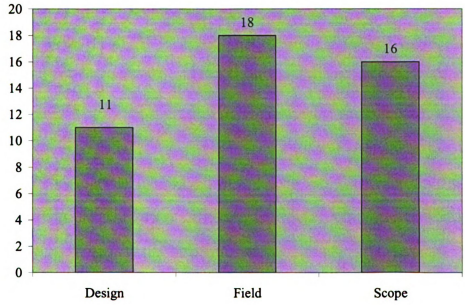


FIGURE 4.5
CSI DIVISION 1 – NUMBER OF CHANGE ORDER ITEMS PER GROUPED REASON CODES

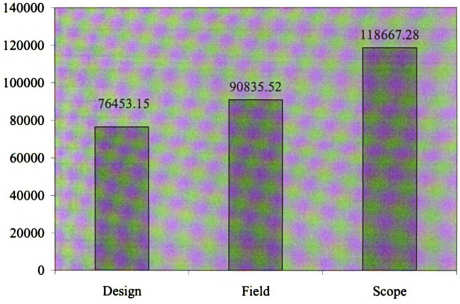


FIGURE 4.6
CSI DIVISION 1 – COST OF CHANGE ORDER ITEMS PER GROUPED REASON CODES

CSI	Variable	Design	Field	Scope	Totals grouped reason codes, Design, Field and Scope	Totals grouped reason codes, including Design, Field, Scope, Miscellaneous and Reason not specified
1	Number	11	18	16	45	72
	Cost	$76,453	$90,835	$118,667	$285,955	$310,597
2	Number	28	107	27	162	208
	Cost	$50,440	$1,219,840	$170,545	$1,440,825	$2,437,182
3	Number	12	22	20	54	69
	Cost	$7,285	$260,228	$175,119	$442,632	$468,204
4	Number	31	5	20	56	74
	Cost	$168,434	$12,339	$227,706	$408,479	$418,578
5	Number	53	34	9	96	112
	Cost	$136,468	$168,331	$197,102	$501,901	$613,062
6	Number	14	7	10	31	48
	Cost	$17,448	$5,129	$41,125	$63,702	$81,899
7	Number	15	7	13	35	49
	Cost	$14,919	$18,016	$28,449	$61,384	$62,280
8	Number	47	7	25	79	94
	Cost	$117,750	$3,820	$35,870	$157,440	$179,260
9	Number	39	23	39	101	148
	Cost	$53,948	$31,705	$87,470	$173,123	$267,833
10	Number	10	2	24	36	40
	Cost	$12,498	$9,187	$37,128	$58,813	$59,188
11	Number	6	1	9	16	28
	Cost	$9,112	$312	$5,195	$14,619	$60,953
12	Number	2	0	6	8	8
	Cost	$4,504	$0	$25,225	$29,729	$29,729
13	Number	1	0	0	1	2
	Cost	($1,964)	$0	$0	($1,964)	$2,635
14	Number	0	0	1	1	3
	Cost	$0	$0	$25,655	$25,655	$29,623
15	Number	119	57	44	220	308
	Cost	$627,891	$92,464	$212,864	$933,219	$1,196,302
16	Number	61	44	69	174	267
	Cost	$216,560	$99,055	$339,529	$655,144	$842,847

TABLE 4.2 NUMBER AND AGGREGATE COSTS OF CHANGES BY CSI DIVISION

CSI 1 – General Data

CSI division 1 represents "General Requirements" of a project, which include: price and payment procedures, administrative requirements, quality requirements, temporary facilities and controls, product requirements and execution requirements, etc., In the MSU database, 45 change order items were associated with CSI division 1 and

were used for analysis. When considering the grouped reason code analysis, field conditions (18) accounted for the most change order items, followed by scope (16), design errors and omissions (11). The cost analysis showed that scope changes (118,667 dollars) accounted for the greatest cost increase, followed by field changes ($90,835) and design changes ($76,453).

CSI 2 – Site Work

CSI division 2 addresses site construction, demolition, restoration and rehabilitation. In the MSU database, 162 change order items were associated with division 2, and were used for analysis. Field conditions (107) accounted for the most change order items, whereas design errors and omissions and scope changes were 28 and 27 respectively. The cost analysis show that field changes ($1.2 million) accounted for 90 percent of the total cost increased within the division, followed by scope changes ($170,545, 8%), and design errors and omissions ($50,440, 2.1%). CIID 493, 474 and 482 caused by field conditions accounted for $812,332 of the total $1,219,840 caused by field conditions, and therefore this grouped reason code accounted for the greatest cost increase.

CSI 3 – Concrete

54 items were associated with CSI division 3, and were used for analysis. As in division 2, field conditions (22) was the dominate cause of change order items contributing 41 percent of total changes. However, scope changes (20) were also a significant cause constituting approximately 37 percent. The results of the cost analysis were consistent with the number of change order items. Field changes ($260,228) accounted for 58 percent of the total cost increase, followed by scope changes

($175,119), which were approximately 40 percent. Design errors and omissions ($7,285) were the least, approximately 1.5 percent of total dollar amount ($442,632). As in CSI divisions 1 and 2, field changes are associated with the most change order items and greatest cost increase. Change order items associated with the addition of an electrical ductbank, and communication ductbank heavily influenced the cost of the "field" grouped reason code.

CSI 4 – Masonry

56 items were associated with CSI division 4, and were used for analysis. Design errors and omissions (31) accounted for the most change order items, constituting approximately 56%. These were followed by scope changes (20) and field conditions (5). The cost analysis show that scope changes ($227,706, 35%) accounted for the greatest total cost increase within the division, followed by design errors and omissions ($168,434) and field changes ($12,339). The change order items coded as design errors and omissions are mostly due to lack of information on plans and specifications, which prompted drawing revisions and change in scope of work.

CSI 5 – Metals

CSI division 5 Metals includes: structural steel, joists, metal framing, and other fabrication metal items. In the database, 96 change order items were associated with CSI division 5. Design errors and omission (53) accounted for the most change order items, whereas field changes and scope changes were 34 and 9 respectively. In the cost analysis, the order was reversed with scope ($197,102) causing the greatest increase, and was followed by field conditions ($168,331), and design errors and omissions ($136,468).

From the change order item descriptions, it can be found that these changes are due to revisions in layout, change in materials, and missing information or details.

CSI 6 – Wood & Plastics

CSI division 6 includes work associated with basic wood and plastic materials. In the database, 31 items were associated with CSI division 6. Design errors and omissions (14, 45%) accounted for the most change order items, followed by scope (10, 32%), and field conditions (7, 23%). The cost analysis showed that scope changes ($41,125, 65%) accounted for the greatest increase in cost, followed by design errors and omissions ($17,448) and field conditions ($5,129). Value engineering of millwork for one project accounted for significant amount of the scope change total.

CSI 7 – Thermal and Moisture Protection

Thermal and moisture protection, dampproofing, waterproofing, shingles, flashing, sealers, roofing and siding panels constitute the major part of CSI division 7. In the database 35 change order items were associated with CSI division 7. Design errors and omissions (15), accounted for the most change order items, followed by scope changes (13) and field conditions (7). The cost analysis showed that scope changes ($28,449, 46%) accounted for greatest cost increase, followed by design errors and omissions ($14,919, 28%), and field changes ($18,016, 7%). In this division, change order items caused by errors and omissions, accounted for the greatest number of change order items and cost increase. These items were generally caused by drawings errors or details which would not achieve the objective as designed, or missing information.

CSI 8 – Doors and Windows

79 items were associated with CSI division 8. Design errors and omissions (47) accounted for the most change order items, followed by scope (25) and field conditions (7). The cost analysis showed that design errors and omissions ($117,750) accounted for the greatest cost increase, followed by scope ($35,870) and field conditions ($3,820).

CSI 9 – Finishes

101 items were associated with CSI division 9. In this division, design errors and omissions (39) and scope changes (39) generated the same number of change order items, each causing 39 percent of the total items, followed by field changes (23) at 23 percent. The cost analysis showed that scope changes ($87,470) accounted for the greatest increase in cost, followed by design errors and omissions ($53,948) and field conditions ($31,705). The cost increase in design errors and omissions are due to updates to documents.

CSI 10 – Specialties

CSI division 10 includes several specialty areas of construction, such as louvers and vents, telephone specialties, toilet, bath and laundry specialties, service walls, fire protection specialties, etc. 36 change order items were associated with CSI division 10. In this division, cost increases are closely tied to the number of items. Scope changes generated the most change order items (24), and accounted for the highest cost increase ($37,128).

CSI 11 – Equipment

CSI division 11 include: equipment and maintenance of equipment, etc. 16 change order items were associated with CSI division 11. Scope changes (9) generated

the most change order items, followed by design errors and omissions (6), and field conditions (1). The cost analysis showed that design errors and omissions ($9,112) accounted for the greatest cost increase at 62 percent, followed by scope changes ($5,195), and field ($312). In "design errors and omissions," the cost increases are influenced by items related to plumbing and compliance with codes.

CSI 12 – Furnishings

CSI division 12 includes fabric, art, interior planters and furniture. In the database, eight change order items were associated with CSI divisions 12. There were no change order items generated by field changes. Scope changes caused 6 items, and design errors and omissions caused 2 items. Overall this division had a minor impact on aggregate cost increase for the project set.

CSI 13 – Special Construction

CSI division 13 addresses special construction such as: air-supported structures, building modules and aquatic park facilities. This division generated only two items, one was D4 (errors) and other was "reason not specified." Thus, only one reason code was reported in this analysis.

CSI 14 – Conveying Systems

Elevators, escalators, scaffolding, etc. fall under the category of conveying systems included in CSI division 14. This division generated only three reason codes, two were from scope, and "no reason" was identified for the other.

CSI 15 – Mechanical

CSI division 15 addresses several HVAC, plumbing and fire protection systems. In the database, 220 change order items were associated with CSI division 15, and were

used for analysis. In the grouped reason code analysis, design errors and omissions (119, 54%) accounted for the most change order items, followed by field conditions (57) and scope (44). The cost analysis showed that design errors and omissions ($627,891) accounted for 55 percent of the total cost increase within the division, followed by scope changes ($212,864) and field conditions ($92,464). From the analysis, it was found that most of the change order items are caused by missing information or by a portion of the work which would not achieve its intended result.

CSI 16 – Electrical

CSI division 16 addresses electrical materials and methods including service, distribution, lighting, alarms and communication systems. 174 items were associated with CSI division 16. Scope changes (69) generated the most change order items contributing approximately 40 percent, followed by design errors and omissions (61, 35%), and field conditions (44, 25%). The cost analysis showed that the number of items caused by each reason code was closely associated with the total cost increase with design errors and omissions ($216,560), field conditions ($99,055), and scope ($339,529). In this division CIID 487 (scope change $112, 520 – revision of layout, materials, and details) and 494 (design error and omissions $70,626 – change requested to revise the electrical light poles) acted as outliers. Other than these two items, the remaining items were equally spread across the reason codes, thus correlating with the results of the grouped reason code analysis.

Summary of CSI division Analysis

CSI division 2 is associated with the highest cost increase, followed by CSI division 15, which accounted for the greatest number of change order items and the

second largest increase in cost. Division 16 generated the third highest costs. The researcher found two outliers in CSI division 2, which skewed the data. Through the research, the researcher recognized that some owners may preplan for change orders if budget is available, some items may deliberately be deleted, and later procured via change order. These outliers made scope changes the most "expensive" grouped reason code. These outlier items were CIID 477 and CIID 487 of the MSU Bio-Physical Sciences project, which were preplanned and generated approximately $880,000. One of the items was repeated in all of the above-mentioned CSI divisions, except CSI division 6 and 10. This resulted in a higher dollar amount even though there were fewer change order items caused by site scope.

From analysis of CSI divisions 1 through 7, a trend was observed in the change order items caused by design errors and omissions, in that the percentage of change order items was higher than the percentage of cost increases associated with them. Similarly, change order items caused by scope changes showed an opposite trend, where the percentage of change order items was lower than the percentage of associated costs. The implication may be that scope changes are generally more expensive than changes caused by design errors and omissions for these divisions.

CSI divisions 4, 5, 6, 7, 8, 9 and 15 showed that design errors and omissions to be the dominant cause of change orders, however only CSI divisions 8, 11 and 15 showed that design errors and omissions accounted for the greatest increase in cost.

4.3 Narrative description analysis of MSU database

At completion of the quantitative analysis, the researcher examined narrative descriptions in the database for each change order item and developed keywords from each CSI division. From the Keywords-In-Context (KWIC)[5] approach various key words were identified for frequency counts for each CSI division. The search was performed using MS Excel software. Key words were documented with the number of occurrences in each CSI division. The same keywords were also used for the "All Data" worksheet, which acted as a supplement to the keyword search performed for each CSI division. The frequency of recurring words was recorded. Keywords that had lower rates of recurrence were compared with the literature review, Civitello's checklist, QCC (Quality control checklist from University of Notre Dame), the quantitative analysis and interview results. If they were found to be relevant, those items were also included in the checklist. Refer to Table 4.3 for list of keywords.

[5] Key-words-in-context (KWIC) is closely associated with indigenous categories. KWIC is based on a simple observation: if you want to understand a concept, then look at how it is used. In this technique, researchers identify key words and then systematically search the corpus of text to find all instances of the word or phrase. Each time they find a word, they make a copy of it and its immediate context. Themes get identified by physically sorting the examples into piles of similar meaning (Ryan et.al., 2003)

CSI Division	Description	Occurrence
1	Drawing	7
	Bulletin reproduction costs	6
2	Excavate	6
	Pipe	11
	Flooring	11
	Pavements	11
	Walk	15
	Concrete	15
	Asbestos	8
3	Pier	4
	Concrete	14
	Beam	4
	Footings	4
	Slab	6
4	None	
	20/31 items are from one project	
5	Steel	17
	Beam	22
	Lintel	6
	Angle	6
	Column	8
	Roof	22
	Plate	7
	Deck	5
6	None	
7	Flashing	5
	Dampproof and waterproof	6
	Sealant	4
	Caulk	2
	Blocking	2
	Laminate	1
8	Windows	7
	Doors	72
	Frame	14
	Hardware	15

CSI Division	Description	Occurrence
9	Doors	31
	Ceilings	14
	Frame	14
	Roof	71
	Drywall	8
	Painting	23
	Metal	9
10,11,12,13,14	None	
15	Pipe	44
	Insulation	13
	Drainage	26
	Duct	35
	Valve	24
	Damper	8
	Grill	9
	Steam	20
	Air	33
	Supply	18
16	Switches	17
	Duct	17
	Detector	7
	Circuit	16
	Fire	12
	Wire	12
	Fixture	22
	Light	43
	Conduit	29
	Security	5
	Communication	12
	Data	16

TABLE 4.3 KEYWORDS FOR EACH CSI DIVISION

In CSI division 1, two keywords, "drawing" and "bulletin reproduction costs" occurred seven and six times respectively, no consistent cause could be determined for these keywords. For other divisions, such as CSI division 8, some keywords had a significant number of occurrences. 72 citations of doors were found in the database.

Through this process, the researcher was able to identify areas for further examination. This process was applied to each CSI division. For example, in CSI division 2, the researcher found the following commonly occurring keywords: excavation (6 occurrences), pipe (11 occurrences), flooring (11 occurrences), pavements (11 occurrences), walk (15 occurrences), concrete (15 occurrences), and asbestos (8 occurrences). Upon determining those words with frequent occurrences, the researcher examined the narrative descriptions more closely to determine the causes of change orders. For this division, items related to "pipe" were generally related to the type of pipe material. For the keyword "sidewalk", causes included: drawing dimensions and additional portion of sidewalks were replaced. The results of this analysis are reported in Table 4.3.

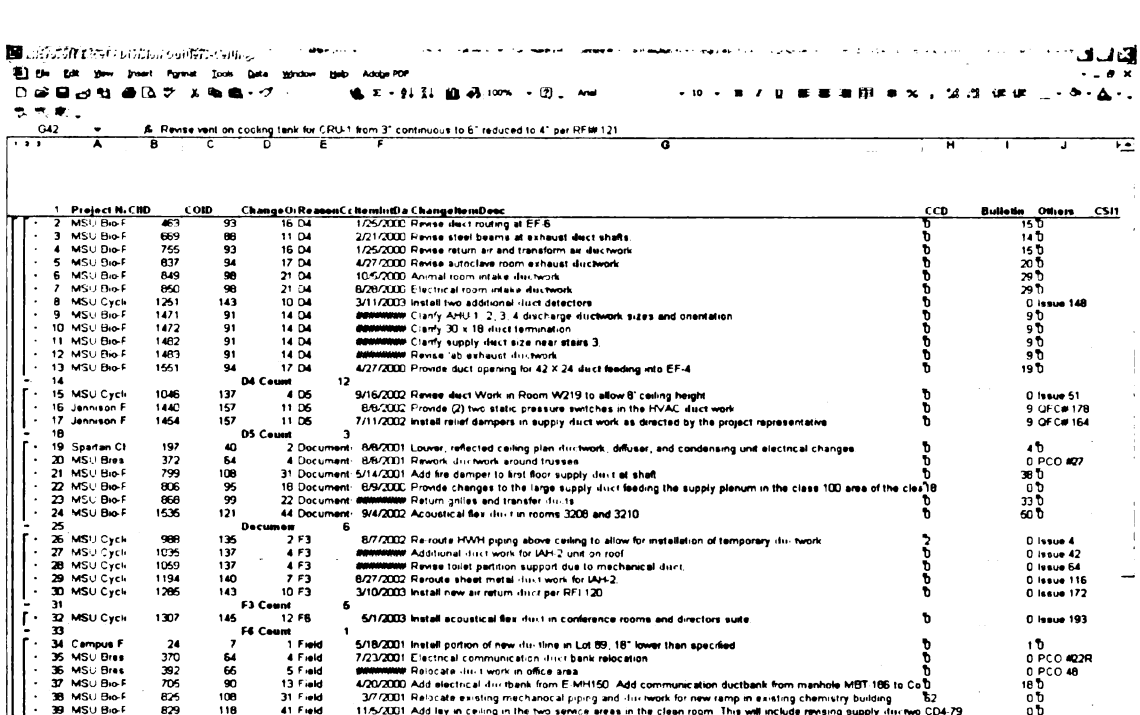
Based on the results of the keyword searches, areas of emphasis could be identified for correlation with Civitello's change order discovery checklist. Some of the keywords that were most prominent in the database were: duct, columns, beams, ceiling spaces, doors and light fixtures.

4.4. Comparison with the Civitello Change Order Discovery Checklist

In this analysis, the MSU database was compared with the Civitello change order discovery checklist discussed in chapter 2. Civitello identified a variety of issues related to the sources of change orders and gave detailed descriptions of problem areas. The process of comparison was similar to that used for the narrative descriptions discussed above. Recurring terms were identified as sources of potential change orders.

The entire database was searched using keywords, and individual spreadsheets of recurring words were developed in MS Excel. Refer to Figure 4.7 for an example for the

keyword: duct. After individual spreadsheets were developed, the researcher developed reports that showed the correlations between the issues addressed by Civitello and the MSU projects database.



	Project N.	CBD	COBD	Change	Or	Reason	Cc	Itemized	Da	ChangeItemDesc	CCD	Bulletin	Others	CSI
2	MSU Bio-F	469	93	16	D4			1/25/2000		Revise duct routing at EF-6	0	15	0	
3	MSU Bio-F	669	88	11	D4			2/21/2000		Revise steel beams at exhaust duct shafts	0	14	0	
4	MSU Bio-F	755	93	16	D4			1/25/2000		Revise return air and transform air ductwork	0	15	0	
5	MSU Bio-F	837	94	17	D4			4/27/2000		Revise autoclave room exhaust ductwork	0	20	0	
6	MSU Bio-F	849	98	21	D4			10/5/2000		Animal room intake ductwork	0	29	0	
7	MSU Bio-F	850	98	21	D4			8/28/2000		Electrical room intake ductwork	0	29	0	
8	MSU Cycli	1261	143	10	D4			3/11/2003		Install two additional duct detectors	0	0	Issue 148	
9	MSU Bio-F	1471	91	14	D4			########		Clarify AHU-1, 2, 3, 4 discharge ductwork sizes and orientation	0	9	0	
10	MSU Bio-F	1472	91	14	D4			########		Clarify 30 x 18 duct termination	0	9	0	
11	MSU Bio-F	1482	91	14	D4			########		Clarify supply duct size near stairs 3	0	9	0	
12	MSU Bio-F	1483	91	14	D4			########		Revise lab exhaust ductwork	0	9	0	
13	MSU Bio-F	1551	94	17	D4			4/27/2000		Provide duct opening for 42 X 24 duct feeding into EF-4	0	19	0	
14				D4 Count		12								
15	MSU Cycli	1046	137	4	D5			9/16/2002		Revise duct Work in Room W219 to allow 8' ceiling height	0	0	Issue 51	
16	Jennison F	1440	157	11	D5			8/8/2002		Provide (2) two static pressure switches in the HVAC duct work	0	9	QFC# 178	
17	Jennison F	1464	157	11	D5			7/11/2002		Install relief dampers in supply duct work as directed by the project representative	0	9	QFC# 164	
18				D5 Count		3								
19	Spartan Cl	197	40	2	Document			8/8/2001		Louver, reflected ceiling plan ductwork, diffuser, and condensing unit electrical changes	0	4	0	
20	MSU Bres	372	64	4	Document			8/8/2001		Rework ductwork around trusses	0	0	PCO #27	
21	MSU Bio-F	799	108	31	Document			5/14/2001		Add fire damper to first floor supply duct at shaft	0	38	0	
22	MSU Bio-F	806	95	18	Document			8/9/2000		Provide changes to the large supply duct feeding the supply plenum in the class 100 area of the clea	18	0	0	
23	MSU Bio-F	868	99	22	Document			########		Return grilles and transfer ducts	0	33	0	
24	MSU Bio-F	1535	121	44	Document			9/4/2002		Acoustical flex duct in rooms 3208 and 3210	0	60	0	
25				Documen		6								
26	MSU Cycli	988	135	2	F3			8/7/2002		Re-route HWH piping above ceiling to allow for installation of temporary duct work	2	0	Issue 4	
27	MSU Cycli	1035	137	4	F3			########		Additional duct work for IAH-2 unit on roof	0	0	Issue 42	
28	MSU Cycli	1059	137	4	F3			########		Revise toilet partition support due to mechanical duct	0	0	Issue 64	
29	MSU Cycli	1194	140	7	F3			8/27/2002		Reroute sheet metal duct work for IAH-2	0	0	Issue 116	
30	MSU Cycli	1285	143	10	F3			3/10/2003		Install new air return duct per RFI 120	0	0	Issue 172	
31				F3 Count		6								
32	MSU Cycli	1307	145	12	F6			5/1/2003		Install acoustical flex duct in conference rooms and directors suite	0	0	Issue 193	
33				F6 Count		1								
34	Campus F	24	7	1	Field			5/18/2001		Install portion of new duct line in Lot 89, 18" lower than specified	0	1	0	
35	MSU Bres	370	64	4	Field			7/23/2001		Electrical communication duct bank relocation	0	0	PCO #22R	
36	MSU Bres	392	66	5	Field			########		Relocate duct work in office area	0	0	PCO 48	
37	MSU Bio-F	706	90	13	Field			4/20/2000		Add electrical duct bank from E MH150. Add communication ductbank from manhole MBT 186 to Co	0	18	0	
38	MSU Bio-F	825	108	31	Field			3/7/2001		Relocate existing mechanical piping and duct work for new ramp in existing chemistry building	62	0	0	
39	MSU Bio-F	829	118	41	Field			11/5/2001		Add lay in ceiling in the two service areas in the clean room. This will include revising supply duct wo	CD4-79	0	0	
40	Campus F	964	7	1	Field			9/10/2001		Relocate duct line entry location into manholes near Crop Science	0	1	0	
41	Jennison F	1365	152	6	Field			########		Reroute duct work on 2nd floor per RFI#89	0	0	QFC# 54	
42	Jennison F	1366	152	6	Field			1/4/2002		Revise vent on cooling tank for CRU-1 from 3" continuous to 6" reduced to 4" per RFI# 121	0	0	QFC# 90	

FIGURE 4.7 EXCERPT OF MS EXCEL DISPLAYING KEYWORD "DUCT" RECURRENCE

4.4.1. Major Findings of Comparison of MSU Database with the Civitello Change Order Discovery Checklist

Civitello developed recommendations for identifying potential change orders and listed various causes. Civitello's suggestions were checked for correlation with the MSU construction projects. Little or no correlation in the database did not, necessarily disprove a specific Civitello recommendation; rather, the term "no correlation" signifies that

keywords used by Civitello were not present in the database of 16 university projects. In some instances the specific narrative descriptions may not have used the precise words of Civitello, or in other instances Civitello may have used keywords that were not as applicable to university projects such as "zoning". Given the above mentioned limitation, the correlation checks were used only as guiding paths for the research, rather than proving or disproving the recommendations developed by Civitello. Table 4.4 indicates the list of keywords used for each search.

Major Cause	Keyword	Occurrence
Boring (Subsurface Data)	Soil	13
Boring (Subsurface Data)	Testing	24
Building Code Compliance	Code	5
Temporary Utilities	Temporary	15
Easement/ Rights of Way	Walkway	4
Ceiling Spaces	Structural Members	9
Ceiling Spaces	Plumbing	10
Ceiling Spaces	Heating Systems	3
Ceiling Spaces	Fire systems	40
Ceiling Spaces	Insulation	2
Ceiling Spaces	Lighting	10
Ceiling Spaces	Duct	47
Ceiling Spaces	Pipe	12
Ceiling Spaces	Vent	3
Ceiling Spaces	Sprinkler systems	2
Ceiling Spaces	Steel reinforcements	6
Ceiling Spaces	Ceilings	36
Ceiling Spaces	Soffits	1
Columns and Beams	Beams	33
Columns and Beams	Columns	19
Light fixtures	Light	54
Price/Bid Allowances	Allowance	13
Price/Bid Allowances	Deducts	17

TABLE 4.4
LIST OF KEYWORDS USED IN ANALYSIS OF COMPARISON WITH CIVITELLO'S CHECKLIST

Significant findings of the Civitello's comparisons and analysis are presented below.

Boring (Subsurface Data)

Keywords: soil and testing.

The soil borings provide relevant information about subsurface conditions of the site. Accurate subsurface data can help prevent change orders that arise from soil conditions. In the MSU projects database, it was found that 37 change order items were caused by unsuiTable soil. All change order items related to subsurface data were for removal of the unsuiTable soil, as it was hindering construction progress. Civitello explained that experienced estimators know how to research the precise definitions of technical terms in order to gain a clear understanding of the exact conditions described in the data. If accurate data are provided, the information can help reduce change orders due to soil. According to Civitello, the important considerations are:

1) Relevance of the boring locations and data to the construction area, and
2) Consistency of data throughout the site.

Building Code Compliance

Keyword: code

From the keyword search it was found that out of 1,341 change order items, only five change order items were due to building codes, indicating that failure to follow building codes was generally not a significant problem.

Easements/Right of Way

Keyword: walkway

According to Civitello, one of the potential sources of change orders related to a site was "restrictions in site access." "Production and efficiency are dramatically reduced because of sudden, unexpected complications in moving about the site," (Civitello, 2002). Little evidence was found in the database with this issue; only four change order items were generated by problems with easements and rights of way, presumably because of the larger campus setting without local government restrictions. However this issue may be more pronounced with private development or in development which requires approval of local government.

Temporary Utilities – Availability within the Contract Limits

Keyword: temporary

Another important factor related to project sites were temporary utilities. Civitello identified many items related to temporary utilities that have to be considered during estimation, such as telephone poles, power availability, lighting, etc. The keyword search resulted in 14 items, but these items were not directly related to the items specified by Civitello. Few change order items in the data were found to be caused by a lack of temporary utilities.

The other aspects of predesign identified by Civitello included: special agency approvals, interference from utilities not properly shown, and plan approvals (building permit), showed no correlation with the MSU projects database, presumably may be because of the university's control over the construction site and also adjacent sites which belong to MSU.

Contract and Bid Documents

Keywords: allowance and deduct

Several contractual issues were suggested by Civitello as sources of change orders and included:

1) Award Date
2) Named Subcontractors
3) Price/Bid Allowances and Contract Time

As this research studied topics related to "design errors and omissions," the time aspects related to change orders were considered to be out of scope, "award date" and "contract times" were not considered for the keyword search.

