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Characteristics and causal factors of claims in michigan highway construction projects

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CHARACTERISTICS AND CAUSAL FACTORS OF CLAIMS IN MICHIGAN HIGHWAY CONSTRUCTION PROJECTS

by

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DEDICATION

I would like to dedicate this to my loving parents, my precious mom who spent numerous years infusing in me the love of learning, and my great dad who gave me impetus of quality work and spurred in me the value of excellence. Also, to my beloved family who were so patient with me in pursuing my dream of higher education at the expense of spending more quality time with them. Without all of their support and inspiration, I would not have been able to make this a reality.

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LIST OF ABBREVIATIONS

CII	Construction Industry Institute
CM	Contract Modification
CPM	Capital Preventive Maintenance
DBE	Disadvantage Business Enterprise
FHWA	Federal Highway Administration
IDR	Inspector Daily Reports (IDR)
ITS	Intelligent Transportation System
JN	Job Number
LA	Local Agency
MDOT	Michigan Department of Transportation
MFOS	Michigan Financial Obligation System
MOT	Maintenance of Traffic
MPINS	Michigan Project Information System
NCHRP	National Cooperative Highway Research Program
NHS	National Highway System
PCIA	Project's Construction Influence Area
SOW	Scope of Work
STA	State Transportation Agency
TSC	Transportation Service Center

Chapter 1 Introduction

1.0 Background and Need

The United States (US) highway system is the largest road network system in the world. The Michigan Department of Transportation (MDOT) is responsible for both the National Highway System and the State Trunk-line System in the State of Michigan. As of 2010, these roadway networks total approximately 9,722 route-miles, which equate to approximately 28,000 lane-miles of roadway [1].

Hundreds of projects worth billions of dollars in tax monies are let every year by the State Transportation Agency (STA) to maintain and preserve this capital investment. The projects' scopes of work (SOW) include road resurfacing and construction, bridge rehabilitation and construction, capital preventive maintenance (CPM), intelligent transportation system (ITS), and others. The majority of these projects are successfully completed in terms of meeting their initial scope of work, schedule, and cost and quality requirements. However, some projects end up in litigation and dispute resolution, costing taxpayers a great amount of money and the STA a great amount of time and resources.

From 1999 to 2010, for which data were available, hundreds of claims have been filed by the STA's contractors, resulting in hundreds of millions of dollars in claim payout amounts. In the Metro Detroit Region, which encompasses Wayne, Oakland, Macomb, and St. Clair counties (Figure 1.1), records show that more than $100 million dollars in claims have been filed with the STA and paid out to contractors for claim resolution during this period (1999-2010).

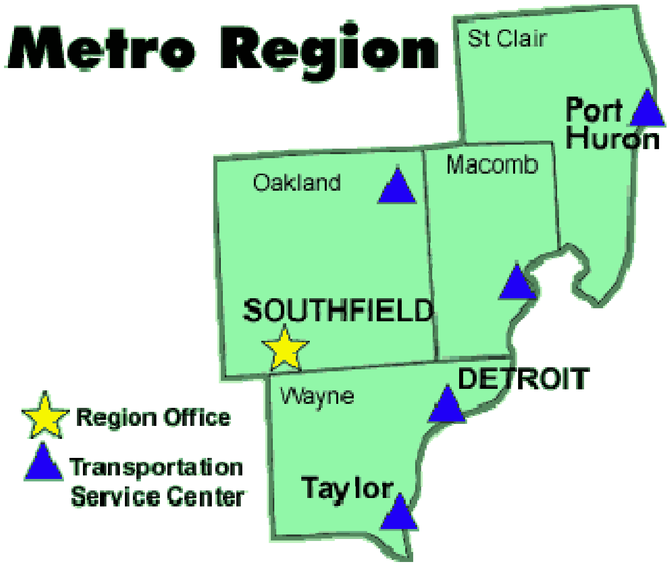

Figure 1.1 Location Map of Metro Region and its Transportation Service Centers (TSCs)

In the face of economic slowdown and an increase in the cost and magnitude of these construction claims, research is needed to investigate the factors affecting this increase in the number and magnitudes of highway construction claims and to seek new ways to improve the efficiency and effectiveness of highway project delivery by reducing the number and cost of claims.

1.1 Problem Statement

Although measuring the performance of any construction project in terms of success or failure may appear simple, it is in fact a very complex process. In general, project success is most commonly identified with performance related to cost and time. However, attempting to define or limit the list of factors that contribute to project success would be certain to generate lengthy debate among project managers, researchers and practitioners.

Many factors contributing to project success have been identified in previous research and have subsequently been reported in the literature as shown in Table 1.1.

Table 1.1 *Groupings of Critical Success Factors (CSF) in Earlier Studies*

Chua et al. [2]	**Nguyen et al. [3]**	**Anton de Wit [4]**	Avots I. **[5]**
Project characteristics	Comfort	Goals and objectives	Project-related factors
Contractual arrangements	Competence	Performance monitoring	Human-related factors
Project participants	Commitment	Transformation	Process-related factors
Interactive processes	Communications	Communication	Input-related factors
		Environment	Output-related factors
		Boundaries	
		Resources	
		Continuity	

Chua et al. [2] identified sixty-seven project success-related factors for construction project addressing budget performance, schedule performance, quality performance, and overall project success according to the project objectives of budget, schedule, and quality. These factors were grouped under four main projects aspects, namely, project characteristics, contractual arrangements, project participants, and interactive processes in the hierarchical model for project success. Chua utilized a questionnaire approach to facilitate data collection in this study and invited experts in the construction industry to participate in the survey. Chua also compared his findings with findings of previous studies using neural network approach.

Nguyen et al [3] explored the success factors in large-scale construction projects and their underlying relationships by utilizing questionnaire and interview surveys with construction professionals which resulted in formulation of four factor groupings which were together called critical COMs of success and were labeled as COMprehension, COMpetence, COMmitment, and COMmunication, respectively.

Highlighted the distinction between project success and the success of the project management effort, bearing in mind that good project management can contribute towards project success but is unlikely to be able to prevent failure. Utilized project objectives for the project success and based the success on the degree to which these objectives have been met (which tends to be restricted to cost, time and quality/performance). Also added that the need to consider the objectives of all stakeholders throughout the project life cycle and at all levels in the management hierarchy to properly attempt to measure project success.

Anton de Wit [4] highlighted the distinction between project success and the success of the project management effort by utilizing project objectives for the project success and based the success on the degree to which these objectives have been met (which tends to be restricted to cost, time and quality/performance). Wit also added that the need to consider the objectives of all stakeholders throughout the project life cycle and at all levels in the management hierarchy to properly attempt to measure project success.

Most of these studies have involved projects in the private and the public sectors, in the US and abroad, though infrequently in the highway construction domain. Consequently, it is unknown whether the same success factors are applicable to highway projects. Furthermore, it is unclear how the unique features of a highway project, in terms of its scope of work and other important variables, may affect the success or failure of the project in the context of the number and magnitude of construction claims.

1.2 Claim Overview

A claim can be defined as a demand for additional compensation that is formally submitted to an authorized agent of the STA outside of the normal process for change approvals. In simple terms, a continued demand for payment is termed a “claim” if it has been previously denied under the STA's normal procedures for change approval.

Both the STA and the contractor share in the responsibility for claims. Many claims could be avoided if reviews of the contract documents were more thorough, both in preparation of the project and in bidding the project. According to the Construction Industry Institute (CII)[6] problems occur most often when an STA rushes a project with incomplete or inadequate plans through the letting process.

The CII also concluded in the same study that, in many instances and due to public pressure, states sometimes promise to get work under construction or to open highways to traffic on some predetermined date. This approach may cause claims as plans and specification may not be completed and error free. Similarly, “shelf projects,” those projects with plans that were developed several years earlier, can be especially dispute-prone because traffic patterns and other field conditions may have changed.

The CII [7] also concluded that most states acknowledge that projects containing known errors are sometimes let for bid because the time frame does not allow for errors to be corrected. Contractors may contribute to claims through ineffective project management, scheduling practices and substandard work.

The National Cooperative Highway Research Program (NCHRP)[8] pointed out that highway construction is more dispute-prone than other types of construction and the impression that claims have increased are a reflection of economic conditions that result when new construction activities decline. The NCHRP [8] also pointed out that as competition among contractors becomes intense and construction costs increase, contractors' bids contain a smaller margin for absorbing unanticipated expenses, and some contractors may use claims to make their profit.

1.3 Research Rationale

An initial review of existing critical success factors (CSF) on construction projects, as summarized in Table 1.1, showed that the lists comprise several factors under various categories such as project procedure, external environment, human-related factors, project-related factors, and project management system. Only a few of these studies have attempted to explore the underlying relationships of these factors within the various categories. Li et al. [9] also share this view in their study of critical success factors for public–private-partnership projects and argue that, ''While many CSFs have been identified, their importance relative to one another has received less attention.''

Most research studies assume that various success factors are independent of each other and have no interrelationships. This assumption can lead to incomplete conclusions as it is likely that some success factors, even though they initially fall under different categories, are actually related to each other. There are very few studies where the interrelationships of critical success factors are analyzed.

The Water Design-Build Council (WDBC) [10] concluded that common critical success factors on public projects (Table 1.2) can be grouped together to include: budget, time, cost, quality, satisfaction, expectation, functionality, schedule and administration. However, none of these factors (See Table 1.2) had any mention of claims as a factor of a project success or failure.

Table 1.2 Groupings of Common Criteria for CSFs in Earlier Studies

Metrics	Definitions
Budget	The project is completed at or under the contracted cost
Cost	The completed project's unit cost, cost growth and intensity
Time	The project's construction speed, delivery speed and schedule growth
Quality	The completed project meets or exceeds the accepted standards of workmanship in all areas
Satisfaction	The completed project meets or exceeds the user's envisioned goals in all areas
Functionality	The completed project meets or exceeds all technical performance specifications provided by the owners
Schedule	The project is completed on or before the contracted finish time
Safety	The project meets or exceeds the standards of safety or warranties in all areas
Administration burden	The construction process does not unduly burden the owner's project management staff
Expectation	Relative comparison of owner expectations from project concept as compared to the completed project

It is very important to study these interrelationships to determine and understand all of the factors that affect a project's success or failure, especially as it relates to claims.

More importantly, very few studies on critical success factors have been conducted at State Transportation Agencies and the research is very limited when it comes to investigation of the factors that affect claims on highway construction. In fact, El-Rayes et al [11] concluded that the available studies addressed only the effect of a few factors on the success or failure of a highway construction project and none of the available studies or research identified a claim as a factor of project success or failure on either general construction projects or on highway construction projects.

1.4 Research Objectives

The primary objectives of this study are to:

- Identify factors affecting claim and payout outcomes and their frequency of occurrence at the State Transportation Agency,
- Develop a methodology for studying factors affecting highway construction claims based on Michigan data,
- Examine the relationships among the different project variables to determine how these factors affect claim and payout outcomes, and based on the results of this research
- Recommend certain improvements for future research projects

All of these objectives are aimed at increasing the likelihood of a project's success at the STA by reducing, both, the frequency and the costs of claims. These objectives are consistent with the stated goals of the STA to better serve the traveling public while meeting the strategic goals and immediate needs for improved project success and sustained economic benefits.

1.5 Research Approach

The approach of this study incorporated four phases that included:

- Survey of available literature;
- Methodology Development
- Data acquisition, organization, and analysis; and
- Interpretation of results, and discussion of subsequent conclusions and recommendations.

A brief discussion of these phases is included in the following sections.

1.5.1 Literature Survey

The first phase of the research involved a state-of-the art and a state-of-the practice review of information related to project success factors, both at a general level and specifically as they apply to the highway construction industry, as well as the factors affecting construction claims in highway construction. This information is included in Chapter 2 of this dissertation.

1.5.2 Methodology Development

Based on the literature review and the research objectives a methodology was developed to outline the steps for obtaining and organizing the projects' relevant data for analysis. The details of this phase are included in Chapter 4.

1.5.3 Data Acquisition, Organization, Methodology Development

This phase included surveying, reviewing, and organizing data from construction claims available through the Transportation Service Centers (TSCs), Metro Region office, other region offices, and the Central Office of the STA. It also included surveying, reviewing, and organizing data of all the successfully completed projects at the STA. These projects were combined in a master spreadsheet for analysis. This information is detailed in Chapter 3.

1.5.4 Analysis Results, Discussion, Conclusion, and Recommendations

This phase involved the statistical data analysis, which is described in detail in Chapter 4. This chapter also details the initial and the final analysis performed on the data to determine the significant project factors affecting the success of the highway construction projects in the context of claims. In Chapter 5, a detailed discussion of the results is presented based on this analysis. Chapter 6 presents a detailed discussion of the research conclusions and contributions, and ends with suggestions and recommendations for improved claim management and areas of opportunity for future research.

Chapter 2 State-of-the-Art Literature Review

2.0 Initial State-of-the-Art Review

An initial state-of-the-art review was conducted to identify what is currently known about project critical success factors (CSFs) in the Unites States and abroad regarding, both, general construction (building and heavy) and highway construction. Additional reviews were conducted to determine whether any research specifically addressed claims in highway construction projects. These literature reviews were conducted to capture available information and to detail how the data were organized, analyzed and modeled by the researchers.

Invariably, construction stakeholders (such as owners, financiers, users, suppliers, contractors, subcontractors, and other vendors) have distinct interests and potentially competing in any given construction project and; therefore, the perception of success may also vary accordingly (Bryde et al. [12]. In the case of transportation and highway construction projects, numerous stakeholders from diverse socio-economic and cultural backgrounds interact to accomplish the project objectives. Therefore, it is important to ascertain which factors each interest group considers important to project success. Rubin and Seeling [13] first introduced the concept of project success factors in 1967 and Rockart [14] used the terminology critical success factors for the first time in 1982.

There has been a considerable increase in the number of studies related to CSFs for construction projects during the last two decades. A few of the most cited works in the literature include Ashley et al. [15], Pinto et al. [16], Savindo et al. [17], Tiong et al. [18], Songer et al. [19], Chan et al.[20], Jefferies et al. [21], Cooke-Davies et al. [22], and Nguyen et al. [23]. It is apparent from the findings of the aforementioned studies and despite the fairly large volume of these studies on the subject, there seems to be little agreement on CSFs. This disagreement could be due to the different backgrounds of the researchers in the industry and their affiliation, as well as possible problems with obtaining all available and pertinent data on the studied projects. Because each stakeholder may have different interests and perceptions about project success and failure, researchers stress the need for more work in the area (Chan et al) [20]. Due to the varying nature and specific objectives of every construction project, success factors are likely to be different (Chua et al.) [24]. Furthermore, at micro and macro levels, participants may perceive success differently and, hence, parties involved at micro and macro levels may attribute different success factors to the same project (Lim et al.) [25].

The Project Management Institute (PMI) pointed out that research-based recommendations about the success factors of different construction projects can be generally applied to highway and transportation projects (PMI) [26] (such as meeting the project scope, cost, time, quality, risk, procurement, communication, staffing, and integration requirements). However, the Federal Highway Administration (FHWA) [27] notes that there are elements unique to the success factors of a highway and transportation projects, including:

1. Highway projects are funded with public monies. A higher level of expectation and scrutiny is associated with these types of projects because of the source of funding and the vast number of stakeholders involved.

2. These types of projects usually affect great numbers of users (customers) by their success or lack thereof.

3. Success will mean saving a great amount of money, as these are very expensive projects and undertakings. Similarly, failures can mean significant losses for the same reasons.

4. The need to make sure that the causes for success are implemented and the causes for failure are avoided is mandated by the Federal Government and required by FHWA.

2.1 Construction Project Success Factors

The initial literature review revealed a number of critical attributes for different types of construction projects. It can be seen from the following summary that most of these studies have focused on specific success parameters and the critical success factors derived are applicable to a particular industry or contract type. Some researchers have adopted a questionnaire survey approach forwarded to experts in the field and analyzed the data as Anderson et al. [28] for data collection. Chua Dk et al. [24] employed mathematical tools like Analytic Hierarchy Process (AHP) and Neural Networks (NN) for data analysis and recommendations. Anderson et al. [28] utilized statistical techniques such as factor analysis and multivariate regression for analysis and conclusions. Chen and Ao [29] employed linear regression techniques to determine the relationship between procurement duration and design-build success in transportation projects. The project success criteria included in the reviews ranged from conventional factors like schedule, cost, and quality to more recently adapted criteria like perceived performance and client satisfaction as Toor et al. [30] has outlined in his research. Importantly, no one in the reviewed literature noted that claims could be used as an indicator of project success or failure. This factor is covered in the following chapters.

2.2 Highway Project Success Factors

Research conducted by the Construction Industry Institute [31] identified that schedule reduction could be achieved without increases in project cost provided certain techniques are applied during project development and especially during design [32]. Early research by O'Connor et al. [33] found that poor specifications can cause construction rework and delays. In fact, these authors state that 22% of all constructability problems are related to ineffective communication of engineering information, plans, and specifications, especially inadequacies in project specifications. Anderson et al. [28] confirmed the latter problem in a national-level study.

2.3 Factors Affecting Claims in Construction

Barry et al. [34] described the state of practice with respect to procedures used throughout the United States to resolve disputes and avoid construction claims. They emphasized the importance of settling disputes at their inception, before they become formal claims or lawsuits. Rubin et al. [35] addressed the key aspects of prosecuting and defending claims, from claims presentation to formal dispute resolution. Complete with forms and checklists, plus case histories, mini-cases, and more, this edition is a resource for those involved in construction and construction law and litigation.

Tyrrell et al. [36] provided a list of root causes of claims and extra costs arising in the earthworks sector of highway construction. The study was carried out for the Transport and Road Research Laboratory. Records for ten (10) contracts carried out between 1957 and 1977 have been analyzed; these projects involved the construction of about 23 miles of major road at tender prices totaling more than $20,000,000 and additional costs totaling $6,750,000.

Tyrrell's analyses [36] show that extra costs arising from earthwork difficulties alone were not necessarily greater than those resulting from other types of difficulties. Those extra costs from ground-related and pavement construction work also a significant part of total extra costs. Main areas that gave rise to the extra costs were planning of site investigation, interpretation of site investigation results, and overall project planning and management.

Netherton [37] divided the main causes of highway construction claims into four (4) main categories relevant to their contributions that include the following:

1. Contractor practices (such as scheduling, methods and means),
2. State Transportation Agency practices (such as quality of the plans and specifications),
3. Personal factors (such as the key staff involved on the project), and
4. Institutional factors (such as regulatory requirements).

Netherton [37] recommended utilization of a program to compile statistical data on highway construction claims so that causes could be studied more systematically. Such data were not available to him at the time of his study and are available for this research.

Ellis [38] identified the root causes of highway construction claims through a survey of state transportation agencies and highway contractors and ranked the reasons in terms of their importance and frequencies as the five most frequent reasons for delays in highway construction. According to Ellis the top five (5) reasons for highway claims per the STA are as follows:

1. Utility relocations

2. Differing site conditions (utility conflicts)

3. Errors in plans and specifications

4. Weather

5. Permitting issues

Ellis [38] also identified the Contractors most frequent reasons for delays in highway construction as follows:

1. Utility relocations

2. Errors in plans and specifications

3. Differing site conditions (utility conflicts)

4. Weather

5. Owner requested changes

2.4 Review Summary

From the preceding reviews, it can be seen that extensive research has been done to identify, analyze and model the factors affecting the success and failure of different types of construction projects in the US and abroad; however, the research has not addressed the success factors of a project from the perspective of claims. It is also evident that the research material is limited when it comes to identifying the uniqueness of highway projects and in understanding the relationships among the different variables on the different types of highway construction (road, bridge, maintenance, or a traffic and safety) projects.