Ceiling Spaces

Keywords: structural members, plumbing, heating systems, fire systems, insulation, lighting, duct, pipe, vent, sprinkler systems, steel reinforcements, ceilings, and soffits

Civitello identified ceiling spaces as a significant source of conflict that generates change orders. He said that generally all projects have some conflicts related to ceiling spaces.

Since ceiling spaces are related to other construction items, such as structure, HVAC, fire protection, etc., the entire database was analyzed using the keywords "structural" (9), "plumbing "(10), and "heating systems" (3). These items generated a limited number of occurrences. However, fire protection systems were a significant source being listed in over forty change order items. Most of these change order items were due to design errors and omissions. The CSI divisions most affected were CSI 15 and CSI 16.

According to Civitello, ductwork was considered to be one of the prime sources of conflict for change orders involving ceilings. The database analysis shows that ductwork was associated with 47 change order items, which was significant when compared to other keywords related to ceiling spaces. The divisions that were impacted most by "ductwork" were CSI 15 and 16.

"The smaller the area and the more complex the building system, the greater the probability of conflicts and change orders," (Civitello, 2002). In the database, most ductwork changes flowed from problems related to ceiling heights and air ductwork. Another major factor was re-routing/relocating the ductwork, which affected other CSI divisions.

Column and Beam Locations

Keywords: beams and columns

Civitello identified sources of change orders involving columns and beam locations as errors in information provided in the drawings, as well as a lack of coordination. Change order items in the database were searched using keywords, "columns" and "beams", and further analyzed for correlation with the recommendations made by Civitello, which include the dimension and location of columns and beams, and coordination with architectural, electrical and mechanical disciplines. CSI division 5 was heavily influenced by changes due to ceilings and beams. In this analysis, it was found that most change orders generated were due to errors in documents.

Civitello also indicated that there might be problems with walls, plumbing, windows, ducts, and equipment, which may not be coordinated with column and beam locations. During the analysis of the database it was found that there were a number of

changes generated by location of walls (columns – 19, beams – 33), ducts (47) , and fire sprinkler systems (40). The major changes in columns and beams were revision of beam sizes and changes in reinforcement.

Light Fixture Locations

Keyword: light

In his explanation regarding light fixtures, Civitello suggests that a major cause of change orders is lack of coordination between design professionals of light fixtures during development of plans and specifications.

The database showed that there were 54 change order associated items with the keyword "light". These change order items were generated by requests for additional light fixtures, changes in layout of fixtures, change of fixtures type from those indicated in the plans or specifications, or changing the complete lighting layout. The majority of change order items were requested in order to change or replace the type of light fixtures. These items were often generated by lack of coordination between design professionals, and were related to inadequate ceiling spaces, fire sprinkler systems, and ductwork.

Changed Existing Conditions

The database showed that some change orders occurred as a result of changes at the site or by hidden conditions. Civitello noted, "This situation is one in which conditions or circumstances at the site become different from those that were documented and observed at the time of the bid." According to the database analysis, 31% of change order items are caused by field conditions. These changes occurred due to several site conditions, such as discovery of a regulated hazard, poor soil conditions, hidden conditions and changes in local, state or national codes during the construction.

4.4.2. Summary of Comparison with the Civitello Change Order Discovery Checklist

Important findings of this analysis are that lack of coordination between design disciplines is a significant cause of change orders. Civitello identified numerous problem areas, such as "ceiling spaces," "light fixtures," "columns, "beams," and "ducts," and the database supported many of his detailed suggestions. Following the analysis, Table 4.4 along with Table 4.3 of the narrative description analysis were used by the researcher to focus the development of the plan review checklist.

4.5. Interviews

As part of the umbrella project, the researcher conducted interviews with ten MSU construction administrators, outside designers, contractors, subcontractors, and construction administrators of four other research intensive universities in order to gain insight into their current change order management practices. The purposes of these interviews were: 1) to gather information regarding change order trends, 2) to identify existing change order management practices, and 3) to gather information about possibilities for improvements in the change order process. Data collected from the interviews was used in conjunction with the results of the change order database analysis and literature review in order to develop recommendations suiTable for universities.

Interviews were conducted by faculty and graduate research assistants. Data from the open-ended interviews were paraphrased, tabulated, and aggregated. Refer to Appendix III for the tabulated data of the interviews.

4.5.1. Interview Responses

As a part of the umbrella project, six contractors, three subcontractors, two outside designers, ten MSU construction administrators, and staff from four research intensive universities were interviewed to solicit opinions regarding change order management and practices. A total of 45 open-ended questions were asked, 20 of which were related to preconstruction issues. Questionnaires were specific to each interview group, although some similar questions were included. The interview responses are reported below in two categories: (1) industry interviews (architects/engineers, contractors and subcontractors), and (2) university interviews. Reported below are the general themes expressed by the respondents.

Industry Interview Responses

In this section, interview response of contractors, subcontractors, outside designers, MSU construction administrators and staff from four research intensive universities are reported. The questions asked included several aspects of change orders, such as: classification of change orders, tracking the performance of lower tier personnel, testing programs of soils and environmental conditions, soliciting information on change order histories, use of International Organization for Standardization (ISO), programming and functional briefing, plan review processes, university standards, partnering, commissioning, pre-bid walk-thrus, and CSI divisions influencing change orders. The questions and verbatim responses are included in Appendix III.

When interviewees were asked if they classified change orders, it was observed that architects, contractors, and subcontractors did not classify the causes of change orders. From experience, contractors and subcontractors mentioned design errors and

omissions, field conditions (which include hidden conditions), scope changes, and poor coordination between various design disciplines as the dominant causes of change orders.

When asked about monitoring or tracking the performance of lower tier personnel, with respect to change orders, respondents indicated that although no formal procedure was adopted, every group implemented its own informal process.

When asked about testing programs, respondents noted that testing programs, such as soils testing and environmental conditions were generally determined by the owners in consultation with their consultants.

Questions were asked regarding soliciting information on change order histories from project participants. Respondents indicated that quality-based selection was generally adopted, although various other factors such as experience and quality of drawings were considered. Information was typically solicited through an RFP process. When asked about soliciting information on change orders from contractors and subcontractors, the interviewer found that, in general, there was no practice of requesting such information.

The researcher was interested in learning if construction, design, or construction management firms that participated in ISO usually had a reduced number of change orders. Respondents indicated that ISO certification likely does not have any impact on reducing the number of change orders.

When those interviewed were asked if the spread (variation) of bids influenced change order rates, and if it can act as a good predictor of change orders, their responses were mixed. Though the majority of the group agreed that there would not be any major

effect, everyone intuitively felt that there should be an impact and that this factor might serve as a predictor of change orders.

Two questions related to programming (functional briefing). Contractors and subcontractors were asked about the frequency of change orders occurring when there were communication lapses between architects and owners. The group collectively considered this issue to be a frequent problem occurring on most projects. The second question asked about the processes used for establishing programs and documentation. Designers indicated that they were generally involved with the owner, either by direct meetings or through the exchange of written responses and comments.

Contractors and subcontractors were asked if A/E firms adequately reviewed drawings prior to bidding. A similar question asked about university plan review processes. This group of respondents felt that there was room for improvement in the plan review process of architects and engineers. Responses were mixed with regard to the plan review processes of the university. Contractors and subcontractors indicated that due to lack of time and understaffing, the university personnel typically had limited time for plan review. In general, though, they expressed satisfaction with the process.

Interviewees were asked if MSU standards had an impact on the number and type of change orders. Most interviewees indicated that these standards did not generally lead to change orders; however, they also stated that although the standards were good, they should be updated.

When asked about partnering and commissioning, there was an overwhelming response that these two practices were not effective in reducing the number of change orders. Although, a minority of the respondents indicated that these practices might help

to improve communication among project participants. The respondents expressed various opinions about partnering and commissioning, which included:

1) Commissioning might increase the number of change orders, because during this process hidden problems are identified that might have been ignored in regular practice.
2) Commissioning would be effective, if experienced people were involved in it.
3) Formal partnering sometimes helps in reducing miscommunication, which could decrease processing time for change orders and expedite a project.

Architects, contractors, and subcontractors were asked if pre-bid meetings/walk-thrus were effective in reducing change order rates. The majority of contractors and subcontractors felt that this process would not be very effective, whereas designers stated that pre-bid meetings helped in submitting better bids, and eventually reduced the number of change orders.

When asked about which CSI divisions caused the most change orders, the unanimous answer from all respondents was CSI divisions 15 and 16. In addition to these divisions, CSI division 2 was also reported as a division that generated a significant number of change orders, due to hidden conditions. Almost all of the respondents indicated that, in general mechanical and electrical design professions caused the maximum number of change orders.

When respondents were asked for additional ideas that could be employed to reduce change order rates, a variety of ideas surfaced, including:

1) Better coordination between design interfaces
2) Improvement in the quality of drawings

3) Repeat work as an incentive to do good work

4) Institution of a mandatory 30 day review period prior to bidding

5) Preplanning of the front-end activities and allocating more time for these activities

6) Better plan review process

7) Make pre-bid walk-thrus more effective.

From the industry interview responses, it was found that poor coordination between various design disciplines is a dominant cause of change orders. Regarding the classification of change orders, there is no such process of classification, however respondents informally classified causes as design errors and omissions, field conditions and scope changes. Also, the respondents generally indicated that ISO, partnering and commissioning has little influence in reducing the number of change orders. Additionally respondents also mentioned that spread (variation) of bids does not heavily influence change orders. In addressing prevention strategies, interviewees indicated that good functional briefing, adequate time for plan review process, and pre-bid walk-thru processes can help to reduce the number of change orders.

University Interviews Responses

In this section, interview responses of university personnel are reported. The questions asked addressed several issues related to change orders, such as: causes of change orders, change orders history, ISO use, programming and functional briefing, plan review processes, availability of university standards to trade partners, partnering, commissioning, and pre-bid walk- thrus.

University administrators mentioned design errors and omissions, field conditions (which include hidden conditions), scope changes, and poor coordination between various design discipline interfaces as the dominant causes of change orders.

A question was asked about soliciting information on change order histories of project participants before they could qualify for the work. Although one of the universities mentioned that they had a vendor performance program in place, none of the universities formally requested change order history information.

University administrators were asked if construction, design, or construction management firms that participate in ISO usually had a reduced number of change orders. Respondents indicated that ISO certification likely does not have any impact on reducing the number of change orders.

University administrators were asked if the spread (variation) of bids influenced change order rates, and if this could act as a good predictor of change orders. Most of the respondents indicated that there would not likely be any major effect. But some respondents indicated that the spread cold have an impact and this factor might serve as a predictor of change orders.

A question related to establishing functional briefs and programming was included. All of the universities had similar processes, where one specialized department in the university was always involved in developing functional briefs for projects and aids concerned departments. All universities considered that scope definition was not a significant cause of change orders.

One question focused on plan review processes and respondents indicated that they could be improved. Another question asked university personnel to describe their

individual plan review process. It was observed that individuals and offices generally had varying processes for periodic plan reviews. The University of Wisconsin, in addition to various levels of plan reviews, instituted a review charrette, which included various people from shops, the design architect office, project representatives, etc., for plan reviews. Purdue University had a rule of turning in documents 30 days prior to bidding, in order to leave sufficient time for plan review. The University of Notre Dame used a checklist for plan review processes.

Construction administrators were asked if their universities had any published standards or specifications that established requirements for design and specification of projects. Additionally, it was asked whether or not failure to follow these standards by designers was a frequent problem. All universities indicated that they had published construction standards, and the respondents specified that problems due to the failure to comply with the standards were not common.

In a question related to partnering and commissioning, the group collectively indicated that these two practices were not effective in reducing the number of change orders. A minority of the respondents indicated that these practices might help to improve communication among project participants, but did not reduce change orders.

The next question inquired if pre-bid meetings/walk-thrus were conducted by the universities. Interviews with university construction administrators indicated that pre-bid meetings/walk-thrus were conducted, but they were mandatory at only one university.

When asked about which CSI divisions causes the most change orders, all respondents indicated that CSI divisions 15 and 16 cause the most change orders. Also,

the group indicated that CSI division 2 generated a significant number of change orders due to hidden conditions.

The major findings of university interview responses concur with the industry interview responses. Design errors and omissions, field conditions, scope changes, and coordination between design disciplines are considered to be the dominant cause of change orders. Architectural, mechanical and electrical disciplines are considered to cause the most change orders. New industry practices, such as partnering, commissioning, use of ISO program are not considered to be effective in reducing change orders. However, better programming and functional briefing, pre-bid walk-thrus, improved plan review processes are considered to be effective tools for reducing change orders.

4.5.2. Checklist Development Interviews

To gain the perspectives of construction personnel regarding plan review processes, the researcher interviewed four people from the MSU Engineering and Architectural Services (EAS) staff who were involved in all stages of plan review processes from the conceptual stage to contract documents. The plan reviewers were from varied design disciplines, and their experience with plan reviews varied from 14 to 30 years. Their paraphrased responses are included in Appendix IV.

From the interviews it was apparent that none of the plan reviewers had an official plan review protocol or process in their respective departments, although they had an informal checklist they implemented on the basis of their expertise and experience. Two of the respondents explained their informal process of plan review. One respondent indicated that in their department, they typically review for two weeks then made written

comments, and submitted them to their consulting A/E. The plans and comments were then reviewed by the consulting A/Es, who answered the written comments and sent the responses back to the concerned department. Necessary actions were then taken to correct the plans and specifications according to the comments made. In another department, the plan review process was done by three people, and they traded the plans among themselves to gain everyone's perspective.

The researcher was interested in knowing which factors could be included at the various levels of design (conceptual, schematic, design development, and contract documents). There was no clear answer for this question, but coordination was indicated to be an important aspect to include at each level. One respondent indicated that the conceptual and schematic levels blend together, and it should be made clear that all aspects discussed during these stages were related to each other and were well defined. Similarly, the stages of design development and contract documents blended together and at this point it was important that issues discussed in the conceptual and schematic stages were addressed during design development and preparation of contract documents.

Since one of the goals of developing a checklist was to improve the plan review process, the researcher was interested in learning the typical duration of this process at various completion levels. All respondents said that it depended on the complexity of the project, and it might vary from a few hours to a couple of months. Some mentioned that the time typically allocated was insufficient, although one of the respondents indicated that this period was generally adequate. Three respondents mentioned that too many levels of approvals in the plan review process were another factor that created a barrier during plan review.

The researcher asked if there would be any barriers in implementing standardized checklists. One of the respondents indicated there would not be any barrier, whereas a second respondent said that there may be some resistance from people who were already using their own processes. A third respondent said that if the checklist was complex and specific, it would not be implemented. A fourth respondent indicated that the time period would be a barrier to implement a checklist. All of these respondents felt that training staff in the implementation of a standardized checklist would be very helpful.

Three of the respondents mentioned that a checklist should not be specific and complicated; rather, it should be simple and general in order to help the current existing informal practices. All suggested that the organization of a checklist should be based on a specific design discipline and should be implemented at each of the design stages.

The major findings of checklist development interviews include: no formal plan review protocol is used in any department, however an informal process is adopted by plan reviewers. Respondents indicated that a checklist should be developed by design disciplines, however no classification had been mentioned. The duration of plan review depends on the type and complexity of a project. It was also found that a plan review checklist should be simple and general, such that it can be customized to match the current informal process.

4.6. Summary

This chapter presents the data used in this research, followed by data handling and reporting procedures. As a part of this research, sixteen MSU projects were analyzed and eleven construction professionals and construction administrators of five research intensive universities were interviewed. The analyses reported in this chapter are: "All

Data" analysis, CSI division analysis, narrative description analysis and comparison of MSU database with Civitello's checklist, construction industry interviews, university interviews and checklist development interviews. The interview responses were tabulated in separate spreadsheets for quick reference and are included in Appendix III. The results obtained from the data analysis and the responses obtained from the interviews indicated trends in the sources of problems leading to change orders. These trends and patterns were integrated with the literature review and summarized to create a plan review checklist and recommendations, which are discussed in Chapter 5.

CHAPTER 5

CHAPTER 5: PLAN REVIEW CHECKLIST

5.0. Introduction

This chapter discusses the plan review checklists, which are an important deliverable of this research. In this research, various sources were used throughout the course of the study to develop a plan review checklist and included: (1) quantitative analysis of the "All data" and CSI divisions spreadsheets, (2) study of narrative descriptions of the MSU database, (3) comparison of the MSU database with the Civitello change order discovery checklist, (4) the quality control checklist (QCC) used at the University of Notre Dame as part of its quality assurance program (refer to Appendix VII for a complete Notre Dame checklist), (5) RediCheck plan review checklist procedures, and (6) interviews with MSU construction personnel. The researcher integrated all sources and developed a checklist that could be used at the four stages of design.

The organization of the checklist was based on the interview responses of MSU construction personnel, who suggested that the list should be organized by design discipline. The University of Notre Dame checklist was also structured this way. Therefore, the checklist was developed on the basis of work disciplines (architectural, civil/structural, mechanical, and electrical) and for the four levels of design (conceptual, schematic, design development, and contract documents). Data from the various sources was discussed in chapter 4. In this chapter, the development of the checklist is reported along with discussion of the organization and structure of the checklist, and its validation process.

5.1. Quantitative Analysis of MSU Database

From the quantitative analysis, it was found that 42 percent of change orders were due to design errors and omissions. The change order items caused by design errors and omissions are due to the portion of work which might not have achieved the objective as designed or are due to missing relevant information. This was a very broad category that addressed a variety of issues, such as inadequate level of detail, numerous details, dimension strings, and coordination between design disciplines. This provided a quantitative base for the recommendations developed by Civitello in his "plans and specifications" section.

5.2. Study of Narrative Descriptions in the MSU Database

During the narrative description analysis, keywords were identified and checked for recurrence. This helped to identify the trends and sources of change orders. Frequently recurring words were recorded and considered for inclusion in the checklist.

5.3. Comparison of Civitello Change Discovery Checklist with MSU Database

Keywords identified by Civitello were compared with the MSU database to find correlations. The items identified by Civitello which were supported by the analysis of the database narrative descriptions were included in the checklist. Also, Civitello identified several areas of potential change orders that did not occur in the narrative descriptions of the change order items in the database. But the researcher believed that these items were still relevant to the current research, and therefore these items were included in the checklist. One of these areas was Civitello's, "plans and specifications." The researcher could not find any direct use of the phrases in the database narrative

descriptions; however it was clear from the reason code analysis that there were many change orders due to design errors, so the researcher included these items in the checklist.

5.4. Quality Control Checklist Used by the University of Notre Dame

The organization of the checklist was developed based on the responses of the interviews and a Quality Control Checklist (QCC) used at the University of Notre Dame. The researcher compared the results of the quantitative analysis, the analysis of narrative descriptions, and the Civitello checklist with the Notre Dame checklist. Some items from the QCC were directly incorporated into the plan review checklist proposed by the researcher. The QCC checklist is included in Appendix Appendix VII.

QCC consisted of a description of the scope and purpose of the document and laid out guidelines for implementing a quality plan review checklist. QCC was structured into four design development levels: (1) conceptual design drawings checklist, (2) schematic design drawings checklist, (3) design development drawings checklist, and (4) 100 percent construction drawings checklist, which was further divided into respective design disciplines (architectural, civil/structural, mechanical, and electrical).

QCC generally includes the following: (1) Conceptual design drawings checklist: this section consisted of ten questions that together addressed all design disciplines related to conceptual level drawings. (2) Schematic design drawings checklist: this section was divided into five sections, of which one segment consisted of two common questions, and the other questions were distributed among four design disciplines: architectural, civil/structural, mechanical, and electrical. (3) Design development drawings checklist: this section of the checklist was designed similarly to the schematic design drawings checklist; however, it included another section titled "cost", which

consisted of one question about the correlation of cost with the established budgets. The common questions addressed in this checklist consisted of eight questions mostly addressing CSI division 15 and 16 issues. (4) 100 percent Construction drawings checklist: this was the final section of the checklist that was organized on the basis of the four major design disciplines mentioned above. In the architectural section, questions were specific to floor plans, elevations, reflected ceiling plans, scale, section and details, schedules and legends, and miscellaneous. The other design disciplines consisted of questions in a general format, which covered several issues related to 100 percent construction documents. In the civil/structural section, questions were related to structural elements and dimensions. The mechanical section was focused on equipment, fire sprinkler systems, ducts, coordination issues and piping. The electrical section addressed aspects related to coordination among design disciplines, riser diagrams, panel board information, low voltage specifications and type of fixtures.

The QCC helped in several ways in developing the plan review checklist. The proposed checklist is heavily influenced by the QCC in its organization and structure. Also, relevant questions have been incorporated into the proposed plan review checklist.

5.5. RediCheck – Plan Review Checklist Services

RediCheck Associates is an organization that offers plan review services to locate design errors and omissions. "RediCheck is both a systematic method of construction document quality control and a professional group of architects and engineers who are authorized to perform RediCheck services directly for clients," (website: http://redicheck-review.com/, date visited: 03/17/2004). This organization uses various checklists based on each design discipline, which are titled together as "Interdisciplinary Checklists," and

include: civil, structural, architectural, mechanical/plumbing, kitchen/dietary, specifications checklists, and consolidated RediCheck checklists. The RediCheck approach to dividing checklists on the basis of design discipline was adopted for the suggested plan review checklist developed by the researcher.

5.6. Interviews

The responses of the checklist development interviewees helped in the organization and development of the checklist. Using information gained from the interviews, the researcher was able to organize a checklist on the basis of design discipline and implementation at the four design levels. The respondents felt that keeping the checklist informal and general would help in improving the current plan review process. Therefore, the checklist was developed to be general for broader categories, such as dimensions and standards pertinent to a specific design discipline, but detailed on issues with a high recurrence of keywords in the database, such as ceiling spaces and ducts. Refer to appendix IV for the questionnaire of checklist development interviews.

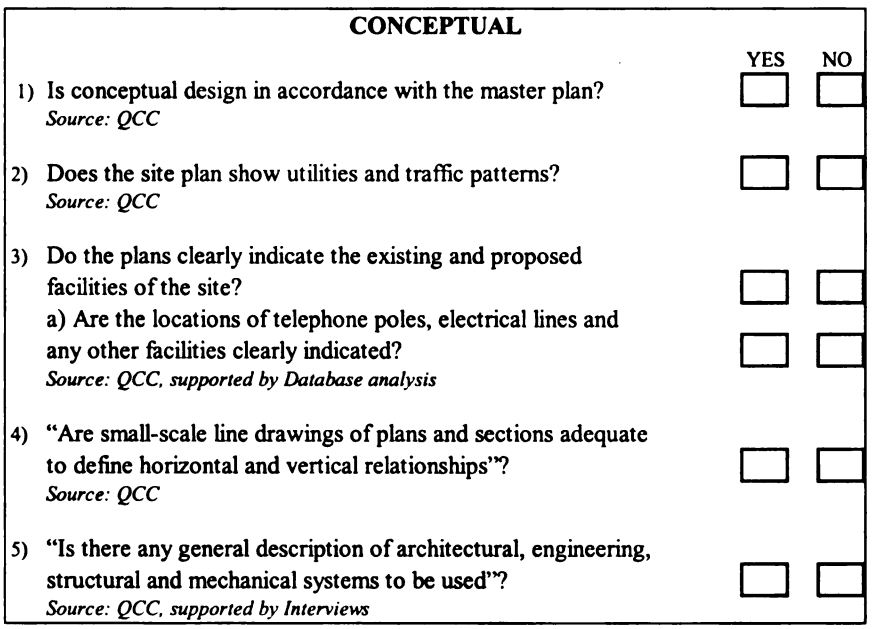
5.7. Plan Review Checklist

From the analyses and the information obtained from the interviews, a plan review checklist was developed that was organized on the basis of design discipline, and could be implemented at the four design development levels. The purpose of this checklist is to assist the staff of a university in the plan review process. Use of the checklist would aid in identifying various design review issues that were sometimes overlooked in university projects. This checklist should be used as a supplement to current plan review processes and as a vehicle for improving plan review processes. The

organization of the checklist is presented below, followed by discussion of the validation procedure. The checklist is included in its entirety in Appendix VIII.

5.7.1. Organization of the Checklist

The organization and structure of the checklist was mostly influenced by the Notre Dame's Quality Control Checklist, the MSU interviews, and RediCheck. The researcher adopted a similar approach as the QCC, and organized the checklist at two levels: (1) design phase of the project and (2) construction discipline. The design phase includes four subdivisions: conceptual design development level, schematic design development level, design development level, and contract documents level. The subdivisions of design phases are classified into construction disciplines, which include: architectural, civil/structural, mechanical and electrical. Interviews conducted to validate the proposed checklist suggested a similar approach. This organization of the checklist will be helpful in reviewing each discipline individually and addressing the coordination issues simultaneously. Refer to Figure 5.1 for an excerpt of the plan review checklist and refer to appendix VIII for plan review checklist.



CONCEPTUAL

	YES	NO
1) Is conceptual design in accordance with the master plan? *Source: QCC*	☐	☐
2) Does the site plan show utilities and traffic patterns? *Source: QCC*	☐	☐
3) Do the plans clearly indicate the existing and proposed facilities of the site?	☐	☐
a) Are the locations of telephone poles, electrical lines and any other facilities clearly indicated? *Source: QCC, supported by Database analysis*	☐	☐
4) "Are small-scale line drawings of plans and sections adequate to define horizontal and vertical relationships"? *Source: QCC*	☐	☐
5) "Is there any general description of architectural, engineering, structural and mechanical systems to be used"? *Source: QCC, supported by Interviews*	☐	☐

FIGURE 5.1 EXCERPT OF PLAN REVIEW CHECKLSIT

The questions listed in the checklist were drawn from the various sources discussed above, but heavily draws on the QCC of the University of Notre Dame. Many of the questions in the conceptual and the design development level of the proposed checklist are adopted from QCC.

The checklist consists of 128 questions with multiple sub-questions under each specific question. The checklist includes 6 questions at the conceptual level, and 27 questions at the schematic level. At the schematic level, one question is common to all disciplines, and seven questions are in the architectural category, four for civil, eight for mechanical and eight for electrical.

The design development level plan review checklist contains five categories: a common category, followed by architectural, civil/structural, mechanical, and electrical,

and includes 39 questions. The common category contains questions related to applicable codes and standards. 12 out of total 14 questions in the architectural category were developed from the database analysis. Two questions that were related to insulation and fire systems were adopted from the QCC. The mechanical category includes 6 questions, which were mostly influenced by the interviews and database analysis. Interviewees suggested several issues, which were incorporated in this category. The electrical questions related to communication systems, etc., were adopted from the QCC. The remaining electrical questions were identified through the database analysis.

The final section of the checklist was titled "Contract Documents", whereas in the QCC it was titled as "100 percent Construction Drawings Checklist." The researcher opted for a different title because it was mentioned in the interviews that the final set of drawings that are reviewed would not always be 100 percent complete; consequently, they suggested the title, "contract documents." It includes 55 questions. This section was heavily influenced by Civitello's recommendations and the database analysis, although the QCC was used in various instances. The architectural section includes 7 questions which were identified through the comparison of database with the Civitello's checklist. The questions address several aspects, such as specifications, code compliance, match lines and orientation, floor plans and dimension, elevations, ceiling plans and legends.

The civil questions were derived from the database analysis, and include questions related to footings and foundation drawings, whereas QCC questions used include: dimensions of structural elements and review of column layouts.

In the mechanical category, there are 18 questions, of which questions derived from the interviews include: compliance of equipment and systems with MSU standards

and identification of spaces for equipment and their respective locations. The questions related to duct and ceiling places were extracted from the database comparison with Civitello's checklist. All remaining questions were identified through database analysis, and include: review of types of pipes, sprinkler systems layout and specialty equipment.

In the electrical category there are 17 questions. Questions related to panel boards, riser diagrams, specifications, and grounding were adopted from the QCC. The remaining questions resulted from the database analysis, and included: compliance of electrical systems with university standards, legend, lighting plans, conflicts with mechanical and structural elements, and type of fixtures.

The questions in the checklist address recurring causes of change orders discovered during database analysis, the review of the Civitello change order discovery checklist, review of QCC and checklist development interviews. Questions in the checklist are organized on the basis of design development phase, and subdivided into design discipline. The checklist addressed items which may generally be overlooked during the plan review process.

5.7.2. Implementation

The plan review checklist addresses various design related elements and is organized at four different design levels. Plan reviewers should check the listed items during the plan review process. All "no" responses should be provided with written descriptions explaining the necessary actions to be taken to correct the items listed. The complete plan review checklist is included in Appendix VIII. This checklist can act as a supplement to the current plan review process. During the MSU staff interviews it was suggested this checklist should be used with the current informal/formal plan review

process followed by university personnel. It was indicated that this checklist should be used by experienced plan reviewers of the university, who would be able to customize it according to their needs. New plan reviewers or any third party should be trained to use this proposed checklist. Also, this checklist should be used by plan reviewers with relevant information provided, such as functional briefing and narrations of mechanical and electrical systems. Building codes and standards which will assist in a better plan review process should also be provided.

5.8. Validation

To validate the checklist, interviews were conducted with construction administrators at Michigan State University. The checklist was provided to three MSU construction personnel in advance for their review. Interviewees were asked for their views and suggestions regarding the checklist. All plan reviewers had approximately 20 years of experience in plan review processes and were involved in all stages of plan review. The specific responses of interviews are included in Appendix V.

Interview responses were generally similar. All interviewees indicated that using this checklist would be helpful and would serve as a tool to reduce the number of change orders. When asked if there would be any barriers to implementing this checklist, one of the respondents indicated that it should be able to be tailored to the needs of the plan reviewer. Two of the respondents indicated that training staff to follow this checklist would be a good idea. When asked if the checklist should be made mandatory in the plan review process, all indicated that it should not be mandatory; rather, it should be left to the plan reviewer's discretion to follow it. The final question asked if this checklist would increase or reduce plan review process time; in general the respondents stated that the

checklist would increase plan review process time, as it would prompt them to review more options.

5.9 Summary

This chapter presents the plan review checklist, which was developed from the database analysis, literature review and interview responses. This chapter also describes the process of checklist development, followed by the discussion of its organization, implementation procedure, and validation.

CHAPTER 6

CHAPTER 6: RECOMMENDATIONS

6. 0. Introduction

This chapter presents discussion of preconstruction change order prevention strategies. The "plan review checklist," was discussed in Chapter 5. These strategies were developed by integrating the results of the database analysis and comparing the Civitello checklist with items in the database, interview responses, and through a literature review.

6.1. Recommendations

6.1.1. Recommendations for University Personnel

During interviews, respondents were asked to suggest recommendations that could help reduce the number of change orders on university projects. Most of the responses suggested that good programming and better university plan reviews would reduce the number of change orders. From the responses, the following recommendations were made:

1. University personnel should receive periodic training in the plan review process and in university standards.
2. University personnel should be given ample time to review plans and specifications.
3. University personnel should place more emphasis on coordination issues among various design disciplines (architectural, civil, structural, electrical and mechanical).
4. University personnel should make sure that consultant A/E's are following university standards during design and contract document stages.

5. Designers of university projects should receive training in the university standards, and frequent communication should be promoted between university personnel and designers.
6. University standards should be made available to subcontractors.

6.1.2. Recommendation for CSI Division Focus

From the database analysis, it was evident that CSI divisions 15 and 16 generated the most change orders items. Also interview respondents unanimously agreed with this research conclusion. Based on the responses of the interviews and literature review, the following recommendations were made:

1) Since the major problems in these divisions are related to lack of coordination between design disciplines, more emphasis needs to be placed on communication and coordination between the parties.
2) More time should be provided for the review of shop drawings due to the complexity of divisions 15 and 16.

6.1.3. Recommendations Related to Programming and Scope Definition

In section 2.3 (1) of the literature review, Kamara et.al., (2001) addressed the importance of functional briefing in an article titled "Improving Construction Client Satisfaction Through Functional Briefing", similarly Hassanen et.al., (2000) discussed functional briefing and programming. From these articles, it was found that communication between the owner and architect plays a vital role in project success. From the interviews, it was found that some change orders arise due to poor scope

definition and a lack of communication between the architect and the owner. Specific recommendations for improving scope definition are as follows:

1) Scope changes can be reduced by utilizing strong programming practices. End user involvement during the development of a functional brief is critical. Architects should take the lead in developing accurate functional briefs and should educate the owner about the project.
2) More time should be allocated for programming, and to identify the needs of a project. The scope should be clearly defined to help architects develop designs for the project, which satisfy the owner's objectives.
3) During the interviews, it was suggested that the owner should make sure that designers are following university standards during the design development stage. Any deviations from standards should be checked during the review and brought to the attention of designers.

6.1.4. Prequalification of Architects

Based on the literature review, it is recommended that architects be prequalified for the work. The researcher reviewed QBS and architect selection criteria adopted by universities.

To ascertain qualifications of architects, questions relating to the following can be included: (1) project related experience, and number of years of experience in industry, (2) hierarchy of the firm, and information related to the assignment of staff for university projects and the determination of their responsibilities, (3) protocols and plans adopted to reduce design errors and omissions and information related to an internal quality program (if any), (4) the plan review process and coordination with other design disciplines, (5)

schedule of planned activities, and (6) familiarity with university standards and the challenges faced in university projects

6.2. Summary

This chapter discussed the recommendations developed through the literature review and interview responses. Recommendations are suggested for reducing change orders causing by design errors and omissions, and are categorized as: recommendations for university personnel, which are focused on better university plan reviews, coordination between project participants, communication practices among the owner and an architect, such as programming and scope definition. In the final section, recommendations related to prequalification of architects are included.

CHAPTER 7

CHAPTER 7: SUMMARY AND CONCLUSION

7.0. Introduction

This research was intended to identify preconstruction change order prevention strategies for university projects and the focus of this research has been on reducing change orders caused by design errors and omissions in university projects. This chapter provides an overview of this report and concludes by identifying future areas of research.

7.1. Overview of the Report

The first chapter of this report introduced the research topic and established the need for the study. In chapter 2, literature related to change order practices and preconstruction change order issues was presented. Chapter 3 presented data collection methods used for this research, and chapter 4 discussed data analysis. Chapter 5 presented the plan review checklist, which was an important deliverable of this research. This was followed by the discussion of preconstruction change order prevention strategies and recommendations in Chapter 6.

7.2. Understanding Preconstruction Activities

To gain an understanding of preconstruction activities, the researcher identified papers and articles, related to functional briefing, scope definition, pre-bid issues, prequalification of project participants, coordination issues of design disciplines, partnering, and commissioning. These were used in conjunction with the database analysis and interview responses for formulating recommendations.

7.3. Identifying the Causes of Change Orders by Studying the Case Study University

In order to identify the sources of change orders, a database of recent MSU projects was analyzed. Paper files, including correspondence, bulletins, and other documentation for each item, were reviewed to determine reason codes. A database of 16 MSU projects, 19 contracts, 157 change orders, and 1,675 change order items was developed in MS Access as a part of the umbrella project. This database was analyzed to find the sources of problems within individual CSI divisions. A study of the narrative descriptions using KWIC was conducted to identify recurring sources of change orders on MSU projects. These analyses were used in developing a plan review checklist. The major findings of the database analyses were: (1) 42% of change orders in the database resulted from design errors and omissions, (2) CSI divisions 15 and 16 were associated with the greatest number of change order items in the database and accounted or the greatest cost increases compared to other CSI divisions, and (3) ceiling spaces, light fixtures, ductwork, columns, and beams were identified as likely causes of potential change orders.

7.4. Compilation of Current Preconstruction Change Order Issues

In addition to database analysis, interviews with construction personnel were conducted to gain their perspectives on change order management practices in industry. The respondents included two architects, six contractors, three subcontractors, and construction personnel from five research intensive universities. The five research intensive universities participating in these interviews were: (1) University of Wisconsin, (2) Purdue University, (3) University of Minnesota, (4) University of Notre Dame and (5)

Michigan State University. Open-ended questions were used for the interviews, with a total of 45 questions. The obtained data was paraphrased, tabulated, aggregated, and was used in the development of recommendations.

During the university interviews, it was found that design errors and omissions, field conditions, scope changes, and coordination between design disciplines are dominant causes of change orders. Architecture, mechanical and electrical disciplines are associated with greatest number of change order items. Respondents also indicated that partnering, commissioning, and usage of ISO program were not effective in reducing change orders. However, better programming and functional briefing, pre-bid walk-thrus, and improved plan review processes can help in reducing change orders.

7.5. Development of Recommendations

The database analysis, literature review, interviews with construction industry professionals, and interviews with MSU construction personnel formed the basis for the development of recommendations. Individual reports were made for each analysis and interpretations were drawn from each report. The researcher integrated data from the various sources and used it to form the recommendations of the research.

7.6. Limitations of the Research

This research was aimed at developing preconstruction change order prevention strategies and utilized a case study to identify the causes of change orders. Michigan industry professionals with a variety of backgrounds and construction firms were interviewed to learn about change order activities. Therefore the limitations of the study included: (1) because the database analysis reflect a limited number of projects from one university; it may not be representative of the construction systems of all research

intensive universities, (2) the interviewees represented only Michigan-based firms, and Midwest universities, findings for other geographic locations or for other types of organization may be different.

7.7. Conclusions

Preconstruction is the first phase of construction, and has a significant impact on all subsequent activities. From the literature it was found that change orders identified at the early stages have a smaller impact than change orders identified during the later stages of a project, which suggests the importance of front-end activities of a project. Unidentified issues during the early stage of a project often creep up during construction, which can increase the cost of a project. Because few researchers consider change orders as a value added process, most of the time a sense of resistance is observed by the project participants. This research made an attempt to reduce the list of unidentified issues during the preconstruction stage by proposing a plan review checklist, which may reduce the number of change orders. Though this research addresses various preconstruction issues, the scope was limited to design errors and omissions. The next step of this research could be to expand its scope in order to address other areas of preconstruction with greater depth.

7.8. Areas of Future Research

This research addressed preconstruction change order issues and, focused on design errors and omissions. As a part of this study, 16 projects of one university were studied and construction professionals were interviewed to learn about preconstruction activities. Data collection could be expanded to more than one university, such that recommendations can be generalized to the larger group of universities.

The KWIC (Keywords In Context) approach was used during the database analysis to identify common sources of change orders. The list of keywords used, could be made available to plan reviewers to expand the current checklist and make it more comprehensive. This could have the potential to improve the current checklist. Checklists could be developed into different types, depending upon the time available for plan review. A checklist could be developed for a quick review or an extensive review of a project.

Another area of preconstruction activity that plays a vital role in the success of a project is scope definition, which is done as a part of developing a functional brief. "Briefing has risen on the construction client's agenda as building users have become more demanding and clients have increasingly found that the buildings they procure are often inappropriate for their needs," (NBS, 2002). A strong brief can make a major contribution to the success of a project. This research could be expanded to include the process of scope definition through functional briefing, and could include recommendations to improve communication between project participants at the preconstruction stage and also could examine briefing processes.

During the interviews, respondents mentioned that prebid walk-thrus can be an effective tool in reducing change orders. This occasion can be used as a platform to understand the project scope and learn about goals and objectives of the project. This phase of preconstruction can be studied in detail to provide more recommendations to improve efficiency of walk-thrus, and making them mandatory. Recommendations can be developed addressing several issues which include: (1) prior to the session - developing a well defined agenda, (2) during the session - providing accurate and important

information, which can help trade partners to understand more about the project, and (3) after the session – distributing meeting minutes to all trade partners for review and future reference.

Although change orders may play a role of an uninvited guest in a project, it is possible to foresee them and adopt necessary measures to avoid them before they occur. By adopting good project planning strategies and implementing necessary actions during the preconstruction stage, change orders can be significantly reduced. This research provided a tool and recommendations which can reduce change orders caused by design errors and omissions in large university projects. The plan review checklist can act as a vehicle for identifying potential areas of change orders, which are generally overlooked during plan review.

General recommendations provided by the researcher can also aid universities processes for improving quality and coordination of design documents, which can lead to a reduction in changes caused by errors and scope definition.

APPENDIX I

REASON CODES

DESIGN ERRORS AND OMISSIONS

Reason Code	Description	Explanatory Description
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
Documents	-	General term used prior to CGO detailed codes

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 filed changes not described above
Field	-	General term used prior to CGO detailed codes

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
Site scope	-	General term used prior to CGO detailed codes
Scope	-	General term used prior to CGO detailed codes

APPENDIX II

KEYWORDS FOR CSI DIVISIONS USED FOR KWIC SEARCH

KEYWORDS FOR CSI DIVISIONS USED FOR KWIC SEARCH

CSI Division	Description	Occurrence
1	Drawing	7
	Bulletin reproduction costs	6
2	Excavate	6
	Pipe	11
	Flooring	11
	Pavements	11
	Walk	15
	Concrete	15
	Asbestos	8
3	Pier	4
	Concrete	14
	Beam	4
	Footings	4
	Slab	6
4	None	
	20/31 items are from one project	
5	Steel	17
	Beam	22
	Lintel	6
	Angle	6
	Column	8
	Roof	22
	Plate	7
	Deck	5
6	None	
7	Flashing	5
	Dampproof and waterproof	6
	Sealant	4
	Caulk	2
	Blocking	2
	Laminate	1
8	Windows	7
	Doors	72
	Frame	14
	Hardware	15

CSI Division	Description	Occurrence
9	Doors	31
	Ceilings	14
	Frame	14
	Roof	71
	Drywall	8
	Painting	23
	Metal	9
10,11,12,13,14	None	
15	Pipe	44
	Insulation	13
	Drainage	26
	Duct	35
	Valve	24
	Damper	8
	Grill	9
	Steam	20
	Air	33
	Supply	18
16	Switches	17
	Duct	17
	Detector	7
	Circuit	16
	Fire	12
	Wire	12
	Fixture	22
	Light	43
	Conduit	29
	Security	5
	Communication	12
	Data	16

APPENDIX III

TABLES OF INTERVIEW RESPONSES USED FOR UMBRELLA PROJECT

SUBCONTRACTOR INTERVIEWS

SUBCONTRACTOR INTERVIEWS – TABLE A3.1

Feed back from SubContractors			
Question Code	**Question**	**Response**	**Response code**
Q1	What is the title of your position within your firm?	President	**S1**
		CEO	**S2**
		Divisional manager	**S3**
Q2	Can you provide approximate recent construction data for your company (or department) such as approximate number of projects, types of projects, dollar value and or project profiles?	Data omitted for confidentiality	**S1**
		Data omitted for confidentiality	**S2**
		Data omitted for confidentiality	**S3**
Q3	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 project records aggregated for the purposes of determining average change order rates?	No	**S1**
		Yes. Put jobs in archives. Send a 2 page survey to owners to get information on the company (performance, fairness on change orders, working with other trades, if we were thinking ahead). Yes Daily. We use timberline PM module (since 2 years) and have daily reports on job sites. Actually owners must put everything on the internet too: RFIs, invoices, all documents.	**S2**
		Nothing formal, daily review of job cost, daily loss and profit is detailed. Nothing on CO's	**S3**
Q4	Has any analysis been undertaken to determine change order causes? Can you describe this process?	No, Informally YES. In new projects for roofing the design didn't meet the standards of the university. Designers have to pay more attention to MSU standards	**S1**

	What were its findings? Were recommendations made and implemented?	PM and estimators compare change orders to bids. We look at it for: request for change (money change), no change (no change on money. For example shift doors before wall are built) and N/A change orders (ones which donor affect us). This is the only classification we use.	S2
		Yes, not formal, missed on plans, specifications are not an issue. Some contractor review can help. Experience people are required, better training of design Engg.	S3
Q5	Have you standardized systems for classifying causes (such as scope, document error or field conditions)? Describe.	No	S1
		No	S2
		No	S3
Q6	Have you drawn any conclusions with respect to the dominant causes of change orders? What are they?	No	S1
		Not enough time to bid. Not enough time for architects to prepare drawings. RFI should be answered. Poor communication. Use of Construction management instead of General contracts.	S2
		Designs work on paper, not on field. Lack of experience in design and require constructability reviews.	S3
Q7	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 typical change order rates?	No	S1
		No. Most contractors do not want change orders contrary to owner's beliefs.	S2
		No	S3
Q8	Is that rate of changes orders seen as acceptable by owners? Explain.	Sophisticated owners understand, I don't know	S1
		Maybe	S2
		They get surprised, but no problems with MSU. Dealing with one of Mau's organization directly or through a GC on EAS projects	S3
Q9	Are you aware of any published industry average rates for change orders?	No	S1
		No	S2
		No	S3
Q10	Are performance	N/A	S1

	records of your lower tier subcontractors formally or informally considered with respect to change orders? If yes, can you describe how they are monitored by your organization?	No. But we rate the other people we work with and our competitors. We have set up a database of costs, markups, bids, who were the people involved in each job within our firms and other project participants. We use a weighted rating system that rates them for performance, fairness, schedule, estimated project profit. Then we add a factor in our bids depending on all this.	S2
		Yes, through job costing. No work is done unless CO are signed and approved. CO's are not tracked for CO's.	S3
Q11	What are the typical durations for processing change orders? Do these durations contribute to additional costs such as extended general conditions, ripple effects or impact change orders?	Way too long, 60-120 days from discovery of change including payment process. Problems are in MSU authorization time. Durations contribute to extended general conditions, but we don't increase cost	S1
		6 -10 months. Identification of change to MSU authorization. It affects our morale more than anything else.	S2
		Depends on the schedule, processing happens quickly if it will hit the schedule. Takes 2-3 weeks from identification of change to MSU authorization date. CO's don't impact us much.	S3
Q12	When general contractors or construction managers award construction contracts, are change order histories of subcontractors considered in determining if they are "qualified" for the work. How is this information solicited?	To a very small extent, no experience as such, low bid is the only factor	S1
		I don't know, but like I said we do.	S2
		No	S3
Q13	In your opinion do subcontracting, construction or design firms which participate in ISO programs usually have reduced change order rates on projects?	No	S1
		No not consistently. ISO is highly over rated. Quality is very important, having a quality plan is more important than using ISO.	S2
		What is ISO? N/A	S3
Q14	Do you have any	GC 1, CM 2, DB 3 High to low.	S1

	opinion or analysis on whether the project delivery method such as design build, construction management or general contracting influences change order rates? Explain.	Negotiated general contract is the best in my opinion. General contracts were always better. GCs bid the job hard dollar, more time was given o bids, trained skilled people were there to answer questions and they knew what they were doing. CMs when they began were GCs doing CM jobs and they still employed skilled experienced people on jobs. Now that generation has retired. We have fresh graduates with little experience brought onto jobs with no training. They should be tapped for other skills, not field skills. We need answers to open items and incomplete drawings. CMs do a poor job and work for the owner, not for the project. I don't know much about design build but I guess owner has poor control on these projects.	**S2**
		Yes. Lowest DB, CM, GC. CMs have better field of civil.	**S3**
			S4
			S5
			S6
			S7
Q15	Do you have any opinion on whether the spread (variation) of quotes received from subcontractors influences change order rates? Are they a good predictor of change orders on a project?	Yes, by rule of thumb. If low bidder misses something who would ask for CO, but it isn't a good predictor of CO	**S1**
		-	**S2**
		Effects a lot. Lower bidder will markup Cos. I don't like the low bid system. It's better to have prequalification system.	**S3**
Q16	How common is it for change orders to be caused because the designer and owner failed to communicate on aspects of the design, leading to scope changes necessary to make the design work properly for the owner?	Big one, very often	**S1**
		Very common.Owners need to take responsibility and commit to time. They should hire experienced architects not people who have never worked with MSU before and put them on important jobs.	**S2**
		N/A	**S3**
Q17	Are construction documents adequately reviewed and coordinated by A/E	There is a room for improvement. In few projects, MSU didn't detail the projects enough. They dint had enough time to finish drawings	**S1**

	firms prior to bidding? Explain.	There is not much time given for that. RFIs don't get answered prior to bidding. Drawings are always hastily prepared. 20 years ago and architect would discuss problems before the bid. Now with CM jobs architects are no longer doing that job and don't take any calls. Opportunities to get answers for better bids, better details, and completed drawings are lost. MSU is preventing getting a better deal for itself by blocking direct communication with architects by use of CM jobs. Specifications are not specific anymore. You're letting contractors bid on chances instead of reality. Ambiguity goes in favor of trade contractors and not owners. They must understand that. Give more time to architects and let them directly communicate. Speed isn't everything, speed on drawings affects quality. People aren't given enough time to think.	**S2**
		Yes and No. We basically verify the quantities	**S3**
Q18	On university projects, are construction documents reviewed adequately by the university in detail prior to bidding? Explain.	No, MSU doesn't understand a lot about roofing. Architects don't design as per MSU standards, more conflicts with Architectural trades. Don't know constraints of roofing projects. Original standards are Ok!	**S1**
		They spend time on it. But somehow things always slip through. Like I said give architects their powers like earlier, don't shift these vital responsibilities to Construction managers. Sometimes architects don't even come on site, they are out of state and never communicate. What answers will new hires on CM teams give us?	**S2**
		N/A	**S3**
Q19	Has your organization been involved with projects which have used commissioning services? Have these been effective in reducing change order rates?	No	**S1**
		Yes worked very well. Also involve more experienced people when drawings are at 80% completion stage bring qualified people, job site people and some subcontractors. Get people talking like before.	**S2**
		N/A	**S3**

Q20	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?	Yes, worked on partnering. Not effective in reducing CO's	**S1**
		Yes. It works. But nobody partners with employees. Get everybody involved, it saves time in the long run.	**S2**
		No	**S3**
Q21	Are probed meetings or wakthrus conducted for university projects? Always? Describe? Have they been effective in reducing change order rates?	Yes, nearly always. They have been effective in reducing CO's. An addendum or preconstruction meetings need to be published. This helps in coordination	**S1**
		Yes. Yes. Sometimes they are not very good.	**S2**
		Yes, sometimes. They are not always effective in reducing CO's. Many may not point out deficiency in cashing out CO's later. If there was a glaring error, contractor will not bring it out. If clarification is required, they will ask, for example. Material already present in built work	**S3**
Q22	Which design professions cause the most change orders for your organization? Explain.	Architecture profession. More the experience of architects, the better it is	**S1**
		N/A	**S2**
		Site work	**S3**
Q23	Based on your work with large owners and contractors, what organizational traits or processes contribute to excessive numbers of change orders?	Don't know. Design should be closely watched	**S1**
		Define the leader, who is making all the decisions and what kind of decisions. MSU has made good progress over the last 5 years. The PRs and PMs are very good assets now. It wasn't so earlier. But they need to make more progress. They should define their processes clearly. It's nothing to do with organization. It's everything to do with people and attitude.	**S2**
		N/A	**S3**
Q24	Based on your work with large owners and	Don't know. Too many people in the pie may not talk enough.	**S1**

	contractors, what organizational traits or processes contribute to reduced impacts of change orders?	Large owners have talented and experience people. They are supposed to make quicker decisions. Why debate on prices over and over again after negotiations. Even after work is done we can't bill for it and for so long. Sometimes in large organizations documents even get lost. Subs are not allowed to directly communicate with owners so no body knows if the GC is messing up or the owner. "Talk more within departments" and define processes. Assign defined responsibilities and trust them with it.	**S2**
		Lack of experience in site work. Qualified field supervisor and construction reps. Don't start work unless CO's approved. XXX has good process.	**S3**
Q25	What impact do the design/construction standards of Michigan State University have on the number and types of change orders? Explain.	Large impact. Architects use incorrect material or designs to some degree on every job. Don't know about number of changes.	**S1**
		MSU has good standards. Of all the universities MSU understands its projects better. But the architects that are employed, does MSU make sure they understand them too?	**S2**
		N/A	**S3**
Q26	How are overhead and profit normally determined on your university projects? Are rates typically allocated in the construction contract? Are disagreements over mark-ups for overhead and profit on change orders common?	Not in contract. For CO's it is dictated in the contract. Disagreements are common, 15% is not fair	**S1**
		By contract. MSU has been a good teacher.15% is fine, but when owners extend processing time and don't consider you on your years of experience and loyalty on bid day, it shows disrespect.	**S2**
		Yes, Yes. No disagreements with MSU.	**S3**
Q27	Are disagreements over extended general conditions costs, mobilization costs or loss of productivity common? Do owners generally under stand indirect costs which you incur on changes? Explain.	Not an issue. Not a factor except delivery change.	**S1**
		Yes but we don't charge them to MSU	**S2**
		No, MSU understands well	**S3**

Q28	Can you comment on the effectiveness of Michigan State University's change order process? What should be changed?	Don't know the total process. Proj rep doesn't process paper work. Need commitment on time. Penalty charge for late payment will force them to approve.	**S1**
		We don't know if MSU sits on change orders or the contractor is not paying us. Other owners care for project relations. If contractors put unrelated items in change orders and due to some problem on some other subs items our items get held up. Both contractors and owners should be good leaders. If you expect 110% , you get it only if you treat people with respect for their time and work. Don't disrespect RFIs.	**S2**
		Works pretty well. We work closely with one of the departments and we have no complaints.	**S3**
Q29	From your perspective do you have any suggestions that could be employed by Michigan State University to reduce change orders or their impacts?	Better review or architectural documents. Closer coordination of MSU and architect. Requires clearer design intent.	**S1**
		Respect everyone's time. Trust more. Define your responsibilities as leaders. Define your process. Have prequalified contractors for certain projects and look at the subs they bring to the table before accepting. Low bid isn't everything. Clean your documents and specs and have open communication.	**S2**
		Soil conditions improve	**S3**
Q30	Do you provide construction services for universities other than Michigan State University or other large public sector owners? Can you comment on what aspects of their change order management processes should be considered for adoption by Michigan State University? Explain.	Yes, more commitment.	**S1**
		Yes. Inviting bids from prequalified contractors and subs for certain projects. Let the people who just entered as bidders for MSU learn and aim for performing better and to get into the prequalified list. MSU understands its project very well, better than most others.	**S2**
		N/A. MSU does good job, it is very thorough and stream lined	**S3**

Q31	Do you have any other comments regarding change orders that you would add?	No. Incomplete drawings. Approval should be done with more authority, such that payment process should not be delayed. Define what CO's are, so that it will be easy to bid for changes on incomplete drawings Vs more complete drawings. Payment process is Reasonable.	**S1**
		MSU is extremely picky, to the extent that it is counterproductive. Time taken to process change orders is so long that it shows that such an important process is not getting the attention that it requires. Don't avoid necessary changes. The product should satisfy the end user, those are legitimate. Avoid unnecessary changes like drawings errors, omissions. MSU interferes in the construction a lot, which is good and bad. But when you're done you're done, why argue over changes then, you were involved so closely. Change orders are an indication of an unclean system of construction management and drawings.	**S2**