It is also evident from the review that no study looked into the factors that can affect the outcome of a highway construction project in the context of claims as an indicator of a project success or failure. In addition, the research material becomes almost non-existent when it comes to utilizing the information obtained from actual claim documents on highway projects to identify the characteristics and causal factors of claims in highway construction projects. Addressing this gap is attempted in this research, as outlined in the following sections.

Chapter 3 Data Acquisition and Organization

3.0 Overview

The primary objective of this research is to identify factors affecting claim and payout outcomes and their frequency of occurrence at the State Transportation Agency in the context of claim management. To do that, all of the projects with claims filed had to be acquired and reviewed for all of the specific factors. Additional projects that were classified as successful in the context of meeting the budgeted cost and implementation schedule, and were completed without any claim were also reviewed for the same factors. The list of both sets of projects were combined and all of the factors were collected, organized, and tabulated for a variety of analyses.

The STA keeps project records in a variety of media and locations. Most of the project records for the construction phase are kept in paper format at the TSC office where the project is located and actively managed. Some additional construction information is kept in an electronic filing system accessible to project managers. Specific information regarding the initiation, planning, and design phases of the projects are kept in the regional and central offices in both paper and electronic format. All of the information about each project (with claims filed and those that were successfully completed without claims) had to be obtained, reviewed, organized, and analyzed for this research.

3.1 Data Acquisition and Sources of Information

This research required a great amount of specific project information that was available at the STA in different forms which included the following:

1. General information on the project such as the control section, job number, and the project location and limits,
2. Detailed project design information such as the existing site conditions, scope of work, and the material specified,
3. Detailed project construction requirements such the Maintenance of Traffic (MOT) requirement, special restrictions, utility coordination, and major pay items,
4. Detailed construction progress information such as the work progress and schedule, contractors working on the project, Number of subs, percent participation of Disadvantaged Business Enterprise (DBE), and number and values of contract modifications (CMs),
5. Detailed financial information such as the project's budgeted amount, awarded contract amount, changed amount, payment progress, and project engineer's estimate,
6. Specific claim information such as the reason(s) for the claim, initial amount of the claim, and final amount,
7. Detailed bidding such as the date of the bidding, the number of the bidders, and other information as necessary,

All of the needed data were obtained from the STA and the personal identifying information was deleted to protect the identity of the individuals and entities. All of the projects that had any claim filed were searched, retrieved, and analyzed. They totaled two hundred eleven (211) projects in the entire state agency. Projects of each possible type that had no claim filed and did not have a single contract modification (CM) were also searched, retrieved, and analyzed for the same period (1999-2010). This aspect of the search was very time consuming as the list of projects that the STA had let was very long (> 2000 projects) and the projects that did not have any contract modifications were very scarce (47 projects) as illustrated in Figure 3.1

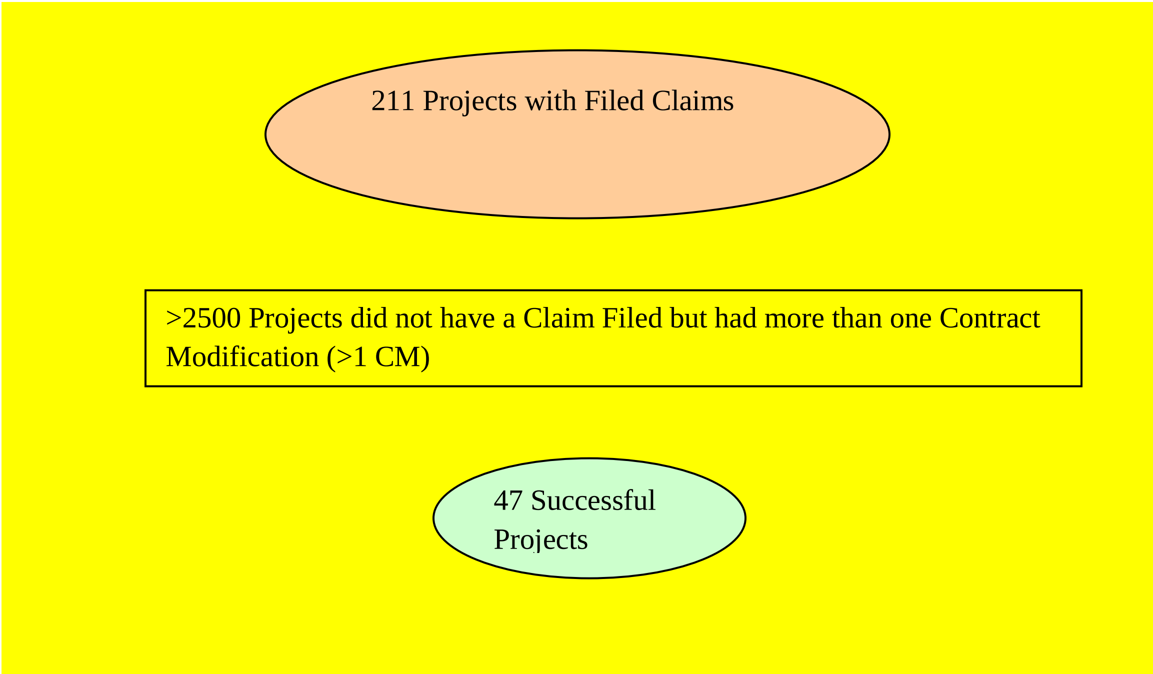

Figure 3.1 Breakdown of Analyzed Projects

It is relevant to note at this time that most of the projects at the STA had contract modifications to account for any change in the cost, scope of work, schedule, or other requirements that were previously stipulated in the contract documents. Any change from the contract documents that affected the cost, schedule, material, had to be captured by a contract modification for proper project closeout per the federal requirements. These projects that had a contract modification but did not file a claim (which constituted the majority of projects at the STA) were not included in this research. The lists of projects that did not have any contract modification and did not have any claim filed were searched from the list of the entire set of projects that were let in STA and were analyzed in this dissertation. These projects totaled forty seven (47). The two sets of projects were combined together and totaled two hundred fifty eight (258) as shown in the Figure 3.2.

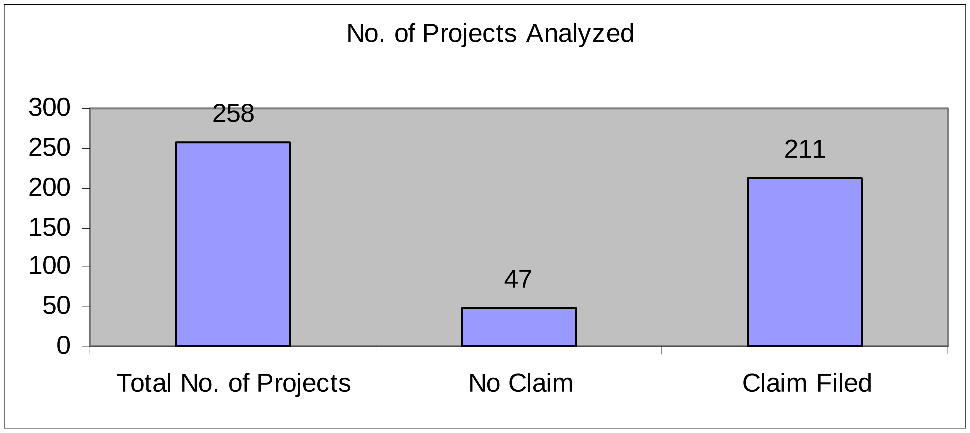

Figure 3.2 Breakdown of Analyzed Projects

To accomplish the stated research objectives discussed in Chapter 1, the research methodology explained illustrated in Figure 3.3 is utilized.

As shown in Figure 3.3 that a complete research of all the projects with claims filed was researched. This task was followed by a complete research of all the successful projects at the STA that were completed successfully (without a single change in the cost, schedule, or any other requirements). The list of the two (2) sets of projects were combined and analyzed. It is important to note at this juncture that most of the projects at the STA did not experience any claim filed, but rather experienced a change in the cost, schedule, or other contractual factors that were captured a contract modification. These projects were not included in this research as the purpose of this research was to identify the characteristics of the projects with claims and compare them to a set of successful projects that did not experience any change in the cost, schedule, or other contractual requirements.

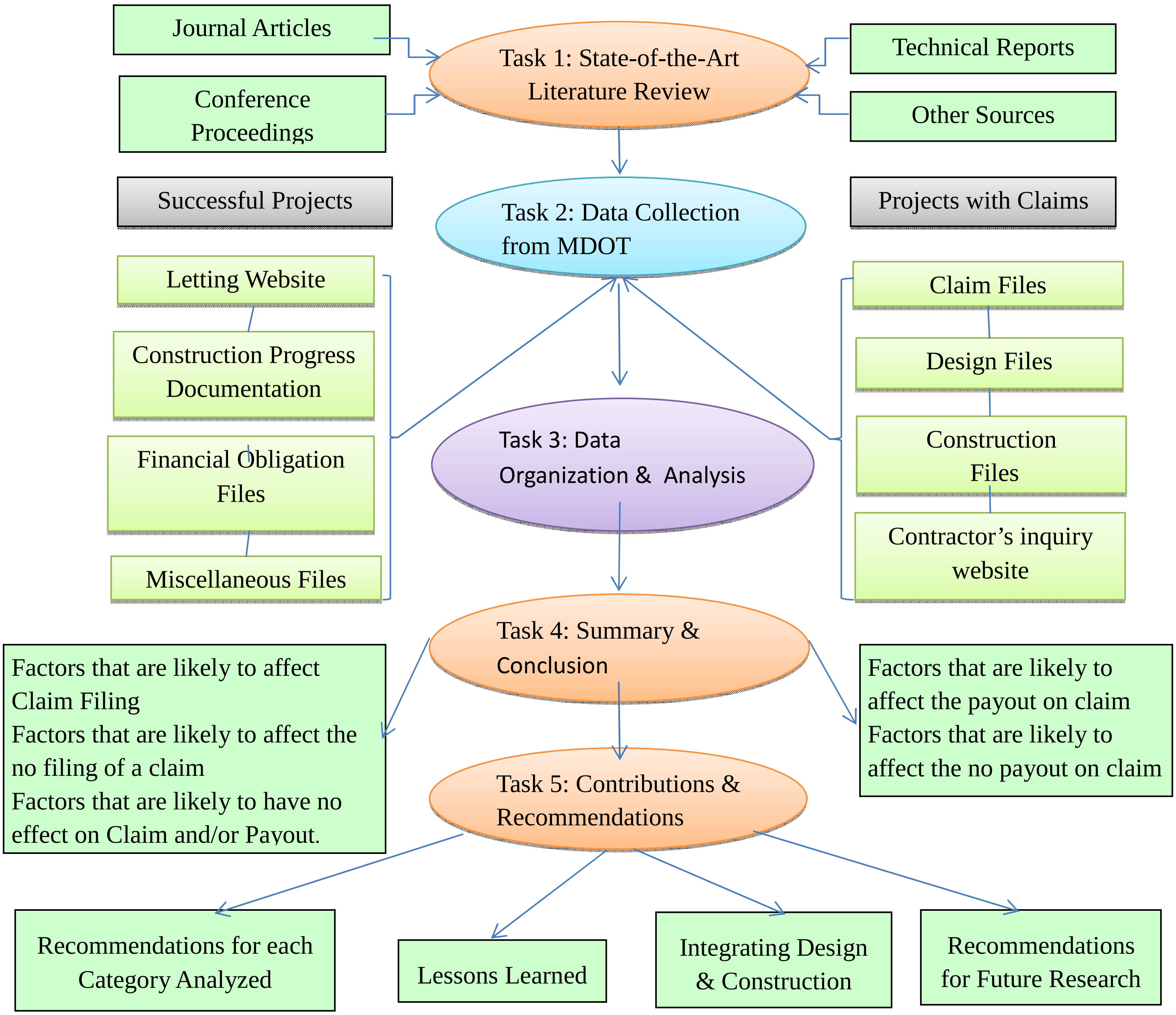

Figure 3.3 Flow Chart for Research Methodology

These projects were separated into four (4) major categories based on their scope of works and included the following (The list does not include special and less frequent projects such as office building, car pool and rest area facility construction projects):

1. Road projects include all of the projects that are located on all transportation systems (NHS, State Trunk-line, or local agencies). The scope of work included reconstruction or major resurfacing,

2. Bridge projects include all of the projects that are located on bridges on the transportation system and the scope of the work can be total construction or rehabilitation,
3. Capital preventive maintenance (CPM) projects include all minor resurfacing, white topping, or crack and joint repair works located on the transportation system, and
4. Intelligent transportation system (ITS) projects involve work on traffic control devises, instruments, signage, or pavement markings on the transportation system.

* Other types of projects such as research projects, facility construction, rest areas, car pool, guard rails, and other less frequent projects were not included in this research because of the shear small number of these projects and their unique scope of work.

3.1.1 Claim Letter

Every project that had a claim had a "Claim Decision Letter" in its file. The claim decision letters were retrieved from all available sources within the different offices of the STA that include the Transportation Service Centers (TSCs), Region Offices, and the Central Office. Each claim decision letter was reviewed and analyzed for the underlying reasons of the claim, the initial amount of the claim, and the final determination on the claim that included the final amount paid, if any. A spread sheet was created with claim specific information and the project identification numbers such as the control section (CS) that shows the location on the state map and the project's job number (JN). Once the CS and the JN were obtained, a search into the actual plan, proposal, and the complete design and construction files were initiated for each project. The result of the research was tabulated in a master spreadsheet (MSP).

3.1.2 Project Plan

Detailed information on each project was retrieved from the project plans, such as the scope of work and project type (road resurfacing, road reconstruction, bridge rehabilitation, bridge construction, CPM, or ITS). Project limits and the location of each project on the transportation system such as on the National Highway System (NHS), State Trunk-line, or Local Agency was also obtained and tabulated. The information on the project design team was also identified and tabulated in the Master Spreadsheet that included whether the project was designed by the state agency, the local agency, or by consultants. The applicable design and construction standards on the project, namely the 1996 or the 2003 Specification Books were also obtained and tabulated.

The 1996 Specification Book addressed requirements in the metric measurement system on the projects while the 2003 was revised to the english measurements and revised certain material and quality requirements.

3.1.3 Project Proposal

Detailed information on the projects were also obtained from the project proposals and were tabulated in the master spreadsheets such as the progress schedule with the start and completion dates, the length of construction duration in days and in construction seasons, stipulation of liquidated damages, utility coordination clause, maintenance of traffic (MOT), unique special provisions, and any other restrictions applicable to the project such as the need to coordinate with other active projects within the project’s construction influence area (PCIA).

3.1.4 Project Financial Information

The financial information was searched and documented for each project in terms of its source of funding (federal, state, or local). Based on the type of funding on a project the applicable requirements may differ. State projects can be funded entirely by the state or federal government. Local agency projects can be supported by local or state funding. Very rarely, local agency projects are funded entirely by the federal government. Based on the funding of the projects certain guidelines are required. Additional information on the difference between the engineer's estimate during the design phase and the amount of the lowest responsible bidder were also retrieved and tabulated in the same master spreadsheet for the analysis.

3.1.5 Project Construction Files

Additional specific project information such as the identity of the prime contractor, number of subcontractors, percent participation of the DBE, total number of CMs and the total amounts for were added. The increases and the decreases in the project's costs were added and the percentages of the net change were tabulated for each project.

3.2 Identification and Description of Major Categories

In the master spreadsheet, more than a hundred factors were identified and obtained for each project entry. Organization and coding all of these entries in a master spreadsheet and an initial analysis resulted in reduction to seventy-four (74) factors that were later grouped into the following ten (10) major categories: Letting year, project location, contracting factors, scope of work, major material, and restrictions in the contract, project administration, financial factors, quality factors, and the basis of the claim filed. These categories are listed in Table 3.1 with brief descriptions. The ten (10) major categories considered in this research as the independent variables are further discussed in the following sections.

Table 3.1 *Classifications of Major Categories of the Independent Variables*

Category Number	Major Categories	Description
1	LETTING YEAR	Year when the project was let.
2	LOCATION	Geographic and physical location of the project.
3	CONTRACTING FACTORS	Variety of contracting factors specific to each project.
4	SCOPE OF WORK	Scope of work on the project.
5	MATERIAL	Primary material used on the project.
6	RESTRICTIONS IN CONTRACT	Restrictions and special conditions specific to the project.
7	PROJECT ADMINISTRATION	Administration of the project.
8	FINANCIAL FACTORS	Financial factors specific to each project.
9	QUALITY FACTORS	Quality factors specific to each project.
10	CLAIM BASIS	Basis of the claim on the project.

3.2.1 Letting Year

The combined list of the projects (projects that had claims filed and those that did not have any claim filed and did not have any contract modification during the construction implementation phase) was separated into three (3) different groups based on the year the project was let for construction. Projects that were let prior to the issuance of the 2003 Specification Book, during the time when the 1996 Specification Book was in effect, were grouped "prior to 2003." Projects that were let after the issuance of the 2003 Specification Book were grouped "after 2003." And the projects that were let during 2003, when the 2003 Specification Book was first introduced, were grouped as "during 2003 grouping" to determine if this introduction had any affect on the designers and/or the constructors as indicated in Table 3.2.

Table 3.2 *Groupings of Category No.1 "LETTING YEAR"*

Letting Year	Classes	No. of Projects Analyzed
Prior to 2003	Year of 1999	4
	Year of 2000	5
	Year of 2001	10
	Year of 2002	6
During 2003	Year of 2003	17
After 2003	Year of 2004	17
	Year of 2005	44
	Year of 2006	55
	Year of 2007	18
	Year of 2008	46
	Year of 2009	30
	Year of 2010	6

Table 3.2 shows that the group named "prior to 2003" had all the projects that were let from 1999 through year 2002. The group labeled as "during 2003" had only the projects that were let in year 2003. The group called "after 2003" had the remaining projects that were let in 2004 through April of 2010 up to the time of initiation of the analysis work in this research.

3.2.2 Project Location

It was evident from the initial survey of the claim inventory lists that the Metro Detroit Region had the greatest number of projects with claims filed in the entire state agency. It was also evident from the inventory list of the claims and master spreadsheet that the Metro Region also had the greatest number of claims filed and paid-out in the STA. To capture any potential differentiations and distinctive characteristics of the different project locations, they were grouped based on their geographical and physical locations as shown in Table 3.3 and explained in the following sections.

3.2.2.1 Geographical Location

Because of its transportation program size and its geographical location in the State, the STA divided the Metro Region into five (5) Transportation Service Centers (TSCs). This decentralized approach allowed each TSC to closely manage its own projects with full control of its management and coordination. The rest of the State outside the Metro Region was also divided into different regions with each region office having a certain number of TSCs. For the purpose of this research and based on the size of the program and the number of claims filed in the state agency, it was decided to keep the rest of the state lumped into a separate area as indicated in Table 3.3.

Table 3.3 *Groupings of Category No.2 "PROJECT LOCATION"*

Project Location	Locations	No. of Projects
Geographical Location	Metro Region TSC 1	47
	Metro Region TSC 2	64
	Metro Region TSC 3	32
	Metro Region TSC 4	35
	Metro Region TSC 5	38
	Rest of the State	42
Physical Location	National Highway System (NHS)	45
	State Trunk Line System	138
	Local Agency System	75

3.2.2.2 Physical Location

It is also shown in Table 3.3 that the transportation projects let within the STA can be grouped, based on their physical location and jurisdictional responsibility, into projects that are located on the national highway system (NHS), projects that are located on the State Trunk-line, and projects that are located on a local agency route. Local agencies include all the local governments that receive money from the State and/or the federal government for the improvement and maintenance of their transportation system, such as those located in cities and counties.