CONTRACTOR INTERVIEWS

CONTRACTOR INTERVIEWS – TABLE A.3.2

Feed back from Contractors			
Question Code	**Question**	**Response**	**Response code**
Q1	What is the title of your position within your firm?	PM and safety administrator	C1
		Vice presidents(preconstruction, estimating)	C2
		Project Directory	C3
		Senior Estimator, Project Manager for GC	C4
		Proj mgr	C5
		Licensed structural engineer. Sr Project Mgr & VP & Proj Eng	C6
Q2	Can you provide approximate recent construction data for your company (or department) such as approximate number of projects, types of projects, dollar value and or project profiles?	Data omitted for confidentiality	C1
		Data omitted for confidentiality	C2
		Data omitted for confidentiality	C3
		Data omitted for confidentiality	C4
		----	C5
		Data omitted for confidentiality	C6
Q3	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 project records aggregated for the purposes of determining average change	Every project >$10,000. Use master builder software. Process of formally keeping records.	C1
		Formal Analysis at preconstruction, midconstruction, post construction. Not aggregated post construction. Financial status reports go through change orders, schedules, projects	C2
		Yes, Gather info for future projects. Analyze sqft cost, man hrs, reevaluate the schedule, informally find out causes of CO	C3
		Internally Yes, not formally. When owners ask for CO, you tend to push more number of CO's, which is not a good thing	C4
		No autopsy done	C5

	order rates?	No formal program. Quality analysis. Lessons learned on job in general, not specific to Change orders	C6
Q4	Has any analysis been undertaken to determine change order causes? Can you describe this process? What were its findings? Were recommendations made and implemented?	Not as a company, but individually PMs have. Have studied about 500 items for negotiation.	C1
		No	C2
		Not really, errors & omissions, poor quality design, owner scope, field conditions, site work. Give arch ample time to follow, pay architect upfront for more detailed analysis, Contract language doesn't require architect to do any detailed analysis. Give university personnel ample time for detailed analysis	C3
		No formal analysis. Lessons learnt report	C4
		No	C5
		drawings, lack of coordination of drawings, owners scope changes, field conditions	C6
			C7
Q5	Have you standardized systems for classifying causes (such as scope, document error or field conditions)? Describe.	Reason codes being assigned. Mostly same: scope, doc, and field.	C1
		No	C2
		Yes, all 3. Done only for marketing purposes. Owners ask for CO% and where the costs can be reduced	C3
		No	C4
		No. A/Es cause errors and omissions. Personally I classify as owner, field and scope	C5
		No because we don't want to get into finger pointing at to who was at fault.	C6
Q6	Have you drawn any conclusions with respect to the dominant causes of change	Owners change scope, lack of info/ contradiction/vagueness, field conditions, no of layers of people who make changes but arrive late on projects, not updated standards.	C1

	orders? What are they?	Scope changes, Field conditions, document errors. Varies with jobs and parties. Usually projects for big owners have scope changes. For bonded projects usually we have field changes and errors. Scope changes depend on end users involvement in programming and architects. More time required on planning and mock up construction would bring in end user input.	C2
		-	C3
		Lack of information and details, (smaller dollar amount), Architects drawings, coordination between A/E and M,E. Scope changes by owner(large dollar amount)	C4
		CM more, GC, DB least. Method of contracting is major source. Dimension issues. 3 weeks - 1 month time given to contractor. CM can't check the drawings as well as A/Es.	C5
		Lack of skill in drafters, people unaware of building systems. Coordination is biggest problem in fast track projects. Same details are put in and are used over and over again, without thinking if they are applicable. Documents are not laid out in a way that it is easy to verify.	C6
Q7	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?	New 3, complexes 6, renov 7, science 7.	C1
		A = 2.5% d = 7%	C2
		5-10%	C3
		5, 7-10, 7-10, 7-10, 2, 5, 5-7%	C4
		10, 12-13, 12-13, 15-17, 25, 25	C5
		8, 10-15, 10-15, 10-15, smaller amounts, smaller amounts. Sports 12-20 depends on quality of docs.	C6
Q8	Has any analysis been conducted which helps you to predict change orders rates for projects? If so can you describe your process or	Not typically. While bidding consider 7% contingency, we don't bid for extras. Photocopying costs alone are a lot. Not a predictor. Variability is accounted for in bids	C1
		Define the change order process, define change orders	C2

	methods? What are your change order rates?	No detailed analysis. We look at contingency of a project. Analysis done job specific, for ex depends on what time of a year, schedule constraints, rule of thumb	C3
		No, Details missing, may be more errors in drawings	C4
		No	C5
		No	C6
Q9	Is that rate of changes orders seen as acceptable by owners? Explain.	don't know.	C1
		Some may see it as acceptable, some don't.	C2
		Sophisticated owners accept CO	C3
		Knowledgeable owners accept it, now and then it's a problem	C4
		Yes, A/Es are considered for changes, as it reflects their design. Volume of CO's, speed of processing is important.	C5
		No. but money is an issue with them.	C6
Q10	Are you aware of any published industry average rates for change orders?	3% perhaps	C1
		CII don't know what the rate is actually	C2
		Don't know. There might be published data, but be wont rely.	C3
		No, may be meaningless, it depends on how contractors report it. There is no point in just reducing change orders, the quality has to improve first.	C4
		No	C5
		Maybe	C6
			C7
Q13	Are project contingencies established by owners generally reasonable or are they unrealistic?	How they are spent is important. Maybe spent on scope changes not having enough on docs and errors. No but don't think it should be. If they had passed through the process, they should not be disputed.	C1
		Reasonable but should be quoted upfront	C2
		Hard bid (owners wont disclose contingency). CM projects owner, architect, CM decide contingency)	C3
		reasonable.	C4
		Generally reasonable.	C5
		Reasonable.	C6

Q14	When owners award construction contracts, are change order histories of general contractors considered in determining if they are "qualified" for the work. How is this information solicited?	No	**C1**
		No. although there is a question on budgeted cost and actual cost, which is not enough to draw conclusions and hence is inappropriate.	**C2**
		No performance data is solicited. Informal information is sought.	**C3**
		No of CO's can't determine the quality of GC's. For CM Yes. Yes	**C4**
		No	**C5**
		Not really. Personal experience, size, finances. Want t know original budget and change orders which is unfair. What about scope changes due to owners, that isn't a fair representation of our reputation.	**C6**
Q15	In your opinion do construction or design firms which participate in ISO programs usually have reduced change order rates on projects?	No	**C1**
		No. Probably more since it institutes a more rigid process. Cannot afford to have relationship based decisions.	**C2**
		It's relatively new to construction. Yes, it should reduce CO	**C3**
		No, not at all. If architects implement, then it may improve CO's.	**C4**
		No	**C5**
		Not really, Can reduce errors maybe. ISO cannot control change order process as it has many variations. Nobody knows right answers in construction industry. A Framework does not really apply.	**C6**

Q16	When interviewing for construction management services, are performance records for change orders usually considered by owners when making their selection? How is that information solicited?	yes, unfair.	**C1**
		Pvt owners dont ask for questions regarding change order history as they expect change orders. When there is a lumpsum fee there is no need for change orders by construction management services.	**C2**
		Questions are barely related to analytical data. Performance records are answered by owners (informal, like how will you protect me from CO, saving costs?)	**C3**
		same as before	**C4**
		No	**C5**
		Yes. But the best thing to do is Give the best to the owner in terms of quality and money, not just educe change orders or payment.	**C6**
Q17	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.	Yes. Gc more, then CM, then DB.	**C1**
		Design build- least only scope changes but owners have less control on design. CM more thean DB less than CM. Plan review is better, owners control is more. In GC most number of Cos. Plans and specs are black and white.	**C2**
		Yes, got analytical data. CM, DB, GC (Lowest to highest), CM is cost effective, level of service, program management is better. GC's look for profitability. DB reduces finger pointing.	**C3**
		1GC, 2CM,3DB high to low	**C4**
		No	**C5**
		Cant compare and doesn't matter. The dialogue between parties is important. However in DB owner has less control on projects.	**C6**
Q18	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?	Should be intuitively, but ideally it wont happen.	**C1**
		GC scrutinize scope incredibly. CM more scrutiny on change order process. SC locate potential CO but will not inform GC & will show on bids. Variation is a red flag- need to keep it in mind but is not necessarily a good predictor.	**C2**
		Yes. Not sure regarding good predictors, large spread indicate unclear drawings. In low bids, bidder will look for opportunity for Cost	**C3**
		No, not really, but there is a perception that very low bidder can dig for CO's. If there is an error, we will aggressively follow it to makeup for losses, if we are low bidders or we made a mistake on bid day.	**C4**
		No	**C5**

		Sometimes it is indicative. Poor set of drawings indicate change order rates better.	C6
Q19	How common is it for change orders to be caused because the designer and owner failed to communicate on aspects of the design, leading to scope changes necessary to make the design work properly for the owner?	Most common.	C1
		-	C2
		Fairly common	C3
		Its common	C4
		35% are due to bad programming. Frequent	C5
		Common. 20% - 30% of changes.	C6
			C7
Q20	Are construction documents including engineering documents adequately reviewed by A/E firms prior to bidding? Explain.	Nobody's perfect. Standard of care of architects is very high. With budget cuts it is difficult. Coordination however is always an issue.	C1
		It's getting increasingly worse. QC is poor. MSU does a good job on choosing A/E.	C2
		Depends, they look at it differently compared to contractors. Architects look for completion and if their designs are efficiently expressed	C3
		They do a good job, but they have their stumbling blocks. Coordination with other designers is poor	C4
		No	C5
		No. more time should be allotted to A/E.	C6

ARCHITECT INTERVIEWS

ARCHITECT INTERVIEWS – A3.3.

Feed back from architects/ engineers			
Question Code	**Question**	**Response**	**Response code**
Q1	What is the title of your position within your firm?	VP	**A1**
		Senior associate. (civil engineer)	**A2**
Q2	Can you provide approximate recent construction data for your company (or department) such as approximate number of projects, types of projects, dollar value and or project profiles?	Data omitted for confidentiality	**A1**
		Data omitted for confidentiality	**A2**
Q3	How are typical design projects staffed when working on university projects? What are the specific responsibilities of the offices or individuals involved in your construction project administration process?	Estimating, proj mgmt, engineering is outsourced, project supervision project controller, safety rep and warehouse control. Proj mgr, controller involved in CO tracking	**A1**
		PM, Lead discipline, (structural, engineering, architectural etc) . Generally all projects are staffed like this. For MSU projects specially we use people who are familiar with MSU jobs.	**A2**
Q4	Do you conduct any formal post construction analysis of projects with respect to budget, schedule, change orders, or performance of the parties involved? Describe.	No	**A1**
		Yes internal. Post project evaluation, peer review of project all looked at. Written and documented.	**A2**

Q5	To what extent does your office monitor change orders on projects? Are project records aggregated for the purposes of determining average change order rates?	Yes, we record everything we quote. When a CO comes in, we check with quote. Check outstanding items before it is too late to get paid for. Items notified earlier, but are not approved like field orders	**A1**
		Project representatives from owner's side take a lot of responsibility. We still take responsibility to monitor change. We keep track of it for use on proposals. Owners ask for it in proposals.	**A2**
Q6	Has any analysis been undertaken to determine change order causes? Can you describe this process? What were its findings? Were recommendations made and implemented?	No	**A1**
		Informally. Our goal is to keep change order to minimum. Aggressive on documentation. Analysis is not client specific. Projects vary so much that we don't track causes. Continuous improvement process program is used to implement some recommendations.	**A2**
Q7	Have you standardized systems for classifying causes (such as scope, document error or field conditions)? Describe.	Field work orders, but don't get addressed to CCD, CO	**A1**
		Clients have classification. We only track dollar amounts and how they relate to our CIP.	**A2**

Q8	Have you drawn any conclusions with respect to the dominant causes of change orders? What are they?	errors, omission, incomplete drawings. scope changes, end user changes. Jobs where bids are called with incomplete drawings will have field changes, and too many RFIs are brought out, that are not even answered	**A1**
		Not necessarily dominant. General trend is that schedule driven push change orders up. Design process, review/bid shortened in such projects.	**A2**
Q9	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?	less than 5, <5, 20, 5, na, na	**A1**
		5, 5,10, 10-12, 15, 15	**A2**
Q10	Has any analysis been conducted which helps you to predict change orders rates for projects? If so can you describe your process or methods?	no	**A1**
		yes there are statistical summaries. % given earlier or lower than that.	**A2**
Q11	Is that rate of changes orders seen as acceptable by owners? Explain.	pricing is a problem, 15% overhead is poor. State of MI is 27.5%	**A1**
		yes and no.	**A2**
			A3
Q12	Are you aware of any published industry average rates for change orders?	No	**A1**
		AIA, EJCDC have lots of data. % given earlier would be comparable.	**A2**
Q13	Are performance records of consultants (engineering, landscape architects, etc monitored or tracked formally or informally with respect to change orders? If yes, can you describe how they are monitored by your organization?	n/a	**A1**
		Yes we ask for changeorders. Based on previous work, based on relation, quality reputation ismore important than change orders. We don't work with new contractors. Will work only through some previous contact, experience or known member of that organisation.	**A2**
Q14	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?	60-90 days, sometimes 4-5 months. Bulletins are faster, takes 30 days. CCDs and bulletins force us to work ahead, but payment is late, therefore we need to markup more on Cos, deduct Cos	**A1**
		Depends on amount and complexity of change rder. Between identifying problems to MSU takes froma a couple of days(purchase order) to couple of months(For formal/major projects)	**A2**

Q15	Are project contingencies established by owners generally reasonable or are they unrealistic?	Don't know.	**A1**
		We try to advice on what is realistic. But they insist on zero and zero is not reasonable.	**A2**
Q16	Who determines the testing program for elements such as soils testing, environmental conditions? How are they determined? Have testing programs generally been adequate or is this an area of concern or cause of change orders?	N/A	**A1**
		Joint decision. MSU provides.	**A2**
Q17	How are your design consultants 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?	Only for specializations, check on quality of drawings	**A1**
		-	**A2**
Q18	When	N/A	**A1**

	advising owners on award of construction contracts, are change order histories of general contractors considered in determining if they are "qualified" for the work. How is this information solicited?	It is certainly a factor. Contractors sometimes have very aggressive reputations for change orders, but their work is good quality and good on schedule. So it is only an awareness factor. NO. Change is nothing more than an indication of the circumstances in the project.	**A2**
Q19	In your opinion do construction or design firms which participate in ISO programs usually have reduced change order rates on projects?	Not at all, like partnering it's a dog and pony show, only a marketing strategies	**A1**
		Same parallel as CIP. Firms that aggressively involve a quality program makes things good for everybody.	**A2**
Q20	When advising owners in 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?	N/A	**A1**
		Not much info on that.	**A2**
Q21	Are you ever involved in assisting the owner in	Yes, no	**A1**
		Yes. Yes.	**A2**

	selecting construction managers? When selecting or considering construction managers are their performance records for change orders considered?		
Q22	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.	Yes, CM has less CO, they work for owners, but more disagreements with subs, bids will be higher. GC bids are better, but have more CO, GC thinks for subs, better drawings, subs would rather work for a GC. DB has less Cos, only scope Changes, prices are higher, less CO.	**A1**
		Yes. GC is good is adequate time is given to designers to do their jobs. In DB owners are not involved when job begins later as awareness increases scope changes come in.	**A2**

Q23	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?	-	A1
		no, owner may think that way, if bidder is low on a job or misses an item, they will try to make it up.	A2
Q24	How are building programs (needs briefs) established and documented? Are misunderstandings about program occasionally or commonly a cause of scope changes by the end user department? Describe.	could be, it shows on the job. Occasionally to often, not consistently.	A1
		Very strong emphasis of our approach to design. Direct meetings with ownes, written responses to review comments. Most projects weve worked on we had direct contact with end user	A2
Q25	Are construction documents including those of your design consultants formally reviewed by your organization in detail prior to bidding? Are checklists used? Describe this process.	n/a	A1
		Yes. Different levels of review, discipline specific, independent review, QA QC, standards and design document clash checks, constructability reviews.	A2

Q26	On university projects, are construction documents formally reviewed by the university in detail prior to bidding? Describe this process.	Yes, errors and drawings. Conflicts between standards and drawings. No language in contract that says what takes precedence.	**A1**
		Yes. When time is available they do a through job. Follow up is usually face to face. Multi disciplined review team. If there is something done that confounds MSU standards it is notified in written format.	**A2**
Q27	Has your organization been involved with university projects which have used commissioning services? Have these been effective in reducing change order rates?	No	**A1**
		Yes. Yes effective in getting the system working properly. Not change orders.	**A2**
Q28	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?	Yes, not at all. Partnering is introduced after bidding, but discrepancies will remain and cost you money. More communication will help, partnering does discuss on approval time, but doesn't get implemented	**A1**
		Few projects. Good idea to improve project communication. I don't know about change orders. Processing time is discussed in these meetings, how to reduce change orders, it also defines accountability and responsibilities. Set expectations on timely communication. People follow it to the end.	**A2**

Q29	Are pre bid meetings or wakthrus conducted for projects? Always? Describe? Have they been effective in reducing change order rates?	Yes, always, only if it's mandatory it will help. Spend more time on preconstruction stage, better to qualify contractors and negotiate with them. Sometimes owner force with out a bid date.	**A1**
		Necessary for contractors to submit better bids. It's to everybody's advantage . If contractors asks for information prior to addenda date.	**A2**
Q30	Which CSI divisions seem to cause the most change orders for your organization?	9 to 16	**A1**
		Don't know.	**A2**
Q31	Which design professions because the most change orders for your organization?	Schedule impact is more	**A1**
		Biggest challenge is scope change. Anything you can do in design process works to everybody's advantage. Most of the times end user is not a technical person and doesn't see a difference till it is built.	**A2**
Q32	Which construction trades tend to be most frequently involved with change orders for your organization?	Carpenters	**A1**
		Don't see a trend. Every trade has its own challenges.	**A2**

Q33	Based on your work with other large owners, what organizational traits or processes contribute to excessive numbers of change orders?	Yes, MSU has most number of Change orders, walk through should be mandatory. Specify who reviews at MSU. Specifically on renovations projects, so many things go unnoticed. Architects need to be more thorough. Owners know more about the building than architects, therefore they must communicate. walkthroughs should be mandatory for GCs and Subs while considering bids.	**A1**
		Owner scope change. Poor set of construction drawings. If bids come low owner tends to brings in things those they it could not afford earlier. Scope changes increase. Nothing to do with organization I guess.	**A2**
Q34	Based on your work with other large owners, what organizational traits or processes contribute to reduced impacts of change orders?	More time in bidding, not get bulletins, CCDs at end of projects, answer them upfront	**A1**
		Large owners may have poor communication. They should have internal commitment to go through changes fast. Sheer volume of projects handled by MSU makes them different from other large owners. Possibly they are understaffed as well.	**A2**
Q35	What impact do the design/construction standards of Michigan State University have on the number and types of change orders? Explain.	Not really, subs don't get standards. Mention that standards on specifications are online at meeting minutes and walk through.	**A1**
		Helps reduce them if owner Clearly communicates with consistency and designers know what MSU needs. Standards are also present online.	**A2**

Q36	How are overhead and profit normally determined on your university projects? Are rates typically allocated in the construction contract? Are disagreements over the contractor's mark-ups for overhead and profit on change orders common?	Yes, should get more, state of mi 20%	**A1**
		Yes. Based on prevalent wage rate and business requirements. There are but it is a reason for disagreement all the time. 15% is enough. With state projects maybe contractors make less money and hence need more profit on change orders. MSU allows reasonable markup, but if contractors are upset over processing time they should voice their concerns clearly to MSU.	**A2**
Q37	Are disagreements over contractor's extended general conditions or loss of productivity claims common? Explain.	No, mainly it spoils customer relations	**A1**
		Yes but not prevalent. It could also be due to contractor's poor initial schedule. Contractors deal with projects pretty aggressively if they still see a problem with these things and don't discuss it, it is their problem.	**A2**
Q38	Can you comment on the effectiveness of Michigan State University's change order process? What should be changed?	Refer to previous answers	**A1**
		Process is good. Needs to be documented and needs speed in processing. For each department define an acceptable period of time for processing and strive to reach it. If contractor is too laid back initially it turns into a problem later on and then they pursue it, when it is too late.	**A2**

Q39	From your perspective do you have any suggestions that could be employed by Michigan State University to reduce change orders or their impacts?	Preconstruction and walk thrus, architect should be pre qualified like subs and GCs	**A1**
		Its is a balancing act. Go through a thorough design process and give time change orders go down, but if you take away the schedule in doing so change orders go up. I think one should not push the schedule too hard. They must also spend time on review process.	**A2**
Q40	Do you provide architectural or engineering services for universities other than Michigan State University or other large public sector owners? Can you comment on what aspects of their change order management processes should be considered for adoption by Michigan State University? Explain.	Process takes too long, there is something wrong	**A1**
		Yes. Pvt sector are budget driven and hence are more competitive. If there is an open item they will discuss it and fix prices aggressively. Public owners take their money lightly.	**A2**

Q41	Do you have any other comments regarding change orders that you would add?	If liquidated damages are there and not meeting contract time, they should pay premium for acceleration, give incentives for finishing early. Prequalification of architects	**A1**
		Everybody in process has a responsibility and when we have adequate/ reasonable time for design, our statistical data show that change orders are low. We look forward to fast track projects, but risks go up and everybody should be more responsible and alert.	**A2**

MICHIGAN STATE UNIVERSITY INTERVIEWS

MICHIGAN STATE UNIVERSITY INTERVIEWS – TABLE A3.4

Feed back from MSU administrators			
Question Code	**Question**	**Response**	**Response code**
Q1	What is the title of your position within your firm?	Data omitted for confidentiality	U1
		Data omitted for confidentiality	U2
		Data omitted for confidentiality	U3
		Data omitted for confidentiality	U4
		Data omitted for confidentiality	U5
		Data omitted for confidentiality	U6
		Data omitted for confidentiality	U7
		Data omitted for confidentiality	U8
		Data omitted for confidentiality	U9
		Data omitted for confidentiality	U10
Q2	Can you identify the offices or departments which procure construction services for your university (or department)?	Response already given	U1
		40 projects, 300M annual volume Health Care, Historic preservation, Heavy Commercial, K-12, Institutional	U2
		EAS, housing, construction and design, and land management	U3
		purchasing contracts and grants, land management, interior design, housing and food services, maintenance.	U4
		University housing and interior design, CP& P, Physical plant, power plant, land management.	U5
		Information already provided.	U6
		Information provided earlier	U7
		Information provided earlier	U8
		Information provided earlier	U9
		Information provided earlier	U10
Q3	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 could we obtain this	Unofficial, yes. Just informal discussions.	U1
		Formal analysis at preconstruction, midconstruction, post construction. Financial status exports go through change orders, schedules, projects	U2
		Information already provided.	U3
		Given earlier	U4
		Information already provided.	U5
		Information already provided.	U6

	information?	Information already provided.	U7
		Info provided earlier	U8
		Info provided earlier	U9
		Info provided earlier	U10
Q4	Does an organizational chart exist which outlines your university's (or department's) construction project management parties? If so, can we obtain a copy of this chart? If not, can you identify the offices which are involved?	Yes, Reason codes. A/E or CR assigns Reason code.	U1
		No	U2
		Information already provided.	U3
		Already given.	U4
		Given earlier	U5
		Information already provided.	U6
		Information already provided.	U7
		Info provided earlier	U8
		Info provided earlier	U9
		Info provided earlier	U10
Q5	What are the specific responsibilities of the offices or individuals involved in your construction project management process?	-	U1
		-	U2
		Information already provided.	U3
		Given earlier	U4
		-	U5
		Architect, designer, PIA, open orders most, bid work for $8000+, all paper work is performed by PIA.	U6
		Easy, preliminary planning after programming is developed for occupany,several org consulted	U7
		procure projects, monitor budget, prepare contracts for signature	U8
		Information provided earlier	U9
		Information provided earlier	U10

Q6	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 it a report available for review?	Discipline coordination. Non-compliance to university construction standards. Missing code compliance issues. Field conditions. Level of scope of execution by contractor. Industry understanding on projects.	**U1**
		Scope changes, Field conditions, document errors. Varies with jobs and parties. Usually projects for big owners have scope changes. For bonded projects usually we have field changes and errors. Scope changes depend on end users involvement in programming and architects. More time required on planning and mock up construction would	**U2**
		No	**U3**
		No.	**U4**
		informally.	**U5**
		nothing formal main stream system	**U6**
		no formal, the construction process is reexamined on ongoing bases, YES	**U7**
		yes, informal studies, having PO issued in direct pay vouchers	**U8**
		no. informally	**U9**
		informal, discuss to find easiest ways consistent evaluation. Yes, famis	**U10**
Q7	Do you conduct any formal post construction analysis of projects with respect to budget, schedule, change orders or performances of the parties involved? Describe. Are findings or a report available for our review?	No answer	**U1**
		a = 2.5% d = 7%	**U2**
		No	**U3**
		No formal.	**U4**
		Yes. Project closeout debriefing, physical plant with client. No.	**U5**
		nothing formal.	**U6**
		Yes on projects that exceptionally good and bad. NO	**U7**
		yes, less things learnt. Final budget report excess funds to appropriate parties	**U8**
		no	**U9**
		yes, informally. YES	**U10**

Q8	If an analysis has been conducted, can you describe, in general terms, its findings?	No	**U1**
		Define the change order process, define change orders	**U2**
		N/A	**U3**
		N/A	**U4**
		No.	**U5**
		N/A	**U6**
		Solicited ideas about what factors went well contractors thrown on a project they don't have the experience, poor design docs, incomplete and inattention by A/E	**U7**
		See above	**U8**
		No	**U9**
		Charges posted to the wrong accounts, things shouldn't be there, errors	**U10**
Q9	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?	No answer	**U1**
		Some may see it as acceptable, some don't.	**U2**
		Don't	**U3**
		What they are and how much they are. No . N/A	**U4**
		For every item. No. No.	**U5**
		Review/discuss questions within dept. No	**U6**
		For budget impact, type scope, design, etc., YES, not this dept, NA	**U7**
		Start with attending progress meetings, bulletins and CCDs are logged in excel and famis. Reason codes track time. YES	**U8**
		A lot managed directly. NO. NA	**U9**
		Fully total against ledger, total against contractor >NO	**U10**
Q10	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?	-	**U1**
		CII don't know what the rate is actually	**U2**
		No	**U3**
		Response given. Discussed with firms.	**U4**
		Yes. Done by consultant's reason codes. Skewed based on source (who assigns the codes) no.	**U5**
		No	**U6**
		Yes	**U7**
		No	**U8**

		Scope changes by client, unforeseen conditions, consultants poor design	**U9**
		-	**U10**
Q11	Have you standardized systems for classifying causes (such as scope, document error or field conditions)? Describe.	Design engineers--very informally (known for missing contract items.). University project managers--informally.	**U1**
		End of project review of Subcontractors not specific to CO. Informally assess SC for CO and work ethics	**U2**
		Yes, reason codes	**U3**
		Yes.	**U4**
		Yes.	**U5**
		No	**U6**
		Yes	**U7**
		Yes	**U8**
		No	**U9**
		Information already provided.	**U10**
Q12	Have you drawn any conclusions with respect to the dominant causes of change orders? What are the dominant causes?	No answer. No	**U1**
		Put Cos are quick in negotiations due to less hierarchy in approval (I week processing + 30 days payment). They can contribute to extended general conditions. The 1st CO may not have a major effect but the 5th will have a cumulative effect. Impacts include, financial burden on SC, relationships breakdown, detrimental to administration. Owners have to understand that SC payment is important. If delay in payment is anticipated they include it in their cost. If they trust the process time they will quote realistically.	**U2**
		Unforeseen conditions, errors and omissions, scope	**U3**
		Document errors.	**U4**
		Field conditions, documents.	**U5**
		Field conditions	**U6**
		Depends on proj, customer change scope, renovations, hidden conditions, new design error	**U7**
		All play a role	**U8**

		Scope changes, consultant design	U9
		Scope, field conditions	U10
Q13	If you can, either from statistical data, or from your experience indicate the usual change order rate percentages of original project budget for the of the following project types?	Experience/Rule of thumb. 10-15%	U1
		Reasonable but should be quoted upfront	U2
		3-4%, 3-7%,3-20%,3-12%,10,12	U3
		2-3, 3-4, 2-3, 3-4, N/A, N/A.	U4
		5, 5010, 10, 10+, 10 or less, 10+	U5
		No,no,10,no,no,no	U6
		4-5,4-5,7-8,7-8,10 and 8	U7
		4-5,6,7-8,10,3,5-6	U8
		No, no, 10-15,no,no,no	U9
		N/A	U10
Q14	Has any analysis been conducted which helps you to predict change order rates for projects? What are your change order rates?	No	U1
		No. Although there is a question on budgeted cost and actual cost, which is not enough to draw conclusions and hence is inappropriate.	U2
		No	U3
		No. consultants are informally asked their experience with change order rates.	U4
		No.	U5
		Historical data, perform lots of same type of buildings	U6
		no	U7
		Yes, historical data, 7%	U8
		Nothing formal	U9
		No, 5-6% small projects	U10
Q15	Is that rate of change orders seen as acceptable? Explain.	No	U1
		No. Probably more since it institutes a more rigid process. Cannot afford to have relationship based decisions.	U2
		N/A	U3
		N/A	U4
		N/A	U5
		Yes, know expect	U6
		N/A	U7
		No could be lower, trying to avoid scope changes	U8
		N/A	U9

		Yes	U10
Q16	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?	No. N/A.	U1
		Private owners don't ask for questions regarding change order history as they expect change orders. When there is a lump sum fee there is no need for change orders by construction management services.	U2
		Informally, mentally.	U3
		No.	U4
		Informally for all listed.	U5
		No,no,no - only negative performance, no neg per, no neg per, NA	U6
		Informal	U7
		No, informally	U8
		No	U9
		No	U10
Q17	Please outline the process of receiving, reviewing and approving change orders within your organization.	No answer	U1
		Design build- least only scope changes but owners have less control on design. CM more than DB less than CM. Plan review is better, owners control is more. In GC most number of Cos. Plans and specs are black and white.	U2
		Chart	U3
		Already provided.	U4
		Given earlier	U5
		Bulletin, quote, review, pay or reject	U6
		N/A	U7
		Info already provided	U8
		Items discovery, discussion, issue change orders or reject or resubmit	U9
		Info already provided	U10

Q18	What are the typical durations for processing change orders? Do these durations contribute to additional costs such as for extended generally conditions, ripple effects or impact change orders?	No, experience tells you what the spread	**U1**
		GC scrutinize scope incredibly. CM more scrutiny on change order process. SC locate potential CO but will not inform GC & will show on bids. Variation is a red flag- need to keep it in mind but is not necessarily a good predictor.	**U2**
		2 months, yes sometimes	**U3**
		2 months, yes.	**U4**
		2-3 months. Yes.	**U5**
		2days, no	**U6**
		3-4 months, usually not, primarily contractor is authorized to proceed via CCD	**U7**
		Two weeks is what we try, 80% of them, No, not directly. Rarely pay extended general conditions	**U8**
		2days.	**U9**
		1-2 weeks or as long as one month, NO	**U10**
Q19	How are project contingencies established for projects? What are typical rates?	-	**U1**
		_	**U2**
		Based on MP's of project, approved budget allowance, 8-15%	**U3**
		Designated by board of trustees to have 10%, may increase if unknown conditions exist.	**U4**
		By designer, new 5%, renovation 10%	**U5**
		10% based on historical data	**U6**
		Sometimes, nature of the project, new = lowest 5-7, renovation medium 8-12, underground high 10-15%	**U7**
		Project manger recommends a number	**U8**
		10% or less, historical data	**U9**
		Info already provided	**U10**

Q20	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?	Comments from management often submitted to A/E. A/E responds in writing to each issue.	**U1**
		It's getting increasingly worse. QC is poor. MSU does a good job on choosing A/E.	**U2**
		Sits there. Depends on funding sources	**U3**
		Don't know. Not generally.	**U4**
		Sits there. Yes.	**U5**
		Sits there, possible	**U6**
		Remain in construction account until project completes, YES	**U7**
		Sits there. Depends on from where funding comes from. 30+ sources	**U8**
		Sits in account, yes	**U9**
		Information already provided	**U10**
Q21	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?	Not all. Schematic review. Design and development review. 30%, 60% and 90% review.	**U1**
		MSU better than most owners. It's good.	**U2**
		Easy, standards, adequate	**U3**
		A/E. based on soil borings. Ok.	**U4**
		A/E in consultation with Univ construction supervisor. Past experience. Empirical information. Inadequate for complicated underground work.	**U5**
		Go through physical plant, go through physical plant, great	**U6**
		Architect, code requirement, adequate usually included in contract for controlling, contract doesn't chance on testing	**U7**
		Designer	**U8**
		Physical plant, adequate	**U9**
		-	**U10**
Q22	How are design professionals hired for projects? When selecting or considering design professionals are their performance records for errors, omissions, and change orders	Yes. No answer.	**U1**
		Not analyzed with CO. They have been effective in customer satisfaction. Commissioning finds out flaws & more money is spent on CO & fixing goes over the years and is paid later. Testing brings out more Cos but its not bad	**U2**

	considered? If they are considered when hiring, how is this information solicited?	A quality based selection process. Yes. Ask about claims outstanding, change orders rate done during the interview	U3
		Based on fee. Below 50,000 dollars. Selection based on experience and availability. Above 50,000 there is a specified formal selection process advertised in Michigan contract and builder. Experience based on building type. 6 % present, reduced to 6-4% and they are interviewed. informally.	U4
		Qualification based selection. Yes. Thought he request for proposal and past experiences.	U5
		Easy at phys plant, informally	U6
		QBS, YES, determine based on contact with previous clients	U7
		N/A	U8
		Information already provided.	U9
		?	U10
Q23	When awarding construction contracts, are change order histories or general contractors considered in determining if they are "qualified" for the work? How is this information solicited?	No answer.	U1
		Good at negotiating CO. OK-but may not reduce CO. SC and owners benefit from it.	U2
		No	U3
		No	U4
		No	U5
		No	U6
		No	U7
		No	U8
		Yes, opinions from previous projects	U9
		?	U10
Q24	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	Yes. Yes. A published time for pre-bid walkthru is established. Obligatory attendance.	U1
		Yes. Yes	U2
		N/A	U3
		No	U4
		No	U5
		No	U6
		No	U7

	firms?	No	**U8**
		More	**U9**
		No	**U10**
Q25	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?	No answer.	**U1**
		15,16, 2, 9	**U2**
		No	**U3**
		No	**U4**
		No	**U5**
		Informally	**U6**
		No, cm be considered	**U7**
		No	**U8**
		Yes, opinions from previous projects	**U9**
		?	**U10**
Q26	How are construction managers hired for projects? When selecting or considering construction professionals are their performance records for errors, omissions and change orders considered?	No answer.	**U1**
		M, E, P Lack of coordination between these three parties and with A/E. They are not involved in design process early on. Unforeseen conditions,	**U2**
		Quality based selection process. No. Advertising, Solicit proposals, shortlist.	**U3**
		Same as A/E process. No informally.	**U4**
		Qualification based selection. No.	**U5**
		quality based selection process. Informally	**U6**
		QBS, based on info from past clients	**U7**
		No	**U8**
		Na	**U9**
		?	**U10**

Q27	Has your organization used design build firms for projects? If so, describe frequency and project types.	Yes. Very inefficient depends on nature of	**U1**
		yes. Rarely, for simple structures DB will be	**U2**
		Yes. Once, specialized construction, where there is limited designers and contractors with that expertise.	**U3**
		Once.	**U4**
		Yes. One.	**U5**
		no	**U6**
		rarely, pole barns, specialized medical facilities	**U7**
		yes, pharmaceutical, pole barns	**U8**
		once, bad experience	**U9**
		?	**U10**
Q28	Have you been generally satisfied with projects delivered through the design build project delivery method? Explain.	Yes and No. as long as we can maintain control. There are problems with sharing control.	**U1**
		Clearly defined decision network. CM allowances. 100% free discretion of owners. Should be used to handle changes.	**U2**
		No. Very little control over the process. They pay for change orders they didn't believe were warranted.	**U3**
		No. No selection process told who to use. There is a tough time buying into MSU construction standards.	**U4**
		n/a	**U5**
			U6
		no, owner had less day to day control of project, bad for knowledgably owners	**U7**
		no, GMP, disputes in scope	**U8**
		No, DB team is thrown together	**U9**
		hard to control	**U10**

Q29	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.		**U1**
		Define process	**U2**
		Yes. More change orders with GC. They throw the bids together and it is more adversarial by design.	**U3**
		Process doesn't influence much as the team.	**U4**
		No.	**U5**
		No	**U6**
		Design build the nature pay for CO in advance, hidden contingencies built in. Neither reduce owners cost.	**U7**
		Can't guarantee CM will come less than GC. Fearless likely to bust the budget	**U8**
		All can have CO problems, has more to do with design time spent preconstruction	**U9**
		No, not much difference	**U10**
Q30	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?	No. Experience tell you what the spread is. Project specific.	**U1**
		Needs updating but they are fairly ok. Reduces CO, less guessing by A/E, contractors and owners.	**U2**
		No. No.	**U3**
		Yes, can be.	**U4**
		Yes. No.	**U5**
		Yes, yes	**U6**
		Yes, its an indication of document quality	**U7**
			U8
		Not really	**U9**
		No, no	**U10**
Q31	Is the contractor's overhead and profit mark up typically contractually specified? What are the standard specified rates? If not, how is overhead and mark up incorporated into the contractor's change order pricing?	Yes. 15 and 5. 15% on self performed work. 5% on subcontracted.	**U1**
		Dictated by contract. Causes disputes sometimes.	**U2**
		Yes. 15 and 5	**U3**
		Yes. 15 and 5	**U4**
		Yes. 15 and 5.	**U5**
		Yes,5% on subs, 20% materials	**U6**
		Yes, 15,5	**U7**
		N/A	**U8**
		Yes, 5% subs, 20% materials	**U9**
		Info already provided	**U10**

Q32	Has overhead and profit mark up been a source of dispute on projects? Explain.	Occasionally , some contractors think it should be higher.	U1
		productivity losses common. Affects sequencing. General conditions always .	U2
		Yes. Contractors feel it is inadequate.	U3
		yes. Contractors don't read the contract.	U4
		Yes. Contractors feel it is inadequate to cover costs.	U5
		no	U6
		yes, not adequate of co for work to be done out of sequence	U7
		no	U8
		not generally, contractually no when going into a project	U9
		?	U10
Q33	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.		U1
		Natural distrust. Reduce negotiation time by having upfront costs.	U2
		Negotiated a s separate change oafter the fact. Yes, difficult for a contractor to prove his case, sets the stage for conflict.	U3
		try not ot do/ negotiate. Varies by project.	U4
		Can the contractors justify time? Yes justifying the true impact of scope or work.	U5
		no	U6
		reluctant to add time for CO/issue which ignored. Yes, bemore diligent about time impact	U7
		make contractor show there is a problem. YES, but few. Historical relationships	U8
		na	U9
		?	U10

Q34	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.	Description at conceptual stage, how much dialogue exchange between parties. Meeting minutes, problems statements, memos, reports, emails. Personnel turnover, how instigated.	**U1**
		GCs track CO, PRs have to push. Too many layers of approvals. MSU must plan for CO. Sometimes takes about 6 months to process CO.	**U2**
		Established by department and documented in word form their needs. Yes. Not a total understanding of what the needs are.	**U3**
		A document is written. No, unless you have personnel changes.	**U4**
		A/E and end user. Occasionally A/E didn't explain or capture the intent.	**U5**
		Meetings, memos, email. YES, expectation is the architects know what to do	**U6**
		Done by facility planning and space mgmt process. NO	**U7**
		Contractually adding to project completion date for each person's piece as designated amount of time. Limit the number of bulletin items on a bulletin and should have the change orders processed in certain amount of time.	**U8**
		Consultants should know. YES, people clients don't know exactly what they want	**U9**
		?	**U10**

Q35	Are construction documents formally reviewed by your organization in detail prior to bidding? Describe this process.	Not all. Schematic review. Design and development review. 30%, 60% and 90% review. Comments for maintenance are submitted to A/E , who respond to each issue.	**U1**
		See other interview responses, and not always done.	**U2**
		Yes. Each discipline goes through the documents for completeness.	**U3**
		Information was provided earlier. Done at the 50 -90 %. No longer at 30, 60, 90 % design completion stages. Distributed to staff positions, (M,E,S) also to shops, telecom, fire marshal, custodial, client. It's done in a meeting with all parties.	**U4**
		Yes. A/E walk thrus to the university and then break up into disciplines.	**U5**
		Yes,PIA and architect review and comment	**U6**
		Yes, reviewed by A/e and maintenance shop supervisor. Large projects and independent review firm	**U7**
		Expected time we offer them equals quality	**U8**
		Big projects self performed	**U9**
		-	**U10**
Q36	Does your organization have published construction standards or specification 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.	Yes. Yes most projects have at least one.	**U1**
		Decentralize control on CO. too many levels of authority and approvals.	**U2**
		Yes . Occasionally.	**U3**
		Yes. No. Occasionally.	**U4**
		Yes. No.	**U5**
		Physical plant, can be	**U6**
		Yes, yes they deviate from our const standards	**U7**
		No	**U8**
		Physical plant, yes, contractors think their work superior to standards. Try to trick Msu, see if they caught	**U9**
		-	**U10**

Q37	Do you believe there is a difference in change order rates designed within your organization when compared to when you use outside design firms? Explain.		**U1**
		Yes. Higher when used outside, because of failure to use standards. Not familiar with our buildings, they don't spend enough time assessing historical data.	**U2**
		Yes. Much lower when designed in house.	**U3**
		Yes. We review our standards and recurring design firms, familiar are better.	**U4**
		Yes. Interior designer, single designer, no miscommunication between buildings.	**U5**
		Same.	**U6**
		In-house lower, no const standards	**U7**
		No	**U8**
		Yes, experience take time to ask questions to design and solve problems	**U9**
		Yes, outside larger projects, more things easily missed	**U10**
Q38	Has your organization utilized commissioning services? Have these been effective in reducing change order rates?	Yes. Don't know.	**U1**
		Yes. No. Problems are flushed out in designs that are incorrect and don't work as intended.	**U2**
		Yes. No. Adds due to problems that are identified during start up phase.	**U3**
		Yes. No comment.	**U4**
		Yes. Yes.	**U5**
		No	**U6**
		Yes, yes	**U7**
		Yes, reduces them if agent use them in design	**U8**
		No,	**U9**
		No	**U10**
Q39	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?		**U1**
		Yes. Yes. Team player mentality, informal agreements and negotiations.	**U2**
		Yes.Dont know. Don't know.	**U3**
		Don't know. No comment.	**U4**
		No. No.	**U5**
		1,no,no	**U6**
		No, not that can be identified	**U7**
		No	**U8**
		Sort of	**U9**
		Yes, less conflicts more agreements. Needed for new contractors not familiar with MSU expectations	**U10**
Q40	Are prebid meetings or wakthrus conducted for projects? Always? Describe?	Yes. Yes. A published time for pre-bid walkthru is established. Obligatory attendance.	**U1**
		Yes. Yes. Designer meets with contractors on site and allows questions.	**U2**

		Yes. Yes.	U3
		Yes. Yes. NO response.	U4
		Yes. Yes. Show up to site and architects explains projects.	U5
		Yes,yes,show up and allow questions	U6
		Yes,yes,architect meets contractor for questions	U7
		Na	U8
		Yes, yes, walk through and ask questions	U9
		Info already provided	U10
Q41	Which CSI divisions cause the most change orders for your organization? Why do you think these divisions have the most change orders?		U1
		15 and 9. 15 mechanical systems are expensive, difficult to design and its large division. 9 because most changes affect finishes.	U2
		2 and 15. 2 has unforeseen conditions. 15 has complex mechanical SYSTEMS HARD TO DESIGN.	U3
		Not specific.	U4
		2 and 25 hidden conditions.	U5
		15 because of cost of items	U6
		2,15. 2 unanticipated conditions, 15 complex structures	U7
		2 soils most likely, unknown conditions	U8
		Depends on projects, depends on CSI divisions as a percentage of the whole projects	U9
		16	U10
Q42	Which design professions cause the most change orders for your organization?		U1
		Mechanical	U2
		Civil and mechanical.	U3
		Not specific.	U4
		Civil and mechanical.	U5
		?	U6
		Mechanical	U7
		No	U8
		Architectural. Elec/Mech must install percodes	U9
		?	U10

Q43	From your perspective do you have any suggestions that could be employed to reduce change orders frequency and their impact on projects?	Having enough time to do a thorough review of the docs. Post bid, contractor looks at how he will get from point A to point B.	**U1**
		Yes. Quality assurance, quality control need to be designed in the project (during design). Stupid mistakes make up a lot of change orders (errors and omissions). More time built in the schedule for internal design reviews.	**U2**
		Using ready check to review documents consistently. More time on field investigation on existing conditions. Disallow scope changes.	**U3**
		The size of the addendums associated with the project indicate a possible problem. Better communication with team members.	**U4**
		More thorough reviews of plans and specs.	**U5**
		Better review of docs,better communications	**U6**
		Provide adequate time for doc review	**U7**
		Improve processing time, administrative effect and will create better good will	**U8**
		Hire good consultants, review docs for maintenance perspective to understand if it actually works, more people take seriously the importance	**U9**
		Reduce number of items in CO, on bulletins, write clear descriptions	**U10**
Q44	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?	Solvable at preconstruction phase. How and what are CCDS used for, identifying things before it is an emergency.	**U1**
		Contractually adding to project completion date for each person's piece as designated amount of time. Limit the number of bulletin items on a bulletin and should have the change orders processed in certain amount of time.	**U2**
		Analysis of the reason codes. Target areas of concern for pre and post. During construction: quick responses to contractor's questions.	**U3**

		Preconstruction a person with intimate knowledge of project should determine if it is valid. During construction, contractors should have quick pricing for extras, ideal would be one pay application period.	**U4**
		Preconstruction will have plan review, post construction more timely and less.	**U5**
		None, good existing system	**U6**
		Better way to communicate the budget status, simplify the steps, clear expectations, locking unit prices, better personnel to perform plan reviews, better commitments from these people	**U7**
			U8
		Change order slow the project down. T and M based on unit prices	**U9**
		Submit complete info when submitting CO	**U10**
Q45	Do you have any other comments regarding change orders that you would add?		**U1**
		Change orders are a fact. Mistakes are inevitable, what makes mistakes so long time to solve are people's egos. Analysis of every project should be done to keep data to know what projects need.	**U2**
		They are an inefficient way to deliver a project, but they are necessary.	**U3**
		No.	**U4**
		Would like to streamline the process at the university	**U5**
		Necessary evil, maintain relationships	**U6**
		Give them the importance they do and handle timely	**U7**
		Discourage scope changes, sometimes its best alternative	**U8**
		No	**U9**
		?	**U10**

APPENDIX IV
UNIVERSITY INTERVIEWS

UNIVERSITY INTERVIEWS – TABLE A4.1

Feed back from University Administrators			
Question Code	**Question**	**Response**	**Response code**
Q1	What is the title of your position within your university?	-	**U1**
		Data omitted for confidentiality	**U2**
		Data omitted for confidentiality	**U3**
		Data omitted for confidentiality	**U4**
Q2	Can you identify the offices or departments which procure construction services for your university (or department)?	Data omitted for confidentiality	**U1**
		Data omitted for confidentiality	**U2**
		Data omitted for confidentiality	**U3**
		Data omitted for confidentiality	**U4**
Q3	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?	Data omitted for confidentiality	**U1**
		Data omitted for confidentiality	**U2**
		Data omitted for confidentiality	**U3**
		Data omitted for confidentiality	**U4**
Q4	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?		**U1**
		Not available	**U2**
			U3
		Yes	**U4**
Q5	What are the specific responsibilities of the offices or individuals involved in your		**U1**
		DOA. Major projects - project manager, no authority work with DSF	**U2**
		Refer to chart	**U3**

	construction project management process?	When we have a new project, Univ architect assigns job to PM. PM handles concept, program definition, end user coordination, works with CM, Arch, other designers at conceptual stage, PM works through construction and closeout stage. CM and architect make their separate estimates and discuss later, so architects intent comes out clearly and everybody's ideas are brought out. The same team (C,SC,TC,CM,Arch) works from start to finish. Owners goes though each and every RFI, Project begins when 100% budget is committed and 70% is in hand.	U4
Q6	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?	Audit Internal processes - Documents	U1
		Heavy State process - State approach has been reviewed. None within	U2
		Internal modifying as appropriate. RFI, monitor audit, predict audit financial by state agency	U3
		We have a quality manual. Approval signature sheets and checklists for conceptual, design, schematic, construction drawings. We track project costs and administration costs and there are separate forms depending on dollar amounts. we implemented this system and it works very well, we have client satisfaction and lower change order rates.	U4
Q7	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?	Recommended a one place - no formal process. Vendor Performance program	U1
		In house post mortem. Informal, provide no vendors list	U2
		No formed, budget reconciliation is always	U3
		Project closeout : over/ under budget evaluation, sq footage, and change orders. This goes into a databse which is referenced in future. Results vary.	U4
Q8	If an analysis has been conducted can you describe in general		U1
		-	U2
		Not applicable	U3

	terms its findings?	Evaluate performance of architects, contractors and call a meeting to talk about what the univ thinks, so they get a chance to improve and they are generally pleased with it.	U4
Q9	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?	Not aggregates. Guestimate - 7 - 10%	U1
		Forms are copied. And at end of projects poor coding. Can request monthly report	U2
		Monthly report, excel sheets	U3
		Is price reasonable is it documented. Monitor changes through our system. Once a month issue change orders, so contractors have more confidence. If change orders value is less than 250,000 VP of business Op signs it, If more P signs it.	U4
Q10	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?	Use Famis	U1
		No. May do for campus project when needed budget sensitive usually response to questions	U2
		Grouped by 7 categories, customer request, C&O, field, design deficiency for recovery	U3
		No formal analysis, mechanical and structural changes. Coordination is an issue. Mechanical engineers don't listen very well. We have design standards and sometimes they don't read it, that's a bigger issue than inadequacy of design. Standards will be online very soon.	U4
Q11	Have you standardized systems for classifying causes (such as scope, document error or field conditions)? Describe.	6 Room Codes at change order level not items	U1
		10-15 categories - unforeseen conditions, errors and omissions, scope, coordination	U2
			U3
		Same. Only have difference in owner initiated and contractor initiated. Hold architects accountable for bad design and errors, but not for omissions.	U4
Q12	Have you drawn any conclusions with respect to the	Design Documents/ Coordination	U1
		Most significant coordination, field and scope	U2

	dominant causes of change orders? What are the dominant causes?	scope,e&O, field. customer requesting big issues, no statistical data	U3
		Our process is good so far, catches most changes early and hence can be avoided. Have human errors and there are some obvious design errors sometimes, but rarely occurs. Poor coordination between designs , should overlay drawings and talk more. We don't hire contractors to do quality reviews of architects work, they are here to build. Our industry has a problem, people do not admit mistakes.	U4
Q13	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?	New buildings - 5%, science - 5%, renovations - 10%, new infrastructure - 3%	U1
			U2
		<3%, N/A, <3%, - , < 5%, <5%	U3
		3, 3, 7 (GMP) and 5 (CM), 7-5 (as before), service agreements 3 yr contracts for heavy infrastructure new and renovation	U4
Q14	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?	-	U1
			U2
		Just experience	U3
		No.	U4
Q15	Is that rate of changes orders seen as acceptable? Explain.		U1
		Inevitable, ok	U2
		Generally it has gone up since expanding. Architect services to other A/E	U3
		N/A	U4
Q16	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?	Vendor Performance	U1
		Coordination is main problem, not held accountable, use incentives	U2
		Brief check sheet exists evaluation form	U3
		Yes all. As mentioned before evaluate them through formal forms and send these evaluations to the parties and meet with them to discuss things. Their change order histories are tracked for fairness, timeliness but not necessarily for number. We seek references though from whom we get this information informally.	U4

Q17	Please outline the process of receiving, reviewing and approving change orders within your organization.		U1
		None because DSF	U2
		C.O physical plant form. PP. (RFP) prepared by inspector bulletin. Developing compose and complete specifications	U3
		Most change order are done well in advance, so there are no grievances. PM, Business manager, Director of QA and construction, Univ architect and Vice Pres review and sign changes. Architect uses AIA document though none of our agreements or contracts are AIA. we write our own contracts. Contractor initiates change through RFI, MM or Proposal request and issues it to architect and owner. they review it simultaneously Architect then gives a formal recommendation to owner stating why it is accepted or rejected. our review form is attached to Architects AIA form . We have file color system which identifies any high priori out the same day from the office. It takes sometime to get signs from the VP. but we issue change orders monthly. If it gets delayed occasionally because both the P/ VP are out for several days, then the contractors understand.	U4
Q18	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?	2 Months + 30 days after invoice	U1
		2 months - 6 months from proper . Yes they do create issues. No CCD process done verbal to get work done	U2
		From acceptance, 30 days max. Verbal or sped note	U3
		Less than 2 weeks to 2 months. Contractors are satisfied. We try to keep our change orders less than 250,000 so that VP signs them instead of P who is out very often. We do not use CCDs as they have to be signed by the president.	U4
Q19	How are project contingencies established for projects? What are	Project by project this differ	U1
		Major projects, previously discussed	U2
		Estimate between arch and construction office	U3

	typical rates?	Start with 10% estimate contingency , 5% design contingency and 5 % owner scope change in conceptual design stage, which comes down to 0% owner scope, 5% estimate contingency, 3% change order contingency at the end of design drawing stage and in construction stage we have only 3% change order contingency and no other contingency. scope changes are avoided.	U4
Q20	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?	Stay with project returns to department	U1
		Always spent - usually projects run over	U2
		spent on project	U3
		Nothing is returned till project closeout. Yes sometimes if programmatic changes are proved. If there are savings owner retains the savings.	U4
Q21	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?	In consultancy with CP&P	U1
		State with consultant, varies system and situation	U2
		Preconstruction controlling. Design of record plus inspector. Been adequate	U3
		Geotech consultants are hired mostly tough separate agreements, sometimes through architects. Yes.	U4
Q22	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?	Prequalified list upto 50,000 fee picked by OP. To competitive over 200 for state federal	U1
		by state	U2
			U3
		Prequalification, 6-8 firms are invited to response to RFP. Evaluate based on strength of team, past project type experience, check whether the team people have work with each other before, references.	U4
Q23	When awarding construction contracts, are change order histories of general contractors considered in determining if they are "qualified" for the	Starting to	U1
		Low bid methods, not prequalification	U2
		State law required low bid only	U3
		Not necessary.	U4

	work. How is this information solicited?		
Q24	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?	No experience, but not important	U1
		No improvement	U2
		Not applicable	U3
		Don't know	U4
Q25	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?	Vendor Performance program, considered in through past performance	U1
		Prime contractors - no low bid method	U2
		Could reject subject, yes for agency low bids	U3
		No performance is considered.	U4
Q26	How are construction managers hired for projects? When selecting or considering construction professionals are their performance records for errors, omissions and change orders considered?	RFP process - YES	U1
		By state via qualifications, political, legal	U2
		QBS	U3
		We seek this info from references but we are more interested in Performance and prequalification.	U4
Q27	Has your organization used design build firms for projects? if so describe frequency and project types?	YES	U1
		Yes, rarely	U2
		not allowed for state projects for design build	U3
		Yes 2 projects. Doing it because some trustees wanted it. Not very comfortable with it, as owners are less involved and informed.	U4
Q28	Have you been generally satisfied with projects delivered through the design build project delivery method? Explain	50:50 Yes. Not on state funded project	U1
		Yes very good	U2
		Mixed views, some successful, some not	U3
		Outstanding in commercial not comfortable for university projects	U4
Q29	Do you have any opinion or analysis on	GMP	U1
		Not really function of delivery method	U2

	whether the project delivery method such as design build, construction management or general contracting influences change order rates? Explain.	GC for general buildings is test, nature of project	U3
		CM at risk lower, Hard bid higher, DB too early to say.	U4
Q30	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?	Intuitive it does, when very low bid	U1
		Spread is not a prediction	U2
		No	U3
		Can be. But for is it is not an impact. We bring in two of the lowest bidders and ask for breakups. They are prequalified and we discuss if they may have missed items, but we don't disclose numbers. Finally results are published, we chose them based on performance, and hence it doesn't affect us.	U4
Q31	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?	Yes	U1
		change orders matter - 15%	U2
		Yes for cost plus basis items - 10%, not too much	U3
		On lumpsum we don't know and don't care. otherwise as in contract for change orders in hard bids, 15% for subC 10% for sub subC 5%.	U4
			U5
Q32	Has overhead and profit markup been a source of dispute on projects? Explain.	Yes	U1
		not really	U2
			U3
		NO.	U4
Q33	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?	Temporary Facilities	U1
		Can be care by care basis	U2
		No, on occasions	U3
		No	U4
Q34	How are building programs (needs brief) established and documented? Are misunderstandings	Exterior Design Standards	U1
		Major projects, works with user department. Scope changes not an issue	U2
		2 phase space management dept works with academic program (Architect office	U3

	about program occasionally or commonly a cause of scope changes by the end user department? Describe.	converts to building turned areas), department reviews documents)	
		As described earlier, PM does that.	U4
Q35	Are construction documents formally reviewed by your organization in detail prior to bidding? Describe this process.	Distribution Matrix. Internal review distribution matrix. University architects, but small staff standards. Zone office	U1
		Review charettle, pm consultants, opportunity to review physical plant constructability.	U2
		Hope to get documents 15% Design development, 60% concept development. senior staff reviews. Each review has options	U3
		Yes. As mentioned earlier through our checklists and quality system.	U4
Q36	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.	Yes standards exist. Not really	U1
		State guidelines, university guidelines	U2
		Web address, on occasions will	U3
		Yes. Sometimes.	U4
Q37	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.	Not currently designing for outside. Little in house design, but few changes - 2 sort build	U1
		Not applicable	U2
		Not applicable	U3
		No in-house design we do not want any liabilities.	U4
Q38	Has your organization utilized commissioning services? Have these been effective in reducing change order rates?	Used commissioning generally helpful	U1
		Yes they have used. A/E should do commissioning, experienced others with in house service	U2
		Not used to date, but may be finds errors, that would not have been found	U3
		We use consultants sometimes, but it hasn't helped much except for helping users know how to use the systems.	U4
Q39	If you have used "partnering" agreements on	Yes, formal and informal	U1
		No improvement	U2
		1 time	U3

	projects, have those projects typically experienced lower change order rates than others? Has partnering been effective in reducing change orders?	No. takes too much of peoples time and no one has that kind of time.	U4
Q40	Are prebid meetings or wakthrus conducted for projects? Always? Describe?	Yes, clearly identified in bid docs and RFIs	U1
		Yes	U2
		For renovation projects but not new building	U3
		Yes. Yes. Not mandatory. If GC couldn't make it to the walktrhu and requests to see the site, we allow them to.	U4
Q41	Which CSI divisions cause the most change orders for your organization? Why do you think these divisions have the most change orders?	M/E	U1
		MEP - rarely soils, quality not there because of expertise. Electrical more careful	U2
		15 but not data to support, 14?	U3
		Don't know, haven't done a formal analysis, but guess that it is div 15.	U4
Q42	Which design professions cause the most change orders for your organization?	M/E	U1
			U2
		Initials instead of names	U3
		Mechanical.	U4
Q43	From your perspective do you have any suggestions that could be employed to reduce change orders frequency and their impact on projects?	Coordination by AE + GC	U1
		Quality of documents, lack of accountability or repeat work	U2
		Mandatory 30 day review, documents before goes to bid, could improve standards	U3
		Our systems work well for us. People need to talk more, coordinate better and architects should clearly show their intent on paper.	U4
Q44	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?	Earliest management/ look ahead for future problems	U1
		Post mortum, make staff ensure	U2
		Make tougher, review period , standards, estimating process	U3
		Preconstruction meetings with GCs, Subc, C to make sure everyone's expectations are the same. Change orders are going to happen no ones perfect.	U4
Q45	Do you have any other comments regarding change orders that you would add?		U1
			U2
		4% renovation, 1-3/4% new major, 2% whole project	U3