It is important to note that there are three different and possible oversight requirements during the design and the construction implementation phases on projects let at the STA that are dependent on the location and the funding types on these projects. The STA and the Federal Highway Administration (FHWA) closely monitor all projects that are located on NHS in the design, construction and final closeout phases. Projects that are located on the local agency's route are closely managed by the local agency's own staff or its consultants and require minimal supervision from the STA and FHWA. Projects that are located on the State Trunk-lines are managed by the STA's own staff or its consultants and also require minimal oversight from the federal government.

3.2.3 Contracting Factors

Projects let through the bidding process at the STA are advertised on the State's web site on a regular basis per a specific monthly schedule throughout the year. Pre-qualified bidders can bid on any state project according to the bidder's pre-approved sets of qualifications and the matching project's scope of work. Before the project is awarded to the lowest responsible bidder, an exact match of the contractors' approved qualifications and the projects' specific requirements have to be confirmed.

For the purpose of this research, six (6) groupings were created. These are number of bidders on the project, the letting schedule, the number of the projects in the letting, the identity of the prime contractor, the number of subcontractors working on the project, and the percent required and achieved of the disadvantage business enterprise participation as displayed in Table 3.4; the details are given in the following sections.

3.2.3.1 Number of Bidders

The number of bidders on each project may differ based on the time of the year and the availability of local contractors to perform the work taking into account the project's scope of work, construction timetable, as well as other specific requirements as stipulated in the contract documents and the plan and proposal. The number of bidders on each project was categorized into fewer than five (<5) bidders and five or more bidders. The majority of the projects let at the STA had more than five bidders on them. The wining bid, based on the current requirement, is the lowest responsible bidder. The cost has to be the lowest among the rest of the bidders and the bidder has to be qualified to do the work stipulated in the bid requirement. All bidding contractors have to be already approved to bid and to do work on the STA projects for specific project size, magnitude, and scope of work. Bidders who are not qualified to do work with the STA are not considered in the bid evaluation. Contractors who are approved to do specific work on STA projects can not bid on projects that they are outside their areas of expertise and qualifications.

Table 3.4 *Groupings of Category No.3 "CONTRACTING FACTORS"*

Contracting Factors	Classes	No. of Projects
No. of Bidders	Fewer than five (1-4) Bidders	121
	Five or more Bidders	137
Letting Schedule	Winter Season	90
	Spring Season	58
	Summer Season	35
	Fall Season	75
No. of Projects in a Letting	Fewer than fifty (<50) Projects	78
	Between fifty and hundred (50-100) projects	87
	More than hundred (>100) projects	93
Prime Contractor Identity	Contractor A	29
	Contractor B	34
	Contractor C	35
	Contractor D	37
	Contractor E	42
	Contractor F	36
	Other Contractors (G)	45
No. of Subcontractors	Fewer than ten (<10) subcontractors	87
	Between ten and fifteen (10-15) subcontractors	66
	More than fifteen (>15) subcontractors	105
DBE Participation	Less than five percent (<5%)	95
	Between five and fifteen percent (5-15 %)	111
	More than fifteen percent (>15 %) subcontractors	52

3.2.3.2 Letting Schedule

Each month and throughout the year, the STA let a certain number of projects into construction immediately or soon after the completion of the project's design and the quality reviews. These projects include all state and federally funded projects designed by the state and the local agencies. These projects were advertised on the state's web site for a minimum of three (3) weeks and as long as six (6) weeks based on the size and complexity of the project. For the period that the research data were generated, the projects in the master spreadsheet were divided into four (4) seasons according to the month the project was let by the STA. Every month about the same time, the STA agency let a certain number of projects on the STA website for the contracting community to bid on them. The initial analysis of the master spreadsheet revealed that STA advertises most of its projects during the fall and winter season to accommodate the request of the contracting community. These four seasons are as follows: Winter Season that includes January, February, and March; Spring Season that includes April, May, and June; Summer Season that includes July, August, and September; and Fall Season that includes October, November, and December.

3.2.3.3 Number of Projects in a Letting

The number of projects in a letting is not a fixed number but rather a number that is based on the availability of design projects ready to be advertised and the available funding. The number of projects included in the master spreadsheet varied from as few as fifty (50) projects to as many as one hundred twenty (120) projects in a specific letting. The number in each letting was classified as fewer than fifty (<50), between fifty and one hundred (50-100), and more than one hundred (>100) projects in a letting as indicated in Table 3.4.

3.2.3.4 Prime Contractor Identification

Every project at the STA was awarded to the lowest responsible and pre-qualified bidder according to the STA’s predetermined criteria and taking into consideration the magnitude of the project and matching the contractor’s qualifications and the project's specific SOW. In the Metro Region due to its location in the state and due to the magnitude of the projects and their complexity, the majority of the projects were awarded to a certain group of local prime contractors based on their qualifications and ability to work in a metro setting. These prime contractors were coded as Contractor A, B, C, D, E, F, and G (for the other contractors) as indicated in Table 3.4.

3.2.3.5 Number of Subcontractors

The number of subcontractors was different for most of the projects and ranged from zero (0) to as many as fifty (50). The number also depended on the SOW, the size of the project, and the pre-qualifications of the prime contractor doing all or some part of the work. This number is determined by the prime contractor making the bid on the project to allow it to do the entire work of the project with the required STA's requirement that prime can sublet as much as sixty percent (60%) of the entire work but has to perform a minimum of forty percent (40%) of the awarded projects. Contractors based on their set of skills and expertise utilized the services of subcontractor to complement their work and qualifications. They do that during the bidding process where they solicit the bids of other smaller contractors to be their subcontractors on the project. The number of subcontractors was classified as fewer than five (<5), between five and fifteen (5-15), and more than fifteen (>15) subcontractors on a project as shown in Table 3.4.

3.2.3.6 DBE Participation

Based on the type of funding (local, state, or federal) and the project scope of work, a great portion of the projects required some work to be performed by a disadvantaged business enterprise (DBE) subcontractor. The DBE requirements ranged from zero percent (0%) on some state and locally funded projects to as high as fifteen percent (15%) or more on some federally funded projects. This required percent participation is mandated on federally funded projects based on the type of work, location of qualified DBE contractors at the area of the project. The federal requirement do not apply to projects that are entirely funded by state funds, but the STA sometimes include a required DBE participation if the scope of work can allow for DBE participation available for the project within a certain geographical area. DBE participation requirements on the projects were classified as less than five percent (<5%) of the total project value, between five and fifteen percent (5-15%), and more than fifteen percent (>15%) on a project as shown in Table 3.4.

3.2.4 Scope of Work

As stated previously, projects that were let through the STA can be divided into at least four (4) groupings based on the location of the project in the transportation system (road, bridge, NHS, etc) and the relevant scope of work (reconstruction, rehabilitation, CPM, ITS, etc). Projects that entail road work (reconstruction or major resurfacing) are grouped under road projects. Projects that include rehabilitation or construction work on a bridge are grouped under bridge projects. Projects that include minor resurfacing, white topping, or crack and joint repairs on roads or bridges are grouped under capital preventive maintenance projects. Projects that involve work on traffic control devices, instruments, or signage are grouped under ITS projects, which are all presented in Table 3.5.

Table 3.5 *Groupings of Category No.4 "SCOPE OF WORK"*

SCOPE OF WORK	No. of Projects	Classes
Road	95	Resurfacing
		Reconstruction
Bridge	70	Rehabilitation
		Reconstruction
Capital Preventive Maintenance (CPM)	55	Minor Resurfacing
		White Topping
		Crack and Joint Repair
Intelligent Transportation System (ITS)	38	Traffic Control Devices
		Electronic Instruments
		Signage

3.2.5 Major Material

Certain road projects required the use of Hot Mix Asphalt (HMA) for resurfacing and reconstruction (Figure 3.4), while other road projects required the use of Portland cement concrete (PCC) products (Figure 3.5). This decision by the STA usually is based on many factors including life cycle cost analysis. Bridge projects typically use PCC products for rehabilitation and may require the use of HMA to resurface the wearing layer of the deck. CPM projects use HMA products for HMA surface repair and micro-resurfacing projects, and may also use cement concrete for concrete joint repairs, white topping (concrete layer on top of an HMA layer), and concrete spall (chipping of concrete wearing surface) repairs. ITS projects typically use metal, electrical material and electronic instruments. Details of the different groupings of major material used are illustrated in Table 3.6.

Table 3.6 *Groupings of Category No.5 "MAJOR MATERIAL"*

Major Material	No. of Projects	Classes
Hot Mix Asphalt (HMA)	77	Minor Resurfacing
		Resurfacing
		Reconstruction
		Crack and Joint Repair
Concrete	89	White Topping
		Resurfacing
		Reconstruction
		Joint Repair
Others	92	Traffic Control Devices
		Electronic Instruments
		Signage

Figure 3.4 HMA Project (Source: MyConstructionPhotos)

Figure 3.5 Concrete Project (Source: MDOT)

3.2.6 Restrictions in Contract

Each project had a set of specific restrictions and requirements of the contractor during the construction implementation phase of the project. These special conditions were based on the uniqueness of each project as it relates to the scope of work, the project location, the construction schedule of implementation, and other components specific to each project. These special restrictions may include requirements to coordinate, for the purpose of maintenance of traffic (MOT) and mobility, with all known and active construction projects located within the project's construction influence area (PCIA). Project's construction influence area is the area that is directly or directly become affected by the construction activity on the project. These traffic restrictions are to allow traffic to get to their destinations by providing alternate routes to the ones under constructions.

Other restrictions required of the prime contractor by the STA on the project may require, for the purpose of maintenance of traffic and mobility, to either perform construction activities on the project under the condition of keeping the project partially opened to traffic so that the road is not closed during the project (Figure 3.6 and Figure 3.7) or completely closing the project to traffic, if the activity are such that they may expose the traveling public to danger or can substantially reduce the project duration and cost (Figure 3.8).

Figure 3.6 Project Open to Traffic (Source: MyConstructionPhotos)

Figure 3.7 Project Open to Traffic (Source: MDOT)

Figure 3.8 Project Closed to Traffic (Source: MDOT)

Failure to comply with the restrictions stipulated in the contract documents, including the completion of the project by a certain date, may expose the contractor to penalties in the form of payment of liquidated damages for every day that the contractor was in violation. The lists of possible restrictions in the contract are illustrated in Table 3.7.

Table 3.7 *Groupings of Category No.6 "RESTRICTIONS IN CONTRACT"*

Restriction in Contract	No. of Projects	Classes
Coordination	176	Coordination with other Projects
Mobility	204	Open to Traffic During Construction
Financial	258	Liquidated Damages in Contract
Schedule	258	Final Completion Date Stipulated in Contract

3.2.7 Project Administration

For the purpose of this research, the projects were only examined during the design and construction phases. The planning, initiation and closeout phases of the project's life cycle are not discussed. Based on the funding source and the location of the project on the transportation system, the administration of the project may differ as illustrated in Table 3.8.

Table 3.8 *Groupings of Category No.7 "PROJECT ADMINISTRATION"*

Project Administration	No. of Projects	Classes
Design Team	154	State Agency
	65	Consultant
	39	Local Agency
Construction Team	82	State Agency
	150	Consultant
	26	Local Agency
Specification Book	190	1996 Specification Book
	68	2003 Specification Book

Projects that are located on the NHS are designed and administered during the design phase by the STA or its consultants with the federal government's active involvement. The STA or its approved consultants design projects that are located on the State Trunk-line and the federal oversight is minimal. Similarly, the local agency or its designated consultant designs projects that are located on the local agency routes with minimal federal oversight. The same is true for the construction administration of the projects. STA personnel or its designated consultants manage the projects that are located on the NHS and the State Trunk-lines during the construction phase. Projects that are located within the local agency's jurisdictions are also managed during the construction implementation by the local agency's own staff or its designated consultants.

3.2.8 Financial Factors

Project design engineers of the STA develop estimated construction costs for the entire project prior to its advertisement. This estimate is used for budgeting purposes and program planning. In developing the estimate, the engineers use a set of established average costs for each pay-item in order to come up with the project's entire estimated cost. This data set, however, does not capture the uniqueness of each special pay item on any given project but rather utilizes a statewide average of most common pay items.

Projects' bids sometimes come in lower than the engineer's estimates, and sometimes they come in higher than the estimates. Very rarely, they come in about the same as the engineer's estimates. The difference between the engineer's estimate on the project and the lowest responsible bid was analyzed in this study under three (3) different scenarios for when the difference is less than five (5 %) percent, between five and ten percent (5-10%), and more than ten percent (10%). The details of the financial factors are shown in Table 3.9.

Table 3.9 *Groupings of Category No.8 "FINANCIAL FACTORS"*

Financial Factors	No. of Projects	Classes
Engineer's Estimate	132	< 5% diff between Eng. Est. and Lowest Bid
	60	5-10% diff between Eng. Est. and Lowest Bid
	66	> 10% diff between Eng. Est. and Lowest Bid

3.2.9 Quality Factors

During the construction of the project, changes in quantities, scope of work, or other conditions that may affect the cost, schedule, material, or quality requirements may take place. This research captured such changes by considering the number of contract modifications (CMs) in a single contract. Depending on the measurements and payment of the changed pay-item(s) an increase or decrease of quantity and, or payment may be required. In this research, the numbers of the CMs were examined if they were fewer than twenty (20) CMs, twenty to fifty (20-50) CMs, and more than fifty (50) CMs as shown in Table 3.10. These ranges were developed that divided the list of projects into three subcategories with almost equal numbers of projects in each.

As stated previously, projects that were considered successful in meeting the scope of work, initial cost and schedule, as well as the quality requirements did not have any CM and were included in this research for analysis. Additionally, projects that did not have a claim filed but had contract modifications were not included in this research for analysis and can be evaluated in future researches.

Table 3.10 *Groupings of Category No.9 "QUALITY FACTORS"*

Quality Factors	No. of Projects	Classes
Number Of Contract Modifications	75	< 20 Contract Modifications
	96	20-50 Contract Modifications
	87	> 50 Contract Modifications

3.2.10 Claim Basis

When a claim was filed for additional compensation, the reasons for the claim were identified and analyzed. The stated reasons were then grouped into two categories (contract documents and field conditions) based on the source of the claim basis as shown in Table 3.11. Contract documents basis were due to conditions stipulated in the contract documents such as unique special provisions or a supplemental specification; scheduling requirement as stipulated in the progress clause and schedule; quality issues due to imposed quality requirements as stipulated in the contract to meet certain measurements or tolerances; or errors in the plan quantities.

Field condition grouping was based on conditions discovered on the job site during construction implementation such as the discovery of a utility conflict or differing site conditions than shown in the plans and stipulated in the contract documents.

Table 3.11 *Groupings of Category No.10 "CLAIM BASIS"*

Claim Basis	No. of Projects	Sub Class
Field Conditions	13	Utility Conflict
	49	Differing Site Conditions
Contract Documents	18	Special Provision Issues
	14	Scheduling Issues
	87	Quality Issues
	30	Quantity Issues

Chapter 4 Statistical Methodology

4.0 Methodology Overview

The data described in chapter 3 provide a rich source of information that can be utilized to study the characteristics and causal factors of claims in highway construction projects at the state transportation agency, and to possibly improve on the effectiveness and efficiency of projects' delivery in its efforts in claim management. However, until this point, these separate data sets were not integrated and much of it was not utilized for this type of research or analytical purposes. As such, the initial task of this study was collecting the data from the different sources and presenting it in a single file that could be analyzed and studied.

To accomplish the stated research objectives discussed in Chapter 1, a research of all of the claim letters in the metro region was initiated that was followed by research and collection of all of the projects that experienced claims in the rest of the STA. a similar research was performed to capture all of the successful projects at the STA that were completed for the same period (1999-2010). All of the projects were organized and the project's specific information were entered for all of the seventy four specific factors for analysis. These entries were also coded analysis per LIMDEP [39] requirements as detailed in the in the following sections and illustrated in Figure 4.1.

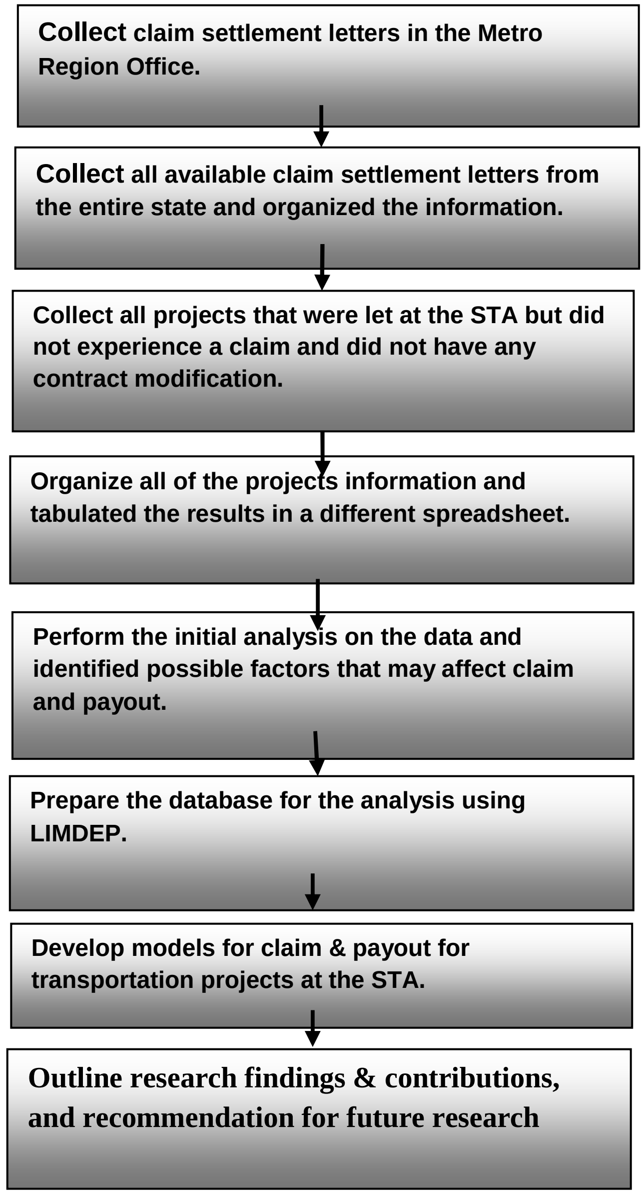

Figure 4.1 Flow Chart for Research Methodology

4.1 Initial Analysis

Initially, all of the claim settlement letters at the region office were retrieved, reviewed and analyzed for specific information related to the project location, the identity of the contractors working on the project, the project's control section (CS) and job number (JN); conditions that gave rise to the claim, the amount of the initial claim, the final settlement amount of the claim, and if the claim was fully or partially paid out. Then the CS and JN were utilized to locate the plan and proposal for more specific information on the project itself. Additional resources were utilized such as the financial obligation website, programming website, bid letting information, design information, and construction information from the different intranet sites at the STA. These sources were used to provide the information needed for the seventy four project specific variables that were identified for analysis that included financial information, types of funding, construction cost, construction implementation schedule and progress, contract modifications, changes in the original scope of work, as well as other contractual and quality requirements. All of this information was organized for each project in a spreadsheet. Once the information was organized and tabulated, a variety of tests were performed to evaluate the variables such as simple frequency and percentage analysis utilizing Microsoft Excel, as well as Logistic Regression Analysis utilizing LIMDEP software [39]. When the initial analysis demonstrated that certain factors exhibited significant effects on the likelihood of claims and payouts, the rest of the projects located state wide were also retrieved, reviewed, organized, and tabulated in the same spreadsheet.