		Change orders have a negative connotation, we understand we are doing well, but there is always room for improvement. Its about excellence not about perfection.	U4

APPENDIX V

CHECKLIST DEVELOPMENT/VALIDATION INTERVIEWS

TABLE A5.1 – CHECKLIST DEVELOPMENT INTERVIEWS

Question Code	Question	Response	Response code
1	What is your position and title within the university?	Data omitted for confidentiality	P1
		Data omitted for confidentiality	P2
		Data omitted for confidentiality	P3
		Data omitted for confidentiality	P4
		Data omitted for confidentiality	P5
2	How many years have you been working with MSU?	Data omitted for confidentiality	P1
		Data omitted for confidentiality	P2
		Data omitted for confidentiality	P3
		Data omitted for confidentiality	P4
		Data omitted for confidentiality	P5
3	Are you personally involved with plan review? In what capacity?	Yes, all levels (also works with different work disciplines	P1
		Yes, all stages (not detailed level)	P2
		All stages, areas of expertise. Not my project, at 50% contract docs	P3
		Yes, all stages.(from conceptual to contract docs) sometimes may not involve in final contract docs	P4
		Yes, all stages. Conceptual to construction. We don't have different disciplines expertise like in physical plant, so we do everything	P5
4	Do standard plan review protocols and processes exist within your department? Explain		P1
		No formal checklist, shops are asked to write comments	P2
		Two people have informal checklist in our dept	P3
		No formal procedure. Check for clearances, compliance with msu standards. Dimensions are not checked because of lack of time	P4
		Not formally	P5

			P1
		As above	P2
		As above	P3
		We get set of docs and 2 weeks of time - make written comments - submitted to A/E - they are supposed to respond (who may not) - we review - necessary action	P4
5	Can you describe your (departments) plan review processes and protocols?	3 of us in staff when time permits, plans are passed to get different perspectives. I have been doing this work from so long, that I don't need a checklist.	P5
			P1
		We use MSU standards	P2
		We use MSU standards	P3
	Do you use a standardized departmental or personally developed checklists for plan reviews to reduce/ prevent design	An informal checklist. Coordination is issue	P4
6	errors and omissions?	No	P5
			P1
		On web	P2
		On web	P3
		Check the attachment	P4
7	Can you provide a sample of it?	N/A	P5
			P1
		N/A	P2
		N/A	P3
	At what stages in plan development is	Refer to 3	P4
8	the checklist implemented?	N/A	P5
			P1
		N/A	P2
		N/A	P3
	Is this checklist based on design	N/A	P4
9	discipline, work scope or other criteria?	N/A	P5
10	What are the factors to be considered during the development of checklists for the following plan development stage? Conceptual, schematic, design development and contract docs		P1
		Conceptual level - programming req by dep are addressed. Facility mgmt dept is involved in all programming + ind dept (dean or chair) +	P2

		Physical plant rep (not always)	
		As above	P3
		Refer to 3	P4
		Conceptual and schematic blend together - at this stage make sure that relationships are well defined, analyzing traffic patterns and pathways. Design level + contract docs blend together - at this stage check if the earlier discussed things are place properly and fits the project	P5
11	How much time is typical spent by you or your department in reviewing plans at each of the following stages? Conceptual, schematic, design development and contract docs		P1
		More detailed review, more time - depends on the project	P2
		Depends on the project	P3
		5 min - few days (depends). In general day or two or may be few hours	P4
		Varies all over. For all levels together, it takes few weeks to 8 months	P5
12	Is this amount of time adequate? Explain.		P1
		No.	P2
		No	P3
		No - many things to do	P4
		Depends on how it comes out. If its good, then its adequate. Generally yes	P5
13	What barriers add to difficulty in conducting plan review? Explain		P1
		Time, hierarchy	P2
		Too many levels of approvals. Priorities are dictated by someone else	P3
		Time - too many projects at a time	P4

		Time - too many projects at a time and administration some times gives ridiculously short time	P5
14	What barriers exist which would limit the use or effectiveness of plan review checklists?		P1
		No barrier	P2
		Little bit of resistance from people who already use their own process	P3
		Simple, which should generate results, should be accessible. It shouldn't be complex and specific. As small as possible	P4
		Time to do it, and make a checklist	P5
15	Would plan review training be useful in reducing errors and omissions on plans?		P1
		It will be helpful	P2
		In-house training will be helpful	P3
		It will be helpful	P4
		Oh yeah	P5
16	Can you provide any additional comments regarding the use of plan review checklists, which will be helpful as we develop a checklist for MSU?		P1
		Keep it general	P2
		Do not be specific, let it help the process	P3
		Discussed earlier	P4
		Shouldn't be done in vacuum, should go through plan reviews and then switch the process and develop checklist. Just analyzing and developing will not help. When I retire, I should write a checklist. How many times did I build a running track, sparty move, tennis court? None.	P5
17	Are you aware of any plan review checklists or research on checklists developed by any other organizations?		P1
		No	P2
		No	P3
		No	P4

		No	P5
18	What suggestions do you have for how a checklist should be organized?		P1
		Based on design discipline	P2
		CSI divisions wise doesn't work, discipline level will be good	P3
		What is building for? Whats proj for? 4 different levels of implementation	P4
		It should be made in the perspective of the builder	P5
19	What suggestions for what should be be included in a checklist?		P1
		Comply with MSU standards, should mention this.	P2
		Can access to all plan, should be generic	P3
		Make it general	P4
		Earlier discussed	P5
20	What suggestions do you have for how a checklist could be implemented within the appropriate MSU departments?		P1
		Should be informal, shouldn't be focused on each item	P2
		Should work as a guideline, say "look at dimensions", be general	P3
		Each person involved should have it. Make a project record individually or together. Touch in base with maintenance while reviews it will help	P4
		Checklist should be provided and it's the responsibility of the respective proj rep to use it or not. Resource is given, its upto you how will it be used. If they are experienced, they may not.	P5

TABLE A5.2 PLAN REVIEW CHECKLIST VALIDATION INTERVIEWS

Question Code	Question	Response	Response code
1	What is your position and title within the university?	Data omitted for confidentiality	V1
		Data omitted for confidentiality	V2
		Data omitted for confidentiality	V3
2	How many years have you been working with MSU?	Data omitted for confidentiality	V1
		Data omitted for confidentiality	V2
		Data omitted for confidentiality	V3
3	Are you personally involved with plan review? In what capacity?	All stages	V1
		All stages	V2
		All stages	V3
4	Did you receive the questionnaire that I sent you, and did you have time to review it?	Yes	V1
		Yes	V2
		reviewing now	V3
5	Do you have any questions or do you need clarification on any items or aspects of the proposed checklist?	No, need to spend more time	V1
		No	V2
		No	V3
6	Are there any items which you feel are missing and would be important to include in the final form of the checklist?	No, its good as a general format	V1
		No	V2
		Snow melting system, water quality system, equipment areas	V3
7	Will use of this checklist be helpful in avoiding design errors and omissions prior to bidding?	In theory it should help.	V1
		Always helpful. This checklist will be tool to remind	V2
		Yes	V3
8	What barriers exist which will make implementation of this checklist difficult?	Let this checklist allowed to be tailored	V1

		Nothing	V2
		Time	V3
9	Do you think it is important to train staff before implementing this checklist?	Yes	V1
		Not really, just providing information	V2
		Yes	V3
10	What do you think are the potential benefits of this checklist?	It should save money	V1
		It would help in reducing mistakes	V2
		Definitely reduce change orders	V3
11	Should use of this checklist be mandatory?	Not mandatory. It should be left to the discrete of professionals	V1
		No, it should just be a recommendation	V2
		No, depends. Should be left on the person reviewing	V3
12	Do you feel use of this checklist will add or reduce the amount of staff time spent for reviewing a particular set of plans? Can you estimate how much might be added or subtracted from your typical current package?	It would add time, but don't know how much	V1
		It should reduce time	V2
		Add, may be 25% more time.	V3
13	Do you have any additional suggestions or comments?	No	V1
		No	V2
		No	V3