To compare the list of projects that experienced claims to a set of projects that did not have any claims and were considered successful in terms of meeting the scope of work, cost, schedule (as expressed by the fact that these projects were free of any contract modification) a state-wide search in each project type category was initiated that entailed going over the list of projects of each letting at the STA to obtain the project CS and JN and then to determine if a claim was filed on this project or not. If a claim was not filed on this project, a research into the construction filed to determine if a CM was entered on it or not. The projects that had a CM were not included in the list of the projects. The projects that were completed successfully and did not have any CM were included in the list for analysis. These "successful" projects were identified, retrieved, tabulated, and were added to the same spreadsheet (47 projects). As soon as the list was complete and all of the aforementioned projects were organized and tabulated, analytical tests were performed as detailed in the following sections.

4.2 Frequency and Percentage Analysis

All of the projects' data in the different categories included in the master spreadsheet were analyzed for frequency for each of the categories and their subcategories by utilizing the Microsoft Excel Software. Bar charts were created utilizing the same software for side-by-side comparison and to identify any trends. Pie charts were also used to demonstrate the percentages of the different categories and to show simple proportional part-to-whole information.

4.3 Logistic Regression Analysis

Upon completion of the frequency analysis on the data set in the master spreadsheet, logistic regression analysis employing LIMDEP [39] was performed. Logistic regression is a mathematical modeling approach (sometimes called the logistic model or logit model) that is used to examine the probability an event's occurrence by fitting data to a logit function curve that takes on the shape of the letter S. It demonstrates a logistic function, with C_{laim} on the horizontal axis and f (C_{laim}) on the vertical axis. The S curve demonstrates when the probability of a Claim increases the probability of the No Claim decreases and vise versa. If the claim probability is 1 then the probability of a no claim outcome is zero (0). The same can be illustrated for a payout and a no payout when a claim is filed. In other words, if the likelihood of a payout is increased then the likelihood of the payout is decreased. And if the likelihood of the payout is 1 then the likelihood of the no payout is zero (0).

According to Sanford and Weisburg [40] a binomial regression model is a technique in which the response (often referred to as Y) is the result of a series of Bernoulli trials, or a series of one of two possible disjoint outcomes (traditionally denoted "success" or 1, and "failure" or 0). Logistic regression modeling technique has been utilized on studies in highway construction similar to the one that was performed by Ford [41]. In that research, Ford modeled the effect of constructability reviews on reducing highway construction project schedule without increasing cost.

Like any other model building technique, the goal of the logistic regression analysis is to find the best fitting and most parsimonious, yet reasonable, model to describe the relationship between an outcome and a set of independent (predictor or explanatory) variables [42]. The logistic regression does not have the requirements of the outcomes to be normally distributed, linearly related, nor have equal variances within each group [42]. Cohen et al [43] concluded that logistic regression analysis extends the techniques of multiple regression analysis to research situations in which the outcome variable is categorical, while linear regression analysis is mainly used for continuous variables.

UNESCO Institute of Statistics [44] identifies a variable as any measured characteristic or attribute that differs for different subjects such as the type of project, material used, final cost, and number of subcontractors working on the project. Variables can be qualitative or quantitative. A quantitative variable is measured on a numeric or quantitative scale for which meaningful arithmetic operations make sense such as the cost of the project and the number of contract modifications. Variables that are not quantitative are known as qualitative variables, and are called categorical variables. Categorical variables may be coded similar to a quantitative variable by arbitrarily assigning numbers or values to categories, such as a project where no claim is filed will be assigned the number zero (0) while a project with a claim filed is assigned a value of number one (1). For the subsets of category 1 (claim filed), a project with a claim paid gets a value of number one (1) assigned to it, and a claim that was denied (not paid) will be assigned the value of number zero (0). Additionally, in an experiment, the independent variable is the variable that is varied or manipulated by the researcher, and the dependent variable is the response that is measured (Happner et al.) [45].

The logistic regression model uses the independent variables, which can be categorical or continuous to predict the probability of specific outcomes (dependent variable). For this research, the logistic regression analysis was performed using LIMDEP [39] to test all of the independent variables individually and collectively on the dependent variable and any of its possible outcomes utilizing a variety of logistic regression analysis such as the binary logistic and multinomial logistic regression analysis as detailed in the following sections.

4.3.1 Binary Logistic Regression Analysis

Binary Logistic regression models the relationship between indicator variable and the response variables in a data set. Simple linear regression is used mainly to examine the relationship between a single indicator variable and a single response variable. When there are several indicator variables, similar to this research, multiple regressions are used. However, often the response is not a numerical value. Instead, the response is simply a designation of one of two possible discrete outcomes (a binary response such as claim vs. no claim, payout vs. no payout) is utilized.

Logistic regression software (such as LIMDEP [39]) uses maximum likelihood estimates to model parameters and can also generate diagnostic plots which can be used to identify data that are not well-fitted (Agresti and Alan) [46]. Binary logistic regression test was used in this research to determine the specific project factors that affect the project outcome in terms of whether a claim is filed or not and, further, whether the claim is paid out or not. The analysis was used on the entire independent project-specific factors one at a time (individually) and collectively (simultaneously) to determine all the significant factors that may affect each outcome (claim, no claim, payout, and no payout).

4.3.2 Multinomial Logistic Regression Analysis

A multinomial logistic model is a regression model which generalizes the binary logistic regression by allowing more than two discrete outcomes. It is a model that is used to examine the probability (or likelihood) of the different possible outcomes of a categorically distributed dependent variable, given a set of independent variables (which may be continuous, binary, or multinomial). It is used when the dependent variable in question is categorical and consists of more than two categories. It is appropriate in cases where the response is not ordinal in nature and there is no apparent order. This model assumes that data are case specific; that is, each independent variable has a single value for each case. In this research this test was performed on the claim, no claim, payout, and no payout with keeping one of these options as the base line.

4.4 Modeling

To gain some insight into the factors that significantly affect the likelihood of a claim outcome, two statistical models were developed for this research; 1) a model of the probability of the project having a claim; 2) a model of the probability of a project with a claim filed being paid out. These models involve discrete and binary outcomes (having a claim filed or not, a claim filed paid out or not). The binary/multinomial logit formulation is an appropriate modeling methodology for all of these cases. To arrive at this formulation, a linear function of covariates that determine the likelihood of project *n* having discrete outcome *i* (i.e. having a claim) as:

$$H_{in} = \boldsymbol{\beta}_i \boldsymbol{X}_n + \varepsilon_{in}, \tag{4.1}$$

where $\boldsymbol{X}_n$ is a vector of measurable characteristics that determine outcome *i* (e.g., type of project, type of major material used, any of the contracting factor, etc.), $\boldsymbol{\beta}_i$ is a vector of estimable coefficients, and ε_{in} is an error term that accounts for unobserved factors influencing resulting outcomes. McFadden [49] has shown that if ε_{in} are assumed to be generalized extreme value distributed, the standard multinomial logit model results,

$$P_n(i) = \frac{\exp[\boldsymbol{\beta}_i \boldsymbol{X}_n]}{\sum_I \exp[\boldsymbol{\beta}_I \boldsymbol{X}_n]}, \tag{4.2}$$

where $P_n(i)$ is the probability that project *n* has discrete outcome *i* and *I* is the set of possible outcomes.

The general equation (4.2) can be simplified and further expressed for each outcome by the following equations:

$$P(\text{Claim=1}) = \frac{e^{U_{\text{claim}}}}{e^{U_{\text{claim}}} + e^{U_{\text{no claim}}}} \tag{4.3}$$

or

$$P(\text{No Claim=1}) = \frac{e^{U_{\text{no claim}}}}{e^{U_{\text{claim}}} + e^{U_{\text{no claim}}}} \tag{4.4}$$

The relationships can also be expressed in the following general algebraic equations (4.3) and (4.4):

$$U_{Claim} = \beta_{0Claim} + \beta_{1Claim}X_1 + \beta_{2Claim}X_2 + ... + \beta_{nClaim}X_n \quad (4.5)$$

$$U_{No\ Claim} = \beta_{0No\ Claim} + \beta_{1NoClaim}X_1 + \beta_{2No\ Claim}X_2 + ... + \beta_{nNoClaim}X_n \quad (4.6)$$

Where β_{is} are the estimated coefficients and X_{ni} are the projects' significant indicator variables.

Similarly, for the payout outcome, the equations can take the form of the following equations (4.5) and (4.6):

$$P(Payout=1) = \frac{e^{U\ payout}}{e^{U\ payout} + e^{U\ no\ payout}} \quad (4.7)$$

or

$$U_{Payout} = \beta_{0\ Payout} + \beta_{1\ Payout}\ X_1 + \beta_{2\ Payout}\ X_2 + ... + \beta_{n\ Payout}\ X_n \quad (4.8)$$

For the no payout outcome, the equation can be written as shown in equations (4.7) and (4.8):

$$P(No\ Payout=1) = \frac{e^{U\ no\ payout}}{e^{U\ payout} + e^{U\ no\ payout}} \quad (4.9)$$

or

$$U_{No\ Payout} = \beta_{0\ Payout} + \beta_{1\ Payout}\ X_1 + \beta_{2\ Payout}\ X_2 + ... + \beta_{n\ Payout}\ X_n \quad (4.10)$$

In order to start analyzing the different variables, selection of all the statistically significant (95% confidence) independent variables was performed. To do this, a stepwise selection process was used that included a forward selection and backward elimination. Forward selection was utilized by starting with the constant-only model and adding variables one at a time in the order that they were best by established criterion until the cutoff level was reached (until the step at which all variables not in the model have significance higher than .05) The independent variable with highest chi-square value that met the p value criterion were selected. This process was repeated until no further independent variable with a significant p value existed. Backward elimination started with all variables and deleted one at a time, in the order they were farthest by the established criterion. The two selections methods provide the same list of significant variables and their results were tabulated.

Maximum likelihood estimation, MLE, is the method used to calculate the logit Coefficients for the parameter estimation and to determine the parameters that maximize the probability of the outcome. This method assured, from a statistical point of view, the application that would maximize the probability that would yield good statistical properties.

The test statistic used to test the hypothesis was the T-test that could be written as:

$$T_0 = B_i / (SE\ B_i) \qquad (4.11)$$

Null hypothesis was rejected in favor of the alternate hypothesis when:

$$T_0 > t_\alpha/2,_{n-2} \qquad (4.12)$$

Variables that had T_0 >2.0 and P<.05 would be significant at 95 % significance level were used in this research.

4.5 Elasticity Calculations

To assess the effect of the vector of estimated coefficients (βi), **e**lasticity Calculations were completed for each significant project indicator factor. Due to the fact that in this research the project's indicator variables take on the values of 0 and 1, the measure of the sensitivity of the indicator variables (elasticity calculation) is conducted by computing pseudo-elasticity. Pseudo-elasticity is defined as the percentage change in the probability of an outcome when an indicator variable is changed from zero (0) to one (1).

The following equation is used to calculate pseudo-elasticity where I_n is the set of alternate outcomes with x_k in the function determining the outcome, and I is the set of all possible outcomes (Washington et al. [47].

$$E_{x_{ki}}^{P(i)} = \left[\frac{\exp\left[\Delta\left(\boldsymbol{\beta}_i \boldsymbol{X}_i\right)\right] \sum_{\forall I} \exp\left(\beta_{kI} \mathrm{x}_{kI}\right)}{\exp\left[\Delta\left(\boldsymbol{\beta}_i \boldsymbol{X}_i\right)\right] \sum_{\forall I_a} \exp\left(\beta_{kI} x_{kI}\right) + \sum_{\forall I \neq I_a} \exp\left(\beta_{kI} x_{kI}\right)} - 1 \right] \times 100, \qquad (4.13)$$

Where I_a is the set of alternate discrete outcomes with X_k in the function determining the outcome, and I is the set of all possible discrete outcomes. The pseudo-elasticity of a variable with respect to a discrete outcome represents the percent change in the probability of outcome I when the variable is changed from zero to one. Thus, a pseudo-elasticity of 40% for a project indicator variable means that when the value of the variable in the sub-set of observations where $X_k = 0$ are changed from 0 to 1, the probability of the outcome for these observations increased, on average, by 40%. Washington et. al. [47] has a complete discussion of elasticities in the context of statistical and economical models.

The relative elasticity calculated and shown in this research is demonstrated by the following equations:

$$\text{Elasticity for a specific project indicator for a claim outcome} = \frac{P\ (\text{Claim}/X=1)}{P\ (\text{Claim}/X=0)} \qquad (4.14)$$

$$\text{Elasticity for a specific project indicator for a Payout outcome} = \frac{P\ (\text{Payout}/X=1)}{P\ (\text{Payout}/X=0)} \qquad (4.15)$$

The results are tabulated and discussed in the following Chapter (Chapter 5).

Chapter 5 Results and Discussion

5.0 Analysis Summary

This study relied on logistic regression analyses to examine the relationships between the claim outcomes and project specific factors. The data were analyzed using computer programs such as Microsoft (MS) Excel and LIMDEP [39]. The initial test utilized the frequency analysis built in Microsoft Excel to determine the frequencies of each occurrence listed in the master spreadsheet and to get a general idea about the breakdowns of all the factors to be analyzed. The logistic regression analysis was utilized to examine the effect of all the specific project factors on the dependent variable outcomes (filing or not filing of a claim, paying or not paying out on the filed claims). Using LIMDEP [39] and its logistic regression analysis and modeling features, the project factors covered in Chapter 4 were analyzed individually for their likely effects on all possible claim outcomes. It is important to mention that partial payment on claims was considered as payment for the purpose of this analysis as the additional breakdown was not practical for this limited set of data that was currently available. The project factors were examined simultaneously in a binary analysis to determine the likelihood of a claim vs. no claim, and a payout vs. no payout. The project factors were also examined simultaneously in a multinomial logit analysis (MLA) to determine their probable effects and likelihood on any and all of the possible claim outcomes.

Other analyses were utilized such as the mixed logit analysis and the nested multinomial logit analysis, but they showed no significance, so the results were not included in this dissertation.

5.1 Frequency Analysis

All of the organized data categories in the master spreadsheet (MS) were analyzed for frequencies and percent breakdown utilizing the functions readily available within MSFT Excel software. As discussed in Chapter 3, the total number of projects that had claims filed was 211, and the total number of projects that were successfully completed (i.e., met their original scope of work, budgeted cost and duration, and were completed without any contract modifications or claims) was 47.

Table 5.1 *Frequency Analysis and Percent Distributions of Projects Breakdown*

Projects Breakdown	No. of Projects (Frequency)	Percent
Projects with claims filed	211	81.78%
Successful projects (no claims filed & no CM)	47	18.22%
Total projects	258	100.00%
Projects with claims paid out	118	55.92%
Projects with claims not paid	93	44.08%
Total projects	211	100.00%

Table 5.1 shows the frequency of claim outcomes on all the projects that were included in the master spreadsheet. It shows that projects with filed claims exhibited the highest frequency among all of the analyzed projects. They were followed by projects with claims paid out and by those projects that had their claims denied for payment

(See Figure 5.1). Projects that were successfully completed and without claims constituted about 20% of the total projects included on the list.

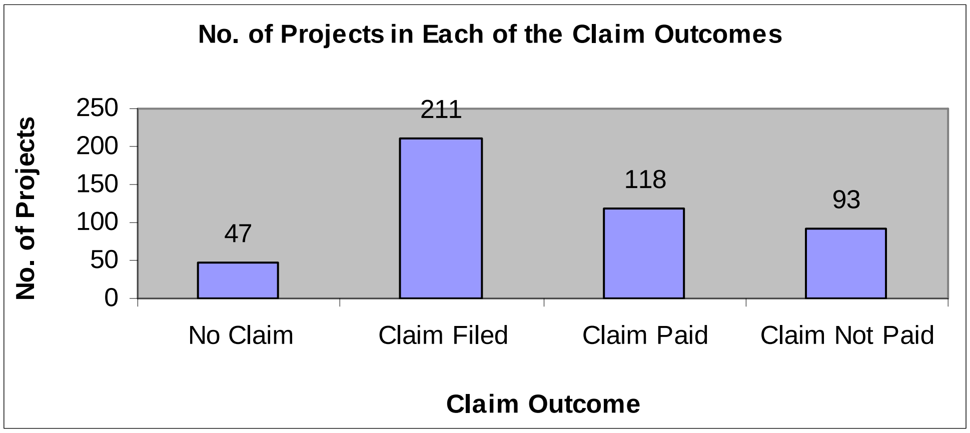

Figure 5.1 Breakdown of Projects in Each of the Claim Outcomes

The claims that were paid constituted about 56% of the projects that had claims filed, and the projects whose claims were denied constituted about 44% as illustrated in Figure 5.2

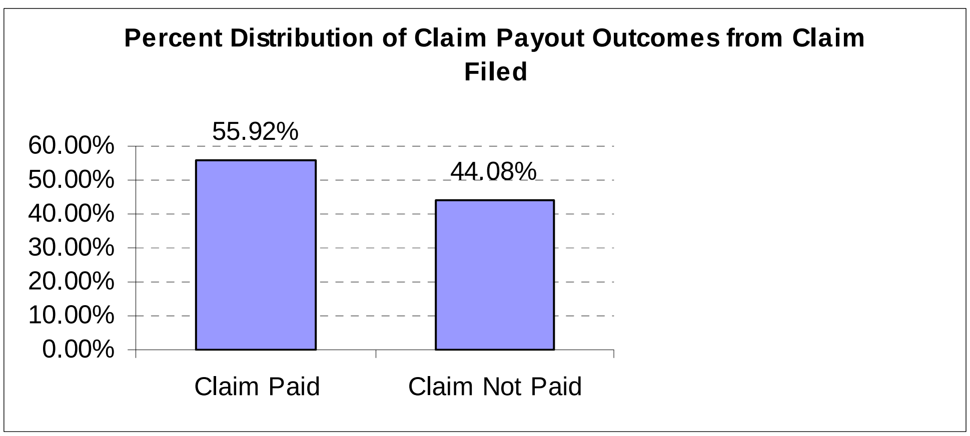

Figure 5.2 Percent Distribution of Claims Paid vs. Not Paid

Table 5.2 shows the projects that were let in 2005, 2006 and 2008 exhibited the highest frequencies in the analyzed list of projects, and projects on the list that were let in 1999, 2000, and 2010 exhibited the least frequency.

Table 5.2 *Frequency Analysis and Percent Distributions of Projects Letting Year*

Letting Year	Frequency	Percent
1999	4	1.55%
2000	5	1.94%
2001	10	3.88%
2002	6	2.33%
2003	17	6.59%
2004	17	6.59%
2005	44	17.05%
2006	55	21.32%
2007	18	6.98%
2008	46	17.83%
2009	30	11.63%
2010	6	2.33%

Table 5.2 shows that only six (6) projects were included in this analysis for projects that were let and constructed in 2010. This was due to the fact that this analysis started before the conclusion of the 2010 construction season and only projects that were either successfully completed or had their claims settled were included in the list for analysis. Records for projects that were let and constructed prior to 1999 were not available for this analysis. Projects with available records between 1999 and 2002 totaled only 25 projects as illustrated in Figure 5.3.

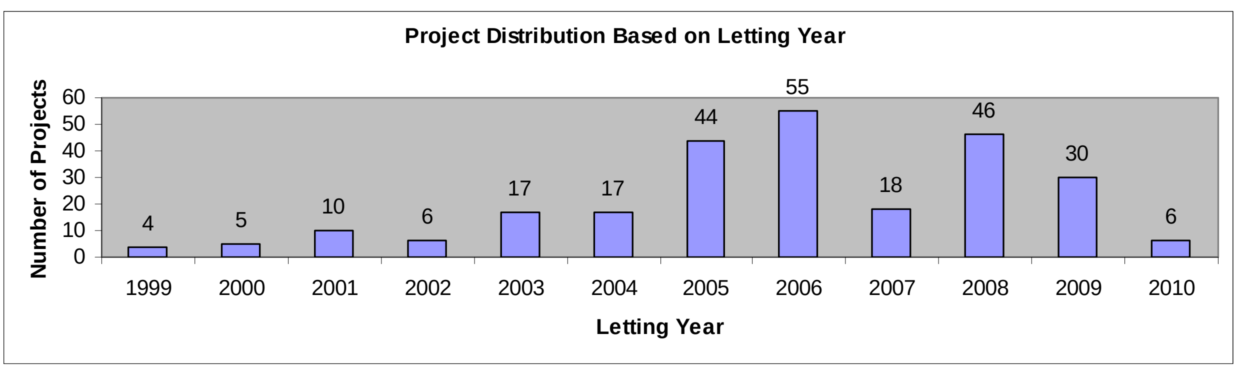

Figure 5.3 Breakdown of Projects Distribution Based on Letting Year

Table 5.3 and Figure 5.4 show that the number of projects with claims filed for 1999 through 2002 were fewer than ten (10) projects for each of the year analyzed. The number of projects with claims filed for 2003 and 2004 were fewer than twenty projects for each year. The analysis also show a significant increase in the number of claims filed with STA in 2005.

Table 5.3 *Breakdown Analysis of Projects in the Master List*

Year	Total No. of projects in the master list	No. of projects with a claim filed	No. of "Successful" projects (no claim filed & no CM)
1999	4	1	3
2000	5	1	4
2001	10	9	1
2002	6	3	3
2003	17	14	3
2004	17	16	1
2005	44	39	5
2006	55	48	7
2007	18	15	3
2008	46	34	12
2009	30	26	4
2010	6	5	1
Total	**258**	**211**	**47**

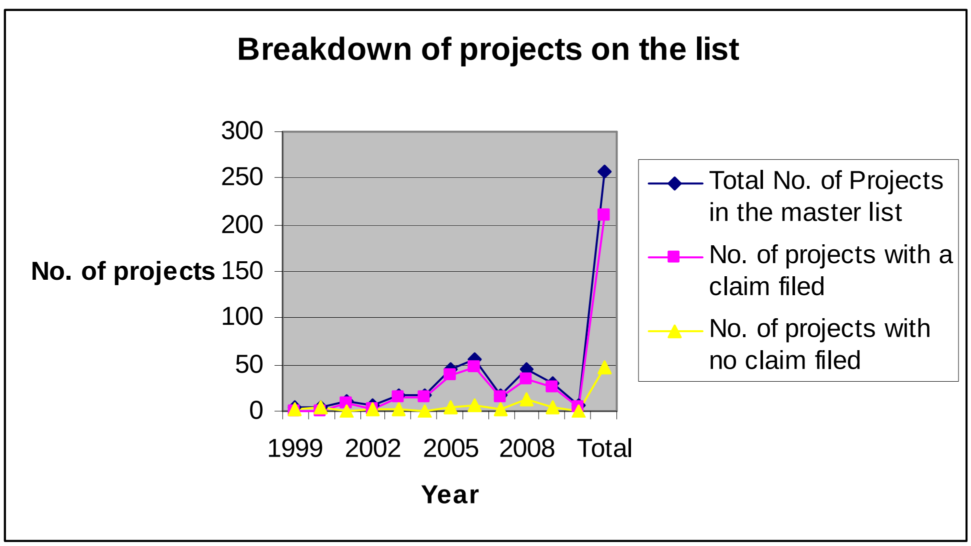

Figure 5.4 Breakdown of Projects in the Master List

Table 5.4 and Figure 5.5 show that starting with 2001 a great number of the projects analyzed in this research had claims filed. The percentages ranged from 50% to 94%. The overall percentage of projects with claims in the list totaled about 82%.

Table 5.4 *Number and Percent Distribution of Project with Claims*

Year	No. of projects in the master list	No. of projects with a claim filed	Percent of projects with a claim filed
1999	4	1	25%
2000	5	1	20%
2001	10	9	90%
2002	6	3	50%
2003	17	14	82%
2004	17	16	94%
2005	44	39	89%
2006	55	48	87%
2007	18	15	83%
2008	46	34	74%
2009	30	26	87%
2010	6	5	83%
Total	**258**	**211**	**82%**

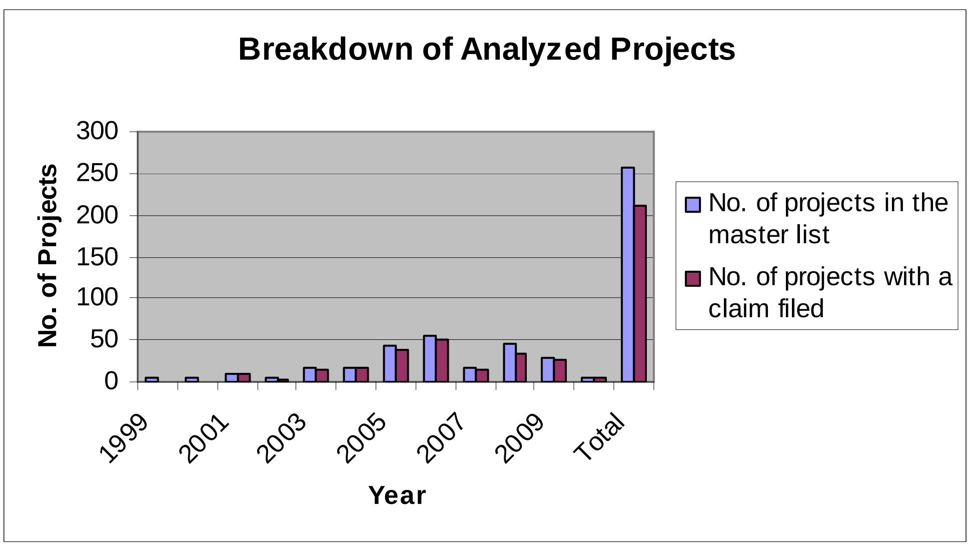

Figure 5.5 Projects with Claims vs. Total Projects

Table 5.5 and Figure 5.6 show that starting with 2003 there is a noticeable decrease in the percentage of projects that did not have a claim filed. The percentage of projects in the list that did not have a claim filed for 1999 and 200t were 75% and 80% respectively. In 2002, that percentage was 50%. Starting with 2003, there was a great decrease in the percent of projects that did not have claims filed. The overall percentage of projects in the list that did not have a claim filed was about 18%.

Table 5.5 *Number and Percent Distribution of Projects without Claims*

Year	No. of projects in the master list	No. of "Successful" projects (no claim filed and no CM)	Percent of successful projects (no filed claim and no CM)
1999	4	3	75%
2000	5	4	80%
2001	10	1	10%
2002	6	3	50%
2003	17	3	18%
2004	17	1	6%
2005	44	5	11%
2006	55	7	13%
2007	18	3	17%
2008	46	12	26%
2009	30	4	13%
2010	6	1	17%
Total	**258**	**47**	**18%**

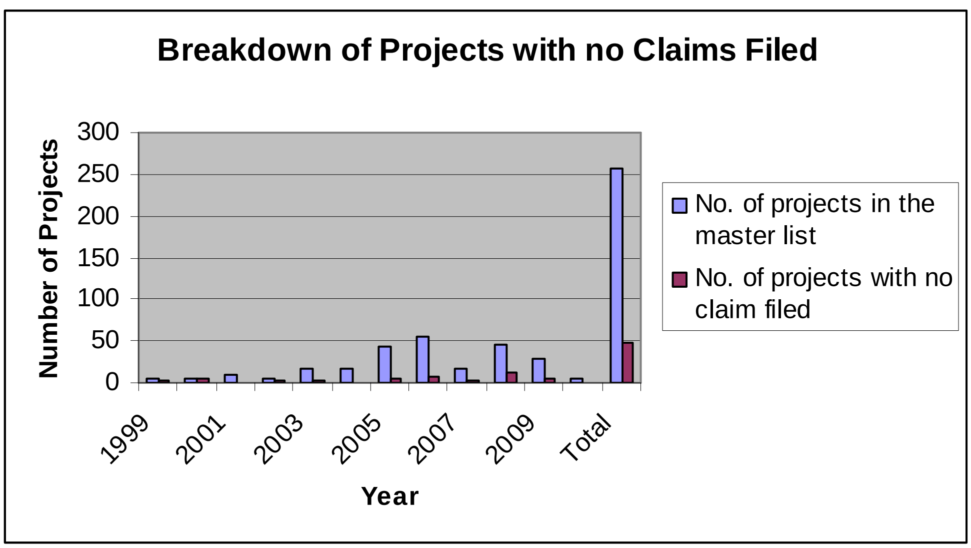

Figure 5.6 Breakdown of Projects with No Claims in the Master List

Table 5.6 shows the projects located in Metro Region TSC 2 exhibited the highest frequency, followed by TSC 1, and the rest of the state. Projects located in the Metro Region TSC 3 exhibited the lowest frequency in the list of analyzed projects.

Table 5.6 *Frequency Analysis and Percent Distributions of Project Locations*

Geographical Location	No. of Projects (Frequency)	Percent
Metro Region TSC 1	47	18.22%
Metro Region TSC 2	64	24.81%
Metro Region TSC 3	32	12.40%
Metro Region TSC 4	35	13.57%
Metro Region TSC 5	38	14.73%
Rest of State	42	16.28%
Total	258	100.00%
Physical Location	**Frequency**	**Percent**
National Highway System	45	17.44%
State Trunk-line	138	53.49%
Local Agency Route	75	29.07%
Total	258	100.00%

Projects that were located on the state Trunk-line system also exhibited the highest frequency, followed by local agency, and those projects located on the National Highway System as illustrated in Figure 5.7.

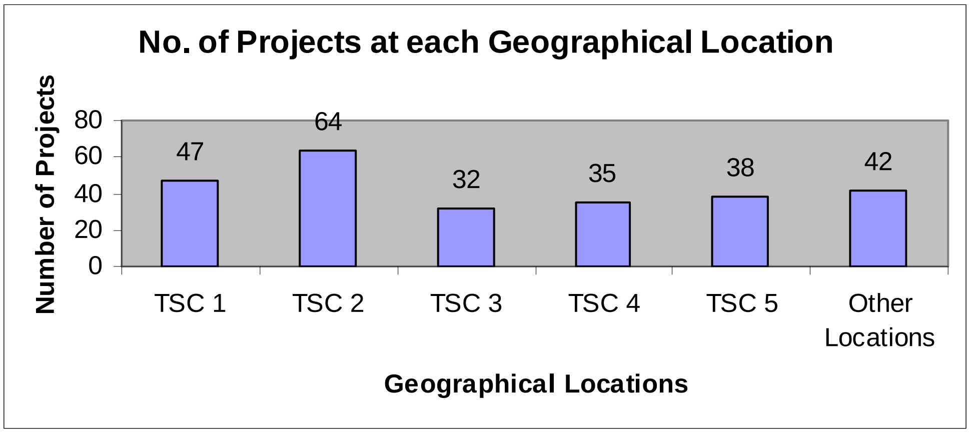

Figure 5.7 Breakdown of Projects Based on Geographical Locations

Table 5.7 shows the projects that had five (5) or more bids had the higher frequency on the list and was followed by those projects that had fewer than five bids on them in the bidding stage. Projects that were let during the winter and the fall season exhibited the highest frequency, followed by projects that were let in the spring and the summer seasons as illustrated in Figure 5.8. Projects on the list that were let with more than a hundred other projects were the most on the list. Contractor G was awarded most of the projects on the list, followed by contractor E, while contractor A was awarded the least number of projects on the list. Projects that had more than fifteen (15) subcontractors working on them constituted the majority of the analyzed projects, while projects that had a number of ten to fifteen subcontractors working on them were the least on the list of projects as illustrated in Figure 5.9.

Table 5.7 *Frequency Analysis and Percent Distributions of Contracting Factors*

Category	Variables	Frequency
Number of Bidders	Fewer than 5	121
	More than 5	137
	Total	**258**
Letting Season	Winter Season	90
	Spring Season	58
	Summer Season	35
	Fall Season	75
	Total	**258**
No. of Projects in a Letting	Fewer than 50 in a letting	78
	50 to 100 Projects in a Letting	87
	More than 100 Projects in a Letting	93
	Total	**258**
Prime Contractor Identification	Contractor A	29
	Contractor B	34
	Contractor C	35
	Contractor D	37
	Contractor E	42
	Contractor F	36
	Other Contractors (G)	45
	Total	**258**
No. of Subcontractors on the Project	Fewer than 10 Subs on the Project	87
	Between 10 & 15 Subs on the Project	66
	More than 15 Subs on the Project	105
	Total	**258**
Percent of DBE Participation on Project	Less than 5% DBE Participation	95
	Between 5% and 15% DBE Participation	111
	More than 15% DBE Participation	52
	Total	**258**

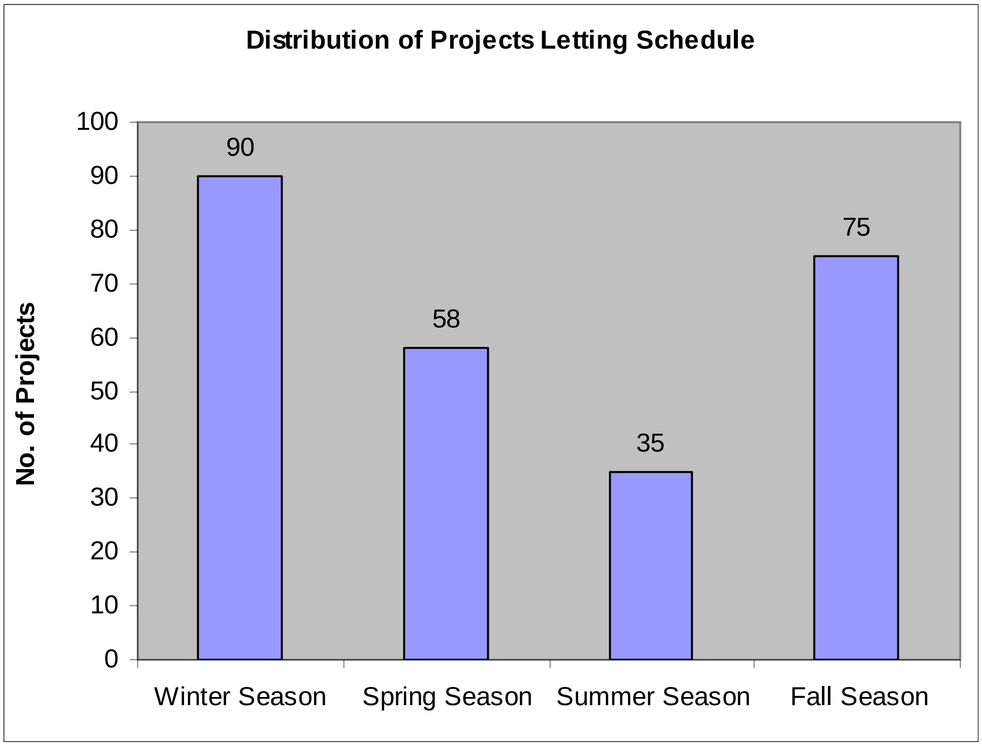

Figure 5.8 Distribution of Projects Based on Letting Season

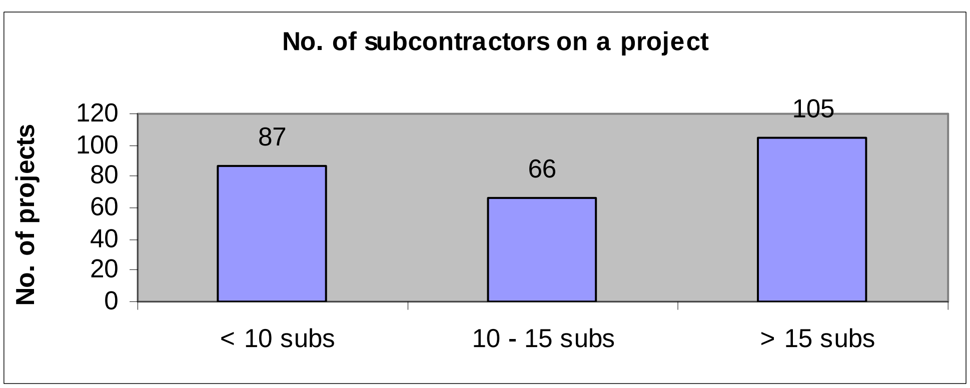

Figure 5.9 Breakdown of Projects Based on No. of Subcontractors

Additionally, projects that had DBE participation of ten to fifteen (10-15) percent were the most in the list of projects, and the projects that had more the fifteen (15) percent were the least on the list of project as shown in Figure 5.10.

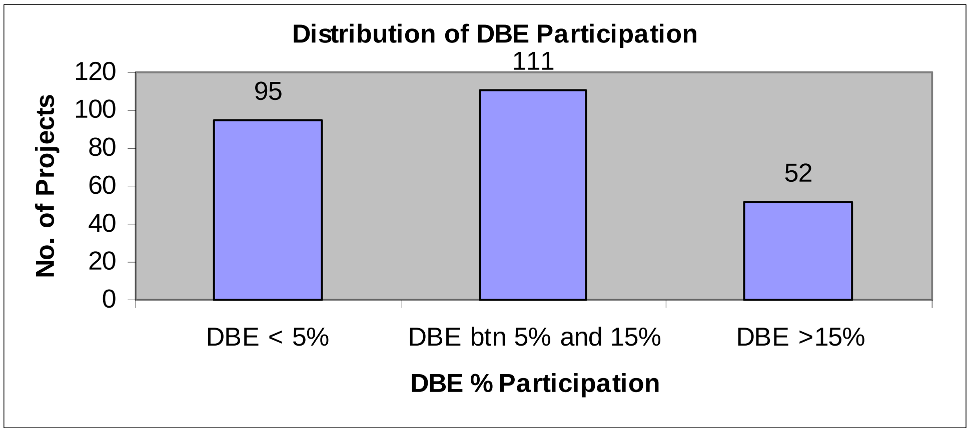

Figure 5.10 Breakdown of Projects Based on DBE Participation

Table 5.8 and Figure 5.11 show the projects designated as road projects, based on their scope of work, exhibited the highest frequency and were followed, in order of frequency, by bridge, CPM, and ITS projects

Table 5.8 *Frequency Analysis and Percent Distribution of Projects Scope of Work*

Scope of Work	Frequency	Percent
Road Project	95	36.82%
Bridge Project	70	27.13%
CPM Project	55	21.32%
ITS Project	38	14.73%
Total	**258**	**100.00%**

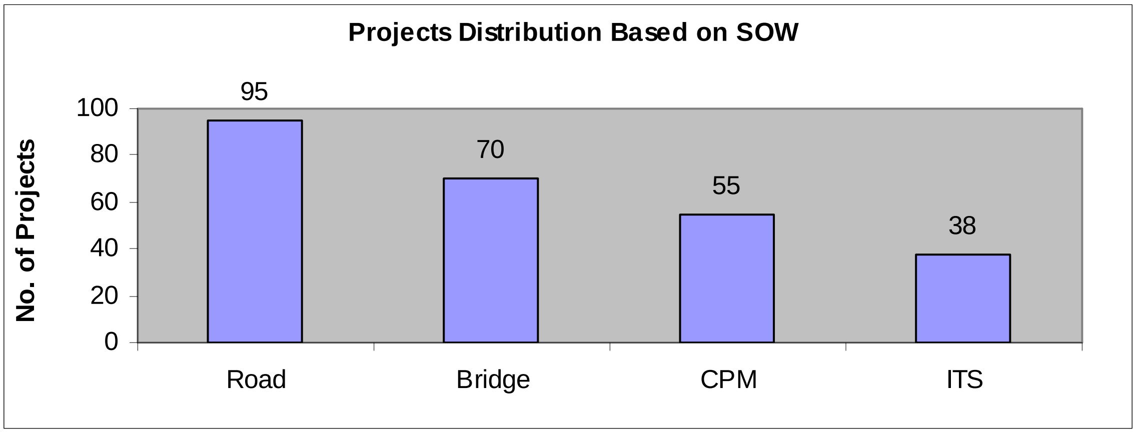

Figure 5.11 Breakdown of Projects Based on Scope of Works

Table 5.9 and Figure 5.12 show that projects constructed utilizing material other than concrete or HMA were the most frequent among the analyzed projects, followed by concrete and HMA.