APPENDIX VI
CHARTS OF CSI DIVISION ANALYSIS

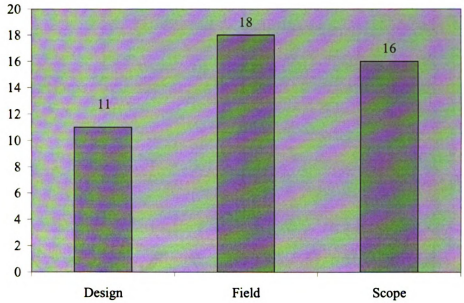


FIGURE A 6.3. CSI 1-C.O. ITEMS PER GROUPED REASON CODE

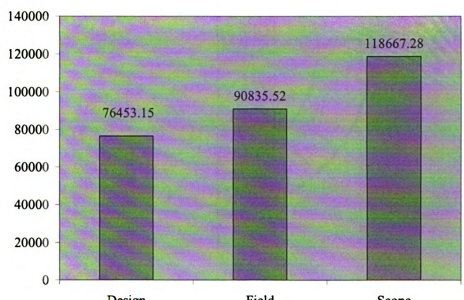


FIGURE A 6.4. CSI 1-COST PER GROUPED REASON CODE

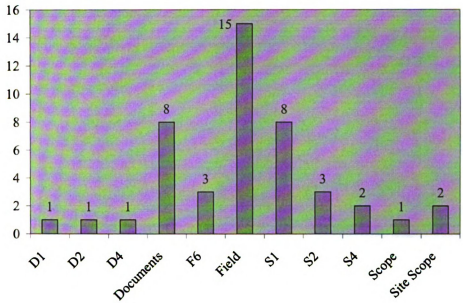


FIGURE A 6.5. CSI 1-C.O. ITEMS PER INDIVIDUAL REASON CODE

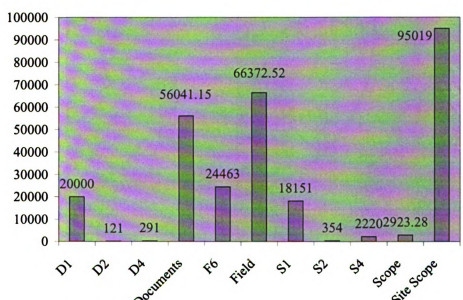


FIGURE A 6.6. CSI 1- COST PER INDIVIDUAL REASON CODE

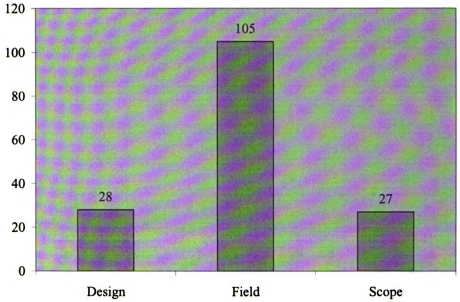


FIGURE A 6.7. CSI 2-C.O. ITEMS PER GROUPED REASON CODE

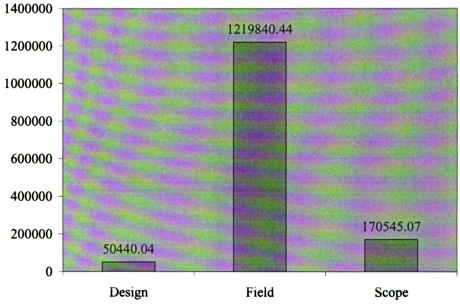


FIGURE A 6.8. CSI 2-COST PER GROUPED REASON CODE

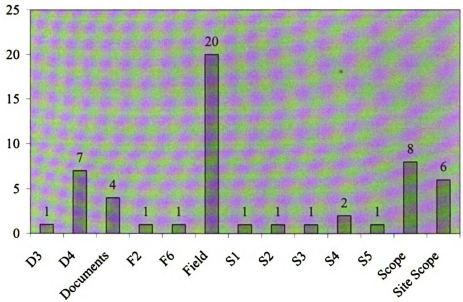


FIGURE A 6.9. CSI 2-C.O. ITEMS PER INDIVIDUAL REASON CODE

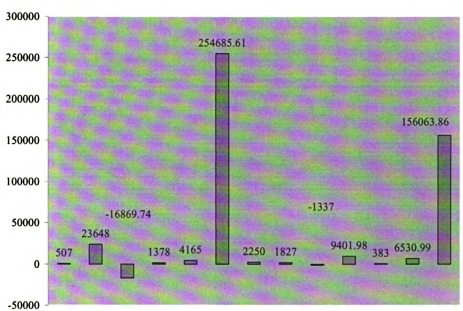


FIGURE A 6.10. CSI 2- COST PER INDIVIDUAL REASON CODE

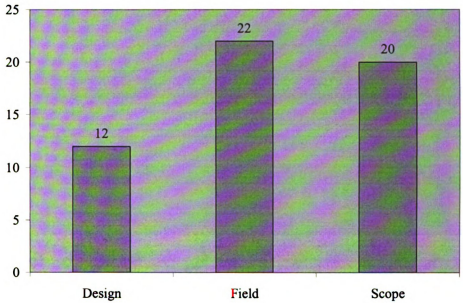


FIGURE A 6.11. CSI 3- C.O. ITEMS PER GROUPED REASON CODE

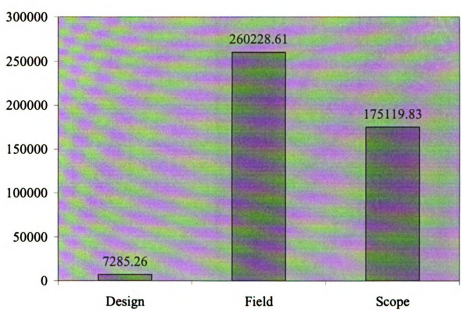


FIGURE A 6.12. CSI 3- COST PER GROUPED REASON CODE

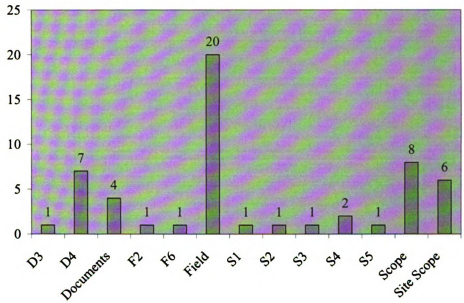


FIGURE A 6.13. CSI 3-C.O. ITEMS PER INDIVIDUAL REASON CODE

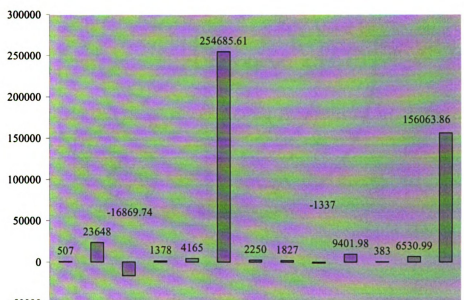


FIGURE A 6.14. CSI 3-COST PER INDIVIDUAL REASON CODE

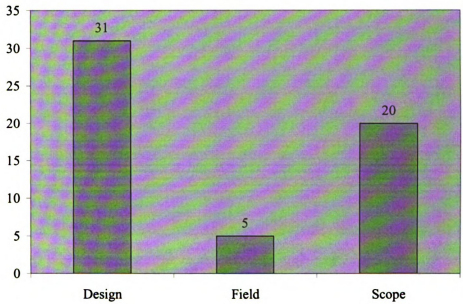


FIGURE A 6.15. CSI 4-C.O. ITEMS PER GROUPED REASON CODE

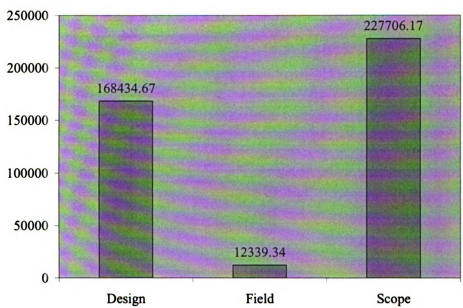


FIGURE A 6.16. CSI 4- COST PER GROUPED REASON CODE

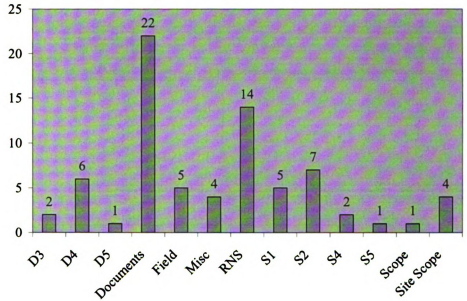


FIGURE A 6.17. CSI 4-C.O. ITEMS PER INDIVIDUAL REASON CODE

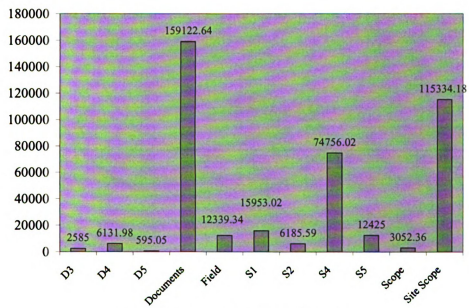


FIGURE A 6.18. CSI 4-COST PER INDIVIDUAL REASON CODE

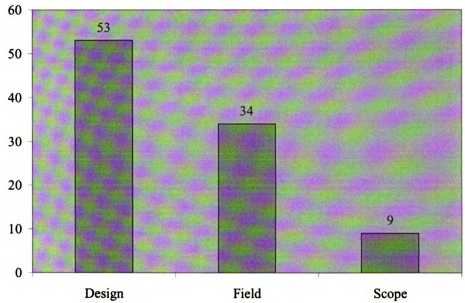


FIGURE A 6.19. CSI 5-C.O. ITEMS PER GROUPED REASON CODE

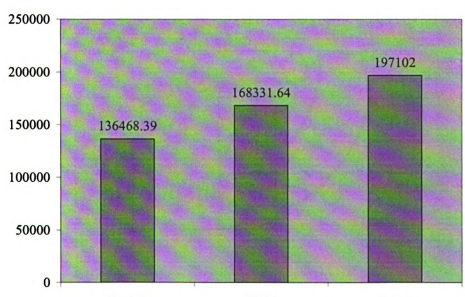


FIGURE A 6.20. CSI 5- COST PER INDIVIDUAL REASON CODE

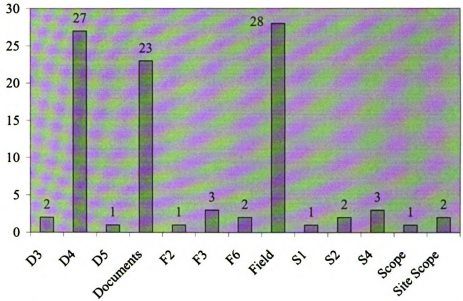


FIGURE A 6.21. CSI 5-C.O. ITEMS PER INDIVIDUAL REASON CODE

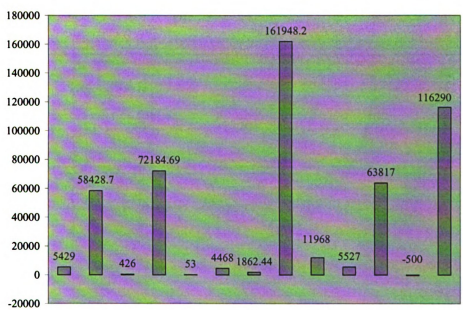


FIGURE A 6.22. CSI 5-COST PER INDIVIDUAL REASON CODE

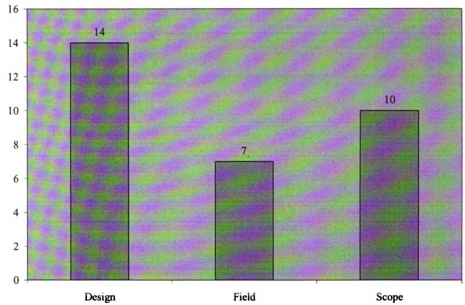


FIGURE A 6.23. CSI 6-C.O. ITEMS PER GROUPED REASON CODE

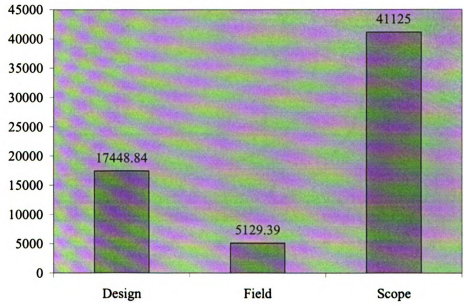


FIGURE A 6.24. CSI 6-COST PER GROUPED REASON CODE

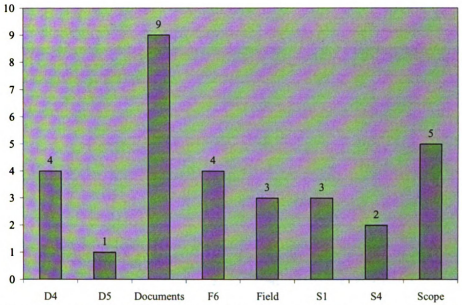


FIGURE A 6.25. CSI 6-C.O. ITEMS PER INDIVIDUAL REASON CODE

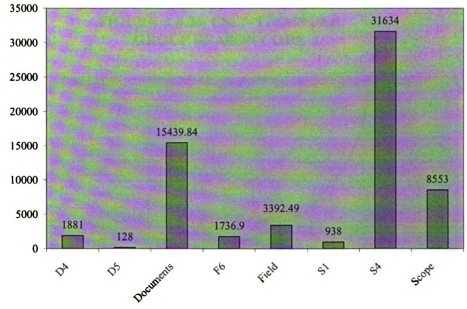


FIGURE A 6.25. CSI 6-C.O. ITEMS PER INDIVIDUAL REASON CODE

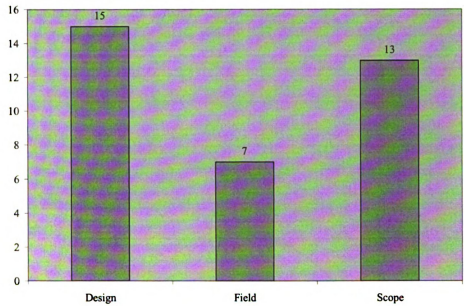


FIGURE A 6.26. CSI 7- ITEMS PER GROUP REASON CODE

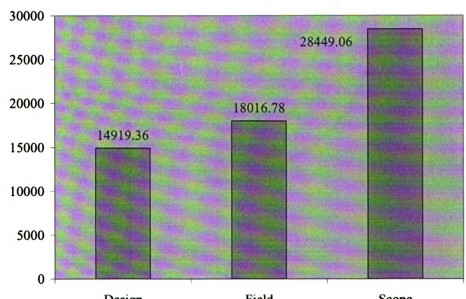


FIGURE A 6.27. CSI 7-C.O. COST PER GROUP REASON CODE

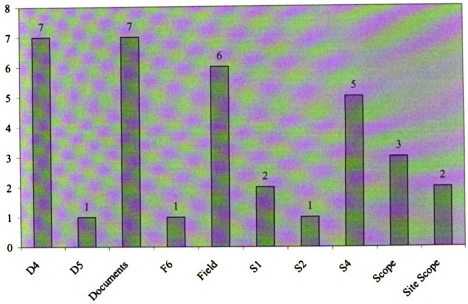


FIGURE A 6.28. CSI 7-ITEMSPER INDIVIDUAL REASON CODE

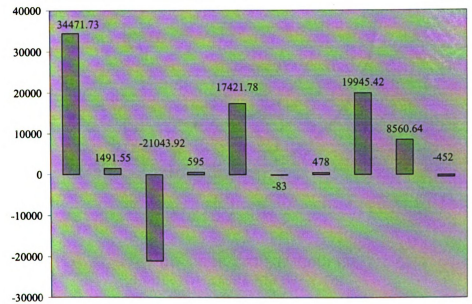


FIGURE A 6.29. CSI 7-C.O. COST PER INDIVIDUAL REASON CODE

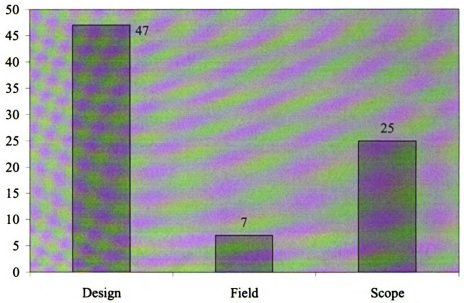


FIGURE A 6.30. CSI 8- ITESM PER GROUP REASON CODE

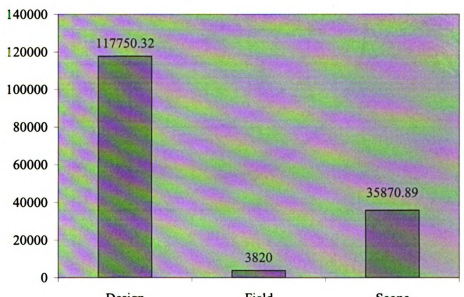


FIGURE A 6.31. CSI 8-C.O. ITEMS PER GROUPED REASON CODE

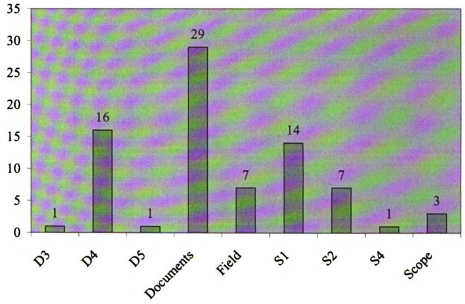


FIGURE A 6.32. CSI 8-ITEMS PER INDIVIDUAL REASON CODE

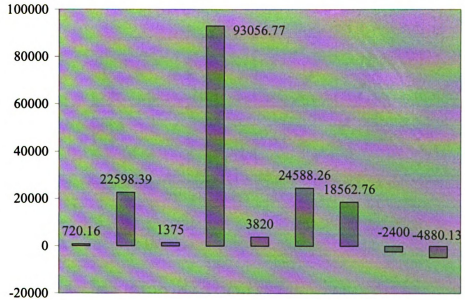


FIGURE A 6.33. CSI 8-C.O. COST PER INDIVIDUAL REASON CODE

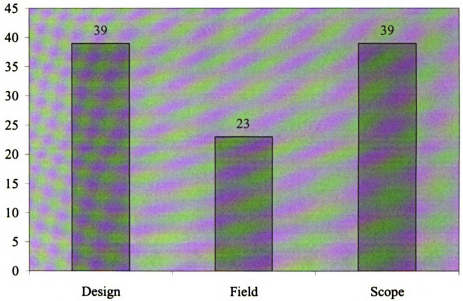


FIGURE A 6.34. CSI 9- ITEMS PER GROUP REASON CODE

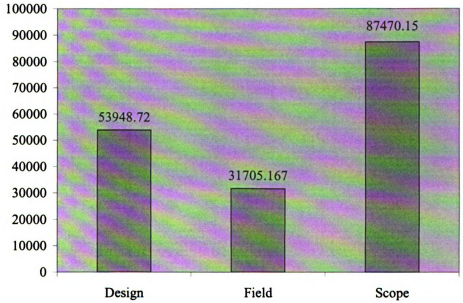


FIGURE A 6.35. CSI 9-C.O. COST PER GROUPED REASON CODE

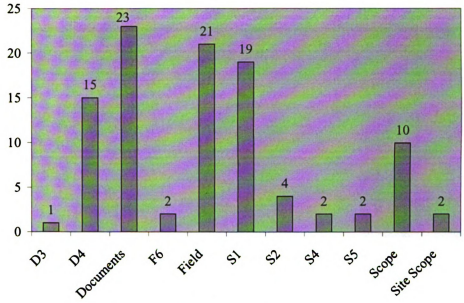


FIGURE A 6.36. CSI 9-ITEMS PER INDIVIDUAL REASON CODE

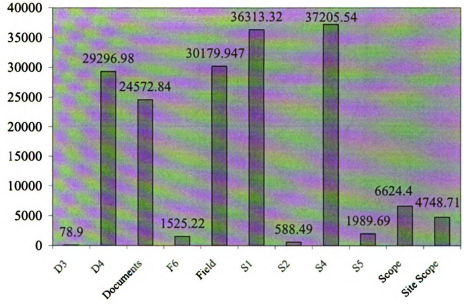


FIGURE A 6.37. CSI 9-C.O. COST PER INDIVIDUAL REASON CODE

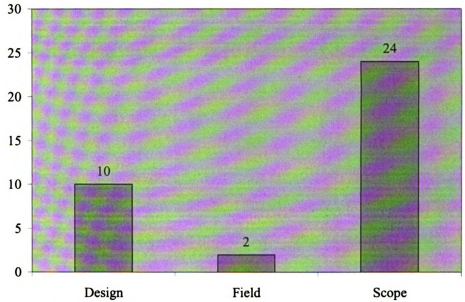


FIGURE A 6.39. CSI 10-C.O. ITEMS PER GROUPED REASON CODE

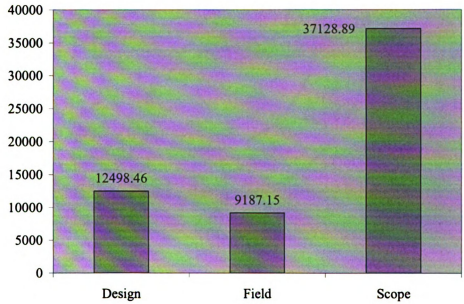


FIGURE A 6.40. CSI 10-COST PER GROUPED REASON CODE

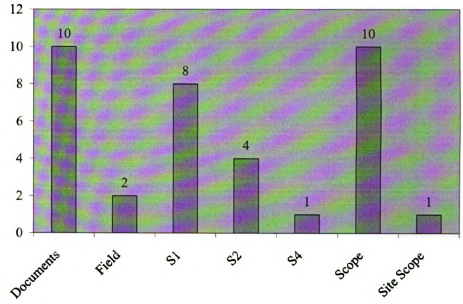


FIGURE A 6.41. CSI 10-C.O. ITEMS PER INDIVIDUAL REASON CODE

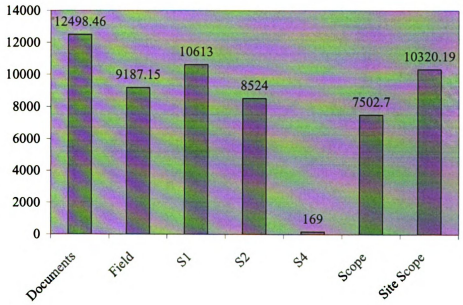


FIGURE A 6.42. CSI 10- COST PER INDIVIDUAL REASON CODE

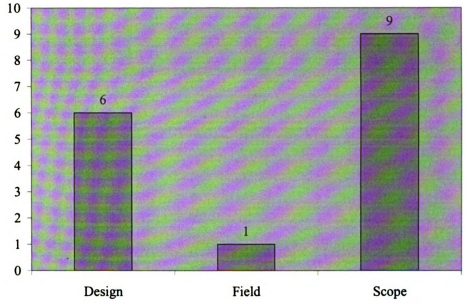


FIGURE A 6.43. CSI 11-C.O. ITEMS PER GROUPED REASON CODE

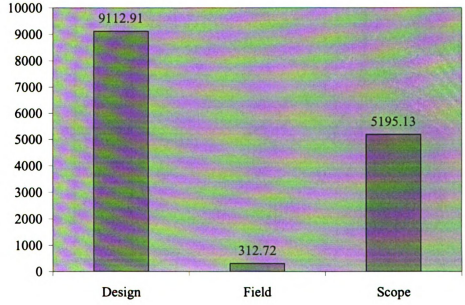


FIGURE A 6.44. CSI 11-COST PER GROUPED REASON CODE

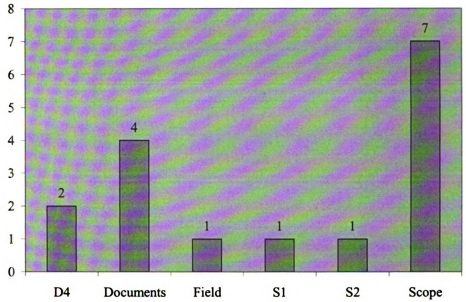


FIGURE A 6.45. CSI 11-C.O. ITEMS PER INDIVIDUAL REASON CODE

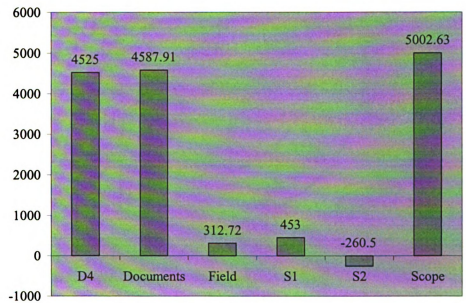


FIGURE A 6.46. CSI 11- COST PER INDIVIDUAL REASON CODE

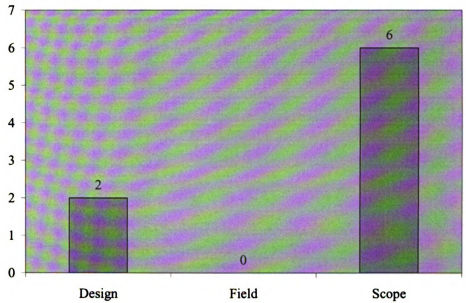


FIGURE A 6.47. CSI 12-C.O. ITEMS PER GROUPED REASON CODE

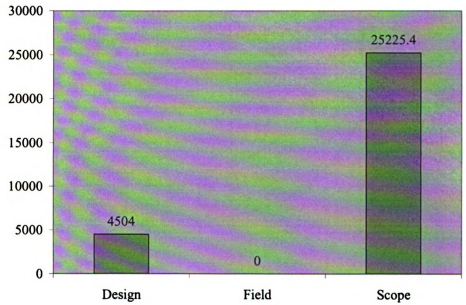


FIGURE A 6.48. CSI 12-COST PER GROUPED REASON CODE

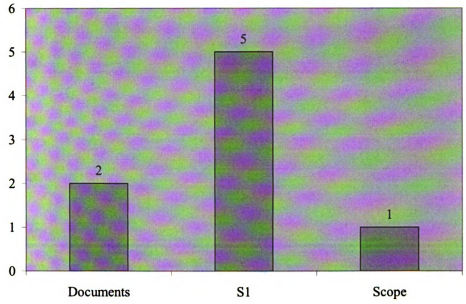


FIGURE A 6.49. CSI 12-C.O. ITEMS PER INDIVIDUAL REASON CODE

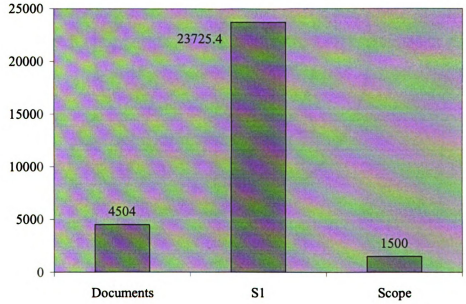


FIGURE A 6.50. CSI 12- COST PER INDIVIDUAL REASON CODE

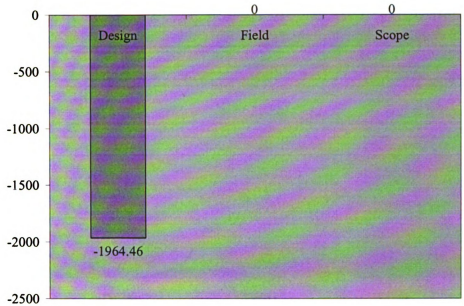


FIGURE A 6.51. CSI 13-COST PER GROUPED REASON CODE

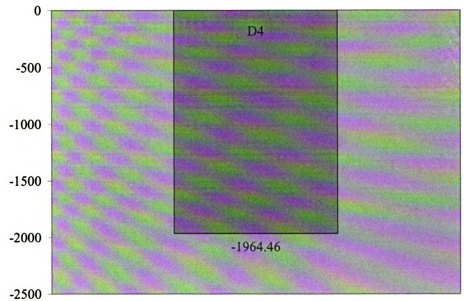


FIGURE A 6.52. CSI 13- COST PER INDIVIDUAL REASON CODE

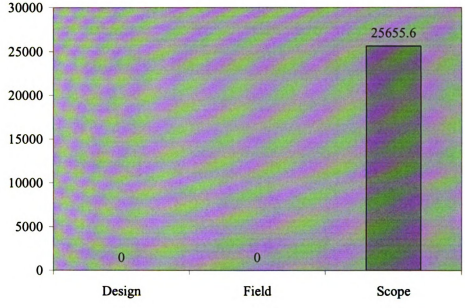


FIGURE A 6.53. CSI 14-COST PER GROUPED REASON CODE

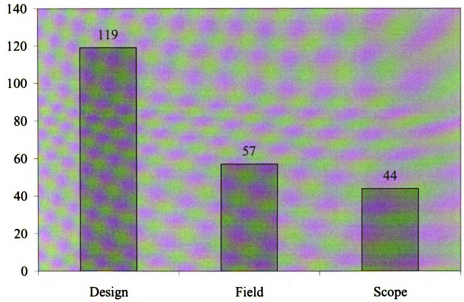


FIGURE A 6.54. CSI 15-C.O. ITEMS PER GROUPED REASON CODE

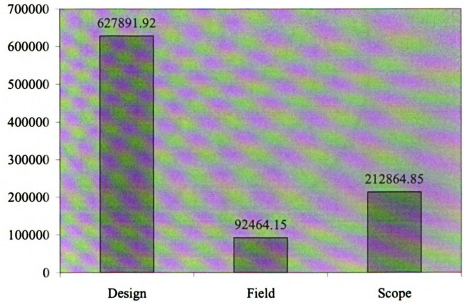


FIGURE A 6.55. CSI 15-COST PER GROUPED REASON CODE

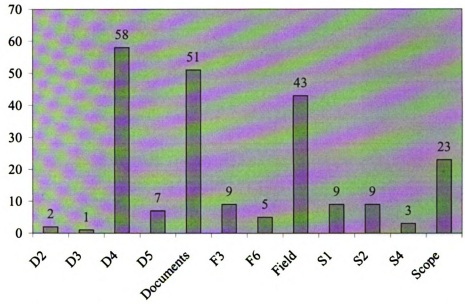


FIGURE A 6.56. CSI 15-C.O. ITEMS PER INDIVIDUAL REASON CODE

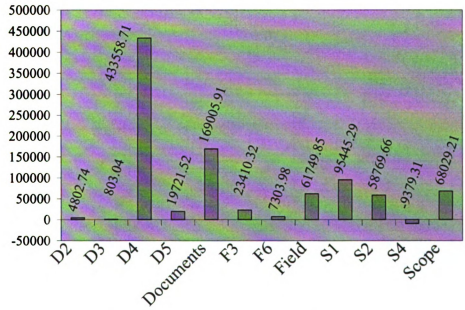


FIGURE A 6.57. CSI 15- COST PER INDIVIDUAL REASON CODE

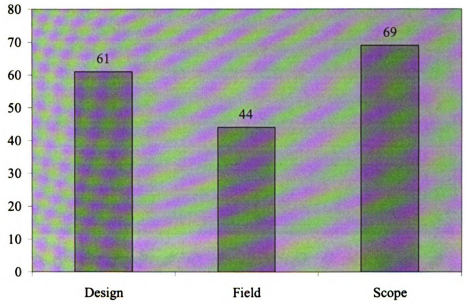


FIGURE A 6.58. CSI 16-C.O. ITEMS PER GROUPED REASON CODE

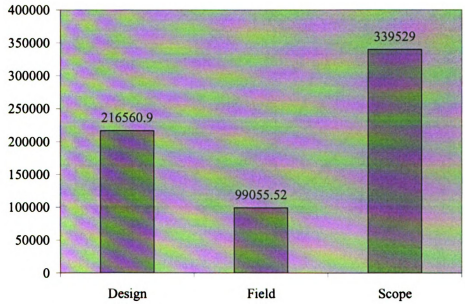


FIGURE A 6.59. CSI 16-COST PER GROUPED REASON CODE

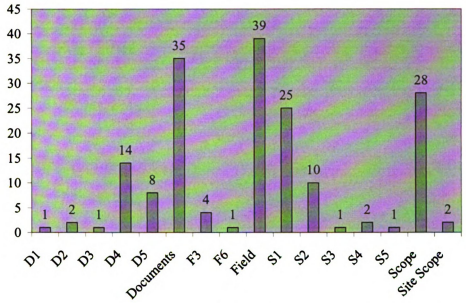


FIGURE A 6.60. CSI 16-C.O. ITEMS PER INDIVIDUAL REASON CODE

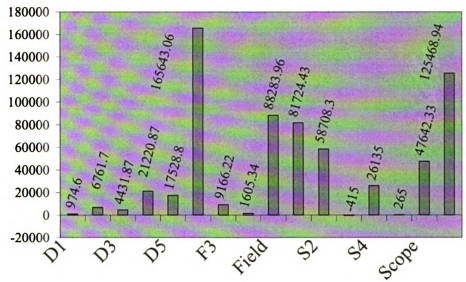


FIGURE A 6.61. CSI 16- COST PER INDIVIDUAL REASON CODE

APPENDIX VII

UNIVERSITY OF NOTRE DAME CHECKLIST

OFFICE OF THE UNIVERSITY ARCHITECT
DOCUMENT QUALITY ASSURANCE PLAN

1. PURPOSE

The purpose of this document is to provide the University's design consultants, the staff of the Office of the University Architect, and Facilities' Operations staff with the design review issues frequently overlooked or for those items requiring special attention in order to achieve a high level of quality documents.

2. SCOPE

The scope of this document describes the expectations of the University for the contents of Schematic Design, Design Development, and Construction Document drawings and specifications. All "No" responses of the quality checklist require a written explanation including what is necessary to achieve the item listed.

Note: This guideline does not relieve the Contractor nor the Design Consultant of their responsibilities as described in their contract with the University.

QUALITY CHECKLIST

A. Conceptual Design Drawings Checklist

1)	Does design conform to existing master plan?	☐	☐
2)	Does site plan show utilities and circulation?	☐	☐
3)	Does site plan show topographic features?	☐	☐
4)	Are small-scale line drawings of plans and sections adequate to define horizontal and vertical relationships?	☐	☐
5)	Do plans show existing and proposed facilities in their relative arrangement?	☐	☐
6)	Do plans accommodate the handicapped?	☐	☐
7)	Is there a general description of architectural, engineering, structural and mechanical systems to be used?	☐	☐
8)	Is there a listing of minimum codes to be used?	☐	☐
9)	Do square footage areas correlate to the program requirements?	☐	☐
10)	Does cost correlate to established budgets?	☐	☐

B. Schematic Design Drawings Checklist

1)	Have applicable codes, standards and rules been cited?	☐	☐
2)	Is there a differentiation between new construction and existing items?	☐	☐
3)	Architectural:		
a)	Is life safety plan information provided?	☐	☐
b)	Is occupancy classification indicated?	☐	☐
c)	Are separations (fire and smoke) shown?	☐	☐
d)	Are sprinkler requirements explained?	☐	☐
e)	Is construction type stated?	☐	☐
f)	Are typical exterior wall and roof sections shown?	☐	☐
g)	Are the numbers of floors described?	☐	☐
h)	Is the square footage per floor shown in accordance to the program?	☐	☐
i)	Does cost correlate to established budgets?	☐	☐
j)	Are overall plan dimensions indicated?	☐	☐

4) Civil/Structural:

a) Are the design parameters given?

b) Is a topographical survey provided?

c) Is a narrative of drainage concept provided?

d) Is a statement on flood considerations provided?

e) Is a statement of availability of utility services provided?

f) Is the building system narrative provided?

g) Are the proposed road and parking described?

h) Is a soil report provided?

i) Are overall plan dimensions indicated?

5) Mechanical:

a) Are the design parameters given?

b) Is the source of utility services shown?

c) the design of any specialty systems provided (i.e., laboratory gases)?

d) Are the energy requirements included?

e) Are the energy management/temperature controls and and/or building automation systems described?

f) Are indoor environmental requirements described?

6) Electrical:

a) Are the design parameters provided?

b) Is the source and voltage of electrical service provided?

c) Is the fire alarm system described?

d) Is the security system described?

e) Is the communication system described?

f) Is the lighting system described?

g) Is the computing data networking system described

C. **Design Development Drawings Checklist**

1) Does the design development submission represent the philosophy of design? ☐ ☐

2) Are the outline specifications included? ☐ ☐

3) Do the drawings show overall floor plans, outside elevations, location and orientation on the site? ☐ ☐

4) Are the system schematics shown for the facility? ☐ ☐

   a) HVAC ☐ ☐

   b) Plumbing ☐ ☐

   c) Electrical Power Distribution ☐ ☐

   d) Fire Alarm ☐ ☐

   e) Security ☐ ☐

   f) Site Water ☐ ☐

   g) Site Storm Sewer ☐ ☐

   h) Site Sanitary Sewer ☐ ☐

5) Does HVAC schematic diagram depict the following?

   a) Approved results of the life-cost analysis. ☐ ☐

   b) Approved results of the energy analysis. ☐ ☐

   c) Are schematic diagrams shown for campus type of utilities for the following? ☐ ☐

   d) Chilled Water ☐ ☐

   e) Steam ☐ ☐

   f) Fire ☐ ☐

   g) Domestic Water Distribution ☐ ☐

7) Do the outline specifications describe the following?

   a) Scope of project. ☐ ☐

   b) Applicable codes. ☐ ☐

   c) Applicable rules. ☐ ☐

   d) Applicable standards ☐ ☐

   e) Applicable regulations. ☐ ☐

   f) Each discipline with required design values shown. ☐ ☐

8) Are the project location, Architect and Engineering firms' addresses and telephone numbers shown? ☐ ☐

9) Architectural:

   a) Are occupancy types and floor areas indicated? ☐ ☐

b) Are square footage calculations shown for every space in accordance with program requirements? ☐ ☐

c) Is a description of the shape and façade of the building provided? ☐ ☐

d) Are all code-required features shown? ☐ ☐

e) Is the fire protection system described? ☐ ☐

f) Are the insulation "U" values shown? ☐ ☐

g) Are the glazing type "U" values shown? ☐ ☐

h) Are the exiting requirements stated? ☐ ☐

1.) Are the required numbers of exits clearly shown? ☐ ☐

2.) Are the capacity calculations clearly shown? ☐ ☐

i) Are dimension strings indicated on column grid? ☐ ☐

10) Civil/Structural:

a) Is a site plan shown? ☐ ☐

b) Is a grading plan, including contours and finish floor elevations provided? ☐ ☐

c) Is a utility plan included? ☐ ☐

d) Is a statement of loadings provided? ☐ ☐

e) Are preliminary foundation plans shown? ☐ ☐

j) Are preliminary floor and roof plans shown? ☐ ☐

k) Is a soil report relating to foundation design provided? ☐ ☐

l) Are dimension strings indicated on column gird? ☐ ☐

11) Mechanical/Plumbing:

a) Are HVAC and plumbing plans showing preliminary layout of equipment areas provided? ☐ ☐

b) Is a description of HVAC controls included? ☐ ☐

c) Is a description of energy management system included? ☐ ☐

d) Is a description of the building automation system included? ☐ ☐

e) Are the critical interfaces with life safety systems such as fire/smoke dampers, firestopping and fire control interlocks described? ☐ ☐

f) Are special plans and criteria for mechanical/ plumbing systems shown (i.e., kitchen hoods, paint storage ventilation, fuel systems, and compressed gas systems)? ☐ ☐

g) Are fire protection plans shown? ☐ ☐

h) Were the NFPA requirements for construction phase submittal reviewed? ☐ ☐

i) Do the drawings reflect the approved scheme resulting from the energy and life cycle cost analysis? ☐ ☐

12) Electrical:

a) Is the lighting layout provided? ☐ ☐

b) Are the calculations to show foot-candle intensities in each room provided? ☐ ☐

c) Do lighting illumination levels comply with the requirements of the Energy Analysis? ☐ ☐

d) Are the preliminary electrical equipment locations shown? ☐ ☐

e) Are the phase and voltage electrical characteristics shown? ☐ ☐

f) Is the type of wiring system indicated? ☐ ☐

g) Are the preliminary communications and data plans shown? ☐ ☐

h) Are the preliminary fire alarm plans shown? ☐ ☐

i) Are the preliminary security plans with card readers shown? ☐ ☐

j) Is a narrative on proposed power distribution system provided? ☐ ☐

13) Cost:

a) Does cost correlate to established budgets? ☐ ☐

D. 100% Construction Drawings Checklist

1) Are the following shown?

a) All necessary information previously described. ☐ ☐

b) All necessary details. ☐ ☐

c) All sections. ☐ ☐

d) All schedules. ☐ ☐

e) All system diagrams. ☐ ☐

f) All construction types. ☐ ☐

g) All wall ratings - fire and "U" values. ☐ ☐

h) All listed firestop systems. ☐ ☐

2) Do the documents clearly depict the following?

a) All design and construction requirements. ☐ ☐

b) Adequate information to permit accurate Contractor take-off and pricing. ☐ ☐

c) The finalization of the previously submitted and approved design phases. ☐ ☐

d) The agreed upon responses of earlier design review quality comments. ☐ ☐

e) All items provided by Owner installed by Contractor. ☐ ☐

f) All items installed by Owner. ☐ ☐

g) Project name, project number and project location. ☐ ☐

h) Compass orientation the same on all plan view sheets. ☐ ☐

i) All easements, right-of-way, and interfaces with public, city or county utilities. ☐ ☐

j) All proposed alternates shown clearly and accurately. ☐ ☐

k) All previously approved energy and life-cycle cost analyses, schemes and architectural features. ☐ ☐

l) All necessary building code approvals. ☐ ☐

m) Drawing sheet signed and sealed by Architect or Engineer? ☐ ☐

n) Do square footage areas correlate to program requirements? ☐ ☐

o) Does cost correlate to established budgets? ☐ ☐

3) Architectural:

a) Are wall details shown that ensure the minimum "U" value is met? ☐ ☐

b) Are roof details shown that ensure the minimum "U" value is met? ☐ ☐

c) Floor Plans:

1.a) Are all dimensions and all spaces identified? ☐ ☐

1.b) Are all walls dimensioned from column lines? ☐ ☐

2.) Are rated partitions identified? ☐ ☐

3.) Area ADA handicapped features identified? ☐ ☐

4.) Is the location of all drinking fountains, fire extinguishers, hoses, etc. shown? ☐ ☐

5.) Is all built-in equipment identified? ☐ ☐

6.) Is the orientation (north arrow) shown on all plans? ☐ ☐

7.) Is the scale shown for all drawings? ☐ ☐

d) Elevations:

1.) Are all elevations of the building shown? ☐ ☐

2.) Are all materials labeled? ☐ ☐

3.) Are all vertical dimensions shown? ☐ ☐

4.) Is the roof slope identified? ☐ ☐

e) Reflected Ceiling Plans:

1.) Is the plan fully coordinated by CAD overlay with mechanical, electrical, data, and sprinkler system drawings? ☐ ☐

2.) Are all ceiling materials identified? ☐ ☐

3.) Is the design intent of ceiling grid clearly shown? ☐ ☐

f) Scale of Plans:

1.) Are all plans shown at "1/8 inch equals one foot" scale, except for enlarged plan view for equipment rooms, stairs, etc? ☐ ☐

g) Sections and Details. Identify:

1.) All exterior wall sections minimum 3/4" = 1'-0". ☐ ☐

2.) All interior wall sections minimum 3/4" = 1'-0". ☐ ☐

3.) All roof edges, expansion joints, penetrations shown with isometric drawing of scupper or any non-standard situations. ☐ ☐

4.) All head, jamb and sill details shown for all doors and windows. ☐ ☐

5.) All expansion joints shown ☐ ☐

h) Schedules and Legends. Identify:

1.) Finishes ☐ ☐

2.) Doors and windows ☐ ☐

3.) Toilet accessories ☐ ☐

4.) All abbreviations ☐ ☐

i) Miscellaneous:

1.) Show mounting heights for all handicapped items; toilet room accessories, ramp slopes, stair design, seating capacity. ☐ ☐

2.) State on the drawings the code and year that applies to the project. ☐ ☐

3.) Show design loads on drawings. ☐ ☐

4) Civil/Structural:

a) Show anchor bolt embedments and projections. ☐ ☐

b) Provide footing elevations. ☐ ☐

c) Identify connections and services. ☐ ☐

e) Indicate top elevation of all catch basins and manholes. ☐ ☐

f) Match contours with top elevations of catch basins and manholes. ☐ ☐

f) Is the type of pipe specified? ☐ ☐

k) Are the datum elevations correlated with the USGS elevations? ☐ ☐

i) Are the finish floor elevations shown? ☐ ☐

j) Is the finish floor elevation above 100-year flood elevation? ☐ ☐

j) Are pavement sections shown? ☐ ☐

m) Are control joints shown in all slabs? ☐ ☐

n) Are proper control joints shown in all masonry walls? ☐ ☐

o) Are all structural elements properly and accurately dimensioned from column grid lines? ☐ ☐

5) Mechanical/Plumbing:

a) Are all fire/smoke dampers provided in all rated walls/ceilings? ☐ ☐

b) Is a detail shown for sealing all wall and ceiling penetrations? ☐ ☐

c) Is the water heater relief piping and discharge point shown? ☐ ☐

d) Is all ductwork designed in compliance with ASHRAE and SMACNA? ☐ ☐

e) Are all systems in compliance with University standards? ☐ ☐

f) Are all plumbing systems in compliance with applicable codes? ☐ ☐

g) Is the following equipment provided in all attics?

1.) Access opening, platforms, and walkways ☐ ☐

2.) Lighting ☐ ☐

3.) Auxiliary pans/drains for air conditioning equipment ☐ ☐

4.) GFI convenience outlets ☐ ☐

g) Do all kitchen hoods conform to mechanical and fire codes. ☐ ☐

h) Are all air conditioning condensate lines with discharge shown? ☐ ☐

1.) Does the discharge conform to code? ☐ ☐

j) Are all required backflow prevention devices shown? ☐ ☐

k) Does the fire sprinkler system show:

1.) Details of water source?

2.) Type of sprinkler system?

3.) Plan of sprinkler system?

4.) Are risers shown?

5.) Are connections to existing systems shown?

6.) Are all valves and controls shown?

l) Is the temperature control system provided?

m) Is the energy management system provided?

n) Is the building automation system provided?

o) Are temperature control energy management and building automation systems' schematics shown on the drawings?

p) Are the sequences of the HVAC systems' of operation provided?

6) Electrical:

a) Is an electrical site plan shown?

b) Was a CAD overlay made of the electrical work to ensure no conflicts with other work or equipment?

c) Is lighting system in accordance with University energy guidelines?

d) Does all electrical work comply with the latest National Electrical Code?

e) Are all conductors copper?

f) Is the electrical legend complete?

g) Are all panelboard schedules provided?

1.) Do they show voltage and phase?

2.) Is the rating of the main disconnect shown?

3.) Are all circuit numbers shown?

4.) Are the number of poles shown?

5.) Are all trip-amperes shown?

6.) Are all volt-amperes shown?

7.) Are all wire sizes shown?

8.) Are all conduit sizes shown?

i) Is lighting fixture schedule shown?

1. Are all fluorescent lamps and ballasts of the energy-saving type?

i) Are riser diagrams shown for the following:

1.) Electrical service?

2.) Fire alarm system?

3.) Intercom system?

4.) Telecommunications system?

5.) Computer data system?

j) Is the following transformer data provided?

1.) Voltage?

2.) Phase?

3.) KVA rating?

j) Is the division of work between contractor, University of Notre Dame Utilities and AEP clearly shown?

k) Is the voltage and KVA rating of all generators shown?

l) Is the voltage and KVA rating of all transfer switches shown?

m) Is sufficient space shown as required by the National Electrical Code for the following:

1.) Panelboard locations?