Table 5.9 *Frequency Analysis and Percent Distributions of Major Materials*

Major Material Used	Frequency	Percent
HMA	77	29.84%
Concrete	89	34.50%
Others Material	92	35.66%
Total	**258**	**100.00%**

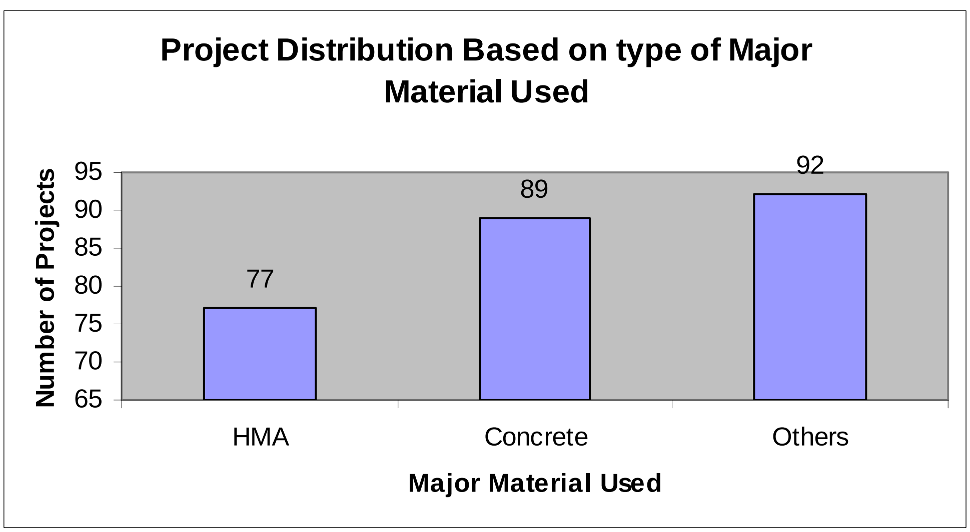

Figure 5.12 Breakdown of Major Material Used

Table 5.10 shows that all of the projects on the list included liquidated damage stipulation and final completion date requirements in the contract documents. The table also shows that only a small percentage of projects had constructability reviews performed on them.

Table 5.10 *Frequency Analysis and Percent Distributions of Project Restrictions*

Contract Restriction	Frequency	Percent
Coordination w. other known projects in PCIAs	176	68.22%
Open to traffic during construction	204	79.07%
Final completion in contract	258	100.00%
Liquidated damages included in contract	258	100.00%
Constructability review performed	28	10.85%

Table 5.11 shows that most of the projects on the list were designed by the staff directly working for the STA, followed by projects that were designed by consultants, and the local agency staff respectively.

Table 5.11 *Frequency Analysis and Percent Distributions of Project Administration*

Project Design	Frequency	Percent
STA Design	154	59.69%
Consultant Design	65	25.19%
Local Agency Design	39	15.12%
Total	**258**	**100.00%**
Project Construction Administration	**Frequency**	**Percent**
STA Construction	82	31.78%
Consultant Construction	150	58.14%
Local Agency Construction	26	10.08%
Total	**258**	**100.00%**
Applicable Specification Book	**Frequency**	**Percent**
Specification Book 2003	190	73.64%
Specification Book 1996	68	26.36%
Total	**258**	**100.00%**

Figure 5.13 also shows that most of the construction projects were managed during construction by the utilization of consultants, followed by STA and the local agencies.

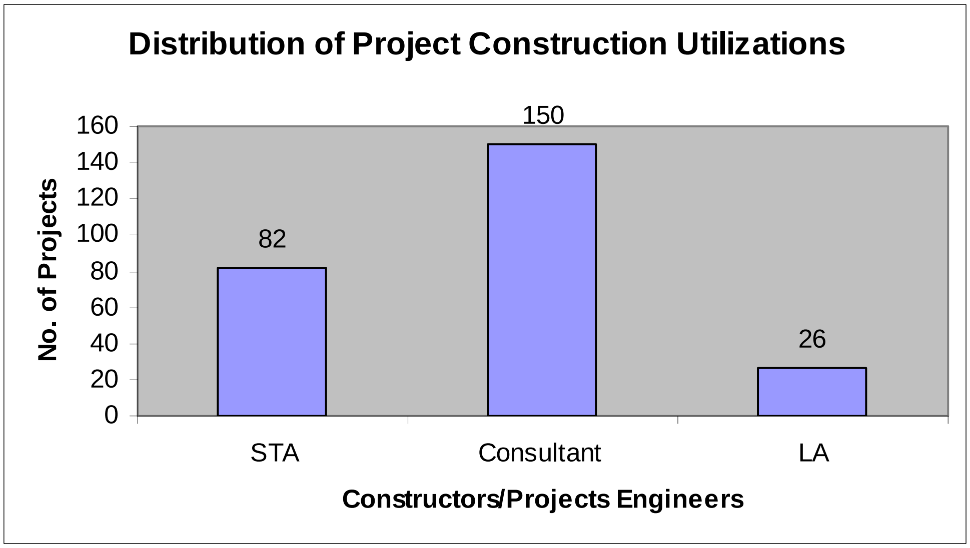

Figure 5.13 Breakdown of Projects Construction Utilization

Table 5.12 shows that most of the projects on the list had less than five (5) percent difference between the engineers' estimate of construction and the lowest responsible bidders, followed by more than ten (10) percent and between five and ten (5-10) percent difference in the list of projects that were analyzed.

Table 5.12 *Frequency Analysis and Percent Distributions of Financial Factors*

Financial Factors	Frequency	Percent
Less than 5% diff between Engineer's estimate & Lowest Bid	132	51.16%
5-10 % diff between Engineer's estimate & Lowest Bid	60	23.26%
More than 10% diff between Engineer's estimate & Lowest Bid	66	25.58%

Figure 5.14 illustrates that projects with 5-10 % differences between engineer's estimate and the lowest bidder and projects where the estimates are greater than 10% are about equal to those projects on the list where the difference is less than 5%.

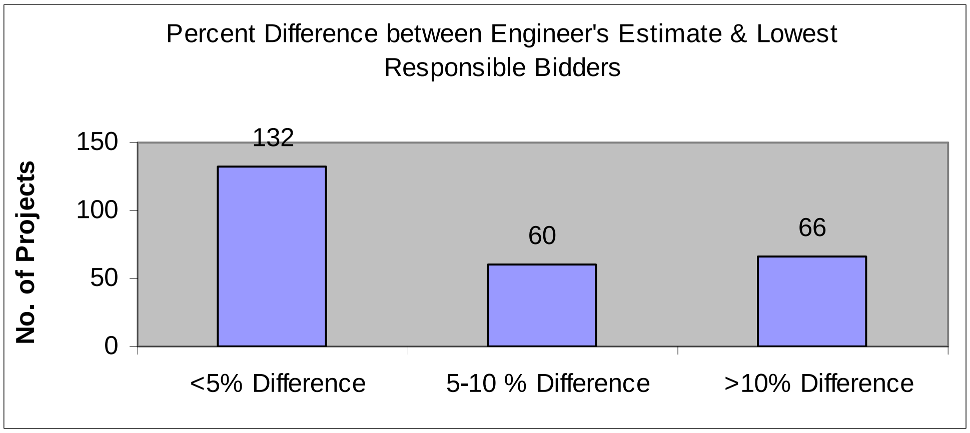

Figure 5.14 Breakdown of Differences between Estimates and Lowest Bids

Table 5.13 and Figure 5.15 show that projects that had fewer than twenty (20) CMs each were the least frequent on the master list, while projects that each had between twenty to fifty (20-50) contract modifications each were the most frequent on the list followed by those projects that had more than fifty (50) CMS.

Table 5.13 *Frequency Analysis and Percent Distributions of Quality Factors*

Quality Factors	Frequency	Percent
Fewer than 20 CMs	75	29.07%
Between 20 and 50 CMs	96	37.21%
More than 50 CMs	87	33.72%

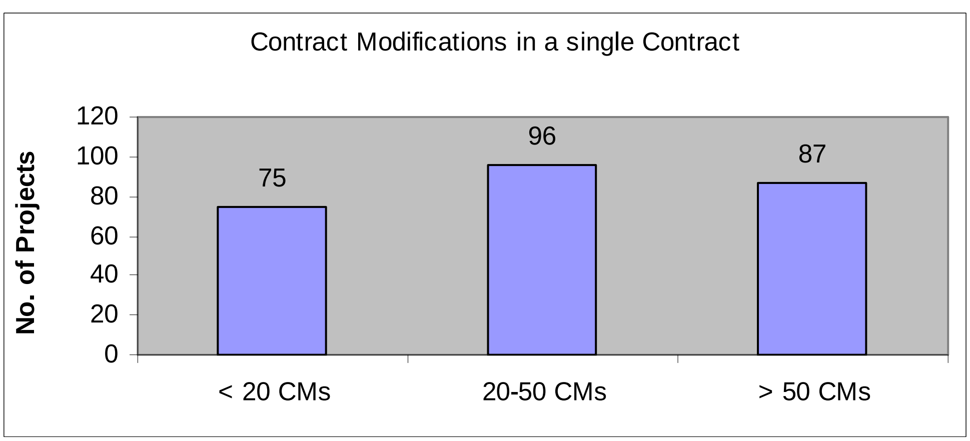

Figure 5.15 Breakdown of the No. of Contract Modifications in a Single Contract

Table 5.14 shows projects that utilized the quantity errors in the plan as the basis of their claims were the highest frequency in the list of projects, followed by special provision issues. Projects that utilized utility conflicts, scheduling issues, and differing site conditions demonstrated the least frequencies among all of the projects as shown in Figures 5.16 and 5.17.

Table 5.14 *Frequency Analysis and Percent Distributions Claim Basis*

Claim Basis	Frequency	Percent
Utility Conflict Basis for Claim	13	5.04%
Special Provision (S.P) Issues Basis for Claim	49	18.99%
Differing Site Conditions Basis for Claim	18	6.98%
Scheduling Issues Basis for Claim	14	5.43%
Quantity Errors Basis for Claim	87	33.72%
Quality Issues Basis for Claim	30	11.63%
Total Projects with Claims Filed	**211**	**81.79%**

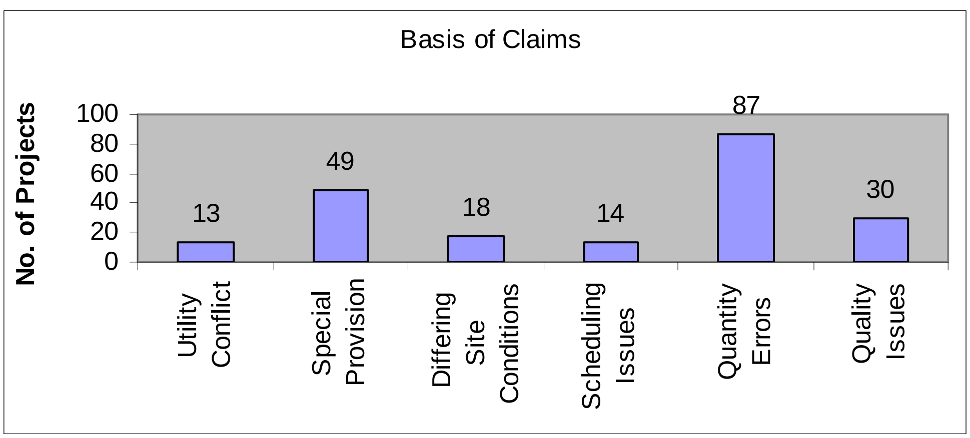

Figure 5.16 Breakdown of Claim Basis

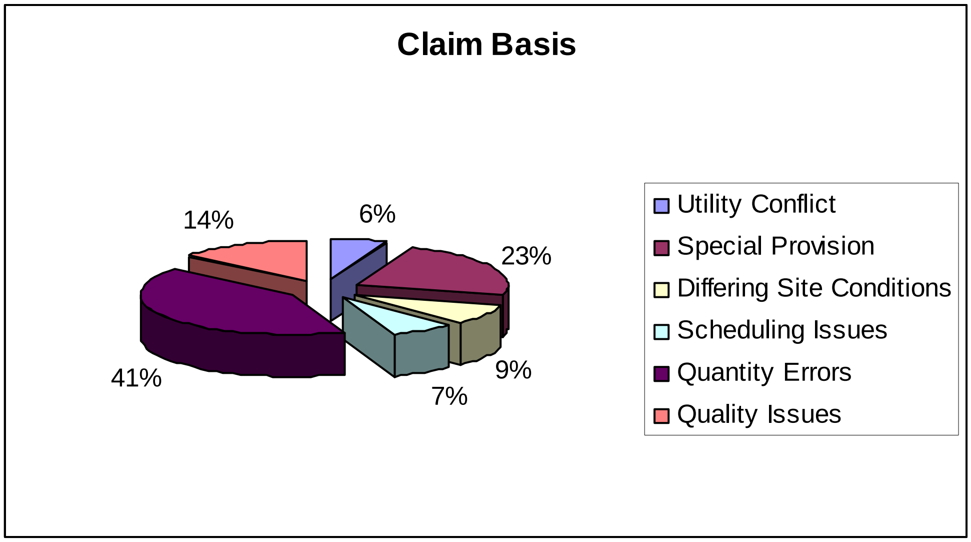

Figure 5.17 Percent Distribution of Claim Basis

5.2 Logistic Regression Analysis

As discussed in the previous chapter, logistic regression models were developed in this research to determine the various factors that can affect any of the possible outcomes of claims. LIMDEP Version 9 software is used for the analysis as it allows flexibility in terms of model specification (Greene. 2002) [50]. The initial test was to examine each individual project variable on its own merit to determine its significance and likely effect on the possible claim outcome. The following test was to examine all of the different factors simultaneously on a claim filing vs. no filing and a claim payout vs. non-payment of a filed claim. The final analysis was performed to simultaneously determine all of the significant project factors that affect all outcomes as the following sections detail.

5.2.1 Individual Variable Analysis on the Filing of a Claim

The following analysis performed on the data set was to examine each individual and specific project variable, on its own merit using LIMDEP software, to determine its significance and likely effect on filing, not filing, payout, or non-payout of a claim. The results are tabulated and organized based on the four (4) models that include:

- Filing of a claim,
- Claim not filed,
- Payment of a filed a claim, and
- No payment of a filed claim.

The results of the analysis are organized with all of the significant factors and the values of their coefficient, standard error, T-Statistics, P-Values, and logit elasticity calculations. Brief explanations of these values are explained as follows (Washington et al. (2003) [51] :

- Coefficient: A positive coefficient means the variable is more likely to result in the outcome, while the negative coefficient means that variable examined is less likely to result in the outcome. The positive coefficient on any factor suggests that an increase in that factor gives a higher probability of an affirmative claim outcome and the negative coefficient suggests that an increase in that factor gives a higher probability of a negative outcome.

- Standard error is the standard deviation of the error in the sample mean relative to the true mean, or the difference between the estimate and the true value and it measures the precision with which an estimate from one sample approximates the true population value. The lower the value of the Standard error the more fitting the model is.

- T-Statistics is a measure of how extreme a statistical estimate is and the hypothesized value is reasonable when the t-statistic is close to zero. The hypothesized value is not large enough when the t-statistic is large positive, and an indication that the hypothesized value is too large is when the t-statistic is large negative. It is measured by dividing the coefficient by the standard error values.

- P-Value is a measure of how much evidence we have against the null hypothesis and it is also a measure of how likely we are to get a certain sample result or a result "more extreme," assuming null hypothesis is true. The smaller the p-value, the more evidence we have against the null hypothesis. If the P-value is less than or equal to type 1 error rate α then the null hypothesis is rejected [48]

- Logit elasticity is a measure of responsiveness of one variable to changes in another variable and is calculated by dividing a percent change of an independent variable over the percent change of the dependent variable such as filing or paying for a claim.

The first model utilized LIMDEP [39] and its Multinomial Logit Model (Discrete Choice), Maximum Likelihood Estimate Function, and resulted in a list of factors that may individually affect the likelihood of filing a claim on transportation projects (See Table 5.15).

As the results in Table 5.15 show only one (1) of the twelve (12) sub classes in the LETTING YEAR Category (See also Table 3.2) showed any significance in the filing of a claim outcome and that was for projects let in 1999. The results showed that when the project was let in the year 1999 using the 1996 Specification Book it was less likely that a claim would be filed (coefficient of -1.925). This could be due in part to the limited availability of records for year

1999 and earlier and the limited utilization of computer software to store project files at the STA. The other years did not show any significance for the filing of a claim by way of this analysis.

Considering the elasticities presented in Table 5.15 the results show that letting a project in 1999 using the 1996 Specification Book is less likely to result in a claim being filed and utilization of the 1996 Specification Book in 1999 results in an average decline 47% in the probability of filing a claim.

Three (3) out of the six (6) sub classes in the geographical location category showed significance in the filing of a claim; they are Metro Region TSC 1, Metro Region TSC 3, and Metro Region TSC 4. Metro Region TSC 2, Metro Region TSC 5, and the rest of the state did not show any significance in the filing of claim by way of this analysis and were not included in Table 5.15. The coefficient values for TSC 1 and TSC 3 are positive and indicate that projects at these two (2) locations were more likely to result in a filed claim. On the other hand, the coefficient value of Metro TSC 4 was negative and indicated that projects at TSC 4 were less likely to result in filed claims. This conclusion could be due to many possible factors related to the type of projects implemented at these different TSCs, the scope of work, location, or other factors. This observation can be further studied in future researches and studies.

Considering the elasticities presented in Table 5.15 the results show that a project located at Metro Region TSC 1 is more likely to result in a claim being filed and an increase in this factor results in an average 18% increase in the probability of having a claim filed on it. A project located at Metro Region TSC 3 is more likely to result in a claim being filed and an increase in this factor results in an average increase 12% in the probability of filing a claim on it. A project located in Metro Region TSC 4 is less likely to result in a claim being filed and an increase in this factor results in an average decline 41% in the probability of filing a claim on it.

Table 5.15 *Statistics and Elasticity Calculations of Individual Factors on Claims*

Claim Individual Variable Examined	Coefficient Values	Standard Error	t-Statistics	P-Values	Elasticity
Project let in 1999 using old (1996) Specification Book	-1.925	0.48	-3.97	0.0001	-47%
Project located in Metro Region TSC 1	1.352	0.62	2.18	0.0293	18%
Project located in Metro Region TSC 3	0.749	0.44	1.71	0.0873	12%
Project located in Metro Region TSC 4	-1.671	0.5	-3.32	0.0009	-41%
Project let during winter season	0.89	0.37	2.39	0.0167	16%
> 100 projects in a letting	0.028	0.01	3.2	0.0014	2%
Prime Contractor D	1.992	1.03	1.93	0.0532	21%
Prime Contractor E	1.428	0.75	1.91	0.0559	18%
< 10 subs on project	-2.163	0.37	-5.84	<.0001	-35%
10 to 15 subs on project	1.475	0.54	2.71	0.0067	21%
> 15 subs on project	1.423	0.41	3.45	0.0006	24%
< 5 % DBE Participation	-1.433	0.34	-4.25	<.0001	-27%
5 to 15 % DBE Participation	1.324	0.33	3.95	0.0001	33%
Coordination required w. other projects within PCIA	1.455	0.34	4.32	<.0001	35%
Open to Traffic Restriction during construction activities	1.472	0.35	4.21	<.0001	43%
Consultant utilized during construction	0.641	0.33	1.97	0.0486	13%
< 20 Contract Modifications	-1.491	0.34	-4.39	<.0001	-26%
> 50 Contract Modifications	2.172	0.61	3.54	0.0004	28%

The results in Table 5.15 also show that five out of six sub-classes in the contracting factors grouping showed a significant likelihood effect on the filing of a claim. The rest of the project contracting factors did not seem to have any significant effect on the likelihood of filing a claim on the project by way of this analysis. The results also show that only projects that were let in the winter season showed any significant effect on claim filing way of this analysis. The positive coefficient number shows that projects that were let in the winter season were more likely to result in a filed claim. On the other hand, projects that were let in the spring, summer, or the fall did not have any significant influence on the likelihood of filing a claim by way of this analysis. The elasticity results show that an increase in the number of projects let during the winter season results in an average increase of 16% in the probability of filing a claim.

The results in Table 5.15 also show that only projects that were let with more than one hundred (100) other projects in the same letting showed that they were more likely to result in claims but that number was very close to zero (0). Projects let with fewer than one hundred (100) other projects in a letting did not show any significance in the likelihood of a filed claim by way of this analysis. In other words, the number of projects in a letting did not have that much effect on filing of claims on these projects by way of this analysis.

The results show that only two (2) prime contractors (D & E) from the list of all prime contractors (See Table 5.15) working on the analyzed projects showed any significant effect on filing claims. The rest of the contractors did not show any significant effect in the likelihood of filing claims. The results show that both prime contractors D & E had positive coefficients in this analysis which indicated that they were more likely to file claims on STA projects. This could be explained by the type of projects these contractors worked on, or indicate that these contractors were not likely to relinquish the pursuit of any claim. This observation needs to be analyzed and studied in more depth to determine the mitigating factors of these circumstances. Looking at the elasticity calculations (See Table 5.15) show an increase in the involvement of prime contractor D on transportation projects within the STA resulted in an average increase of

21% in the probability of filing a claim, and an increase of the involvement of prime contractor E resulted in an average increase of 18% in the probability of filing a claim.

The results in Table 5.15 show that number of subcontractors on the project has a significant impact in this analysis for the likelihood of filing or not filing of a claim for all of the analyzed categories. For example, when the number of subcontractors on the project was fewer than ten (10) subcontractors, between ten and fifteen (10-15), and more than fifteen (15) subcontractors this analysis showed significant results on the likelihood of filing a claim or not filing a claim. It is important to note that when the number of subcontractors on the project was fewer than ten (<10), the project is less likely to have a claim filed on it (as indicated by the negative value of coefficient). When the number of subcontractors on the project were more than ten (>10) subcontractors, the coefficients were positive and indicated that the projects were more likely to result in claims. The elasticity in Table 5.15 show an increase in the criteria that a project has fewer than ten (< 10) subcontractors working on it results in an average decline of 35% in the probability of filing a claim, between ten and fifteen (10-15) subcontractors on a project results in an average decrease of 21% in the probability of filing a claim on it, and a increase in the number of subcontractors to more than fifteen (>15) on the project results in an average increase of 24% in the probability of filing a claim.

The results also show that the percent of participation of DBE subcontractors on the project seemed to have a significant impact on the likelihood of filing or not filing of a claim. When the project had less than five percent (<5%) DBE participation the project was less likely to result in a claim as illustrated by the negative value of the coefficient value. To the contrary, when the project had more than five percent (>15%) DBE participation, the project was more likely to result in a claim as indicated by the positive coefficient value. The elasticity calculations in same table show an increase in the criteria of less than five percent (<5%) DBE participation results in an average decrease of 27% in the probability of filing a claim, and an increase in of the DBE participation to more than fifteen percent (>15%) results in an average increase of 33% in the probability of filing a claim on the project.

The scope of work and whether the project was a Road, Bridge, CPM, or ITS did not affect the likelihood of a project having a claim filed by way of this analysis. This may indicate that there were not any intrinsic or inherited characteristic in these types of projects and may depend on the complexity and the characteristics of each project on its own merit. The major material used on the project such as Hot Mix Asphalt (HMA), Concrete, or other material did not have any effect on the likelihood of filing a claim by way of this analysis. This could also indicate that there is not any intrinsic or inherited characteristic in the use of any of these material types. The results of analysis in Table 5.15 show that coordination requirements with other projects within the Project's Construction Influence Area (PCIA) and Maintenance of Traffic (MOT) on such projects during the construction activities show a claim is more likely to be filed on these projects. Liquidated damages and final completion dates stipulated in the contract did affect likelihood of a claim filing by way of this analysis. The elasticity results in Table 5.15 show an increase in the need of the contractor to coordinate with other active projects in the immediate vicinity of the project results in an average increase of 35% in the probability of filing a claim on the project, and an added requirement on the contractor to maintain traffic open in the construction area during the construction activities results in an average increase of 43% in the probability of filing a claim on the same project. In other words, these requirements increase the probability of claims filed on the project.

The results in Table 5.15 show that the utilization of a consultant during the construction implementation phase had a significant effect on the likelihood of a claim being filed on the project. The elasticity result shows an increase in the utilization of a consultant to perform the construction oversight on the STA project results in an average increase of 13% in the probability of filing a claim on the same project. This observation can be further studied to understand the underlying factors that may contribute to increased likelihood of claims on projects that are managed by consultants. The results in Table 5.15 also show that the number of contract modifications (CM) during the construction phase of the project seemed to have a significant impact in this analysis for the filing or not filing of a claim. When the number of CMs was fewer than twenty (20), it showed significant impact in this analysis for not filing a claim as the value of the coefficient was negative, and when the CMs was more than fifty (50) it showed significant impact for filing of a claim as the coefficient value was a positive number. When the number of CMs was in the range of twenty and fifty (20-50), the analysis showed no significance in the filing or not filing of the claim. In other words, a project that had fewer than twenty (<20) CMs was less likely to have a claim filed, and when a project had more that fifty (>50) CMs it was more likely to result in a claim filed. The elasticity results in Table 5.15 show that when the project has fewer than twenty (<20) CMs it results in an average decrease of 26% in the probability of filing a claim. The results in the same table show that an increase of the number of CMs to more than fifty (>50) can increase the probability of a claim on a project by about 28%. In other words, the change in the number of CMs from fewer than twenty (<20) to more than fifty (>50) CMs can potentially increase the probability of a claim filed on the project by more than fifty percent (50%). This emphasizes the importance of managing CMs on projects during the design and the construction phases.

5.2.2 Individual Variable Analysis on Payout Outcomes

The second analysis performed was to separately examine each project variable and to determine its contribution to the likelihood of a claim payout. Table 5.16 lists the factors that show a significant likelihood of paying out a claim, when filed. The analysis was performed using LIMDEP program and the results are tabulated and organized the results in Table 5.16 show that a project located in Metro Region TSC 2 is less likely to be paid out if a claim is filed; and an increase in this project factor results show an average decrease of 69% in the probability of having the claim paid out at that location. A project located on the NHS is less likely to be paid out if a claim is filed. An increase in this project factor results in an average decrease of 32% in the probability of having the claim paid out. A project let during the spring season is less likely to result in a payout and an increase in this factor results in an average of decrease 62% in the probability of having the claim paid out.

On the other hand, a project let during the fall season is more likely to result in payout and an increase in this factor results in an average of increase 65% in the probability of having the claim paid out. A project that was let with fewer than fifty (<50) other projects in the same letting is less likely to result in payout, and an increase in this factor results in an average of decrease 51% in the probability of having the claim paid out. A project that was let with more than one hundred (>100) other projects in the same letting is more likely to payout a claim, and an increase in this factor results in a significant increase of about 238% in the probability of having the claim paid out.

Table 5.16 *Statistics and Elasticity Results of "PAYOUT" Outcomes*

Payout Individual Variable Examined	Coefficient	Standard Error	t-Statistics	P-Values	Elasticity
Project located on NHS	-0.634	0.34	-1.89	0.0588	-32%
Project let during spring season	-1.486	0.39	-3.84	0.0001	-62%
Project let during fall season	1.033	0.36	2.88	0.004	65%
< 50 projects in a letting	-1.086	0.53	-2.05	0.0402	-51%
> 100 projects in a letting	1.747	0.51	3.45	0.0006	238%
Road Project	-0.571	0.28	-2.04	0.0414	-27%
Bridge Project	0.642	0.28	2.28	0.0224	43%
Project designed by a local agency	1.134	0.43	2.63	0.0086	68%
Consultant utilized during construction	1.126	0.67	1.69	0.0912	113%
1996 Specification Book utilized	-0.98	0.29	-3.39	0.0007	-43%
2003 Specification Book utilized	1.058	0.29	3.67	0.0002	82%
5-10% diff between Eng. Est. and lowest bidder.	-0.526	0.32	-1.67	0.0958	-27%
Utility conflict used as the basis for the claim	-2.343	1.05	-2.23	0.0257	-83%
Differing Site Conditions	-1.965	0.76	-2.57	0.0101	-76%
Special Provision is Ground for the Claim	1.022	0.34	3.03	0.0025	65%
Scheduling Issues	-1.126	0.67	-1.69	0.0912	-53%
Quantity Errors in the Plan is Ground for the Claim	1.316	0.29	4.47	<.0001	102%

The results show that a road project is less likely to result in a claim payout and an increase in "road project classification" results in an average decrease of 27% in the probability of having the claim paid out. However, a bridge project is more likely to result in a claim payout than other types of projects and an increase in this class results in an average of increase 43% in the probability of having the claim paid out. In other words, bridge projects are more likely to result in a claim payout according to this analysis as the positive coefficient value indicates when compared to other types of projects. The road project is less likely to result in a claim payout in comparison to the other types of projects. The results in Table 5.16 show that a project designed by the local agency is more likely to result in a claim payout, and an increase in this factor results in an average of increase 68% in the probability of having the claim paid out. A project that utilized a consultant during the construction implementation phase is more likely to result in a claim payout and an increase in the utilization of a consultant during construction implementation results in a substantial increase (about 113%) in the probability of having the claim paid out.

A project that utilized the 1996 Specification Book was less likely to result in a claim payout, and an increase in the utilization of 1996 Specification Book results in an average decrease of 47% in the probability of having the claim paid out. On the other hand, a project that utilized the 2003 Specification Book was more likely to result in a claim payout as compared to the projects that utilized the 1996 Specification Book and an increase in the utilization of the 2003 Specification Book results in an average increase of 82% in the probability of having the claim paid out. The results in Table 5.16 also show that a project with less than ten percent (<10%) in the difference between the engineer's estimate and the lowest responsible bid was less likely to have a claim payout as demonstrated by the negative coefficient value, and an increase in the classification of project that its engineer's estimate is within 5-10% from the lowest bid amount results in an average decrease of 27% in the probability of having the claim paid out on it.

A project that had filed a claim based on utility conflict was less likely to payout the claim, and increase in this factor results in an average of 83% decrease in the probability of having the claim paid out. A project that had filed a claim based on differing site conditions in the field was also less likely to payout the claim, and an increase in this factor results in an average decrease of 76% in the probability of having the claim paid out. A project that had filed a claim based on scheduling issues was less likely to payout the claim, and increase in this factor results in an average decrease of 53% in the probability of having the claim paid out. A project that had a filed claim on the basis of the problems with the special provision outside of the applicable Specification Book was more likely to result in a payout of a claim, and increase in this factor results in an average increase of 65% in the probability of paying out the claim.

Finally, a project that had a filed claim on the basis of the problems with the quantities in the project plans was more likely to result in a payout of a claim, and increase in quantity errors in the plan results in a substantial increase of about 102% in the probability of paying out the claim as shown in the results of the analysis and tabulated in Table 5.16.

5.3 Claim vs. No Claim Binary Analysis

A Multinomial Logit Model (Discrete Choice) using the Maximum Likelihood Estimate Function resulted in a list of factors that may jointly and simultaneously affect the likelihood of filing or not filing of claim.

Table 5.17 *Statistics and Elasticity Calculations of "Claim vs. No Claim" Outcomes*

Claim	Significant Project Factors	Coefficient	Standard Error	P-Value	Elasticity
	Project let during winter season	1.14	0.47	0.0154	24%
	> 15 subs on project	2.077	0.65	0.0014	48%
No Claim	**Significant Project Factors**	**Coefficient**	**Standard Error**	**P-Value**	**Elasticity**
	Project located in Metro Region TSC 2	1.626	0.68	0.0163	-31%
	< 50 projects in a letting	2.668	0.52	<.0001	-48%
	< 20 Contract Modifications	0.986	0.41	0.0167	-15%

5.3.1 Claim Outcome

The results in Table 5.17 show that a project let during the winter season is more likely to result in a filed claim as both the positive value of the coefficient and positive value of the elasticity calculation indicate, the latter resulting in an average increase of 24% in the probability of a claim being filed. A construction project at the STA that has more than fifteen (>15) subcontractors working on it is more likely to have a claim filed on it, and an increase in number of subcontractors working on a project to more than fifteen (>15) results in an average of increase 48% in the probability of a claim being filed.

5.3.2 No Claim Outcome

A project located at Metro Region TSC 2 is more likely to result in a claim not filed (positive coefficient value for the no-claim model), and an increase in the project located at Metro Region TSC 2 results in an average decrease of 31% (as the negative value of the elasticity indicates) in the probability of a claim not being filed on its projects. A project that was let with fewer than fifty (<50) other projects in the same letting is less likely to have a claim filed, and an increase in this factor results in an average of decrease 48% in the probability of a claim not being filed on its projects. A project that had fewer than twenty CMs (<20 CM) during the construction implementation phase is less likely to have a claim filed, and a decrease in number of CMs on a project to less than fifteen (<20) results in an average decrease of 15% in the probability of a claim not being filed.

5.4 Payout vs. No Payout Binary Analysis

The fourth analysis performed was a Multinomial Logit Model (Discrete Choice) using the Maximum Likelihood Estimate Function and resulted in a list of factors that jointly and simultaneously affect the likelihood of paying or not paying out a claim on transportation projects as Table 5.18 and the following detail.

Table 5.18 *Statistics and Elasticity Calculations of "Payout vs. No Payout" Outcomes*

Significant Payout Factors	Coefficient	Standard Error	t-Statistics	P-Values	Elasticity
Project let during fall season	1.804	0.55	3.29	0.001	116%
Project let during winter season	2.013	0.54	3.75	0.0002	117%
50 to 100 projects in a letting	4.004	1	4.01	0.0001	151%
Coordination required w. other projects within PCIA.	0.95	0.54	1.76	0.0783	105%
Project designed by the local agency	2.986	0.77	3.86	0.0001	154%
Special provision is ground for the claim	0.948	0.45	2.12	0.0341	94%
Significant No Payout Factors	**Coefficient**	**Standard Error**	**t-Statistics**	**P-Values**	**Elasticity**
Project located in Metro Region TSC 2	2.371	0.95	2.51	0.0122	-83%
< 10 subs on project	2.325	0.66	3.5	0.0005	-79%
5 to 15 % DBE participation	2.001	0.55	3.63	0.0003	-65%
1996 Specification Book Utilized	1.968	0.46	4.31	<.0001	-70%
Utility conflict used as the basis for the claim	3.974	1.13	3.51	0.0005	-96%

5.4.1 Payout Outcome

The results in Table 5.18 show that a project let during the fall season is more likely to result in a payout of a claim, and an increase in this factor results in an average increase of 116% in the probability of a claim being paid out. A project let during the winter season is also more likely to result in a claim payout and an increase in this factor results in an average increase of 117% in the probability of a claim being paid out. A project let with fifty to one hundred (50-100) other projects in the same letting is more likely to result in a paying out of its claim, and an increase in this factor results in an average increase of 151% in the probability of a claim being paid out.

A project that required coordination with other active projects within the PCIA was more likely to result in a payout of its claim, and an increase in this factor results in an average increase of 105% in the probability of a claim being paid out. A project designed by a local agency was more likely to result in a payout of the claim, and an increase this factor results in an average increase of 154% in the probability of a claim being paid out. A project that utilized the Special Provision (supplement to the applicable specification book) as the ground for its claim was more likely to result in a claim payout, and an increase in this factor results in an average increase of 94% in the probability of a claim being paid out.

5.4.2 No Payout Outcome

As shown in Table 5.18 a project located at Metro Region TSC 2 is more likely to result in nonpayment of a claim, if filed. An increase in this factor results in an average decrease of 83% in the probability of a claim being paid on its projects. A project that had fewer than ten (<10) subcontractors working on it was more likely to result in non-payment on its claim, if filed. An increase in this factor results in an average decrease of 79% in the probability of a claim being paid out.

A project with five to fifteen percent (5-15%) DBE participation on the project is more likely to result in a non-payment of its claim, and an increase in this factor results in an average decrease of 65% in the probability of a claim being paid. A project that used utility conflict as the basis for its claim was more likely to result in a non-payment of its claim, and an increase in this factor results in an average decrease of 96% in the probability of a claim being paid out.

5.5 Multinomial Logit Analysis

The fifth analysis utilized the Discrete Choice Model Maximum Likelihood Estimates "Multinomial Logit Analysis" (MNL) to examine all the project's specific factors that are more likely to simultaneously affect any of the models in this study (claim, no claim, payout and no payout). Table 5.19 lists all the project's specific factors that had shown significant likelihood on all possible outcomes of a claim on the project.

Table 5.19 *MNL Statistics and Elasticity Calculations on Claim Outcomes*

Dependent Variable Outcomes	Significant Project Factors	Coefficient	Standard Error	P-Values	Elasticity
No Claim	Project located in Metro Region TSC 1	-2.358	0.93	0.0108	**-87%**
	Project located on NHS	0.994	0.4	0.0136	47%
	< 50 projects in a letting	1.259	0.51	0.0141	**173%**
	< 10 subs on project	2.478	0.51	<.0001	**684%**
	Project let during fall season	-1.273	0.43	0.0034	**-39%**
	Coordination required w. other projects within PCIA.	-0.843	0.39	0.0315	**-24%**
No Payout	< 5% diff between Eng Est. and Lowest Bid.	0.931	0.42	0.0255	**21%**
	5-10% diff between Eng Est. and lowest bid.	-0.999	0.45	0.0254	**-42%**
	> 50 Contract Modifications	-0.744	0.41	0.0708	**-32%**
	Utility conflict as the basis for the claim	2.672	1.16	0.0213	**24%**
	Project located in Metro TSC 2	-2.868	0.86	0.0009	**-92%**
	50 to 100 projects in a letting	1.983	0.63	0.0017	**493%**
Payout	Road Project	-1.273	0.37	0.0007	**-63%**
	Project designed by a local agency	1.816	0.67	0.0066	**318%**
	Quantity errors in plan ground for claim	1.273	0.36	0.0005	**90%**

5.5.1 Claim Outcome

A project located at Metro Region TSC 1 is more likely to have a claim filed on it (the negative value for the coefficient is for the no claim model) and an increase in a project located at Metro

Region TSC 1 results in an average increase of 87% in the probability of a claim being filed on its projects. A project located on the NHS is more likely not to have a claim filed on it, and an increase in this factor results in an average decrease of 47% of the probability of a claim being filed on it.

A project that was let with fewer than fifty (<50) other projects in the same letting was more likely not to have a claim on it, and an increase in this factor results in a substantial increase (173%) in the probability of a claim not being filed on it. In other words, a project that was let with fewer than fifty (<50) other projects in the same letting was less likely to have a claim on it, and an increase in this factor results in a substantial decrease (173%) in the probability of a claim being filed on it.