2.) Switchgear locations?

3.) Transformer locations?

o) Are ensurences made that no water lines are above electrical panels or switchgear?

p) Are all locations of mechanical equipment and their circuits shown?

q) Are all circuits for kitchen equipment shown?

r) Are all rooms designated as shown on the architectural plans?

s) Is the lighting layout coordinated with the architectural reflected ceiling plan?

t) Is all grounding shown?

u) Is all the electrical equipment shown on the floor plans?

v) Are all circuits shown on the floor plans?

w) Are specifications provided for the following?

1.) All electrical equipment.

2.) The fire alarm system.

3.) The intercom system.

4.) The lightning protection.

5.) The security system.

6.) The telecommunications system.

7.) The computer data system.

8.) The firestopping details.

9.) All grounding, including equipment grounding. ☐

APPENDIX VIII

PLAN REVIEW CHECKLIST

Plan review checklist

Checklist to assist plan review process – Design discipline specific

Purpose

The purpose of this checklist is to assist university staff in conducting plan reviews, and will help to identify design and coordination issues which are sometimes overlooked. This checklist should act as a supplement to current plan review processes.

Organization of the document

This document is organized at four broad categories and is specific to each design discipline level:

Conceptual design development level

Schematic design development level

Design development level and

Contract documents level.

Instructions for plan reviewers

This document can be used for design review and is organized at four different levels. Plan reviewers should check the listed items during the plan review process. All "No" responses should be provided with written descriptions explaining the necessary action to be taken to correct the items listed.

CONCEPTUAL

	YES	NO
1) Is conceptual design in accordance with the master plan? *Source: QCC*	☐	☐
2) Does the site plan show utilities and traffic patterns? *Source: QCC*	☐	☐
3) Do the plans clearly indicate the existing and proposed facilities of the site?	☐	☐
a) Are the locations of telephone poles, electrical lines and any other facilities clearly indicated? *Source: QCC, supported by Database analysis*	☐	☐
4) "Are small-scale line drawings of plans and sections adequate to define horizontal and vertical relationships"? *Source: QCC*	☐	☐
5) "Is there any general description of architectural, engineering, structural and mechanical systems to be used"? *Source: QCC, supported by Interviews*	☐	☐
6) Are square footage areas in conformance with programming? *Source: QCC*	☐	☐

SCHEMATIC

1) Are all applicable codes and standards indicated? ☐ ☐
Source: QCC

Architectural

1) Are the functional requirements of all rooms provided?
a) Does this information clearly specify the function of the room? ☐ ☐
Source: Database analysis

b) Does it describe any technical requirements such as communication systems, which should be considered while designing? ☐ ☐
Source: Database analysis

c) Does this layout address the common areas to be built? ☐ ☐
Source: Database analysis

2) Is the occupancy of rooms described? ☐ ☐
Source: QCC

3) Is the square footage per floor shown in accordance to the program? ☐ ☐
Source: Database analysis

4) Are all dimensions of spaces and elements provided? ☐ ☐
Source: Database analysis

5) Are typical sections of walls and roofs shown? ☐ ☐
Source: QCC

6) Is there any description explaining the fire protection systems? ☐ ☐
Source: Database analysis

7) Are there specifications of services to be provided? ☐ ☐
Source: Interviews

Civil/Structural

1) Are all dimensions and requirements provided? ☐ ☐
Source: Database analysis

2) "Is a soil report provided?" (Foundations and excavations) ☐ ☐
Source: QCC

3) "Is a statement of availability of utility services provided"? ☐ ☐
Source: QCC

4) "Is the building system narrative provided"? ☐ ☐
Source: QCC

Mechanical

1) Are the design requirements given? ☐ ☐
Source: QCC

2) "Is the source of utility services shown"? ☐ ☐
Source: QCC, supported by Interviews

3) Is the description of mechanical equipment/systems provided? ☐ ☐
Source: QCC, supported by Interviews

4) "Is the design of specialty systems provided" (if any)? ☐ ☐
Source: QCC, supported by Interviews

5) Is the square footage (area) of mechanical spaces provided? ☐ ☐
Source: Interviews

6) "Are the energy requirements included"? ☐ ☐
Source: QCC

7) "Are the energy management/temperature controls and/or building automation systems described"? ☐ ☐
Source: QCC

8) "Are indoor environmental requirements described"? ☐ ☐
Source: QCC

Electrical

1) "Are the design parameters provided"? ☐ ☐
Source: QCC

2) Is the square footage of electrical spaces provided? (communication room, electrical vaults) ☐ ☐
Source: Database analysis

3) "Is the source and voltage of electrical service provided"? ☐ ☐
Source: QCC

4) "Is the fire alarm system described"? ☐ ☐
Source: QCC, supported by Interviews

5) "Is the security system described"? ☐ ☐
Source: QCC, supported by Interviews

6) "Is the communication system described"? ☐ ☐
Source: QCC, supported by Interviews

7) "Is the lighting system described? ☐ ☐
Source: QCC, supported by Interviews

8) "Is the computing data networking system described"? ☐ ☐
Source: QCC

DESIGN DEVELOPMENT

1) Is the design development submission in correlation with the briefing needs? ☐ ☐
Source: Database Analysis

2) Do the outline specifications describe the following?
a) Does it address the scope of the project? ☐ ☐
Source: Database Analysis

b) Applicable local codes ☐ ☐
Source: Database Analysis

3) "Do the drawings specify all floor plans, sections, elevations, orientation and location on the site"? ☐ ☐
Source: QCC

4) Do plans address schematic layout of the proposed utilities in the drawings? ☐ ☐
Source: Database Analysis

Architectural

1) Are the following specified?
a) Is the occupancy of rooms specified? ☐ ☐
Source: QCC

b) Are floor areas clearly specified? ☐ ☐
Source: Database Analysis

c) Are names and the function of each room specified? ☐ ☐
Source: Database Analysis

d) Do plans indicate all walking areas (common areas) clearly? ☐ ☐
Source: Database Analysis

e) Are there any functional conflicts in the room?
(i) Are the square footage areas of individual areas in conformance with the programming needs? ☐ ☐
Source: Database Analysis

(ii) How many telephone outlets are needed for particular room? ☐ ☐
Source: Database Analysis

(iii) Are pathways/walkways checked to know if it can accommodate the equipment moved in that way? ☐ ☐
Source: Database Analysis

(iv) Are there any insufficient physical spaces, or unusual corners? ☐ ☐
Source: Database Analysis

2) Are the insulation values specified? ☐ ☐
Source: QCC

3) Are the fire protection systems described? ☐ ☐
Source: QCC

4) Are door and window frames correctly placed as per requirements? ☐ ☐
Source: Database Analysis

5) Is the correct door type provided? ☐ ☐
Source: Database Analysis

6) Are frames provided for all doors? Is there any missing data? ☐ ☐
Source: Database Analysis

7) Do all doors have required frames? ☐ ☐
Source: Database Analysis

8) Are doors correlating with elevation? ☐ ☐
Source: Database Analysis

9) Do plans and specifications correctly name doors and windows? ☐ ☐
Source: Database Analysis

10) Are door swings placed in correct direction? ☐ ☐
Source: Database Analysis

11) Are threshold and weather-stripping provided to required doors? ☐ ☐
Source: Database Analysis

12) Are floor stops' and wall stops' provided for all required doors? ☐ ☐
Source: Database Analysis

13) Is hardware sufficient for all doors and windows? ☐ ☐
Check the hardware schedule in specifications.
Source: Database Analysis

14) Does provided hardware match doors and windows? ☐ ☐
Source: Database Analysis

Civil/Structural

1) "Is a site plan shown"? ☐ ☐
Source: QCC

2) Is a preliminary soil analysis provided? Does it also define the report of the foundation design? ☐ ☐
Source: QCC, supported by Database analysis

3) Are plans provided showing finished floor elevations? ☐ ☐
Source: QCC

4) "Is a statement of loadings provided"? ☐ ☐
Source: QCC

5) Are preliminary drawings of the following shown?
a) Foundations ☐ ☐

b) Beams and columns ☐ ☐

c) Floor and roof plans ☐ ☐
Source: Database Analysis

6) Are beam sizes checked for the structural stability, which address issues such as reinforcement? ☐ ☐
Source: Database Analysis

7) Are structural members such as beams adequate? ☐ ☐
Source: Database Analysis

8) Are all dimensions shown? ☐ ☐
Source: Database Analysis

Mechanical

1) Do plans show preliminary layout of the equipment areas provided? ☐ ☐
Source: Database Analysis

2) Do plans show location of equipment? ☐ ☐
Source: Interviews

3) Do plans indicate air distribution devices, return grills and supply diffusers? ☐ ☐
Source: Interviews

4) Is the appropriate water quality provided by the plumbing system? ☐ ☐
Source: Interviews

5) Do plans show the route of ducts? ☐ ☐
Source: Database Analysis

6) Is a preliminary layout and description of the following provided:
a) HVAC ☐ ☐
Source: Interviews/ Database

b) Energy management system ☐ ☐
Source: Interviews/ Database

c) Building automation system ☐ ☐
Source: Interviews/ Database

d) Fire/smoke dampers, fire stopping and fire control interlocks ☐ ☐
Source: Interviews/ Database

e) Specialty equipment ☐ ☐
Source: Interviews/ Database

f) Plumbing system ☐ ☐
Source: Interviews/ Database

g) Sprinkler systems ☐ ☐
Source: Interviews/ Database

h) Snowmelt system ☐ ☐
Source: Interviews/ Database

i) Are there any places in the plans where the ducts are obstructed by beams? ☐ ☐
Source: Interviews/ Database

Electrical

1) "Is the lighting layout provided"? ☐ ☐
Source: QCC

2) Compliance with foot-candle intensities
a) "Are the calculations to show the foot-candle intensities in each room provided"? ☐ ☐
Source: QCC, supported by Database analysis

b) Are void spaces taken care off? Do these places need lighting or is it too dark? ☐ ☐
Source: QCC, supported by Database analysis

c) Are corridors well lit? Do these walking areas comply with calculated foot-candle intensities? ☐ ☐
Source: QCC, supported by Database analysis

d) Are the light types and fixture types comply with the calculation of foot candle intensities, which suits functionality of the room? ☐ ☐
Source: QCC, supported by Database analysis

3) "Do lighting illumination levels comply with the requirements of the Energy Analysis"? ☐ ☐
Source: QCC

4) Are preliminary lighting equipment shown? ☐ ☐
Source: QCC

5) Are the technical details such as voltage electrical characteristics, power distribution system specified? ☐ ☐
Source: Database analysis

6) Is the type of wiring system specified? ☐ ☐
Source: Database analysis

7) Are preliminary plans of the following shown:
a) Communication systems ☐ ☐
Source: Database analysis

b) Fire alarm systems ☐ ☐
Source: Database analysis

c) Security systems ☐ ☐
Source: Database analysis

CONTRACT DOCUMENTS

Architectural

1) Specifications – Pay attention to the following:
   a) Are there any repetitions of specifications from similar project? ☐ ☐
   Source: Civitello change order discovery checklist

   b) Any manufacturer's specifications followed? ☐ ☐
   Source: Civitello change order discovery checklist

   (i) If yes, for above two questions, was it made sure that this would suit this particular project? ☐ ☐
   Source: Civitello change order discovery checklist

   c) Are there any vague or ambiguous specifications, which are difficult to understand? ☐ ☐
   Source: Civitello change order discovery checklist

2) Code Compliance
   a) Are all applicable codes followed? ☐ ☐
   Source: Civitello change order discovery checklist

   b) Are codes and standards of university followed? ☐ ☐
   Source: Civitello change order discovery checklist

3) Match lines and orientation
   a) Are there any match lines in the drawings? ☐ ☐
   Source: Civitello change order discovery checklist

   b) If yes, are they in the same location? ☐ ☐
   Source: Civitello change order discovery checklist

   c) Is the orientation shown in all plans? ☐ ☐
   Source: Civitello change order discovery checklist

   d) Is the orientation on the same place on the each plan? ☐ ☐
   Source: Civitello change order discovery checklist

   e) Do all drawings show the scale? ☐ ☐
   Source: Civitello change order discovery checklist

4) Floor plans
   a) Are all floor plans provided? ☐ ☐
   Source: Civitello change order discovery checklist/ Database analysis

   b) Are all dimensions specified? ☐ ☐
   Source: Civitello change order discovery checklist/ Database analysis

c) Do all floor plans show the location and ratings of all fire-rated walls? ☐ ☐
Source: Civitello change order discovery checklist/ Database analysis

d) Is square footage of each floor plan shown on the related floor plan? ☐ ☐
Source: Civitello change order discovery checklist/ Database analysis

e) Are there any discrepancies of walls with the column lines? ☐ ☐
Source: Civitello change order discovery checklist/ Database analysis

f) Are the locations of specialty amenities shown in the plans such as drinking fountains, fire extinguishers? ☐ ☐
Source: Civitello change order discovery checklist/ Database analysis

g) Are handicapped features shown (if necessary)? ☐ ☐
Source: Civitello change order discovery checklist/ Database analysis

5) Elevations

a) Are all elevations shown? ☐ ☐
Source: Civitello change order discovery checklist

b) Are all materials labeled? ☐ ☐
Source: Civitello change order discovery checklist

c) Are all dimensions shown? ☐ ☐
Source: Civitello change order discovery checklist

d) Do the elevations define overall building height and floor-to-floor heights? ☐ ☐
Source: Civitello change order discovery checklist

e) Does wall section show proposed materials & fire-rated systems? ☐ ☐
Source: Civitello change order discovery checklist

6) Ceiling Plans

a) Are all dimensions in ceiling plans provided, such as ceiling heights, mechanical and electrical equipment? ☐ ☐
Source: Civitello change order discovery checklist/ Database analysis

b) Do ceiling plans show the sprinkler heads layout, walls, and show all dimensions? ☐ ☐
Source: Civitello change order discovery checklist/ Database analysis

c) Are all the materials identified? ☐ ☐
Source: Civitello change order discovery checklist/ Database analysis

d) Overlay mechanical, electrical, sprinkler systems and structural layout to check for the conflicts. Any problems found? ☐ ☐
Source: Civitello change order discovery checklist/ Database analysis

7) Does legends and schedule show:
a) Finishes ☐ ☐
Source: Civitello change order discovery checklist/ Database analysis

b) Doors and Windows – does the door schedule specify the applicable hardware, ratings, and types of the doors? ☐ ☐
Source: Civitello change order discovery checklist/ Database analysis

c) Toilet accessories ☐ ☐
Source: Civitello change order discovery checklist/ Database analysis

d) Indicate abbreviations ☐ ☐
Source: Civitello change order discovery checklist/ Database analysis

Civil

1) Are the elevations of footings clearly shown? ☐ ☐
Source: Database analysis

2) Do the foundation drawings show the slab elevations and specify the type of foundation? ☐ ☐
Source: Database analysis

3) Do the foundation drawings indicate all dimensions? ☐ ☐
Source: Civitello change order discovery checklist/ Database analysis

4) Footings
a) Is a footing schedule provided? ☐ ☐
Source: Database analysis

b) Does schedule show footing sizes? ☐ ☐
Source: Database analysis

c) Does it specify the reinforcement? ☐ ☐
Source: Database analysis

d) Does it show the depth of footing? ☐ ☐
Source: Database analysis

5) "Are the finished floor elevations shown"? ☐ ☐
Source: QCC

6) "Are structural elements accurately dimensioned from column grid lines"? ☐ ☐
Source: QCC

7) Review should check for:
a) Column layouts to find out if there are any discrepancies ☐ ☐
Source: Civitello change order discovery checklist/ Database analysis

b) Beam layout to find out if there are any discrepancies ☐ ☐
Source: Civitello change order discovery checklist/ Database analysis

8) Are all dimensions and specifications related to structural details provided? ☐ ☐
Source: Civitello change order discovery checklist/ Database analysis

Mechanical

1) Are all equipment and systems in compliance with university standards? ☐ ☐
Source: Interviews

2) Is all the equipment stated during the design development stage shown in the drawings? Are mechanical plans provided for each floor? ☐ ☐
Source: Interviews

3) Are all rooms identified as per mechanical equipment/systems location? ☐ ☐
Source: Interviews

4) Is sufficient space provided to access fire/smoke detectors and controls? ☐ ☐
Source: Interviews

5) Is owner training being provided for special equipment (ex: autoclave)? ☐ ☐
Source: Interviews

6) Are the water relief piping and discharge point shown? ☐ ☐
Source: Interviews

7) Fire sprinkler system
a) Is the layout of sprinkler system provided? ☐ ☐
Source: Interviews

b) Is the type of sprinkler system specified? ☐ ☐
Source: Interviews

c) Are the details of water source mentioned? ☐ ☐
Source: Interviews

d) Are all connections shown? ☐ ☐
Source: Interviews

e) Are valves and controls shown? ☐ ☐
Source: Interviews

8) Equipment
a) Is the temperature control system shown? ☐ ☐
Source: Interviews

b) Is the building automation system shown? ☐ ☐
Source: Interviews

9) Duct

a) Is the size of duct reviewed to avoid conflict with ceiling size? ☐ ☐
Source: Civitello change order discovery checklist/ Database analysis

b) Is routing of duct correct? ☐ ☐
Source: Civitello change order discovery checklist/ Database analysis

c) Are there any conflicts of ducts with structural members such as beam, columns, and trusses? ☐ ☐
Source: Civitello change order discovery checklist/ Database analysis

d) Are there any conflicts with piping, lighting, sprinkler systems? ☐ ☐
Source: Civitello change order discovery checklist/ Database analysis

e) Is there any colliding of ducts with construction members? ☐ ☐
Source: Civitello change order discovery checklist/ Database analysis

f) Are fire/smoke dampers provided wherever required? ☐ ☐
Source: Civitello change order discovery checklist/ Database analysis

10) Is there any specialty equipment used at ceilings? ☐ ☐
Source: Database analysis

11) If yes, consider the requirements and check for an unusual projections over the ceiling. Does it fit in the approved ceiling height? ☐ ☐
Source: Database analysis

12) Overlay the electrical and mechanical plans to check if there are any conflicts of ducts with:

a) Pipes ☐ ☐
Source: Civitello change order discovery checklist/ Database analysis

b) Beams ☐ ☐
Source: Civitello change order discovery checklist/ Database analysis

c) Electrical equipment ☐ ☐
Source: Civitello change order discovery checklist/ Database analysis

13) Overlay the structural plans and ducting plans to find the conflicts (consider insulation thickness for pipes and ducts) ☐ ☐
Source: Civitello change order discovery checklist/ Database analysis

14) Review of various kinds of piping to check for the conflicts among different types of pipes (consider insulation thickness for pipes and ducts)

a) Review of sanitary piping ☐ ☐
Source: Database analysis

b) Review of steam piping ☐ ☐
Source: Database analysis

c) Review of condensate piping ☐ ☐
Source: Database analysis

d) Review of storm piping ☐ ☐
Source: Database analysis

e) Review of gas service piping ☐ ☐
Source: Database analysis

15) Is required piping provided for emergency showers and refrigerators? (Exclusive for science buildings and laboratories) ☐ ☐
Source: Database analysis

16) Do drawings for each floor plan indicate the fire sprinkler pipe layout? ☐ ☐
Source: Database analysis

17) Does the layout indicate all the pipe sizes and pipe material type? ☐ ☐
Source: Database analysis

18) Does distribution system airflow match with equipment capacity? ☐ ☐
Source: Database analysis/ Interviews

Electrical

1) Are the electrical systems in accordance with the university standards? ☐ ☐
Source: Database analysis

2) Does the legend specify all details? ☐ ☐
Source: Database analysis

3) Does plan layout show the connection of fire sprinkler systems with alarm system? ☐ ☐
Source: Database analysis

4) Are lighting plans provided for each floor? ☐ ☐
Source: Database analysis

5) Is electrical service provided to all mechanical equipment? ☐ ☐
Source: Interviews

6) Review the following in panel board schedules:
a) "Do they show voltage and phase"? ☐ ☐
Source: QCC

b) "Is the rating of the main disconnect shown"? ☐ ☐
Source: QCC

c) "Are all circuit numbers cited"? ☐ ☐
Source: QCC

d) "Are the trip amperes shown"? ☐ ☐
Source: QCC

e) "Are all wire-amperes shown"? ☐ ☐
Source: QCC

f) "Are all conduit sizes specified"? ☐ ☐
Source: QCC

7) "Are riser diagrams shown for the following":
a) Electrical service ☐ ☐
Source: QCC

b) Fire alarm system ☐ ☐
Source: QCC

c) Communication systems ☐ ☐
Source: QCC

d) Computer data systems ☐ ☐
Source: QCC

8) "Is all grounding shown"? ☐ ☐
Source: QCC

9) Are specifications provided for the following:
a) The electrical equipment ☐ ☐
Source: QCC

b) The fire alarm system ☐ ☐
Source: QCC

c) The intercom system ☐ ☐
Source: QCC

d) The lighting protection ☐ ☐
Source: QCC

e) The security system ☐ ☐
Source: QCC

f) The telecommunications system ☐ ☐
Source: QCC

g) The computer data system ☐ ☐
Source: QCC

h) The firestopping details ☐ ☐
Source: QCC

i) All grounding equipment ☐ ☐
Source: QCC

10) Is lighting layout checked for conflicts with structural members ducting, and fire safety equipment? Overlay the respective plans. ☐ ☐
Source: Civitello change order discovery checklist/ Database analysis

11) Are the correct type of light fixtures provided? ☐ ☐
Source: Database analysis

12) Consider the heights of the light equipment fixtures above the ceiling, and check if there are any conflicts with the duct size and ceiling spaces. ☐ ☐
Source: Civitello change order discovery checklist/ Database analysis

13) Overlay the lighting plans with ceilings plans to check if there are any conflicts:
a) between various types of lighting fixtures ☐ ☐

b) lighting fixtures placed in corners or the place where the ceiling shape changes ☐ ☐
Source: Civitello change order discovery checklist/ Database analysis

14) Overlay the lighting plans with architectural plans to check if there are conflicts with:

a) Walls ☐ ☐
Source: Database analysis

b) Interior design elements ☐ ☐
Source: Database analysis

c) Cabinets ☐ ☐
Source: Database analysis

15) Overlay the plans with HVAC to check for conflicts with:

a) Duct work ☐ ☐
Source: Database analysis

b) Grills ☐ ☐
Source: Database analysis

c) Diffusers ☐ ☐
Source: Database analysis

d) Size of light fixtures above the ceiling, such that it does not become a hindrance in duct routing ☐ ☐
Source: Database analysis

16) Also check for the conflicts with light fixtures with smoke detectors, and fire sprinkler systems ☐ ☐
Source: Database analysis

17) Is the fire alarm system colliding with regular electrical appliances? ☐ ☐
Source: Database analysis

REFERENCE

Anderson, S., and Oyetunji, A. (2003). "*Selection Procedure for Project Delivery and Contract Strategy*". Winds of Change: Integration and Innovation in Construction, Proceedings of the Construction Research Congress held in Honolulu, Hawaii, ASCE, VA.

Alsugair, A. M., (1999). "*Framework for Evaluation Bids of Construction Contractors.*" Journal of Management in Engineering, Vol. 15, No. 2.

Bridgers, Mark W., Daniels, David M. (2001) (http://www.fminet.com/global/Articles/ChangeOrder.pdf) date visited: 09/14/04

Battersby, L. C., and Yates, J. K. (2003). *"Designer Construction Knowledge and Its Effects."* Winds of Change: Integration and Innovation in Construction, Proceedings of the Construction Research Congress held in Honolulu, Hawaii, ASCE, VA.

Brown, M. G. (2001). *"Choosing a Company's Building Design: Models for Strategic Design Decisions* ." http://business.fullerton.edu/journal/papers/pdf/past/vol22n0102/04.81_106.pdf, date visited 04/09/04.

Bubshait, A. A., and Al-Atiq, T. H. (1997). *"ISO 9000 Quality Standards in Construction."* Journal of Management in Engineering, Vol. 15, No. 6.

Calder, D.A. J. P.E. (1997). *"Construction Quality Auditing."* Journal of Management in Engineering, Vol. 13, No. 6.

Civitello, Jr. A. M. (2002). *"Contractor's Guide to Change Orders."* 2nd Ed., Prentice Hall, New York.

Crowley, L. G., and Hancher, D. E. (1995). *"Evaluation of Competitive Bids."* Journal of Construction Engineering and Management, Vol. 121, No.2.

CSI, (www.aiapvc.org/glossary.htm) date visited: 10/15/2004

Diekmann, J.E., and Nelson, M.C. (1985). *"Construction Claims: Frequency and Severity."* ASCE Journal of Construction Engineering and Management, Vol. 111, No. 1.

Dozzi, P. Hartman F., Tidsbury N., and Ashrafi R. (1996). *"."* Journal of Construction Engineering and Management, Vol. 122, No. 1.

Drexler, Jr. J. A., and Larson, E. W. (2000). *"Partnering: Why Project Owner-Contractor Relationships Change"*. Journal of Construction Engineering and Management, Vol. 126, No. 4.

EAS (2002) (http://www.pp.msu.edu/eas/) date visited 09/14/04

Gutman, R. (1988). *"Architectural Practice: A Critical View"*. Princeton Architectural Press, New York, NY.

Glavinich, T. E. (1995), "*Improving Constructability during Design Phase.*" Journal of Architectural Engineering, Vol. 1(No. 2).

Hassanen, M. Bouchlaghem, D., and Austin, S. (2003). *"Framework for IT and Information Management: A report describing the development of Delivery 1.",* Winds of Change: Integration and Innovation in Construction, Proceedings of the Construction Research Congress held in Honolulu, Hawaii, ASCE, VA.

Hatush, Zedan, and Skitmore, Martin. *"Evaluating Contractor Prequalification Data; Selection Criteria and Project Success Factors."* Construction Management and Economics. 1997. vol 15, 129-147

Hegazy, T., Zaneldin, E., and Grierson, D. (2001). *"Improving Design Coordination for Building Projects."* Journal of Construction Engineering and Management, Vol. 127, No. 4.

Ibbs, William (1997) *"The Impact of Timing on Labor Productivity"*. (http://www.ce.berkeley.edu/~ibbs/BRICS/Materials/Impact_of_Change_s_Timing.pdf) date visited: 09/14/04

Kamara, et.al. (2001); Salisbury, (1990) as quoted in Seay P. C. Anumba C. J., Hill R., and Bouchlaghem D. (2003). *"Improving Construction Client Satisfaction through Functional Briefing."* Winds of Change: Integration and Innovation in Construction, Proceedings of the Construction Research Congress held in Honolulu, Hawaii, ASCE, VA.

Kartam, N. A. (1995). *"Making Effective Use Of Construction Lessons Learned In Project Life Cycle."* www.bnet.com, *d*ate visited: 03/17/2004.

Lee, S. Pena-Mora, F., and Park, M. (2003). *"Quality and Change Management Framework for Concurrent Design and Construction."* Winds of Change: Integration and Innovation in Construction, Proceedings of the Construction Research Congress held in Honolulu, Hawaii, ASCE, VA.

Mendelson, R. (1997). *"The Constructibility Review Process: A Constructor's Perspective."* Journal of Management in Engineering.

Michigan QBS (1984). *"Qualification-Based Selection of Design Professionals."*

Mrozowski, T. (2004) *"Change Orders Research and Philosophies."* Michigan Chapter Meeting.

O' Brien, J. J. (1998). *"Construction Change Orders."* McGraw-Hill, New York.

Potter, K. J., and Sanvido, V. (1995). *"Implementing a Design/Build Prequalification system."* Journal of Construction Engineering and Management, Vol. 11, No. 3.

Potter, M. (1995), *"Planning to build: A Practical Introduction to the Construction Process."* Construction Industry Research and Information Association (CIRIA), London.

QCC, *"Quality Control Checklist."* University of Notre Dame. (http://architect.nd.edu/images/qualityassurance.pdf) date visited: 02/24/04

Redicheck Associates, website: (http://redicheck-review.com/) date visited: 03/17/04

Seay, P. C., Anumba, C. J. Hill, R., and Bouchlaghem, D. (2003). *"Improving Construction Client Satisfaction through Functional Briefing".* Winds of Change: Integration and Innovation in Construction, Proceedings of the Construction Research Congress held in Honolulu, Hawaii, ASCE, VA.

Short, D. L. www.tempetcompany.com/est_article.htm, date visited 3/17/2004.

Tarek H. (2001). *"Improving Design Coordination for Building Projects. I. Information Model."* Journal of Construction Engineering and Management, Vol. 127, No. 4, July/August 2001.