A project that had fewer than ten (<10) subcontractors working on it is less likely not to have a claim filed on it, and an increase in this factor results in an average increase of 684% in the probability of a claim not going to be filed on it.

5.5.2 No Payout Outcome

The analysis and the results in Table 5.19 show that a project that was let during the fall season was less likely to result in a no payout (or more likely to result in a payout) of its claim, if filed, and an increase in this factor results in an average increase of 39% in the probability of a claim being paid out. A project that required coordination with other active projects in the PCIA is more likely to result in a payout of its claim, and an increase in the required coordination results in an average increase of 24% of the likelihood of a payout on it.

A project in which the engineer’s estimate was within five percent (5%) of the lowest bid is more likely to result in a non-payment, and an increase in this factor results in an average increase of

21% in the likelihood of a non-payment on it. A project in which the engineer's estimate was within five to ten percent (5-10%) of the lowest bid is more likely to result in a claim payment, and an increase in this factor results in an average increase of 42% in the likelihood of a non-payment on it. A project that had more than fifty CMs is less likely to result in a no payout of a claim on it (or more likely to result in a payout of the claim), and an increase in factor results in an average of 32% increase in the likelihood of a payment on it. A project that based its claim on the presence of a utility conflict in the field was more likely to result in a non-payout of its filed claim, and an increase in this factor results in an average decrease of 24% in the likelihood of payment.

5.5.3 Payout Outcome

The results in Table 5.19 also show that a project located at Metro Region TSC 2 is less likely to payout on its filed claims, and an increase in factor results in an average decrease of 92% in the probability of a claim being paid out on its projects. A project that was let with fifty to a hundred (50-100) other projects in the same letting was more likely to have a payout, and an increase in this factor results in a substantial increase (493%) in the probability of a claim being paid. A claim on a road project is less likely to result in a payout, and an increase in this category results in an average decrease of 63% in the likelihood of a payout on it.

A project designed by the local agency is more likely to result in a pay out, and an increase this factor results in a substantial increase (318%) in the likelihood of a claim payment. A project that had based its claim on quantity errors in the plans was also more likely to result in a payout of its filed claim, and an increase in this factor results in an average increase of 90% in the likelihood of a payment on it.

5.6 Other Analysis

Other analyses were utilized such as the Mixed Logit Analysis and the Nested Multinomial Logit Analysis but showed no significance and the results were not included in this dissertation.

Chapter 6 Conclusions, Summary and Research Contributions

6.0 Research Overview

This research aimed to determine the characteristics and causal factors of claims in highway construction projects and to define the unique features of highway projects in terms of scope of work, type of project or the material used, certain contractual restrictions, or any other unique and important factors that may affect the success or failure of a highway project at the state transportation agency in the context of the number and magnitude of claims. A structure was developed to analyze the effects of the different transportation project and identify the entire common and unique feature of all of the project types at the STA, as well as to identify important factors that impact the filing and paying out of claims made by the projects' contractors. This framework was tested on data for a sampling of projects in the Metro Detroit Region and was then applied to all of the projects that had claims filed within the Metro region and the entire state.

The research began with a comprehensive review of past work related to projects success or failure on construction projects in general and on highway construction projects in particular, with focus on studies related to construction claims. An assessment was conducted of the data currently collected and maintained by the state transportation agency in the different filing systems and locations as it relates to claim resolution and management. This included project design and proposal files, claim settlement letters, project construction files, and other important sources of information on each project available from the different filing systems at the STA. All of data obtained from the STA was organized, tabulated, and analyzed to create a database that was subsequently used to assess the interrelationships of the common and unique project factors that may contribute to filing of claims, paying out, or not paying out on these claims.

6.1 Conclusion

One of the early tasks of this research was to examine whether the project specific data available at the state transportation agency could be used to identify the characteristics and the causal factors of claims within the STA. This study, nevertheless, is the first of its kind because of the new application of project specific data model for claim outcome determination. Different frequency and regression models were developed in determine the likely significant effect of the project factors on claims and payout. There was obvious consistency in all of the models and the results of the different analysis are presented in the following order:

- Factors that can possibly prevent claims from being filed from the outset,
- Factors that possibly affect the claim to be filed,
- Factors that can possibly prevent a claim from being paid out,
- Factors that possibly affect a claim being paid out, if filed, and finally
- Factors that possibly have no effect on the filing or the payment of a claim.

6.1.1 Factors that are Likely to Affect the No Filing of Claims

The previous analysis consistently showed that certain factors may significantly prevent the filing of a claim. These factors are grouped together in Table 6.1 which includes a project that is located on the national highway system, under the jurisdiction of Metro Region TSC 4, let with fewer than fifty other projects in the same letting, and had fewer than ten (10) subcontractors working on it.

Table 6.1 *Factors that are likely to Affect the No Filing of Claims*

Category No.	Category Name	Independent Variable Examined
2	PROJECT LOCATION	Project located in Metro Region TSC 4
3	PROJECT LOCATION	Project located on NHS
3	CONTRACTING FACTORS	Projects in a letting < 50
3	CONTRACTING FACTORS	<10 subcontractor on a project

6.1.2 Factors that are Likely to Affect the Filing of a Claim

The analysis showed that certain factors significantly affect the likelihood of filing claims such as a project that is located on a local agency route, under the jurisdiction of Metro Region TSC 1 or TSC 3, was managed by a consultant during the construction implementation phase, was let in fall or winter season along with more than a hundred (100) other projects in the same letting, had prime contractor D or E along with more than ten (10) subcontractors, and required certain coordination clauses as shown in Table 6.2.

Table 6.2 *Factors that are likely to Affect Filing of Claims*

Category No.	Category Name	Independent Variable Examined
2	PROJECT LOCATION	Project located in Metro Region TSC 1
2	PROJECT LOCATION	Project located in Metro Region TSC 3
2	PROJECT LOCATION	Project located on a local agency route
3	CONTRACTING FACTORS	Project let during fall season
3	CONTRACTING FACTORS	Project let during winter season
3	CONTRACTING FACTORS	100 projects in a letting
3	CONTRACTING FACTORS	Prime Contractor D
3	CONTRACTING FACTORS	Prime Contractor E
3	CONTRACTING FACTORS	Number of subcontractors between 10 to 15 subcontractors on project
3	CONTRACTING FACTORS	Number of subcontractors greater than 15 subcontractors on project
6	RESTRICTIONS IN CONTRACT	Coordination required w. other projects within PCIA
6	RESTRICTIONS IN CONTRACT	Open to Traffic restriction during construction activities
7	PROJECT LOCATION	Consultant utilized during construction
9	QUALITY FACTORS	Contract Modifications > 50

6.1.3 Factors that are Likely to Affect the No Payment of a Filed Claim

The analysis has shown that certain factors may affect the non-payment of a claim such as a road project, located on the NHS and under the jurisdiction of the Metro Region TSC 2, had a utility conflict, and its engineer's estimate was within five percent (5%) of the lowest and responsible bid amount as shown in Table 6.3.

Table 6.3 *Factors that are likely to Affect the No Payment on Claims*

Category No.	**Category Name**	**Independent Variable Examined**
2	PROJECT LOCATION	Project located in Metro Region TSC 2
2	PROJECT LOCATION	Project located on NHS
4	SCOPE OF WORK	Road Project
8	FINANCIAL FACTORS	The difference between the Engineer's estimate and the Lowest Bid < 5%
10	CLAIM BASIS	Utility conflict as the basis for the claim

6.1.4 Factors that are Likely to Affect the Payout on Claims

The analysis has also shown that certain factors may affect the payment of a claim such as a project that was designed by a local agency, let in the fall or the winter season along with more than a hundred (100) other projects in the same letting, had a problem with a special provision, and included certain restrictions in the contract during the construction implementation phase as shown in Table 6.4.

Table 6.4 *Factors that are likely to Affect Payout on Claims*

Category No.	Category Name	Independent Variable Examined
2	PROJECT LOCATION	Project let during fall season
2	PROJECT LOCATION	Project let during winter season
3	CONTRACTING FACTORS	Number of projects in a letting more than 100 projects
6	RESTRICTIONS IN CONTRACT	Coordination required w. other projects within PCIA
7	PROJECT ADMINISTRATION	Project designed by a local agency
10	CLAIM BASIS	Special Provision is ground for the claim
10	CLAIM BASIS	Quantity Errors in the plan is ground for the claim

6.1.5 Factors that are Likely to have No Effect on Claims

The analysis has shown that certain factors may not have any effect on the filing or payment of claims such as the number of bidders on the project, the utilization of any major construction material, and performed by any other approved prime contractor on the list with the exception of prime contractors D & E as shown in Table 6.5.

Table 6.5 *Factors that are likely to have No Effect on Claims*

Category No.	Category Name	Independent Variable Examined
3	CONTRACTING FACTORS	Number of bidders on a project
3	CONTRACTING FACTORS	Certain Contractors
5	MAJOR MATERIAL	Hot Mix Asphalt
5	MAJOR MATERIAL	Cement Concrete
5	MAJOR MATERIAL	Other Construction Material

6.2 Summary

From the results tabulated in this dissertation it was consistently obvious that certain factors may significantly affect the different claim outcomes (Claim/No Claim; Payout/No Payout). These factors are grouped together in the following table for each possible outcome (estimated coefficient values >1.4 and elasticity calculation values >20%) so as to highlight the contribution of this research as shown in Table 6.6:

Table 6.6 *Summary of Significant Factors with High Relative Elasticities*

Factors that are likely to Affect Filing of Claims	Prime Contractor D
	Prime Contractor E
	10 to 15 subs on project
	> 15 subs on project
	Coordination required w. other projects within PCIA
	Open to Traffic Restriction during construction activities
	Project located in Metro Region TSC 1
	> 50 Contract Modifications
Factors that are likely to Affect the no Filing of Claims	< 10 subs on project
	< 5 % DBE Participation
	< 20 Contract Modifications
	Project located in Metro Region TSC 2
	< 50 projects in a letting
Factors that are likely to Affect the Payout on Claims	50 to 100 projects in a letting
	Project designed by a local agency
Factors that are likely to Affect the no Payment on Claims	Project located in Metro TSC 2
Factors that are likely to Have no Affect on Filing and/or Payout of Claims	Number of bidders on a project
	Certain Contractors
	Hot Mix Asphalt
	Cement Concrete
	Other Construction Material

6.3 Recommendations for Claims Management

After the completion of this research and the analysis, it is evident that outstanding efforts are being undertaken by the STA in meeting the expectations, needs, and requests of the traveling public, tax payers and the contracting communities. This is in addition to all the challenges in balancing and satisfying the varied interests of the stakeholders on public projects as the literature review revealed. Recent implementation of certain improvements to the claim tracking system at the STA have already shown some potential benefits that need to be assessed in future research to determine its effectiveness and possible continued improvement. This research accomplished a scientific analysis of specific project factors that may affect the filing and payout of construction claims at the Michigan DOT. The results may not be applicable to other state transportation agencies but surely the approach and the methodology can be utilized in any state and jurisdiction. Recommendations in this study are made to mitigate the risk of claims on transportation projects at the STA by highlighting the results in the following sections.

6.2.1 Project Location

The research showed that Metro Region TSC 1 and TSC 3 are more prone to having claims being filed on their projects, and Metro Region TSC 2 and TSC 4 are less prone to having claims filed on their projects. Metro Region TSC 2 is also more prone to denying claims when filed. The rest of the TSCs and the state did not show any significance for any of the potential claim outcomes. The research also showed that projects located on the National Highway System (NHS) are less likely to have claims filed and paid out. This conclusion can benefit the STA in investigating the different factors that are implemented on the NHS projects and can be implemented on state and local agency projects and at the different TSC locations to reduce the likelihood of claims on their projects.

6.2.2 Contracting Factors

The research showed that most of the projects at the STA are let in the fall and the winter seasons and these projects were more prone to having claims filed and required payouts. Projects that are let with more than one hundred other projects in the same letting were also more likely to have claims on them and are more likely to result in claim payout. Additionally, the research also showed that certain contractors are more prone to filing claims than other contractors.

6.2.3 Scope of the Work

The research showed a road project is less likely to result in a claim and a payout of a claim, and a bridge project is more prone to having claims filed and paid. Possible mitigation to these differing levels of risk is to separate the two types of projects and let them separately. This approach will have an added benefit in terms of limiting the number of subcontractors on the project, which is known to contribute to the success of the project, and to allow construction engineers to work in their respective areas of expertise. It is also that it is less common to have construction staff or contractors who can do both types of projects (roads and bridges) with the same level of competency and expertise.

6.2.4 Major Material

The research showed that the material used on the project, whether HMA, concrete, or other material, does not increase or decrease the likelihood of filing a claim in the context of this research. This is also a beneficial conclusion to the STA, contracting community, and the material suppliers. The STA can continue choosing the material on its projects based on the life cycle analysis that is currently utilized for concrete and HMA.

6.2.5 Restrictions in the Contract

The research has shown that a project, which requires coordination with other active projects in the construction influence area, is more likely to have a claim filed and paid out. Limiting the number of projects in a letting and limiting the scope of work on the projects can reduce the need for contractors to work on the projects under open traffic conditions. This is important as the analysis showed that these restrictions can increase the likelihood of filing and paying out claims.

6.2.6 Project Administration

The analysis showed that a project designed by the local agency is more likely to result in a payout on a filed claim, and a project located on the NHS is less likely to have a claim filed and paid out. The research also has shown that utilizing the services of consultants during the construction phase can increase the likelihood of paying out the claims.

6.2.7 Financial Factors

The analysis showed that when a project engineer's estimate was within five percent (5%) of the lowest, responsible and awarded bid was less likely to result in a claim payout.

6.2.8 Quality Factors

The research showed that a project with more than fifty contract modifications (>50 CM) is more likely to result in a claim and a payout.

6.2.9 Claim Basis

The results from this research showed that a claim, which is based on quantity errors in the plan, is more likely to result in a payout; similarly, a claim that is based on deficiencies or ambiguities in the special provision was more likely to result in a payout, as well. The research also showed that special provision is a basis for a claim and payout.

6.2.10 Lessons Learned

It is very important to document the lessons learned at the end of each project, especially in the areas of cost control and claim management, and to share this knowledge with the rest of the construction staff at the same TSC and at other TSCs within the STA. This event should be coordinated so that the maximum benefit can be attained. It is very important to share the lessons with the design staff in order to prevent potential claims on future similar projects.

6.2.11 Integrating Design and Construction

Bringing the lessons back from construction to design is a step in the right direction, but taking this a step further would be a great stride towards continuous improvement. This integration can be done at different levels.

1. The first level is at the project engineer (PE) level. Facilitating open communication between the design PE and the construction PE during the design phase of the project, and maintaining a line of communication between design and construction PEs regarding any encountered issues or difficulties in the field during construction implementation can possibly address some of the factors that may contribute to filing and paying out of claims.

2. The second level of integration is to encourage the design PE to visit the construction sites on a regular basis and to attend the construction progress meetings. This will allow the designers to become more familiar with any on-going issues in the field and will

allow the design engineers to become better designers on future and similar projects by taking all of the learned lessons back with them to the design table.

3. The third level of integration is to get the input and active involvement of the construction staff during the design phase of the project. This integration will produce better design that is more reflective of the conditions in the field and that will incorporate the best fixes to the problems.

6.3 Future Research

1. The results of all of the analysis that were detailed in Chapter 5 indicated that certain transportation services centers (TSCs) were more prone to having claims filed and paid than other TSCs in the Metro Region and in the rest of the state. Future research can seek to further understand the underlying causes of these observations.

2. The results also showed that both prime contractors D & E, had more claims filed than the rest of the contracting community working on state transportation projects. This could be explained by the type of projects (road, bridge) these contractors were working on, or that these contractors were more focused on not relinquishing the pursuit of any claim. This observation, nevertheless, needs to be analyzed further and studied in more depth to determine the mitigating factors of these circumstances.

3. The results also showed that the utilization of a consultant during the construction implementation phase showed significant effect on the likelihood of a claim being filed on the project. This observation could be related to the complexity of the project and needs to be studied further to understand the underlying factors.

4. Due to the fact that a limited number (258) of projects were available for this research, it is recommended that the STA perform similar research in about ten (10) years on all available claims to determine if there has been any shift in the number of claims submitted as well as the factors contributing to the claim filing.

5. A similar research can also be undertaken to look into all of the projects that have had substantial increases in their construction costs in the context of contract modifications to determine the mitigating factors for this phenomenon. This research can also capture the significant factors that influence the increased costs and the ever increased number of contract modifications on construction projects. This is essential as there are a great number of projects at the STA that experience a great increase in the cost and contract modifications but did not have any filed claim.

6. Additionally, as the STA is transforming into incorporating alternative contracting methods (Design-Build, Design-Build-Finance, and Best Value Contracting) it will be worth the investment in a research project to compare the outcomes of the projects that are let using the traditional method (Lowest Responsible Bid) with the projects that are let using the alternative contracting methods in term of the number and magnitude of the construction claims and their final costs.

To facilitate future research, it will be worth the investment to incorporate the following recommendations:

1. Do away with paper correspondences for the benefit of a secured electronic correspondence for all aspects of project planning, design, and construction management,

2. Install software that will allow for a complete integration of all aspects of the project life cycle (initiation, planning, design, construction, and closeout),

3. Incorporate, as a mandatory step in the project life cycle, a step that will allow for the documentation of all of the lessons learned throughout each step of the project life cycle in the project electronic file,

4. A separate research can be undertaken to study the underlining causal and characteristics of projects that exhibits a large number of contract modification and address this phenomena. And finally,

5. A research is needed on possible steps that can be taken and implemented to prevent claims in lieu of merely managing claims.

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ABSTRACT

CHARACTERISTICS AND CAUSAL FACTORS OF CLAIMS IN MICHIGAN HIGHWAY CONSTRUCTION PROJECTS

by

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The US highway system is the largest road network system in the world. MDOT administers about 9,722 route-miles, (28,000 lane-miles) of roadway networks in Michigan. Every year, hundreds of projects worth millions of dollars are let by the State Transportation Agency (STA).

Majority of these projects are successfully completed within the original scope of work, budget, schedule, and without litigation. However; some projects end up in litigation and disputes costing tax payers a great amount of money and the STA a great amount of resources. The number and cost of these construction claims has been substantially increasing in recent years.

Research on this topic has been limited to-date. Therefore, a research on this subject is needed to investigate all of the factors affecting highway construction claims to improve efficiency and effectiveness of highway project delivery.

The data available at the STA provide a rich source of information that can be utilized to study the characteristics and causal factors of claims in highway construction projects at the STA. However, until this point, these separate data sets were not integrated and much of it was not utilized for this type of research or analytical purposes.

A research of all of the projects that experienced claims was initiated that was followed by research and collection of all of the projects that were categorized as successful projects at the STA. All of the projects were organized and analyzed using logistic regression modeling. LIMDEP software was utilized to determine the factors that are more likely to affect the filling of construction claims and their likely payouts. The results were tabulated for all of the significant factors based on the values of their Estimated Coefficient, Standard Error, T-Statistic, P-Value, and Logit Relative Elasticity Calculations.

The analysis showed that certain projects factors are more likely to affect the filling of a claim, and that certain factors are more likely to affect the payout on the claims. The results also indicated that certain project factors do not seem to have any significant affect on the likelihood of filing of a claim or the payouts of these claims.

This research is the first of its kind as it categorizes the projects specific factors according to their likely affect on the filing of construction claims and the payout of these filed claims based on Michigan data. This methodology can be tested and applied in other state transportation agencies to mitigate the risks of construction claims on highway transportation projects.

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